Idaho National Laboratory Site

Site Environmental Report

Calendar Year 2008

Environmental Surveillance, Education and Research Program

DOE/ID-12082(08)
ISSN 1089-5469
STOLLER-ESER-122
October 2009

DOE/ID-12082(08)

ISSN 1089-5469

STOLLER-ESER-122

IDAHO NATIONAL LABORATORY

SITE ENVIRONMENTAL REPORT

CALENDAR YEAR 2008

Environmental Surveillance, Education and Research Program

U.S. Department of Energy Idaho Operations Office

September 2009

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

Acknowledgments

The following people have provided primary authorship of this report:

- Marilyn Case, Russell Mitchell and Roger Blew with the Environmental Surveillance, Education and Research Program managed by S.M. Stoller Corporation
- Bradley Andersen, Dave Frederick, and Thomas Haney with Battelle Energy Alliance
- Roger Wilhelmsen with CH2M-WG Idaho
- Betsy Holmes with the U.S. Department of Energy-Idaho Operations Office
- Richard Eckman with the National Oceanic and Atmospheric Administration
- Roy Bartholomay with the United States Geological Survey
- Technical editing of this report was provided by Pamela Lilburn with CH2M-WG Idaho

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

- Brad Bugger, Brett Bowhan, Charles Ljungberg, Dave Wessman, Donald Rasch, Greg Bass, Jack Depperschmidt, Jan Hagers, Jerry Wells, Jim Cooper, Katherine Medellin, Kathleen Hain, Keith Lockie, Mark Arenaz, Mary Willcox, Michael O'Hagan, Nicole Hernandez, Nicole Telford, Richard Kauffman, Robert Boston, Robert Gallegos, Talley Jenkins, Tim Jackson, Tim Safford, and Vanica Dugger with the U.S. Department of Energy (DOE)-Idaho Operations Office
- Jenifer Nordstom with Battelle Energy Alliance
- Scott Bergen, Kristy Howe, Christopher Jenkins, and Adam Narish with the Wildlife Conservation Society
- Amber Hoover, Brandy Janzen, Charles R. Peterson, Daniel Mummey, David Delehanty, David Hilliard, Joel Sankey, Ken Aho, Kevin Faris, Lachy Ingram, Lawrence Cook, Matthew Germino, Marjorie Matocq, Nancy Glenn, Nancy Hampton, Nancy Huntly, Peter Coates, Rick Williams, Scott Cambrin, and Susan Parsons with Idaho State University
- Stephen Bunting, Andrea Kuchy, Amanda Price, and Janet Rachlow with University of Idaho
- Lora Perkins, and Robert Nowak with the University of Nevada Reno
- Alana Jensen, Brande Hendricks, Amy Forman, Jackie Hafla, Doug Halford, and Jeremy Shive with the S.M. Stoller Corporation

Powell Townsite

Preface

Every person in the world is exposed to ionizing radiation, which may have sufficient energy to remove electrons from atoms, damage chromosomes, and cause cancer. There are three general sources of ionizing radiation: those of natural origin unaffected by human activities, those of natural origin but enhanced by human activities, and those produced by human activities (anthropogenic). The first general source includes terrestrial radiation from natural radiation sources in the ground, cosmic radiation from outer space, and radiation from radionuclides naturally present in the body. Exposures to natural sources may vary depending on the geographical location and altitude at which the person resides. When such exposures are substantially higher than the average, they are considered to be elevated.

The second general source includes a variety of natural sources from which the radiation has been increased by human actions. For example, radon is a radioactive gas which is heavier than air. It comes from the natural decay of uranium and is found in nearly all soils. Concentrations of radon inside buildings may be elevated because of the type of soil and rock upon which they are built (high in uranium or radon) and may be enhanced by cracks and other holes in the foundation (providing access routes for the gas). Another example is the increased exposure to cosmic radiation that airline passengers receive when traveling at normal cruising altitudes.

The third source includes a variety of exposures from human-made materials and devices such as medical x-rays, radiopharmaceuticals used to diagnose and treat disease, and consumer products containing minute quantities of radioactive materials (UNSCEAR 2000).

To verify that exposures resulting from operations at U.S. Department of Energy (DOE) nuclear facilities remain very small, each site where nuclear activities are conducted operates an environmental surveillance program to monitor the air, water, and other pathways whereby radionuclides from operations might conceivably reach workers and members of the public. Environmental surveillance and monitoring results are reported annually to DOE Headquarters. This report presents a compilation of data collected in 2008 for the environmental monitoring and surveillance programs conducted on and around the Idaho National Laboratory (INL) Site. It also presents a summary of sitewide environmental programs and discusses potential impacts from INL Site operations to the environment and the public. These programs are managed by various private companies and other Federal agencies through contracts and interagency agreements with the DOE-Idaho Operations Office (DOE-ID).

Beginning in 2005, the research and development activities at the site became the INL, which is managed and operated by Battelle Energy Alliance (BEA). BEA conducts effluent and facility monitoring, as well as sitewide environmental surveillance on the INL Site. The cleanup operations, called the Idaho Cleanup Project (ICP), are managed separately by CH2M-WG Idaho (CWI). CWI performs environmental monitoring at and around waste management facilities involved in the ICP. The Environmental Surveillance, Education, and Research Program (ESER), managed by S. M. Stoller Corporation, performs environmental surveillance of offsite locations.

The U.S. Geological Survey (USGS) performed groundwater monitoring both on and off site. The ICP contractor also conducted onsite groundwater monitoring related to waste management, clean-up/restoration, and environmental surveillance. The National Oceanic and Atmospheric Administration (NOAA) collected meteorological data.

The Advanced Mixed Waste Treatment Project (AMWTP), located on the INL Site at the Radioactive Waste Management Complex (RWMC), is operated by Bechtel BWXT Idaho, LLC. AMWTP performs regulatory compliance monitoring and other limited monitoring as a best management practice. These monitoring activities are reported to DOE-ID and regulators as required and are not presented in this report.

The Naval Reactors Facility (NRF), operated by Bechtel Bettis, Inc (BBI), is excluded from this report. As established in Executive Order 12344 (FR 1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 450.1 (DOE 2003), and 5400.5 (DOE 1993). The director, Naval Nuclear Propulsion Program, established reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. NRF's program is documented in the NRF Environmental Monitoring Report.

This report also contains information on nonradiological monitoring performed during the year. Results of this monitoring, both chemical (liquid effluent constituent concentrations) and physical (particulates) are presented. Nonradiological parameters monitored are those required under permit conditions or are related to material released from INL Site operations.

This report, prepared in accordance with the requirements in DOE Orders 450.1 and 231.1A, is not intended to cover the numerous special environmental research programs conducted at the INL Site (DOE 2003, 2004).

REFERENCES

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000, "Sources and Effects of Ionizing Radiation," Vol. 1, UNSCEAR 2000 Report to the General Assembly with Scientific Annexes.

Department of Energy (DOE), 1993, "Radiation Protection of the Public and the Environment," Order 5400.5, January.

Department of Energy (DOE), 2003, "Environmental Protection Program," DOE Order 450.1, January.

Department of Energy (DOE), 2004, "Environment, Safety, and Health Reporting," DOE Order 231.1A, June.

Executive Summary

The *Idaho National Laboratory Site Environmental Report Calendar Year 2008* was prepared to inform the public, regulators, stakeholders, and other interested parties of the Idaho National Laboratory (INL) Site environmental performance during 2008.

Purpose of the INL Site Environmental Report

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

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

Major INL Site Programs and Facilities

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

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

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

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

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

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

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

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

The CITRC includes the INL Site’s 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.

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 for use on the nation's space missions. The INL contractor runs the MFC.

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

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

The RWMC was established in 1952 as a burial location for low-level radioactive waste. Starting in 1954, however, transuranic waste and organic sludge from Rocky Flats, Colorado, was also buried in the Subsurface Disposal Area (SDA)—the actual burial grounds at the RWMC. In 1970, the federal government stopped burying transuranic waste at the RWMC and began placing it in retrievable storage for later transfer to a federal repository, but the INL Site continued to dispose of low-level radioactive waste in pits at the SDA. The AMWTP contractor operates the SDA and is responsible for low-level waste management activities as well as monitoring and remediation activities associated with contamination from past waste disposal practices. Cleanup of the RWMC is the responsibility of the ICP contractor.

The Research and Education Campus, located in Idaho Falls, is home to the DOE Idaho Operations Office and INL contractor administration and a wide variety of other facilities. At the INL Research Center, scientists working in dozens of laboratories conduct cutting-edge research in fields as varied as robotics, genetics, biology, chemistry, metallurgy, computational science and hydropower.

One of the main missions at TAN now is the manufacture of tank armor for the U.S. Army's battle tanks at the Specific Manufacturing Capability Project. This project is operated for the U.S. Department of Defense by the INL contractor.

Compliance with Environmental Laws, Regulations, and Policies

One measure of the achievement of the environmental programs at the INL Site is compliance with applicable environmental regulations, which have been established to protect human health and the environment. The federal laws which apply to INL Site activities include the Clean Air Act, the Clean Water Act, Safe Drinking Water Act, National Environmental Policy Act, and CERCLA. Overall, the INL Site met all federal, state and local regulatory commitments in 2008.

The INL Site attained ISO 14001 certification of its Environmental Management System effective November 24, 2005, and continues to maintain certification. The Pollution Prevention and Sustainability Program is part of the Environmental System. Its scope incorporates waste prevention and elimination, reduction of environmental releases, environmentally preferable purchasing, environmental stewardship in program planning and operational design, and recycling of solid wastes. The program is designed to minimize the environmental impact of the INL Site while enhancing support for the mission. In 2008, 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.” According to the 2008 NESHAPS report, an estimated total of

5,326 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2008. The highest releases were from INTEC and the ATR Complex.

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 2008, the INL contractor monitored ambient air outside 14 INL Site facilities and at five locations offsite. 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 eight 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 composites and were analyzed for gamma-emitting radionuclides, such as cesium-137. Particulate filters were also composited quarterly 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 offsite. Trends in the data appear to be seasonal in nature and do not demonstrate any INL site influence on the monitoring results. This indicates that INL Site airborne effluents do not measurably impact the environment.

The INL and ESER contractors also collected atmospheric moisture samples at two stations on and five stations off the INL Site. In addition, the ESER contractor sampled precipitation at two stations on the INL Site and one location off the INL Site. These samples were all analyzed for tritium. The results were within historical measurements and below DOE standards and are 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 at 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

2008, liquid effluent and groundwater monitoring were conducted in support of water reuse permit requirements. An annual report was prepared and submitted to the Idaho Department of Environmental Quality. No permit limits were exceeded, however, several elevated concentrations of aluminum, iron, and manganese were detected in some samples taken from a well at TAN near a closed sewage treatment plant. An investigation of these results was conducted in 2007 and it was concluded that factors other than wastewater effluent discharges are causing the elevated results.

Drinking water was sampled in 11 drinking water systems at the INL Site in 2008. 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 2008. 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 fourth quarter 2008. 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 was detected in the sample above historical measurements and may be attributed the significant amount particulate matter in the sample. The detected concentration does 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 2008, 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 continued to be detected by USGS in monitoring wells, including drinking water wells, at the INL Site. The concentration of tetrachloromethane (carbon tetrachloride) was above the EPA maximum contaminant level during 2008. 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, nitrate, and chromium were also below the applicable standards in 2008.

Groundwater surveillance monitoring continued for the CERCLA Waste Area Groups (WAGs) on the INL Site in 2008. At TAN, 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 show declining concentrations of chromium, strontium-90, tritium, and gross alpha activity. Monitoring of groundwater for the CFA landfills consists of sampling 11 wells for metals, volatile organic compounds, and anions. Some of the metals and anions exceeded their maximum contaminant levels in 2008, but concentrations were within historic levels. None of the organic compounds exceeded any EPA maximum contaminant level. At the RWMC, over 3,500 analyses were performed on samples from 15 monitoring wells. Two analytes exceeded their EPA maximum contaminant levels in 2008. Carbon tetrachloride exceeded the level in four of 32 analyses but has shown a declining trend south of the facility since 2003. Gross beta activity was above the maximum contaminant level attributable to elevated levels of naturally occurring potassium-40 at the monitoring location.

Monitoring of Agricultural Products and Wildlife and Direct Radiation Measurements

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, wheat, and potatoes) and wildlife were sampled and analyzed for radionuclides in 2008. The agricultural products were collected on, around, and distant from the INL Site by the ESER contractor. Wildlife sampling included collection of ducks from sanitation waste ponds in the vicinity of the ATR Complex and the MFC, as well as big game animals killed by vehicles on roads within the INL Site. In addition, direct radiation was measured on and off the INL Site in 2008.

Some human-made radionuclides were detected in agricultural product and wildlife samples. However, measurements were consistent with those made historically. Direct radiation measurements made at offsite, boundary, and onsite locations (except RWMC) were consistent with historical and 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. Two different computer programs were used to estimate doses. 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 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 2008. 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 calculations were used to estimate the dose to the population within 50 miles of the INL Site facilities.

The maximum calculated dose to the maximally exposed individual, 0.131 mrem, was well below the10 mrem standard established by the Clean Air Act. For comparison, the dose from natural background radiation was estimated in 2008 to be 354 mrem. The maximum potential population dose to the approximately 300,656 people residing within an 80-km (50-mi) radius of any INL facility was calculated as 0.78 person-rem, below that expected from exposure to background radiation (106,432 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 0.052 mrem and 0.227 mrem, respectively. These estimates are conservatively high.

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Based on this approach, there is no evidence that INL Site-related radioactivity in soil or water is harming populations of plants or animals.

Ecological 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 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 2008 there were 13 major ecological research projects taking place on the Idaho NERP. The researchers were from Idaho State University, University of Idaho, Boise State University, University of Nevada Reno, Montana State University, Texas A&M University, New Mexico State University, Colorado State University, the Wildlife Conservation Society, and ESER.

Quality Assurance

Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to ensure precise, accurate, representative, and reliable results and maximize data completeness. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, these laboratories participate in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP and ESER contractors during 2008 were addressed with the laboratories and resolved.

Pygmy Rabbit

Helpful Information

Scientific Notation

Scientific notation is used to express numbers that are very small or very large. A very small number is expressed with a negative exponent, for example, 1.3×10^{-6}. To convert this number to the decimal form, the decimal point must be moved left by the number of places equal to the exponent (six, in this case). The number, thus, becomes 0.0000013.

For large numbers, those with a positive exponent, the decimal point is moved to the right by the number of places equal to the exponent. The number 1,000,000 can be written as 1.0×10^{6}.

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 1000 of a given unit. One kilometer is, therefore, equal to 1000 meters. Table HI-1 shows fractions and multiples of units.

Table HI-1. Fractions and Multiples of Units.

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

Units of Radioactivity, Radiation Exposure, and Dose

The basic unit of radioactivity used in this report is the curie (abbreviated Ci). The curie is historically based on the number of disintegrations that occur in 1 gram of the radionuclide radium-226, which is 37 billion nuclear disintegrations per second. For any other radionuclide, 1 Ci is the amount of the radionuclide that decays at this same rate.

Radiation exposure is expressed in terms of the roentgen (R), the amount of ionization produced by gamma radiation in air. Dose is given in units of roentgen equivalent man (or rem), which takes into account the effect of radiation on tissues. For the types of environmental radiation generally encountered, the unit of roentgen is approximately numerically equal to the unit of rem. A person-rem is the sum of the doses received by all individuals in a population.

The concentration of radioactivity in air samples is expressed in units of microcuries per milliliter (µCi/mL) of air. For liquid samples, such as water and milk, the units are in picocuries per liter (pCi/L). Radioactivity in agricultural products is expressed in picocuries per gram (pCi/g) dry weight. Annual human radiation exposure, measured by environmental dosimeters, is expressed in units of milliroentgens (mR). This is sometimes expressed in terms of dose as millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor.

The Système International is also used to express units of radioactivity and radiation dose. The basic unit of radioactivity 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. Radiation dose may also be expressed using the Système International unit sievert (Sv), where 1 Sv equals 100 rem.

Uncertainty of Measurements

There is always an uncertainty associated with the measurement of environmental contaminants. For radioactivity, a major source of uncertainty is the inherent statistical nature of radioactive decay events, particularly at the low activity levels encountered in environmental samples. The uncertainty of a measurement is denoted by following each result with plus or minus (±) uncertainty term. Individual analytical results are presented in tables in this report with plus or minus one analytical deviation (± 1s). Generally the result is considered “detected” if the measurement is greater than three times its estimated analytical uncertainty (3s) unless noted otherwise, for consistency with other INL Site environmental monitoring reports.

Negative Numbers as Results

Negative values occur in radiation measurements when the measured result is less than a preestablished average background level for the particular counting system and procedure used. These values are reported as negative, rather than as “not detected” or “zero,” to better enable statistical analyses and observe trends or bias in the data.

Radionuclide Nomenclature

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different isotopes, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the atom). Most commonly used radionuclide symbols used in this report are shown in Table HI-2.

Table HI-2. Most Commonly Used Radionuclides and Symbols Used in this Report.

Radionuclide	Symbol
Actinium-227	^{227}Ac
Americium-241	^{241}Am
Americium-242	^{242}Am
Americium-242m[a]	^{242m}Am
Americium-243	^{243}Am
Antimony-124	^{124}Sb
Antimony-125	^{125}Sb
Antimony-126	^{126}Sb
Antimony-126m[a]	^{126m}Sb
Antimony-127	^{127}Sb
Argon-41	^{41}Ar
Barium-133	^{133}Ba
Barium-137	^{137}Ba
Barium-139	^{139}Ba
Barium-140	^{140}Ba
Barium-141	^{141}Ba
Beryllium-7	^{7}Be
Bismuth-210	^{210}Bi
Bismuth-211	^{211}Bi
Bismuth-212	^{212}Bi
Bismuth-214	^{214}Bi
Cadmium-115m[a]	^{115m}Cd
Californium-252	^{252}Cf
Carbon-14	^{14}C
Cerium-141	^{141}Ce
Cerium-143	^{143}Ce
Cerium-144	^{144}Ce
Cesium-134	^{134}Cs
Cesium-135	^{135}Cs
Cesium-137	^{137}Cs
Cesium-138	^{138}Cs
Chlorine-36	^{36}Cl
Chromium-51	^{51}Cr
Cobalt-57	^{57}Co
Cobalt-58	^{58}Co
Cobalt-60	^{60}Co
Curium-242	^{242}Cm
Curium-243	^{243}Cm
Curium-245	^{245}Cm
Curium-246	^{246}Cm
Curium-247	^{247}Cm
Curium-248	^{248}Cm
Curium-244	^{244}Cm
Europium-152	^{152}Eu
Europium-154	^{154}Eu
Europium-155	^{155}Eu
Francium-221	^{221}Fr
Francium-223	^{223}Fr
Hafnium-181	^{181}Hf
Holmium-166	^{166}Hf
Holmium-166m[a]	^{166m}Ho
Iodine-125	^{125}I
Iodine-129	^{129}I
Iodine-131	^{131}I
Iodine-132	^{132}I
Iodine-133	^{133}I
Iodine-134	^{134}I
Iodine-135	^{135}I
Indium-115	^{115}In
Iridium-192	^{192}Ir
Iron-55	^{55}Fe
Iron-59	^{59}Fe
Krypton-85	^{85}Kr
Krypton-85m[a]	^{85m}Kr
Krypton-87	^{87}Kr
Krypton-88	^{88}Kr
Lanthanum-140	^{140}La
Lead-209	^{209}Pb
Lead-210	^{210}Pb
Lead-211	^{211}Pb
Lead-212	^{212}Pb
Lead-214	^{214}Pb
Manganese-54	^{54}Mn
Mercury-203	^{203}Hg
Molybdenum-99	^{99}Mo
Neodymium-147	^{147}Nd
Neptunium-237	^{237}Np
Neptunium-238	^{238}Np
Neptunium-239	^{239}Np
Neptunium-240	^{240}Np
Neptunium-240m[a]	^{240m}Np
Nickel-59	^{59}Ni
Nickel-63	^{63}Ni
Niobium-93m[a]	^{93m}Nb
Niobium-94	^{94}Nb
Niobium-95	^{95}Nb
Niobium-95m[a]	^{95m}Nb
Palladium-107	^{107}Pd
Potassium-40	^{40}K
Plutonium-236	^{236}Pu

Table HI-2. Most Commonly Used Radionuclides and Symbols Used in this Report.

Radionuclide	Symbol
Plutonium-238	^{238}Pu
Plutonium-239	^{239}Pu
Plutonium-239/240	$^{239/240}$Pu
Plutonium-240	^{240}Pu
Plutonium-241	^{241}Pu
Plutonium-242	^{242}Pu
Plutonium-243	^{243}Pu
Plutonium-244	^{244}Pu
Polonium-210	^{210}Po
Polonium-218	^{218}Po
Praseodymium-144	^{144}Pr
Praseodymium-144m[a]	^{144m}Pr
Promethium-147	^{147}Pm
Promethium-148	^{148}Pm
Promethium-148m[a]	^{148m}Pm
Protactinium-231	^{231}Pa
Protactinium-233	^{233}Pa
Radium-223	^{223}Ra
Radium-225	^{225}Ra
Radium-226	^{226}Ra
Radium-228	^{228}Ra
Rhodium-103m[a]	^{103m}Rh
Rhodium-105	^{105}Rh
Rubidium-87	^{87}Rb
Rubidium-88	^{88}Rb
Rubidium-88d	^{88d}Rb
Rubidium-89	^{89}Rb
Ruthenium-103	^{103}Ru
Ruthenium-106	^{106}Ru
Samarium-147	^{147}Sm
Samarium-151	^{151}Sm
Scandium-46	^{46}Sc
Silver-109m[a]	^{109m}Ag
Silver-110	^{110}Ag
Silver-110m[a]	^{110m}Ag
Sodium-22	^{22}Na
Sodium-24	^{24}Na
Strontium-89	^{89}Sr
Strontium-90	^{90}Sr
Strontium-91	^{91}Sr
Strontium-92	^{92}Sr
Zirconium-95	^{95}Zr
Technetium-99	^{99}Tc
Technetium-99m[a]	^{99m}Tc
Tellurium-127	^{127}Te
Tellurium-127m[a]	^{127m}Te
Tellurium-129	^{129}Te
Tellurium-129m[a]	^{129m}Te
Terbium-160	^{160}Tb
Tin-113	^{113}Sn
Tin-123	^{123}Sn
Tin-126	^{126}Sn
Thallium-207	^{207}Tl
Thallium-208	^{208}Tl
Thalllium-209	^{209}Tl
Thorium-227	^{227}Th
Thorium-230	^{230}Th
Thorium-231	^{231}Th
Thorium-232	^{232}Th
Tritium	^{3}H
Tungsten-187	^{187}W
Uranium-232	^{232}U
Uranium-233	^{233}U
Uranium-233/234	$^{233/234}$U
Uranium-234	^{234}U
Uranium-235	^{235}U
Uranium-236	^{236}U
Uranium-237	^{237}U
Uranium-238	^{238}U
Uranium-240	^{240}U
Xenon-127	^{127}Xe
Xenon-131m[a]	^{131m}Xe
Xenon-133	^{133}Xe
Xenon-133m[a]	^{133m}Xe
Xenon-135	^{135}Xe
Xenon-135m[a]	^{135m}Xe
Xenon-137	^{137}Xe
Xenon-138	^{138}Xe
Yttrium-90	^{90}Y
Yttrium-90m[a]	^{90m}Y
Yttrium-91	^{91}Y
Zinc-65	^{65}Zn
Zirconium-93	^{93}Zr

a. The letter 'm' after a number denotes a metastable (transitional isotope normally with very short half lives) isotope.

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
ASER	Annual Site Environmental Report
ATR	Advanced Test Reactor
BBI	Bechtel Bettis, Inc.
BBS	Breeding Bird Survey
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
BEA	Battelle Energy Alliance
BLM	U.S. Bureau of Land Management
BNFL	British Nuclear Fuels Limited
BOD	Biochemical Oxygen Demand
BLR	Big Lost River
CAES	Center for Advanced Energy Studies
CAP-88PC	Clean Air Act Assessment Package, 1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
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
COC	Contaminant of Concern
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
DD&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
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
FFV	Flex Fuel Vehicles
FR	Federal Regulations
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
HpGe	High-Purity Germanium Detector
ICDF	INL 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
LLW	Low-Level Waste
LMAES	Lockheed Martin Advanced Environmental Systems
LOFT	Loss-of-Fluid Test
LTS	Long-Term Stewardship
LTV	Long-Tern 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
MTBE	Methyltertiary-butyl ether
ND	Non Detected
NE	Nuclear Energy, Science and Technology
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	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
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NS	No Sample
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment
PCS	Primary Constituent Standard
P2	Pollution Prevention
PE	Performance Evaluation

POC	Purgeable Organic Compounds
PPOA	Polution Prevention Opportunity Assessment
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
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
SAR	Sodium Absorption Ratio
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
SP	Suspended Particle
SRP	Snake River Plain
STF	Security Training Facility
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TIC	Total Integrated Concentration
TLD	Thermoluminescent Dosimeter
TMI	Three-Mile Island
TRA	Test Reactor Area
TRU	Transuranic (waste)
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility

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

Big Lost River Sinks

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		

Pronghorn

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."

This annual report describes the Idaho National Laboratory (INL) Site's impact to the public and the environment with emphasis on radioactive contaminants. Specific sections of this annual report cover the following:

- Description of DOE's INL Site (Chapter 1)
- Summary of INL compliance with local, state, and federal environmental laws and regulations (Chapter 2)
- Environmental programs (Chapter 3)
- Environmental monitoring of air (Chapter 4)
- Compliance monitoring of drinking water, liquid effluent, and groundwater (Chapter 5)
- Environmental monitoring of the Eastern Snake River Plain Aquifer and Surface Water (Chapter 6)
- Environmental monitoring of agricultural products, wildlife, soil, and direct radiation (Chapter 7)
- Radiological doses to the public and biota (Chapter 8)
- Summary of ecological research at the Idaho National Environmental Research Park (Chapter 9)
- Quality assurance programs (Chapter 10).

1.1 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.

1.1.1 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.

1.1.2 Idaho Cleanup Project

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

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

1.1.3 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) between 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.

1.1.4 Primary Idaho National Laboratory Site Facilities

The INL Site is located on 2,305 km^2 (890 mi^2) of mostly undeveloped, cool desert terrain in southeastern Idaho (Figure 1-1). 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. 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 border.

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, environmental and radiological monitoring, security, fire protection, warehouses, and calibration activities. It is operated by the INL contractor.

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

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

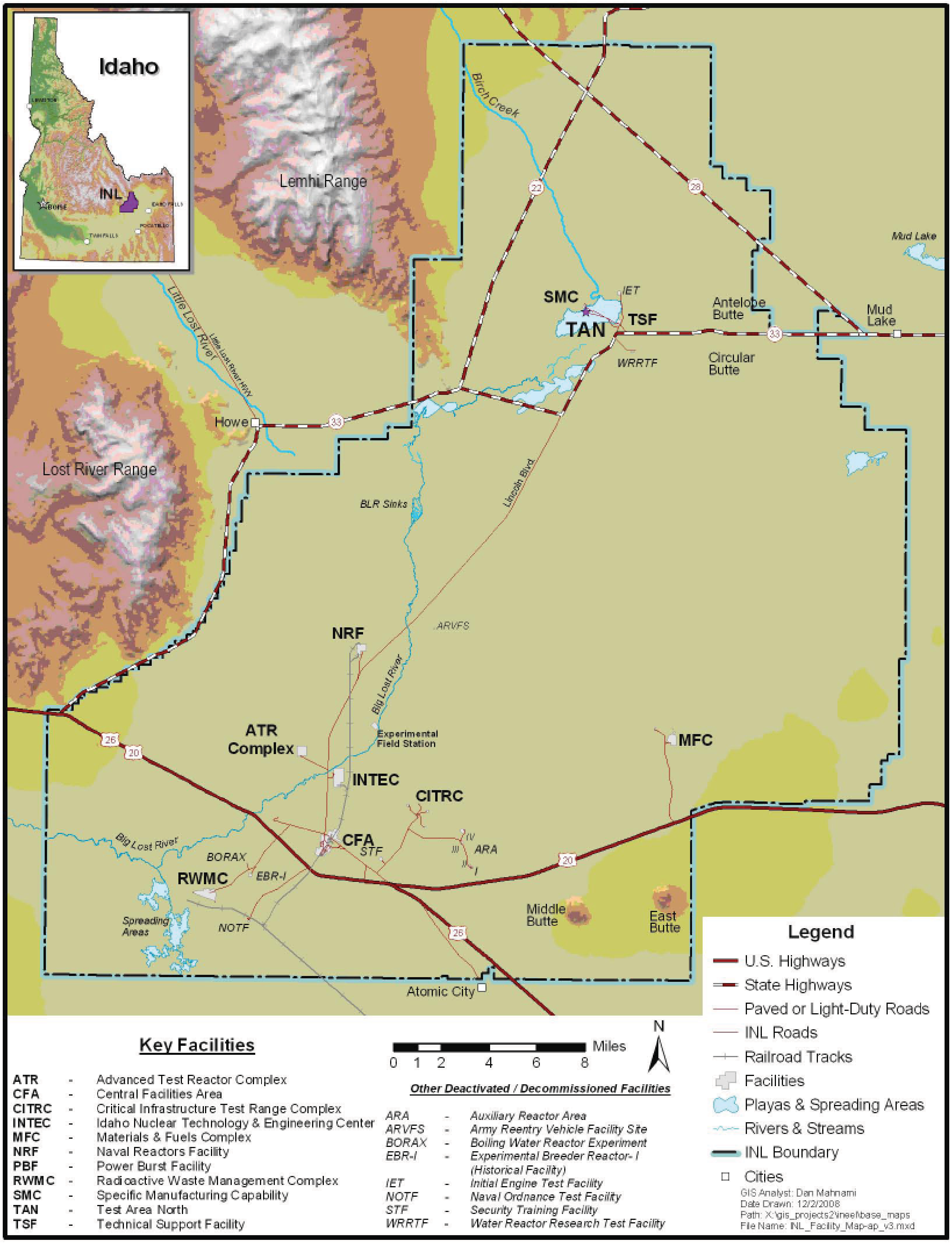


Figure 1-1. Location of the Idaho National Laboratory Site, Showing Facilities.

Materials and Fuels Complex—The Materials and Fuels Complex (MFC), formerly Argonne National Laboratory-West, 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 for Naval Reactors by Bechtel Bettis, Inc. Developmental nuclear fuel material samples, naval spent fuel, and irradiated reactor plant components/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 (FR 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 (BBI 2007).

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 our quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. The Center for Advanced Energy Studies, designed to promote education and world class research and development, is also located at the Research and Education Campus. New laboratory facilities are under development, and other facilities proposed over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure close to current campus buildings. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory.

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

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.

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

1.2 Physical Setting of the Idaho National Laboratory Site

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. Approximately 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. An inventory counted 409 plant species 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 counts include six fishes, one amphibian, nine reptiles, 164 birds, and 39 mammals (Reynolds et al. 1986).

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

The fractured volcanic rocks under the INL Site form a portion of the Eastern Snake River Plain Aquifer, 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 80 to 120 million hectare-ft (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.

1.3 History of the INL Site

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

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

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

People of European descent were the earliest explorers of 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 developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas. The National Reactor Testing Station was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory in 1997 to reflect the Site's leadership role in environmental management. The U.S. Atomic Energy Commission was renamed the U.S. Energy Research and Development Administration in 1975 and reorganized to the present-day DOE in 1977.

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

1.4 Regional Impact

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 report analyzes three dimensions 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.

The research for Impacts 2006 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."

REFERENCES

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

BBI, 2007, *2007 Environmental Monitoring Report for the Naval Reactor Facility*, NRFRC-EE-012, Bechtel Bettis, Inc.

Black, G., D. Holley, and J. Church, 2006, *Idaho National Laboratory Impacts 2006: An Analysis of INL's Impacts on the Idaho Economy*, Boise State University.

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

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

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

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

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

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

Executive Order 12344, 1982, “Naval Nuclear Propulsion Program.”

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

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

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

Smith, R. B. and L. J. Siegel, 2000, “The Geologic Story of Yellowstone and Grand Teton National Parks,” *Windows of the Earth*.

Big Lost River Headgate

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 2008, and programs are in place to address areas for continued improvement.

The N*ational Emission Standards for Hazardous Air Pollutants-Calendar Year 2008 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2008, 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 National Response Center and appropriate state and local authorities following three reportable environmental releases.

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 2009 *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 *Idaho Hazardous Waste Generator Annual Report – Calendar Year 2008* was submitted to the state of Idaho, which is authorized by Environmental Protection Agency (EPA) to regulate hazardous waste under the Resource Conservation and Recovery Act. The state of Idaho approved closure plans for three facilities in 2008. The State also conducted a hazardous waste compliance inspection of the INL Site and issued four alleged violations, which were successfully resolved.

In 2008, 38 INL Site projects were screened for potential impacts to archeological resources. Three archival and field investigations of INL's historic archeological sites were also conducted.

There are 54 active permits for air emissions, groundwater, wastewater, and hazardous waste compliance that have been granted to the INL Site from the city of Idaho Falls, state of Idaho, Environmental Protection Agency, and the Corps of Engineers.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

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

2.1 Air Quality and Radiation Protection

2.1.1 Clean Air Act

The Clean Air Act is the law that forms the basis for the national air pollution control effort. Basic elements of the Clean Air Act include:

- National ambient air quality standards
- National emissions standards for hazardous air pollutants
- Mobile source program
- New source performance standards
- Acid rain program
- Stratospheric ozone protection program
- Operating permit program
- Enforcement provisions.

The Environmental Protection Agency (EPA) is the federal regulatory agency of authority, but states may administer and enforce provisions of the Clean Air Act by obtaining EPA approval of a state implementation plan. The state of Idaho has been delegated such authority for all elements of the Clean Air Act except the National Emission Standards for Hazardous Air Pollutants Program.

The Idaho Air Quality Program is primarily administered through the permitting process. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is specifically exempt from permitting requirements or if the source's emissions of regulated air pollutants equal or exceed the significant emission rates. If emission rates are determined to be significant, several actions may occur:

- Permitting determinations to demonstrate that the project or process either is below emission thresholds or listed as exempted source categories in state of Idaho regulations allowing self-exemption.
- Submitting an application for a Permit to Construct. If emissions are determined to be major per Prevention of Significant Deterioration regulations, then a Prevention of Significant Deterioration analysis must be completed. If emissions are not determined to be significant per Prevention of Significant Deterioration regulations, an application for only a Permit to Construct, without the additional Prevention of Significant Deterioration modeling and analysis, is needed. All Permits to Construct are applied for using the state of Idaho air regulations and guidelines.
- A Title V operating permit (also known as a Tier I operating permit) is required for major sources. Major sources are sources that emit, or may emit, 100 or more tons of any regulated air pollutant per year, 10 or more tons per year of any one hazardous air pollutant, or 25 or more tons per year of any combination of hazardous air pollutants.

Title V Operating Permit—Title V of the 1990 Clean Air Act Amendments required EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state or local air pollution agencies or both. EPA promulgated regulations in July 1992 that defined the requirements for state programs. Idaho has promulgated regulations, and EPA has given full approval of the Idaho Tier I Operating Permit Program. The INL Site has two Tier I operating permits with effective dates of June 28, 2005, and November 15, 2006.

National Emission Standards for Hazardous Air Pollutants—40 Code of Federal Regulations (CFR), Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” applies to facilities owned or operated by DOE. Administration of this subpart has not been delegated to Idaho and is regulated by EPA. The Department of Energy Idaho Operations Office (DOE-ID) submitted the *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2008 INL Report for Radionuclides* (DOE-ID 2009a) to EPA, DOE Headquarters, and state of Idaho officials in June 2009. 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.” Permitted sources of air pollutants at the INL Site are listed in Table 2-1.

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

DOE Order 5400.5, “Radiation Protection of the Public and the Environment” represents DOE’s objective to operate its facilities and conduct its activities so that radiation exposures to members of the public are maintained within the limits established in the Order and to control radioactive contamination through the management of real and personal property. Another DOE objective is that potential exposures to members of the public be as far below the limits as is reasonably achievable and that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and nonroutine releases and to assess doses to members of

Table 2-1. INL Site Emergency Planning and Community Right-to-Know Act (EPCRA) Reporting Status (2008).

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

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
- Performing radiation dose evaluations 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.

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 are used throughout this report for comparison to and interpretation of environmental monitoring and radiological dose data.

2.2 Environmental Remediation and Protection

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, 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 2-1.

Section 304—Section 304 requires owners and operators of facilities where hazardous chemicals are produced, used, or stored to report releases of CERCLA hazardous substances or extremely hazardous substances that exceed reportable quantity limits to state and local authorities (i.e., state emergency response commissions and local emergency planning committees). In 2008, there was one release of a CERCLA-reportable chemical at the INL Site. At the Materials and Fuels Complex, 13.6 kg (30 lb) of lead pieces were discovered beyond the facility fence boundary sitting on the soil surface. The lead was removed and sent to a hazardous waste satellite accumulation area within 24 hours of discovery. The lead was considered to be a spill that exceeded the CERCLA hazardous substance reportable quantity of 4.5 kg (10 lb). Notifications were made to the National Response Center and to appropriate state and local authorities.

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 are also 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 Toxics 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, lead, naphthalene, nickel, polycyclic aromatic compounds, and toluene to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases—In addition to the release reported under EPCRA Section 304, two other environmental releases were determined to be reportable to external agencies in 2008. Both releases were appropriately remediated, and neither posed significant threats to the environment or human health. The following two releases were reported:

- At Test Area North, a hydraulic hose that feeds the processor device to a trackhoe broke, causing 113.6 L (35 gal) of hydraulic fluid to spill to debris, snow, and soil. The trackhoe was placed out of service until the broken hose was replaced. The quantity of hydraulic fluid exceeded the reportable quantity of 94.6 L (25 gal). The spill was remediated within 24 hours of discovery.
- At the Advanced Test Reactor Complex, approximately 236.6 mL (8 oz) of oil leaked from a fire water pump located in Building TRA-633, to a drain that feeds to the cold industrial waste pond. The cold waste pond is unlined and receives approximately 250,000 gallons of water per day. No visible sheen was on the water. Although no reportable quantity limits were exceeded, the release was determined to be reportable because the release 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 February 8, 2008. 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. The final EIS 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. An additional record of decision for high-level waste calcine disposition is scheduled for issuance in 2009.

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 January 19, 2009.

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, and 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.

One federally protected species, the gray wolf (*Canis lupus*), may occasionally spend time on the INL Site. Gray wolves found in the geographical region that includes the INL Site are identified as an experimental/nonessential population and treated as a threatened species. There have been unsubstantiated sightings of gray wolves on the INL Site.

Sage-grouse and pygmy rabbits are resident INL Site species. The U.S. Fish and Wildlife ervice 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.

2.2.6 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).

2.2.7 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 may also 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 U.S. Fish and Wildlife Service National Wetlands Inventory map is used to identify potential jurisdictional wetlands and nonregulated sites with ecological, environmental, and future development significance. In 2008, no actions took place or had an impact on 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.

2.2.8 Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management

On January 24, 2007, President George W. Bush signed Executive Order 13423, “Strengthening Federal Environmental, Energy, and Transportation Management.” Executive Order 13423 establishes requirements to meet or exceed the goals and objectives of the Energy Policy Act of 2005 for energy efficient, renewable energy, transportation energy, and water conservation at federal facilities. 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 environmental management systems to manage and continually improve sustainable practices.

The new DOE Order 430.2B, “Departmental Energy, Renewable Energy, and Transportation Management,” contains requirements that DOE will accomplish to implement Executive Order 13423. 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 2009 *INL Site Executable Plan for Energy and Transportation Fuels Management* (DOE-ID 2008a) to DOE Headquarters in November 2008. 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 13423, DOE Order 430.2B, and DOE Order 450.1A before the end of Fiscal Year 2015.

The INL Site as a whole spent over $11.7 M in 2008 for facility and equipment energy. Of this total, $11.2 M was spent for building energy, and $500 K was spent on equipment fuel. The managed area consumes over 1.08 trillion Btu of energy and over 3.8 billion L (1 billion gal) of water annually. Energy consumption at the INL Site for 2008 on a Btu/ft^2 basis has been reduced by 6.6 percent when compared to the base year of 2003.

Transportation fuel use across the INL Site totaled over 3.8 M L (1 M gal) of various types of fuels for 2008. The INL Site fleet is comprised of light duty vehicles fueled by gasoline, E85, liquefied natural gas, and compressed natural gas. Heavy-duty vehicles include over-the-road buses fueled by diesel, biodiesel, and liquefied natural gas, and a complex assortment of trucks and equipment. Typically, 152.9 M km (9.5 M mi) are driven annually, and over 50,000 hours are logged on heavy equipment. Table 2-2 lists energy and water use reduction goals for the INL Site. A more detailed discussion of environmental management systems, waste minimization, and pollution prevention programs is provided in Chapter 3.

Table 2-2. Estimated Future Energy and Water Use Reduction for the INL Site (2008).

Performance Area	Baseline[a]	2015 Goal
Total building energy use (M Btu)	981,300	702,280
Total building water use (M gal)	1,010.0	810.1

a. 2003 is the baseline year for energy use, and 2007 is the baseline year for water use.

2.3 Waste Management

2.3.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE orders, regulates radioactive wastes and the radioactive part of mixed wastes. 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 *Idaho Hazardous Waste Generator Annual Report – Calendar Year 2008* (INL 2009). 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 2008:

- INTEC Rare Gas Plant North Gas Cell System (INTEC-055) (DOE-ID 2008b)
- INTEC CPP-601 Waste Transfer Lines to the Tank Farm Facility (INTEC-601) (DOE-ID 2008c)
- Advanced Test Reactor Complex TRA-604 Laboratory Components (VCO-5.8.d) (DOE-ID 2008d).

Notices of Violation/Non-compliance—On May 5–9, 2008, DEQ conducted an inspection of the INL Site. DEQ issued a warning letter to DOE-ID, the INL contractor (Battelle Energy Alliance, LLC) and the ICP contractor (CH2M-WG Idaho, LLC) on June 17, 2008, for four alleged violations. Through a series of meetings and conference calls in June and July, DOE-ID and the two contractors were able to resolve all the issues surrounding the alleged violations. On July 29, 2008, DEQ notified DOE-ID, the INL contractor, and the ICP contractor that all corrective actions to resolve items in the warning letter had been successfully completed.

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* were finalized and signed by the state of Idaho on November 1, 1995 (DEQ 1995). A status of Site Treatment Plan milestones for 2008 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, replaces DOE Order 5820.2A, "Radioactive Waste Management," and includes the requirements that DOE facilities and operations must meet in managing radioactive waste. Change 1 was added to the Order in August 2001. INL Site activities related to this Order are discussed in Chapters 3 and 6.

2.3.5 1995 Settlement Agreement

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

The INL Site continues to ship transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, in compliance with the Settlement Agreement requirement to ship a running average of no fewer than 2,000 m^3 (2,616 yd^3) of transuranic waste per year out of Idaho. The running average over the past three years is 6,863 m^3 (8,969 yd^3). In calendar year 2008, 5,036 m^3 (6,581 yd^3) of transuranic waste was shipped out of Idaho. This amount included 43 m^3 (56 yd^3) of remote-handled transuranic waste.

The INL Site received seven truck cask shipments containing a combined total of 0.0891 metric tons (196 lb) of spent nuclear fuel. This included spent nuclear fuel from the DOE Hanford Site (three shipments), DOE Sandia National Laboratories (two shipments), and Romania (two shipments). By the end of the calendar year 2008, 2,337 of 3,186 fuel handling units identified in the ICP contract had been moved to dry storage.

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, set by EPA, for specific industry categories 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 sections below.

Administrative Order—In August, 2007, analysis of samples taken from the CPP-2018 monitoring well at INTEC detected petroleum products in the groundwater. 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 any further actions that may be necessary. DEQ tentatively accepted the Schedule and Criteria on February 2, 2009, pending DOE and ICP submission and approval of a groundwater monitoring plan and any proposed corrective actions on March 23, 2009. DOE and ICP will continue to monitor the CPP-2018 well and surrounding wells for indications of petroleum products.

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 2008 were within compliance levels established on the acceptance permit.

Storm Water Discharge Permits for Construction Activity—DOE-ID obtained coverage for the INL Site under the General Permit for Storm Water Discharges from Construction Sites issued in June 1993. The coverage under the general permit has been renewed twice. INL Site contractors obtain coverage under the general permit for individual construction projects. Storm water pollution prevention plans are completed for individual construction projects. Only construction projects that are determined to have a reasonable potential to discharge pollutants to a 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 in the state. 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 for irrigation and is absorbed by the crop or assimilated into the soil structure. 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
- Combined INTEC Sewage Treatment Plant effluent and service wastewater for disposal at the INTEC New Percolation Ponds.

DEQ is reviewing a permit application for the Materials and Fuels Complex Industrial Waste Pond. The Test Area North/Technical Support Facility Sewage Treatment Plant was also permitted but was closed in 2008 under a DEQ-approved Closure Plan (ICP 2007).

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 are then consulted to mitigate these effects. Significant survey and research efforts were also 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 2009b) 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 2-3 summarizes the cultural resources surveys performed at the INL Site by the INL Cultural Resources Management Program. In 2008, 38 INL 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 23 cases, INL Cultural Resources Management (CRM) staff provided feedback on archaeological sensitivity for large-scale siting studies or worked directly with project managers in the field to protect 113 archaeological sites (70 newly recorded in 2008, 43 previously recorded) that were potentially threatened by proposed project activities in specific areas. In 20 cases, field investigations ranging from 0.4 to 37.4 hectares (1 to 80 acres) in area were conducted on lands that had never been archaeologically surveyed or in areas where previous surveys were completed more than a decade ago. Approximately 176.4 hectares (436 acres) were intensively examined during these project surveys, and 70 new archaeological sites were identified and recommended for avoidance or other protective measures during project implementation.

The largest project-related field surveys of 2008 were completed in relatively remote, undeveloped areas to assess the potential impacts of the expansion of safety fans associated with three INL gun and security test ranges. Numerous archaeological sites were identified around the perimeters of the new safety fans, and all were avoided during installation of new signage. The INL CRM Office continues to work with project managers to ensure that these sensitive sites are not adversely impacted by yearly maintenance of the signs. Avoidance was

Table 2-3. Cultural Resources Surveys Performed at the INL Site (2008).

National Historic Preservation Act Section	Surveys Performed
Section 106	38[a]
Section 110	3[b]

a. Does not include those surveys performed related to INL Cultural Resources Management Office research interests.
b. Includes a survey project, a mapping project, and an archival investigation.

also accomplished for significant archaeological sites located in a 32-hectare (80-acre) project area near the Big Lost River where INL and National Oceanic and Atmospheric Administration researchers proposed to conduct a series of atmospheric dispersion tests.

After a decade of drought conditions in eastern Idaho, it is not surprising that INL firefighters were called to respond to another range fire in 2008. In a third sizeable 2008 project survey, approximately 32 hectares (80 acres) of fire-breaks were surveyed within and around a newly burned area, and three sensitive archaeological sites were identified. Work to protect the identified resources during future rehabilitation and revegetation will continue into 2009. Several smaller project surveys less than 13 hectares (32 acres) in area also contribute to the totals reported in this section. Proposed activities included road improvements, powerline testing, cellular towers, temporary wind towers, ecological sampling, wells, various test pads, and miscellaneous cleanup activities. INL project managers and CRM staff cooperated to ensure that no sensitive archaeological resources were threatened by these smaller projects.

The results of project-specific INL CRM surveys and other activities are documented in a number of ways per the guidelines of the INL Cultural Resource Management Plan. Recommendations tailored to specific projects and any archaeological resources that may require consideration become part of the project’s NEPA-driven Environmental Checklist and permanent record. In 2008, 38 of these recommendations were issued. For larger projects, external technical reports are often prepared to synthesize archaeological information and recommendations, but none of these more detailed documents were required in 2008. However, INL CRM staff feedback on archaeological sensitivity did appear in several technical reports, such as *Site Selection Study for the High Temperature Gas-Cooled Reactor Component Test Facility* (INL 2008). Feedback is also incorporated into environmental assessments and EISs prepared to support NEPA compliance.

Section 110 archival and field investigation of INL’s historic archaeological sites also continued. The INL CRM Office spent a major portion of their Section 110 effort on a multi-year project exploring and documenting human lacustrine and riverine adaptations on the Eastern Snake River Plain. In 2008, field surveys were focused on 242.8 hectares (600 acres) along the Big Lost River and playa margins where 65 archaeological resources spanning some 12,500 years were recorded. In 2009, the results of this long-term project will be compiled into a final report.

In one significant effort, state-of-the-art geophysical tools were employed in an ongoing investigation of an important stage station from the late 19th century. Results of this investigation will be published in conference proceedings in 2009. Regional archival holdings (identified in Big Lost River Irrigation Company records and General Land Office Tract records) were also visited to support an ongoing investigation of late 19th and early 20th century homesteading activities on what is now the INL Site. Among the early records, INL CRM staff identified 56 homestead claims that can be added to the INL Site inventory. In the future, these claims will be investigated in the field to determine if any archaeological materials are present.

Cultural Resources Monitoring—The INL CRM Office implements a yearly program of cultural resource monitoring that includes many archaeological resources. In 2008, 43 archaeological localities were revisited, including two sites of heightened Shoshone-Bannock tribal sensitivity, four lava tube caves, 31 prehistoric archaeological sites, two historic stage stations, two historic homesteads, a portion of Goodale’s Cutoff of the Oregon Trail, and a portion of historic trail T-2. Although no significant impacts were observed during the annual monitoring, investigations were completed for incidents, including new graffiti, evidence of surface artifact collection, and bioturbation at three lava tube caves. The Experimental Breeder Reactor-I National Historic Landmark and several active INL project areas were also monitored in 2008.

The Powell Stage Station is one of only two historic stage stations known to have existed within the INL Site boundary. Because of its central location on the Snake River Plain between central Idaho mining camps and eastern Idaho railroad depots, it played a key role in late 19th century transportation and economic development. Surface structures and features at the stage station today show only a small footprint of what would have been a major stopover and resting place for stagecoach customers and freighters. Additionally, early photographs from the 1890s suggest that there might have been more buildings at the site than the foundations exposed on the surface today illustrate. In an attempt to identify unknown subsurface features, INL CRM staff employed geophysical equipment at the site in 2008. The cart-mounted ground-penetrating radar used to survey the site has revealed a hidden road and an additional foundation. Data used from this activity will improve resource protection and management and guide future investigations.

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 2008, several sites of tribal sensitivity were monitored, with tribal participation. Sites included caves, buttes, craters, and locations of known remains. No evidence of unauthorized human activity was observed, and details of sites are kept to a minimum to ensure protection of ancestral properties and resources.

2.6 Summary of Environmental Permits

Table 2-4 summarizes active and pending permits for the INL Site through year-end 2008 that were issued for sitewide and/or individual facility operations that have been referenced in previous sections of this chapter.

Table 2-4. Environmental Permits for the INL Site (2008).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	15
Title V Operating Permit	2
Groundwater:	
Injection Well	22
Well Construction	1
Surface Water:	
Wastewater Reuse Permit	4
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2
Part B[a]	7

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

REFERENCES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DOE-ID, 1995, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*, DOE/EIS-0203-F, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2004, "*Programmatic Agreement between the Department of Energy Idaho Operations Office, the Idaho State Historic Preservation Office, and the Advisory Council on Historic Preservation Concerning Management of Cultural Resources on the Idaho National Engineering and Environmental Laboratory*," signed by U.S. Department of Energy Idaho Operations Office, Idaho State Historic Preservation Office, Advisory Council on Historic Preservation.

DOE-ID, 2008a, *INL Site Executable Plan for Energy and Transportation Fuels Management*, DOE/ID-11383, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008b, *HWMA/RCRA Closure Plan for the INTEC Rare Gas Plant North Gas Cell System*, DOE/ID-11352, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008c, *HWMA/RCRA Closure Plan for the CPP-601 Waste Transfer Lines to the Tank Farm Facility*, DOE/ID-11325, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008d, *HWMA/RCRA Closure Plan for the Materials Test Reactor Wing (TRA-604) Laboratory Components*, DOE/ID-11320, Rev. 3, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2009a, *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2008 INL Report for Radionuclides*, DOE/ID-10890(09), U.S. Department of Energy Idaho Operations Office.

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

Executive Order 11988, 1977, “Floodplain Management.”

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

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

ICP, 2007, *Closure Plan for Wastewater Land Application Permitted Test Area North/ Technical Support Facility Sewage Treatment Facility at the Idaho National Laboratory Site*, RPT-409, Idaho Cleanup Project.

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

INL, 2008, *Site Selection Study for the High Temperature Gas-Cooled Reactor Component Test Facility*, INL/EXT-08-14052, Idaho National Laboratory.

INL, 2009, *Idaho Hazardous Waste Generator Annual Report – Calendar Year 2008, 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.

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; wildlife; and direct radiation. More than 6,114 samples were collected and analyzed in 2008 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 2008 accomplishments are:

- Remediation of contaminated soil sites at Test Area North was completed
- Four Site Treatment Plan milestones involving the backlog of mixed waste were completed on schedule
- 4,993 m^3 (6,525 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
- More than 2,793 m^3 (3,653 yd^3) of mixed low-level waste and 75 m^3 (98 yd^3) of low-level waste were shipped offsite for treatment and/or disposal
- Approximately 6,350 m^3 (8,305 yd^3) of legacy and newly generated low-level waste were disposed onsite at the Radioactive Waste Management Complex
- 37,282 m^2 (401,295 ft^2) of buildings and structures were demolished.

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 re-registration audits without any nonconformances and a third contractor developed a self-certifying environmental management system in compliance with the Order.

In 2008, the Pollution Prevention Program successfully accomplished the goals of the INL Site Pollution Prevention Plan through projects such as: pollution prevention opportunity assessments at the INL Site; the Idaho Falls household hazardous waste event; an initiative to purchase more fuel efficient flex fuel vehicles at the INL Site; success in the Federal Electronics Challenge; infrastructure improvement; participation in Earth Day; and minimization of sanitary waste produced by Site operations.

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), and Waste Management (Section 3.3). Sections 3.4 and 3.5 summarize other significant INL Site environmental programs and activities.

3.1 Environmental Monitoring Programs

INL Site facilities may release materials, including both radioactive and nonradioactive contaminants, into the environment. These materials can enter the environment through two primary routes: into the atmosphere as airborne effluents and into surface water and groundwater as liquid effluents or storm water runoff. Contaminants can be transported away from INL Site facilities through a variety of exposure pathways (Figure 3-1), and could impact people and the environment.

The major objectives of the INL Site environmental monitoring programs are to identify the key pollutants released to the environment, to evaluate pathways through which pollutants move in the environment, and to determine the potential effects of these pollutants on the public and on the environment.

Monitoring information is used to verify compliance with a variety of applicable environmental protection laws, regulations, and permits, described in Chapter 2. U.S. Department of Energy (DOE) Order 450.1A requires establishing and operating an environmental monitoring program at the INL Site. The various environmental monitoring programs are also used to (1) detect, characterize, and report unplanned releases, (2) evaluate the effectiveness of effluent treatment, control, and pollution abatement programs, and (3) determine compliance with commitments made in environmental impact statements, environmental assessments, safety analysis reports, and other official DOE documents.

INL Site environmental monitoring consists of effluent monitoring and environmental surveillance. Effluent monitoring is measuring constituents within a waste stream before they are released to the environment, such as the monitoring stacks or discharge pipes, to determine compliance with standards and regulations. Environmental surveillance is measuring contaminants in the environment. Surveillance involves determining whether or not contaminants are present or measurable in environmental media and, if present, in what concentrations, to assess any potential effects that INL Site operations may have on human health and the environment. Airborne and liquid effluent monitoring are conducted by various INL Site organizations. Routine surveillance of all exposure pathways is performed on specific environmental media (air, water, agricultural products, animal tissue, soil, direct radiation).

Battelle Energy Alliance, LLC is the INL contractor. CH2M-WG Idaho, LLC is the Idaho Cleanup Project (ICP) contractor. The monitoring activities performed by the INL and ICP contractors comprise the monitoring program on the INL Site. The monitoring activities performed by the Environmental Surveillance, Education, and Research contractor, S.M. Stoller Corporation, comprise the monitoring program offsite. Two federal agencies also operate environmental monitoring programs under interagency agreements with the DOE Idaho Operations Office (DOE-ID). The National Oceanic and Atmospheric Administration conducts meteorological monitoring, and the U.S. Geological Survey (USGS) conducts water monitoring and research.

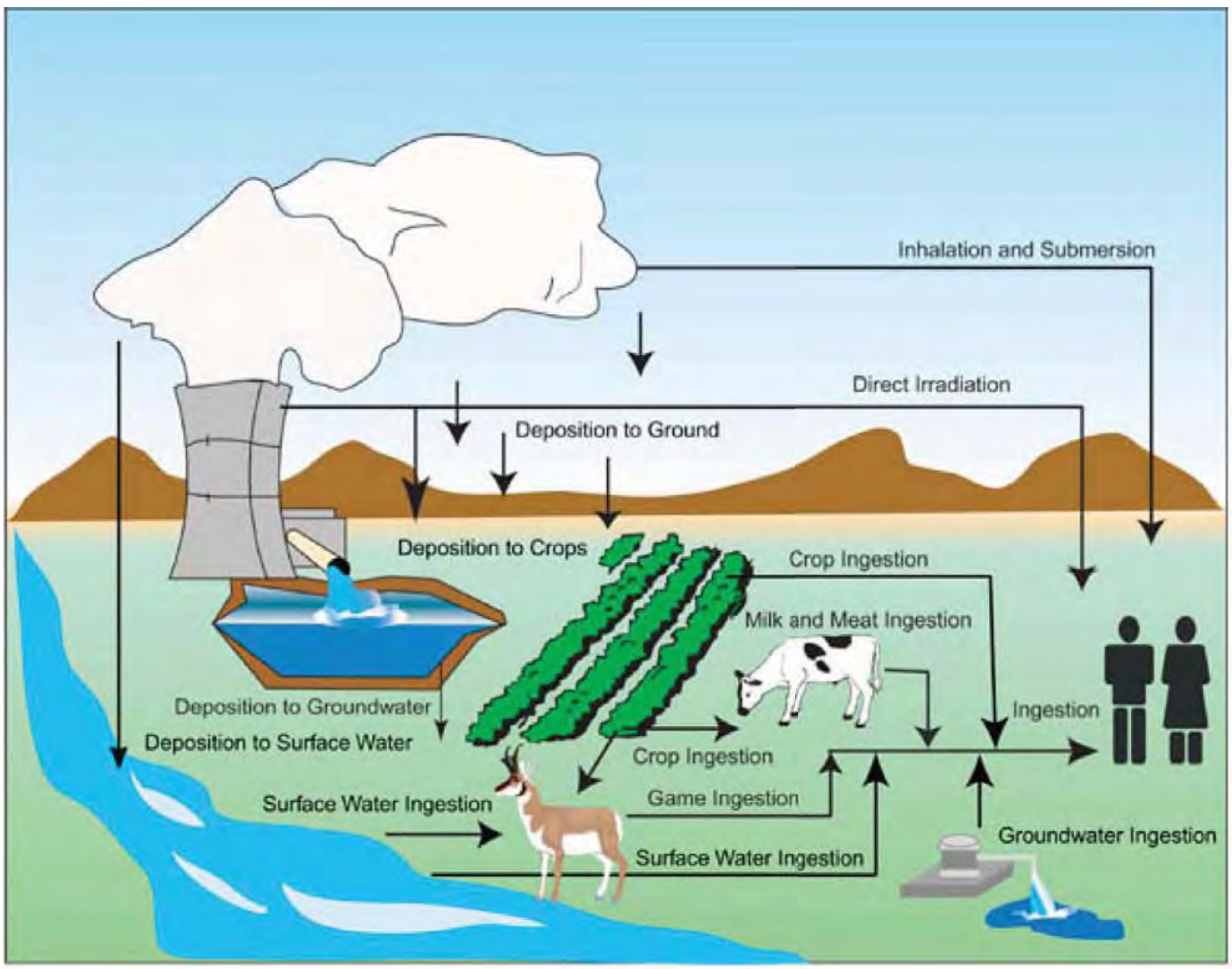


Figure 3-1. Potential Exposure Pathways to Humans from the INL Site.

Tables 3-1 through 3-6 present a summary of the environmental surveillance programs conducted by the Environmental Surveillance, Education, and Research contractor, the INL and ICP contractors, and the USGS in 2008. 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 six multi-depth sampling wells. This expanded constituent list changes from year to year in response to USGS program remedial investigation/feasibility study (RI/FS) requirements. The constituents collected during 2008 for the multi-depth wells were major anions and cations, trace elements, nutrients, total organic carbon, selected radionuclides including low-level tritium, and selected stable isotopes. These data are available from the USGS by request.

Results of the environmental monitoring programs for 2008 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 2008 results on current ecological research programs at the INL Site. Quality assurance activities of the various organizations conducting environmental monitoring are described in Chapter 10. Historical INL Site environmental monitoring activities are summarized in Appendix B.

3.1.1 Sitewide Monitoring Committees

The Monitoring and Surveillance Committee was formed in March 1997 and holds bimonthly meetings to coordinate activities between groups involved in environmental monitoring on and off the INL Site. This standing committee includes representatives of DOE-ID, INL Site contractors, Environmental Surveillance, Education, and Research contractor, Shoshone-Bannock Tribes, 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, the Advanced Mixed Waste Treatment Project, INL Site contractors, and the Naval Reactors Facility.

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.

3.2 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 will comply with 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.

Table 3-1. Environmental Surveillance, Education and Research Program Summary (2008).

Medium Sampled	Type of Analysis	Locations and Frequency: Onsite	Locations and Frequency: Offsite	Minimum Detectable Concentration
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	10×10^{-15} µCi/mL
	Gross beta	4 weekly	14 weekly	2×10^{-12} µCi/mL
	Specific gamma	4 quarterly	14 quarterly	3×10^{-16} µCi/mL
	^{238}Pu	2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	$^{239/240}Pu$	2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	^{241}Am	2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	2 quarterly	7 quarterly	6×10^{-17} µCi/mL
	^{131}I	4 weekly	14 weekly	2×10^{-15} µCi/mL
	Total particulates	4 quarterly	14 quarterly	10 µg/m^3
Air (high volume)[b]	Gross beta	None	1, twice per week	1×10^{-15} µCi/mL
	Gamma scan	None	If gross β >1 pCi/m^3	1×10^{-14} µci/mL
			1 annually	
	Isotopic U and Pu	None		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
	^{131}I	Varies annually	Varies annually	3 pCi/g
Agricultural products (milk)	^{137}Cs	None	1 weekly	1 pCi/L
	^{131}I	None	1 weekly/9 monthly	3 pCi/L
	^{90}Sr	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
	^{90}Sr	None	8-10 annually	0.2 pCi/g
Agricultural products (wheat)	Specific gamma	None	11 annually	0.1 pCi/g
	^{90}Sr	None	11 annually	0.2 pCi/g
Agricultural products (lettuce)	Specific gamma	None	7-9 annually	0.1 pCi/g
	^{90}Sr	None	7-9 annually	0.2 pCi/g
Soil	Specific gamma	None	12 biennially	0.001 pCi/g
	^{238}Pu	None	12 biennially	0.005 pCi/g
	$^{239/240}Pu$	None	12 biennially	0.1 pCi/g
	^{241}Am	None	12 biennially	0.005 pCi/g
	^{90}Sr	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; offsite 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 Environmental Radiation Ambient Monitoring System.

d. Only big game animals (pronghorn, elk or mule deer) that are victims of road-kills or natural causes are sampled onsite. 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 (2008).

Medium Sampled	Type of Analysis	Locations and Frequency: Onsite	Locations and Frequency: Offsite	Minimum Detectable Concentration[a]
Air (low volume)	Gross alpha	19 weekly[b]	4 weekly	1×10^{-15} µCi/mL
	Gross beta	19 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	19 quarterly	4 quarterly	Varies by analyte
	^{238}Pu	19 quarterly[c]	4 quarterly	2×10^{-18} µCi/mL
	$^{239/240}$Pu	19 quarterly[c]	4 quarterly	2×10^{-18} µCi/mL
	^{241}Am	19 quarterly[c]	4 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	19 quarterly[c]	4 quarterly	2×10^{-14} µCi/mL
	Particulate matter	19 quarterly	4 quarterly	10 µg/m^3
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	Not collected	Varies by analyte
Direct radiation exposure (TLDs)	Ionizing radiation	135 semiannually	13 semiannually	5 mR
Mobile radiation surveys	Gamma radiation	Facilities and INL Site roads[d]	Not collected	Not Applicable

a. Detection limits vary with each laboratory analysis, but approximate values are provided.
b. Onsite includes 17 locations and two replicate samples.
c. Note that after the second quarter, the INL contractor changed its analysis strategy. Instead of automatically completing radiochemistry analyses (e.g., $^{239/240}$Pu, ^{90}Sr, and ^{241}Am) quarterly on composited filters, the contractor now reviews the individual gross alpha and gross beta and composited gamma spectroscopy results for anomalies (i.e., unusual spikes). If there is no anomaly, which was the case for the third and fourth quarters, then the radiochemistry analyses are not completed. See Chapter 4 for additional discussion on the overall program.
d. Surveys are performed each year at different onsite facilities on a rotating three-year schedule. All INL Site roadways over which waste is transported are surveyed annually.

Table 3-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2008).

Medium/Contaminant Type	Type of Analysis	Frequency (on INL Site)	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	6 annually, 9 semiannually	0.03 pCi/L
	^{129}I	6 annually, 9 semiannually	1 pCi/L
	^{90}Sr	6 annually, 9 semiannually	8 pCi/L
	^{99}Tc	6 annually, 9 semiannually	900 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	14 annually	10 mg/L (as nitrogen)
Drinking water/microbial	Microbes	14 quarterly 13 monthly 1 monthly during summer	If <40 samples/ month, no more than one positive for total coliform
Drinking water/volatile organic compounds	Volatile organic compounds	2 annually	Varies

Table 3-4. Idaho Cleanup Project Contractor Environmental Surveillance Program Air, Surface Water, Vegetation, and Radiation Survey Summary (2008).

Medium Sampled	Type of Analysis	Location and Frequency: RWMC	Location and Frequency: INTEC	Minimum Detectable Concentration[a]
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 1^{0-18} μCi/mL
	Strontium-90	8 quarterly	1 quarterly	1 x 10^{-16} μCi/mL
Surface water runoff	Specific gamma	3 quarterly[b]	None	Varies by analyte
	Plutonium isotopes	3 quarterly[b]	None	0.02 pCi/L
	Uranium-233/234	3 quarterly[b]	None	0.06 pCi/L
	Uranium-235	3 quarterly[b]	None	0.04 pCi/L
	Uranium-238	3 quarterly[b]	None	0.04 pCi/L
	Americium-241	3 quarterly[b]	None	0.02 pCi/L
	Strontium-90	3 quarterly[b]	None	0.3 pCi/L
Vegetation	Specific gamma	5 annually[c]	None	Varies by analyte
	Plutonium isotopes	1 annually[c]	None	0.003 pCi/g
	Uranium-233/234	1 annually[c]	None	0.002 pCi/g
	Uranium-235	1 annually[c]	None	0.001 pCi/g
	Uranium-238	1 annually[c]	None	0.001 pCi/g
	Americium-241	1 annually[c]	None	0.0006 pCi/g
	Strontium-90	1 annually[c]	None	0.012 pCi/g
Mobile radiation surveys	Gamma radiation	1 annually	None	Not applicable

a. Detection limits vary with each laboratory analysis, but approximate values are provided.
b. Precipitation occurred to cause a surface water runoff event only during the fourth quarter of 2008. Therefore, surface water runoff was sampled only during the fourth quarter.
c. Due to recontouring and construction activities at RWMC, Russian thistle was not available for sampling in 2008.

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

The INL Site is divided into 10 waste area groups (WAG) 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 Further Action” listing is possible, or if it is appropriate to proceed with an interim cleanup action or further investigation using a RI/FS. The RI/FS 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 RI/FS form the basis for assessment of risks 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

Table 3-5. Idaho Cleanup Project Drinking Water Program Summary (2008).

Medium Sampled	Type of Analysis	Location and Frequency[a]		Maximum Contaminant Level, Action Level
		RWMC	INTEC	
Drinking Water Systems	**Microbiological Contaminants**	2 monthly	3 monthly	<40 samples/month, no more than one positive for total coliform
	Disinfection Byproducts			
	Haloacetic acids	1 annually	1 annually	0.060 mg/L
	Total trihalomethances	1 annually	1 annually	0.080 mg/L
	Inorganic Chemicals			
	Antimony	1 annually	1 annually	0.006 mg/L
	Arsenic	1 annually	1 annually	0.010 mg/L
	Barium	1 annually	1 annually	2 mg/L
	Beryllium	1 annually	1 annually	0.004 mg/L
	Cadium	1 annually	1 annually	0.005 mg/L
	Chromium	1 annually	1 annually	0.1 mg/L
	Copper	10 annually	10 annually	1.3 mg/L
	Lead	10 annually	10 annually	0.015 mg/L
	Mercury	1 annually	1 annually	0.002 mg/L
	Nickel	1 annually	1 annually	Not applicable
	Nitrate (as nitrogen)	1 annually	1 annually	10 mg/L
	Selenium	1 annually	1 annually	0.05 mg/L
	Thallium	1 annually	1 annually	0.002 mg/L
	Radionuclides			
	Gross alpha	1 semiannually	1 semiannually	15 pCi/L
	Gross beta	1 semiannually	1 semiannually	4 mrem/yr
	Radium-226 and radium-228	2 annually	2 annually	5 pCi/L
	Strontium-90	1 annually	1 annually	4 mrem/yr
	Tritium	2 semiannually	2 semiannually	4 mrem/yr
	Uranium (total)	1 annually	1 annually	30 µg/L
	Synthetic Organic Chemicals			
	Atrazine	1 annually	None	0.003 mg/L
	di(2-ethylhexy)adipate	1 annually	None	0.4 mg/L
	di(2-ethylhexyl)phthalate	1 annually	None	0.006 mg/L
	Pentachlorophenol	1 annually	None	0.001 mg/L
	Volatile Organic Chemicals[b]	2 quarterly	1 annually	Varies

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

Table 3-6. U.S. Geological Survey Monitoring Program Summary (2008).

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	65	65	4	1	~1.5 pCi/mL
Gross beta	65	65	4	1	~3.4 pCi/mL
Tritium	156	150	7	4	~200 pCi/mL
Gamma-ray spectroscopy	105	100	4	1	—[b]
Strontium-90	111	105	—[c]	—	2 pCi/mL
Americium-241	23	22	—[c]	—	0.03 pCi/mL
Plutonium isotopes	23	22	—[c]	—	0.02 pCi/mL
Iodine-129	0	0	—[c]	—	<1 aCi/L
Specific conductance	156	150	7	4	Not applicable
Sodium ion	152	146	—[c]	—	0.1 mg/L
Chloride ion	156	150	7	4	0.1 mg/L
Nitrates (as nitrogen)	117	114	—[c]	—	0.05 mg/L
Fluoride	5	5	—[c]	—	0.1 mg/L
Sulfate	108	102	—[c]	—	0.1 mg/L
Chromium (dissolved)	84	80	—[c]	—	0.005 mg/L
Purgeable organic compounds[d]	29	39	—[c]	—	Varies
Total organic carbon	51	50	—[c]	—	0.1 mg/L
Trace elements	13	13	—[c]	—	Varies

a. Number of samples does not include 16 replicates and two equipment blanks collected in 2008. 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 32 zones from 6 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.

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 records of decision have been signed and are being implemented. Comprehensive remedial investigation/feasibility studies have been completed for WAG 1, 2, 3, 4, 5, 7, 8, 9, and 6/10 (6 is combined with 10). Closeout activities at WAG 1, 2, 4, 5, and 8 have been completed. The WAG 10, Operable Unit 10-08 ROD (East Snake River Plain Aquifer contamination) is the only ROD that remains to be completed.

A complete catalog of 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 monitoring results are summarized in Chapter 6.

3.2.1 Waste Area Group 1 – Test Area North

During 2008, remediation of contaminated soil sites at Test Area North were completed and documented in the final Remedial Action Report (DOE-ID 2008a). In addition to the contaminated soils work, the Operable Unit 1-07B groundwater cleanup continued throughout 2008. The in situ bioremediation nutrient injection system continued to reduce contaminant concentrations in 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 in 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.

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 of 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. In 2008, all institutional controls were maintained.

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

Operations continued at the Idaho CERCLA Disposal Facility during 2008, disposing of contaminated soil and debris in the landfill cell as well as liquid waste to the evaporation pond. The Idaho CERCLA Disposal Facility consolidates low-level contaminated soils and debris from CERCLA cleanup operations and segregates those wastes from potential migration to the aquifer, reducing risk to the public and environment. In 2008, remediation of 10 CERCLA release sites near the Fuel Receipt and Storage Facility (CPP-603) was completed as required by the Operable Unit 3-13 ROD (DOE-ID 1999). Interim actions were maintained at the Tank Farm Facility to reduce water infiltration that has the potential to cause the transport of contaminants from the perched water to the aquifer.

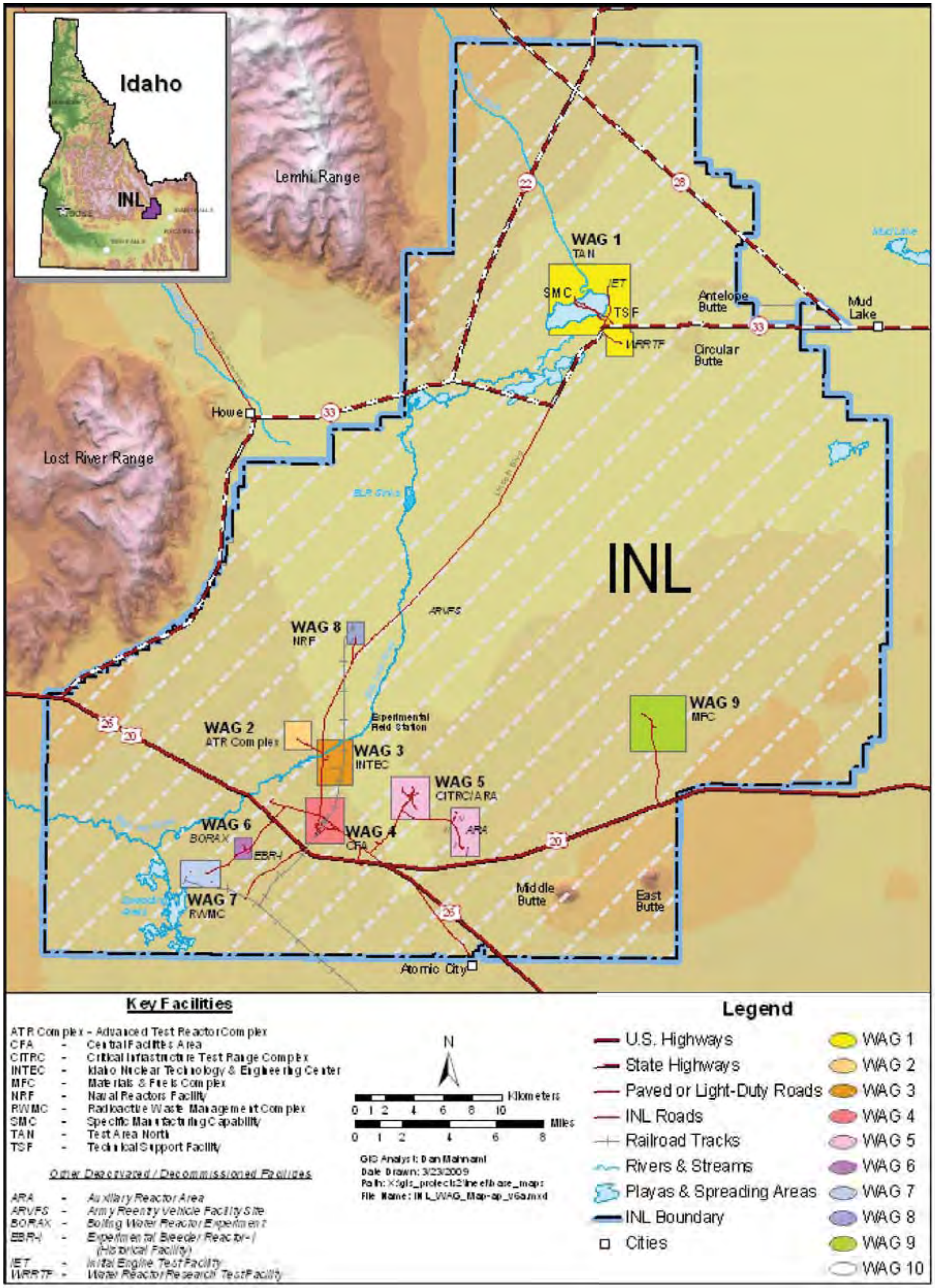


Figure 3-2. Map of the Idaho National Laboratory Site Showing Locations of the Facilities and Corresponding Waste Area Groups.

3.2.4 Waste Area Group 4 – Central Facilities Area

Remediation of WAG 4 was completed in 2004. Institutional controls are in place to maintain and monitor the completed remediation.

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.

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

Ecological and groundwater monitoring continued during 2008. The Operable Unit 10-08 Remedial Investigation (Cahn et al. 2008), Feasibility Study (Holdren et al. 2008), and Proposed Plan (DOE, EPA, DEQ 2008) were completed and submitted to the regulatory agencies. Operable Unit 10-08 addresses INL Site-related issues that are associated with the Eastern Snake River Plain Aquifer but are not addressed under the purview of the other WAG.

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 over time in accordance with laws and practices current at the time of disposal. Initial operations were limited to shallow, landfill disposal of waste generated at the INL Site. Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the Radioactive Waste Management Complex for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. A variety of radioactive waste streams were disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of transuranic waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste has been disposed of in the Subsurface Disposal Area. Disposal of waste from offsite generators was discontinued in the early 1990s.

A major accomplishment for WAG 7 occurred in 2008 when the Operable Unit 7-13/14 ROD (DOE-ID 2008b) was signed. The ROD is consistent with DOE's obligations for removal of transuranic waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the state of Idaho and DOE, effective July 3, 2008 (DOE 2008). The ROD calls for exhuming a minimum of 6,238 m^3 (8,159 yd^3) of targeted waste from a minimum combined area of 2.3 hectares (5.69 acres). Targeted waste for retrieval contains transuranic elements, such as plutonium, as well as uranium and co-located 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. The targeted and co-located organic waste that is retrieved 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 2007 in other parts of Pit 4 and Pit 6, and a third excavation in another part of Pit 6 commenced in 2008. The Accelerated Retrieval Project phases have collectively retrieved and packaged more than 2,330 m^3 (3,048 yd^3) of targeted waste from a combined area of 0.30 hectares (0.73 acres).

In addition to expanding current waste retrieval, 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.

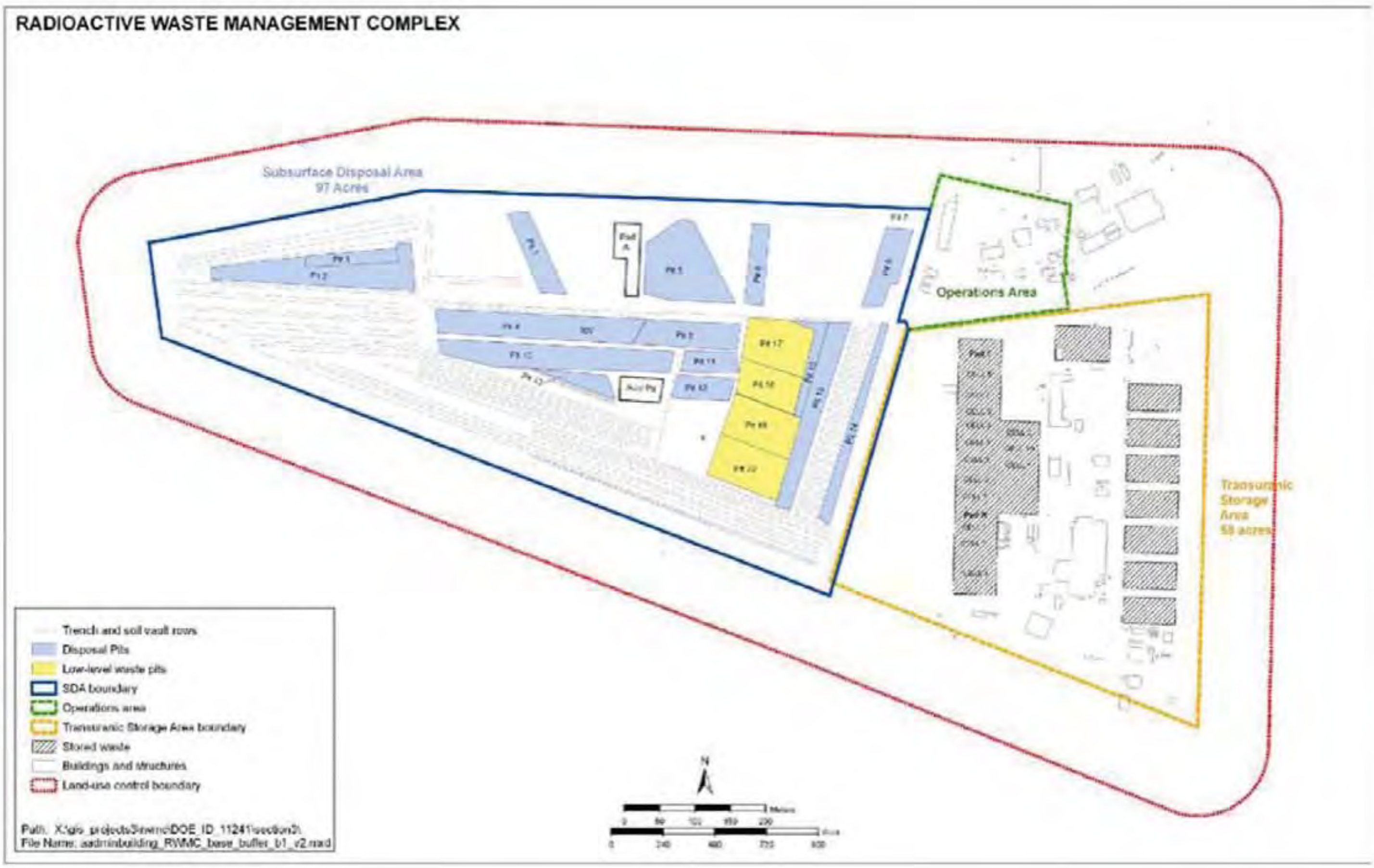


Figure 3-3. Radioactive Waste Management Complex Subsurface Disposal Area (2008).

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 (^{137}Cs) to background levels.

3.3 Waste Management and Disposition

Waste management and disposition covers a variety of operations and functions including: (1) storage of waste pending disposition, (2) characterization of waste in order to allow it to be placed in storage or offered for transportation, treatment, or disposal, (3) transportation of waste to onsite or offsite locations for treatment and/or disposal, (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 required the 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, the INL Site began receiving offsite mixed waste 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 2008, the INL Site treated or processed 5,405 m^3 (7,026 yd^3) of legacy mixed waste, 41 m^3 (53 yd^3) of mixed low-level waste, and 5,364 m^3 (6,973 yd^3) of mixed contact-handled transuranic waste. Additionally, 80 m^3 (104 yd^3) of remote-handled transuranic waste was shipped offsite for disposition, the majority of which was specified by the INL Site Treatment Plan.

Four INL Site Treatment Plan milestones were completed on schedule in 2008, and the milestones associated with the Remote-handled Waste Disposition Project were revised to start in 2012. The milestones completed are:

- Commercial backlog treatment/disposal – 10 m^3 (13 yd^3)
- Advanced Mixed Waste Treatment Project processing – 4,500 m^3 (5,886 yd^3)
- High efficiency particulate air filter leach backlog – 7 m^3 (9 yd^3)
- Sodium Components Maintenance Shop backlog – 2 m^3 (2.6 yd^3).

3.3.2 Advanced Mixed Waste Treatment Project

Operations at the Advanced Mixed Waste Treatment Project (AMWTP) require the 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 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). These four separate payloads are then 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 put through various visual and mechanical inspections 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 2008, the AMWTP shipped 4,993 m^3 (6,525 yd^3) of transuranic waste to the Waste Isolation Pilot Plant for a cumulative total of 25,311 m^3 (33,079 yd^3) of waste shipped offsite. In addition, the AMWTP shipped offsite 1,986 m^3 (2,596 yd^3) of mixed low-level waste that historically had been managed as transuranic waste.

3.3.3 High-Level Waste and Facilities Disposition

In 1953, reprocessing of SNF 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 SNF in 1992. Calcining of all non-sodium-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 non-sodium-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 the year 2012.

In October 2002, DOE issued the final Idaho High-Level Waste and Facilities Disposition 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 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.

During 2008, construction continued on the new Sodium-Bearing Waste Treatment Project facility, 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 68811) in November 2006. Activities to fill the seven cleaned tanks and their surrounding vaults began in November 2006 and were completed in March 2008.

The FEIS also included analysis of alternatives for treating the calcined waste. DOE-ID prepared a conceptual design on a system to retrieve the existing high-level waste calcine from the consolidated calcine storage facilities (bin sets) and to evaluate treatment technologies to comply with repository disposal requirements. A National Environmental Policy Act ROD will be issued by December 31, 2009. The ROD is expected to select treatment option(s) for calcine.

3.3.4   Low-Level and Mixed Radioactive Waste

In 2008, more than 2,793 m^3 (3,653 yd^3) of mixed low-level waste and 75 m^3 (98 yd^3) of low-level waste was shipped offsite for treatment or disposal or both. Approximately 6,350 m^3 (8,305 yd^3) of legacy and newly generated low-level waste were disposed of at the Subsurface Disposal Area in 2008.

3.4   Environmental Management System

The INL Site contractors continue to make progress on the effort initiated in 1997 to develop and implement a sitewide environmental management system. The environmental management system meets the requirements of International Organization for Standardization (ISO) 14001, an international voluntary standard for environmental management systems. This standard is being vigorously embraced worldwide, as well as within the DOE complex. An environmental management system provides an underlying structure to make managing environmental activities more systematic and predictable. The environmental management system 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.

An audit and readiness review conducted onsite 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. In November 2008, both the INL and ICP contractors went through a reregistration audit. No nonconformances were identified, and the auditor recommended continued ISO 14001 registration.

The AMWTP contractor has developed a self-certifying environmental management system in accordance with DOE Order 450.1A. All three environmental management systems have been successfully integrated into each contractor's Integrated Safety Management System. DOE performed an annual evaluation of the contractors' environmental management systems and found them satisfactory and compliant with DOE Order 450.1A.

3.4.1 Pollution Prevention and Sustainability

The Pollution Prevention (P2) and Sustainability Program incorporates national and DOE policies 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 P2 Act, RCRA, and environmental management. In 2007, Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," was passed.

The P2 and Sustainability Program is part of the Environmental System. Its scope incorporates waste prevention and elimination, reduction of environmental releases, environmentally preferable purchasing, environmental stewardship in program planning and operational design, and recycling of solid wastes. The program is designed to minimize the environmental impact of the INL Site while enhancing support for the mission. In some instances, the INL Site P2 Program has become a nationally recognized leader of environmental stewardship and sustainability (e.g., electronics stewardship). The INL Site P2 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 that occur as normal components of project planning, execution, and evaluation. The following specific projects addressed these goals during 2008:

- **Pollution Prevention Opportunity Assessment**—A P2 opportunity assessment was performed on alternatives to landfill disposal of scrap metal from the decontamination and decommissioning activities of the Coal Fired Steam Generation Facility at INTEC. As decontamination and decommissioning completes the phased demolition on the buildings and structures, metal debris are separated from other demolition debris (e.g., plastic, concrete) and staged on a nearby asphalt pad. Bids are then solicited from the general public for the purchase of the scrap metal. After selecting the winning bid, the successful bidder comes to the project site and removes the scrap for reuse or recycling. So far, this alternative to the disposal of scrap metal has saved over $300,000 in cost avoidance and brought in nearly $100,000 in contract award fees.

  The Integrated Waste Treatment Unit Project at INTEC completed a pollution prevention opportunity assessment on alternatives to disposing of approximately 2,676 m^3 (3,500 yd^3) of excess and waste grout slurry. Rather than sending it to the landfill, the excess grout is used to fill void space at a different landfill where concrete grout was being purchased for stabilization. The potential cost savings is over $350,000 for the landfill and $100,000 for the Integrated Waste Treatment Unit Project.

- **Household Hazardous Waste Collection Event**—In 2008, the ICP contractor was the lead sponsor of the Idaho Falls household hazardous waste event, providing financial support and participating on the organizing committee. Many INL Site employees volunteered during the event. Over 1,400 households—a 50 percent increase from 2007—properly disposed of their household hazardous waste. Some of the items received included 7,571 L (2,000 gal) of used motor oil, 7,257 kg (8 tons) of electronic equipment (e-waste), 1,136 L (300 gal) of antifreeze, and over 500 auto batteries. In addition, educational and guidance materials covering the three Rs (reduce, reuse, recycle), hazardous waste minimization through substitution, and conservation were distributed. The event proved to be an effective way for the community to protect the environment through reduction of potential environmental releases. Pictured on the previous page are some of the wastes collected during the 2008 household hazardous waste event.

- **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 33 percent of the fleet and are growing every year. In 2008, 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 incorporates buses (pictured right) and automobiles that use alternative fuels, such as liquified natural gas, compressed natural gas, E85 ethanol, and biodiesel. INL Site Fleet Operations developed the alternative fueling infrastructure to include two E85 fueling stations, two biodiesel fueling stations, a compressed natural gas fueling station, and one liquified 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 2008.

- **Federal Electronics Challenge**—The Federal Electronics Challenge is a federal program that encourages federal facilities and agencies to purchase greener electronic products, reduce the impacts of electronic products during use, and manage obsolete electronics in an environmentally responsible way. The INL Site P2 Program leads the DOE complex in its electronics stewardship program. Electronics stewardship achievements in Fiscal Year 2008 include recipient of the 2008 Federal Electronics Challenge Bronze Award for reducing the environmental impacts of electronic equipment. (The INL Site also received the Bronze Award in 2007.) For the second year in a row, the INL Site won the Electronics Reuse and Recycling Campaign sponsored by the Office of the Federal Environmental Executive (Figure 3-4). The goal of the campaign is to maximize reuse and recycling of electronic equipment.

- **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 is designing a new ATR Complex Common Support Building that will be 10 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 will be LEED certifiable. In the Idaho Falls area, the new Center for Advanced Energy Studies is currently planned for a LEED Silver Certification, but may achieve the Gold Certification after the facility is complete.
- **Infrastructure Improvement**—A landmark $33 million infrastructure improvement project at Materials and Fuels Complex (MFC) designed to modernize heating, lighting, and other utility equipment, systems, and controls was initiated. The project includes lighting upgrades; heating, ventilation, and air conditioning improvements; compressed air optimization; solar transpired heating; and digital controls for buildings. The carbon 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. The carbon reduction will come from removal of 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**—The INL Site contractors participated in the organizing committee for the 2008 Idaho Falls Earth Day celebration and sponsored booths at the event. Attended by thousands from the surrounding area, the event included information booths, talks, presentations, and hands-on demonstrations that highlighted energy efficiency.
- **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 3-7 presents a summary of materials reused and recycled during 2008.

In summary, the INL Site P2 Program continued to successfully meet the five goals of the INL Site P2 Plan. The INL Site achieved these goals to protect the environment and enhance

Figure 3-4. Federal Electronics Challenge Awards Ceremony in Big Sky, Montana. Award recipients are Robert Gallegos, DOE-ID; Dave Gianotto, CWI/ICP; Jennifer Morton, CWI/ICP; James Guilliford, Environmental Protection Agency; and Gary Robinson, Bechtel BWXT Idaho, LLC/Advanced Mixed Waste Treatment Project.

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 INL Site continued with an aggressive deactivation, decontamination and decommissioning (DD&D) approach to reducing the "footprint" of DOE Environmental Management-owned buildings and structures (i.e., ICP facilities). This effort significantly reduced cost and risk by eliminating aging facilities that are no longer necessary for the INL Site mission. In 2008, emphasis was placed on decommissioning high-risk facilities. Twenty-three facilities were demolished, for a total 37,282 m^2 (401,295 ft^2) of buildings and structures. Descriptions of specific projects at various facilities follow.

Test Area North (TAN)—All facilities contracted for DD&D were completed in 2008. The areas were graded and seeded to match surrounding terrain. In 2008, 15,222 m^2 (163,844 ft^2) of footprint was reduced at TAN.

Table 3-7. Reused and Recycled Materials (2008).

Material Reused or Recycled	Weight kg (lb)
Antifreeze	1,950 (4,300)
Excess computers and equipment to schools	98,430 (217,000)
Excess materials to other DOE sites, INL orgs, state, etc.	1,061,406 (2,340,000)
Excess materials to public	2,222,603 (4,900,000)
Lead batteries	18,597 (41,000)
Lead scrap	268 (590)
Lithium batteries	395 (870)
Mercury	25 (54)
Paper and cardboard at INL Site	205,023 (452,000)
Paper and cardboard in Idaho Falls	58,059 (128,000)
RCRA scrap	1,406 (3,100)
Silver scrap	27 (60)
Toner cartridges	726 (1,600)
Universal waste lamps	2,359 (5,200)
Used oil (bulk)	45,359 (100,000)
Used oil (containerized)	27,216 (60,000)
Wood chips	22,680 (50,000)
Total	3,764,817 (8,300,000)

Advanced Test Reactor Complex (ATR Complex)—Emphasis was placed on decommissioning the Engineering Test Reactor and starting decommissioning on the Materials Test Reactor. DD&D was completed on the Engineering Test Reactor, with final grading completed to compliment surrounding operations. A total of 7,371 m^2 (79,339 ft^2) of buildings and structures was DD&D'd at the ATR Complex.

Idaho Nuclear Technology and Engineering Center (INTEC)—In 2008, DD&D started at INTEC. Initial emphasis was placed on DD&D of the coal plant and satellite (stand-alone) facilities. In 2008, 14,689 m^2 (158,112 ft^2) of buildings and structures was demolished at INTEC.

3.5.2 Spent Nuclear Fuel

Spent nuclear fuel, or 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, by the Naval Nuclear Propulsion

Program at the Naval Reactors Facility, and by Nuclear Energy 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 a SNF and high-level waste repository. The Idaho Settlement Agreement requires all INL Site fuel be removed from the state of Idaho by 2035. The INL Site's goal is to begin shipping SNF to the repository as soon as the facility is licensed and operating.

In 2008, 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 completed the year well ahead of schedule in moving SNF from wet to safer dry storage. A facility to place SNF in standard canisters for transport to the repository will be built after 2013.

All ICP-managed SNF was consolidated at INTEC in 2003. Descriptions of SNF storage facilities at INTEC follow.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666)—This INTEC facility, also called FAST, is divided into two parts, a 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 2009. Eventually, all SNF will be removed from this underwater storage pool and placed in dry storage in preparation for shipment to a repository. In 2008, the ATR Complex did not send shipments of SNF to the Fluorinel Dissolution Process and Fuel Storage Facility (FAST) or storage.

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, the DD&D of the old fuel storage basin (the wet side) was completed. The Irradiated Fuel Storage Facility was approximately 85 percent full at the end of 2008 and will continue to receive SNF from the CPP-666 basin and foreign and domestic research reactors in 2009.

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 below-ground vaults for the dry storage of SNF and houses 193 underground vaults of various sizes for the dry storage of nuclear fuel rods. 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 2008, this facility stored SNF, as well as special nuclear material (unirradiated fuel) from the Shippingport Reactor. This material was retrieved and disposed of offsite in 2008. CPP-749 will be used to store additional types of SNF to achieve the 2009 goal for all ICP SNF to be in dry storage.

Fort Saint Vrain Independent Spent Fuel Storage Installation—DOE-ID manages this offsite 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 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 is 0.5 miles north of the MFC perimeter fence. It is a fenced outdoor four-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 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. 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 is in operation 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) between DOE-ID; DOE Naval Reactors, Idaho Branch Office; and the state of Idaho maintains the state's program of independent oversight and monitoring established under the first agreement in 1990 that created the state of Idaho INL Oversight Program. The main objectives of the current five-year agreement are to:

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

The INL Oversight Program's main activities include environmental surveillance, radiological emergency planning and preparedness, impact analyses, and public information. 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 and 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 (non-voting) 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 agency's policies and views.

