Site Environmental Report Calendar Year 2007

Environmental Surveillance, Education and Research Program

ESER

Environmental Surveillance, Education and Research Program

DOE/ID-12082(07)
ISSN 1089-5469
STOLLER-ESER-114
September 2008

DOE/ID-12082(07)

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STOLLER-ESER-114

IDAHO NATIONAL LABORATORY
SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 2007

Environmental Surveillance, Education and Research Program
U.S. Department of Energy Idaho Operations Office
September 2008

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
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Acknowledgments

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- Marilyn Case, Russell Mitchell and Roger Blew with the Environmental Surveillance, Education, and Research Program managed by S. M. Stoller Corporation
- Dave Frederick, John Giles, Chris Oertel, Scott Lee, Tom Haney, and Brad Andersen with Battelle Energy Alliance
- Lee Nelson, Michael Roddy, Richard Wells, and Roger Wilhelmsen with CH2M-WG Idaho
- Betsy Holmes with the U.S. Department of Energy Idaho Operations Office
- Kirk Clawson and Richard Eckman with the National Oceanic and Atmospheric Administration
- Roy Bartholomay with the United States Geological Survey

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:

- Jack Depperschmidt, Richard Kauffman, Tim Safford, Jerry Wells, Keith Lockie, Dave Wessman, Kathleen Hain, Nolan Jensen, Michael O'Hagan, Donald Rasch, Talley Jenkins, Robert Gallegos, Katherine Medellin, Mary Willcox, Karl Hugo, Jim Cooper, Brett Bowhan, Robert Boston, Greg Bass, Teresa Perkins, Tim Jackson, Charles Ljungberg, Vanica Dugger, and Nicole Brooks with the U.S. Department of Energy (DOE) - Idaho Operations Office
- Betty Tucker with the U.S. Geological Survey
- Neil Hukari, Roger Carter, Jason Rich with the National Oceanic and Atmospheric Administration
- Robert Breckenridge and Jeff Einerson with Battelle Energy Alliance
- Christopher Jenkins with the Wildlife Conservation Society
- Charles R. Peterson, Scott Cambrin, Lawrence Cook, Brandy Janzen, Matthew Germino, David Hilliard, Susan Parsons, Marjorie Matocq, Nancy Hampton, Nancy Huntly, Joel Sankey, and Nancy Glenn with the Idaho State University
- Stephen Bunting, Maxine Dakins, Lee Vierling, Andrea Kuchy, Amanda Price, and Janet Rachlow with University of Idaho
- William Clark and Paul Blom with Albertson College of Idaho
- Terence McGonigle with Brandon University
- Lora Perkins, Robert Nowak, and Kimberly Allcock with the University of Nevada Reno
- Jerry Harbour with the National Training Center
- Alana Jensen, Brande Hendricks, Amy Forman, Jackie Hafla, Doug Halford, Jeremy Shive, Greg Studley, Sue White, Kathy Morgan and Wendy Purrington with the S. M. Stoller Corporation

Red Fox

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 2007 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 NFT 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.

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

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

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

Executive Summary

Approximately 8500 people work at the Idaho National Laboratory (INL) Site, making it the largest employer in eastern Idaho and the third largest employers in the State. The INL Site has a tremendous economic impact on eastern Idaho. In 2007, Boise State University's College of Business and Economics studied the effects of INL operations on the Idaho economy and found that the INL Site accounts for more than 2.5 percent of personal income and 3 percent of all tax revenues in Idaho. Moreover, the impacts of employees' charitable contributions, educational outreach and volunteer activities are significant to the region and state.

The prime contractors at the INL Site are: Battelle Energy Alliance (BEA), the management and operations (M&O) contractor for the INL and CH2M-WG Idaho, LLC (CWI) which manages ongoing cleanup operations under the Idaho Cleanup Project or ICP. Other contractors include Bechtel BWXT Idaho, LLC, which operates the Advanced Mixed Waste Treatment Project (AMWTP), and Bechtel Bettis, Inc., which manages the Naval Reactors Facility.

This Annual Site Environmental Report (ASER) summarizes environmental data, information, and regulations, and highlights major environmental programs and efforts during calendar year 2007 at the INL Site. The 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 (DOE 2004).

ENVIRONMENTAL PROGRAM INFORMATION

Many environmental programs help implement the environmental compliance policy for the INL Site. The compliance status of the INL Site is summarized in Chapter 2. Most of the regulatory compliance activity is performed through environmental monitoring programs, the Environmental Restoration Program, the Waste Management Program, and other risk reduction activities, as described in Chapter 3.

The major objectives of the environmental monitoring programs conducted at the INL Site are to identify the key contaminants released to the environment, to evaluate different pathways through which contaminants move in the environment, and to determine the potential effects of these contaminants on the public and the environment. This is accomplished through sampling and analysis of air; surface, subsurface, and drinking water; soil; wildlife; and vegetation, as well as measurement of direct radiation. During 2007, BEA and CWI had primary responsibility for environmental monitoring at the INL Site. The Environmental Surveillance, Education and Research Program (ESER) contractor, which is a team led by the S. M. Stoller Corporation, is responsible for offsite environmental monitoring.

Ambient air, drinking water, surface water, groundwater, soils, vegetation, agricultural products, wildlife, and direct radiation were sampled by the monitoring programs. Samples were analyzed for a variety of contaminants including, but not limited to, pH, inorganics, volatile organics, gases, gross alpha and gross beta activity, and specific radionuclides, such as tritium (^{3}H), strontium-90 (^{90}Sr), and plutonium isotopes.

The ICP continued progress during 2007 toward final cleanup of contaminated sites at the INL Site. Examples of significant accomplishments during 2007 are:

- Over 4285 m^2 (46,119 ft^2) of buildings and structures were demolished;

- Exhumation and processing of targeted waste from the Accelerated Retrieval Project continued, resulting in the total removal thus far of 7645 m^3 (10,000 yd^3) of waste from the Radioactive Waste Management Complex (RWMC);
- Remediation of the V-9 tank and surrounding contaminated soil at Test Area North (TAN) was completed;
- Seven high-level waste tanks and their surrounding vaults at the Idaho Nuclear Technology and Engineering Center (INTEC) were cleaned and filled, completing their closure;
- A total of 5988 m^3 (7832 yd^3) of transuranic waste was shipped to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico.

ENVIRONMENTAL MONITORING PROGRAMS

The INL Site environmental surveillance programs, conducted by the INL and ICP contractors and the ESER contractor, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to receptors. The INL contractor monitors airborne effluents at individual INL facilities and ambient air outside the facilities to comply with appropriate regulations and DOE orders. CWI focuses on environmental surveillance of waste management facilities. The ESER contractor samples ambient air at locations within, around, and distant from the INL Site. Chapter 4 presents results of airborne monitoring.

An estimated total of 4720 Ci of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2007. Samples of airborne particulates, atmospheric moisture, and precipitation were analyzed for gross alpha and gross beta activity, as well as for specific radionuclides, primarily tritium, ^{90}Sr, iodine-131 (^{131}I), cesium-137 (^{137}Cs), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). All concentrations were below regulatory standards and were within historical measurements.

Nonradiological pollutants, including particulates, were monitored at select locations around the INL Site. All results were below regulatory standards.

One potential pathway for exposure (primarily to workers) to the contaminants released from the INL Site is through surface, drinking, and groundwater. INL Site contractors monitored liquid effluents, drinking water, groundwater, and storm water runoff at the INL Site to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., Wastewater Reuse Permit [WRP] requirements). Chapter 5 presents results of monitored drinking water, effluent and WRP site performance.

During 2007, liquid effluent and groundwater monitoring were conducted in support of WRP requirements for INL Site facilities that generate liquid waste streams covered under WRP rules. The WRPs generally require compliance with the Idaho groundwater quality primary and secondary constituent standards in specified groundwater monitoring wells. The permits specify annual discharge volume and application rates and effluent quality limits. As required, an annual report was prepared and submitted to the Idaho Department of Environmental Quality (DEQ). Additional parameters were also monitored in the effluent in support of surveillance activities.

Most wastewater and groundwater regulatory and surveillance results were below applicable limits in 2007. However, several elevated concentrations of aluminum, iron, and manganese were detected in some samples taken from wells at INTEC and at the TAN. An investigation of these exceedances was conducted. Laboratory reports and groundwater monitoring logbooks were reviewed and no anomolies with the analyses or sample collection methods were identified. Wastewater effluent concentrations of these metals are below applicable limits so it was concluded that factors other than wastewater effluent discharges are causing the elevated results.

A maximum effective dose equivalent of 0.3 mrem/year (3 μSv/year), less than the 4 mrem/year (40 μSv/year) U.S. Environmental Protection Agency (EPA) standard for public drinking water systems, was calculated for workers at the Central Facilities Area (CFA) on the INL Site in 2007.

The DOE no longer conducts compliance activities associated with industrial storm water as it was determined by EPA that no facility has a reasonable potential to discharge to U.S. waters.

Chapter 6 presents the results of environmental monitoring of the Eastern Snake River Plain Aquifer and surface water. Results from a number of special studies conducted by the (U.S. Geological Survey) USGS of the properties of the aquifer were published during 2007. Two monitoring wells downgradient of Reactor Technology Complex (RTC) and INTEC show the highest tritium concentrations in the aquifer and are thus representative of maximum tritium concentration trends in the rest of the aquifer. Tritium concentrations in these two wells demonstrate a decreasing trend over time and were below the EPA maximum contaminant levels (MCLs). Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells at the INL Site. Concentrations of organic compounds were below the state of Idaho groundwater primary and secondary constituent standards for these compounds, except for carbon tetrachloride in the production well at the RWMC. Drinking water at RWMC is below MCLs including carbon tetrachloride.

Groundwater surveillance monitoring continued for the Waste Area Groups (WAGs) on the INL Site in 2007. At TAN, results of groundwater monitoring indicated that in situ bioremediation of the plume of Trichloroethene (TCE) has been effective. Chromium was detected above the MCL in two wells located south of the RTC. However the concentrations of chromium have been decreasing in these wells over time. Strontium-90 exceeded the MCL in a different well located south of the RTC; however, the concentration has been decreasing over time in this well. Gross alpha activity was detected above the MCL for the first time in one WAG-2 well. At INTEC, three constituents (^{90}Sr, technetium-99, and nitrate) exceeded their MCLs, but concentrations of the radionuclides are decreasing over time. Nitrate concentrations were attributed to past tank farm releases. Monitoring at CFA detected nitrate and some metals in unfiltered samples above their respective MCLs. Nitrates has been consistently detected above the MCL in one well located south of CFA. The metals are associated with suspended sediment, which has increased since water levels have dropped in the CFA landfill wells. Carbon tetrachloride was above the MCL in two wells at the RWMC.

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, wheat, and potatoes), wildlife, and soil were sampled and analyzed for radionuclides (see Chapter 7). In addition, direct radiation was measured on and off the INL Site in 2007. Some human-made radionuclides were detected in agricultural product, wildlife, and soil samples. However, the concentrations were within background and historical measurements.

Direct radiation measurements made at offsite, boundary, and onsite locations (except RWMC) were consistent with background levels.

DOSE TO THE PUBLIC AND BIOTA

Chapter 8 provides an analysis of the potential radiation dose to members of the public and to biota. Potential radiological doses to the public from INL Site operations were evaluated 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 (CAP-88PC) 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 (MEI). The mesoscale diffusion (MDIFF) air dispersion model, developed by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory-Field Research Division (ARL-FRD) to evaluate dispersion of pollutants in arid environments such as those found at the INL Site, was used to estimate the dose to the population within 50 miles of the INL Site facilities. The maximum calculated dose to the MEI was well below the applicable radiation protection standard of 10 mrem/year. The dose to the MEI was calculated to be 0.093 mrem (0.93 µSv). For comparison, the dose from natural background radiation was estimated to be 363 mrem (3.6 mSv). The maximum potential population dose to the approximately 295,793 people residing within an 80-km (50-mi) radius of any INL facility was calculated as 0.32 person-rem (3.2×10^{-3} person-Sv), below that expected from exposure to background radiation (106,031 person-rem or 1060 person-Sv).

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 0.015 mrem (0.15 µSv), and 0.01 mrem (0.1 µSv), 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

Chapter 9 describes the ecological and meteorological research activities that took place on the INL Site. The INL Site was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in the 1970s 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 to train researchers and introduce the public to ecological science. They have been used to educate grade school and high school students and the general public about ecosystem interactions at DOE sites; to 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 at the INL Site began in 1950 with the establishment of the long-term vegetation transect. This is perhaps DOE's oldest ecological data set and one of the oldest vegetation data sets in the West. Ecological research on the NERPs is leading to planning for better land use, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increasing contributions to ecological science in general.

The following ecological research projects took place at the Idaho NERP during 2007:

- Monitoring amphibian and reptile populations on the INL Site as indicators of environmental health and change;
- Developing a conservation management plan for the INL Site;
- Historical fire regimes of Wyoming and Basin Big Sagebrush Steppe on the Snake River plain;
- Minimizing risk of cheatgrass invasion and dominance at the Idaho National Laboratory Site;
- Development and evaluation of a monitoring program for pygmy rabbits;
- Landscape genetics of Great Basin rattlesnakes, *Crotalus Oreganus Lutosus*, on the upper Snake River plain;
- Modeling and mapping reptile distributions on the Idaho National Laboratory Site;
- Plant community classification and mapping at the Idaho National Laboratory Site;
- Long-term vegetation transects;
- The Protective Cap/Biobarrier Experiment;
- Developing a habitat selection model to predict the distribution and abundance of the sagebrush defoliator moth;
- Dynamics of post-wildfire wind erosion of soil in semiarid rangelands in Idaho; and
- Improving rangeland monitoring and assessment integrating remote sensing, Geographic Information Systems (GIS), and unmanned aerial vehicle systems.

The NOAA ARL-FRD provides meteorological support to the INL Site, including the meterological Site Mesonet and development and implementation of atmospheric dispersion models. Meteorological research projects conducted by the ARL-FRD during 2007 include:

- Improved atmospheric dispersion modeling for the INL Site
- Improving INL wind forcasting with cluster analysis of wind patterns.

QUALITY ASSURANCE

Chapter 10 describes programs used at the INL Site to ensure environmental data quality. 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 were addressed with the laboratories and resolved.

Sage Thrasher

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 while, Table HI-2 provides useful conversions.

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.

Table HI-2. Most Commonly Used Radionuclides and Symobls 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

Radionuclide	Symbol
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 Symobls Used in this Report. (continued)

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
Technetium-99	^{99}Tc

Radionuclide	Symbol
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
Zirconium-95	^{95}Zr

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

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 3.7×10^{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 pre-established 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.

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
ERRC	Environmentally 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-Term Vegetation
M&O	Management and Operating
Ma	Million Years
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MFC	Materials and Fuels Complex
MNA	Monitored Natural Attenuation
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	Pollution 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

Short-Horned Lizards

Units

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

Middle Butte and the INL Desert

Chapter 1. Introduction

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1. INTRODUCTION

This report provides an introduction to the U.S. Department of Energy's (DOE) Idaho National Laboratory (INL) Site, discusses INL Site missions, and highlights the INL Site's various environmental-related programs. Included are sections discussing INL Site compliance with local, state, and federal environmental laws and regulations; INL Site operations including environmental restoration, waste management, and footprint reduction activities; effluent and emissions from INL Site facilities; onsite and offsite environmental monitoring activities; radiological doses to public and biota; and ecological research activities at the INL Site. The report describes the INL Site's impact to the public and the environment, particularly with regard to radioactive contaminants. It is prepared annually in compliance with DOE Orders 231.1A, 450.1, and 5400.5.

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 project activities stemming from past operations. 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 (NE) and the Office of Environmental Management (EM). NE is the Lead Program Secretarial Office for all DOE-ID managed operations on the INL Site, while EM provides direction and guidance to DOE-ID for environmental cleanup operations 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 so fall outside the purview of DOE-ID.

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 (CAES), and proven leadership in nonproliferation and critical infrastructure protection. The management and operation responsibility for the INL belongs to Battelle Energy Alliance (BEA).

Idaho Cleanup Project

The Idaho Cleanup Project (ICP) involves the safe environmental cleanup of the DOE's INL Site, which was contaminated with waste generated during World War II-era conventional weapons testing, government-owned research and defense reactors, laboratory research, fuel reprocessing, and defense missions at other DOE sites. The 7-year, $2.9 billion cleanup project, led by CH2M-WG Idaho (CWI) and funded through the EM, focuses equally on meeting Idaho Settlement Agreement 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.

CWI 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 labs used for radioactive experiments.

Advanced Mixed Waste Treatment Project (AMWTP)

The AMWTP Facility is a cornerstone of DOE's commitment to prepare and ship contact-handled transuranic waste out of Idaho. AMWTP is managed and operated by Bechtel BWXT Idaho.

Operations at AMWTP require the retrieval, characterization, treatment, and packaging of transuranic waste currently stored at the DOE's Idaho Site. The project's schedule is aligned with court-mandated milestones in a 1995 Settlement Agreement among the state of Idaho, the U.S. Navy, and DOE to remove the waste from Idaho. The vast majority of the waste AMWTP processes resulted from the manufacture of nuclear weapons components at Colorado's Rocky Flats Plant. Shipped to Idaho in the 1970s and early 1980s for storage, the waste 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 21,000 cubic meters of waste historically managed as transuranic have been shipped offsite.

Primary INL Site Facilities

The INL Site is a 2305 km^2 (890 mi^2) area located in southeastern Idaho. The INL Site consists of several facility areas situated on an expanse of otherwise undeveloped, cool desert terrain (Figure 1-1). Most buildings and structures at the INL Site occur within those developed site areas, which

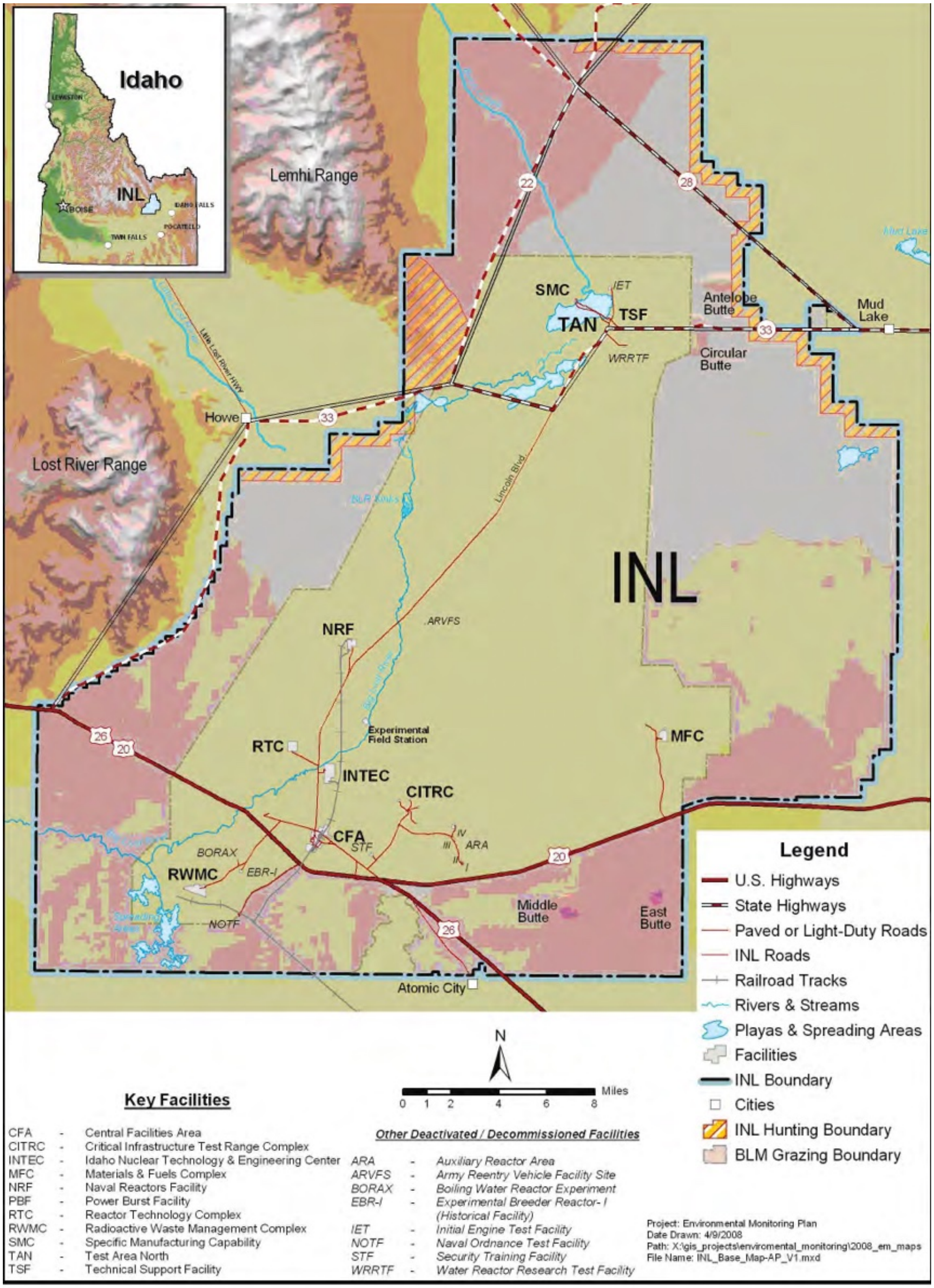

Figure 1-1. Location of the INL Site, showing Facilities.

are typically less than a few square miles in size and separated from each other by miles of primarily 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 (CFA) - CFA is the main service and support center for INL's desert facilities. Activities here support transportation, maintenance, construction, environmental and radiological monitoring, security, fire protection, warehouses and calibration activities. CFA is operated by BEA.

Critical Infrastructure Test Range Complex (CITRC) - 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. The Test Range provides open landscape, technical employees, and specialized facilities for performing work in three main areas: Physical Security, Contraband Detection, and Infrastructure Testing. CITRC is operated by BEA.

Idaho Nuclear Technology and Engineering Center (INTEC) - 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, which 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. Calcination reduced the volume of liquid radioactive waste generated during reprocessing and placed it in a more-stable granular solid form. The facility underwent an ambitious modernization during the 1980s, when safer, cleaner, and more efficient structures were built to replace most major facilities. In 1992, the DOE announced that the changing world political situation and the lack of demand for highly enriched uranium made reprocessing no longer necessary. In 1998, the plant was renamed the Idaho Nuclear Technology and Engineering Center. Current operations at INTEC include management of sodium-bearing waste, special nuclear material disposition, spent nuclear fuel storage, nuclear material disposition, environmental remediation, and demolition of excess facilities. INTEC is operated by CWI.

Materials and Fuels Complex (MFC) - The 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. MFC is operated by BEA.

Naval Reactors Facility (NRF) - The 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. NRF is also preparing the current inventory of naval fuel for dry storage and eventual transportation to a repository.

NRF 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 414.1c, 450.1, and 5400.5. The director, Naval Nuclear Propulsion Program, establishes 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 (BBI 2007).

Radioactive Waste Management Complex (RWMC) - Since the 1950s, the DOE has used the RWMC to manage, store, and dispose of waste contaminated with radioactive elements generated in national defense and research programs. The RWMC manages solid transuranic and low-level radioactive waste. The facility 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 (WIPP). Management of stored wastes at the RWMC is the responsibility of Bechtel BWXT Idaho (BBWI). During 2007, BBWI successfully maintained regular processed transuranic waste shipments to WIPP, totaling over 20,000 cubic meters since the start of the project.

The Subsurface Disposal Area (SDA) is a 39-ha (97-acre) radioactive waste landfill that is the major focus for remedial decisions at the RWMC. The landfill has been used for more than 50 years. Approximately 14 of the 39-ha contain waste from historical operations, including weapons production and reactor research. This waste includes radioactive elements, organic solvents, acids, nitrates, and metals. Organic solvents are now found in the aquifer beneath the SDA. 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 transuranics do not threaten the aquifer, they could one day pose a threat through exposure at the surface if no action is taken.

DOE is developing a Record of Decision (ROD) in coordination with U.S. Environmental Protection Agency and the state of Idaho for comprehensive remediation activities within the SDA. The ROD will be available to the public when it is final and signed by the three agencies. Synchronous with the finalization of the ROD, DOE is operating a series of non-time-critical removal actions to perform limited excavation and retrieval of selected waste streams from a designated portion of the SDA. These projects, referred to as the Accelerated Retrieval Projects, were evaluated in Engineering Evaluation/Cost Analyses, which were released for public review. The focused objective of the non-time-critical removal actions is to perform a targeted retrieval of certain Rocky Flats Plant waste streams that are highly contaminated with transuranic radionuclides, solvent waste, and various isotopes of uranium. Pursuit of the non-time-critical removal actions in advance of actions implemented under the Operable Unit 7-13/14 ROD is maintaining an uninterrupted targeted waste retrieval schedule as was outlined in the Proposed Plan for Radioactive Waste Management Complex Operable Unit 7-13/14.

In addition, in 2007 buildings and equipment at Pit 9 of the SDA were dismantled and disposed to make way for future remediation of the SDA. The buildings, which were constructed by Lockheed Martin Advanced Environmental Systems (LMAES) during the mid-1990s, were left in place when LMAES' contract was terminated in 1998. Cleanup of the RWMC is managed by CWI.

Reactor Technology Complex (RTC) - RTC 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 RTC is operation of the Advanced Test Reactor, the world's premier test reactor, which is used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The 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. RTC will be the focal point for designing, testing and proving the new technologies of the nuclear renaissance. RTC is operated by BEA.

Science and Technology Campus - The Research and Education Campus, operated by BEA, is the collective name for INL's administrative, technical support, and computer facilities in Idaho Falls, as well as the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. The name of this cadre of facilities indicates both basic science research and the engineering that translates new knowledge into 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. New laboratory facilities and a new building for the CAES are under development within this campus environment. The CAES facility is designed to promote education and world-class research and development. Other facilities proposed over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure–all in close proximity 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 (TAN) – TAN was established in the 1950s to support the government's Aircraft Nuclear Propulsion program. The goal was 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. LOFT, 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 recreate 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 received the results from these accident tests and incorporated the data into commercial reactor operating codes. The facility conducted 38 experiments, including several small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island in Pennsylvania, before the LOFT facility was closed.

TAN also housed the Three Mile Island (TMI) Unit 2 Core Offsite Examination Program that ended in 1990. Shipment of TMI-2 core samples to the INL Site began in 1985 to study and obtain technical data necessary to understand the sequential events tied to the TMI-2 reactor accident. INL scientists also used the core samples to develop a database that predicts how nuclear fuel will behave when a reactor core degrades. Currently, the TAN facilities support one project. The Specific Manufacturing Capability Project, operated for the U.S. Department of Defense by BEA, manufactures protective armor for the U.S. Army M1-A1 and M1-A2 Abrams tanks. TAN personnel have completed cleanup of environmental contamination from previous operations. The TAN decommissioning process is complete. The project involved the demolition of the LOFT reactor building, the TAN Hot Shop, hot cells, spent nuclear fuel storage pool, high bay facility, and decontamination shop. The cleanup mission at TAN is performed by CWI.

1.2 Physical Setting of the INL 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 1500 m (4900 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 rangeland, foothills, or agricultural fields. Agricultural activity 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/year [9 in./year]), 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 (SRP). 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, which produce a rolling topography, cover most of the plain. Vegetation is visually dominated by big sagebrush (*Artemisia tridentata*). Beneath these shrubs are grasses and flowering plants, most adapted to the harsh climate. A recent 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 toward the northeast, ending in a playa area, called the Big Lost River Sinks, on the northwest portion of the Site. Here it evaporates or infiltrates into the subsurface with no surface water moving offsite. The fractured volcanic rocks under the INL Site, however, form a portion of the Eastern Snake River Plain Aquifer (ESRPA), 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 ha-ft (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from waters of the Henry's Fork and the South Fork of the Snake River, as well as the Big Lost River, the Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally to the southwest at a rate of

1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The ESRPA emerges in springs along the Snake River between Milner and Bliss, Idaho. The primary use of both surface water and groundwater on the SRP is crop irrigation.

1.3 History of the INL

The geologic events that have shaped the modern SRP 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 (YSRP) volcanic field is based on the time-progressive volcanic origin of this region that is characterized by several large calderas in the eastern SRP 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 and are followed by a sequence of silicic centers at about 6 Ma, southwest of Yellowstone. A third group, near ~10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the SRP are ~16 Ma, and are distributed across a 150 km-wide (93 mi-wide) zone in southwestern Idaho and northern Nevada, the suspected origin of the YSRP (from Smith and Siegal, 2000).

Humans first appeared on the upper SRP approximately 11,000 years ago. Tools recovered from this period indicate these earliest human inhabitants were almost certainly hunters of large game. The ancestors of the present-day Shoshone and Bannock people came north from the Great Basin around 4500 years ago (ESRF 1996).

The earliest exploratory visits by European descendants came between 1810 and 1840. Trappers and fur traders were some of the first to make their way across the plain seeking new supplies of beavers for 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 Station 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. The DOE's predecessor, the U.S. Atomic Energy Commission (AEC), needed an isolated location with an ample groundwater supply on which to build and test nuclear power reactors. The relatively isolated SRP was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station (NRTS) in 1949.

By the end of 1951, EBR-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 NRTS was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory (INEEL) in 1997 to reflect the Site's leadership role in environmental management. The AEC 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 the DOE announced in 2003 that Argonne National Laboratory-West (ANL-W) and the INEEL would be the lead laboratories for development of the next generation of power reactors. On February 1, 2005, the INEEL and ANL-W became the INL. The INL is committed to providing international nuclear leadership for the 21st Century, developing and demonstrating compelling national security technologies, and delivering excellence in science and technology as one of the DOE's multi-program national laboratories.

1.4 Regional Impact

In 2006, Boise State University's (BSU) 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 to stakeholders the significant and positive effects INL Site operations have on the region immediately surrounding its facilities, as well as on the entire state.

The report provides an analysis of three dimensions of the lab'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 the lab and its employees on state and local tax revenues. Third, the study examines the effects of INL Site 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 8452 employees, ranking behind only Micron and state government. 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 the INL Site and its employees approach $85 million or nearly three 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.
- The INL Site 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 BSU economists - Dr. Geoffrey Black, chair of the Economics Department; Dr. Don Holley, former corporate economic forecaster and analyst and now a visiting professor; and John Church, former corporate economist and now special lecturer in the Economics Department and a member of the Western Blue Chip Forecast Panel (Black et al. 2006).

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

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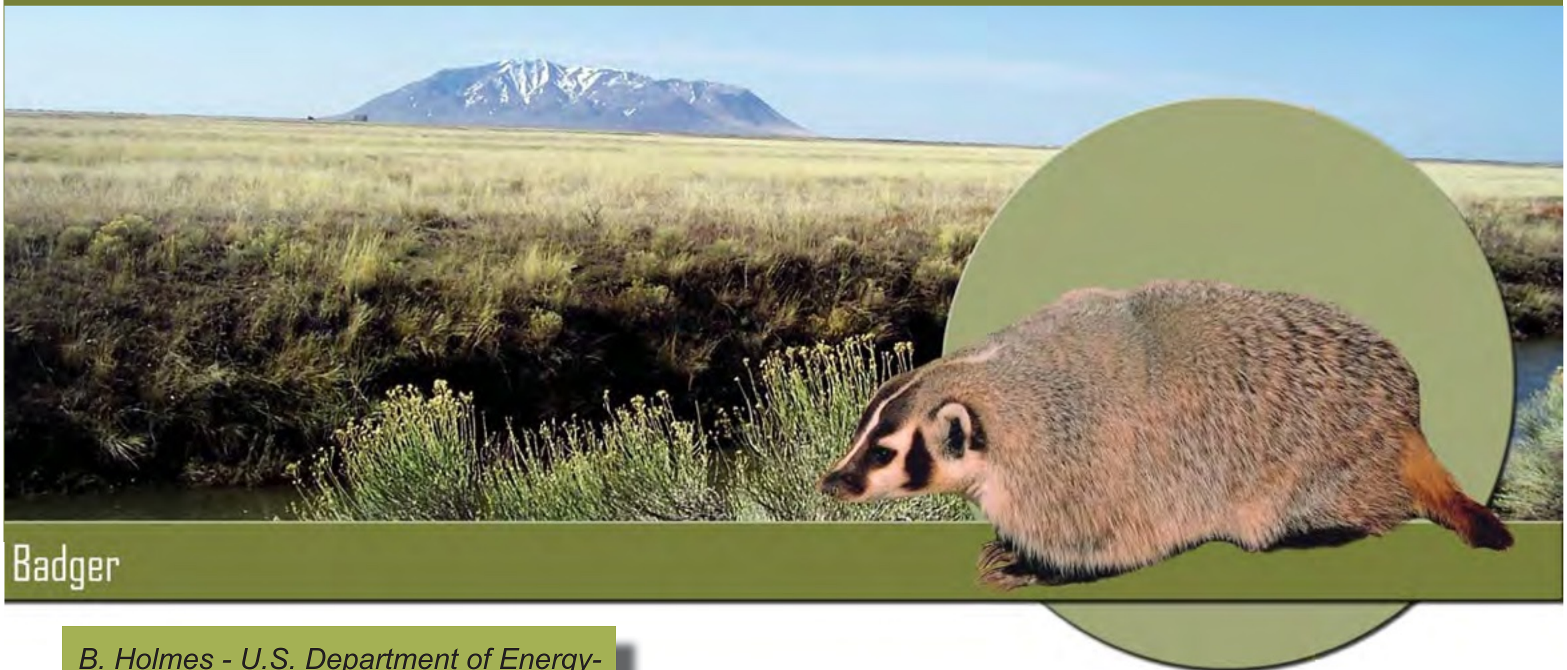
Chapter 2. Environmental Compliance Summary



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2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (INL) Site with environmental protection requirements. Section 2.1 discusses the compliance status of the INL Site with respect to major environmental acts, agreements, and orders. Section 2.2 discusses environmental occurrences, which are nonpermitted releases that require notification of a regulatory agency outside of the U.S. Department of Energy (DOE). Section 2.3 presents a summary of environmental permits for the INL Site. The programs in place to attain compliance with major acts, agreements, and orders are discussed in Chapter 3.

2.1 Compliance Status

Operations at the INL Site are subject to numerous federal and state environmental statutes, executive orders, and DOE orders. These are listed in Appendix A. This section presents a brief summary of the INL's compliance status with those regulations. Table 2-1 shows how the discussion is organized.

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 and/or radioactive substances. 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. The U. S. Department of Energy-Idaho Operations Office (DOE-ID), the state of Idaho, and the U.S. Environmental Protection Agency (EPA) Region 10 signed the Federal Facility Agreement and Consent Order (FFA/CO) in December 1991. The cleanup contractor, CH2M-WG Idaho, LLC (CWI) in accordance with the FFA/CO, is conducting environmental restoration activities at the INL Site.

Table 2-1. Environmental Compliance Status (2007).

Activity	Governing Statute or Order
Radiation Protection	DOE Order 5400.5, "Radiation Protection of the Public and the Environment"
Environmental Remediation and Protection	Comprehensive Environmental Response, Compensation, and Liability Act
	DOE Order 450.1, "Environmental Protection Program"
	Emergency Planning and Community Right-to-Know Act
	DOE Order 451.1B, "National Environmental Policy Act"
	Endangered Species Act
	Executive Order 11988 – Floodplain Management
	Executive Order 11990 – Protection of Wetlands
	Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management
Waste Management	Resource Conservation and Recovery Act
	Federal Facility Compliance Act
	Toxic Substances Control Act
	DOE Order 435.1, "Radioactive Waste Management"
	State of Idaho Wastewater Land Application Permits
	Idaho Settlement Agreement
Air Quality and Protection	Clean Air Act
Water Quality and Protection	Clean Water Act
	Safe Drinking Water Act
Cultural Resources	National Historic Preservation Act
	Native American Graves Protection and Repatriation Act

The INL Site is divided into ten Waste Area Groups (WAGs) as a result of the FFA/CO. Field investigations are used to evaluate potential release sites within each WAG 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 remedial investigation/ feasibility study (RI/FS). Results from the RI/FS form the basis for assessment of risks and alternative cleanup actions. This information, along with the agencies proposed cleanup plan is presented to the public in a document called a Proposed Plan. After reviewing public comments, DOE-ID, EPA, and the State reach a final cleanup decision, which is documented in a Record of Decision (ROD). Cleanup activities then can be designed, implemented, and completed. Specific environmental restoration activities are discussed in Chapter 3.

Natural Resource Trusteeship and Natural Resources Damage Assessment – Executive Order 12580, Section 2(d), appoints the Secretary of Energy as the primary Federal Natural Resource Trustee for natural resources located on, over, and under land administered by DOE. Natural resource trustees act on behalf of the public when natural resources may be injured, destroyed, lost, or threatened as a result of the release of hazardous substances. In the case of the INL Site, other natural resource trustees with jurisdiction over trust resources are the state of Idaho and U.S. Department of Interior (Bureau of Land Management and the U.S. Fish and Wildlife Service). Past releases of hazardous substances resulted in the INL Site's placement on the National Priorities List. These same releases created the potential for injury to natural resources. DOE is liable under CERCLA for damages to natural resources resulting from releases of hazardous substances to the environment.

Although the ecological risk assessment is a separate effort from the Natural Resources Damage Assessment, it is anticipated that the ecological assessment performed for CERCLA remedial actions can be used to help resolve natural resource issues. Ecological risk assessments at the INL Site have been conducted using the established guidance manual for conducting screening level ecological risk assessments (Van Horn et al. 1995).

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (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.

311 Report – EPCRA Section 311 reports were submitted quarterly for those chemicals that met the threshold planning quantities. These reports were sent to local emergency planning committees, the State Emergency Response Commission, and to local fire departments for each quarter in calendar year 2007. These quarterly reports satisfied the 90-day notice requirement for new chemicals brought onsite.

312 Report – The Emergency and Hazardous Chemical Inventory (Tier II) Report for calendar year 2006 was provided to local and state planning and response agencies. This report identified the types, quantities, and locations of hazardous and extremely hazardous chemicals stored at INL Site facilities that exceeded regulatory thresholds. The threshold for Extremely Hazardous Substances is 230 kg (500 lbs) or the Threshold Planning Quantity, whichever is lower, and 4536 kg (10,000 lbs) for other hazardous chemicals.

313 Report – The Toxic Chemical Release Inventory Report was transmitted to the EPA and the state of Idaho by the July 1, 2007, due date. The report identifies quantities of 313-listed toxic chemicals that were used above activity thresholds for manufacturing, processing, or otherwise use. Once these activity thresholds are exceeded, a Toxic Release Inventory Form R report must be completed for each specific chemical. Releases under EPCRA 313 reporting include transfers to offsite waste storage and treatment, air emissions, recycling, and other activities. The INL Site submitted seven reports for calendar year 2006 for benzene, lead, naphthalene, nickel, polycyclic aromatic compounds, toluene, and xylene.

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 Code of Federal Regulations (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.

The DOE-ID issued the Annual NEPA Planning Summary in January 2007. 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 (EAs) expected to be prepared in the next 12 months,
- Environmental impact statements (EISs) expected to be prepared in the next 24 months, and
- The planned cost and schedule for completion of each NEPA review identified.

Ongoing NEPA reviews of INL Site projects are described below.

Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (Idaho HLW & FD EIS) – This EIS 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 ROD for the Idaho HLW & FD EIS. 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 (HLW) 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 ROD consistent with clean closure methods and planned to be clean closed when their missions are complete; and develop HLW calcine retrieval demonstration process and conduct risk-based analysis, including disposal options, focused on the calcine stored at INTEC. An amended ROD addressing closure of the INTEC Tank Farm Facility was issued in November 2006 in coordination with the Secretary of Energy’s determination, in consultation with the Nuclear Regulatory Commission, under Section 3116 of the Fiscal Year 2005 Ronald W. Reagan National Defense Authorization Act. An additional ROD for HLW calcine disposition and bin set closure is scheduled for issuance in 2009.

Environmental Assessment for the Idaho National Laboratory Remote-Handled Waste Disposition (Formerly known as the Remote Treatment Project) - The proposed action is to provide heavily shielded handling services for the sodium contaminated remote-handled (RH) waste stored at the Materials and Fuels Complex (MFC) and the Hanford Reservation and other INL Site legacy RH waste. The project would include a shielded hot cell with equipment for sorting, characterizing, treating and repackaging highly radioactive transuranic, mixed, and other radioactive waste. The facility mission is to make RH radioactive wastes ready for shipment to disposal locations. Much of the proposed action was analyzed in the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final EIS (DOE-ID 1995) as the Remote Mixed Waste Treatment Facility project. DOE notified the state of Idaho and Shoshone-Bannock Tribal contacts in January of 2001. The draft EA is scheduled for public comment in 2008.

Environmental Assessment for the National Security Test Range – In April 2007, DOE issued the final environmental assessment and determined that a finding of no significant impact was appropriate. The test range is specifically designed and constructed to accommodate testing activities in support of analyzing the effects of explosives and explosive devises, munitions, and similar items on security systems, facilities, vehicles, structures, and other materials. The draft environmental assessment was released on December 6, 2006, for public review and comment.

Environmental Assessment for the Consolidation and Expansion of Idaho National Laboratory Research and Development at a Science and Technology Campus – In March 2007, DOE issued the final environmental assessment and determined that a finding of no significant impact was appropriate. Research and development programs that could be conducted at the campus (located near University Place in Idaho Falls) include microbiology (less than Bio safety level 3), geochemistry, materials characterization and testing, welding, ceramics, thermal fluids behavior, analytical and environmental chemistry, and biotechnology. The draft environmental assessment was released on November 29, 2006, for public review and comment.

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. It requires that all federal departments and agencies shall seek to conserve endangered species and threatened species and shall use their authorities in furtherance of 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.

Executive Order 11988 – Floodplain Management

Executive Order 11988 – Floodplain Management 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 reflect consideration of flood hazards and floodplain management. It is the intent of this Executive Order that federal agencies implement floodplain requirements through existing procedures such as those established to implement NEPA. The 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, INL, Idaho, U.S. Bureau of Reclamation, 2005. This flood hazard report based on geomorphological models and has undergone peer review. On January 12, 2006, DOE-ID directed the Idaho Cleanup Project 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 (TAN), the 100-year floodplain has been delineated in a U.S. Geological Survey (USGS) report (USGS 1997).

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 Section 404 and 402 of the Clean Water Act (CWA).

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 2007, no actions took place or had an impact on potentially jurisdictional wetlands on the Site, 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.

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. Idaho DEQ has issued two RCRA Part A permits for the INL Site and seven Part B permits. One additional Part B permit is pending.

Notices of Violation/Non-compliance – On March 5-9, 2007, Idaho DEQ conducted an inspection of the INL Site. The Idaho DEQ issued a Warning Letter to DOE-ID and INL Site contractors Bechtel BWXT Idaho, LLC (BBWI), Battelle Energy Alliance (BEA), and CWI on May 29, 2007, for four alleged violations. DOE-ID, BEA and Idaho DEQ conducted a meeting on June 21, 2007, to discuss the four alleged violations. Information on corrective actions and deliverables to resolve the issues raised in the Warning Letter were provided to Idaho DEQ for review. On October 2, 2007, Idaho DEQ determined that no further action would be taken on the four alleged violations based upon the corrective actions taken and information provided by the INL Site.

RCRA Closure Plans – The state of Idaho approved closure plans for the following facilities in 2007:

- Reactor Technology Complex Materials Test Reactor Warm Waste System (TRA-007)
- INTEC Fluorinel Dissolution Process Make-up and Cooling and Heating Systems (INTEC-066, 067, 068, and 072)
- INTEC Headend Storage Tank System (CPP-640)
- INTEC Westside Waste Holdup Tank System (CPP-641).

RCRA Reports – As required by the state of Idaho, the INL Site submitted the Idaho Hazardous Waste Generator Annual Report for 2007. The report contains information on waste generation, treatment, recycling, and disposal activities at INL Site facilities.

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 INL Site Proposed Site Treatment Plan formed the basis for negotiations between the state of Idaho and DOE-ID on the consent order for mixed waste treatment at the INL Site. The Federal

Facility Compliance Act Consent Order and Site Treatment Plan were finalized and signed by the state of Idaho on November 1, 1995.

A status of Site Treatment Plan milestones for 2007 is provided in Chapter 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 CWA, and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with TSCA at the INL Site is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls (PCBs). Removal of PCB-containing light ballasts continues at buildings undergoing demolition. The ballasts are disposed of off-site in a TSCA-approved disposal facility.

A release of polychlorinated biphenyls occurred at the MFC during maintenance on electrical equipment in July 2006. The release was cleaned up in accordance with Federal regulations. The INL contractor, BEA, received a Notice of Violation issued by EPA in July 2007. The issue was closed in December 2007 with BEA paying a fine of $30,500.

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. INL Site activities related to this Order are discussed in Chapters 3 and 6.

State of Idaho Reclamation and Reuse of Municipal and Industrial Wastewater Permits

Applications for state of Idaho Reclamation and Reuse of Municipal and Industrial Wastewater (formerly Wastewater Land Application) Permits have been submitted for all existing land application facilities. The Central Facilities Area Sewage Treatment Plant, the Test Area North/Technical Support Facility (TAN/TSF) Sewage Treatment Plant, the Reactor Technology Complex Cold Waste Ponds, and the combined INTEC Sewage Treatment Plant effluent and service wastewater for disposal at the new INTEC percolation ponds have current permits. Idaho DEQ is reviewing the permit application for the MFC industrial waste pond. As part of decontamination and decommissioning activities, the TAN/TSF Sewage Treatment Plant is being closed under an Idaho DEQ-approved closure plan. Effluent discharge ceased in 2007 and closure activities are expected to be completed in 2008.

Idaho 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 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 make transuranic (TRU) waste shipments in compliance with the Settlement Agreement requirement to ship a running average of no fewer than 2,000 cubic meters of TRU waste per year out of Idaho. The running average over the past three years stands at 6108 cubic meters (7989 cubic yards). In calendar year 2007, 5988 cubic meters (7832 cubic yards), including 35 cubic meters (46 cubic yards) of remote-handled, TRU waste were shipped out of Idaho.

The INL Site received nine truck cask shipments containing a combined total of 0.235 metric tons (2,205 lbs) spent nuclear fuel from DOE Hanford (six shipments); DOE Sandia National Lab (two shipments); and Texas A&M University (one shipment). By the end of the calendar year 2007, 1801 of 3178 fuel handling units identified in the Idaho Cleanup Project contract had been moved to dry storage.

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 act include national ambient air quality standards for major air pollutants, hazardous air pollutant standards, state attainment plans, motor vehicle emissions standards, stationary source emissions standards and permits, acid rain control measures, stratospheric ozone protection, and enforcement provisions.

The EPA is the federal regulatory agency of authority, but states may administer and enforce provisions of the act by obtaining EPA approval of a state implementation plan. Idaho has been delegated such authority.

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 and if the source's emissions are significant or insignificant. If emissions are determined to be significant, several actions may occur:

- Permitting determinations to demonstrate that the project/process either is below emission thresholds or listed as exempted source categories in state of Idaho regulations allowing self-exemption.
- Submittal of an application for a Permit to Construct (PTC). If emissions are deemed major under Prevention of Significant Deterioration (PSD) regulations, then a PSD analysis must be completed. If not deemed significant per PSD regulations, an application for only a PTC without the additional PSD modeling and analyses is needed. All PTCs are applied for using the state of Idaho air regulations and guidelines.
- Additionally, 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 the EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state and/or local air pollution agencies. The 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 has two Tier I operating permits with effective dates of June 28, 2005, and November 15, 2006.

National Emission Standards for Hazardous Air Pollutants – CFR Title 40, part 61, subpart H applies to operations of facilities owned and operated by DOE. Administration of this subpart has not been delegated to Idaho and is regulated by the EPA. DOE-ID submitted the *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2007 INL Report for Radionuclides* to EPA, DOE Headquarters, and state of Idaho officials in June 2008. 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."

Permitted sources of air pollutants at the INL Site are listed in Table 2-2.

Clean Water Act

The 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 the 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 permits are:

- Discharges from Idaho Falls facilities to the city of Idaho Falls publicly owned treatment works.
- 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).

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. Industrial Wastewater Acceptance Forms are obtained for facilities that discharge process wastewater through the City of Idaho Falls sewer system. In 2007, the City determined that most of the facilities with Industrial Wastewater Acceptance Forms did not have discharges that met the criteria for issuance. Therefore, there is only one Industrial Wastewater Acceptance permit which covers discharges from specified buildings at the INL Research Center. All others were withdrawn by the City.

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 2007 were within compliance levels established on the acceptance form.

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 Plans are completed for individual construction projects. Inspections of construction sites are performed in accordance with permit requirements.

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 Permit.

Safe Drinking Water Act

The Safe Drinking Water Act was reauthorized on August 6, 1996. It 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 facilities at the INL Site perform sampling of drinking water as required by the State and EPA. Chapter 5 contains details on drinking water monitoring results.

National Historic Preservation Act

Preservation of historic properties on lands managed by DOE is mandated under Section 106 of the National Historic Preservation Act (NHPA) of 1966. The Section 106 process is the legal mechanism used to determine if adverse effects to historic properties will occur and if so, the nature and extent of these adverse effects. Consultation with the Idaho State Historic Preservation Office (SHPO) and interested parties are then conducted to mitigate these effects.

The INL Site Cultural Resources Management Plan (CRMP) was written specifically for site resources, providing a tailored approach to comply with Section 106 of the NHPA. The CRMP is reviewed and updated annually. Additionally, a Programmatic Agreement between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho SHPO, dated July 2004, *Concerning Management of Cultural Resources on the INL Site*, formally implements the CRMP.

In 2007, 40 known resources, five projects, and three ground disturbing activities were reviewed on the INL for compliance with the CRMP. Briefly, there were no adverse effects to historic properties during the 2007 time frame. Several U.S. Navy built brick buildings from the World War II period were monitored to update their documented condition. The buildings have evolved from being targets for demolition as they are recognized as features of the historic landscape of the INL. The Experimental Breeder Reactor-I was monitored as it is the INL's single national Historic Landmark because of its role in early development of U.S. nuclear reactors and reactor technology.

The Experimental Test Reactor, TAN Hot Shop, and Power Burst Facility were covered under the previous negotiations with SHPO. Mitigation of adverse impacts to signature properties is completed or in the process of being completed as required by the Programmatic Agreement and as outlined in a memorandum of agreement regarding these properties with the SHPO. No new negotiations with SHPO were required for 2007 as no new properties not previously identified and negotiated have been impacted.

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 2007, 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.

2.2 Environmental Occurrences

In 2007, three releases were deemed reportable to external regulatory agencies:

- On March 22, 2007, a diesel oil spill was discovered at the Central Facilities Area (CFA). Approximately 3900 gallons of diesel #2 spilled from the B-646 day tank used for the CFA-688 boiler. The diesel overflowed from the day tank and spread to the asphalt in the parking lot and the soil. Approximately 300 gallons were estimated to have reached the soil. The spill exceeded the reportable quantity of 25 gallons and could not be completely remediated within 24 hours of discovery. Notification was made to appropriate authorities within the state of Idaho according to regulatory requirements and the area of the spill was subsequently remediated.

- On July 20, 2007, a mineral oil spill was discovered at an Idaho Falls facility. A tank pump within the INL Engineering Demonstration Facility contained a leaking flange and approximately 350 gallons of mineral oil leaked from the tank into the building. Approximately 25 gallons of mineral oil reached the soil outside the building. The spill was remediated within 24 hours of discovery. Notification was made to appropriate authorities within the state of Idaho.

- On November 8, 2007, mercury were spilled during decontamination and decommissioning operations at TAN. Voluntary Consent Order (VCO) lines in the former V-Tank area were being drained. These VCO lines are subject to 40 CFR 265.196(d) (Subpart J). Approximately 1.3 kg (3 lbs) elemental mercury were released to the soil. The spill also contained various radionuclides at activity levels below reportable quantities. The leak was discovered immediately and the mercury was retrieved in its entirety within 24 hours of discovery, including incidental underlying soils. Since the spill was to soil and exceeded the 0.5 kg (1 lb) reportable quantity, notification was made to appropriate authorities within the state of Idaho according to regulatory requirements.

None of these releases posed significant threats to the environment or human health. All releases were appropriately remediated.

2.3 Permits

Table 2-2 summarizes active and pending permits for the INL site through year-end 2007.

Table 2-2. Active and Pending Permits for the INL Site Through Year-end 2007.

Media/Permit Type	Issuing Agency	Active	Pending
Air			
Permit to Construct	State of Idaho	17	0
Operating Permit	State of Idaho	2	0
Groundwater			
Injection Well	State of Idaho	22	0
Well Construction	State of Idaho	1	0
Surface Water			
Wastewater Land Application Permit	State of Idaho	5	1
Industrial Waste Acceptance	City of Idaho Falls	1	0
RCRA			
Part A	State of Idaho	2	0
Part B[a]	State of Idaho	7[b]	1[b]

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

REFERENCES

Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," January 2007.

Executive Order 12580, "Superfund Implementation," January 1987.

Executive Order 11988, "Floodplain Management," May 1977.

Executive Order 11990, "Protection of Wetlands," May 1977.

Executive Order 13101, "Greening the Government through Waste Prevention Recycling and Federal Acquisition, September 1998.

U.S. Department of Energy, 2006, "Compliance with Floodplain and Wetland Environmental Review Requirements," Code of Federal Regulations, 10 CFR 1022, Office of the Federal Register.

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

U.S. Department of Energy Order 451.1B, Change 1, 2001, "National Environmental Policy Act Compliance Program," U.S. Department of Energy, September 28.

U.S. Department of Energy Order 435.1, Change 1, 2001, "Radioactive Waste Management," U.S. Department of Energy, August 28.

U.S. Department of Energy Idaho Operations Office (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. Environmental Protection Agency 63 FR 31, 1998, "Reissuance of NPDES General Permits for Storm Water Discharges From Construction Activities," Federal Register, February 17, p. 7857.

U.S. Geological Survey (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, DOE/ID-22138.

VanHorn, R.L., Hampton, N.L., and Morris, R.C., 1995, Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL, INEL-95/0190, June.

Chapter 3. Environmental Program Information

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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), Risk Reduction (Section 3.2), Environmental Restoration (Section 3.3), and Waste Management (Section 3.4). Sections 3.5 and 3.6 summarize other significant INL Site environmental programs and activities.

3.1 Environmental Monitoring Programs

Environmental monitoring consists of two separate activities: effluent monitoring and environmental surveillance. Effluent monitoring is the measurement of constituents within a waste stream before its release to the environment, such as the monitoring of stacks or discharge pipes. Environmental surveillance is the measurement of contaminants in the environment. Surveillance involves determining whether or not contaminants are present or measurable in environmental media and, if present, in what concentrations are they found.

Effluent monitoring is conducted by various INL Site organizations. Airborne effluent measurements and estimates, required under the Idaho State Implementation Plan and National Emission Standards for Hazardous Air Pollutants Subpart H,, are the responsibility of the regulated facilities. At the INL Site, these facilities include Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Critical Infrastructure Test Range Complex/ Power Burst Facility, Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North/Specific Manufacturing Capability. The Liquid Effluent Monitoring Program is designed to demonstrate compliance with the Clean Water Act, Wastewater Reuse Permits (WRPs), and other associated permits.

Environmental surveillance is the major environmental monitoring activity conducted at the INL Site. As such, much of this report concentrates on this task. The remainder of this section summarizes environmental monitoring program objectives; the history of environmental monitoring at the INL Site; and information on monitoring of specific environmental media (air, water, agricultural products, animal tissue, and soil), direct radiation, and meteorology.