The Citizens Advisory Board is chartered by DOE through the Federal Advisory Committee Act. The Citizens Advisory Board's charter is to provide input and recommendations to DOE on topics such as cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of nonstockpile nuclear materials, excess facilities, future land use and long-term stewardship, risk assessment and management, and cleanup science and technology activities. The Citizens Advisory Board has provided 140 recommendations during its tenure. More information about the Board's recommendations, membership, and meeting dates and topics can be found at http://www.inlemcab.org/.

REFERENCES

71 FR 68811, 2006, *Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement and Determination Under Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility at the Idaho National Laboratory*, Office of the Federal Register.

Cahn, L. S., W. L. Jolley, S. O. Magnuson, R. L. Van Horn, R. P. Wells, 2008, *Operable Unit 10-08 Sitewide Groundwater and Miscellaneous Sites Remedial Investigation and Baseline Risk Assessment*, DOE/ID-11332, Rev. 0, U.S. Department of Energy Idaho Operations Office.

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

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

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

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

DOE, 2007, *Transformational Energy Action Management Initiative*, U.S. Department of Energy.

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

DOE, EPA, and DEQ, 2008, *Proposed Plan for Sitewide Groundwater, Miscellaneous Sites, and Process for Future Sites, Operable Unit 10-08*, DOE/ID-11366, U. S. Department of Energy, U.S. Environmental Protection Agency, Idaho Department of Environmental Quality.

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

DOE-ID, 1999, *Final Record of Decision Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13*, DOE/ID-10660, U.S. Department of Energy Idaho Operations Office.

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

DOE-ID, 2005b, *Environmental Oversight and Monitoring Agreement (Agreement in Principle) Between the United States Department of Energy and the State of Idaho*, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008a, *Final Removal Action Report for Test Area North 607A and 607*, DOE/ID-11362, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008b, *Record of Decision for Radioactive Waste Management Complex Operable Unit*

7-13/14, DOE/ID-11359, U.S. Department of Energy Idaho Operations Office.

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

Holdren, K. J., T. E. Bechtold, L. S. Cahn, L. C. Tuott, R. P. Wells, 2008, *Operable Unit 10-08 Sitewide Groundwater and Miscellaneous Sites Feasibility Study*, DOE/ID-11338, U.S. Department of Energy Idaho Operations Office.

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

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

Chapter 4 - Environmental Monitoring Programs (Air)

Chapter Highlights

An estimated total of 5,326 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 2008. The highest contributors to the total release were the Idaho Nuclear Technology and Engineering Center (INTEC) at 50 percent and the Advanced Test Reactor Complex at 39 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 2008.

Approximately 2,000 charcoal cartridges, typically collected on a weekly basis using a network of low-volume air samplers, were analyzed for radioiodine during 2008. Iodine-131 was detected in one sample obtained from Craters of the Moon, but it was well below the Department of Energy (DOE) health-based limit for radioiodine in air and was likely a false positive.

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. 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 2008 do not indicate any link between radionuclides released from the INL Site and environmental concentrations measured offsite.

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 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 2008. No gamma-emitting radionuclides were detected at any waste management facility in 2008. Plutonium and americium-241 detections were comparable to past measurements and are likely due to resuspended soils from increased activity at the Radioactive Waste Management Complex.

Atmospheric moisture and precipitation samples were obtained and analyzed for tritium. Tritium was detected in 25 of 97 atmospheric moisture samples collected and was detected in eight of 35 precipitation samples collected during 2008. The highest concentration, 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 below the DOE health-based limit for tritium in water.

4. ENVIRONMENTAL MONITORING PROGRAMS (AIR)

This chapter presents results of radiological and nonradiological analyses of airborne effluents and ambient air samples collected on and off the Idaho National Laboratory (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. These results are compared to the U.S. Environmental Protection Agency (EPA) health-based levels established in either or both environmental statutes or the U.S. Department of Energy (DOE) Derived Concentration Guides (DCGs) for inhalation of air (Appendix A).

4.1 Purpose and Organization of Air Monitoring Programs

INL Site facilities have the potential to release both radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations. Ranked in terms of relative importance, air is the most important transport pathway (EG&G 1993). The INL Site environmental surveillance programs emphasize measurement of airborne contaminants because air has the potential to transport large amounts of radioactive and nonradioactive materials to receptors in a relatively short period and can directly expose offsite receptors. Table 4-1 summarizes the air monitoring activities at the INL Site.

The INL contractor monitors airborne effluents at individual INL Site facilities and ambient air outside the facilities at regional locations (Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg) to comply with applicable statutory requirements and DOE orders. The INL contractor collected 2,106 air samples (primarily on the INL Site) for analyses in 2008. Results of air monitoring by the INL contractor are summarized in Section 4.2.

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 4.3 discusses air sampling by the ICP contractor in support of waste management activities.

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	Suspended Particulates
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 2008 for compliance with Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H, National Emissions Standards for Hazardous Air Pollutants (NESHAP) Regulation. The exception is NRF.

c. Gamma-emitting radionuclides and strontium-90, plutonium-238, plutonium-239/240, and americium-241.

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 collect samples on, around, and distant from the INL Site.

The ESER contractor collects 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 Program collected approximately 2,000 air samples, primarily off the INL Site, for analyses in 2008. Results of air monitoring by the ESER contractor are summarized in Section 4.2.

The INL Oversight Program 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 publishes an independent annual report, and their results are not reported in Chapter 4.

Unless specified otherwise, the radiological results in the following sections are those greater than three times the associated uncertainty (see Appendix C for information on statistical methods).

4.2 Air Sampling

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 are contained in the National Emission Inventory database and can be obtained from the EPA Clearinghouse for Inventories and Emission Factors (CHIEF) web site (http://www.epa.gov/ttn/chief/index.html). Information on radiological effluents are contained in DOE/ID-10890 (09), "*National Emission Standards for Hazardous Air Pollutants—Calendar Year 2008 INL Report for Radionuclides*" Effluent monitoring is not the responsibility of the environmental surveillance programs. Instead, the INL, ICP, and ESER contractors' environmental surveillance programs monitor air pathways. Figure 4-1 shows the surveillance air monitoring locations for the INL Site.

Air surveillance monitoring filters are generally 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 for gross alpha and gross beta activity and then composited quarterly for gamma analysis and radiochemical analysis for specific alpha- and beta-emitting radionuclides. The charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I). 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 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 Facility 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/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

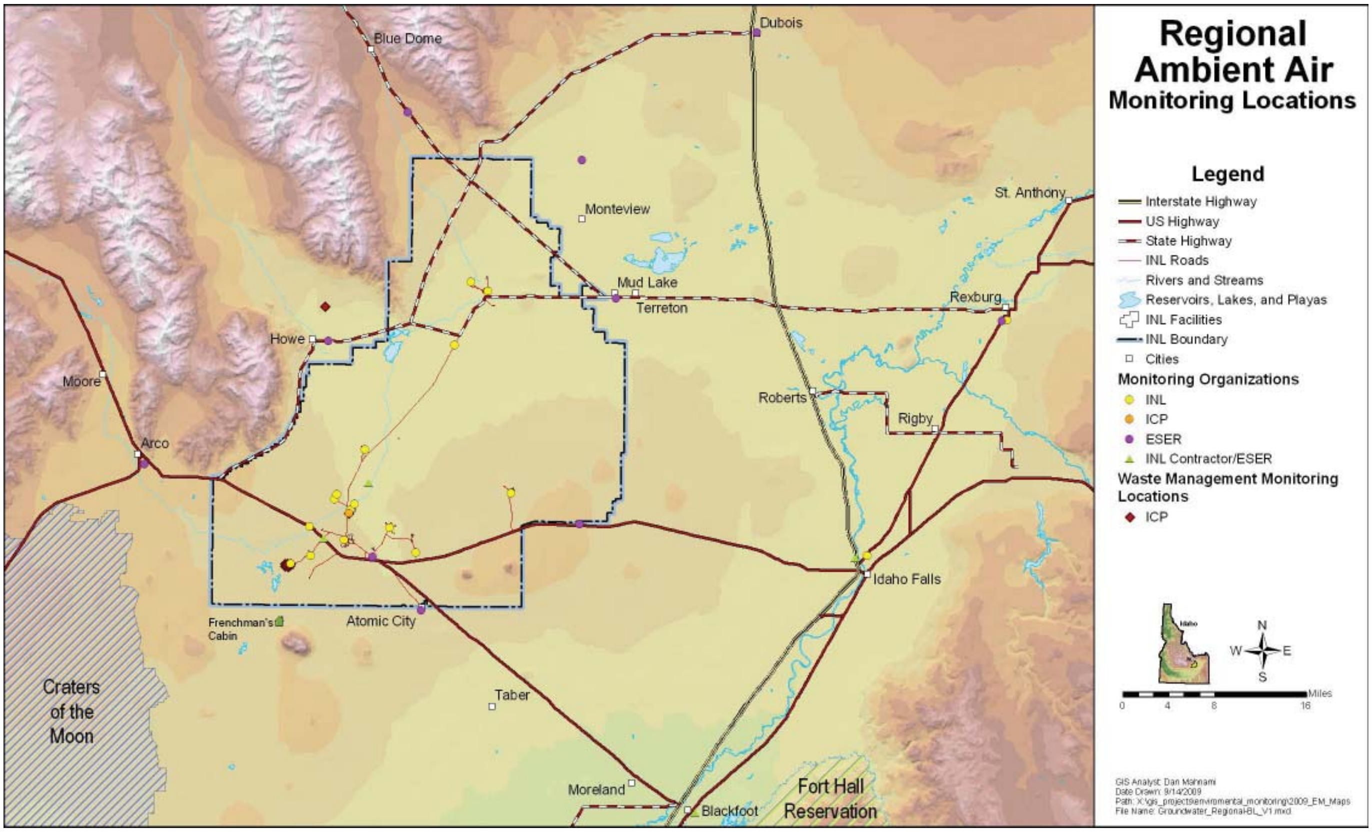


Figure 4-1. Idaho National Laboratory Site Environmental Surveillance Air Sampling Locations.

concentrations from the longer sampling period were statistically higher, presumably because the longer sampling period allowed for ingrowth of natural radioactive progeny. The INL contractor returned to the 57-L/minute (2-ft^3/minute) weekly sampling period in 2009.

There is no requirement to monitor the dust burden at the INL Site, but the INL contractor does so to compare information to other monitoring programs. The suspended particulate dust burden is monitored with the same low-volume filters used to collect the radioactive particulate samples by weighing the filters before and after weekly use.

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.

4.2.1 Airborne Effluents

The National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2008 INL Report for Radionuclides (DOE-ID 2009) describes three categories of airborne emissions:

- The first category includes sources that require continuous monitoring under the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulation
- The second category consists of releases from other point sources
- The final category is nonpoint, or diffuse, sources which include radioactive waste ponds and contaminated soil areas and decontamination and decommissioning of facilities by the ICP.

INL Site emissions include all three of these categories, as represented in Table 4-2, Radionuclide Composition of INL Site Airborne Effluents. During 2008, an estimated 5,326 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 75% of the radioactive effluent was in the form of noble gases (argon, krypton, and xenon), and most of the remaining effluent was tritium. The following facilities were the highest contributors to the total emissions (Table 4-2):

- Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (50% 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, Liquid Effluent Treatment and Disposal). These radioactive emissions include particulates and gaseous radionuclides (e.g., noble gases, 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.
- Advanced Test Reactor Complex (ATR Complex) Emissions Sources (39% 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. Other radiological air emissions are associated with hot cell operations, sample analysis, site remediation, research and development activities, and decommissioning and demolition activities. In 2008, 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 contaminated soils characterization and disposal.

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008).

Radionuclide	Half-life	Airborne Effluent (Ci)[a]							Total
		ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	
Ac-227	21.7 y	—	—	—	2.11E-13	—	—	—	2.11E-13
Ac-228	6.15 h	6.57E-13	—	—	—	—	—	—	6.57E-13
Ag-108	2.37 m	1.01E-09	—	—	—	—	—	—	1.01E-09
Ag-108m	418 y	6.43E-06	—	—	6.48E-08	—	—	1.88E-06	8.37E-06
Ag-110	24.6 s	9.34E-09	—	—	—	—	—	—	9.34E-09
Ag-110m	249.9 d	1.07E-06	—	—	2.03E-05	—	—	—	2.14E-05
Am-241	432.2 y	9.25E-05	3.81E-06	—	1.12E-04	—	1.05E-03	1.92E-03	3.18E-03
Am-243	7380 y	2.61E-10	1.35E-05	—	1.85E-11	—	—	—	1.35E-05
Ar-39	269 y		—	—	—	—	7.77E-08	—	7.77E-08
Ar-41	1.827 h	1.22E+03	—	—	—	1.52E+00	5.09E-09	—	1.22E+03
Ba-133	10.5 y	3.23E-08	—	—	—	—	—	—	3.23E-08
Ba-137m	2.552 m	7.74E-05	—	—	1.14E+00	—	9.17E-09	—	1.14E+00
Ba-139	82.7 m	4.96E-03	—	—	—	—	—	—	4.96E-03
Ba-140	12.74 d	2.34E-06	—	—	—	—	—	—	2.34E-06
Ba-141	18.3 m	7.35E-10	—	—	—	—	—	—	7.35E-10
Be-7	53.3 d		—	—	—	—	1.09E-12	—	1.09E-12
Be-10	1.6E6 y	4.72E-14	—	—	2.20E-07	—	—	—	2.20E-07
Bi-212	60.6 m	6.57E-13	—	—	—	—	1.08E-10	—	1.09E-10
Bi-214	19.9 m	6.57E-13	—	—	—	—	—	—	6.57E-13
Br-80m	4.5 h	—	—	—	—	—	3.51E-06	—	3.51E-06
Br-82	1.47 d	—	—	—	—	—	2.13E-05	—	2.13E-05
Br-83	2.4 h	—	—	—	—	—	1.01E-13	—	1.01E-13
C-14	5730 y	1.75E-06	3.84E-05	—	3.38E-04	—	9.95E-02	9.47E-02	1.95E-01
Cd-109	462.6 d	1.58E-09	3.60E-10	—	—	—	—	—	1.94E-09
Ce-139	137.64 d	5.11E-11	1.20E-11	—	—	—	—	—	6.31E-11
Ce-141	32.5 d	1.89E-07	—	—	—	—	—	—	1.89E-07
Ce-144	284.3 d	4.49E-05	—	—	6.54E-08	—	1.10E-10	—	4.50E-05

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008) (cont).

Radionuclide	Half-life	Airborne Effluent (Ci)[a]							
		ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	Total
Cf-249	350.6 y	1.25E-09	—	—	—	—	—	—	1.25E-09
Cl-36	3.01E5 y	2.20E-08	—	—	3.36E-08	—	1.19E-14	—	5.56E-08
Cl-38	37.24 m	—	—	—	—	—	2.00E-20	—	2.00E-20
Cm-242	162.8 d	2.10E-08	—	—	4.58E-11	—	—	9.38E-05	9.38E-05
Cm-243	28.5 y	2.97E-07	3.77E-11	—	1.34E-12	—	—	9.38E-05	9.41E-05
Cm-244	18.11 y	5.81E-07	—	—	8.56E-08	—	2.20E-09	9.38E-05	9.45E-05
Cm-245	8500 y	—	—	—	1.96E-16	—	—	—	1.96E-16
Cm-246	4730 y	—	—	—	1.38E-17	—	—	—	1.38E-17
Cm-247	1.6E7 y	—	—	—	7.55E-24	—	—	—	7.55E-24
Co-57	270.9 d	4.29E-08	1.16E-10	—	—	—	—	—	4.30E-08
Co-58	70.8 d	1.05E-05	—	—	7.88E-08	—	—	9.38E-09	1.06E-05
Co-60	5.271 y	5.17E-03	1.12E-10	—	6.02E-04	—	4.08E-10	1.59E-03	7.36E-03
Cr-51	27.704 d	2.16E-02	—	—	1.11E-07	—	—	—	2.16E-02
Cs-134	2.062 y	1.77E-03	1.21E-10	2.99E-10	1.33E-06	—	4.52E-10	3.50E-06	1.78E-03
Cs-135	2.3E6 y	9.60E-12	—	—	—	—	—	—	9.60E-12
Cs-137	30.0 y	9.06E-02	2.00E-08	8.24E-08	1.23E+00	—	9.21E-09	1.47E-01	1.47E+00
Cs-138	32.2 m	3.36E-01	—			—	—	—	3.36E-01
Eu-152	13.33 y	3.08E-04	—	6.55E-11	4.86E-02	—	—	9.46E-05	4.90E-02
Eu-154	8.8 y	3.23E-04	—	7.03E-12	3.67E-02	—	—	2.16E-04	3.73E-02
Eu-155	4.96 y	6.71E-05	—	—	4.70E-05	—	—	9.40E-05	2.08E-04
Fe-55	2.7 y	7.38E-03	9.00E-09	—	3.82E-07	—	4.60E-12	1.17E-04	7.50E-03
Fe-59	44.4529 d	2.68E-07	—	—	3.67E-08	—	—	—	3.05E-07
Gd-153	240.4 d	2.99E-07	—	—		—	—	—	2.99E-07
H-3	12.35 y	6.98E+02	1.70E+00	—	3.75E+02	3.15E+00	5.21E+02	1.15E+00	1.60E+03
Hf-175	70 d	1.34E-06	—	—	—	—	—	—	1.34E-06
Hf-181	42.39 d	1.41E-05	—	—	—	—	—	—	1.41E-05
Hg-203	46.6 d	1.10E-05	2.70E-08	—	—	—	—	—	1.11E-05
I-125	60.1 d	1.00E-03	—	—	—	—	—	—	1.00E-03
I-128	24.99 m	5.58E-03	—	—	—	—	—	—	5.58E-03

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008) (cont).

Radionuclide	Half-life	Airborne Effluent (Ci)[a]							Total
		ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	
I-129	1.57E7 y	2.29E-05	8.96E-08	2.62E-10	4.06E-02	—	—	9.38E-02	1.34E-01
I-131	8.04 d	6.03E-01	—	—	—	—	—	—	6.03E-01
I-132	2.3 h	2.75E-02	—	—	—	—	—	—	2.75E-02
I-133	20.8 h	9.60E-02	—	—	—	—	—	—	9.60E-02
I-134	52.6 m	9.90E-05	—	—	—	—	—	—	9.90E-05
I-135	6.61 h	2.31E-04	—	—	—	—	—	—	2.31E-04
Ir-192	74.02 d	1.18E-08	—	—	—	—	—	—	1.18E-08
K-40	1.277E8 y	6.76E-13	2.81E-09	—	1.23E-07	—	1.66E-12	—	1.26E-07
Kr-85	10.72 y	1.27E-01	—	—	2.30E+03	3.70E+01	—	5.06E-03	2.34E+03
Kr-85m	4.48 h	1.30E+01	—	—	—	—	—	—	1.30E+01
Kr-87	76.3 m	3.09E+01	—	—	—	—	—	—	3.09E+01
Kr-88	2.84 m	2.98E+01	—	—	—	—	—	—	2.98E+01
Mn-54	312.5 d	1.52E-04	1.38E-08	—	5.01E-08	—	—	9.38E-07	1.53E-04
Mo-99	66.0 h	1.28E-04	—	—	—	—	—	—	1.28E-04
Na-22	2.6 y	3.00E-08	—	—	—	—	—	—	3.00E-08
Na-24	15.0 h	2.08E-04	—	—	—	—	—	—	2.08E-04
Nb-94	2.03E4 y	1.98E-07	—	—	7.57E-07	—	—	—	9.55E-07
Nb-95	35.15 d	1.34E-05	—	—	6.02E-08	—	—	—	1.35E-05
Ni-59	7.5E4 y		—	—	2.05E-06	—	—	1.05E-04	1.07E-04
Ni-63	96 y	7.55E-04	7.87E-09	3.37E-09	4.15E-04	—	1.45E-11	1.51E-03	2.68E-03
Np-237	2.14E6y	1.18E-07	3.00E-06	—	3.42E-06	—	4.15E-11	2.25E-04	2.32E-04
Np-239	2.355 d	1.00E-06	—	—	—	—	—	—	1.00E-06
P-32	14.262 d	—	3.23E-11	—	—	—	—	—	3.23E-11
P-33	25.34 d	—	—	—	—	—	7.70E-17	—	7.70E-17
Pa-231	3.34E4 y	6.57E-13	—	—	3.11E-13	—	—	—	9.68E-13
Pa-234	6.7 h	6.57E-13	—	—	—	—	—	—	6.57E-13
Pb-210	22.3 y	8.40E-13	—	—	1.79E-16	—	3.30E-13	—	1.17E-12
Pb-211	36.1 m	6.57E-13	—	—	—	—	—	—	6.57E-13
Pb-212	13.6 h	6.57E-13	—	—	—	—	1.08E-10	—	1.09E-10

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008) (cont).

Radionuclide	Half-life	Airborne Effluent (Ci)[a] ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	Total
Pb-214	26.8 m	6.57E-13	—	—	—	—	—	—	6.57E-13
Pd-107	6.5E6 y	—	—	—	—	—	—	—	0.00E+00
Pm-145	17.7 y	2.25E-11	—	—	—	—	—	—	2.25E-11
Pm-147	2.6234 y	3.45E-04	—	—	6.80E-05	—	1.11E-10	—	4.13E-04
Po-212	0.305 ms	—	—	—	—	—	6.93E-11	—	6.93E-11
Po-216	0.15 s	—	—	—	—	—	1.08E-10	—	1.08E-10
Pr-144	17.3 m	4.62E-12	—	—	—	—	1.11E-10	—	1.16E-10
Pu-236	2.9 y	4.44E-16	5.48E-11	—	—	—	—	2.41E-04	2.41E-04
Pu-238	87.74 y	1.65E-05	2.22E-11	—	1.03E-04	—	1.07E-06	—	1.21E-04
Pu-239	24065 y	2.03E-05	3.00E-06	—	1.03E-04	1.49E-06	5.79E-03	1.51E-03	7.43E-03
Pu-240	6537 y	5.96E-06	2.64E-13	—	2.49E-04	—	1.30E-03	—	1.55E-03
Pu-241	14.4 y	4.35E-04	4.78E-11	—	9.55E-03	—	2.66E-05	9.38E-03	1.94E-02
Pu-242	3.8E5 y	2.68E-09	3.42E-10	—	7.95E-10	—	3.51E-11	—	3.86E-09
Ra-223	11.4 d	6.57E-13	—	—	—	—	—	—	6.57E-13
Ra-224	3.66 d	6.57E-13	—	—	—	—	1.08E-10	—	1.09E-10
Ra-226	1600 y	2.28E-10	9.62E-11	—	5.61E-09	—	—	9.38E-05	9.38E-05
Ra-228	5.75 y	4.05E-06	—	—	—	—	—	—	4.05E-06
Rb-89	15.2 m	1.37E-01	—	—	—	—	—	—	1.37E-01
Re-188	17.005 h	2.04E-05	—	—	—	—	—	—	2.04E-05
Rh-105	1.47 d	8.63E-06	—	—	—	—	—	—	8.63E-06
Rh-106	368.2 d		—	—	—	—	—	—	0.00E+00
Rn-219	3.96 s	2.19E-06	—	—	—	—	—	—	2.19E-06
Ru-103	39.26 d	2.78E-08	—	—	—	—	—	—	2.78E-08
Ru-106	373.59 d	3.49E-05	—	—	9.91E-08	—	—	2.31E-05	5.81E-05
Sb-122	2.7238 d	5.95E-06	—	—	—	—	—	—	5.95E-06
Sb-124	60.2 d	6.50E-06	—	—	—	—	—	—	6.50E-06
Sb-125	2.77 y	3.83E-05	—	—	6.15E-06	—	6.72E-12	9.55E-04	9.99E-04
Sb-127	3.85 d	4.29E-07	—	—	—	—	—	—	4.29E-07
Sc-46	83.83 d	3.82E-07	—	—	—	—	—	—	3.82E-07

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008) (cont).

		Airborne Effluent (Ci)[a]							
Radionuclide	Half-life	ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	Total
Se-79	65,000 y	6.57E-13	—	—	2.02E-10	—	—	—	2.02E-10
Sm-151	90 y	1.41E-06	—	—	3.31E-04	—	—	9.38E-05	4.26E-04
Sn-113	115.09 d	9.36E-11	2.10E-11	—	—	—	—	—	1.15E-10
SN-119m	293 d	4.80E-06	—	—	—	—	—	—	4.80E-06
Sn-126	1E5 y	4.50E-12	—	—	—	—	—	—	4.50E-12
Sr-85	64.84 d	6.95E-08	5.86E-07	—	—	—	—	—	6.56E-07
Sr-89	50.5 d	8.45E-06	—	—	—	—	—	—	8.45E-06
Sr-90	29.12 y	2.90E-02	3.19E-07	7.77E-10	2.82E-01	1.45E-05	9.44E-09	9.29E-02	4.04E-01
Sr-91	9.5 h	7.67E-11	—	—	—	—	—	—	7.67E-11
Sr-92	2.7 h	1.11E-10	—	—	—	—	—	—	1.11E-10
Ta-182	114.43 d	6.10E-04	—	—	—	—	—	—	6.10E-04
Ta-183	5.1 d	2.97E-10	—	—	—	—	—	—	2.97E-10
Tc-99	2.13E5 y	4.35E-07	7.18E-07	2.16E-09	7.32E-05	—	—	9.38E-05	1.68E-04
Tc-99m	6.02 h	7.89E-05	—	—	—	—	—	—	7.89E-05
Te-123m	119.7 d	1.98E-14	—	—	—	—	—	—	1.98E-14
Te-125m	58 d	3.68E-06	—	—	—	—	—	—	3.68E-06
Th-227	18.7 d	6.57E-13	—	—	—	—	—	—	6.57E-13
Th-228	1.9116 y	3.73E-11	—	—	7.96E-09	—	1.08E-10	—	8.11E-09
Th-229	7340 y	2.29E-10	6.09E-10	—	2.87E-13	—	—	—	8.38E-10
Th-230	7.7E4 y	2.46E-08	7.96E-11	—	7.12E-09	—	—	—	3.18E-08
Th-231	25.5 h	—	—	—	—	—	—	9.38E-05	9.38E-05
Th-232	1.405E10 y	4.59E-09	8.39E-08	—	7.96E-09	—	2.98E-11	—	9.65E-08
Th-234	24.1 d	7.91E-13	—	—	—	—	—	—	7.91E-13
Tl-208	3.07 m	6.57E-13	—	—	—	—	3.89E-11	—	3.96E-11
U-232	72 y	6.30E-09	2.00E-05	—	2.12E-12	—	1.06E-10	—	2.00E-05
U-233	1.585E5 y	2.67E-07	2.52E-04	—	6.86E-08	—	4.16E-09	1.08E-04	3.60E-04
U-234	2.457E5 y	3.88E-07	1.54E-10	—	1.11E-07	—	2.36E-11	3.78E-10	4.99E-07
U-235	7.038E8 y	1.56E-07	1.08E-10	—	2.91E-05	—	3.11E-11	9.48E-05	1.24E-04
U-236	4.468E9 y	7.71E-10	—	—	8.54E-10	—	—	3.11E-06	3.11E-06

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2008) (cont).

		Airborne Effluent (Ci)[a]							
Radionuclide	Half-life	ATR Complex[b]	CFA[c]	CITRC[d]	INTEC[e]	MFC[f]	RWMC[g]	TAN[h]	Total
U-238	4.5E9 y	1.90E-07	1.60E-10	—	1.18E-04	—	3.12E-09	—	1.18E-04
W-187	23.9 h	1.18E-05	—	—	—	—	—	—	1.18E-05
Xe-131m	11.8 d	3.00E-07	—	—	—	—	—	—	3.00E-07
Xe-133	5.245 d	1.85E+01	—	—	—	—	—	—	1.85E+01
Xe-133m	5.2 d	7.40E-08	—	—	—	—	—	—	7.40E-08
Xe-135	9.09 h	4.99E+01	—	—	—	—	—	—	4.99E+01
Xe-135m	15.29 m	7.30E-06	—	—	—	—	—	—	7.30E-06
Xe-138	14.17 m	1.67E+01	—	—	—	—	—	—	1.67E+01
Y-88	106.64 d	3.06E-10	3.40E-11	—	—	—	—	—	3.40E-10
Y-90	64.0 h	7.80E-13	—	—	2.65E-01	—	8.23E-09	—	2.65E-01
Zn-65	243.9 d	1.43E-03	6.76E-08	—	1.06E-09	—	—	8.15E-07	1.43E-03
Zr-93	1.5E6 y	2.70E-11	—	—	—	—	—	8.83E-06	8.83E-06
Zr-95	63.98 d	2.57E-06	—	—	1.71E-06	—	—		4.28E-06
Total		2.08E+03	1.70E+00	8.93E-08	2.68E+03	4.16E+01	5.21E+02	1.60E+00	5.33E+03

a. Radionuclide release information provided by INL contractor (Battelle Energy Alliance, LLC).
b. ATR = Advanced Test Reactor.
c. CFA = Central Facilities Area.
d. CITRC = Critical Infrastructure Test Range Complex.
e. INTEC = Idaho Nuclear Technology and Engineering Center.
f. MFC = Materials and Fuels Complex.
g. RWMC = Radioactive Waste Management Complex, including Advanced Mixed Waste Treatment Project.
h. TAN = Test Area North.

- Radioactive Waste Management Complex (RWMC) Emissions Sources (10% of total) - Emissions from the 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 the retrieval, characterization, and treatment of transuranic waste, alpha-contaminated low-level mixed waste, and low-level mixed waste.
- Materials and Fuels Complex (MFC) Emissions Sources (0.8% 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. On a monthly basis, the effluent streams from Fuel Conditioning Facility, Hot Fuel Examination Facility, and other non-continuous emission monitoring radiological facilities are sampled and analyzed for particulate radionuclides. The Fuel Conditioning Facility and Hot Fuel Examination Facility are also sampled monthly for gaseous radionuclides. Minor amounts of gaseous and particulate radionuclides may also be released during laboratory analysis, waste handling and storage, and maintenance operations. Both measured and estimated emissions from MFC sources are consolidated for NESHAP reporting on an annual basis.

The INL Site dose was calculated using all sources that emitted radionuclides to the environment (DOE-ID 2009). Radiological dose to the public is discussed further in Chapter 8 of this report.

4.2.2 Ambient Air

Gaseous Radioiodines—The ESER and INL Site contractors collected charcoal cartridges weekly or biweekly and analyzed them for gamma-emitting radionuclides. Charcoal cartridges are primarily used to collect gaseous radioiodines. If traces of any human-made radionuclides were detected, the filters were individually analyzed. During 2008, the ESER contractor analyzed 952 cartridges, looking specifically for ^{131}I. No ^{131}I was detected in any of the individual ESER samples.

The INL contractor collected and analyzed 1,053 charcoal cartridges in 2008. Of these 1,053 cartridges, a single statistically positive detection ($1.1 \pm 0.35 \times 10^{-14}$ µCi/mL) of ^{131}I was reported by the laboratory for a sample collected December 17, 2008, from the Craters of the Moon background location; 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 DCG of 2×10^{-8} µCi/mL. In addition, no ^{131}I was detected in the ESER contractor collocated sample or any other ESER or INL Site contractor sample collected in 2008.

Gross Activity—Particulates filtered from air were sampled weekly as part of the INL Site Environmental Surveillance Programs, except as noted in Section 4.2. All samples were analyzed for gross alpha activity and gross beta activity.

Gross Alpha. There was little difference between ESER and INL contractor gross alpha activity data. Both data sets indicated gross alpha concentrations at INL site locations, which are usually undisturbed by soil suspending events, were generally equal to or lower than those at boundary locations.

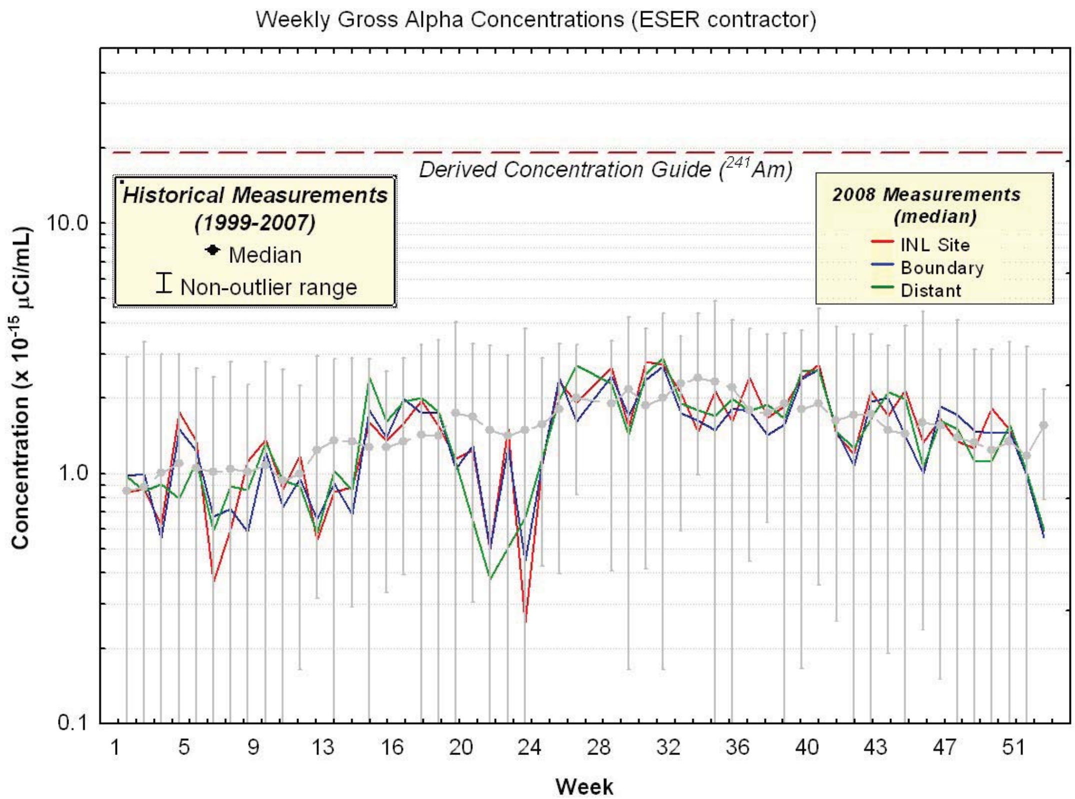
True positive gross alpha concentrations detected in weekly ESER contractor samples (i.e., measurement results that were greater than their associated 3-sigma uncertainties) ranged from a minimum of 0.39×10^{-15} µCi/mL at Craters of the Moon during the week ending December 31, 2008, to a maximum of 5.0×10^{-15} µCi/mL during the week ending October 1, 2008, at the Federal Aviation Administration tower. True positive gross alpha concentrations measured in INL contractor samples ranged from a low of 2.6×10^{-15} µCi/mL collected at INTEC on October 1, 2008, to a high of 5.2×10^{-15} µCi/mL collected at RWMC on July 23, 2008.

Figure 4-2 displays the median weekly gross alpha concentrations for the ESER and INL contractors at INL Site, boundary, and distant sampling groups. It also shows historical medians and ranges measured by the ESER contractor from 1999 to 2007. Each median weekly concentration was computed using all results, including those that were less than their associated 3-sigma uncertainties. Note that the INL contractor went form a one week to a biweekly sample collection period after October 1. These data, weekly and biweekly, are typical of the annual natural fluctuation pattern for gross alpha concentrations in air. According to Figure 4-2, the highest median weekly gross alpha concentration was measured by the ESER contractor on the INL Site in the third quarter of 2008. The maximum median weekly gross alpha concentration, 2.9×10^{-15} µCi/mL, was below the DCG for the most restrictive alpha-emitting radionuclide in air (americium-241 [^{241}Am]) of 20×10^{-15} µCi/mL.

Median annual gross alpha concentrations calculated by the ESER contractor ranged from 1.1×10^{-15} µCi/mL at Blue Dome to 1.6×10^{-15} µCi/mL at several locations (Table 4-3). Confidence intervals are not calculated for median annual concentrations. Median annual gross alpha concentrations calculated by the INL contractor ranged from 0.72×10^{-15} µCi/mL at Blackfoot to 1.4×10^{-15} µCi/mL at the ATR Complex. In general, gross alpha concentrations were typical of those detected previously and well within the historical range for 1996 through 2008 (Figure 4-3).

Gross Beta. Gross beta concentrations in ESER contractor samples were fairly consistent with those of INL contractor samples.

Weekly gross beta concentrations detected in ESER contractor samples ranged from a low of 0.68×10^{-14} µCi/mL on May 28, 2008, at Dubois and Blue Dome to a high of 6.2×10^{-14} µCi/mL on January 2, 2008, at Mud Lake. Gross beta concentrations in INL contractor samples ranged from a low of $0.54 \pm 1.4 \times 10^{-14}$ µCi/mL at Specific Manufacturing Capability on May 28, 2008, to a high of $6.6 \pm 0.9 \times 10^{-14}$ µCi/mL at MFC on February 20, 2008.



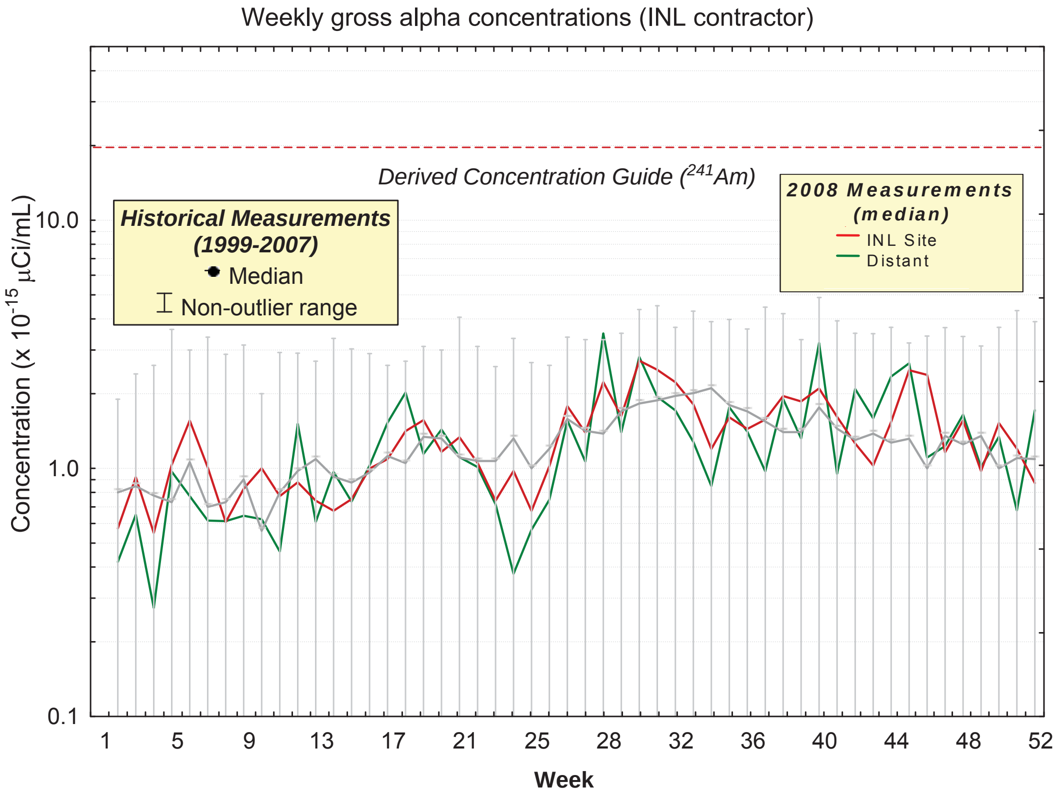


Figure 4-2. Median Weekly Gross Alpha Concentrations in Air (2008).

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2008).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median[c] ($\times 10^{-15}$ µCi/mL)
ESER Contractor				
Distant	Blackfoot CMS	53	0.03 – 3.3	1.4
	Craters of the Moon	53	0.21 – 2.8	1.2
	Dubois	50	0.16 – 2.8	1.3
	Idaho Falls	50	0.39 – 3.0	1.6
	Jackson	47	0.02 – 2.6	1.4
	Rexburg CMS	51	0.51 – 2.9	1.6
			Distant Median:	1.4
Boundary	Arco	52	-0.04 – 3.29	1.5
	Atomic City	53	0.39 – 2.9	1.4
	Blue Dome	49	0.04 – 2.6	1.1
	Federal Aviation Administration Tower	49	0.26 – 5.0	1.3
	Howe	52	0.31 – 2.6	1.4
	Monteview	53	0.47 – 3.0	1.6
	Mud Lake	53	-0.04 – 3.1	1.6
			Boundary Median:	1.4
INL Site	EFS	49	0.08 – 2.8	1.5
	Main Gate	50	0.07 – 3.0	1.5
	Van Buren	52	0.49 – 3.5	1.5
			INL Site Median:	1.5
INL Contractor				
Distant	Blackfoot	44	-0.36 – 4.8	0.72
	Craters of the Moon	43	0.11 – 3.5	1.2
	Idaho Falls	44	0.01 – 4.0	1.2
	Rexburg	43	0.09 – 5.0	1.2
			Distant Median:	1.2
INL Site	ARA	45	-0.01 – 2.0	0.89
	ATR Complex (formerly RTC)	44	-0.02 – 3.8	1.4
	ATR Complex (NE corner)	44	-0.23 – 8.0	1.2
	CFA	44	-0.22 – 5.0	1.2
	CITRC	43	-0.18 – 2.7	0.92
	CPP (historic location name at INTEC)	44	0.00 – 4.3	1.1
	EBR-I	43	0.13 – 4.1	0.91
	EFS	42	-0.07 – 4.0	1.0
	Gate 4	44	0.10 – 3.0	0.91
	INTEC	44	-0.15 – 4.8	1.2
	MFC	42	-0.29 – 5.2	1.2
	NRF	44	-0.31 – 3.6	1.2
	Rest Area	45	0.43 – 3.0	1.1
	RWMC	43	-0.19 – 3.9	1.2
	SMC	44	0.31 – 3.9	1.1
	TAN	44	0.10 – 3.4	0.96
	Van Buren	41	0.09 – 4.4	1.1
			INL Site Median:	1.1

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CFA = Central Facilities Area; CITRC = Critical Infrastructure Test Range Complex; CMS = Community Monitoring Station; CPP = Chemical Processing Plant; EBR-I = Experimental Breeder Reactor No. 1; EFS = Experimental Field Station; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; NE = northeast; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; RTC = Reactor Technology Complex; SMC = Specific Manufacturing Capability; TAN = Test Area North. See Figure 4-1 for locations on INL Site.

b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements taken at Atomic City and Blue Dome

c. All measurements, including those less than three times their analytical uncertainty, 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.

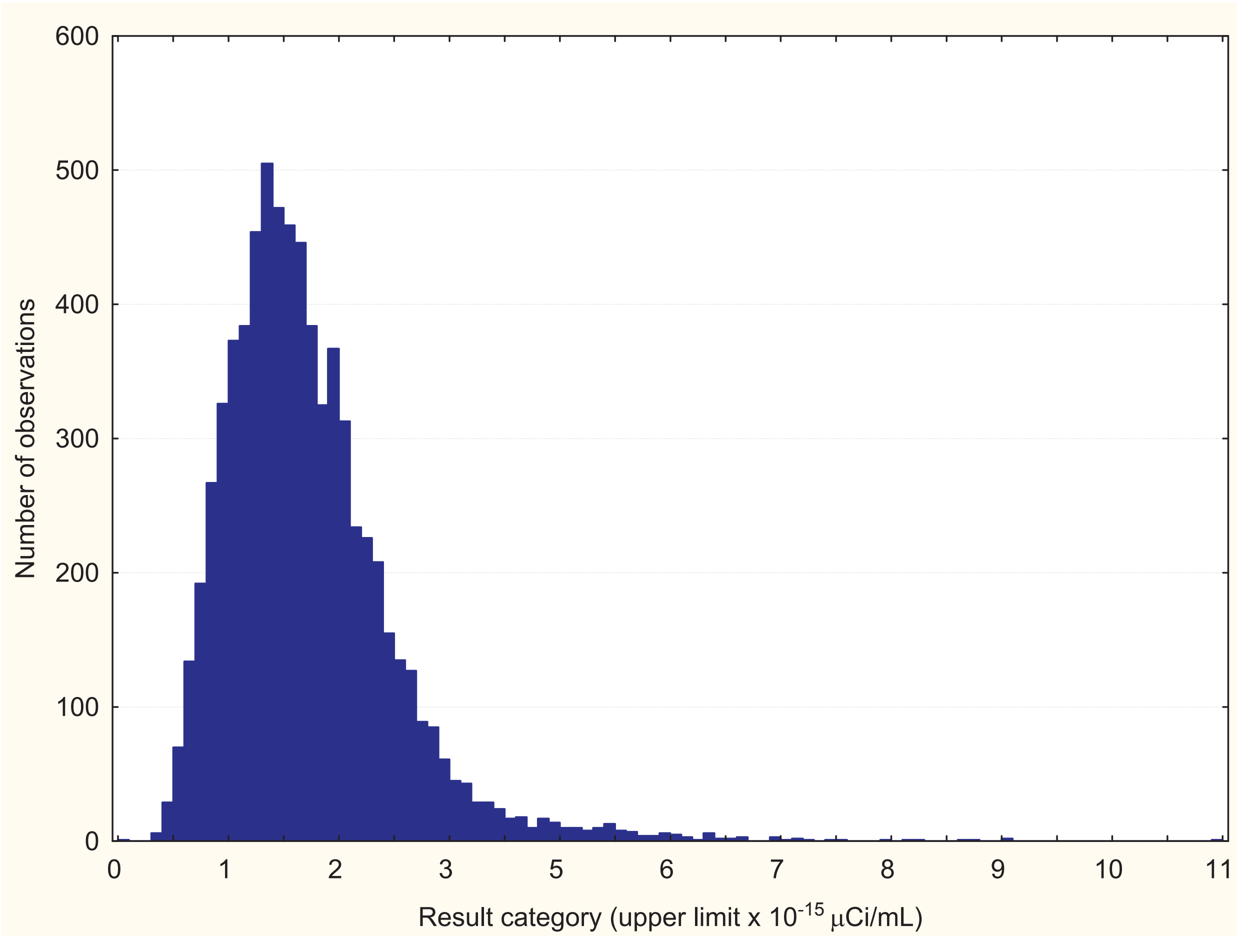
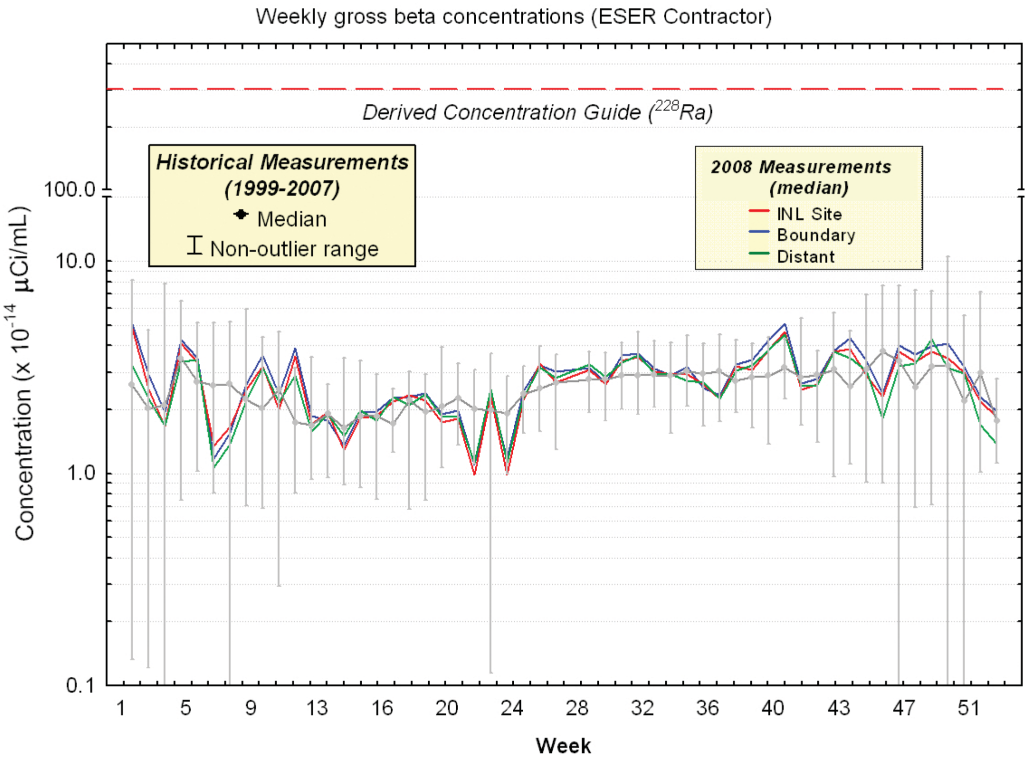


Figure 4-3. Frequency Distribution of Gross Alpha Activity Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor (1996–2008).

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 data measured by the ESER contractor from 1999 to 2007. 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. The highest median weekly concentration of gross beta activity was detected in the fourth quarter of 2008 by the INL contractor on the INL Site. Each median value was calculated using all measurements, including those that were less than their associated 3-sigma uncertainties. 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 for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

ESER contractor median annual gross beta concentrations ranged from 2.3×10^{-14} µCi/mL at Craters of the Moon and Jackson to 2.9×10^{-14} µCi/mL at Mud Lake (Table 4-4). INL contractor



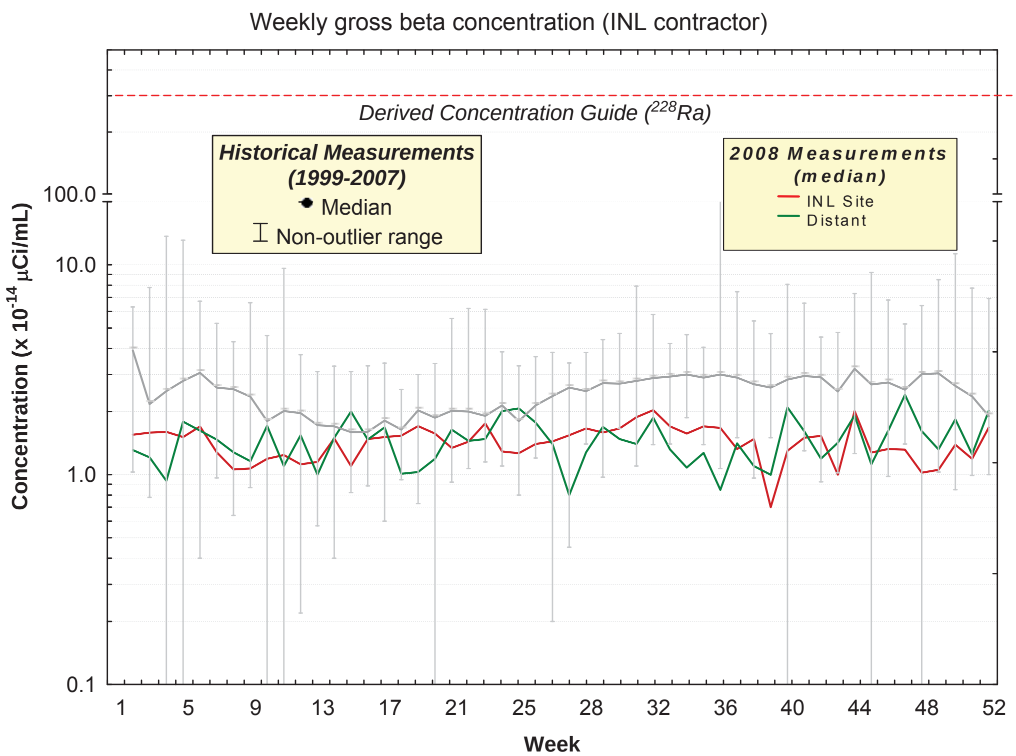


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2008).

data ranged from a median annual concentration of 2.0 × 10^{-14} µCi/mL at MFC to 2.7 × 10^{-14} µCi/mL at ATR Complex. In general, airborne radioactivity levels for the three groups (on INL Site, boundary, and distant locations) tracked each other closely throughout the year. In addition, all results greater than 3 sigma reported by the ESER contractor are well within valid measurements taken within the last 13 years (Figure 4-5). 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. Gross beta concentrations, unlike gross alpha concentrations, are typically positive at the 3-sigma uncertainty levels. Concentrations can vary widely from location to location as a result of a variety of factors, such as soil type and meteorological conditions. When statistical differences are found in gross beta activity, these and other factors are examined to assist with identifying the potential cause for the differences, including a possible INL Site release.

Statistical comparisons were made using the gross beta radioactivity data collected from the INL Site, boundary, and distant locations (see Appendix C for a description of statistical methods). Figure 4-6 compares all gross beta concentrations measured during 2008 by the ESER contractor. The results are grouped by location (i.e., on boundary, distant and INL Site). The figure indicates no significant difference between locations. The figure also shows that the largest measurement was well below the DCG for the most restrictive beta-emitting radionuclide (^{228}Ra) in air of 300 × 10^{-14} µCi/mL. 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 between annual concentrations collected from the INL Site, boundary, and distant locations in 2008.

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2008 that can be attributed to expected statistical variation in the data.

INL contractor data sets from on the INL Site and distant locations were compared, and there were no statistical differences.

Specific Radionuclides—Human-made radionuclides were observed above 3-sigma values in some ESER contractor and INL contractor quarterly composite samples (Tables 4-5 and 4-6).

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 four quarterly composited samples collected on the INL Site at EFS and at boundary locations Howe and Atomic City. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past 12 years is shown in Figure 4-7. The results detected in 2008 are within the historical range and all well below the ^{241}Am DCG of 20,000 × 10^{-18} µCi/mL.

Table 4-4. Median Annual Gross Beta Concentrations in Air (2008).

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	53	0.93 – 4.7	2.7
	Craters of the Moon	53	1.1 – 4.1	2.3
	Dubois	50	0.68 – 4.3	2.4
	Idaho Falls	50	1.1 – 2.8	2.8
	Jackson	48	0.93 – 4.3	2.3
	Rexburg CMS	51	1.1 – 4.8	2.7
			Distant Median:	2.5
Boundary	Arco	52	0.93 – 4.9	2.6
	Atomic City	53	1.0 – 4.9	2.7
	Blue Dome	49	0.68 – 4.1	2.4
	Federal Aviation Administration Tower	49	0.82 – 5.1	2.5
	Howe	52	0.99 – 4.8	2.6
	Monteview	53	0.97 – 5.6	2.7
	Mud Lake	53	0.99 – 6.2	2.9
			Boundary Median:	2.6
INL Site	EFS	49	9.4 – 5.2	2.8
	Main Gate	50	0.02 – 5.2	2.7
	Van Buren	52	1.1 – 5.1	2.9
			INL Site Median:	2.8
INL Contractor				
Distant	Blackfoot	44	0.87 – 4.0	2.1
	Craters of the Moon	43	0.90 – 3.7	2.3
	Idaho Falls	44	0.94 – 3.7	2.2
	Rexburg	43	0.97 – 4.2	2.2
			Distant Median	2.8
INL Site	ARA	45	0.83 – 4.5	2.3
	ATR Complex (formerly RTC)	44	0.95 – 3.9	2.2
	ATR Complex (NE corner)	44	0.94 – 4.2	2.7
	CFA	44	0.84 – 5.3	2.3
	CITRC	43	1.2 – 3.7	2.2
	CPP	44	0.74 – 5.2	2.3
	EBR-I	43	0.97 – 3.9	2.1
	EFS	42	0.94 – 4.2	2.4
	Gate 4	44	0.92 – 4.5	2.4
	INTEC	44	1.0 – 3.7	2.3
	MFC	42	0.67 – 6.6	2.0
	NRF	44	0.81 – 4.0	2.4
	Rest Area	45	0.97 – 3.7	2.1
	RWMC	44	0.84 – 4.0	2.1
	SMC	43	0.54 – 4.5	2.3
	TAN	44	0.61 – 4.5	2.3
	Van Buren	41	1.0 – 4.2	2.5
			INL Site Median:	2.8

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; NE = northeast; NRF = Naval Reactors Facility; RTC = Reactor Technology Complex; 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 Atomic City and Blue Dome

c. All measurements, including those less than three times their analytical uncertainty, are included in this table and in computation of median annual values.

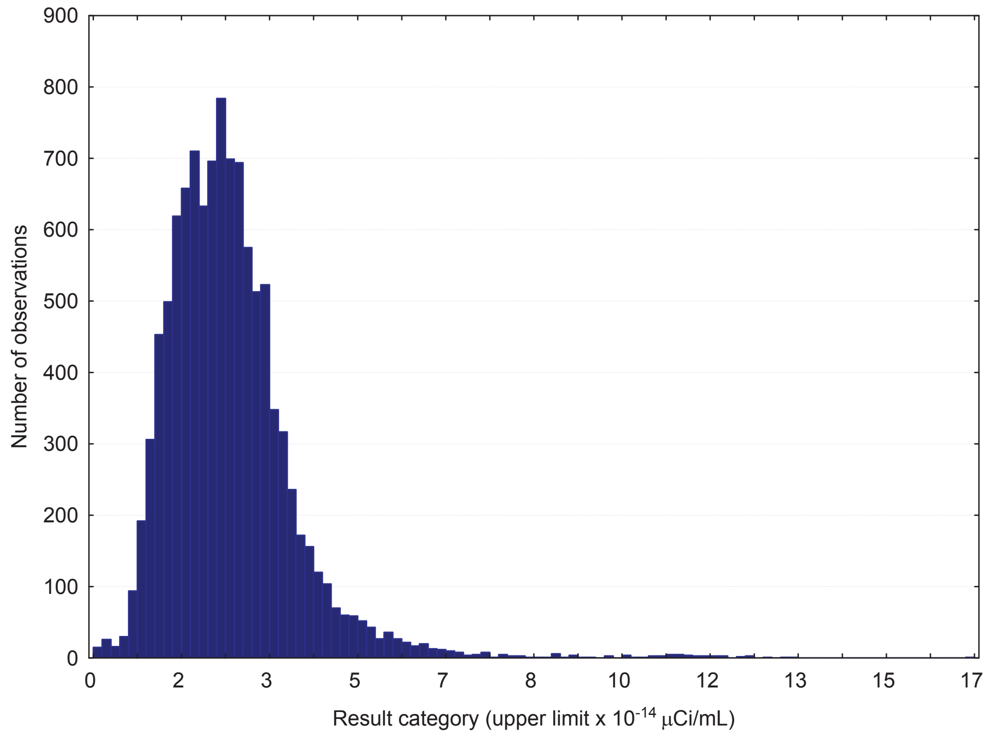


Figure 4-5. Frequency Distribution of Gross Beta Activity Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor (1996—2008).

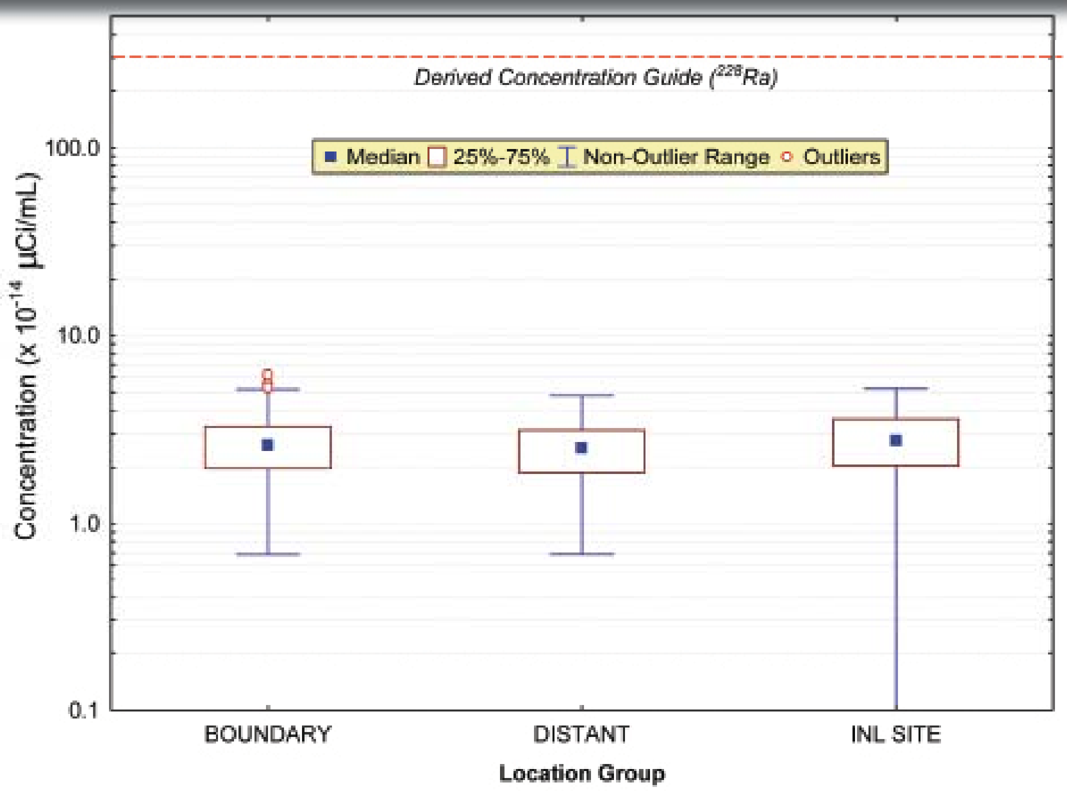


Figure 4-6. Comparisons of Gross Beta Concentrations Measured in Air at Distant, Boundary, and INL Site Locations by the ESER Contractor (2008).

Table 4-5. Human-made Radionuclides in ESER Contractor Quarterly Composite Air Samples (2008).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}$Pu
		First Quarter 2008		
Blackfoot CMS	529 ± 136	ND[b]	ND	ND
Main Gate	ND	ND	7.8 ± 1.4	ND
		Second Quarter 2008		
Atomic City	ND	ND	ND	9.6 ± 1.9
Blue Dome	ND	ND	ND	13 ± 1.6
EFS	ND	ND	ND	5.2 ± 1.7
		Third Quarter 2008		
Main Gate	ND	ND	ND	ND
		Fourth Quarter 2008		
Atomic City	ND	3.3 ± 0.62	ND	ND
EFS	ND	16.0 ± 1.8	ND	ND
Howe	ND	7.6 ± 1.5	ND	ND

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{-18} µCi/mL.)

b. ND = Not detected (result < 3s analytical uncertainty or result not valid.)

Table 4-6. Human-made Radionuclides in INL Site Contractor Quarterly Composited Air Samples (2008).[a]

Location	^{241}Am	^{90}Sr	^{234}U	^{238}U
		First Quarter 2008		
ANLW	17 ± 5	ND[b]	ND	ND
Location A (TAN)	ND	580 ± 100	ND	ND
NRF	ND	ND	ND	16 ± 5
Rexburg	ND	ND	34 ± 8	21 ± 7
TAN	ND	216 ± 60	ND	ND
		Second Quarter 2007		
ANLW	ND	ND	44 ± 10	ND
Blackfoot	ND	160 ± 50	42 ± 10	ND
CFA	ND	300 ± 70	ND	ND
Craters of the Moon	ND	280 ± 70	ND	ND
Rexburg	ND	ND	59 ± 10	ND

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{-18} µCi/mL.)

b. ND = Not detected (result < 3s analytical uncertainty or result not valid.)

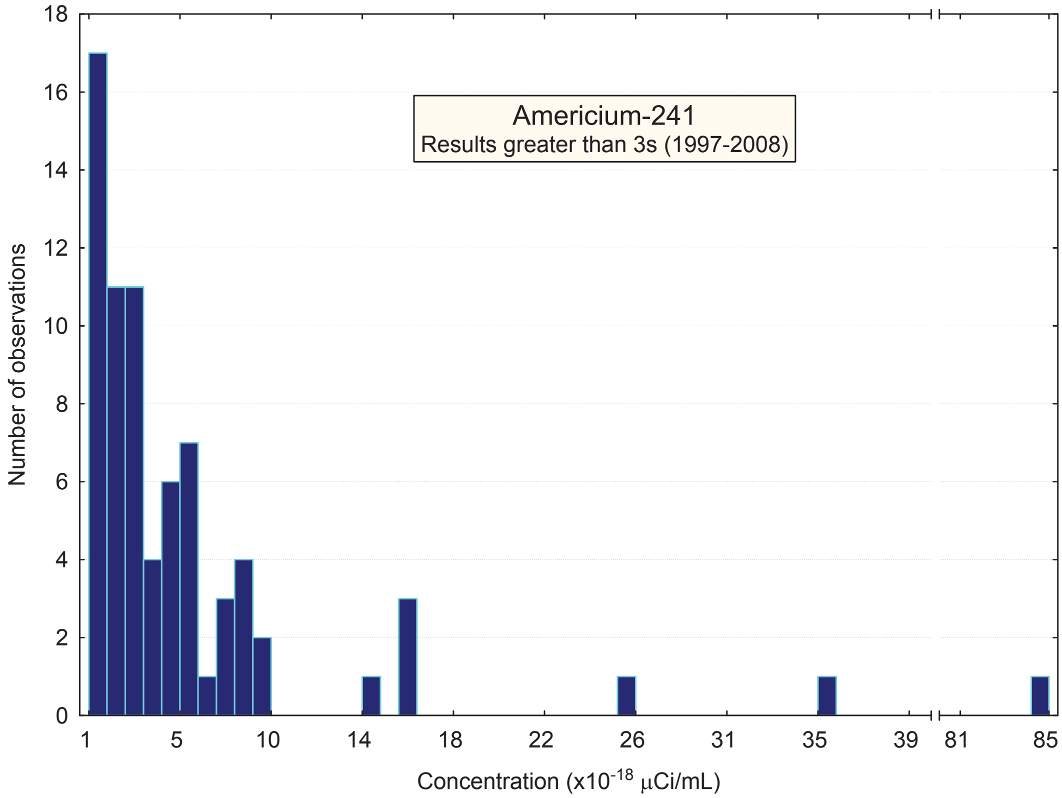


Figure 4-7. Frequency Distribution of Americium-241 Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor (1997–2008).

Plutonium isotopes were detected in some INL Site and boundary ESER samples in 2008. Statistically positive plutonium-238 (^{238}Pu) was measured in one sample within historical concentrations and below the DCG of 3.0 × 10^{-14} μCi/mL. Plutonium-239/240 ($^{239/240}$Pu) was detected in four samples at levels consistent with worldwide levels related to atmospheric nuclear weapons testing and are well within past measurements and below the DCG of 2.0 × 10^{-14} μCi/mL (Figure 4-8).

Strontium-90 (^{90}Sr) was not detected in any ESER sample.

Cesium-137 (^{137}Cs) was detected in one ESER sample at Blackfoot. This detection was well within historical measurements and below the DCG of 3 × 10^{-7} μCi/mL. These data were not graphed as there are relatively few historic results to plot.

Natural beryllium-7 (^{7}Be) was detected in numerous INL contractor quarterly composites 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. Strontium-90 was detected in five samples collected on and off the INL Site. Uranium-234 was detected in four samples collected on and off the INL Site. Uranium-238 was detected in two samples collected on and off the INL Site. Americium-241 was detected in one

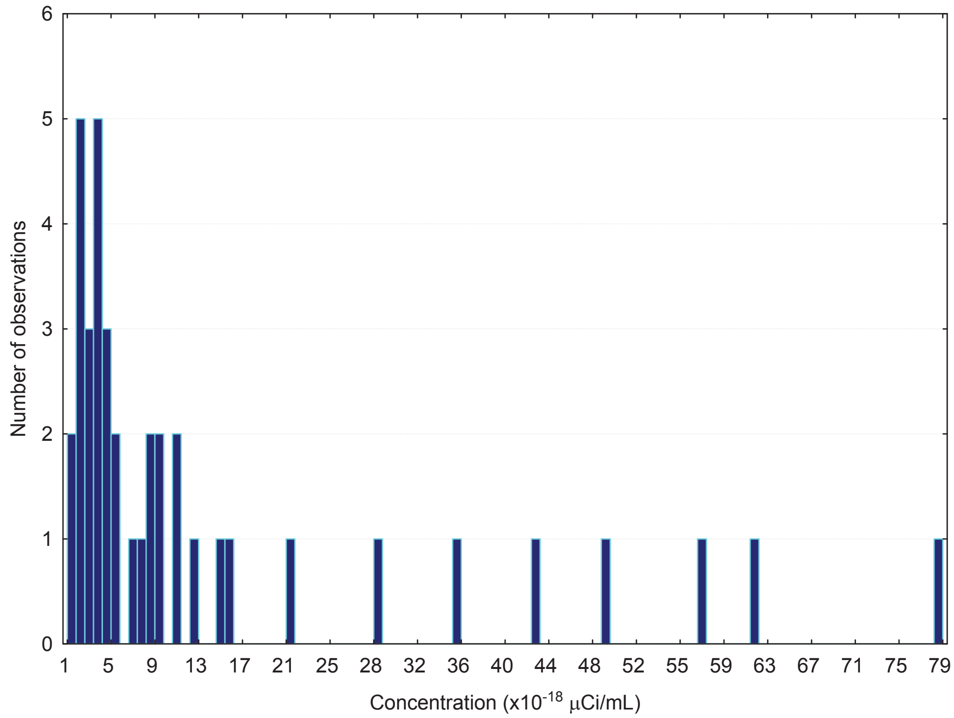


Figure 4-8. Frequency Distribution of Plutonium-239/240 Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor (1997–2008).

sample collected on the INL Site. Concentrations of these isotopes were slightly above the detection limits and well below the respective DCGs.

4.2.3 Atmospheric Moisture

During 2008, the ESER contractor collected 62 atmospheric moisture samples at Atomic City, Blackfoot, Idaho Falls, and Rexburg using molecular sieve material. Table 4-7 presents the range of values for each station by quarter.

Tritium was detected in 25 samples. Samples that exceeded the respective 3-sigma uncertainties ranged from a low of 3.0×10^{-13} µCi/mL at Idaho Falls to a high of 19×10^{-13} µCi/mL at Blackfoot.

These detected radioactive concentrations were similar at distant and boundary locations. This similarity suggests that the detections 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.

Table 4-7. Tritium Concentration Ranges in ESER Contractor Atmospheric Moisture Samples (2008).

Location	First Quarter[a]	Second Quarter[a]	Third Quarter[a]	Fourth Quarter[a]
	(× 10^{-13} μCi/mL)			
Atomic City	ND[b]	ND	4.1 ± 1.3 – 8.4 ± 2.3	ND
Blackfoot	4.6 ± 1.2 – 5.9 ± 1.6	ND	4.1 ± 0.93 – 19 ± 2.8	4.6 ± 1.4 – 14 ± 1.7
Idaho Falls	3.0 ± 0.9 –7.0 ± 1.3	ND	8.0 ± 2.3 – 15 ± 2.7	5.5 ± 1.6[c]
Rexburg	3.5 ± 1.0	8.9 ± 2.7	9.3 ± 3.0 – 10.5 ± 2.4	5.1 ± 1.4

a. Concentrations shown are greater than 3-sigma analytical uncertainty.
b. ND = Not detected (result less than 3-sigma analytical uncertainty or result not valid).
c. When a single value is reported, tritium was detected in only one sample.

The INL contractor collected atmospheric moisture samples at the EFS and at Van Buren Boulevard on the INL Site and at Idaho Falls and Craters of the Moon off the INL Site. During 2008, 35 samples were collected. Tritium was not detected above the 3-sigma uncertainty in any sample. All values are less than the DCG for tritium in air.

4.2.4 Precipitation

The ESER contractor collects precipitation samples weekly at EFS and monthly at CFA and off the INL Site in Idaho Falls. A total of 44 precipitation samples were collected during 2008 from the three sites. Tritium concentrations were measured above the 3-sigma uncertainty in eight samples, and results ranged from 100 to 221 × 10^{-13} µCi/mL (100 × 10^{-4} to 221 × 10^{-4} pCi/L). Table 4-8 shows the concentration ranges by quarter for each location. The highest radioactivity was from a sample collected at EFS during the fourth quarter and is far 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 EPA in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past 10 years (http://www.epa.gov/enviro/html/erams/).

4.2.5 Suspended Particulates

In 2008, ESER and INL contractors 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. Unlike the fine particulate samplers discussed in the next section, these samplers do not selectively filter out particles of a certain size range, so they collect the total particulate load greater than 0.3 µm in diameter.

Particulate concentrations from ESER contractor samples ranged from 6.9 µg/m^3 at Blue Dome to 25.9 µg/m^3 at Rexburg. 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.

The total suspended particulate concentrations measured by the INL contractor ranged from 0.0 µg/m^3 at several locations and to 142 µg/m^3 at RWMC during the December 3 to December 17, 2008, sample period.

Table 4-8. Tritium Concentration Ranges in ESER Contractor Precipitation Samples (2008).

Location[b]	First Quarter[a]	Second Quarter[a]	Third Quarter[a]	Fourth Quarter[a]
		($\times 10^{-13}$ µCi/mL)		
CFA	ND	145 ± 34[c]	135 ± 34	100 ± 32
EFS	ND	155 ± 34 – 221 ± 36	ND	139 ± 34 –156 ± 35
Idaho Falls	ND	ND	ND	ND

a. Concentrations shown are greater than 3-sigma analytical uncertainty.
b. CFA = Central Facilities Area; EFS = Experimental Field Station.
c. When a single value is reported, tritium was detected in only one sample.

4.2.6 IMPROVE Samplers

Interagency Monitoring of Protected Visual Environments (IMPROVE) samplers began continuous operation at Craters of the Moon and the Central Facilities Area in spring of 1992. EPA removed the Central Facilities Area sampler from the national network in May 2000, when the location was determined to be no longer necessary. The most recent data available for the Craters of the Moon station are through November 2003.

The IMPROVE samplers measure several elements, including aluminum, silicon, calcium, titanium, and iron. These elements are derived primarily from soils and show a seasonal variation, with lower values during the winter when the ground is often covered by snow.

Other elements are considered tracers of various industrial and urban activities. Lead and bromine, for example, result from automobile emissions. Annual concentrations of lead at IMPROVE sites in the mid-Atlantic states are commonly in the range of 2 to 6 ng/m^3, or up to 10 times higher than at Craters of the Moon. Selenium, in the 0.1-ng/m^3 range at Craters of the Moon, is a tracer of emissions from coal-fired plants.

Fine particles with a diameter less than 2.5 microns ($PM_{2.5}$) are the size fraction most commonly associated with visibility impairment. During sampler operation at Craters of the Moon, $PM_{2.5}$ has ranged from 409 to 25,103 ng/m^3, with a mean of 3,443 ng/m^3.

4.3 Waste Management Surveillance Monitoring

4.3.1 Gross Activity

The ICP contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, “Radioactive Waste Management.” Currently, ICP waste management operations occur at the Subsurface Disposal Area at RWMC and the Idaho CERCLA Disposal Facility at INTEC and have the potential to emit radioactive airborne particulates. The ICP contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2008. The ICP contractor also collected samples from a control location north of Howe, Idaho (Figure 4-1), 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 4-9 shows the suspended particle 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.

4.3.2 Specific Radionuclides

In 2008 no human-made radionuclides were detected at the Idaho CERCLA Disposal Facility and no human-made gamma-emitting radionuclides were detected that exceeded the 3-sigma uncertainty.

Table 4-10 shows radiochemical detections of alpha- and beta-emitting radionuclides greater than the 3-sigma uncertainty for 2008. 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 2007 to 2008, and are likely due to resuspended soils from increased activity at the Subsurface Disposal Area and at the Accelerated Retrieval Project. Some ^{90}Sr results were rejected due to analytical laboratory problems (i.e., blank contamination, performance evaluation sample results). The ICP contractor will continue to closely monitor these radionuclides for any abnormal trends.

Table 4-9. ICP Contractor Gross Activity Concentrations (2008).

Radionuclide	High (µCi/mL)	Low (µCi/mL)	Annual Mean (µCi/mL)
Subsurface Disposal Area (SDA)			
Gross Alpha	$(1.39 \pm 0.40) \times 10^{-14}$ 2nd half of August SDA 1.3	$(1.51 \pm 2.90) \times 10^{-16}$ 2nd half of March SDA 4.3	2.90×10^{-15}
Gross Beta	$(5.52 \pm 0.88) \times 10^{-14}$ 1st half of March SDA 4.2	$(7.08 \pm 1.17) \times 10^{-15}$ 2nd half of May SDA 4.2	2.45×10^{-14}
Idaho CERCLA Disposal Facility (ICDF)			
Gross Alpha	$(6.62 \pm 1.97) \times 10^{-15}$ 2nd half of August ICDF (INT 100.3)	$(5.98 \pm 4.55) \times 10^{-16}$ 1st half of June ICDF (INT 100.3)	2.98×10^{-15}
Gross Beta	$(5.06 \pm 0.78) \times 10^{-14}$ 2nd half of November ICDF (INT 100.3)	$(1.42 \pm 0.23) \times 10^{-14}$ 1st half of June ICDF (INT 100.3)	2.69×10^{-14}

Table 4-10. Human-made Radionuclides in ICP Contractor Air Samples[a] (2008).

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Am-241	(2.26 ± 0.55) × 10^{-17}	SDA[b] 4.2	2nd
	(2.58 ± 0.57) × 10-^{17}	SDA 4.3	2nd
	(1.03 ± 0.30) × 10^{-17}	SDA 2.3	3rd
	(2.80 ± 0.55) × 10^{-17}	SDA 4.2	3rd
	(3.06 ± 0.58) × 10^{-17}	SDA 4.3	3rd
	(1.02 ± 0.30) × 10^{-17}	SDA 9.3	3rd
	(8.10 ± 2.63) × 10^{-18}	SDA 2.3	4th
	(1.85 ± 0.39) × 10^{-17}	SDA 4.2	4th
	(9.73 ± 2.86) × 10^{-18}	SDA 4.3	4th
Pu-239/240	(1.10 ± 0.34) × 10^{-17}	SDA 4.2	2nd
	(6.62 ± 0.99) × 10^{-17}	SDA 4.2	3rd
	(1.51 ± 0.38) × 10^{-17}	SDA 4.3	3rd
	(7.44 ± 2.40) × 10^{-17}	SDA 6.3	3rd
	(7.04 ± 2.27) × 10^{-18}	SDA 9.3	3rd
	(2.25 ± 0.41) × 10^{-18}	SDA 4.2	4th

a. Detections greater than the 3-sigma uncertainty.
b. SDA = Subsurface Disposal Area.

REFERENCES

40 CFR 50.6, "National Primary and Secondary Ambient Air Quality Standards for Particulate Matter," *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.

DEQ, 2003, *Idaho State Implementation Plan for the Control of Air Pollution*, Idaho Department of Environmental Quality.

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

DOE-ID, 2009, *National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2008 INL Report for Radionuclides*, DOE -ID-10890(09), U.S. Department of Energy Idaho Operations Office.

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

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

Chapter Highlights

Liquid effluents, drinking water, and storm water runoff were monitored in 2008 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 2008, 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 2008.

Closure activities at the Test Area North/Technical Support Facility Sewage Treatment Facility were completed in 2008. In addition, groundwater samples were collected from six permitted wells one final time in April 2008. Most groundwater parameters were below primary and secondary constituent standards in the state of Idaho “Ground Water Quality Rule.” However, groundwater samples collected from one well exceeded secondary constituent standards for aluminum, iron, manganese, and total dissolved solids. Elevated concentrations of these parameters have been measured and studied in the past and are not linked to the closed facility.

Additional liquid effluent monitoring was performed in 2008 at ATR Complex, CFA, INTEC, and Materials and Fuel Complex to comply with environmental protection objectives of the Department of Energy (DOE). All reported concentrations were consistent with historical data and below applicable health-based standards.

Eleven drinking water systems were monitored in 2008 for parameters required by “Idaho Rules for Public Drinking Water Systems.” Water samples collected from most 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 to be 0.30 mrem for 2008.

Surface water runoff from the Subsurface Disposal Area of the Radioactive Waste Management Complex was sampled in 2008 for radionuclides in compliance with DOE limits. All results were within historical measurements with the exception of an americium-241 detection. The sample was collected from standing water containing significant amounts of particulate matter that may have influenced the results. Surface water runoff will continue to be monitored closely to detect any abnormal trends.

5. COMPLIANCE MONITORING FOR LIQUID EFFLUENTS, GROUNDWATER, 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). Results are compared to applicable regulatory limits of compliance standards to protect human health and the environment.

Section 5.1 presents a general overview of the organizations responsible for water monitoring at the INL Site. Section 5.2 describes liquid effluent and related groundwater monitoring required by the City of Idaho Falls and state of Idaho wastewater reuse permits. Section 5.3 describes liquid effluent surveillance monitoring at participating INL Site facilities. Section 5.4 discusses the INL Site drinking water programs. Section 5.5 describes surface water runoff monitoring at the Radioactive Waste Management Complex on the INL Site to comply with Department of Energy (DOE) Order 435.1.

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 D.

5.1 Summary of Monitoring Programs

The INL contractor and ICP contractor monitor liquid effluent, groundwater, drinking water, and surface water runoff at the INL Site to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., wastewater reuse permit requirements).

In 2008, the INL Oversight Program collected split samples of groundwater with the INL contractor and ICP contractor. The INL Oversight Program publishes an independent annual report (DEQ 2007), and their results are not reported here. INL Oversight Program reports can be accessed on the Internet at http://www.deq.state.id.us/inl_oversight/library.cfm.

Table 5-1 presents water monitoring performed on the INL Site and the Research and Education Campus (Idaho Falls facilities).

Table 5-1. Water Monitoring at the Idaho National Laboratory Site and the Research and Education Campus.

Area/Facility	Media				
	Liquid Effluent (Permitted)	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				•	•
Test Area North/Technical Support Facility			•		
INL Contractor: Battelle Energy Alliance, LLC (BEA)					
Advanced Test Reactor Complex	•	•	•	•	
Central Facilities Area[a]	•	•		•	
Materials and Fuels Complex		•		•	
Power Burst Facility				•	
Research and Education Campus (Idaho Falls Facilities)	•				
Test Area North/Technical Support Facility				•	

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

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. Wastewater is typically discharged to the ground surface and evaporation ponds. Wastewater discharges to the ground surface at the following areas:

- Percolation ponds at the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds, Materials and Fuels Complex (MFC) Industrial Wastewater 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 groundwater quality and 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 compliance (required by regulations) or do so 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 current status of each wastewater reuse-permitted facility.

The permits generally require that data from groundwater monitoring wells at the INL Site comply with the Idaho groundwater quality primary constituent standards and secondary constituent standards (IDAPA 58.01.11). The permits specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2009a, 2009b, 2009c; INL 2009a, 2009b) were prepared and submitted to the state of Idaho Department of Environmental Quality (DEQ) as required for permitted facilities.

During 2008, 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.

Table 5-2. Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2008	Explanation
Advanced Test Reactor Complex Cold Waste Pond	Permit issued	DEQ 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. The permit was modified on October 19, 2005, and expires on January 25, 2010.
Idaho Nuclear Technology and Engineering Center New Percolation Ponds	Permit issued	DEQ issued Permit LA-000130-04 on November 19, 2004, modified on October 25, 2005, and March 16, 2007, and expires on November 18, 2009.
Materials and Fuels Complex Industrial Waste Pond	Permit application submitted to DEQ	A permit application has been submitted to DEQ.
Test Area North/Technical Support Facility Sewage Treatment Facility	Permit terminated	DEQ issued Permit #LA-000153-02 January 2005, and issued a minor modification in October 2005. A closure plan (ICP 2007b) was submitted to DEQ on November 2, 2007 and approved by DEQ on November 13, 2007. A final closure plan (ICP 2009c) was submitted to DEQ on August 28, 2008. Termination of the permit was approved November 4, 2008.

DEQ = Idaho Department of Environmental Quality

5.2.1 Research and Education Campus

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

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

Wastewater Monitoring Results—Table 5-3 summarizes the semiannual monitoring results conducted at the Research and Education Campus in March and September 2008. As the table shows, all results were below the discharge limit, and most were below the detection limit.

Table 5-3. Semiannual Effluent Monitoring Results for Research and Education Campus (2008).

Parameter	March 2008[a]		September 2008	Discharge Limit[b]
Arsenic (mg/L)	0.0025 U[c]	0.0025 U	0.0031	0.04
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U	0.26
Chromium (mg/L)	0.0025 U	0.0025 U	0.0025 U	2.77
Copper (mg/L)	0.0481	0.0476	0.0609	1.93
Cyanide (mg/L)	0.005 U	0.005 U	0.005 U	1.04
Lead (mg/L)	0.0004 U	0.00044	0.0011	0.29
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U	0.002
Molybdenum (mg/L)	0.273	0.273	0.0025 U	None
Nickel (mg/L)	0.0033	0.005 U	0.0025 U	2.38
pH (standard units)	8.12–8.56[d]		7.75–7.95[d]	5.5–9.0
Selenium (mg/L)	0.0006	0.00064	0.0005 U	None
Silver (mg/L)	0.005 U	0.005 U	0.005 U	0.43
Zinc (mg/L)	0.0251	0.0255	0.0305	0.90

a. Regular and duplicate samples were collected in March.
b. Limit as set in the applicable Industrial Wastewater Acceptance Permit.
c. U flag indicates that the result was below the detection limit.
d. Values are the range of the grab samples collected during the semiannual monitoring.

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 resuse area (see Chapter 7 for results pertaining to soils). In 2008, 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 June and July. All samples were collected as 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables D-1 and D-2 summarize the results.

Wastewater was intermittently applied via the center pivot irrigation system in June and July 2008. On the days it operated, discharge to the pivot irrigation system averaged 638,955 liters per day (168,794 gallons per day).

A total of 2.88 million gallons (MG) of wastewater was applied to the land in 2008, which is equivalent to a loading rate of 1.45 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 (0.94 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 (16.33 lb/acre/yr) was less than state guidelines of 50 lb/acre/day (which is equivalent to 18,250 lb/acre/yr).

The annual total phosphorus loading rate (0.17 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 efficiencies for biochemical oxygen demand and total suspended solids were above the design criterion of 80 percent, and the removal efficiency for chemical oxygen demand was above the projected efficiency of 70 percent. The removal efficiency for total nitrogen was 97.8 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 analytical results are summarized in Table D-3.

Concentrations of sulfate and total dissolved solids are higher during reactor operation because of evaporative concentration and additives used to control corrosion and the pH of the reactor cooling water.

Groundwater Monitoring Results for the Wastewater Reuse Permit—To measure potential impacts from the Cold Waste Pond (CWP), the permit requires groundwater monitoring in April and October at five wells (Table D-4). Sampling was not required in April because the permit was not issued until February 2008.

Monitoring well USGS-065 is the nearest downgradient well from the Cold Waste Pond. The secondary constituent standards for sulfate and Total Dissolved Solids (TDS) are 250 mg/L and 500 mg/L, respectively. As expected, well USGS-065 had the highest concentrations of these two parameters but below the Secondary Constituent Standard (SCSs) with sulfate at 160 mg/L and TDS at 427 mg/L. The other three permit wells sampled in October showed lower levels of these two parameters than found in USGS-065. Though the sulfate and TDS concentrations are elevated in USGS-065, the extent does not appear to be significant or far reaching.

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

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

The INTEC Sewage Treatment Plant is 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 wastewater in four lagoons. After treatment in the lagoons, the effluent is gravity fed to lift station CPP-2714 where it is pumped to the service waste system. Automatic flow-proportional composite samplers are located at control stations CPP-769 (influent) and CPP-773 (wastewater effluent from the Sewage Treatment Plant to the service waste system).

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 for CPP-769 and CPP-773 are presented in Tables D-5 and D-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 2008, neither total suspended solids nor total nitrogen exceeded the permit limit in the combined effluent. The complete results of all parameters monitored at the combined effluent are presented in Table D-7.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. Table 5-5 shows the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds. As the table shows, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits during 2008.

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 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at CPP-797 (2008).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Total nitrogen[c] (mg/L)	1.61	6.80	2.80	20
Total suspended solids (mg/L)	2.0[d]	2.0[d]	2.0[e]	100

a. Duplicate samples were collected in March for nitrogen. Duplicate results are included in the summaries.

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

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

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

e. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.

Table 5-5. Hydraulic Loading Rates for Idaho Nuclear Technology and Engineering Center New Percolation Ponds (2008).

	2008 Flow	Permit Limit
Maximum daily (MG)	1.416	3
Yearly total (MG)	375.439	1,095

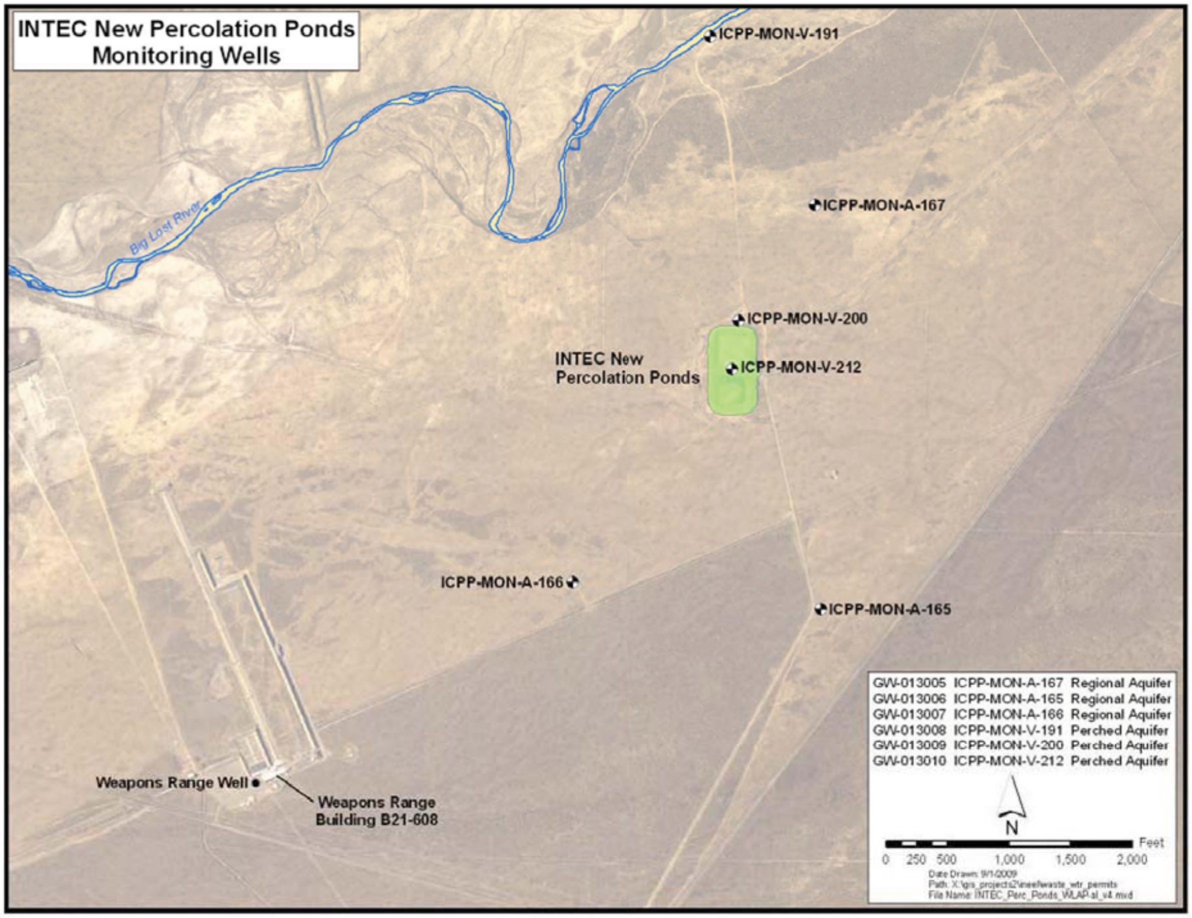


Figure 5-1. Permitted Monitoring Locations at the Idaho Nuclear Technology and Engineering Center (Weapons Range Well is not a permitted well and is shown for location reference only).

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 D-8 shows the April and October 2008 analytical results for all parameters specified by the permit for the aquifer wells. Table D-8 also depicts the depth to water table and water table elevations determined before purging and sampling. Table D-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 2008 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 2008 sampling event. This was the first time a sample was collected from this well since April 2005 because the well was dry. However, during the October 2008 sampling event, the well only had 0.24 m (0.79 ft) of water in it. This was not enough water for the bailer to reach, 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 for determining compliance for the perched water wells.

Concentrations of aluminum, iron, and manganese in aquifer Well ICPP-MON-A-165, and manganese in aquifer Well ICPP-MON-A-166, were below their associated secondary constituent standards, as shown in Table D-8. Concentrations of aluminum and iron in aquifer Well ICPP-

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.

MON-A-166 exceeded their associated secondary constituent standards, but were below the preoperational concentrations in upgradient aquifer Well ICPP-MON-A-167 (Table 5-6).

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, 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). The ICP contractor will recommend to DEQ that the permit be modified to require collecting both filtered and unfiltered metals samples and to base compliance on filtered samples.

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 D-9. Upgradient perched water Well ICPP-MON-V-191 was dry in April and October 2008, and samples could not be collected.

Total Dissolved Solids and Chloride Concentrations in Groundwater—Total dissolved solids concentrations were below the secondary constituent standard in perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 in 2008 (Table D-9). In the past, total dissolved solids concentrations exceeded the secondary constituent standard in these two perched water wells (May and October 2007) (ICP 2008).

Total dissolved solids concentrations in the downgradient aquifer monitoring Well ICPP-MON-A-165 have been steadily increasing since the INTEC New Percolation Ponds were placed into service in August 2002. For example, the total dissolved solids concentration in Well ICPP-MON-A-165 in October 2002 was 234 mg/L, compared to 380 mg/L in October 2008 (Table D-8). Similar increases in the chloride and sodium concentrations also have been noted. However, significant increases in total dissolved solids, chloride, and sodium concentrations have not been identified in downgradient aquifer monitoring Well ICPP-MON-A-166.

Although the chloride concentration in perched water Well ICPP-MON-V-200 (253 mg/L) exceeded the secondary constituent standard in October 2007 (ICP 2008), it decreased to 81 mg/L in April 2008 and 134 mg/L in October 2008 (Table D-9). A similar decrease in chloride concentration was also identified in Well ICPP-MON-V-212 during the 2008 reporting year. Total dissolved solids and sodium concentrations also decreased in perched water Well ICPP-MON-V-200 and ICPP-MON-V-212.

Concentrations of total dissolved solids, as well as chloride and sodium, in groundwater near the INTEC New Percolation Ponds are influenced by the wastewater discharges from the CPP-606 Treated Water System (ICP 2007a). To reduce concentrations of total dissolved solids, chloride, and sodium in the groundwater, a new water treatment system was installed at INTEC. The project was completed in December 2007. As shown in Tables D-8 and D-9, concentrations of total dissolved solids, chloride, and sodium were below the groundwater quality standards in 2008. Similarly, salt usage was reduced in 2008.

5.2.5 Test Area North/Technical Support Facility Sewage Treatment Facility and Disposal Pond

Description—The ICP contractor submitted a closure plan (ICP 2007b) for the Test Area North/ Technical Support Facility (TAN/TSF) Sewage Treatment Facility to DEQ on November 2, 2007, and the plan was approved by DEQ on November 13, 2007. The closure plan satisfies standard Permit Condition J.10 of the permit and identifies specific closure, site characterization, and site restoration tasks, with task completion dates.

The closure activities identified in the closure plan were conducted between November 2007 and February 2008. Wastewater ceased discharging to the TAN Disposal Pond on November 29, 2007. All actions identified in the closure plan have been completed, and the ICP contractor submitted a final closure report (ICP 2009c) on August 28, 2008. Permit LA-000153-03 was terminated on November 4, 2008.

Groundwater Monitoring Results for Wastewater Reuse Permit—To measure potential TAN/ TSF Disposal Pond impacts to groundwater, the permit requires that groundwater samples be collected from six monitoring wells (Figure 5-2):

- One background aquifer well (TANT-MON-A-001) upgradient of the TAN/TSF Disposal Pond
- Four aquifer wells (TAN-10A, TAN-13A, TAN-20, and TANT-MON-A-002) that serve as points of compliance
- One perched water well (TSFAG-05) located inside the Disposal Pond fence.

The six permitted wells were sampled one final time in April 2008 and included permit-specified parameters for analysis. The results of the April 2008 sampling event are included in Table D-10. As specified in Section F of Permit LA-000153-02, parameter concentrations in Wells TAN-10A (except for iron), TAN-13A, TAN-20, and TANT-MON-A-002 are limited to the primary constituent standards and secondary constituent standards in IDAPA 58.01.11, “Ground Water Quality Rule.”

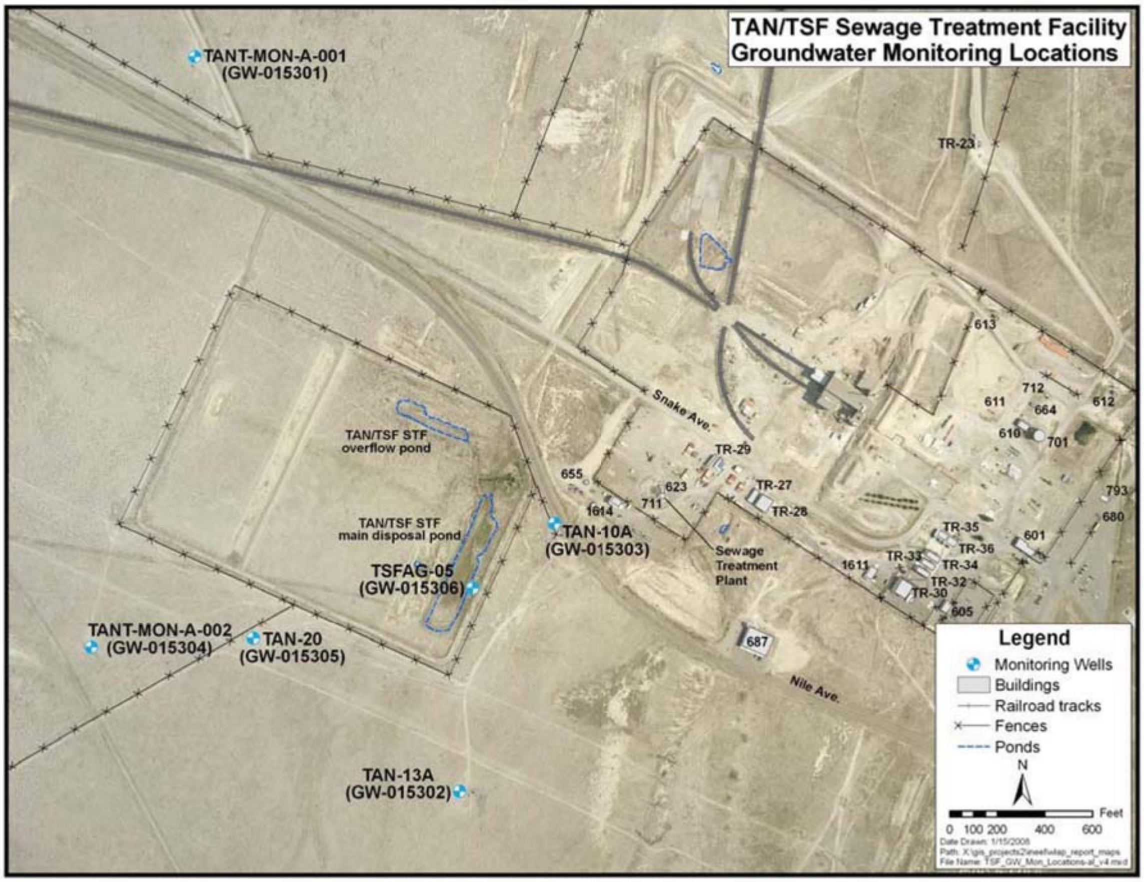


Figure 5-2. Permitted Monitoring Locations at Test Area North/Technical Support Facility.

All permit-required samples are collected as unfiltered samples.

Table D-10 shows water table elevations and depth to water table, determined before purging and sampling, and analytical results for all parameters specified by the permit. Well TSFAG-05 was dry during April 2008. Therefore, no analytical results are presented for this well.

Most groundwater parameters were below their respective primary constituent standards and secondary constituent standards. In Well TAN-10A, aluminum, iron, manganese, and total dissolved solids concentrations exceeded the secondary constituent standards in April 2008 (Table 5-7).

The 2007 Wastewater Land Application Site Performance Report (ICP 2008) discusses elevated aluminum, iron, manganese, and total dissolved solids levels, including a historical summary and potential causes of these elevated levels. This report notes that while elevated concentrations of aluminum, iron, and manganese historically have been detected in some of the permitted monitoring wells at TAN, wastewater effluent concentrations of these constituents have usually been below secondary constituent standards. The report states that factors other than wastewater are believed to be causing the elevated metals in permitted wells. The report

Table 5-7. Groundwater Exceedances for Test Area North/Technical Support Facility Sewage Treatment Facility for April (2008).

Parameter	TAN-10A (GW-015303) 4/22/2008	TAN-10A (GW-015303) 4/22/2008[a]	SCS[b]
Aluminum (mg/L)	0.220	0.0847	0.2
Iron (mg/L)	3.32[c]	1.98[c]	0.3
Manganese (mg/L)	0.830	1.11	0.05
Total dissolved solids (mg/L)	652	630	500

a. Duplicate sample.

b. Secondary constituent standard in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.

c. Iron concentrations in Well TAN-10A are exempt from the limit, and therefore, these exceedences are not permit noncompliances.

concludes that the elevated metals in the TAN permitted wells are likely due to redox reaction products from the nearby in situ bioremediation. The Test Area North Record of Decision (DOE-ID 1999) states that metals are not a contaminant of concern and that metals are expected to return to below the secondary constituent standards.

Increases of total dissolved solids in Well TAN-10A in early 2000 seem to follow earlier increases in the effluent; however, no pattern is evident from 2000 forward, with increases in Well TAN-10A occurring prior to increases in the effluent.

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 D-11 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Groundwater monitoring results are summarized in Table D-12. The tritium concentrations are below the Idaho groundwater primary constituent standard for tritium (20,000 pCi/L), which is the same as the EPA health-based maximum contaminant level (MCL) for tritium in drinking water. Strontium-90 was detected once below its MCL 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 D-13 lists surveillance monitoring results for 2008 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 D-14 summarizes the additional monitoring conducted during 2008 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 2008, most additional parameters were within historical concentration levels, except for conductivity at CPP-773, which was about 200 µS/cm above its historical average, and gross beta at CPP-797, which was about 9 pCi/L above its historical average. The 2008 INTEC New Percolation Ponds Radiological Monitoring Report (ICP 2009b) provides additional information.

5.3.4 Materials and Fuels Complex

During 2008, 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. The Industrial Waste Pond was dry in January. Tables D-15 to D-17 summarize the analytical results for parameters that were detected in at least one sample.

Radioactive parameters were monitored and reported when detected. Tritium and potassium-40 were detected in some of the samples collected from the Sanitary Sewage Lagoon. The tritium in the lagoon is from a historical release and the activity is declining; potassium-40 is typical in sewage.

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 MCLs 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), 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, TAN/Contained Test Facility (CTF), and TAN/TSF. 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 either 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. These nonregulated additional samples resulted in two positive bacteria detections in 2008. Bacteria were detected in the ATR Complex valve in July and at MFC in August. 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 2008, the INL contractor collected 235 routine samples and 31 quality control samples from the eleven INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 38 nonroutine samples after a water main was repaired and before placing the water main back into service. 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 2008 lead and copper were monitored at ATR Complex, CFA, MFC, and TAN/CTF. Because the results were less than the action level of 15 ppb, 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 5-3) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay.

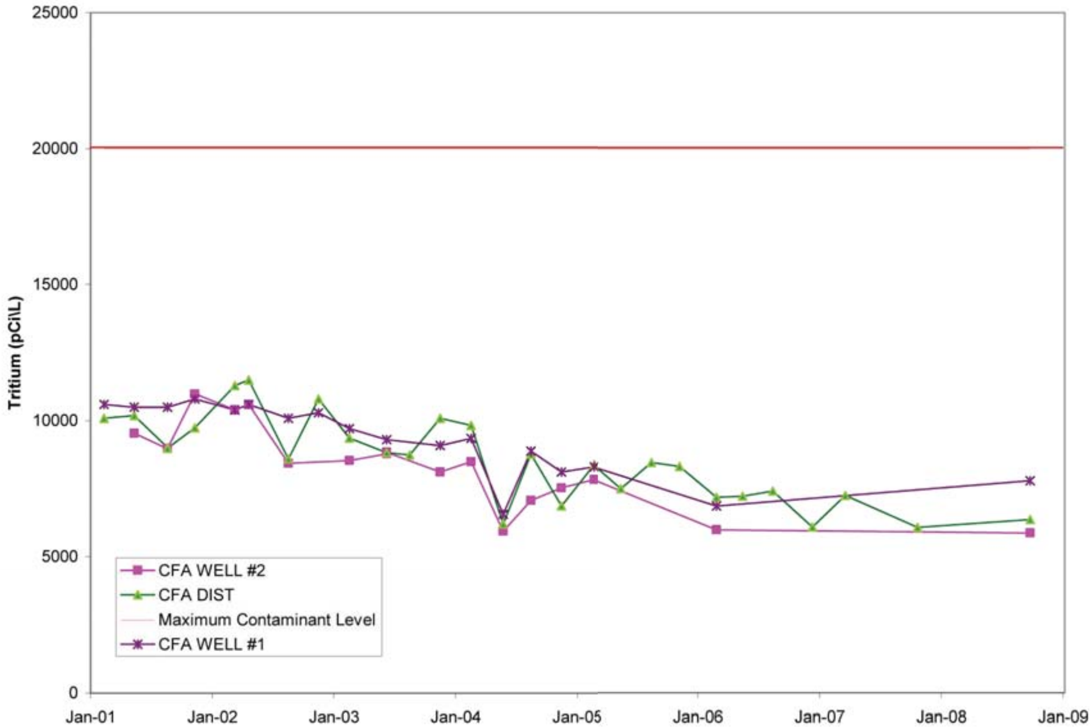


Figure 5-3. Tritium Concentrations in Two Central Facilities Area Wells and Distribution System (2001–2008).

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 from Well CFA #1 at CFA-651, once 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 2008 calculation was based on the mean tritium concentration for the CFA distribution system in 2008. For the 2008 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. This assumption overestimates the actual dose because workers typically consume only about half their total intake during working hours and typically work only 240 days rather than 365 days per year. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2008 was 0.30 mrem (3.0 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 2008, the following drinking water samples were collected at INTEC:

- 40 routine (compliance) samples
- 10 quality control samples (4 field duplicates, 1 trip blank, 5 performance evaluation samples)
- 45 nonroutine samples (45 bacterial samples, associated primarily with water main repairs).

All parameters monitored at INTEC were below their respective drinking water limits in 2008.

5.4.4 Materials and Fuels Complex and Advanced Test Reactor Complex

In August 2008, total coliform bacteria were detected during the routine monitoring at MFC. The disinfection system was out of service, and there was no chlorine residual, resulting in the total coliform detection. The system owner was notified, the water system was disinfected, flushed, and resampled, and no bacteria were detected. The MFC water system was manually chlorinated until the automatic disinfection system was repaired.

Total coliform bacteria detections at ATR Complex (TRA-608) were noncompliance (construction) samples. Resampling was conducted, and no total coliform or E. coli bacteria were detected.

5.4.5 Radioactive Waste Management Complex

During 2008, the following drinking water samples were collected at RWMC:

- 21 routine (compliance) samples
- 20 quality control samples (9 field duplicates, 4 trip blanks, 7 performance evaluation samples)
- 45 nonroutine samples (38 bacterial samples, primarily associated with water main repairs; 7 samples for 524.2 volatile organics).

All RWMC-monitored parameters were below their respective drinking water limits in 2008.

5.4.6 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to less than 25 employees at the 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 of TSF #2, samples are collected to monitor trichloroethylene concentrations due to the historical contamination. Since mid-2006 concentrations have been declining.

Figure 5-4 illustrates the trichloroethylene concentrations in both TSF #2 and the distribution system from 2001 through 2008. Table 5-8 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2008 was less than the detection limit of 5.0 µg/L.

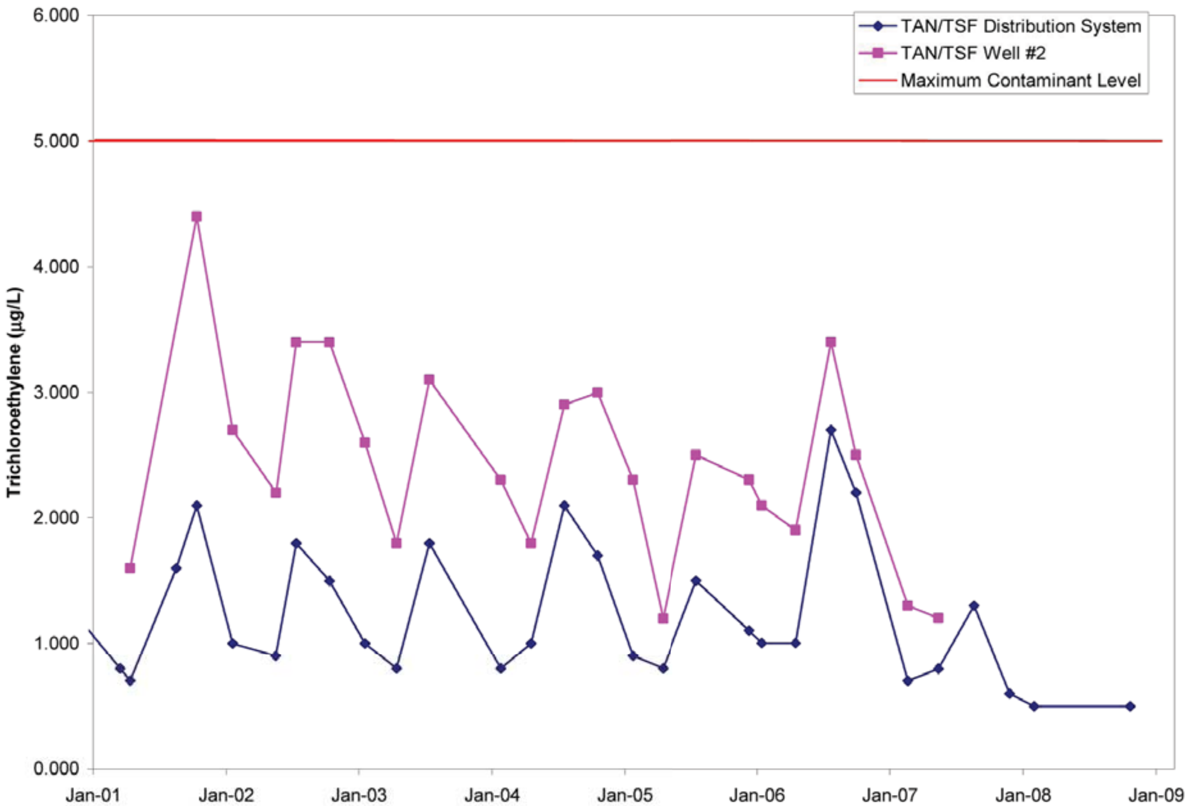


Figure 5-4. Trichloroethylene Concentrations in Technical Support Facility Drinking Water Well and Distribution System (2001–2008).

Table 5-8. Trichloroethylene Concentrations at Test Area North/Technical Support Facility Well #2 and Distribution System (2008).

Location	Number of Samples	Trichloroethylene Concentration (µg/L) Minimum	Maximum	Mean	MCL
TAN/TSF #2 (612)[a]	2	1.2	1.3	1.25	NA[b]
TAN/TSF Distribution (610)	4	0.6	1.3	0.825	5.0

a. Regulations do not require sampling at this well.
b. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

5.5 Waste Management Surveillance Surface Water Sampling

In compliance with DOE Order 435.1, the ICP contractor collects surface water runoff samples at the RWMC Subsurface Disposal Area (SDA) from the location shown in Figure 5-5. 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.

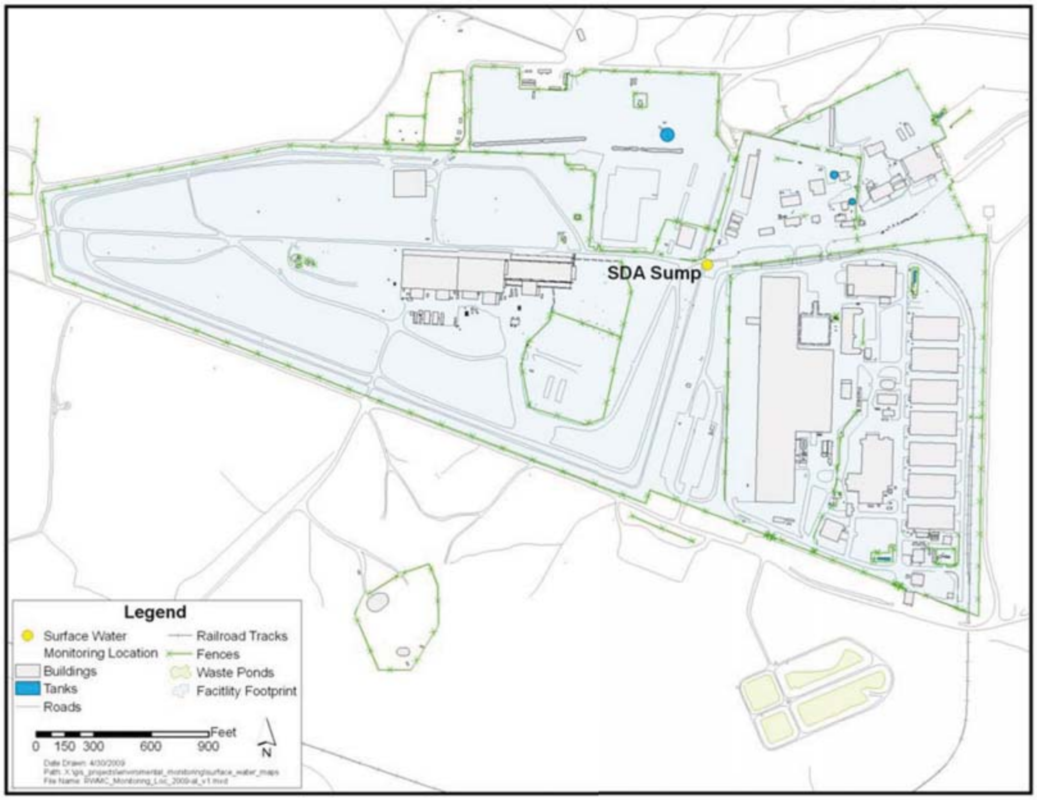


Figure 5-5. Surface Water Sampling Location at RWMC Subsurface Disposal Area.

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.

Surface water runoff samples were collected at the SDA during the fourth quarter of 2008. Table 5-9 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The americium-241 detection at the SDA is higher than typical historical concentrations. The sample was collected from standing water and contained significant amounts of particulate that may have influenced the sample results. The ICP contractor will continue to closely monitor radionuclides for any abnormal trends.

Table 5-9. Surface Water Runoff Results at RWMC Subsurface Disposal Area (2008).

Parameter	Maximum Concentration (pCi/L)	% Derived Concentration Guide
Americium-241	3.19 ±0.34	10.6
Plutonium-239/240	0.73 ± 0.09	2.4

REFERENCES

40 CFR 141, 2009, “National Primary Drinking Water Regulations,” Code of Federal Regulations, Office of the Federal Register.

40 CFR 142, 2007, “National Primary Drinking Water Regulations Implementation,” Code of Federal Regulations, Office of the Federal Register.

40 CFR 143, 2007, “National Secondary Drinking Water Regulations,” Code of Federal Regulations, Office of the Federal Register.

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

DEQ, 2007, INL Oversight Program Annual Report 2007, Idaho Department of Environmental Quality.

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

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

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

DOE-ID, 1999, Final Record of Decision for Test Area North Operable Unit 1-10, DOE/ID 10682, Rev. 0, U.S. Department of Energy Idaho Operations Office; U. S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare, Division of Environmental Quality.

ICP, 2007a, 2006 Wastewater Land Application Site Performance Report for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds (LA-000130-04), RPT-286, Idaho Cleanup Project.

ICP, 2007b, Closure Plan for Wastewater Land Application Permitted Test Area North/Technical Support Facility Sewage Treatment Facility at the Idaho National Laboratory Site, RPT-409, Idaho Cleanup Project.

ICP, 2008, 2007 Wastewater Land Application Site Performance Report for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds (LA-000130-04), RPT-473, Idaho Cleanup Project.

ICP, 2009a, 2008 Wastewater Land Application Site Performance Report for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds (LA-000130-04), RPT-598, Idaho Cleanup Project

ICP, 2009b, 2008 Radiological Monitoring Results Associated with the Idaho Nuclear Technology and Engineering Center New Percolation Ponds, RPT-599, Idaho Cleanup Project.

ICP, 2009c, Final Closure Report for Wastewater Land Application Permitted Test Area North/ Technical Support Facility Sewage Treatment Facility at the Idaho National Laboratory Site, RPT-537, Idaho Cleanup Project.

IDAPA 58.01.08, 2009, “Idaho Rules for Public Drinking Water Systems,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.11, 2009, “Ground Water Quality Rule,” Idaho Administrative Procedure Act, Idaho Department of Environmental Quality.

IDAPA 58.01.16, 2009, “Wastewater Rules,” Idaho Administrative Procedure Act, Idaho Department of Environmental Quality.

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

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

INL, 2009a, 2008 Wastewater Land Application Site Performance Report for the Idaho National Laboratory Sites’s Central Facilities Area Sewage Treatment Plant, INL/EXT-08-15209, Idaho National Laboratory.

INL, 2009b, 2008 Annual Industrial Wastewater Reuse Report for the Idaho National Laboratory Site’s Advanced Test Reactor Complex Cold Waste Pond, INL/EXT-09-15246, Idaho National Laboratory.

Shepherd's Monument

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. The U.S. Geological Survey performs groundwater monitoring, analyses, and studies of the Eastern Snake River Plain Aquifer under and adjacent to the INL Site. In 2008, the U.S. Geological Survey published five documents covering hydrogeologic conditions at the INL Site and other areas of interest.

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 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 U.S. Geological Survey 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 2008. 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, nitrate, and chromium were also below the applicable standards in 2008.

Groundwater surveillance monitoring required in area-specific Records of Decisions under the Comprehensive Environmental Response, Compensation, and Liability Act was performed in 2008.

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 2008 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, tritium, and gross alpha.

Monitoring of groundwater for the Central Facilities Area landfills consists of sampling 11 wells for metals, volatile organic compounds, and anions. Some of the metals and anions exceeded their maximum contaminant levels in 2008, but concentrations were within historic levels. None of the organic compounds exceeded a maximum contaminant level.

At the Radioactive Waste Management Complex, over 3,500 analyses were performed on samples from 15 monitoring wells. Two analytes exceeded their maximum contaminant levels in 2008. Carbon tetrachloride exceeded the level in four of 32 analyses but has shown a declining trend south of the facility since 2003. Gross beta was above the maximum contaminant level attributable to elevated levels of naturally occurring potassium-40 at the monitoring location.

6. Environmental Monitoring Program—Eastern Snake River Plain Aquifer

This chapter presents the following groundwater sampling results:

- Radiological surveillance
- Nonradiological surveillance
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

This chapter 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 (PCSs) of Idaho Administrative Procedures Act (IDAPA) 58.01.11
- State of Idaho secondary constituent standards (SCSs) of IDAPA 58.01.11
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water
- U.S. Department of Energy (DOE) Derived Concentration Guide for ingestion of water.

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.

This chapter presents the following topics:

- Summary of monitoring programs—Section 6.1

- Hydrogeology of the Idaho National Laboratory (INL) Site—Section 6.2
- Hydrogeologic data management—Section 6.3
- Aquifer studies related to the INL Site and Eastern Snake River Plain Aquifer (ESRPA)—Section 6.4
- U.S. Geological Survey radiological monitoring of groundwater at the INL Site—Section 6.5
- U.S. Geological Survey nonradiological monitoring of groundwater at the INL Site—Section 6.6
- CERCLA groundwater monitoring during 2008—Section 6.7.

6.1 Summary of Monitoring Programs

The USGS INL Project Office 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 the INL Site (Figures 6-1 and 6-2) and at locations throughout the Eastern Snake River Plain (ESRP). Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2008, USGS personnel collected and analyzed over 1,300 samples for radionuclides and inorganic constituents, including trace elements and approximately 40 samples for purgeable organic compounds. USGS uses the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory.

As detailed in Chapter 3, 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 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 and surface water monitoring activities performed on and around the INL Site.

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 ESRP, with the site boundaries coinciding with the Mud Lake sub-basin and the Big Lost Trough. The ESRPA 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).

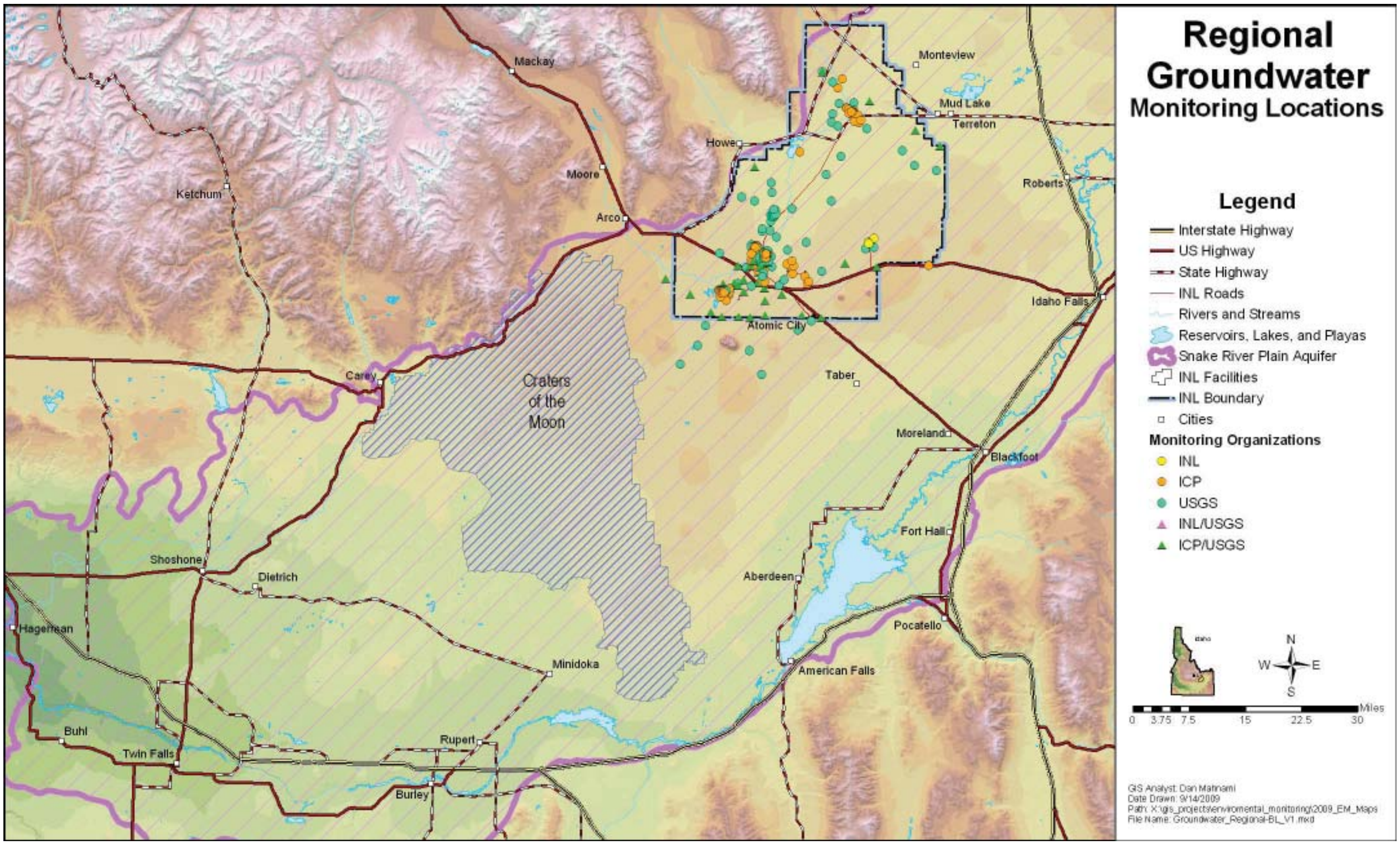


Figure 6-1. Regional Groundwater Monitoring Locations.

The subsiding ESRP 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. Northeast–southwest directed extension of the ESRP 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 ESRPA 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 ESRP architecture and porous media.

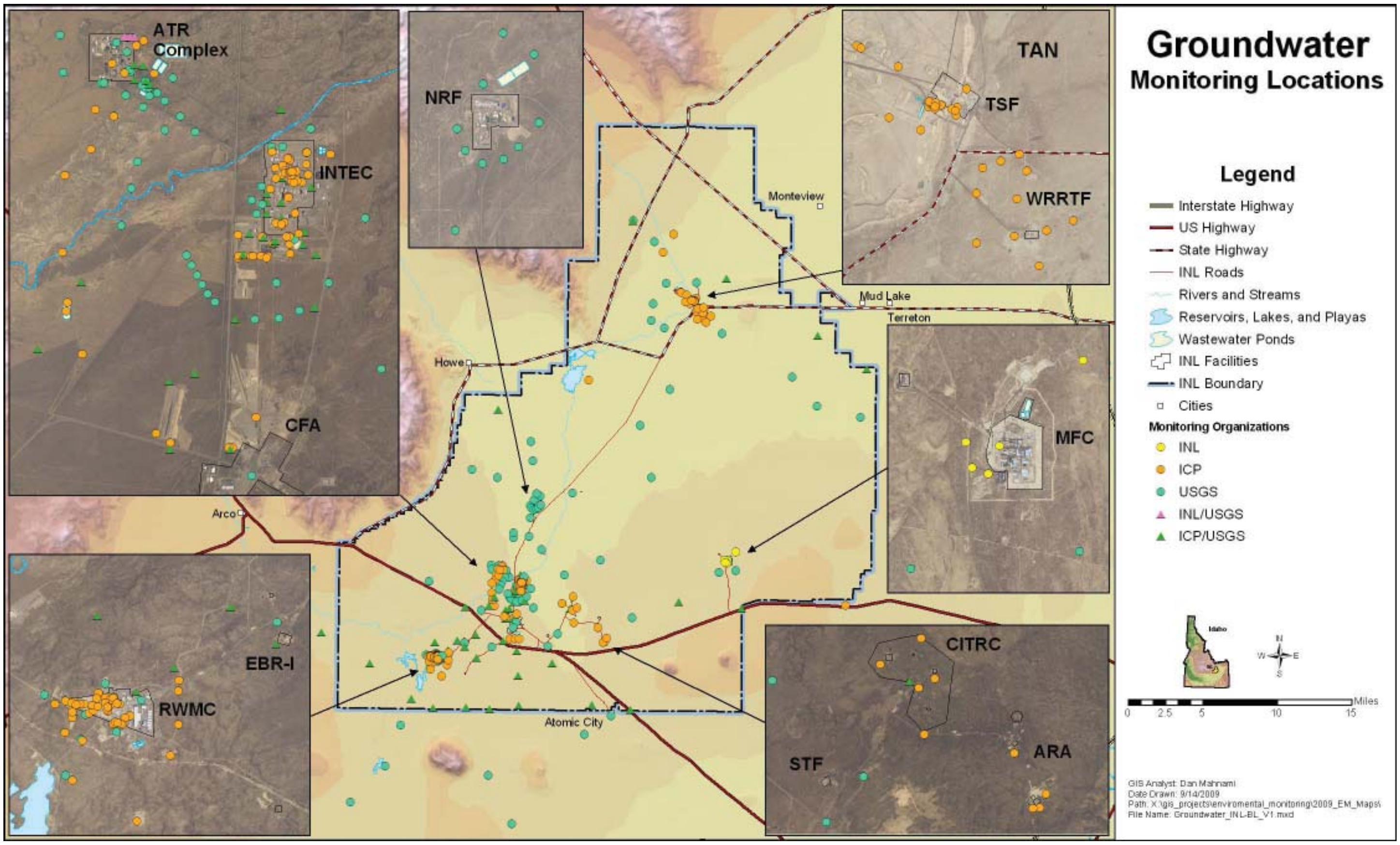


Figure 6-2. Idaho National Laboratory Site Groundwater Monitoring Locations.

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 provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.

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

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

Area/Facility	Media: Groundwater (Radiological)	Groundwater (Nonradiological)	Groundwater (CERCLA)	Surface Water[a]	Drinking Water[b]
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				•	•
U.S. Geological Survey					
INL Site/Distant	•	•		•[c]	

a. Chapter 5 provides details of surface water (liquid effluent and stormwater) monitoring.
b. Chapter 5 covers compliance monitoring of drinking water.
c. Most surface water samples are collected by USGS Idaho Water Science Center Field Offices and are not discussed in this report. The USGS INL office collects samples from the Big Lost River, Little Lost River, Birch Creek and Mud Lake. Data can be accessed 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 ESRPA serves as the primary source for drinking water and crop irrigation in the Upper Snake River Basin. A description of the hydrogeology of the INL Site and water movement in the aquifer is given in Section 6.2. Further information may be found in numerous USGS publications. Some of these publications can be accessed at http://id.water.usgs.gov/projects/INL/publication.html or requested from the USGS INL Project Office by calling (208) 526-2438. During 2008, USGS INL Project Office personnel published five documents covering hydrogeologic conditions at the INL Site, on the ESRPA, and in other areas of interest around the world. The abstracts to each of these reports are presented in Appendix E.

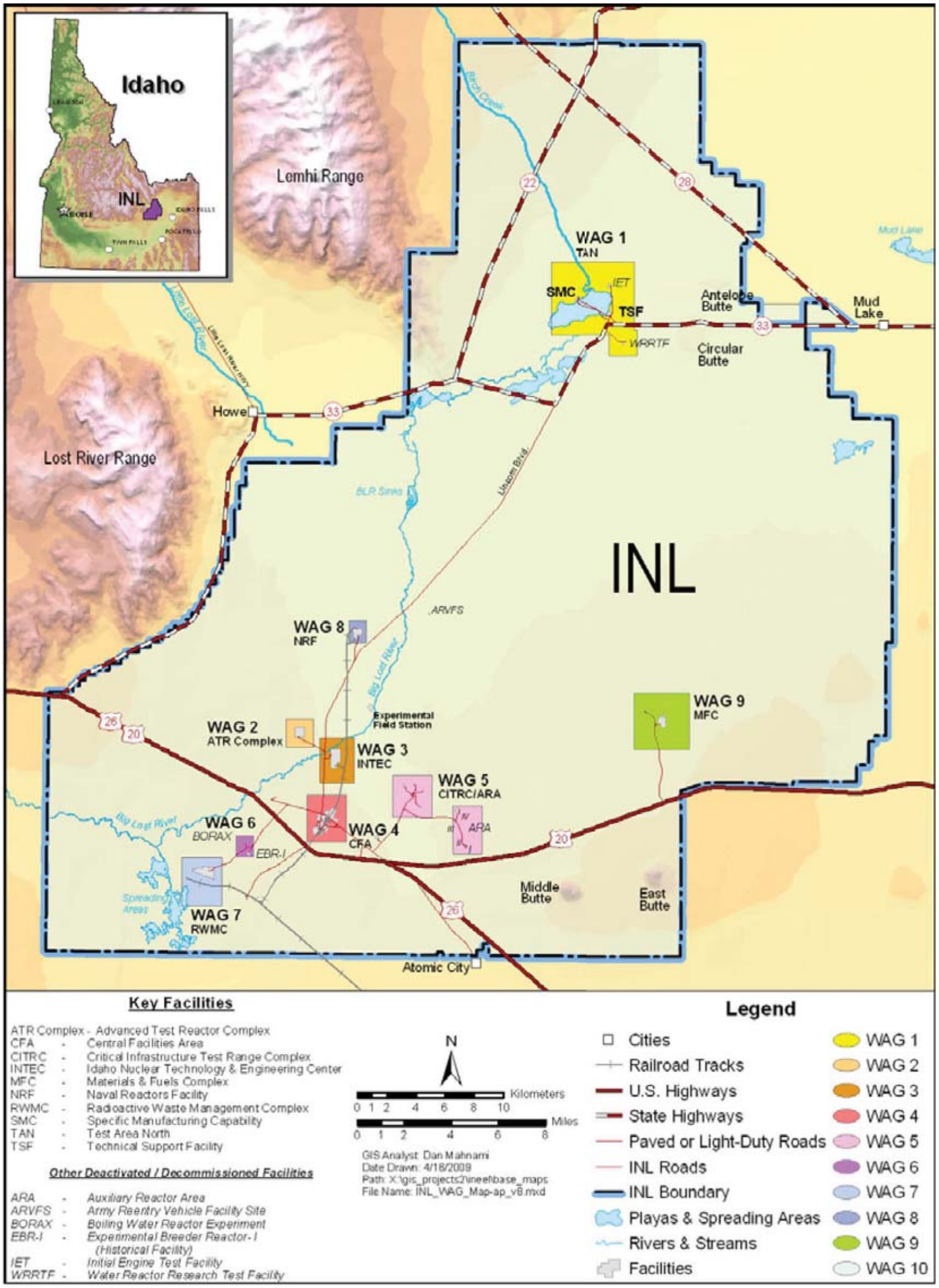


Figure 6-3. Map of the Idaho National Laboratory Site Showing Locations of Facilities and Corresponding Waste Area Groups.

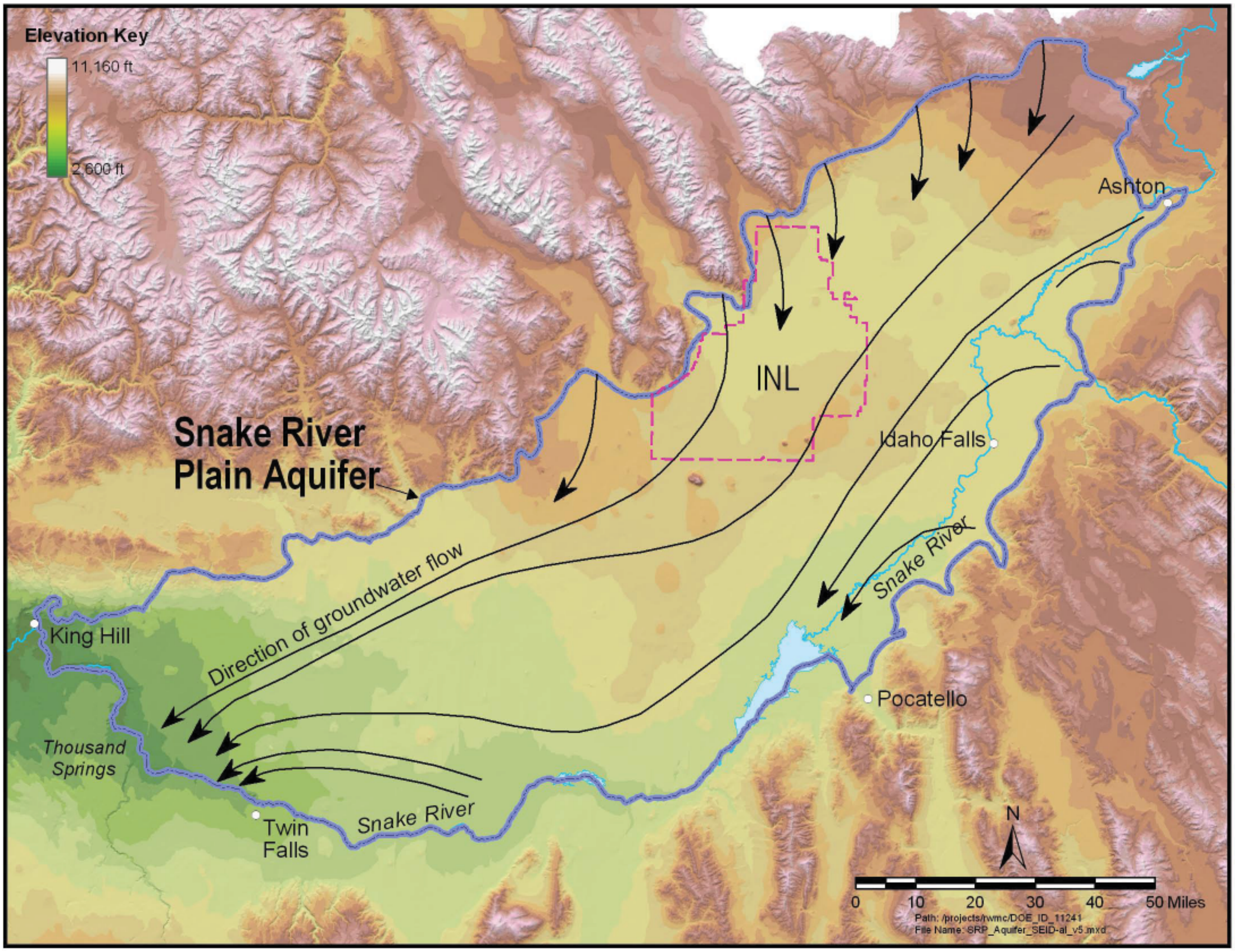


Figure 6-4. Location of the Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

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 ESRPA 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 high 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 1990. When direct injection ceased, wastewater from INTEC 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 stopped the input of tritium to groundwater.

The average combined rate of tritium wastewater disposal at the 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 the ATR Complex and about 57 Ci at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the aquifer at the 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, only ^{90}Sr continues to be detected by the ICP contractor and USGS above the PCS in some surveillance wells between INTEC and Central Facilities Area (CFA). Other radionuclides (e.g., gross alpha) have been detected above their PCS in wells monitored by individual WAGs.

6.5.1 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 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 (approximately 20 mi^2) in 1998 (Bartholomay et al. 2000).

The area of elevated 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 the ATR Complex decreased from $(6.1 \pm 0.3) \times 10^3$ pCi/L in 2007 to $(5.71 \pm 0.19) \times 10^3$ pCi/L in 2008; the tritium concentration in USGS-077 south of INTEC decreased from $(6.69 \pm 0.16) \times 10^3$ pCi/L in 2007 to $(5.62 \pm 0.15) \times 10^3$ pCi/L in 2008.

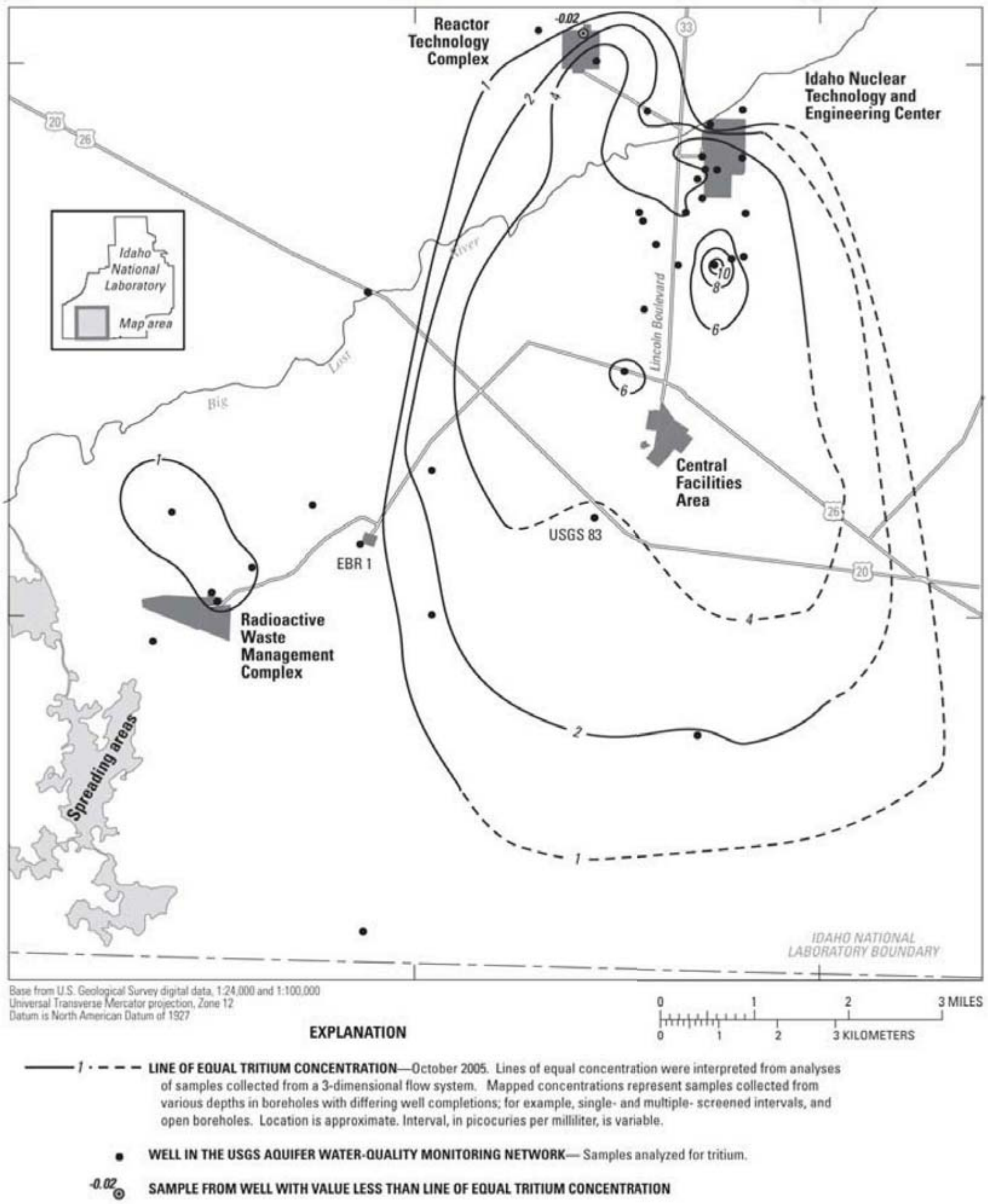


Figure 6-5. Distribution of Tritium in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2005 (from Davis 2008).

The Idaho groundwater PCS for tritium (20,000 pCi/L) is the same as the EPA MCL for tritium in drinking water. The values in both 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.

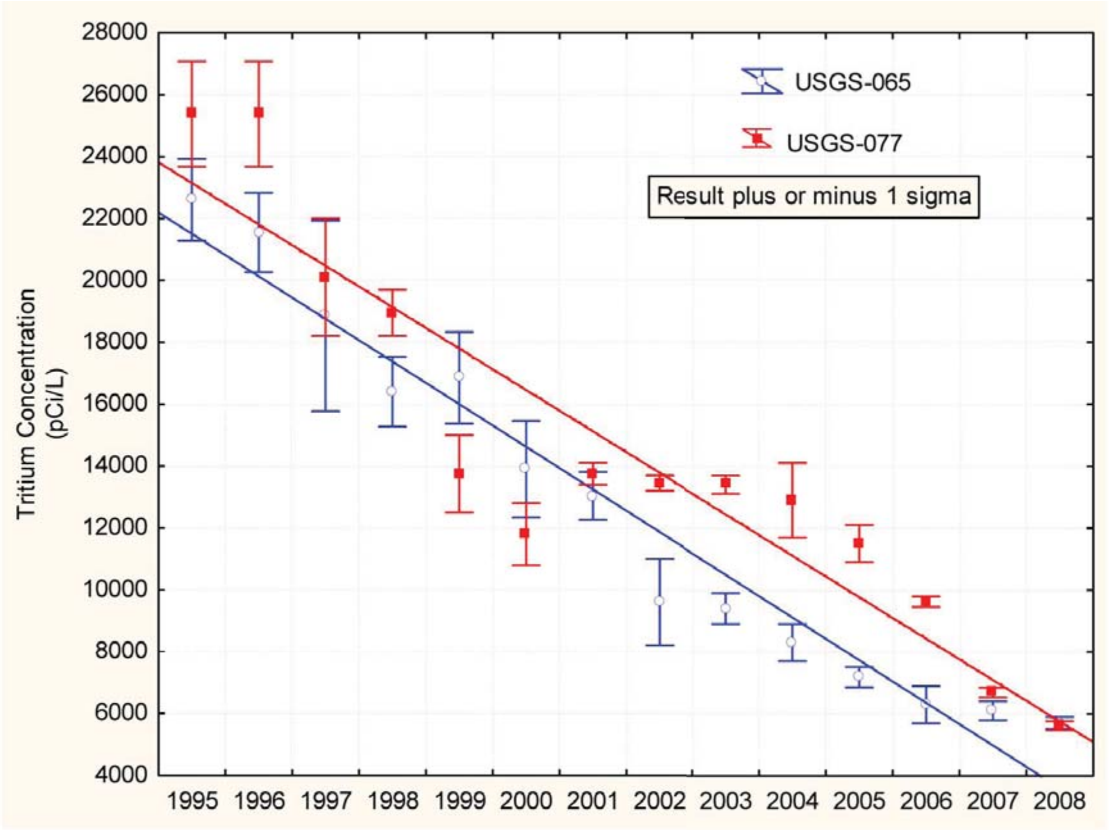
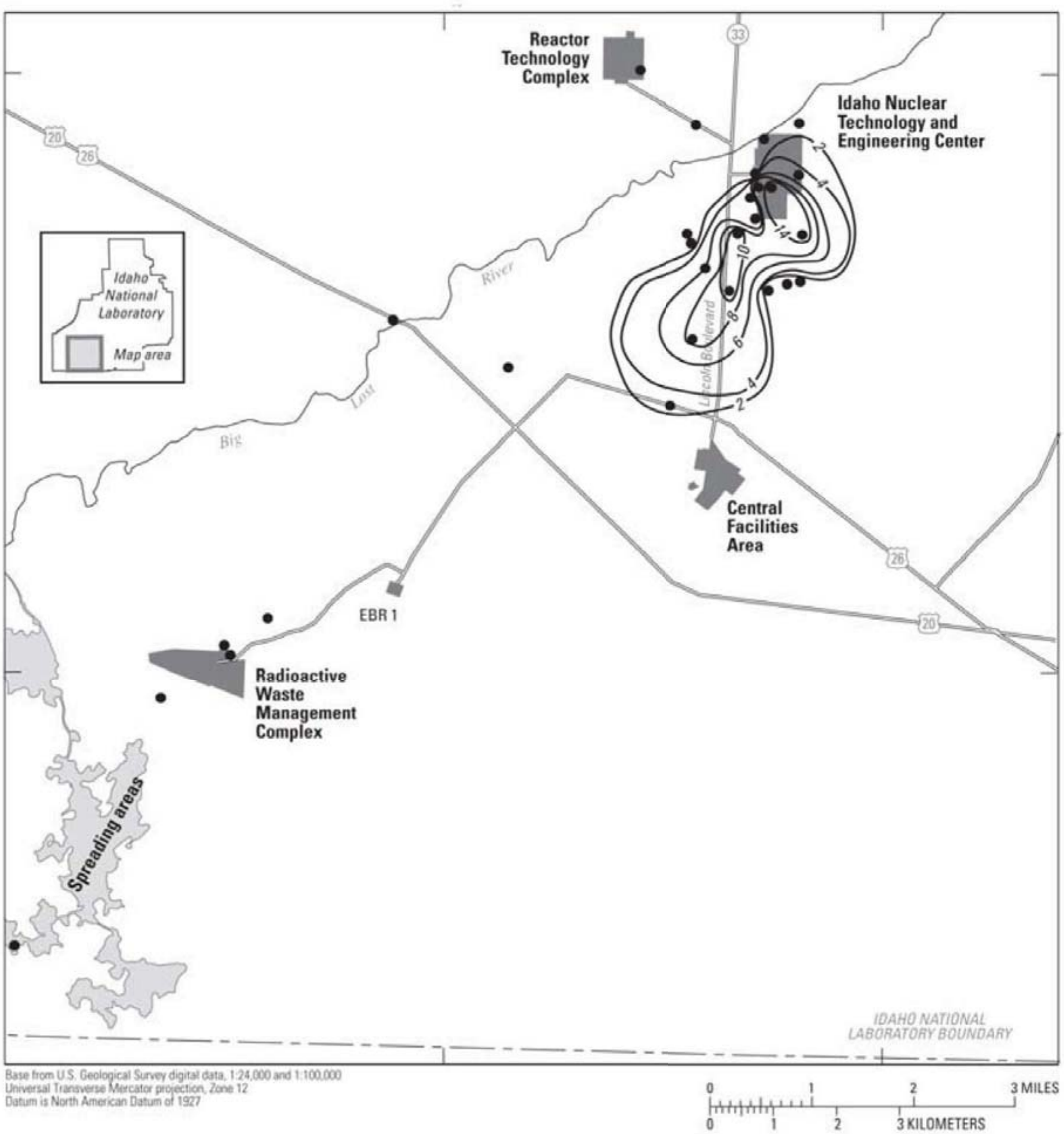


Figure 6-6. Long-Term Trend of Tritium in Wells USGS -065 and -077 (1995–2008).

6.5.2 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 in the Snake River Plain Aquifer near the ATR Complex during 2008. All ^{90}Sr at the ATR Complex was disposed of to infiltration ponds in contrast to the direct injection that occurred at INTEC. At the ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and the perched groundwater zones. The area of the ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 18 years (1990–2008) in USGS-047, USGS-057, and USGS-113 is shown in Figure 6-8. Concentrations in USGS-047 have been variable through time, and concentrations in USGS-057 and USGS-113 indicate a general decrease. The general decrease in concentration 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 increases prior to the last few years were thought to be due, in part, to a lack of recharge from the Big Lost River that would act to dilute the ^{90}Sr. Other reasons may also 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).



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).

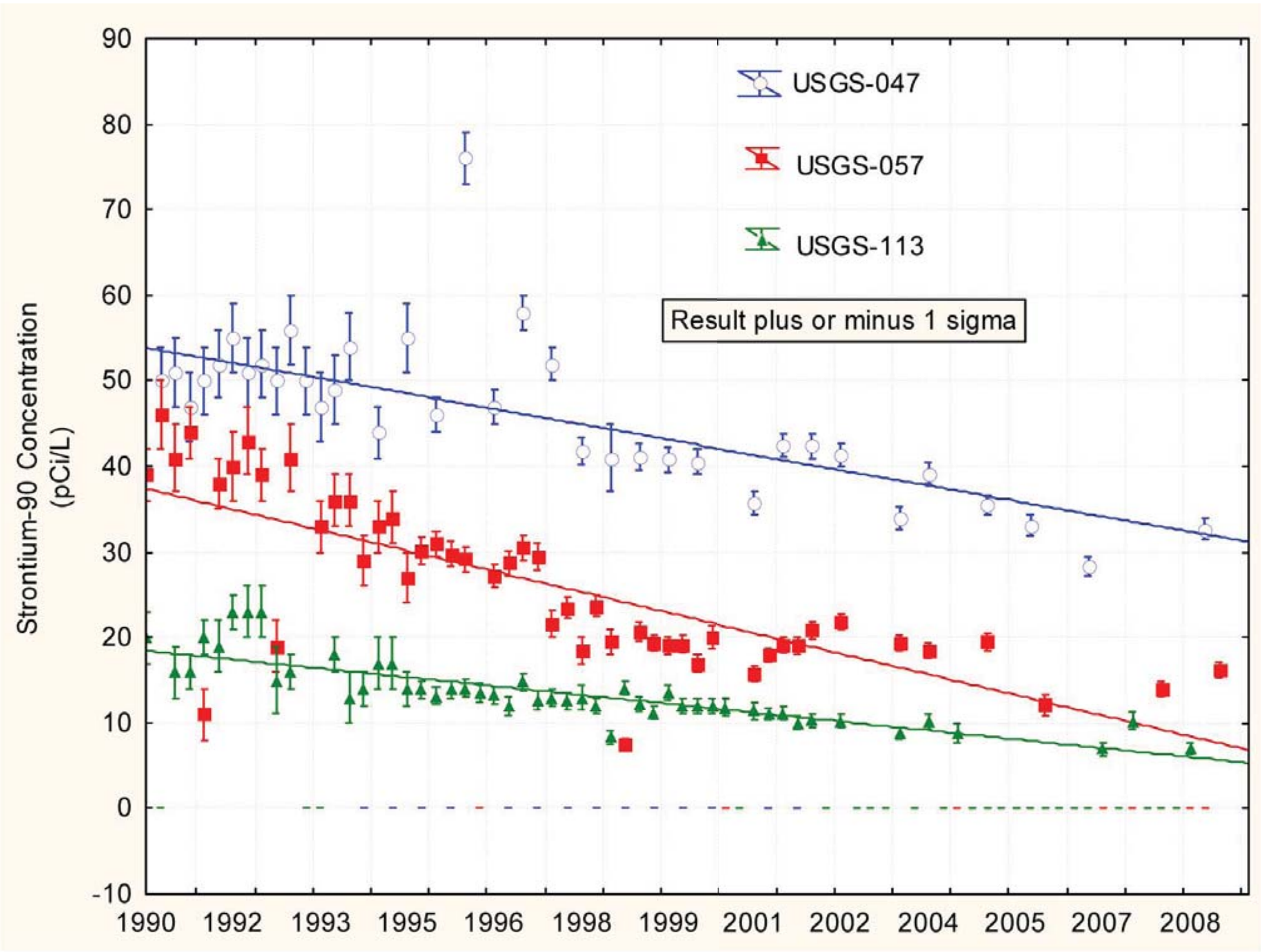


Figure 6-8. Long-Term Trend of Strontium-90 in Wells USGS-047,-057, and -113 (1990–2008).

6.5.3 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, plutonium, and americium isotopes (Table 3-6), and results for wells sampled in 2008 are available at http://waterdata.usgs.gov/id/nwis/. Monitoring results for 2002–05 are summarized in Davis (2008). During 2002–05, 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 ± 2 to 44 ± 4 pCi/L. The gross-beta particle radioactivity showed steady or decreasing concentration trends during 2002–05 (Davis 2008).

USGS has periodically sampled for ^{129}I in the Snake River Plain Aquifer, and monitoring programs from 1977, 1981, 1986, and 1990–91 were summarized in Mann et al. (1988) and Mann and Beasley (1994). USGS evaluated results from samples collected in 2003 and 2007 and discussion of results can be found in Bartholomay (2009). Average concentrations of 19 wells sampled in 1990–91, 2003, and 2007 decreased from 0.975 pCi/L in 2003 to 0.25 pCi/L in 2007. The maximum concentration in 2007 was 1.16 ± 0.04 pCi/L, which exceeded the MCL for drinking water. 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 the movement of remnant perched water below INTEC. The configuration and extent of ^{129}I in groundwater, based on the latest published 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). A detailed discussion of sample results for samples collected during 2002–05 is found in Davis (2008). Chromium had a concentration greater than the MCL of 100 µg/L in Well 65 in 2005 (Davis 2008), but the concentration has continually decreased and was 93 µg/L in 2008. The concentrations of chloride, nitrate, sodium, and sulfate have historically 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).

USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2008. Samples from 28 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). Eight purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-2). The production well at the Radioactive Waste Management Complex (RWMC) is monitored monthly, and concentrations of tetrachloromethane (also known as carbon tetrachloride) exceeded the EPA MCL of 5 µg/L all 12 months in 2008 (Table 6-3). None of the other measured constituents was above their respective PCS. Annual average concentrations of these compounds in this well have generally increased through time (Davis 2008).

6.7 CERCLA Groundwater Monitoring During 2008

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities at the Site, with the addition of the Site-wide WAG 10. Locations of the various WAGs are shown in 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.

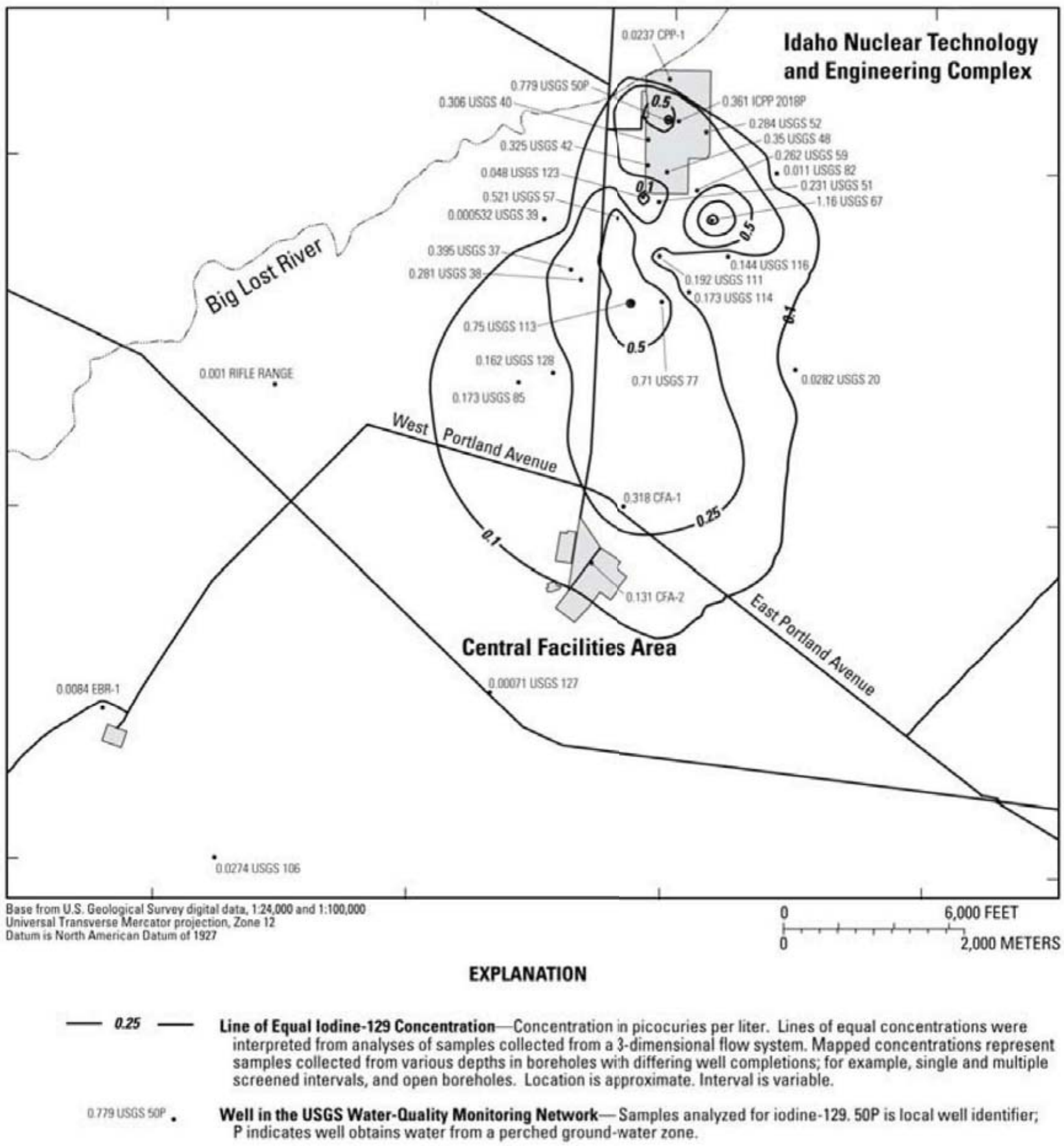


Figure 6-9. Distribution of Iodine-129 in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2007 (from Bartholomay 2009).

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.

Table 6-2. Purgeable Organic Compounds in Annual U.S. Geological Survey Well Samples (2008).

Constituent	USGS-065	USGS-077	USGS-087	USGS-088	USGS-098	USGS-12
Bromodichloromethane (µg/L)	ND[a]	ND	ND	ND	0.127	ND
Tetrachloromethane (µg/L)	ND	ND	3.085	0.595	ND	1.786
Trichloromethane (µg/L)	ND	ND	0.281	0.434	0.131	0.284
Toluene (µg/L) (PCS[b]=1,000)	0.251	ND	ND	ND	ND	ND
Tetrachloroethane (µg/L) (PCS=5)	ND	ND	0.127	ND	ND	ND
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.105	0.129	0.174	ND	ND	0.131
Dichlorodifluoromethane (µg/L)	ND	ND	0.414	ND	ND	ND
Trichloroethene (µg/L) (PCS=5)	ND	ND	0.705	0.421	ND	0.539

a. ND = not detected.

b. 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 (2008).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Bromodichloromethane (µg/L)	ND[a]	0.123	0.847	0.839	0.745	0.109	ND	ND	ND
Tetrachloromethane (µg/L)	6.890	7.118	6.672	6.292	7.534	7.986	11.58	5.382	7.064
Tribromomethane (µg/L)	ND	0.0388	0.878	0.844	0.914	0.993	0.202	ND	ND
Dibromochloromethane (µg/L)	ND	ND	1.12	1.14	1.17	0.225	ND	ND	ND
Trichloromethane (µg/L)	1.55	1.67	2.28	2.33	2.10	1.93	2.32	1.40	1.70
Tetrachloroethane (µg/L) (PCS=5)[b]	0.310	0.326	0.298	0.304	0.351	0.351	0.404	0.300	0.309
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.470	0.499	0.475	0.451	0.522	0.571	0.697	0.425	0.514
Trichloroethene (µg/L) (PCS=5)	2.933	3.57	2.843	2.704	3.467	3.369	4.180	2.864	3.274

a. ND = not detected.

b. PCS = primary constituent standard values from IDAPA 58.01.11.

Hot Spot Zone (trichloroethene [TCE] concentrations exceeding 20,000 µg/L)—In situ bioremediation is used in the hot spot (TSF-05) to promote bacterial growth by supplying essential nutrients to bacteria that occur naturally in the aquifer and are able to break down contaminants. The hot spot concentration was defined using data from 1997 and is not reflective of the current concentrations (Figure 6-10).

The current injection strategy consists 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 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 2008 groundwater monitoring data indicate that the in situ bioremediation hot spot remedy is operating as planned at reducing the concentration of volatile organic compounds in the hot spot zone, and progress toward the remedial action objectives is being made (DOE-ID 2009a).

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 groundwater, treating through air strippers, and reinjecting treated groundwater into the aquifer. Air stripping brings clean air into close contact with contaminated liquid, allowing the volatile organic compounds to pass from the liquid into the air. TCE concentrations for the medial zone are based on data collected before remedial actions started and do not reflect current concentrations (Figure 6-10).

The TCE concentrations in the medial zone wells are significantly lower than the historically defined concentration range of 1,000 to 20,000 µg/L. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 continue to be below 200 µg/L in 2008. 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. If concentrations in TAN-33, TAN-36, and TAN-44 increase to above 200 µg/L, the pulsed-pumping operational strategy will resume until concentrations fall below 100 g/L.

Distal Zone (TCE concentrations between 5 and 1,000 µg/L)—Monitored natural attenuation

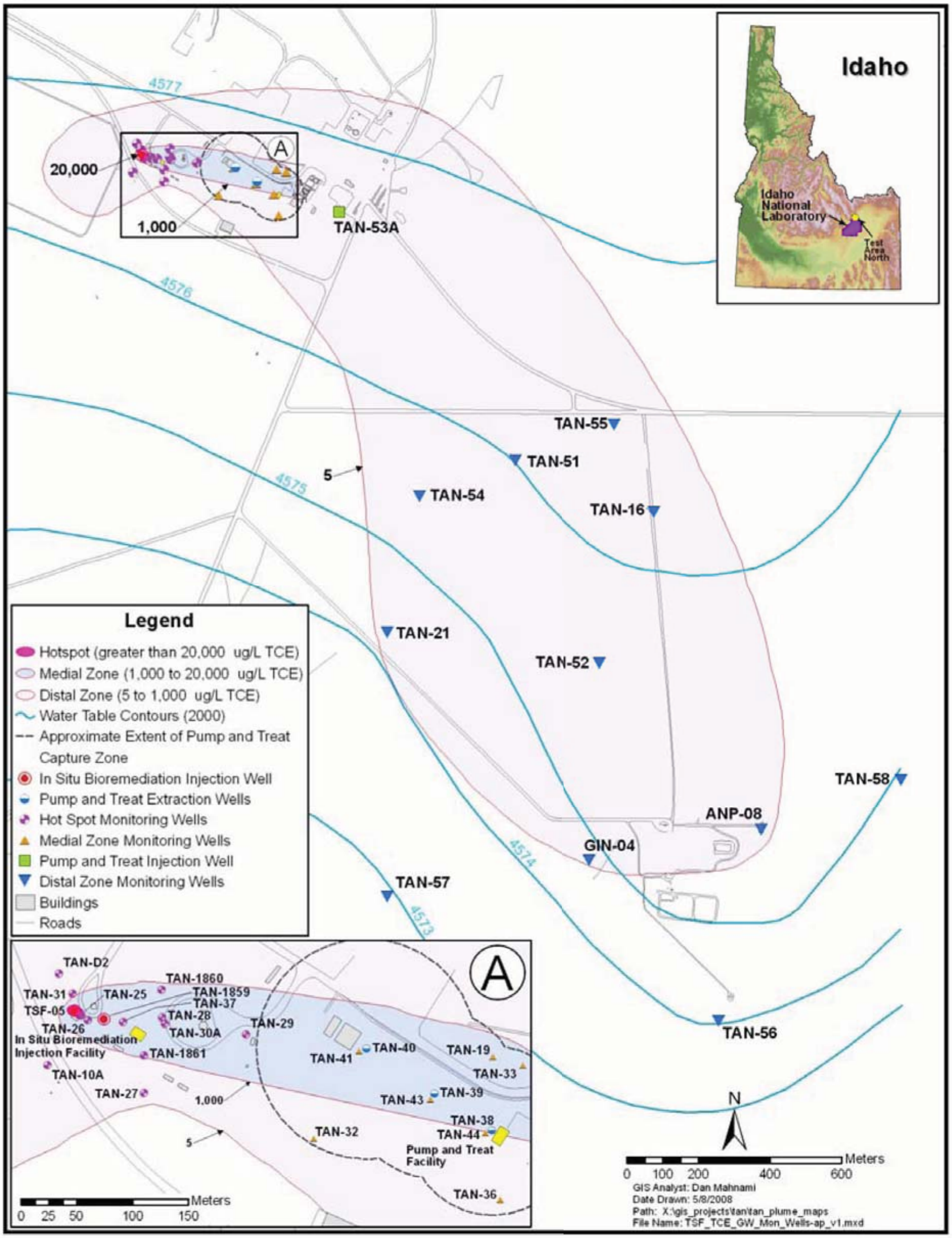


Figure 6-10. Trichloroethene Plume at Test Area North in 1997.

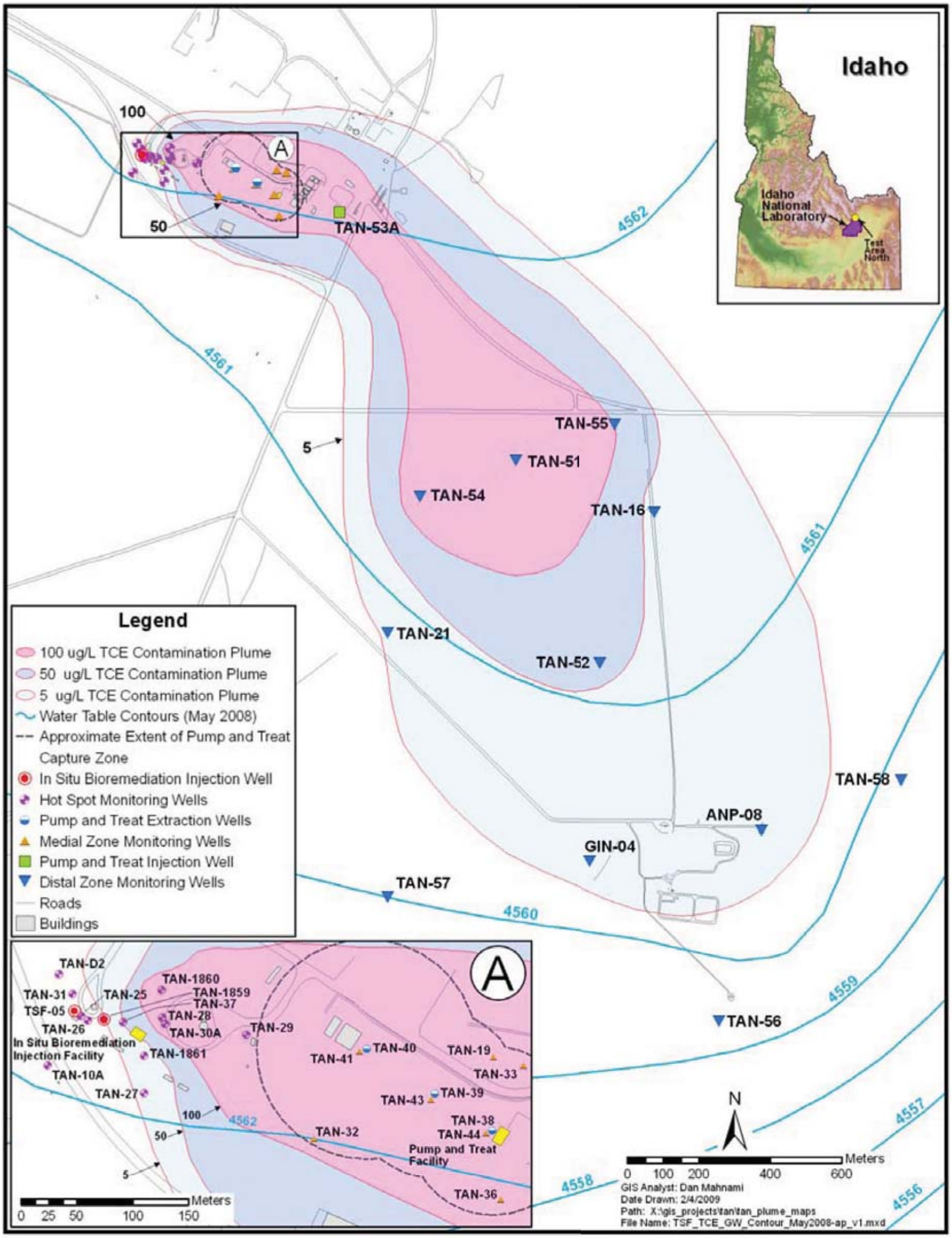


Figure 6-11. Trichloroethene Plume at Test Area North in 2006.

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 Action Work Plan (DOE-ID 2003) outlines three technical components to be evaluated annually. The first component is TCE concentration data. These data are collected to determine if the natural degradation rates will meet MCLs by 2095. Data collected during 2008 and beyond will be used to determine if monitored natural attenuation will 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. These wells were last sampled in August 2006, and TCE concentrations were below the MCL. These concentrations indicate that the TCE plume has not expanded (compare Figures 6-10 and 6-11). These wells will be sampled again in 2009.

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 bioremediaiton operations in the hot spot area of the plume, these increases did not result in downgradient migration of radionuclides to 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, the ATR Complex, during 2008. The locations of the wells are shown in Figure 6-12, except for the Highway 3 well (a public access potable water well), which is shown in the figure for WAG 10 sampling locations. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples were also analyzed for chromium (unfiltered and filtered). Unfiltered samples obtain the total concentration of the metal in the sample; filtered samples are used to obtain the dissolved concentration. The data for the October 2008 sampling event are included in the 2009 Annual Report for WAG 2 (ICP 2009a). The October 2008 sampling data are summarized in Table 6-4.

Only unfiltered chromium was detected above its MCL in aquifer wells. However, the highest filtered chromium concentration was 98.1 µg/L in Well USGS-065 and was below the chromium MCL of 100 µg/L. The highest unfiltered chromium concentration occurred in Well TRA-07, but the filtered chromium concentration was below the MCL in this well. Both of these wells appear to show downward chromium concentration trends.

Strontium-90 was detected at 6.56 pCi/L, below its MCL of 8 pCi/L in Well TRA-08, but ^{90}Sr concentrations have been decreasing in this well since the first occurrence in 2005.

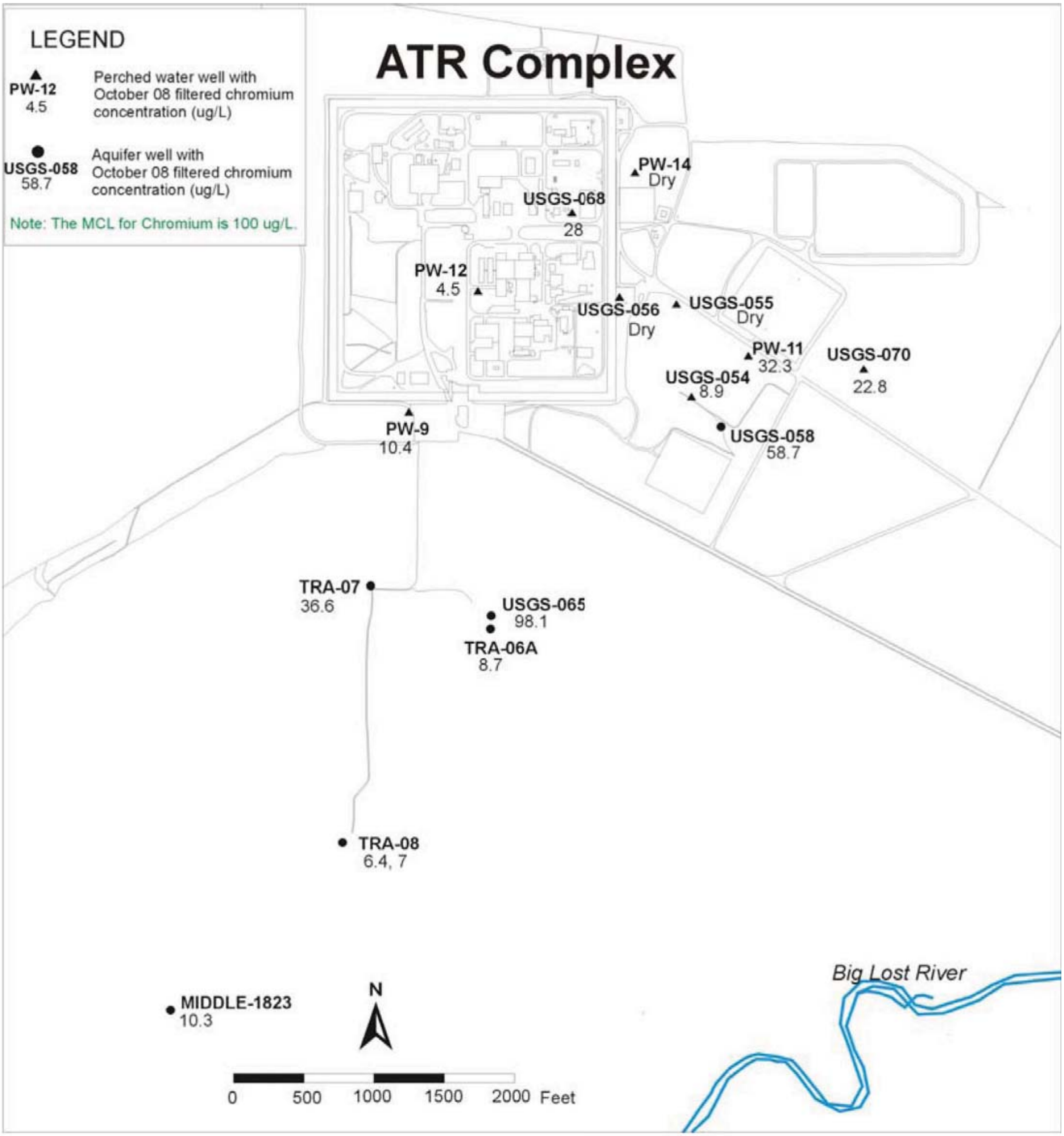


Figure 6-12. Locations of Waste Area Group 2 Monitoring Wells and Chromium Concentrations for 2008 (Note: Highway 3 well is not shown on this map).

Table 6-4. Waste Area Group 2 Aquifer Groundwater Quality Summary (2008).

Analyte	MCL	Background[a]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2–3	98.1	2.1	0
Chromium (unfiltered) (µg/L)	100	NA	331	2.3	1
Sr-90 (pCi/L)	8	0	6.56	ND	0
Tritium (pCi/L)	20,000	75–150	6,300	ND	0
Gross alpha (pCi/L)	15	0–3	6.72	ND	0
Gross beta (mrem/yr)	4	0–7	37.1	ND	NA

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

MCL maximum contaminant level
NA not applicable
ND not detected

Consistent with past sampling, tritium concentrations were above background concentrations in all aquifer wells sampled; however, all concentrations were below the MCL and 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 and the revised modeling performed after the first five-year review.

To address ^{90}Sr in Well TRA-08, additional parameters, including metals and anions were sampled in select aquifer wells to evaluate water sources and determine the ^{90}Sr source impacting TRA-08. Although the sulfate data indicated increased influence from the cold waste ponds, the elevated concentrations of chloride and potassium in TRA-08 were not consistent with any known ^{90}Sr source area within the ATR Complex.

To address the elevated gross alpha concentration in MIDDLE-1823, total uranium was added for sampling for 2009 to evaluate the cause of elevated gross alpha levels in this well. However, the gross alpha concentration fell below the MCL in 2009, and the uranium concentration was at background concentrations. The cause of the gross alpha in MIDDLE-1823 remains uncertain.

The water table maps prepared for the Snake River Plain Aquifer in the vicinity of the ATR Complex were consistent with previous maps showing similar water levels and groundwater flow directions. Water levels declined in the aquifer from October 2007 to October 2008.

6.7.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

The CERCLA Operable Unit 3-14 Project did not collect any groundwater samples at INTEC during 2008. The next Operable Unit 3-14 groundwater sampling event is scheduled for spring 2009.

The 2008 aquifer groundwater levels were similar to those reported previously (Figure 6-13), with small fluctuations from year to year in response to wet-dry climate cycles (DOE-ID 2009b). Groundwater levels declined during 2000–2005 as a result of drought during this period. However, as a result of above normal precipitation during 2005–2007, and corresponding periods of flow of the Big Lost River during those years, the rate of groundwater level decline has slowed.

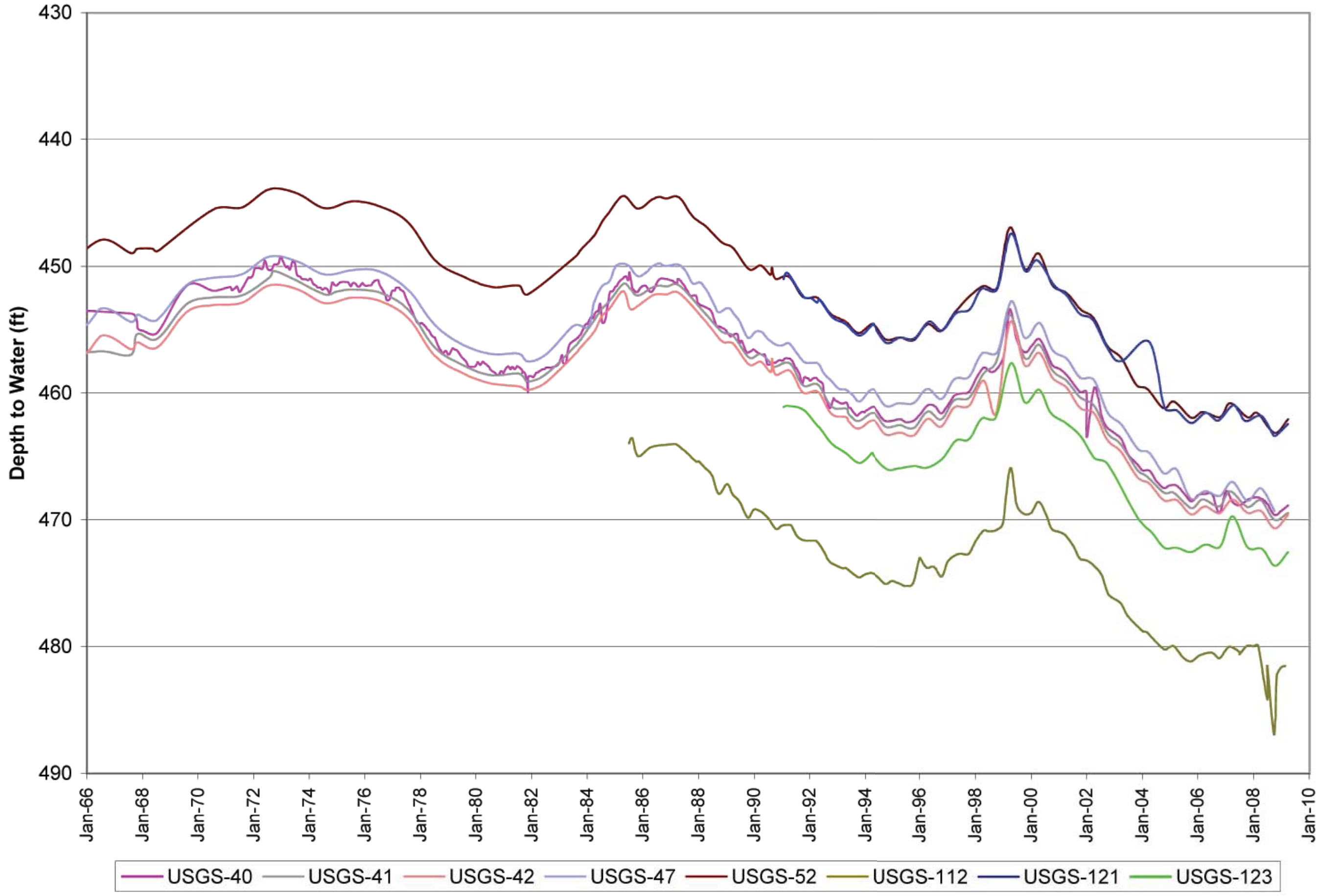


Figure 6-13. Hydrographs for Selected Groundwater Monitoring Wells at the Idaho Nuclear Technology and Engineering Center.

6.7.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

Groundwater monitoring for CFA landfills consisted of sampling 11 wells for metals (filtered), volatile organic compounds, and anions (nitrate, chloride, fluoride, and sulfate) in September 2008 in accordance with the Field Sampling Plan (ICP 2006). The CFA monitoring well locations are shown in Figure 6-14. Because of falling water levels in the aquifer, two wells, LF2-08 and LF2 09, were sampled only for volatile organic compounds in February 2008. Analytes detected in groundwater are compared to regulatory levels in Table 6-5. A complete list of the groundwater sampling results is contained in the CFA Landfills 2008 Monitoring Report (ICP 2009b).

Nitrate, at 16 mg/L-N, continued to exceed its groundwater MCL of 10 mg/L-N in Well CFA MON-A-002 downgradient of CFA. The nitrate concentration of 9.1 mg/L-N in CFA MON-A-003 is below the MCL and within its historic range of 8 to 11 mg/L-N. Except for the 2005 nitrate spike concentration in CFA MON-A-003, nitrate concentrations in CFA-MON-A-002 and -003 have been relatively consistent since monitoring started in 1995.

Iron exceeded its secondary maximum contaminant level in three samples, but elevated iron concentrations are inconsistent with high dissolved oxygen concentrations and slightly alkaline pH. The highest iron concentration was from Well LF3-09, which was sampled by bailing, a sampling method resulting in a high suspended sediment load, and the high iron concentration probably was due to sediment particles breaking through the filter.

Aluminum and chromium were also above their regulatory levels in the sample from Well LF3-09. The high aluminum concentration, 613 μg/L, in LF3-09 is inconsistent with the slightly alkaline pH for the water from this well. This indicates that aluminum is probably associated with suspended particulates that are small enough to pass through the filter pores or due to filter breakthrough. Chromium occurred at 132 μg/L in the sample from LF3-09 and was above its MCL of 100 μg/L. The elevated chromium in LF3-09 is probably due to suspended particulates because it occurs in the same sample with elevated iron and aluminum concentrations.

The elevated metal concentrations in the filtered sample from LF2-08 from February 2008 were not used in the evaluation of inorganic contamination from the landfills because the elevated concentrations are due to the influence of grout and sediment breakthrough in the filtered sample rather than reflecting landfill leachate effects.

Chloroform and toluene were the only volatile organic compounds detected downgradient of the CFA landfills in the September 2008 sampling. Chloroform was detected in the sample from CFA-1931 near its detection limit (0.79 μg/L) and well below the MCL of 100 μg/L. The maximum toluene detection of 27.3 μg/L was well below the MCL of 1,000 μg/L and occurred in CFA-1932. The source of the chloroform and toluene is uncertain because concentrations in soil gas are very low.

The compounds 1,2,4-trimethylbenzene, 2-butanone, 2-hexanone, acetone, chloroform, toluene,

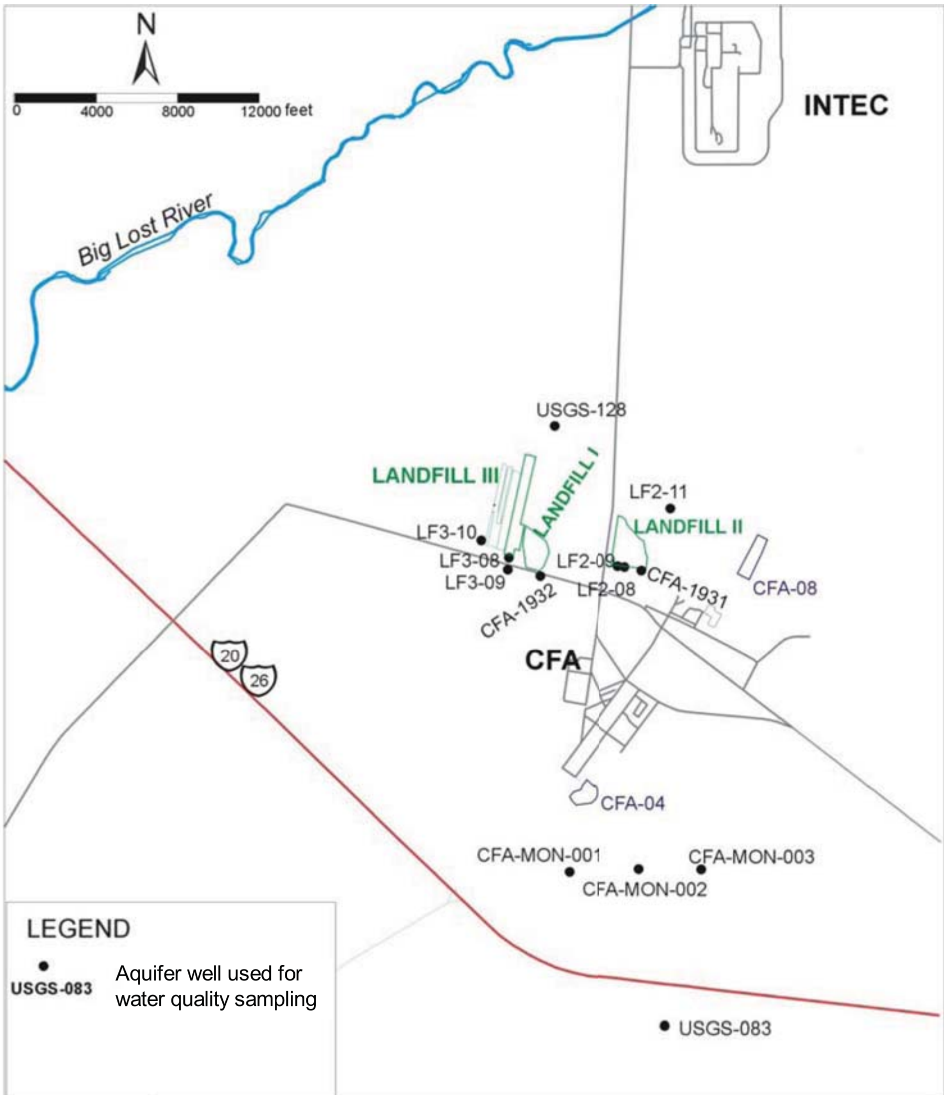


Figure 6-14. Locations of Waste Area Group 4/Central Facilities Area Monitoring Wells Sampled in 2008.

and xylene (total) were detected in the February 2008 samples from LF2-08 and LF2-09. Toluene was detected in both LF2-08 and LF2-09 in February 2008, with a maximum concentration of 41 µg/L at LF2-09. The source of the toluene and other volatile organic compounds is uncertain. Although toluene and volatile organic compounds have been detected in some wells in previous sampling events, the past detections have been at very low concentrations and sporadic.

The most common volatile organic compounds detected in the soil gas samples were 1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, TCE, dichlorodifluoromethane, and trichlorofluoromethane. The halogenated compounds are common solvents, constituents found in solvents, or freons. The compound occurring at the highest concentration was

Table 6-5. Comparison of Waste Area Group 4 Groundwater Sampling Results to Regulatory Levels (2008).

Compound	MCL or SMCL[a]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*	53.6	0
Fluoride (mg/L)	*2*	0.277	0
Sulfate (mg/L)	*250*	30.5	0
Nitrate/nitrite (mg-N/L)	10	16	1
Central Facilities Area Landfill Wells			
Anions			
Alkalinity-bicarbonate (mg/L)	None	181	NA
Chloride (mg/L)	*250*	86.3	0
Fluoride (mg/L)	*2*	0.231	0
Sulfate (mg/L)	*250*	38.9	0
Nitrate/nitrite (mg-N/L)	10	3.03	0
Common Cations			
Calcium (µg/L)	None	62,800	NA
Magnesium (µg/L)	None	17,500	NA
Potassium (µg/L)	None	4,170	NA
Sodium (µg/L)	None	38,600	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND	0
Aluminum (µg/L)	*50–200*	613	1
Arsenic (µg/L)	10	3.4	0
Barium (µg/L)	2,000	105	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	132	1
Copper (µg/L)	1,300/*1,000*	5	0
Iron (µg/L)	*300*	1,580	3
Lead (µg/L)	15[b]	1.4	0
Manganese (µg/L)	50	23.1	0
Mercury (µg/L)	2	0.038	0
Nickel (µg/L)	None	95.2	NA
Selenium (µg/L)	50	1.2	0
Silver (µg/L)	*100*	ND	0
Thallium (µg/L)	2	0.53	0
Vanadium (µg/L)	None	8.3	NA
Zinc (µg/L)	*5,000*	728	0
Detected Volatile Organic Compounds			
1,2,4-Trimethylbenzene (µg/L)	None	0.459	0
Acetone (µg/L)	None	0.279	NA
2-hexanone (µg/L)	None	0.273	NA
2-butanone (µg/L)	None	0.572	NA
Toluene (µg/L)	1,000	27.3	0
Chloroform (µg/L)	100	0.731	0
Xylenes (µg/L)	10,000	96	NA

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

1,1,1-trichloroethane at 5,900 ppbv in Well GSP3 1 at a nominal depth of 77.5 ft. Other compounds occurring at concentrations above 2,000 ppbv included trichlorofluoromethane, 1,1-dichloroethane, and 1,1-dichloroethene. Other solvents detected in the soil gas samples included F-113, carbon tetrachloride, cis-1,2 dichloroethene, and tetrachloroethene. None of these volatile organic compounds was detected in the groundwater. Observed soil gas volatile organic compounds concentrations did not exceed soil gas “trigger” concentrations. Although chloroform and toluene were detected in the groundwater sample from CFA-1931, their concentrations in soil gas samples were relatively low, with maximum concentrations of only 54 and 46 ppb, respectively.

The water level data for the CFA landfill wells suggest that the recent sharp drop in water levels might be stabilizing because water levels have changed little in the past 3 years. A water table map produced from water levels collected in September 2008 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 2008. 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

More than 3,500 analyses were performed on samples collected from 15 RWMC aquifer monitoring wells in 2008. Locations of RWMC aquifer monitoring wells are shown in Figure 6-15. Analytes detected above reporting limits in 2008 include carbon tetrachloride, gross beta, trichloroethylene, tritium, uranium-234, and uranium-238 (Koeppen et al. 2009). Most detections exceeding background reporting limits occurred immediately northeast of the Subsurface Disposal Area (i.e., M3S, M7S, and M16S). Relevant analytes for 2008 are: (1) risk-based contaminants of concern for Operable Unit 7 13/14 and (2) radionuclides of interest to operation of the Active Low-Level Waste Disposal Facility. A list of relevant analytes is shown in Table 1 of the 2008 Environmental Monitoring Report for the RWMC (Koeppen et al. 2009). Operable Unit 7 13/14 reports results for any analyte, including those other than relevant, that (1) exceeds the MCL or (2) exhibits a meaningful trend.

Carbon tetrachloride was the only relevant analyte to exceed an MCL in the aquifer in 2008 (Table 6-6). It was detected at concentrations above the reporting (quantitation) limit of 1 µg/L at seven monitoring locations in 2008, and the MCL was exceeded at Wells M7S and M16S. Increasing concentration trends that were previously observed at Well M7S and other locations northeast of the Subsurface Disposal Area have not been evident for more than two years. The presence of carbon tetrachloride is most likely due to migration from waste disposed of in the Subsurface Disposal Area because volatile organic compounds are not present in plumes from upgradient sources. To date, trichloroethylene concentrations have not exceeded the MCL anywhere in the aquifer near RWMC.