Results of the environmental monitoring programs for 2007 and additional information on major programs can be found 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 2007 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.

Objectives of Environmental Monitoring

Operations of INL Site facilities have the potential to release materials, which may include 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. Through a variety of exposure pathways (Figure 3-1), contaminants can be transported away from INL Site facilities, where they could potentially impact the surrounding environment and the population living in these areas.

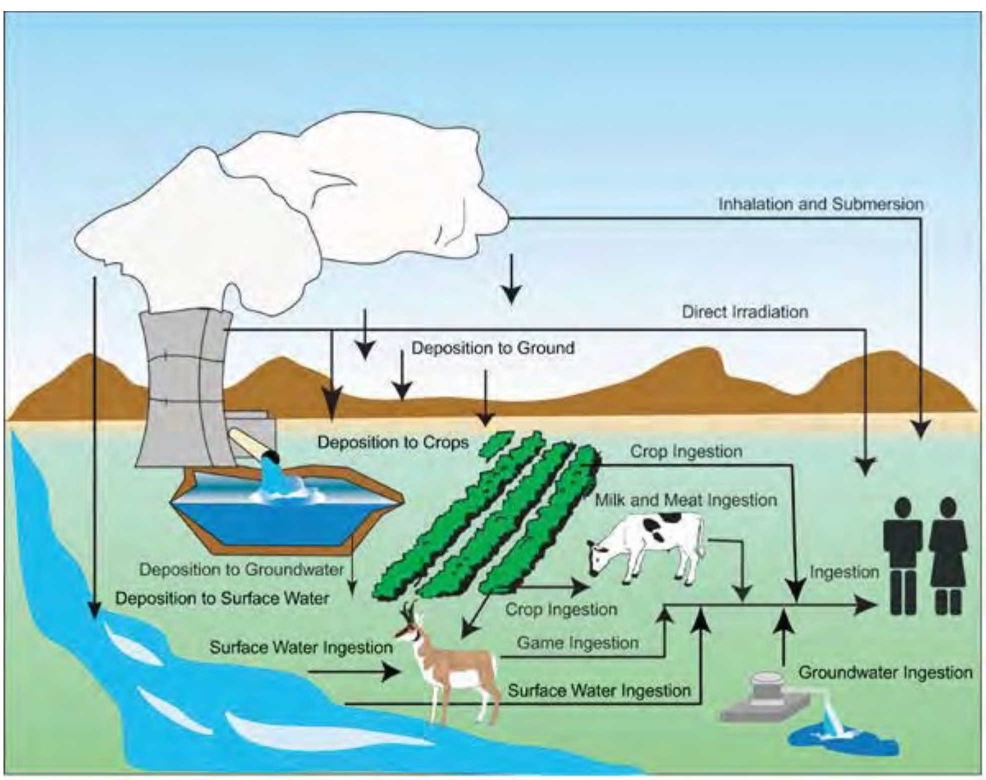

Figure 3-1. Potential Exposure Pathways to Humans From the INL Site.

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

As discussed previously, monitoring also provides the information to verify compliance with a variety of applicable environmental protection laws, regulations, and permits, described in Chapter 2. The establishment and conduct of an environmental monitoring program at the INL Site is required by the U.S. Department of Energy (DOE) Order 450.1 (DOE 2003). The various environmental monitoring programs are also used to detect, characterize, and report unplanned releases; evaluate the effectiveness of effluent treatment, control, and pollution abatement programs; and determine compliance with commitments made in environmental impact statements (EIS), environmental assessments, safety analysis reports, and other official DOE documents.

History of Environmental Monitoring

Environmental monitoring has been performed at the INL Site by DOE 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's Radiological and Environmental Sciences Laboratory (RESL), 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 and for effluent monitoring.

Early monitoring activities focused on evaluating the potential of 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 and its predecessor agencies sampled and analyzed environmental media that could be affected by atmospheric releases. During those early years, the various INL Site contractors conducted sampling of liquid and airborne effluents from facilities to develop waste inventory information.

Throughout the history of the INL Site, the U.S. Geological Survey (USGS) has monitored groundwater quantity and quality in the Eastern Snake River Plain Aquifer (ESRPA), with emphasis on the portion of the aquifer beneath the INL Site. The National Oceanic and Atmospheric Administration (NOAA) has also monitored weather conditions at the INL Site since the Site's inception.

In 1993, the DOE environmental monitoring program was divided into separate onsite and offsite programs. Responsibility for the onsite program was transferred to the INL Site contractor. During 2007, Battelle Energy Alliance (BEA) was the prime INL contractor. CH2M-WG Idaho, LLC (CWI) assumed responsibility for the Idaho Cleanup Project (ICP) on May 1, 2005. The monitoring activities performed by BEA and CWI comprise the onsite monitoring program. The offsite monitoring program is performed by the Environmental Surveillance, Education, and Research (ESER) Program contractor. During 2007, ESER offsite monitoring activities were performed by a team led by the S. M. Stoller Corporation.

Air Monitoring

Historical Background – Low-volume air samplers have been operating on and in the vicinity of the INL Site since 1952. Table 3-1 lists the areas where samplers have been located and the dates of operation for these samplers (derived from DOE-ID 1991). Before 1960, radiation detection devices, such as a Geiger-Műller tube, were used to record the amount of radioactivity on the filters. Gross beta measurements were made starting in 1960, and by 1967 the present series of analytical measurements were being performed.

High-volume air samplers were operated at the Experimental Field Station (EFS) and CFA from 1973 until October 1996. In 1996, a program evaluation determined that the cost of operating the high-volume samplers was not commensurate with the data being collected, and operations were suspended. Also in 1973, a high-volume sampler began operation in Idaho Falls as part of the U.S. Environmental Protection Agency's (EPA's) nationwide Environmental Radiation Ambient Monitoring System, now known as RadNet.

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 this time.

One monitoring location at CFA collected samples of noble gases, with specific interest in krypton-85 (^{85}Kr) from approximately 1984 until 1992. This station was used to monitor releases of ^{85}Kr from the INTEC during periods when fuel reprocessing was taking place.

Nitrogen dioxide and sulfur dioxide were first monitored for a nine-week period at five onsite locations in 1972. A nitrogen dioxide sampling station operated from 1983 to 1985 to monitor waste calcining operations at INTEC. A sulfur dioxide sampler was also used from 1984 to 1985. The two sampling locations were reactivated in 1988 for nitrogen dioxide and operated through 2003, and one station operated from 1989 through 2001 for sulfur dioxide.

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 EPA program to measure fine particles of less than 2.5 µm in diameter ($PM_{2.5}$). These particles are the largest cause of degraded visibility. In May 1992, one IMPROVE sampler was established at CFA on the INL Site and a second was located at Craters of the Moon National Monument as part of the nationwide network. Each of the two samplers 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. Operation of the CFA sampler ceased in May 2000 when the EPA removed it from the nationwide network.

Current Programs – Both the ESER and INL contractors maintain a network of low-volume air samplers to monitor for airborne radioactivity (Figure 3-2). ESER operates 13 samplers at locations offsite and three onsite. Two of the onsite samplers are located at INL Site entrances that are in close proximity to public access via State Highway 20/26. The third onsite sampler is located at the EFS, which is typically within the highest air concentration isopleths estimated by air dispersion models

Table 3-1. Historic Low-Volume Radiological Air Sampling Locations and Dates of Operation.

Sampling Location	Dates of Operation
Distant 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	
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	1976–present
Materials and Fuels Complex (formerly ANL-W)[b]	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
Reactor Technology Complex (formerly TRA)[c]	1953–1956, 1958–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

b. ANL-W = Argonne National Laboratory West

c. TRA = Test Reactor Area

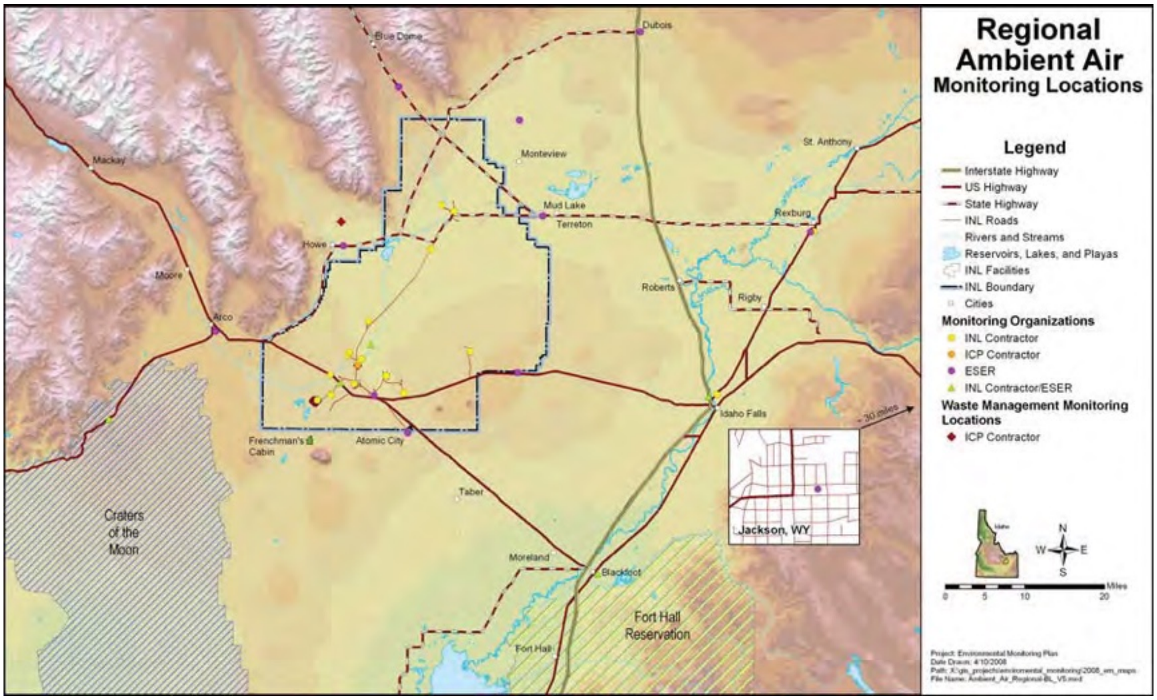

Figure 3-2. ESER and INL Site Contractors Low-Volume Radiological Air Sampling Locations.

(see Figure 8-1). ESER added the thirteenth offsite sampler in June 2001 at Jackson, Wyoming. Two samplers were also moved to new locations in July 2001 when the landlords terminated the leases at the previous stations. The sampler at Blackfoot was moved to Dubois and the sampler at Reno Ranch/Birch Creek was moved to Blue Dome. The INL contractor maintains 17 onsite and four offsite sampling locations. Additional samplers were added at Specific Manufacturing Capability (SMC), Gate 4, the RTC and INTEC due to increased decontamination and dismantlement activity.

Each low-volume air sampler maintains an average airflow of 57 L/minute (2.0 ft^3/minute) through a set of filters consisting of a 1.2 µm pore membrane filter followed by a charcoal cartridge. The membrane filters are 99 percent efficient for airborne particulates with an aerodynamic diameter of 0.32 µm, and higher for larger diameter particulates.

Filters from the low-volume air samplers are collected and analyzed weekly. Charcoal cartridges are analyzed for iodine-131 (^{131}I) either individually or in batches of up to ten cartridges. During batch counting, if any activity is noted in a batch, each cartridge in that batch is recounted individually. Particulate filters are analyzed weekly using a proportional counting system. Filters are analyzed after waiting a minimum of four days to allow naturally occurring radon progeny to decay. Gross alpha and beta analyses are used as a screening technique to provide timely information on levels of radioactivity in the environment.

Specific radionuclide analyses are more sensitive than gross alpha and gross beta analyses for detecting concentrations of anthropogenic (human-made) radionuclides in air. The particulate filters of the low-volume samplers are composited by location at the end of each quarter, and all composites are analyzed for specific radionuclides by gamma spectrometry. Composites are then submitted for analyses for specific transuranic radionuclides (americium-241 [^{241}Am], plutonium-238 [^{238}Pu], plutonium-239/240 [$^{239/240}$Pu]), and strontium-90 (^{90}Sr).

Measurements of suspended particulates are also performed on the 1.2 μm pore membrane filters from the low-volume air samplers. Both the ESER and INL contractors weigh filters weekly before and after sampling to determine the amount of material collected. In both cases, the amount of material collected is determined by subtracting the presampling (clean filter) weight from the postsampling (used filter) weight. The concentration of suspended particulates is calculated by dividing the amount of material collected on the filters by the total volume of air that passed through the filters.

Samplers for tritium in atmospheric moisture are located at two onsite and four offsite locations. In these samplers, air is pulled through a column of desiccant material (i.e., silica gel or molecular sieve) at 0.3–0.5 L/hour (0.01-0.02 ft^3/hour). The material in the column adsorbs water vapor. Columns are changed when sufficient moisture to obtain a sample is adsorbed (typically from one to three times per quarter). The adsorbed water is removed from the desiccant through heat distillation. Tritium concentrations in air are then determined from the adsorbed water (distillate) by liquid scintillation counting. Atmospheric concentrations are determined from the tritium concentration in the distillate, quantity of moisture collected, and the volume of air sampled.

Tritium is also monitored using precipitation samples collected on the INL Site monthly at CFA and weekly at EFS. A monthly sample is also obtained offsite in Idaho Falls. Each precipitation sample is submitted for tritium analysis by liquid scintillation counting.

Water Monitoring

Historical Background – The USGS has conducted groundwater studies at the INL Site since its inception in 1949. The USGS was initially assigned the task to characterize water resources of the area. 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 (ESRPA). The first well, USGS 1, was completed and monitored in December 1949. USGS personnel have maintained an INL Project Office since 1959 (Knobel et al. 2005). During 2005, the USGS released a report documenting their monitoring programs for the period 1949-2001 (Knobel et al. 2005).

In 1993, the DOE Idaho Operations Office (DOE-ID) initiated a program to integrate all of the various groundwater monitoring programs at the Site. This resulted in the development of the Site's Groundwater Monitoring Plan (DOE-ID 1993a) and the Groundwater Protection Management Plan (DOE-ID 1993b). The monitoring plan described historical conditions and monitoring programs, and it included an implementation plan for each facility. The protection management plan established policy and identified programmatic requirements.

Sampling and analyses of drinking water both onsite and offsite began in 1958. Analysis for tritium began in 1961. Up to 28 locations were sampled before increased knowledge of the movement of groundwater beneath the INL Site led to a decrease in the number of sampling locations. In 1988, a centralized drinking water program was established. Each contractor participates in the INL Site Drinking Water Program. The Drinking Water Program was established to monitor drinking water and production wells, which 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 Regulations for Public Drinking Water Systems and the federal Safe Drinking Water Act establish requirements for the Drinking Water Program. A program to monitor lead and copper in drinking water in accordance with EPA regulations has been in place since 1992. Three successive years of monitoring lead and copper levels in drinking water were concluded in 1995. Since regulatory values were not exceeded, this monitoring has been reduced to once every three years beginning in 1998.

Current Programs – USGS personnel collect samples from 171 observation or production wells, auger holes, surface water sites, and multi-depth sampling wells (32 samples are collected from six multi-depth sites) and have them analyzed for selected organic, inorganic, and radioactive constituents. Sampling is performed on schedules ranging from monthly to annually. These samples are submitted to the RESL at CFA for analysis of radioactive constituents and to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analyses of organic and inorganic constituents. The USGS also records water levels at 211 selected wells on schedules ranging from monthly to annually.

The USGS also conducts special studies of the groundwater resources of the ESRPA. The abstract of each study published in 2007 is provided in Appendix C. These special studies provide more specific geological, chemical, and hydrological information on the characteristics of the aquifer and the movement of chemical and radiochemical contaminants in the groundwater.

The Idaho National Engineering Laboratory (INEL) Groundwater Monitoring Plan was updated in 2003 to include the monitoring wells, constituent lists, and sampling frequencies of current programs. The updated plan does not replace the 1993 plan but uses it as the basis for the information previously presented regarding operational history, contaminant sources, and monitoring networks for each INL Site facility. The updated plan modifies groundwater monitoring recommendations in accordance with more recent information (i.e., requirements in records of decision), relying on existing multiple groundwater programs rather than a single comprehensive program.

Agricultural Products and Vegetation Monitoring

Historical Background – 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 limit for ^{131}I has decreased from about 15,000 pCi/L in early sampling to the current detection level of about 2 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 was resumed in 1994 in response to public interest. Lettuce has been collected since 1977.

Current Programs – Milk samples are collected from both commercial and single-family dairies. A 2 L (0.5 gal) sample is obtained from Idaho Falls weekly. Other locations are sampled monthly. Each milk sample is analyzed for ^{131}I and other gamma-emitting radionuclides. One sample at each location is analyzed for ^{90}Sr and tritium during the year.

Wheat samples are collected from farms or grain elevators in the region surrounding the INL Site. All wheat samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

Potato samples are collected from farms or storage warehouses in the vicinity of the INL Site, with three to five samples from distant locations. The potatoes, with skins included, are cleaned and weighed before processing. All potato samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

Lettuce samples are obtained from self-contained growing boxes distributed throughout the region, usually at existing air monitoring locations, and at private gardens in the vicinity of the INL. Lettuce is grown from seed at each location and collected when mature. The use of self-contained growing boxes allowed the collection of samples at areas on the INL Site (e.g., EFS) and at boundary locations where lettuce could not previously be obtained (e.g., Atomic City). Samples are washed to remove any soil as in normal food preparation, dried, reduced to a powdered form, and weighed. All lettuce samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

The ICP contractor annually collects perennial and grass samples from around the major waste management facilities. These samples are analyzed for gamma-emitting radionuclides.

Animal Tissue Monitoring

Historical Background – 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 was instituted. The first studies on waterfowl that were using wastewater disposal ponds containing various amounts of radionuclides occurred the following year. Waterfowl studies have covered the periods 1974–1978, 1984–1986, and 1994–present. In 1998, the collection of waterfowl became part of the regular surveillance program.

Mourning doves were collected in 1974 and 1975 as part of a radioecology research project. Periodic dove sampling as part of the environmental surveillance program was initiated in 1996. In 1998, periodic sampling of yellow-bellied marmots was added to the sampling program.

During 1998, 2000, 2002, and 2003, a total of 15 marmots were collected from the RWMC and 11 from control areas and analyzed for specific radionuclides. The radionuclides concentrations detected in 2002 and 2003 were well below those observed in other wildlife species collected historically at the RWMC as well as in control animals collected in previous studies. Because of this, marmots were not included in the routine monitoring program.

Sheep that grazed onsite were part of the routine monitoring program from 1975 through 2006. Sheep sampling was discontinued for the following reasons: 1) radionuclide concentrations remained unchanged since 2002; 2) results were statistically equal to background levels; and 3) game animals are theoretically a better indicator of any onsite releases to the environment as they may graze in the vicinity of facility areas. Beef cattle grazing in the vicinity of RWMC were also monitored biennially during the period 1978 to 1986. Grazing near RWMC was discontinued due to drought conditions.

Current Programs – All INL Site animal tissue monitoring is performed by the ESER Program. Selected tissues (muscle, liver, and thyroid) are collected from big game animals accidentally killed on INL Site roads. Thyroid samples are placed in vials and analyzed within 24-hours by gamma spectrometry specifically for ^{131}I. Muscle and liver samples are processed, placed in a plastic container, and weighed before gamma spectrometry analysis.

Waterfowl samples are collected from waste disposal ponds at up to four facilities on the INL Site. Control samples are also taken in areas distant from the INL Site. Waterfowl samples are separated into an external portion (consisting of the skin and feathers); edible portion (muscle, liver, and gizzard tissue); and the remaining portion. All samples are analyzed by gamma spectrometry. Selected samples are also analyzed for ^{90}Sr and transuranic radionuclides.

Mourning doves are collected in some years from the vicinity of INTEC and RTC wastewater ponds and from a control area distant to the INL Site. Because of the small size of a typical dove, muscle tissues from several doves collected at the same location are composited into one sample. Samples are analyzed for gamma-emitting radionuclides.

Soil Monitoring

Historical Background – Soil sampling has been included as part of routine monitoring programs since the early 1970s, although some limited soil collection was performed around various facilities as far back as 1960. Offsite soil sampling at distant and boundary locations was conducted 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 m^2 (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 (~1076 ft^2) area.

A soil sampling program began in 1973 around onsite facilities. Soils at each facility were sampled every seven years. In 2001, all locations were sampled as the frequency was increased to every two years.

Current Programs – Twelve offsite soil locations are sampled in even numbered years by the ESER contractor. Following collection, soil samples are dried for at least three hours at 120°C (250°F) and sieved. Only soil particles less than 500 µm in diameter (35-mesh) are analyzed. All offsite samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and transuranic radionuclides.

The INL contractor performed in situ gamma analysis at various onsite sampling locations. Thirty-four locations were sampled in 2007. Each sample consisted of compositing 10 split spoon samples from a predetermined array centered at the in situ location out to 30 feet. Each of the 10 split spoon samples were removed and divided by one inch depth to form twelve composite samples. Each of these one-inch composite samples from the 34 in situ locations were then analyzed for gamma emitting radionuclides to determine the cesium-137 (^{137}Cs) depth profiles. The INL contractor also performs annual sampling of the CFA sewage treatment plant irrigation spray field to show compliance with the WRP soil loading limits.

Direct Radiation Monitoring

Historical Background – Measurements of radiation in the environment have been made on the INL Site since 1958. The technology used for radiation measurements at fixed locations has evolved from film badges to thermoluminescent dosimeters (TLDs). In addition to these 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.

Current Programs – Environmental TLDs are used to measure ambient ionizing radiation exposures. The TLDs measure ionizing radiation exposures from all external sources. External sources include natural radioactivity in the air and soil, cosmic radiation from space, residual fallout from nuclear weapons tests, radioactivity from fossil fuel burning, and radioactive effluents from INL Site operations and other industrial processes.

At each location, a TLD holder containing four individual chips is placed one meter (3.3 ft) above ground level. The INL contractor maintains dosimeters at 13 offsite locations and approximately 135 locations onsite. The ESER contractor has dosimeters at 17 offsite locations. The dosimeter card at each location is changed semiannually, and cumulative gamma radiation is measured by the INL contractor Dosimetry Unit.

In addition to TLDs, a radiometric scanner arrangement is used to conduct gamma radiation surveys onsite. Two plastic scintillation detectors and global positioning system equipment are mounted on a four-wheel drive vehicle. The vehicle is driven slowly across the area to be surveyed while radiometric and location data are continuously recorded.

Meteorological Monitoring

Historical Background – In 1948 a U.S. Weather Bureau Research Station was established at the National Reactor Testing Station (NRTS), as the current INL Site was then called. The station’s task was 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 CFA in 1949. A small network of monitoring sites was deployed during the 1950s. To help 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 old Weather Bureau went through various governmental reorganizations over time, and meteorological activities now fall under the NOAA. The original Research Station at the INL Site is now the Field Research Division of the NOAA Air Resources Laboratory (NOAA ARL-FRD).

The INL meteorological tower network (called the INL Mesonet) has undergone several upgrades 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 off-site towers, which the DOE contractor had previously operated, were integrated into the NOAA system. Although additional component upgrades have taken place since then, the basic Mesonet configuration and data reporting have remained largely unchanged since the 1990s modernization.

Current Programs – NOAA ARL-FRD currently maintains 35 towers in the INL Mesonet. This network spans the full width of the Snake River Plain and extends from Dubois in the north to Richfield well to the southwest of INL. These towers provide continuous measurements of many meteorological parameters including air temperature, wind speed and direction, humidity, barometric pressure, solar radiation, and precipitation. In addition, NOAA ARL-FRD operates two special systems that provide vertical profiles of winds and temperature above INL. One is a radar profiler that can remotely measure winds up to several km above the ground and temperatures up to just under 1 km. The other is a minisodar that uses sound pulses to measure winds and turbulence up to 100-150 m above the ground. Data are transmitted via radio and telephone lines back to the NOAA ARL-FRD facility in Idaho Falls, where they undergo quality control and archiving.

Sitewide Monitoring Committees

A Monitoring and Surveillance Committee was formed in March 1997 and holds bimonthly meetings to coordinate activities between groups involved in INL Site-related onsite and offsite environmental monitoring. This standing committee brings together representatives of DOE-ID; INL Site contractors; ESER contractor; Shoshone-Bannock Tribes; state of Idaho INL Oversight Program; NOAA; 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 and INL Site contractors.

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, NOAA, and other agencies that have an interest in INL Site water issues but are not necessarily part of the governing agencies.

Monitoring Summary

Tables 3-2 through 3-4 present a summary of the environmental surveillance programs conducted by the ESER contractor, the INL Site contractors, and the USGS, respectively, in 2007. In addition to the monitoring constituents listed in Table 3-4, the USGS collects samples twice a year from 13 wells in cooperation with the Naval Reactors Facility (NRF) and collects an expanded list of constituents from six multi-depth sampling wells. This expanded constituent list will change from year to year in response to USGS program Remedial Investigation/Feasibility Study (RI/FS) requirements. The additional constituents collected during 2007 for the multi-depth wells were major anions and cations, uranium isotopes, iodine-129 (^{129}I), selected dissolved gases, and selected stable isotopes. These data are available from the USGS by request.

3.2 Risk Reduction

The mission of the Office of Environmental Management (EM) is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. DOE-ID's EM objectives include completing efforts to safely achieve risk reduction, to safely achieve footprint reduction, and continued protection of the Snake River Plain Aquifer.

The risk reduction objectives are now embodied in DOE's new performance-based cleanup contract with CWI that will achieve accelerated cleanup priorities through 2012. The INL Site made significant progress in 2007, most notably:

- Demolished over 4285 m^2 (46,119 ft^2) of buildings and structures.
- Issued a Proposed Plan for Operable Unit (OU) 7-13/14 which recommended a remedy for the Subsurface Disposal Area (SDA).
- Completed the Test Area North (TAN) V-Tank area soil excavation.
- Completed treatment of the TAN V-Tank waste and disposed of the waste, treatment system, and the tanks.
- Completed remediation of the Waste Area Group (WAG) 10 STF-02 Gun Range.
- Completed the OU 3-14 (INTEC Tank Farm Soils and Groundwater) Record of Decision (ROD).
- Began waste exhumation in the Accelerated Retrieval Project II.

Accelerated cleanup activities are further discussed throughout this Chapter in specific program emphasis areas.

3.3 Environmental Restoration

Since the Federal Facility Agreement and Consent Order (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. Cleanup of this contamination is being conducted under

Table 3-2. ESER Environmental Surveillance Program Summary (2007).

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
	Isotopic U and Pu	None	1 annually	2×10^{-18} µCi/mL
Air (PM_{10})	Weighing filter	None	3 weekly	± 0.0001 g
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 (TLDs)	Ionizing radiation	None	17 semiannually	5 mR

a. Onsite includes three locations and a replicate, offsite includes 13 locations and a replicate.
b. Filters are collected by ESER personnel and sent to EPA for analysis. Data are reported by EPA's RadNet at http://www.epa.gov/narel/radnet/.
c. A portion of the monthly sample collected at Idaho Falls is sent to EPA 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 RTC, MFC, and control areas.

Table 3-3. INL Site Contractors Environmental Surveillance Program Summary (2007).

INL Contractor				
		Locations and Frequency		
Medium Sampled	**Type of Analysis**	**Onsite**	**Offsite**	**Minimum Detectable Concentration[a]**
Air (low volume)	Gross alpha	19 weekly[b]	4 weekly	1 x 10^{-15} µCi/mL
	Gross beta	19 weekly	4 weekly	5 x 10^{-15} µCi/mL
	Specific gamma	19 quarterly	4 quarterly	Varies by analyte
	Specific alpha[c]	19 quarterly	4 quarterly	2 x 10^{-18} µCi/mL
	^{90}Sr	19 quarterly	4 quarterly	2 x 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 x 10^{-11} µCi/mL (water)
Soil	In-situ gamma	Varies annually[d]	None	Varies by analyte
Drinking Water Systems	Gross alpha	9 semiannually	None	1 pCi/L
	Gross beta	9 semiannually	None	4 pCi/L
	Tritium	9 semiannually	None	1,000 pCi/L
	^{129}I	1 semiannually	None	2 pCi/L
	Volatile organics	1 quarterly	None	Varies by analyte
		5 annually/	None	
	Semivolatile organics	5 triennially	None	Varies by analyte
	Inorganics	5 triennially	None	Varies by analyte
	Nitrates	9 annually	None	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[e]	None	Not Applicable

ICP Contractor					
		Locations and Frequency			
Medium Sampled	**Type of Analysis**	**RWMC**	**INTEC**	**ICDF**	**Minimum Detectable Concentration**
Air (low volume)	Gross alpha	8 Bimonthly[a]	None	1 Bimonthly[a]	1 x 10^{-15} µCi/mL
	Gross beta	8 Bimonthly	None	1 Bimonthly	5 x 10^{-15} µCi/mL
	Specific gamma	8 Monthly	None	1 Monthly	Varies by analyte[c]
	Specific alpha[b]	8 quarterly	None	1 quarterly	2 x 10^{-18} µCi/mL
	^{90}Sr	8 quarterly	None	1 quarterly	2 x 10^{-14} µCi/mL
Drinking Water System	Volatile organics	2 monthly	2 monthly	None	Varies by analyte
	Nitrates	1 annually	1 annually	None	Varies by analyte
Vegetation	Specific gamma	5 annually	None	None	Varies by analyte
	Pu Isotopes	5 annually	None	None	0.003 pCi/g
	^{241}Am	5 annually	None	None	0.003 pCi/g
	^{90}Sr	5 annually	None	None	0.06 pCi/g
Mobile radiation surveys	Gamma radiation	SDA	None	None	Not Applicable

a. Approximate detection limits vary with each laboratory analysis, but approximate values are provided.
b. Onsite includes 17 locations and two replicate samples.
c. Includes ^{241}Am, ^{238}Pu, and $^{239/240}$Pu.
d. Onsite soil sampling is performed each year at different onsite facilities on a rotating two-year schedule.
e. 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 3-4. U.S. Geological Survey Monitoring Program Summary (2007).

Constituent	Groundwater		Surface water		Minimum Detectable Concentration
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross Alpha	65	61	4	1	3 pCi/mL
Gross Beta	66	62	4	1	3 pCi/mL
Tritium	173	157	7	4	400 pCi/mL
Specific Gamma	105	92	4	1	__[b]
Strontium-90	111	102	__[c]	__	5 pCi/mL
Americium-241	23	22	__	__	5 pCi/mL
Plutonium Isotopes	23	22	__	__	4 pCi/mL
Iodine-129	44	75	__	__	<1aCi/L
Specific Conductance	173	158	7	4	Not applicable
Sodium Ion	153	142	__	__	0.1 mg/L
Chloride Ion	173	157	7	4	0.1 mg/L
Nitrates (as nitrogen)	117	115	__	__	0.05 mg/L
Fluoride	5	5	__	__	0.1 mg/L
Sulfate	108	97	__	__	0.1 mg/L
Chromium (dissolved)	84	78	__	__	0.005 mg/L
Purgeable Organic Compounds[d]	30	40	__	__	Varies
Total Organic Carbon	51	50	__	__	0.1 mg/L
Trace elements	13	13	__	__	Varies

a. Number of samples does not include 15 replicates and 2 equipment blanks collected in 2007. Number of samples was less than the number of sites because several sites were dry or had unresolved pump problems.

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.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). By the end of 2007:

- Twenty-three Record of Decisions (RODs) have been signed and are being implemented.
- One RI/FS was completed and one RI/FS is under development.
- Closeout activities at WAG 2, 4, 5, and 8 have been completed.

By progressing on these cleanup projects, workers were able to significantly reduce risks posed by past contamination at INL Site facilities. Also, by reducing the number of unneeded buildings, money that would otherwise have been applied to upkeep can now be applied to cleanup projects.

Comprehensive RI/FSs have been completed for WAGs 1, 2, 3, 4, 5, 8, 9, and 10 (6 is combined with 10). The comprehensive RI/FSs, which take an average of 40 months to complete, accomplish the following:

- Determine risks by assessing the combined impact release sites being assessed.
- Review assumptions used in previous investigations.
- Identify data gaps and recommend actions, such as field sampling or historical document research, to resolve questions.
- Perform feasibility studies to evaluate cleanup alternatives.

The information in the RI/FS is summarized in a Proposed Plan, which is provided for public comment. Proposed Plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments DOE, EPA, and the state of Idaho develop a ROD selecting a cleanup approach from the alternatives evaluated.

The general procedure for all comprehensive investigations begins with developing a work plan outlining potential data gaps and release sites that may require more field sampling. When the investigation is complete, DOE, EPA and the state of Idaho hold public comment meetings on the proposed cleanup alternative. Responses to comments and the final cleanup decision are documented in the ROD. Two RODs remain to be completed:

- Buried waste at the RWMC (WAG 7) - public comment completed in 2007.
- ESRPA contamination (WAG 10, OU 10-8) – public comment expected during 2008.

A complete catalog of documentation associated with the FFA/CO is contained in the CERCLA Administrative Record at http://ar.inel.gov/. The location of each WAG is shown on Figure 3-3.

Waste Area Group 1 – Test Area North

During 2007, the remediation of the V-9 tank was completed along with surrounding contaminated soil. The remedy consisted of soil removal, treatment of tank contents using air sparging followed by stabilization, and disposal at INL Idaho CERCLA Disposal Facility (ICDF) landfill.

In addition to the V-tank work, the OU 1-07B groundwater cleanup continued throughout 2007. The in situ bioremediation nutrient injection system continued to reduce contaminant concentrations in the aquifer. The New Pump and Treat Facility remained on standby to test rebound of aquifer contamination levels. The rebound test was completed in early 2007. Significant rebound did not occur through the end of 2007.

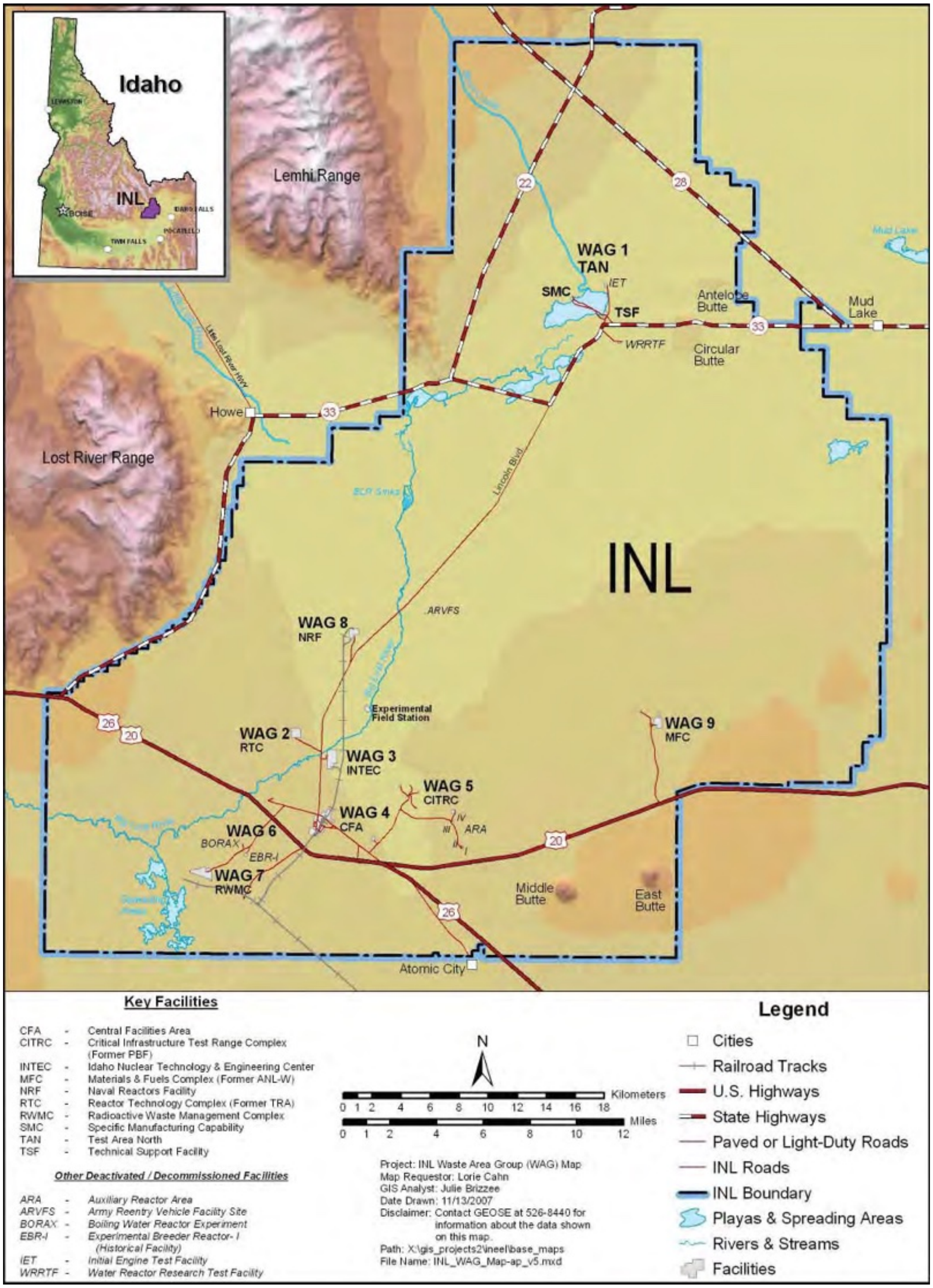

Figure 3-3. Map of the INL Site Showing Locations of the Facilities and Corresponding WAGs.

Waste Area Group 2 – Reactor Technology 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 2007, all of these Institutional Controls were maintained.

Waste Area Group 3 – Idaho Nuclear Technology and Engineering Center

Operations continued at the ICDF during 2007, disposing of contaminated soil and debris in the landfill cell as well as liquid waste to the evaporation pond. This site 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. Other major accomplishments at WAG 3 include:

- Finalized the OU 3-14 ROD which called for reduction of infiltration around the tank farm area including construction of a low permeability cap.
- The OU 3-13, Group 4 Monitoring Report and Decision Summary was finalized.
- Maintained interim actions at the Tank Farm Facility to reduce water infiltration that might transport contaminants from tank farm soils toward the aquifer.

Waste Area Group 4 – Central Facilities Area

Remediation of WAG 4 was completed in 2004. As with WAG 2, Institutional Controls are in place to maintain and monitor the completed remediation.

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

Cleanup activities at WAG 5 are complete. This area supported two reactor facilities–the PBF and the Auxiliary Reactor Area. The Remedial Action Report was completed during 2005.

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 2007. The OU 10-08 RI/FS was completed and submitted to the agencies. Operable Unit 10-08 addresses INL-related issues that are associated with the Snake River Plain Aquifer but are not addressed under the purview of the other WAGs.

Waste Area Group 7 – Radioactive Waste Management Complex

Waste Area Group 7 includes the SDA, a 39 hectare (97 acre) disposal area containing buried hazardous and radioactive waste. Organic solvents contained in this waste are a source of groundwater contamination and are being removed by an ongoing cleanup action. The Accelerated Retrieval Project (ARP) and ARP-II project continued during 2007. The ARP team has exhumed more than 7645 m^3 (10,000 yd^3) of targeted waste. These projects are larger-scale excavations (one-half acre) in Pits 4 and 6 using many of the safe operating concepts developed during the Glovebox Excavator Method project and are being performed as CERCLA Removal Actions. Additional excavations are anticipated in future years as the retrieval approach is proven effective.

The following accomplishments were achieved at WAG 7 in 2007:

- Completed the OU 7-13/14 Feasibility Study and Proposed Plan, which recommended a remedy for the SDA.
- Public meetings were held on the OU 7-13/14 Proposed Plan.
- Continued the Organic Contamination in the Vadose Zone project, a vacuum extraction system that removes solvent vapors that have escaped from buried waste. The vapors are brought to the surface and destroyed using thermal and catalytic processes.
- ARP excavations of buried waste continued during 2007. Actions were taken to address subsidence issues in both ARP and ARP-II. Retrieval excavations for ARP-II began in 2007.
- Continued to ship remote handled transuranic waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico, completing 98 shipments by year's end.

Waste Area Group 8 - Naval Reactors Facility
NRF results are not included in this report.

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 ^{137}Cs to background levels.

3.4 Waste Management and Disposition

The INL Site's waste management activities provide safe, compliant, and cost-effective management services for facility waste streams. 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/disposal, (3) transportation of waste to onsite and/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 and the INL Site Treatment Plan (STP).

Federal Facility Compliance Act
The Federal Facility Compliance Act requires the preparation of a STP for the treatment of mixed wastes (those containing both radioactive and nonradioactive hazardous materials) at the INL Site.

In accordance with the STP, the INL Site began receiving offsite mixed waste for treatment in January 1996. The INL Site received mixed waste 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 in permitted storage at the Waste Reduction Operations Complex and INTEC. During 2007, the INL Site treated/processed a total of 6406 m^3 (8379 yd^3) of legacy mixed waste, 231 m^3 (302 yd^3) of mixed low-level waste, and 7812 m^3 (10,218 yd^3) of contact-handled transuranic (TRU). Additionally, a total of 35 m^3 (46 yd^3) of remote-handled TRU was shipped, the majority of which was STP waste. Five STP milestones were completed on or ahead of schedule, one milestone was moved before being completed, and one milestone was moved from 2007 to 2008. The milestones completed were as follows:

- Commercial backlog treatment/disposal—100 m^3 (131 yd^3)
- Advanced Mixed Waste Treatment Project (AMWTP) Processing—4500 m^3 (5915 yd^3)
- Transmit Permit Modification for Integrated Waste Treatment Unit (IWTU)
- Initiate Construction for IWTU
- Define Project for Calcine Disposition.

Advanced Mixed Waste Treatment Project

The overall goal of the AMWTP is the treatment of alpha-containing low level mixed and TRU mixed wastes for final disposal by a process that minimizes overall costs while ensuring safety. This will be accomplished through a treatment facility with the capability to treat specified INL Site waste streams and the flexibility to treat other INL Site and DOE regional and national waste streams. The facility will treat waste to meet the most current requirements, reduce waste volume and life-cycle cost to DOE, and perform tasks in a safe, environmentally compliant manner.

During 2007, AMWTP shipped 5988 m^3 (7832 yd^3) of TRU waste to WIPP for a cumulative total of 20,353 m^3 (26,621 yd^3) of waste shipped offsite. In addition, AMWTP shipped offsite 736 m^3 (963 yd^3) of mixed low-level waste that historically had been managed as TRU waste.

High-Level Waste and Facilities Disposition

In 1953, reprocessing of Spent Nuclear Fuel (SNF) began at the INTEC, resulting in the generation of liquid High Level Waste (HLW) 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, known as 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 HLW was completed on February 20, 1998, four months ahead of the June 30, 1998, Idaho Settlement Agreement milestone. Calcining of remaining sodium bearing waste (SBW) began immediately following completion of non-sodium liquid HLW treatment, more than three years ahead of the Idaho Settlement Agreement milestone. Per that Agreement, all such waste is required to be calcined by the end of the year 2012.

In October 2002, DOE-ID issued the Final Idaho HLW and Facilities Disposition Environmental Impact Statement (FEIS) that included alternatives other than calcination for treatment of the SBW. DOE-ID issued a ROD for this FEIS on December 13, 2005. This ROD chose steam reforming to treat the remaining SBW in the Tank Farm. DOE-ID plans to complete SBW treatment using this technology by December 31, 2012. The state of Idaho, in a letter dated November 17, 2005, to James A. Rispoli, DOE Assistant Secretary for Environmental Management, stated, “Solidification via steam reforming is, therefore, an acceptable substitute technology for meeting DOE’s commitment under the 1995 court settlement in Public Service Company of Colorado v. Kempthorne, CV-91-0035-S-EJL to ‘complete calcination of sodium-bearing liquid HLWs by December 31, 2012….The State notes that steam reformed waste shall be subject to other 1995 court settlement requirements for treatment and removal of calcined waste from the state of Idaho.” It should be noted that there are no Settlement Agreement requirements to remove calcine from the State by a particular timeframe, just to have 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 SBW that has been consolidated into three 1.14 million L (300,000 gal) below grade tanks at the INTEC Tank Farm for interim storage.

During 2007, the SBW Treatment Project completed final design activities for the new facility and began construction, with a goal of commencing steam reforming operations in fiscal year 2011. Seven other 1.14 million L (300,000 gal) 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 EIS ROD in November 2006. Activities to fill the seven cleaned tanks and their surrounding vaults began in November 2006 and were completed during 2007.

The FEIS also included analysis of alternatives for treatment of the calcined waste. DOE-ID has performed a conceptual design on a system to retrieval of the existing HLW 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, which will move the option of disposal of untreated calcine in the repository forward along with an alternative treatment technology (to be decided) if direct disposal does not prove feasible. A final decision on direct disposal of untreated calcine or the treatment alternative will be made in an amended ROD to be issued in the 2011 timeframe.

Low-Level and Mixed Radioactive Waste

In 2007, the INL Site shipped offsite more than 3075 m^3 (4022 yd^3) of mixed low-level waste and 54 m^3 (71 yd^3) of low-level waste for treatment and disposal. Approximately 5060 m^3 (6618 yd^3) of legacy and newly generated low-level waste were disposed at the Subsurface Disposal Area in 2007.

Pollution Prevention and Waste Minimization

The Pollution Prevention (P2) and Sustainability Program reflects the national and DOE policies to reduce, reuse, and recycle wastes generated and pollutants by implementing cost-effective techniques, practices, and programs. Such actions are required by various Federal statutes including, but not limited to, the Pollution Prevention Act, the Resource Conservation and Recovery Act (RCRA), and, in 2007, significant changes occurred at the Federal level in regards to environmental management with the passage of Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management.

As part of the Environmental Management System (EMS), the P2 and Sustainability Program scope incorporates waste prevention/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.

- Electronics Reuse and Recycling - In 2007, the INL Site P2 program was recognized for its leadership and commitment at the Federal Electronics Challenge (FEC) conference in Washington, DC as our program was highlighted for voluntary successful changes made to “green up” the INL Site computing resources. In May, the INL Site was awarded the FEC Bronze Award in the Operation and Maintenance life cycle phase as a result of the efforts. Managed by the EPA and the Office of the Federal Environmental Executive, the Federal Electronics Challenge is a voluntary partnership program that encourages Federal facilities and agencies to purchase greener electronic products (monitors, desktops, and laptops), reduce impacts of electronic products during use, and manage obsolete electronics in an environmentally responsible way. The INL Site reused and donated over 49,895 kg (110,000 lb) of electronic equipment during the Federal Electronics Reuse and Recycling Campaign (ERRC) to win first place in the Large Facility Western Region division. The ERRC is a challenge to Federal agencies to see how much electronic equipment can be reused, recycled, and/or donated to reduce pollution.

- Alternative Fuels and Fuel Conservation in Transportation - In 2007, the INL Site established objectives in our EMS through our Pollution Prevention Plan and Energy Management Plan to increase alternative fuel use of ethanol and biodiesel. The impact of alternative fuel use at the INL Site has decreased petroleum dependency by 538,728 L (142,317 gal) as a result. An ongoing initiative is to purchase more fuel efficient flex fuel vehicles (FFVs) to replace older inefficient gasoline vehicles as a means of conservation. A 2008 initiative is to expand E85 fueling stations to multiple locations to meet the needs of the increased FFV’s to achieve a minimum of 25 percent alternative fuel use. Additionally, E10, as available in procurement is being selected to supply the gasoline fleet though not required by EPA or Idaho. E10 replaces Methyl tertiary-butyl ether and other petroleum based oxygenates in gasoline which are more harmful to the environment.

- Household Hazardous Waste Collection Day - In May, the INL Site P2 program helped to organize and plan the Bonneville County Household Hazardous Waste (HHW) Collection Day. Over 900 households – double what was expected – participated in the proper disposal of their HHW. Some 4452 L (1200 gal) of used motor oil, one ton (2205 lb) of electronic equipment, 1893 L (500 gal) of antifreeze, and over 500 auto batteries were among the items received. In addition, educational and guidance materials were distributed.

- Earth Day - The INL Site P2 program sponsored a booth emphasizing the increasing importance of electronics stewardship at the 2007 Idaho Falls Earth Day event. Attended by thousands from the surrounding area, the event included information booths, talks, presentations, and hands-on demonstrations that highlighted energy efficiency, planting trees, pollution prevention, waste minimization, recycling, and a host of other environmental topics. The INL Site continued to reuse and recycle a significant portion of waste/excess materials generated and also developed creative methods for minimizing waste streams.

- P2/Waste Minimization Annual Assessment - An evaluation of janitorial products used was completed. The recommendation was to work with procurement and the janitorial management to preferentially purchase Green Seal™ products and increase worker awareness of Affirmative Procurement and Environmentally Preferable Purchasing (EPP) opportunities.

- Pollution Prevention Opportunity Assessment (PPOA) - The IWTU project completed a PPOA on alternatives to disposing of approximately 2676 m^3 (3500 yd^3) of excess/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 IWTU.

- Affirmative Procurement/EPP Assessment - The procurement organization assessed the EPP program as affected by the transition to a new procurement software (PassPort to PeopleSoft) and the preferred purchasing of biobased products. Gaps discovered were addressed to ensure appropriate and increased preferable purchases are made.

- Sanitary and Hazardous Waste Recycled – The INL Site recycled over 1,163,657 kg (2,565,423 lb) of waste in 2007.

3.5 Environmental Management System

The INL contractor continued to make progress on the effort initiated in 1997 to develop and implement a sitewide EMS. The EMS 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 EMS provides an underlying structure to make the management of environmental activities more systematic and predictable. The EMS focuses on three core concepts: pollution prevention, environmental compliance, and continuous improvement. The primary system components are (1) environmental policy, (2) planning, (3) implementation and operation, (4) checking and corrective action, and (5) management review.

An audit and onsite readiness review conducted in 2001 by an independent ISO 14001 auditor concluded that the INL Site was ready for a formal registration audit. A registration audit was conducted May 6–10, 2002, by a third-party registrar. There were no nonconformances identified during the audit and the lead auditor recommended ISO 14001 registration for INL Site facilities, which was received in June 2002. Throughout 2007, both CWI and BEA have maintained their ISO 14001 registration. Bechtel BWXT Idaho (BBWI) has developed a self-certifying EMS in accordance with DOE Order 450.1. All three EMS programs have been successfully integrated into each contractor's Integrated Safety Management System. DOE performed annual evaluations of the contractor's EMS and found the programs satisfactory and compliant with the standards outlined in the DOE Order 450.1.

3.6 Other Major Environmental Issues and Activities

Deactivation, Decontamination, and Decommissioning Activities

The INL Site continued with an aggressive deactivation, decontamination and decommissioning (DD&D) approach to reducing the EM "footprint" of EM-owned buildings and structures. This effort achieved significant cost and risk reductions by eliminating aging facilities no longer necessary for the

INL mission. In 2007 efforts were placed on the deactivation & decontamination of high-risk facilities in preparation for final decommissioning. Seventy-five buildings were demolished in 2007. In total, 8642 m^2 (93,016 ft^2) of buildings and structures were razed. Specific projects at various facilities are described below.

Test Area North – Minor structures and buildings no longer having a mission, including the Hot Shop at TAN, were demolished along with the Containment Service Building (TAN-650) which was part of the Loss of Fluid Test Reactor Complex. In 2007 a total of 6654 m^2 (71,616 ft^2) of footprint reduction was achieved at TAN. This success will allow the completion of the active cleanup mission at TAN in 2008.

Reactor Technology Complex – Emphasis was placed on the decontamination of the Engineering Test Reactor (ETR) complex which is slated for final decommissioning in 2008. Various buildings and structures were demolished at RTC that no longer have a mission. This included the complete removal of the ETR vessel and building. A total of 1988 m^2 (21,400 ft^2) of buildings and structures were demolished in 2007. Decontamination work continued in the ETR Complex and DD&D work was initiated on the Materials Test Reactor complex.

Idaho Nuclear Technology and Engineering Center – There was no footprint reduction at INTEC in 2007. However, characterization, deactivation and decontamination work continued on the INTEC Fuel Reprocessing Complex (CPP-601/640). The tank farm team grouted four 15,000-gallon and seven 300,000-gallon underground waste tanks. Design approval was received and construction on the Integrated Waste Treatment Unit is well underway. In early 2008, demolition work will start on the low-risk buildings and structures at INTEC that no longer have a mission.

Spent Nuclear Fuel

SNF is defined as 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 ICP at INTEC, by the Naval Nuclear Propulsion Program at NRF, and by Nuclear Energy at RTC and MFC. Over 220 different types of SNF ranging in size from 0.9 kg (2 lbs), to 0.45 metric ton (0.5 ton) 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 spent nuclear fuel and HLW 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 2007, INL Site SNF was stored in both wet and dry condition. 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. The capacity to place SNF in standard canisters for transport to the repository will be built after 2013. SNF storage facilities are described below. All ICP-managed SNF was consolidated at INTEC in 2003.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666) – This INTEC facility, also called FAST, is divided into two parts, an SNF storage basin area and the Fluorinel Dissolution Facility, which operated from 1983 to 1992. The storage area consists of six storage basins currently storing SNF under about 11 million L (3 million gal) of water, which provides protective shielding and cooling. ICP-managed SNF is being removed from the basins and stored in the INTEC dry storage facilities described below. All ICP-managed SNF will 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 2007, the Advanced Test Reactor (ATR) sent shipments of SNF to FAST for 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 2007, the DD&D of the old fuel storage basin was completed. The IFSF was approximately 75 percent full at the end of 2007 and will continue to receive SNF from the CPP-666 basin, and foreign and domestic research reactors SNF in 2008.

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

Peach Bottom Fuel Storage Facility (CPP-749) – This INTEC facility consists of below-ground vaults for the dry storage of SNF. Located on approximately 2 ha (5 acres), this facility 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 2007 this facility stored SNF as well as special nuclear material (unirradiated fuel) from the Shippingport Reactor that was located in Pennsylvania. This material was being retrieved in 2007 and will be disposed off-site 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 – The 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 IFSF, described above.

Advanced Test Reactor (TRA-670) – The ATR is located at the RTC. 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 FAST, as described above. The ATR canal is designated as a working facility rather than a storage facility. The ultimate disposition of ATR spent fuel may be either recycle or disposition in the repository.

Radioactive Scrap and Waste Facility (MFC-771) – The Radioactive Scrap and Waste Facility (RSWF) is located 0.5 miles north of the MFC perimeter fence. It is a fenced outdoor four-acre compound with over 1000 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 RSWF has been operated since 1964 for the dry storage of spent nuclear fuel 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 are also cathodically-protected from corrosion. As of December 2007, 20 metric tons (44,093 lb) of spent nuclear fuel, mostly from the deactivated Experimental Breeder Reactor-II (EBR-II), are stored in the steel pipe storage vaults.

Since 1996, 3.4 metric tons (7496 lb) of the original EBR-II inventory have been removed from the RSWF 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 an MFC facility known as the Transient Reactor Test Facility Warehouse. DOE is seeking to provide this extracted uranium to the commercial nuclear fuel fabrication industry for reuse. The two high-level waste forms are destined for the national geologic repository at Yucca Mountain, Nevada. The RSWF also stores mixed waste (primarily steel reactor components waste contaminated with sodium metal) and is managed under a RCRA hazardous waste storage permit.

Environmental Oversight and Monitoring Agreement

The 2005 Environmental Oversight and Monitoring Agreement 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 DOE activities in Idaho
- Assure citizens of Idaho that all 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 response, impact assessment, and public information. More information can be found on the Oversight Program website at http://www.deq.idaho.gov/.