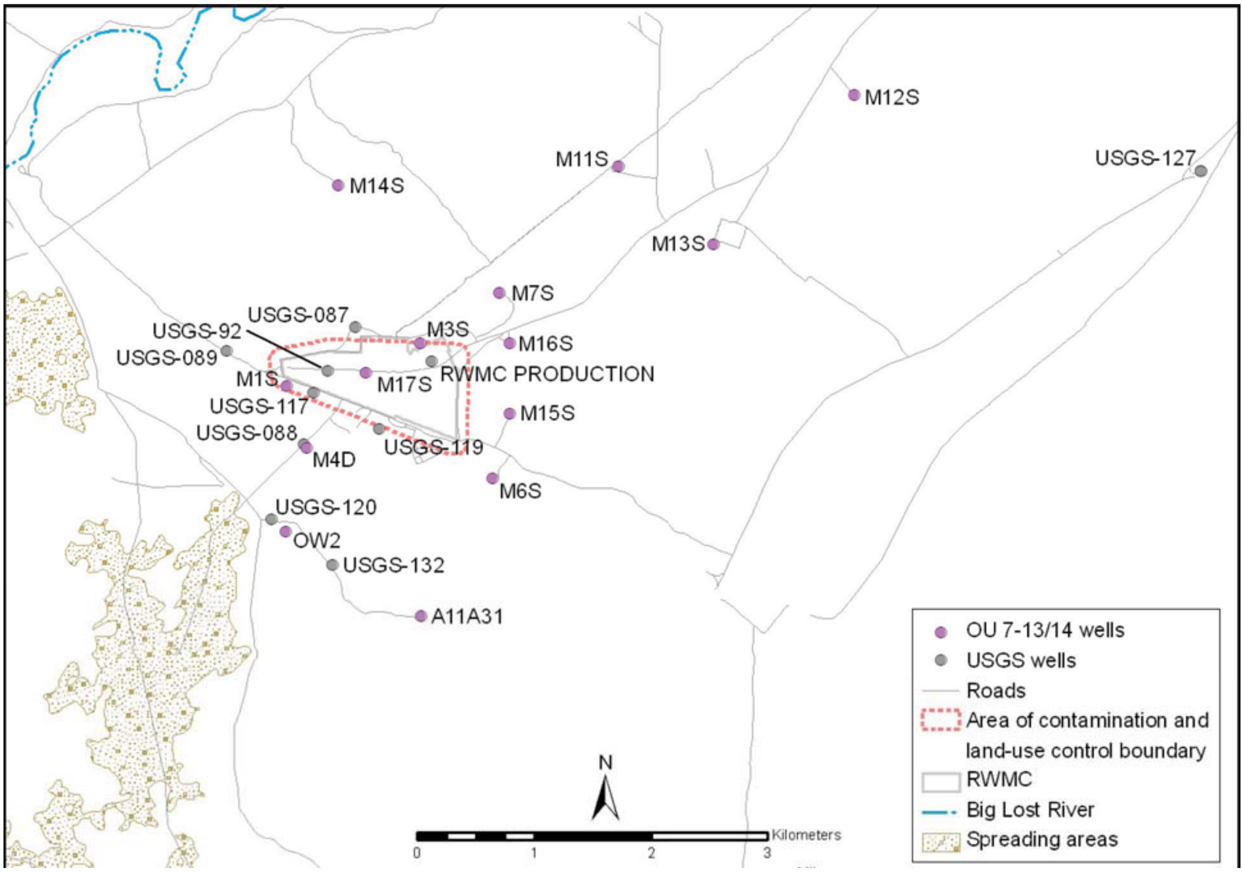


Figure 6-15. Locations of Waste Area Group 7 Aquifer Monitoring Wells at the Radioactive Waste Management Complex.

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 then (ICP 2008). Chloride, sodium, and sulfate concentrations are also elevated in wells south of the Subsurface Disposal Area and also have been decreasing since 2003. 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 infiltration has transported soluble analytes and volatile organic compounds to the aquifer.

Tritium was present in samples from seven monitoring wells, and concentrations were considerably below MCLs. Most wells with tritium concentrations above the background reporting threshold are located north-northeast of the Subsurface Disposal Area. Elevated tritium concentrations have been detected in this area since 1975, but concentrations in wells closest to the Subsurface Disposal Area (e.g., M3S, M7S, and M16S) have varied little since then. Recent studies conducted in collaboration with WAG 10 indicate tritium in wells north-northeast of the

Table 6-6. Summary of Waste Area Group 7 Aquifer Sampling and Analyses Data for Relevant Analytes (2008).[a]

Relevant Analyte	Number of Wells Sampled	Number of Analyses	Number of Detections Greater Than Background Reporting Threshold or Quantitation Limit[b]	Concentration Exceeding Reporting Threshold Maximum ±1 Sigma	Number of Detections Greater Than Maximum Contaminant Level[c]	Name of Monitoring Wells Exceeding Maximum Contaminant Level
Carbon tetrachloride	15	32	17	6.71 µg/L	4	M7S, M16S
Gross beta	15	32	3	22 ± 2 pCi/L	2	M4D
Trichloroethylene	15	32	7	2.54 µg/L	0	NA
Tritium	15	32	15	1,510 ± 116 pCi/L	0	NA
Uranium-233/234	15	32	1	1.72 ± 0.13 pCi/L	NA[d]	NA
Uranium-238	15	32	2	0.84 ± 0.07 pCi/L	NA[d]	NA
Total uranium	15	32	2	2.5 ± 0.2 pCi/L[e]	0	NA

a. Sample results specific to each sampling event, monitoring well, and analyte that exceeded reporting thresholds are presented in 2008 Environmental Monitoring Report for Radioactive Waste Management Complex (Koeppen et al. 2009).
b. 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. Maximum contaminant levels are from "National Primary Drinking Water Regulations" (40 CFR 141) established by the Environmental Protection Agency to protect public drinking water sources. The MCL for Sr-90 (i.e., 8 pCi/L) is applied to gross beta concentrations.
d. The maximum contaminant level is not applicable to each individual uranium isotope, but to total uranium only.
e. Total uranium derived by converting isotopic uranium results (pCi/L) to mass units (µg/L) and summing the results.

NA not applicable

Subsurface Disposal Area is likely associated with plumes originating at INTEC and the ATR Complex (DOE-ID 2006).

Gross beta activity exceeded the background reporting threshold and MCL at Well M4D in 2008. Gross beta activity at this location consistently exceeds the MCL and is likely attributable to potassium-40, which is a naturally occurring isotope of potassium. Potassium concentrations at this location are nearly 10 times higher than background levels; therefore, the fraction of potassium-40 in naturally occurring potassium is the most probable cause of elevated gross beta activity.

Uranium-234 and uranium-238 slightly exceeded background thresholds at Well OW2. These are frequently detected slightly above background reporting thresholds at Well OW2, and concentrations have been stable since monitoring began. Uranium concentrations are generally about 40 percent higher at this well than other RWMC monitoring wells and are attributed to small amounts of dirt and sediment in the sample because the lower section of the well is uncased. The well is cased to a depth of 600 ft bgs and then uncased to its well completion depth approximately 1,000 ft bgs.

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 quality parameters as required under the WAG 9 Record of Decision. The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-7. All results were below their respective water quality limits with the exception of one result for lead. Overall, the data showed 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 14 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 with six and seven sampling intervals in each (referred to as packer sampling), USGS-132 and USGS-103, were sampled in 2008. Well USGS-105 could not be sampled because the well was being deepened by USGS. Although originally scheduled for 2007, the analytical results for the packer sampling at USGS-105 were incorporated into the WAG 10 Annual Monitoring Status Report (DOE/ID 2009c) because the packer sampling was completed in 2008.

Each well was sampled for volatile organic compounds (contract laboratory program target analyte list), metals (filtered), anions (including alkalinity), and radionuclides (^{129}I, tritium, ^{99}Tc, gross alpha, gross beta, and ^{90}Sr) during June 2008. The results are summarized in Table 6-8 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 2009c).

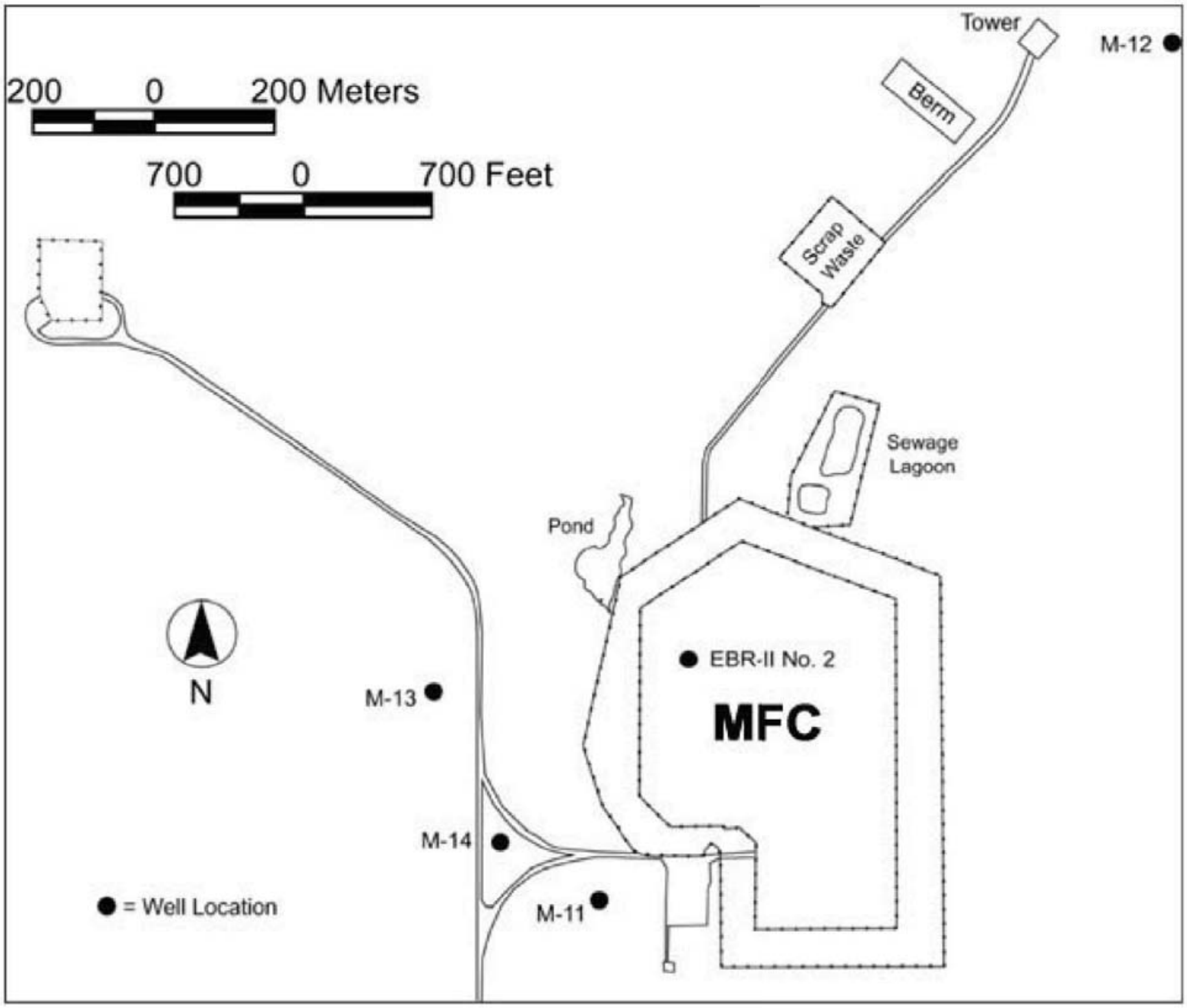


Figure 6-16. Locations of Waste Area Group 9 Monitoring Wells Sampled in 2008.

No contaminant exceeded an MCL in a groundwater well along the southern INL Site boundary or in the guard wells in 2008. Lead was detected at its action level of 15 µg/L in one well, USGS-106. However, the elevated lead concentration is probably due to corrosion of the galvanized riser pipe in this well. Elevated zinc concentrations also noted in this well implicates the galvanized riser pipe as the cause of the elevated lead concentration.

Iron was above its secondary MCL of 300 µg/L in seven wells, with the highest concentration, 416 µg/L, in USGS-110. The elevated iron concentrations are 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 conditions and slightly alkaline pH.

Table 6-7. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2008).

Well	M-11		M-12		M-13		M-14		EBR-II No. 2		MCL/ SMCL[a]
Sample Date	4/28/08	11/5/08	4/28/08	10/8/08	4/28/08	10/8/08	4/28/08	11/5/08	4/28/08	10/8/08	
Parameter											
Radionuclides[b]											
Gross beta (pCi/L)	4.33 ± 0.762	4.3 ± 1.14 (3.31 ± 1.07)	4.01 ± 0.757	1.6 ± 0.594 U[c]	2.31 ± 0.707	4.22 ± 0.949	3.4 ± 0.747	3.77 ± 1.12	1.04 ± 0.67 U	2.85 ± 0.747	50[d]
U-233/234 (pCi/L)	1.52 ± 0.156	1.55 ± 0.186 (1.24 ± 0.153	1.34 ± 0.141	1.79 ± 0.223	1.36 ± 0.144	1.45 ± 0.182	1.59 ± 0.165	1.66 ± 0.197	1.44 ± 0.15	1.63 ± 0.201	186,000
U-235 (pCi/L)	0.0278 ± 0.0127	0.0712 ± 0.0359 (0.0955 ± 0.0395)	0.0449 ± 0.0163	0.11 ± 0.05	0.0219 ± 0.0111	0.182 ± 0.0606	0.0163± 0.00954	0.119 ± 0.0494	0.0281 ± 0.0128	0.0104 ± 0.0211 U	66
U-238 (pCi/L)	0.629 ± 0.0766	0.673 ± 0.11 (0.489 ± 0.0863	0.579 ± 0.0724	0.625 ± 0.115	0.623 ± 0.768	0.777 ± 0.122	0.681 ± 0.082	0.672 ± 0.111	0.553 ± 0.0698	0.557 ± 0.104	9.9
Metals											
Barium (µg/L)	37.2	35.3 (35.4)	41.2	42.2	36.7	40	36.4	36.4	36.6	38.2	2,000
Calcium (mg/L)	37.1	34.2 (34.4)	38.5	38.1	37.4	37.2	37.3	35.1	37.1	37.2	NE[e]
Chromium (µg/L)	2.5 U	2.5 U (2.5 U)	2.6	2.5 U	3	5.8	3.3	2.5 U	2.5 U	2.5 U	100
Copper (µg/L)	46.9	19.1 (146)	47	57.6	30.6	4.6	21.6	2.5 U	5	2.5 U	1,300/1,000
Iron (µg/L)	148	68.2 (81.6)	50 U	99	50 U	239	50 U	48.6	50 U	44.7	300
Lead (µg/L)	14.7	5.1 (22.8)	15.4	7.8	7	0.5 U	5.6	0.57	1.9	1.8	15
Magnesium (mg/L)	12.1	11.7 (11.8)	11.7	12	12.2	12.6	12.1	11.9	12.2	12.6	NE
Manganese (µg/L)	6.2	2.5 U (2.5 U)	2.6	2.5 U	3.3	13.8	2.5 U	2.5 U	2.5 U	2.5 U	50
Nickel (µg/L)	2.5	2.5 U (2.5 U)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NE
Potassium	3.13	3	3.47	3.36	3.18	3.08	3.04	2.99	3.02	3.03	NE

Table 6-7. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2008) (cont.).

Well	M-11		M-12		M-13		M-14		EBR-II No. 2		MCL/ SMCL[a]
Sample Date	4/28/08	11/5/08	4/28/08	10/8/08	4/28/08	10/8/08	4/28/08	11/5/08	4/28/08	10/8/08	
(mg/L)		(3.01)									
Selenium (µg/L)	0.71	0.79 (0.68)	0.66	0.7	0.72	0.65	0.7	0.71	0.7	0.72	50
Sodium (mg/L)	16.7	15.9 (16)	16.8	16.9	17.6	17.6	17	16.3	17	16.8	NE
Vanadium (µg/L)	5.2	4.9 (4.9)	5.4	4.9	5.6	6.2	5.6	5	4.8	5.2	NE
Zinc (µg/L)	14.3	4.6 (36.6)	8.9	9.5	10.8	2.5 U	13	2.5 U	27.8	19.4	5,000
Anions											
Chloride (mg/L)	18.1	18.2 (18.3)	18.1	17.4	19	18	19.3	18.2	19.8	18.1	250
Nitrate (mg/L)	1.93	1.87 (1.87)	1.82	1.86	1.89	1.91	1.9	1.83	1.9	1.9	10
Sulfate (mg/L)	17.2	17 (17)	16.5	16.6	19.3	19.3	18.3	17.6	18	17.5	250
Water Quality Parameters											
Alkalinity (mg/L)	139	131 (134)	138	135	135	131	132	138	132	131	NE
Bicarbonate alkalinity (mg/L)	139	131 (134)	138	135	135	131	132	138	132	131	NE
Total dissolved Solids (mg/L)	236	239 (246)	239	256	241	273	241	235	249	284	500
Total organic halides (µg/L)	1 U	1.38 1.84	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	NE

a. MCL—maximum contaminant level; SMCL—secondary maximum contaminant level.
b. Counting error for radionuclides is 1 standard deviation.
c. U—not detected at the concentration shown.
d. The MCL for gross beta activity is 4 mrem/yr. A value of 50 pCi/L has been established as a screening level concentration.
e. Not established. A primary or secondary constituent standard has not yet been established for this constituent.

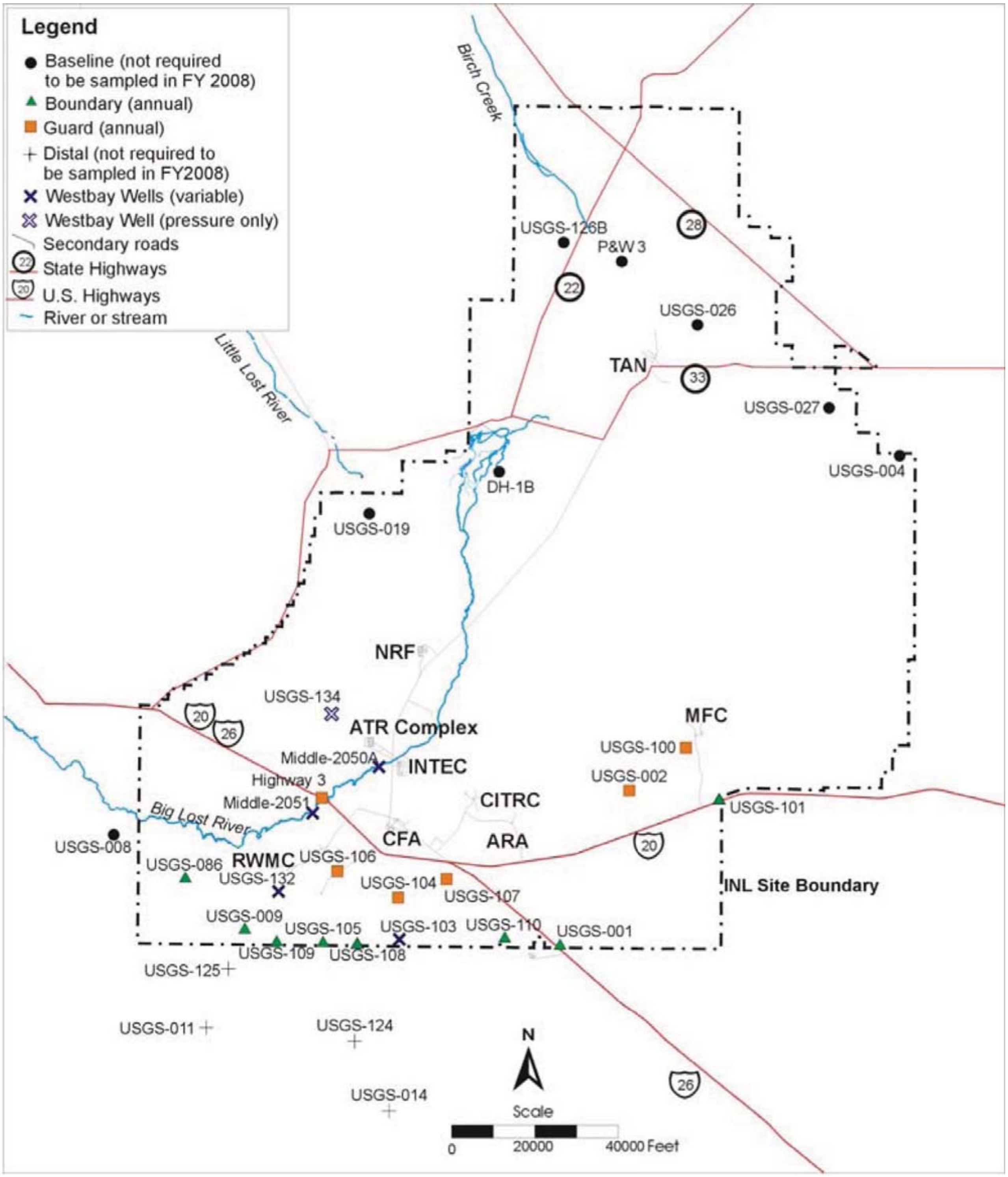


Figure 6-17. Locations of Waste Area Group 10 Monitoring Wells.

Table 6-8. Comparison of Detected Analytes with Maximum Contaminant Levels or Secondary Maximum Contaminant Levels for Waste Area Group 10 (2008).

Analyte	MCL/SMCL[a]	Maximum Concentration	Detections above MCL/SMCL
Radionuclides			
Gross beta (pCi/L)	50[b]	5.97	NA
Gross alpha (pCi/L)	15	3.24	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	1,150	0
Volatile Organic Compounds[c]			
Carbon tetrachloride (µg/L)	5	0.73	0
Toluene (µg/L)	1,000	1.42	0
Chloromethane (µg/L)	None	0.603	0
Anions			
Alkalinity (mg/L)	None	151	NA
Chloride (mg/L)	*250*	24.5	0
Fluoride (mg/L)	*2*	0.86	0
Nitrate/nitrite as N (mg/L)	10	1.85	0
Sulfate (mg/L)	*250*	39.6	0
Common Cations			
Calcium (µg/L)	None	45,200	NA
Magnesium (µg/L)	None	17,300	NA
Potassium (µg/L)	None	3,780	NA
Sodium (µg/L)	None	26,100	NA
Metals			
Aluminum (µg/L)	*50 to 200*	77.2	0
Antimony (µg/L)	6	0.71	0
Arsenic (µg/L)	10	3.2	0
Barium (µg/L)	2,000	51.6	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	0.46	0
Chromium (µg/L)	100	11.7	0
Cobalt (µg/L)	None	0.31	NA
Copper (µg/L)	1,300/*1,000*	2	0
Iron (µg/L)	*300*	416	8
Lead (µg/L)	15[d]	15.9	1
Manganese (µg/L)	*50*	42.3	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	2.8	NA
Selenium (µg/L)	50	1.6	0
Silver (µg/L)	None	ND	NA
Strontium (µg/L)	None	241	NA
Thallium (µg/L)	2	0.51	0
Uranium (µg/L)	30	3	0
Vanadium (µg/L)	None	13.5	NA
Zinc (µg/L)	*5,000*	203	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

The primary radiological analytes detected in the boundary and guard wells included gross alpha, gross beta, and tritium (Table 6-8). 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 both of these wells have a history of tritium detections. Over the past 20 years, both wells have exhibited a downward trend in tritium concentration. The tritium concentrations in these wells currently are less than 1,150 pCi/L and are considerably less than the MCL of 20,000 pCi/L (Table 6-8).

Three volatile organic compounds—chloromethane, toluene, and carbon tetrachloride—were detected at concentrations well below MCLs. Except for carbon tetrachloride in USGS-109, the volatile organic compound detections were not consistent with past sampling results. Carbon tetrachloride was detected in Well USGS-109 south of RWMC on the INL Site boundary and also was detected in two intervals from Westbay Well USGS-132 south of RWMC. The maximum detected concentration was 0.73 µg/L in the uppermost sample, 646.7 ft bgs, from Well USGS-132 south of RWMC. In addition, carbon tetrachloride was detected in both the shallow and deep packer samples from Well USGS-105, with a maximum concentration of 0.53 µg/L in the deep sample from a depth of 769 ft bgs. Historically, carbon tetrachloride has been detected in Well USGS-105 at concentrations near the detection limit. A carbon tetrachloride plume originates at RWMC, and the carbon tetrachloride detections at Wells USGS-132 and -109 could represent migration from RWMC.

REFERENCES

40 CFR 141, 2008, “National Primary Drinking Water Regulations,” *Code of Federal Regulations*, Office of the Federal Register.

ANL-W, 1998, *Final Record of Decision for Argonne National Laboratory-West*, W7500-000-ES-04, Argonne National Laboratory-West.

Bartholomay, R. C., B. J. Tucker, L. C. Davis, and M. R. Greene, 2000, *Hydrogeologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering and Environmental Laboratory, Idaho, 1996 Through 1998*, Water-Resources Investigation Report 00-4192, DOE/ID 22167, U.S. Geological Survey.

Bartholomay, R. C., L. L Knobel, and J. P. Rousseau, 2003, *Field Methods and Quality-Assurance Plan for Quality-of-Water Activities*, U.S. Geological Survey Open-File Report 03-42, DOE/ID 22182, U.S. Geological Survey.

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

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

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

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

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

DOE-ID, 2006, *Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Annual Status Report for Fiscal Year 2005*, DOE/NE ID-11274, Rev. 1, U.S. Department of Energy Idaho Operations Office.

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

DOE-ID, 2009a, *Annual Operations Report for the Final Groundwater Remediation, Test Area North, Operable Unit 1-07B, Fiscal Year 2008*, DOE/ID-11392, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID 2009b, *2008 Annual Report for Operable Unit 3-14, Tank Farm Soil and INTEC Groundwater*, DOE/ID-11395, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID 2009c, *Waste Area Group 10, Operable Unit 10-08, Annual Monitoring Status Report for Fiscal Year 2008*, DOE/ID-11388, Rev. 0, U.S. Department of Energy Idaho Operations Office.

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

ICP, 2006, *Field Sampling Plan for the Post Record of Decision Monitoring Central Facilities Area Landfills I, II, and III Operable Unit 4-12*, INEL-95/0585, Rev. 9, Idaho Cleanup Project.

ICP 2008, *Fiscal Year 2007 Environmental Monitoring Report for the Radioactive Waste Management Complex*, RPT-512, Rev. 0, Idaho Cleanup Project.

ICP 2009a, *Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2008*, RPT-651, Rev. 0, Draft, Idaho Cleanup Project.

ICP, 2009b, C*entral Facilities Area Landfills I, II, and III Annual Monitoring Report – 2008*, RPT-645, Rev. 0, Idaho Cleanup Project.

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

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

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

Koeppen, L. D., T. E. Bechtold, and K. J. Holdren, 2009, *Fiscal Year 2008 Environmental Monitoring Report for the Radioactive Waste Management Complex*, RPT-620, Rev. 0, Idaho Cleanup Project.

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

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

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

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

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

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

Chapter Highlights

To help assess the impact of contaminants released to the environment by operations at the Idaho National Laboratory (INL) Site, agricultural products (milk, lettuce, wheat, and potatoes), wildlife (waterfowl and large game animals), and soil were sampled and analyzed for radionuclides in 2008. In addition, direct radiation was measured on and around the INL Site using thermoluminescent dosimeters, field-based gamma spectrometry and a Global Positioning System Radiometric Scanner.

Some human-made radionuclides were detected in agricultural products and soil samples. However, the results could not be directly linked to operations at the INL Site. Concentrations of radionuclides detected in agricultural products and soil samples were consistent with fallout levels from atmospheric weapons testing. The maximum levels for these radionuclides were all well below regulatory health-based limits for protection of human health and the environment.

Human-made radionuclides were also found in some samples of waterfowl and game animals. Concentrations of several of these radionuclides were higher in waterfowl taken from ponds in the vicinity of the Advanced Test Reactor Complex than in control samples. Results were similar to those found in the previous two years and significantly lower than in previous research studies. Concentrations of cesium-137 in large game animals were within the range of background samples collected across the western United States, with one exception. A mule deer collected from the vicinity of the Radioactive Waste Management Complex had cesium-137 at elevated levels in muscle and liver samples.

Direct radiation measurements made at offsite, boundary, and onsite (except in the vicinity of some INL Site facilities) locations were consistent with background levels. The measured annual dose equivalent from external exposure was 122 mrem at both boundary and 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 consistent with those made historically at that location.

7. ENVIRONMENTAL MONITORING PROGRAMS - AGRICULTURAL PRODUCTS, WILD LIFE, SOIL, AND DIRECT RADIATION

This chapter summarizes the various environmental monitoring activities currently conducted on and around the Idaho National Laboratory (INL) Site (Table 7-1).

The INL and Idaho Cleanup Project (ICP) contractors monitor soil, vegetation, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The contractors collect over 400 soil, vegetation, and direct radiation samples for analysis each year.

The Environmental Surveillance, Education and Research Program (ESER) contractor conducted environmental surveillance off the INL Site and collected samples from an area of approximately 23,308 km^2 (9,000 mi^2) of southeastern Idaho at locations on, around, and distant from the INL Site. The ESER contractor collected approximately 300 agricultural products, wildlife, and direct radiation samples for analysis in 2008.

Section 7.1 presents agricultural products and biota surveillance results sampled by the ESER contractor. Section 7.2 presents soil sampling results by the ESER contractor and the INL contractor. Section 7.3 presents direct radiation surveillance results. Section 7.4 presents waste management surveillance results.

7.1 Agricultural Products and Biota Sampling

7.1.1 Milk

During 2008, the ESER contractor collected 132 milk samples (77 monthly and 55 weekly) at various locations off the INL Site (Figure 7-1). All samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples were analyzed either for strontium-90 (^{90}Sr) or tritium.

Iodine-131 was not detected in any milk sample in 2008. Cesium-137 was initially reported in one sample at a level outside the normal range of detections. It was subsequently found that a gamma check source had been removed from the detector and placed on top of the shield. The sample was recounted twice, and no ^{137}Cs was reported.

Strontium-90 was detected in five of seven milk samples, ranging from 0.24 pCi/L at Fort Hall to 0.73 pCi/L at Terreton. All ^{90}Sr 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 ingestion of grass by cows (EPA 1995). The maximum value in milk samples is far lower than the DOE Derived Concentration Guide for ^{90}Sr in water of 1,000 pCi/L.

Tritium was detected in three of seven milk samples analyzed at concentrations ranging from 102 to 117 pCi/L. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples.

Table 7-1. Other Environmental Monitoring Activities at the Idaho National Laboratory Site.

	Media			
Area/Facility[a]	Agricultural Products	Soil	Biota	Direct Radiation
INL and ICP Contractors				
MFC		•	•	•
RWMC		•	•	•
Sitewide		•	•	•[b]
Environmental Surveillance, Education and Research Contractor				
INL Site/Regional	•	•	•	•

a. MFC = Materials and Fuels Complex, RWMC = Radioactive Waste Management Complex.

b. Sitewide includes thermoluminescent dosimeters located at major facilities.

7.1.2 Lettuce

The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site. Some home gardens were replaced with prototype lettuce planters because the availability of lettuce from home gardens was unreliable at some locations. Also, the planters can be placed and lettuce collected at areas previously unavailable to the public, such as on the INL Site. In addition, the planters allow deposited radionuclides to accumulate on the plant surface throughout the growth cycle. The planters are set out in the spring, filled with soil, and sown with lettuce seed.

Four lettuce samples were collected from portable planters at Arco, Atomic City, the Experimental Field Station, and the Federal Aviation Administration Tower (Figure 7-1). In addition, samples were obtained from home gardens at Basalt, Blackfoot, Carey, Howe, Idaho Falls, and Monteview.

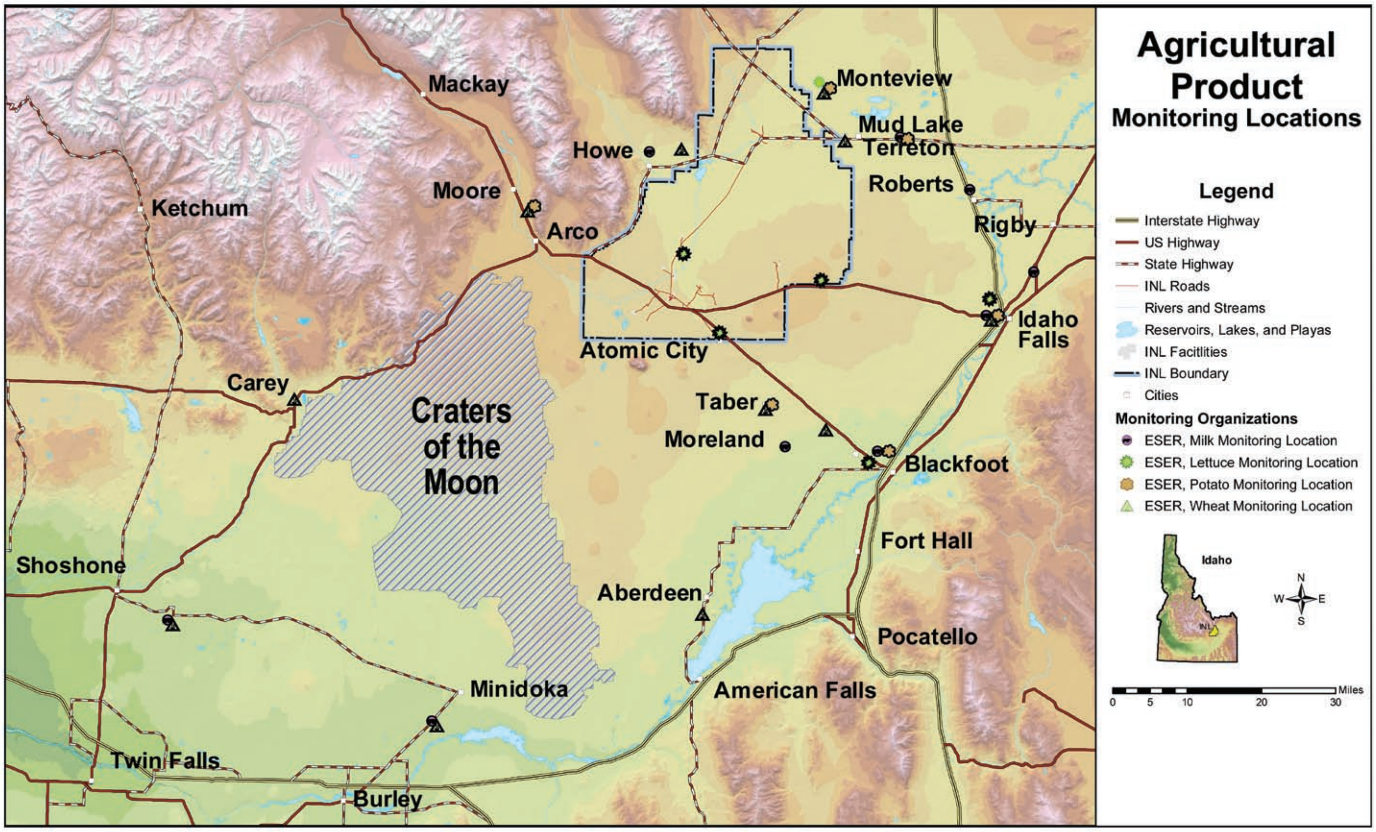


Figure 7-1. Locations of Agricultural Product Samples Collected During 2008.

Strontium-90 was detected above the 3-sigma uncertainty in six of the lettuce samples collected. Strontium-90 in lettuce results from plant uptake of this isotope in soil and deposition from airborne dust containing ^{90}Sr. Strontium-90 is present in soil as a residual of fallout from aboveground nuclear weapons testing, which occurred between 1945 and 1980. The maximum concentration of 90 pCi/kg was within historical concentrations (Table 7-2) and was most likely from weapons testing fallout. No other human-made radionuclides were detected in any of the samples.

7.1.3 Wheat

None of the eight wheat samples (including one duplicate) collected in 2008 (Figure 7-1) contained a measurable concentration of ^{90}Sr above the 3-sigma uncertainty. Current and historical results are presented in Table 7-3.

7.1.4 Potatoes

The following eight potato samples, including one duplicate, were collected during 2008: two samples and one duplicate from boundary locations (Arco and Monteview), three samples from distant locations (Blackfoot, Idaho Falls, and Minidoka), and two samples from out-of-state

Table 7-2. Strontium-90 Concentrations in Lettuce (2003–2008).[a]

Location	2003	2004	2005	2006	2007	2008
	($\times 10^{-3}$ pCi/g ± 1s dry weight)					
Distant Group						
Basalt	NS[b]	NS	NS	NS	NS	27 ± 3
Blackfoot	228 ± 83	97 ± 56	-17 ± 15	26 ± 8	17 ± 4	22 ± 4
Carey	220 ± 180	97 ± 66	NS	NS	NS	18 ± 4
Idaho Falls	254 ± 170	328 ± 110	160 ± 55	69 ± 8	96 ± 8[c]	18 ± 6
Pocatello	NS	135 ± 110	160 ± 55	NS	NS	NS
Grand Mean	**234 ± 87**	**164 ± 44**	**35 ± 15**	**48 ± 6**	**52 ± 9**	**21 ± 2**
Boundary Group						
Arco	126 ± 160	154 ± 85	111 ± 37	NS	NS	22 ± 7[c]
Atomic City	282 ± 130[c]	155 ± 130[c]	57 ± 30[c]	35 ± 6[c]	26 ± 4[c]	90 ± 15[c]
Federal Aviation Admin. Tower	NS	NS	NS	18 ± 10[c]	52 ± 28[c]	70 ± 11[c]
Howe	25 ± 81	NS	49 ± 25	NS	NS	14 ± 7
Monteview	214 ± 140	NS	NS	29 ± 9[c]	64 ± 3[c]	-5 ± 4
Mud Lake (Terreton)	NS	148 ± 79	55 ± 26	NS	NS	NS
Grand Mean	**162± 66**	**152 ± 58**	**68 ± 15**	**27 ± 5**	**47 ± 9**	**38 ± 4**
INL Site						
Experimental Field Station	442 ± 130[c]	225 ± 86[c]	SD[d]	48 ± 9[c]	39 ± 44[c]	17 ± 28[c]

a. Approximate minimum detectable concentration of ^{90}Sr in lettuce is 2 × 10-4 pCi/g dry weight. The table contains all sample results including those not considered detected at the three sigma level.

b. NS indicates no sample collected or that the sample was lost before analysis.

c. Sample was grown in a portable lettuce planter.

d. SD indicates that the sample was destroyed, in this case, by yellow jackets.

Table 7-3. Strontium-90 Concentrations in Wheat (2003–2008).[a]

Location	2003	2004	2005	2006	2007	2008
	(pCi/kg ± 1s dry weight)					
Distant Group						
Aberdeen[b] (American Falls)	84 ± 62	-1 ± 25 32 ± 29	12 ± 18	0.7 ± 3.3	1.3 ± 2.8	NS[c]
Blackfoot	NS	16 ± 25	16 ± 25	-0.4 ± 2.8	3.8 ± 2.5	4.4 ± 2.3
Carey[b]	-53 ± 47	65 ± 27	NS	2.3 ± 2.7	7.4 ± 2.5	1.7 ± 2.4 0.3 ± 2.6
Dietrich	NS	17 ± 17	-27 ± 17	6.0 ± 2.7	NS	NS
Idaho Falls[b]	121 ± 64	46 ± 22 26 ± 27	15 ± 24	7.8 ± 2.5	2.0 ± 3.6	5.5 ± 2.0
Minidoka	61 ± 48	NS	4 ± 24	NS	-1.3 ± 2.8	7.5 ± 2.7
Roberts (Menan)[b]	54 ± 55	NS	7 ± 16 -11 ± 18	NS	NS	NS
Rockford	195 ± 68	NS	NS	NS	NS	NS
Rupert (Burley)	-26 ± 52	NS	NS	8.3 ± 3.5	4.5 ± 2.7	NS
Taber	NS	NS	NS	3.2 ± 3.3	-1.6 ± 2.5	NS
Grand Mean	**62 ± 22**	**29 ± 9**	**-0.9 ± 7**	**4.0 ± 1.1**	**2.3 ± 1.1**	**3.9 ± 1.1**
Boundary Group						
Arco[b]	2.0 ± 55	16 ± 25	109 ± 38	2.0 ± 2.9 7.0 ± 2.6	-0.7 ± 3.0	-1.7 ± 2.2
Howe	-19 ± 49	-4 ± 19	5 ± 18	3.0 ± 2.9	5.2 ± 5.5	1.4 ± 2.8
Monteview	NS	NS	-41 ± 229	2.9 ± 2.8	NS	NS
Mud Lake	8 ± 56	21 ± 18	-5 ± 20	6.5 ± 2.5	8.0 ± 4.9	NS
Terreton	5 ± 43	-6 ± 22	NS	NS	NS	2.1 ± 2.1
Grand Mean	**-1 ± 26**	**7 ± 11**	**68 ± 15**	**27 ± 5**	**4.1 ± 2.6**	**0.6 ± 1.4**

a. Approximate minimum detectable concentration of ^{90}Sr in wheat from 2003 through 2005 was 20–100 pCi/kg dry weight. In 2006, the minimum detectable concentration decreased to approximately 10 pCi/kg. The table contains all sample results including those not considered detected at the three sigma level.

b. Duplicate samples were collected from this area during certain years.

c. NS indicates no sample collected or that the sample was lost before analysis.

locations (Colorado and Oregon) (Figure 7-1). Strontium-90 was detected in samples from Idaho Falls and Minidoka at concentrations of 4.5 and 4.9 pCi/kg. Strontium-90 is present in soil as a result of fallout from aboveground nuclear weapons testing, which is the likely source of these detections. No other human-made radionuclides were detected in potatoes.

7.1.5 Large Game Animals

Muscle samples were collected from six game animals (four pronghorn, one mule deer, and one elk) accidentally killed on INL Site roads. Thyroids were obtained from five of the animals, and liver samples were collected from four of the animals.

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. Each background sample had small, but detectable, ^{137}Cs concentrations in its muscle ranging from 5.1 to 15 pCi/kg. These values can be attributed to the ingestion of plants containing radionuclides from fallout associated with aboveground nuclear weapons testing.

The ^{137}Cs concentrations detected in most of the 2008 muscle and liver samples were at the lower end of the background range (5.1 to 15 pCi/kg) and within the range of historical values. There was one exception—a mule deer collected immediately adjacent to the Radioactive Waste Management Complex had detectable ^{137}Cs in the muscle tissue at 167 pCi/kg and in the liver at 80.2 pCi/kg. While these concentrations are within the range of historical concentrations, they are considerably higher than the range of the past several years. The last time ^{137}Cs concentrations were detected at these levels in game tissues was 1988. Areas of soil contamination exist on the INL Site, and past detections in this range have been attributed to ingestion of plants growing in the soil contamination areas. Mule deer have tended to have higher concentrations of radionuclides than pronghorn because they tend to congregate closer to facilities.

No ^{131}I was detected in any of the thyroid samples.

7.1.6 Waterfowl

Nine ducks were collected during 2008. Four were collected from wastewater ponds at the Advanced Test Reactor Complex, three from wastewater ponds near the Materials and Fuels Complex (MFC), and two control samples from Mud Lake. Each sample was divided into the following three subsamples: (1) edible tissue (muscle, gizzard, heart, and liver), (2) viscera, and (3) all remaining tissue (bones, feathers, feet, bill, head, and residual muscle). All were analyzed for gamma-emitting radionuclides, ^{90}Sr, plutonium-238 (^{238}Pu), plutonium-239,240 ($^{239/240}$Pu), and americium-241 (^{241}Am). Radionuclide concentrations measured in the edible tissues of waterfowl in 2008 are shown in Table 7-4.

Several man-made radionuclides were detected in the samples from the Advanced Test Reactor Complex ponds, including ^{241}Am, ^{137}Cs, cobalt-60 (^{60}Co), ^{90}Sr, and zinc-65 (^{65}Zn). All these

Table 7-4. Radionuclide Concentrations Detected in Waterfowl.

	Waterfowl Location		
Radionuclide	Advanced Test Reactor Complex (4 samples)	Materials and Fuels Complex (3 samples)	Mud Lake (2 samples)
		Edible	
Americium-241	Sample #1: (105 ± 11)[a] Sample #3: (109 ± 16) Sample #4: (267 ± 24)	No detections	No detections
Cesium-137	Sample #1: (159 ± 7) Sample #2: (117 ± 17) Sample #3: (182 ± 23) Sample #4: (520 ± 14)	No detections	No detections
Cobalt-60	Sample #1: (12 ± 3) Sample #4: (81± 4)	No detections	No detections
Plutonium-238	No detections	No detections	Sample #2: (122 ± 21)
Plutonium-239	No detections	No detections	Sample #2: (56 ± 13)
Strontium-90	Sample #1: (5.1 ± 1.2) Sample #2: (7.2 ± 1.1) Sample #3: (8.6 ± 1.3) Sample #4: (3.1 ± 0.8)	No detections	No detections
Zinc-65	Sample #4: (275 ± 15)	No detections	No detections
		Viscera	
Americium-241	No detections	No detections	Sample #1: (851 ± 74)
Cesium-137	Sample #1: (45 ± 7) Sample #2: (25 ± 3) Sample #3: (69 ± 5) Sample #4: (186 ± 8)	Sample #2: (22 ± 3)	No detections
Cobalt-60	Sample #3: (15 ± 3) Sample #4: (20 ± 3)	No detections	No detections
Strontium-90	Sample #1: (16.0 ± 1.0) Sample #2: (7.5 ± 0.9) Sample #3: (13.5 ± 0.8) Sample #4: (5.5 ± 0.8)	Sample #1: (4.9 ± 0.7) Sample #2: (16.8 ± 0.9) Sample #3: (15.2 ± 1.0)	Sample #1: (5.5 ± 0.8) Sample #2: (6.8 ± 1.0)
Zinc-65	Sample #1: (43 ± 14) Sample #4: (311 ± 19)	No detections	No detections
		Remainder	
Cesium-137	Sample #1: (135 ± 6) Sample #2: (60 ± 5) Sample #3: (164 ± 15) Sample #4: (454± 17)	No detections	No detections
Cobalt-60	Sample #1: (75 ± 4) Sample #2: (27 ± 3) Sample #3: (40 ± 13) Sample #4: (93 ± 10)	No detections	No detections
Strontium-90	Sample #1: (31.0 ± 1.1) Sample #2: (19.3 ± 1.0) Sample #3: (18.2 ± 1.0) Sample #4: (22.6 ± 1.2)	Sample #1: (11.1 ± 0.8) Sample #2: (17.2 ± 1.0) Sample #3: (14.8 ± 1.0)	Sample #1: (7.8 ± 0.8) Sample #2: (11.4 ± 0.8)
Zinc-65	Sample #4: (212 ± 22)	No detections	No detections

a. All units are 10^{-3} pCi/g

radionuclides were also found in at least one edible tissue sample. Samples from the Materials and Fuels Complex ponds contained ^{137}Cs and ^{90}Sr, but neither was found in edible tissues. One detection each of ^{241}Am, ^{238}Pu, and $^{239/240}Pu$ was reported in the control samples.

Because human-made radionuclides were found more frequently and at higher concentrations in ducks from the INL Site than in those from other 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 similar to those from 2006 and 2007, and ^{137}Cs concentrations were significantly lower than in 2005. In addition, concentrations were lower in 2008 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 also used the evaporation pond. Further information on potential doses from consuming waterfowl is contained in Chapter 8.

7.2 Soil Sampling

Soils are sampled to determine if long-term deposition of airborne materials from the INL Site have resulted in a buildup of radionuclides. The sampling also supports the Wastewater Reuse Permit for the Central Facilities Area Sewage Treatment Plant.

Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and certain actinides. Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am (which potentially could be released from INL Site operations) are of particular interest because of their abundance resulting from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment because of long half-lives (e.g., $^{239/240}Pu$, with a half-life of 24,110 years). Levels found around INL Site facilities are consistent with worldwide fallout levels. Soil sampling locations are shown in Figure 7-2.

The ESER contractor collects soil samples off the INL Site every two years (in even years), so soil was sampled in 2008. Results from 1998 to 2008 are presented in Figure 7-3. The geometric means were used because the data were log-normally skewed. The shorter-lived radionuclides (^{90}Sr and ^{137}Cs) show overall decreases through time, consistent with their approximate 30-year half-lives. Concentrations of $^{239/240}Pu$, a long-lived radionuclide, have demonstrated a decreasing trend similar to that of ^{90}Sr. However, concentrations of ^{238}Pu, $^{239/240}Pu$, and ^{241}Am, 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.

The INL contractor performed 343 field-based gamma spectrometry measurements in 2008. Table 7-5 summarizes the measurements. In addition to the in situ gamma spectrometry measurements, 33 in situ gamma locations on the INL Site were selected to determine the actual ^{137}Cs depth profile. Samples were collected at each of the 33 locations according to a specific sampling pattern that encompassed the field-of-view of a detector at that location. Soil

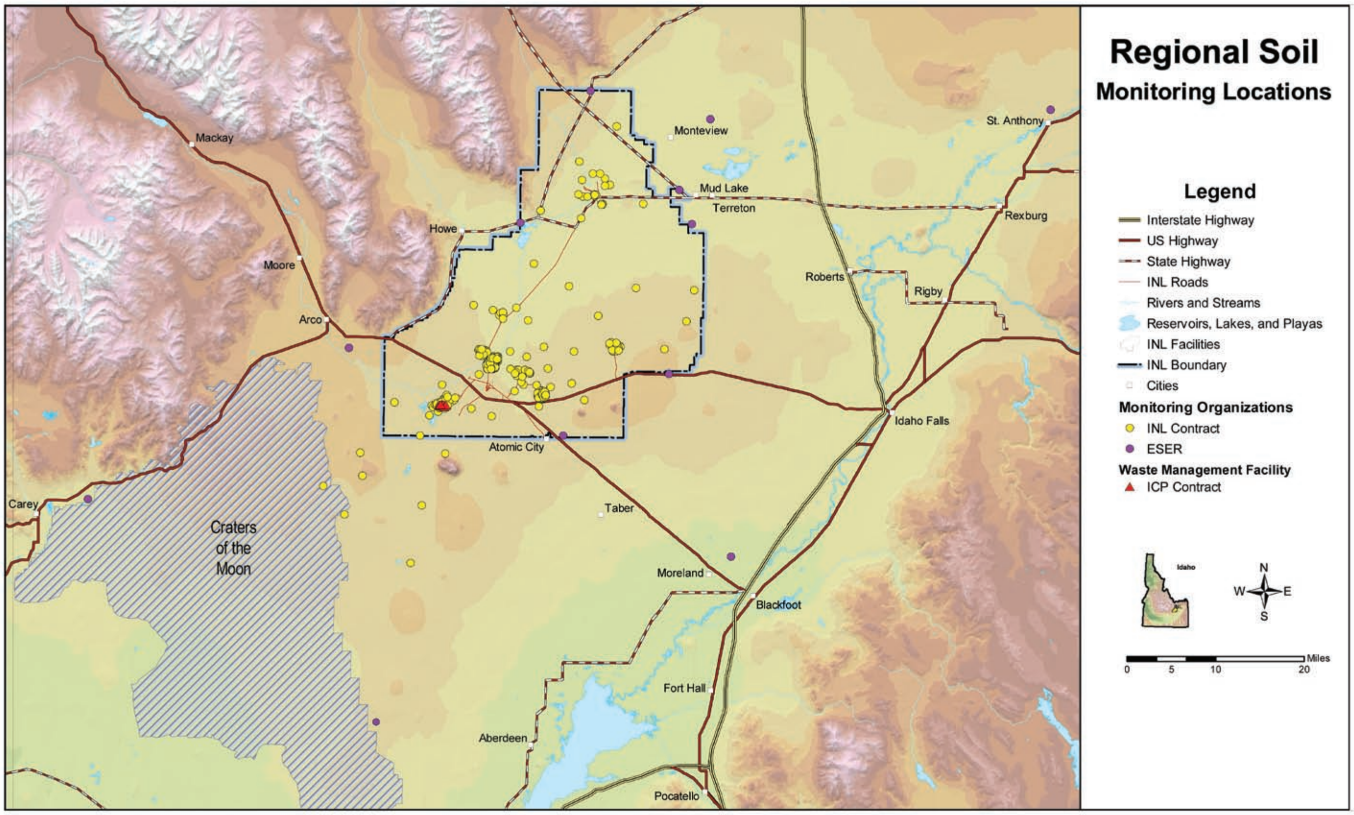


Figure 7-2. Soil Sampling Locations.

samples were collected using a split spoon sampler to a depth of 12 inches in 1–inch increments. Soils were then sorted by depth and packaged into pucks. These were then analyzed using conventional laboratory-based gamma spectroscopy systems, and the Cs-137 depth profiles were determined. Comparison between the 2007 and 2008 overall site means shows the two data sets to be statistically different at the 95 percent confidence level ($p<0.0001$). For all sites except the Idaho Nuclear Technology and Engineering Center (INTEC), the mean and 95 percent upper confidence limit values increased from 2007 to 2008 as shown in Table 7-5.

7.2.1 Wastewater Reuse Permit Soil Sampling at CFA

The Wastewater Reuse Permit for the Central Facilities Area Sewage Treatment Facility allows nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation. Soils are sampled at 10 locations within the land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.), 30 to 61 cm (12 to 24 in.), and 61 to 91 cm (24 to 36 in.) at each location and composited for each depth interval, yielding three samples, one from each depth. These samples are analyzed for pH, electrical conductivity, sodium adsorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the Wastewater Reuse Permit, to determine if wastewater application is adversely affecting soil chemistry. The analytical results for the soil samples are summarized in Table 7-6. The analytical results for 2007 are included for comparison.

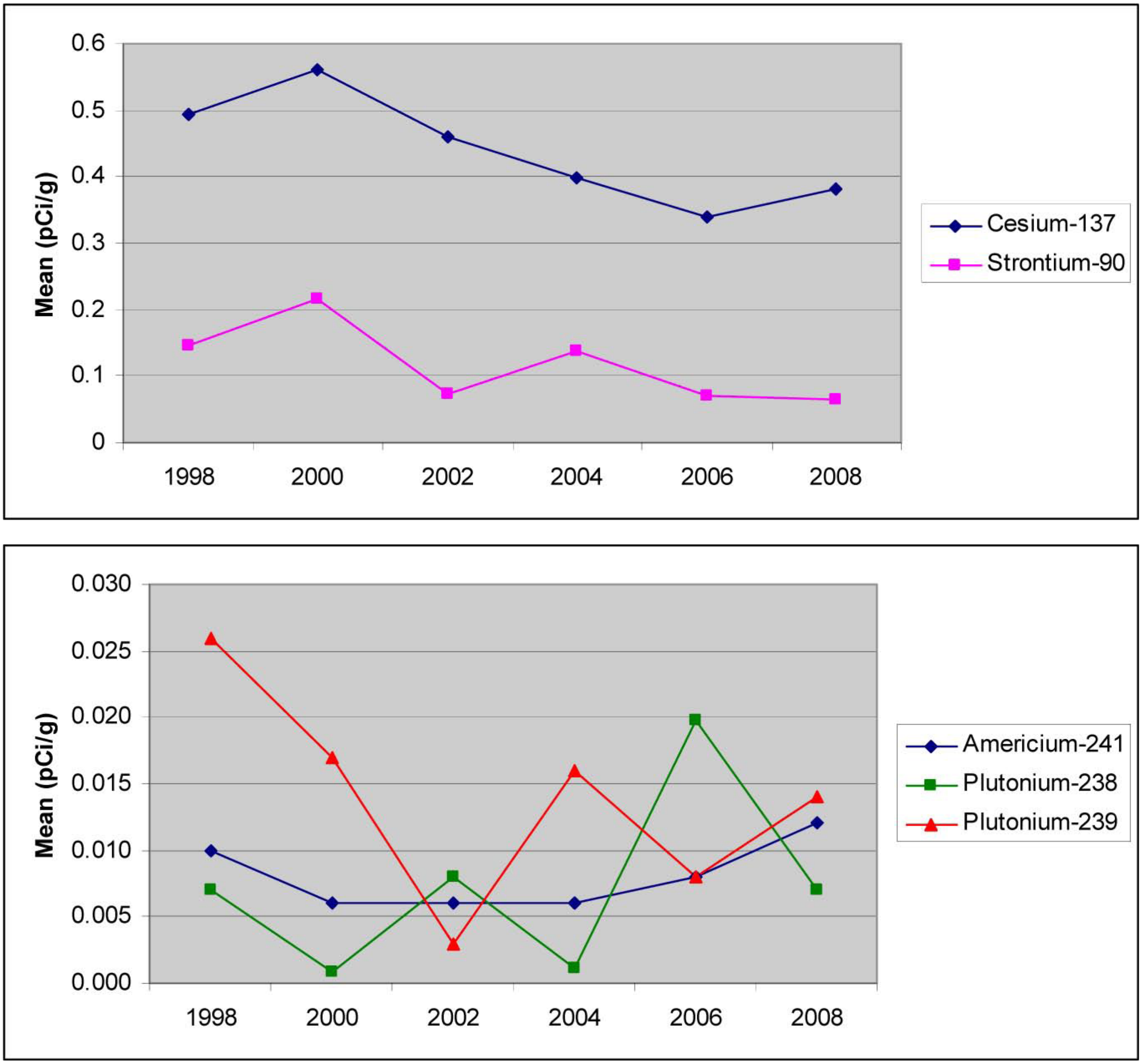


Figure 7-3. Geometric Mean Activity in Surface (0–5 cm [0–2 in.]) Soils off the INL Site (1998–2008).

Table 7-5. 2008 In Situ Gamma Scan Results for INL Sites and Large Grid.

Site[a]	Obs	Min	Max	Mean[b]	Median[b]	Variance	SD[b]	Skew	Kurtosis	CV	Dist[c]	Mean[b] 2007	Mean[b] 2008	95% UCL[b] 2007	95% UCL[b] 2008
	(pCi/g of ^{137}Cs)														
ARA	78	0.07	4.81	1.04	0.54	1.31	1.144	1.553	1.688	1.096	NP	2.28	0.96	1.71	1.85
ATR Complex	24	0.11	0.70	0.33	0.29	0.03	0.160	1.084	0.694	0.493	G	0.20	0.29	0.34	0.39
CITRC	16	0.12	0.22	0.17	0.17	0.00	0.029	-0.234	-1.086	0.170	N	NA	0.11	0.16	0.18
INTEC	95	0.07	5.04	1.30	0.97	0.93	0.964	1.684	2.881	0.741	G	0.88	1.38	3.40	1.47
Large Grid	42	0.10	13.39	0.49	0.19	4.16	2.039	6.477	41.96	4.148	NP	0.08	0.15	0.16	1.86
MFC	18	0.01	0.27	0.17	0.19	0.00	0.064	-0.723	0.632	0.373	N	NA	0.11	0.16	0.20
NRF	5	0.12	0.36	0.21	0.18	0.01	0.092	1.206	1.724	0.435	N	NA	0.08	0.12	0.30
RWMC	45	0.12	0.22	0.18	0.18	0.00	0.027	-0.328	-0.524	0.156	N	0.11	0.17	0.18	0.18
TAN-SMC	18	0.07	0.86	0.23	0.17	0.03	0.180	2.94	9.796	0.799	NP	0.14	0.15	0.28	0.41
Overall	342	0.01	13.39	0.74	0.24	1.28	1.130	5.249	47.15	1.531	NP	0.46	0.68	1.27	1.21

a. ARA = Auxiliary Reactor Area, ATR Complex = Advanced Test Reactor Complex, CITRC = Critical Infrastructure Test Range Complex, INTEC = Idaho Nuclear Technology and Engineering Center MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, TAN-SMC = Test Area North-Specific Manufacturing Capability.

b. See Appendix C for explanation of terms.

c. N = Normal, G = Gamma, NP = Nonparametric.

Table 7-6. Soil Monitoring Results for the Central Facilities Area Sewage Treatment Facility Wastewater Reuse Permit Area (2007 and 2008).

Parameter	Depth (in.)	2007	2008
pH	0–12	8.05	8.21
	12–24	8.00	7.88
	24–36	8.09	8.00
Electrical conductivity (mmhos/cm)	0–12	1.221	0.722
	12–24	2.03	2.66
	24–36	1.95	2.20
Organic matter (%)	0–12	1.33	1.49
	12–24	0.774	0.874
	24–36	0.483	0.867
Nitrate as nitrogen (ppm)	0–12	3.18	1.16
	12–24	0.977 U[a]	0.996 U
	24–36	1.00 U	0.986 U
Ammonium nitrogen (ppm)	0–12	0.516	1.46
	12–24	0.489 U	0.498 U
	24–36	0.500 U	0.493 U
Extractable phosphorus (ppm)	0–12	9.05	11.2
	12–24	1.77	3.98
	24–36	1.19	2.84
Sodium adsorption ratio	0–12	3.79	4.06
	12–24	4.00	4.73
	24–36	3.69	3.48

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

Idaho Department of Environmental Quality guidance (DEQ 2007) states, “bacteria that decompose organic matter function best at a pH range between 6.5 and 8.5.” The 2008 soil pH for all soil depths were within this range (Table 7-6).

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 to have negligible effects on plant growth. The soil salinity levels at the 0-12-in. and 24-36-in. depths in the 2008 sample were below the 2-mmhos/cm level. The 2008 soil salinity level in the 12-24-in. depth was slightly above the 2-mmhos/cm level at 2.03 mmhos/cm.

Poor drainage is the most common cause of salt buildup in soils (Blaylock 1994). This can be expected due to the low volume of water applied to the Central Facilities Area Sewage Treatment Facility pivot application area. 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 the 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 10 are acceptable.”

The nitrogen data in Table 7-6 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 7-6 shows the phosphorus concentration well below the level of concern at 2.84 ppm.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures to ambient ionizing radiation. The TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. The 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 7-4). 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 2008 were from November 2007 through April 2008 (spring) and from May 2008 through October 2008 (fall).

The measured cumulative environmental radiation exposure for locations off the INL Site from November 2007 through October 2008 is shown in Table 7-7 for two adjacent sets of dosimeters maintained by the ESER and INL contractor. For purposes of comparison, annual exposures from 2004 to 2007 also are included for each location.

The mean annual exposures from distant locations in 2008 were 117 milliroentgens (mR) measured by the ESER contractor dosimeters and 120 mR measured by the INL contractor

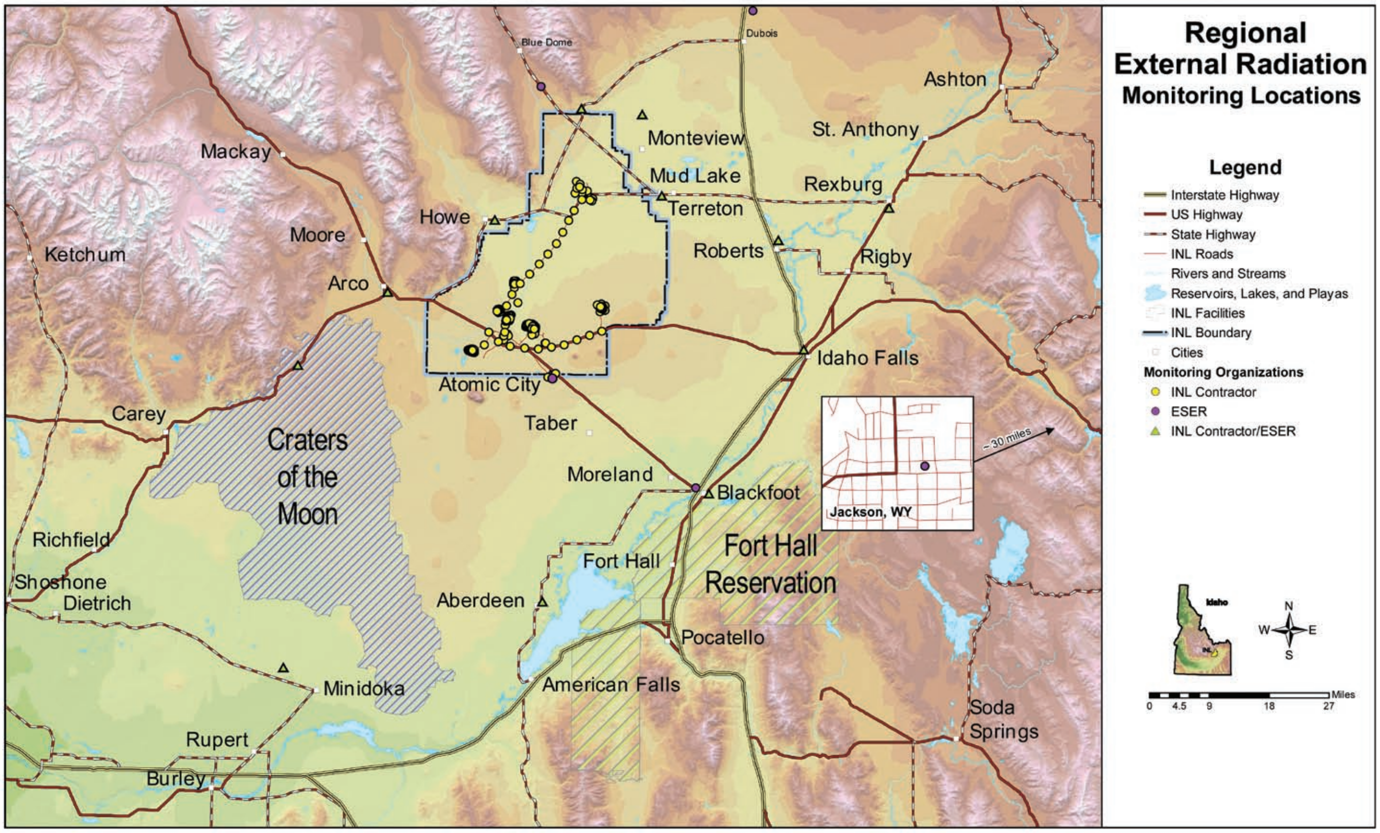


Figure 7-4. Regional Direct Radiation Monitoring Locations.

dosimeters (Table 7-7). For boundary locations, the mean annual exposures were also 117 mR measured by the ESER contractor dosimeters and 120 mR measured by the INL contractor dosimeters. Using both ESER and INL contractors' data, the average dose equivalent of the distant group was 122 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 also was 122 mrem.

Thermoluminescent dosimeters maintained on the INL Site by the INL contractor representing the same exposure period as the dosimeters off the INL Site are shown in Appendix F, Figures F-1 through F-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. At some facilities, elevated exposures result from soil contamination areas around the perimeter of these facilities.

The maximum exposure recorded on the INL Site during 2008 was 647 mR at a the Radioactive Waste Management Complex (RWMC). This location, RWMC 41, is near active waste storage and management areas. The exposure is lower than the previous year.

Table 7-7. Annual Environmental Radiation Exposures (2004–2008).

Location	2004		2005		2006		2007		2008	
	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor
	(mR ± 1 s)									
Distant Group										
Aberdeen	130 ± 9	127 ± 9	124 ± 7	130 ± 9	126 ± 9	124 ± 9	129 ± 6	127 ± 6	128 ± 9	132 ± 9
Blackfoot	N/A	109 ± 8	129 ± 9	113 ± 8	115 ± 8	104 ± 7	119 ± 6	109 ± 5	118 ± 8	111 ± 8
Blackfoot (CMS)[a]	108 ± 8	N/A	117 ± 2	N/A	106 ± 7	N/A	109 ± 5	N/A	110 ± 8	N/A
Craters of the Moon	118 ± 8	—[b]	138 ± 8	122 ± 8	111 ± 7	112 ± 8	120 ± 6	129 ± 6	116 ± 8	117 ± 8
Dubois[a]	105 ± 7	N/A	117 ± 5	N/A	95 ± 7	N/A	101 ± 5	N/A	100 ± 7	N/A
Idaho Falls	124 ± 9	114 ± 8	122 ± 2	116 ± 8	119 ± 8	110 ± 8	123 ± 2	119 ± 6	121 ± 8	117 ± 8
Jackson[a]	100 ± 7	N/A	106 ± 7	N/A	90 ± 6	N/A	97 ± 5	N/A	102 ± 7	N/A
Minidoka	108 ± 8	107 ± 7	116 ± 3	112 ± 8	107 ± 7	103 ± 7	109 ± 5	111 ± 5	109 ± 8	112 ± 8
Rexburg	137 ± 10	118 ± 8	152 ± 2	121 ± 8	134 ± 9	113 ± 8	145 ± 7	120 ± 6	135 ± 9	116 ± 8
Roberts	133 ± 9	132 ± 9	126 ± 11	N/A	126 ± 9	123 ± 9	137 ± 7	133 ± 7	129 ± 9	132 ± 9
Mean	118 ± 3	118 ± 3	121 ± 3	119 ± 3	113 ± 2	113 ± 3	119 ± 6	121 ± 6	117 ± 3	120 ± 3
Boundary Group										
Arco	124 ± 9	126 ± 9	124 ± 9	120 ± 8	115 ± 8	111 ± 8	127 ± 6	125 ± 6	119 ± 8	121 ± 8
Atomic City	132 ± 9	—[b]	123 ± 9	—[b]	119 ± 8	112 ± 8	129 ± 6	124 ± 6	126 ± 9	120 ± 8
Blue Dome[a]	104 ± 7	N/A	115 ± 8	N/A	101 ± 7	N/A	104 ± 5	N/A	106 ± 7	N/A
Howe	121 ± 8	114 ± 8	126 ± 9	116 ± 8	108 ± 8	105 ± 7	118 ± 6	120 ± 6	117 ± 8	116 ± 8
Monteview	119 ± 8	116 ± 8	109 ± 8	121 ± 8	110 ± 8	107 ± 7	115 ± 6	119 ± 6	115 ± 8	120 ± 8
Mud Lake	130 ± 9	133 ± 9	132 ± 9	130 ± 8	119 ± 8	120 ± 8	128 ± 6	132 ± 6	128 ± 9	129 ± 9
Birch Creek Hydro	112 ± 8	108 ± 8	110 ± 8	—[b]	104 ± 7	103 ± 7	111 ± 5	109 ± 5	110 ± 8	114 ± 8
Mean	120 ± 3	119 ± 4	120 ± 3	119 ± 4	111 ± 3	110 ± 3	119 ± 6	121 ± 6	117 ± 3	120 ± 3

a. The INL contractor does not sample at this location.
b. Dosimeter was missing at one of the collection times.

Locations ATR-Complex 2, 3, and 4 are adjacent to the former radioactive disposal ponds, which have been drained and covered with clean soil and large rocks. The levels at ATR-Complex 2 and 3 are less than one-fourth of the 2002 values (DOE-ID 2003).

The INTEC 20 TLD is near a radioactive material storage area with an annual exposure of 208 mR. Exposures at INTEC 20 and the INTEC Tree Farm for 2008 were comparable to historical exposures.

Table 7-8 summarizes the calculated effective dose equivalent an individual receives on the Snake River Plain from various 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 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr. Because snow cover can reduce the effective dose equivalent Idaho residents receive from the soil, a correction factor must be made each year to the estimated 76 mrem/yr. For 2008, this resulted in a corrected dose of 66 mrem/yr because of snow cover, which ranged from 2.54 to 50.8 cm (1 to 20 in.) deep over 117 days with recorded snow cover (Table 7-8).

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

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2008 was 114 mrem/yr (Table 7-8). This is slightly lower than the 122 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 (Table 7-7 and Table 7-8). 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 ^{238}U plus decay products are 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 the 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 7-8 for this component of the total background dose because no specific estimate for southeastern Idaho has been made and

Table 7-8. Calculated Effective Dose Equivalent from Background Sources (2008).

Source of Radiation Dose Equivalent		Total Average Annual Dose Calculated (mrem)	Total Average Annual Dose Measured (mrem)
External			
	Terrestrial	66	NA[a]
	Cosmic	48	NA
	Subtotal	114	122
Internal			
	Cosmogenic	1	
	Inhaled radionuclides	200	
	^{40}K and others	39	
	Subtotal	240	
Total		354	

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

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 may actually be higher or lower than the total estimated background dose of about 354 mrem/yr shown in Table 7-8 and will vary from one location to another.

7.4 Waste Management Surveillance Sampling

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

7.4.1 Vegetation Sampling

At RWMC, vegetation is collected from the four major areas shown in Figure 7-5. Russian thistle is collected in even-numbered years if available. Control samples are collected near Frenchman's Cabin (see Figure 7-6), which is approximately seven miles south of the Subsurface Disposal Area at the base of Big Southern Butte. Due to recontouring and construction activities at RWMC, Russian thistle was not available for sampling in 2008.

7.4.2 Soil Sampling

Soil samples are collected every three years at RWMC. Soil samples were collected during 2006; thus, no soil samples were collected at RWMC in 2008.

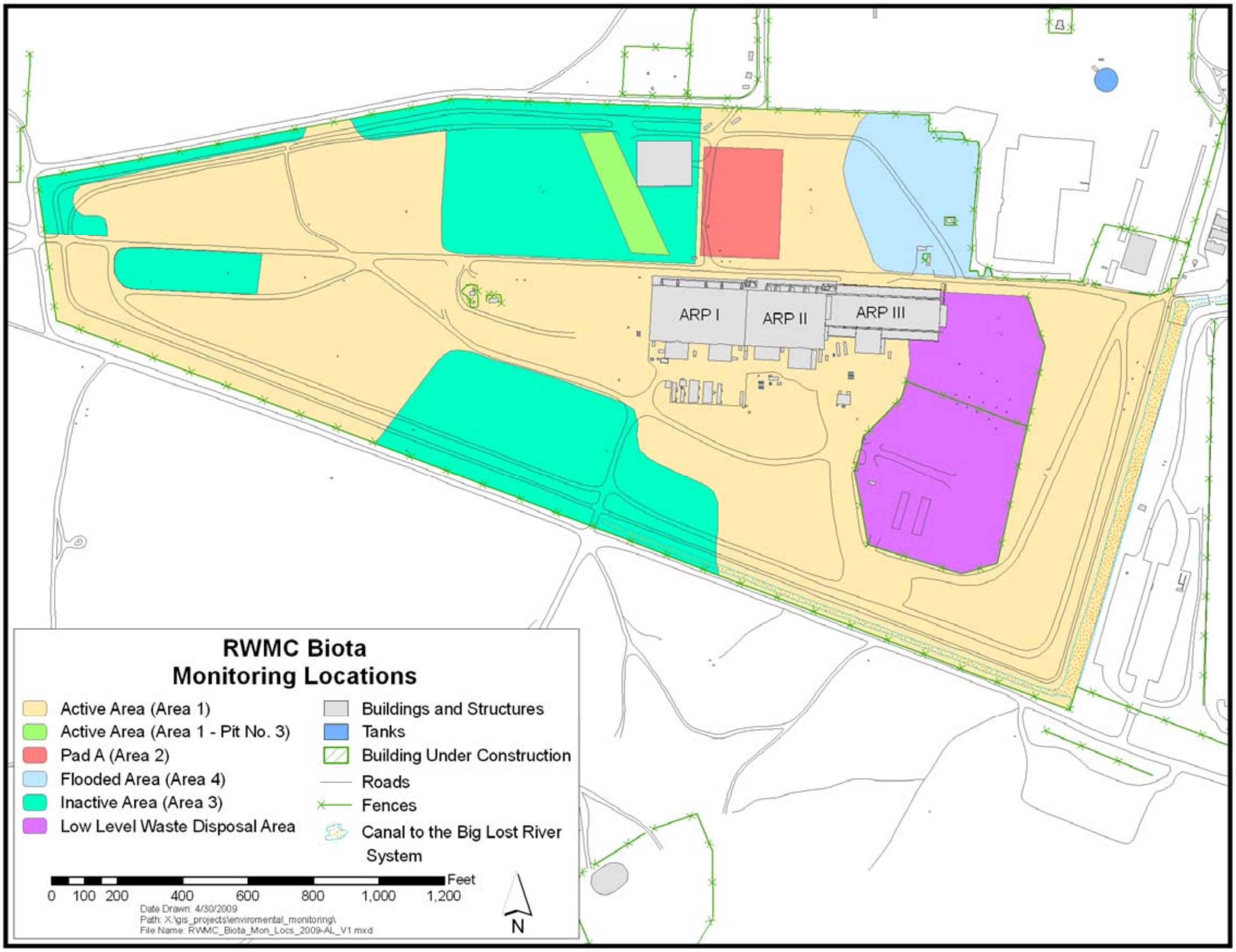


Figure 7-5. Radioactive Waste Management Complex Vegetation Sampling Locations (Areas 1–4).

7.4.3 Direct Radiation

The Global Positioning Radiometric Scanner was used to conduct soil surface radiation (gross gamma) surveys at the Subsurface Disposal Area to complement soil sampling. The radiometric scanner is mounted on a four-wheel drive vehicle. The system includes two plastic scintillators that measure gross gamma radiation in cps with no coincidence corrections or energy compensation (elevated count rates indicate possible areas of contamination or elevated background). Both Global Positioning System and radiometric data are continuously recorded.

Figure 7-7 shows the radiation readings from the 2008 RWMC annual survey. The maximum gross gamma radiation around the active low-level waste pit was 36,789 cps. The maximum gross gamma radiation on the remainder of the Subsurface Disposal Area was 5,462 cps measured at the western end of the SVR-7 soil vault row.

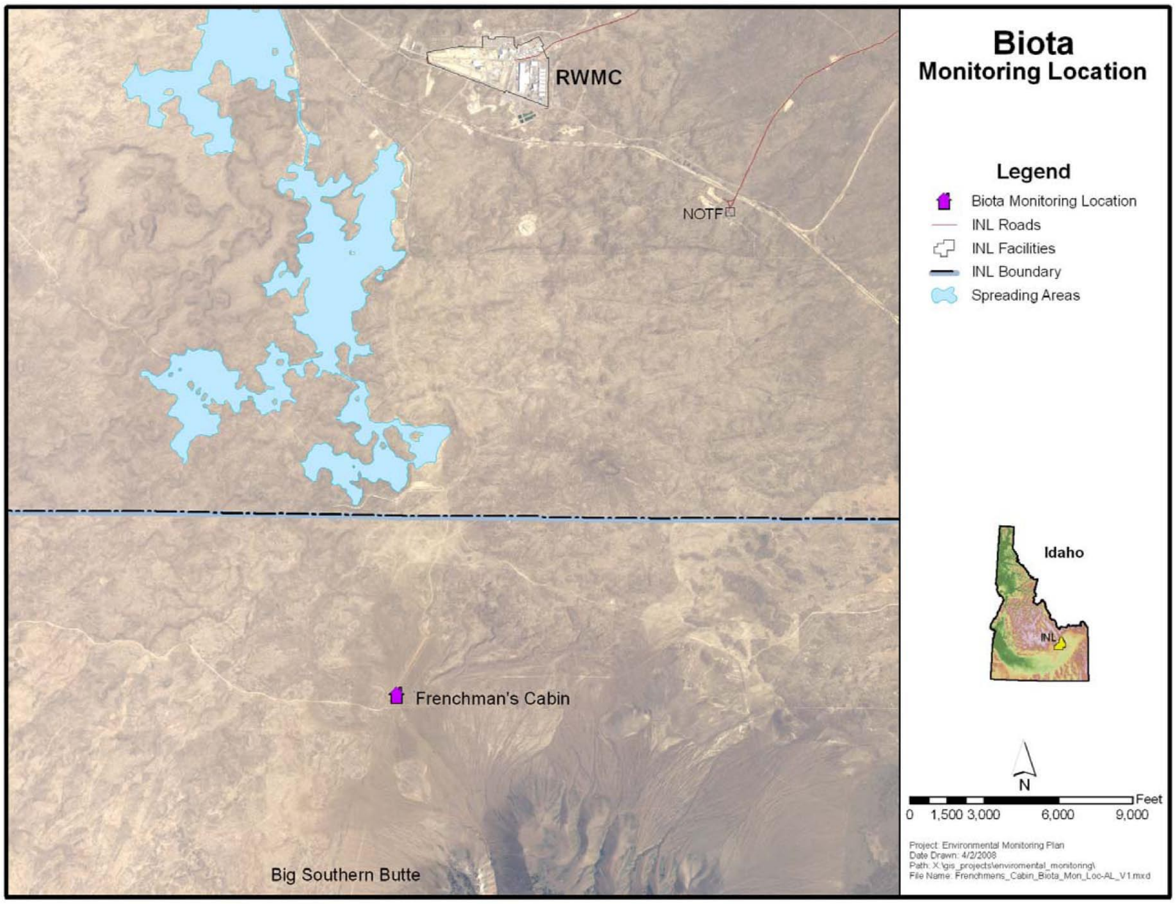


Figure 7-6. Vegetation Control Sampling Location at Frenchman's Cabin.

Although readings vary slightly from year to year, the results are comparable to previous years' measurements (see Table 7-9). In 2007, the active low-level waste pit measurements were higher than historical measurements due to waste handling activities. The 2008 results have returned to levels comparable to previous years.

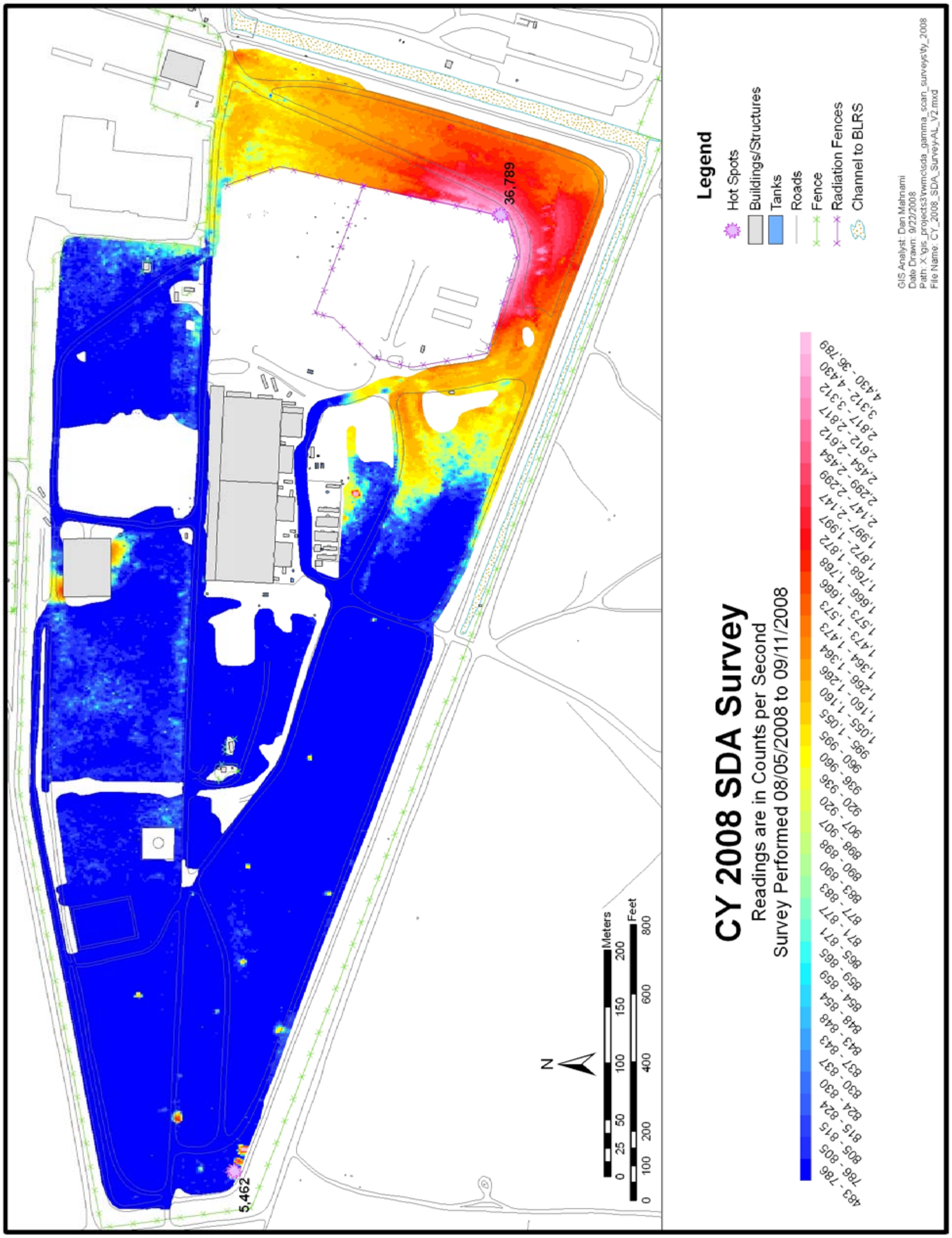


Figure 7-7. Vegetation Control Sampling Location at Frenchman's Cabin.

Table 7-9. Radioactive Waste Management Complex Survey Comparison to Previous Years.

Location	2003	2004	2005	2006	2007	2008
	(cps)					
Soil Vault Row-7	30,000	25,600	24,800	22,725	7,917	5,462
Active Pit	13,800	15,000	30,200	13,463	151,091	36,789

REFERENCES

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

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

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

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

DOE-ID, 2003, *Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar-Year 2002*, DOE/ID-12082 (02), U.S. Department of Energy Idaho Operations Office.

EPA, 1995, *Environmental Radiation Data Reports 79 82, July 1994-June 1995*, U.S. Environmental Protection Agency.

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

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

NRC, 1997, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50*, Appendix I, Regulatory Guide 1.109, Revision 1, Nuclear Regulatory Commission.

Swift, C. E., Ph.D., 1997, Salt Tolerance of Various Temperate Zone Ornamental Plants, Area Extension Agent, Colorado State University, http://www.coopext.colostate.edu/TRA/PLANTS/stable.html.

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

Chapter 8 - Dose to the Public and Biota

Chapter Highlights

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package-88PC 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 0.131 mrem (1.31 µSv), well below the applicable standard of 10 mrem (100 µSv).

The maximum potential population dose to the approximately 300,656 people residing within a 80 km (50-mi) radius of any INL Site facility was also evaluated using an air dispersion model developed by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division. For 2008, the estimated potential dose was 0.78 person-rem (7.8×10^{-3} person-Sv), or about 0.0007% of that expected from exposure to background radiation.

Using the maximum radionuclide concentrations in collected waterfowl and large game animals, a maximum potential dose from ingestion was calculated. The maximum potential dose was estimated to be 0.052 mrem (0.52 µSv) for waterfowl and 0.227 mrem (2.3 µSv) for game animals.

The potential dose to aquatic and terrestrial biota from contaminated soil and water was also evaluated, using a graded approach. Based on this approach, there is no evidence that INL Site related radiological contamination is having an adverse impact on plants or animal populations.

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 dose to members of the public and to the environment based on the 2008 radionuclide concentrations from operations at the Idaho National Laboratory (INL) Site.

8.1 General Information

The radiological dose to the public surrounding the INL Site is too small to be measured by available monitoring techniques. To comply with federal regulations established to ensure public safety, the dose from INL Site operations was calculated using the reported amounts of radionuclides released during the year from INL Site facilities (see Chapter 4) and appropriate air dispersion computer codes. During 2008, this dose was calculated for the radionuclides summarized in Table 4-2. Because the radionuclides that were released in the largest concentrations are noble gases, they contribute very little to the cumulative dose (affecting immersion only). Other than argon-41 (^{41}Ar) and tritium (^{3}H), the radionuclides contributing to the overall dose were 0.01 percent of the total radionuclides released.

The following estimates were made using the release data:

- The effective dose equivalent to the hypothetical maximally exposed individual (MEI), as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, using the Clean Air Act Assessment Package (CAP)-88PC, Version 3, computer code (EPA 2007). Before 2007, calculations were performed using CAP-88PC mainframe.
- The collective effective dose equivalent (population dose) for the population within 80 km (50 mi) of any INL Site facility using dispersion values from the mesoscale diffusion (MDIFF) model (Sagendorf et al. 2001) to comply with DOE Order 5400.5.

In this chapter, the term dose refers to effective dose equivalent unless another term is specifically stated. Dose was calculated by summing the effective dose equivalents from immersion, inhalation, ingestion, and deposition. Effective dose equivalent includes doses received from both external and internal sources and represents the same risk as if an individual's body were uniformly irradiated. The CAP-88PC computer code uses dose and risk tables developed by the U.S. Environmental Protection Agency (EPA). EPA dose conversion factors and a 50-year integration period were used in combination with the MDIFF air dispersion model output for population dose calculations for internally deposited radionuclides (Eckerman et al. 1988) and for radionuclides deposited on the ground surface (Eckerman and Ryman 1993). The CAP-88PC computer code does not include shielding by housing materials, but it does include a factor to allow for shielding by surface soil contours from radioactivity on the ground surface. No allowance is made in the dose calculations using MDIFF for shielding by housing materials, which is estimated to reduce the dose by about 30 percent, or less than year-round occupancy in the community.

Of the potential exposure pathways by which radioactive materials from INL Site operations could be transported offsite (Figure 3-1), atmospheric transport is the principal potential pathway for exposure to the surrounding population. This is because winds can carry airborne radioactive material rapidly and some distance from its source. The water pathways are not considered major contributors to dose because no surface water flows off the INL Site and no radionuclides from the INL Site have been found in drinking water wells offsite. Because of these factors, doses are determined using computer codes that model atmospheric dispersion of airborne materials.

8.2 Maximum Individual Dose

The NESHAP 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 CFR 61, Subpart H). This includes releases from stacks and diffuse sources. EPA requires using an approved computer code to demonstrate compliance with 40 CFR 61. The INL Site uses Clean Air Act Assessment Package (CAP)-88PC, Version 3 (EPA 2007), to demonstrate NESHAP compliance.

The dose from INL Site airborne releases of radionuclides calculated to demonstrate compliance with NESHAP are published in the *National Emissions Standards for Hazardous Air Pollutants-Calendar Year 2008 INL Report for Radionuclides* (DOE-ID 2009). For these calculations, 63 potential maximum locations were evaluated. The CAP-88PC computer code predicted the highest dose to be at Frenchman's Cabin, located at the southern boundary of the INL Site (Figure 7-6). This location is inhabited only during portions of the year, but it must be considered as a potential MEI location according to NESHAP. At Frenchman's Cabin, an effective dose equivalent of 0.131 mrem (1.31 μSv) was calculated in 2008 (Table 8-1). Table 8-1 compares the doses calculated for 2004 through 2008. As Table 8-1 shows, 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.

8.3 Eighty Kilometer (50 Mile) Population Dose

The National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division (NOAA ARL-FRD) developed a mesoscale air dispersion model called MDIFF (formerly known as MESODIF) (Sagendorf et al. 2001) around 1970. The MDIFF diffusion curves were developed by the NOAA ARL-FRD from tests in arid environments (e.g., the INL Site and the Hanford Site in eastern Washington). The MDIFF code is a dispersion model only and does not account for plume depletion and radioactive decay.

Table 8-1. Comparison of Effective Dose Equivalents (2004–2008).

Year	Effective Dose Equivalent (mrem)
2004	0.044
2005	0.077
2006	0.039
2007	0.093
2008	0.131

Using data gathered continuously at 35 meteorological stations on and around the INL Site and the MDIFF model, the NOAA ARL-FRD prepared a mesoscale map (Figure 8-1) showing the calculated 2008 time integrated concentrations (TICs). These TICs were based on a unit release rate weighted by percent contribution for each of six INL Site facilities: Advanced Test Reactor (ATR) Complex, Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN). To create the isopleths shown in Figure 8-1, the TIC values were contoured. Average air concentrations (in curies per cubic meter [Ci/m^3]) for a radionuclide released from a facility are estimated from a TIC isopleth (line of equal air concentration) in Figure 8-1. To calculate the average air concentration, the TICs were multiplied by the quantity of the radionuclides released (in curies [Ci]) during the year and divided by the number of hours in a year squared (8,760 hour)^2 or 7.67 x 107 hour^2. This estimate does not account for plume depletion, radioactive decay, or in-growth or decay of radioactive progeny; therefore, the calculated doses are overestimated.

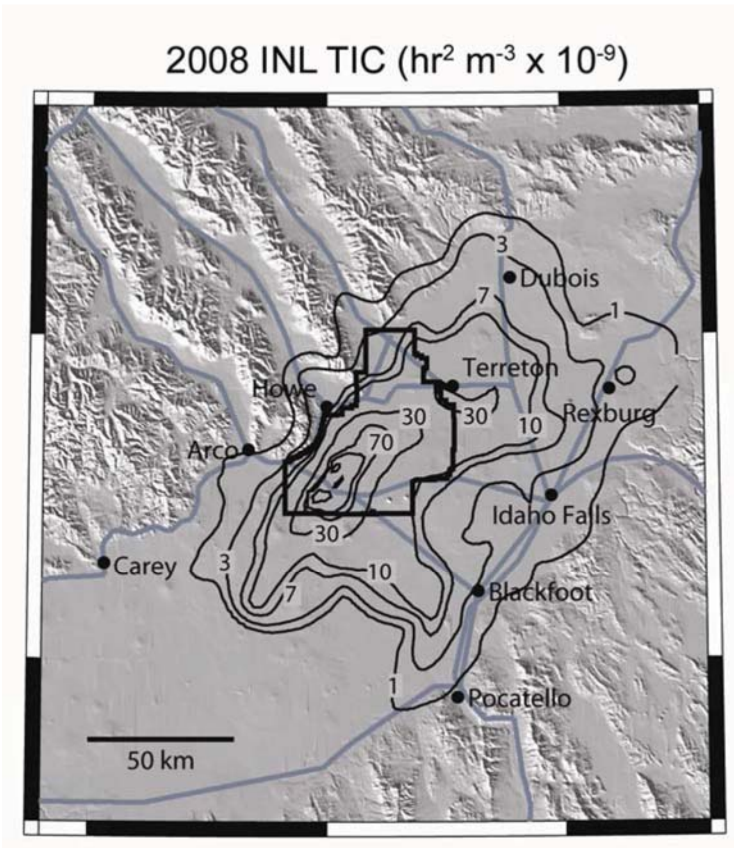


Figure 8-1. INL Site Time Integrated Concentrations (hr^2 m^{-3} x 10^{-9}) (2008).

The average air concentrations calculated by MDIFF were input into a Microsoft Excel spreadsheet program developed by the Environmental Surveillance, Education and Research Program to calculate doses using Nuclear Regulatory Commission methods (NRC 1977) and EPA dose conversion factors (EPA 2002). The collective effective dose equivalent, or population dose, was estimated from inhalation, submersion, ingestion, and deposition resulting from airborne releases of radionuclides from the INL Site. This collective dose included all members of the public within 80 km (50 mi) of any INL Site facility reported to release airborne radionuclides. The population dose was calculated in a spreadsheet program that multiplies the average TIC for the county census division (in hours squared per cubic meter [hr^2/m^3]) by the population in each census division within that county division and the normalized dose received at the MEI location (in rem per year per hour squared per meter cubed [$rem/yr/hr^2/m^3$]). This calculation gives an approximate dose received by the entire population in a given census division (Table 8-2).

The dose received per person is calculated by dividing the collective effective dose equivalent by the population in that particular census division. This calculation overestimates dose because the model conservatively does not account for radioactive decay of the isotopes during transport over distances greater than the distance from each facility to the residence of the MEI located northwest of Mud Lake. Idaho Falls, for example, is about 50 km (31 mi) from the nearest facility (MFC) and 80 km (50 mi) from the farthest. The calculation also tends to overestimate the population doses because they are extrapolated from the dose computed for the location of the potential MEI. This individual is potentially exposed through ingestion of contaminated leafy garden vegetables grown at that location.

The 2008 MDIFF TICs used for calculating the population dose within each county division were obtained by averaging the results from appropriate census divisions within those county divisions. The total population dose is the sum of the population doses for the various county divisions (Table 8-2). The estimated potential population dose was 0.78 person-rem (7.8×10^{-3} person-Sv) to a population of approximately 300,656. When compared with an approximate population dose of 106,432 person-rem (1,064 person-Sv) from natural background radiation, this represents an increase of only about 0.0007 percent. The largest collective doses are in the Idaho Falls and Pocatello census divisions due to their greater populations and in areas in the northern portion of the grid (Rexburg, Rigby, and Hamer).

The largest contributor to the dose was plutonium-241 [^{241}Pu] at 42 percent of the total dose (Figure 8-2). In addition, strontium-90 [^{90}Sr], plutonium-239 [^{239}Pu], americium-241 [^{241}Am], cesium-137 (^{137}Cs), and iodine-129 (^{129}I) contributed to the dose, and their percentages are shown in Figure 8-2.