Citizens Advisory Board

The INL Site Environmental Management Citizens Advisory Board, one of the EM Site Specific Advisory Boards, was formed in March 1994. Its charter is to provide input and recommendations on DOE EM site-specific topics. These topics include cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of non-stockpile 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 produced 135 recommendations during its tenure. More information about the Board's recommendations, membership, and meeting dates and topics can be found at http://www.inlemcab.org/.

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Chapter 4. Environmental Monitoring Programs (Air)


Townsend's Ground Squirrel

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T. Haney - Battelle Energy Alliance
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4. ENVIRONMENTAL MONITORING PROGRAMS (AIR)

This chapter presents the results of radiological and nonradiological analyses performed on airborne effluents and ambient air samples taken at locations both on the Idaho National Laboratory (INL) Site and offsite. Results from sampling conducted by the INL contractor, the Idaho Cleanup Project (ICP) contractor, and the Environmental Surveillance, Education and Research Program (ESER) contractor are presented. Results are compared to the U.S. Environmental Protection Agency (EPA) health-based levels established in environmental statutes and/or the U.S. Department of Energy Derived Concentration Guides (DCGs) for inhalation of air (Appendix A).

4.1 Purpose and Organization of Air Monitoring Programs

The facilities operating on the INL Site release both radioactive and nonradioactive constituents into the air. Various pathway vectors (such as air, soil, plants, animals, and groundwater) may transport radioactive and nonradioactive materials from the INL Site to nearby populations. These transport pathways have been ranked in terms of relative importance (EG&G 1993). The results of the ranking analysis indicate that air is the most important transport pathway. The INL Site environmental surveillance programs emphasize measurement of airborne contaminants because air has the potential to transport a large amount of radioactive and nonradioactive materials to a receptor in a relatively short period and can result in direct exposure to offsite receptors. Table 4-1 summarizes the air monitoring activities conducted at the INL Site.

The INL contractor monitors airborne effluents at individual INL Site facilities and ambient air outside the facilities to comply with applicable statutory requirements and DOE orders. The INL contractor collected approximately 2400 air samples (primarily on the INL Site) for analyses in 2007.

Table 4-1. Air Monitoring Activities by Organization.

Area/Facility[a]	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs								
	Airborne Effluents[b]	Low-Volume Charcoal Cartridges (iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation	Suspended Particulates	Filtered Particulates (PM_{10})[d]	IMPROVE samplers
INL & ICP Contractors: Battelle Energy Alliance (BEA) & CH2M-WG Idaho, LLC (CWI)										
INTEC	●									
MFC	●									
RWMC	●	●	●	●	●	●		●	●	
INL/Regional		●	●	●	●	●		●	●	
Naval Reactors Facility										
NRF[e]	●									
Environmental Surveillance, Education and Research Program										
INL/Regional		●	●	●	●	●	●	●	●	●[f]
National Oceanic and Atmospheric Administration										
INL/Regional						●	●	●	●	
INL Oversight Program Environmental Surveillance Program[g]										
INL/Regional		●	●	●	●	●	●		●	

a. CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, CITRC = Critical Infrastructure Test Range, RTC = Reactor Technology Complex, RWMC = Radioactive Waste Management Complex,

b. Facilities with stacks that required continuous monitoring during 2007 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. See footnote e.

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

d. PM_{10} = particles with an aerodynamic diameter less than or equal to 10 microns.

e. NRF is not required to continuously monitor any stack for NESHAP compliance. However, NRF has a number of stacks and vents with emissions that are monitored and calculated by NRF for confirmation that emissions continue to be below regulatory limits. The NRF source terms are included in the calculation of the annual dose to the public for NESHAP compliance (Chapter 8).

f. The IMPROVE samplers are operated by the National Park Service for the Environmental Protection Agency. This program, administered by the state of Idaho, generates data that can be used to verify and supplement the results reported by INL and ICP contractors and the Environmental Surveillance, Education and Research Program. The data are reported separately by the state of Idaho and are not reported in this chapter (Chapter 4).

The ESER contractor collects samples from approximately 23,309 km^2 (9000 mi^2) area of southeastern Idaho and Jackson, Wyoming, at locations on, around, and distant to the INL Site. The ESER Program collected approximately 2300 air samples, primarily off the INL Site, for analyses in 2007. Section 4.2 summarizes results of air monitoring by the INL and ESER contractors.

The ICP contractor monitors waste management activities on the Subsurface Disposal Area (SDA) at Radioactive Waste Management Complex (RWMC). Section 4.3 discusses air sampling performed by the ICP contractor in support of waste management activities.

The INL Oversight Program operates a series of air monitoring stations, often collected at locations used by the INL and ESER contractors. These results are presented in annual reports prepared by the Oversight Program and are not reported in Chapter 4.

Unless specified otherwise, the radiological results discussed in the following sections are those greater than three times the associated analytical uncertainty (see Appendix B for information on statistical methods). Each individual result is reported in tables as the measurement plus or minus one sigma analytical (± 1s) uncertainty for that radiological analysis.

4.2 Air Sampling

Airborne effluents are measured at or estimated for regulated facilities as required under the Idaho State Implementation Plan. Monitoring or estimating effluent data is the responsibility of programs associated with the operation of each INL Site facility and not the environmental surveillance programs.

Environmental surveillance of air pathways is the responsibility of the INL, ICP, and ESER contractors. Figure 4-1 shows the surveillance air monitoring locations for the INL Site environmental surveillance programs.

For onsite and offsite air surveillance monitoring, filters are collected weekly from a network of low-volume air monitors. Air flows (at an average of about 57 L/minute [2 ft^3/minute]) through a set of filters consisting of a 5 cm (2 in.), 1.2 µm pore membrane filter followed by a charcoal cartridge. The membrane filters are analyzed weekly for gross alpha and gross beta activity. Filters are then composited quarterly by location for analysis of gamma-emitting radionuclides using gamma spectrometry and for specific alpha- and beta-emitting radionuclides using radiochemical techniques. In addition to the membrane filter samples, charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) using gamma spectrometry.

There is no requirement to monitor the dust burden at the INL Site, but the INL contractor monitors this to provide comparison 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 their use in the field.

The ESER contractor also monitors particles with an aerodynamic diameter less than or equal to 10 microns (PM_{10}) to compare to EPA air quality standards.

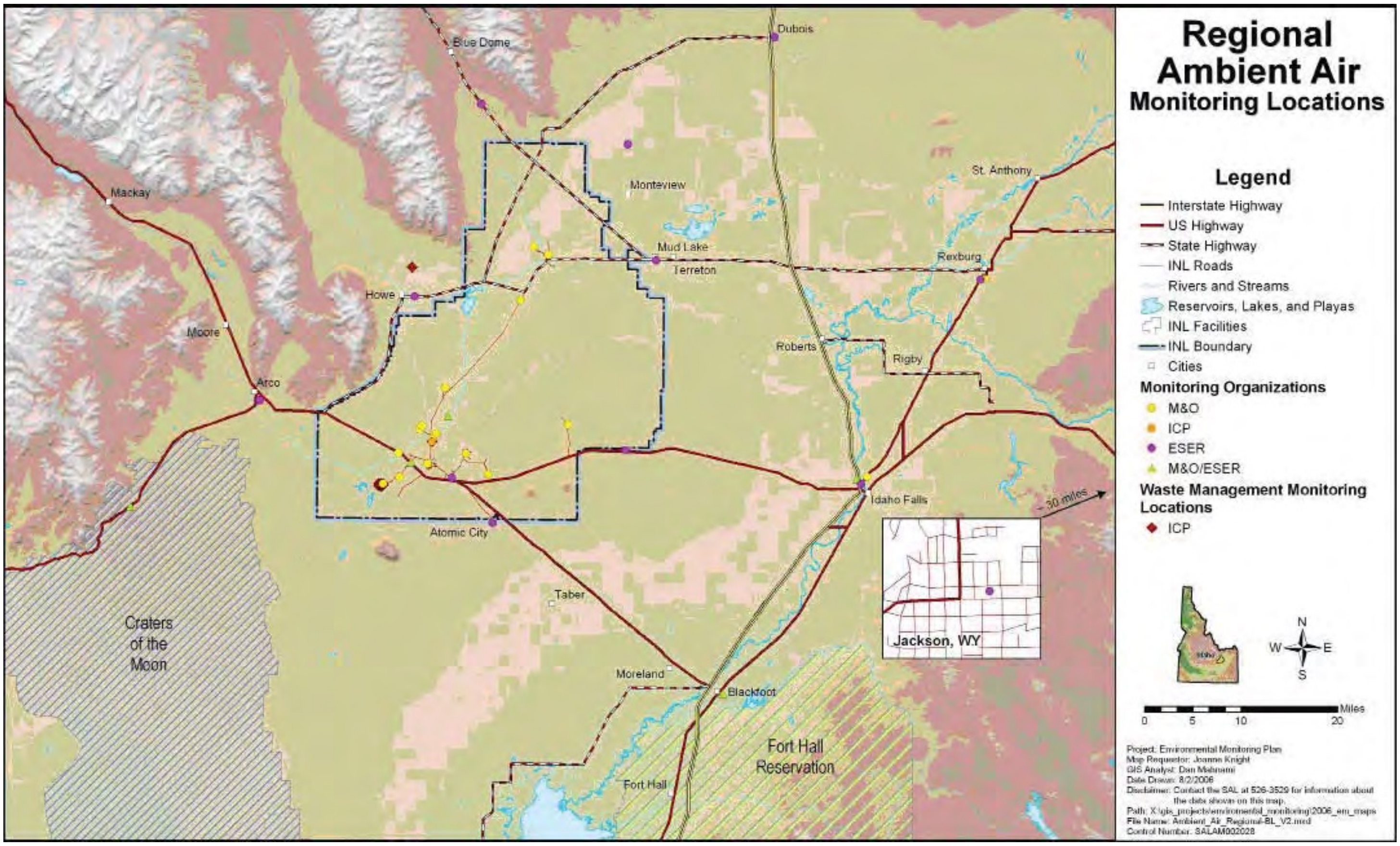


Figure 4-1. INL Site Environmental Surveillance Air Sampling Locations.

Tritium in atmospheric water vapor in ambient air is monitored by the INL and ESER contractors using samplers located at two onsite locations (Experimental Field Station [EFS] and Van Buren Boulevard) and five offsite locations (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 changed when the material adsorbs sufficient moisture to obtain a sample. Water is extracted from the material by distillation and collected. Tritium concentrations are then determined by liquid scintillation counting of the water extracted from the columns.

Airborne Effluents

During 2007 an estimated 4720 Ci of radioactivity were released to the atmosphere from all INL Site sources. The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Calendar Year 2007 INL Report for Radionuclides (DOE-ID 2008) describes three categories of airborne emissions. The first category includes sources that require continuous monitoring under the NESHAP regulation. The second category consists of releases from other point sources. The final category is nonpoint, or diffuse, sources. These include radioactive waste ponds and contaminated soil areas. All three categories are represented in Table 4-2 of this report. The INL Site dose was calculated using all sources that emitted radionuclides to the environment (DOE-ID 2008).

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2007).[a]

		Airborne Effluent (Ci)[a]							
Nuclide	Half-life	CFA[b]	CITRC[c]	INTEC[d]	MFC[e]	RTC[f]	RWMC[g]	TAN[h]	TOTAL
AC-227	21.7 y			3.25E-11		1.94E-08			1.94E-08
AC-228	6.15 h			1.10E-07		2.19E-06		4.57E-06	6.87E-06
AG-108	2.37 m					1.20E-12			1.20E-12
AG-108M	418 y			8.55E-06		2.48E-07		2.28E-06	1.11E-05
AG-110	24.6 s					5.83E-09			5.83E-09
AG-110M	249.9 d			8.00E-06		8.98E-07		0.000308	3.17E-04
AM-241	432.2 y	5.26E-10		7.43E-05		1.14E-05	9.98E-04	0.001535	2.62E-03
AM-242M	152 y			2.16E-08					2.16E-08
AM-243	7380 y	4.00E-13		4.49E-08		5.20E-04			5.20E-04
AM-244	432.2 y					5.54E-17			5.54E-17
AR-41	1.827 h				1.52E+00	7.34E+02			7.36E+02
BA-133	10.5 y					3.25E-09			3.25E-09
BA-137M	2.552 m			1.08E-02		4.28E-05	1.97E-07		1.09E-02
BA-139	82.7 m					2.19E-03			2.19E-03
BA-140	12.74 d					3.31E-07			3.31E-07
BA-141	18.3 m					1.15E-09			1.15E-09
BE-7	53.3 d						2.88E-12		2.88E-12
BE-10	1.6E6 y			1.09E-05		3.73E-07			1.13E-05
BI-207	38 y			1.39E-22					1.39E-22
BI-210	5 d					9.07E-10			9.07E-10
BI-211	2.1 m					1.95E-08			1.95E-08
BI-212	60.6 m			8.68E-08		2.19E-06	2.34E-09	3.61E-06	5.89E-06
BI-213	45.59 m								0.00E+00
BI-214	19.9 m			1.02E-07		3.04E-09		4.24E-06	4.35E-06
C-14	5730 y			4.02E-04		5.67E-04	4.71E-02	9.21E-07	4.81E-02
CD-109	462.6 d	2.35E-09							2.35E-09
CE-139	137.64 d	1.20E-10							1.20E-10
CE-141	32.5 d					8.89E-07			8.89E-07
CE-144	284.3 d			8.29E-09		6.34E-05	2.38E-09	1.1E-05	7.44E-05
CF-249	350.6 y			1.51E-09		2.98E-10			1.81E-09
CF-250	13.08 y					1.78E-08			1.78E-08
CF-251	898 y			8.03E-34					8.03E-34
CF-252	2.638 y					1.60E-04			1.60E-04
CL-36	3.01E5 y			3.83E-06		1.26E-07			3.96E-06
CM-242	162.8 d			2.34E-09		2.23E-09		2.6E-10	4.83E-09
CM-243	28.5 y			1.85E-08		5.12E-10		2.84E-08	4.74E-08

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2007).[a] (continued)

		Airborne Effluent (Ci)[a]							
Nuclide	Half-life	CFA[b]	CITRC[c]	INTEC[d]	MFC[e]	RTC[f]	RWMC[g]	TAN[h]	TOTAL
CM-244	18.11 y			9.33E-06		4.03E-07	4.73E-08	2.76E-08	9.81E-06
CM-245	8500 y			5.53E-09		6.05E-11			5.59E-09
CM-246	4730 y			7.31E-08		6.68E-11			7.32E-08
CM-247	1.6E7 y			7.11E-11		4.71E-16			7.11E-11
CM-248	3.45E5 y			3.82E-10		8.45E-15			3.82E-10
CM-250	6.9E3 y			1.91E-17					1.91E-17
CO-57	270.9 d	1.43E-09				1.08E-06			1.08E-06
CO-58	70.8 d			8.47E-08		4.77E-05		2.71E-07	4.80E-05
CO-60	5.271 y	2.59E-08		5.73E-02		6.04E-03	8.77E-09	0.000688	6.40E-02
CR-51	27.704 d					2.73E-03			2.73E-03
CS-132	6.475 d					2.95E-07			2.95E-07
CS-134	2.062 y	4.19E-09		2.58E-06		7.63E-06	9.74E-09	0.004264	4.27E-03
CS-134M	2.9 h								0.00E+00
CS-135	2.3E6 y			5.25E-12					5.25E-12
CS-137	30.0 y	2.30E-08	2.83E-02	3.91E-01		3.03E-03	1.98E-07	0.114644	5.37E-01
CS-138	32.2 m					2.56E-01			2.56E-01
EU-152	13.33 y			1.57E-02		6.13E-05		1.61E-06	1.58E-02
EU-154	8.8 y			1.17E-02		5.65E-05		0.000122	1.19E-02
EU-155	4.96 y			8.42E-05		1.65E-05		3.36E-07	1.01E-04
FE-55	2.7 y	3.98E-10		4.93E-09		3.23E-03	9.92E-11	2.3E-05	3.25E-03
FE-59	44.4529 d					3.70E-06			3.70E-06
FR-223	21.8 m					2.68E-10			2.68E-10
GD-153	240.4 d					6.43E-09			6.43E-09
H-3	12.35 y	1.95E+00		3.71E+02	2.35E+00	5.75E+02	2.15E+02	0.168516	1.17E+03
HF-175	70 d					1.36E-06			1.36E-06
HF-181	42.39 d					1.18E-05			1.18E-05
HG-203	46.6 d					3.55E-05			3.55E-05
I-125	60.1 d					1.10E-03			1.10E-03
I-128	24.99 m					7.30E-03			7.30E-03
I-129	1.57E7 y			4.66E-02		1.04E-04		1.59E-09	4.67E-02
I-131	8.04 d					1.56E-01			1.56E-01
I-132	2.3 h					1.45E-02			1.45E-02
I-133	20.8 h					5.35E-04			5.35E-04
I-134	52.6 m					4.90E-04			4.90E-04
I-135	6.61 h					3.15E-04			3.15E-04
IR-192	74.02 d					2.77E-07			2.77E-07
K-40	1.277E8 y			1.63E-06		2.11E-09	3.84E-12	6.77E-05	6.93E-05

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2007).[a] (continued)

		Airborne Effluent (Ci)[a]							
Nuclide	Half-life	CFA[b]	CITRC[c]	INTEC[d]	MFC[e]	RTC[f]	RWMC[g]	TAN[h]	TOTAL
KR-85	10.72 y			2.70E+03	1.65E+01	2.50E-01	6.02E-10		2.72E+03
KR-85M	4.48 h					7.94E+00			7.94E+00
KR-87	76.3 m					9.51E+00			9.51E+00
KR-88	2.84 m					1.06E+01			1.06E+01
MN-54	312.5 d	1.78E-09		7.74E-10		3.29E-04		7.99E-08	3.29E-04
MO-90	5.67 h					5.10E-05			5.10E-05
MO-99	66.0 h					1.05E-07			1.05E-07
NA-22	2.6 y					1.00E-07			1.00E-07
NA-24	15.0 h					3.17E-04			3.17E-04
NB-94	2.03E4 y			9.14E-05		4.93E-06		1.49E-06	9.78E-05
NB-95	35.15 d			7.97E-10		2.51E-04		3.28E-08	2.51E-04
NB-95M	86.6 h					4.73E-07			4.73E-07
NI-59	7.5E4 y			3.83E-03		1.42E-04		1.13E-05	3.98E-03
NI-63	96 y	1.44E-09		7.00E-01		2.53E-02	3.14E-10	0.002293	7.27E-01
NP-237	2.14E6y	1.50E-13		1.03E-06		2.05E-08		9.5E-10	1.06E-06
NP-239	2.355 d					8.99E-05			8.99E-05
P-32	14.262 d					4.77E-13			4.77E-13
PA-231	3.34E4 y			4.71E-11		4.65E-08			4.65E-08
PA-234	6.7 h					3.87E-05			3.87E-05
PB-210	22.3 y			1.75E-07		9.10E-10	8.67E-13	7.26E-06	7.44E-06
PB-211	36.1 m					1.95E-08			1.95E-08
PB-212	13.6 h			1.00E-07		1.40E-06	2.34E-09	0.000416	4.18E-04
PB-214	26.8 m			1.10E-07		3.04E-09		4.58E-06	4.69E-06
PD-107	6.5E6 y			1.34E-13					1.34E-13
PM-147	2.6234 y			9.73E-05		5.57E-04	2.40E-09		6.54E-04
PO-210	138.4 d					9.07E-10			9.07E-10
PO-211	0.516 s					5.35E-11			5.35E-11
PO-212	0.305 µs					1.40E-06	1.49E-09		1.40E-06
PO-214	164.3 µs					3.04E-09			3.04E-09
PO-215	0.00178 s					1.95E-08			1.95E-08
PO-216	0.15 s					2.19E-06	2.34E-09		2.19E-06
PO-218	3.05 m					3.04E-09			3.04E-09
PR-144	17.3 m						2.39E-09		2.39E-09
PU-236	2.9 y	2.50E-13		1.94E-16		3.16E-13			5.67E-13
PU-238	87.74 y	6.67E-11		1.47E-04		8.10E-06	1.02E-05	0.000167	3.32E-04
PU-239	24065 y	1.40E-10	2.83E-06	1.13E-03	3.48E-07	2.66E-05	5.49E-03	0.001511	8.16E-03
PU-240	6537 y			2.50E-04		6.79E-06	1.22E-03	4.27E-05	1.52E-03

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2007).[a] (continued)

		Airborne Effluent (Ci)[a]							
Nuclide	Half-life	CFA[b]	CITRC[c]	INTEC[d]	MFC[e]	RTC[f]	RWMC[g]	TAN[h]	TOTAL
PU-241	14.4 y			1.12E-02		2.82E-05	1.68E-05	0.000477	1.18E-02
PU-242	3.8E5 y	1.50E-13		5.61E-09		4.20E-10	9.13E-11	2.71E-10	6.40E-09
PU-244	8.3E7 y			4.51E-14		2.67E-16			4.54E-14
RA-223	11.4 d					2.27E-08			2.27E-08
RA-224	3.66 d					2.19E-06	2.34E-09		2.19E-06
RA-226	1600 y			1.23E-06		3.04E-09		5.79E-06	7.03E-06
RA-228	5.75 y			2.60E-21		2.19E-06			2.19E-06
RB-89	15.2 m					4.60E-02			4.60E-02
RE-188	17.005 h					1.96E-05			1.96E-05
RH-106	368.2 d			5.64E-20					5.64E-20
RN-219	3.96 s					1.95E-08			1.95E-08
RN-220	17.005 s					2.19E-06			2.19E-06
RN-222	3.8235 d					3.04E-09			3.04E-09
RU-103	39.26 d					8.34E-06			8.34E-06
RU-106	373.59 d			1.82E-08		3.54E-05		3.27E-05	6.81E-05
S-35	87.51 d					2.53E-08			2.53E-08
SB-122	2.7238 d					2.22E-06			2.22E-06
SB-124	60.2 d					5.45E-06			5.45E-06
SB-125	2.77 y			1.05E-05		1.86E-06	1.44E-10	0.000155	1.67E-04
SC-46	83.83 d					1.93E-06			1.93E-06
SM-151	90 y			3.61E-04		2.48E-06			3.64E-04
SN-113	115.09 d	4.43E-10							4.43E-10
SN-126	1E5 y			4.40E-12					4.40E-12
SR-85	64.84 d	4.26E-10				1.21E-07			1.21E-07
SR-89	50.5 d			5.22E-07		8.11E-07			1.33E-06
SR-90	29.12 y	4.21E-10		1.00E-01	6.53E-06	3.16E-04	1.78E-07	0.10578	2.07E-01
SR-91	9.5 h					1.03E-10			1.03E-10
SR-92	2.7 h					1.90E-10			1.90E-10
TA-182	114.43 d					3.10E-06			3.10E-06
TA-183	5.1 d					6.13E-16			6.13E-16
TC-99	2.13E5 y			2.23E-05		3.21E-08		1.39E-09	2.23E-05
TC-99M	6.02 h					7.55E-05			7.55E-05
TE-125M	58 d			6.67E-08					6.67E-08
TH-227	18.7 d					1.92E-08			1.92E-08
TH-228	1.9116 y			5.37E-09		2.19E-06	2.34E-09		2.20E-06
TH-229	7340 y			3.85E-11		3.96E-11			7.81E-11
TH-230	7.7E4 y			1.99E-11		5.53E-07			5.53E-07

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2007).[a] (continued)

		Airborne Effluent (Ci)[a]							
Nuclide	**Half-life**	**CFA[b]**	**CITRC[c]**	**INTEC[d]**	**MFC[e]**	**RTC[f]**	**RWMC[g]**	**TAN[h]**	**TOTAL**
TH-231	25.5 h					5.84E-05			5.84E-05
TH-232	1.405E10 y	1.81E-13		1.03E-10		2.25E-06	6.42E-10		2.25E-06
TH-234	24.1 d			6.45E-08		3.86E-05		2.68E-06	4.13E-05
TL-206	4.2 m					1.15E-15			1.15E-15
TL-207	4.77 m					1.94E-08			1.94E-08
TL-208	3.07 m			2.81E-08		7.87E-07	8.37E-10	1.17E-06	1.98E-06
U-232	72 y	2.50E-13		5.12E-09		8.49E-08	2.28E-09		9.23E-08
U-233	1.585E5 y			3.11E-07		3.01E-08	8.95E-08	1.94E-05	1.99E-05
U-234	2.457E5 y	1.30E-10		9.91E-07		1.09E-03	5.08E-10	1.68E-05	1.11E-03
U-235	7.038E8 y	1.51E-14		3.44E-06		5.84E-05		5.41E-05	1.16E-04
U-236	4.468E9 y			1.54E-08		1.47E-05		6.23E-07	1.53E-05
U-238	4.5E9 y	1.38E-10		1.33E-06	1.06E-10	3.87E-05		1.05E-05	5.05E-05
W-187	23.9 h					4.35E-06			4.35E-06
XE-131M	11.8 d					3.00E-07			3.00E-07
XE-133	5.245 d					1.32E+01			1.32E+01
XE-133M	5.2 d					1.00E+00			1.00E+00
XE-135	9.09 h					4.26E+01			4.26E+01
XE-135M	15.29 m					7.30E-06			7.30E-06
XE-138	14.17 m					9.97E+00			9.97E+00
Y-88	106.64 d	9.05E-10							9.05E-10
Y-90	64.0 h			2.30E-03		3.89E-06	1.78E-07		2.31E-03
ZN-65	243.9 d	3.29E-09		3.47E-08		9.39E-05		9.81E-07	9.49E-05
ZR-93	1.5E6 y			7.80E-12					7.80E-12
ZR-95	63.98 d			5.23E-06		0.000108		8.87E-06	1.22E-04
Total		1.95E+00	2.83E-02	3.08E+03	2.04E+01	1.41E+03	2.16E+02	4.01E-01	4.72E+03

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

The largest facility contributions to the total emissions came from the Idaho Nuclear Technology and Engineering Center (INTEC) at 65 percent, Reactor Technology Complex (RTC) at approximately 30 percent, the Materials and Fuels Complex (MFC) at 0.4 percent, and the RWMC at 5 percent (Table 4-2). Approximately 75 percent of the radioactive effluent was in the form of noble gases (argon, krypton, and xenon) and most of the remaining effluent was tritium.

Low-Volume Charcoal Cartridges

Both the ESER and INL Site contractors collected charcoal cartridges weekly 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 2007, the ESER contractor analyzed 936 cartridges, looking specifically for ^{131}I. No ^{131}I was detected in any of the individual ESER samples.

The INL Site contractor collected and analyzed 1140 cartridges in 2007. Iodine was not detected in excess of the 3-sigma value in any sample.

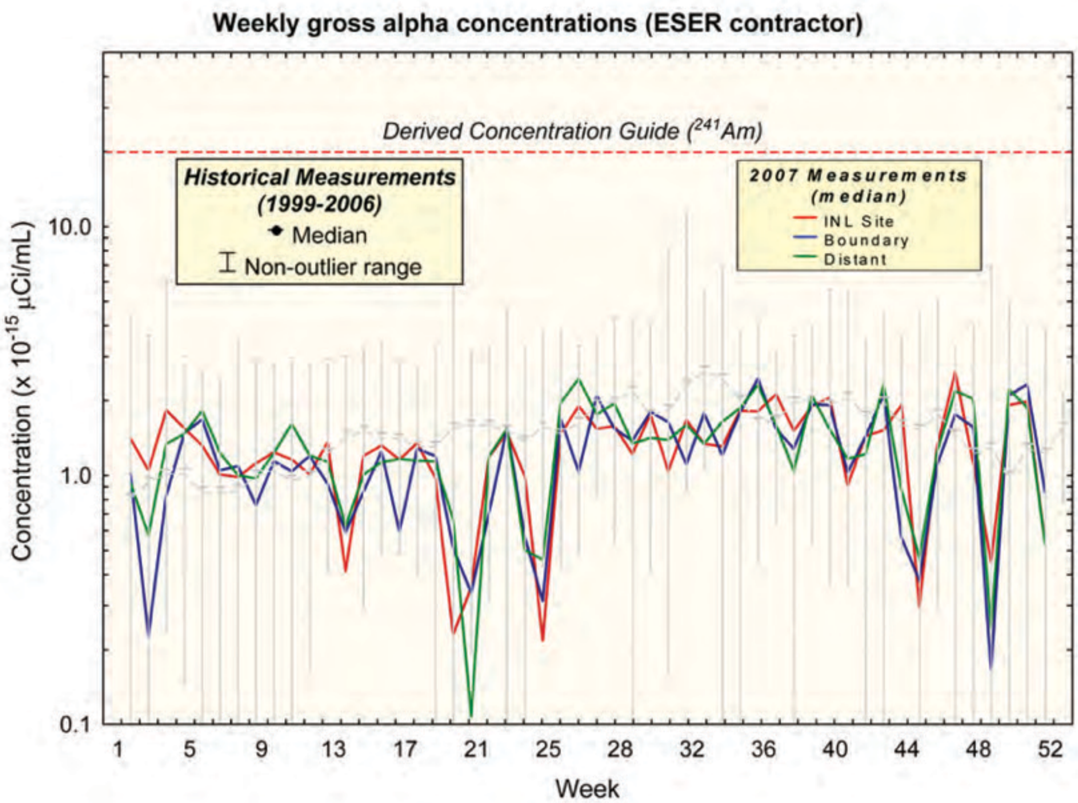
Low-Volume Gross Alpha

Particulates filtered from the air were sampled weekly as part of the INL Site environmental surveillance programs (see Figure 4-1). All were analyzed for gross alpha activity and gross beta activity. There was little difference between ESER and INL contractor data. Both sets of data indicated gross alpha concentrations at onsite locations were generally equal to or lower than concentrations at boundary locations.

Weekly gross alpha concentrations detected in valid ESER contractor samples (i.e., measurements which exceeded their associated 3-sigma uncertainties) ranged from a minimum of 0.45×10^{-15} µCi/mL at Rexburg during the week ending December 27, 2007, to a maximum of 5.0×10^{-15} µCi/mL during the week ending May 2, 2007, at Blue Dome. Concentrations measured by the INL contractor that exceeded their 3-sigma uncertainty ranged from a low of 8.0×10^{-15} µCi/mL collected at Craters of the Moon on January 3, 2007, to a high of 8.9×10^{-15} µCi/mL collected at Rexburg on March 7, 2007.

Figure 4-2 displays the median weekly gross alpha concentrations for the ESER and INL contractors at onsite, boundary, and distant station groups. It also shows historical medians and ranges measured by the ESER contractor from 1996-2006. Each weekly median was computed using all measurements, including those less than their associated 3-sigma uncertainties. These data are typical of the annual natural fluctuation pattern for gross alpha concentrations in air. According to Figure 4-2, the highest median weekly concentration of gross alpha was measured by the ESER contractor for the onsite in the third quarter of 2007. The maximum median weekly gross alpha concentration was 3.7×10^{-15} µCi/mL and is below the DCG for the most restrictive alpha-emitting radionuclide in air (americium-241 [^{241}Am]) of 20×10^{-15} µCi/mL.

Annual median gross alpha concentrations calculated by the ESER contractor ranged from 1.2×10^{-15} µCi/mL at Blue Dome to 1.9×10^{-15} µCi/mL at Idaho Falls (Table 4-3). Confidence intervals are not calculated for annual medians. Annual median gross alpha concentrations calculated by the



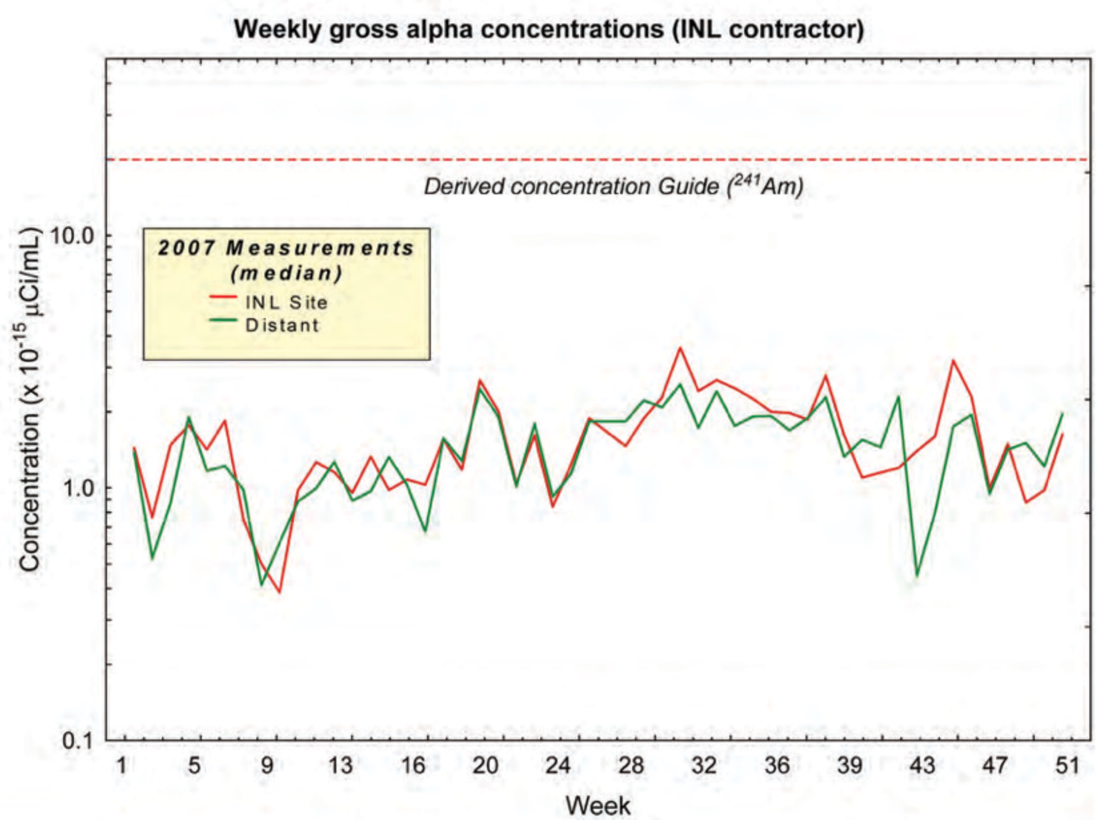


Figure 4-2. Median Weekly Gross Alpha Concentrations in Air (2007).

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2007).[a]

ESER Contractor Data			Concentration[a,b]	
Group	**Location**	**No. of Samples[c]**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS[d]	52	0.69 – 3.5	1.7
	Craters of the Moon	52	0.16 – 4.3	1.2
	Dubois	46	0.00 – 4.1	1.4
	Idaho Falls	52	0.49 – 4.0	1.9
	Jackson	48	-0.24 – 4.0	1.6
	Rexburg CMS	52	-0.10 – 3.1	1.5
			Distant Median:	1.6
Boundary	Arco	51	0.29 – 4.0	1.5
	Atomic City	50	0.52 – 3.3	1.6
	Blue Dome	51	0.40 – 5.0	1.2
	Federal Aviation Administration Tower	42	0.00 – 5.2	1.3
	Howe	52	0.46 – 4.0	1.5
	Monteview	52	0.43 – 4.1	1.8
	Mud Lake	51	016 – 3.6	1.6
			Boundary Median:	1.4
INL Site	EFS	52	0.11 – 3.7	1.4
	Main Gate	50	0.30 – 3.8	1.5
	Van Buren	52	0.38 – 3.3	1.5
			INL Site Median:	1.5
INL Contractor Data			**Concentration[a,b]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	51	0.26 - 2.5	1.4
	Craters of the Moon	51	0.30 - 3.6	1.2
	Idaho Falls	51	0.23 - 3.4	1.5
	Rexburg	51	0.52 - 8.9	1.5
			Distant Median	1.4
INL Site	MFC (formerly ANL-W)	51	-0.18 - 4.2	1.2
	ARA	45	0.006 - 4.4	1.4
	CFA	51	0.13 - 4.1	1.4
	CPP	50	0.23 - 4.6	1.3
	EBR-I[d]	51	0.3 - 5.1	1.4
	EFS	49	0.14 - 4.1	1.7
	Gate 4	51	0.005 - 3.9	1.5
	INTEC	50	0.30 - 3.8	1.5
	NRF	51	0.004 - 3.4	1.6
	CITRC (formerly PBF)	51	0.39 - 6.7	1.4
	Rest Area	13	0.43 - 3.0	1.5
	RTC (formerly TRA)	51	0.20 - 3.5	1.5
	RTC (NE corner)	47	0.32 - 4.8	1.5
	RWMC	50	0.11 - 4.1	1.5
	SMC	51	0.23 - 4.0	1.5
	TAN	51	0.0 - 3.7	1.4
	Van Buren	45	0.40 - 3.8	1.6
			INL Site Median	1.5

a. All values are × 10^{-15} µCi/mL.
b. All measurements, including those less than three times their analytical uncertainty, are included in this table and in computation of annual median values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. Includes valid samples only. Does not include duplicate measurements taken at EFS and Mud Lake.
d. CMS = Community Monitoring Station; EBR-I = Experimental Breeder Reactor No. 1

INL contractor ranged from 1.2 × 10^{-15} µCi/mL at the Craters of the Moon to 1.7 × 10^{-15} µCi/mL at the EFS. In general, gross alpha concentrations were typical of those detected previously and well within the range of measurements observed historically for the eleven-year period from 1996 through 2007 (Figure 4-3).

Low-Volume Gross Beta

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

Weekly gross beta concentrations detected in ESER contractor samples ranged from a low of 0.8 × 10^{-14} µCi/mL on January 10, 2007, at Jackson to a high of 12.3 × 10^{-14} µCi/mL at Monteview on November 28, 2007 (Table 4-4). Concentrations measured above 3-sigma by the INL contractor ranged from a low of 5.9 × 10^{-16} µCi/mL at CFA on December 5, 2007, to a high of 9.6 × 10^{-14} µCi/mL at Rexburg on March 7, 2007.

Figure 4-4 displays the median weekly gross beta concentrations for the ESER and INL contractors at INL Site, boundary, and distant station groups, as well as historical median and range data measured by the ESER contractor from 1996-2007. These data are typical of the annual natural fluctuation pattern for 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 2007 by the INL contractor on the INL Site. Each median value was calculated using all measurements, including those less than their associated 3-sigma uncertainties. The maximum weekly median gross beta concentration was 10.7 × 10^{-14} µCi/mL and is significantly below the DCG of 300 × 10^{-14} µCi/mL for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

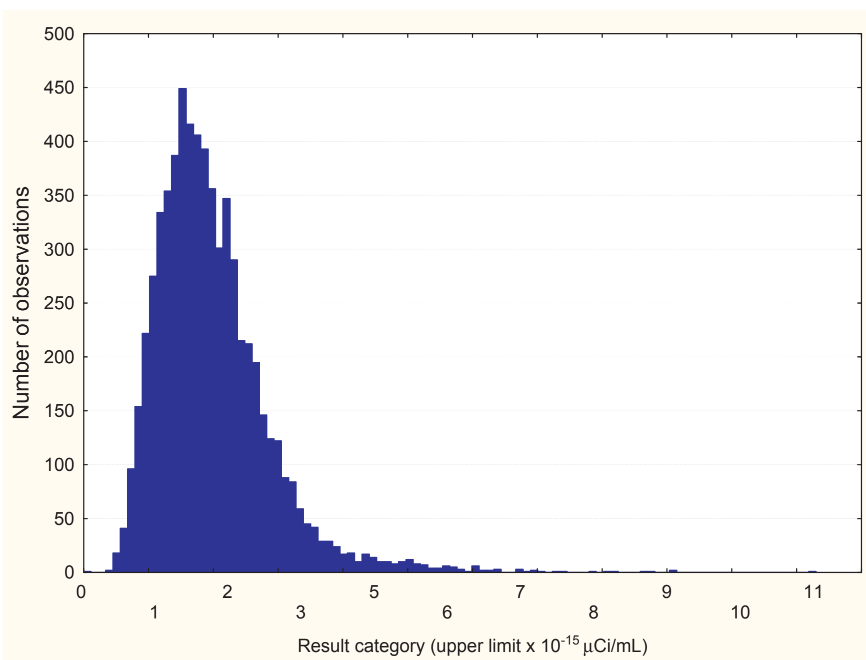


Figure 4-3. Frequency Distribution of Gross Alpha Activity Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor From 1996 Though 2007.

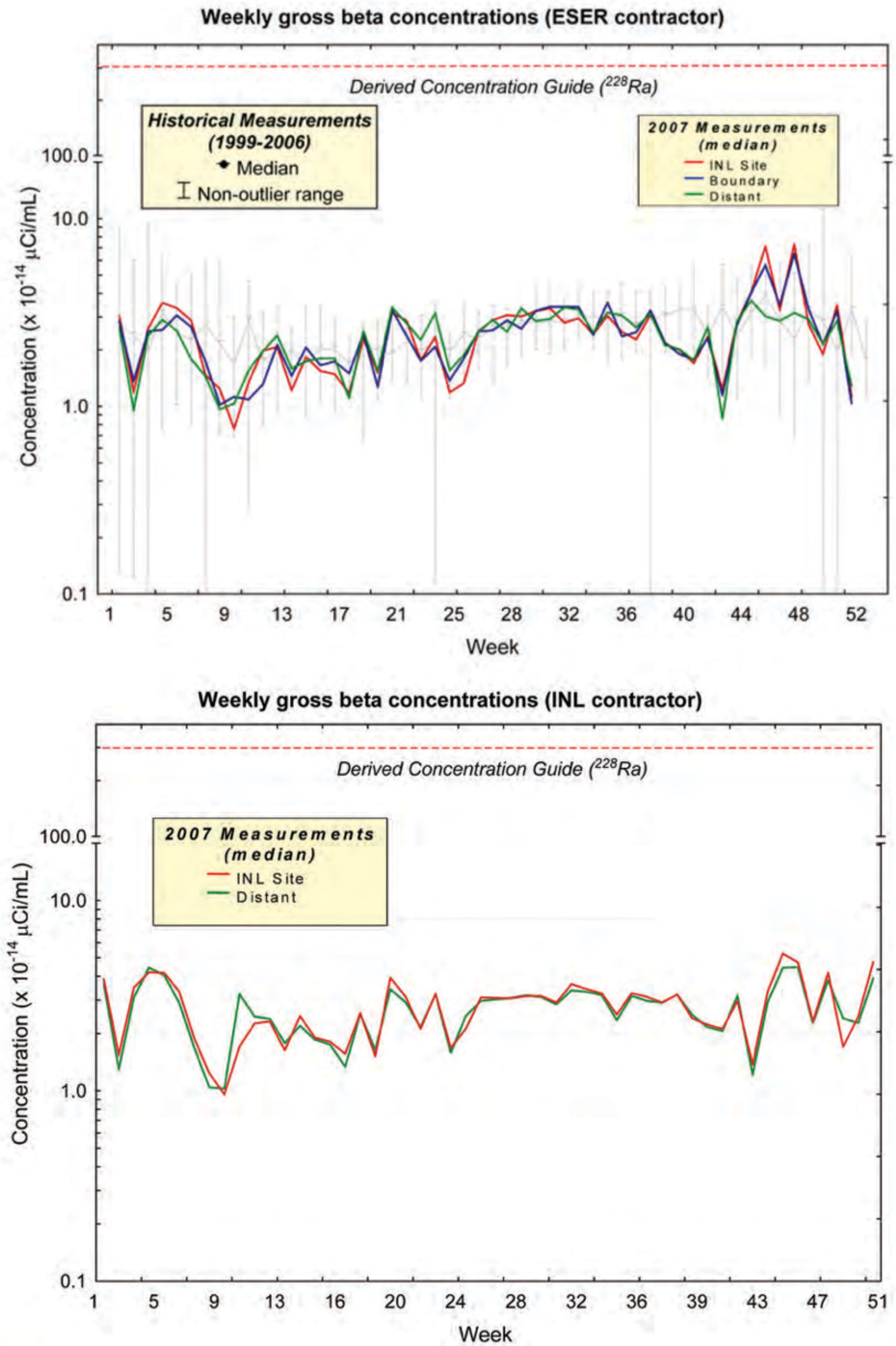


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2007).

ESER contractor annual median gross beta concentrations ranged from 2.6 × 10^{-14} μCi/mL at Blue Dome and Dubois to 3.2 × 10^{-14} μCi/mL at Atomic City. INL contractor data ranged from an annual median of 2.5 × 10^{-14} μCi/mL at the RWMC to 3.4 × 10^{-14} μCi/mL at the Rest Area. In general, the levels of airborne radioactivity for the three groups (onsite, 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 eleven years (Figure 4-5). This indicates that the pattern of fluctuations occurring over the entire sampling network is representative of natural conditions and is not caused by a localized source such as a facility or activity at the INL Site.

Statistical Comparisons

Gross beta concentrations, unlike gross alpha concentrations, are typically detected above the 3-sigma uncertainty levels. They can vary widely from location to location as a result of a variety of factors, such as local 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 cause for the differences, including a possible INL Site release.

Statistical comparisons were made using the gross beta radioactivity data collected from the onsite, boundary, and distant locations (see Appendix B for a description of statistical methods). Figure 4-6 is a graphical comparison of all gross beta concentrations measured during 2007 by the ESER contractor. The results are grouped by location (that is, onsite, boundary, and distant stations). Looking at the graph, there appeared to be no 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, concentrations of contaminants would be statistically greater at boundary locations than at distant locations. There were no statistical differences between annual concentrations collected from onsite, boundary, and distant locations in 2007.

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2007. The differences observed can be attributed to expected statistical variation in the data.

INL contractor onsite and distant data sets were compared and there were no statistical differences between data obtained from onsite and distant locations.

Specific Radionuclides in Air

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 there has been no discernable pattern with respect to time or location. Americium-241 was again detected in three quarterly composited samples collected onsite at EFS and at boundary locations Howe and Mud Lake in 2007. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past ten years is shown in Figure 4-7. The results detected in 2007 are within the range measured historically and well below the ^{241}Am DCG of 20,000 × 10^{-18} μCi/mL.

Table 4-4. Median Annual Gross Beta Concentrations in Air (2007).[a]

ESER Contractor Data			Concentration[a,b]	
Group	**Location**	**No. of Samples[c]**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS[d]	52	1.1 - 11	2.9
	Craters of the Moon	52	0.92 - 11	2.8
	Dubois	46	0.0 - 10	2.6
	Idaho Falls	52	1.2 - 11	3.1
	Jackson	48	0.83 - 7.7	2.9
	Rexburg CMS	52	1.1 - 9.8	3.1
			Distant Median:	2.2
Boundary	Arco	51	1.2 - 11	3.1
	Atomic City	50	1.0 - 12	3.2
	Blue Dome	51	1.0 - 9.0	2.6
	Federal Aviation Administration Tower	42	0.0 - 11	2.9
	Howe	52	1.2 - 12	2.9
	Monteview	52	1.2 - 12	2.9
	Mud Lake	51	1.3 - 12	3.1
			Boundary Median:	2.2
INL Site	EFS	52	1.0 - 12	3.1
	Main Gate	50	0.94 - 12	3.0
	Van Buren	52	1.1 - 11	3.0
			INL Site Median:	3.0
M&O Contractor Data			**Concentration[a,b]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	51	0.92 - 4.6	2.7
	Craters of the Moon	51	0.90 - 5.4	2.7
	Idaho Falls	51	0.87 - 5.3	2.7
	Rexburg	51	0.98 - 9.6	2.9
			Distant Median	2.8
INL Site	MFC (formerly ANL-W)	51	1.0 - 4.9	2.7
	ARA	45	0.74 - 4.3	2.6
	CFA	51	0.59 - 5.4	2.9
	CPP	51	0.97 - 5.6	2.8
	EBR-I[d]	51	0.73 - 5.2	3.0
	EFS	49	1.0 - 5.4	3.0
	Gate 4	51	1.2 - 5.1	2.8
	INTEC	50	1.0 - 5.5	2.9
	NRF	51	0.94 - 5.3	2.8
	CITRC (formerly PBF)	51	0.69 - 5.7	2.8
	Rest Area	13	0.84 - 5.0	3.4
	RTC (NE corner)	51	0.94 - 4.2	2.7
	RWMC	47	1.1 - 5.4	2.9
	SMC	50	0.0 - 5.0	2.5
	TAN	51	1.0 - 5.7	2.8
	RTC (formerly TRA)	51	1.2 - 5.2	3.0
	Van Buren	45	0.34 - 5.1	2.9
			INL Site Median	2.8

a. All values are × 10^{-14} μCi/mL.
b. All measurements, including those less than three times their analytical uncertainty, are included in this table and in computation of annual median values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. Includes valid samples only. Does not include duplicate measurements taken at EFS and Mud Lake.
d. CMS = Community Monitoring Station; EBR-I = Experimental Breeder Reactor No. 1.

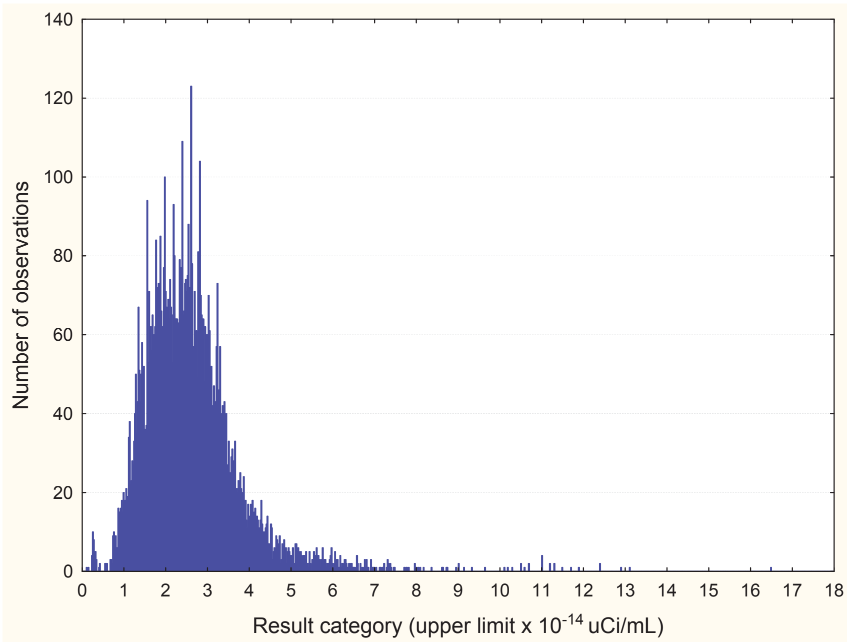


Figure 4-5. Frequency Distribution of Gross Beta Activity Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor From 1996 Through 2007.

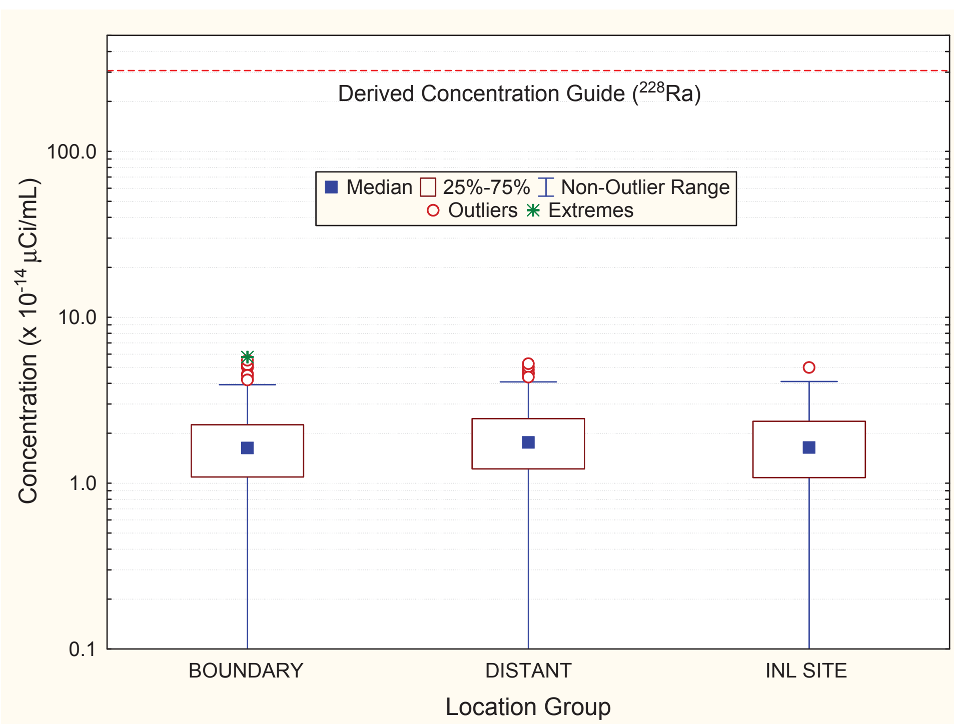


Figure 4-6. Comparisons of Gross Beta Concentrations Measured in Air at Distant, Boundary, and INL Site Locations by the ESER Contractor (2007).

Table 4-5. Human-made Radionuclides on ESER Contractor Quarterly Composite Air Samples (2007).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}Pu$	^{90}Sr
First Quarter 2007					
Blackfoot	ND[b]	ND	ND	4.2 ± 1.0	ND
EFS	ND	1.9 ± 0.50	ND	ND	ND
Monteview	541 ± 125.	ND	ND	ND	ND
Mud Lake (rep)	492 ± 126	ND	ND	ND	ND
Rexburg	ND	ND	3.4 ± 0.75	ND	ND
Second Quarter 2007					
Atomic City	ND	ND	ND	ND	286 ± 31
FAA Tower	ND	ND	16 ± 2	ND	ND
Idaho Falls	ND	ND	8.9 ± 1.5	5.5 ± 1.2	ND
Main Gate	ND	35 ± 5.6	ND	ND	ND
Rexburg	ND	ND	ND	ND	62 ± 19
Van Buren	ND	ND	ND	11 ± 1.5	ND
Third Quarter 2007					
Main Gate	ND	ND	ND	ND	44 ± 14
Fourth Quarter 2007					
FAA Tower	842 ± 202	5.7 ± 1.7	ND	ND	ND
Idaho Falls	ND	2.0 ± 0.12	ND	ND	ND
Monteview	630 ± 177	ND	ND	ND	ND
Mud Lake (rep)	ND	2.0 ± 0.65	ND	ND	ND
Van Buren	ND	14 ± 1.8	33 ± 3.7	8.5 ± 1.6	ND

a. Concentrations shown are: Result x 10^{-18} µCi/mL air ± 1s analytical uncertainty.
b. ND = Not detected. Result < 3σ.

Table 4-6. Human-made Radionuclides in INL Site Contractor Quarterly Composited Air Samples (2007).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	^{90}Sr
First Quarter 2007				
CFA	ND[b]	19 ± 4.6	ND	ND
EBR-1	ND	11 ± 3.5	ND	ND
Van Buren	ND	13 ± 4.0	ND	ND
Second Quarter 2007				
EBR-1	ND	ND	ND	1880 ± 393
EFS	ND	ND	ND	1140 ± 360
Gate 4	ND	ND	ND	1010 ± 313
Idaho Falls	ND	ND	ND	3510 ± 439
RWMC	ND	14 ± 4.4	ND	ND
Third Quarter 2007				
ANL	ND	22 ± 5.3	ND	ND
CFA	ND	22 ± 5.5	ND	ND
INTEC	ND	ND	14 ± 4.4	ND
Fourth Quarter 2007				
RWMC	ND	8.3 ± 2.7	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.)

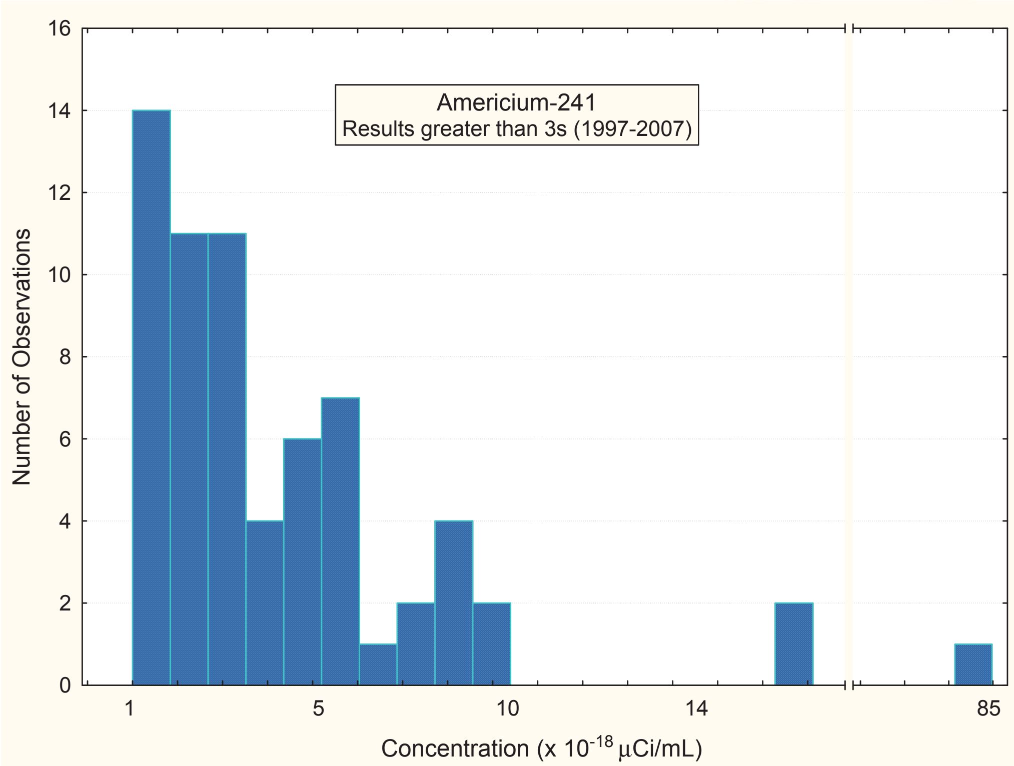


Figure 4-7. Frequency Distribution of ^{241}Am Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor From 1997 Through 2007.

Plutonium isotopes were detected in some onsite and boundary ESER samples in 2007. Valid plutonium-239/240 ($^{239/240}Pu$) concentrations measured historically in ESER samples are consistent with worldwide levels related to atmospheric nuclear weapons testing and are well within past measurements (Figure 4-8).

Strontium-90 (^{90}Sr) was detected in two onsite and three boundary ESER samples within the range of historical measurements (Figure 4-9). The values measured are much below the DCG of 9,000,000 × 10^{-18} µCi/mL.

Cesium-137 (^{137}Cs) was detected in four ESER samples at onsite, boundary and distant locations. All were well with historical measurements and below the DCG.

The INL contractor detected ^{241}Am in four samples. The detections showed no temporal or spatial pattern and concentrations were within the range of historical results. Low concentrations of ^{90}Sr were detected in four air samples from the second quarter; however the concentration of ^{90}Sr in the associated blank (which should have been a non-detect) was equivalent to those reported in the field samples. Therefore, the likely source of the ^{90}Sr was external contamination introduced in the sampling, handling, or analytical process and not an air concentration. A review of site operations for this period showed no abnormal release events.

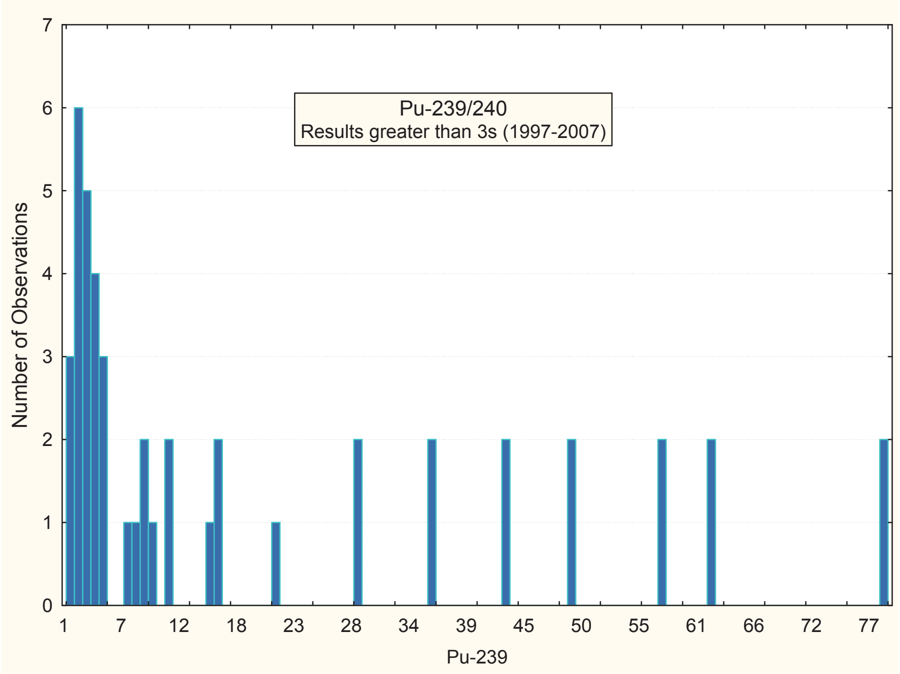


Figure 4-8. Frequency Distribution of $^{239/240}Pu$ Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor From 1997 Through 2007.

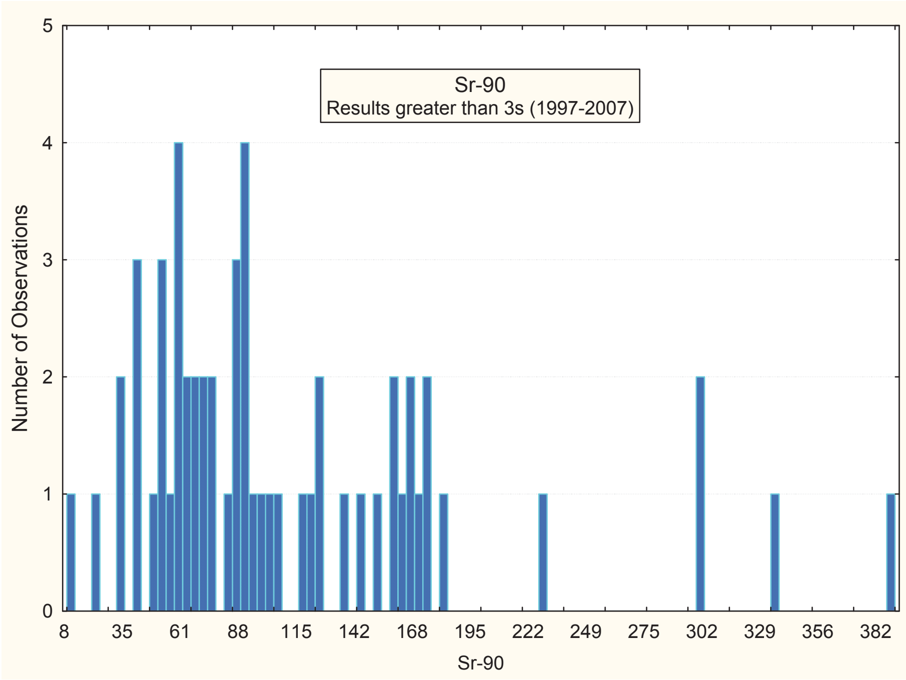


Figure 4-9. Frequency Distribution of ^{90}Sr Detected Above the 3-Sigma Uncertainty in Air Filters Collected by the ESER Contractor from 1997 through 2007.

Mercury-203 (^{203}Hg), plutonium-238 (^{238}Pu), and sodium-22 (^{22}Na) were each detected in single, separate INL contractor air filter composite samples within the 1997-2006 range of values. The ^{203}Hg was detected at a concentration of approximately 2.1×10^{-12} µCi/L in a sample collected March 28, 2007, from Location A, which is colocated with the Test Area North (TAN) monitor. Mercury-203 was not detected at the colocated TAN monitor during the same sample period. The ^{238}Pu was detected at a concentration of approximately 1.4×10^{-14} µCi/L in a sample collected on October 8, 2007, from INTEC. The ^{22}Na was detected at a concentration of approximately 1.4×10^{-12} µCi/L in a sample collected October 8, 2007, from the EFS. Pinpointing the sources even of high concentrations of common radionuclides can be difficult. For these trace concentrations, determining the source is virtually impossible. The INL will continue monitoring for these and other radionuclides.

Isotopes of uranium (^{234}U, ^{235}U, or ^{238}U), lead-210 (^{210}Pb), and beryllium-7 (^{7}Be) were detected in numerous INL contractor quarterly composites at levels which are within background levels. Detected ^{7}Be concentrations ranged from 6×10^{-14} to 3×10^{-9} µCi/L. Lead-210 concentrations detected in samples ranged from 2 to 3×10^{-11} µCi/L. Uranium-234 was detected most frequently (in 30 percent of the samples) and ranged in concentration from 1 to 3×10^{-14} µCi/L, well within background levels.

Atmospheric Moisture

During 2007 the ESER contractor collected 65 atmospheric moisture samples from four locations (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 54 of the samples. Samples that exceeded the respective 3-sigma uncertainties ranged from a low at Rexburg of 3.0×10^{-13} µCi/mL to a high of 17×10^{-13} µCi/mL at Idaho Falls.

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

Table 4-7. Tritium Concentrations in ESER Contractor Atmospheric Moisture Samples (2007).

	Range[a]			
Location	**First Quarter**	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
Atomic City	4.7 ± 1.0 – 8.0 ± 1.0	6.3 ± 1.1 – 9.3 ± 1.6	4.7 ± 1.4 – 15 ± 2.0	ND[b]
Blackfoot	4.2 ± 1.0 – 6.4 ± 1.4	6.2 ± 1.2 – 12 ± 2.4	9.2 ± 1.8 – 13 ± 2.6	8.3 ± 2.0[c]
Idaho Falls	3.5 ± 1.1 – 6.5 ± 0.89	8.2 ± 1.4 – 15 ± 2.9	9.7 ± 2.5 – 17 ± 2.8	ND
Rexburg	3.0 ± 0.85 – 6.8 ± 1.2	6.0 ± 1.2 – 11 ± 2.7	6.4 ± 2.0 – 9.7 ± 2.7	ND

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{-13} µCi/mL.)
b. ND = Not detected (result < 3s analytical uncertainty or result not valid.)
c. When a single value is reported, tritium was detected in only one sample.

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.

The INL contractor collected atmospheric moisture samples at the EFS and at Van Buren Boulevard on the INL Site and at Idaho Falls and off the INL Site (Table 4-8). During 2007, 43 samples were collected. Tritium detected above the 3-sigma uncertainty ranged from a low of 2.7 × 10^{-13} µCi/mL at Idaho Falls to a high of 1.2 × 10^{-12} µCi/mL at Van Buren Boulevard. All values are less than the DCG for tritium in air.

Precipitation

The ESER contractor collects precipitation samples weekly at the EFS and monthly at the Central Facilities Area (CFA) and offsite in Idaho Falls. A total of 37 precipitation samples were collected during 2007 from the three sites. Tritium concentrations were measured above the 3-sigma uncertainty level in 32 samples and results ranged from 100 to 331 pCi/L. Table 4-9 shows the maximum concentration by quarter for each location. The highest radioactivity was from a sample collected at EFS during the second quarter and is far below the DCG level for tritium in water of 2 × 10^6 pCi/L. The concentrations are well within the normal range observed historically at the INL Site. The maximum concentration measured since 1998 was 553 pCi/L, measured at the EFS in 2000. The results are also well within measurements made by the EPA in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past ten years (http://www.epa.gov/enviro/html/erams/).

Table 4-8. Tritium Concentrations in INL Contractor Atmospheric Moisture Samples (2007).

	Range[a]		
Location	**First Quarter**	**Second Quarter**	**Third Quarter**
	First Quarter 2007		
EFS	ND[b]	3.3 ± 1.0 – 4.5 ± 1.1	7.6 ± 1.9[c]
Van Buren	ND	ND	12 ± 2.8
Idaho Falls	ND	2.7 ± 8.9	ND

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{-13} µCi/mL.)
b. ND = Not detected (result < 3s analytical uncertainty or result not valid.)
c. When a single value is reported, tritium was detected in only one sample.

Table 4-9. Tritium Concentrations in ESER Contractor Precipitation Samples (2007).

	Range[a]			
Location	**First Quarter**	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
CFA	125 ± 31 – 126 ± 31	147 ± 31 – 167 ± 31	138 ± 33 – 295 ± 34	107 ± 33 – 196 ± 34
EFS	100 ± 30 – 192 ± 32	182 ± 33 – 331 ± 35	165 ± 33 – 207 ± 34	183 ± 33 – 270 ± 35
Idaho Falls	119 ± 31 – 123 ± 31	145 ± 32 – 200 ± 32	164 ± 31[b]	100 ± 32

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{13} µCi/mL.)
b. When a single value is reported, tritium was detected in only one sample.

Suspended Particulates

In 2007, both the 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.

Annual particulate concentrations from ESER contractor samples ranged from 6.3 µg/m^3 at Federal Aviation Administration (FAA) Tower to 26.8 µg/m^3 at Idaho Falls. In general, particulate concentrations were higher at distant locations than at the onsite stations. This is mostly influenced by agricultural activities in offsite areas.

The weekly total suspended particulate concentrations measured by the INL contractor ranged from 0.0 µg/m^3 at numerous locations and dates to 246 µg/m^3 at the RTC during the April 11 through April 18, 2007, sample period.

Filtered Particulates

The EPA's annual air quality standard was historically based on concentrations of "particles with an aerodynamic diameter less than or equal to 10 microns" (PM_{10}) (40 CFR Part 50.6). Particles of this size can reach the lungs and were considered to be responsible for most of the adverse health effects associated with airborne particulate pollution. Until October 2006, the air quality standards for PM_{10} were an annual average of 50 µg/m^3, with a maximum 24-hour concentration of 150 µg/m^3. The EPA revoked the annual PM_{10} standard because current evidence does not suggest a link between long-term inhalation of coarse particles and health problems. However, it retained the maximum 24-hr PM_{10} concentration to protect the public from short-term exposure to inhalable coarse particles. It also strengthened the 24-hr standard for fine particles less than or equal to 2.5 microns ($PM_{2.5}$) from 65 µg/m^3 to 5 µg/m^3 and retained the annual $PM_{2.5}$ standard of 15 µg/m^3.

The ESER contractor collected 43 valid 24-hour PM_{10} samples at Rexburg, Blackfoot, and Atomic City from January through March 2007. A valid sample is one that has run for the proper length of time (24 hours continuously) and that has a beginning weight less than the ending weight (does not yield a negative weight). Concentrations of PM_{10} particulates collected at Rexburg ranged from 1.8 to 32.0 µg/m^3. At the Blackfoot Community Monitoring Station, concentrations ranged from 1.5 to 21 µg/m^3. At Atomic City, concentrations ranged from 0.2 to 8.0 µg/m^3. All measurements were less than the EPA 24-hr standard. The ESER contractor ceased operation of the PM_{10} samplers after March because the data are not used by the program for regulatory purposes.

IMPROVE Samplers

Interagency Monitoring of Protected Visual Environments (IMPROVE) samplers began continuous operation at Craters of the Moon and CFA during the spring of 1992. The EPA removed the CFA 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 station at Craters of the Moon 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 ten 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. At Craters of the Moon, $PM_{2.5}$ has ranged over the period of sampler operation from 409 to 25,10^3 ng/m^3, with a mean of 3443 ng/m^3.

More IMPROVE data and information can be accessed at http://vista.cira.colostate.edu/improve/.

4.3 Waste Management Surveillance Monitoring

Gross Alpha and Gross Beta Air Monitoring Results

The ICP contractor monitors the perimeter of the SDA and the Idaho CERCLA Disposal Facility for compliance with DOE Order 435.1. Samples of airborne particulate material were collected from these waste management areas by the ICP contractor in 2007. Samples were obtained using suspended particle (SP) monitors. Gross alpha and gross beta activity were determined on all SP samples. Table 4-10 shows the SP monitoring results.

Specific Radionuclides

No human-made gamma-emitting radionuclides were detected in 2007 that exceeded the 3-sigma uncertainty.

Table 4-11 shows radiochemical detections of alpha- and beta-emitting radionuclides greater than the 3-sigma uncertainty for 2007. These detections are consistent with levels measured in resuspended soils at the RWMC in previous years. The number of plutonium and americium detections increased from 2006 to 2007 because of resuspended soils from increased activity at the SDA and at the Accelerated Retrieval Project. Strontium-90 was also detected at the Idaho CERCLA Disposal Facility. The detected ^{90}Sr levels are expected during normal operation. The ICP contractor will continue to closely monitor these radionuclides for any abnormal trends.

Table 4-10. Suspended Particle Monitoring Results Greater Than 3-Sigma Uncertainty in 2007.

Radionuclide	High	Low	Annual Mean (µCi/mL)
Gross Alpha	(1.09 ± 0.28) E-14 1st half of January Subsurface Disposal Area (SDA) 4.2	(-1.70 ± 2.56) E-16 2nd half of February SDA 2.3	2.71 × E-15
Gross Beta	(6.97 ± 1.06) E-14 1st half of November INTEC-100.3	(7.40 ± 1.24) E-15 2nd half of February SDA 6.3	2.61 × E-14

Table 4-11. Radionuclide Detections Greater Than the 3-Sigma Uncertainty in 2007.

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Pu-239/240	(1.27 ± 0.36) E-17	SDA 4.3	2nd
	(1.37 ± 0.38) E-17	SDA 9.3	2nd
	(5.27 ± 1.01) E-17	SDA 1.3	3rd
	(2.24 ± 0.70) E-17	SDA 6.3	3rd
	(1.56 ± 0.46) E-17	SDA 4.2	4th
Sr-90	(6.41 ± 1.96) E-17	INT 100.3	3rd
	(7.74 ± 2.22) E-17	SDA 1.3	3rd
	(9.24 ± 2.64) E-17	INT 100.3	4th
Am-241	(1.25 ± 0.39) E-17	SDA 2.3	2nd
	(2.02 ± 0.53) E-17	SDA 4.2	2nd
	(1.61 ± 0.46) E-17	SDA 4.3	2nd
	(1.20 ± 0.39) E-17	SDA 2.3	3rd
	(2.21 ± 0.69) E-17	SDA 4.3	3rd

REFERENCES

40 Code of Federal Regulations, Part 50.6, "National Primary and Secondary Ambient Air Quality Standards for Particulate Matter," Code of Federal Regulations, Office of the Federal Register.

EG&G of Idaho, Inc., 1993, New Production Reactor Exposure pathways at the INEL, EGG-NPR-8957.

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2008, National Emissions Standards for Hazardous Air Pollutants (NESHAPs) – Calendar year 2007 INEL Report for Radionuclides, DOE/NE-ID-10890(08), June 2008.

U.S. Department of Energy Order 435.1, Change 1, 2001, "Radioactive Waste Management," U.S. Department of Energy, August 28.

Chapter 5. Compliance Monitoring for Drinking Water, Liquid Effluent, and WRP Site Performance

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5. COMPLIANCE MONITORING FOR DRINKING WATER, LIQUID EFFLUENT, AND WASTEWATER REUSE PERMIT SITE PERFORMANCE

This chapter presents results from analyses of various water samples collected at both onsite and offsite locations. Results from sampling conducted by the Idaho National Laboratory (INL) and Idaho Cleanup Project (ICP) contractors are presented here. Results are compared to the appropriate and applicable regulatory limit for compliance standards to protect human health and the environment.

A general overview of the organizations responsible for the various types of water monitoring at the INL Site is presented in Section 5.1. Sections 5.2 describes liquid effluent and related groundwater monitoring as required by the city of Idaho Falls and Idaho Wastewater Reuse Permits (WRPs), and effluent monitoring that is done for surveillance activities only. Section 5.3 describes liquid effluent surveillance monitoring at the participating facilities at the INL Site. The INL Site drinking water programs are discussed in Section 5.4. Section 5.5 describes surface runoff monitoring conducted at the onsite waste management facility.

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 (MCLs). Data tables for other monitoring results are found in Appendix F.

5.1 Summary of Monitoring Programs

The INL Site contractors Battelle Energy Alliance (BEA) and CH2M-WG Idaho, LLC (CWI) monitor liquid effluent, groundwater, drinking water, and surface water runoff at the INL Site to comply with applicable laws and regulations, Department of Energy (DOE orders), and other requirements (e.g., WRP requirements).

In 2007, the INL Oversight Program collected split samples of groundwater with CWI and BEA. Results of the Oversight Program's monitoring are presented in annual reports prepared by that organization and are not reported here.

Table 5-1 presents the various water-related monitoring activities performed on and around the INL Site.

5.2 Liquid Effluent and Related Groundwater Compliance Monitoring

The INL contractor and the ICP contractor monitor various constituents of concern in liquid waste influent, effluent, and groundwater. Wastewater is typically discharged to the ground surface and evaporation ponds. Discharges to the ground surface are through infiltration ponds and a sprinkler irrigation system at the following areas:

- Percolation ponds at the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds, Test Area North (TAN)/Technical Support Facility (TSF) Sewage Treatment Facility Disposal Pond, Materials and Fuels Complex (MFC), and the Reactor Technology Complex (RTC) Cold Waste Pond.

Table 5-1. Water-related Monitoring at the INL Site and Surrounding Area.

	Media				
Area/Facility[a]	**Liquid Effluent (Permitted)**	**Liquid Effluent (Surveillance)**	**Groundwater (Permitted)**	**Drinking Water**	**Surface Runoff**
Idaho Cleanup Project: CH2M-WG Idaho, LLC (CWI)					
INTEC	●	●	●	●	
TAN/TSF	●	●	●		
RWMC				●	●
INL Contractor: Battelle Energy Alliance (BEA)					
CFA[b]	●	●		●	
IRC	●				
MFC		●		●	
PBF				●	
RTC	●[c]	●		●	

a. CFA - Central Facilities Area, INTEC - Idaho Nuclear Technology and Engineering Center, MFC - Materials and Fuels Complex, RTC - Reactor Technology Complex, TAN/TSF - Test Area North/Technical Support Facility, RWMC-Radioactive Waste Management Complex, PBF - Power Burst Facility, IRC- INL Research Center.

b. Includes Weapons Range, EBR-I (Experimental Breeder Reactor-I), and Main Gate.

c. The Idaho DEQ has not issued a Wastewater Land Application Permit (WLAP) for RTC. However, RTC follows WLAP regulations for total suspended solids and nitrogen.

- A sprinkler irrigation system at the Central Facilities Area (CFA) that is used during the summer months to apply industrial and treated sanitary wastewater.

Discharge of wastewater to the land surface is regulated under WRP rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). A WRP 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 or do so for surveillance purposes. The liquid effluent and groundwater monitoring programs support WRP requirements for INL Site facilities that generate liquid waste streams covered under WRP rules. Table 5-2 lists the current WRP status of each facility.

The permits generally require that data acquired show compliance with the Idaho groundwater quality primary constituent standards (PCSs) and secondary constituent standards (SCSs) in groundwater monitoring wells at the INL Site. The permits specify annual discharge volumes, application rates,

Table 5-2. Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2007	Explanation
CFA Sewage Treatment Facility	WRP issued	Idaho Department of Environmental Quality (DEQ) issued WRP (#LA-000141-02) permit in January 2005. The permit was modified on 10/19/05.
INTEC New Percolation Ponds	WRP issued	WRP LA-000130-04 was issued on November 19, 2004 (Johnston 2004), revised on October 25, 2005 (Johnston 2005a) and March 16, 2007 (Rackow 2007a), and expires on November 18, 2009. The permit covers the combined effluent from the Sanitary and Service Waste Systems to the INTEC New Percolation Ponds.
MFC Industrial Waste Pond	WRP application submitted to Idaho DEQ	A Wastewater Land Application Permit was submitted to the Idaho DEQ on August 16, 2007.
TAN/TSF Sewage Treatment Facility	WRP issued	Idaho DEQ issued WRP (#LA-000153-02) permit in January 2005 (Johnston 2005b), and issued a minor modification in October 2005 (Johnston 2005c). A closure plan (ICP 2007b) was submitted to DEQ on November 2, 2007 (McNeel 2007c) and approved by DEQ on November 13, 2007 (Rackow 2007b). Termination of the permit will be requested from DEQ upon completion of closure activities in 2008.
RTC Cold Waste Pond	WRP application submitted to Idaho DEQ	Idaho DEQ has not issued a WRP. Idaho DEQ authorized INL to operate the wastewater land application facility under the conditions and terms of State of Idaho WRP rules and Idaho DEQ’s Handbook for Land Application of Municipal and Industrial Wastewater until a permit is issued (Johnston 2001).

and effluent quality limits. As required, for permitted facilities, annual reports (ICP 2008a, 2008b) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2007, the contractors (CWI and BEA) conducted monitoring as required by the permits for the following facilities (see Table 5-2):

- CFA Sewage Treatment Plant
- INTEC New Percolation Ponds
- TAN/TSF Sewage Treatment Facility.

The RTC Cold Waste Pond has not been issued a permit; however, samples for total nitrogen and total suspended solids (TSS) are collected to show compliance with the regulatory effluent limits for rapid infiltration systems. The following subsections present results of wastewater and groundwater monitoring for individual facilities conducted for permit compliance purposes.

Additional parameters are also monitored in the effluent to comply with DOE Orders 450.1 and 5400.5 (DOE 2003, DOE 1993) environmental protection objectives. Section 5.3 discusses the results of liquid effluent surveillance monitoring.

Idaho Falls Facilities

Description – The city of Idaho Falls is authorized by the Clean Water Act (CWA), National Pollutant Discharge Elimination System (NPDES) to set pretreatment standards for non-domestic 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 INL Research Center (IRC) specifies 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 IRC in March and August of 2007. As the table reports, most values for all of the constituents monitored were below laboratory method detection limits (U flagged) and therefore, in compliance with the applicable effluent discharge limits. The values reported for monitored constituents that were not U flagged were significantly below the set permit limits.

Central Facilities Area Sewage Treatment Facility

Description – The CFA Sewage Treatment Facility (STF) 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.

Table 5-3. Semiannual Effluent Monitoring Results for INL Research Center (2007).[a]

Parameter	INL Research Center			Discharge Limit[c]
	March 2007	August 2007[b]		
Cyanide	0.005 U[d]	0.005 U	0.005 U	1.04
Silver	0.0025 U	0.0025 U	0.0025 U	0.43
Arsenic	0.0025 U	0.005 U	0.005 U	0.04
Cadmium	0.001 U	0.001 U	0.001 U	0.26
Chromium	0.0025 U	0.0025 U	0.0025 U	2.77
Copper	0.0411	0.0393	0.0388	1.93
Mercury	0.0002 U	0.0002 U	0.0002 U	0.002
Molybdenum	0.269	0.213	0.209	None
Nickel	0.0025 U	0.0025 U	0.0025 U	2.38
Selenium	0.002 U	0.0005 U	0.0005 U	None
Zinc	0.0221	0.0853	0.0851	0.90
Lead	0.0004 U	0.001	0.001	0.29
Conductivity (µS/cm)	700.1/654.6[e]	652.2/576.3[e]		NA
pH (standard units)	7.58/7.39[e]	8.28/7.32[e]		5.5-9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Regular and duplicate samples were collected in August.
c. Limit as set in the applicable Industrial Wastewater Acceptance Permit.
d. U flag indicates that the result was below the detection limit.
e. Values are the maximum and average of the grab samples collected during the semiannual monitoring.

A 1500-L/min (400-gal/min) pump applies wastewater from a 0.2-ha (0.5-acre) lined, polishing pond to approximately 30 ha (74 acres) of desert rangeland through a computerized center pivot irrigation system. The permit limits wastewater application to 23 acre-inches/acre/year from April 1 through October 31.

WRP Wastewater Monitoring Results – The permit requires influent and effluent monitoring, as well as soil sampling in the application area (see Chapter 7 for results pertaining to soils). Influent samples were collected monthly from the lift station at CFA (prior to Lagoon No. 1) during 2007. Effluent samples were collected from the pump pit (prior to the pivot irrigation system) in June and August, the only two months of wastewater reuse permit in 2007. All samples collected were 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables F-1 and F-2 in Appendix F summarize the results.

Wastewater was intermittently applied via the center pivot irrigation system in June and August 2007. On the days it was operational, discharge to the pivot irrigation system averaged 575,621 liters per day (152,063 gallons per day).

A total of 3.16 million gallons (MG) of wastewater was applied to the land application area in 2007, which is equivalent to a loading rate of 1.59 acre-inch/acre/year. This is significantly less than the permit limit of 46 MG (23.0 acre-inch/acre/year). The nitrogen loading rate (0.83 lb/acre/yr) was significantly lower than the projected maximum loading rate of 32 lb/acre/yr. As a general rule, nitrogen loading should not exceed the amount necessary for crop utilization plus 50 percent. However, wastewater is applied to rangeland 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/year) (CES 1993). The low 2007 nitrogen loading rate had a negligible effect on nitrogen accumulation.

The 2007 annual total chemical oxygen demand (COD) loading rate at the CFA Sewage Treatment Facility (14.16 lb/acre/year) was less than state guidelines of 50 lb/acre/day (which is equivalent to 18,250 lb/acre/year).

The annual total phosphorus loading rate (0.06 lb/acre/year) was below the projected maximum loading rate of 4.5 lb/acre/year. 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 (REs) were calculated to gauge treatment. The REs for biochemical oxygen demand (BOD) and TSS were above the design criterion of 80 percent, and the RE for COD was above the projected efficiency of 70 percent. The RE for total nitrogen was 98.7 percent.

WRP Groundwater Monitoring Results – The WRP does not require groundwater monitoring at the CFA Sewage Treatment Plant.

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

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

The INTEC Sewage Treatment Plant (STP) is east of INTEC, outside the INTEC security fence. It treats and disposes of sanitary and other related waste at INTEC.

The STP 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. For the STP, automatic flow-proportional composite samplers are located at control stations CPP-769 (influent) and CPP-773 (wastewater effluent from the STP to the service waste system).

WRP Wastewater Monitoring Results – Monthly samples were collected from:

- CPP-769—influent to STP

- CPP-773—effluent from STP 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 taken 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 results for CPP-769 and CPP-773 are presented in Appendix F, Tables F-3 and F-4.

The permit sets monthly concentration limits for TSS (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. The complete results of all parameters monitored at the combined effluent are presented in Table F-5. As Table 5-4 shows, during 2007, neither TSS nor total nitrogen exceeded the permit limit in the combined effluent.

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, during 2007, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits.

WRP Groundwater Monitoring Results –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 [Note: The Weapons Range Facility depicted in Figure 5-1 is for location reference only and is not part of the INTEC WRP]):

Table 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at CPP-797 (2007).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
	(mg/L)			
Total nitrogen[c]	1.459	2.470	1.893	20
Total suspended solids	2.0[d]	5.5	2.3	100

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

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

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

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

Table 5-5. Hydraulic Loading Rates for INTEC New Percolation Ponds (2007).

	2007 Flow (MG)	Permit Limit (MG)
Maximum daily	1.640	3
Yearly total	448.546	1,095

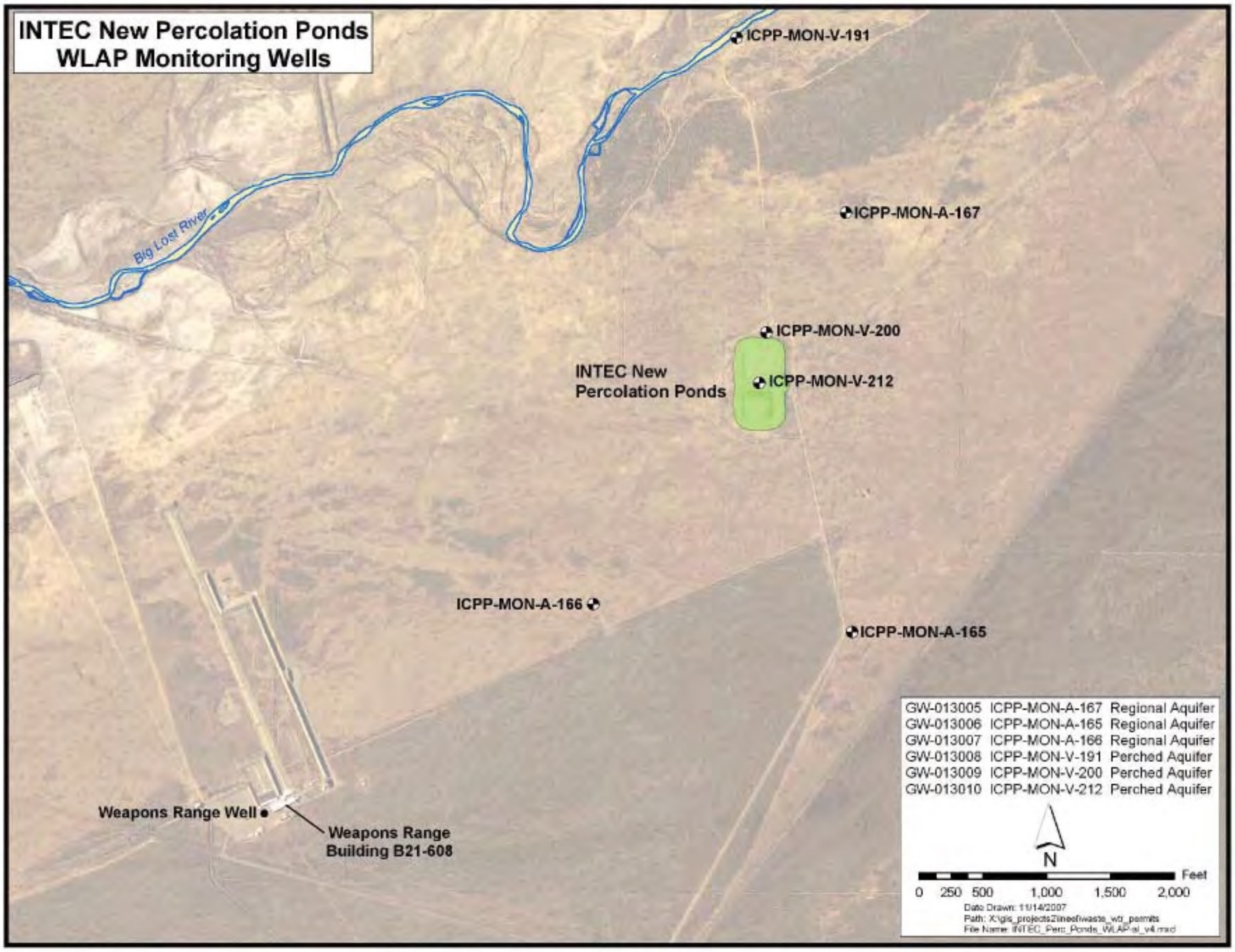

Figure 5-1. Wastewater Reuse Permit Monitoring Locations at INTEC.

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

Aquifer wells ICPP-MON-A-165 and ICPP-MON-A-166 and perched water wells ICPP-MON-V-200 and ICPP-MON-V-212 are the permit compliance points. Aquifer well ICPP-MON-A-167 and perched water well ICPP-MON-V-191 are listed in the permit as 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 PCS and SCS specified in IDAPA 58.01.11, "Ground Water Quality Rule." All permit-required samples are collected as unfiltered samples.

Table F-6 shows the April and October 2007 analytical results for all parameters specified by the permit for the aquifer wells. Table F-6 also depicts the depth to water table and water table elevations determined before purging and sampling. Table F-7 presents similar information for the perched water wells. The majority of the permit-required monitoring parameters remained below their respective PCS or SCS during 2007 for all wells associated with the INTEC New Percolation Ponds. Table 5-6 shows permit noncompliances (SCS) related to groundwater exceedances identified during 2007. No other permit noncompliances occurred. As required by the permit, Idaho DEQ was notified of the noncompliances (McNeel 2007a, 2007b). The 2007 Wastewater Land Application

Table 5-6. Permit Noncompliances.

	ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)			
	4/18/2007	10/3/2007	4/25/2007	5/10/2007[a]	10/1/2007	SCSs[b]
Parameter	(mg/L)					
Aluminum	—	—	1.04	—	—	0.2
Chloride	—	253	—	—	—	250
Iron	—	—	1.19	—	—	0.3
Total dissolved solids	517	626	—	520	618	500

a. Sample recollected because analytical laboratory failed to analyze April 2007 sample for total dissolved solids.

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

Report for the INTEC New Percolation Ponds [ICP 2008a]) discusses the causes, corrective actions implemented to reduce or eliminate each noncompliance, and status of each noncompliance.

Upgradient aquifer well ICPP-MON-A-167 was dry during the April and October 2007 sampling events. This well was last sampled in April 2005. The pump in well ICPP-MON-A-167 is currently near the bottom of the well and cannot be lowered any farther because of well construction limitations. Unless the water level rises above the pump intake, future samples cannot be collected from this well.

Aluminum and Iron 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 (see Table 5-7) 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 an SCS, 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 PCSs and SCSs from the "Ground Water Quality Rule" (IDAPA 58.01.11) are used for determining compliance for the perched water wells.

Iron concentrations in the unfiltered samples from well ICPP-MON V-212 were first detected above the SCS in October 2004. Iron concentrations remained above the SCS in well ICPP-MON-V-212 in April 2007 (see Table 5-6) and dropped below the standard in October 2007 (see Table F-7). In addition, the April aluminum concentration exceeded the SCS in well ICPP-MON-V-212 (see Table 5-6).

Table 5-7. Preoperational Concentrations and Secondary Constituent Standard.[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 standard (SCS) from Idaho Administrative Procedures Act 58.01.11.

Past investigations of exceedances of aluminum, iron, manganese, and other constituents in permitted wells at INTEC have been reviewed and are summarized in the 2007 Wastewater Land Application Report for the INTEC New Percolation Ponds [ICP 2008a]). Until the 2006 reporting year, concentrations of iron and aluminum in all filtered samples from perched water wells had been below the associated groundwater quality standards, indicating that the elevated metals are not in solution, but are associated with the sediment in the unfiltered samples being dissolved during the analytical process (e.g., acidification). It is being recommended that during the permit renewal process, a modification be made to require collecting both filtered and unfiltered metals samples and to base compliance on filtered samples. Continuing semiannual monitoring of the permitted wells is also recommended.

Total Dissolved Solids and Chloride Concentrations in Groundwater - During 2007, total dissolved solids (TDS) concentrations exceeded the SCS in perched water wells ICPP-MON-V-200 (April and October 2007) and ICPP-MON-V-212 (May and October 2007) (see Table 5-6).

TDS concentrations in the downgradient aquifer monitoring well ICPP-MON-A-165 also have been steadily increasing since the INTEC New Percolation Ponds were placed into service in August 2002. The concentration of TDS in well ICPP-MON-A-165 in October 2002 was 234 mg/L, compared to 363 mg/L in October 2007 (see Table F-6). Similar increases in the chloride and sodium concentrations also have been noted. However, significant increases in TDS, chloride, and sodium concentrations have not been identified in downgradient aquifer monitoring well ICPP-MON-A-166.

The chloride concentration exceeded the SCS in perched water well ICPP-MON-V-200 in October 2007 (see Table 5-6).

The concentrations of TDS, as well as chloride and sodium, in the groundwater near the INTEC New Percolation Ponds are influenced by the wastewater discharges from the CPP-606 Treated Water System (ICP 2007a). The following corrective actions are being implemented to reduce or eliminate concentrations of TDS, chloride, and sodium in the groundwater:

- A new water treatment system was installed at INTEC. The project is planned to be completed in January 2008. The new water treatment system is expected to reduce TDS and chloride concentrations in the effluent to the INTEC New Percolation Ponds to below groundwater quality standards. Semiannual monitoring of permitted wells will continue for the constituents of concern for compliance standards.

TAN/TSF Sewage Treatment Facility

Description – The TAN/TSF Sewage Treatment Facility (TAN-623) was constructed and designed to treat raw wastewater by biologically digesting the majority of the organic waste and other major contaminants, then applying it to the land surface for infiltration and evaporation. The Sewage Treatment Facility consists of:

- Wastewater-collection manhole
- Imhoff tank

- Sludge drying beds
- Trickle filter and settling tank
- Contact basin (chlorination not performed)
- Infiltration disposal pond.

The TAN/TSF Disposal Pond was constructed in 1971 and consists of a primary disposal area and an overflow section, both of which are located within an unlined, fenced 14-ha (35-acre) area (see Figure 5-2). The Overflow Pond is rarely used; it is used only when the water is diverted to it for brief periods of cleanup and maintenance. The TAN/TSF Disposal Pond and Overflow Pond areas are approximately 0.4 ha (0.9 acres) and 0.13 ha (0.330 acres), respectively, for a combined area of approximately 0.5 ha (1.23 acres). In addition to receiving treated sewage wastewater, the TAN/TSF Disposal Pond also receives process wastewater, which enters the facility at the TAN-655 lift station.

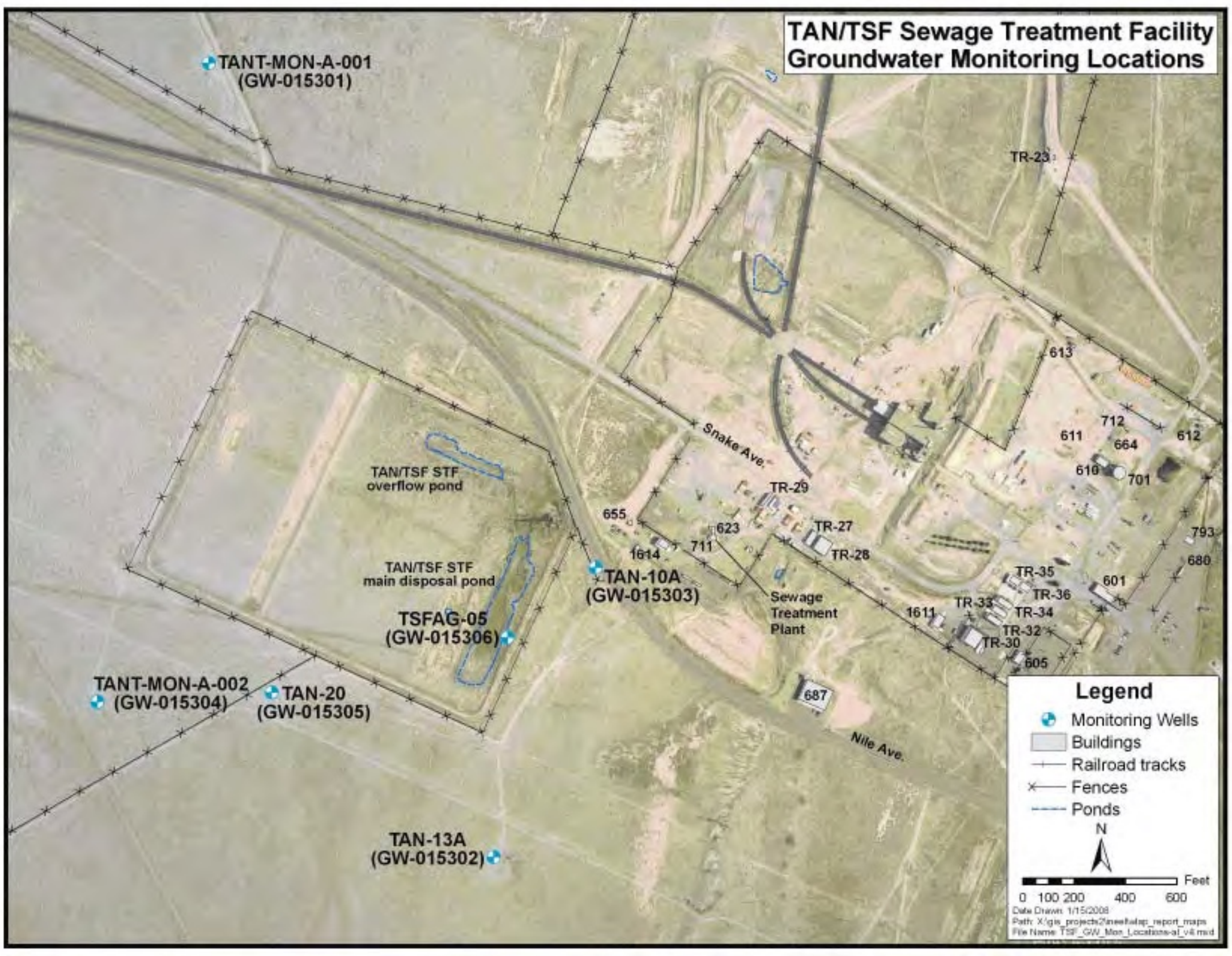

Figure 5-2. Wastewater Reuse Permit Monitoring Locations at TAN/TSF.

The TSF sewage primarily consists of spent water containing waste from restrooms, sinks, and showers. The sanitary wastewater goes to the TAN-623 Sewage Treatment Facility, and then to the TAN-655 lift station, which pumps to the TAN/TSF Disposal Pond.

The process drain system collects wastewater from process drains and building sources originating from various TAN facilities. The process wastewater consists of liquid effluent, such as steam condensate; water softener and demineralizer discharges; fire water discharges; and cooling, heating, and air conditioning water. The process wastewater is transported directly to the TAN-655 lift station, where it is mixed with sanitary wastewater before being pumped to the TAN/TSF Disposal Pond.

Decommissioning and Demolition Activities – Most office buildings and plant facilities that discharged into the TAN/TSF Sewage Treatment Facility have been decommissioned and demolished. Temporary office trailers have been brought onsite and will be in use until approximately the end of 2008. Decommissioning and demolition workers will use comfort stations and porta potties for their personal hygiene needs. A licensed septic tank pumper will collect the septage from these units and transport it to the INTEC Sewage Treatment Plant for disposal.

General decommissioning and demolition of the TAN/TSF Sewage Treatment Facility began in November 2007. The ICP contractor submitted the Closure Plan (ICP 2007b) to Idaho DEQ on November 2, 2007 (McNeel 2007c). The Closure Plan identifies specific closure, site characterization, and site restoration tasks, with scheduled task completion dates. The Closure Plan was approved by Idaho DEQ on November 13, 2007 (Rackow 2007b). Wastewater effluent discharges from TAN-655 to the TAN/TSF Disposal Pond ceased on November 29, 2007. The TAN/TSF Sewage Treatment Facility permitted facilities are scheduled to be closed by June 2008.

WRP Wastewater Monitoring Results – The permit specifies a maximum annual hydraulic loading rate to the TAN/TSF Disposal Pond. Table 5-8 shows the yearly flow through November 29, 2007, when flow ceased, to the TAN/TSF Disposal Pond. As the table shows, during 2007, the yearly total flow to the TAN/TSF Disposal Pond was below the permit limit. The calendar year 2007 total effluent flow was less than that for calendar year 2006 (10.84 MG) because of decommissioning and demolition activities.

During 2007, 24-hour composite samples (except pH, fecal coliform, and total coliform, which were grab samples) were collected from the TAN-655 lift station effluent monthly. The permit for the TAN/TSF Sewage Treatment Facility specifies the parameters that are required to be sampled and analyzed. The permit sets limits for only two of the parameters: TSS (100 mg/L) and total nitrogen (20 mg/L). Table 5-9 shows the TSS and total nitrogen results, and Table F-8 shows the monitoring results for all required parameters. As Table 5-9 shows, all monthly total nitrogen and TSS concentrations were below the permit limits.

In addition to the permit-required wastewater effluent monitoring, samples were collected at the Sewage Treatment Facility (TAN-623) in January, February, and March 2007. This additional monitoring was performed in anticipation of the reduced process wastewater flows to TAN-655 and to determine if there would be any nutrient loading and other impacts to the TAN/TSF Disposal Pond.

Table 5-8. Yearly Flow to TAN/TSF Disposal Pond (2007).

	2007 Flow (MG)	Permit Limit (MG)
Yearly total (through 11/29/2007)	3.61	15
Yearly average	10,871	NA

Table 5-9. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results for TAN/TSF Sewage Treatment Facility at TAN-655 (2007).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
	(mg/L)			
Total nitrogen[c]	2.059	12.52	7.451	20
Total suspended solids	2.0[d]	46.9	15.6	100

a. Duplicate samples were collected in March for all parameters, 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. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.

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

Table F-9 presents the monitoring results. The results from TAN-623 are similar to the results from TAN-655 and were below permit limits. All monthly total nitrogen concentrations were below the permit limit of 20 mg/L. All monthly total suspended solids concentrations were below the permit limit of 100 mg/L.

WRP Groundwater Monitoring Results – To measure potential TAN/TSF Disposal Pond impacts to groundwater, the permit requires that groundwater samples be collected from six monitoring wells (see 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.

Sampling must be conducted semiannually and must include permit-specified parameters for analysis. As specified in Section F of WRP-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 PCSs and SCSs in IDAPA 58.01.11, “Ground Water Quality Rule.” All permit-required samples are collected as unfiltered samples.

During 2007, groundwater samples were collected in April/May and October. Table F-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 both April and October 2007. Therefore, no analytical results are presented for this well.

As Table F-10 shows, most groundwater parameters were below their respective PCSs and SCSs. Table 5-10 shows the parameters that exceeded their respective PCS or SCS in 2007. As required by the permit, the groundwater exceedances were reported to Idaho DEQ (McNeel 2007b, 2007c, 2008). None of these exceedances endangered public health or the environment.

Iron and filtered iron concentrations in well TAN-10A were above the SCS of 0.3 mg/L in April 2007 and October 2007 (see Table F-10). However, Section F of WRP-LA-000153-02 exempts the iron concentrations in well TAN-10A from the limits set forth in IDAPA 58.01.11; therefore, these exceedances do not represent permit noncompliances.

The following subsections discuss exceedances of aluminum, total coliform, iron, manganese, and TDS. The 2007 Wastewater Land Application Report for the TAN/TSF Sewage Treatment Facility (ICP 2008b) also contains interpretive discussions of these exceedances.

Aluminum Concentrations in Well TANT-MON-A-002 - The aluminum concentration in well TANT-MON-A-002 (0.203 mg/L) exceeded the SCS of 0.2 mg/L in October 2007 (see Table 5-10). However, the duplicate sample (0.0534 mg/L) was below the SCS (see Table F-10). The exceedance is about four times higher than the duplicate result. The laboratory report and the groundwater monitoring logbook were reviewed, and no anomalies with the analysis or sample collection methods were identified.

Table 5-10. Groundwater Exceedances for TAN/TSF Sewage Treatment Facility for April, May and October (2007).

Parameter	TANT-MON-A-002 (GW-015304)	TAN-10A (GW-015303)			
	10/9/2007	4/4/2007	5/7/2007[a]	10/17/2007	SCS[b]
Aluminum (mg/L)	0.203	—	—	—	0.2
Coliform, total (colonies/100 mL)	—	—	—	28.0	1 col/100 mL
Iron (mg/L)	0.320	—	—	—	0.3
Manganese (mg/L)	—	0.926	—	0.960	0.05
Total dissolved solids (mg/L)	—	—	537	575	500

a. Samples recollected because analytical laboratory failed to analyze April 2007 sample for total dissolved solids.

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

Past reports have investigated aluminum exceedances at TAN and are summarized in the 2007 WRP Report (ICP 2008b). Aluminum samples will be collected from well TANT-MON-A-002 and other permitted wells at TAN during the final scheduled permitted sampling event in April 2008 (ICP 2007b).

Iron Concentrations in Well TANT-MON-A-002 - The iron (unfiltered) concentration (0.320 mg/L) exceeded the SCS of 0.3 mg/L in well TANT-MON-A-002 in October 2007 (see Table 5-10). However, the duplicate sample (0.164 mg/L) was below the standard (see Table F-10). The laboratory report and the groundwater monitoring logbook were reviewed, and no anomalies with the analysis or sample collection methods were identified. In contrast to the unfiltered iron exceedance, all filtered iron results were below the standard in well TANT-MON-A-002 during 2007 (see Table F-10).

Elevated iron concentrations historically have been detected in the TAN permitted monitoring wells. Several investigations of iron exceedances at TAN have been performed and are summarized in the 2007 WRP Report (ICP 2008b). Iron samples will be collected from well TANT-MON-A-002, as well as other permitted wells at TAN, during the final scheduled permitted sampling event in April 2008 (ICP 2007b).

Manganese and Total Dissolved Solids Concentrations in Well TAN-10A - In well TAN-10A, manganese concentrations (0.926 mg/L in April 2007 and 0.960 mg/L in October 2007) exceeded the SCS (0.05 mg/L), and TDS concentrations (537 mg/L in May 2007 and 575 mg/L in October 2007) exceeded the SCS (500 mg/L) (see Table 5-10). Concentrations of both manganese and TDS have been above their SCSs in well TAN-10A in the past. Increases of TDS 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. Similarly, no pattern is evident for the concentrations of manganese in the effluent when compared to concentrations in well TAN-10A.

To further evaluate manganese and TDS concentrations, semiannual samples were collected from 17 nonpermitted wells in addition to the six permitted wells during the 2006 and 2007 reporting years. The additional wells are within the trichloroethene plume, and five of the 17 wells are in the TSF-05 injection well hot spot. During the 2006 reporting year, exceedances of manganese and TDS were reported in all of the additional wells (ICP 2007c). Similar to the 2006 reporting year, exceedances of manganese were reported in all 17 wells, and exceedances of TDS were reported in 16 wells during the 2007 reporting year (ICP 2008b).

The 2007 WRP report summarizes past reports that have evaluated manganese and TDS exceedances (ICP 2008b). Samples will be collected for manganese and TDS from well TAN-10A and other permitted wells at TAN during the final scheduled permitted sampling event in April 2008 (ICP 2007b).

Total Coliform Concentrations in Well TAN-10A - Total coliform (28.0 colonies/100 mL) exceeded the primary constituent standard of 1 colony/100 mL in October 2007 in well TAN-10A (see Table 5-10). However, fecal coliform was absent in this well (see Table F-10). Total coliform also has been reported sporadically in TAN/TSF Sewage Treatment Facility permitted wells since 1996. Wastewater effluent from the TAN/TSF Sewage Treatment Facility contains total and fecal coliform and could be a potential source of the contamination. However, the sporadic reports of total coliform and an absence of fecal coliform in well TAN-10A and the other permitted monitoring wells suggest that the October 2007 total coliform result is not related to the TAN-623 treatment process and wastewater effluent disposal.

In situ bioremediation activities may be impacting the water quality in well TAN-10A. In situ bioremediation is the remedy being used to clean up the groundwater in the TAN/TSF area under the CERCLA OU 1-07B Remedial Action. The in situ bioremediation process uses an amendment to promote bacterial growth. The bacterial growth breaks down the contaminants in the groundwater. Videos taken of well TAN-10A in February and March 2007 show black biofilm in the well screen area; in situ bioremediation may have caused or contributed to the biofilm. A sample was collected of the biofilm buildup on the TAN-10A pump/piping in November 2007, and several biological activity reaction tests (BART) were performed. The SLYM BART test indicated that slime-forming organisms were present in the water sample. Coliform bacteria can persist within slime formed by naturally occurring groundwater microorganisms. The detected coliform bacteria could have been from this source.