Table 8-3 shows the contribution to the dose by facility. For 2008, TAN contributed 89 percent to the dose.

Table 8-4 summarizes the annual effective dose equivalents for 2008 from INL Site operations calculated and population. A comparison is shown between these doses and the EPA airborne pathway standard and the estimated dose from natural background.

Table 8-2. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2008).

Census Division[a]	Population[b]	Population Dose: Person-rem	Population Dose: Person-Sv
Aberdeen	3,514	1.69×10^{-3}	1.69×10^{-5}
Alridge	775	1.72×10^{-4}	1.72×10^{-6}
American Falls	4,055	7.97×10^{-4}	7.97×10^{-6}
Arbon (part)	32	1.15×10^{-6}	1.15×10^{-8}
Arco	2,387	5.14×10^{-2}	5.14×10^{-4}
Atomic City (division)	3,906	4.45×10^{-2}	4.45×10^{-4}
Blackfoot	13,556	2.63×10^{-2}	2.63×10^{-4}
Carey (part)	1,329	2.23×10^{-3}	2.23×10^{-5}
East Clark	75	1.63×10^{-4}	1.63×10^{-6}
Firth	3,610	5.28×10^{-3}	5.28×10^{-5}
Fort Hall (part)	1,933	2.02×10^{-3}	2.02×10^{-5}
Hailey-Bellevue (part)	6	1.47×10^{-10}	1.47×10^{-12}
Hamer	2,371	7.48×10^{-2}	7.48×10^{-4}
Howe	353	1.00×10^{-2}	1.00×10^{-4}
Idaho Falls	83,395	1.46×10^{-1}	1.46×10^{-3}
Idaho Falls, west	1,862	9.48×10^{-3}	9.48×10^{-5}
Inkom (part)	614	3.07×10^{-4}	3.07×10^{-6}
Island Park (part)	86	1.85×10^{-4}	1.85×10^{-6}
Leadore (part)	3	8.25×10^{-8}	8.25×10^{-10}
Lewisville-Menan	4,451	2.58×10^{-2}	2.58×10^{-4}
Mackay (part)	1,153	5.16×10^{-6}	5.16×10^{-8}
Moody (part)	5,545	7.09×10^{-3}	7.09×10^{-5}
Moreland	9,955	6.32×10^{-2}	6.32×10^{-4}
Pocatello (part)	83,847	1.12×10^{-1}	1.12×10^{-3}
Rexburg (part)	23,464	6.05×10^{-2}	6.05×10^{-4}
Rigby	14,709	5.29×10^{-2}	5.29×10^{-4}
Ririe	1,591	1.05×10^{-3}	1.05×10^{-5}
Roberts	1,784	1.57×10^{-2}	1.57×10^{-4}
Shelley	7,561	1.48×10^{-2}	1.48×10^{-4}
South Bannock (part)	313	3.91×10^{-4}	3.91×10^{-6}
St. Anthony (part)	2,357	6.06×10^{-3}	6.06×10^{-5}
Sugar City	6,274	2.31×10^{-2}	2.31×10^{-4}
Swan Valley (part)	5,538	6.82×10^{-4}	6.82×10^{-6}
Ucon	6,695	2.01×10^{-2}	2.01×10^{-4}
West Clark	1,557	4.86×10^{-3}	4.86×10^{-5}
Total	**300,656**	**0.784**	**7.84×10^{-3}**

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

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

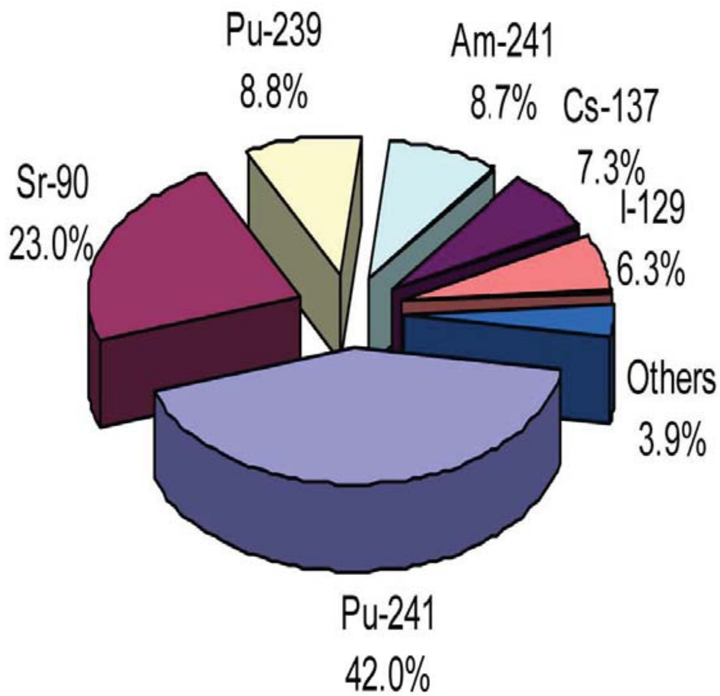


Figure 8-2. Radionuclides Contributing to Dose to Maximally Exposed Individual (as calculated using the MDIFF air dispersion model) (2008).

Table 8-3. Contribution to Dose to Maximally Exposed Individual by Facility (2008).

Facility	% of Dose to Maximally Exposed Individual
Test Area North	89
Idaho Nuclear Technology and Engineering Center	5.5
Radioactive Waste Management Complex	4
Advanced Test Reactor Complex	<2
Naval Reactors Facility, Materials and Fuels Complex, Central Facilities Area	0.02

Table 8-4. Summary of Annual Effective Dose Equivalents from INL Site Operations (2008).

	Maximum Dose to an Individual[a] CAP-88PC[b]	Population Dose MDIFF
Dose	0.131 mrem (1.3×10^{-3} mSv)	0.78 person-rem (7.8×10^{-3} person-Sv)
Location	Frenchman's Cabin	Area within 80 km (50 mi) of any INL Site facility
Applicable radiation protection standard[c]	10 mrem (0.1 mSv)	No standard
Percentage of standard	1.31%	No standard
Natural background	354 mrem (3.5 mSv)	106,432 person-rem (1,064 person-Sv)
Percentage of background	0.04%	0.0007%

a. Hypothetical dose to the maximally exposed individual residing near the INL Site.

b. Effective dose equivalent calculated using CAP-88PC, Version 3 (EPA 2007).

c. Although the DOE standard for all exposure models is 100 mrem/yr as given in DOE Order 5400.5, DOE guidance states that DOE facilities will comply with the EPA standard for the airborne pathway of 10 mrem/year.

The calculated maximum dose resulting from INL Site operations (0.784 person-rem) is still a small fraction (0.0007 percent) of the average dose received by individuals in southeastern Idaho from cosmic and terrestrial sources of naturally occurring radiation in the environment. The total annual dose to this population from all natural sources is estimated at approximately 106,432 person-rem (Table 8-1).

8.4 Individual Dose—Game Ingestion Pathway

The potential dose an individual may receive from occasionally ingesting meat from game animals continues to be investigated at the INL Site. Such studies include the potential dose to individuals who may eat (1) waterfowl that reside briefly at wastewater disposal ponds at ATR Complex and MFC that are used for the disposal of low-level radioactive wastes and (2) game birds and game animals that may reside on or migrate across the INL Site.

8.4.1 Waterfowl

In 2008, four ducks were collected from the ATR Complex wastewater ponds, three from MFC wastewater ponds, and two from off the INL Site (Mud Lake) as controls. No waterfowl were collected from INTEC in 2008 because none were present during the collection attempts. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2008 is presented in Table 8-5. Radionuclide concentrations used to determine these doses are reported in Table 7-4. Doses from consuming waterfowl are based on the assumption that ducks are eaten immediately after leaving the ponds.

The maximum potential dose of 0.052 mrem (0.52 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). The ducks were not collected directly from the hypalon-lined radioactive wastewater ponds but from the adjacent sewage lagoons. However, they likely used the radioactive wastewater ponds while they were in the area.

8.4.2 Big Game Animals

A conservative estimate of 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 estimated at 2.7 mrem in a study on the INL Site from 1976 to 1986 (Markham et al. 1982). Game animals collected at the INL Site during the past few years have shown much lower concentrations of radionuclides. As noted in Chapter 7, however, a mule deer collected near RWMC had the

Table 8-5. Maximum Annual Potential Dose From Ingesting Tissue of Waterfowl Using INL Site Wastewater Disposal Ponds in 2008.[a]

Radionuclide	ATR Complex Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
^{241}Am	4.54×10^{-2}	0	0
^{60}Co	2.29×10^{-4}	0	0
^{137}Cs	5.87×10^{-3}	0	0
^{238}Pu	0	0	2.32×10^{-2}
$^{239/240}Pu$	0	0	2.82×10^{-3}
^{90}Sr	1.97×10^{-3}	0	0
^{65}Zn	9.03×10^{-4}	0	0
Total Dose	**5.15×10^{-2}**	**0**	2.60×10^{-2}

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

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

highest ^{137}Cs concentrations detected since 1988. Based on the ^{137}Cs concentrations in the muscle and liver of this game animal, the potential dose from consuming the above quantities of muscle and liver was approximately 0.227 mrem (2.3 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.

8.5 Biota Dose Assessment

8.5.1 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 (ISCORS 2004). The graded approach evaluates the impacts of a given set of radionuclides on aquatic and terrestrial ecosystems by comparing available concentration data in soils and water with biota concentration guides. A biota concentration guide is defined as 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/day (10 mGy/day) to aquatic animals or terrestrial plants or 0.1 rad/day (1 mGy/day) to terrestrial animals. If the sum of the measured 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.

The approach is graded because it begins the evaluation using conservative default assumptions and maximum values for all currently available data. 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. Several specific steps for adding progressively more realistic model assumptions are recommended. After applying the recommended changes at each step, if the combined sum of fractions is still greater than one, the graded approach recommends evaluating the next step. The steps can be summarized as:

- Consider using mean concentrations of radionuclides rather than maxima
- Consider refining the evaluation area
- Consider using site-specific information for lumped parameters, if available
- Consider using a correction factor other than 100 percent for residence time and spatial usage in favor of more realistic assumptions
- Consider developing and applying more site-specific information about food sources, uptake, and intake

- Conduct a complete site-specific dose analysis. This may be a large study, measuring or calculating doses to individual organisms, estimating population level impacts, and, if doses greater than the limits are present, culminating in recommendations for mitigation.

Each step of this graded approach requires appropriate justification before it can be applied. For example, before using the mean concentration, assessors must discuss why the maximum concentration is not representative of the radionuclide concentration to which most members of the plant or animal population are exposed.

Evaluations beyond the initial general screening require assessors to make decisions about assessment areas, organisms of interest, and other factors. Of particular importance for the terrestrial evaluation portion of the 2008 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types (Figure 8-3). Details and justification are provided in Morris (2003).

The graded approach (DOE 2002) and RESRAD-Biota (DOE 2004; ISCORS 2004) are designed to evaluate certain common radionuclides. Thus, this biota dose assessment evaluated potential doses from radionuclides detected in soil or water on the INL Site that are also included in the graded approach (Table 8-6).

8.5.2 Aquatic Evaluation

For the aquatic evaluation, maximum pond water and effluent data were used. Effluent data are assumed to overestimate actual pond water concentrations because of dilution in the larger volume of the pond. In the absence of measured pond sediment concentrations, the software calculates sediment concentrations based on a conservative sediment distribution coefficient. The highest available radionuclide-specific concentrations detected in 2008 were for ^{90}Sr in the ATR Cold Waste Pond, tritium in CFA effluents, and uranium-233, 234 (^{233,234}U) (assumed conservatively to be ^{234}U), ^{235}U, and ^{238}U in the MFC Industrial Waste Pond (Table 8-7). These data were combined in a Site-wide general screening analysis. The combined sum of fractions was less than one (0.0137) and passed the general screening test (see Morris 2003 for a detailed description of the assessment procedure).

8.5.3 Terrestrial Evaluation

For the initial terrestrial evaluation, maximum concentrations from the INL Site contractors' 2006 soil sampling were used (see Morris 2003 for a detailed description of the assessment procedure). The combined sum of fractions was less than one (0.0427) and passed the general screening test (Table 8-8).

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

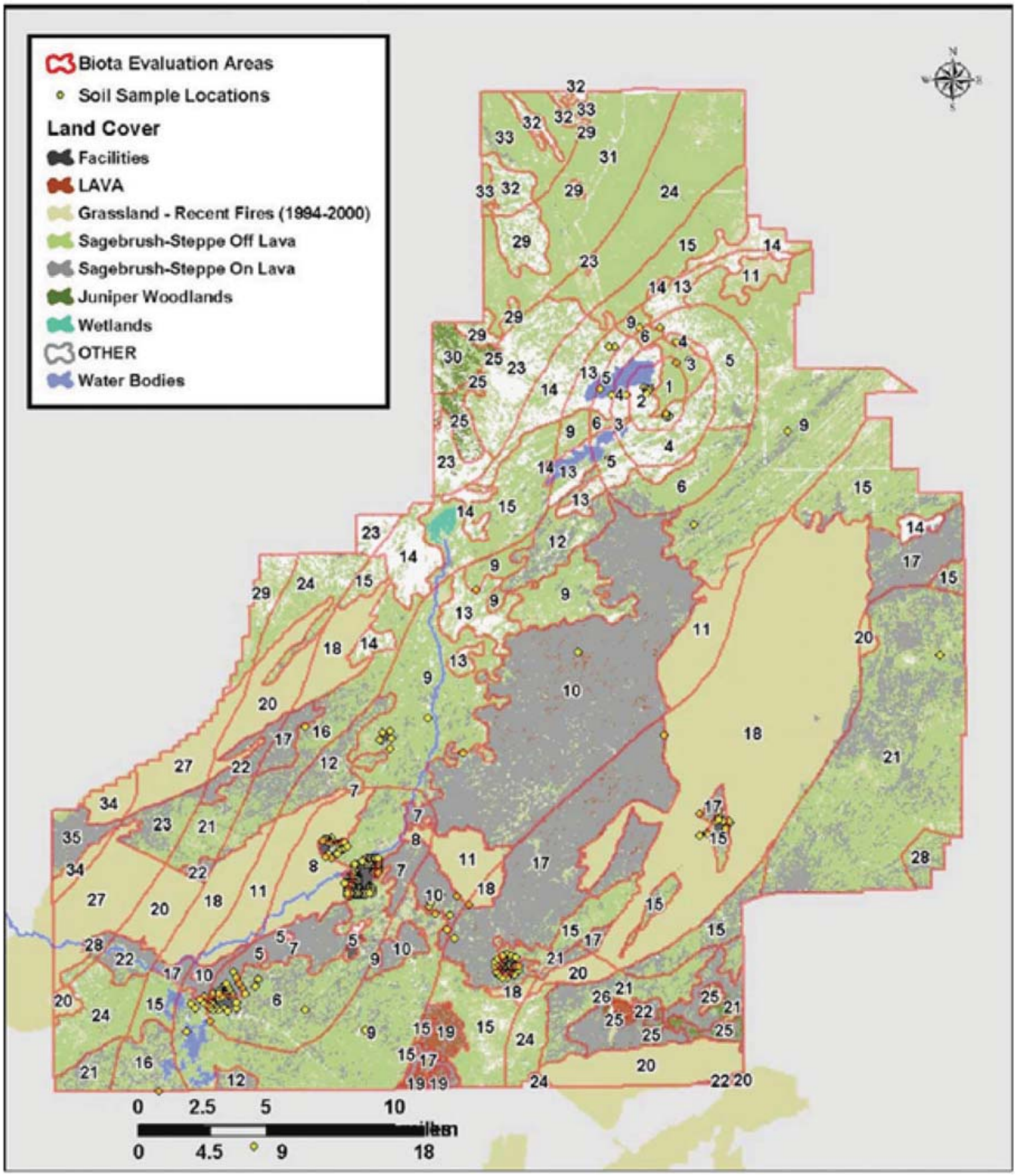


Figure 8-3. Evaluation Areas and Current Soil Sampling Locations on the INL Site. (Areas with the same number are in the same evaluation area.) (Morris 2003).

Table 8-6. Radionuclides That Can Currently be Evaluated Using the Graded Approach (DOE 2002).

Graded Approach	Detected
^{241}Am[a]	**^{241}Am**
^{144}Ce	**^{60}Co**
^{135}Cs	**^{137}Cs**
^{137}Cs	**^{3}H**
^{60}Co	**^{129}I**
^{154}Eu	**$^{239/240}$Pu**[b]
^{155}Eu	**^{226}Ra**
^{3}H	**^{90}Sr**
^{129}I	**^{232}Th**
^{131}I	**$^{233/234}$U**[c]
^{239}Pu	**^{235}U**
^{226}Ra	**^{238}U**
^{228}Ra	
^{125}Sb	
^{90}Sr	
^{99}Tc	
^{232}Th	
^{233}U	
^{234}U	
^{235}U	
^{238}U	
^{65}Zn	
^{95}Zr	

a. Radionuclides in **bold type** are present in both lists and were included in this assessment.
b. Analyzed as ^{239}Pu.
c. Analyzed as ^{233}U.

Table 8-7. Biota Dose Assessment of Aquatic Ecosystems on the INL Site (2008).

Radionuclide	Effluent Concentration (pCi/L)	Water BCG[a] (pCi/L)	Partial Fraction[b]	Sediment Concentration[c] (pCi/g)	Sediment BCG (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
			First Screening[f]				
^{3}H	4.02×10^{3}	4.99×10^{9}	8.05×10^{-7}	0.00402	7.04×10^{6}	0	8.05×10^{-7}
^{90}Sr	1.29	5.39×10^{4}	2.39×10^{-5}	0.0387	3.52×10^{4}	0	2.39×10^{-5}
^{234}U	1.7	202	8.43×10^{-3}	0.085	3.08×10^{6}	0	8.43×10^{-3}
^{235}U	0.227	217	1.04×10^{-3}	0.01135	1.05×10^{5}	0	1.04×10^{-3}
^{238}U	0.933	223	4.18×10^{-3}	0.04665	4.28×10^{4}	1.09×10^{-6}	4.18×10^{-3}
						Combined Sum of Fractions[g]	**1.37×10^{-2}**

a. Biota concentration guide for aquatic animal.
b. Effluent concentration/water BCG.
c. Calculated by the RESRAD-BIOTA software (DOE 2004) based on the effluent concentration.
d. Calculated sediment concentration/sediment BCG.
e. Sum of the partial fractions.
f. See the text for the rationale for the various screenings.
g. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

Table 8-8. Biota Dose Assessmemt of Terrestrial Ecosystems on the INL Site (2008).

Radionuclide	Effluent Concentration (pCi/L)	Water BCG[a] (pCi/L)	Partial Fraction[b]	Soil Concentration (pCi/g)	Soil BCG[a] (pCi/g)	Partial Fraction[c]	Sum of Fractions[d]
^{137}Cs	0	5.99×10^{6}	0	0.664	20.8	3.2×10^{-2}	3.2×10^{-2}
^{3}H	4.02×10^{3}	2.31×10^{8}	1.74×10^{-5}	0	1.74×10^{5}	0	1.74×10^{-5}
^{90}Sr	1.29	5.45×10^{4}	2.37×10^{-5}	0.241	22.5	1.07×10^{-2}	1.07×10^{-2}
^{234}U	1.7	4.04×10^{5}	4.21×10^{-6}	0	5.13×10^{3}	0	4.21×10^{-6}
^{235}U	0.227	4.19×10^{5}	5.41×10^{-7}	0	2.77×10^{3}	0	5.41×10^{-7}
^{238}U	0.933	4.06×10^{5}	2.3×10^{-6}	0	1.58×10^{3}	0	2.3×10^{-6}
						Combined Sum of Fractions[e]	**4.27×10^{-2}**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Soil concentration/soil BCG.
d. Sum of the partial fractions.
e. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

REFERENCES

40 CFR 61, 2008, "National Emission Standards for Hazardous Air Pollutants," *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.

Chew, E. W. and R. G. Mitchell, 1988, *1987 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082(87), U.S. Department of Energy Idaho Operations Office.

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

DOE, 2004, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*, DOE/EH-0676, U.S. Department of Energy.

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

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

DOE-ID, 2009, *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2008 INL Report for Radionuclides*, DOE/ID 10890(09), U.S. Department of Energy Idaho Operations Office.

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

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

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

EPA, 2007, *Clean Air Act Assessment Package-1988 (CAP88-PC)*, Version 3.0, http://www.epa.gov/radiation/assessment/CAP88/index.html, updated December 9, 2007, Web page visited July 13, 2009, U.S. Environmental Protection Agency.

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

Hoff, D. L., E. W. Chew, and S. K. Rope, 1987, *1986 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082(86), U.S. Department of Energy Idaho Operations Office.

Hoff, D. L., R. G. Mitchell, and R. Moore, 1989, *1988 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082(88), U.S. Department of Energy Idaho Operations Office.

ISCORS, 2004, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*, ISCORS Technical Report 2004-02, DOE/EH-0676, National Technical Information Service, available from http://homer.ornl.gov/oepa/public/bdac/.

Lewellen, W. S., R. I. Sykes, S. F. Parker, and F. C. Kornegay, 1985, *Comparison of the 1981 INEL Dispersion Data with Results from a Number of Different Models*, NUREG/CR-4159, U.S. Nuclear Regulatory Commission.

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

Morris, R. C., 2003, *Biota Dose Assessment Guidance for the INL*, NW ID 2003-062, North Wind Inc.

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

Sagendorf, J. F. and J. E. Fairobent, 1986, *Appraising Atmospheric Transport and Diffusion Models for Emergency Response Facilities*, NUREG/CR-4603, U.S. Nuclear Regulatory Commission.

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

Start, G. E., J. H. Cate, J. F. Sagendorf, G. R. Ackerman, C. R. Dickson, N. H. Hukari, and L. G. Thorngren, 1985, *1981 Idaho Field Experiment, Volume 3*, "Comparison of Trajectories, Tracer Concentration Patterns and MESODIF Model Calculations," NUREG/CR-3488, Vol. 3, U.S. Nuclear Regulatory Commission.

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

Chapter 9 - Ecological Research at the Idaho National Environmental Research Park

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 2008, 13 ecological research projects were conducted on the Idaho NERP:

- Determining Greater Sage-grouse Abundance and Patterns of Landscape Use on the Idaho National Laboratory Site
- Development and Evaluation of a Monitoring Program for Pygmy Rabbits
- Minimizing Risk of Cheatgrass Invasion and Dominance at the Idaho National Laboratory
- Plant Community Classification and Mapping at the Idaho National Laboratory
- Landscape Genetics of Great Basin Rattlesnakes, *Crotalus oreganos lutosus*, on the Upper Snake River Plain
- Historical Fire Regimes of Wyoming and Basin Big Sagebrush Steppe on the Snake River Plain
- 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
- Developing a Habitat Selection Model to Predict the Distribution and Abundance of the Sagebrush Defoliator Moth (*Aroga websteri* Clarke)
- Long-Term Vegetation Transects
- The Protective Cap/Biobarrier Experiment
- The Influence of Precipitation, Vegetation, and Soil Properties on the Ecohydrology of the Eastern Snake River Plain

- Common Raven, *Corvus corax*, Abundance in Relation to Anthropogenic Resources and Potential Impact to Greater Sage-grouse (*Centrocercus urophasianus*) Occurring on the Idaho National Laboratory Site, a Preliminary Analysis

9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

The Idaho National Laboratory (INL) Site 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 to preserve 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 NERPs:

- Develop methods for assessing and documenting the environmental consequences of human actions related to energy development
- Develop methods for predicting the 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.

NERPs 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 NERPs 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 before NERPs 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, the Protective Cap/Biobarrier Experiment was initiated, which evaluates the long-term performance of evapotranspiration caps and biological intrusion barriers.

The Idaho NERP provides coordination of ecological research and information exchange at the INL Site. It facilitates ecological research on the INL Site by attracting new researchers, providing background data for new research projects, and assisting researchers to obtain access to the INL Site. The Idaho NERP provides infrastructure support to ecological researchers through the Experimental Field Station and reference specimen collections. The Idaho NERP tries to foster cooperation and research integration by encouraging researchers to collaborate, develop interdisciplinary teams to address more complex problems, encourage data sharing, and leveraging funding across projects to provide more efficient use of resources. It is also integrates research results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho NERP has developed a centralized ecological database to provide an archive for ecological data and to facilitate retrieval of data for new research projects and land management decisions. It also provides interpreted 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.

During 2008, 13 ecological research projects were conducted on the Idaho NERP. The thirteen projects include nine graduate student research projects, with students and faculty researchers from Idaho State University, University of Idaho, Boise State University, University of Montana, and University of Nevada Reno. Five of these graduate students receive 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.

Nine of the 13 projects were funded in whole or part by DOE-ID through the Environmental, Surveillance, Education, and Research Program. Other funding sources included U.S. Department of the Interior, U.S. Department of Defense, National Science Foundation, Idaho Department of Fish and Game, Idaho State University, University of Idaho, Nevada Agricultural Experiment Station, American Museum of Natural History, Inland Northwest Research Alliance, and the National Center for Airborne Laser Mapping.

Most of the DOE-ID-funded research, and much of the research funded by other agencies addresses conservation planning issues on the INL Site. These issues include preparing for potential Endangered Species Act listings, understanding wildland fire effects, minimizing invasive species impacts, long-term trends in plant community composition, sagebrush health, and potential effects of climate change.

The following are summaries of the 13 ecological research projects.

9.1 Determining Greater Sage-grouse Abundance and Patterns on Landscape use on the Idaho National Laboratory Site

Investigators and Affiliations

Scott Bergen, Ph.D., Wildlife Conservation Society, North America Program-Lost River Sinks Project, 120 Technology Drive, Idaho Falls, Idaho

Kristy Howe, M.S. Candidate, Idaho State University, Wildlife Conservation Society, North America Program-Lost River Sinks Project, 120 Technology Drive, Idaho Falls, Idaho

Adam Narish, M.S. Candidate, Boise State University, Wildlife Conservation Society, North America Program-Lost River Sinks Project, 120 Technology Drive, Idaho Falls, Idaho

Funding Sources

U. S. Department of Energy-Idaho Operations Office

Background

Greater sage-grouse (*Centrocercus urophasianus*) have been studied on the INL Site since the mid-1970s (Connelly 1982). Sage-grouse have been recorded at lek locations in March, April, and/or May over separate periods between 1977 and 2001, usually by the state of Idaho Fish and Game Department personnel. Sage-grouse have received increasing attention from state and federal entities as their numbers have decreased (Connelly et al. 2004; Idaho Sage-grouse Advisory Committee 2006). Currently, sage-grouse are being reconsidered for listing as a threatened or endangered species. The U.S. Fish and Wildlife Service was due to submit a decision on December 4, 2008, but the decision has been delayed until June 2009 to consider new scientific information to make this decision.

If the sage-grouse is listed under the Endangered Species Act, the U.S. Fish and Wildlife Service would be required to prepare a Biological Assessment and a Biological Opinion for any new project at the INL Site. Also, the U.S. Fish and Wildlife Service would be required to review ongoing and maintenance activities for their potential to impact the protected species. In addition, the U.S. Fish and Wildlife Service would be required to develop a Conservation Agreement to establish guidelines for ongoing and maintenance activities, as well as to establish a conservation plan for the sage-grouse on the INL Site.

Possibly, the status review would result in finding that the sage-grouse be considered as a “candidate” for listing rather than as either threatened or endangered. In this case, a Candidate Conservation Agreement would be developed. A Candidate Conservation Agreement is similar to a Conservation Agreement, but without the specific guidelines for ongoing and maintenance activities. Conserving candidate species is important because by definition their status could be changed to threatened or endangered and receive full protection as priorities change or resources become available. Early conservation of candidate species also preserves future management options, reduces the eventual cost of recovery and compliance, and reduces the future potential for more restrictive land use policies.

Timely development of Candidate Conservation Agreements, Conservation Agreements, Biological Assessments, and Biological Opinions is limited by the availability of high quality, relevant data on sage-grouse and their habitats on the INL Site.

If greater sage-grouse are listed under the Endangered Species Act, potentially, further development and current activities on the INL Site could be delayed or halted to assess the potential effects on sage-grouse. Therefore, a Conservation Management Plan and Candidate Conservation Agreements were initiated through the Environmental Surveillance, Education and Research Program operated for DOE-ID by S.M. Stoller Corporation (Stoller). Stoller enlisted the conservation planning expertise of the Wildlife Conservation Society, North America Program in developing the Conservation Management Plan. The Conservation Management Plan is intended to minimize disruption to DOE-ID mission-related activities through considered and deliberate management of sensitive, threatened, and endangered species and their associated habitat.

The Wildlife Conservation Society is delineating sage-grouse occurrence across the INL Site using radio telemetry data gathered from sage-grouse fitted with radio transmission collars. These data will be used to parameterize spatially explicit statistical models that will delineate the areas of occurrence for sage-grouse on the INL Site from locations recorded over a two-year period (2008–2010). Sage-grouse on the INL Site were fitted with radio collars during March to May of 2008. The sage-grouse locations are tracked from ground and air (weather and logistics permitting) throughout the year. Radio collars are equipped with a mortality signal that signals if the individual sage-grouse dies. Telemetry locations of female sage-grouse are intensively monitored to locate nests. Nests are monitored and apparent nest success recorded.

Objectives

- Track radio-collared sage-grouse from point of capture until the radio collar either indicates the bird is dead or the transmitter has stopped
- Use telemetry locations for a spatial statistical model that will delineate areas of sage-grouse occurrence
- Record mortality of sage-grouse to use in population models estimating the population trajectory (or Lambda)
- Use telemetry locations of hens to locate and record apparent nest success and failure and renesting.

Accomplishments through 2008

- In spring of 2008, 34 sage-grouse from 10 lek locations on the INL Site were fitted with radio collars

- The Wildlife Conservation Society has just completed the first year tracking individual locations, the number of sage-grouse present at these locations (for ground telemetry), and individual survivorship
- The Wildlife Conservation Society found 20 sage-grouse nests and followed their success and failure
- All sage-grouse locations have been compiled in a Geographic Information System (GIS), and initial analysis of the description of sage-grouse habitats has started.

Results

Twenty-two hens were captured. Of these 22, ten were yearlings and the rest were mature hens. All hens had a mortality rate of 23 percent per year. Twelve males, two yearlings and 10 mature adults, were collared. The male mortality rate of 25 percent per year was slightly higher.

From the location data gathered by telemetry, 20 nests established by 18 hens were found. Of these nests, only six had at least one egg hatch, yielding an apparent nest success of 30 percent. In review of the scientific literature, typical apparent nest successes of 25 to 60 percent have been recorded. The INL Site's nest success is considered low compared to the distribution of sage-grouse nest success across western North America. Of the six successful nests, four raised broods until September (when it became difficult to distinguish young of year from adults).

The Wildlife Conservation Society has compiled all of the locations derived from the 34 sage-grouse (Figure 9-1.). Exceeding expectations, sage-grouse occupied habitats from just south of Leadore to just east of Blackfoot, Idaho. Collared birds did not disperse in a predictable manner relative to the site where they were captured. In one example, Figure 9-2, birds collared at the same lek had disparate migrations during the year, with a male ascending Birch Creek past Gilmore summit and within the Birch Creek Valley until late fall. A female collared at the same lek reared her young of year east of Blackfoot.

The telemetry data tells where and when sage-grouse have migrated to and from the INL Site. The lowest percentage of sage-grouse located on the INL Site occurred in September (Figure 9-3). The highest percentage of sage-grouse on the INL Site was April 2008 at 100 percent (but this is limited to capture locations within the INL Site). Toward the end of the summer 2008, most sage-grouse had migrated off the INL Site, presumably to habitats where water and temperature are physiologically less stressful. Sage-grouse utilized INL Site habitats more frequently starting in late fall (October–November), with peak usage occurring in March 2009. Of the 34 collared sage-grouse, five females and one male did not leave the INL Site (23 and 8 percent, respectively, Figure 9-4). Hens have 68 percent of their locations occurring on the INL Site. Males spend slightly less time on the INL Site, 55 percent. Spatial analysis of all telemetry locations collected show that the INL Site is used more than any other land stewardship (Figure 9-5). Lands under Bureau of Land Management stewardship provide 25 percent of the locations, Idaho state lands provide 7 percent, private stewardship provides 4 percent, and U.S. Forest Service provides a fraction (1 percent).

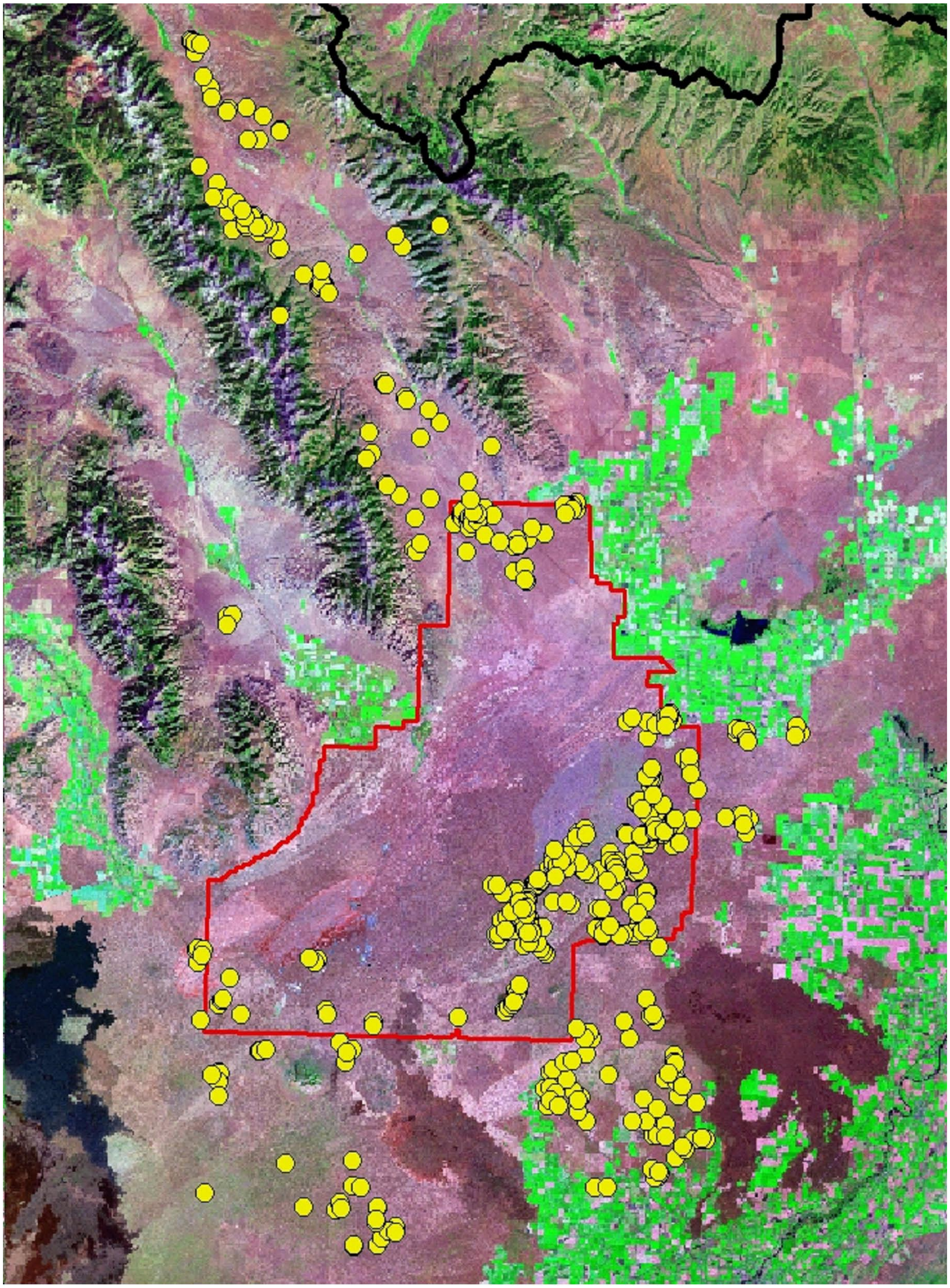


Figure 9-1. Greater Sage-grouse (*Centrocercus urophasianus*) Locations from Ground and Aerial Telemetry for 34 Individuals Collected from April 2008 to March 2009 (yellow dots) and Boundaries of the INL Site (red line).

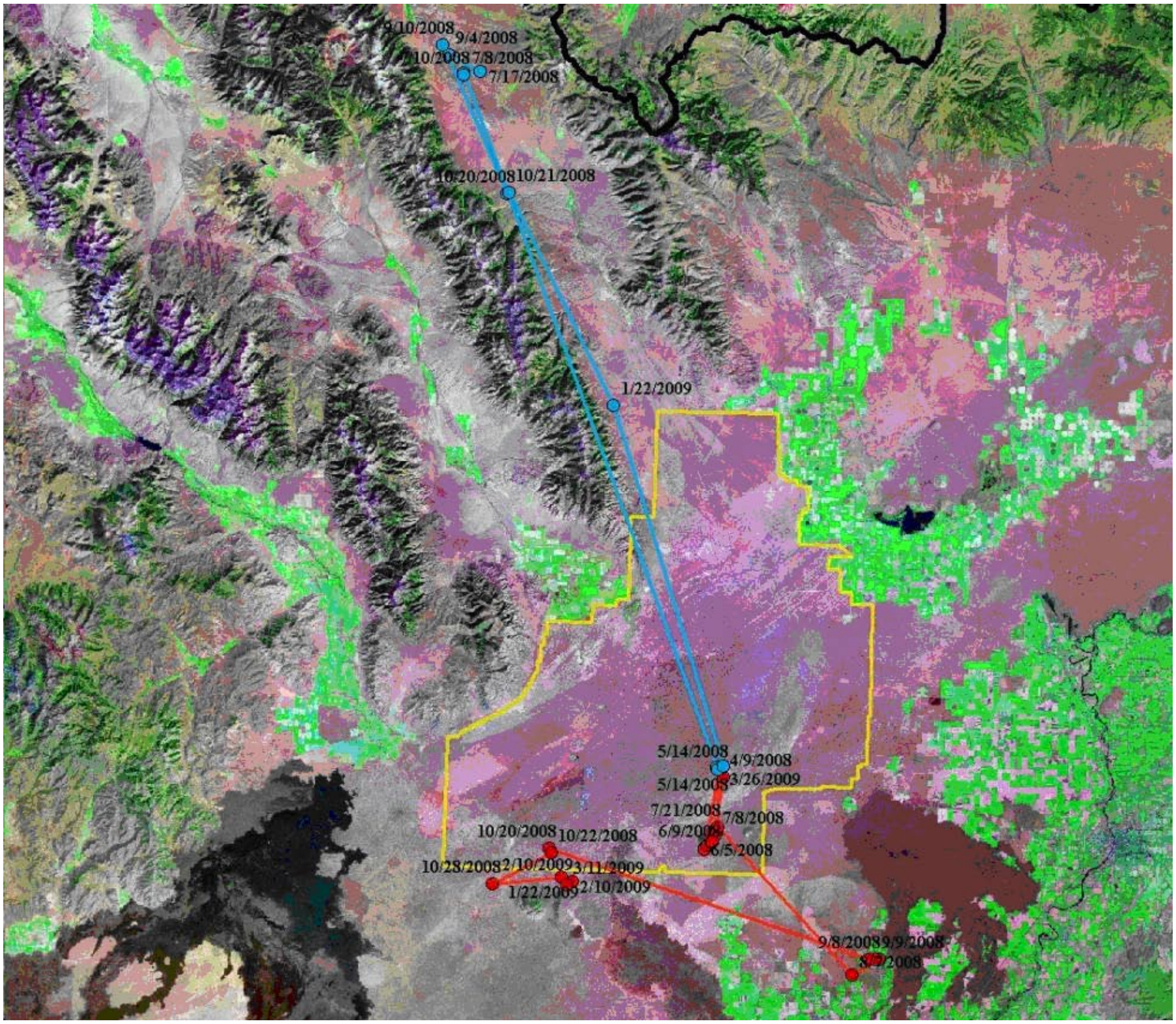


Figure 9-2. Movement Paths of One Male (blue) and One Female (red) Sage-grouse Collared from the Tractor Flats lek on the INL Site during Spring 2008 to Spring 2009. There is great movement disparity between individuals captured from the same lek within INL Site boundaries (yellow line).

Plans for Continuation

Sage-grouse will be fitted with radio telemetry collars in spring 2009, after which, radio collars from both the 2008 and 2009 seasons will be collected. Special telemetry studies identifying nest locations will be used to estimate nest success.

From the first year's telemetry locations, the study will investigate and test the use of different spatially explicit techniques that have been used to delineate areas of occurrence. The Wildlife Conservation Society intends to analyze the telemetry location data using resource selection

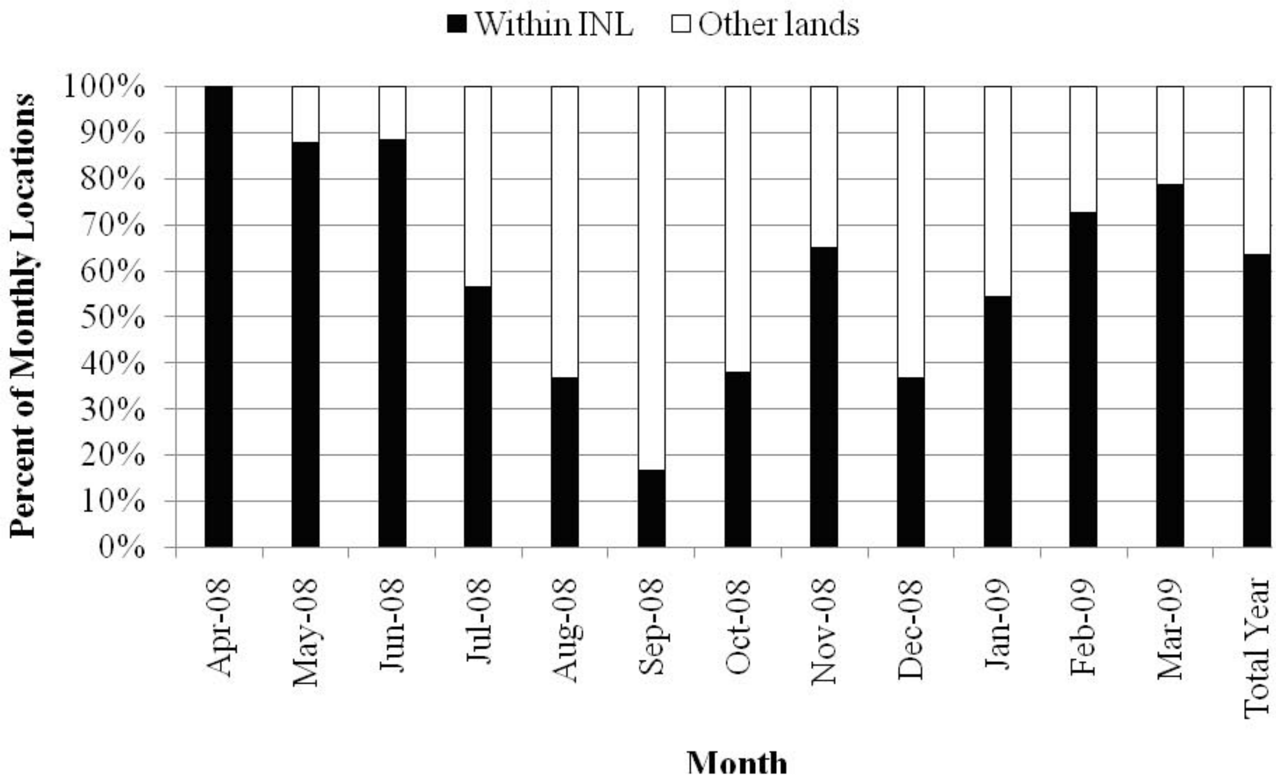


Figure 9-3. The Percent of Telemetry Locations Occurring on the INL Site Landholdings and Other Lands from April 2008 to March 2009 by Month and Total Locations for the Year.

function modeling and other types of occurrence mapping protocols to delineate patterns of use by sage-grouse on the INL Site.

The Wildlife Conservation Society will analyze the telemetry data collected thus far and assess population demographic parameters through several methods. One promising method is called MARK. MARK has become established as the prevalent means of estimating wildlife population demographic parameters.

Publications, Theses, and Reports

No reports have been written at this time, but researchers are discussing the preparation of manuscripts for peer review. The Wildlife Conservation Society will be integrating the data into the Natural Resources Data Management System to provide a systematic approach to data archive and retrieval that will support the Candidate Conservation Agreements and Conservation Management Plan.

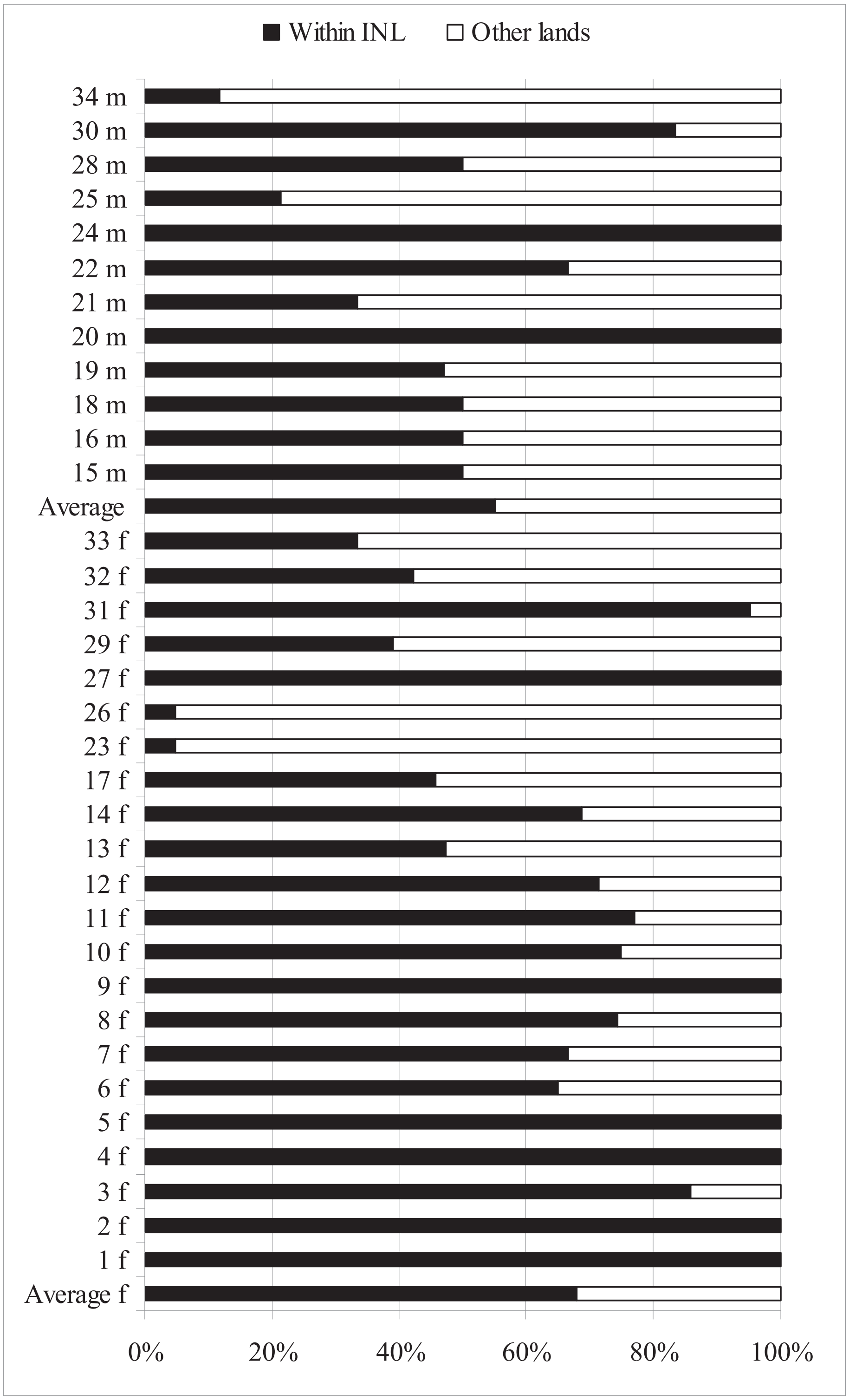


Figure 9-4. Percent of Telemetry Locations of Collared Sage-grouse that Occurred on the INL Site by Individual and Sex *(f = female, m = male)*.

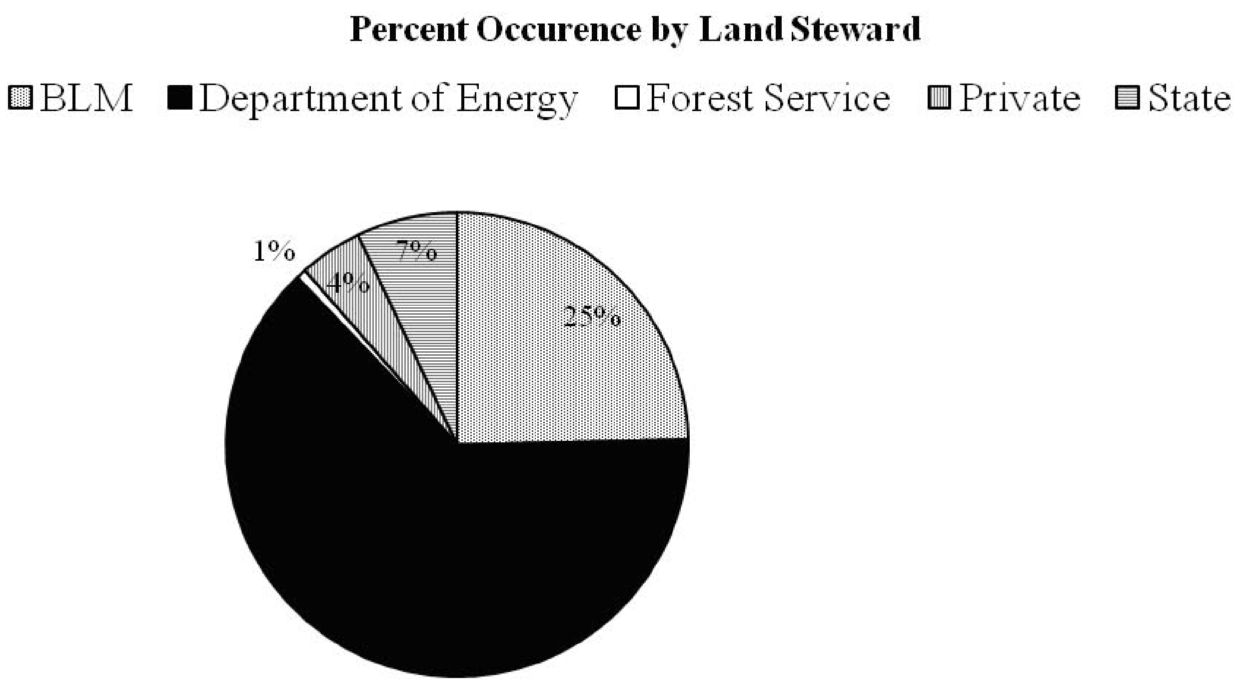


Figure 9-5. Percent of Telemetry Locations from 34 Sage-grouse Collared on the INL Site by Land Stewardship During April 2008 to March 2009.

9.2 Development and Evaluation of a Monitoring Program for Pygmy Rabbits

Investigators and Affiliations

Amanda J. Price, Master's Candidate, Department of Fish & Wildlife Resources, University of Idaho, Moscow, Idaho

Janet Rachlow, Ph.D., Associate Professor, Department of Fish & Wildlife Resources, University of Idaho, Moscow, Idaho

Scott Bergen, Ph.D., Conservation Scientist, North American Program, Wildlife Conservation Society, Bozeman, Montana

Funding Sources

U.S. Department of Energy-Idaho Operations Office

Bureau of Land Management

Idaho Department of Fish and Game

Background
The recent petition for Endangered Species Act listing of the pygmy rabbit was, in part, based on a perceived decline in the species (73 FR 1312-1313 2008); however, data to evaluate this perceived decline are not available. Numerous new occurrences of pygmy rabbits have been documented in Idaho during the past 2–3 years, which have helped identify the statewide distribution of pygmy rabbits. However, it is not known if pygmy rabbit populations fluctuate or cycle, as documented in other lagomorphs, and some observations suggest that populations may shift across a landscape over time. Therefore, an understanding of population trends over time requires information on changes in both abundance and distribution. This work addresses the changes in abundance.

Monitoring burrow systems of pygmy rabbits over the past 6 years in the Lemhi Valley has documented marked fluctuations in density of active burrows, which likely reflect fluctuations in their population density. Although burrow entrance counts are commonly used to estimate population abundance for semi-fossorial mammals, this relationship has not been evaluated for pygmy rabbits. The ongoing project is investigating the link between density of burrow systems and density of pygmy rabbits on the INL Site. This information will be used to evaluate whether a density index based on burrow systems could be used to monitor changes in abundance of pygmy rabbits over time.

Objectives
The purpose of this research is to evaluate and develop a standardized method to monitor abundance of pygmy rabbits. Specific objectives are to:

- Conduct censuses of burrow systems at sites across the INL Site
- Evaluate use of snow-tracks to estimate numbers of rabbits using sites
- Evaluate feasibility of an index of abundance based on burrow systems
- Design standardized protocols for monitoring abundance.

Accomplishments through 2008
A total of 24 16-hectare sites were delineated on the INL Site in 2008 (Figure 9-6) to assess both number of burrows and number of rabbits. A complete census of burrow systems was conducted at all sites in 2008. For each burrow system, Global Positioning System (GPS) locations and the number of burrow entrances were recorded, pellets were collected at a random selection of active burrow systems for species confirmation, and each system was classified based on sign or activity as described by Roberts (2001). The censuses indicated marked variation in the density of burrow systems on each site. Sites 18 and 226 had the lowest overall density of active and recently active burrows, and Site 114 had the highest density (Table 9-1).

Snow-track surveys were completed for six of 24 sites through December 2008. To conduct snow-track surveys, site maps of burrow systems and GPS locations of active and recently active burrows (as determined during earlier burrow censuses) were compiled, and observers navigated back to each of those sites. Occupancy was determined by presence of rabbits, tracks in the snow, and evidence of digging at burrow entrances within 1 day after snowfall.

Rabbit abundance was low for all sites. Site 114, which had the highest density of burrows, yielded evidence of just two rabbits. Pygmy rabbit signs (tracks or scat) at other sites also revealed relatively low abundances (sign of two rabbits was documented at Site L, one at Site 50, and no sign at Sites 18, 63, 84, and 99). Two plots were eliminated from snow surveys conducted during 2008 because they lacked any active or recently active burrow systems.

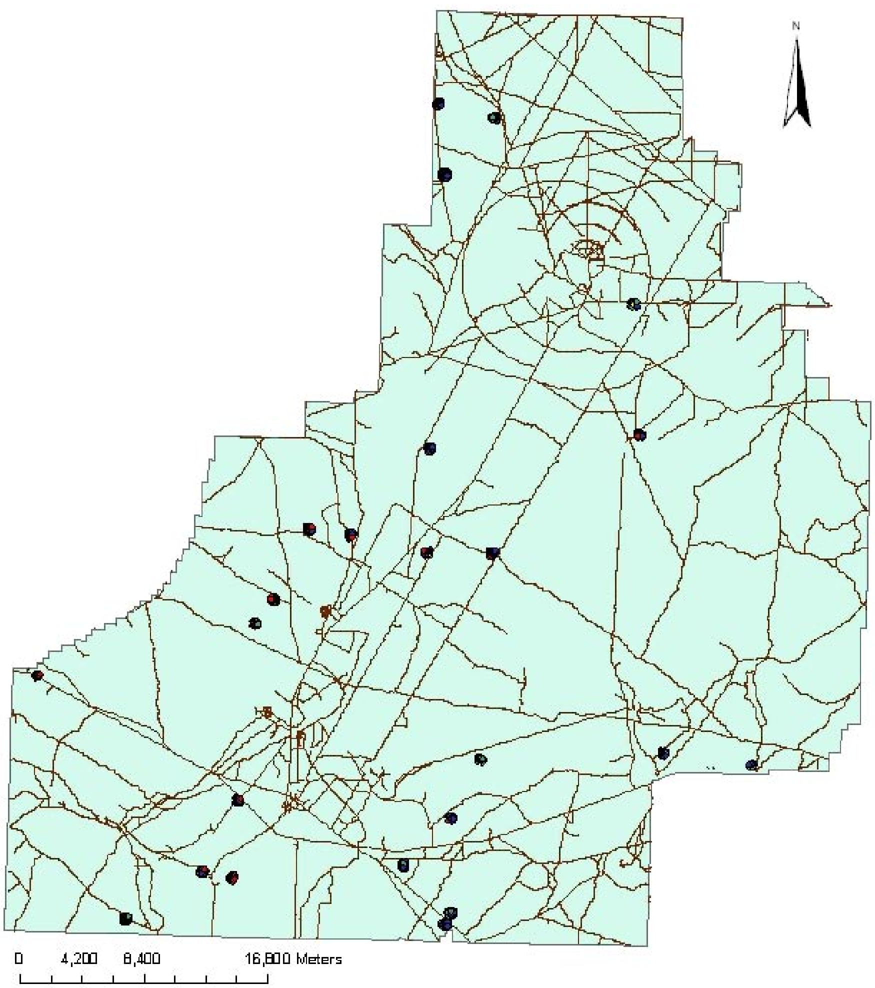


Figure 9-6. Location of 24 16-ha Sites Selected for Censuses of Pygmy Rabbit Burrow and Estimates of Abundance of Rabbits Based on Snow-track Surveys.

Table 9-1. Summary Results From Censuses of Pygmy Rabbit Burrow Systems Conducted on 24 16-ha Plots During September Through November 2008.
Activity of burrow systems was assessed based on presence and appearance of pellets and integrity of burrow entrances.

Site ID	# Active Burrow Systems	# Recent + Active Burrow Systems	Total	Burrow Density (#/ha)
O	0	0	0	0.00
K	0	2	2	0.13
A	2	7	9	0.56
D	0	0	0	0.00
L	6	12	18	1.13
2	4	8	12	0.75
18	0	1	1	0.06
37	17	6	23	1.44
50	6	18	24	1.50
51	10	14	24	1.50
60	3	6	9	0.56
63	0	9	9	0.56
66	0	2	2	0.13
84	0	7	7	0.44
99	7	20	27	1.69
104	12	26	38	2.38
111	7	13	20	1.25
112	0	10	10	0.63
114	39	51	90	5.63
115	10	18	28	1.75
141	5	19	24	1.50
163	9	17	26	1.63
174	3	6	9	0.56
226	1	0	1	0.06

Plans for Continuation

In 2009, researchers plan to continue conducting snow-track surveys as weather permits on all sites. Upon completion of all surveys or the end of the snow season, data will be analyzed to evaluate the relationship between abundance of burrows and abundance of pygmy rabbits.

Publications, Reports, and Theses

Data analysis and work on the M.S. thesis, publications, and final report will be completed during 2009.

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

Investigators and Affiliations

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

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

Funding Sources

U.S. Department of Energy Idaho Operations Office

Nevada Agricultural Experiment Station

Background

Predicting plant community susceptibility to invasion by introduced species and determining mechanisms of resistance are fundamental concerns of ecology and ecosystem management. In the Great Basin, the invasive annual cheatgrass (*Bromus tectorum*) was introduced in the late 1800s and by the 1990s had grown to dominate more than 3 million acres, with another 14 million acres heavily infested and 60 million acres considered at risk for potential domination (Pellant and Hall 1994). However, the eastern portion of the Snake River Plain, including the INL Site, has largely escaped the cheatgrass dominance found in the western portions of the Snake River Plain and in northern and central Nevada.

Several characteristics of the Eastern Snake River Plain might contribute to the relatively minor extent of cheatgrass invasion. The maintained cover of native species may make the vegetation of the INL Site resistant to invasion (Anderson and Inouye 2001). The INL Site has a markedly different landscape disturbance history than more heavily cheatgrass-invaded sites. Climate variables, such as colder winter temperatures and more late spring precipitation on the eastern Snake River Plain, also differ from most cheatgrass-dominated areas. The relatively minor extent of cheatgrass invasion at the INL Site compared with surrounding areas provides an exciting and unique opportunity to identify environmental conditions, community characteristics, or management practices conferring ecosystem resistance to invasion.

Objectives

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

Comparative Surveys—We are conducting comparative surveys along a latitudinal climatic gradient from central Nevada, where cheatgrass dominates much of the landscape, to the INL Site. We are establishing sampling plots at several hundred locations along this “mega-transect” taking care to adequately sample sites with different types of disturbance legacies, management histories, vegetation composition, temperature, and precipitation regimes. We will continue to sample intensively at the INL Site, at sites near the INL Site that are climatically similar but with different land use and disturbance histories, and at sites in both northern and central Nevada with a range of disturbance, community composition, and climatic variables. We are 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 (Grace 2006) and specifically test hypotheses about how site characteristics affect invasion success of cheatgrass.

The structural equation model is a powerful statistical way to infer causality: specifically, we are using it to determine why cheatgrass is more abundant in certain locations and less in others. An additional benefit of the structural equation model is that we can include variables based on “expert opinion” rather than relying on strictly empirical data. This means we can include a lot of invaluable information that would not be otherwise useable in a more traditional quantitative model.

Controlled Greenhouse Studies—We are using controlled-environment experiments that involve individual species and constructed communities to establish a mechanistic understanding of competition between cheatgrass and native species. We are investigating competitive relationships, effects of diversity, density, and disturbance, and response to variation in water regime (timing and pulse size). Preliminary single-species trials indicate that cheatgrass and perennial species differ in their abilities to respond to water pulses depending on size and frequency of water events, and that moisture at the right time in the life cycles of cheatgrass could promote high competitive ability and possible invasion (K. Allcock, unpublished data). A mesocosm experiment is currently underway to test the interactions of precipitation timing and community composition in determining invasion success.

Accomplishments through 2008

Comparative Surveys—GIS data collected in 2006 were used to help identify potential sampling points. For plots at the INL Site, we selected areas with a diversity of vegetation type and fire history. In June 2007, we visited the INL Site and sampled the first 100 sites. In May and June 2008, 300 more sites were visited. Our 2008 field sites were located at the INL Site and in central and northern Nevada. We measured several plant community characteristics, signs of disturbance, and physical environment variables. Soil samples were collected and analyzed for soil nutrients, texture, seed bank, and soil food web dynamics. Climate data were collected from National Oceanic and Atmospheric Administration weather stations. Fire history and stocking rates were gathered from published Bureau of Land Management maps and maps provided by the Environmental, Surveillance, Education, and Research Program (S.M. Stoller Corporation).

Most of our field sites will be visited only once, enabling us to sample across a wide area and providing the maximum variation in most landscape and vegetation variables. The remainder of our field sites will be visited for multiple years. This will allow us to examine the effects of inter-annual variation on cheatgrass distribution.

The data collected are being processed and used for model building and method refinement.

Controlled Greenhouse Studies—In late 2006 and early 2007, we established a series of two-species plant communities in 50-gallon barrels on the University of Nevada Reno. These communities were comprised of combinations of early-season native species (*Poa secunda*, *Acnatherium hymenoides*, or *Elymus elymoides*), late-season native species (*Pseudoroegneria spicata*, *Achnatherum thurberii*, or *Hesperostipa comata*), or one of each group. All plants were collected from the wild and transplanted to our constructed communities. One-fourth of the barrels were not planted with any perennial species. All barrels were seeded with cheatgrass at a rate of 2,000 seeds per square meter. Each of these communities (early, late, mixed, or no perennials) was then subjected to either elevated total precipitation (150 percent normal precipitation for Reno, Nevada) or ambient total precipitation (equal to the amount of precipitation received through the growing season in Reno, Nevada). Finally, this "precipitation" was either all distributed evenly through the course of the experiment (watered uniformly once per week), or 50 percent of the total precipitation amount was distributed evenly and the other 50 percent was applied in three randomly-timed "storm events" in which barrels received one-sixth of the total allotted water volume for that treatment over the course of three days. We had six replicates of each community type, water amount, and water distribution combination, giving a total of 96 barrels.

Substantial mortality of transplanted perennials in the constructed communities in early 2007 meant that many plants had to be replaced at the beginning of the 2007 growing season (March–April 2007), so we delayed implementing our experimental treatments until June 2007 to allow the replaced plants to establish. Watering treatments continued through November 2007, and final harvest occurred in December 2007. At the time of harvest, we recorded density of cheatgrass, clipped above-ground biomass, and sorted by species.

Results

Comparative Surveys—We have data from only 350 of the anticipated more than 500 sites in the comparative survey, and we are still processing the samples and data. Thus, preliminary results are not yet available.

Controlled Greenhouse Studies—We are processing the aboveground biomass samples collected in December 2007. While the data are not yet ready to analyze, it appears that the ambient-amount, irregular-distribution watering regime caused some stress to both cheatgrass and perennial transplants, with fewer cheatgrass plants germinating and emerging, and several perennial transplants dying. The higher-precipitation treatments fared better. Emergence of cheatgrass in the high-precipitation, irregular-distribution treatment was initially low, but increased dramatically after the first storm event. The planted species did not appear to have any obvious visual effect on cheatgrass density or biomass. Planted species had no effect on soil water content (as measured by time domain reflectometry) in the top 10 cm of soil, and minimal effect on the watering treatments on surface soil water content 24 hours after the water pulses were applied.

Plans for Continuation

This project will continue through 2010. We will continue collecting field data for the comparative survey at the INL Site and other field sites in 2008 and 2009. Structural equation models require a large number of data points for the algorithms to identify reliable parameter values (Tanaka 1987); accordingly, we plan to sample approximately 500 sites through the course of this study.

Publications, Reports, and Theses

We anticipate several peer-reviewed publications and conference proceedings on varied topics (such as, but not limited to: the effects of soil microbial community on cheatgrass success, the effects of soil surface morphology on cheatgrass germination, and the effects of varied precipitation regime on cheatgrass competitive ability), in addition to the Ph.D. dissertation to be completed by Lora Perkins in 2010.

9.4 Plant Community Classification and Mapping at the Idaho National Laboratory

Investigators and Affiliations

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

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

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

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

Funding Source

U.S. Department of Energy-Idaho Operations Office

Background

Accurate classification and mapping of vegetation communities have become increasingly important tools for conservation management. By understanding the distribution and condition of plant communities on a landscape, a number of conservation goals can more easily be met, including:

- Determining which community types are intrinsically rare or have been severely degraded
- Identifying the best remaining occurrences of natural communities across their geographic ranges
- Assessing the impacts of various land-use scenarios on areas supporting different vegetation types
- Developing habitat suitability models for predicting species occurrences
- Ranking vegetation classes with respect to their importance in conservation management planning.

Previous vegetation maps of the INL Site are inadequate to serve these conservation management planning goals, in part, because they are outdated. The most recent effort was almost 20 years ago and does not capture important habitat changes that have occurred since that time, including fires, sagebrush die-off, and invasion by non-native plants. Prior mapping efforts also lack assessments of accuracy, making it difficult to quantify uncertainty associated with habitat models derived from data contained in those maps. Furthermore, methodologies for vegetation classification and mapping have been refined and standardized since earlier INL Site maps, allowing for continuity among classifications and mapping on the INL Site and on neighboring lands managed by other agencies.

Understanding the distribution and condition of plant communities on the INL Site will support the Conservation Management Plan through habitat mapping, development of Habitat Suitability Indices, and will help to focus surveys for sensitive species. Additional benefits to land management at the INL Site include guiding revegetation and weed management efforts, increasing the efficiency of assessing environmental impacts, and siting plots for inventory and monitoring activities. It will also serve as an important background database for research on the Idaho NERP.

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 communities types present on the INL Site
- Define the spatial distribution of those community types
- Conduct an accuracy assessment of the resulting map.

Our approach is based on a process developed by the U.S. Geological Survey and National Park Service for use in land management planning (USDI and NPS 2009) and includes two parallel tasks, plant community classification and map unit delineation. Plant community classification entails multivariate analysis of applicable historic 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 (FGDC 2008). 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 are then reconciled by assigning vegetation classes to map units, resulting in a map for which accuracy will then be assessed.

Accomplishments through 2008

On June 15, 2007, color-infrared digital imagery was collected at 1-m ground sample distance across the entire INL Site. In 2007, quality assurance and quality control assessments of the imagery were completed to determine if they met our data quality requirements.

Preliminary plant community classifications were completed on historic INL Site vegetation data in the spring of 2008 in collaboration with the state of Idaho Department of Fish and Game Conservation Data Center to identify the range of vegetation classes potentially occurring on the INL Site. Activities associated with the preliminary classification also included drafting a preliminary key for plant communities on the INL Site. Vegetation data were collected on 314 plots during the summer of 2008, based on results from the preliminary classification and a stratified-random sampling design combined with the manual selection of discretionary plots to meet minimum sample size requirements and guarantee all important regions of the INL Site were adequately represented.

The stratified-random plot site selection process utilized existing GIS data sets to filter the landscape into a potential sampling area. A potential sampling area was generally constrained to distances from existing roads ranging between 100 m and 1 km, with 20 additional plots located in more remote areas. These distances were chosen to provide a balance between logistical considerations and to minimize the influence of roads on adjacent vegetation communities. All disturbed ground (e.g., gravel pits and facilities) and areas within facility boundaries also were removed from the potential sampling area. Plot locations also were stratified according to the relative area of vegetation communities in the McBride et al. (1978) vegetation map that was updated to reflect burned areas (Figure 9-7). We limited the number of plots in each community to a maximum of 20 and a minimum of five, resulting in 236 total plots selected through the stratified random process and 78 plots selected strategically or opportunistically to fill in data gaps for uncommon or under-sampled communities previously identified in the preliminary classification process.

Plots were generally 20 × 20 m (Figure 9-8); however two additional plot sizes and shapes (3 × 3 m and 20 m linear) were used occasionally to sample plant community types that tend to occur at unique scales (i.e., basalt ridges, playas, and riparian corridors). Metrics collected at each plot location included: Global Positioning System (GPS) position, photographs, species list and abundance ranks, identification of plant community according to a preliminary key, surface characteristics, visual obstruction, vegetation cover data, sagebrush condition rank, soil texture, and sensitive animal sign.

A Microsoft Access database was designed and populated with the plot data listed above. Finalized plant community classifications were initiated in September 2008 using percent absolute cover data from all 314 plots. Idaho State University was subcontracted to provide statistical guidance and perform the multivariate analyses required for the final classifications. Eight multivariate classification models were compared using six geometric and non-geometric evaluators, and the most appropriate model was chosen for use in further analysis. The optimal number of clusters, or vegetation classes, was then determined using the appropriate model and six geometric and indicator-species evaluators.

In 2008, we began delineating vegetation community boundaries using traditional aerial photograph interpretation methods. The delineations are being produced within a GIS that

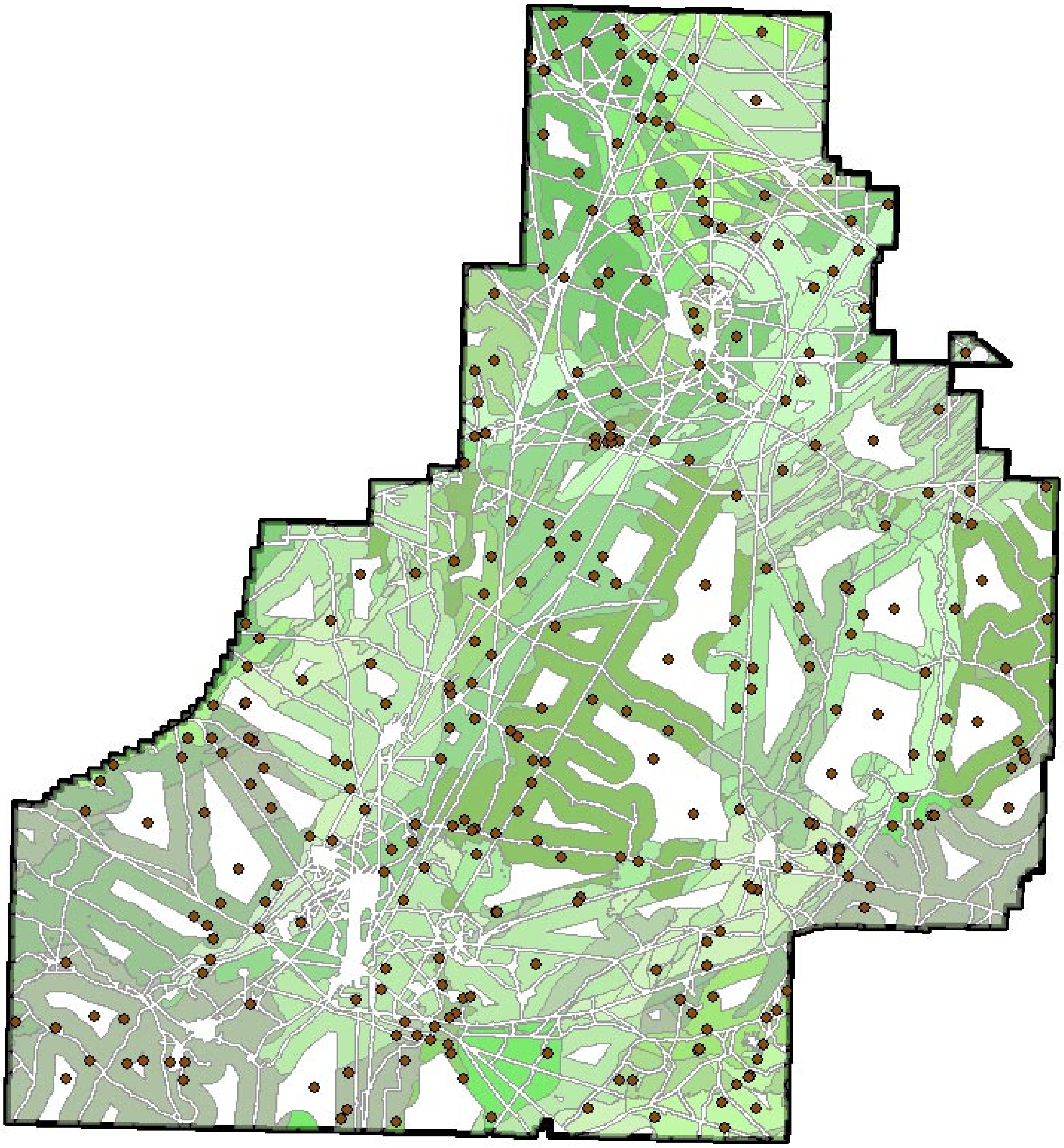


Figure 9-7. A Visual Representation of the Stratified-random Sampling Design and the 236 Plot Locations Selected Based on that Design for Data Collected in 2008 to Support a Plant Community Classification of Vegetation on the INL Site.

enables multiple data sets to help identify and refine potential community boundaries. A number of GIS data sets, such as soils, geology, and fire boundaries, are being incorporated into the delineation process and are primarily being used as reference data because accuracy of each of these data sets is unknown. We are relying on the 2004 National Agricultural Imaging Program to fill in the gaps across the landscape in the 2007 imagery caused by clouds. A number of

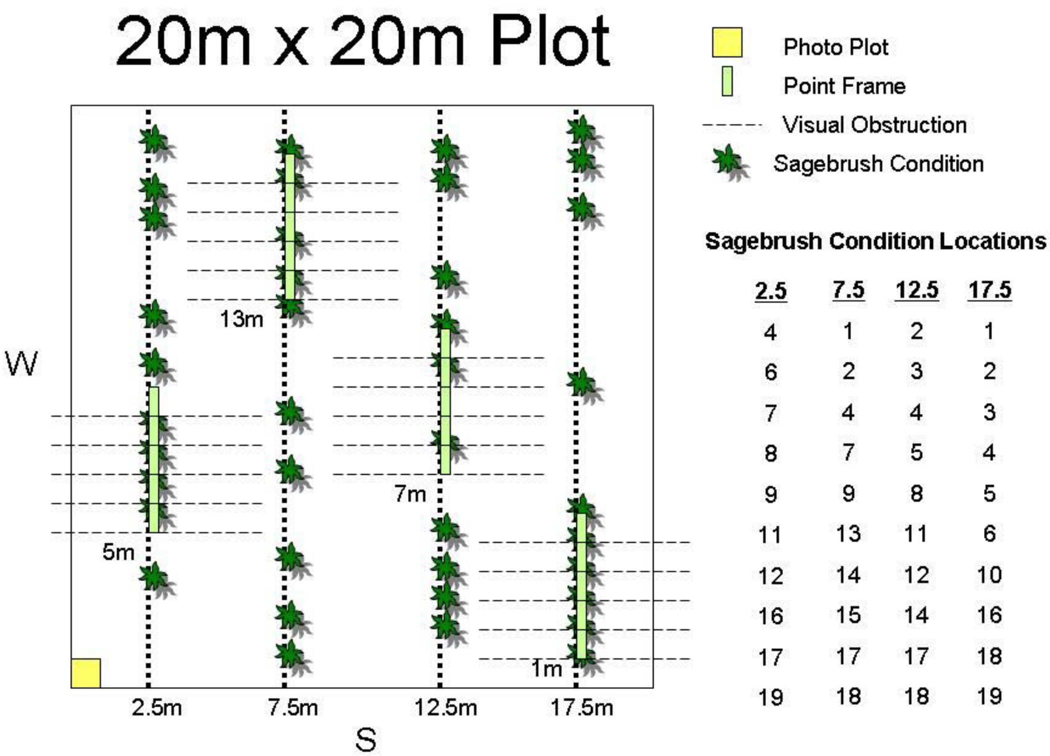


Figure 9-8. Plot Diagram for 2008 Vegetation Data Collection to Support Plant Community Classification and Mapping Efforts at the INL Site.

derived data layers were also calculated from the imagery, including two vegetation indices (Normalized Difference Vegetation Index and Soil-Adjusted Vegetation Index) and a statistical texture layer (3 × 3 pixel range). Each of these image layers contributes additional information not evident in the raw imagery, and both are being used to assist with the delineation process.

Finally, in preparation for the process of reconciling the plant community classes with the delineated polygons, the vegetation plots corners were imported into a GIS, and all sampling plots were digitally recreated and georeferenced to the color-infrared imagery. Summary statistics for all pixels within the vegetation plots were calculated to investigate the spectral separability of community types and identify which communities may need to be combined into a single map class.

Results

For the plant community classification component of the project, multivariate models that created spherical clusters were favored by both geometric and non-geometric evaluators. Flexible β = -0.25 created the strongest classification, with the highest evaluator scores for all six evaluators. The optimal number of clusters determined using geometric evaluators was approximately

22, and the optimal number of clusters determined using indicator species evaluators was approximately 12.

Review of relevé tables generated from each set of clusters revealed that the 22-cluster solution provided a reasonable representation of plant communities likely to occur on the INL Site and good separation in plant community composition among those communities. A few clusters had relatively high beta diversity, and a few plant communities known to occur on the INL Site did not correspond to any of the clusters identified by the classification. Further analysis will be required to refine the classification results and finalize the list of plant communities to be used for the map.

Plans for Continuation

In 2009, 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 on the INL Site also will be generated. Plant community descriptions will be drafted to accompany the final map, utilizing a format similar to that used by the National Park Service at the Upper Columbia Basin Network of Parks (including Craters of the Moon National Monument and Preserve).

Draft delineations are scheduled to be completed in April 2009, and assigning vegetation classes identified in the final classification to each polygon will be completed shortly thereafter. Independent field data will be collected during the summer of 2009 and will be used to validate the draft vegetation map. The 2009 field data will be used to calculate class and overall map accuracies and will be included in the final report. The final report and project completion are expected in 2010.

Publications, Reports, and Theses

Because the project has just begun, no publications or reports have been produced.

9.5 Landscape Genetics of Great Basin Rattlesnakes, *Crotalus oreganos lutosus*, on the Upper Snake River Plain

Investigators and Affiliations

Susan B. Parsons, Graduate Student, Herpetology and Molecular Ecology Laboratories, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Charles R. Peterson, Ph.D., Professor, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Marjorie D. Matocq, Ph.D., Professor, Molecular Ecology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Rick Williams, Ph.D., Assistant Professor, Plant Evolutionary Ecology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Funding Sources

U.S. Department of Energy-Idaho Operations Office

National Science Foundation GK-12 Grant

American Museum of Natural History

Idaho State University Molecular Core Research Facility Seed Grant

Background

Over the last three decades, a significant body of baseline data has been amassed addressing various aspects of Great Basin rattlesnake ecology on the INL Site through efforts of an 18-year reptile monitoring project funded by the Department of Energy and various theses completed by students of Idaho State University's Herpetology Laboratory. Although data exist on population size dynamics, reproduction, neonate survivorship, and disturbance effects, there has yet to be a population connectivity study in this ongoing research. Population connectivity is important for maintaining genetic diversity, as reduced diversity and the effects of inbreeding depression are implicated in population declines and increased risk of extinction (Frankham et al. 2005). The field of landscape genetics, made possible by Geographic Information System (GIS) and DNA imaging technologies, correlates habitat heterogeneity with patterns of gene flow and population structure (Manel et al. 2003; Storfer et al. 2006). Molecular and landscape genetic analyses are valuable for providing information on how to avoid the deleterious effects of habitat fragmentation, reproductive isolation, and genetic drift on genetic variability and population viability of snake species (Bushar et al. 1998), as well as understanding the interplay between rattlesnake ecology and their physical environment.

Previous studies on rattlesnakes show a nonrandom pattern of gene flow in populations spatially correlated with rocky outcrops and increased relatedness among individuals from hibernacula sharing centrally located basking locations (Clark et al. 2008). Additionally, the Great Basin rattlesnakes found on the Upper Snake River Plain of southeastern Idaho den and over-winter communally in large, spatially distinct hibernacula complexes, often in groups numbering in the hundreds (Dr. Charles Peterson, personal communication). This known and spatially stratified distribution of sampling locations throughout a heterogeneous sagebrush-steppe habitat, combined with high den/hibernaculum fidelity (Cobb 1994), presents an excellent opportunity to study habitat-mediated population structure in a communal snake species.

Objectives

- To determine if the rattlesnake denning groups on the INL Site exhibit population substructure, or they can be characterized by high levels of connectivity
- To determine how the availability of intervening denning habitat affects gene flow among rattlesnake hibernacula on the INL Site.

Accomplishments through 2008

Two hundred individual rattlesnakes from ten distinct hibernacula/denning locations were genotyped, and patterns of flow among denning groups and population substructuring were evaluated. A GIS-based den probability map was generated for the INL Site study area. Genetic distance (Fst) was correlated with the availability of intervening denning habitat.

Results

The ten rattlesnake denning complexes in this study (Figure 9-9) can be described as a single, panmictic population (Table 9-2); however, there are significant genetic differences between Crater Butte and the rest of the INL Site dens (Table 9-3). It is interesting to note that these differences cannot be explained by simple isolation-by-distance. The availability of suitable denning habitat between dens (Figure 9-10) is a better predictor of fine-scale population structuring than is distance (Table 9-4). From a conservation perspective, preserving corridors of high quality denning habitat between rattlesnake denning locations is important for maintaining genetic diversity in this population.

Plans for Continuation

This master's thesis will be completed and defended during 2009.

Publications, Reports, and Theses

This research will be submitted for journal publication in fall 2009.

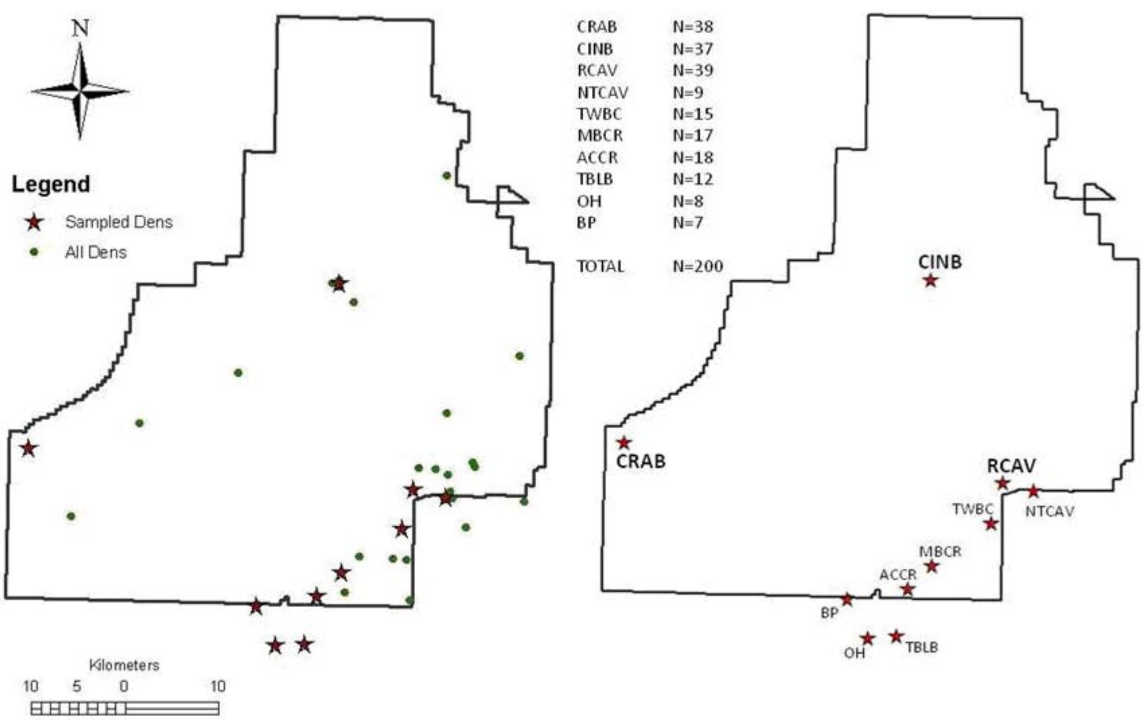


Figure 9-9. Map Showing All Known Rattlesnake Dens, Sampled Dens, Sampling Locations, and Sample Sizes.

Table 9-2. Analysis of Molecular Variance (AMOVA) Tables for All Samples in the Study. The majority of genetic variation is found among individuals, rather than among hibernacula, evidence that there are high levels of gene flow among hibernacula on the INL.

All Samples

Source of Variation	*df*	*Sum of Squares*	*Variance Components*	*Percentage of Variation*
Among PPNS	9	38.328	0.05765 Va	2.74
Within PPNS	390	799.254	2.04937 Vb	97.26
Total	399	837.582	2.10702	

Table 9-3. Fst Values, Indicating Pairwise Genetic Connectivity for Each Den Pairing. Insignificant Fst values are shown in red, with significance determined by P≤0.05. Fst estimates, AMOVA results, and other measures of genetic connectivity not discussed in this report indicate that there is only modest population substructuring on the INL, and that the substructuring that does exist is primarily between CRAB and several of the other INL dens.

	CRAB	CINB	RCAV	ACCR	MBCR	TWBC	NTCAV	TBLB	OH
CINB	0.02183								
RCAV	0.04963	0.02863							
ACCR	0.04378	0.01683	0.043						
MBCR	0.05325	0.0341	-0.00361	0.04529					
TWBC	0.05122	0.036	0.0237	0.0284	0.04515				
NTCAV	0.00916	0.00968	0.01766	0.01384	0.02724	0.00264			
TBLB	0.01571	0.02043	-0.00054	0.03626	-0.00144	0.01871	-0.00098		
OH	0.01685	0.02248	0.03138	0.01486	0.03365	0.01831	0.00351	-0.00741	
BP	0.0511	0.05618	0.03809	0.04768	0.00211	0.05149	0.02434	0.00996	0.01283

Figure 9-10. Map Showing Probability of Appropriate Denning Habitat Across the INL Site. This map was generated with Mahalanobis distance tool in ArcView 3.3 (http://www.jennessent.com/arcview/arcview_extensions.htm), using 10m slope and aspect, and appropriate lava age. Yellow indicates low probability of finding rattlesnake dens, while red indicates high probability of finding rattlesnake dens.

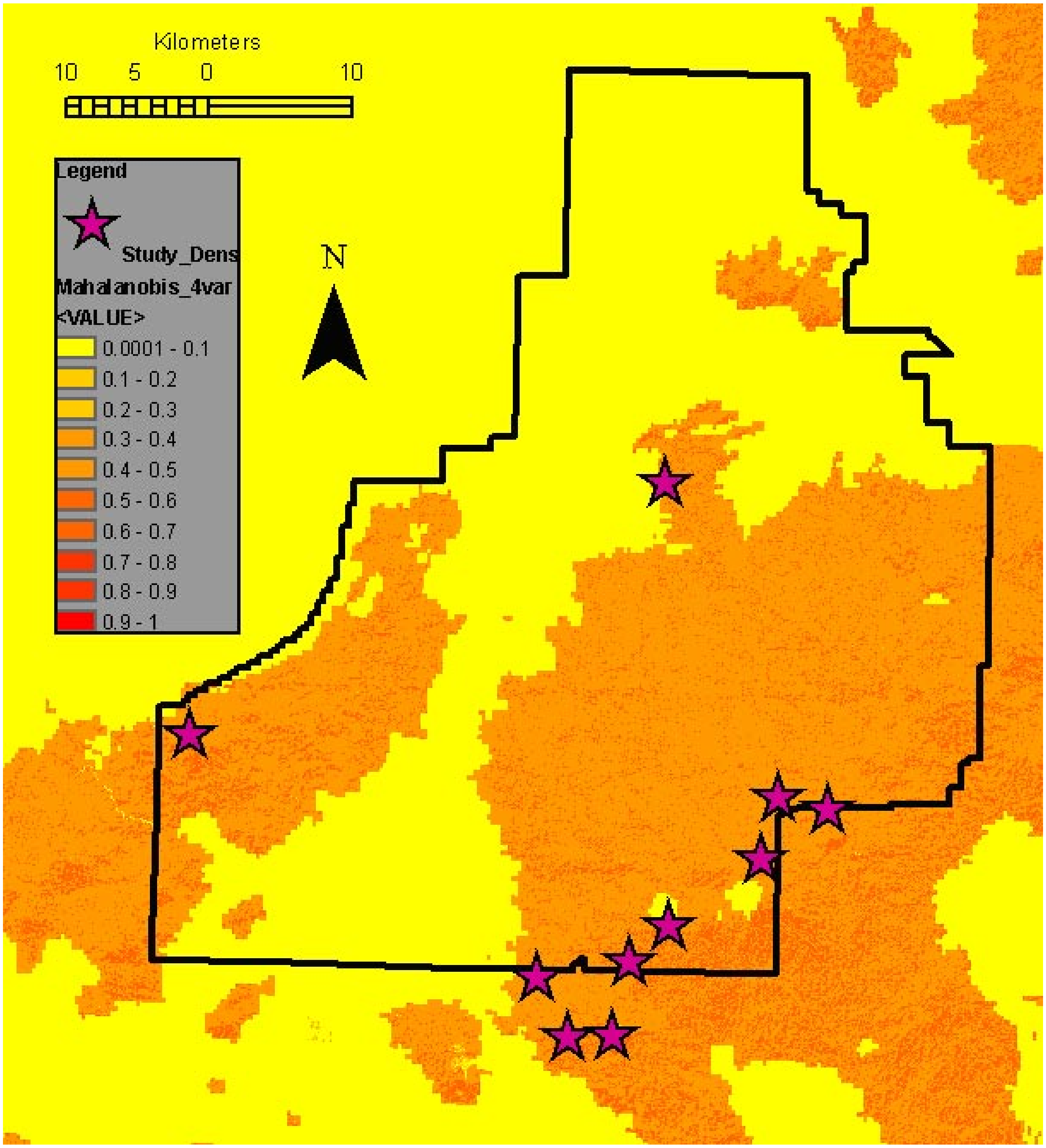


Table 9-4. Initial Mantel Test Results, Correlating Fst (Genetic Connectivity) with the Average Availability of Denning Habitat Between Dens.

Fst is not significantly correlating with Euclidean distance, least cost distance, or topographic distance, but is significantly correlated with the availability of denning habitat along both Euclidean and least cost movement paths that have been buffered 1000m, 2000m, and 3000m.

Mantel Tests, Response Variable FST	
Predictor Variable	Spearman
Euclidean Dist.	r=0.2384, P=0.1198
Euclidean Dist., topographically corrected	r=0.2364, P=0.1213
Least Cost Path Dist.	r=0.2346, P=0.1299
Least Cost Path Dist., topographically corrected	r=0.2345, P=0.1297

Mantel Tests, Response Variable FST	
Predictor Variable=Den Probability between Den Pairs	Spearman
Den Prob Euclidean 1000	**r=0.3859, P=0.0074**
Den Prob Euclidean 2000	**r=0.4086, P=0.0071**
Den Prob Euclidean 3000	**r=0.3670, P=0.0263**
Den Prob Least Cost 1000	**r=0.3884, P=0.0194**
Den Prob Least Cost 2000	**r=0.4132, P=0.0103**
Den Prob Least Cost 3000	**r=0.3823, P=0.0186**

9.6 Historical Fire Regimes of Wyoming and Basin Big Sagebrush Steppe on the Snake River Plain

Investigators and Affiliations

Stephen C. Bunting, Ph.D., Professor of Rangeland Ecology, Department of Rangeland Ecology and Management, University of Idaho, Moscow, Idaho

Andréa L. Kuchy, Graduate Research Assistant, Department of Rangeland Ecology and Management, University of Idaho, Moscow, Idaho

Funding Sources

U.S. Department of Energy-Idaho Operations Office

University of Idaho, College of Natural Resources, Department of Rangeland Ecology and Management, Moscow, Idaho

Background

The fire histories of sagebrush-dominated vegetation types are difficult to document with traditional methods, such as utilizing multiple fire scars or macroplot population demographic composition. Individual sagebrush plants do not fire scar, and a fire usually removes all sagebrush plants within the burned area. In some areas sagebrush steppe fire history has been extrapolated from adjacent vegetation types that contain conifer species that are fire scarred (e.g., western juniper [*Juniperus occidentalis*], ponderosa pine [*Pinus ponderosa*], Douglas-fir [*Pseudotsuga menziesii*]). These species, however, are largely not available on most of the Snake River Plain.

Understanding the relationship between seasonal climate patterns and large fire potential in sagebrush steppe is urgently necessary because little information is available on the relationship of climate and fire size for sagebrush ecosystems. As the impact of climate variability and extreme climatic events on fire occurrence and size can vary depending on scales at which they are analyzed, fire history is being reconstructed across multiple spatial scales, with the INL Site at the finest scale.

Studies of fire history and ecology are vital to understanding and forecasting the impacts of climate change on sagebrush steppe ecosystems. An improved understanding and the ability to forecast future impacts can serve as the scientific foundation upon which fire and land management decisions can be based.

Objectives

There are few studies of fire history in the sagebrush steppe and none that examine the changes in occurrence of large fires (5,000+ acres) and consecutive climatic conditions. The specific objectives of this research are to:

- Reconstruct the fire history (1960–2003) for sagebrush steppe ecosystems across three spatial scales of sagebrush-dominated steppe: (1) the INL Site, (2) the Snake River Plain, and (3) portions of the Northern Basin and Range to include the Snake River Plain
- Examine the links between climate and large fire events in sagebrush-steppe vegetation by investigating a range of potentially important climatic variables (e.g., drought, large-scale climatic fluctuations such as El Niño Southern Oscillation and Pacific Decadal Oscillation)
- Develop predictive models to assess how climate variation will affect fire frequency and size characteristics within sagebrush steppe ecosystems.

Accomplishments through 2008

- Completed analysis of fires by date from the Great Western Fire Map.
- Removed duplicate fires from fire record. Sorted and summarized fires by size and year of occurrence.
- Completed temperature and precipitation summaries for all climate stations.
- Completed ArcInfo operations for topology, etc.
- Executed ArcMap operations (Triangulated Irregular Networks, contours, etc).
- Completed spatial analyses using Geoda and ArcMap.
- Acquired, compiled, and analyzed PRISM data.
- Completed fire summaries for each of the three study regions.
- Completed synthesis of climate and large fires.
- Downloaded STATSGO soil moisture data sets and began investigating in context of fire occurrences and size.
- Continued additional data analysis and preparation of peer-reviewed journal publications from research results as suggested by Kuchy Graduate Committee.