Total and fecal coliform samples will be collected from well TAN-10A during the final scheduled permitted sampling event in April 2008 (ICP 2007b).

Actions To Address Groundwater Quality Standard Exceedances – The 2007 WRP report (ICP 2008b) summarizes investigations of exceedances of iron, manganese, and aluminum at the INL Site. 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 aluminum, iron, and manganese have usually been below SCSs. Therefore, factors other than wastewater effluent discharges are believed to be causing the elevated aluminum, iron, and manganese concentrations in permitted wells. The report concludes that because of historically elevated metals concentrations, both filtered and unfiltered metals samples will be collected from TAN permitted wells during the final scheduled sampling event in April 2008.

5.3 Liquid Effluent Surveillance Monitoring

Additional radiological and nonradiological parameters also are monitored. This additional monitoring is performed to comply with DOE Order 450.1 and 5400.5 environmental protection objectives. The following sections discuss results of this additional monitoring by individual facility.

Central Facilities Area

Both the influent and effluent to the CFA Sewage Treatment Facility are monitored according to the WRP issued for the plant. Table F-11 summarizes the additional surveillance monitoring conducted during 2007 at the CFA Sewage Treatment Facility and shows those parameters with at least one detected result during the year. During 2007, most additional parameters were within historical concentration levels.

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Table F-12 summarizes the additional monitoring conducted during 2007 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 2007, most additional parameters were within historical concentration levels. The 2007 INTEC New Percolation Ponds Radiological Monitoring Report (ICP 2008c) provides additional information.

Materials and Fuels Complex

During 2007, the Industrial Waste Pond, Industrial Waste Ditch, and Secondary Sanitary Lagoon were sampled monthly for iron, sodium, chloride, fluoride, sulfate, pH, conductivity, TSS, turbidity, biochemical oxygen demand, gross alpha, gross beta, gamma spectrometry, tritium, and various other parameters. Additionally, a sample for selected metals is collected once a year. The Industrial Waste Pond was dry in January. Tables F-13 to F-15 summarize the analytical results for parameters that were detected in at least one sample.

Radioactive parameters were also monitored and reported when detected. Plutonium-241 was reported at an activity of 9.47 pCi/L from the MFC Industrial Waste Pond on July 25, 2007. Tritium was detected in the samples collected from the Sanitary Sewage Lagoon every month except February. Potassium-40 was also reported but was U flagged; representing the sample result was below the laboratory method detection limit. Monitored radiological parameters, including gross alpha and gross beta, are below applicable standards.

Test Area North/Technical Support Facility

The effluent to the TAN/TSF Disposal Pond receives a combination of process water and treated sewage waste. Additional monitoring for surveillance purposes is conducted monthly for metal parameters and conductivity and quarterly for radiological parameters (with the exception of strontium-89 (^{89}Sr), iodine-129 (^{129}I), and tritium, which are monitored annually, and strontium-90 (^{90}Sr), which was monitored monthly starting in March 2005). There are no permit limits for these additional parameters. Table F-16 summarizes the results of this additional monitoring for those parameters detected in at least one sample during the year. During 2007, the concentrations of most additional parameters were within historical concentration levels. The 2007 TAN/TSF Radiological Monitoring Report (ICP 2008d) provides additional information.

Reactor Technology Complex

The effluent to the Cold Waste Pond receives a combination of process water from various RTC facilities. Monitoring for surveillance purposes was conducted quarterly for metals and for radiological parameters: in July the monitoring frequency was increased to monthly in anticipation of a wastewater reuse permit from the Idaho DEQ. Table F-17 summarizes the results of this additional monitoring for those parameters with at least one detected result.

During 2007, concentrations of sulfate and TDS were elevated in samples collected during reactor operation. These differences are caused by the normal raw water hardness, as well as corrosion inhibitors and sulfuric acid added to control the pH of the cooling water.

5.4 Drinking Water Monitoring

The INL Site monitors 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 within three-years intervals. Parameters with secondary MCLs are monitored every three years based on a recommendation by the U.S. Environmental Protection Agency (EPA). 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 eleven onsite drinking water systems. The INL Site contractors, BEA and CWI, monitor these systems to ensure a safe working environment. BEA monitors nine of these drinking water systems and CWI monitors two (INTEC and Radioactive Waste Management Complex [RWMC]). 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 four BEA transient, noncommunity water systems are at the Experimental Breeder Reactor No. 1 (EBR-I), Weapons Range (Live Fire Test Range), Critical Infrastructure Test Range Complex (CITRC), and the Main Gate. The five remaining BEA water systems are classified as nontransient, noncommunity water systems. These systems are located at CFA, MFC, RTC, TAN/Contained Test Facility (CTF), and TAN/TSF. The two CWI drinking water systems (INTEC and RWMC) are classified as nontransient, noncommunity water systems.

As required by the state of Idaho, the INL Site Drinking Water Program uses EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and Title 40 Code of Federal Regulations (CFR) Parts 141–143. State regulations also require the use of laboratories that are either certified by the State or by another state whose certification is recognized by Idaho. The Idaho DEQ oversees the certification program and maintains a listing of approved laboratories.

Because of historic or problematic contaminants in the drinking water systems, BEA and CWI monitor certain parameters more frequently than required by regulation. For example, bacterial analyses are conducted monthly rather than quarterly at all nine BEA drinking water systems during months of operation. These non-regulated, additional samples resulted in four positive detections for the year. Bacteria were detected in the RTC valve in February, the Main Gate in October, and Specific Manufacturing Capability (SMC) in October and December. Because of known groundwater plumes near two BEA drinking water wells, additional sampling is conducted for tritium at CFA and for trichloroethylene at TAN/TSF.

INL Site Drinking Water Monitoring Results

During 2007, BEA collected 314 routine samples and 19 quality control samples from the nine INL Site drinking water systems. In addition to routine samples, BEA also collected 28 non-routine samples after repairs were made to a water main and prior to placing the water main back into service. Drinking water systems at EBR-I, CITRC, Weapons Range, MFC, RTC, and TAN/CTF were well below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report.

Central Facilities Area

The CFA water system serves approximately 600 people daily. Since the early 1950s, wastewater containing tritium was disposed to the Eastern Snake River Plain Aquifer (ESRPA) at INTEC and at RTC through injection wells and infiltration ponds. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. This practice of disposing of wastewater through injection wells was discontinued in the mid-1980s. In general, tritium concentrations in groundwater have been decreasing (see Figure 5-3) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay.

Since December 1991, the mean tritium concentration has been tracked using three sampling locations within the CFA water distribution system. Prior to 2007, water 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 for compliance purposes. All of the 2006 results were below the MCL for tritium. Thus in 2007, BEA decreased the frequency of the tritium sampling to semi-annual and reduced the number of sampling locations to CFA-1603 (manifold).

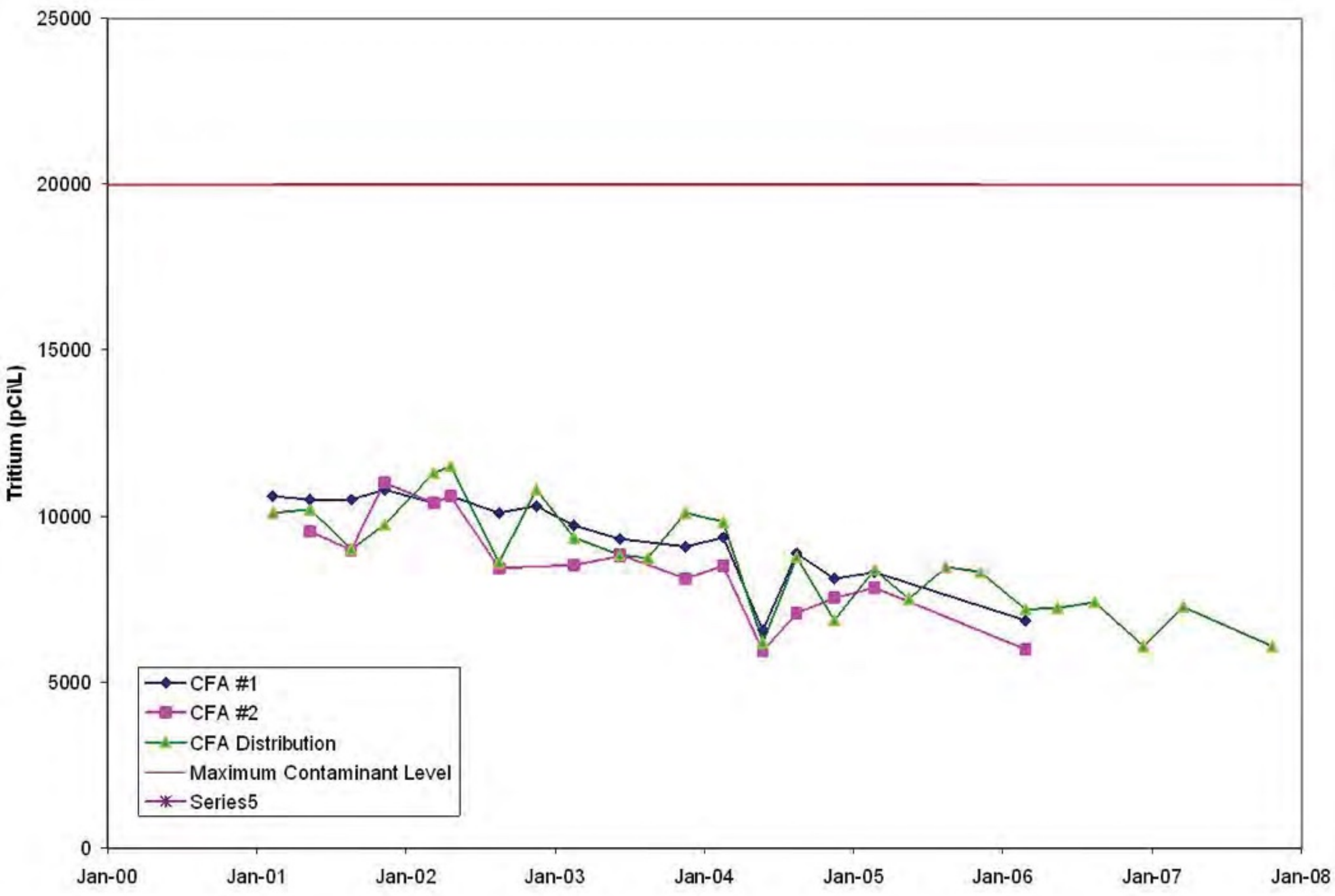

Figure 5-3. Tritum Concentrations in Two CFA Wells and CFA Distribution System (2000-2007).

CFA Worker Dose – Because of the potential impacts to workers at CFA from an upgradient plume of radionuclides in the ESRPA, the potential effective dose equivalent from radioactivity in water was calculated. The 2007 calculation was based on the mean tritium concentration for the CFA distribution system in 2007. For the 2007 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 2007 was 0.30 mrem (3.0 µSv), below the EPA standard of 4 mrem/yr for public drinking water systems.

Idaho Nuclear Technology and Engineering Center

During 2007, the following drinking water samples were collected at INTEC:

- 42 routine (compliance) samples
- 6 quality control samples (4 field duplicates; 1 trip blank; 1 performance evaluation sample)
- 16 non-routine samples (15 bacterial samples, associated primarily with water main repairs; 1 sample for EPA Method 524.2 volatile organics).

All INTEC monitored parameters were below their respective limits in 2007. Nitrate is required to be monitored annually. The nitrate result for 2007 at INTEC was 0.74 mg/L, well below the MCL of 10 mg/L.

Main Gate Badging Facility/Reactor Technology Complex/Specific Manufacturing Capability Coliform Bacteria

In October 2007, total coliform bacteria was detected during the regulatory compliance monitoring. The system owner was notified, the filters were replaced, the water system disinfected and flushed, resampled, and results indicated no detection of bacteria. It should be noted that this drinking water system does not have an automatic disinfection system.

Total coliform bacteria detections at SMC and RTC (TRA 608) were noncompliance (construction) samples. Re-sampling was conducted with no total coliform or E. coli bacteria detections.

Radioactive Waste Management Complex

The RWMC production well is located in WMF-603 and supplies all of the drinking water for more than 500 people. The well was put into service in 1974. A chlorine residual has been maintained throughout the distribution system since 2004. Water samples collected for monitoring purposes were from the well head (WMF-603), from the point of entry to the distribution system (WMF-604), and from various buildings throughout the distribution system.

During 2007, the following drinking water samples were collected at RWMC:

- 31 routine (compliance) samples

- 16 quality control samples (8 field duplicates, 4 trip blanks, 4 performance evaluation samples)
- 18 non-routine samples (15 bacterial samples, primarily associated with water main repairs; 3 samples for EPA Method 524.2 volatile organics).

In the past, carbon tetrachloride, trichloroethylene, and nitrate have been detected in the drinking water system at RWMC. All other regulatory parameters were well below drinking water limits in 2007. Concentrations of carbon tetrachloride, trichloroethylene, and nitrate remained below their respective MCLs in 2007 as presented in the following tables:

- Carbon tetrachloride (see Table 5-11)
- Trichloroethylene (see Table 5-12)
- Nitrate (required to be monitored annually) (see Table 5-13).

Historically carbon tetrachloride and trichloroethylene had consistently been detected in samples collected at WMF-603 and WMF-604. The sample collected in April 2006 at WMF-603 indicated a carbon tetrachloride 6.5 µg/L concentration, the highest level since 1993. The April 2006 sample

Table 5-11. Carbon Tetrachloride Concentrations in the RWMC Drinking Water Well and Distribution System (2007).

Location	Number of Samples	Minimum	Maximum (µg/L)	Average[a]	MCL
WMF-603[b]	5	4.9	6.1	5.4	NA[c]
WMF-604 Distribution[d]	5	0.25[e]	4.30	1.06	5

a. Half the reported detection limit was used in any calculation for those data reported as below the detection limit.

b. Sampled for surveillance purposes (not required to be sampled).

c. NA—Maximum contaminant level is not applicable to the well concentration.

d. Entry point to the distribution system and used for the purpose of determining compliance with the maximum contaminant level.

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

Table 5-12. Trichloroethylene Concentrations in the RWMC Drinking Water Well and Distribution System (2007).

Location	Number of Samples	Minimum	Maximum (µg/L)	Average[a]	MCL
WMF-603[b]	5	2.20	2.90	2.54	NA[c]
WMF-604 Distribution[d]	5	0.25	2.00	0.60	5

a. Half the reported detection limit was used in any calculation for those data reported as below the detection limit.

b. Sampled for surveillance purposes (not required to be sampled).

c. NA—Maximum contaminant level is not applicable to the well concentration.

d. Entry point to the distribution system and used for the purpose of determining compliance with the maximum contaminant level.

Table 5-13. Nitrate Result for RWMC Drinking Water Distribution System (2007) (Nitrate as Nitrogen).

Location	Concentration (mg/L)	MCL
WMF-604 Distribution	0.87	10

result from WMF-604 returned 4.5 µg/L. In July 2006, RWMC facility management decided to install a packed tower air stripping treatment system. Design approval was received from Idaho DEQ in December 2006 and the treatment system became operational in July 2007.

Carbon tetrachloride and trichloroethylene were detected in samples collected at WMF-603 in August 2007 and November 2007; these contaminants were not detected (<0.5 µg/L) in the samples collected at WMF-604 in August 2007 and November 2007.

Test Area North/Technical Support Facility

In 1987, trichloroethylene was detected at both TSF #1 and #2 wells, which supply drinking water to less than 100 employees at TSF. The inactive TSF injection well (TSF-05) is believed to be the principal source of trichloroethylene contamination at the TSF. Bottled water was provided until 1988 when a sparger system (air stripping process) was installed in the water storage tank to volatilize the trichloroethylene to levels below the MCL.

During the third quarter of 1997, TSF #1 was taken offline, and TSF #2 was put online as the main supply well because the trichloroethylene concentration of TSF #2 had fallen below the MCL of 5.0 µg/L. Therefore, by using TSF #2, no treatment (sparger air stripping system) is implemented other than the chlorination system.

Figure 5-4 illustrates the concentrations of trichloroethylene in both TSF #2 and the distribution system from 2000 through 2007. Since mid-2006 the concentration levels have been declining.

Table 5-14 summarizes the trichloroethylene concentrations at TSF #2 and the distribution 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). The mean concentration at TSF #2 and distribution system for 2007 are 1.25 µg/L and 0.825 µg/L, respectively, which are below the MCL.

5.5 Waste Management Surveillance Surface Water Sampling

In compliance with DOE Order 435.1, CWI collects surface water runoff samples at the RWMC Subsurface Disposal Area (SDA). Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data.

Table 5-14. Trichloroethylene Concentrations at TSF Well #2 and Distribution System (2007).

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. MCL applies to the distribution system only.

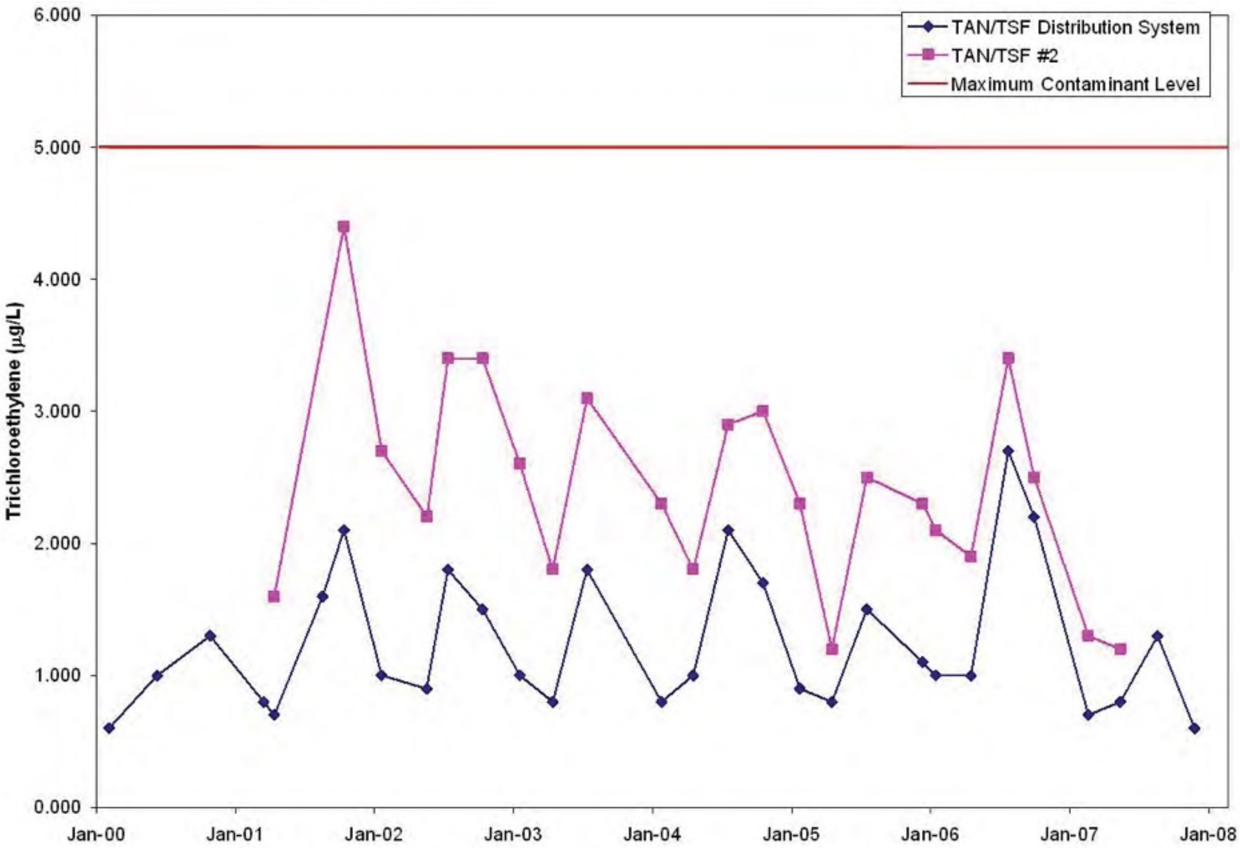

Figure 5-4. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2000-2007).

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 the RWMC. The canal also carries runoff from outside the RWMC that has been diverted around the SDA.

During 2007, no precipitation occurred to cause a surface water runoff event at the RWMC SDA. Therefore, no surface water runoff was available for sampling at the RWMC SDA.

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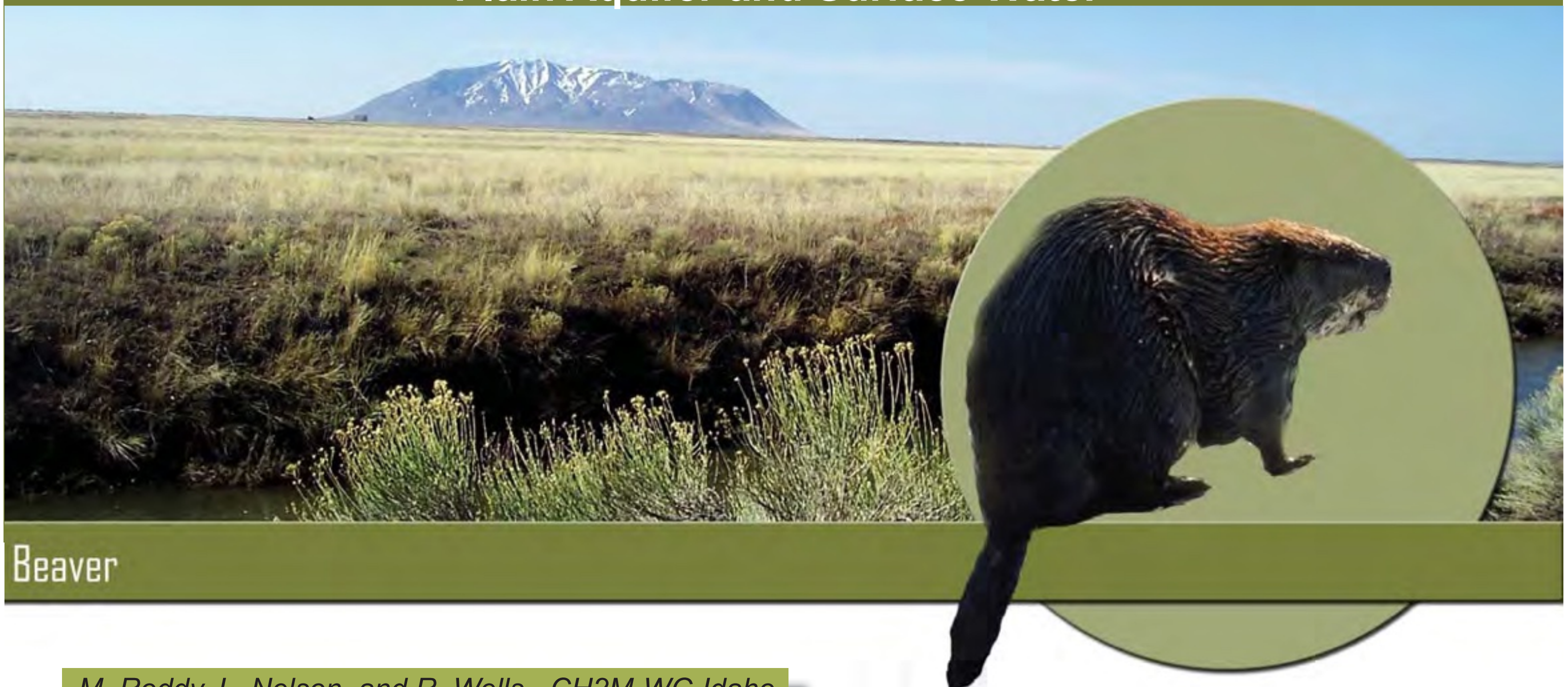
Chapter 6. Environmental Monitoring Programs - Eastern Snake River Plain Aquifer and Surface Water



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6. ENVIRONMENTAL MONITORING PROGRAMS - EASTERN SNAKE RIVER PLAIN AQUIFER AND SURFACE WATER

This chapter presents results from both radiological and nonradiological surveillance sampling and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sampling of groundwater. Reported results from sampling conducted by the Idaho Cleanup Project (ICP) contractor, CH2M-WG Idaho (CWI), and the U.S. Geological Survey (USGS) are presented here. Results are compared for informational purposes to the state of Idaho groundwater primary constituent standards (PCSs) and secondary constituents standards (SCSs) of Idaho Administrative Procedures Act (IDAPA) 58.01.11 and the U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCL) for drinking water and/or the U.S. Department of Energy (DOE) Derived Concentration Guide for ingestion of water. Results ascertain compliance with all the applicable regulatory guidelines, and if exceedances are reported, that all stake holders and regulatory agencies are notified so appropriate actions can be addressed.

Section 6.1 summarizes the monitoring programs. Sections 6.2 and 6.3 present discussions of the hydrogeology of the Idaho National Laboratory (INL) Site and hydrogeologic data management, respectively. Section 6.4 describes aquifer studies related to the INL Site and Eastern Snake River Plain Aquifer (ESRPA). Radiological and nonradiological monitoring of groundwater at the INL Site is discussed in Sections 6.5 and 6.6, respectively. Section 6.7 outlines the CERCLA groundwater activities performed in 2007.

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. This is done through 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

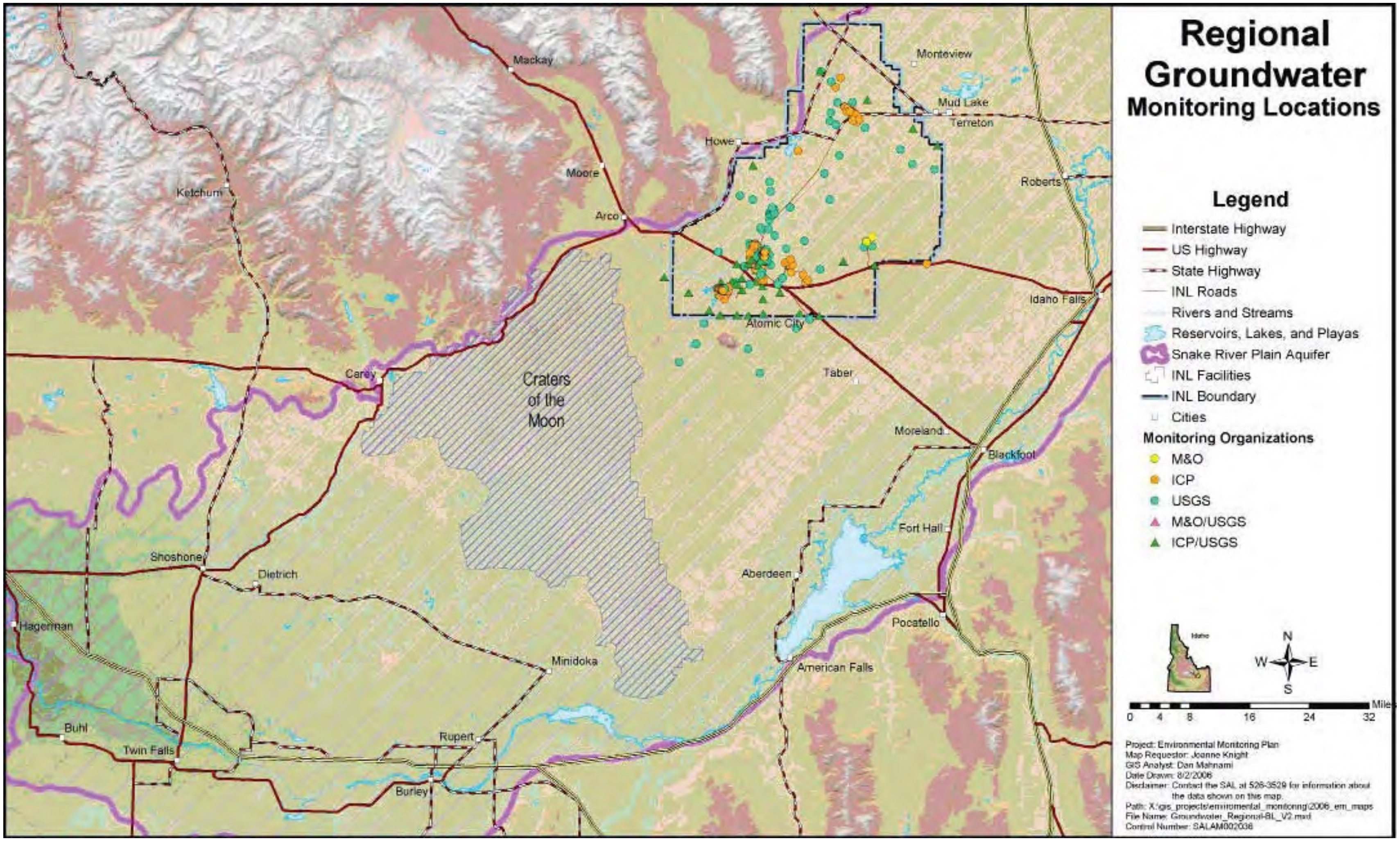

Figure 6-1. The INL Site and Regional Groundwater Monitoring Locations.

River Plain (ESRP). Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2007, 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.

As detailed in Chapter 3, CERCLA activities at the INL Site are divided into ten Waste Area Groups (WAGs) (Figure 3-3). Each WAG addresses groundwater for its particular contaminant(s) of concern. 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 (RODs) are approved for each WAG, many of the groundwater monitoring activities will be turned over to the Long-Term Stewardship program as an effort 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

The INL Site occupies 2,300 km^2 (890 mi^2) at the northwest edge of the ESRP, with the site boundaries coinciding with the Mud Lake sub-basin and the Big Lost Trough. The ESRPA owes its existence and abundance to a unique sequence of tectonic, volcanic, and sedimentologic processes associated with the migration of the North American tectonic plate southwestward across the Yellowstone hotspot, or mantle plume (Geslin et al. 1999). The basalt lava flows that host the aquifer and comprise the overlying vadose zone are very porous and permeable due to emplacement processes and fracturing during cooling. Rubble zones between lava flows and cooling fractures allow very rapid flow of water in the saturated zone, rapid infiltration of water and contaminants, and deep penetration of air into the vadose zone. Alluvial, eolian, and lacustrine sediments interbedded within the basalt sequence are generally fine-grained, commonly serving as aquitards below the water table, and affecting infiltration and contaminant transport in the vadose zone (Smith 2004).

The subsiding 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 >200 m thick (650 ft) 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 6-3) with velocities ranging from 0.5 to 6.1 m/day (2-20 ft/day). This is much faster than most studied aquifers and is attributed to the ESRP architecture and porous media.

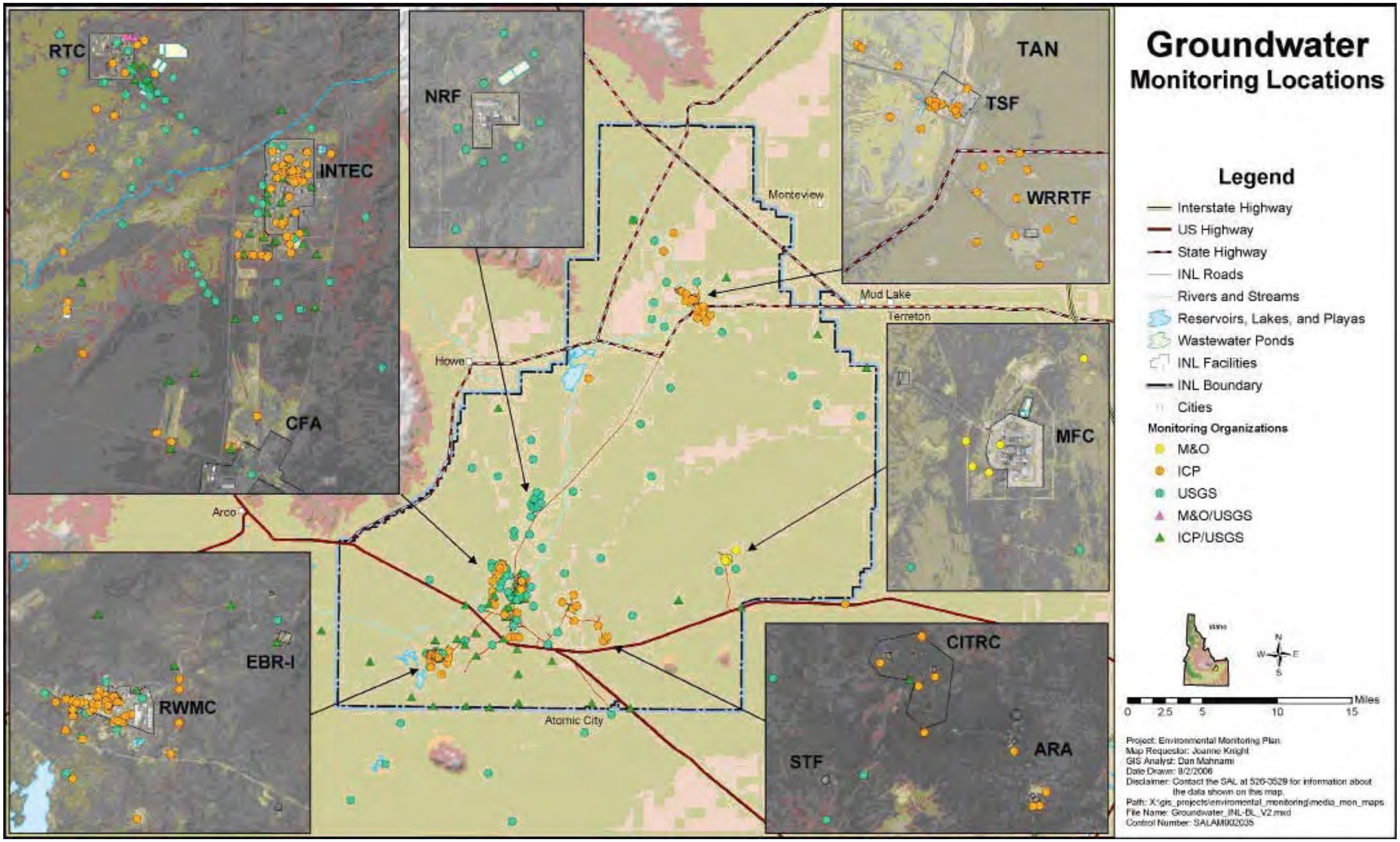

Figure 6-2. The INL Site Groundwater Monitoring Locations.

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

Area/Facility[a]	Media: Groundwater (Radiological)	Groundwater (Nonradiological)	Groundwater (CERCLA)	Surface Water	Drinking Water
INL/ICP Contractor	●	●	●	●[b]	●[c]
CFA	●	●	●		
INTEC	●	●	●	●	●[c]
MFC	●	●	●	●[b]	●[c]
RTC	●	●	●	●[b]	●[c]
TAN	●	●	●	●[b]	●[c]
RWMC	●	●	●	●[b]	●[c]
PBF/CITRC				●[b]	●[c]
U.S. Geological Survey					
INL Site/Regional	●	●		●[d]	

a. CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, RTC = Reactor Technology Complex, TAN = Test Area North, RWMC = Radioactive Waste Management Complex, PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range Complex.

b. See Chapter 5 for details of surface water (liquid effluent and stormwater) monitoring.

c. Compliance monitoring of drinking water can be found in Chapter 5.

d. Surface water samples are collected by the regional office of the USGS and are not discussed in this report.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, INL Site contractors and subcontractors, including the USGS. One of the functions of the INL Site Hydrogeologic Data Repository (HDR) is to maintain and make the data generated by these varied groups available to users and researchers. The HDR was established as a central location for the storage and retrieval of hydrologic and geologic information at the INL Site. The HDR is used to maintain reports, data files, maps, historic records, subcontractor reports, engineering design files,

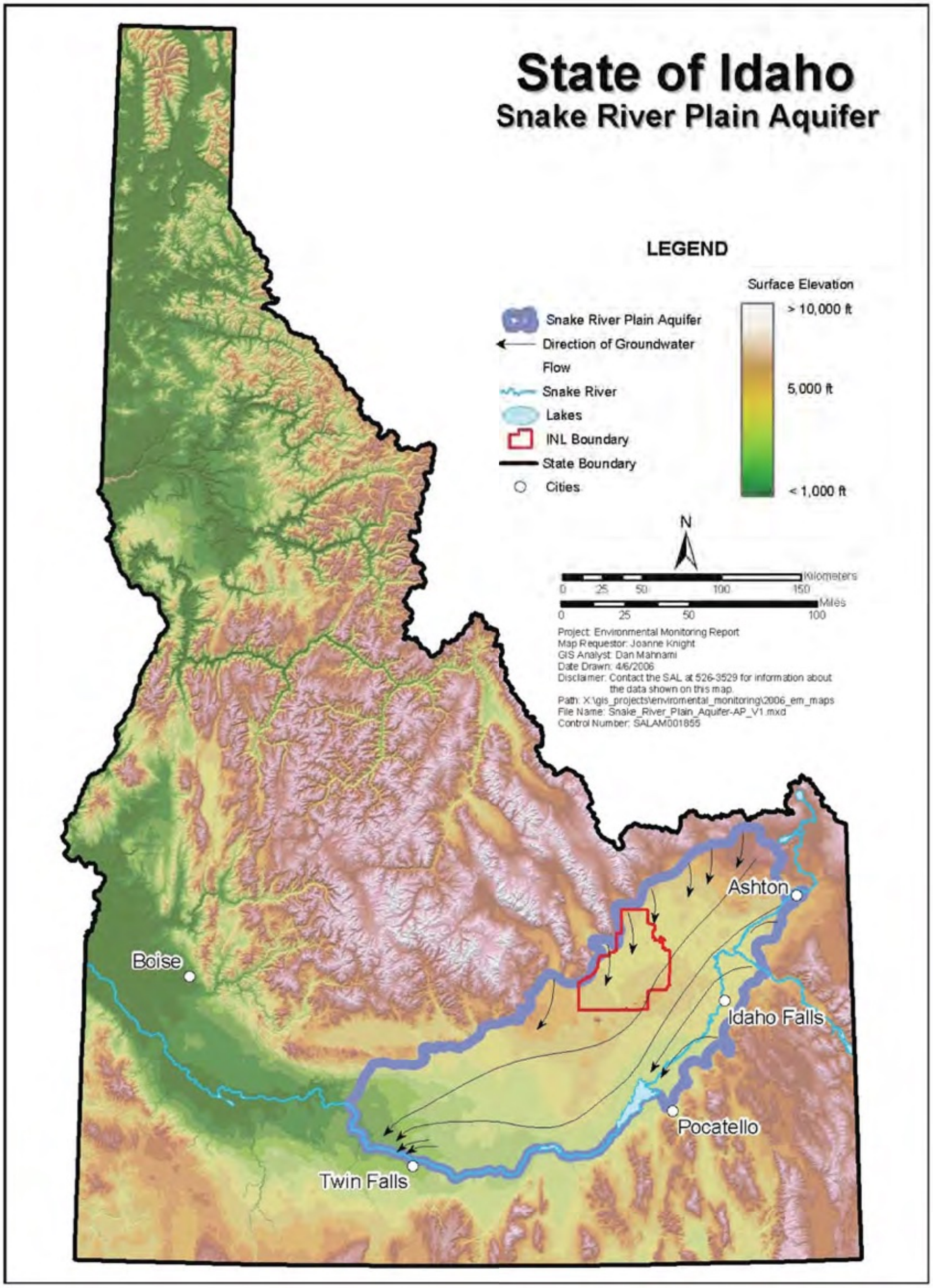

Figure 6-3. Location of the INL Site in Relation to the Eastern Snake River Plain Aquifer.

letter reports, subsurface information, and other data in many formats. This information is related to the hydrology and geology of the INL Site, the ESRP, and the ESRPA. The HDR is also used to maintain the INL Site Comprehensive Well Inventory, with records of well construction, modification, abandonment, and logging. The HDR also maintains databases of historic and current water analysis, water levels, and special studies.

The INL Site Sample and Analysis Management (SAM) Program was established to provide consolidated environmental sampling activities and analytical data management. The SAM provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records. The SAM develops statement(s) of work, procedures, and guidance documents to establish and maintain analytical and validation contracts. The consolidated approach is based on the need for site-wide reporting compliance, comprehensive technical analyses, and increased consistency in the manner in which analytical data are managed at the INL Site. The SAM also participates in monitoring laboratory performance and annual onsite laboratory audits to ensure quality and compliance. The USGS uses the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory.

6.4 Aquifer Studies

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 the movement of water in the ESRPA is given in Section 6.2. Further information may be found in numerous publications of the USGS. Copies of 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 2007, personnel of the USGS INL Project Office published three documents and funded one Masters Thesis 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 C.

6.5 Radiological Groundwater Monitoring

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) facility used direct injection as a disposal method up to 1984. The wastewater in the injection well contained high concentrations of tritium, strontium-90 (^{90}Sr) and iodine-129 (^{129}I). The injection well was sealed in 1990. When direct injection ceased, wastewater from INTEC was directed to shallow percolation ponds, where the water infiltrates 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 clean closed, and the new INTEC percolation ponds went into operation in August 2002. The Reactor Technology Complex (RTC), formerly known as the Test Reactor Area, also had a disposal well but primarily discharged contaminated wastewater to a shallow percolation pond. The RTC 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 RTC and INTEC was highest during 1952 to 1983 (910 Ci/year), decreased during 1984 to 1991 (280 Ci/year), and continued to decrease during 1992 to 1995 (107 Ci/year). From 1952 to 1998, the INL Site disposed approximately 93 Ci of ^{90}Sr at RTC and about 57 Ci at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the ESRPA at RTC; however, at INTEC a portion of the ^{90}Sr was injected directly to the ESRPA. From 1996 to 1998, the INL Site disposed 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 CWI and the USGS at levels above the PCS value in some surveillance wells between INTEC and Central Facilities Area (CFA). Other radionuclides (i.e., gross alpha) have been detected above their PCS values in wells monitored by individual WAGs.

U.S. Geological Survey

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 6-4 (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. This is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of RTC (USGS-065) and INTEC (USGS-077) have continually shown the highest tritium concentrations in the aquifer over time. 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 south of RTC decreased from $(6.3 \pm 0.6) \times 10^3$ pCi/L in 2006 to $(6.1 \pm 0.6) \times 10^3$ pCi/L in 2007; the tritium concentration in USGS-077 south of INTEC was not received from the analytical laboratory in time for inclusion in this annual report, but concentrations decreased from $(11.5 \pm 0.3) \times 10^3$ pCi/L in 2005 to $(9.62 \pm 0.17) \times 10^3$ pCi/L in 2006.

The Idaho groundwater PCS value 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), a cessation of tritium disposal, advection/dispersion, diffusion, and dilution within the ESRPA (See Figure 6-5).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Davis 2008). The contamination originates from INTEC as a remnant of the earlier injection of wastewater. No ^{90}Sr was detected in the vicinity of RTC during 2007. All ^{90}Sr at RTC was disposed to infiltration ponds in contrast to the direct injection that occurred at the INTEC. At RTC, ^{90}Sr is retained in surficial sedimentary deposits, sedimentary interbeds, and in the perched groundwater zones. The area of the ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

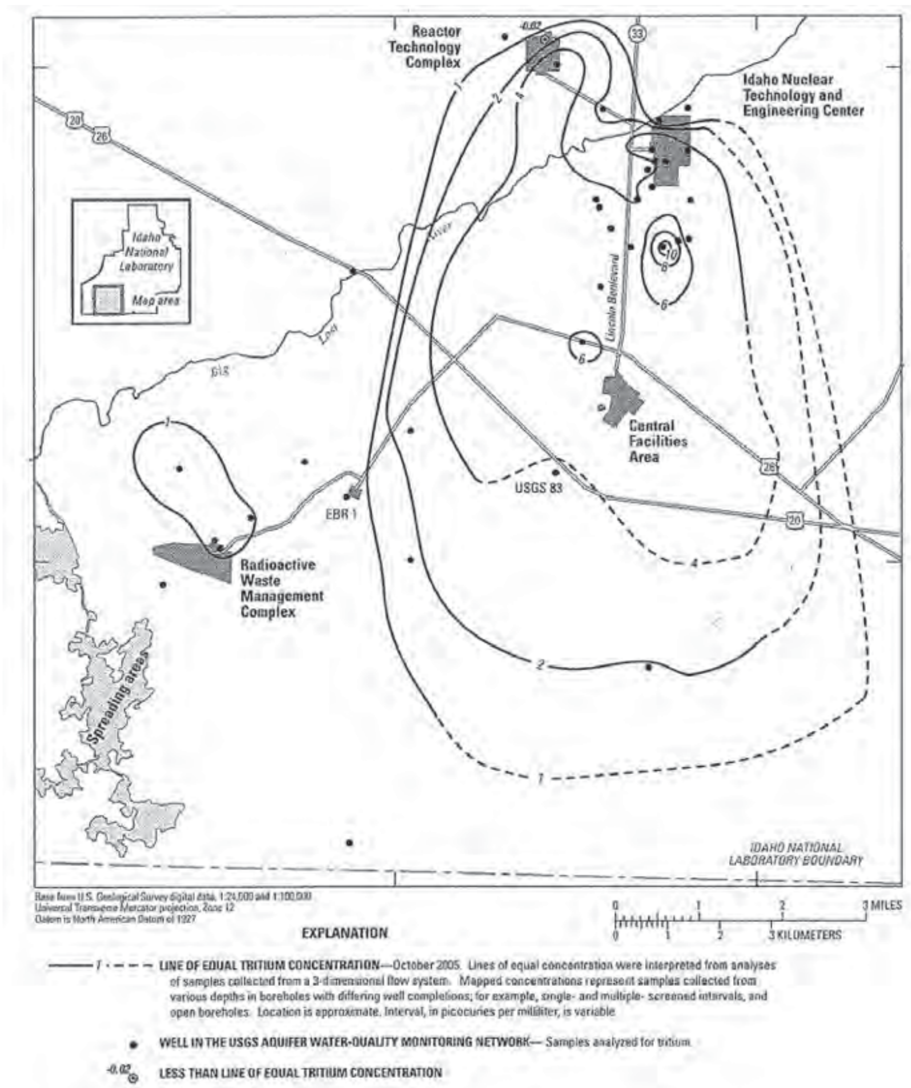

Figure 6-4. Distribution of Tritium in the Eastern Snake River Plain Aquifer at the INL Site for 2005 (from Davis 2008).

The trend of ^{90}Sr over the past 16 years (1990-2006) in USGS-047, USGS-057 and USGS-113 is shown in Figure 6-7. Concentrations in well 047 have been quite variable through time, and concentrations in wells 057 and 113 indicate a general decrease in concentration. The general decrease in concentration is probably the result of radioactive decay (^{90}Sr has a half-life of 29.1 years), a decrease of ^{90}Sr disposal, diffusion, advection/dispersion, and dilution within the ESRPA. The increases seen 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 an increase in the 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).

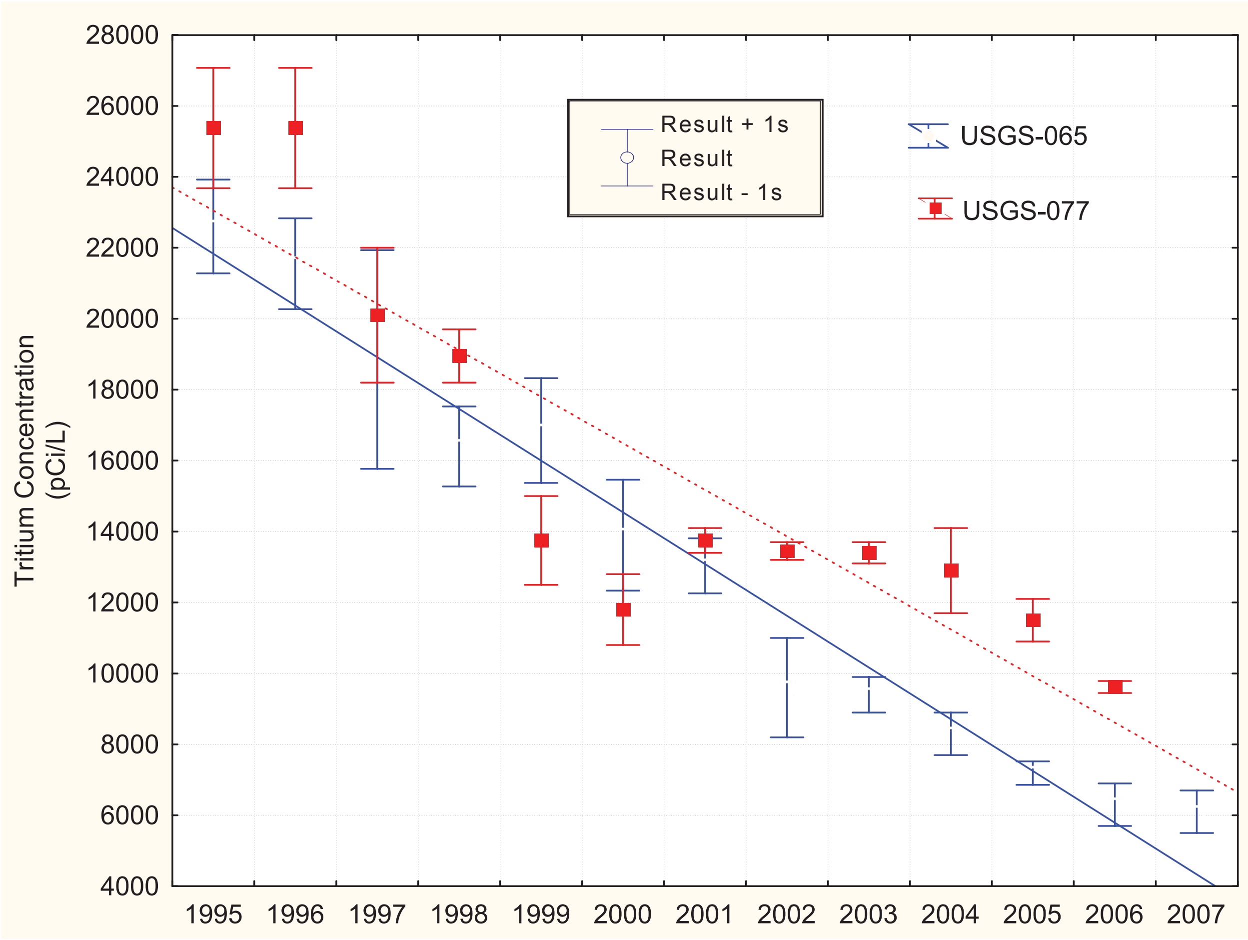

Figure 6-5. Long-Term Trends of Tritium in USGS-065 and USGS-077 (1995-2007).

Summary of other USGS radiological ground water monitoring – The USGS annually collects samples from select wells at the INL for gross alpha, gross beta, gamma spectroscopy analyses, plutonium, and americium isotopes (Table 3-4); however, complete results for wells sampled in 2007 are not available from the analytical laboratory. Monitoring results for 2002-2005 are summarized in Davis (2008). During 2002-05, concentrations of cesium-137 (^{137}Cs) (as determined by gamma spectroscopy), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}Pu$), americium-241 (^{241}Am), and gross alpha-particle radioactivity in all samples analyzed were less than the threshold 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).

The USGS has periodically sampled for ^{129}I in the ESRPA and monitoring programs from 1977, 1981, 1986 and 1990-91 were summarized in Mann et al. (1988) and Mann and Beasley (1994). The USGS is currently evaluating results from samples collected in 2003 and 2007 and discussion of results will be included in the 2008 Site Environmental Report.

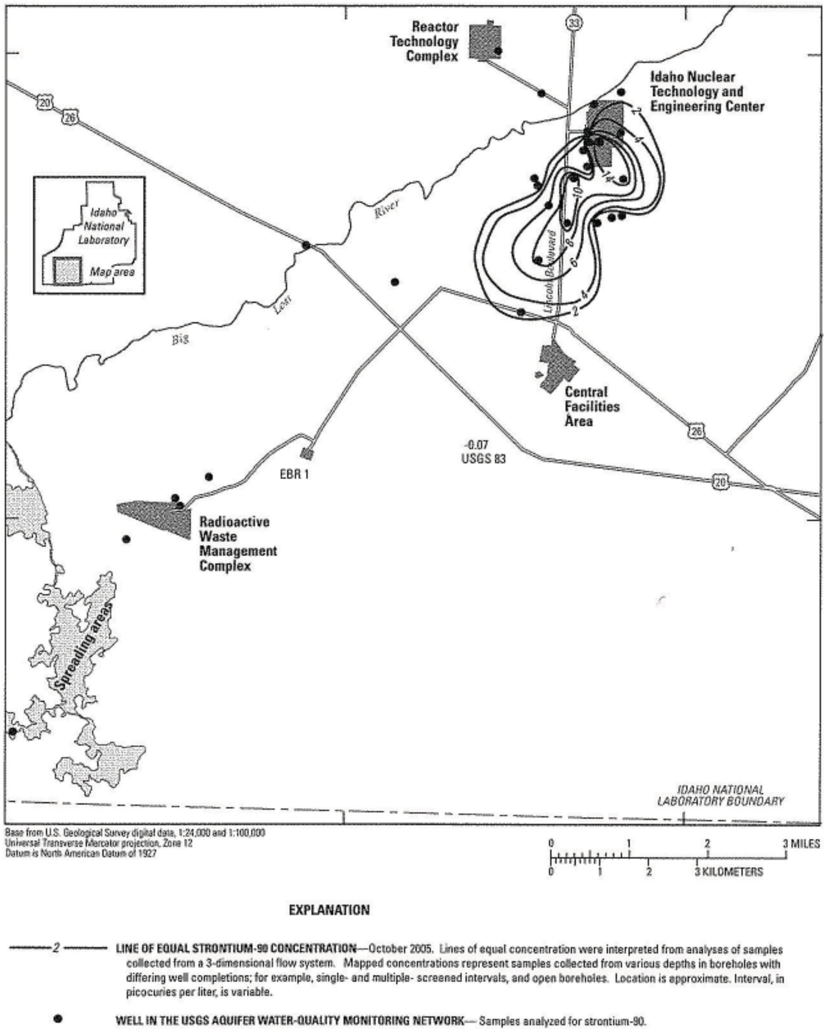

Figure 6-6. Distribution of ^{90}Sr in the Eastern Snake River Plain Aquifer at the INL Site for 2005 (from Davis 2008).

6.6 Nonradiological Groundwater Monitoring

U.S. Geological Survey

The USGS annually collects samples from select wells at the INL for chloride, sulfate, sodium, fluoride, nitrate, chromium and selected other trace elements, total organic carbon and purgeable organic compounds (Table 6-2). A detailed discussion of sample results for samples collected during 2002-2005 is found in Davis (2008). Chromium had a concentration greater than the MCL of 100 µg/L in well USGS-065 in 2005 (Davis 2008), but the concentration has continually decreased and was 97 µg/L in 2007. The concentrations of chloride, nitrate, sodium, and sulfate have historically been above background concentrations in many wells at the INL, but concentrations were below established MCLs or secondary maximum contaminant level (SMCLs) in all wells during 2005 (Davis 2008).

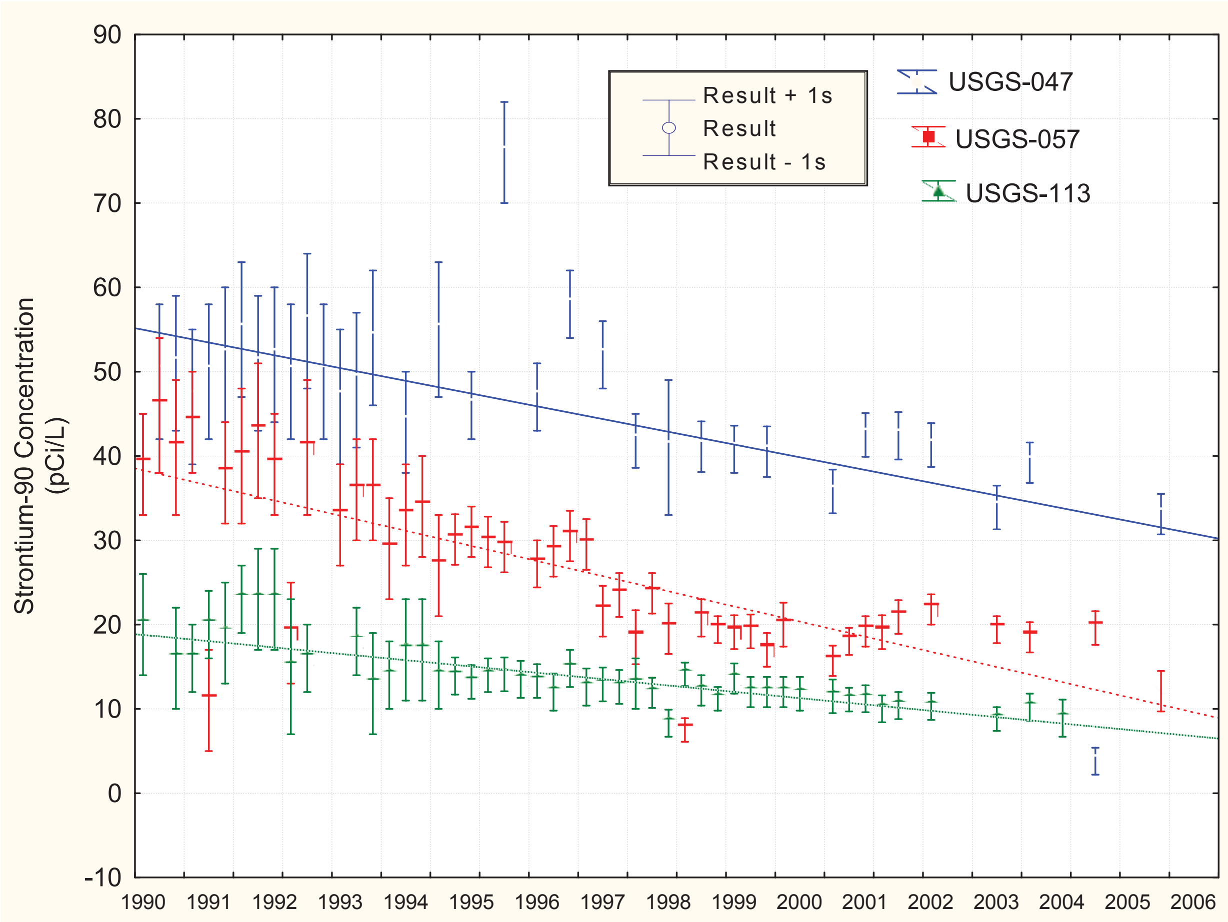

Figure 6-7. Long-Term Trends of ^{90}Sr in USGS-047, USGS-057 and USGS-113 (1990-2007).

Sampling for purgeable (volatile) organic compounds in groundwater was conducted by the USGS at the INL Site during 2007. Water samples from 29 groundwater monitoring wells were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996, Bartholomay et al. 2003). Ten purgeable organic compounds were detected at concentrations 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 carbon tetrachloride (tetrachloromethane) exceeded the EPA MCL of 5 µg/L for all 12 months in 2007 (Table 6-2). None of the other measured constituents were above their respective PCS.

The RWMC production well contained detectable concentrations of eight of these purgeable organic compounds. Annual average concentrations of these compounds in this well have generally increased through time (Davis 2008).

Table 6-2. Concentrations of Purgeable Organic Compounds in USGS Well Samples (2007).[a]

Well ID	Date	Bromodi chloro methane	Tetrachlor omethane	Tribromo methane	Dibromoc hloromet hane	Trichloro methane	Toluene	Tetrachlo ro ethene	1,1,1-Trichloro ethane	Dichlorodi fluoro methane	Trichloro ethene
RWMC	01/11	ND[b]	9.79	0.24	ND	1.65	ND	0.37	0.60	ND	3.85
Production	02/08	ND	11.01	0.46	ND	1.85	ND	0.37	0.62	ND	4.19
Well	03/08	ND	6.73	ND	ND	1.45	ND	0.32	0.51	ND	3.18
	04/23	0.76	10.15	0.98	1.12	2.82	ND	0.43	0.71	ND	4.49
	05/10	ND	9.47	ND	ND	2.17	ND	0.35	0.69	ND	4.28
	06/18	ND	10.63	ND	ND	2.05	ND	0.35	0.67	ND	4.29
	07/12	ND	7.68	ND	ND	1.81	ND	0.29	0.55	ND	3.56
	08/14	ND	9.69	ND	ND	1.63	ND	0.32	0.62	ND	3.60
	09/13	ND	7.53	ND	ND	1.54	ND	0.32	0.53	ND	3.30
	10/11	ND	8.71	ND	ND	1.62	ND	0.31	0.58	ND	3.47
	11/08	ND	9.75	ND	ND	1.80	ND	0.39	0.62	ND	3.61
	12/13	ND	8.62	ND	ND	1.53	ND	0.31	0.52	ND	3.27
38 (SW of INTEC)	04/16	ND	ND	ND	ND	ND	0.16	ND	0.17	ND	ND
65 (S of RTC)	04/23	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND
77 (S of RTC)	10/18	ND	ND	ND	ND	ND	ND	ND	0.11	ND	ND
87 (N of RWMC)	04/23	ND	3.24	ND	ND	0.24	ND	0.13	0.18	0.44	0.72
88 (S of RWMC)	10/16	ND	0.87	ND	ND	0.48	ND	ND	ND	ND	0.50
PCS[e]							**1000**	**5**	**200**		**5**

a. All values are in micrograms per Liter (μg/L).

b. ND = Not Detected.

c. PCS = Primary constituent standard values from IDAPA 58.01.11.

6.7 Summary of CERCLA Groundwater Monitoring Activities for Calendar Year 2007

As noted in Section 6.1, CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities at the INL Site, with the addition of the site-wide WAG 10. Locations of the various WAGs are shown on Figure 6-8. 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.inl.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

Summary of WAG 1 Groundwater Monitoring Results

Groundwater monitoring is performed at WAG 1 to measure the progress of the remedial action at Test Area North (TAN). The groundwater plume at TAN has been divided into three zones to facilitate remediation. The monitoring program and the results are summarized by zone in the following paragraphs.

Hot Spot Zone (trichloroethene [TCE] concentrations exceeding 20,000 μg/L) – In situ bioremediation (ISB) is used in the hot spot to promote bacterial growth by supplying essential nutrients to bacteria that occur naturally in the aquifer and are able to break down contaminants. An amendment (such as whey) is injected into well TSF-05 or other wells in the immediate vicinity. Amendment injections increase the rate at which the microbes break down the organic compounds into harmless compounds by supplying needed nutrients. The amendment supply is distributed as needed, and the treatment system operates year-round.

In general, activities performed during 2007 included periodic whey injections, groundwater sampling and analysis, well maintenance, and minor construction activities. Groundwater samples were collected monthly from 12 sampling locations and quarterly from 6 locations in the treatment cell to track the progress of ISB. Results of groundwater monitoring indicated that the ISB remedy continues to be effective at reducing the concentration of volatile organic compounds (VOCs) in the hot spot zone (RPT-488).

Medial Zone (TCE concentrations between 1000 and 20,000 μg/L) – Pump-and-treat is used in the medial zone. This process involves extraction of contaminated groundwater, treatment through air strippers, and re-injection of treated groundwater into the aquifer. Air stripping is a process that brings clean air into close contact with contaminated liquid, allowing the VOCs to pass from the liquid into the air.

On March 5, 2007, the New Pump and Treat Facility re-started following a 2-year rebound test. It was agreed that the facility would operate four days per week until TCE concentrations in several medial zone monitoring wells drop below 100 μg/L. Groundwater sampling of medial zone monitoring wells is completed on a monthly basis. The monitoring results are used to evaluate the need to operate the facility (RPT-488).

Distal Zone (TCE concentrations between 5 and 1,000 μg/L) – Monitored natural attenuation (MNA) is the treatment for the distal zone of the plume. MNA is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility,

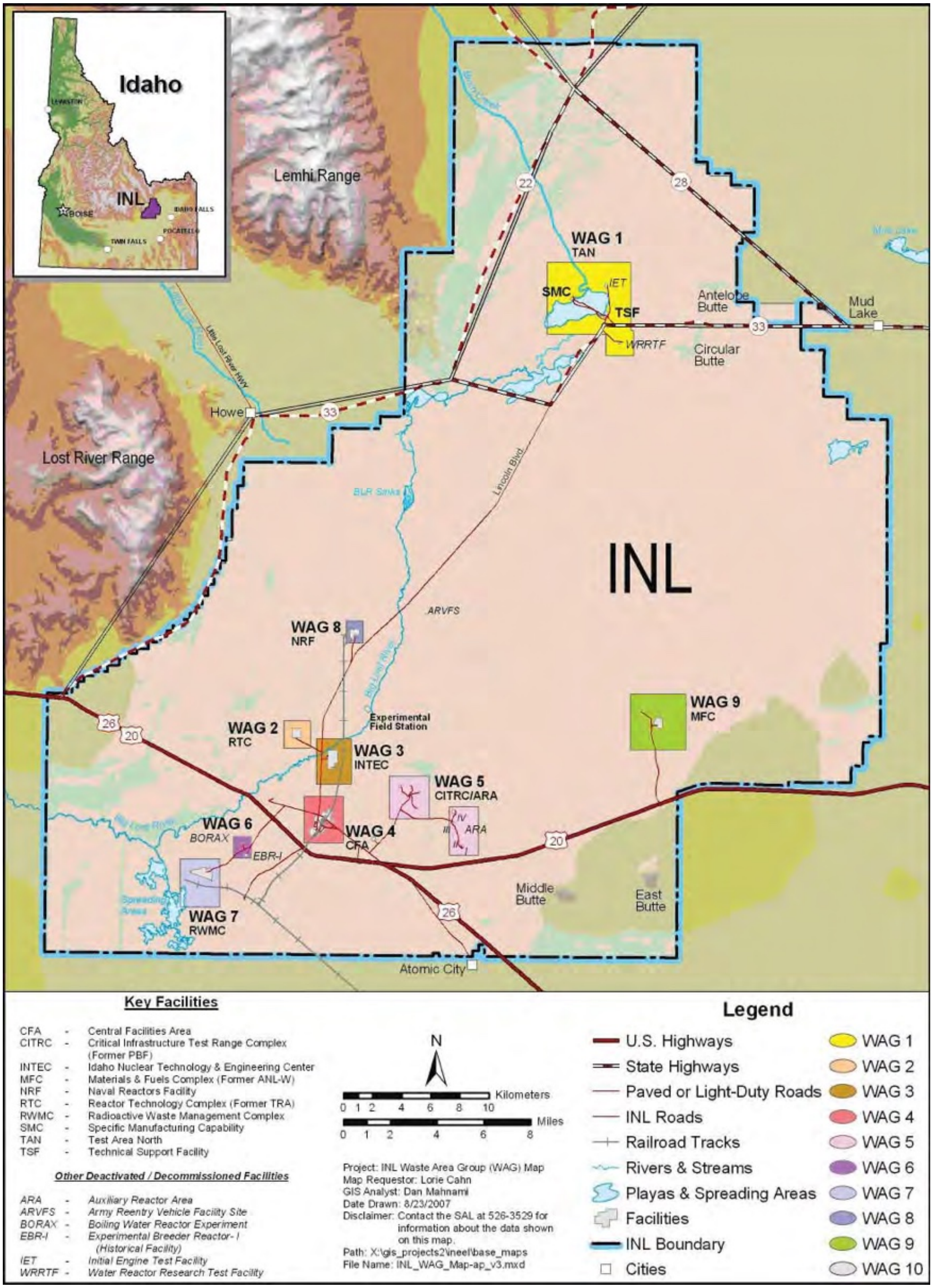

Figure 6-8. The INL Site Facilities Locations and Corresponding WAGs.

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. During the early part of the restoration timeframe, the contaminant plume may continue to increase slowly in size until the natural attenuation process overtakes it.

The primary MNA activities performed during 2007 were groundwater sampling and data analysis. Groundwater samples were collected for VOCs and/or radiological parameters from 60 sampling locations using 18 monitoring wells. Several of these locations were equipped with FLUTe™ systems and were sampled at multiple discrete depths below land surface. TCE concentration data and other data related to TCE degradation indicate that MNA will meet the remedial action objectives for the distal zone of the plume. Radionuclide groundwater monitoring in 2007 indicates that the natural attenuation mechanisms, as defined in the MNA Remedial Action Work Plan for the radionuclides tritium, ^{137}Cs, ^{90}Sr, and Uranium-234 (^{234}U), continue to be functional within the contaminant plume. Future groundwater monitoring, as outlined in the MNA Operations, Monitoring, and Maintenance Plan (DOE-ID 2003), will be sufficient to track the progress of the MNA remedy for radionuclides at TAN Operable Unit (OU) 1-07B (RPT-488).

Summary of WAG 2 Groundwater Monitoring Results

Groundwater samples were collected from six aquifer wells for WAG 2 (RTC) during calendar year 2007. The locations of the wells are shown on Figure 6-9, except for the Highway 3 well (a public access potable water well), which is shown on the figure for WAG 10 sampling locations. The Highway 3 well was not sampled in 2007 because the well was inaccessible due to construction taking place at the rest stop near the well's location. Aquifer samples were analyzed for total chromium (filtered and unfiltered), ^{90}Sr, gamma-emitting radionuclides, gross alpha, gross beta, and tritium. The data for the October 2007 sampling event will be included in the Fiscal Year 2008 annual report for WAG 2 (RPT-509). The data for the October 2007 sampling event are summarized in Table 6-3.

Chromium, ^{90}Sr, and gross alpha were detected above their respective MCLs. Filtered chromium concentrations exceeded the chromium MCL, 100 µg/L, in wells TRA-07 and USGS-065. The highest concentration of 106 µg/L occurred in TRA-07. Wells TRA-07 and USGS-065 each appear to show a declining trend in chromium concentrations.

Strontium-90, 10.6 pCi/L, exceeded its MCL of 8 pCi/L in well TRA-08, but ^{90}Sr concentrations have been decreasing in this well since 2005.

Gross alpha exceeded its MCL in well MIDDLE 1823 for the first time. The source of the elevated gross alpha in MIDDLE-1823 is uncertain.

Consistent with past sampling, tritium concentrations were above background concentrations in all aquifer wells sampled but concentrations were below the MCL and declining. Concentrations of tritium and chromium in the aquifer have declined faster than predicted by WAG 2 models used for the OU 2-12 ROD and the revised modeling performed after the first five-year review (DOE ID 2005).

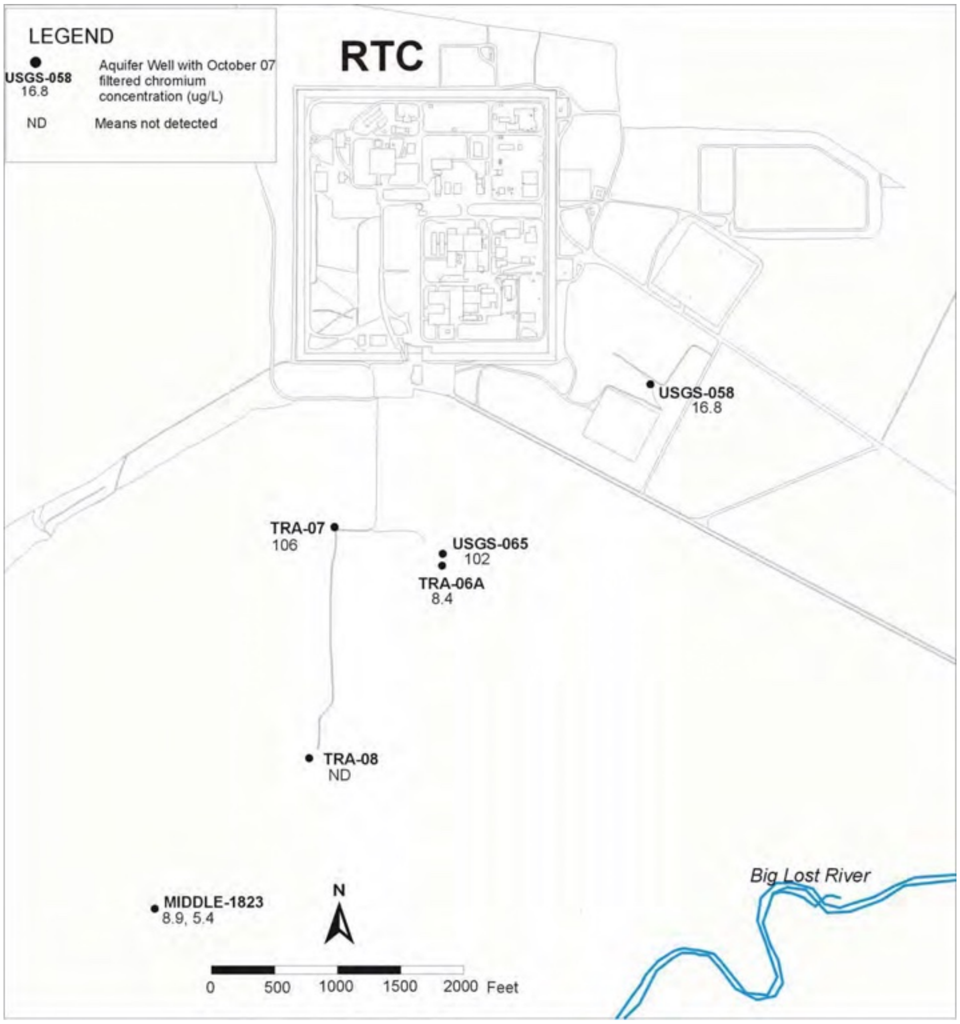

Figure 6-9. WAG 2 Monitoring Well Locations and Chromium Concentrations for 2007 (note: Highway 3 well not shown on this map).

The hydraulic gradient contour maps constructed for the ESRPA in the vicinity of the RTC were consistent with previous maps showing similar water levels and groundwater flow directions.

Summary of WAG 3 Groundwater Monitoring Results

During 2007, groundwater samples were collected from a total of 22 ESRPA monitoring wells, plus five aquifer wells sampled for the INL CERCLA Disposal Facility monitoring program (DOE-ID 2008a) (Figure 6-10). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents. Laboratory results in this report are compared to drinking water MCLs.

For each of the primary constituents of concern, Table 6-4 summarizes the maximum concentration observed during 2007 in the ESRPA groundwater at INTEC, along with the number of MCL exceedances reported for each of these three media.

Table 6-3. WAG 2 Groundwater Quality Summary for 2007 Sampling Events.

Analyte	Units	Background[a]	Minimum	Maximum	MCL	Number of Wells above MCL
Chromium (filtered)	µg/L	2 to 3	ND	106	100	2
Chromium (unfiltered)	µg/L	NA	ND	118	100	2
Sr-90	pCi/L	0	ND	10.7	8	1
Tritium	pCi/L	75 to 150	ND	13,600	20,000	0
Gross alpha	pCi/L	0 to 3	ND	26.4	15	1
Gross beta	pCi/L	0 to 7	ND	32.4	4 mrem/yr	NA

a. Background concentrations are from Knobel, Orr, and Cecil (1992), except tritium from Orr, Cecil and Knobel, 1991.
MCL = maximum contaminant level.
NA = not applicable.
ND = not detected

Strontium-90, Technetium-99 (^{99}Tc), and nitrate exceeded their respective drinking water MCLs in one or more of the ESRPA monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remain above the MCL (8 pCi/L) at 11 of the 22 monitoring wells sampled in 2007, and ^{90}Sr concentrations remained nearly constant (within ±2 sigma) in 11 out of 16 monitoring wells that were sampled during 2004–2007. Only one well located southeast of INTEC (USGS-067) showed a slight ^{90}Sr increase (>2 sigma).

Technetium-99 was detected above the MCL (900 pCi/L) in two wells within the INTEC facility, but concentrations were below the MCL at all other locations. As in the past, the highest ^{99}Tc level was at the monitoring well ICPP-MON-A-230 (1620 pCi/L) located north of the INTEC tank farm. Technetium-99 concentrations declined between 2006 and 2007 at seven of the wells, and ^{99}Tc levels at 9 of the 16 aquifer wells sampled overlapped the results from the previous year. USGS-047 was the only well that showed an increase in ^{99}Tc from 2006 to 2007.

Nitrate was detected in all of the wells sampled during 2007, but only two aquifer wells exceeded the MCL for nitrate-nitrogen of 10 mg/L, ICPP-2021 (21.1 mg/L as N) and MW-18-4 (10.4 mg/L as N). These same wells have shown the highest nitrate concentrations over the past several years. All of these wells are located relatively close to the tank farm, and all show groundwater quality impacts attributed to past tank farm liquid waste releases.

Iodine-129 concentrations at all aquifer well locations were less than the MCL, with the highest concentration, 0.485 pCi/L, reported at well USGS-047, located near the former INTEC injection well. Iodine-129 concentrations for 11 out of 16 aquifer wells were similar to the results from the previous year. Only well USGS-047 showed an increase in ^{129}I from the previous year.

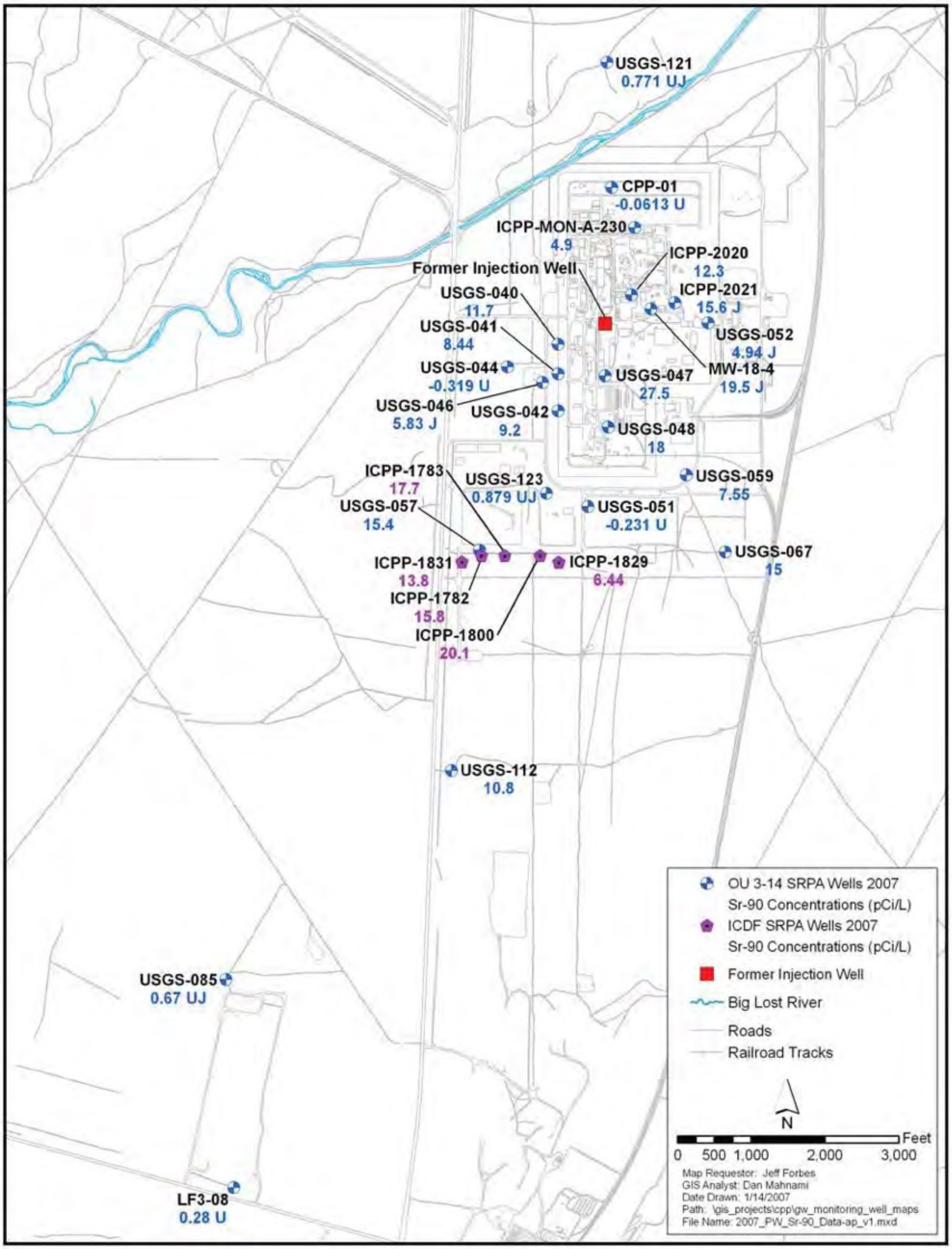

Figure 6-10. Locations of WAG 3 Wells Sampled and the Distribution of ^{90}Sr (pCi/L) in the Eastern Snake River Plain Aquifer in 2007.

Table 6-4. Comparison of WAG 3 2007 Sampling Results for Groundwater Samples From the Eastern Snake River Plain Aquifer to Regulatory Levels.

Constituent	Units	# Results	Maximum Value[a]	MCL	# Results >MCL
Gross alpha	pCi/L	30	10.5	15	0
Gross beta	pCi/L	30	1,190	NA	NA
Cs-137	pCi/L	30	14.8 UJ	200	0
Sr-90	pCi/L	36	27.5	8	22
Tc-99	pCi/L	36	1620	900	3
I-129	pCi/L	28	0.485	1	0
Tritium	pCi/L	29	8,710	20,000	0
Am-241	pCi/L	29	0.0834 U	15	0
Np-237	pCi/L	29	0.0469 U	15	0
Pu-238	pCi/L	29	0.0731 U	15	0
Pu-239/240	pCi/L	29	0.0512 U	15	0
Pu-241	pCi/L	30	5.66 UJ	300	0
U-233/234	pCi/L	36	2.82	15	0
U-235	pCi/L	32	0.244 J	15	0
U-238	pCi/L	36	1.41	15	0
Alkalinity	mg/L	30	226	NA	NA
Calcium	mg/L	28	73.7	NA	NA
Chloride	mg/L	28	151	250	0
Fluoride	mg/L	28	0.301 J	4	0
Magnesium	mg/L	28	25.8	NA	NA
Mercury	µg/L	34	0.13	2	0
Nitrate (as N)	mg/L	28	21.1	10	2
Potassium	mg/L	28	5.12	NA	NA
Sodium	mg/L	28	36.5	NA	NA
Sulfate	mg/L	34	40.1	250	0
Uranium	µg/L	28	4.1 J	30	0
TDS	mg/L	28	463	500	0

a. Data flags have the following meanings: J – estimated value; U – analyte is considered to not be present in the sample; UJ – the analyte might or might not be present. The associated value is an estimate and might be inaccurate or imprecise. The result is considered a nondetect.

MCL = maximum contaminant level.

NA = not applicable.

Tritium concentrations have been below the MCL in all aquifer wells sampled during 2003–2007. The highest tritium concentration in groundwater during 2007 was at USGS-051 (8,710 pCi/L) located near the former percolation pond. The tritium results for 13 of the 16 wells were similar between 2005 and 2007. Only one well showed a tritium increase during this period (USGS-047). Examination of longer-term trends indicates that tritium concentrations in groundwater have continued to decline during the period from 2000 through 2007.

During 2007, none of the actinide elements (e.g., Pu, Am, Np) were detected in the ESRPA groundwater samples. During the previous year, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am were reportedly detected in USGS-112, located approximately one mile south of INTEC. The 2006 results were questionable, so triplicate sampling was performed at this well during 2007. The fact that none of these actinide elements were detected in the 2007 triplicate samples suggests that the 2006 results likely were erroneous.

Mercury was detected from a single location, USGS-047, in the primary groundwater sample and in the field duplicate sample (0.13 µg/L and 0.10 µg/L, respectively). This well is located approximately 213 m (700 ft) south of the former INTEC injection well. The reported values are below the mercury MCL of 2 µg/L.

Uranium-238 was detected in the ESRPA at all sampling locations; however, the reported concentrations of ^{238}U are generally consistent with background concentrations reported for total uranium in the ESRPA elsewhere (Knobel, Orr, and Cecil 1992). Although a slightly elevated ^{238}U concentration was reported in 2006 at USGS-112 (2.8 pCi/L), triplicate samples collected in 2007 showed lower ^{238}U concentrations (0.77 to 1.15 pCi/L), evoking speculation of the earlier result. Uranium-233/234 ($^{233/234}$U) was also detected in all samples at concentrations similar to the ESRPA elsewhere, and ^{234}U/^{238}U ratios were similar to background ^{234}U/^{238}U ratios for the ESRPA. Uranium-235 (^{235}U) was detected in three of the WAG 3, Group 5, aquifer monitoring wells (USGS-059, ICPP-MON-A-230, and ICPP-2020) at concentrations ranging 0.18 pCi/L to 0.24 pCi/L.

The 2007 groundwater hydraulic gradient contour map is similar in shape to the maps prepared for 2003-2006, except that groundwater levels vary from year to year in response to wet-dry climate cycles (DOE-ID 2008a). Groundwater levels declined during 2000–2005 as a result of drought during this time period. However, as a result of above normal precipitation during 2005–2007, and corresponding periods of flow of the Big Lost River during those two years, the aquifer hydrographs show a slight rise in groundwater levels during 2006 and 2007.

Summary of WAG 4 Groundwater Monitoring Results

Groundwater monitoring for the CFA landfills consisted of sampling 11 wells for metals (filtered and unfiltered), VOCs, and anions (nitrate, chloride, fluoride and sulfate) in November-December 2007 in accordance with the Field Sampling Plan (INEEL 2006). The locations of the CFA monitoring wells are shown on Figure 6-11. Because of falling water levels in the aquifer, two wells, LF2-08 and LF2-09, had insufficient water for sampling. Analytes detected in groundwater are compared to regulatory levels in Table 6-5. A complete listing of the groundwater sampling results is contained in RPT-511.

Table 6-5. Comparison of 2007 WAG 4 Groundwater Sampling Results to Regulatory Levels.

Analyte	Units	Maximum Detection[b]	MCL/ SMCL[a]	Number of Wells above MCL/SMCL[c]
Anions				
Alkalinity	mg/L-$CaCO_3$	159	none	NA
Chloride	mg/L	91.3	*250*	0
Fluoride	mg/L	0.271	4 / *2*	0
Sulfate	mg/L	49.9	*250*	0
Nitrate/Nitrite as N	mg/L	18.2	10	1
Metals				
Aluminum	µg/L	5, **3890**	*50-200*	0, 2
Antimony	µg/L	0.6, 0.74	6	0, 0
Arsenic	µg/L	1.5, **12**	10	0, 1
Barium	µg/L	107, 256	2000	0, 0
Beryllium	µg/L	ND, 0.21	4	0, 0
Cadmium	µg/L	ND, 1.1	5	0, 0
Calcium	µg/L	62900, 59300	none	NA
Chromium	µg/L	15.5, **4240**	100	0, 2
Cobalt	µg/L	0.32, 63.9	none	NA
Copper	µg/L	2.2, 122	1,300	0, 0
Iron	µg/L	**355, 27800**	*300*	**3, 9**
Lead	µg/L	1.6, **16.6**	15[d]	0, 2
Magnesium	µg/L	24200, 24700	none	NA
Manganese	µg/L	8.7, **441**	*50*	0, 2
Mercury	µg/L	ND, ND	2	0, 0
Nickel	µg/L	56, 692	none	NA
Potassium	µg/L	4470, 4320	none	NA
Selenium	µg/L	2.7, 2.4	50	0, 0
Silver	µg/L	ND, 0.22	*100*	0, 0
Sodium	µg/L	38100, 39900	none	NA
Thallium	µg/L	ND, ND	2	0, 0
Vanadium	µg/L	7.2, 681	none	NA
Zinc	µg/L	189, **5480**	*5000*	0, 1
Detected VOCs				
1,2,4-Trichlorobenzene	µg/L	0.459	70	0
1,3-Dichlorobenzene	µg/L	0.279	none	NA
1,4-Dichlorobenzene	µg/L	0.273	none	NA
Naphthalene	µg/L	0.572	none	NA
Toluene	µg/L	27.3	1000	0
Chloroform	µg/L	0.731	100	0
Methane	µg/L	96	none	NA

a. Numbers in Italics are for the SMCL.
b. Maximum filtered and unfiltered value shown for metals.

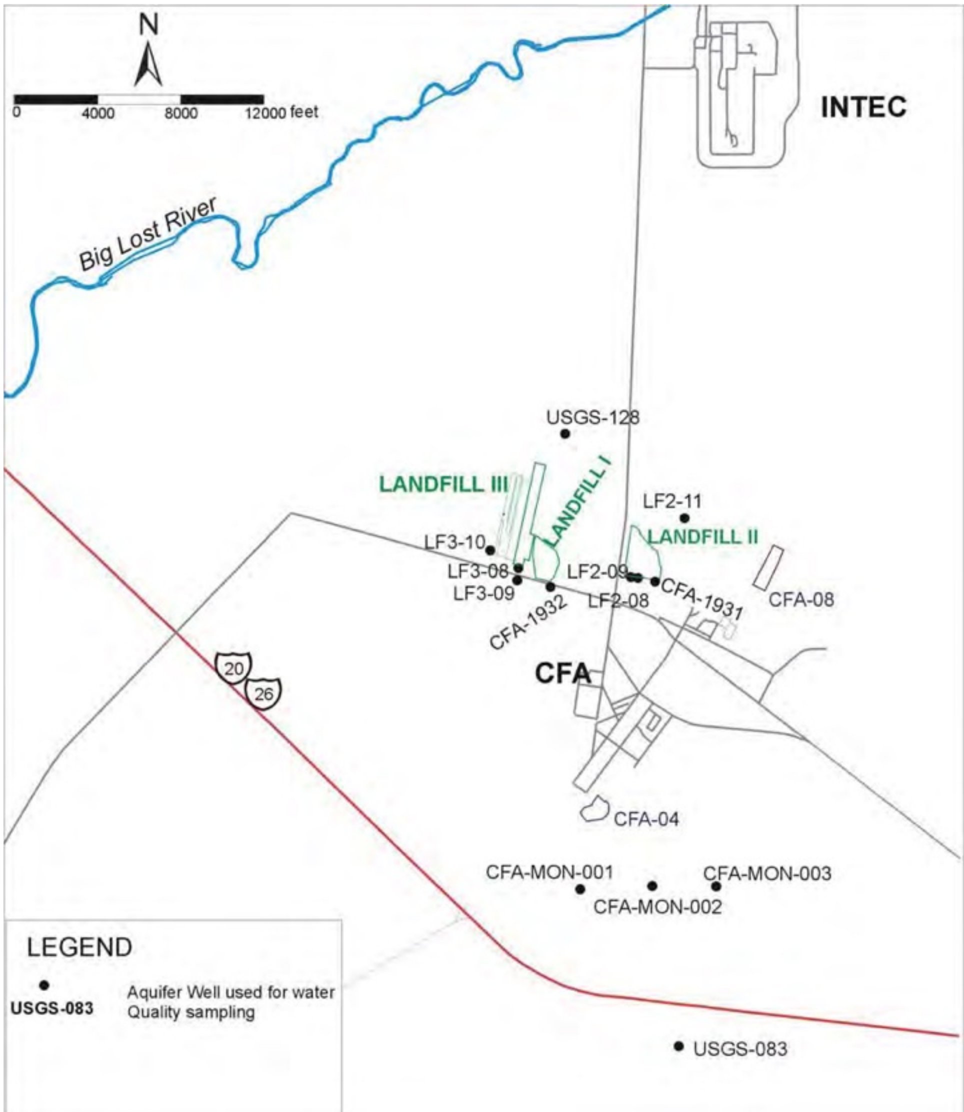

Figure 6-11. Locations of WAG 4 Monitoring Wells Sampled for 2007.

Consistent with previous data, nitrate was detected above its EPA MCL of 10 mg/L in CFA-MON-A-002 (18.2 mg/L-N). In CFA-MON-A-003, nitrate dropped below its MCL (9.06 mg/L-N) but is still within its historical range of between 8 and 11 mg/L-N. Except for the concentration spike in CFA-MON-A-003 in 2005, nitrate concentrations in CFA-MON-A-002 and 003 have remained relatively steady since monitoring began in 1995.

No analyte was detected above its MCL in the filtered metals groundwater samples, and only iron was detected above its SMCL. The elevated iron concentrations in the filtered groundwater samples are inconsistent with high dissolved oxygen concentrations and slightly alkaline pH of the ESRPA water. The elevated iron concentrations are conjectured to be particles small enough to get through the filter.

Several metals including aluminum, arsenic, chromium, iron, lead, manganese, and zinc exceeded their MCLs or SMCLs in unfiltered samples. The highest unfiltered metal concentrations were mostly from LF3-09 and were due to a high suspended sediment load resulting from sampling this well by the bailer method. The occurrence of metals above MCLs or SMCLs in the unfiltered samples is probably the result of suspended particulates, since filtered samples were well below the MCLs or SMCLs. As water levels have dropped in the CFA landfill wells, suspended sediment in the samples has increased.

Chloroform, toluene, and methane were the only VOCs detected downgradient of the CFA landfills. The chloroform was detected in the sample obtained from CFA-1931 near its detection limit, 0.79 µg/L, but well below the MCL 00 µg/L. The maximum toluene detection, 27.3 µg/L, was below the MCL of 1000 µg/L, and occurred in CFA-1932. The source of the toluene is uncertain; laboratory contamination is a possible source, since toluene is a common laboratory contaminant, and the lack of other hydrocarbons suggests this is not part of a fuel or other hydrocarbon product. Methane was detected in CFA-MON-A-002, down-gradient of CFA; however, there is no MCL for methane in groundwater.

The 2007 water level data for the CFA landfill wells suggest that water levels may be stabilizing. Hydraulic gradient and flow directions are consistent with previous years and indicate that elevated nitrate concentrations in CFA-MON-A 002 and -003 should not affect the CFA production wells.

Summary of WAG 5 Groundwater Monitoring Results

No groundwater monitoring was performed for WAG 5 in 2007. Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-ID 2005). WAG 5 well locations are shown in Figure 6-12.

Summary of WAG 7 Groundwater Monitoring Results

More than 3,200 analyses were performed on samples collected from 15 RWMC aquifer monitoring wells in Fiscal Year (FY) 2007. The locations of aquifer monitoring wells at the RWMC are shown on Figure 6-13. Relevant analytes detected above reporting limits in FY 2007 include carbon tetrachloride, ^{90}Sr, trichloroethylene, and tritium (RPT-512).

Carbon tetrachloride and trichloroethylene were consistently detected above the laboratory quantitation (reporting) limit of 1 µg/L in FY 2007. The quantitation limit was exceeded at seven monitoring locations and the carbon tetrachloride MCL (5 µg/L) was exceeded at two locations (M7S and M16S). Carbon tetrachloride concentrations frequently exceed the MCL at M7S and occasionally at M16S. Since the beginning of 2001, carbon tetrachloride concentrations at M7S have steadily increased, and since 2002, concentrations have been consistently above the MCL. The increasing concentration of carbon tetrachloride at M7S also is accompanied by slightly increasing levels of trichloroethylene. To date, trichloroethylene concentrations have not exceeded the MCL anywhere in the aquifer monitoring network near the RWMC.

Carbon tetrachloride and trichloroethylene concentrations are also above reporting limits at wells M3S and M15S, which are located in the general area of M7S; however, concentrations have not exceeded

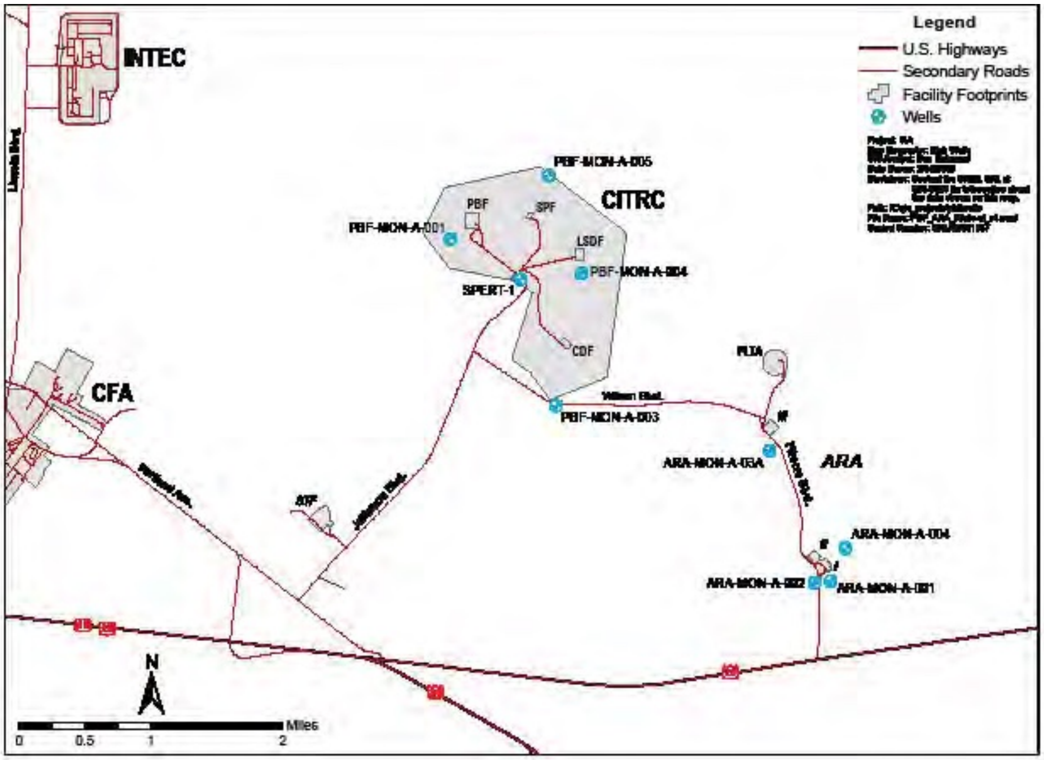

Figure 6-12. Well Locations Sampled for WAG 5.

their MCLs. Gradually increasing concentration trends at these locations began to develop in 2001, and have continued since that time. While concentrations are increasing northeast of the Subsurface Disposal Area (SDA), they are decreasing in monitoring wells south of RWMC (i.e., A11A31, OW2, USGS 088, and USGS 120). In these wells, carbon tetrachloride concentrations peaked between 1997 and 2003, depending on well distance from the RWMC, and have been decreasing steadily.

Tritium was present in samples obtained from six monitoring wells with concentrations considerably below the MCL of 20,000 pCi/L. Most wells with tritium concentrations above the background reporting threshold are located north-northeast of the SDA. Elevated tritium concentrations have been detected in this area since 1975, but concentrations in wells closest to the SDA (e.g., M3S, M7S, and M16S) have varied little since that time. Recent studies, conducted in coordination with WAG 10, indicate tritium detected in RWMC wells north-northeast of the SDA is likely associated with tritium plumes originating at INTEC and RTC (DOE-ID 2006).

Strontium-90 was detected at a low concentration in well M4D. Strontium-90 has been detected on two other occasions at this location (April 1997 and October 1998) and there is no evidence of an increasing concentration trend.

Detections of relevant analytes with concentrations above background reporting thresholds or quantitation (reporting) limits are summarized in Table 6-6.

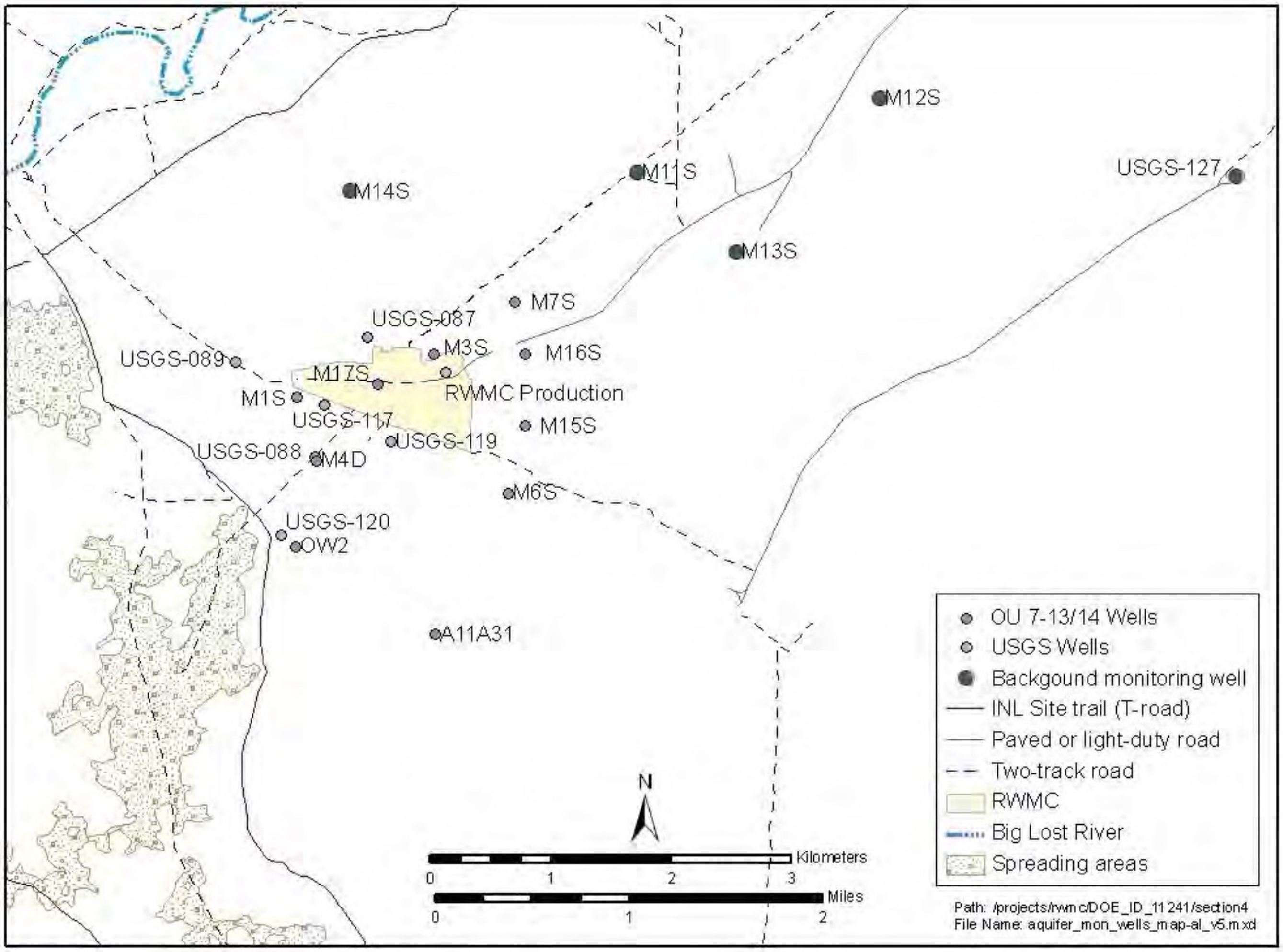

Figure 6-13. Locations of Aquifer Monitoring Wells Sampled at WAG 7.

Various inorganic constituents were detected above background reporting thresholds in the ESRPA at RWMC in FY 2007. Chloride, sodium, and sulfate are the most frequently detected analytes above reporting thresholds and primarily occur in wells south, southwest, and southeast of the SDA (i.e., A11A31, M6S, M15S, OW2, USGS-088, USGS-089, and USGS-120). Although, these analytes are not relevant to remedial decision-making or operation of the Low-Level Waste Disposal Facility, they are included because of meaningful trends. These wells have been above background reporting thresholds since monitoring began in the 1970s, reaching apparent peak concentrations between 1998 and 2003, depending on well location. Concentrations have been steadily decreasing since that time. The most southern wells (i.e., A11A31, OW2, USGS-088, and USGS-120) also contain elevated levels of carbon tetrachloride. Carbon tetrachloride concentration trends at these locations directly correlate with the concentration history of chloride, sodium, and sulfate.

Table 6-6. Aquifer Sampling and Data Analyses Summary for Relevant Analytes in 2007 for WAG 7.

Relevant Analyte	Monitoring Wells Sampled	Number of Analyses	Number of Detections Greater Than Background Reporting Threshold	Number of Detections Greater Than Maximum Contaminant Level[a]	Concentration exceeding background threshold: Maximum Concentration	Concentration exceeding background threshold: Concentration Units	Name of Monitoring Well Exceeding Maximum Contaminant Level
Ac-227[b]	NA	NA	NA	NA	NA	NA	NA
Am-241	15	33	0	0	NA	NA	NA
C-14	15	32	0	0	NA	NA	NA
Cl-36	15	33	0	0	NA	NA	NA
Cs-137	15	33	0	0	NA	NA	NA
Gross alpha	15	33	0	0	NA	NA	NA
Tritium	15	32	15	0	1,310 ± 121	pCi/L ± 1σ	NA
I-129	15	32	0	0	NA	NA	NA
Np-237	15	33	0	0	NA	NA	NA
Pb-210[b]	NA	NA	NA	NA	NA	NA	NA
Pa-231[b]	NA	NA	NA	NA	NA	NA	NA
Pu-238	15	33	0	0	NA	NA	NA
Pu-239/240	15	33	0	0	NA	NA	NA
Ra-226[b]	15	33	0	0	NA	NA	NA
Ra-228[b]	NA	NA	NA	NA	NA	NA	NA
Sr-90[b]	7	9	1	0	1.1 ± 0.3	pCi/L ± 1σ	NA
Tc-99	15	33	0	0	NA	NA	NA
Th-228[b]	NA	NA	NA	NA	NA	NA	NA
U-233/234[c]	15	33	0[c]	NA[d]	NA	NA	NA
U-235/236[c]	15	33	0[c]	NA[d]	NA	NA	NA
U-238[c]	15	33	0[c]	NA[d]	NA	NA	NA
Total uranium[c,d]	15	33	0[c]	0[d]	NA	NA	NA
Carbon tetrachloride	15	32	16[e]	5	7.6	µg/L	M7S, M16S
1,4-Dioxane	15	32	0[e]	0	NA	NA	NA
Methylene chloride	15	32	0[e]	0	NA	NA	NA
Tetrachloroethylene	15	32	0[e]	0	NA	NA	NA
Trichloroethylene	15	32	9[e]	0	3.0	µg/L	NA
Nitrate[f]	15	32	0	0	NA	NA	NA

a. The maximum contaminant level (MCL) is from "National Primary Drinking Water Standards" (40 CFR 141) and *Implementation Guidance for Radionuclides* (EPA 2002).

b. Monitoring is not routinely performed for these analytes. However, Ra-226 is analyzed indirectly by gamma spectrometry analysis, and Sr-90 analysis is performed if gross beta exceeds 5 pCi/L.

c. U-234, -235, and -238 are naturally occurring in the environment, and the number of detections shown is for results that exceeded background reporting thresholds Aquifer background reporting thresholds currently applied to isotopic uranium results are 1.69 pCi/L for U-233/234, 0.15 pCi/L for U-235/236, 0.78 pCi/L for U-238, and 2.36 µg/L for total uranium.

d. Total uranium is the sum of concentrations for each uranium isotope after converting reported activity (pCi/L) to mass (µg/L) and is used for comparison to the MCL. The MCL is from "National Primary Drinking Water Regulations" (40 CFR 141) and pertains to total uranium, not each individual uranium isotope.

e. A background reporting threshold is not applicable, since true background concentrations are essentially zero. Carbon tetrachloride, 1,4-dioxane, methylene chloride, tetrachloroethylene, and trichloroethylene do not occur naturally; however, they may be found in the environment at trace concentrations because of use in a wide variety of industrial and household products.

f. Nitrate occurs naturally in the environment, and the number of detections shown is for results that exceeded the aquifer background reporting threshold of 2.0 mg/L.

NA = not applicable.

Summary of WAG 9 Groundwater Monitoring Results

Five wells (four monitoring and one production; Figure 6-14; ANL-W, 1998) at the Materials and Fuels Complex (MFC; 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 ROD. The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-7.

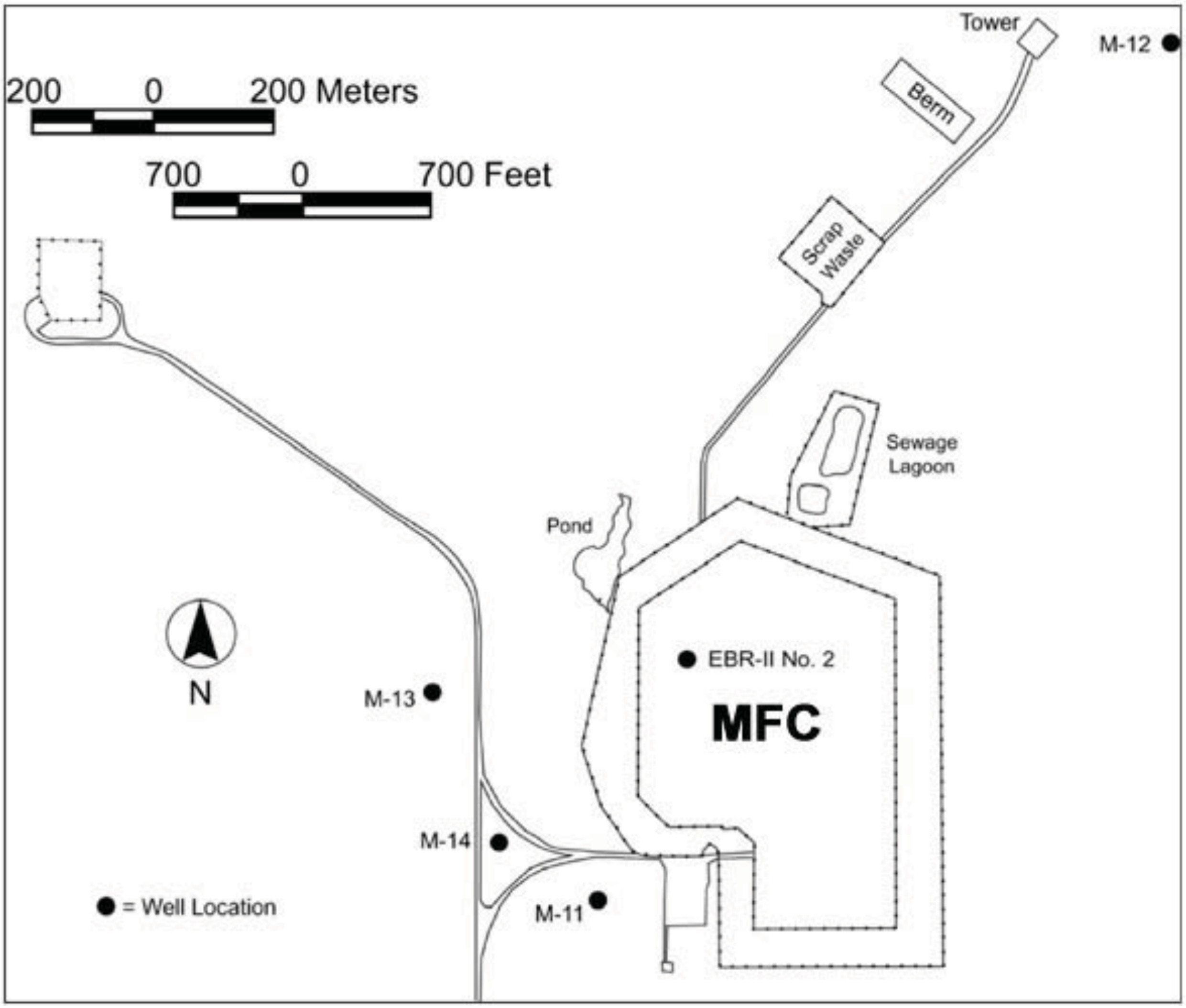

Figure 6-14. Locations of WAG 9 Monitoring Wells Sampled in 2007.