Results

The occurrence of large fires in the western United States raises questions about the effect of climate change on fire regimes in the past and future. Sagebrush steppe has long been exposed to agriculture, excessive grazing, and invasive species. This endangered ecosystem is facing a new threat of increasingly large wildfires and climate change. The objectives of this study were to reconstruct the fire history for sagebrush steppe ecosystems across three spatial scales of sagebrush-dominated steppe: (1) INL Site, (2) Snake River Plain to include the INL Site, and (3) portions of the Northern Basin and Range to include the Snake River Plain and the INL Site (Figure 9-11). This study used Geographic Information Systems (GISs) to correlate size and occurrence of fires over 5,000 ha with topography, vegetation, and climatic variables. Wildfires increased between 1960 and 2003 both in size and number (Tables 9-5 and 9-6). Large wildfires (those greater than 5,000 hectares) increasingly formed a greater proportion

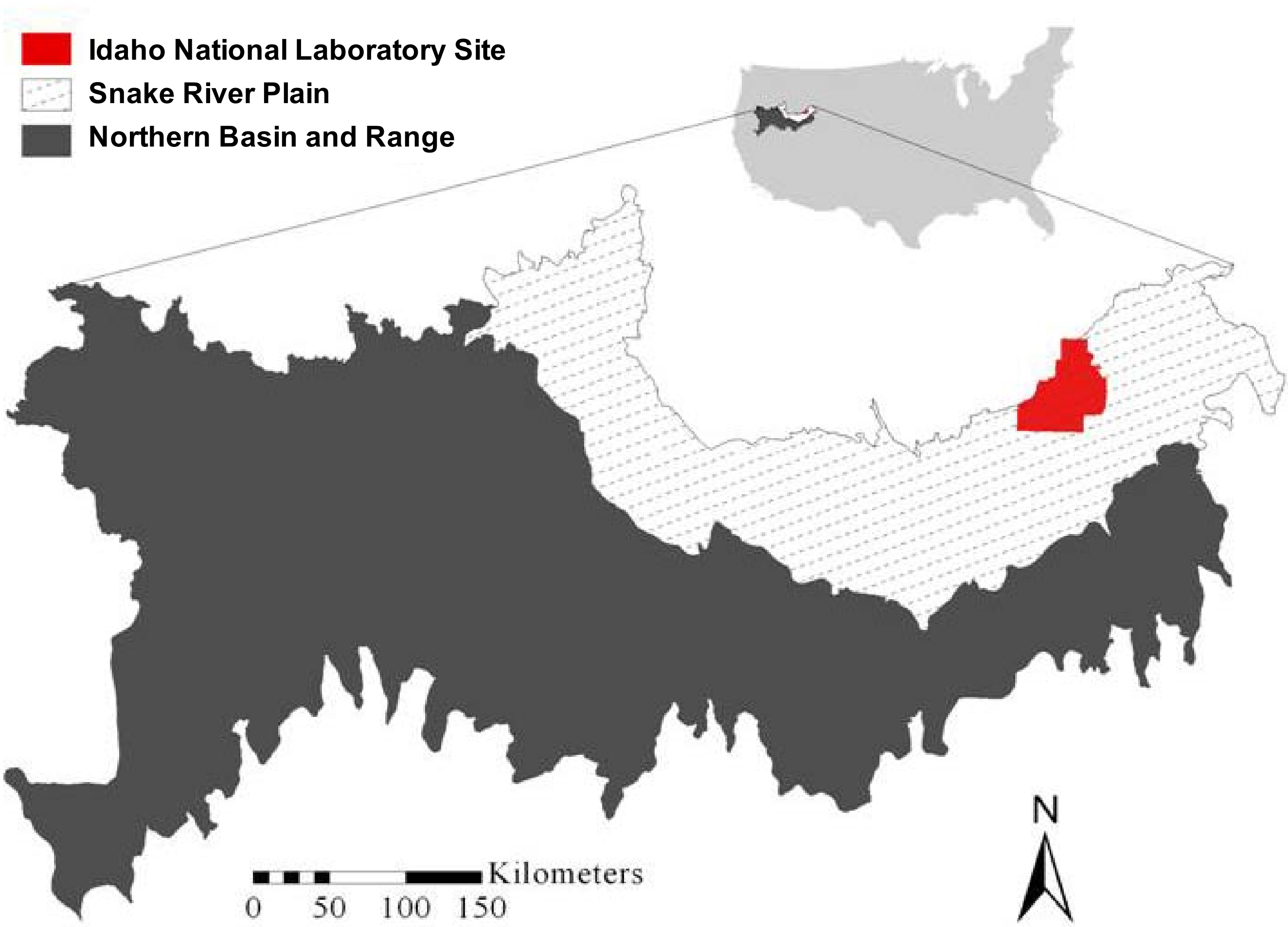


Figure 9-11. The Three Semi-arid Regions Selected for Fire History Reconstruction of Sagebrush Steppe Ecosystems (1960-2003).

of all wildfires over the period studied (Table 9-7). The influence of climate, topography, and vegetation on fire occurrence and size can vary depending on the spatial and temporal scales over which information is collected and analyzed (Table 9-8). At the broadest spatial scale, the size of large fires was positively correlated with average annual maximum temperature during the year of the fire event (r^2 = 0.114, P = 0.038). Fire occurrence and average yearly precipitation one year previous to the large fire event were also correlated (r^2 = 0.054, P = 0.031). There was also some correlation with topographical aspect for occurrence of large fires (r^2 = 0.039, P = 0.009) and for total fires (r^2 = 0.041, P = 0.001). From 1960 to 2003, maximum temperature increased and precipitation decreased in the area. Increases in large fire occurrence and size are attributed to increases in air temperature and exotic grass occurrence. Our results and the projected trend toward warmer, drier growing seasons and summers suggest that sagebrush steppe systems are likely to continue to experience an increase in large fires in the future.

Table 9-5. The Number of Fires by Size Class, Over Time, in the Snake River Plain (Top) and Northern Basin and Range (Bottom) Ecoregions,1960-2003.

Snake River Plain

	Size class (ha)				
	A	B	C	D	Total
Year	0 – 50	51 – 500	501 – 5000	5000+	
1960 - 1969	257	109	53	6	**425**
1970 - 1979	560	416	139	18	**1 133**
1980 - 1989	625	734	401	54	**1 814**
1990 - 1999	1526	734	279	49	**2 588**
2000 - 2003	74	11	0	0	**85**
1860 - 1982	**997**	**734**	**291**	**32**	**2 054**
1983 - 2003	**2 045**	**1 270**	**581**	**95**	**3 991**
Difference	***1 048***	***536***	***290***	***63***	***1 937***

Northern Basin and Range

	A	B	C	D	Total
Year	0 – 50	51 – 500	501 – 5000	5000+	
1960 - 1969	152	61	18	4	**235**
1970 - 1979	108	106	4	0	**170**
1980 - 1989	184	168	110	22	**485**
1990 - 1999	412	461	206	26	**1 073**
2000 - 2003	1380	864	471	93	**2 808**
1960 - 1982	**374**	**231**	**85**	**17**	**707**
1983 - 2003	**1 862**	**1 429**	**724**	**128**	**4 143**
Difference	***1 488***	***1 198***	***639***	***111***	***3 436***

Plans for Continuation

Currently, there are no plans to continue this study. We will pursue publication of study results in 2009.

Publications, Theses, and Reports

Thesis

Kuchy, A. L., 2008, *Implications of Climate Variability on Large Fires across Spatiotemporal Scales in Sagebrush Steppe*, M.S. Thesis: University of Idaho, Moscow.

Table 9-6. The Average Fire Size (Top) and Total Area Burned (Bottom) in Hectares by Fire Size Category Over Time, in the Snake River Plain Ecoregion, 1960-2003.

Average Fire Size (ha)

	Size class (ha)				
	A	B	C	D	Average
Year	0 – 50	51 – 500	501 – 5000	5000+	
1960 - 1969	9	189	1 310	7 418	**2 232**
1970 - 1979	13	172	1 288	15 059	**4 133**
1980 - 1989	16	195	1 478	8 928	**2 654**
1990 - 1999	13	172	1 484	13 392	**3 765**
2000 - 2003	16	184	0	0	**100**
Average (decade)	***13***	***182***	***1 390***	***11 199***	***3 196***
1960 - 1982	**12**	**186**	**1 347**	**9 891**	**2 859**
1983 - 2003	**47**	**548**	**2 996**	**12 027**	**3 904**
Difference	***35***	***362***	***1 649***	***2 136***	***1 045***

Total Area Burned (ha)

	A	B	C	D	Total	Average
	0 – 50	**51 – 500**	**501 – 5000**	**5000+**		
Year			**Hectares**			
1960 – 1969	2 420	3 937	69 446	44 505	**120 308**	**30 077**
1970 - 1979	7 528	71 532	178 980	261 051	**519 091**	**129 773**
1980 – 1989	10 423	142 120	599 544	547 946	**1 300 033**	**325 008**
1990 – 1999	19 998	126 602	413 917	656 220	**1 216 737**	**304 184**
2000 – 2003	1 242	2 030	0	0	**3 272**	**1 636**
Average (decade)	***8 322***	***69 244***	***252 377***	***301 944***		
1960 - 1982	**12 286**	**116 540**	**391 279**	**363 118**	**883 223**	**220 806**
1983 - 2003	**29 325**	**229 681**	**870 608**	**1 146 604**	**2 276 218**	**569 055**
Difference	***17 039***	***113 141***	***479 329***	***783 486***	***1 392 995***	**348 249**

Table 9-7. The Average Fire Size (Top) and Total Area Burned (Bottom) in Hectares by Size Class Over Time, in the Idaho National Laboratory, and the Snake River Plain and Northern Basin and Range Ecoregions,1960- 2003.

Average Fire Size (ha)

	Size class (ha)				
	A	B	C	D	Average
Year	0 – 50	51 – 500	501 – 5000	5000+	
1960 - 1969	9	192	1 350	8 558	**2 527**
1970 - 1979	12	175	1 275	14 503	**4 928**
1980 - 1989	17	189	1 566	10 533	**3 076**
1990 - 1999	13	178	1 463	13 221	**3 719**
2000 - 2003	13	191	1 582	13 395	**3 818**
1960 - 1982	**13**	**152**	**1 407**	**11 135**	**3 177**
1983 - 2003	**44**	**186**	**1 515**	**12 583**	**3 582**
Difference	***31***	***34***	***108***	***1 448***	***405***

Total Area Burned (ha)

	A	B	C	D	Total	Average
Year	0 – 50	51 – 500	501 – 5000	5000+		
1960 - 1969	3 846	32 255	95 872	85 579	**217 551**	**54 388**
1970 - 1979	8 191	82 931	183 867	261 052	**536 040**	**134 010**
1980 - 1989	12 938	165 657	783 108	768 902	**1 730 606**	**432 651**
1990 - 1999	3 526	207 599	702 011	965 111	**1 902 294**	**475 573**
2000 - 2003	9 411	167 774	737 887	1 245 048	**2 170 304**	**542 575**
Average (decade)	***7 582***	***75 074***	***500 549***	***665 138***		
1960 - 1982	**15 564**	**166 059**	**316 438**	**567 312**	**1 065 374**	**266 343**
1983 - 2003	**55 912**	**480 155**	**2 186 308**	**2 759 046**	**5 491 421**	**1 372 855**
Difference	***40 348***	***314 096***	***1 869 870***	***2 191 734***	***4 426 047***	***1 106 512***

Table 9-8. Pearson's Product-moment Correlations Between Precipitation (PPT) and Maximum Temperature (TMAX), and Large Fire Size (ha).

	Current year		1-yr Previous		2-yr Previous	
	r^2	P	r^2	P	r^2	P
BROAD SCALE						
Average Spring/Summer PPT	0.031	0.123	0.089	0.527	0.040	0.153
Average Spring/Summer TMAX	0.057	0.207	0.017	0.406	0.026	0.441
Average Yearly PPT	0.031	0.123	**0.054**	**0.031** *	0.053	0.061
Average Yearly TMAX	**0.114**	**0.038** *	0.064	0.126	0.049	0.247
MEDIUM SCALE						
Average Spring/Summer PPT	0.202	0.143	0.016	0.693	0.0002	0.943
Average Spring/Summer TMAX	0.083	0.421	0.020	0.649	0.021	0.524
Average Yearly PPT	0.016	0.474	0.026	0.312	0.000	0.943
Average Yearly TMAX	0.002	0.844	0.206	0.161	0.104	0.398
FINE SCALE						
Average Spring/Summer PPT	0.249	0.667	0.249	0.667	-	-
Average Spring/Summer TMAX	0.083	0.421	0.057	0.150	-	-
Average Yearly PPT	0.293	0.636	0.289	0.639	0.028	0.786
Average Yearly TMAX	0.240	0.667	0.240	0.667	0.606	0.221

* Significant at alpha = 0.05

Presentations

Kuchy, A. L. and S. C. Bunting, 2008, "Fire History over Four Decades in Semi-arid Sagebrush Steppe," *The Ecological Society of America 93rd Annual Meeting*, August 3–8, 2008, Milwaukee, Wisconsin.

Kuchy, A. L. and S. C. Bunting, 2008, "Recent Large Fire Regime Changes in Semi-arid Sagebrush Steppe," *American Geophysical Union Fall Meeting*, San Francisco, California, December 15–19, 2008.

Kuchy, A. L., and S. C. Bunting, 2009, "Implications of Climate Variability on Large Fires across Spatiotemporal Scales in Sagebrush Steppe," Seminar presented to the INL Environmental Surveillance, Education and Research Program, Idaho Falls, Idaho, February 19, 2009.

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

Investigators and Affiliations

Joel B. Sankey, Graduate Student, Engineering and Applied Science, Idaho State University, Pocatello, Idaho

Amber Hoover, Graduate Student, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Lachlan Ingram, Ph.D., Postdoctoral Scientist, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Nancy F. Glenn, Ph.D., Professor, Geosciences Department, Idaho State University, Pocatello, Idaho

Matthew J. Germino, Ph.D., Professor, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Funding Sources

Inland Northwest Research Alliance

National Center for Airborne Laser Mapping

U.S. Department of Defense

Bureau of Land Management

Background

Aeolian sediment transport is a fundamental geomorphic process that has wide-ranging environmental implications for human and environmental health, ecological functioning at multiple spatial and temporal scales, local and global biogeochemical cycling, and contaminant transport. Aeolian sediment transport is a function of the wind's ability (impeded by vegetation and terrain) to entrain soil particles, and the soil's susceptibility to this entrainment. Field-based research on aeolian transport in nonagricultural systems has largely focused on arid landscapes; however, semiarid landscapes, and shrublands in particular, exhibit considerable annual fluxes of wind-transported sediment. The addition of fire in semiarid landscapes can generate locations that are susceptible to substantial, locally recurring wind erosion.

Objectives

The overall goal of our research is to determine and describe wildland fire effects on wind erosion potential of shrub steppe in southeastern Idaho. The specific objective for our research at the INL Site is to identify hydroclimatological, vegetation, and microtopographical controls on post-fire wind erosion potential.

Accomplishments through 2008

- Monitored saltation, aeolian threshold wind velocity, aeolian sediment flux, and soil loss and deposition at the East Butte Fire, Moonshiner Fire, and an adjacent control site since September 2007.
- With Lachlan Ingram, analyzed soils collected in sediment traps for soil texture and will be tested for carbon and nitrogen, to allow assessment of biogeochemical effects of erosion.
- National Center for Airborne Laser Mapping collected a Light Detection and Ranging (LiDAR) data set for our INL Site study area in November 2007. Processed the LiDAR data to characterize surface roughness (ground and vegetation), which were correlated with ground measurements of soil erosion/deposition.
- Jan Eitel and Lee Vierling of University of Idaho used a ground-based LiDAR tool, known as a terrestrial laser scanner, to begin constructing fine-scale elevation models of the erosion research sites.
- Presented results on hydroclimatological controls on post-fire wind erosion to the International Grasslands Congress and International Rangelands Congress in Huhot, China (July 2008) and to the Joint Soil Science Society of America – Geological Society of America (October 2008).
- Submitted a manuscript based on the hydroclimatological results to a peer-reviewed journal.

Results

Key findings related to hydroclimatological controls on post-fire wind erosion include:

- Erodibility, as measured by threshold wind speed, decreased at the two burned sites during the fall months following fire, and this corresponded with concomitant decreases in aeolian sediment flux
- Soil water content, air moisture content, and air temperature partially explained the observed decease in erodibility, post-fire, and appear to be significant controls on daily variability in erodibility following a fire.

Initial results from soil erosion/deposition (Figure 9-12) show mean change in relative surface elevation for approximately one year following the Twin Buttes fire (3,819 hectares burned in July 2007), Moonshiner fire (1,081 hectares burned in September 2007), and at unburned sites located down-wind (prevailing) of the two fires. Surface elevation change was assessed with repeat measurements of 100, 60, and 120 erosion bridges at the Twin Buttes, Moonshiner, and unburned sites, respectively. The Twin Buttes fire was located predominantly on INL Site lands, and very little vegetation remained following the fire. The Moonshiner fire burned adjacent to the Twin Buttes fire and was located on land managed by the DOE-ID, Bureau of Land Management, and Idaho State Department of Lands. Some cover of burned juniper and sagebrush plants remained following the Moonshiner fire. Calculations suggest that 112,660,500 and 2,432,250 kg of soil might have been mobilized by wind from burned surfaces at the Twin Buttes and

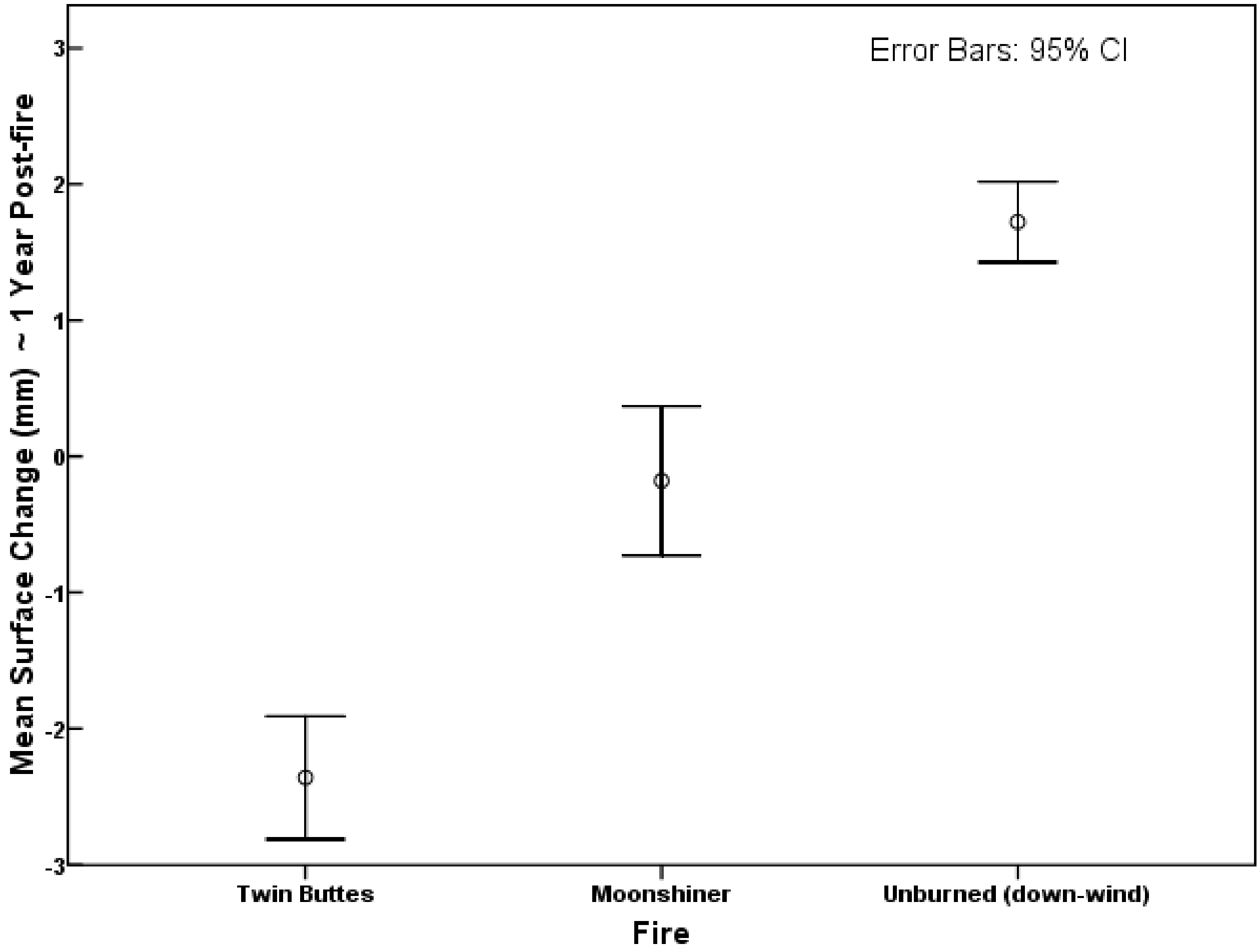


Figure 9-12. Mean Change in Relative Surface Elevation for Approximately One Year Following the Twin Buttes Fire (3,819 Hectare Burned in July, 2007), Moonshiner Fire (1,081 Hectare Burned in September 2007), and at Unburned Sites Located Down-wind (Prevailing) of the Two Fires.

Moonshiner fires, respectively, based on mean surface change, area burned, and an assumed bulk density of 1.25 g/cm^3.

Initial results from LiDAR analysis of soil erosion/deposition show that the smoothest LiDAR-characterized surfaces exhibited net erosion, while the roughest surfaces exhibited minimal erosion or net deposition.

Analysis is underway to determine: (1) the degree to which soil and vegetation roughness elements control erosion/deposition, respectively, and (2) the spatial scale(s) at which LiDAR-derived roughness can explain variability in erosion/deposition.

Plans for Continuation

We intend to continue our monitoring work through at least summer/fall 2009.

Publications, Reports, and Theses

Conference Presentations and Posters

Sankey, J., M. Germino, N. Glenn, 2008, “Hydroclimatological Controls on Aeolian Sediment Transport Following Wildfire,” *The Joint Annual Meeting of the Geological Society of America (GSA), American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA)*, Houston, Texas, October 5–8, 2008 (presenter - Sankey).

Sankey, J., M. Germino, N. Glenn, 2008, “The Increased Potential for Aeolian Transport Following Wildfire,” *The Joint Annual Meeting of the Geological Society of America (GSA), American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA)*, Houston, Texas, October 5–8, 2008 (presenter - Sankey).

Sankey, J. B., M. J. Germino, N. F. Glenn, 2008, “Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho, USA,” *Joint International Grassland Congress/ International Rangeland Congress*, Hohhot, China, June 29–July 5, 2008 (poster).

Conference Proceedings

Sankey, J., M. Germino, N. Glenn, 2008, “Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho, USA,” *Multifunctional Grasslands in a Changing World,* (Eds.) Organizing Committee of 2008 International Grassland Congress and International Rangeland Congress Meeting, Huhhot, China, July 2008, Volume 1, p. 843.

Manuscript in Review

Sankey, J. B., M. J. Germino, N. F. Glenn, “Relationships of Post-fire Aeolian Transport to Atmospheric and Soil Moisture,” (in review with *Journal of Aeolian Research*, submitted January 2009).

Manuscripts in Press

Sankey, J. B., M. J. Germino, N. F. Glenn, “Wind Erosion Following Wildfire in Sagebrush Steppe,” *Journal of Arid Environments*.

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

Investigators and Affiliations

Amber Hoover, Graduate Student, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Joel B. Sankey, Graduate Student, Engineering and Applied Science, Idaho State University, Pocatello, Idaho

Lachlan Ingram, Ph.D., Postdoctoral Scientist, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Nancy F. Glenn, Ph.D., Professor, Geosciences Department, Idaho State University, Pocatello, Idaho

Matthew J. Germino, Ph.D., Professor, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Funding Sources

Inland Northwest Research Alliance

National Center for Airborne Laser Mapping

U.S. Department of Defense

Bureau of Land Management

Background

Aeolian processes play a significant role in shaping arid and semiarid environments. The semiarid shrublands of southeastern Idaho are particularly prone to wind erosion following wildfire. Vegetation is tightly linked to its environment, and therefore, geomorphic processes in sagebrush steppe. Vegetation has large influences on aeolian transport by providing soil cover and decreasing erosion. Soil surfaces resulting from wind erosion influence vegetation. In turn, vegetation influences aerodynamics because plants are roughness elements in wind fields. Large amounts of heterogeneity exist in the soils and vegetation of the sagebrush steppe. This project focuses on heterogeneity in the sagebrush steppe in regards to both the relationship between vegetation and soil surfaces and the relationship between the atmosphere and vegetation.

Objectives

Our goal is to increase understanding of the relationships between vegetation and geomorphic and atmospheric processes. More specifically, we plan to address two main objectives:

- To determine if there is a relationship between post-fire heterogeneity of the soil surface morphology and vegetation recovery following wildfire
- To determine if there is temporal variability in the aerodynamic parameters friction velocity and roughness length at multiple scales and identify how it relates to temporal variations in vegetation.

Accomplishments through 2008

Field studies were conducted during summer 2008 at the sites of two adjacent, fall 2007 wildfires on the Snake River Plain of southeastern Idaho on the INL Site. We characterized the soil surface morphological heterogeneity and the vegetation corresponding to the soil morphologies in the post-erosion environment. In addition, we collected data on temporal changes in aerodynamics (friction velocity and roughness length) and corresponding vegetation at the burn site.

Results

Using Eckert's 1986 classification, the burned landscape was characterized by a mosaic of coppice and playette soil surface morphologies. We speculate that coppices and playettes result from depositional and erosive processes, respectively. The landscape was nearly equally comprised of playette (47.9 percent ±0.9) and coppice (52.0 percent ±0.9) surfaces. Preliminary data suggest that the soil surface morphological types have different physical and hydrological properties. In addition, vegetation abundance is greater on coppices than on playettes at peak biomass. There appear to be seasonal differences in the vegetation corresponding to each soil surface type.

Interestingly, preliminary data on the temporal changes in aerodynamics (friction velocity and roughness length) indicate that these aerodynamic parameters do vary between summer months even when vegetation cover and height are not changing.

Plans for Continuation

Further data on both objectives will be collected during spring and summer 2009.

Publications, Theses, and Reports

In April 2009, a poster presentation of this project will be given at the Intermountain Graduate Research Symposium in Logan, Utah.

Submitted an abstract to give a poster presentation of this project at the Ecological Society of America Annual Meeting in August 2009.

These data will comprise Amber Hoover's M.S. thesis (expected finish is May 2010).

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

Investigators and Affiliations

Nancy Hampton, Graduate Student, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

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

Background

Periodic outbreaks of the sagebrush defoliator moth [*Aroga websteri* Clarke (*Lepidoptera:* Gelechiidae)] can cause widespread damage to rangelands in the western United States. Sagebrush (*Artemisia* spp.) is the exclusive larval host of *A. websteri* and, in high numbers, larvae can kill host plants and reduce the production of foliage and flowering by surviving plants for years. The overall goal of this project is to use habitat data from sagebrush communities in southeastern Idaho to determine which variables (e.g., presence, relative cover, or height of sagebrush species; presence of other plant species; presence of other moth and insect species; land use attributes; or weather conditions) most strongly predict the presence or absence and abundance of *A. websteri*. Developing a predictive model would be a first step toward identifying the locations of potential *A. websteri* outbreaks. A better understanding of the location, timing, and pattern of defoliator outbreaks would allow land managers to better maintain and manage critical sagebrush habitats.

Objectives

Specific project objectives for 2008 were to:

- Determine the presence and relative density of *A. websteri* in remote sagebrush habitat on and off the INL Site
- Measure vegetation and other habitat attributes at each sampling location
- Prepare specimens for identification
- Compile and analyze 2007 field data.

Accomplishments through 2008

Project accomplishments for 2008 include:

- Collected insects in traps over three days and nights in 42 locations within sagebrush habitat on and off the INL Site

- Compiled data on plant species composition, relative abundance rankings, and number and height for each shrub species for each location
- Preserved and sorted specimens of *A. websteri* and nontarget insect species captured in 2007 and 2008
- Summarized climatological data for all sampling dates and completed comparisons of temperatures and precipitation for 2007 and 2008 to long-term averages.

Results

Twenty-one *A. websteri* individuals were captured from 11 of 42 locations (26 percent) in 2008 (Figure 9-13), including five of the locations in which the moth was captured in 2007. A maximum of five individuals was captured in a single location in 2008, whereas the maximum number captured in any location in 2007 was three.

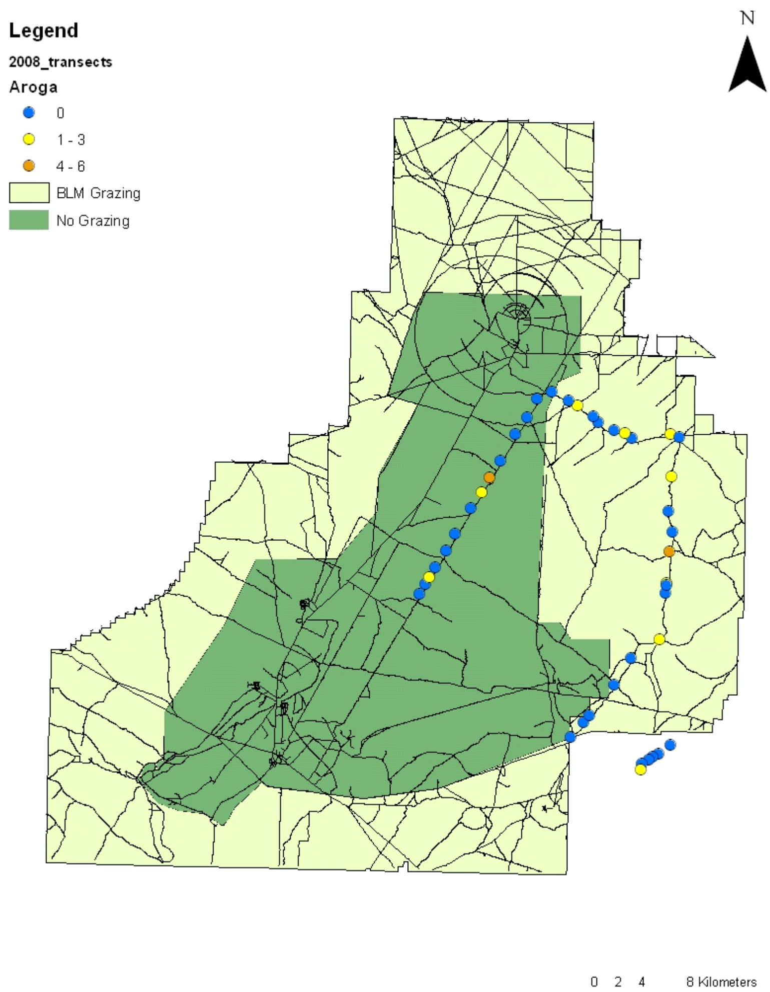


Figure 9-13. The Number of *A. websteri* Captured July 28-31, 2008, at Sampling Locations On and Off the INL (21 Individuals Total).

Evidence of the presence of *A. websteri* was found in sagebrush branch samples from only seven of 40 (20 percent) locations in 2007. *A. websteri* adults were also captured in 2007 at four of the seven sites.

The number of *A. websteri* and proportion of sites at which individuals were captured are too small to support analysis of *A. websteri* abundance with respect to habitat attributes.

Plans for Continuation

Currently, models are being analyzed to determine which habitat variables (e.g., relative cover or height of sagebrush species, presence of other plant species, presence of other moth and insect species, land use attributes, or weather conditions) might predict the presence or absence of *A. websteri*.

A. websteri and other specimens have been preserved and are currently being prepared for submission to taxonomic experts for identification.

Publications, Reports, and Theses

A manuscript documenting project results will be submitted for publication in a peer-reviewed journal in fall 2009. Results also will contribute to other integrated presentations and publications on the biology and outbreak dynamics of *A. websteri* and other insect pests of western rangelands.

9.10 Long-term Vegetation Transects

Investigators and Affiliations

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

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

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

Funding Sources

U.S. Department of Energy-Idaho Operations Office

Background

The long-term vegetation (LTV) transects and associated permanent vegetation plots (Figure 9-14) were established at the Arco Reactor Test Site, now the INL Site, in 1950 for the purpose of assessing the impacts of nuclear energy research and production on surrounding ecosystems (Singlevich et al. 1951). Vegetation abundance data were first collected in 1950 for inclusion in an ecological characterization of the INL Site. Samples of plant and animal tissues were also collected from these plots and analyzed for radionuclide concentrations annually for several

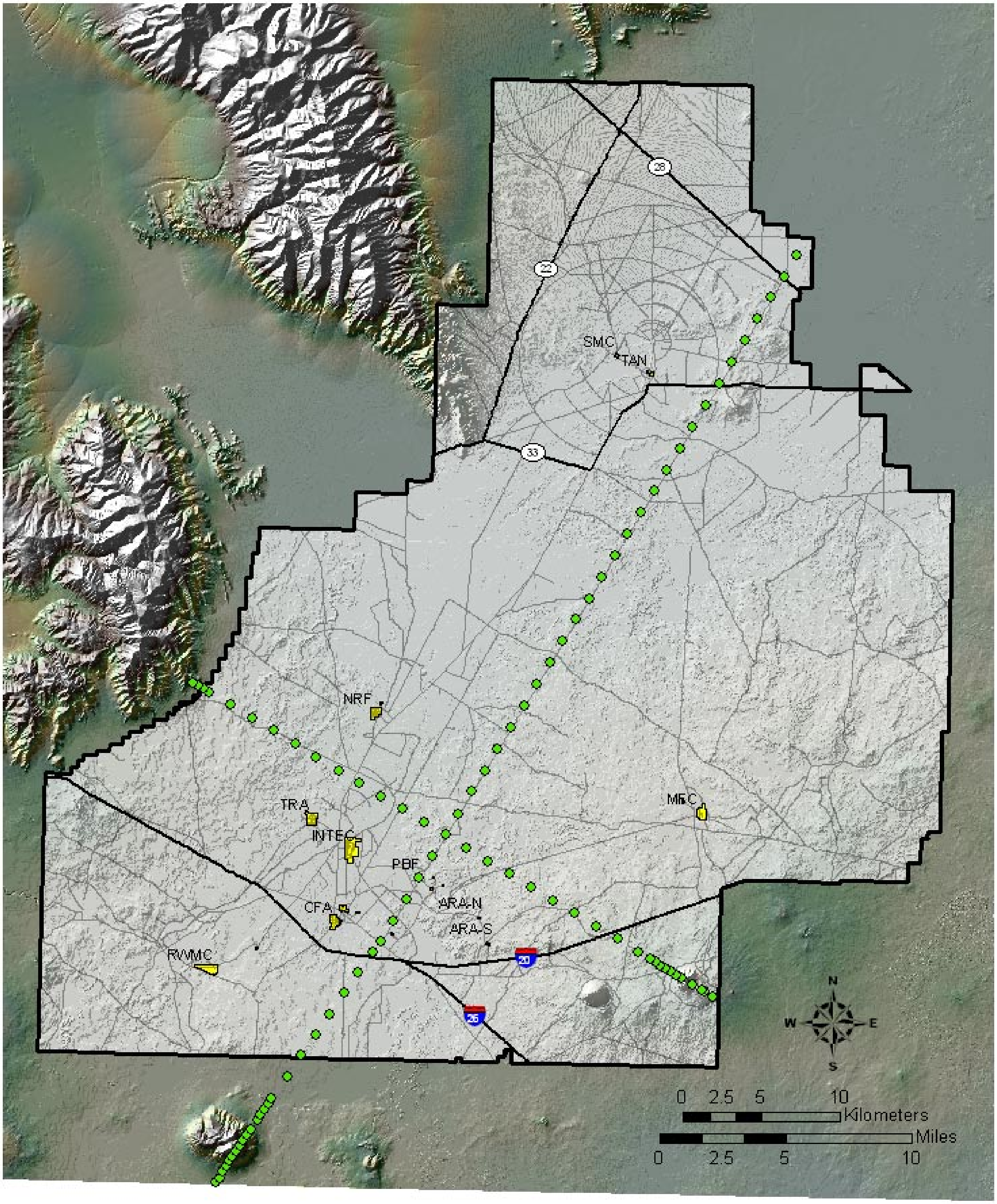


Figure 9-14. Map of the INL Site with Locations for Permanent LTV Plots Located Along Two Macro-Transects.

years. Collection of tissue samples was eventually discontinued because the effects of fallout from nuclear reactors were determined to be negligible (Harniss 1968), at least in terms of radionuclide concentrations in the environment. However, collection of vegetation abundance data has continued regularly for nearly 60 years.

The data generated from the LTV transects comprise one of the oldest, largest, and most comprehensive vegetation data sets for sagebrush steppe ecosystems in North America. Since their establishment, the LTV transects have been used extensively for various tasks to support the Department of Energy-Idaho Operations Office mission and have been the basis for major milestones in understanding practical and theoretical ecology of sagebrush steppe vegetation dynamics. Applications of the LTV data include:

- Classifying and mapping plant communities
- Assessing the effects of drought and livestock grazing
- Understanding fire history and recovery
- Characterizing species invasion patterns
- Testing theories of vegetation succession and change
- As a basis for habitat suitability modeling for sensitive species
- Supporting National Environmental Policy Act processes
- Making appropriate land management recommendations
- Developing specific revegetation recommendations.

In addition to the functions listed above, the LTV data set is still used to assess the impacts of energy development on the environment, as was intended in 1950. However, impacts beyond radioactive fallout, such as exotic species invasion, habitat fragmentation, and global climate change, are of current interest.

Objectives

The eleventh LTV data set was collected during the summer of 2006. Two tasks were undertaken in association with the 2006 data collection. The first task involved a major effort in updating and describing the data archives. The second included summarizing and analyzing the 2006 and all previously collected abundance data.

The last attempt at organizing and archiving the LTV data was completed in the early 1980s. Although care had been taken to format and store data collected since 1983 in a manner consistent with the protocol established at that time, the data archives have become outdated. The software available for archiving and processing data has improved substantially over the past 25 years, necessitating an update of the LTV data files. A considerable amount of the work associated with entering and summarizing the 2006 data includes designing and populating a relational database for all of the LTV data from 1950 to 2006. Additionally, a specific sampling protocol will be developed and a thorough history of the LTV data will be included as part of the reporting effort.

Analyses on the 2006 and previous data can be summarized under two focus areas. The first includes characterizing general plant abundance and community composition trends, similar to analyses described in previous LTV reports. The second area of analyses concentrates on characterizing patterns of exotic species invasion and determining the effects of invasion on vegetation cover and composition of native plant communities subsequent to invasion.

Accomplishments through 2008

Accomplishments through 2008 include collection of the 2006 data and completion of quality assurance/quality control procedures on that data set. The 2006 data also were summarized and formatted for inclusion in a comprehensive database. A specific protocol to collect LTV data was designed and outlined in association with the 2006 data collection effort. A Microsoft Access database was designed to house historical LTV data and to facilitate future data collection, including straightforward processes for updating data tables. The database also will expedite current and future analyses on the complete LTV data set. Incorporation of historical and 2006 LTV data into the database was completed in 2008. Data verification and validation were also finalized in 2008. Historical data were verified and validated to ensure integrity and completeness, as well as to resolve issues associated with taxonomic classifications and scaling as the data were integrated into the new database.

Five chapters were outlined for inclusion in the final report, to be completed by spring 2009. The five chapters include (1) a brief introduction, (2) a comprehensive history of the LTV permanent plots and associated vegetation studies, (3) a detailed protocol to be used to guide data collection efforts and maintain continuity in future data collection efforts, (4) a thorough documentation of the updated database structure, and (5) results of analyses addressing long-term plant community change and invasive species patterns. Drafts of two chapters, one addressing the LTV history and the other documenting the database structure, were completed in 2008.

Results

The database includes seven raw data and metadata tables. The general structure of the database is depicted in Figure 9-15. The metadata tables include information about plant species on the INL Site and information about each of the permanent plots on the LTV transects. The species information contains standardized information for each vascular plant species documented to occur within or adjacent to the INL Site boundary. Information contained in the species information table facilitates summarizing data into functional groups, and allows the definitions of functional groups to be changed easily. The species information table reconciles species codes traditionally used for data collection on the INL Site with a national standard (USDA and NRCS 2009). The plot information data table contains metadata about each permanent plot, including: coordinates, elevation, grazing allotment, plant community classification, soils information, fires, etc. An additional metadata table, the sample frequency table, contains information about the types of data collected and sample periods for collection of each type of data on each plot, as well as deviations from historical sampling conventions. These details are critical for obtaining accurate summary statistics.

The database contains four data tables; three tables are comprised of vegetation abundance data, and one includes information about plot photos. The abundance data tables contain density/frequency data, cover data estimated using line interception, and cover data estimated using point interception. The abundance data incorporated into the data tables were left in as raw a form as possible; however, most of the historical data archives were summarized to some extent, which dictated the level of data summarization used in the updated database. The photograph specifications data table was designed to consolidate data associated with photos taken when LTV data were collected, including photo dates, exposure, aperture, camera angle, etc. The photo data were designed such that each photo record includes a hyperlink to a digital copy of that photo. Accordingly, all of the historical photos were digitized as part of the update to the LTV archive.

Plans for Continuation

Analyses and reporting of the 2006 LTV data will be completed during Fiscal Year 2009. Two peer-reviewed publications containing results from the current LTV data set also will be prepared and submitted as time and funding allow.

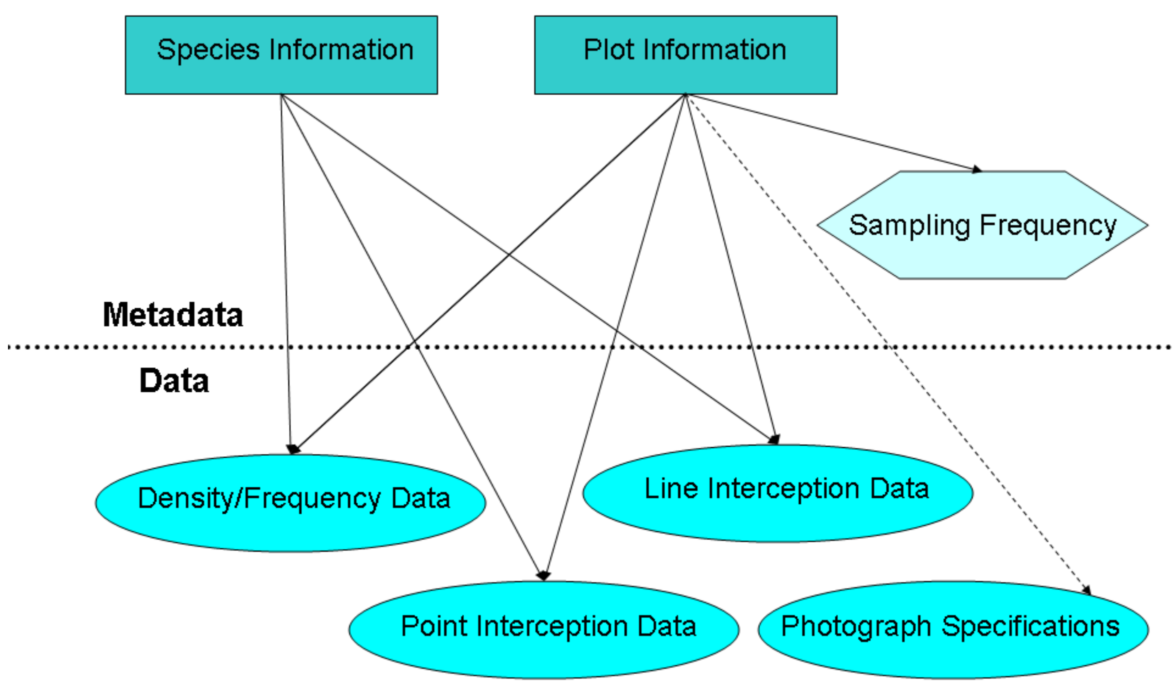


Figure 9-15. Flow Chart Showing Seven Data and Metadata Tables and the Relationships of Those Tables to One Another in the LTV Database.

9.11 The Protective Cap/Biobarrier Experiment

Investigators and Affiliations

Brandy C. Janzen, Graduate Student, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Matthew J. Germino, Ph.D., Associate Professor, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

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

Funding Sources

U.S. Department of Energy-Idaho Operations Office

Background

Shallow land burial is the most common method for disposing of industrial, municipal, and low-level radioactive waste, but in recent decades it has become apparent that conventional landfill practices are often inadequate to prevent movement of hazardous materials into groundwater or biota (Suter et al. 1993; Daniel and Gross 1995; Bowerman and Redente 1998). Most waste repository problems result from hydrologic processes. When wastes are not adequately isolated, water received as precipitation can move through the landfill cover and into the wastes (Nyhan et al. 1990; Nativ 1991). Presences of water may cause plant roots to grow into the waste zone and transport toxic materials to aboveground foliage (Arthur 1982; Hakonson et al. 1992; Bowerman and Redente 1998). Likewise, percolation of water through the waste zone may transport contaminants into groundwater (Fisher 1986; Bengtsson et al. 1994).

In semiarid regions, where potential evapotranspiration greatly exceeds precipitation, it is theoretically possible to preclude water from reaching interred wastes by (1) providing a sufficient cap of soil to store precipitation that falls while plants are dormant and (2) establishing sufficient plant cover to deplete soil moisture during the growing season, thereby emptying the reservoir of stored water.

The Protective Cap/Biobarrier Experiment (PCBE) was established in 1993 at the Experimental Field Station, INL Site, to test the efficacy of four protective landfill cap designs. The ultimate goal of the PCBE is to design a low maintenance, cost effective cap that uses local and readily available materials and natural ecosystem processes to isolate interred wastes from water received as precipitation. Four evapotranspiration cap designs, planted in two vegetation types, under three precipitation regimes have been monitored for soil moisture dynamics, changes in vegetative cover, and plant rooting depth in this replicated field experiment.

Objectives

From the time it was constructed, the PCBE has had the following four primary objectives:

- Comparing the hydrologic performance of four evapotranspiration cap designs
- Examining the effects of biobarriers on water movement throughout the soil profile of evapotranspiration caps
- Assessing the performance of alternative evapotranspiration cap designs under current and future climatic scenarios
- Evaluating the performance of evapotranspiration caps planted with a diverse mix of native species to those planted with a monoculture of crested wheatgrass.

Specific tasks for the PCBE in 2007 included maintenance of the study plots, continuation of the irrigation treatments, and collection of soil moisture and plant cover data. An update to the 2003 PCBE summary report (Anderson and Forman 2003) was finalized in February 2007 (Janzen et al. 2007), which focused upon long-term cap performance. The 2007 report built upon the original objectives by adding four additional objectives: (1) comparing plant cover and soil moisture dynamics from the 1994–2000 study period with the relatively drier 2002–2006 study period, (2) assessing the spatial and temporal stability of total vegetation cover, (3) understanding how vulnerable the native and crested wheatgrass communities are to invasion from neighboring communities, and (4) quantifying the relationship between vegetation cover and evapotranspiration.

During the 2008 field season, collection of finer time-scale vegetation cover measurements and direct transpiration measurements began in order to clarify soil-plant water relationships occurring on the PCBE. Specific objectives for these measurements include: (1) identify the relationship between vegetation cover and evapotranspiration on plots planted with a native seed mix, (2) determine relative contribution by species to plot evapotranspiration, and (3) determine if community dynamics have been shaped by either cap design or irrigation treatment.

Accomplishments through 2008

Two supplemental irrigation treatments were completed on the PCBE in 2008. A summer irrigation treatment was applied biweekly in 50-millimeter increments beginning in late June and ending in early August, totaling 200 millimeters of irrigation. The fall/spring irrigation application of 200 millimeters was completed during late September and early October. Soil moisture data were collected biweekly beginning in April through mid-October 2008. Vegetation cover data were collected throughout July and early August. Fine scale measurements in the form of photographs were taken monthly for all planted native plots beginning in May and ending in October. Transpiration measurements for selected native species were collected on deep-biobarrier caps receiving both fall/spring irrigation and summer irrigation, and RCRA (Resource Conservation and Recovery Act) cap types receiving summer irrigation at the end of July, August, and early October.

Results

Using photographic measures of cover, collected during May, June, July, and August 2007, cover was greater on experimental plots with a 2-m loam soil profile compared to the Environmental Protection Agency-recommended cap construction (Figure 9-16). Observed differences in vegetation cover between the two soil profile types were due to a greater abundance of shrubs on caps with the deeper soil profile.

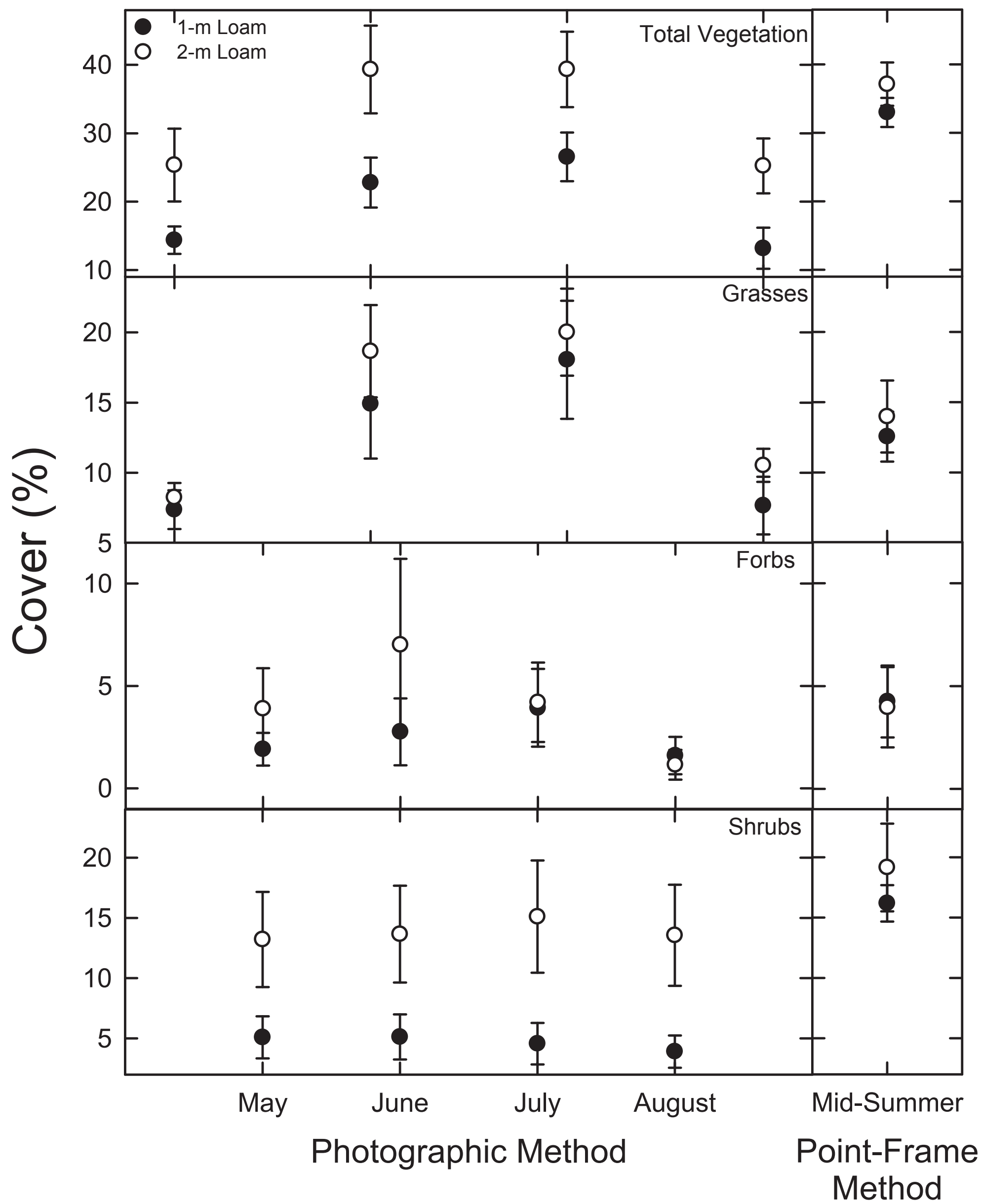


Figure 9-16. Variation in Vegetation, Grass, Forb, and Shrub Cover (Mean ± 1 Standard Error) in 2007 for Different Soil Profile Types.
Values are for photographic cover measurements taken in May, June, July, and August (left panels), and a single snapshot using point-frames (right panels) of vegetative cover. Note differences in scales.

Using photographic measures of vegetation cover, collected during May, June, July, and August 2007, cover was the least on plots receiving ambient precipitation (Figure 9-17). Observed difference in vegetation cover between the irrigation treatments and the control treatment were due to significantly less grass and forb cover through much of the growing season. Additionally, shrub cover was observed to be significantly greater on plots receiving supplemental irrigation during the fall.

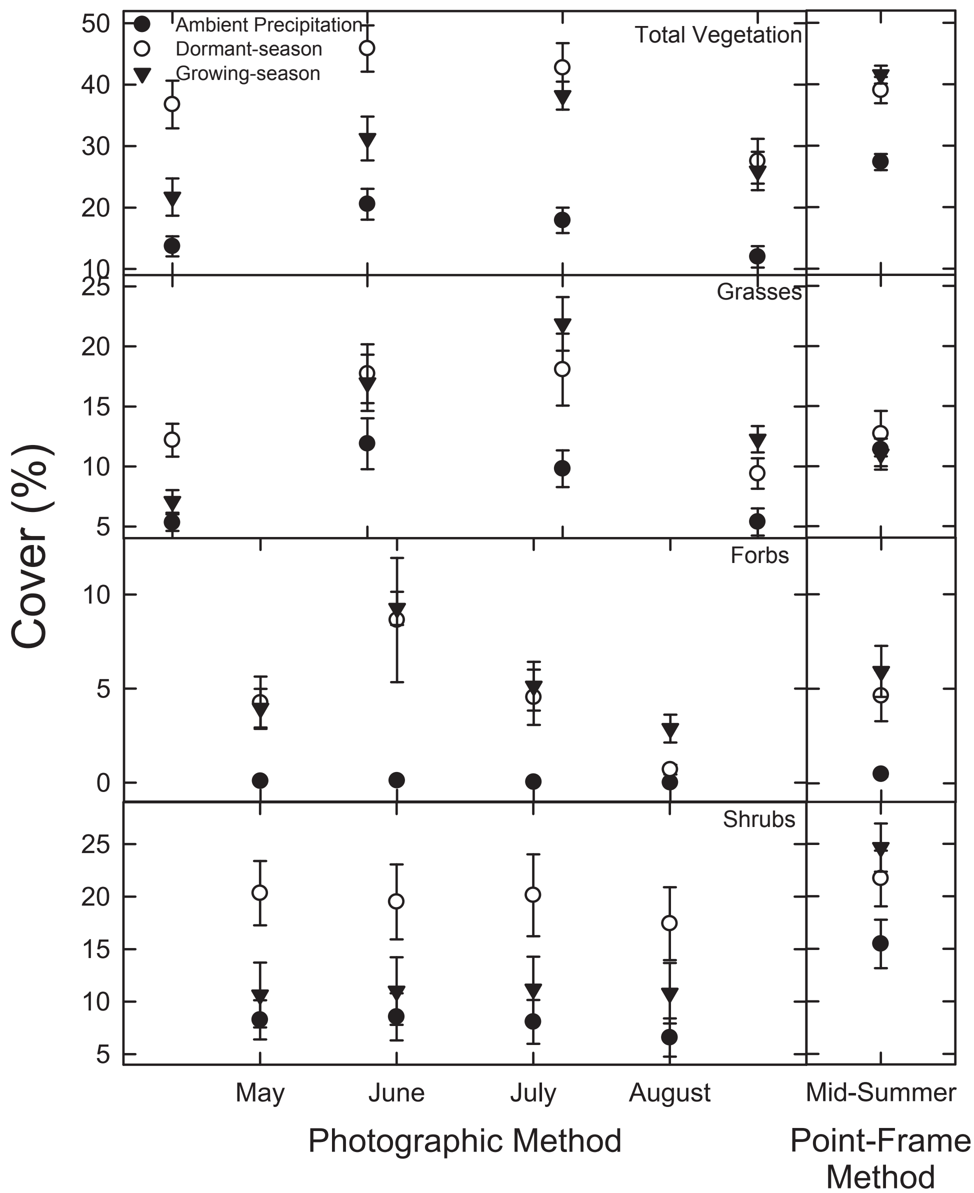


Figure 9-17. Variation in Vegetation, Grass, Forb, and Shrub Cover (Mean ± 1 Standard Error) for 2007 for Different Precipitation Treatments.
Values are for photographic cover measurements taken in May, June, July, and August (left panels), and a single snapshot using point-frames (right panels) of vegetative cover. Note differences in scales.

Vegetative cover and the Inverse Simpson's index values obtained for the RCRA cap types were generally lower than in all other cap types (Figure 9-18). Long-term trends in diversity indices do not differ significantly among cap types when data analysis includes all irrigation treatments.

Vegetative cover and Inverse Simpson's index were lower in the ambient treatment than in either the irrigated treatments (Figure 9-19). Long-term trends in other diversity indices did not differ significantly among irrigation treatments.

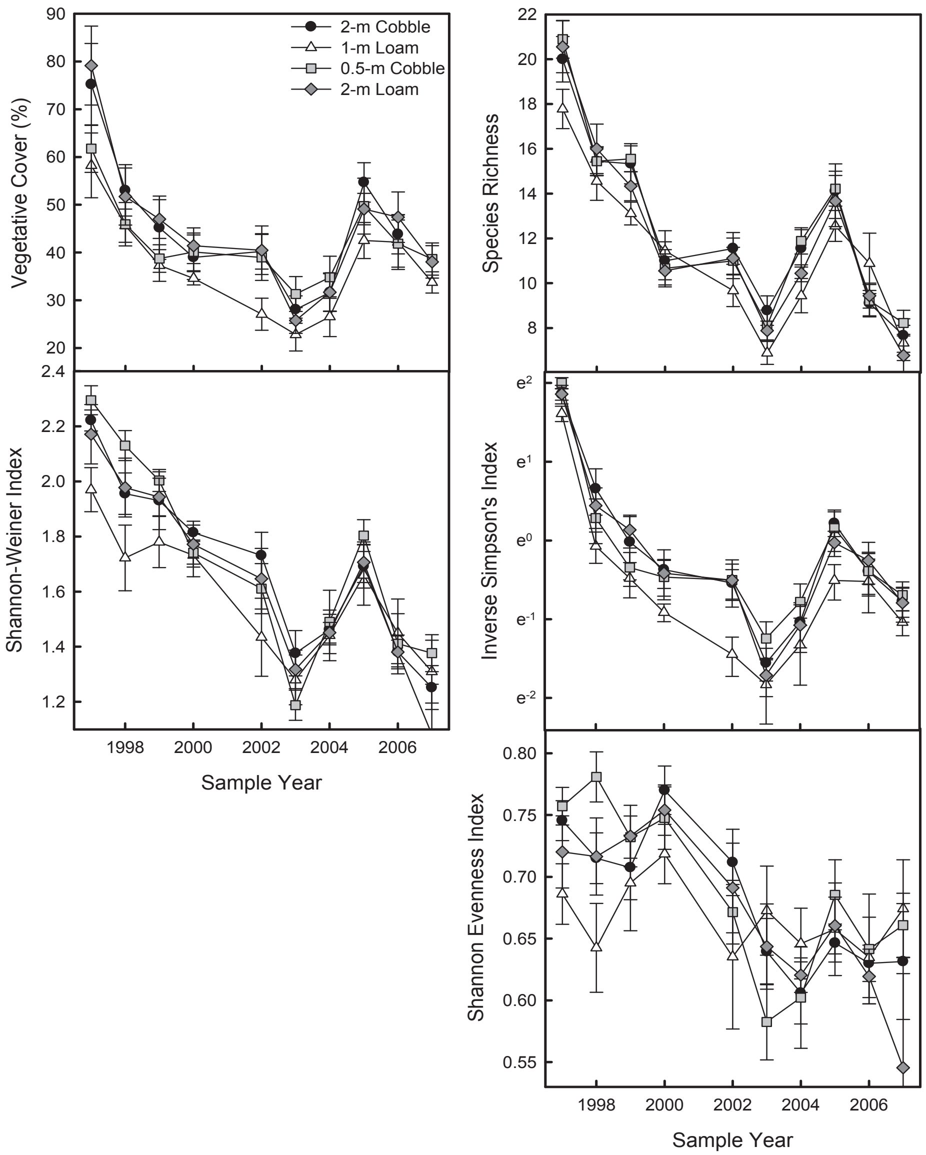


Figure 9-18. Trends in Community Vegetative Cover (%) and Diversity Indices (Mean ± 1 Standard Error) by Soil Profile Treatment for Plots at the Idaho National Laboratory, Idaho, USA, from 1997 to 2007. Note differences in scales.

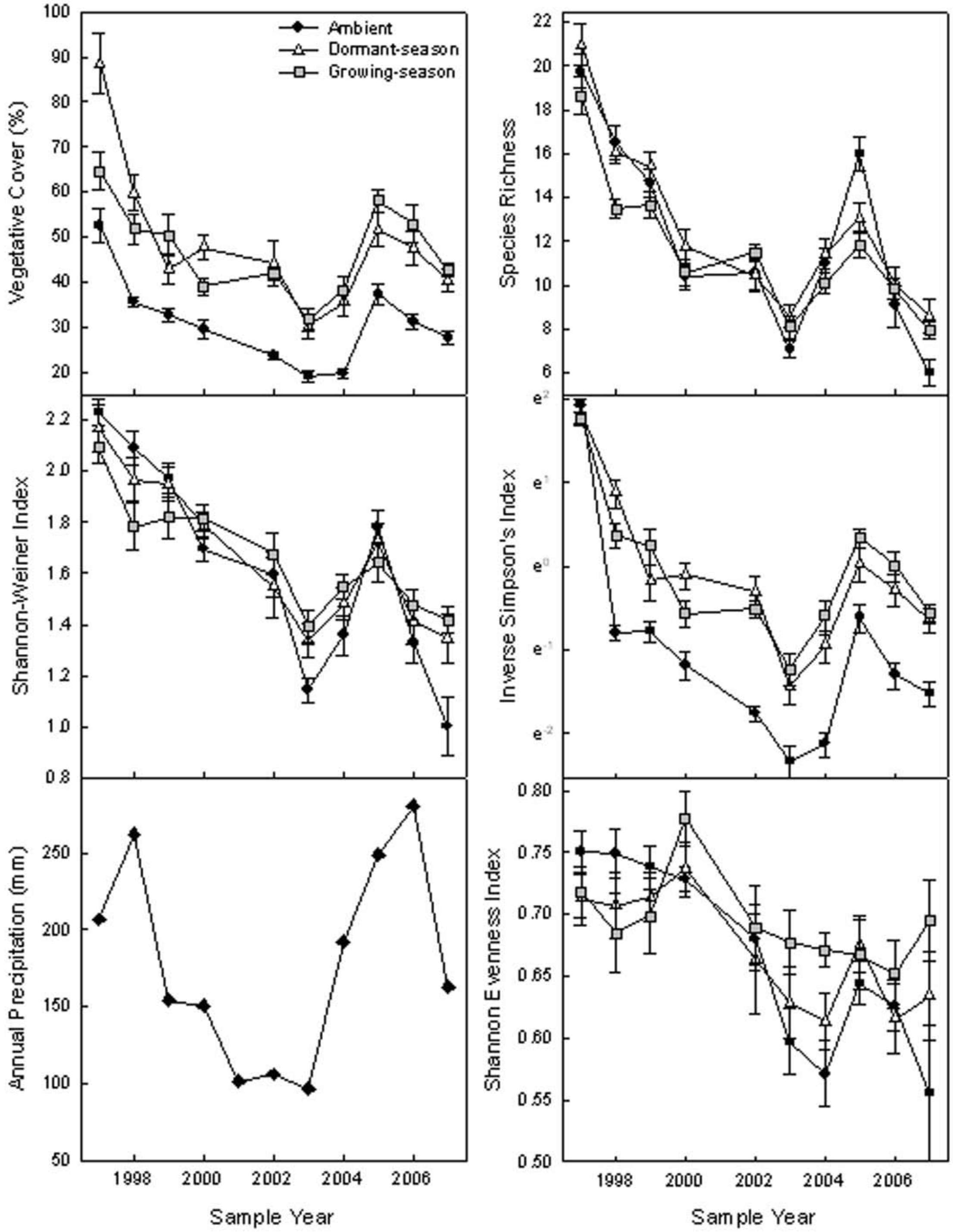


Figure 9-19. Trends in Community Vegetative Cover (%) and Diversity Indices (Mean ± 1 Standard Error) by Precipitation Treatment for Plots at the Idaho National Laboratory, USA, from 1997 to 2007. Growing season precipitation (October through September) is shown in bottom left panel. Note differences in scales.

Long-term trends in species abundance distributions (an alternative method of examining community diversity) indicate that community composition for plots is a result of functional differences among species rather than functional equivalence, regardless of the prescribed irrigation treatment (Figure 9-20).

Community composition of irrigated plots was generally different than plots receiving only ambient precipitation, regardless of seasonal application, using constrained correspondence analysis (Figure 9-21).

Community transpiration data are still being analyzed; therefore, conclusions cannot yet be provided.

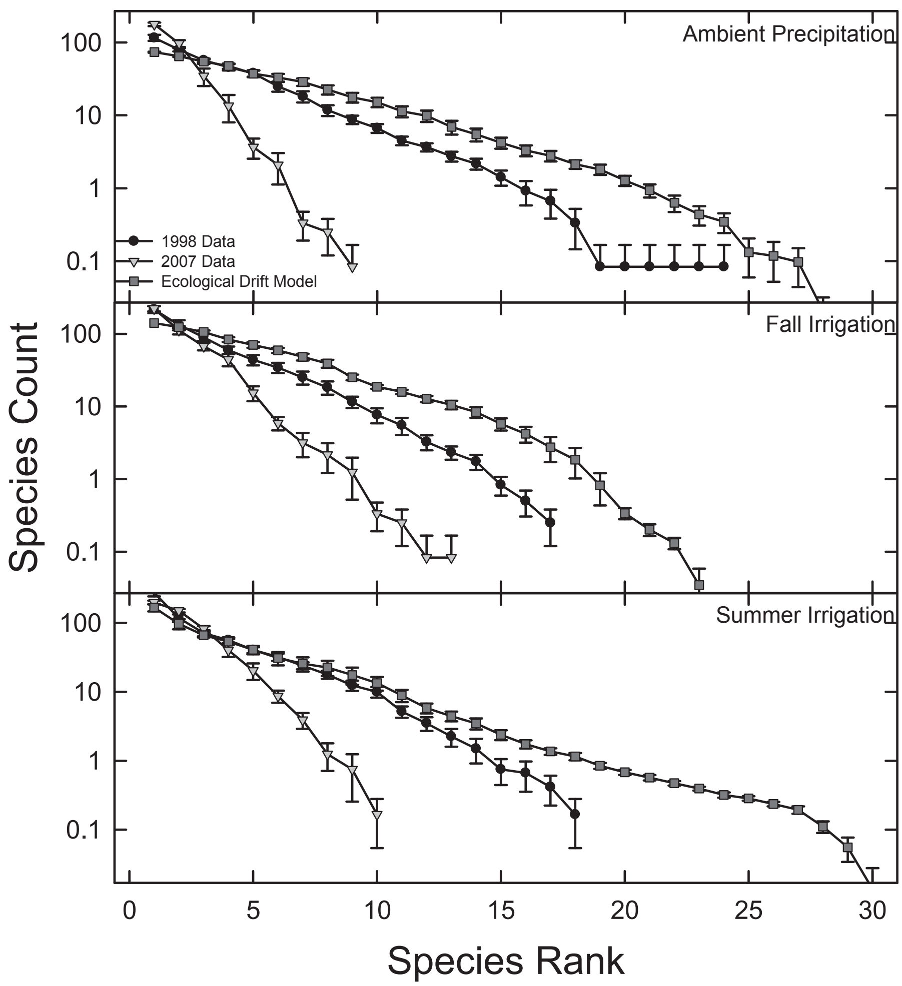


Figure 9-20. Species Rank Abundance Based on Mean (± 1 Standard Error, n=12) Count Data Plotted Against Average Species Count on a Log10 Scale. Data are for 1998 count data, 2007 count data, and results from the ecological drift model (simulated to predict 2007 species abundance distributions based upon species functional equivalence).

Publication, Reports, and Theses

Janzen, B., 2009, *Annual and Seasonal Fluctuations in Community Composition in Response to Experimental Manipulations of Precipitation and Soil Profile*, M.S. Thesis: Idaho State University, Pocatello, Idaho.

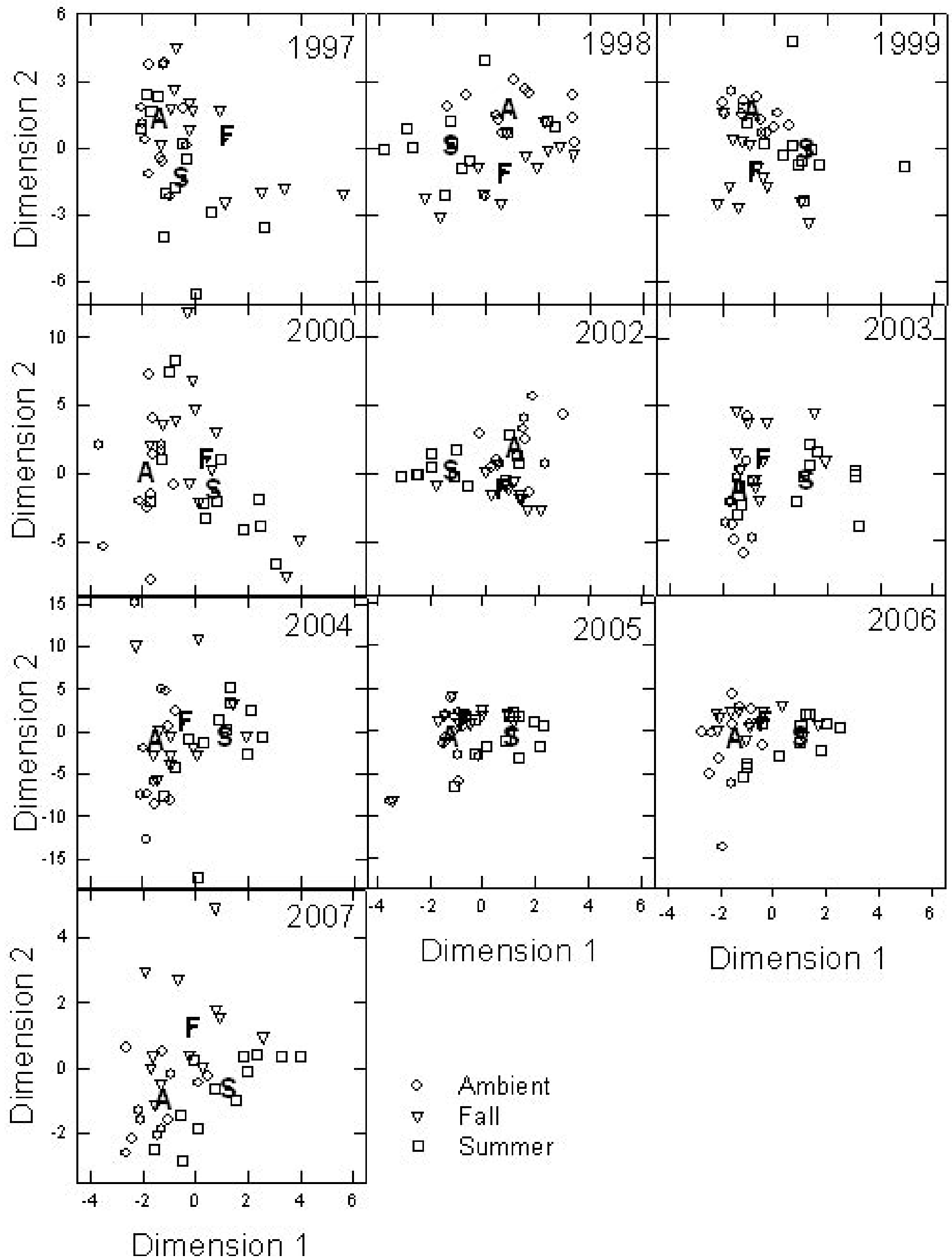


Figure 9-21. Constrained Correspondence Analysis (CCA) of Species Composition in Relation to Precipitation Treatments (Ambient Precipitation, Circles; Growing-Season Irrigation, Squares; Dormant-Season Irrigation, Triangles). Centroids for each precipitation are indicated by the appropriate symbol with a cross within it.

Janzen, B., M. Germino, A. Forman, *Long-term Responses of Community Properties to Manipulations of Spatial and Temporal Patterns of Water Availability in the Cold Desert*, In preparation.

Janzen, B., M. Germino, A. Forman, *Seasonal Fluctuations in Plant Functional Groups in Response to Experimental Manipulations of Water Availability and Storage Capacity*, In preparation.

Plans for Continuation

We anticipate submitting at least two manuscripts to peer-reviewed journals in addition to the completion of a M.S. thesis in early 2009.

9.12 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

Lachlan Ingram, 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

Daniel Mummey, Ph.D., Division of Biological Sciences, The University of Montana, Missoula, Montana

Funding Sources

National Science Foundation

Background

Climate change and its impact on precipitation patterns are likely to lead to changes in plant communities (species present and production) and subsequently soil characteristics. Consequently, it is highly likely that the hydroclimatology of the eastern Snake River Plain will be impacted. This could have long-term impacts for the population centers and agricultural industries that require water from the Snake River to ensure their survival.

Using the Protective Cap/Biobarrier Experiment established in 1993, we are examining the long-term impacts of different plant communities commonly found throughout Idaho (native sagebrush and crested wheatgrass, an introduced species) subject to different precipitation regimes 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.

Objectives

The objectives of this study are as follows:

- To determine the influence of plant communities and vegetation type on subsurface soil water drainage
- To investigate the mycorrhizal status of sagebrush to determine potential water uptake under ambient, summer, and winter precipitation treatments
- To investigate changes in soil carbon pools due to vegetation and precipitation differences.

Other biogeochemical and soil physical aspects of plots also are being evaluated, such as stable isotope compositions that can reveal changes in water patterns and plant water use among plots. Ultimately, we hope to determine how plot responses to the treatments feedback on water infiltration, availability, and use.

Accomplishments through 2008

Throughout 2008, tasks that were undertaken included maintenance of the study plots, continuation of the irrigation treatments, and collection of soil moisture and plant cover data. A new major funding source for this new study was obtained in late 2008. Soil samples for the mycorrhizal study were acquired in the winter of 2008–09. Soil textural and water retention characteristics were determined for a subset of the plots.

Results

Soils sampled in the winter are currently being analyzed to obtain preliminary data on soil carbon, nitrogen, and initial estimates of carbon pools. In addition, molecular analyses to qualitatively determine patterns of mycorrhizal distribution are being undertaken at Boise State University and The University of Montana.

Plans for Continuation

In spring/summer of 2009, soils will be sampled at multiple depths to investigate soil properties. These samples will be used to determine a range of important soil and microbial characteristics that reflect the imposition of the different precipitation and vegetation communities. In addition, the fall/spring and summer watering treatments will be maintained throughout the year. We plan to measure vegetation cover on a portion of the plots and simultaneously record the abundance of animal disturbances that appear to be key to infiltration patterns observed on plots.

9.13 Common Raven, *Corvus corax,* Abundance in Relation to Anthropogenic Resources and Potential Impact to Greater Sage-grouse (*Centrocercus urophasianus*) Occuring on the Idaho National Laboratory Site, a Preliminary Analysis

Investigators and Affiliations

Kristy Howe, Wildlife Conservation Society, 120 Technology Drive, Idaho Falls, Idaho and M.S. Candidate, Ornithology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

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

Peter Coates, Ph.D., Affiliate Faculty, Ornithology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Scott Bergen, Ph.D., Wildlife Conservation Society, 120 Technology Drive, Idaho Falls, Idaho

Christopher Jenkins, Ph.D., Executive Director, Project Orianne, 849 S. 1st Ave, 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

Background

Common raven (*Corvus corax*) populations in the western United States have increased significantly during the last 50 years. Ravens typically are more abundant in human-altered landscapes than in intact ecosystems. Fragmentation of native habitat is likely responsible for the increase in raven populations by providing an overabundance of anthropogenic resources, such as food, water, artificial perches, and shelter. Food and structure subsidies facilitate raven population growth through increased nest success and recruitment. This is cause for concern among land managers because ravens are considered a synanthropic predator (a predator benefiting from anthropogenic resources and land actions) of numerous sensitive species including greater sage-grouse (*Centrocercus urophasianus*) eggs and chicks.

The relationship between land management practices and sage-grouse nest predation is not fully understood. Recent studies have shown that ravens are the primary nest depredators of greater sage-grouse (Coates 2007; Coates et al. 2008). Wildlife Conservation Society field surveys of greater sage-grouse nest success show that ravens are a major predator of greater sage-grouse nests occurring on the INL Site and adjacent lands. Concurrent studies based on breeding bird surveys on the INL Site show a dramatic and exponential growth of raven abundance on the INL Site within the last 20 years (Whiting et al., in preparation). Increases in linear infrastructures (roads and power lines) on the INL Site are likely to further increase raven abundances and subsequently increase greater sage-grouse nest depredation events by ravens. This has the potential to further negatively impact the persistence of greater sage-grouse numbers and population trajectories of greater sage-grouse on the INL Site.

The Idaho Sage-grouse Advisory Committee (2006) identified the need for research into the incidence and extent of avian predation on sage-grouse nest success in areas with and without extensive infrastructure, as well as a need to determine the effect of habitat fragmentation as it relates to the level of predation while developing better methodologies for predator identification. The potential for ravens to limit sage-grouse populations constitutes a need to assess the presence of ravens over large spatial scales within sagebrush-steppe habitat.

This study examines how proximity to anthropogenic resources affects the relationship between common raven abundance and sage-grouse nest success. Determining how anthropogenic resources influence raven density in sagebrush-steppe habitat will provide Bureau of Land Management land managers with information necessary to identify sources of human disturbance. Information gained from this study will aide in the identification of patterns of synanthropic predation and estimates of their impacts on sage-grouse populations.

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.

Accomplishments through 2008

- 717 raven and raptor point count surveys have been conducted
- 24 raven nests were identified during 2007
- 33 raven nests were identified in 2008
- 45 raptor nests were identified in 2007
- 49 raptor nests were identified in 2008
- Digital geospatial data files were compiled, updated, and incorporated into a Geographic Information System and will be for land use, and anthropogenic subsidies such as water guzzlers used for grazing, roads, facilities, power lines, artificial perches and nesting platforms, radio towers, and landfills on the INL Site, surrounding Bureau of Land Management lands, and local communities.

Results

During the 2007 survey season, 722 raven and 467 raptor observations were recorded. Of the raven nests identified, 88 percent were located on artificial substrate and 12 percent on natural substrate (Figure 9-22). Of the raptor nests identified, 18 percent were located on artificial substrate and 82 percent on natural substrate (Figure 9-22). In 2008, 79 percent of raven nests identified were located on artificial substrate and 21 percent on natural substrate (Figure 9-23).

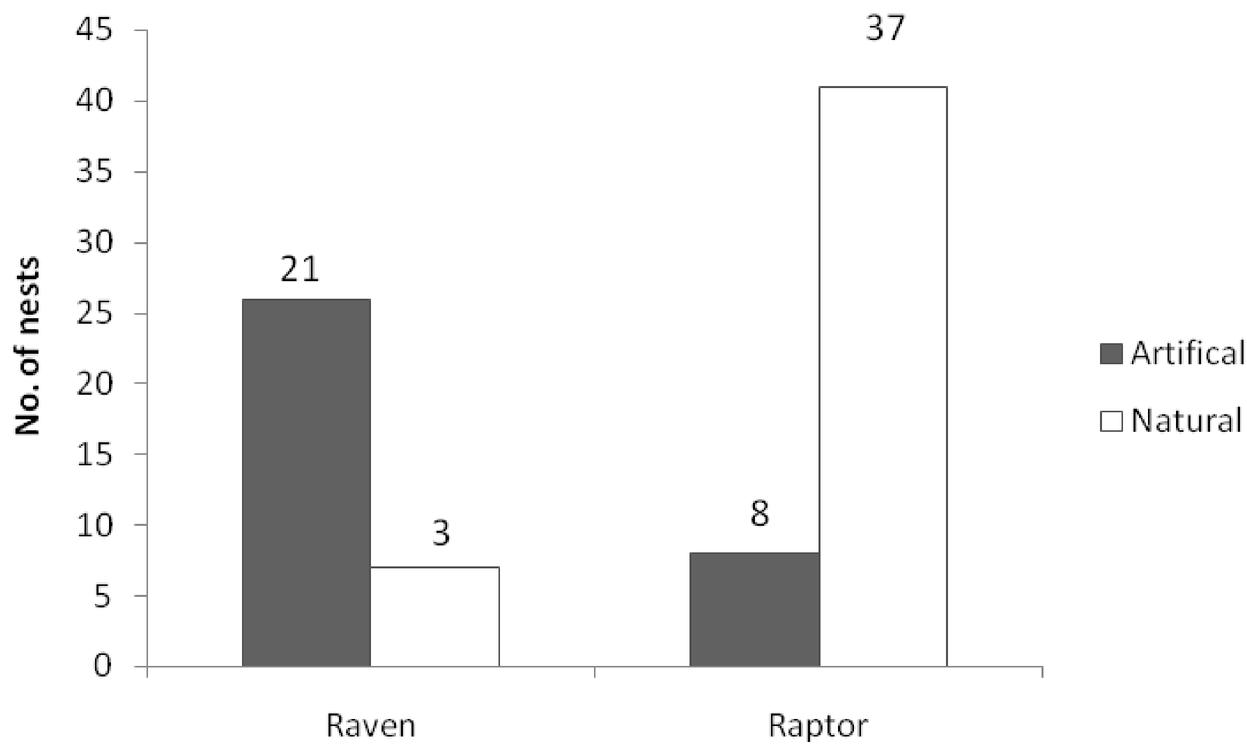


Figure 9-22. 2007 Raven and Raptor Nest Substrate.

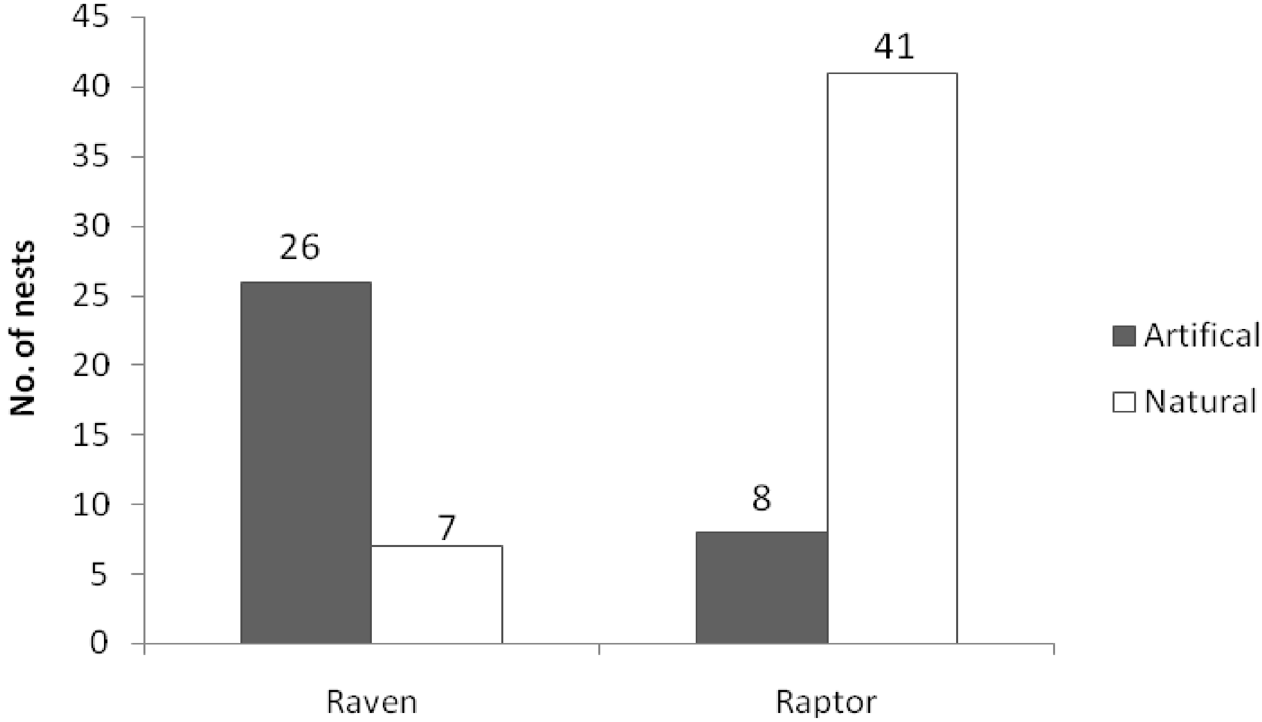


Figure 9-23. 2008 Raven and Raptor Nest Substrate.

Of the raptor nests identified, 16 percent were located on artificial substrate and 84 percent on natural substrate (Figure 9-23).

In a preliminary analysis of the survey data, comparisons between locations with ravens present versus those sites with ravens absent have been assessed via descriptive statistics and Welch Two Sample t-test (Welch 1947). Presence and absence of ravens on anthropogenic structures, such as facilities, power lines, and roads, were compared. Welch Two Sample t-tests are used to analyze if each of the anthropogenic variables statistically influence the presence or absence of ravens. Results show a highly significant positive relationship between distance to roads and power lines and raven presence. On average, sites with raven presence were 1 km closer to roads and over 500 m closer to power lines.

Plans for Continuation

- Raven and raptor point count and nest surveys will continue during the 2009 field season.
- Geo-spatial 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.
- Distance sampling techniques will be used to produce a detection function model to obtain estimates of raven density on the INL Site (Buckland et al. 2001).
- Preliminary analysis shows that ravens are occurring in higher numbers in proximity 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 field survey and analysis.
- The complete results of this study will be completed by March 2011, at which time, a more extensive analysis and discussion on factors influencing raven presence will be provided, including raven associations with all habitat cover types occurring on the INL Site.

Literature Cited

73 FR 1312-1313, 2008, "Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition to List the Pygmy Rabbit (*Brachylagus idahoensis*) as Threatened or Endangered," *Federal Register*.

Anderson, J. E., and A. D. Forman, 2003, *Evapotranspiration Caps for the Idaho National Engineering and Environmental Laboratory: A Summary of Research and Recommendations*, STOLLER-ESER-56, Environmental Surveillance, Education, and Research report, S. M. Stoller Corporation and Idaho State University.

Anderson, J., and R. Inouye, 2001, "Landscape Scale Changes in Species Abundance and Biodi versity of a Sagebrush Steppe over 45 Years," *Ecological Monographs*, Vol. 71, pp. 531–556.

Arthur, W. J., 1982, "Radionuclide Concentrations in Vegetation at a Solid Radioactive Waste Dis posal Area in Southeastern Idaho," *Journal of Environmental Quality*, Vol. 11, pp. 394–399.

Bengtsson, L., D. Bendz, W. Hogland, H. Rosqvist, and M. Akesson, 1994, "Water Balance for Landfills of Different Age," *Journal of Hydrology*, Vol. 158, pp. 203–217.

Bowerman, A. G. and E. F. Redente, 1998, "Biointrusion of Protective Barriers at Hazardous Waste Sites," *Journal of Environmental Quality*, Vol. 27, pp. 625–632.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas, 2001, *Introduction to Distance Sampling*, Oxford: Oxford University Press.

Bushar, L. M., H. K. Reinert, and L. Gelbert, 1998, "Genetic Variation and Gene Flow within and between Local Populations of the Timber Rattlesnake, *Crotalus horridus*," *Copeia*, Vol. 1998, No. 2, pp. 411–422.

Clark, R. W., W. S. Brown, R. Stechert, and K. R. Zamudio, 2008, "Integrating Individual Behavior and Landscape Genetics: The Population Structure of Timber Rattlesnake Hibernacula, *Molecular Ecology*, Vol. 17, pp. 719–730.

Coates, P. S., 2007, *Greater Sage-grouse (Centrocercus urophasianus) Nest Predation and Incubation Behavior*, Ph.D. Thesis: Idaho State University, Pocatello, Idaho.

Coates, P. S., J. W. Connelly, and D. J. Delehanty, 2008, "Predators of Greater Sage-Grouse Nests Identified by Video Monitoring," *Journal of Field Ornithology*, Vol. 79, No. 4 , pp. 421–428, available at http://www2.isu.edu/headlines/?p=1308.

Cobb, V. A., 1994, *The Ecology of Pregnancy in Free-ranging Great Basin Rattlesnakes (Crotalus viridis lutosus)*, Ph.D. Dissertation: Idaho State University, Pocatello, Idaho.

Connelly, J. W., 1982, *An Ecological Study of Sage-grouse in Southeastern Idaho*, Ph.D. Thesis: Washington State University, Pullman, Washington.

Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver, 2004, *Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats*, Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming.

Daniel, D. E., and B. A. Gross, 1995, *Caps*, National Technical Information Service, U.S. Department of Commerce, Springfiled, Virginia.

FGDC, 2008, *National Vegetation Classification Standard*, FGDC-STD-005-2008, Federal Geographic Data Committee.

Fisher, J. N., 1986, *Hydrogeologic Factors in the Selection of Shallow Land Burial for the Disposal of Low-level Radioactive Waste*, USGS Report 973, U.S. Geological Survey.

Frankham, F., J. D. Ballou, and D. A. Briscoe, 2005, *Introduction to Conservation Genetics*, Cambridge, United Kingdom: Cambridge University Press.

Grace, J. B, 2006, *Structural Equation Modeling and Natural Systems*, New York: Cambridge University Press.

Hakonson, T. E., L. J. Lane, and E. P. Springer, 1992, "Biotic and Abiotic Processes," in *Deserts as Dumps? The Disposal of Hazardous Materials in Arid Ecosystems*, C. C. Reith and B. M. Thomson, editors, Pages 101–146, Albuquerque: University of New Mexico Press.

Harniss, R. O., 1968, *Vegetation Changes Following Livestock Exclusion on the National Reactor Testing Station, Southeastern Idaho*, M.S. Thesis: Utah State University, Logan, Utah.

Idaho Sage-grouse Advisory Committee, 2006, *Conservation Plan for the Greater Sage-grouse in Idaho*, Boise, Idaho.

Janzen, B. C., M. J. Germino, J. E. Anderson, and A. D. Forman, 2007, *PCBE Revisited: Long-term Performance of Alternative Evapotranspiration Caps for Protecting Shallowly Buried Wastes under Variable Precipitation*, STOLLER-ESER-101, Environmental Surveillance, Education, and Research Program report, Idaho State University and S. M. Stoller Corporation.

Manel, S., M. K. Schwartz, G. Luikart, and P. Taberlet, 2003, "Landscape Genetics: Combining Landscape Ecology and Population Genetics," *Trends in Ecology & Evolution*, Vol. 18, pp. 189–197.

McBride, R., N. R. French, A. D. Dahl, and J. E. Detmer, 1978, *Vegetation Types and Surface Soils of the Idaho National Engineering Laboratory Site*, IDO-12084, U.S. Department of Energy Idaho Operations Office, Environmental Sciences Branch, Radiological and Environmental Sciences Laboratory.

Nativ, R., 1991, "Radioactive Waste Isolation in Arid Zones," *Journal of Arid Environments*, Vol. 20, pp. 129–140.

Nyhan, J. W., T. E. Hakonson, and B. J. Drennon, 1990, "A Water Balance Study of Two Landfill Cover Designs for Semiarid Regions," *Journal of Environmental Quality*, Vol. 19, pp. 281–288.

Pellant, M. and C. Hall, 1994, "Distribution of Two Exotic Grasses on Intermountain Rangelands: Status in 1992," in S. B. Monsen and S. G. Kitchen (compilers), *Proceedings—Ecology and Management of Annual Rangelands*, General Technical Report INT-GTR-313, USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Roberts, H. B., 2001, Survey of Pygmy Rabbit Distribution, Numbers and Habitat Use in Lemhi and Custer Counties, Idaho, Technical Bulletin 01-11, Idaho Bureau of Land Management, Boise, Idaho.

Singlevich, W., J. W. Healy, H. J. Paas, and Z. E. Carey, 1951, *Natural Radioactive Materials at the Arco Reactor Test Site*, Atomic Energy Commission, Radiological Sciences Department, Richland, Washington.

Storfer, A., M. A. Murphy, J. S. Evans, C. S. Goldberg, S. Robinson, S. F. Spear, R. Dezzani, E. Delmelle, L. Vierling, and L. P. Waits, 2006, “Putting the ‘Landscape’ in Landscape Genetics,” *Heredity*, pp. 1–15.

Suter, G. W. II, R. J. Luxmoore, and E. D. Smith, 1993, “Compacted Soil Barriers at Abandoned Landfill Sites Are Likely to Fail in the Long Term,” *Journal of Environmental Quality*, Vol. 22, pp. 217–226.

Tanaka, J. S., 1987, “How Big Is Big Enough? Sample Size and Goodness-of-fit in Structual Equation Models with Latent Variables,” *Child Development*, Vol. 58, pp. 134–146.

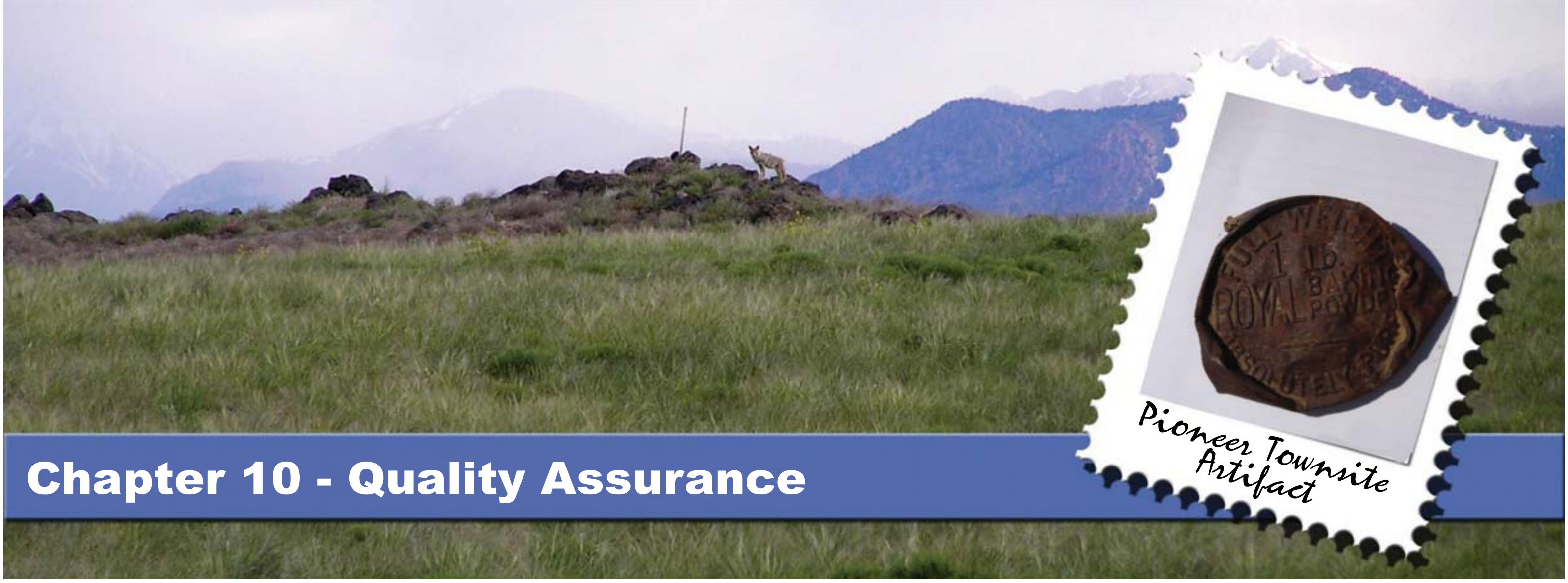
USDA and NRCS, 2009, The PLANTS Database, http://plants.usda.gov, Updated June 16, 2009, Web page visited June 18, 2009, U.S. Department of Agriculture, National Plant Data Center, Baton Rouge, Louisiana.

USDI and NPS, 2009, The Vegetation Mapping Inventory, http://science.nature.nps.gov/im/inventory/veg/index.cfm, Updated November 11, 2008, Web page visited March 31, 2009, U.S. Department of Interior and National Park Service Resource Inventories.

Welch, B. L. 1947. “The Generalization of “Student’s” Problem When Several Different Population Variances Are Involved,” *Biometrika*, Vol. 34, pp. 28–35.

Whiting, J., K. Howe, and S. Bergen, In preparation, *Exponential Increase in Abundance of Ravens (Corvus corax) on Idaho National Laboratory 1975–2008*, S. M. Stoller Corporation, Idaho Falls, Idaho.

Blue Penstemon



10. QUALITY ASSURANCE

Quality assurance (QA) and quality control (QC) programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses. The purpose of a QA/QC program is to:

- Ensure precise, accurate, representative, and reliable results
- Maximize data completeness
- Ensure that data collected at different times are comparable to previously collected data.

Elements of typical QA programs include, but are not limited to, the following (ASME NQA-1 2008; EPA 2002):

- Adherence to peer-reviewed written procedures for sample collection and analytical methods
- Documentation of program changes
- Periodic calibration of instruments with standards traceable to the National Institute of Standards and Technology (NIST)
- Chain of custody procedures
- Equipment performance checks
- Routine yield determinations of radiochemical procedures
- Replicate samples to determine precision
- Analysis of blind, duplicate, and split samples
- Analysis of quality control standards in appropriate matrices to test accuracy
- Analysis of reagent and laboratory blanks to measure possible contamination occurring during analysis
- Analysis of blind spike samples (samples containing an amount of a constituent known to the sampling organization, but not the analytical laboratory) to verify the accuracy of a measurement
- Internal and external surveillance to verify quality elements

- Data verification and validation programs.

10.1 Laboratory Intercomparison Programs

Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. The Idaho National Laboratory (INL) contractor and Idaho Cleanup Project (ICP) contractor, and subcontractors used the following accredited laboratories in 2008:

- The ICP Drinking Water Program used General Engineering Laboratories, LLC for radiological analyses, Intermountain Analytical Service – EnviroChem of Pocatello for microbiological analyses, and Underwriters Laboratories, Inc. for inorganic and organic analyses; the ICP Environmental Surveillance Program used GPL Laboratories Alabama, LLC for radiological analyses; the ICP Effluent Monitoring Program used ICP Analytical Laboratories Department for radiological analyses, ICP Wastewater Laboratory for microbiological analyses, General Engineering Laboratories, LLC for radiological analyses, and Southwest Research Institute for inorganic analyses; the ICP Groundwater Monitoring Program used Assaigai Analytical Laboratories, Inc. for inorganic analyses, ICP Analytical Laboratories Department for inorganic analyses, General Engineering Laboratories, LLC for microbiological analyses, and Southwest Research Institute for inorganic and radiological analyses
- The INL contractor Drinking Water Program used General Engineering Laboratories for radiological analyses, Intermountain Analytical Service – EnviroChem, of Pocatello, and Teton Microbiology Laboratory of Idaho Falls for inorganic and bacterial analyses, and Underwriters Laboratories, Inc. for inorganic and organic analyses. The Liquid Effluent and Groundwater programs used General Engineering Laboratories for radiological analyses and Southwest Research Institute for nonradiological analyses. The INL contractor Environmental Surveillance Program used Paragon Analytics
- The Environmental Surveillance, Education and Research Program (ESER) contractor used the Environmental Assessments Laboratory located at Idaho State University for gross radionuclide analyses (gross alpha, gross beta, and gamma spectrometry), and Teledyne Brown Engineering of Knoxville, Tennessee for specific radionuclide analyses (e.g., strontium-90 [^{90}Sr], americium-241 [^{241}Am], plutonium-238 [^{238}Pu], and plutonium-239/240 [$^{239/240}$Pu])
- The U.S. Geological Survey used the U.S. Department of Energy's (DOE's) Radiological and Environmental Sciences Laboratory for radiological analyses
- The U.S. Geological Survey National Water Quality Laboratory conducted nonradiological analyses and low-level tritium analyses.

All these laboratories participated in a variety of programs to ensure the quality of their analytical data. Some of these programs are described in the following subsections.

10.1.1 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. The program generally distributes samples of air, water, vegetation, and soil for analysis during the first and third quarters. Series 18 was distributed in February 2008, and Series 19 was distributed in June 2008.

Both radiological and nonradiological constituents are included in the program. Results can be found at http://www.inl.gov/resl/mapep/reports.html (DOE 2008).

10.1.2 2008 Mixed Analyte Performance Evaluation Program Results

Figures 10-1 and 10-2 compare MAPEP results for laboratories used by INL Site environmental monitoring organizations in 2008 for gross alpha, gross beta, and actinides in air and water samples. Results for all laboratories were within the MAPEP acceptable range for these analyses, except the Teledyne Brown result for ^{238}Pu in water during Series 19.

10.1.3 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, generally in liquid media, 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 2008.

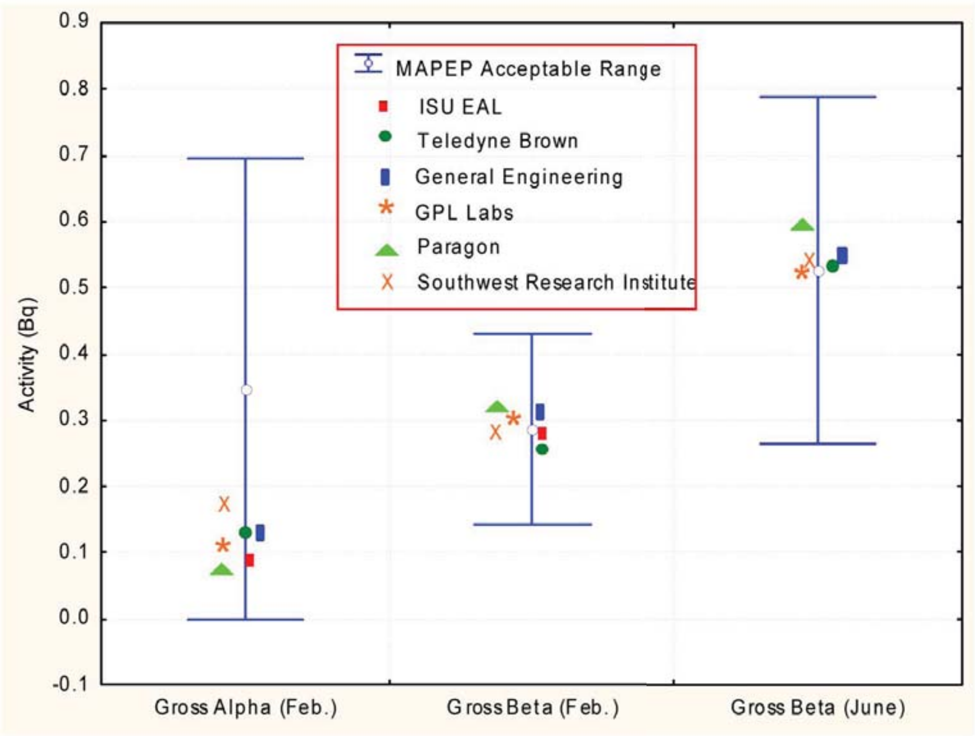
10.1.4 Dosimetry

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 percent 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.

10.1.5 Other Programs

INL Site contractors participate in additional performance evaluation (PE) programs, including those administered by the International Atomic Energy Agency, the U.S. Environmental Protection Agency (EPA), and the American Society for Testing and Materials. Contractors are



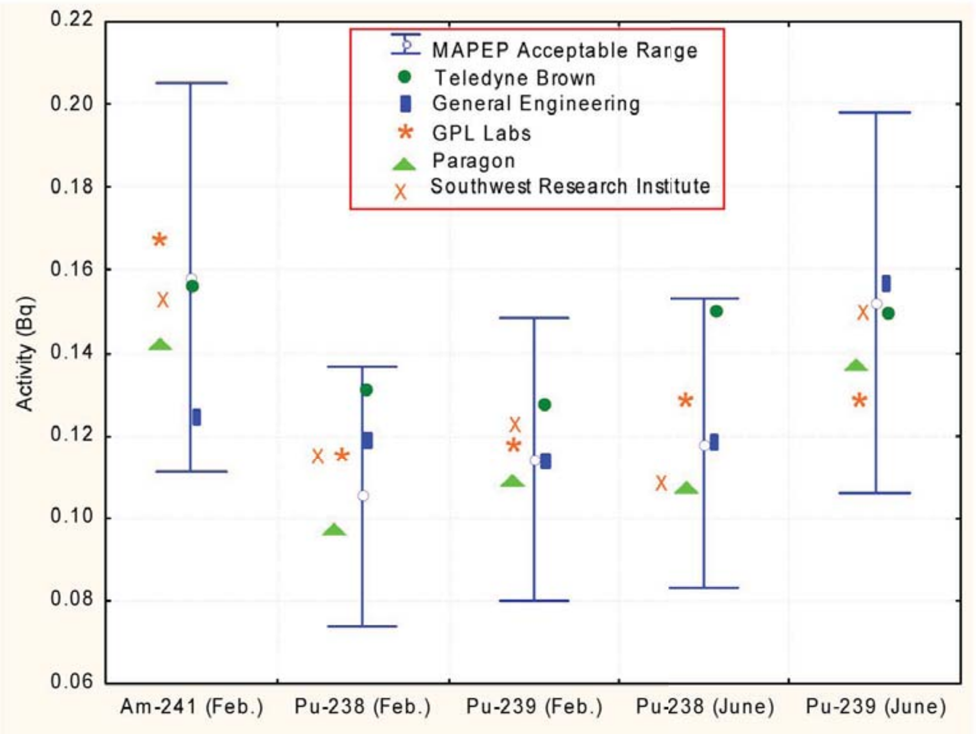


Figure 10-1. Idaho National Laboratory, Idaho Cleanup Project, and Environmental Surveillance, Education and Research Surveillance Laboratory Air Sampling Results from MAPEP Intercomparisons (2008).

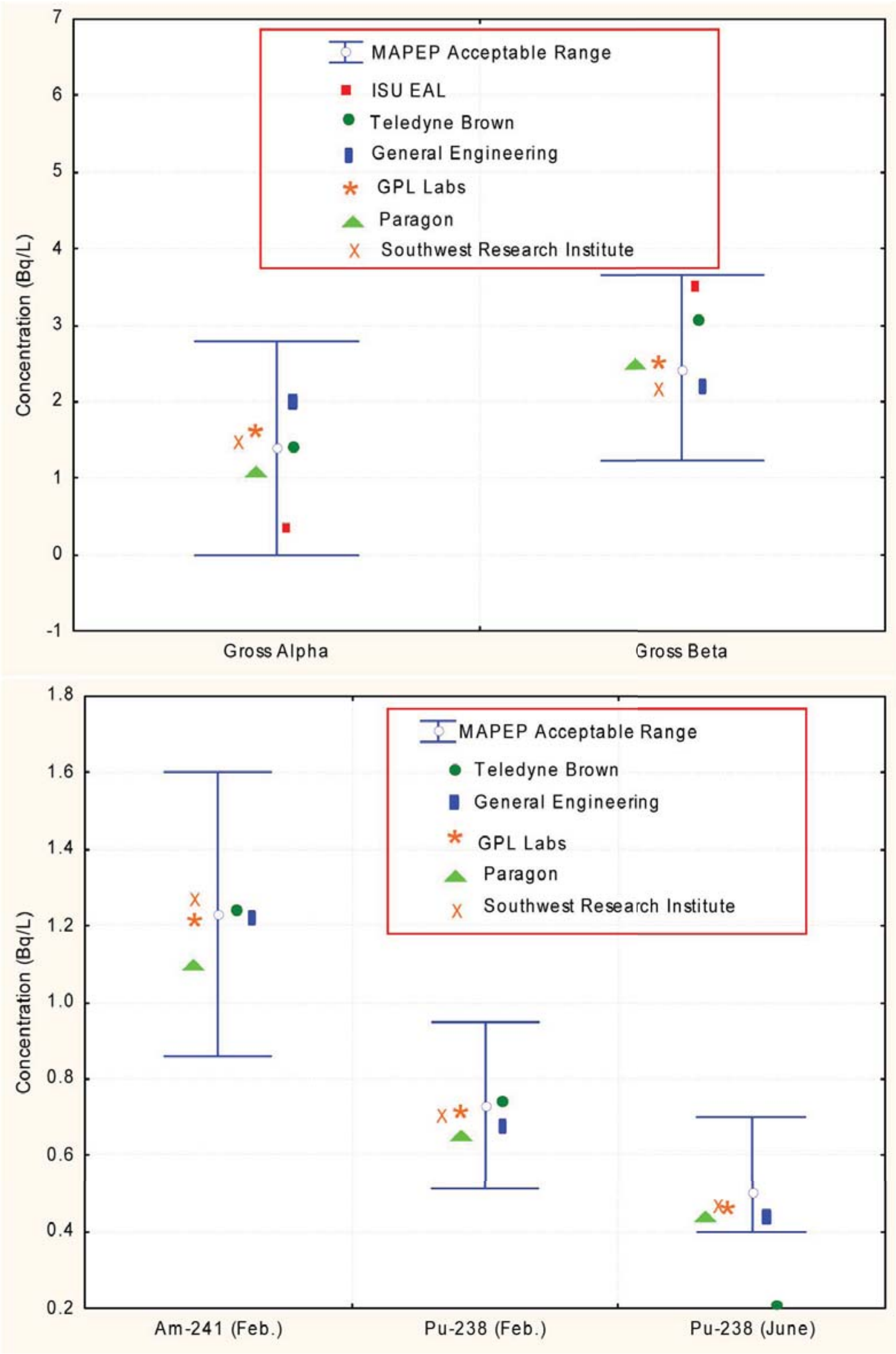


Figure 10-2. Idaho National Laboratory, Idaho Cleanup Project, and Environmental Surveillance, Education and Research Surveillance Laboratory Water Sampling Results from MAPEP Intercomparisons (2008).

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 State 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.

10.2 Data Precision and Verification

As a measure of the quality of data collected, the ESER contractor, INL contractor, ICP contractor, the U.S. Geological Survey, and other contractors performing monitoring use a variety of QC samples of different media. QC samples measure precision of sampling and analysis activities. QC samples include blind spike samples, duplicate samples, split samples, trip blanks, rinsate samples, equipment blanks, and field blanks.

Blind Spike: Used to assess the accuracy of the analytical laboratories. Contractors purchase samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to 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.

Duplicate Sample: 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. Duplicates are useful in documenting the precision of the sampling process.

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.

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.

Equipment Blank (rinsate): Collected to evaluate the effectiveness of equipment decontamination.

Field Blank: Collected to assess the potential introduction of contaminants during sampling.

10.2.1 Duplicate Sampling within Organizations

Both the ESER contractor and the INL contractor maintained duplicate air samplers at two locations during 2008. 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 the Radioactive Waste Management Complex. The INL contractor sampled weekly through September and then biweekly to the end of the year.

Filters from these samplers were collected and analyzed in the same manner as filters from regular air samplers. Graphs of gross beta activity for the duplicate samplers are shown in Figures 10-3 and 10-4. The figures show that duplicate sample results generally tracked each other well.

10.2.2 Duplicate Sampling between Organizations

Data quality also 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 2008 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. Results for 2008 gross beta analyses are shown in Figure 10-5.

The U.S. Geological Survey routinely collects groundwater samples simultaneously with the INL Oversight Program and the Shoshone-Bannock Tribes. Comparison results from this sampling are regularly documented in reports prepared by the two organizations.

10.3 Program Quality Assurance

10.3.1 Liquid Effluent Program Quality Assurance/Quality Control

INL 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 (splits) to provide information on variability caused by sample heterogeneity, collection methods, and laboratory procedures. One duplicate sample is collected each year at each location.

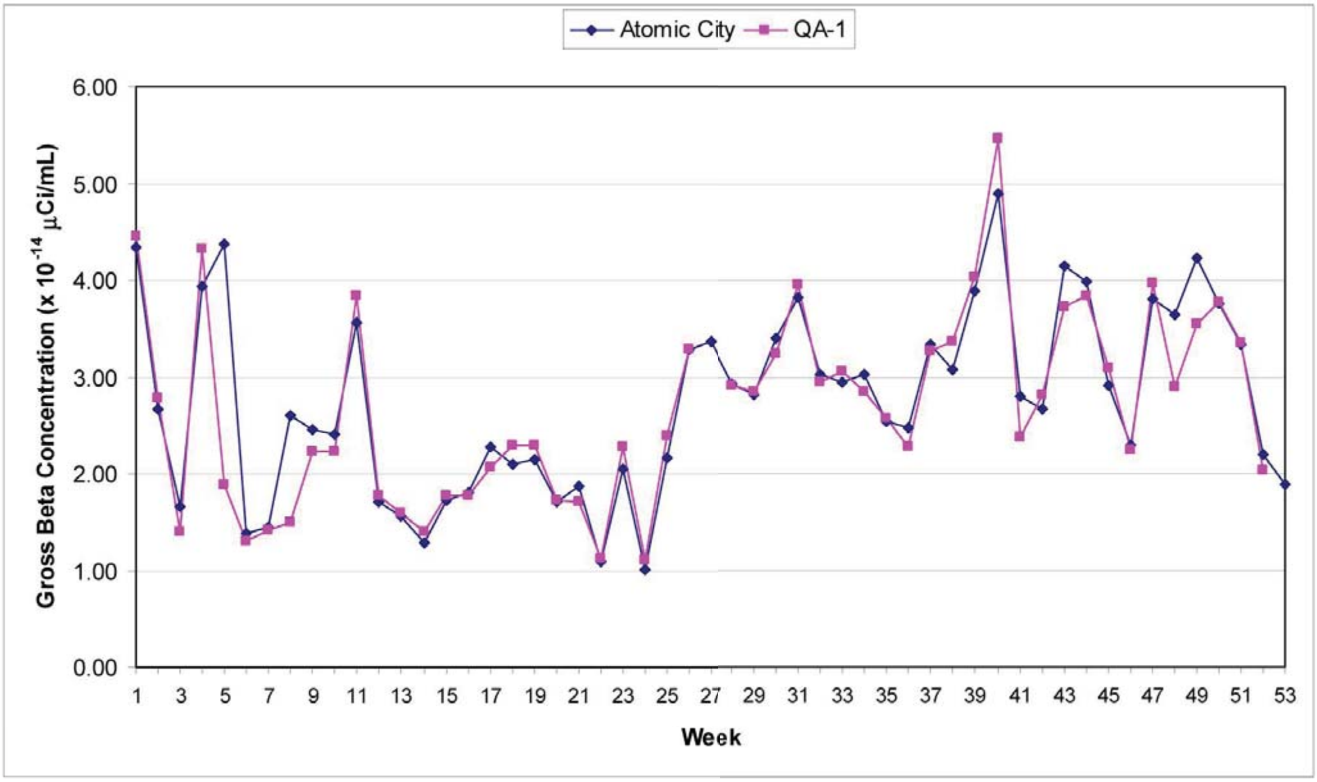
For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the relative percent difference (RPD) using Equation (1):

$$RPD = \frac{|R_1 - R_s|}{(R_1 + R_s)/2} \times 100 \qquad (1)$$

Where

R_1 = concentration of analyte in the first sample

R_2= concentration of analyte in the duplicate sample.



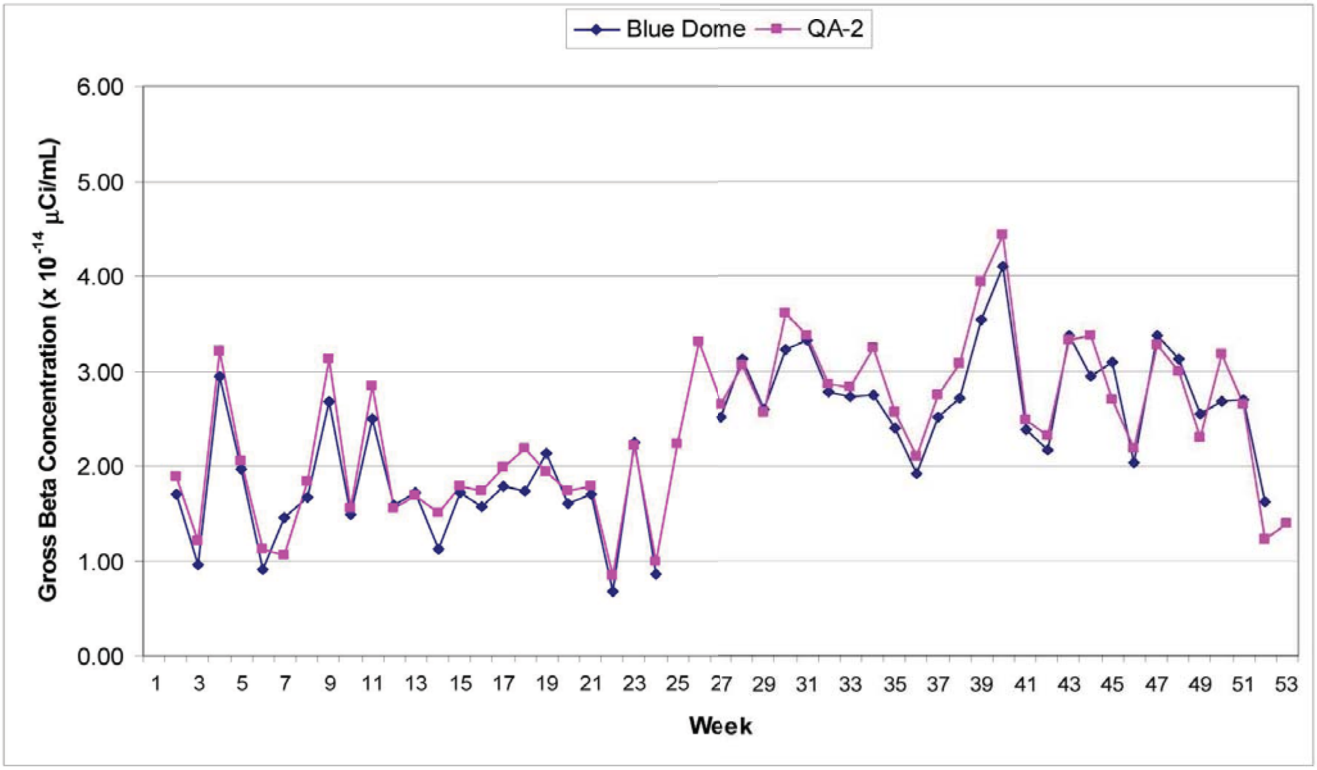
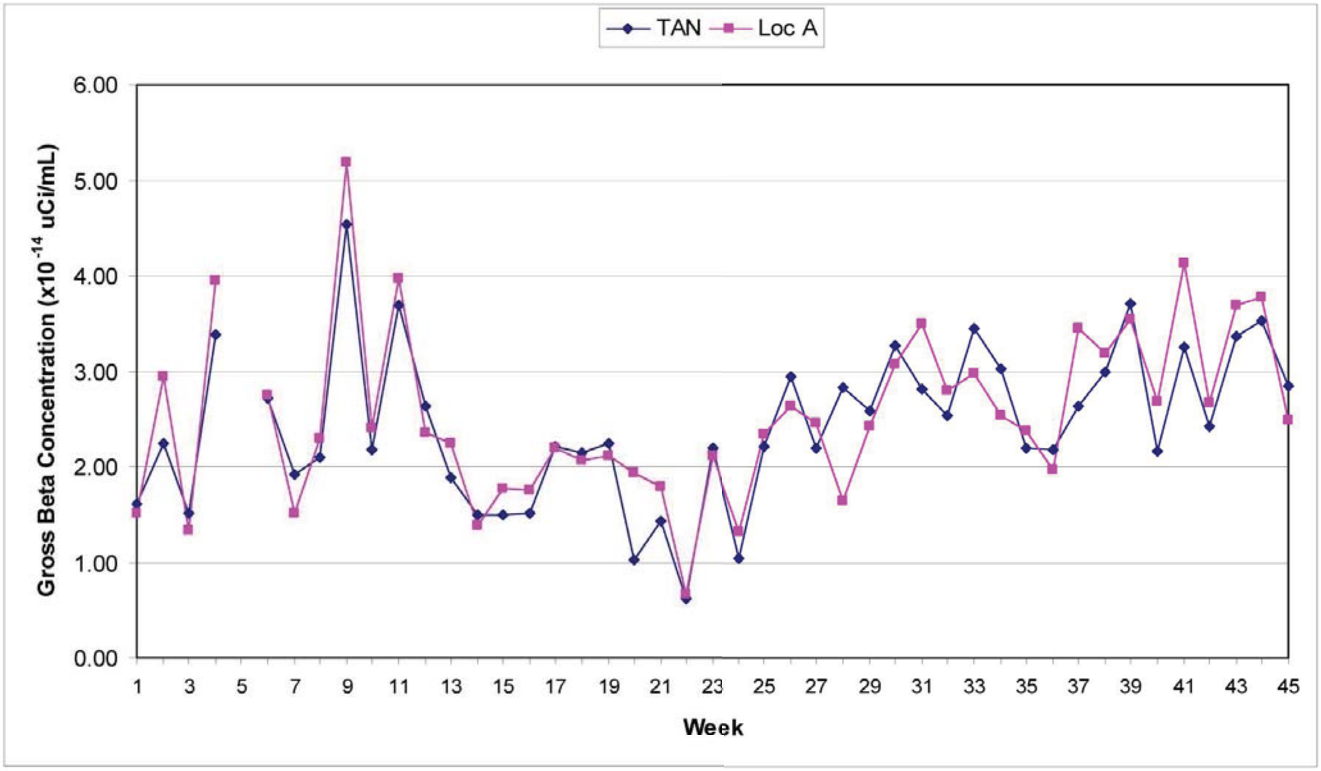


Figure 10-3. Environmental Surveillance, Education and Research Contractor Duplicate Air Sampling Gross Beta Results (2008).



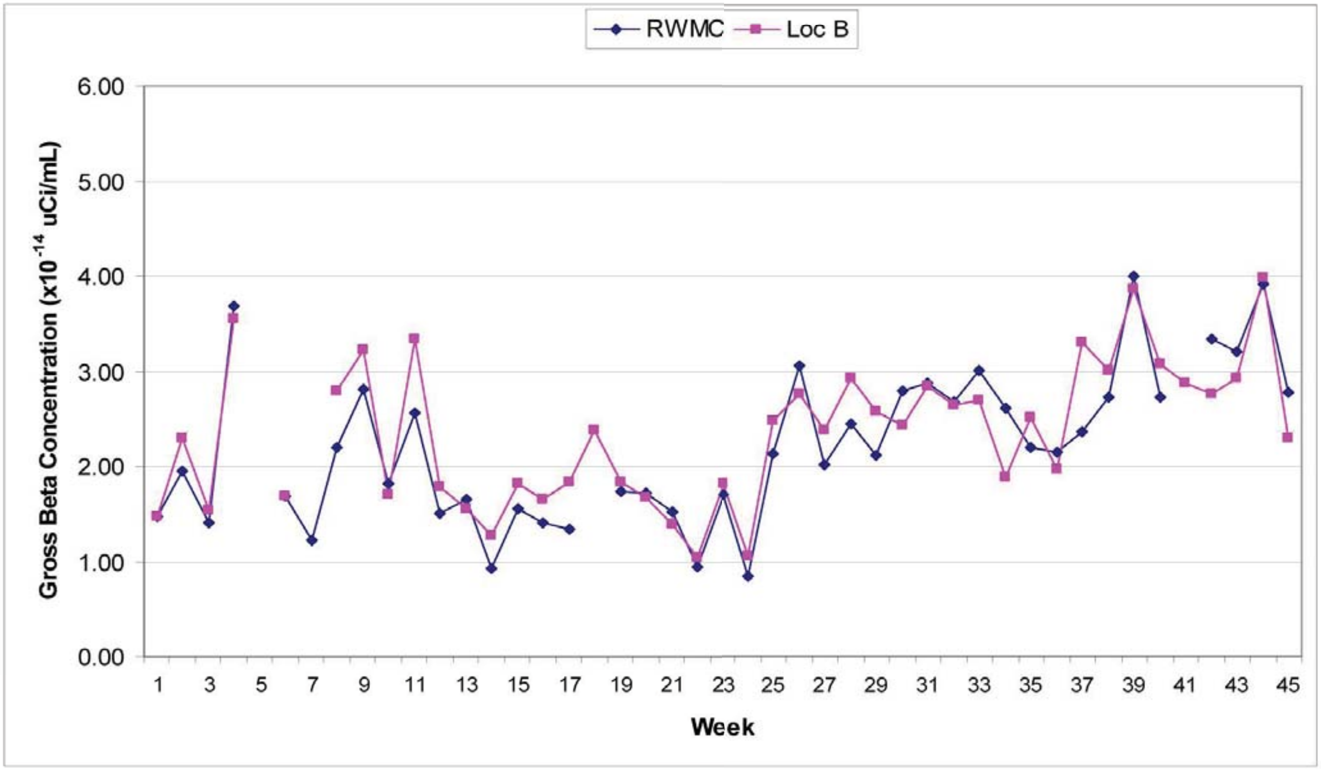
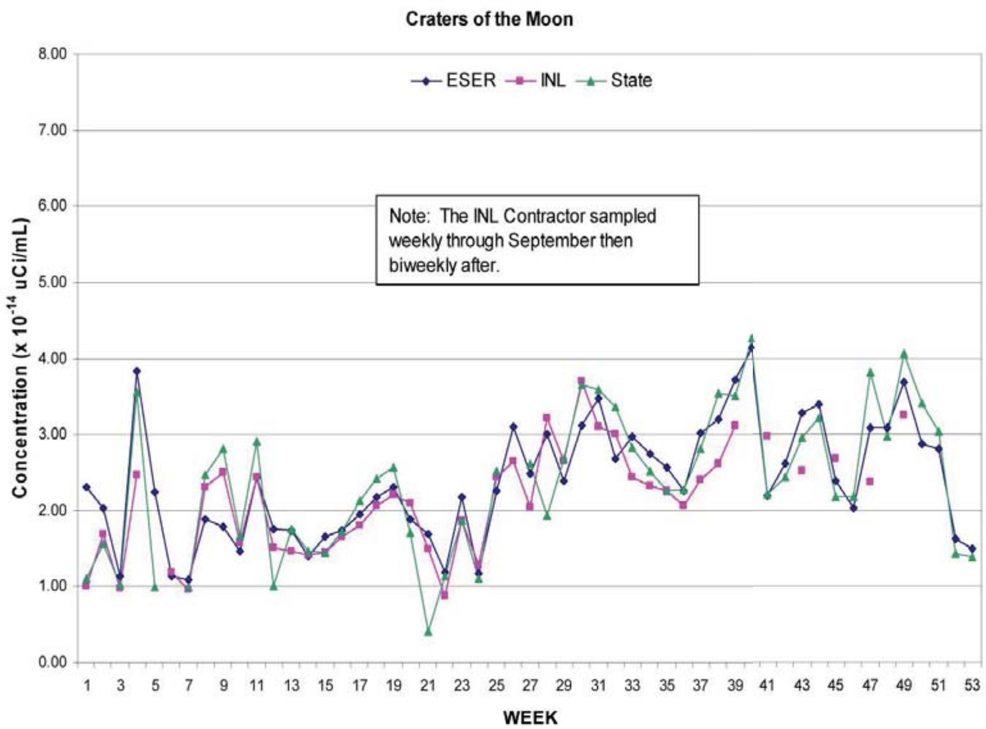


Figure 10-4. Idaho National Laboratory Contractor Duplicate Air Sampling Gross Beta Results (2008).



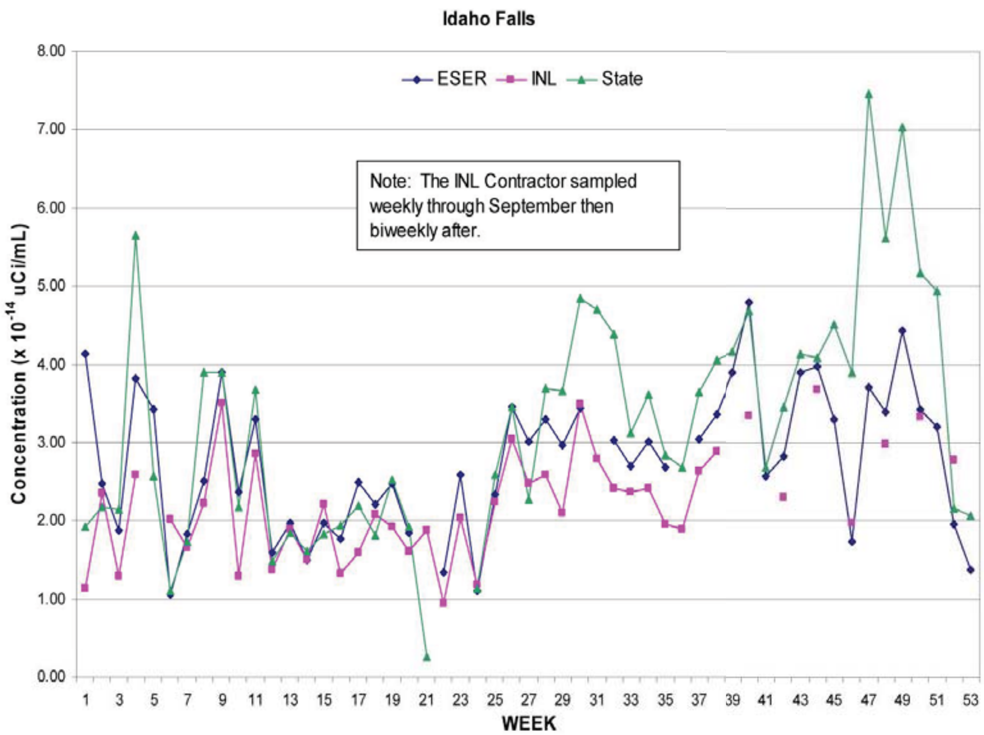
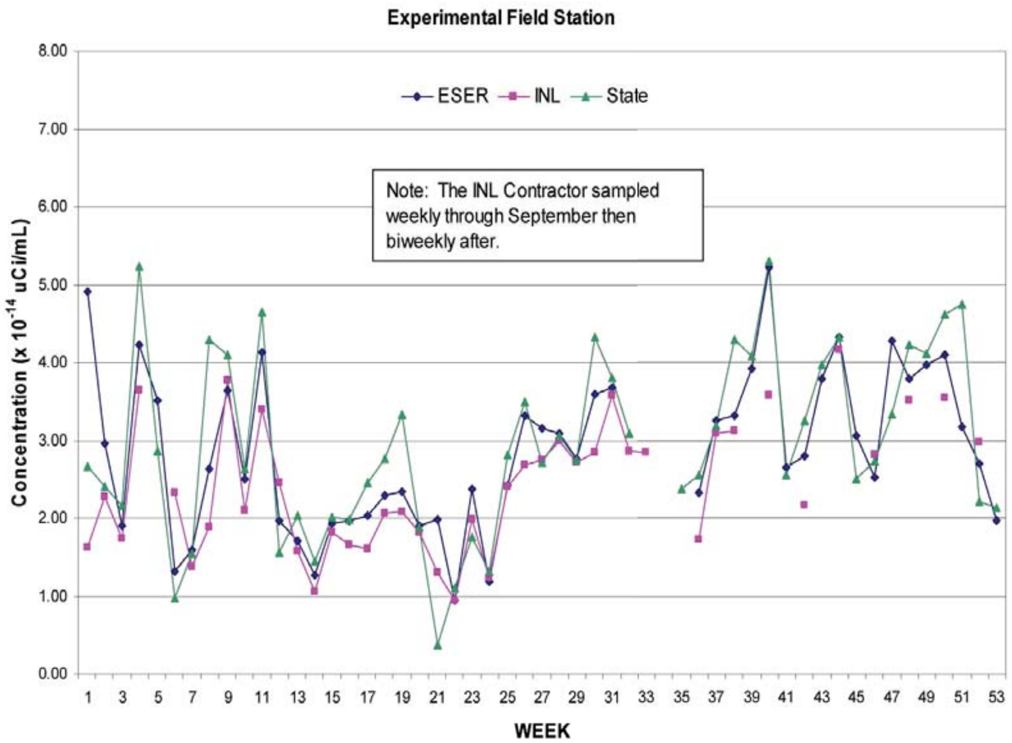


Figure 10-5. Comparison of Gross Beta Concentrations Measured by the Environmental Surveillance, Education and Research Contractor, Idaho National Laboratory Contractor, and State of Idaho (2008).



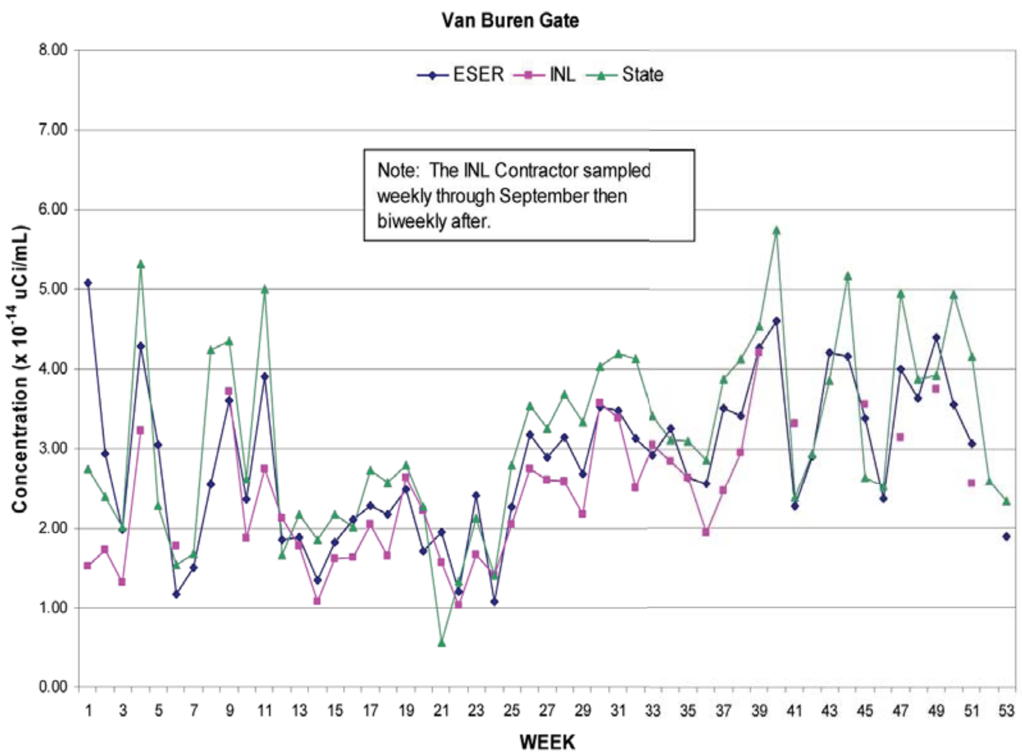


Figure 10-5. Comparison of Gross Beta Concentrations Measured by the Environmental Surveillance, Education and Research Contractor, Idaho National Laboratory Contractor, and the State of Idaho (2008). (continued)

The INL contractor Liquid Effluent Monitoring 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 precision of the radiological results were considered acceptable if the RPD was less than or equal to 35 percent or if the condition in Equation (2) was met:

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

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.

Using the above criteria, 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 2008.

ICP Contractor—The ICP contractor Liquid Effluent Monitoring Program has specific QA/QC objectives for monitoring data. All effluent sample results were usable in 2008.

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 quality control samples:

- PE samples
- Field duplicates (splits)
- Rinsate samples.

PE samples (submitted as field double blind spikes) are required to assess analytical data accuracy. At a minimum, PE samples are required quarterly. During 2008, PE samples were submitted to the laboratory with routine monitoring samples on February 13, 2008, June 11, 2008, August 13, 2008, and November 12, 2008. Most results were within performance acceptance limits. Table 10-1 shows the number of results outside the performance acceptance limits. The laboratory was notified of the results so they could evaluate whether corrective action was required.

Table 10-1. Idaho Cleanup Project Contractor Performance Evaluation Samples Outside Performance Acceptance Limits (2008).

Parameter	Number of Performance Evaluation Samples Outside Performance Acceptance Limits
Biochemical oxygen demand	1
Mercury	2
Silver	2
Sodium	1
Total suspended solids	1

Field duplicates (splits) provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures. Duplicate samples were collected at CPP-769, CPP-773, and CPP-797 on March 19, 2008, and CPP-773 on May 2, 2008. The RPD between the duplicate samples is used to assess data precision. Table 10-2 shows the results for 2008. Variations in the reported concentrations in the field duplicates are most likely the result of sample heterogeneity caused by variations in the amount of solids in the sample.

Rinsate samples are collected to evaluate the effectiveness of equipment decontamination. Rinsate samples were collected at CPP-773 on July 23, 2008. 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 2008, this goal was met.

Table 10-2. Idaho Cleanup Project Contractor Liquid Effluent Program Relative Percent Difference Results[a] (2008).

Parameter	Relative Percent Difference Result
Inorganic and metals	96% of RPD results within program goal of ≤35%.
Radiological	100% of RPD results within program goal of ≤35%.

a. Relative percent difference was not calculated if either the sample or its duplicate was reported as nondetect.

10.3.2 Wastewater Land Application Permit Groundwater Monitoring Quality Assurance/ Quality Control

Groundwater sampling for Wastewater Land Application Permit compliance follow established procedures and analytical methodologies.

During 2008, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center and Test Area North permitted monitoring wells that had sufficient water. Samples were not collected from aquifer Well ICPP-MON-A-167, which was dry during October 2008, perched water Well ICPP MON-V-191, which was dry in April and October 2008, and perched water Well TSFAG-05, which was dry during April 2008. All permit-required samples were collected.

All groundwater sample results were usable, except for some April 2008 sample results that were rejected during data validation because of QC issues. Table 10-3 shows the April 2008 groundwater sample results that were rejected.

Table 10-3. Wastewater Land Application Permit Rejected Groundwater Results (2008).

Parameter	Well	Sample Date	Reason Rejected
Arsenic	ICPP-MON-A-165 (GW-013006)	4/8/2008	Poor laboratory serial dilution sample precision
	ICPP-MON-A-166 (GW-013007)	4/15/2008	
	ICPP-MON-A-167 (GW-013005)	4/9/2008	
	TANT-MON-A-001 (GW-015301)	4/17/2008	
	TANT-MON-A-002 (GW-015304)	4/16/2008	
	ICPP-MON-V-212	4/7/2008	Poor low-level concentration sample precision
Arsenic-filtered	ICPP-MON-A-165 (GW-013006)	4/8/2008	Poor laboratory serial dilution sample precision
	ICPP-MON-A-166 (GW-013007	4/15/2008	
	ICPP-MON-A-167 (GW-013005)	4/9/2008	
	ICPP-MON-V-212	4/7/2008	Poor low-level concentration sample precision
Barium	TAN-10A (GW-015303)	4/22/2008	Poor laboratory serial dilution sample precision
	TAN-13A (GW-015302)	4/22/2008	
	TAN-20 (GW-015305)	4/22/2008	
Chromium	TAN-10A (GW-015303)	4/22/2008	Poor laboratory duplicate sample precision
	TAN-13A (GW-015302)	4/22/2008	
	TAN-20 (GW-015305)	4/22/2008	
Chromium-filtered	ICPP-MON-A-167 (GW-013005)	4/9/2008	Poor low-level concentration sample precision
Iron	ICPP-MON-A-166 (GW-013007)	4/15/2008	Poor laboratory serial dilution sample precision
Iron-filtered	ICPP-MON-A-166 (GW-013007)	4/15/2008	Poor laboratory serial dilution sample precision
Zinc	TANT-MON-A-001 (GW-015301)	4/17/2008	Poor laboratory serial dilution sample precision
	TANT-MON-A-002 (GW-015304)	4/16/2008	

Field quality control 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 2008. Because Test Area North and Idaho Nuclear Technology and Engineering Center are regarded as separate sites, QC samples (duplicate samples, field blanks, and equipment blanks) were prepared for each site.

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. Table 10-4 shows the RPD results. The high percentage (89 percent) of acceptable duplicate results indicates little problem with laboratory operations and good overall precision.

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 2008 sampling event, PE samples were analyzed for inorganics and metals. The results are shown in Table 10-5. The laboratory was notified of the results outside the performance acceptance limits, and the laboratory implemented corrective action.

Table 10-4. Groundwater Relative Percent Difference Results (2008).

	Relative Percent Difference Result
44 duplicate pairs	89% of RPD results within program goal of ≤35%.

Note: The RPD is calculated only if both results are detected (greater than instrument's detection limit).

Table 10-5. Groundwater Performance Evaluation Sample Results (2008).

Parameter	Within Performance Acceptance Limits	Outside Performance Acceptance Limits	Not Detected
Aluminum	X		
Arsenic	X		
Chloride	X		
Cadmium	X		
Chromium	X		
Copper	X		
Fluoride		X	
Iron	X		
Manganese	X		
Mercury	X		
Nitrate as nitrogen	X		
Selenium	X		
Total dissolved solids	X		
Total suspended solids	X		
Zinc	X		

During the October 2008 groundwater sampling event, one PE sample was analyzed for metals. The metals PE sample result was within the QC performance acceptance limits.

10.3.3 Drinking Water Program Quality Assurance/Quality Control

INL 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 using Equation (1).

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 2008, 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.

RPD was not calculated if either the sample or its duplicate was reported as nondetect. For 2008, 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 for 2008. This goal was met in 2008.

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 2008.

ICP 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 2008.

The ICP contractor Drinking Water Program requires that 10 percent of the samples (excluding bacteria) collected be QA/QC samples to include duplicates, trip blanks, and blind spikes. This goal was met in 2008 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 2008, and results are shown in Table 10-6.

Table 10-6. Idaho Cleanup Project Drinking Water Program Relative Percent Difference Results (2008).

Parameter	Relative Percent Difference Result
Inorganic and organic	92% of RPD results within program goal of ≤35%
Radionuclide	100% of RPD results within program goal of ≤35%

Note: Relative percent difference was not calculated if either the sample or its duplicate was reported as nondetect.

In 2008, PE samples were analyzed for:

- Volatile organic chemicals—4 samples
- Disinfection byproducts—2 samples
- Synthetic organic chemicals—2 samples
- Inorganic chemicals—3 samples.

All results were within the QC performance acceptance limits.

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

Each analytical laboratory conducted an internal spike sample program using standards traceable to 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 2008, 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 problems were reported in 2008 for either field or laboratory blanks.

10.3.5 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 the MAPEP and 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 control samples with routine samples for analyses as required.

10.3.6 ICP Environmental Services 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 the MAPEP and National Center for Environmental Research.

All PE samples submitted to the contract laboratory for analysis in 2008 for the Waste Management Surveillance Program showed satisfactory agreement, except the ^{90}Sr analysis. The ^{90}Sr contamination in blank samples and poor PE samples resulted in rejected ^{90}Sr results for 2008.

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 2008, the results for these samples were within the acceptable range.

REFERENCES

ASME NQA-1, 2008, “Quality Assurance Requirements for Nuclear Facility Applications,” American Society of Mechanical Engineers.

DOE, 2008, “Mixed Analyte Performance Evaluation Program,” http://www.inl.gov/resl/mapep/reports.html, Updated January 5, 2009, Web site visited January 24, 2009, U.S. Department of Energy.

EPA, 2002, *EPA Guidance for Quality Assurance Project Plans*, Appendix B, “Glossary of Quality Assurance and Related Terms,” EPA QA/G-5, EPA/240/R-02/009, U.S. Environmental Protection Agency.

Birch Creek Diversion

Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations are applicable, 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, 2009, “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, 2009, “National Emission Standards for Hazardous Air Pollutants,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 112, 2009, “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, 2009, “National Primary Drinking Water Regulations,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 260, 2009, “Hazardous Waste Management System: General,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 261, 2009, “Identification and Listing of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 262, 2009, “Standards Applicable to Generators of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 263, 2005, “Standards Applicable to Transporters of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 264, 2008, “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, 2006, “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, 2009, “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”
- IDAPA 58.01.01, 2009, “Rules for the Control of Air Pollution in Idaho,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.02, 2009, “Water Quality Standards,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.03, 2009, “Individual/Subsurface Sewage Disposal Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

- IDAPA 58.01.05, 2009, "Rules and Standards for Hazardous Waste," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.06, 2009, "Solid Waste Management Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.08, 2009, "Idaho Rules for Public Drinking Water Systems," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.11, 2009, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.15, 2009, "Rules Governing the Cleaning of Septic Tanks," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.17, 2009, "Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

The Derived Concentration Guides (DCGs) 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 DCGs are shown in Table A-1. The most restrictive DCG is listed when the soluble and insoluble chemical forms differ. The DCGs consider only inhalation of air, ingestion of water, and submersion in air. DOE Order 5400.5 provides the principal standards and guides for release of radionuclides at the INL Site. The DOE standard is shown in Table A-2 along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

Ambient air quality standards are shown in Table A-3. Water quality standards are dependent on the type of drinking water system sampled.

Tables A-4 through A-7 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 CFR 141 (2009) and the Idaho groundwater quality values from IDAPA 58.01.11 (2009).

Table A-1. Derived Concentration Guides for Radiation Protection.

Derived Concentration Guide[a,b]			Derived Concentration Guide		
Radionuclide	**In Air**	**In Water**	**Radionuclide**	**In Air**	**In Water**
Gross Alpha[c]	2×10^{-14}	3×10^{-8}	^{125}Sb	1×10^{-9}	5×10^{-5}
Gross Beta[d]	3×10^{-12}	1×10^{-7}	^{129}I	7×10^{-11}	5×10^{-7}
^{3}H	1×10^{-7}	2×10^{-3}	^{131}I	4×10^{-10}	3×10^{-6}
^{14}C	5×10^{-7}	7×10^{-2}	^{132}I	4×10^{-8}	2×10^{-4}
^{24}Na[e]	4×10^{-9}	1×10^{-4}	^{133}I	2×10^{-9}	1×10^{-5}
^{41}Ar	1×10^{-8}	—	^{135}I	1×10^{-8}	7×10^{-5}
^{51}Cr	5×10^{-8}	1×10^{-3}	^{131m}Xe	2×10^{-6}	—
^{54}Mn	2×10^{-9}	5×10^{-5}	^{133}Xe	5×10^{-7}	—
^{58}Co	2×10^{-9}	4×10^{-5}	^{133m}Xe	6×10^{-7}	—
^{60}Co	8×10^{-11}	5×10^{-6}	^{135}Xe	8×10^{-8}	—
^{65}Zn	6×10^{-10}	9×10^{-6}	^{135m}Xe	5×10^{-8}	—
^{85}Kr	3×10^{-6}	—	^{138}Xe	2×10^{-8}	—
^{85m}Kr[f]	1×10^{-7}	—	^{134}Cs	2×10^{-10}	2×10^{-6}
^{87}Kr	2×10^{-8}	—	^{137}Cs	4×10^{-10}	3×10^{-6}
^{88}Kr	9×10^{-9}	—	^{138}Cs	1×10^{-7}	9×10^{-4}
^{88d}Rb	3×10^{-8}	8×10^{-4}	^{139}Ba	7×10^{-8}	3×10^{-4}
^{89}Rb	9×10^{-9}	2×10^{-3}	^{140}Ba	3×10^{-9}	2×10^{-5}
^{89}Sr	3×10^{-10}	2×10^{-5}	^{141}Ce	1×10^{-9}	5×10^{-5}
^{90}Sr	9×10^{-12}	1×10^{-6}	^{144}Ce	3×10^{-11}	7×10^{-6}
^{91m}Y	4×10^{-7}	4×10^{-3}	^{238}Pu	3×10^{-14}	4×10^{-8}
^{95}Zr	6×10^{-10}	4×10^{-5}	^{239}Pu	2×10^{-14}	3×10^{-8}
^{99m}Tc	4×10^{-7}	2×10^{-3}	^{240}Pu	2×10^{-14}	3×10^{-8}
^{103}Ru	2×10^{-9}	5×10^{-5}	^{241}Am	2×10^{-14}	3×10^{-8}
^{106}Ru	3×10^{-11}	6×10^{-6}			

a. Derived concentration guides (DCGs) 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.

b. All values are in microcuries per milliliter (μCi/mL).

c. Based on the most restrictive alpha emitter (^{241}Am).

d. Based on the most restrictive beta emitter (^{228}Ra).

e. Submersion in a cloud of gas is more restrictive than the inhalation pathway.

f. An "m" after the number refers to a metastable form of the radionuclide.

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,c]
Sulfur Dioxide	Secondary	3-hour average	1300
	Primary	24-hour average	365
	Primary	Annual average	80
Nitrogen Dioxide	Primary and Secondary	Annual average	100
	Secondary	24-hour average	150
Total Particulates[d]	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. All values are in micrograms per cubic meter ($\mu g/m^3$).

d. The primary and secondary standard to the annual average applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers."

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Gross alpha	15 pCi/L	15 pCi/L
Gross beta	4 mrem/year[b]	4 mrem/year
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/year effective dose equivalent
Radium-226 plus -228	5 pCi/L	5 pCi/L
Strontium-90	8 pCi/L	8 pCi/L
Tritium	20,000 pCi/L	20,000 pCi/L
Uranium	30 µg/L	
Arsenic	0.01	0.05
Antimony	0.006	0.006
Asbestos	7 million fibers/L	7 million fibers/ L
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium	0.1	0.1
Copper[c]	1.3	1.3
Cyanide	0.2	0.2
Fluoride	4	4
Lead	0.015	0.15
Mercury	0.002	0.002
Nitrate (as N)	10	10
Nitrite (as N)	1	1
Total Nitrate and Nitrite	10	10
Selenium	0.05	0.05
Thallium	0.002	0.002

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. As a matter of practicality a screening level concentration of 50 pCi/L is used for comparison.

c. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

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[a]	Groundwater Quality Standards
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

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

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[a]	Groundwater Quality Standards
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}

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

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 Level[a]	Groundwater Quality Standard
Aluminum	--[b]	0.2
Chloride	--	250
Color	--	15 color units
Foaming agents	--	0.5
Iron	--	0.3
Manganese	--	0.05
Odor	--	3.0 threshold odor number
pH	--	6.5 to 8.5
Silver	--	0.1
Sulfate	--	250
Total dissolved solids (TDS)	--	500
Zinc	--	5

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. The Environmental Protection Agency only has Secondary Maximum Contaminant Levels for these constituents.

REFERENCES

40 CFR 141, 2009, "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 Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0070, U.S. Department of Energy.

IDAPA 58.01.11, 2009, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

Appendix B. Summary of Historical Environmental Monitoring

This summary of INL Site historical environmental monitoring has been adapted from the Idaho National Engineering Laboratory Historical Dose Evaluation (DOE-ID 1991), which contains more detailed information on early environmental monitoring efforts and results.

Environmental monitoring has been performed at the INL Site by the Department of Energy Idaho Operations Office (DOE-ID) and its predecessors, the Atomic Energy Commission (AEC) and Energy Research and Development Administration, as well as by other federal agencies, various contractors, and State agencies since its inception in 1949. The organization of environmental monitoring programs has remained fairly constant throughout much of the history of the INL Site. The AEC's Health Services Laboratory, later named the DOE-ID's Radiological and Environmental Sciences Laboratory, was responsible for conducting most environmental surveillance tasks from the early 1950s to 1993 both on and off the INL Site. Contractors operating the various facilities were responsible for monitoring activities performed within the facility boundaries, including effluent monitoring.

Early monitoring activities focused on evaluating the potential for exposing the general public to a release of radioactive materials from INL Site facilities. Radionuclides were the major contaminants of concern because the INL Site was heavily involved in testing nuclear facilities. DOE-ID and its predecessors sampled and analyzed environmental media that could be affected by atmospheric releases. During those early years, the various INL Site contractors sampled liquid and airborne effluents from facilities to develop waste inventory information.

Throughout the INL Site's history, DOE-ID has maintained agreements with two other Federal agencies to perform specific monitoring activities on and around the INL Site. The U.S. Geological Survey (USGS) has monitored groundwater quantity and quality in the Eastern Snake River Plain Aquifer, emphasizing the portion of the aquifer beneath the INL Site. The National Oceanic and Atmospheric Administration (NOAA) has monitored weather conditions at the INL Site since 1948.

In 1993, the DOE-ID Environmental Monitoring Program was divided into separate onsite and offsite programs. Responsibility for the onsite program was transferred to the INL contractor. During 2008, Battelle Energy Alliance was the INL contractor, managing nuclear research facilities and sitewide functions. CH2M-WG Idaho, LLC assumed responsibility for the Idaho Cleanup Project (ICP) on May 1, 2005 and has responsibility for managing all waste management facilities and related monitoring activities. The monitoring activities performed by the INL and ICP contractors comprise the onsite monitoring program. The offsite monitoring program is performed by the Environmental Surveillance, Education, and Research (ESER) Program, which is managed by the S.M. Stoller Corporation.

B.1 Agricultural Products Monitoring

Milk was the first agricultural product to be monitored, beginning in at least 1957. The number of samples collected per year has been relatively constant since about 1962. Because of improvements in counting technology, the detection level for ^{131}I has decreased from about 1,500 pCi/L in early sampling to the current detection level of about 1 pCi/L.

Wheat was first sampled as part of the radioecology research program in about 1962. The current monitoring program dates back to 1963.

Potatoes were first collected in 1976 as part of an ecological research project. Regular potato sampling resumed in 1994 in response to public interest. Starting in 1999 potatoes grown in other states were collected for comparison to those collected from growers adjacent to the INL Site. Lettuce has been collected since 1977. The collection of lettuce from home gardens around the INL Site was typically random. To make this sampling more deliberate, the ESER contractor added lettuce planters in conjunction with other onsite and offsite sampling locations in 2003. These locations were relatively remote and had no access to water, requiring that a self-watering system be developed. This method allowed for the placement and collection of lettuce at areas previously unavailable to the public (i.e., on the INL Site). This new method also allowed for the accumulation of deposited radionuclides on the plant surface throughout the growth cycle.

B.2 Air Monitoring

Low-volume air samplers have been operating on and in the vicinity of the INL Site since 1952. Table B-1 lists these sampling locations and their dates of operation (derived from DOE-ID 1991). Before 1960, radiation detection devices, such as a Geiger-Müller tube, were used to measure the radioactivity on air filters. Gross beta measurements started in 1960, and by 1967 the present measurements were being taken.

High-volume air samplers operated at the Experimental Field Station and Central Facilities Area from 1973 until October 1996, when operations were suspended after a cost-benefit analysis was performed. Also in 1973, the Environmental Protection Agency began operating a high-volume sampler in Idaho Falls as part of the nationwide Environmental Radiation Ambient Monitoring System, now known as RadNet. The Idaho Falls sampler still operates.

Tritium in atmospheric moisture has been measured at a minimum of two locations since at least 1973. Some limited monitoring may have been performed before then.

One monitoring location at Central Facilities Area collected samples of noble gases, with specific interest in krypton-85 (^{85}Kr), from approximately 1984 until 1992. This station monitored releases of ^{85}Kr from the Idaho Nuclear Technology and Engineering Center (INTEC) when spent nuclear fuel was being reprocessed.

Nitrogen dioxide and sulfur dioxide were first monitored for a nine-week period at five locations on the INL Site in 1972. A nitrogen dioxide sampling station operated from 1983 to 1985 to monitor waste calcining operations at INTEC. A sulfur dioxide sampler also was used from 1984 to 1985. Nitrogen dioxide sampling resumed from 1988 to 2003, and one sulfur dioxide sampler operated from 1989 through 2001. Nitrogen dioxide was sampled using a continuous emissions monitoring system at the INTEC main stack as well as ambient air samplers downwind of the facility. This sampling was performed in conjunction with air permit compliance for INTEC calciner operations. The calciner ceased operations in 2000.

Table B-1. Historical Low-Volume Radiological Air Sampling Locations and Dates of Operations.

Sampling Locations	Dates of Operation
Off INL Site Locations	
Aberdeen	1952–1957, 1960–1970
American Falls	1970
Blackfoot	1968–2001
Blackfoot Community Monitoring Station	1983–present
Carey	1961–1970
Craters of the Moon[a]	1973–present
Dubois	2001–present
Dietrich	1961–1970
Idaho Falls	1953–1955, 1956–present
Jackson	2001–present
Minidoka	1961–1970
Pocatello	1969–1980
Rexburg Community Monitoring Station	1983–present
Spencer	1953–1956
Boundary Locations	
Arco	1968–present
Atomic City	1953–1957, 1960–1970, 1973–present
Butte City	1953–1957, 1960–1973
Blue Dome	2001–present
Federal Aviation Administration Tower	1981–present
Howe	1958–present
Monteview	1958–present
Mud Lake	1958–present
Reno Ranch/Birch Creek	1958–2001
Roberts	1960–1970
Terreton	1953–1956, 1964–1965
INL Site Locations	
Advanced Test Reactor Complex (formerly Reactor Technology Complex)	1953–1956, 1958–present
Aircraft Nuclear Propulsion Program	1953–1955, 1961–1963
Auxiliary Reactor Area	1966–present
Central Facilities Area	1953–present
Critical Infrastructure Test Range Complex/Power Burst Facility	1958–present
East Butte	1953–1955
Experimental Breeder Reactor No. 1	1952–1956, 1958–present
Experimental Field Station	1972–present
Fire Station #2	1958–1963
Gas-Cooled Reactor Experiment	1961–1963
Gate 4	2004-present
Idaho Nuclear Technology and Engineering Center	1953–1956, 1958–1970, 1981–present
Main Gate Materials and Fuels Complex	1976–present 1961–present
Mobile Low Power Reactor No. 1	1961–1963
Naval Reactors Facility	1956, 1958–present
Organic Moderated Reactor Experiment	1957–1963
Radioactive Waste Management Complex	1973–present
Rest Area, Highway 20	2000–present
Specific Manufacturing Capability Facility	2004-present
Stationary Low-Power Reactor No. 1	1961–1963
Test Area North	1953–1955, 1956–present
Van Buren Gate	1976–present

a. Designated as a boundary location 1973–1981.

The National Park Service, in cooperation with other federal land management agencies, began the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program in 1985. This program was an extension of an earlier Environmental Protection Agency program to measure fine particles of less than 2.5 µm in diameter ($PM_{2.5}$). These particles are the major cause of degraded visibility. In May 1992, one IMPROVE sampler was established at the Central Facilities Area on the INL Site, and a second was located offsite at Craters of the Moon National Monument as part of the nationwide network. Each sampler collected two 24-hr $PM_{2.5}$ samples a week. Analyses were performed for particulate mass, optical absorption, hydrogen, carbon, nitrogen, oxygen, and the common elements from sodium through lead on the periodic table. The Central Facilities Area sampler ceased operation in May 2000 when the Environmental Protection Agency removed it from the nationwide network. The Craters of the Moon National Monument sampler ceased operation in 2008 when an Interagency Agreement between DOE-ID and the National Park Service expired. Emissions from the calciner at INTEC had potential to impact visibility at the Monument. The calciner ceased operations in 2000.

B.3 Animal Tissue Monitoring

Monitoring of game animals has focused on research concerning the movement of radionuclides through the food chain. Rabbit thyroids and bones were first sampled in 1956. In 1973, routine sampling of game animal tissues began. The following year, the first studies on waterfowl that were using wastewater disposal ponds containing various amounts of radionuclides were conducted. Waterfowl studies have covered the periods 1974–1978, 1984–1986, and 1994–present. In 1998, waterfowl collection became part of the routine monitoring activities.

In 1998, periodic sampling of yellow-bellied marmots was added. During 1998, 2000, 2002, and 2003, 15 marmots were collected from the Radioactive Waste Management Complex and 11 from control areas and analyzed for specific radionuclides. Measured radionuclide concentrations in 2002 and 2003 were well below those in other wildlife species collected historically at the Radioactive Waste Management Complex, as well as in control animals collected in previous studies. As a result, routine monitoring of marmots ceased.

Monitoring of livestock grazing on and near the INL Site began in 1975. Sheep that grazed on the INL Site were routinely monitored from 1975 through 2006. Sheep sampling was discontinued because (1) radionuclide concentrations remained unchanged since 2002, (2) results were statistically equal to background levels, and (3) game animals theoretically indicate releases to the environment better because they may graze near INL Site facilities. Beef cattle grazing near the Radioactive Waste Management Complex were monitored biennially from 1978 to 1986. Monitoring of beef cattle ceased when grazing near the Radioactive Waste Management Complex was discontinued due to drought conditions.

Sporadic fish sampling has been performed on the INL Site during periods when the Big Lost River flows.

B.4 Direct Radiation Monitoring

Radiation in the environment has been measured on the INL Site since 1958. The technology for measuring radiation at fixed locations has evolved from film badges to thermoluminescent dosimeters. In addition to these fixed locations, surveys using hand-held and vehicle-mounted radiation instruments have been conducted since at least 1959. Aerial radiological surveys were also performed in 1959, 1966, 1974, 1982, and 1990.

B.5 Meteorological Monitoring

In 1948 a U.S. Weather Bureau Research Station was established at the INL Site. The station was used to develop a basic understanding of the regional meteorology and climate, with a specific focus on protecting the health and safety of site workers and nearby residents. The first meteorological monitoring site was installed at Central Facilities Area in 1949. During the 1950s, a small network of meteorological monitoring sites was deployed. To understand the complex wind flows in the area, the station developed innovative technologies that went beyond basic tower measurements. These included special balloons (called tetroons) that were tracked by radar and the use of tracer chemicals to track the movement of air parcels over time.

During the 1960s, the meteorological network was expanded at the INL Site. The more frequent, closely spaced data available from this network allowed local researchers to develop one of the earliest puff dispersion models. Such models are now commonly used worldwide for regulatory and emergency response applications. The Weather Bureau underwent reorganizations over time, and meteorological activities now fall under NOAA. The original Research Station at the INL Site is now the Field Research Division of the NOAA Air Resources Laboratory.

The NOAA/INL meteorological tower network (called the NOAA/INL Mesonet) has been upgraded several times since the 1960s, with the most significant modernization and consolidation taking place in the early 1990s. At that time, most of the towers were replaced, and the towers off the INL Site, which the DOE-ID management and operating contractor had previously operated, were integrated into the NOAA system. Although components have been upgraded since then, the basic Mesonet configuration and data reporting have remained largely unchanged since the 1990s modernization.

B.6 Soil Monitoring

Soil sampling has been part of the routine monitoring program since the early 1970s, although some soil was collected around various facilities as far back as 1960. Soil was sampled at distant and boundary locations off the INL Site annually from 1970 to 1975. The collection interval was extended to every two years starting in 1978. Soil samples in 1970, 1971, and 1973 represented a composite of five cores of soil 5 cm (2 in.) in depth from an approximately 0.9 m2 (10 ft^2) area. In all other years, the five cores were collected from two depths, 0–5 cm (0–2 in.) and 5–10 cm (2–4 in.), within a 100 m^2 (~1,076 ft^2) area.

Soil sampling around INL Site facilities began in 1973. Soils at each facility were sampled every seven years. In 2001, all locations were sampled when the frequency was increased to every two years.

B.7 Water Monitoring

The USGS has conducted groundwater studies at the INL Site since its inception in 1949. The USGS initially was assigned to characterize area water resources. They have since maintained a groundwater quality and water level measurement program to support research and monitor the movement of radioactive and chemical constituents in the Eastern Snake River Plain Aquifer. The first well, USGS 1, was completed and monitored in December 1949. The USGS has maintained an INL Project Office since 1959 (Knobel et al. 2005). During 2005, the USGS released a report documenting their monitoring programs from 1949 to 2001 (Knobel et al. 2005).

In 1993, DOE-ID initiated integrating all the groundwater monitoring programs at the INL Site. This resulted in the development of the sitewide Groundwater Monitoring Plan (DOE-ID 1993a) and the Groundwater Protection Management Plan (DOE-ID 1993b). The Groundwater Monitoring Plan describes historical conditions and monitoring programs and includes an implementation plan for each facility. The Groundwater Protection Management Plan establishes policy and identifies programmatic requirements.

Sampling and analysis of drinking water both on and off the INL Site began in 1958. Analysis for tritium began in 1961. Up to 28 locations were sampled until knowledge of groundwater movement beneath the INL Site increased and, as a result, the number of sampling locations decreased. In 1988, a central drinking water program was established. The Drinking Water Program was established to monitor drinking water and the production wells that supply drinking water; these are multiple-use wells for industrial use, fire safety, and drinking water. Drinking water is monitored to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. The Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08) and the federal Safe Drinking Water Act (42 USC § 300f–300j-26 1974) establish requirements for the Drinking Water Program.

REFERENCES

42 USC § 300f to 300j-26, 1974, “Safe Drinking Water Act,” United States Code.

DOE-ID, 1991, Idaho National Engineering Laboratory Historical Dose Evaluation, Appendix E, “Environmental Surveillance,” DOE/ ID-12119, Vol. 2, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 1993a, Idaho National Engineering Laboratory Groundwater Monitoring Plan, DOE/ID-10441, U.S. Department of Energy Idaho Operations Office and associated 2003 update, Idaho National Engineering and Environmental Laboratory Groundwater Monitoring Plan Update, DOE/ID-11034, U.S. Department of Energy Idaho Operations Office,

DOE-ID, 1993b, Idaho National Engineering Laboratory Groundwater Protection Management Plan, DOE/ID-10274, U.S. Department of Energy Idaho Operations Office.

IDAPA 58.01.08, 2008, “Idaho Rules for Public Drinking Water Systems,” Idaho Administrative Procedures Act.

Knobel, L. L., R. C. Bartholomay, and J. P. Rousseau, 2005, Historical Development of the U.S. Geological Survey Hydrologic Monitoring and Investigative Programs at the Idaho National Engineering and Environmental Laboratory, Idaho, 1949-2001, U.S. Geological Survey Open-File Report 2005-1223, DOE/ID-22195, U.S. Geological Survey.

Appendix C. Statistical Methods used in the Idaho National Laboratory Annual Site Environmental Report

Relatively simple statistical procedures are used to analyze the data collected by the Idaho National Laboratory (INL) Environmental Surveillance, Education and Research (ESER) Program. This appendix presents the methods used to evaluate sample results.

C.1 Guidelines for Reporting Results

The results reported in the quarterly and annual reports are assessed in terms of data quality and statistical significance with respect to laboratory analytical uncertainties, sample locations, reported INL releases, meteorological data, and worldwide events that might conceivably have an effect on the INL environment.

C.2 Initial Radiological Screening

First, field collection and laboratory information are reviewed to determine identifiable errors that would invalidate or limit use of the data. Examples of field observations that could invalidate the data include insufficient sample volume, torn filter, or mechanical malfunction of sampling equipment.

The analytical laboratory also qualifies the results and may reject them for reasons, such as:

- Uncertainty is too high to be accepted by the analyst
- Radionuclide has no supporting photopeaks to make a judgment
- Photopeak width is unacceptable by the analyst
- Result is below the decision critical level
- Other radionuclides display gamma-ray interferences
- A graphical display of analyzed photopeaks showed unacceptable fitting results
- There is no parent activity; therefore, the state of equilibrium is unknown and the radionuclide could not be quantified
- Radionuclide is a naturally occurring one with expected activity.

Evidence of laboratory cross-contamination or quality control issues could also disqualify a result (see Chapter 10).

Data that pass initial screening are further evaluated prior to reporting.

C.3 Reporting Levels

The goal of the ESER Program is to minimize the error of reporting a constituent is absent in a sample population when it is actually present. This is accomplished through the use of the uncertainty term, which is reported by the analytical laboratory with the sample result. For radiological data, individual analytical results are usually presented in this report with plus or minus one sample standard deviation (± 1s). The sample standard deviation is obtained by propagating sources of analytical uncertainty in laboratory measurements. The uncertainty term, "s," is an estimate of the population standard deviation "σ," assuming a Guassian or normal distribution. The approach used by the ESER Program to interpret individual analytical results is based on guidelines outlined by the U.S. Geological Survey in Bartholomay et al. (2000), which are based on methodology proposed by Currie (1984). Most of the following discussion is from Bartholomay et al. (2000).

Laboratory measurements are made on a target sample and on a laboratory-prepared blank. Instrument signals for the sample and blank vary randomly about the true signals. Two key concepts characterize the theory of detection: the "critical value" (or "critical level" or "criterion of detection") and the "minimum detectable value" (or "detection limit" or "limit of detection"). The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. Figure C-1 illustrates these terms.

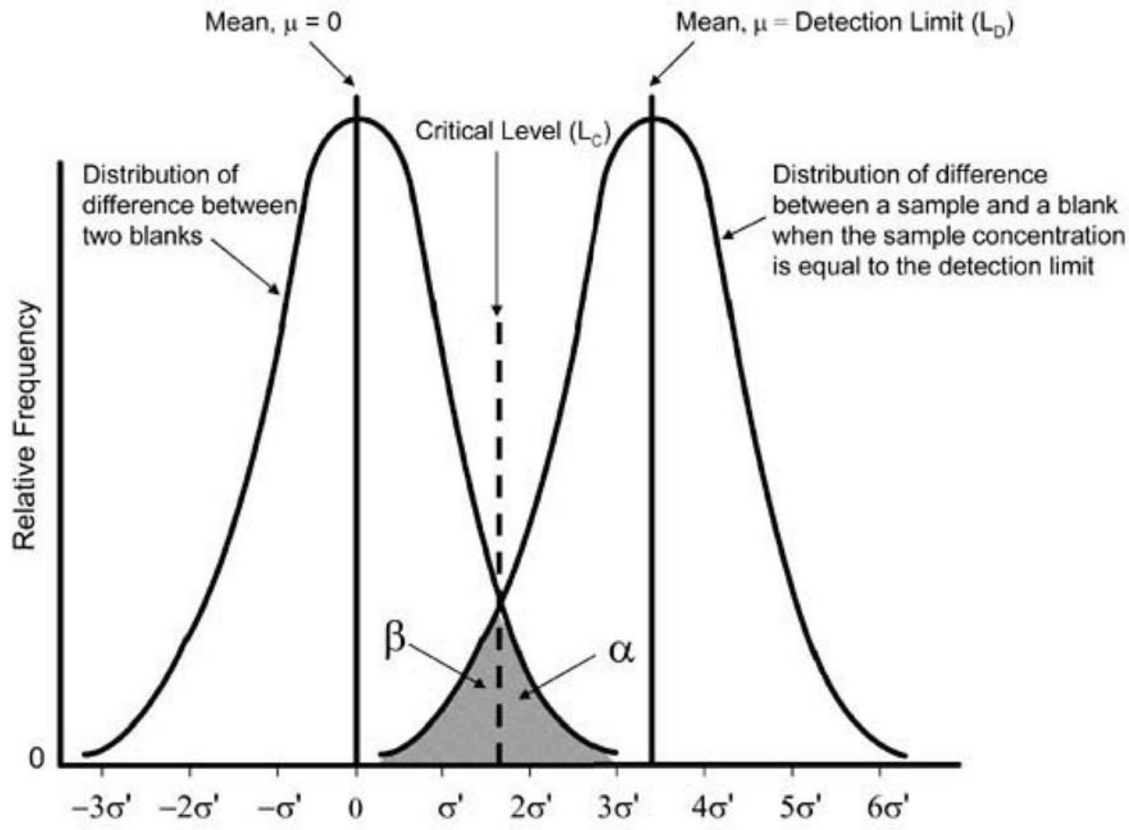


Figure C-1. Illustration of the Relation of the Criterion of Detection (Critical Level) and the Limit of Detection (Detection Limit). Errors of the first kind (false negatives) are represented by the value of α, whereas errors of the second kind (false positives) are represented by the value of β. (from Currie 1984).

The critical level (L_C) is the minimum significant value of an instrument signal or concentration that can be discriminated from the signal or concentration observed for the blank such that the decision can be made that the radionuclide was detected. The decision “detected” or “not detected” is made by comparing the estimated quantity ($\hat{L}$) with L_C. A result falling below L_C triggers the decision “not detected.” That is when the true net signal, zero, intersects L_C such that the fraction 1-α, where α is the error of the first kind (false positive), corresponds to the correct decision “not detected.” Typically, α is set equal to 0.05. Using algorithms in Currie (1984) that are appropriate for our data, the L_C is 1.65s or approximately 2s. At this level, there is about a 95 percent probability that the correct decision—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentration larger than or equal to 2s, which were concluded as being detected, might not contain the radionuclide (i.e., a false positive).

Once the critical level has been defined, the minimum detectable concentration, or detection level (L_D), may be determined. Using the equations in Currie (1984), concentrations that equal 3.29s, or approximately 3s, represent a measurement at the minimum detectable concentration. For true concentrations of 3s or larger, there is 95 percent or larger probability that the radionuclide was detected in a sample. In a large number of samples, the conclusion—not detected—will be made in 5 percent of the samples that contain true concentrations at the minimum detectable concentration of 3s. These are referred to as false negatives or errors of the second kind.

True radionuclide concentrations between 2s and 3s have larger errors of the second kind. That is, there is a larger-than-five-percent probability of false negative results for samples with true concentrations between 2s and 3s. Although the radionuclide might have been detected, such detection may not be considered reliable; at 2s, the probability of a false negative is about 50 percent.

In this report, radionuclide concentrations less than 3s are considered to be below a “reporting level.” Concentrations above 3s are considered to be detected with confidence. Results between 2s and 3s are considered to be “questionable” detections. Each result is reported with the associated 1s uncertainty value for consistency with other INL reports.

C.4 Statistical Tests Used to Assess Data

An example data set is presented here to illustrate the statistical tests used to assess data collected by the ESER contractor. The data set is the gross beta environmental surveillance data collected from January 8, 1997, through December 26, 2001. The data were collected weekly from several air monitoring stations located around the perimeter of the INL Site and air monitoring stations throughout the Snake River Plain. The perimeter locations are termed “boundary,” and the Snake River Plain locations are termed “distant.” There are seven boundary locations: Arco, Atomic City, Birch Creek, Federal Aviation Administration (FAA) Tower, Howe, Monteview, and Mud Lake; and five distant locations: Blackfoot, Blackfoot Community Monitoring Station (CMS), Craters of the Moon, Idaho Falls, and Rexburg CMS. The gross beta data are of the magnitude 10^{-15}. To simplify the calculations and interpretation, these have been coded by multiplying each measurement by 10^{15}.

Only portions of the complete gross beta data set will be used. The purpose of this task is to evaluate and illustrate the various statistical procedures, and not a complete analysis of the data.

C.5 Test of Normality

The first step in any analysis of data is to test for normality. Many standard statistical tests of significance require that the data be normally distributed. The most widely used test of normality is the Shapiro-Wilk W-Test (Shapiro and Wilk 1965). The Shapiro-Wilk W-Test is the preferred test of normality because of its good power properties as compared to a wide range of alternative tests (Shapiro et al. 1968). If the W statistic is significant ($p<0.00001$), then the hypothesis that the respective distribution is normal should be rejected.

Graphical depictions of the data should be a part of any evaluation of normality. The following histogram (Figure C-2) presents such a graphical depiction along with the results of the Shapiro-Wilk W Test. The data used for the illustration are the five years of weekly gross beta

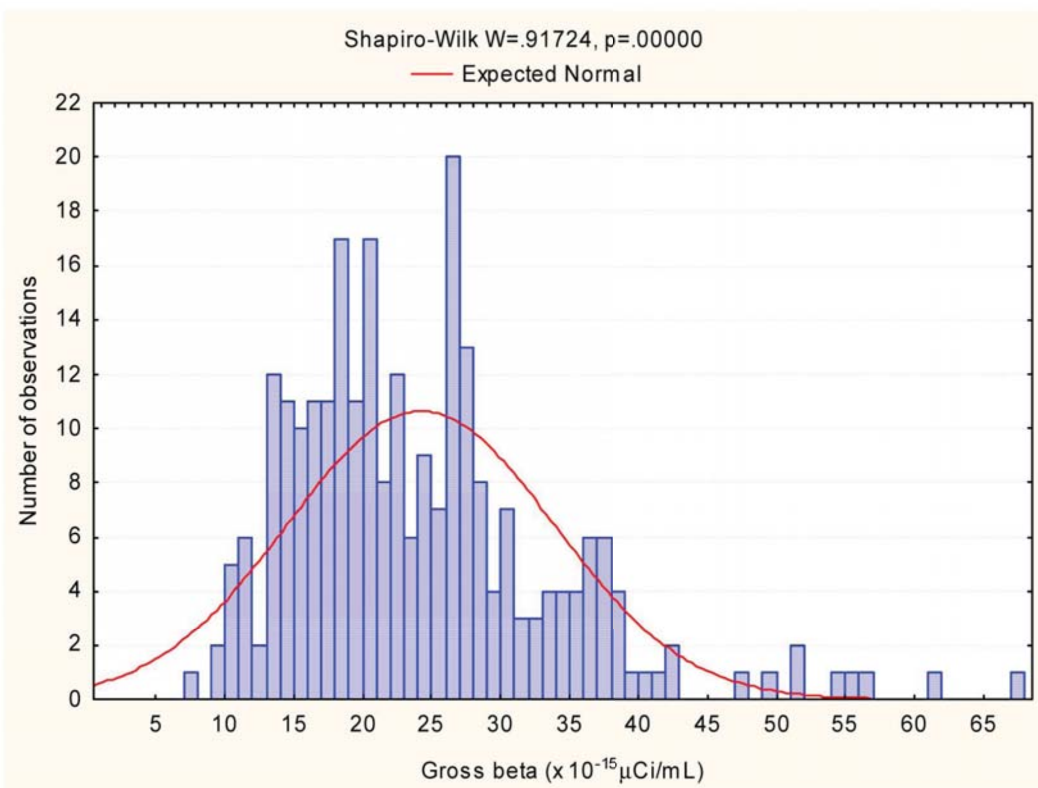


Figure C-2. Test of Normality for Arco Gross Beta Data.

measurements for the Arco boundary location. The W statistic is highly significant ($p<0.0001$), indicating that the data are not normally distributed. The histogram shows that the data are asymmetrical with right skewness. This skew suggests that the data may be lognormally distributed. The Shapiro-Wilk W-Test can be used to test this distribution by taking the natural logarithms of each measurement and calculating the W statistic. Figure C-3 presents this test of lognormality. The W statistic is not significant ($p=0.80235$), indicating that the data are lognormal.

To perform parametric tests of significance such as Student's T-Test or One-Way Analysis of Variance (ANOVA), it is required that all data be normally (or lognormally) distributed. Therefore, if one desires to compare gross beta results of each boundary location, tests of normality must be performed before making such comparisons. Table C-1 presents the results of the Shapiro-Wilk W-Test for each of the seven boundary locations.

From Table C-1, none of the locations consist of data that are normally distributed, and only some of the data sets are lognormally distributed. This is a typical result and a common problem when one desires to use a parametric test of significance. When many comparisons are to be made, attractive alternatives are nonparametric tests of significance.

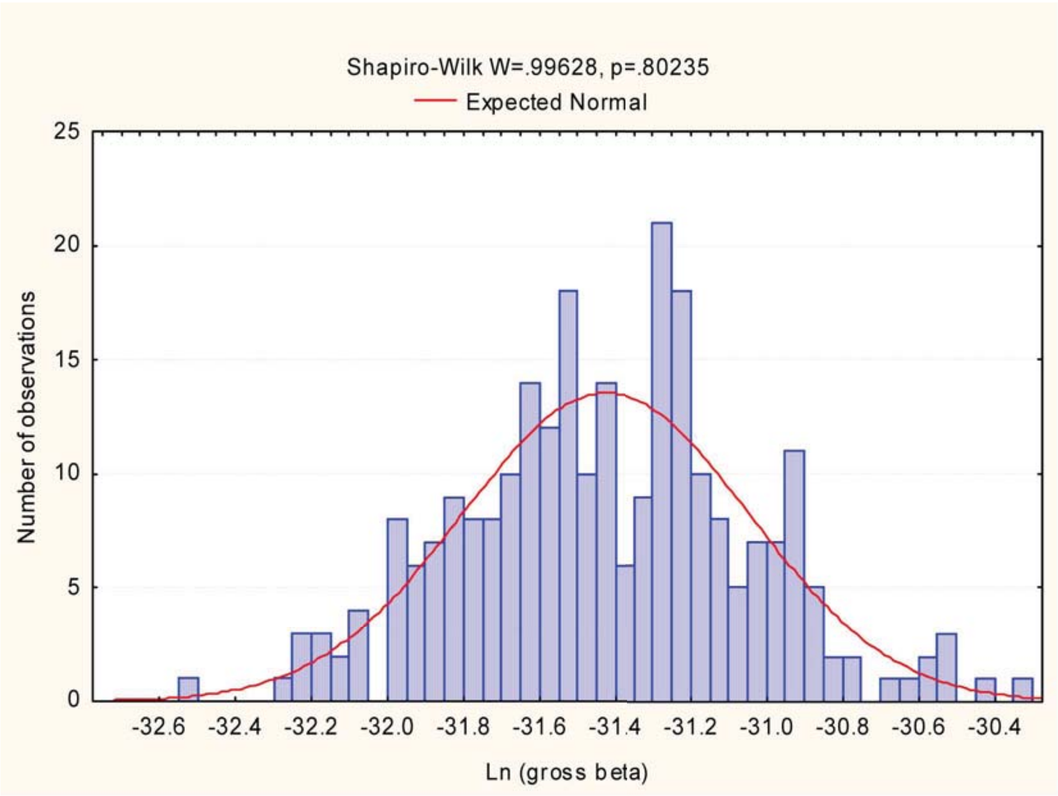


Figure C-3. Test of Lognormality for Arco Gross Beta.

Table C-1. Tests of Normality for Boundary Locations.

Location	Normal		Lognormal	
	W statistic	p-value	W statistic	p-value
Arco	0.9172	<0.0001	0.9963	0.8024
Atomic City	0.9174	<0.0001	0.9411	<0.0001
Birch Creek	0.8086	<0.0001	0.9882	0.0530
FAA Tower	0.9119	<0.0001	0.9915	0.1397
Howe	0.8702	<0.0001	0.9842	0.0056
Monteview	0.9118	<0.0001	0.9142	<0.0001
Mud Lake	0.6130	<0.0001	0.9704	<0.0001

C.6 Comparison of Two Groups

For comparison of two groups, the Mann-Whitney U-Test (Hollander and Wolfe 1973) is a powerful nonparametric alternative to the Student's T-Test. In fact, the U-Test is the most powerful (or sensitive) nonparametric alternative to the T-Test for independent samples; in some instances it may offer even greater power to reject the null hypothesis than the T-Test. The interpretation of the Mann-Whitney U-Test is essentially identical to the interpretation of the Student's T-Test for independent samples, except that the U-Test is computed based on rank sums rather than means. Because of this fact, outliers do not present the serious problem that they do when using parametric tests.

Suppose one wants to compare all boundary locations to all distant locations. Figure C-4 presents the box plots for the two groups. The median is the measure of central tendency most commonly used when there is no assumed distribution. It is the middle value when the data are ranked from smallest to largest. The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile, and 75 percent of the measurements are less than the 75th percentile. The large distance between the medians and the maximums seen in Figure C-4 indicates the presence of outliers. It is apparent that the medians are of the same magnitude, indicating graphically that there is probably not a significant difference between the two groups.

The Mann-Whitney U-Test compares the rank sums between the two groups. In other words, for both groups combined, it ranks the observations from smallest to largest. Then, it calculates the

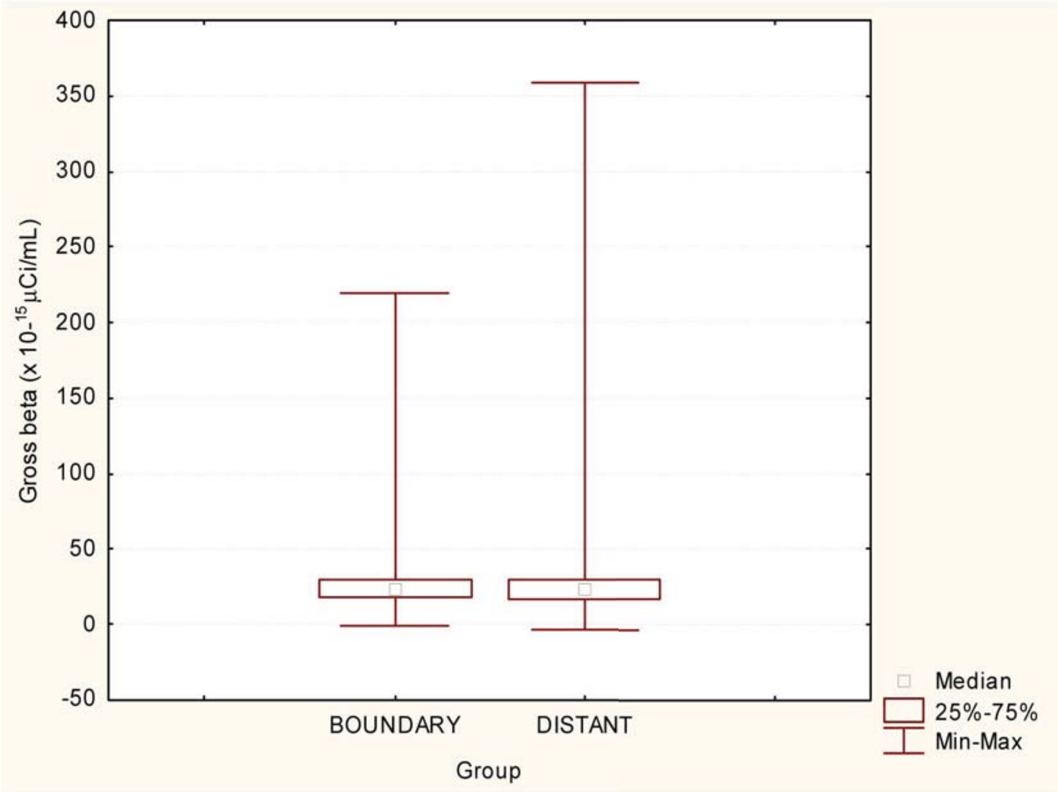


Figure C-4. Box Plot of Gross Beta Data from Boundary and Distant Locations.

sum of the ranks for each group and compares these rank sums. A significant p-value ($p<0.05$) indicates a significant difference between the two groups. The p-value for the comparison of boundary and distant locations is not significant ($p=0.0599$). Therefore, the conclusion is that there is not strong enough evidence to say that a significant difference exists between boundary and distant locations.

C.7 Comparison of Many Groups

Now suppose one wants to compare the boundary locations among themselves. In the parametric realm, this is done with a One-Way Analysis of Variance (ANOVA). A nonparametric alternative to the One-Way ANOVA is the Kruskal-Wallis ANOVA (Hollander and Wolfe 1973). The test assesses the hypothesis that the different samples in the comparison were drawn from the same distribution or from distributions with the same median. Thus, the interpretation of the Kruskal-Wallis ANOVA is basically identical to that of the parametric One-Way ANOVA, except that it is based on ranks rather than means.

Figure C-5 presents the box plot for the boundary locations. The Kruskal-Wallis ANOVA test statistic is highly significant ($p<0.0001$), indicating a significant difference among the seven boundary locations. Table C-2 gives the number of samples, medians, minimums, and maximums for each boundary location. The Kruskal-Wallis ANOVA only indicates that significant

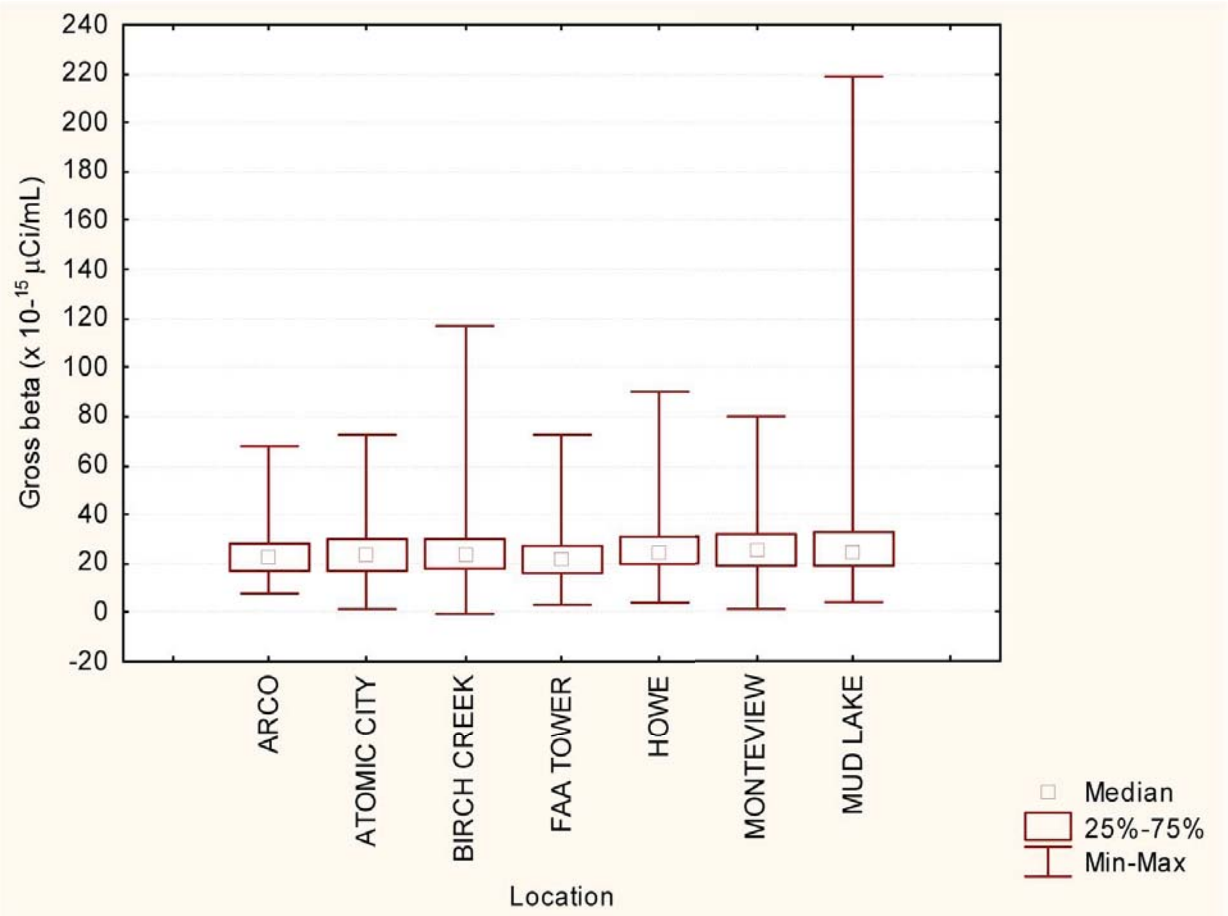


Figure C-5. Box Plot of Gross Beta Data for Each Boundary Location.

Table C-2. Summary Statistics for Boundary Locations.

Location	Number of Samples	Median (10^{-15} µCi/mL)	Minimum (10^{-15} µCi/mL)	Maximum (10^{-15} µCi/mL)
Arco	258	22.49	7.53	67.66
Atomic City	260	23.61	1.13	72.20
Birch Creek	234	23.15	-0.52	117.00
FAA Tower	260	21.90	3.59	72.78
Howe	260	24.55	3.95	90.10
Monteview	260	25.30	1.03	80.10
Mud Lake	260	24.85	4.30	219.19

differences exist between the seven locations and not the individual occurrences of differences. If desired, the next step is to identify pairs of locations of interest and test those for significant differences using the Mann-Whitney U-Test. It is cautioned that all possible pairs should not be tested, only those of interest. As the number of pairs increases, the probability of a false conclusion also increases.

Suppose a comparison between Arco and Atomic City is of special interest due to their close proximity to each other. A test of significance using the Mann-Whitney U-Test results in a p-value of 0.7288, indicating no significant difference exists between gross beta results at Arco and Atomic City. Other pairs can similarly be tested, but with the caution given above.

C.8 Tests for Trends over Time

Regression analysis is used to test whether or not there is a significant positive or negative trend in gross beta concentrations over time. To illustrate the technique, the regression analysis is performed for the boundary locations as one group and the distant locations as another group. The tests of normality performed earlier indicated that the data were closer to lognormal than normal. For that reason, the natural logarithms of the original data are used in the regression analysis. Regression analysis assumes that the probability distributions of the dependent variable (gross beta) have the same variance regardless of the level of the independent variable (collection date). The natural logarithmic transformation helps in satisfying this assumption.