Summary of WAG 10 Groundwater Monitoring Results

WAG 10 groundwater monitoring activities included a groundwater sampling round, evaluation of data from the comprehensive automated site-wide water-level measurement system, and assessment of vertical gradient data in USGS-134. In accordance with the Field Sampling Plan (DOE-ID 2007), 18 boundary and guard wells and two Westbay wells, MIDDLE-2050A and MIDDLE-2051, with two sampling intervals in each, and six intervals in Westbay well USGS-132 were sampled in FY 2007.

Table 6-7. Comparisons of 2007 Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parentheses.

Well		M-11		M-12		M-13		M-14		EBR-II No. 2		
Sample Date Parameter	Units	5/23/07	11/26/07	5/22/07	11/26/07	5/22/07	12/10/07	5/22/07	12/10/07	5/23/07	11/27/07	MCL/SMCL[a]
						Radionuclides[b]						
Gross Alpha	pCi/L	3.15 ± 1.75 U (2.23 ± 1.34 U)	2.1 ± 0.793 UJ	2.28 ± 0.653	2.57 ± 0.822	1.65 ± 1.32 U	2.44 ± 1.13 UJ (3.16 ± 1.27 UJ)	2.96 ± 1.72 U	0.0016 ± 1 U	4.22 ± 1.82 J	0.919 ± 0.818 U	15
Gross Beta	pCi/L	2.14 ± 0.932 (3.98 ± 1.42)	1.84 ± 0.735 UJ	4.53 ± 0.724	1.89 ± 0.735 UJ	3.38 ± 1.38 J	2.91 ± 0.914 (1.66 ± 0.877 U)	2.55 ± 0.95 J	2.13 ± 0.877 UJ	2.73 ± 1.34 J	1.11 ± 0.736 U	50[c]
U-233/234	pCi/L	1.63 ± 0.175 (1.48 ± 0.161)	1.4 ± 0.148	1.46 ± 0.179	1.31 ± 0.137	1.46 ± 0.156	1.25 ± 0.132 (1.44 ± 0.15)	1.72 ± 0.181	1.43 ± 0.149	1.47 ± 0.183	1.33 ± 0.141	186,000
U-235	pCi/L	-0.00921 ± 0.0163 U (0.0596 ± 0.0295)	0.0335 ± 0.014 J	0.0315 ± 0.0274 U	0.00529 ± 0.00531 U	0.0532 ± 0.026 J	0.0486 ± 0.0167 J (0.0301 ± 0.0126 J)	0.061 ± 0.0302 J	0.0219 ± 0.0111 U	0.00806 ± 0.0198 U	0.0214 ± 0.0109 U	66
U-238	pCi/L	0.628 ± 0.0914 (0.581 ± 0.086)	0.626 ± 0.0773	0.881 ± 0.127	0.632 ± 0.076	0.618 ± 0.087	0.527 ± 0.0665 (0.724 ± 0.0845)	0.673 ± 0.0952	0.544 ± 0.0687	0.718 ± 0.113	0.587 ± 0.0726	9.9
						Metals						
Aluminum	µg/L	7.9 U 9.5	31.2	12.6	25 U	306	59.8 (25 U)	9.6	26.3	7.9 U	25 U	50 to 200
Barium	µg/L	34 (33.9)	36.5	41.6	42	44	37 (37)	35.3	38.2	34.7	35.6	2,000
Calcium	mg/L	40.5 (40.1)	37.8	41.8	39.3	44.7	37.7 (38)	39.8	37.3	40.9	37.5	NE[d]
Chromium	µg/L	5.2 (8)	4.5	5.4	2.5 U	89.4	7.2 (5.7)	6.4	4	4.1	2.5 U	100
Copper	µg/L	0.6 (0.68)	2.5 U	1.2	9.2	7.5	40 (40.2)	0.74	18.7	1.5	2.8	1,300/1,000
Iron	µg/L	139 U 284	2320	73.5 U	91.9	5760	146 (91.5)	237 U	164	25.8 U	25 U	300
Lead	µg/L	0.49 U (0.49 U)	0.26	0.49 U	1.5	1.2	11.2 (9.5)	0.49 U	4.5	0.85	1.5	15
Magnesium	mg/L	13.1 (13)	12.3	12.3	11.7	13.3	12.2 (12.3)	12.8	12.1	13.1	12	NE
Manganese	µg/L	0.97 (1.7)	16.2	2.4	2.5	100	4.4 (6.4)	3	5.7	0.34 U	2.5 U	50

Table 6-7. Comparisons of 2007 Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parentheses. (continued)

Well		M-11		M-12		M-13		M-14		EBR-II No. 2		
Sample Date Parameter	Units	5/23/07	11/26/07	5/22/07	11/26/07	5/22/07	12/10/07	5/22/07	12/10/07	5/23/07	11/27/07	MCL/SMCL[a]
Metals (continued)												
Nickel	µg/L	0.68 (1.1)	2.8	1.4	2.5 U	16.9	2.5 U (2.5 U)	0.67	2.5 U	0.75	2.5 U	NE
Potassium	mg/L	3.36 (2.61)	3.26	3.43	3.7	4.22	3.26 (3.3)	3.3	3.38	3.39	3.21	NE
Selenium	µg/L	1 U (1 U)	0.58	1 U	0.64	1 U	0.63 (0.61)	1 U	0.62	1 U	0.63	50
Sodium	mg/L	18.8 (18.7)	17.5	18.9	18.2	19.4	17.8 (18)	18.7	17.2	19.9	17.7	NE
Vanadium	µg/L	5.9 U (5.9 U)	6.2	5.9 U	4.1	8.9	6 (5.4)	5.9 U	5.7	5.9 U	5.1	NE
Zinc	µg/L	1 (1.9)	5.2	3.8	7.3	8.6	71.4 (27.6)	1.7	10.7	33.9	18.4	5,000
Anions												
Chloride	mg/L	18.1 (17.6)	18.3	17.8	18.1	18.3	18.8 (18.9)	18.8	18.9	21.5	19.7	250
Nitrate	mg/L	2 (2)	1.84	1.9	1.75	2	1.81 (1.81)	1.9	1.82	2 J	1.83	10
Nitrite	mg/L	0.02 U (0.02 U)	0.05 U	0.02 U	0.0693 J	0.02 U	0.05 UJ (0.05 UJ)	0.02 U	0.05 UJ	0.02 U	0.05 UJ	1
Sulfate	mg/L	17.5 J 17.3 J	16.8	16.7 J	16.6	18.1 J	19 (18)	18.6 J	19	19.4 J	18.1	250
Alkalinity	mg/L	124 (134)	134	130	142	141	137 (135)	130	139	147	134	NE
Bicarbonate Alkalinity	mg/L	141 (136)	134	130	136	128	137 (135)	128	139	138	134	NE
Total Dissolved Solids	mg/L	232 (217)	240	222	249	229	244 (239)	241	237	237	249	500
Total Organic Halides	µg/L	2.6 J (5 U)	10 U	4.1 J	10 U	5.3 J	10.8 UJ (10 UJ)	3.2 J	10 UJ	2.2 J	10 UJ	NE

a. MCL = maximum contaminant level; SMCL = secondary maximum contaminant level.
b. Counting error for radionuclides is one standard deviation.
c. The MCL for gross beta activity is four mrem/yr. A value of 50 pCi/L has been established as a screening level concentration.
d. NE = not established. A primary or secondary constituent standard has not yet been established for this constituent.
J = result is an estimate; R = result was rejected; U = not detected at the concentration shown..

Each well was sampled for VOCs (contact 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 and July 2007. The locations of the wells are shown on Figure 6-15. The results are summarized in Table 6-8 and briefly described below. The complete listing of results can be found in the WAG 10 Annual Monitoring Status Report (DOE-ID 2008b).

No contaminant exceeded an MCL along the southern boundary or in the guard well monitoring network in the FY 2007 at the INL Site.

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 concentrations of gross alpha and gross beta in the WAG 10 wells were similar to background, based on background values from Knobel, Orr, and Cecil (1992). Tritium was detected in two wells, USGS-104 and USGS-106, with both of these wells having a history of tritium detections. Over the past 20 years, both wells have exhibited a declining trend in tritium concentration. The tritium concentrations are currently less than 600 pCi/L, and are considerably less than the MCL of 20,000 pCi/L (Table 6-8).

In the Westbay wells, only manganese was above its SMCL of 50 µg/L, and occurred in the deepest sample port from MIDDLE-2051, at a concentration of 424 µg/L. The elevated manganese detection is probably due to a naturally occurring lower redox conditions at this depth.

In the Westbay wells, tritium, gross alpha, and gross beta were again the primary radiological analytes detected. Gross alpha and gross beta were at background concentrations. Tritium was detected in both intervals sampled in MIDDLE-2051, 838.1 ft below ground surface (bgs) and 1102.8 ft bgs. Tritium has been consistently detected at the 838.1 ft depth and was detected in the previous round from the 1,102.8 ft depth. In USGS-132, tritium was detected at all sampling depths; however, tritium was not detected in the duplicate sample from the 646 ft depth. All tritium detections in USGS-132, except for the sample from the 836 ft depth, were close to the minimum detectable activity. The highest tritium concentration sample in USGS-132 was 464 pCi/L, and occurred at the 836 ft depth.

Five VOCs—acetone, chloromethane, toluene, methylene chloride, and carbon tetrachloride—were detected at concentrations below their MCLs. Toluene was detected in the sample from USGS-110, at a concentration of 2.65 µg/L, below the toluene MCL of 1,000 µg/L. The source of the toluene is uncertain, but the lack of other hydrocarbons at this location is not consistent with fuel migration. Toluene is reported to be a common laboratory contaminant, so that source cannot be ruled out. Carbon tetrachloride was detected in USGS-105, located south of the RWMC, on the INL Site boundary. Carbon tetrachloride was also detected in two intervals from Westbay USGS-132, also located south of the RWMC, at concentrations less than 0.5 µg/L. These values are estimates, or laboratory J flagged-close to the method detection limit. A carbon tetrachloride plume does originate at the RWMC, and the carbon tetrachloride detections could represent migration from that source. Chloromethane and acetone were detected in the shallowest sample from USGS-132, but the concentrations were near their detection limits. Like toluene, acetone is a common laboratory contaminant.

Table 6-8. Comparisons of Detected Analytes in 2007 with MCLs or SMCLs for WAG 10.

Analyte	Units	Maximum Concentration	MCL/ *SMCL*[a]	Detections above MCL/ SMCL
Radionuclides				
Gross beta	pCi/L	5.71	4 mrem/yr	NA
Gross alpha	pCi/L	4.16	15	0
Iodine-129	pCi/L	ND	1	0
Technetium-99	pCi/L	ND	900	0
Strontium-90	pCi/L	ND	8	0
Tritium	pCi/L	685	20,000	0
VOCs[b]				
Methylene chloride	µg/L	2.01	5	0
Carbon tetrachloride	µg/L	0.379	5	0
Toluene	µg/L	2.65	1,000	0
Acetone	µg/L	2.74	None	0
Chloromethane	µg/L	0.593	None	0
Anions				
Alkalinity	mg/L	163	None	NA
Chloride	mg/L	26.6	*250*	0
Fluoride	mg/L	0.857	*2*	0
Nitrate/Nitrite as N	mg/L	3.59	10	0
Sulfate	mg/L	40.5	*250*	0
Common Cations				
Calcium	µg/L	61400	None	NA
Magnesium	µg/L	18100	None	NA
Potassium	µg/L	3730	None	NA
Sodium	µg/L	31200	None	NA
Metals				
Aluminum	µg/L	17.8	*50 to 200*	0
Antimony	µg/L	ND	6	0
Arsenic	µg/L	3.3	10	0
Barium	µg/L	75.3	2,000	0
Beryllium	µg/L	0.36	4	0
Cadmium	µg/L	0.53	5	0
Chromium	µg/L	19.3	100	0
Cobalt	µg/L	2.5	None	0
Copper	µg/L	2.1	1,300/*1,000*	0
Iron	µg/L	351	*300*	1
Lead	µg/L	15.3	15[c]	1
Manganese	µg/L	386	*50*	1
Mercury	µg/L	ND	2	0
Nickel	µg/L	2.4	None	NA
Selenium	µg/L	1.4	50	0
Silver	µg/L	1.4	None	NA
Strontium	µg/L	270	None	NA
Thallium	µg/L	0.8	2	0
Uranium	µg/L	3.2	30	0
Vanadium	µg/L	19.6	None	NA
Zinc	µg/L	213	*5,000*	0

a. MCLs are in regular text while SMCLs are in *italics*.
b. The VOCs listed are only the detections.
c. The action level for lead is 15 µg/L.
MCL = maximum contaminant level
NA = not applicable
ND = not detected
SMCL = secondary maximum contaminant level
VOC = volatile organic compound

In April, May, and June 2006, a site-wide automated water level measurement network was installed. Data were collected from 50 wells in the continuous water level monitoring network. The site-wide groundwater elevation contour maps for 2006–2007 generated using data from the continuous monitoring network showed little seasonal variation and were consistent with the site-wide, hand-measured water level maps for 2004 and 2005 (DOE-ID 2008b).

Vertical gradients were examined at the Westbay well USGS-134. The pressure data from the multiple-isolated sampling intervals were used to calculate water levels and evaluate vertical gradients. The data collected on March 28, 2007, and July 30, 2007, show a hydraulic downward gradient from 553 to 577 ft bgs, a general up-gradient from 577 to 664 ft bgs, followed by a gradient reversal from 664 to 690 ft. From 690 to 880 ft bgs, the July 30, 2007, data show a slight down gradient, while the March 28, 2007, data have small upward and downward gradient changes, resulting in no distinct vertical hydraulic gradient trend.

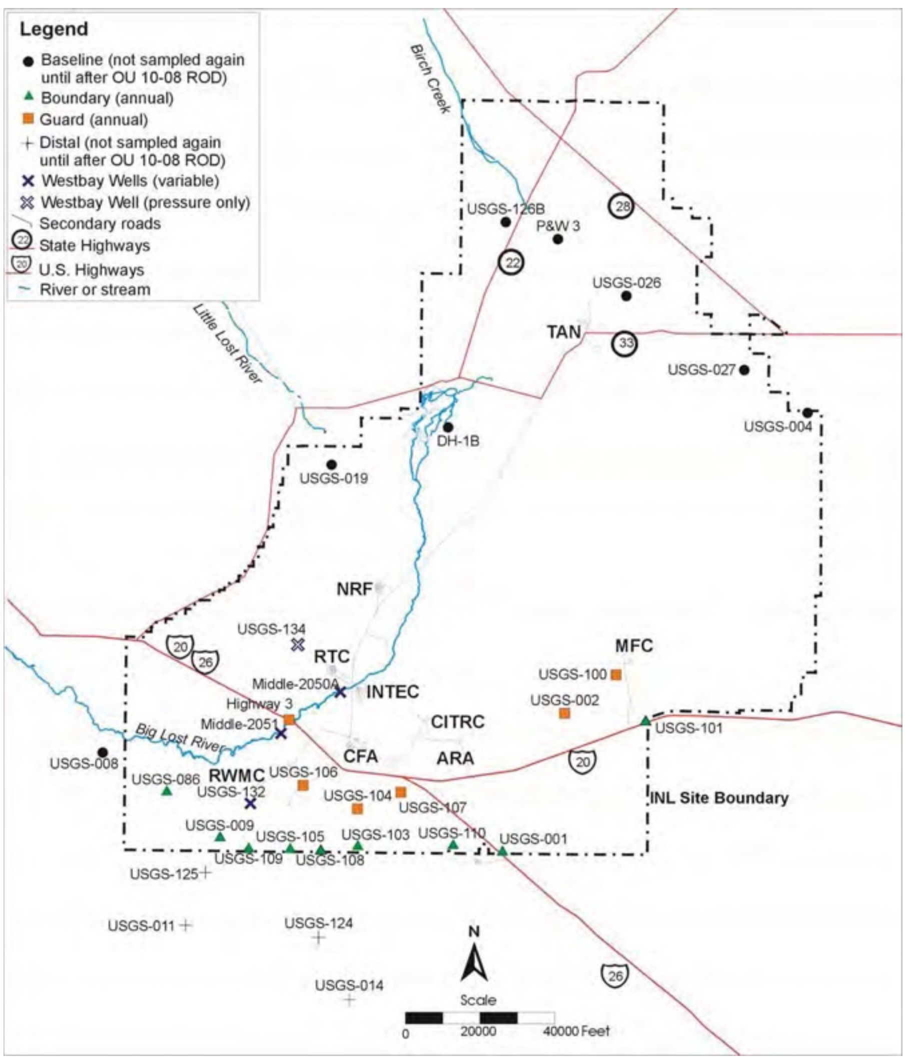

Figure 6-15. Locations of WAG 10 Monitoring Wells Sampled in 2007.

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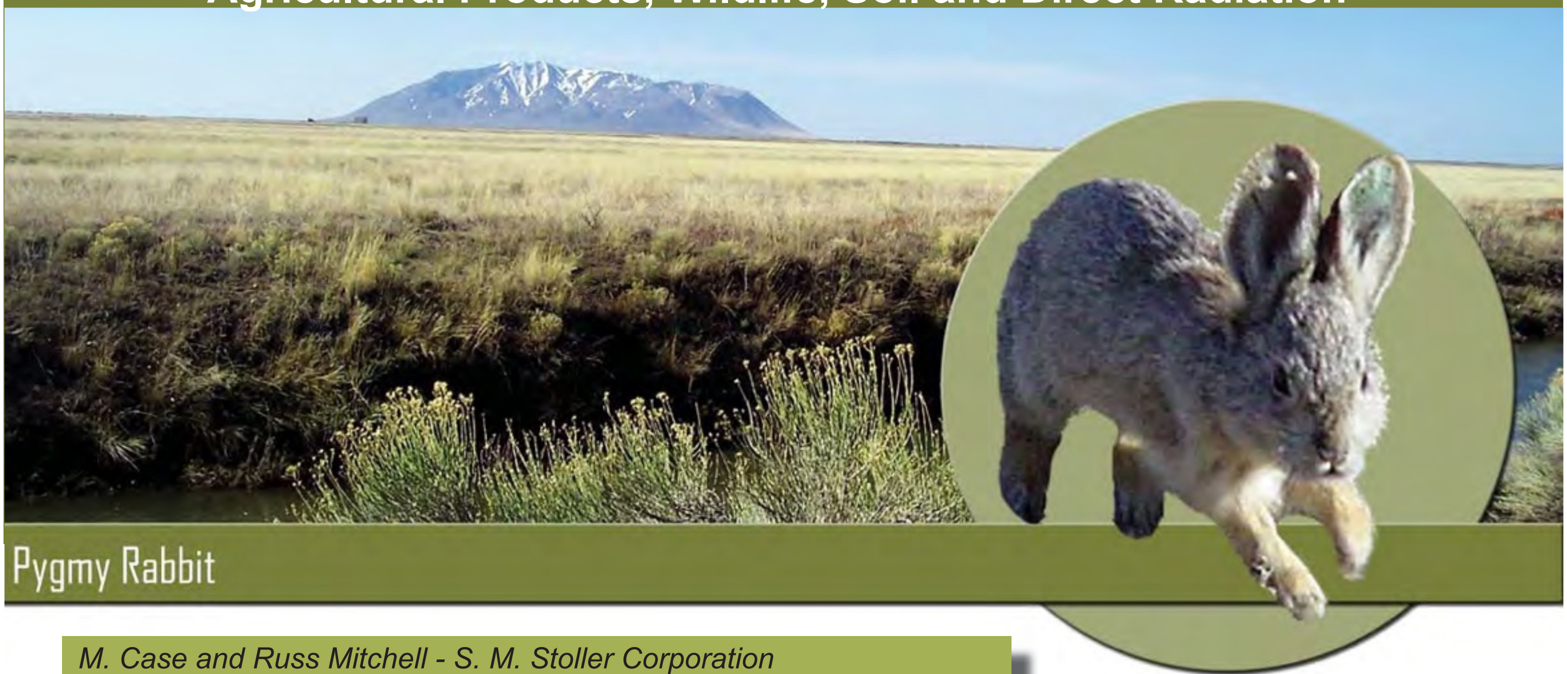
Chapter 7. Environmental Monitoring Programs - Agricultural Products, Wildlife, Soil and Direct Radiation



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

This chapter provides a summary of the various environmental monitoring activities currently being conducted on and around the Idaho National Laboratory (INL) Site (Table 7-1). These media are potential pathways for transport of INL Site contaminants to nearby human populations.

The INL and Idaho Cleanup Project (ICP) contractors monitored 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 offsite environmental surveillance 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 to the INL Site. The ESER contractor collected approximately 300 agricultural products, wildlife, and direct radiation samples for analysis in 2007.

Section 7.1 presents the agricultural products and biota surveillance results sampled under the ESER Program. Section 7.2 presents the results of soil sampling by both the ESER contractor and the INL and ICP contractors. The direct radiation surveillance results are presented in Section 7.3. Results of the waste management surveillance activities are discussed in Section 7.4.

Table 7-1. Other Environmental Monitoring Activities at the INL Site.

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

Milk

During 2007, 149 milk samples (97 monthly and 52 weekly) were collected under the ESER Program at various offsite locations (Figure 7-1). All of the 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.

Strontium-90 was detected in all eight samples (one weekly and seven monthly), ranging from 0.30 pCi/L at Terreton to 0.57 pCi/L at Moreland. All levels of ^{90}Sr in milk were consistent with those data previously reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by ingestion of grass by cows (EPA 1995). The maximum value is far lower than the DOE Derived Concentration Guide (DCG)for ^{90}Sr in water of 1000 pCi/L. Iodine-131, ^{137}Cs, and tritium were not detected in any sample in 2007.

Lettuce

The ESER contractor collects lettuce samples every year from the areas on and adjacent to the INL Site. The collection of lettuce from home gardens around the INL Site typically depends on availability. To make this sampling more reliable, ESER has replaced home gardens with prototype lettuce planters. Because many of the sampling locations are relatively remote and have no access to water, a self-watering system was developed. This method allows for the placement and collection of lettuce at areas previously unavailable to the public, such as on the INL Site. The boxes are set out in the spring, filled with soil, and sown with lettuce seed. This new method also allows for the potential accumulation of deposited radionuclides on the plant surface throughout the growth cycle.

Six lettuce samples, were collected from portable lettuce gardens placed at Atomic City, Blackfoot, the Experimental Field Station, the Federal Aviation Administration Tower, Idaho Falls, and Monteview (Figure 7-1).

Strontium-90 was detected above the 3-sigma uncertainty in four of the six samples collected. Strontium-90 in lettuce results from plant uptake of this isotope in soil as well as deposition from airborne dust containing ^{90}Sr. Strontium-90 is present in soil as a residual of fallout from aboveground nuclear weapons testing, which took place between 1945 and 1980. The maximum concentration

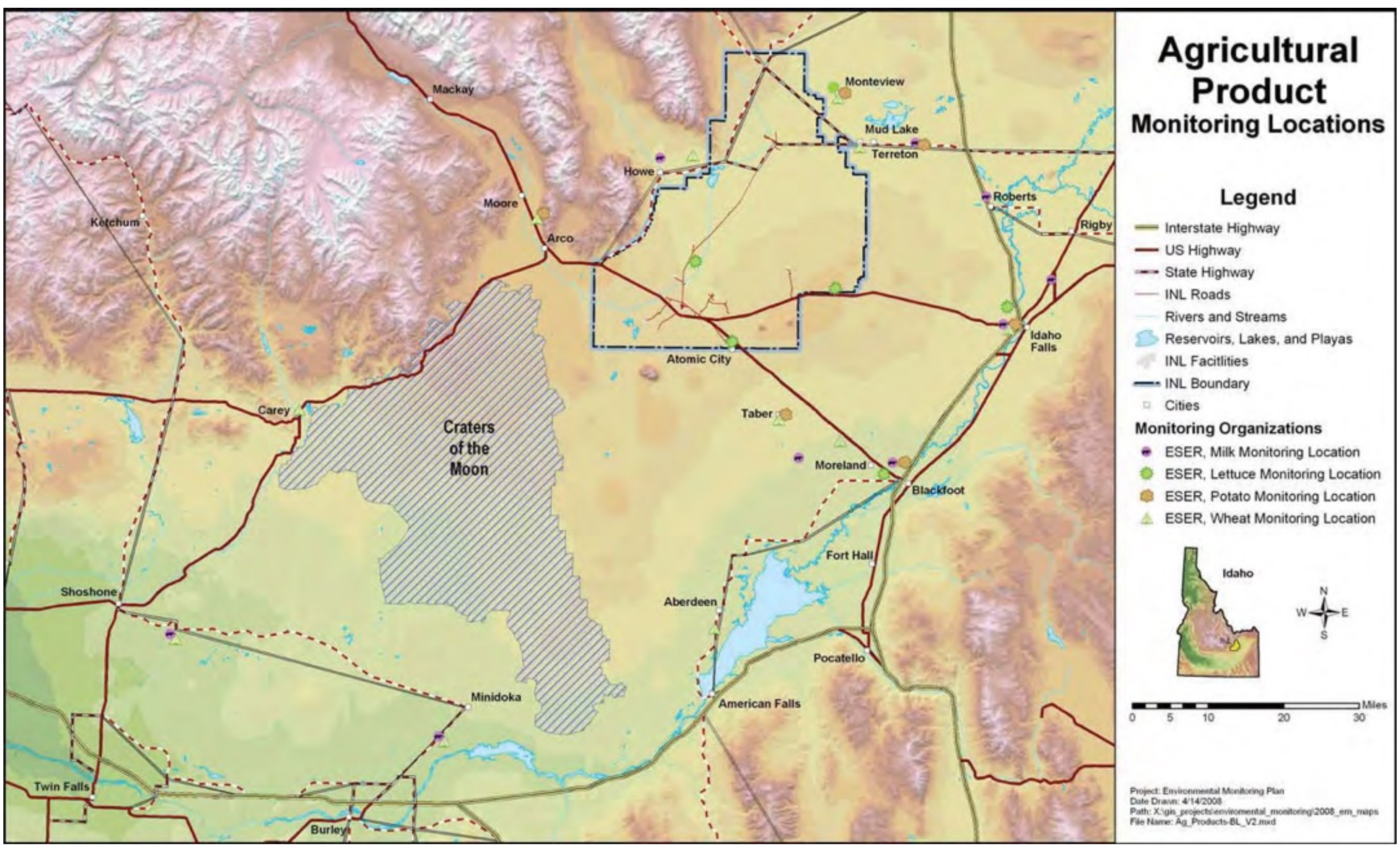

Figure 7-1. Locations of Agricultural Produce Samples Collected During 2007.

of 96 pCi/kg was within concentrations detected historically (Table 7-2) and was most likely from weapons testing fallout. No other manmade radionuclides were detected in any of the samples.

Wheat

None of the 11 wheat samples (including one duplicate) collected during 2007 (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.

Table 7-2. Strontium-90 Concentrations in Garden Lettuce (2002-2007).[a,b,c]

Location	2002	2003	2004	2005	2006	2007
Distant Group						
Blackfoot	116 ± 81	228 ± 83	97 ± 56	-17 ± 15	26 ± 8	17 ± 4
Carey	283 ± 79	220 ± 180	97 ± 66	NS[d]	NS	NS
Idaho Falls	41 ± 25	254 ± 170	328 ± 110	26 ± 24	69 ± 8	96 ± 8[e]
Pocatello	NS	NS	135 ± 110	93 ± 26	NS	NS
Grand Mean	**145 ± 39**	**234 ± 87**	**164 ± 44**	**35 ± 15**	**48 ± 6**	**52 ± 9**
Boundary Group						
Arco	93 ± 23	126 ± 160	154 ± 85	111 ± 37	NS	NS
Atomic City	NS	282 ± 130[e]	155 ± 130[e]	57 ± 30[e]	35 ± 6[e]	26 ± 4[e]
FAA Tower	NS	NS	NS	NS	18 ± 10[e]	52 ± 28[e]
Howe	65 ± 28	25 ± 81	NS	49 ± 25	NS	NS
Monteview	85 ± 22	214 ± 140	NS	NS	29 ± 9[e]	64 ± 3[e]
Mud Lake (Terreton)	109 ± 26	NS	148 ± 79	55 ± 26	NS	NS
Grand Mean	**88 ± 12**	**162± 66**	**152 ± 58**	**68 ± 15**	**27 ± 5**	**47 ± 9**
INL Site						
Experimental Field Station	NS	442 ± 130[e]	225 ± 86[e]	SD[f]	48 ± 9[e]	39 ± 44[e]

a. Analytical results are $\times 10^{-3}$ picocuries per gram (pCi/g).

b. Analytical results are for dry weight plus or minus one standard deviation (± 1s).

c. Approximate minimum detectable concentration (MDC) of ^{90}Sr in lettuce is 2×10^{-4} pCi/g dry weight.

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

e. Sample was grown in a portable lettuce garden.

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

Table 7-3. Strontium-90 Concentrations in Wheat (2002-2007).[a,b,c]

Location	2002	2003	2004	2005	2006	2007
Distant Group						
Aberdeen[d] (American Falls)	36 ± 130	84 ± 62	-1 ± 25 32 ± 29	12 ± 18	0.7 ± 3.3	1.3 ± 2.8
Blackfoot	69 ± 66 81 ± 130	NS[e]	16 ± 25	16 ± 25	-0.4 ± 2.8	3.8 ± 2.5
Carey	28 ± 66	-53 ± 47	65 ± 27	NS	2.3 ± 2.7	7.4 ± 2.5
Dietrich	NS	NS	17 ± 17	-27 ± 17	6.0 ± 2.7	NS
Idaho Falls	50 ± 82	121 ± 64	46 ± 22 26 ± 27	15 ± 24	7.8 ± 2.5	2.0 ± 3.6
Minidoka	0 ± 97	61 ± 48	NS	4 ± 24	NS	-1.3 ± 2.8
Roberts (Menan)[d]	19 ± 65	54 ± 55	NS	7 ± 16 -11 ± 18	NS	NS
Rockford	-220 ± 130	195 ± 68	NS	NS	NS	NS
Rubert (Burley)[d]	90 ± 130	-26 ± 52	NS	NS	8.3 ± 3.5	4.5 ± 2.7
Taber	111 ± 150	NS	NS	NS	3.2 ± 3.3	-1.6 ± 2.5
Grand Mean	**26 ± 35**	**62 ± 22**	**29 ± 9**	**-0.9 ± 7**	**4.0 ± 1.1**	**2.3 ± 1.1**
Boundary Group						
Arco	41 ± 190	2.0 ± 55	16 ± 25	109 ± 38	2.0 ± 2.9 7.0 ± 2.6	-0.7 ± 3.0
Howe	185 ± 76	-19 ± 49	-4 ± 19	5 ± 18	3.0 ± 2.9	5.2 ± 5.5
Monteview	220 ± 98	NS	NS	-41 ± 229	2.9 ± 2.8	NS
Mud Lake	54 ± 87	8 ± 56	21 ± 18	-5 ± 20	6.5 ± 2.5	8.0 ± 4.9
Terreton	86 ± 99	5 ± 43	-6 ± 22	NS	NS	NS
Grand Mean	**84 ± 52**	**-1 ± 26**	**7 ± 11**	**68 ± 15**	**27 ± 5**	**4.1 ± 2.6**

a. Analytical results are picocuries per kilogram (pCi/kg).

b. Analytical results are for dry weight plus or minus one standard deviation (± 1s).

c. Approximate MDC of ^{90}Sr in wheat from 2002 through 2005 was 20-100 pCi/kg dry weight. In 2006, the MDC decreased to approximately 10 pCi/kg.

d. Samples were collected from multiple locations in this area during certain years.

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

Potatoes

Eight potato samples, including one duplicate, were collected during 2007: four samples and one duplicate from distant locations; two samples from boundary locations; and one sample from an out-of-state location (Colorado) (Figure 7-1). The Idaho samples were collected from Arco, Blackfoot, Idaho Falls, Monteview, Mud Lake, and Rupert. Cesium-137 was detected in one of the Idaho samples (Mud Lake) at a concentration of 6.4 pCi/kg. Cesium-137 is present in soil as a result of fallout from aboveground nuclear weapons testing, and these detections were most likely from that fallout. No other anthropogenic radionuclides were detected in potatoes.

Game Animals

Muscle samples were collected from two pronghorn which were accidentally killed on INL Site roads. Thyroid samples were also collected. There was detectable ^{137}Cs radioactivity above 3-sigma in the muscle of one pronghorn taken on or near the INL Site. The result was 7.3 pCi/kg. No tissue samples contained detectable ^{131}I above 3-sigma.

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: 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.

The concentration of ^{137}Cs detected in the muscle sample collected in 2007 was at the lower end of this range. The 2007 results were also within the range of historical values. These values can be attributed to the ingestion of radionuclides in plants from worldwide fallout associated with aboveground nuclear weapons testing. No ^{131}I was detected in any of the thyroid gland samples.

Twelve ducks were collected during 2007. Four were collected from wastewater ponds located at the Reactor Technology Complex (RTC) facility, six came from wastewater ponds near the Materials and Fuels Complex (MFC) facility, and two control samples were collected near the Fort Hall Bottoms. Each duck sample was divided into three sub-samples: one consisting of edible tissue (muscle, gizzard, heart and liver); viscera; and a remainder sample that includes 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). Concentrations of radionuclides measured in the edible tissues of 2007 waterfowl are shown in Table 7-4.

Several manmade radionuclides were detected in the samples taken from the RTC ponds. These included ^{241}Am, ^{137}Cs, chromium-51 (^{51}Cr), cobalt-60 (^{60}Co), ^{90}Sr, and zinc-65 (^{65}Zn). Of these six, three (^{241}Am, ^{137}Cs, and ^{60}Co) were found in the edible tissues. Three radionuclides, ^{241}Am, ^{137}Cs, and ^{90}Sr, were also detected in the birds from the MFC ponds. One manmade radionuclide (^{90}Sr) was found in the control samples.

Since manmade radionuclides were found more frequently and at higher concentrations in ducks taken from the INL Site, it is assumed that the INL Site is the source of these detections. Concentrations of the detected radionuclides from RTC were similar to those from 2006, or

Table 7-4. Radionuclide Concentrations Detected in Waterfowl Using INL Site.[a]

	Waterfowl Location		
	RTC (4 samples)	MFC (6 samples)	Fort Hall Bottoms (2 samples)
Nuclide			
	Edible		
Americium-241	Sample #4: (2.3 ± 0.33)	Sample #1: (1.6 ± 0.08)	No detections
Cesium-137	Sample #2: (1300 ± 30) Sample #3: (120 ± 46)	Sample #5: (22 ± 5.6)	No detections
Cobalt-60	Sample #2: (42 ± 4.2)	No detections	No detections
Plutonium-238	No detections	No detections	No detections
Plutonium-239	No detections	No detections	No detections
Strontium-90	No detections	No detections	No detections
	Viscera		
Americium-241			
Cesium-137	Sample #1: (105 ± 5.3) Sample #2: (513 ± 16) Sample #3: (65 ± 6.0)	Sample #3: (6.8 ± 2.1)	No detections
Cobalt-60	Sample #1: (8.1 ± 2.3) Sample #2: (32 ± 4.2) Sample #3: (11 ± 3.6)	No detections	No detections
Plutonium-238	No detections	No detections	No detections
Plutonium-239	No detections	No detections	No detections
Strontium-90	Sample #1: (2.2 ± 0.069) Sample #2: (5.6 ± 0.010) Sample #3: (1.9 ± 1.0 Sample #4: (1.1 ± 0.07)	Sample #1: (5.2 ± 0.02) Sample #2: (1.4 ± 0.06) Sample #3: (3.7 ± 0.04 Sample #4: (1.2 ± 0.05) Sample #5 (1.9 ± 0.05) Sample #6: (0.84 ± 0.05	Sample #1: (1.3 ± 0.06) Sample #2: (1.2 ± 0.06)
	Remainder		
Americium-241	No detections	No detections	No detections
Cesium-137	Sample #1: (143 ± 12) Sample #2: (776 ± 3.0) Sample #3: (102 ± 6.3) Sample #4: (16 ± 3.7)	Sample #1: (50 ± 15.8) Sample #3: (9.1 ± 2.0) Sample #5: (27± 7.9)	No detections
Cobalt-60	Sample #2: (57 ± 2.8) Sample #3: (39 ± 2.9)	No detections	No detections
Chromium-51	Sample #2: (3290 ± 1010)	No detections	No detections
Plutonium-238	No detections	No detections	No detections
Plutonium-239	No detections	No detections	No detections
Strontium-90	Sample #1: (1.0 ± 0.05) Sample #2: (5.7 ± 0.01) Sample #3: (1.4 ± 0.09 Sample #4: (1.1 ± 0.08)	Sample #1: (2.3 ± 0.07) Sample #2: (1.5 ± 0.06) Sample #3: (4.3 ± 0.08 Sample #4: (1.7± 0.06) Sample #5 (4.4 ± 0.07) Sample #6: (0.90 ± 0.05	Sample #1: (1.1 ± 0.07) Sample #2: (0.83 ± 0.06)
Zinc-65	Sample #2: (34.9 ± 9.4)	No detections	No detections

a. All values are × 10^{-3} picocuries per gram.

significantly lower in the case of ^{137}Cs than those found in 2005. Measured concentrations were also lower than those in ducks taken during a 1994-1998 study (Warren et al. 2001). The ducks were not taken directly from the two-celled hypalon-lined radioactive wastewater RTC Evaporation Pond but from an adjacent sewage lagoon. However, it is likely that the birds also used the RTC Evaporation Pond.

Waterfowl hunting is not allowed on the INL Site, but a maximum potential exposure scenario to humans would be someone collecting a contaminated duck directly from the ponds and immediately consuming all muscle, liver, heart, and gizzard tissue. The maximum potential dose from eating 225 g (8 oz) of meat from the most contaminated waterfowl collected in 2007 was estimated to be 0.015 millirem (mrem) (0.00015 mSv) (Chapter 8, Section 8.4). This dose is lower than dose estimates for some previous periods. The maximum dose estimated for the period from 1993 through 1998 was 0.89 mrem (0.009 mSv) and from 2000 through 2004 was 0.08 mrem (0.0008 mSv). In the late 1970s, when the percolation ponds were still in use, the maximum dose estimated from eating a contaminated duck was estimated to be 54 mrem (0.54 mSv).

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 (WRP) for the Central Facilities Area (CFA) 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 owing to 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 24,390 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 offsite soil samples every two years (in even years); thus, soil sampling was not conducted in 2007. Results from 1975 to 2006 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. Concentrations of $^{239/240}Pu$, a long-lived radionuclide, demonstrate a decreasing trend similar to that of ^{90}Sr. However, concentrations of ^{238}Pu and ^{241}Am, which are also long-lived radionuclides, show no apparent trend. This may be a function of their inhomogeneous distribution in soil and/or a reflection of the specific laboratory and procedure used. For example, the samples collected in 2006 were analyzed using an extraction procedure which resulted in greater radionuclide yields than previous analyses.

The INL contractor performed 343 field-based in situ gamma spectrometry measurements and all roadways and eight facility perimeter measurements in 2007. See Appendix E for location details and a more in-depth discussion. Table 7-5 provides a summary of the measurements performed. In addition to the in situ gamma spectrometry measurements, 34 INL in situ gamma locations were selected to determine the actual ^{137}Cs depth profile. These data were used to refine the input

Table 7-5. In Situ Gamma Results Measured by the INL Contractor (2007).[a]

Location	Distribution[b]	Number of measurements	Minimum	Maximum	Median[b]	Mean[b]	Standard Deviation[b]	95% Upper Confidence Level[b]
MFC	Normal	18	0.09	0.24	0.18	0.18	0.05	0.20
NRF	Normal	5	0.46	0.93	0.47	0.60	0.20	0.79
CITRC	Normal	16	0.16	0.29	0.22	0.22	0.04	0.23
RTC	Nonparametric	24	0.22	1.3	0.45	0.53	0.26	0.63
RWMC	None	47	0.18	1.0	0.26	0.29	0.12	0.32
Large Grid	Gamma	42	0.11	0.56	0.27	0.28	0.09	0.30
TAN-SMC	Nonparametric	18	0.14	1.2	0.25	0.31	0.25	0.57
ARA	Lognormal	78	0.17	9.2	0.78	1.5	1.6	2.0
INTEC	Nonparameter	96	0.02	49	1.0	1.9	5.0	4.1
Overall	Nonparametric	343	0.02	49	0.4	1.0	2.8	1.7

a. All values are in units of pCi/g, ^{137}Cs.
b. See Appendix B for an explanation of terms.

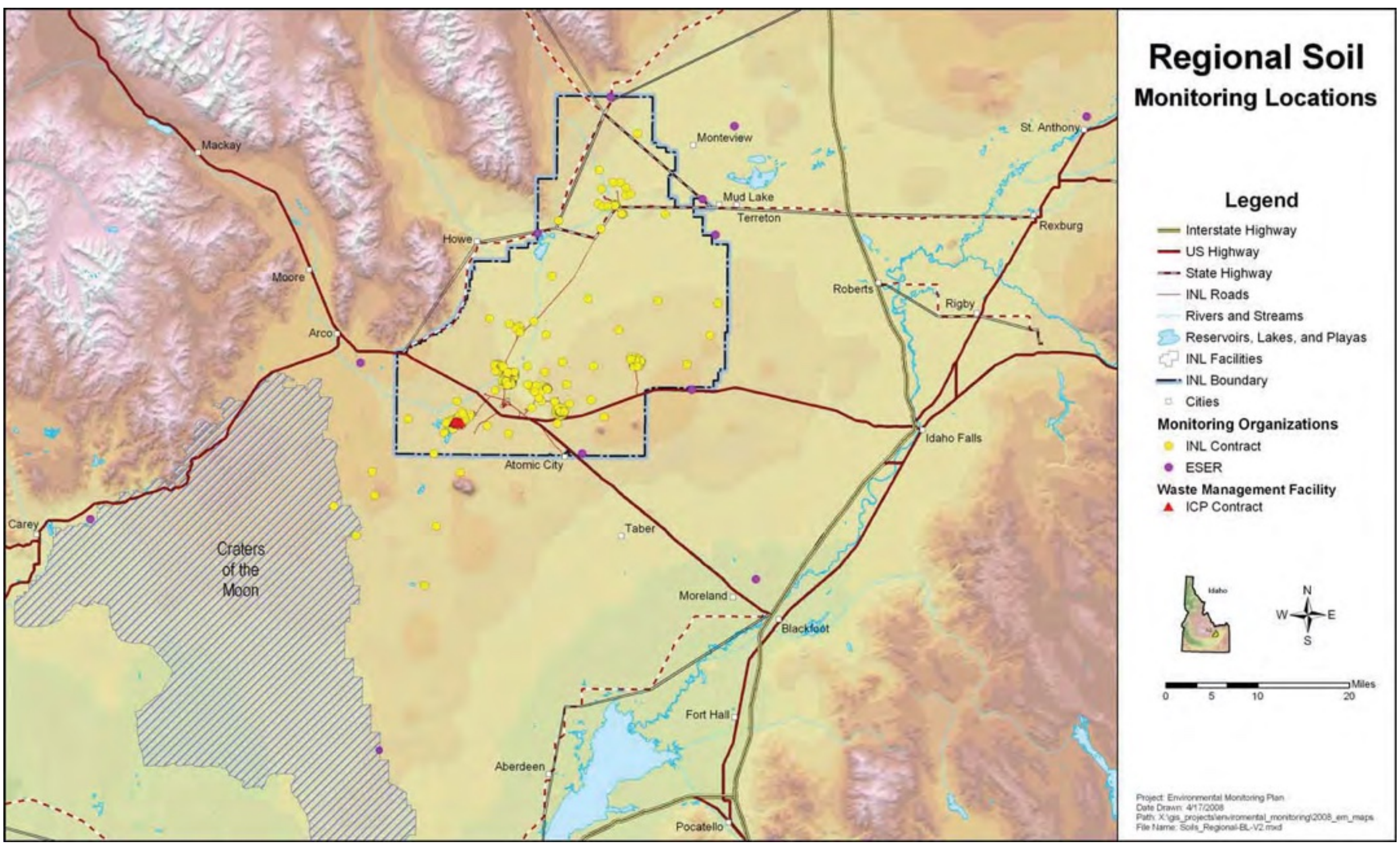

Figure 7-2. Soil Sampling Locations.

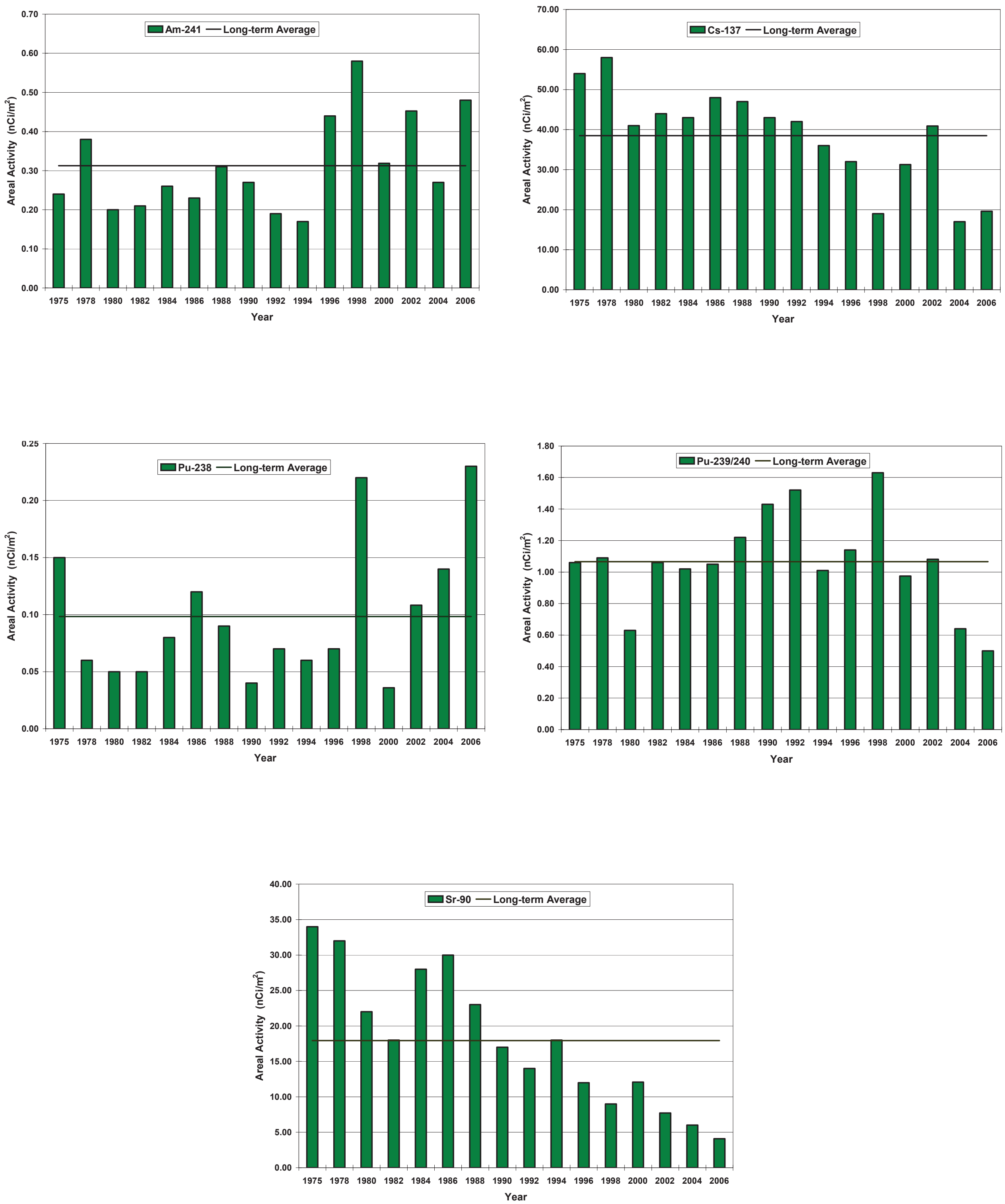

Figure 7-3. Geometric Mean Areal Activity in Offsite Surface (0-5 cm [0-2 in.]) Soils (1975-2006).

parameters for the detectors to the actual INL field parameters. At each of these 34 locations, ten grab samples were collected to a depth of one foot (0-12 in). Each of these soil columns was subdivided into 12 one-inch depth increments. Composited soil pucks were formed by taking the same one-inch segments from each of the ten grab locations.

WRP Soil Sampling at CFA

The WRP for the CFA Sewage Treatment Facility allows for nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation. Soils are sampled at ten locations within the CFA land application area following each application season. Subsamples are taken from 0–30 cm (0–12 in.), 30–61 cm (12–24 in.), and 61–91 cm (24–36 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 absorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the WRP, to determine whether wastewater application is adversely affecting soil chemistry. The analytical results for the soil samples are summarized in Table 7-6. The analytical results for 2006 are included for comparison.

Idaho Department of Environmental Quality (DEQ) guidance (DEQ 2007) states that "bacteria that decompose organic matter function best at a pH range between 6.5 and 8.5." The 2007 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 level at the 0–12 in. and 24–36 in. depths in the 2007 samples were below the 2 millimhos/cm level. The 2007 soil salinity level in the 12–24 in. range was slightly above the 2 millimhos/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 CFA STF 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 wheat grass (Blaylock 1994) and sagebrush (Swift 1997).

Soils with sodium adsorption ratios (SARs) below 15 and electrical conductivity levels below 2 mmhos/cm are generally classified as not having sodium or salinity problems (Bohn, McNeal, and O'Connor 1985). The SAR 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. The 2007 SAR of 3.79 at the 0–12 in. depth was significantly lower than the 2006 historical high of 9.68. The 2007 SARs of 4.00 at the 12–24 in. depth and 3.69 at the 24–36 in. depth were also significantly lower than found in the 2006 samples. All SARs remained well below 15 at all depth intervals. Idaho DEQ guidance (DEQ 2007) states that "For most crops grown on land treatment sites, soil SARs 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 the sagebrush

Table 7-6. Soil Monitoring Results for the CFA Sewage Treatment Facility WasteWater Reuse Permit Area: 2006 and 2007.

Parameter	Depth (in.)	2006	2007[a]
pH	0–12	8.29	8.05
	12–24	8.05	8.00
	24–36	8.15	8.09
Electrical Conductivity (mmhos/cm)	0–12	0.86	1.221
	12–24	3.20	2.03
	24–36	3.54	1.95
Organic Matter (%)	0–12	1.76	1.33
	12–24	0.933	0.774
	24–36	0.562	0.483
Nitrate as Nitrogen (ppm)	0–12	3.07	3.18
	12–24	1.003 U[a]	0.977 U
	24–36	0.998 U	1.00 U
Ammonium Nitrogen (ppm)	0–12	1.99	0.516
	12–24	0.501 U	0.489 U
	24–36	0.501 U	0.500 U
Extractable Phosphorus (ppm)	0–12	10.60	9.05
	12–24	1.94	1.77
	24–36	0.99 U	1.19
Sodium Adsorption Ratio	0–12	9.68	3.79
	12–24	7.45	4.00
	24–36	10.00	3.69

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

and grass vegetation use all of 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 DEQ guidance (DEQ 2007) recommends that to ensure there are no ground water contamination concerns, the total phosphorus should be less than 30 ppm (Olsen method used in these analyses) in the 24–36 in. soil depth. Table 7-6 shows the phosphorus concentration at 1.19 ppm, which is well below the level of concern.

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 (approximately 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 2007 were from November 2006 through April 2007 (spring) and from May 2007 through October 2007 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2006 through October 2007 is shown in Table 7-7 for two adjacent sets of dosimeters maintained by the ESER and Site contractors. For purposes of comparison, annual exposures from 2003-2006 are also included for each location.

The mean annual exposures from distant locations in 2007 were 119 milliroentgens (mR) as measured by the ESER dosimeters and 121 mR as measured by the INL contractor dosimeters (Table 7-7). For boundary locations, the mean annual exposures were 119 mR as measured by ESER contractor dosimeters and 121 mR as measured by INL contractor dosimeters. Using both ESER and INL contractors' data, the average dose equivalent of the distant group was 120 mrem when a dose equivalent conversion factor of 1.03 was used to convert from mR to mrem in tissue (NRC 1997). The average dose equivalent for the boundary group was 120 mrem.

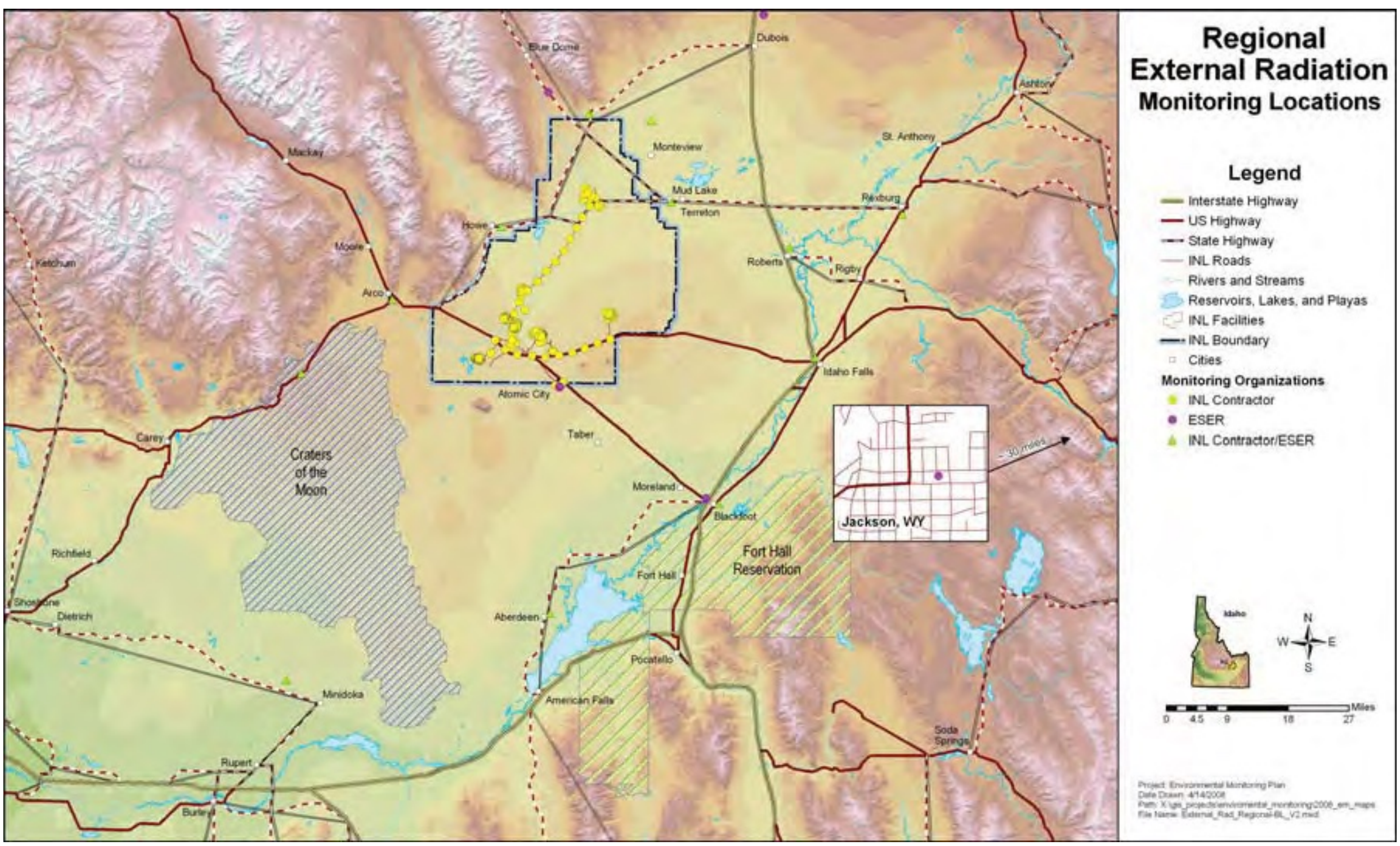

Figure 7-4. Regional Direct Radiation Monitoring Locations.