Figure C-6 presents a scatter plot of the boundary data with the fitted regression line superimposed. Figure C-7 presents the same for the distant data. Table C-3 gives the regression equation and associated statistics. There appears to be slightly increasing trends in gross beta over time for both the boundary and distant locations. A look at the regression equations and correlation coefficients in Table C-3 confirm this. Notice that the slope parameter of the regression equation and the correlation coefficient are equal. This is true for any linear regression fit. So, a test of significant correlation is also a test of significant trend. The p-value associated with testing whether or not the correlation coefficient is different from zero is the same as for testing if the slope of the regression line is different from zero. For both the boundary and distant locations, the slope is significantly different from zero and positive, indicating an increasing trend in gross beta over time.

Another important point of note in Figures C-6 and C-7 is the obvious existence of a cyclical trend in gross beta. It appears as if the gross beta measurements are highest in the summer months and lowest in the winter months. Because the regression analysis performed above is over several years, a positive trend over time can still be detected even though it is confounded somewhat by the existence of a cyclical trend. This is important because a linear regression analysis performed over a shorter period may erroneously conclude a significant positive or negative trend, when in fact, it is a portion of the cyclical trend.

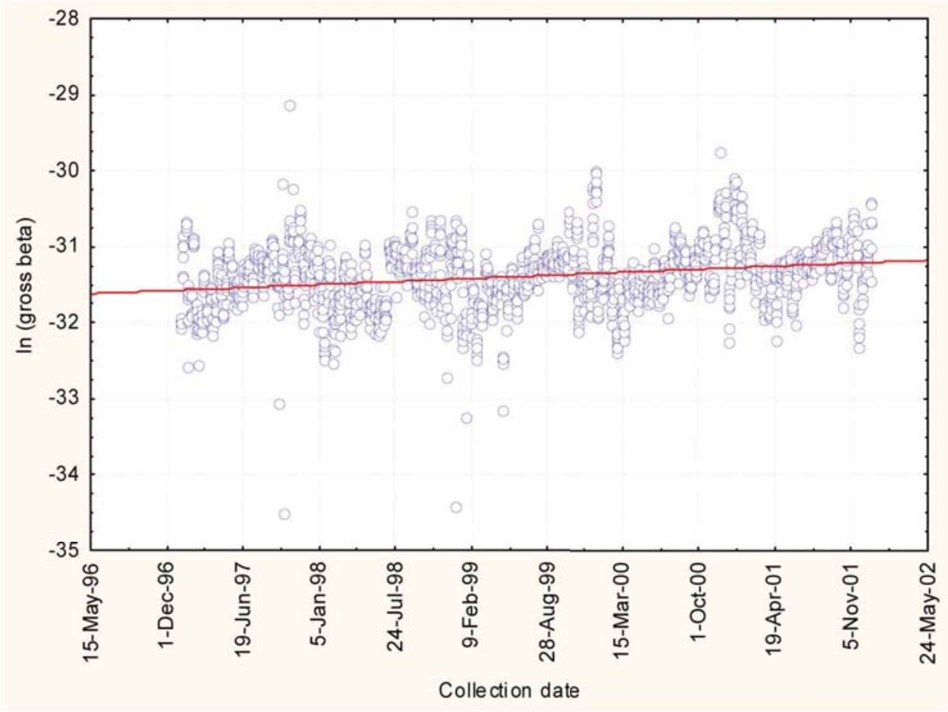


Figure C-6. Scatter Plot and Regression Line for ln (Gross Beta) from Boundary Locations.

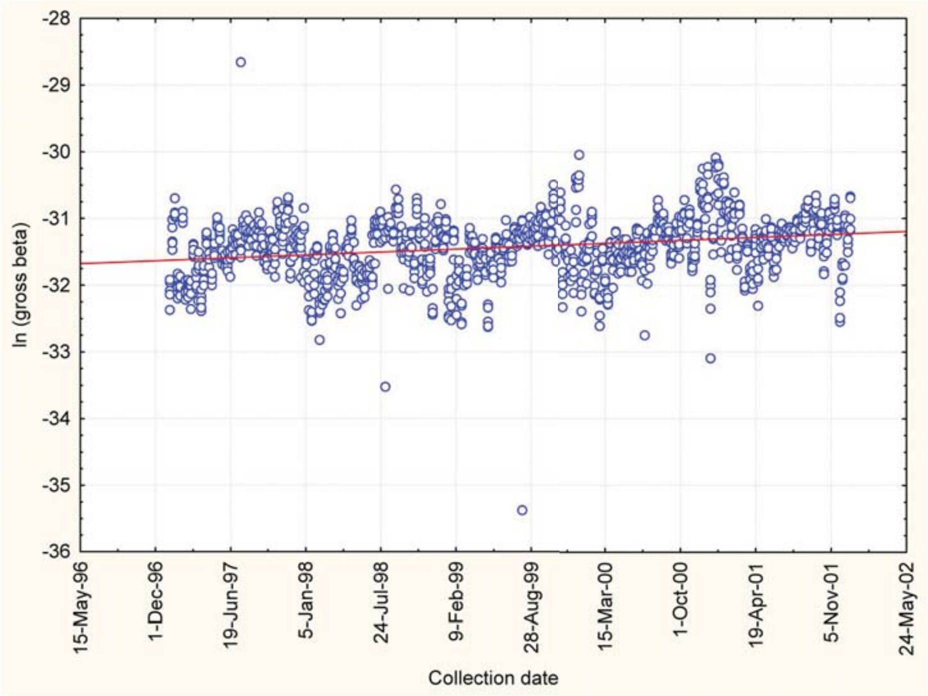


Figure C-7. Scatter Plot and Regression Line for ln (Gross Beta) from Distant Locations..

Table C-3. Regression Equations and Associated Statistics for Boundary and Distant Locations.

Sample Group	Regression Equation	Correlation Coefficient	p-value
Boundary	Ln (gross beta) = -38.7 + 0.245×(date)	0.245	<0.0001
Distant	Ln (gross beta) = -39.4 + 0.253×(date)	0.253	<0.0001

C.9 Comparison of Slopes

A comparison of slopes between the regression lines for the boundary locations and distant locations indicate if the rate of change in gross beta over time differs with location. The comparison of slopes can be performed by constructing 95 percent confidence intervals about the slope parameter (Neter and Wasserman 1974). If these intervals overlap, it can be concluded that there is no evidence to suggest a difference in slopes for the two groups of locations.

A confidence interval for the slope is constructed as shown in Equation (1):

$$b - t_{0.025,n-2} s_b \leq \beta \leq \qquad (1)$$

Where

b = point estimate of the slope

$t_{0.025,n-2}$ = the Student's t-value associated with two-sided 95 percent confidence and n-2 degrees of freedom

s_b = the standard deviation of the slope estimate, b

β = the true slope, which is unknown.

Table C-4 gives the values used in constructing the confidence intervals and the resulting confidence intervals. As seen in the fifth column of Table C-4, the confidence intervals for the slope overlap, and it can be concluded that there is no difference in the rate of change in gross beta measurements for the two location groupings, boundary and distant.

Table C-4. Ninety-five Percent Confidence Intervals on the True Slope.

Sample Group	b	z[a]	s_b	95% CI[b]
Boundary	0.245	1.96	0.0229	[0.200, 0.290]
Distant	0.253	1.96	0.0269	[0.200, 0.306]

a. For large sample sizes, the standard normal z-value is used instead of the Student's t-value.
b. CI = confidence interval.

REFERENCES

Bartholomay, E. C., B. J. Tucker, L. C. Davis, and M. R. Greene, 2000, *Hydrogeological Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering and Environmental Laboratory, Idaho 1996 through 1998*, Water Resources Investigation Report 00-4192, DOE/ID-22167, U.S. Geological Survey.

Currie, L. A., 1984, *Lower Limit of Detection-Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements*, NUREG/CR-4007, U.S. Nuclear Regulatory Commission.

Hollander, M. and D. A. Wolfe, 1973, *Nonparametric Statistical Methods*, New York: John Wiley and Sons, Inc.

Neter, J. and W. Wasserman, 1974, *Applied Linear Statistical Models*, Homewood, Illinois: Richard D. Irwin, Inc.

Shapiro, S. S. and M. B. Wilk, 1965, "An Analysis of Variance Test for Normality (complete samples)," *Biometrika*, Vol. 52, pp. 591–611.

Shapiro, S. S., M. B. Wilk, and H. J. Chen, 1968, "A Comparative Study of Various Tests of Normality," *Journal of the American Statistical Association*, Vol. 63, pp. 1343–1372.

Appendix D. Chapter 5 Addendum

Table D-1. Central Facilities Area Sewage Treatment Facility Influent Monitoring Results (2008).[a,b]

Parameter	Minimum	Maximum	Median
Biochemical oxygen demand (5-day) (mg/L)	27	229	65
Chemical oxygen demand (mg/L)	64.2	344	88.5
Nitrogen, nitrate + nitrite (mg/L)	0.357	1.44	0.846
Nitrogen, total Kjeldahl (mg/L)	8.88	38	16.7
pH[c]	7.22	8.07	7.82
Total suspended solids (mg/L)	41.4	295	86.7

a. Duplicate samples were collected in May for all parameters (excluding pH), and the duplicate results are included in the summaries.
b. There are no permit limits for these parameters.
c. Grab sample.

Table D-2. Central Facilities Area Sewage Treatment Plant Effluent Monitoring Results (2008).[a]

Parameter	6/25/08	6/25/08 (Duplicate)	7/2/08
Biochemical oxygen demand (5-day) (mg/L)	2 U[b]	2 U	2 UR[c]
Chemical oxygen demand (mg/L)	45	48.5	60
Coliform, fecal[d] (/100 mL)	1 U	1 U	6
Coliform, total[d] (/100 mL)	4	3	3
Nitrogen, nitrate + nitrite (mg/L)	0.201	0.205	0.22
pH[d]	9.51	NA	9.24
Nitrogen, total Kjeldahl (mg/L)	2.52	2.67	2.96
Total dissolved solids (mg/L)	999	1,020	1,070
Total phosphorus (mg/L)	0.468	0.455	0.593
Total suspended solids (mg/L)	4 U	4 U	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.

Table D-3. Advanced Test Reactor Complex Cold Waste Pond Effluent Monitoring Results (2008).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0025 U[a]	0.0069	0.005 U
Barium (mg/L)	0.0482	0.168	0.139
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	10.6	36.9	32.1
Chromium (mg/L)	0.0029	0.0116	0.0075
Cobalt (mg/L)	0.0025 U	0.0025 U	0.0025 U
Conductivity (µS/cm)	405	1,400	1,257
Copper (mg/L)	0.001 U	0.0064	0.002
Fluoride (mg/L)	0.177	0.499	0.452
Iron (mg/L)	0.025 U	0.225	0.050 U
Manganese (mg/L)	0.0025 U	0.0073	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg/L)	0.899	3.5	2.78
Nitrogen, total Kjeldahl (mg/L)	0.16	0.697	0.371
Selenium (mg/L)	0.001	0.0048	0.004
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	21.2	618	458
Total dissolved solids (mg/L)	226	1,090	944
Total suspended solids (mg/L)	4 U	4 U	4 U

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

Table D-4. Advanced Test Reactor Complex Cold Waste Pond Aquifer Monitoring Well Groundwater Results (2008).

Well name	USGS-065	TRA-07	USGS-076	TRA-08	Middle-1823	PCS/SCS[a]
Sample date	10/13/08	10/16/08	10/27/08	10/15/08	10/16/08	
Water table depth (ft bgs)	476.17	484.85	484.1	489.89[b]	494	NA[c]
Water table elevation (above mean sea level in ft)	4,452.35	4,450.23	4,449.11	4,448.55[b]	4,448.87	NA
Aluminum (mg/L)	0.025 U[d]	**5.17**[e]	0.025 U	—[f]	0.025 U	0.2
Antimony (mg/L)	0.0005 U	0.0005 U	0.0005 U	—	0.0005 U	0.006
Arsenic (mg/L)	0.005 U	0.005 U	0.005 U	—	0.005 U	0.05
Barium (mg/L)	0.0465	0.181	0.0711	—	0.0794	2.0
Cadmium (mg/L)	0.0025 U	0.0025 U	0.0025 U	—	0.0025 U	0.005
Chloride (mg/L)	18.5	14.7	13.1	—	11.5	250
Cobalt (mg/L)	0.0025 U	0.0025 U	0.0025 U	—	0.0025 U	NA
Copper (mg/L)	0.0025 U	0.126	0.0037	—	0.0025 U	1.3
Fluoride (mg/L)	0.231	0.211	0.176	—	0.185	4.0
Iron (mg/L)	0.025 U	**10.7**	0.025 U	—	0.025 U	0.3
Manganese (mg/L)	0.0025 U	**0.145**	0.0025 U	—	0.0025 U	0.05
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U	—	0.0002 U	0.002
Nitrate nitrogen (mg/L)	1.44	1.02	1.05	—	0.991	10.0
Nitrite nitrogen (mg/L)	0.05 U	0.05 U	0.05 U	—	0.05 U	1.0
pH	7.82	7.94	7.46	—	7.87	6.5 to 8.5
Selenium (mg/L)	0.002	0.0017	0.0013	—	0.0014	0.05
Silver (mg/L)	0.005 U	0.005 U	0.005 U	—	0.005 U	0.1
Sulfate (mg/L)	160	77.7	32.1	—	35.8	250
Total dissolved solids (mg/L)	427	342	264	—	274	500
Total Kjeldahl nitrogen (mg/L)	0.232	0.347	0.291	—	0.419	NA
Total nitrogen[g] (mg/L)	1.697	1.392	1.366	—	1.435	NA

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 level measurement was obtained prior to determining well would not produce enough water to collect samples.
c. NA—Not applicable.
d. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.
e. Concentrations shown in bold are above the Ground Water Quality Rule SCSs.
f. Well had insufficient volume of water to collect samples.
g. 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.

Table D-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results for CPP-769 (2008).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	147	1,420	382
Nitrate + nitrite, as nitrogen (mg/L)	0.056	0.858	0.257
Total Kjeldahl nitrogen (mg/L)	51.2	111	74.4
Total phosphorus (mg/L)	2.86	11.5	7.89
Total suspended solids (mg/L)	60.9	323	183

a. Duplicate samples were collected in March for all parameters. Duplicate results are included in the summaries.

b. Annual average is determined from the average of the monthly values.

Table D-6. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results for CPP-773 (2008).[a]

Parameter	Minimum	Maximum	Average[b]
Biological oxygen demand (5-day) (mg/L)	7.34	148	50.2
Chloride (mg/L)	72.6	168	122
Conductivity (µS/cm) (composite)	630	1,293	962
Nitrate + nitrite, as nitrogen (mg/L)	0.084	3.49	1.12
pH (standard units) (grab)	7.22	8.76	8.13
Sodium (mg/L)	44.6	112	78.7
Total coliform (colonies/100 mL)	81	5,600	1,388
Total dissolved solids (mg/L)	351	640	519
Total Kjeldahl nitrogen (mg/L)	16.0	42.6	29.5
Total phosphorus (mg/L)	2.77	8.45	5.40
Total suspended solids (mg/L)	4.0[c]	51.1	21.2

a. Duplicate samples were collected in March 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 D-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results for CPP-797 (2008).[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.0463	0.0151
Arsenic (mg/L)	0.00125[c]	0.0028	0.00172
Biochemical oxygen demand (5-day) (mg/L)	1.0[c]	22.8	4.1
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	50.7	188	108
Chromium (mg/L)	0.0037	0.0064	0.0052
Conductivity (µS/cm) (composite)	470	816	677
Copper (mg/L)	0.0018	0.0120	0.0052
Fluoride (mg/L)	0.213	0.249	0.234
Iron (mg/L)	0.0125[c]	0.2490	0.0355
Manganese (mg/L)	0.00125[c]	0.00360	0.00143
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrate + nitrite, as nitrogen (mg/L)	1.06	3.15	1.57
pH (grab)	7.31	8.73	8.06
Selenium (mg/L)	0.0012	0.0016	0.0014
Silver (mg/L)	0.00125[c]	0.00250[c]	0.00240[d]
Sodium (mg/L)	34.6	142	73.0
Total coliform (colonies/100 mL)	0.5[c]	970	106
Total dissolved solids (mg/L)	310	550	407
Total Kjeldahl nitrogen (mg/L)	0.465	3.65	1.22
Total nitrogen[e] (mg/L)	1.61	6.80	2.80
Total phosphorus (mg/L)	0.182	1.24	0.380
Total suspended solids (mg/L)	2.0[c]	2.0[c]	2.0[d]

a. Duplicate samples were collected in March 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.

Table D-8. New Percolation Pond Groundwater Results for Aquifer Wells (2008).

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		
Sample Date	4/9/2008	10/1/2008	4/8/2008	10/1/2008	4/15/2008	10/1/2008	PCS/SCS[a]
Depth to water table (ft below brass cap)	499.88	501.21	502.2	504.28	509.05[b]	511.13	NA[c]
Water table elevation at brass cap (ft)[d]	4,450.33	4,449.00	4,450.8	4,448.72	4,450.44[e]	4,448.36	NA
Aluminum (mg/L)	**52.9**[f]	—[g]	0.0681	0.0250 U[h]	0.395[i]	0.256[i]	0.2
Aluminum-filtered (mg/L)	0.0628	—	0.0563 U	0.0250 U	0.0563 U	0.0296	0.2
Arsenic (mg/L)	0.00255 R[j]	—	0.00174 R[j]	0.0050 U	0.00126 R[j]	0.0050 U	0.05
Arsenic-filtered (mg/L)	0.00191 R[j]	—	0.00210 R[j]	0.0050 U	0.00144 R[j]	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	2 U	—	2 U	2 U	2 U	2 U	NA
Cadmium (mg/L)	0.00101 U	—	0.00021 U	0.0025 U	0.00007 U	0.0025 U	0.005
Cadmium-filtered (mg/L)	0.00021 U	—	0.00021 U	0.0025 U	0.00007 U	0.0025 U	0.005
Chloride (mg/L)	9.68	—	81.5	79.8	8.56	8.19	250
Chromium (mg/L)	0.0752	—	0.0292	0.188	0.00806	0.0072	0.1
Chromium-filtered (mg/L)	0.00092 R[j]	—	0.00719	0.0065	0.00618	0.0058	0.1
Coliform, fecal (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	NA
Coliform, total (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	1
Copper (mg/L)	0.0516 U	—	0.00112 U	0.0025 U	0.00259	0.0025 U	1.3
Copper-filtered (mg/L)	0.00086 U	—	0.00086 U	0.0048	0.00125	0.0025 U	1.3
Fluoride (mg/L)	0.29	—	0.23	0.231	0.33	0.292	4
Iron (mg/L)	**35.8**[f]	—	0.202	0.169	0.535 R[k]	0.330[i]	0.3
Iron-filtered (mg/L)	0.0357 U	—	0.0352 U	0.0500 U	0.0186 R[k]	0.0500 U	0.3
Manganese (mg/L)	**0.517**[f]	—	0.00256 U	0.0025 U	0.0268	0.0398	0.05
Manganese-filtered (mg/L)	0.0150	—	0.00230 U	0.0025 U	0.00903 U	0.0269	0.05
Mercury (mg/L)	0.000067 U	—	0.000067 U	0.00020 U	0.000067 U	0.00020 U	0.002
Mercury-filtered (mg/L)	0.000067 U	—	0.000067 U	0.00020 U	0.000067 U	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	0.46	—	0.91	0.905	0.27	0.284	10
Nitrite, as nitrogen (mg/L)	0.025 U	—	0.025 U	0.0500 U	0.025 U	0.0500 U	1
pH	8.04	—	7.73	8.04	7.59	8.16	6.5–8.5
Selenium (mg/L)	0.00107 U	—	0.00126 U	0.0014	0.00107 U	0.00076	0.05
Selenium-filtered (mg/L)	0.00110 U	—	0.00148 U	0.0013	0.00162 U	0.00069	0.05
Silver (mg/L)	0.00014 U	—	0.00014 U	0.0050 U	0.00014 U	0.0050 U	0.1
Silver-filtered (mg/L)	0.00014 U	—	0.00014 U	0.0050 U	0.00014 U	0.0050 U	0.1
Sodium (mg/L)	36.8	—	22.7	21.4	10.3	9.3	NA
Sodium-filtered (mg/L)	27.4	—	22.8	21.2	10.1	9.19	NA
Total dissolved solids (mg/L)	299	—	342	380	191	188	500
Total Kjeldahl nitrogen (mg/L)	0.580	—	0.630	0.243	0.1 U	0.101	NA
Total phosphorus (mg/L)	3.82	—	0.0181	0.0190	0.0352	0.0346	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.
b. The depth to water table measurement for this well was initially recorded as 519.05 ft. The value was corrected by 10 ft based on historical data and a U.S. Geological Survey measurement taken on the same day.
c. NA—Not applicable.
d. Water level elevations referenced to NAVD88 datum.
e. The water table elevation for this well was initially recorded as 4,440.44 ft. The value was corrected by 10 ft. based on historical data and a U.S. Geological Survey measurement taken on the same day.
f. **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.)
g. ICPP-MON-A-167 only had 0.79 ft of water. This was not enough water for the stainless bailer to reach. Therefore, the well could not be sampled.
h. U flag indicates the result was below the detection limit.
i. 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."
j. The reported result was rejected during validation due to poor low level concentration sample precision.
k. The reported result was rejected during validation due to poor laboratory serial dilution sample precision.

Table D-9. New Percolation Pond Groundwater Results for Perched Water Wells (2008).

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)			ICPP-MON-V-212 (GW-013010)			
Sample Date	April 2008	October 2008	4/7/2008	4/7/2008[a]	10/2/2008	4/7/2008	10/2/2008	10/2/2008[a]	PCS/SCS[b]
Depth to water table (ft)	Dry[c]	Dry[c]	105.49	105.49	108.95	234.8	234.62	234.62	NA[d]
Water table elevation at brass cap (ft)	—	—	4,847.48	4,847.48	4,844.07	4,723.58	4,723.76	4,723.76	NA
Aluminum (mg/L)	—	—	0.0572	0.0648	0.0328	0.114	0.0457	0.0250 U[e]	0.2
Aluminum-filtered (mg/L)	—	—	0.0569	0.0563 U	0.0250 U	0.0658	0.0250 U	0.0250 U	0.2
Arsenic (mg/L)	—	—	0.00563	0.00559	0.0051	0.00191 R[f]	0.0050 U	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	—	0.00537	0.00620	0.0061	0.00216 R[f]	0.0050 U	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	—	—	2 U	2 U	2 U	2.44	2.46	2.50	NA
Cadmium (mg/L)	—	—	0.00021 U	0.00021 U	0.0025 U	0.00021 U	0.0025 U	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	0.00021 U	0.00021 U	0.0025 U	0.00021 U	0.0025 U	0.0025 U	0.005
Chloride (mg/L)	—	—	81.0	81.0	134	146	112	112	250
Chromium (mg/L)	—	—	0.00756	0.00751	0.0062	0.00720	0.0061	0.0061	0.1
Chromium-filtered (mg/L)	—	—	0.00630	0.00578 U	0.0056	0.00620	0.0054	0.0054	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
Copper (mg/L)	—	—	0.00233	0.00265 U	0.0025 U	0.00142 U	0.0025 U	0.0025 U	1.3
Copper-filtered (mg/L)	—	—	0.00206 U	0.00298 U	0.0025 U	0.00100 U	0.0025 U	0.0025 U	1.3
Fluoride (mg/L)	—	—	0.26	0.26	0.259	0.23	0.267	0.260	4
Iron (mg/L)	—	—	0.0151 U	0.0171 U	0.0500 U	0.231	0.178	0.0646	0.3
Iron-filtered (mg/L)	—	—	0.00729 U	0.00729 U	0.0500 U	0.0332 U	0.0500 U	0.0500 U	0.3
Manganese (mg/L)	—	—	0.00131 U	0.00131 U	0.0025 U	0.00301 U	0.0026	0.0025 U	0.05
Manganese-filtered (mg/L)	—	—	0.00131 U	0.00131 U	0.0025 U	0.00131 U	0.0025 U	0.0025 U	0.05
Mercury (mg/L)	—	—	0.000067 U	0.000067 U	0.00020 U	0.000067 U	0.00020 U	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	0.000067 U	0.000067 U	0.00020 U	0.000067 U	0.00020 U	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	—	—	1.73	1.72	1.23	1.33	1.22	1.22	10
Nitrite, as nitrogen (mg/L)	—	—	0.025 U	0.025 U	0.100 U	0.025 U	0.100 U	0.100 U	1
pH	—	—	7.53	7.53	7.70	7.54	8.16	8.16	6.5–8.5
Selenium (mg/L)	—	—	0.00166 U	0.00167 U	0.0012	0.00161 U	0.0015	0.0013	0.05
Selenium-filtered (mg/L)	—	—	0.00138 U	0.00152 U	0.0014	0.00169 U	0.0014	0.0015	0.05
Silver (mg/L)	—	—	0.00014 U	0.00014 U	0.0050 U	0.00014 U	0.0050 U	0.0050 U	0.1
Silver-filtered (mg/L)	—	—	0.00014 U	0.00014 U	0.0050 U	0.00014 U	0.0050 U	0.0050 U	0.1
Sodium (mg/L)	—	—	62.4	64.5	74.9	67.9	60.5	60.6	NA
Sodium-filtered (mg/L)	—	—	63.9	63.1	74.9	69.8	59.8	60.7	NA
Total dissolved solids (mg/L)	—	—	359	352	444	356	422	415	500
Total Kjeldahl nitrogen (mg/L)	—	—	0.282	0.230	0.379	0.528	0.336	0.339	NA
Total phosphorus (mg/L)	—	—	0.0916	0.0895	0.0774	0.0257	0.0240	0.0293	NA

a. Duplicate sample.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.
c. ICPP-MON-V-191 is a perched well and was dry in April and October 2008.
d. NA—Not applicable.
e. U flag indicates the result was below the detection limit.
f. The reported result was rejected during validation due to poor low-level concentration sample precision.

Table D-10. Test Area North/Technical Support Facility Groundwater Results (2008).

	TANT-MON-A-001 (GW-015301)	TANT-MON-A-002 (GW-015304)	TAN-10A (GW-015303)		TAN-13A (GW-015302)	TSFAG-05 (GW-015306)	TAN-20 (GW-015305)	
Sample Date	4/17/2008	4/16/2008	4/22/2008	4/22/2008[a]	4/22/2008	April 2008	4/22/2008	PCS/SCS[b]
Depth to water table (ft)	216.61	221.19	218.5	218.5	219.99	Dry[c]	209.63	
Water table elevation at brass cap (ft)	4,566.13	4,563.69	4,565.64	4,565.64	4,564.01	—	4,575.06	NA[d]
Aluminum (mg/L)	0.0595	0.127	**0.220**[e]	0.0847	0.0786	—	0.0563 U[f]	0.2
Aluminum-filtered (mg/L)	0.0563 U	0.0586	0.0621	0.0653	0.0563 U	—	0.0563 U	0.2
Ammonia-nitrogen (mg/L)	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	—	0.050 U	NA
Arsenic (mg/L)	0.0031 R[g]	0.0028 R[g]	0.0023 U	0.0018 U	0.0026 U	—	0.0026 U	0.05
Arsenic-filtered (mg/L)	0.0032 R[g]	0.0025 R[g]	0.0019 U	0.0018 U	0.0027 U	—	0.0026 U	0.05
Barium (mg/L)	0.0790	0.0807	0.317 R[g]	0.285 R[g]	0.0735 R[g]	—	0.0873 R[g]	2
Barium-filtered (mg/L)	0.0836	0.0775	0.292 R[g]	0.287 R[g]	0.0712 R[g]	—	0.0844 R[g]	2
Beryllium (mg/L)	0.00006 U	0.00006 U	0.00011 U	0.00006 U	0.00006 U	—	0.00006 U	0.004
Beryllium-filtered (mg/L)	0.00006 U	0.00006 U	0.00006 U	0.00006 U	0.00006 U	—	0.00006 U	0.004
Biochemical oxygen demand (mg/L)	2 U	2 U	2 U	2 U	2 U	—	2 U	NA
Cadmium (mg/L)	0.0001 U	0.0001 U	0.0002 U	0.0001 U	0.0001 U	—	0.0001 U	0.005
Cadmium-filtered (mg/L)	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	—	0.0001 U	0.005
Chloride (mg/L)	12.2	3.63	122	122	3.29	—	6.20	250
Chromium (mg/L)	0.0050	0.0077	0.0022 R[h]	0.0001 R[h]	0.0051 R[h]	—	0.0067 R[h]	0.1
Chromium-filtered (mg/L)	0.0040	0.0063	0.0013 R[h]	0.0004 R[h]	0.0046 R[h]	—	0.0064 R[h]	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
Fluoride (mg/L)	0.289	0.285	0.222	0.225	0.270	—	0.268	4
Iron (mg/L)	0.0186	0.192	3.32[i]	1.98[i]	0.106	—	0.0510	0.3
Iron-filtered (mg/L)	0.00794	0.0252	2.11[i]	2.00[i]	0.00729 U	—	0.0190	0.3
Lead (mg/L)	0.00006 U	0.00034 U	0.00089	0.00013 U	0.00031 U	—	0.00017 U	0.015
Lead-filtered (mg/L)	0.00004 U	0.00004 U	0.00011	0.00015 U	0.00013 U	—	0.00012 U	0.015
Manganese (mg/L)	0.00218 U	0.0111 U	**0.830**[e]	**1.11** [e]	0.00983	—	0.00273	0.05
Manganese-filtered (mg/L)	0.00195 U	0.00275 U	**1.08**[e]	**1.09**[e]	0.00497 U	—	0.00307 U	0.05

Table D-10. Test Area North/Technical Support Facility Groundwater Results (2008) (cont.).

	TANT-MON-A-001 (GW-015301)	TANT-MON-A-002 (GW-015304)	TAN-10A (GW-015303)		TAN-13A (GW-015302)	TSFAG-05 (GW-015306)	TAN-20 (GW-015305)	
Sample Date	4/17/2008	4/16/2008	4/22/2008	4/22/2008[a]	4/22/2008	April 2008	4/22/2008	PCS/SCS[b]
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	—	0.000067 U	0.002
Mercury-filtered (mg/L)	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	—	0.000067 U	0.002
Nitrate, as nitrogen (mg/L)	0.888	0.580	0.0500 U	0.0500 U	0.421	—	0.652	10
Nitrite, as nitrogen (mg/L)	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	—	0.0500 U	1
pH	7.62	7.57	7.36	7.36	7.47	—	7.55	6.5–8.5
Selenium (mg/L)	0.0029 U	0.0016 U	0.0033 U	0.0011 U	0.0011 U	—	0.0018 U	0.05
Selenium-filtered (mg/L)	0.0019 U	0.0016 U	0.0011 U	0.0011 U	0.0012 U	—	0.0017 U	0.05
Sodium (mg/L)	7.88	6.53	146	60.0	6.08	—	6.57	NA
Sodium-filtered (mg/L)	7.70	6.48	58.0	58.1	5.81	—	6.66	NA
Sulfate (mg/L)	31.5	14.8	37.7	38.8	15.0	—	17.8	250
Total dissolved solids (mg/L)	261	207	**652**[e]	**630**[e]	202	—	225	500
Total Kjeldahl nitrogen (mg/L)	0.294	0.103	0.502	0.450	0.100 U	—	0.106	NA
Total phosphorous (mg/L)	0.0320	0.0378	0.0630	0.0637	0.0228	—	0.0357	NA
Total suspended solids (mg/L)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	—	4.0 U	NA
Zinc (mg/L)	0.0282 R[g]	0.130 R[g]	0.149	0.0322	0.0930	—	0.0548	5
Zinc-filtered (mg/L)	0.0202 R[g]	0.0854 R[g]	0.0373	0.0321	0.0668	—	0.0329	5

a. Duplicate sample.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.
c. Well TSFAG-05 was dry in April 2008.
d. NA —Not applicable.
e. **Bold** text indicates exceedance of primary constituent standard or secondary constituent standard.
f. U flag indicates the result was below the detection limit.
g. The reported result was rejected during validation due to poor laboratory serial dilution sample precision.
h. The reported result was rejected during validation due to poor laboratory duplicate sample precision.
i. Iron concentrations in Well TAN-10A are exempt from the limit, and therefore, these exceedences do not represent permit noncompliance.

Table D-11. Advanced Test Reactor Complex Cold Waste Pond Results (2008).[a]

Parameter	Minimum	Maximum	Median
Antimony (mg/L)	0.00025 U[b]	0.0012	0.00056
Gross alpha (pCi/L ± 1s)	0.255 ± 0.764 U	7.69 ± 2.04	Not calculated
Gross beta (pCi/L ± 1s)	1.27 ± 0.863 U	20.4 ± 2.02	Not calculated
pH (standard units)	7.11	8.03	7.81
Strontium-90 (pCi/L ± 1s)	-0.846 ± 0.224 U	1.29 ± 0.222	Not calculated
Zinc (mg/L)	0.0025 U	0.0029	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 D-12. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Results in October 2008.

Monitoring Well	Sample Date	Parameter	Sample Result[a] (pCi/L)
Middle-1823	10/16/08	Gross alpha	3.13 (± 1.0)
		Gross beta	15.7 (± 1.93)
		Tritium	1,510 (± 204)
TRA-07	10/16/08	Gross alpha	6.75 (± 0.941)
		Gross beta	12.8 (± 1.22)
		Strontium-90	1.36 (± 0.24)
		Tritium	5,200 (± 552)
USGS-065	10/13/08	Gross alpha	ND[b]
		Gross beta	6.02 (± 1.26)
		Tritium	6,090 (± 639)
			12.8 (± 1.22)
			1.36 (± 0.24)
			5,200 (± 552)
USGS-076	10/27/08	Gross alpha	ND
		Gross beta	ND
		Tritium	887 (± 119)
		Gross beta	15.7 (± 1.93)
		Tritium	1,510 (± 204)

a. Uncertainty (1 standard deviation) shown in parentheses.
b. ND—Not detected.

Table D-13. Liquid Influent and Effluent Surveillance Monitoring Results for Central Facilities Area (2008).[a]

Parameter	Minimum	Maximum	Median[b]
Influent to CFA Sewage Treatment Plant			
Total phosphorus	1.52	5.3	2.51
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System			
Chloride[c] (mg/L)	386	386	Not calculated
Barium[c] (mg/L)	0.0136	0.0136	Not calculated
Copper[c] (mg/L)	0.0027	0.0027	Not calculated
Manganese [c] (mg/L)	0.0137	0.0137	Not calculated
Fluoride[c] (mg/L)	0.584	0.584	Not calculated
Sulfate[c] (mg/L)	64.7	64.7	Not calculated
Selenium[c] (mg/L)	0.001	0.001	Not calculated
Sodium[c] (mg/L)	151	151	Not calculated
Gross alpha[c] (pCi/L ± 1s)	2.93 ± 1.04	2.93 ± 1.04	Not calculated
Gross beta[c] (pCi/L ± 1s)	15 ± 1.76	15 ± 1.76	Not calculated
Tritium[c] (pCi/L ± 1s)	4020 ± 420	4020 ± 420	Not calculated

a. Only parameters with at least one detected result are shown.

b. Annual median was calculated using the average of the duplicate samples.

c. Parameter was only analyzed for in the sample collected in July; therefore, the median was not calculated.

Table D-14. Liquid Influent and Effluent Surveillance Monitoring Results for Idaho Nuclear Technology and Engineering Center (2008).[a]

Parameter	Minimum	Maximum	Average[b]
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	728	990	881
pH (standard units) (grab)	8.07	8.89	8.55
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	730	1,266	1,010
Gross beta (pCi/L ± 2s uncertainty)	9.65 ± 2.12	20.1 ± 4.30	11.2 ± 1.42
pH (standard units) (composite)	7.22	8.76	8.13
Effluent to INTEC New Percolation Ponds (CPP-797)			
Conductivity (µS/cm) (grab)	280	2,540	636
Gross alpha (pCi/L ± 2s uncertainty)	0.83 ± 2.08[c]	5.77 ± 3.52	1.85 ± 0.65
Gross beta (pCi/L ± 2s uncertainty)	4.22 ± 5.22[c]	26.8 ± 6.04	31.9 ± 1.20
pH (standard units) (composite)	7.69	8.82	8.14

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 D-15. Surveillance Monitoring Results for Materials and Fuels Complex Industrial Waste Pond (2008).[a]

Parameter	Minimum	Maximum	Median[b]
Aluminum[c] (mg/L)	0.162	0.162	Not calculated
Antimony[c] (mg/L)	0.00042	0.00042	Not calculated
Barium[c] (mg/L)	0.0958	0.0958	Not calculated
Biochemical oxygen demand (5-day) (mg/L)	2 U[d]	2.37	2 U
Chloride (mg/L)	41.7	71.7	59.9
Chromium[c] (mg/L)	0.0042	0.0042	Not calculated
Copper[c] (mg/L)	0.002	0.002	Not calculated
Fluoride (mg/L)	0.544	0.802	0.657
Iron (mg/L)	0.0466	2.19	0.427
Lead[c] (mg/L)	0.29	0.29	Not calculated
Manganese[c] (mg/L)	0.153	0.153	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.05 U	1.88	0.364
Nitrogen, total Kjeldahl (mg/L)	0.19	1.88	0.957
Selenium[c] (mg/L)	0.0017	0.0017	Not calculated
Sodium (mg/L)	33	54.2	42.8
Sulfate (mg/L)	16.4	31.2	20.4
Total dissolved solids (mg/L)	276	395	308
Total phosphorus (mg/L)	0.127	0.483	0.299
Total suspended solids (mg/L)	4 U	27.1	7.4
Zinc[c] (mg/L)	0.0036	0.0036	Not calculated
Gross alpha (pCi/L ± 1s)	0.318 ± 1.13 U	6.34 ± 1.89	Not calculated
Gross beta (pCi/L ± 1s)	1.14 ± 0.613 U	15.2 ± 1.91	Not calculated
Uranium-233/234[c] (pCi/L ± 1s)	1.7 ± 0.242	1.7 ± 0.242	Not calculated
Uranium-235[c] (pCi/L ± 1s)	0.227 ± 0.0872	0.227 ± 0.0872	Not calculated
Uranium-238[c] (pCi/L ± 1s)	0.84 ± 0.159	0.84 ± 0.159	Not calculated

a. Only parameters with at least one detected result are shown.
b. Annual median was calculated using the average result of the duplicate samples.
c. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.
d. U flag indicates the result was below the detection limit.

Table D-16. Surveillance Monitoring Results for Materials and Fuels Complex Industrial Waste Ditch (2008).[a]

Parameter	Minimum	Maximum	Median[b]
Aluminum[c] (mg/L)	0.0469	0.0469	Not calculated
Barium[c] (mg/L)	0.0423	0.0423	Not calculated
Biochemical oxygen demand (5-day) (mg/L)	2 U[d]	2.93	2 U
Chloride (mg/L)	33.6	100	58.3
Copper[c] (mg/L)	0.0066	0.0066	Not calculated
Fluoride (mg/L)	0.586	0.761	0.633
Iron (mg/L)	0.025 U	0.159	0.0402
Lead[c] (mg/L)	0.00047	0.00047	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	1.84	2.3	1.98
Nitrogen, total Kjeldahl (mg/L)	0.126	1.52	0.284
Selenium[c] (mg/L)	0.0012	0.0012	Not calculated
Sodium (mg/L)	28.6	72.7	40.3
Sulfate (mg/L)	17.3	23	19
Total dissolved solids (mg/L)	249	442	315
Total phosphorus (mg/L)	0.144	0.553	0.378
Total suspended solids (mg/L)	4 U	5.1	4 U
Zinc[c] (mg/L)	0.0159	0.0159	Not calculated
Gross alpha (pCi/L ± 1s)	1.04 ± 1.14 U	5.12 ± 1.74	Not calculated
Gross beta (pCi/L ± 1s)	1.32 ± 0.803 U	5.95 ± 1.18 U	Not calculated
Uranium-233/234[c] (pCi/L ± 1s)	1.61 ± 0.237	1.61 ± 0.237	Not calculated
Uranium-238[c] (pCi/L ± 1s)	0.933 ± 0.174	0.933 ± 0.174	Not calculated

a. Only parameters with at least one detected result are shown.
b. Annual median was calculated using the average result of the duplicate samples.
c. Parameter was only analyzed in the samples collected in August ; therefore, the minimum and maximum are the same.
d. U flag indicates the result was below the detection limit.

Table D-17. Surveillance Monitoring Results for Materials and Fuels Complex Secondary Sanitary Lagoon (2008).[a]

Parameter	Minimum	Maximum	Median[b]
Barium[c] (mg/L)	0.0293	0.0294	Not calculated
Biochemical oxygen demand (5-Day) (mg/L)	20	192	43.5
Chloride (mg/L)	96.8	313	194
Fluoride (mg/L)	0.188	0.58	0.329
Iron (mg/L)	0.0275	0.756	0.273
Lead[c] (mg/L)	0.00034	0.0057	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.0561	1.74	0.27
Nitrogen, total Kjeldahl (mg/L)	13.1	87.5	34.8
Selenium[c] (mg/L)	0.0014	0.0016	Not calculated
Sodium (mg/L)	69.1	212	147
Sulfate (mg/L)	15.3	97.2	55.4
Total dissolved solids (mg/L)	535	1400	936
Total phosphorus (mg/L)	7.85	15	10.55
Total suspended solids (mg/L)	15.3	112	39.95
Zinc[c] (mg/L)	0.016	0.0163	Not calculated
Gross alpha (pCi/L ± 1s)	0.825 ± 1.14 U[d]	5.99 ± 1.68	Not calculated
Gross beta (pCi/L ± 1s)	25.7 ± 2.38	80.5 ± 5.83	Not calculated
Tritium (pCi/L ± 1s)	-40.1 ± 94.6 U	1020 ± 145	Not calculated
Potassium-40 (pCi/L ± 1s)	7.93 ± 18.9 U	96 ± 17.8	Not calculated
Uranium-233/234[c] (pCi/L ± 1s)	0.658 ± 0.116	0.746 ± 0.131	Not calculated
Uranium-238[c] (pCi/L ± 1s)	0.229 ± 0.0671	0.423 ± 0.0895	Not calculated

a. Only parameters with at least one detected result are shown.
b. Annual median was calculated using the average result of the duplicate samples.
c. Parameter was only analyzed in July; therefore the minimum and maximum are for the original and duplicate samples.
d. U flag indicates the result was below the detection limit.

Yellow-bellied Marmot

Appendix E. U.S. Geological Survey 2008 Publication Abstracts

An update of hydrologic conditions and distribution of selected constituents in water, Snake River Plain aquifer and perched-water zones, Idaho National Laboratory, Idaho, emphasis 2002-05 (Linda Davis)

Radiochemical and chemical wastewater discharged since 1952 to infiltration ponds, evaporation ponds, and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the Snake River Plain aquifer and perched-water zones underlying the INL. The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains ground-water monitoring networks at the INL to determine hydrologic trends, and to delineate the movement of radiochemical and chemical wastes in the aquifer and in perched-water zones. This report presents an analysis of water-level and water-quality data collected from aquifer and perched-water wells in the USGS ground-water monitoring networks during 2002–05.

Water in the Snake River Plain aquifer primarily moves through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer is recharged primarily from infiltration of irrigation water, infiltration of streamflow, ground-water inflow from adjoining mountain drainage basins, and infiltration of precipitation.

From March–May 2001 to March–May 2005, water levels in wells declined throughout the INL area. The declines ranged from about 3 to 8 feet in the southwestern part of the INL, about 10 to 15 feet in the west central part of the INL, and about 6 to 11 feet in the northern part of the INL. Water levels in perched water wells declined also, with the water level dropping below the bottom of the pump in many wells during 2002–05.

For radionuclides, concentrations that equal 3s, where s is the sample standard deviation, represent a measurement at the minimum detectable concentration, or "reporting level." Detectable concentrations of radiochemical constituents in water samples from wells in the Snake River Plain aquifer at the INL generally decreased or remained constant during 2002–05. Decreases in concentrations were attributed to decreased rates of radioactive-waste disposal, radioactive decay, changes in waste-disposal methods, and dilution from recharge and underflow. In October 2005, reportable concentrations of tritium in ground water ranged from 0.51±0.12 to 11.5±0.6 picocuries per milliliter and the tritium plume extended south-southwestward in the general direction of ground-water flow. Tritium concentrations in water from several wells southwest of the Idaho Nuclear Technology and Engineering Center (INTEC) decreased or remained constant as they had during 1998–2001, with the exception of well USGS 47, which increased a few picocuries per milliliter. Most wells completed in shallow perched water at the Reactor Technology Complex (RTC) were dry during 2002–05. Tritium concentrations in deep perched water exceeded the reporting level in nine wells at the RTC. The tritium concentration in water from one deep perched water well exceeded the reporting level at the INTEC. Concentrations of strontium-90 in water from 14 of 34 wells sampled during October 2005 exceeded the reporting level. Concentrations ranged from 2.2±0.7 to 33.1±1.2 picocuries per liter. However, concentrations from most wells remained relatively constant or decreased since 1989. Strontium-90 has not been detected within the eastern Snake River Plain aquifer beneath the RTC partly because of the exclusive use of waste-disposal ponds and lined evaporation ponds rather than the disposal well for radioactive-wastewater disposal at RTC. At the RTC, strontium-90 concentrations in water from six wells completed in deep perched ground water exceeded the reporting level during 2002-05. At the INTEC, the reporting level was exceeded in water from three wells completed in deep perched ground water. During 2002–05, concentrations of plutonium-238, and plutonium-239, -240 (undivided), and americium-241 were less than the reporting level in water samples from all wells sampled at the INL. During 2002–05, concentrations of cesium-137 in water from all wells sampled by the USGS at the INL were less than the reporting level.

Changes in detectable concentrations of nonradioactive chemical constituents in water from the Snake River Plain aquifer at the INL varied during 2002–05. In April 2005, water from well USGS 65, south of the Reactor Technology Complex (RTC) [formerly known as the Test Reactor Area (TRA)], contained 100 micrograms per liter (µg/L) of chromium, a decrease from the concentration of 139 µg/L detected in October 2001. Other water samples contained from less than 1.7 to 30.3 µg/L of chromium. Chromium was detected in water from 2 wells completed in shallow perched ground water, and in 17 wells completed in deep perched water. During 2002–05, the largest concentration of sodium in water samples from aquifer wells at the INL was 76 milligrams per liter (mg/L) in a sample from well USGS 113, south of INTEC. During April–October 2005, dissolved sodium concentrations in deep perched water at the RTC ranged from 6 to 27 mg/L in all wells except well USGS 68 (370 mg/L). No analyses were made for sodium in shallow perched ground water at the RTC during 2002–05. Dissolved sodium concentrations in water from 16 wells completed in deep perched water at the RTC were determined. At the INTEC, sodium concentrations were determined from one well completed in shallow perched ground water, and from two wells completed in deep perched ground water. In 2005, chloride concentrations in most water samples from the INTEC and the Central Facilities Area (CFA) exceeded ambient concentrations of 10 and 20 mg/L, respectively. Chloride concentrations in water from wells near the RTC were less than 20 mg/L. At the Radioactive Waste Management Complex (RWMC), chloride concentrations in water from wells USGS 88, 89, and 120 were 86, 41, and 20 mg/L, respectively, nearly the same as the 1999–2001 reporting period. Concentrations of chloride in all other wells near the RWMC were less than 13 mg/L. During April to October 2005, chloride concentrations in shallow perched ground water from three wells at the RTC ranged from 10 to 32 mg/L and from 3 to 35 mg/L in deep perched ground water. At the INTEC, dissolved chloride concentrations in deep perched ground water in wells closest to the percolation ponds ranged from 118 to 332 mg/L. In 2005, sulfate concentrations in water from aquifer wells USGS 34, 35, and 39, southwest of INTEC, were 42, 46, and 46 mg/L, respectively. Historically, concentrations in these wells have been at or just below 40 mg/L, the estimated background concentration of sulfate in the Snake River Plain aquifer at the INL. The maximum sulfate concentration in water from wells completed in shallow perched ground water at the RTC was 396 mg/L. During April to October 2005, concentrations of dissolved sulfate in water from wells completed in deep perched ground water at the RTC ranged from 66 to 276 mg/L. Concentrations of dissolved sulfate in water from two wells completed in deep perched ground water at the INTEC were 35 mg/L.

In October 2005, concentrations of nitrate in water from wells USGS 41, 43, 45, 47, 52, 57, 67, 77, 112, 114, and 115 near the INTEC, exceeded the regional background of 5 mg/L (as nitrate) and concentrations ranged from 6 mg/L in well USGS 45 to 34 mg/L in well USGS 43. However, since 1981, nitrate concentrations have decreased overall in water from these wells.

During April to October 2005, water samples from five aquifer wells were analyzed for fluoride; detected concentrations ranged from 0.2 to 0.3 mg/L. These concentrations are similar to the background concentrations, which indicate that wastewater disposal has not had an appreciable affect on fluoride concentrations in the Snake River Plain aquifer near the INTEC.

During 2002–05, 12 volatile organic compounds (VOCs) were detected in water from aquifer wells at the INL. Concentrations of from 1 to 9 VOCs were detected in water samples from 13 wells. Primary VOCs detected included carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene.

During 2002–05, attempts were made each year to sample well USGS 92, completed in perched water at the RWMC; however, lack of water in the well precluded obtaining an adequate sample during most sampling events. Most of the same VOCs except chloroethane that were detected during 1999–2001 were detected during 2002–03; additionally, bromodichloromethane was detected. Concentrations of 16 VOCs were detected during 2002–03. Most VOCs fluctuated through time and show no distinct trend.

Field methods and quality-assurance plan for quality-of-water activities, U.S. Geological Survey, Idaho National Laboratory, Idaho (LeRoy L. Knobel, Betty J. Tucker, and Joseph P. Rousseau)
No abstract was written for this report. The report summarizes the field methods and quality assurance performed as part of the USGS INL Project Office water quality sampling activities.

Construction diagrams, geophysical logs, and lithologic descriptions for boreholes USGS 126a, 126b, 127, 128, 129, 130, 131, 132, 133, and 134, Idaho National Laboratory, Idaho (Brian V. Twining, Mary K. Hodges, and Stephanie Orr)
This report summarizes construction, geophysical, and lithologic data collected from ten U.S. Geological Survey (USGS) boreholes completed between 1999 and 2006 at the Idaho National Laboratory (INL): USGS 126a, 126b, 127, 128, 129, 130, 131, 132, 133, and 134. Nine boreholes were continuously cored; USGS 126b had 5 ft of core. Completion depths range from 472 to 1,238 ft. Geophysical data were collected for each borehole, and those data are summarized in this report. Cores were photographed and digitally logged using commercially available software. Digital core logs are in appendixes A through J. Borehole descriptions summarize location, completion date, and amount and type of core recovered. This report was prepared by the USGS in cooperation with the U.S. Department of Energy (DOE).

Statistical stationarity of sediment interbed thicknesses in a basalt aquifer, Idaho National Laboratory, Eastern Snake River Plain, Idaho (Caleb N. Stroup, John A. Welhan, and Linda C. Davis)

The statistical stationarity of distributions of sedimentary interbed thicknesses within the southwestern part of the Idaho National Laboratory (INL) was evaluated within the stratigraphic framework of Quaternary sediments and basalts at the INL site, eastern Snake River Plain, Idaho. The thicknesses of 122 sedimentary interbeds observed in 11 coreholes were documented from lithologic logs and independently inferred from natural-gamma logs. Lithologic information was grouped into composite time-stratigraphic units based on correlations with existing composite-unit stratigraphy near these holes. The assignment of lithologic units to an existing chronostratigraphy on the basis of nearby composite stratigraphic units may introduce error where correlations with nearby holes are ambiguous or the distance between holes is great, but we consider this the best technique for grouping stratigraphic information in this geologic environment at this time.

Nonparametric tests of similarity were used to evaluate temporal and spatial stationarity in the distributions of sediment thickness. The following statistical tests were applied to the data: (1) the Kolmogorov-Smirnov (K-S) two-sample test to compare distribution shape, (2) the Mann-Whitney (M-W) test for similarity of two medians, (3) the Kruskal-Wallis (K-W) test for similarity of multiple medians, and (4) Levene's (L) test for the similarity of two variances.

Results of these analyses corroborate previous work that concluded the thickness distributions of Quaternary sedimentary interbeds are locally stationary in space and time. The data set used in this study was relatively small, so the results presented should be considered preliminary, pending incorporation of data from more coreholes.

Statistical tests also demonstrated that natural-gamma logs consistently fail to detect interbeds less than about 2–3 ft thick, although these interbeds are observable in lithologic logs. This should be taken into consideration when modeling aquifer lithology or hydraulic properties based on lithology.

Laboratory-measured and property-transfer modeled saturated hydraulic conductivity of Snake River Plain aquifer sediments at the Idaho National Laboratory, Idaho (Kim S. Perkins)

Sediments are believed to comprise as much as 50 percent of the Snake River Plain aquifer thickness in some locations within the Idaho National Laboratory. However, the hydraulic properties of these deep sediments have not been well characterized and they are not represented explicitly in the current conceptual model of subregional scale ground-water flow. The purpose of this study is to evaluate the nature of the sedimentary material within the aquifer and to test the applicability of a site-specific property-transfer model developed for the sedimentary interbeds of the unsaturated zone. Saturated hydraulic conductivity (K_{sat}) was measured for 10 core samples from sedimentary interbeds within the Snake River Plain aquifer and also estimated using the property-transfer model. The property-transfer model for predicting

K_{sat} was previously developed using a multiple linear-regression technique with bulk physical-property measurements (bulk density [ρ_{bulk}], the median particle diameter, and the uniformity coefficient) as the explanatory variables. The model systematically underestimates $K_{sat,}$ typically by about a factor of 10, which likely is due to higher bulk-density values for the aquifer samples compared to the samples from the unsaturated zone upon which the model was developed. Linear relations between the logarithm of K_{sat} and ρ_{bulk} also were explored for comparison.

REFERENCES

Davis, L.C., 2008, An update of hydrologic conditions and distribution of selected constituents in water, Snake River Plain aquifer and perched-water zones, Idaho National Laboratory, Idaho, emphasis 2002-2005: U.S. Geological Survey Scientific Investigations Report 2008-5089 (DOE/ID-22203), 74 p.

Knobel, L.L., Tucker, B.J., and Rousseau, J.P., 2008, Field methods and quality-assurance plan for quality-of-water activities, U.S. Geological Survey, Idaho National Laboratory, Idaho: U.S. Geological Survey Open-File Report 2008-1165 (DOE/ID-22206), 36 p.

Perkins, K.S., 2008, Laboratory-measured and property-transfer modeled saturated hydraulic conductivity of Snake River Plain aquifer sediments at the Idaho National Laboratory, Idaho: U.S. Geological Survey Scientific Investigations Report 2008-5169 (DOE/ID-22207), 14 p.

Stroup, C.N., Welhan, J.A., Davis, L.C., 2008, Statistical stationarity of sediment interbed thicknesses in a basalt aquifer, Idaho National Laboratory, Eastern Snake River Plain, Idaho: U.S. Geological Survey Scientific Investigations Report 2008-5167 (DOE/ID-22204), 20 p.

Twining, B.V., Hodges, M.K.V., and Orr, Stephanie, 2008, Construction diagrams, geophysical logs, and lithologic descriptions for boreholes USGS 126a, 126b, 127, 128, 129, 130, 131, 132, 133, and 134, Idaho National Laboratory, Idaho: U.S. Geological Survey Data Series 350, (DOE/ID-22205), 27 p.

Stage Coach Stop

Appendix F. Onsite Dosimeter Measurements and Locations

Table F-1. Environmental Dosimeter Measurements at the Materials and Fuels Complex (MFC) (2008).

Location	Exposure (mR ± 1s)
MFC 7	137 ± 10
MFC 8	127 ± 9
MFC 9	—[a]
MFC 10	131 ± 9
MFC 11	135 ± 9
MFC 12	112 ± 8
MFC 13	130 ± 9
MFC 14	123 ± 8
MFC 15	131 ± 9
MFC 16	138 ± 10
MFC 17	125 ± 9
MFC 18	138 ± 10

a. Dosimeter missing at one of the collection times.

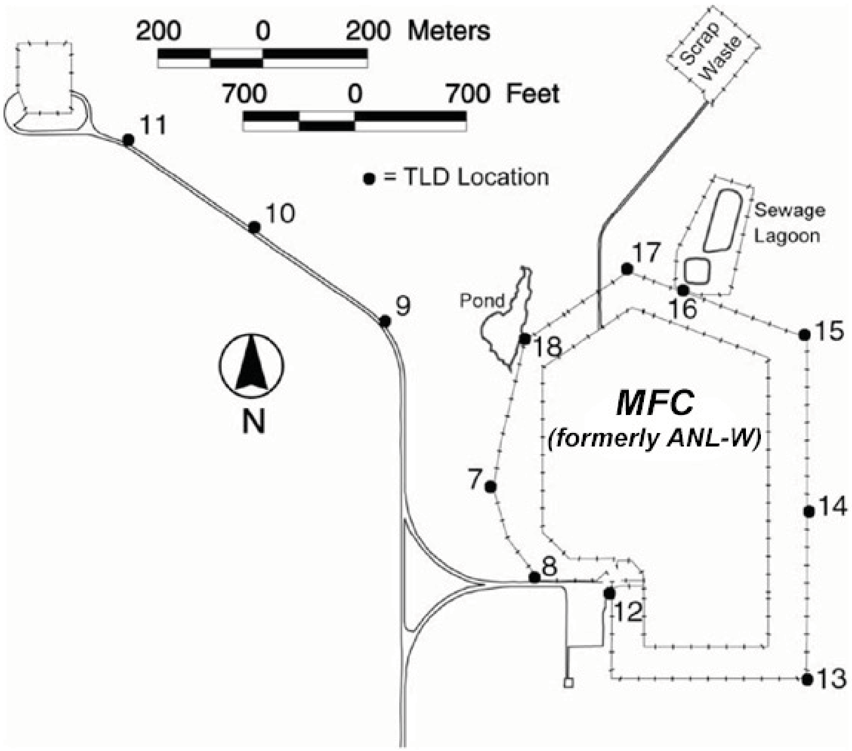


Figure F-1. Environmental Dosimeter Locations at the MFC (2008).

Table F-2 Environmental Dosimeter Measurements at the Auxiliary Reactor Area (ARA) (2008).

Location	Exposure (mR ± 1s)
ARA 1	135 ± 9
ARA 2	131 ± 9
ARA 3	—[a]
ARA 4	—[a]

a. These dosimeter locations were eliminated due to cleanup activities.

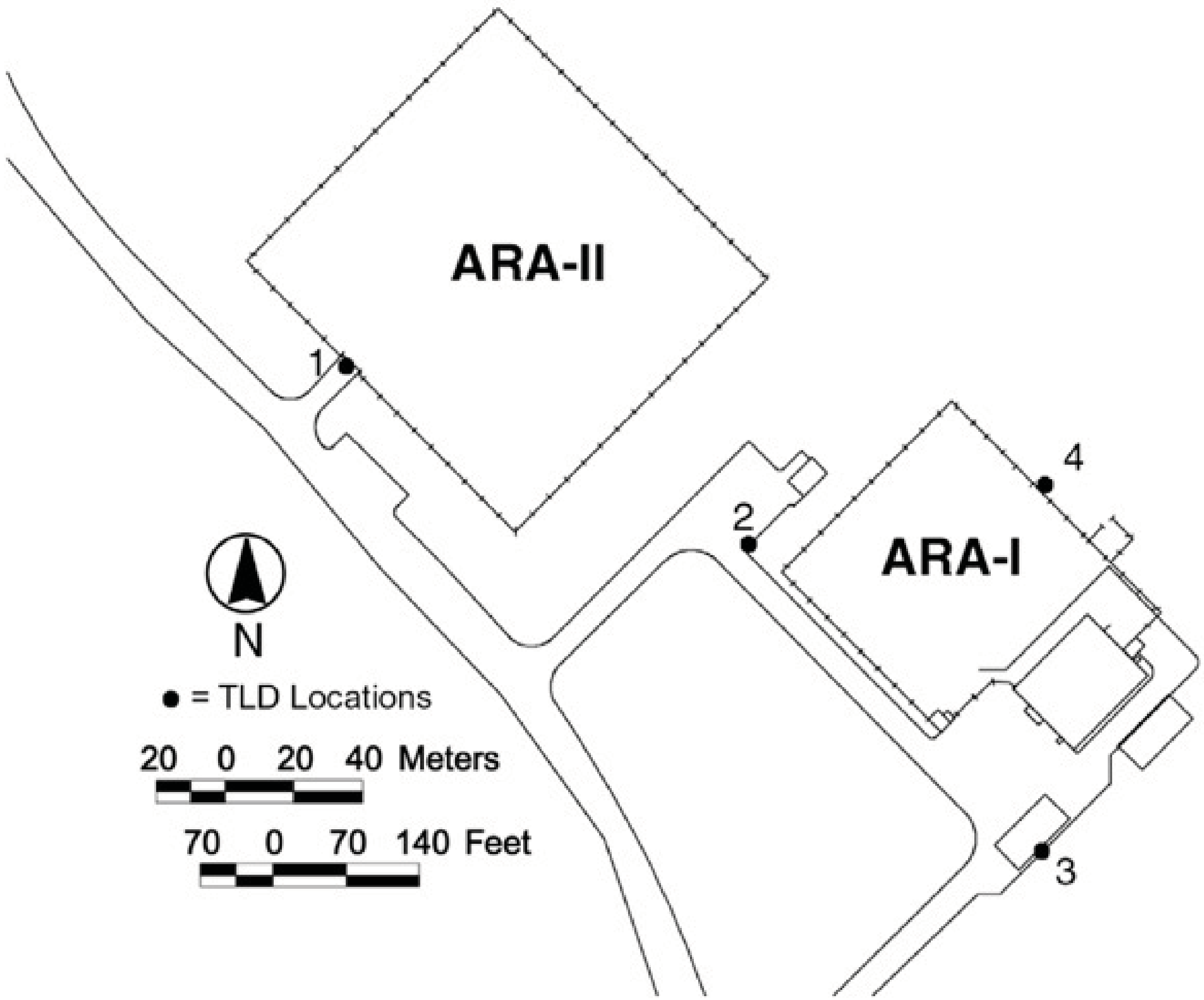


Figure F-2. Environmental Dosimeter Locations at the ARA (2008).

Table F-3. Environmental Dosimeter Measurements at the Central Facilities Area (CFA) (2008).

Location	Exposure (mR ± 1s)
CFA 1	135 ± 9
CFA 2	122 ± 8
CFA 3	138 ± 10
CFA 4	129 ± 9

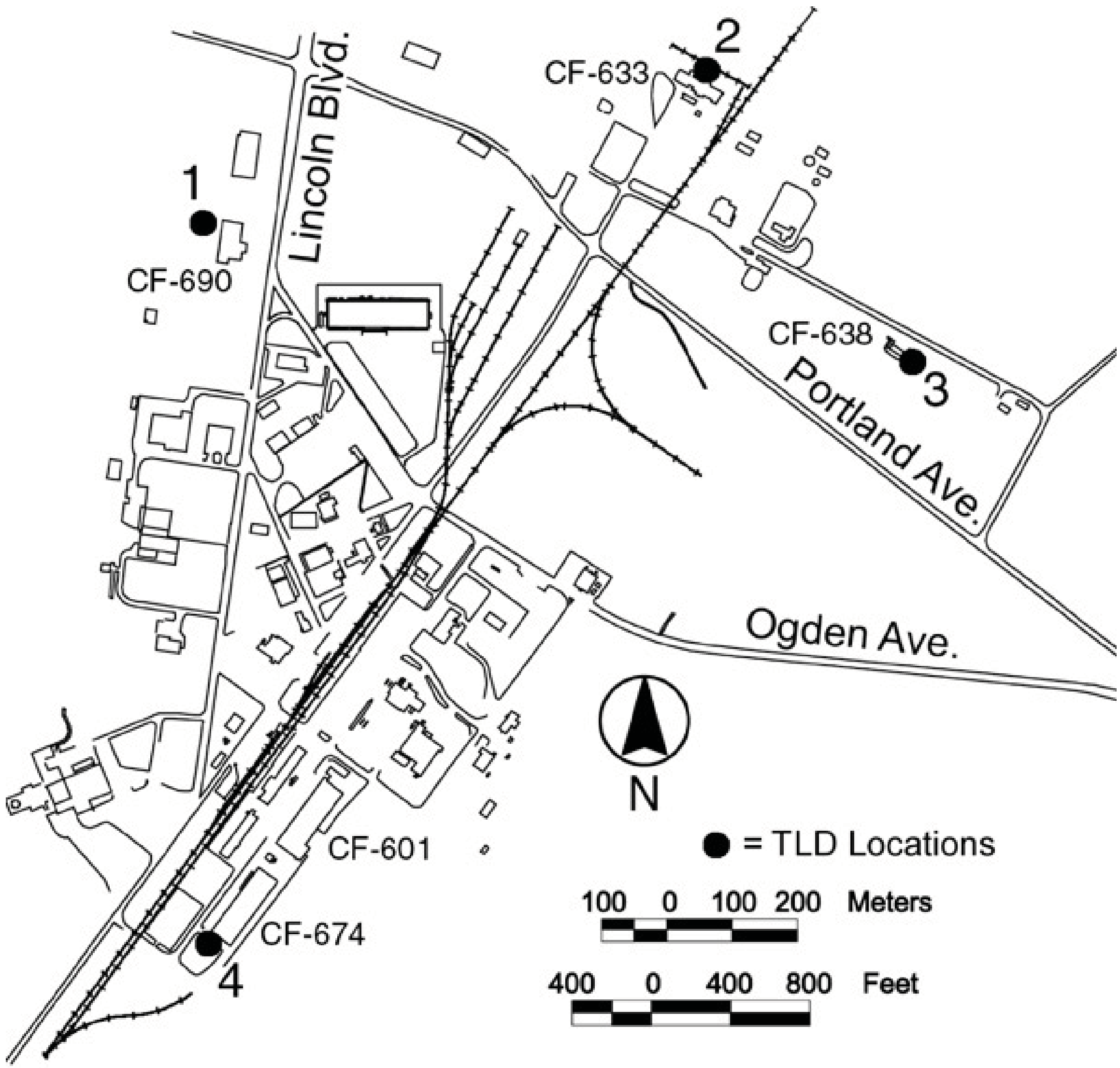


Figure F-3. Environmental Dosimeter Locations at the CFA (2008).

Table F-4. Environmental Dosimeter Measurements at the Idaho Nuclear Technology and Engineering Center (INTEC) (2008).

Location	Exposure (mR ± 1s)
INTEC 1	174 ± 12
INTEC 9	172 ± 12
INTEC 14	145 ± 10
INTEC 15	165 ± 12
INTEC 16	168 ± 12
INTEC 17	139 ± 10
INTEC 18	131 ± 9
INTEC 19	137 ± 9
INTEC 20	208 ± 14
INTEC 21	169 ± 12
INTEC 22	172 ± 12
INTEC 23	140 ± 10
INTEC 24	134 ± 9
INTEC 25	127 ± 9
INTEC 26	132 ± 9
TREE FARM 1	172 ± 12
TREE FARM 2	157 ± 11
TREE FARM 3	159 ± 11
TREE FARM 4	188 ± 13

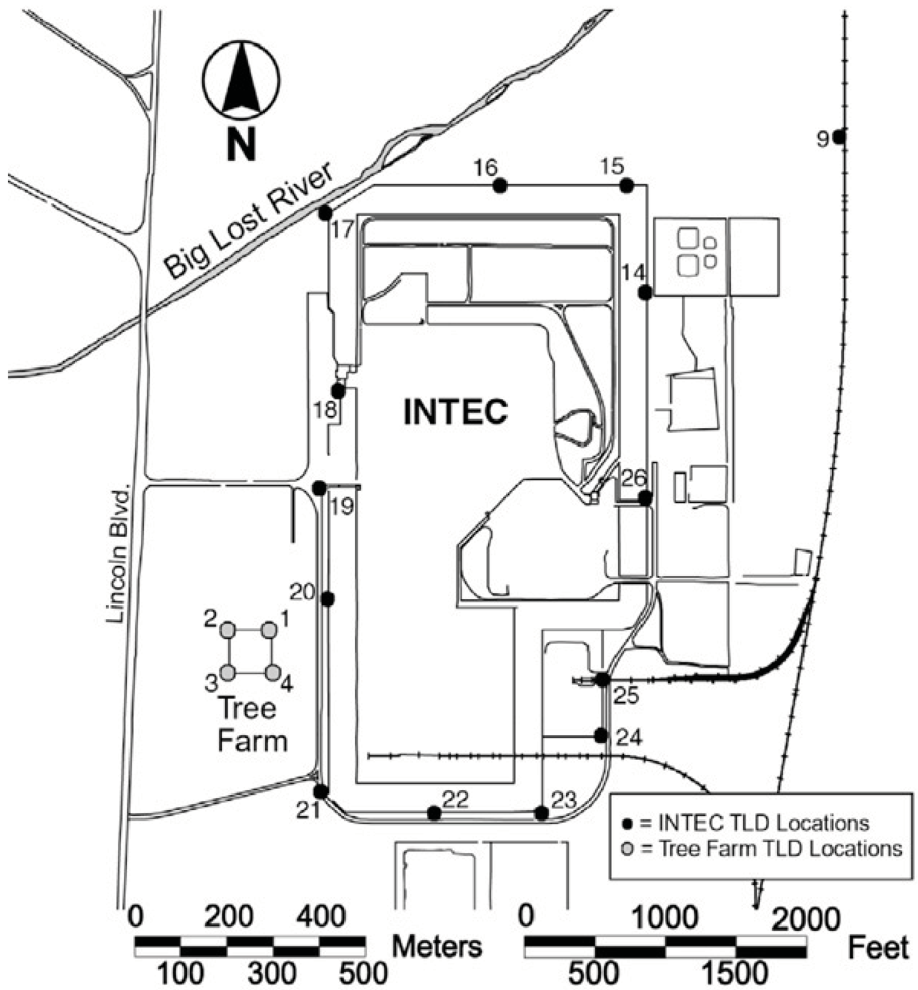


Figure F-4. Environmental Dosimeter Locations at the INTEC (2008).

Table F-5. Environmental Dosimeter Measurements at the Naval Reactors Facility (NRF) (2008).

Location	Exposure (mR ± 1s)
NRF 4	138 ± 10
NRF 5	142 ± 10
NRF 11	138 ± 10
NRF 12	134 ± 9
NRF 13	136 ± 9
NRF 16	137 ± 9
NRF 17	—[b]
NRF 18	139 ± 10
NRF 19	143 ± 10
NRF 20	139 ± 10
NRF 21	—[b]

a. The Idaho National Laboratory contractor (Batelle Energy Alliance) manages dosimeters at Naval Reactors Facility.
b. These locations were eliminated by construction activities.

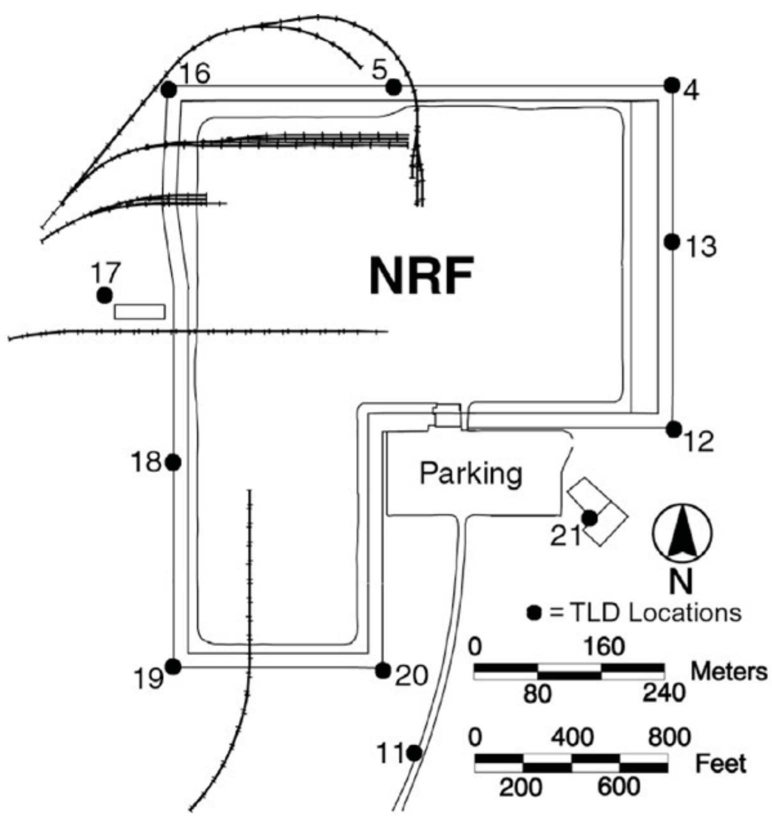


Figure F-5. Environmental Dosimeter Locations at the NRF (2008).

Table F-6. Environmental Dosimeter Measurements at the Critical Infrastructure Test Range Complex (CITRC) (2008).

Location	Exposure (mR ± 1s)
CITRC/SPERT 1	150 ± 11
CITRC/SPERT 2	131 ± 9
CITRC/SPERT 3	136 ± 9
CITRC/SPERT 4	140 ± 10
CITRC/SPERT 5	136 ± 9
CITRC/SPERT 6	142 ± 10
CITRC/WERF 1	137 ± 9
CITRC/WERF 2	119 ± 8
CITRC/WERF 3	131 ± 9
CITRC/WERF 4	137 ± 10
CITRC/WERF 5	133 ± 9
CITRC/WERF 6	129 ± 9
CITRC/WERF 7	140 ± 10

SPERT = Special Power Excursion Reactor Test
WERF = Waste Experimental Reduction Facility

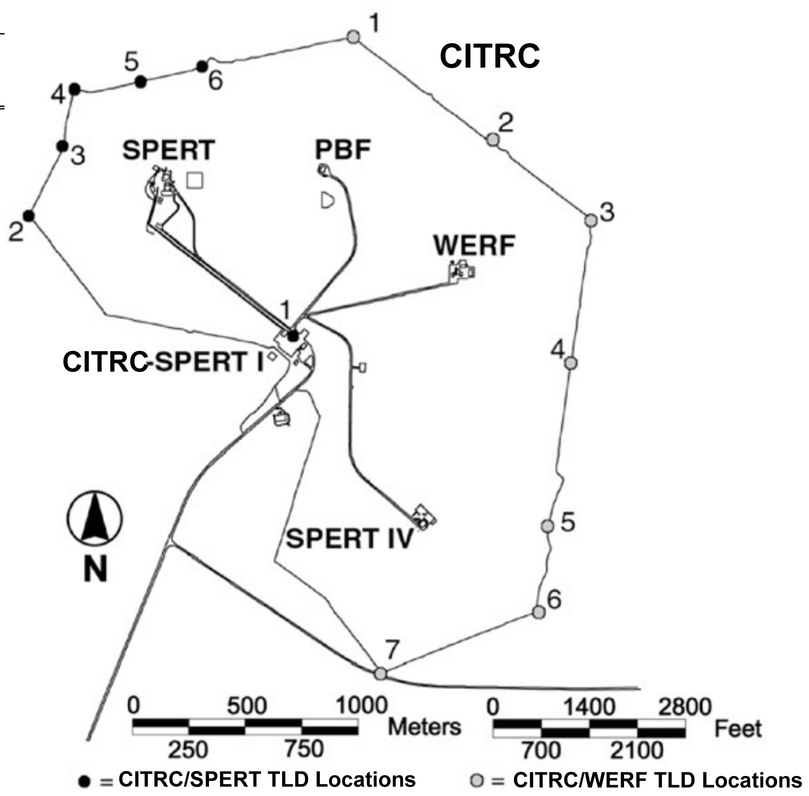


Figure F-6. Environmental Dosimeter Locations at the CITRC (2008).

Table F-7. Environmental Dosimeter Measurements at the Radioactive Waste Management Complex (RWMC) (2008).

Location	Exposure (mR ± 1s)
RWMC 3a	136 ± 9
RWMC 5a	130 ± 9
RWMC 7a	133 ± 9
RWMC 9a	215 ± 15
RWMC 11a	149 ± 10
RWMC 13a	140 ± 10
RWMC15a	131 ± 9
RWMC 17a	134 ± 10
RWMC 19a	128 ± 9
RWMC 21a	139 ± 10
RWMC 23a	138 ± 10
RWMC 25a	156 ± 11
RWMC 27a	260 ± 18
RWMC 29a	448 ± 31
RWMC 31a	263 ± 18
RWMC 37a	129 ± 9
RWMC 39	138 ± 10
RWMC 40	143 ± 10
RWMC 41	647 ± 45
RWMC 42	140 ± 10
RWMC 43	134 ± 9
RWMC 45	144 ± 10
RWMC 46	—[a]
RWMC 47	125 ± 9

a. Dosimeter missing at one of the collection times.

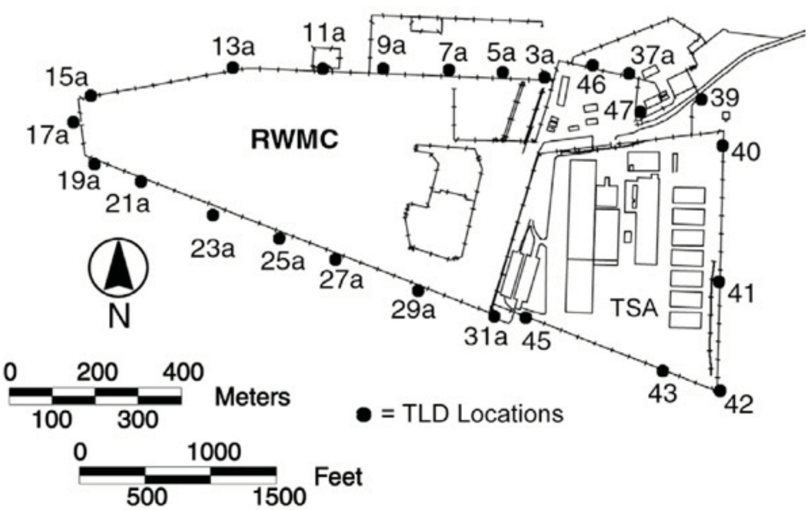


Figure F-7. Environmental Dosimeter Locations at the RWMC (2008).

Table F-8. Environmental Dosimeter Measurements at the Test Area North (TAN) (2008).

Location	Exposure (mR ± 1s)
TAN/TSF 1	113 ± 8
TAN/TSF 2	139 ± 10
TAN/TSF 3	119 ± 8
TAN/TSF 4	140 ± 10
TAN/LOFT 1	137 ± 9
TAN/LOFT 2	152 ± 11
TAN/LOFT 3	120 ± 8
TAN/LOFT 4	116 ± 8
TAN/LOFT 5	122 ± 8
TAN/LOFT 6	142 ± 10
TAN/LOFT 7	144 ± 10
TAN/WRRTF 1	131 ± 9
TAN/WRRTF 2	122 ± 8
TAN/WRRTF 3	123 ± 9
TAN/WRRTF 4	123 ± 9

TSF = Technical Support Facility
LOFT = Loss of Fluid Test Facility
WRRTF = Water Reactor Research Test Facility

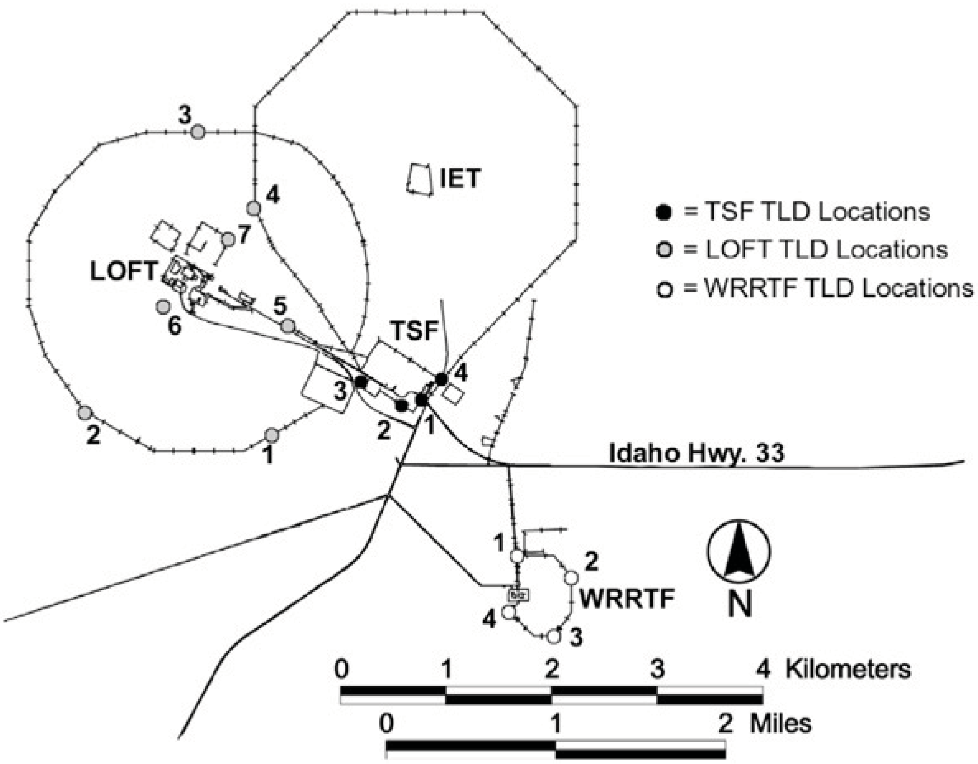


Figure F-8. Environmental Dosimeter Locations at the TAN (2008).

Table F-9. Environmental Dosimeter Measurements at the Advanced Test Reactor (ATR) Complex (2008).

Location	Exposure (mR ± 1s)
ATR 1	141 ± 10
ATR 2	152 ± 11
ATR 3	151 ± 10
ATR 4	173 ± 12
ATR 5	159 ± 11
ATR 6	138 ± 10
ATR 7	141 ± 10
ATR 8	154 ± 11
ATR 9	148 ± 10
ATR 10	—[a]
ATR 11	156 ± 11
ATR 12	165 ± 11
ATR 13	148 ± 10

a. Dosimeter missing at one of the collection times.

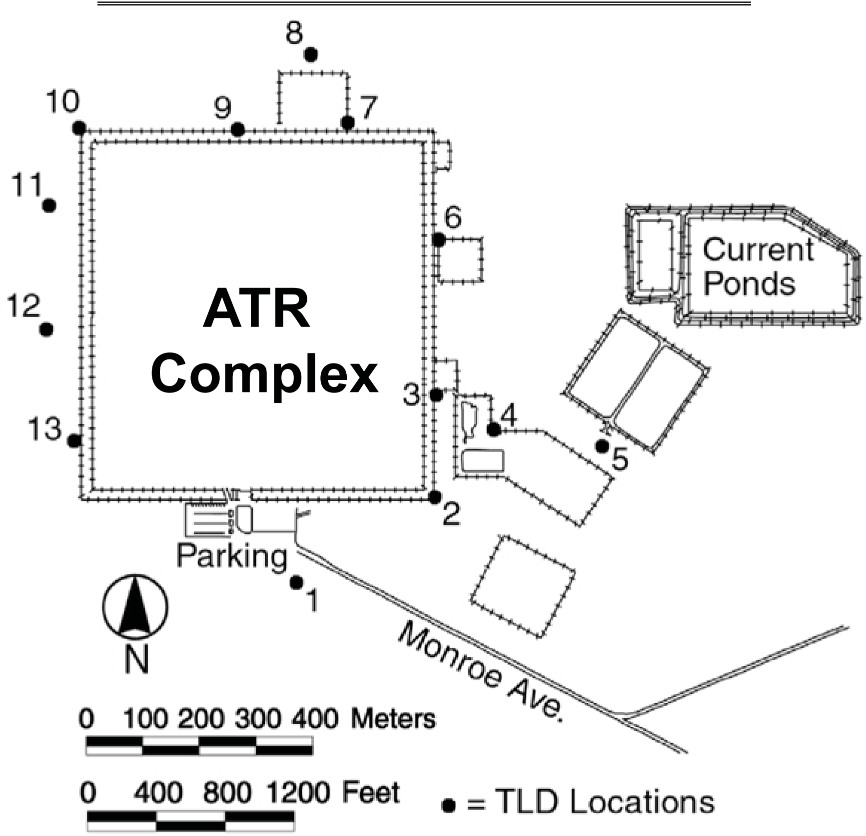


Figure F-9. Environmental Dosimeter Locations at the ATR Complex (2008).

Table F-10. Environmental Dosimeter Measurements Along Lincoln Blvd. and US Highway 20 (2008).

Location	Exposure (mR ± 1s)
LINCOLN BLVD 1	135 ± 9
LINCOLN BLVD 3	145 ± 10
LINCOLN BLVD 5	143 ± 10
LINCOLN BLVD 7	141 ± 10
LINCOLN BLVD 9	139 ± 10
LINCOLN BLVD 11	135 ± 9
LINCOLN BLVD 13	140 ± 10
LINCOLN BLVD 15	141 ± 10
LINCOLN BLVD 17	142 ± 10
LINCOLN BLVD 19	132 ± 9
LINCOLN BLVD 21	130 ± 9
LINCOLN BLVD 23	132 ± 9
LINCOLN BLVD 25	133 ± 9
HWY 26-266	137 ± 10
HWY 26-268	136 ± 9
HWY 26-270	135 ± 9
HWY 20-264	133 ± 9
HWY 20-266	124 ± 9
HWY 20-268	130 ± 9
HWY 20-270	132 ± 9
HWY 20-272	122 ± 8
HWY 20-274	112 ± 8
HWY 20-276	126 ± 9
EBR 1	122 ± 8

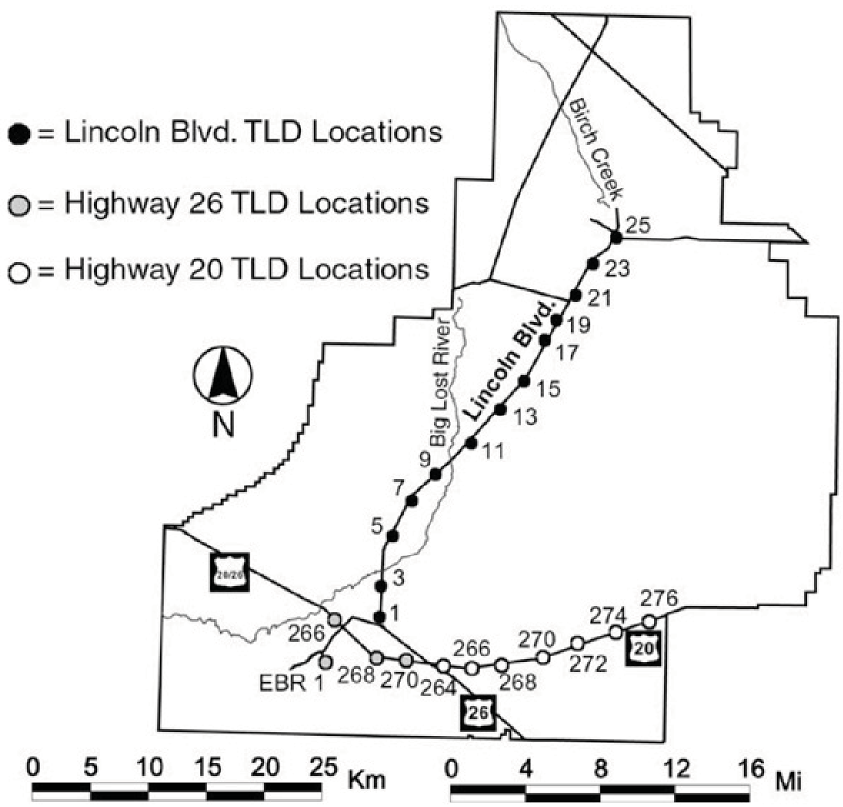


Figure F-10. Environmental Dosimeter Locations Along Lincoln Blvd. and US Highway 20 (2008).

Appendix G. 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 radionuclides: 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 nonsite 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: Beta radiation is 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.

biobarrier: A zone/layer of a cap that consists of some material to prevent intrusion of burrowing animals.

bioremediation: The process of using various natural and/or introduced microbes to degrade, destroy, or otherwise permanently bond contaminants contained in soil and/or water.

biota concentration guide (BCG): 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: A blank is used to demonstrate that cross contamination has not occurred. See field, laboratory, equipment and reagent blank.

blind sample: A blind sample contains a known quantity of some of the analytes of interest added to a sample of the media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in an individual'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 period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a predefined period of time (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.

contaminants of concern: Contaminants 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, those contaminants that are 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 x 10^{10} nuclear decays per second.

D

data gap: An area between all available data and the conclusions that are drawn from the data where the existing data are sparse or nonexistent. An example would be inferring the interactions in the environment of one radionuclide that has not been studied from a chemically similar radionuclide that has been studied.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting the above 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.

deposition velocity: An empirical rate constant that relates the concentration of a radionuclide in air to that on ground or plant surfaces.

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/ immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The U.S. Department of Energy, through Order 5400.5, “Radiation Protection of the Public and the Environment” has established these values.

diffuse sources: 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 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 model, prepared the dispersion coefficients for this report.

dispersion: The process of molecular movement by physical processes.

dose: Also known as dose equivalent, this is a value for comparing the biological effectiveness of different kinds of radiation on a common scale. Technically, it is the product of the absorbed dose, the quality factor, and any other modifying factors. The unit for dose is the rem. One millirem is one one-thousandth of a rem.

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 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 stormwater 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: Samples 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: Refers to 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 chemicals: An extremely hazardous substance listed in the appendices to 40 CFR Part 355 “Emergency Planning and Notification.”

F

fallout: Radioactive material made airborne as a result of above ground 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. Flood plains are 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 radation, 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 found 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.

halogenated: A compound containing one or more of the halogen elements (fluorine, chlorine, bromine, iodine).

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 materials: Materials considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b)(2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture with respect to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act.* The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 (Identification and Listing Hazardous Waste) or that exhibits one or more of four characteristics (corrosiveness, reactivity, flammability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: (1) In environmental surveillance, a localized area of contamination (or higher contamination in an otherwise uncontaminated area. (2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth's surface. The hot spot does not move, but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process of water soaking into a 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 drawn on a map connecting points having the same numerical value of some variable (in this instance the dispersion coefficient).

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. An example 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 and/or analysis. Laboratory blanks are sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

Management and Operating (M&O) Contract: An agreement under which the Government contracts for the operation, maintenance, or support, on its behalf, of a Government-owned or controlled research, development, special production, or testing establishment wholly or principally devoted to one or more major programs of the contracting Federal agency.

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) and/or composition (soil, filter, groundwater, 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, ground water, drinking water supplies, and other such resources belongs to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Indian tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Performance evaluation samples are prepared by adding a known amount of a U.S. Environmental Protection Agency reference compound to reagent water and submitting them 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 laboratory's analytical method.

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.

phytoremediation: The process of using various plants to extract contaminants from soil and water.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

PM_{10}: Particles with an aerodynamic diameter less than or equal to 10 microns.

pollutants: 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 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 deformations, 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: A polychlorinated biphenyl is 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.

pollution: 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.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance: Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control: Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

R

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 happens to emit 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.

raw water hardness: Equivalent to the carbonate concentration of water.

reagent blank: A sample to 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:

$$RPD = \frac{|R_1 - R_s|}{(R_1 + R_s) / 2} \times 100$$

where are X_1 and X_2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem: Stands for roentgen equivalent man, a unit by which human radiation dose is assessed. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR Part 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 individual people or society of using the chemical in the amount and manner proposed an all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

S

sediment distribution coefficient: The ratio of the mass of solute species absorbed or precipitated on the sediment to the solute concentration in water.

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 which are likely to enclose the true value. These values follow form 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.

sodium absorption ratio (SAR): A measure of the concentration of sodium in soils relative to that of calcium magnesium. Soils with a high SAR (12 to 15) have low permeability and are unsuitable for plant growth.

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}}$$

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas that are used for flood control by dispersing and evaporating/infiltrating water from the Big Lost River.

stabilization: The planting of rapid growing plants for the purpose of holding bare soil in place.

standards: A sample containing a known quantity of various analytes. Standards may be prepared and certified by commercial vendors, but they must have traceability 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 (streams, rivers, lakes, oceans).

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.

threshold planning quantity: The quantity of a material listed in Appendices A and B of 40 CFR 355 (Emergency Planning and Notification) that must be present at a site for use in emergency planning preparations.

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.

total organic halogens: A measure of the total organic halogenated compounds in a sample. Will not detect a specific constituent (e.g., trichloroethylene), but will detect the presence of a halogenated compound.

toxic chemicals: Chemicals 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 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

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.

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.

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 parameters: Parameters that are commonly measured to determine the quality of a water body/sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

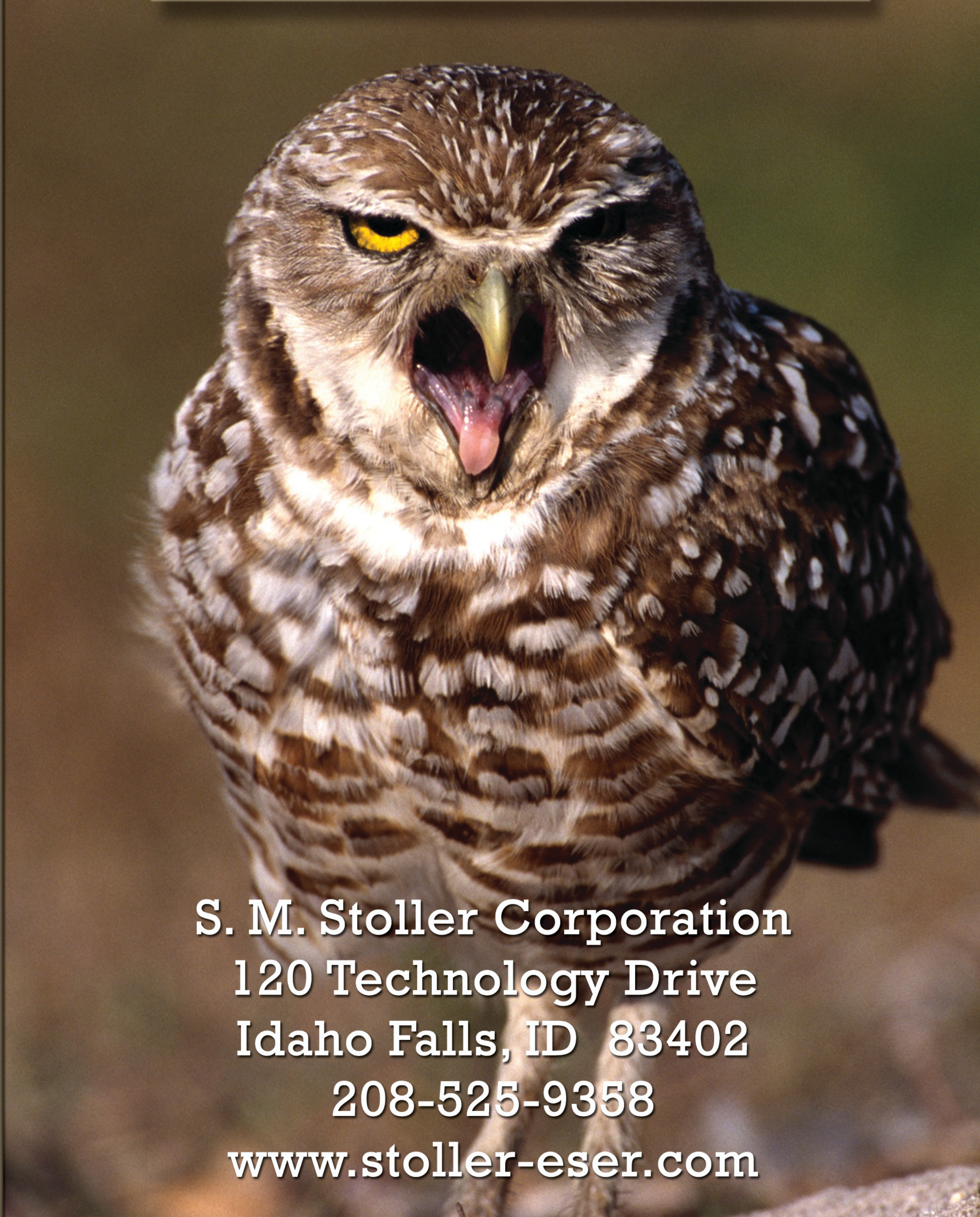
weighting factor: A factor that, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body.

wetlands: Those areas that are inundated or saturated by surface- 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 included playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

U.S. Department of Energy
Idaho Operations Office

Idaho National Laboratory

Environmental Surveillance, Education and Research Program
ESER



S. M. Stoller Corporation
120 Technology Drive
Idaho Falls, ID 83402
208-525-9358
www.stoller-eser.com