Table 7-7. Annual Environmental Radiation Exposures (2003-2007).[a]

Location	2003		2004		2005		2006		2007	
	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors
Distant Group										
Aberdeen	123 ± 4	122 ± 9	130 ± 9	127 ± 9	124 ± 7	130 ± 9	126 ± 9	124 ± 9	129 ± 6	127 ± 6
Blackfoot	117 ± 4	111 ± 8		109 ± 8	129 ± 9	113 ± 8	115 ± 8	104 ± 7	119 ± 6	109 ± 5
Blackfoot (CMS)[b]	101 ± 4		108 ± 8		117 ± 2		106 ± 7		109 ± 5	
Craters of the Moon	116 ± 4	122 ± 9	118 ± 8	NS [c,d]	138 ± 8	122 ± 8	111 ± 7	112 ± 8	120 ± 6	129 ± 6
Dubois[b]	98 ± 3		105 ± 7		117 ± 5		95 ± 7		101 ± 5	
Idaho Falls	126 ± 9	111 ± 8	124 ± 9	114 ± 8	122 ± 2	116 ± 8	119 ± 8	110 ± 8	123 ± 2	119 ± 6
Jackson[b]	97 ± 7		100 ± 7		106 ± 7		90 ± 6		97 ± 5	
Minidoka	111 ± 8	104 ± 7	108 ± 8	107 ± 7	116 ± 3	112 ± 8	107 ± 7	103 ± 7	109 ± 5	111 ± 5
Rexburg	136 ± 5	116 ± 8	137 ± 10	118 ± 8	152 ± 2	121 ± 8	134 ± 9	113 ± 8	145 ± 7	120 ± 6
Roberts	126 ± 4	133 ± 9	133 ± 9	132 ± 9	126 ± 11	NS	126 ± 9	123 ± 9	137 ± 7	133 ± 7
Mean	114 ± 2	117 ± 3	118 ± 3	118 ± 3	121 ± 3	119 ± 3	113 ± 2	113 ± 3	119 ± 6	121 ± 6
Boundary Group										
Arco	113 ± 4	118 ± 8	124 ± 9	126 ± 9	124 ± 9	120 ± 8	115 ± 8	111 ± 8	127 ± 6	125 ± 6
Atomic City	120 ± 4	124 ± 9	132 ± 9	NS	123 ± 9	NS	119 ± 8	112 ± 8	129 ± 6	124 ± 6
Blue Dome[b]	103 ± 4		104 ± 7		115 ± 8		101 ± 7		104 ± 5	
Howe	109 ± 4	110 ± 8	121 ± 8	114 ± 8	126 ± 9	116 ± 8	108 ± 8	105 ± 7	118 ± 6	120 ± 6
Monteview	106 ± 4	112 ± 8	119 ± 8	116 ± 8	109 ± 8	121 ± 8	110 ± 8	107 ± 7	115 ± 6	119 ± 6
Mud Lake	124 ± 4	122 ± 8	130 ± 9	133 ± 9	132 ± 9	130 ± 8	119 ± 8	120 ± 8	128 ± 6	132 ± 6
Birch Creek Hydro	105 ± 4	105 ± 7	112 ± 8	108 ± 8	110 ± 8	NS	104 ± 7	103 ± 7	111 ± 5	109 ± 5
Mean	113 ± 2	115 ± 3	120 ± 3	119 ± 4	120 ± 3	119 ± 4	111 ± 3	110 ± 3	119 ± 6	121 ± 6

a. All values are in milliroentgens with ± 1 standard deviation.
b. The INL contractor does not sample at this location.
c. Dosimeter was missing at one of the collection times.
d. NS = Not Sampled.

Onsite TLDs maintained by the INL contractor representing the same exposure period as the offsite dosimeters are shown in Appendix D, Figures D-1 through D-10. Onsite dosimeters are placed on facility perimeters, concentrated in areas likely to show the highest gamma radiation readings. Other onsite dosimeters are located in the vicinity of radioactive materials storage areas. At some facilities, elevated exposures result from areas of soil contamination around the perimeter of these facilities. The maximum exposure onsite recorded during 2007 was 813 mR at a location at the Radioactive Waste Management Complex (RWMC), RWMC 41. This dosimeter is located near active waste storage and management areas. The exposure is somewhat higher than that of the previous year. Locations RTC 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 RTC 2 and 3 are less than one fourth of the values in 2002 (DOE-ID 2003).

The Idaho Nuclear Technology and Engineering Center (INTEC) 20 TLD is located near a radioactive material storage area with an annual exposure of 287 mR. Exposures at INTEC 20 and the INTEC Tree Farm for 2007 were all 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.

Table 7-8. Calculated Effective Dose Equivalent From Background Sources (2007).

Source of Radiation Dose Equivalent	Total Average Annual Dose[a]	
	Calculated	**Measured**
External		
Terrestrial	75	NA[b]
Cosmic	48	NA
Subtotal	123	120
Internal		
Cosmogenic	1	
Inhaled Radionuclides	200	
^{40}K and others	39	
Subtotal	240	
Total	363	

a. All values are in millirem.

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

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 time 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/year, respectively, for a total of 76 mrem/year. 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 above estimate of 76 mrem/year. For 2007, this resulted in a corrected dose of 75 mrem/year because of snow cover, which ranged from 2.54–12.7 cm (1–5 in.) in depth with an average of 5.1 cm (2.0 in.) over 33 days with recorded snow cover (Table 7-8).

The cosmic component varies primarily with altitude increasing from about 26 mrem at sea level to about 48 mrem at the elevation of the INL Site at 1500 m (4900 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 2007 was 123 mrem (Table 7-8). This is nearly identical to the 120 mrem 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. This also varies between 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 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 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 363 mrem shown in Table 7-8 and will vary from one location to another.

Roadway and Facility Perimeter Surveys

The roads and perimeter survey activities allow for continuity in the baseline radiological information needed for emergency response, data trending, and general information for stake holders and the public. Roadway and facility perimeter surveys were completed by the INL contractor using vehicle-mounted plastic scintillators. The plastic scintillators are mounted in shielded enclosures on the front of a Humvee all-terrain vehicle, along with a differentially-corrected global positioning system (GPS).

This system is identified as the Global Positioning Radiometric Scanner (GPRS). Figure 7-5 shows the roadway and facility survey locations for 2007. The Auxiliary Reactor Area (ARA) and Test Area North (TAN) perimeter surveys were added in 2007. ARA and TAN are areas of known contamination and were added to ensure that all facilities at the INL are included in the surveys.

The GPRS is utilized to perform radiological surveys over large areas. The system is comprised of radiation detectors and a differentially corrected GPS mounted on a Humvee. Custom software provides a real-time display of the radiological and position information as the data are acquired. The system is controlled through a single computer interface. The detectors are positioned at a height

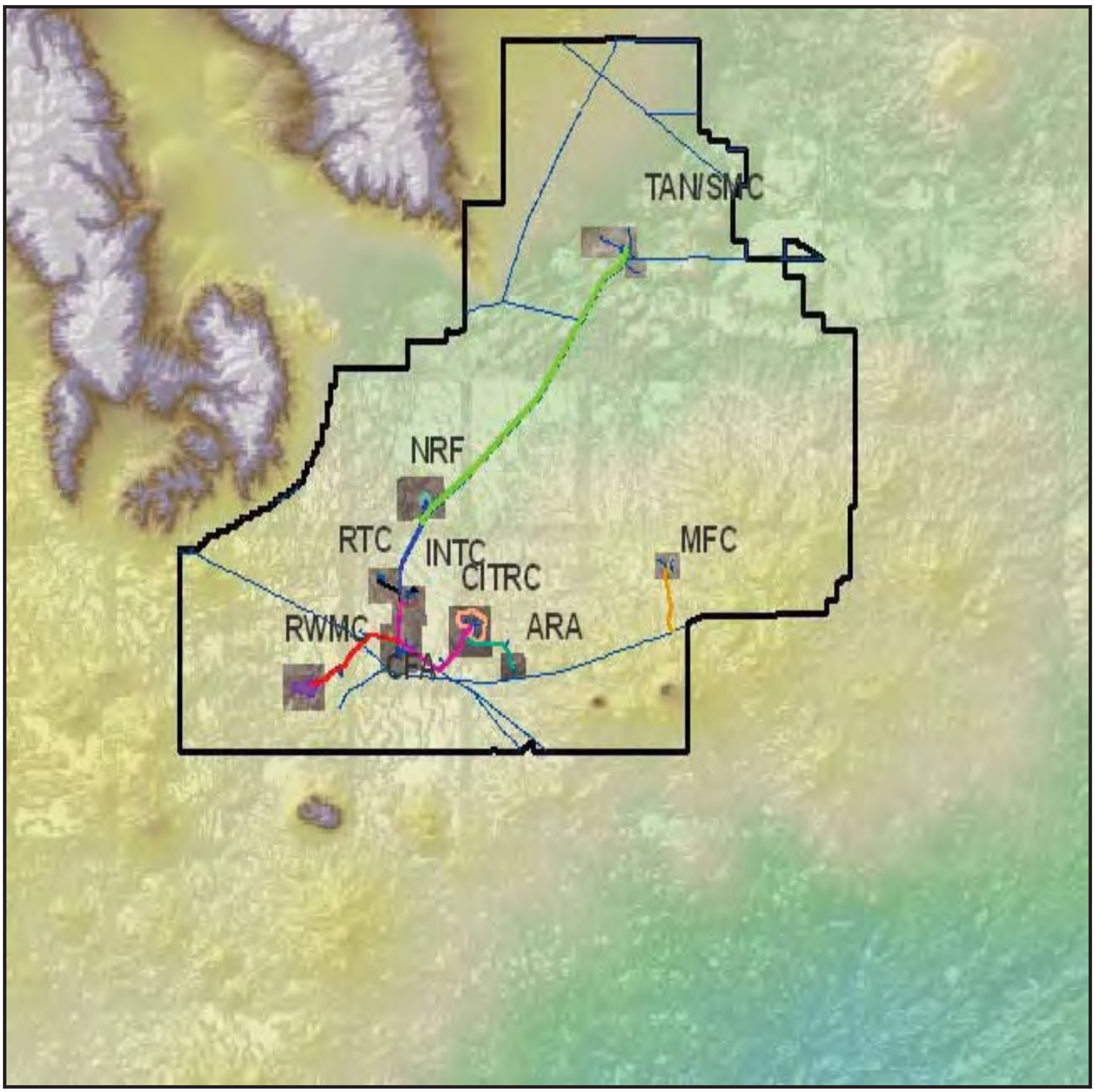

Figure 7-5. Roadway and Facility Surveys Performed in 2007.

of 36-in. above the ground, and the GPS receiver is located directly above the detectors. During the roadway and facility perimeter surveys, the speed of the GPRS is maintained at approximately 5 miles per hour.

All facility perimeter and roadway measurements made in 2007 are shown in Tables 7-9 and 7-10, respectively. Table 7-9 shows the maximum count rates for the facility surveys range from 149 to 2,350 counts per second (cps). Additionally, the facility perimeter survey data show that all average background-corrected count rate values were above zero except for the Critical Infrastructure Test Range Complex perimeter. These average values range from 12.5 cps to over twice the system minimum detectable count (MDC) rate at ARA, INTEC northeast corner, and RWMC. Based on calculations presented in EDF-ER-245, "OU 5-12 Phase II Soil Removal – Global Positioning Radiometric Scanner System Calibration for Use at ARA-23," the MDC rate for these scintillator detector systems is 97.9 cps.

The road survey data in Table 7-10 shows that, for all roads, the average count rates are negative or very low; i.e., they are below background count rates. This is due to variations in the natural radioactivity contained in the materials used to construct the roadways with respect to the natural activity contained in the materials where the background count was taken. The maximum count rates for the roadway surveys are not significantly different from the MDC value with the exception of the MFC and ARA maximum results. The MFC maximum count rate of 956.6 cps shown for the roadway survey occurred due to the proximity of high level radioactive material storage areas very near the surveyed road on the north side of MFC. The ARA road maximum count rate is likely due to windblown contamination originating from the ARA cleanup site.

Table 7-9. Results and Statistical Summary for Facility Perimeter Radiation Measurements for 2007. All values are in counts per second.

Location	Minimum	Maximum	Mean	Standard Deviation
INTEC NE Corner	-400	769.3	198.5	146.6
NRF perimeter	-354.1	148.9	13.1	51.1
CITRC perimeter	-402.9	221.1	-12.5	94.8
RWMC perimeter	-355.2	2350.8	206.3	659.8
INTEC perimeter	-318.8	839.2	106.2	164.6
RTC perimeter	-185.4	1246.6	70.7	128.2
TAN perimeter	-165	615	100.3	178.8
ARA perimeter	-84.4	488.6	205.7	78.3

Table 7-10. Results and Statistical Summary for Site Roadway Radiation Measurements for 2007. All values are in counts per second.

Roadway	Minimum	Maximum	Mean	Standard Deviation
MFC	-311.4	956.6	94.6	119.9
RTC-NRF	-341.2	73.8	-37	39.9
NRF-TAN	-520	211.7	-93.4	212.6
CFA-RTC	-247.9	163.1	-14.3	47.4
CITRC road	-307.2	141.8	11.8	66.3
Main GATE to CFA	-259.2	79.8	-36.2	31.4
RWMC-CFA	-266.5	122.5	-8	55.4
ARA road	-107.2	430	13.5	35.8

Comparison of year 2007 to year 2006 data is presented in Table 7-11. Table 7-11 shows that the RWMC perimeter, INTEC perimeter, MFC road, and ARA road had increased maximum count rates relative to 2006. The RWMC perimeter and INTEC perimeter areas also showed elevated mean count rates compared to 2006. This compares to a range of 204.0 cps to 1,200.0 cps measured in 2006. Higher measured count rate locations around the facility perimeters are due to open excavation pit areas, waste storage areas, radioactive material storage areas, and decontamination and decommissioning activities.

Figures 7-6 and 7-7 show the facility perimeter survey results, and Figure 7-8 shows the road survey results for 2007.

7.4 Waste Management Surveillance Sampling

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

Vegetation Sampling

At the RWMC, vegetation is collected from the four major areas shown in Figure 7-9. Crested wheat grass and perennials (invasive species) are collected in odd-numbered years if available. Control samples are collected near Frenchman’s Cabin (see Figure 7-10), which is approximately seven miles south of the subsurface disposal area (SDA) at the base of Big Southern Butte. Crested wheat grass samples were collected in all major areas of the SDA in 2007. Due to recontouring and construction activities at the RWMC, perennials were not available for sampling in 2007.

Table 7-11. Maximum and Mean Comparison for 2006 and 2007 Survey Data.

	Maximum		Mean	
Facility Perimeter Surveys	***2007***	***2006***	***2007***	***2006***
INTEC NE corner	769.3	1200	198.5	536.7
NRF perimeter	148.9	204.0	13.1	54.7
CITRC perimeter	221.1	310.0	-12.5	92.3
RWMC perimeter	2350.8	836.0	206.3	36.4
INTEC perimeter	839.2	547.0	106.2	70.9
RTC perimeter	1246.6	NA	70.7	NA
TAN perimeter	615	NA	100.3	NA
ARA perimeter	488.6	NA	205.7	NA
Roadway Surveys	***2007***	***2006***	***2007***	***2006***
MFC	956	350.0	94.6	26.6
RTC-NRF	74	94.0	-37.0	-35.0
NRF-TAN	212	821.0	-93.4	-80.8
CFA-RTC	163	NA	-14.3	NA
CITRC road	142	NA	11.8	NA
Main Gate to CFA	80	NA	-36.2	NA
RWMC-CFA	123	89.0	-8.0	-54.7
ARA road	430	182.0	13.5	-103.9

The vegetation samples were analyzed for gamma-emitting radionuclides, ^{90}Sr, and alpha-emitting transuranics. Table 7-12 shows the results. The concentrations were all within the background range for the INL Site.

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 2007.

Direct Radiation

The GPRS was used to conduct soil surface radiation (gross gamma) surveys at the SDA 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 the GPS and radiometric data are continuously recorded.

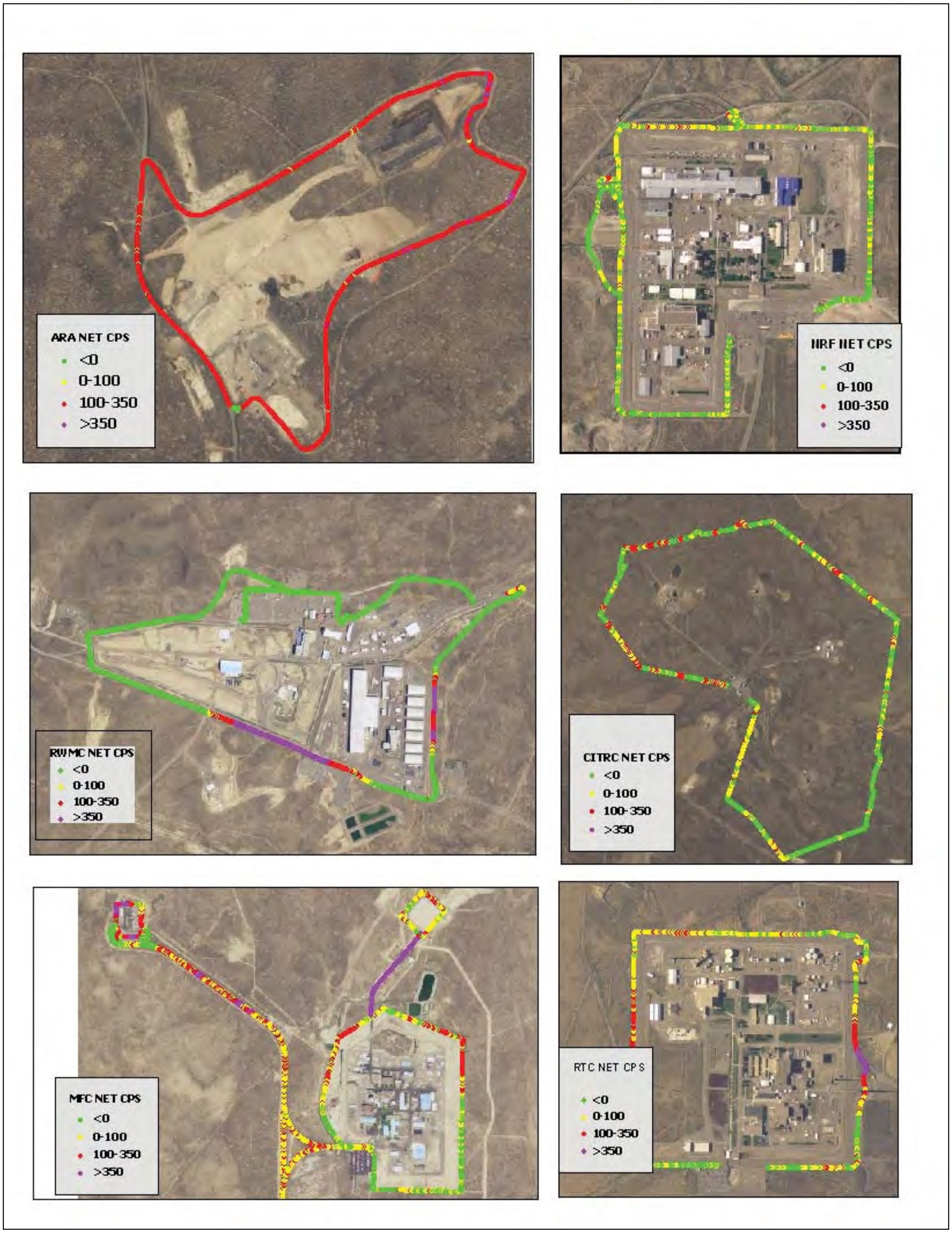

Figure 7-6. Humvee Perimeter Survey Results for 2007 for (clockwise from top) ARA, NRF, CITRC, RTC, MFC, and RWMC.

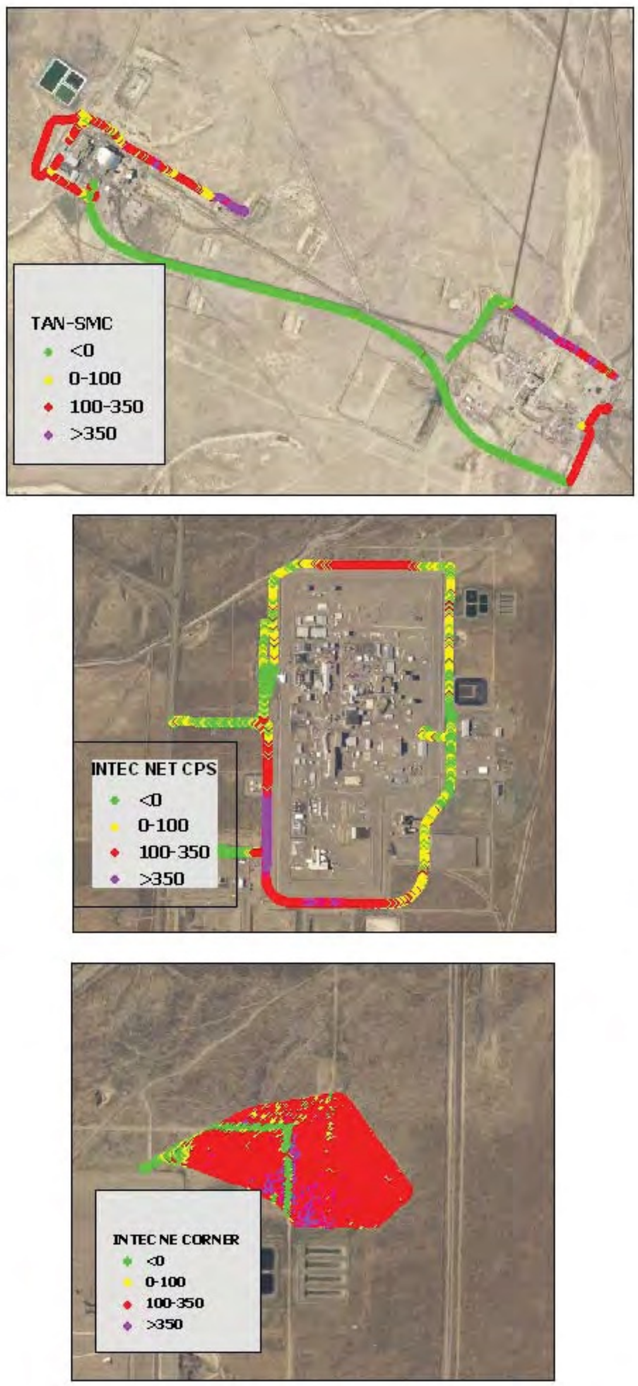

Figure 7-7. Humvee Perimeter Survey Results for 2007 for (from top) SMC-TAN, INTEC, and INTEC Northeast Corner.

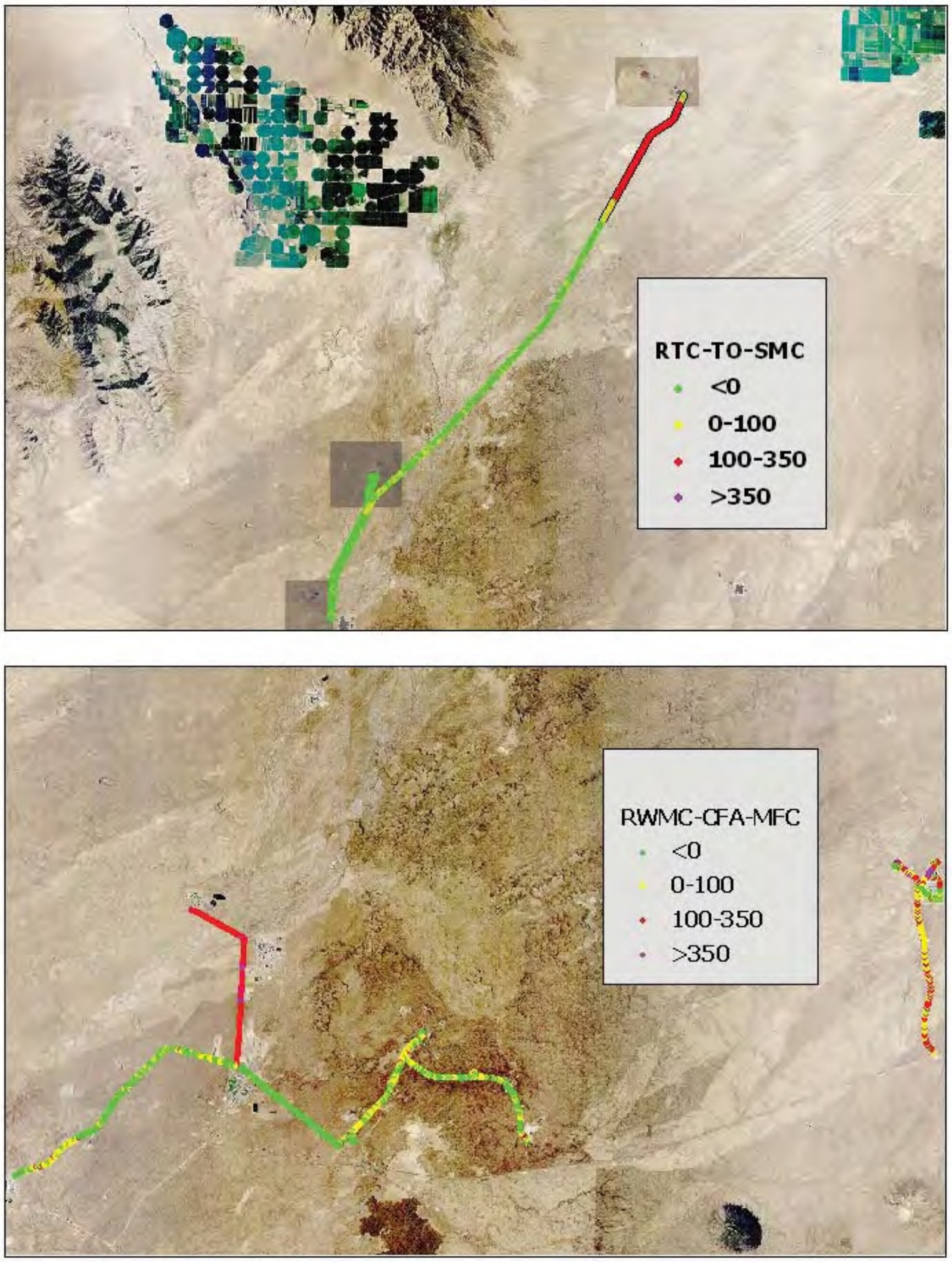

Figure 7-8. Humvee Roadway Survey Results for 2007 for North and South Areas of INL. All values in net counts per second.

Figure 7-11 shows the radiation readings from the 2007 RWMC annual survey. The maximum gross gamma radiation around the active low-level waste pit was 151,091 cps. The maximum gross gamma radiation on the remainder of the SDA was 7917 cps measured at the western end of the SVR-7 soil vault row.

Although readings vary slightly from year to year, the results are comparable to previous years' measurements, with the exception of the active low-level waste pit, which was higher than historical measurements for that area due to waste handling activities (see Table 7-13).

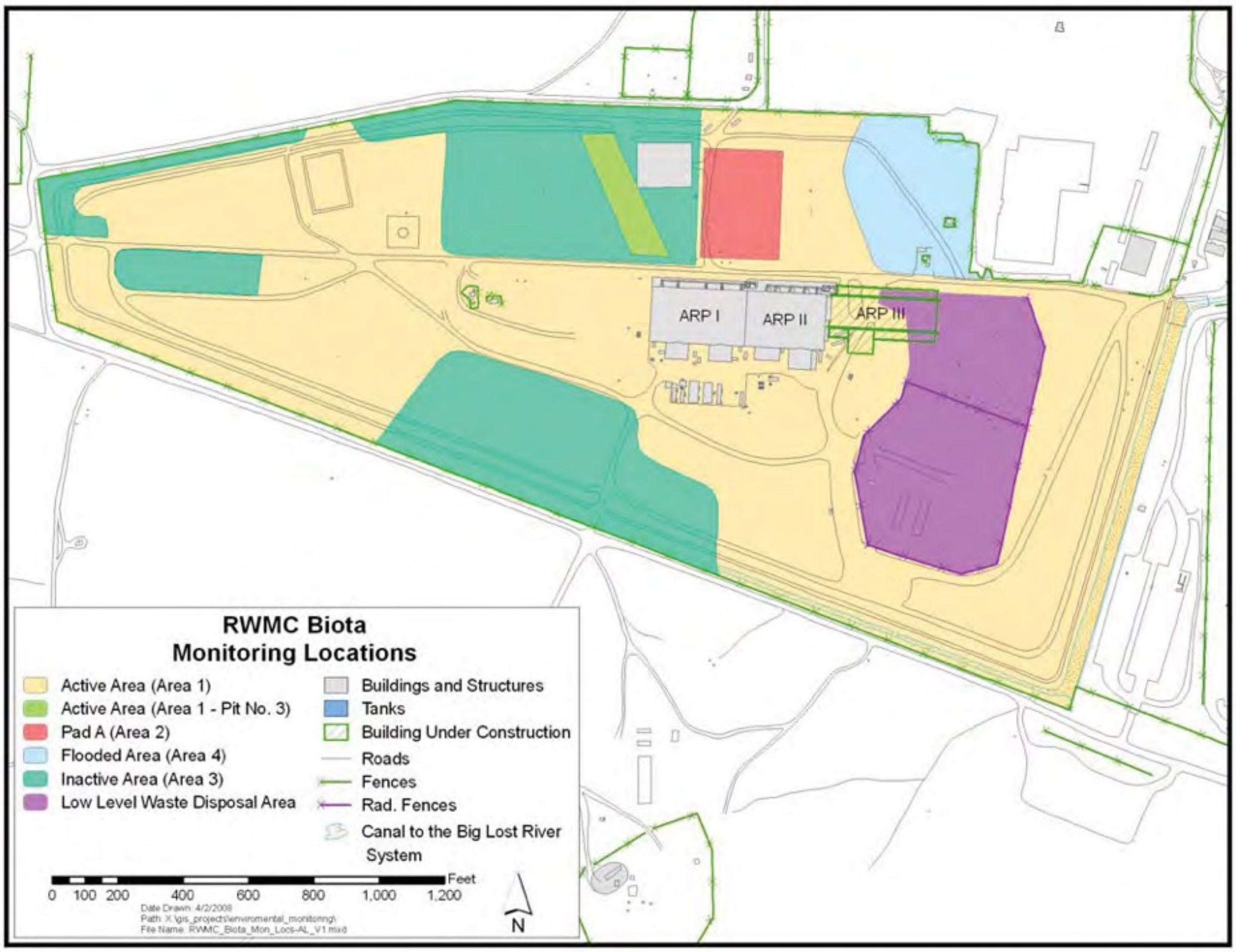

Figure 7-9. RWMC Vegetation Sampling Locations (Areas 1–4).

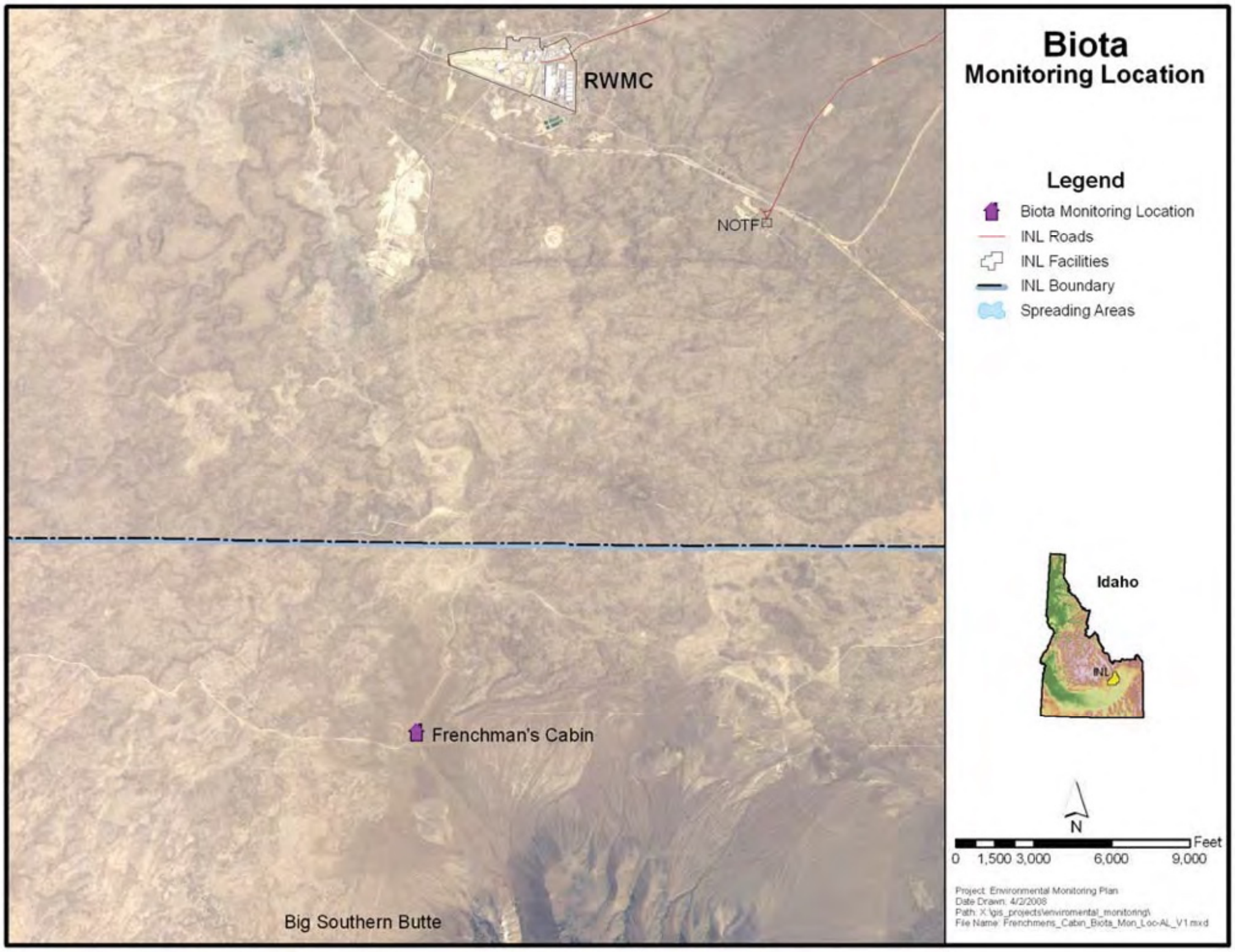

Figure 7-10. Vegetation Control Sampling Location at Frenchman's Cabin.

Table 7-12. Radionuclide Concentrations in SDA Vegetation.

Parameter	Number of Samples	Location	Maximum Activity (pCi/g)
Cesium-137	1	SDA	0.11 ± 0034
Americium-241	3	SDA	0.027 ± 0.003
Plutonium-239/240	3	SDA	0.028 ± 0.003

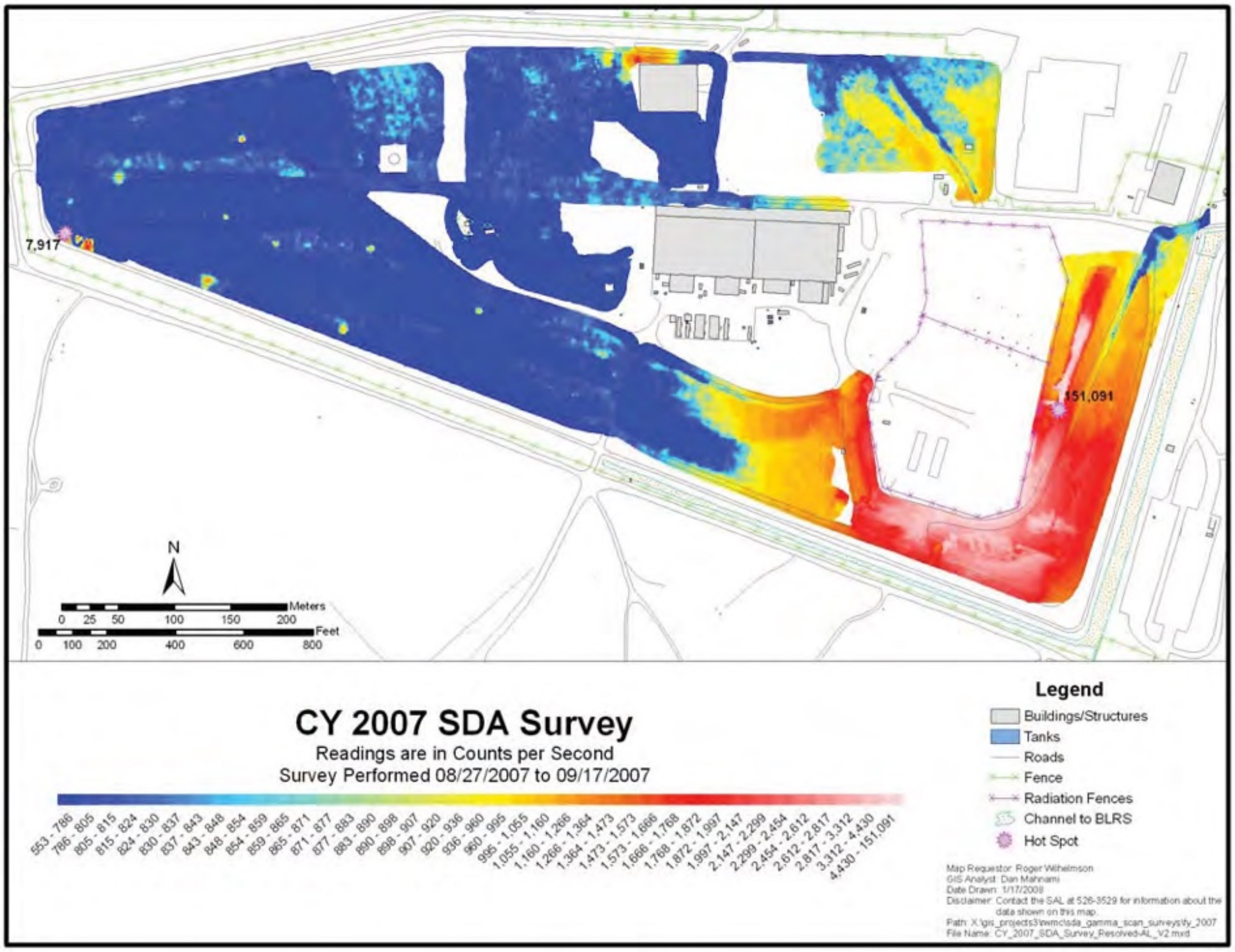

Figure 7-11. RWMC Surface Radiation Survey (2007).

Table 7-13. RWMC Survey Comparison to Previous Years.

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

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Rainbow on the INL

Chapter 8. Dose to the Public and Biota

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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 2003). 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...” (DOE 1993). This chapter describes the dose to members of the public and to the environment based on the 2007 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 show compliance 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 2007, this was accomplished for the radionuclides summarized in Table 4-2. Radionuclide releases for 2007 are summarized in Figure 8-1. The noble gas krypton-85 (^{85}Kr) accounted for approximately 58 percent of the total release, followed by tritium (^{3}H) with 25 percent, and argon-41 (^{41}Ar) at 16 percent of the total. The noble gas xenon-135 (^{135}Xe) contributed 1 percent. However, because these are noble gases they contribute very little to the cumulative dose (affecting immersion only). Other than ^{41}Ar and ^{3}H, the radionuclides contributing to the overall dose were 0.01 percent of the total radionuclides released.

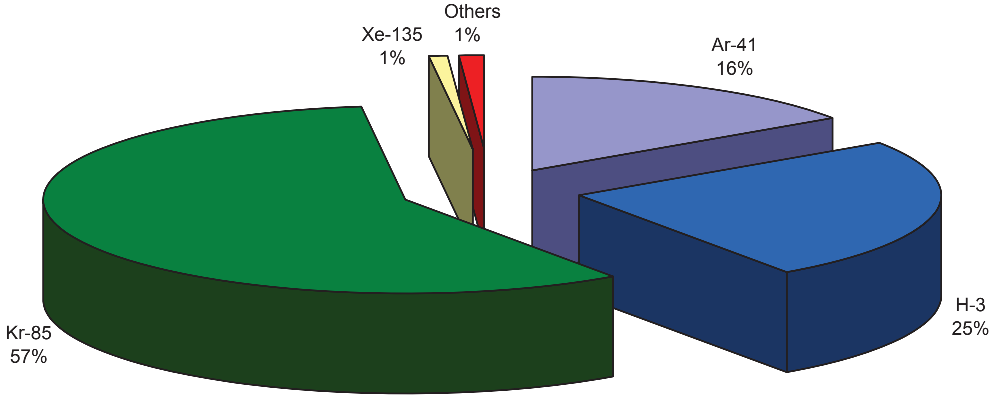

Figure 8-1. Airborne Radionuclides Released to the Environment (2007).

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. Previous years were performed using CAP-88 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 time in the community.

Of the potential exposure pathways by which radioactive materials from INL Site operations could be transported offsite (see 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 through the use of computer codes which model atmospheric dispersion of airborne materials.

8.2 Maximum Individual Dose

The NESHAP, as outlined in Title 40, Code of Federal Regulations (CFR), Part 61 (40 CFR Part 61), Subpart H, requires the demonstration 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/year (EPA 2006). This includes releases from stacks and diffuse sources. The EPA requires the use of an approved computer code to demonstrate compliance with 40 CFR Part 61. The INL Site uses CAP-88PC, Version 3, 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 2007 INL Report for Radionuclides (DOE-ID 2008). 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 (see Figure 7-10). This location is only inhabited during portions of the year, but it must be considered as a potential MEI location according to the NESHAP. At Frenchman's Cabin, an effective dose equivalent of 0.093 mrem (0.93 μSv) was calculated. For comparison, the NESHAPS doses calculated for 2003, 2004, 2005 and 2006 were 0.04 mrem, 0.04 mrem, 0.08 mrem, and 0.04 mrem, respectively, which is well below the whole body dose limit of 10 mrem (100 μSv) for airborne releases of radionuclides established by 40 CFR Part 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.

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 8-2) showing the calculated 2007 time integrated concentrations (TICs). These TICs were based on a unit release rate weighted by percent contribution for each of six INL Site facilities: Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN). To create the isopleths shown in Figure 8-2, 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 8-2. To calculate the average air concentration, the TICs were multiplied by the quantity of the radionuclide released (in curies [Ci]) during the year and divided by the number of hours in a year squared (8760 hour)^2 or 7.67 x 10^7 hour^2. This estimate does not account for plume depletion, radioactive decay, or in-growth or decay

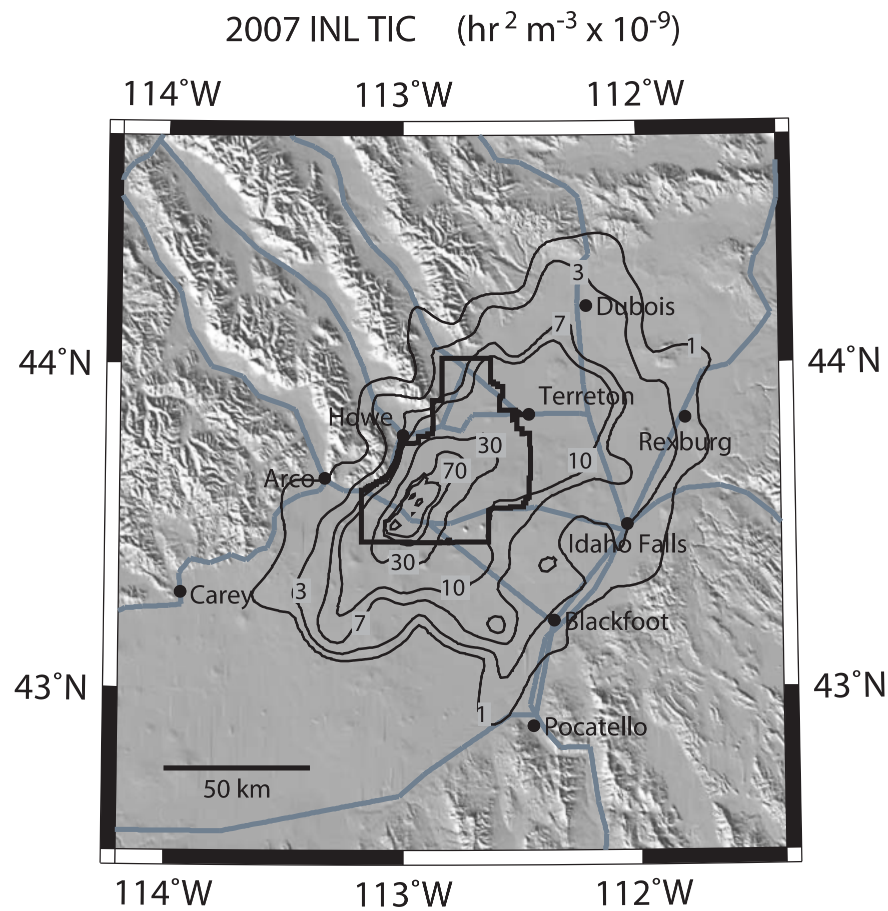

Figure 8-2. 2007 INL Tme Integrated Concentrations (TICs) ($hr^2\ m^{-3} \times 10^{-9}$).

of radioactive progeny therefore overestimating the calculated doses. The MDIFF model predicted that the highest TIC for radionuclides in air at a location with a year-round resident during 2007 would have occurred northwest of Mud Lake.

In previous years, MEI doses calculated from the MDIFF TICs have been somewhat higher than doses calculated using CAP-88PC. Differences between the two computer codes were discussed in detail in the 1986 annual report (Hoff et al. 1987). The primary difference is the atmospheric dispersion portion of the codes. CAP-88PC makes its calculations based on the joint frequency of wind conditions from a single wind station located near the source in a straight line from that source and ignores recirculation. MDIFF calculates the trajectories of a puff using wind information from 36 towers in the Upper Snake River Plain. This allows for more accurate and site-specific modeling of the movement of a release using prevailing wind conditions between time of the release and the time that the plume leaves the INL Site boundary. For this reason, the two computer codes have not agreed historically on the location of the MEI or the magnitude of the maximum dose.

The offsite concentrations calculated using both computer codes were compared to actual monitoring results using the radionuclide antimony-125 at offsite locations in 1986, 1987, and 1988 (Hoff et al.

1987, Chew and Mitchell 1988, Hoff et al. 1989). Concentrations calculated for several locations using the MDIFF TICs showed good agreement (within a factor of 2) with concentrations from actual measurements, with the model calculations generally predicting concentrations higher than those measured. The original computer code (MESODIF) was extensively studied and validated, and compared to other models in the mid-1980s (Lewellen, et al. 1985, Start et al. 1985, Sagendorf and Fairobent 1986). The MDIFF TICs continue to confirm the appropriateness of offsite air monitor locations.

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 methods outlined in U.S. Nuclear Regulatory Commission (NRC 1977) and dose conversion factors provided by EPA (EPA 2002).

An estimate was made of the collective effective dose equivalent, or population dose, 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) by the population in each census division within that county division and the normalized dose received at the location of the MEI (in rem per year per hour squared per meter cubed). This gives an approximation of the dose received by the entire population in a given county division (Table 8-1).

The dose received per person is obtained 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. Neither residence time nor shielding by housing was considered when calculating the MEI dose on which the collective effective dose equivalent is based. 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 2007 MDIFF TICs used for calculation of the population dose within each county division were obtained by averaging the results from appropriate census divisions contained within those county divisions. The total population dose is the sum of the population doses for the various county divisions (Table 8-1). The estimated potential population dose was 0.32 person-rem (3.2×10^{-3} person-Sv) to a population of approximately 295,793. When compared with an approximate population dose of 106,031 person-rem (1060 person-Sv) from natural background radiation, this represents an increase of only about 0.0003 percent. The largest collective doses are found in the Idaho Falls census division due to its greater population and in areas in the northern portion of the grid (Rexburg, Rigby, and Hamer).

Table 8-1. Dose to Population Within 80 Kilometers (50 miles) of INL Site Facilities (2007).

Census Division[a]	Population[b]	Population Dose Person-rem	Person-Sv
Aberdeen	3,482	6.37×10^{-4}	6.37×10^{-6}
Alridge	744	1.16×10^{-4}	1.16×10^{-6}
American Falls	3,875	3.10×10^{-4}	3.10×10^{-6}
Arbon (part)	32	6.09×10^{-6}	6.09×10^{-8}
Arco	2,386	1.61×10^{-2}	1.61×10^{-4}
Atomic City (division)	3,723	1.50×10^{-2}	1.50×10^{-4}
Blackfoot	13,504	9.01×10^{-3}	9.01×10^{-5}
Carey (part)	1,264	1.17×10^{-3}	1.17×10^{-5}
East Clark	74	7.09×10^{-5}	7.09×10^{-7}
Firth	3,560	2.75×10^{-3}	2.75×10^{-5}
Fort Hall (part)	1,944	3.63×10^{-3}	3.63×10^{-5}
Hailey-Bellevue (part)	5	2.60×10^{-10}	2.60×10^{-12}
Hamer	2,363	2.20×10^{-2}	2.20×10^{-4}
Howe	348	3.55×10^{-3}	3.55×10^{-5}
Idaho Falls	82,355	7.99×10^{-2}	7.99×10^{-4}
Idaho Falls, west	1,854	4.69×10^{-3}	4.69×10^{-5}
Inkom (part)	607	6.47×10^{-5}	6.47×10^{-67}
Island Park (part)	85	6.93×10^{-5}	6.93×10^{-7}
Leadore (part)	3	4.54×10^{-8}	4.54×10^{-10}
Lewisville-Menan	4,357	1.43×10^{-2}	1.43×10^{-4}
Mackay (part)	1,150	3.09×10^{-6}	3.09×10^{-8}
Moody (part)	5,376	2.41×10^{-3}	2.41×10^{-5}
Moreland	9,870	2.12×10^{-2}	2.12×10^{-4}
Pocatello (part)	82,884	1.80×10^{-2}	1.80×10^{-4}
Rexburg (part)	22,751	3.22×10^{-2}	3.22×10^{-4}
Rigby	14,072	2.62×10^{-2}	2.62×10^{-4}
Ririe	1,570	3.89×10^{-4}	3.89×10^{-6}
Roberts	1,766	7.38×10^{-3}	7.38×10^{-5}
Shelley	7,636	8.81×10^{-3}	8.81×10^{-5}
South Bannock (part)	309	5.78×10^{-5}	5.78×10^{-7}
St. Anthony (part)	2,337	1.78×10^{-3}	1.78×10^{-5}
Sugar City	6,084	1.01×10^{-2}	1.01×10^{-4}
Swan Valley (part)	5,454	2.76×10^{-4}	2.76×10^{-6}
Ucon	6,500	1.11×10^{-2}	1.11×10^{-4}
West Clark	1,469	1.59×10^{-3}	1.59×10^{-5}
Totals	**295,793**	**0.315**	**3.2×10^{-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 2008 based on county population growth from 1960 to 2000.

The largest contributor to the MEI dose was strontium-90 (^{90}Sr), accounting for 47 percent of the total dose (Figure 8-3). This was followed by isotopes of plutonium (plutonium-238 [^{238}Pu], plutonium-239 [^{239}Pu], plutonium-240 [^{240}Pu], and plutonium-241 [^{241}Pu]) which contribute a total of 27 percent to the dose, isotopes of americium (americium-241 [^{241}Am] and americium-243 [^{243}Am]) which represent 15 percent of the dose, cesium-137 (^{137}Cs) accounting for nine percent of the dose, and iodine-129 (^{129}I) which comprises one percent of the dose.

The respective contribution to the overall dose by facility is as follows: TAN (81 percent), RWMC (10 percent), INTEC (8 percent), RTC (1 percent). MFC and CFA accounted for only 0.02 percent of the dose. The calculated maximum dose resulting from INL Site operations is still a small fraction of the average dose received by individuals in southeastern Idaho from cosmic and terrestrial sources of naturally occurring radiation found in the environment. The total annual dose from all natural sources is estimated at approximately 363 mrem (Table 7-8).

Table 8-2 summarizes the annual effective dose equivalents for 2007 from INL Site operations calculated for the MEI and population. A comparison is shown between these doses and the EPA airborne pathway standard and the estimated dose from natural background.

8.4 Individual Dose - Game Ingestion Pathway

The potential dose an individual may receive from the occasional ingestion of 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 RTC 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.

Waterfowl

In 2007, four ducks were collected from the RTC wastewater ponds, six were collected from wastewater ponds at the MFC, and two were collected from an offsite location (near the Fort Hall Bottoms) as controls. No waterfowl were collected from INTEC in 2007 as none were present during the collection attempts. The maximum potential dose from eating 225 g (8 oz) of meat from ducks collected in 2007 is presented in Table 8-3. 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 0.015 mrem (0.15 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, the birds likely used the radioactive wastewater ponds during the time they were in the area.

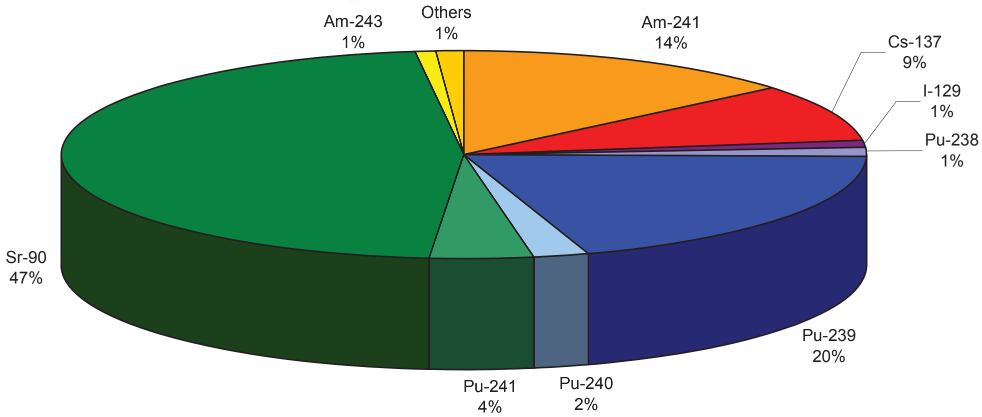

Figure 8-3. Radionuclides Contributing to Population Dose (as calculated using the MDIFF air dispersion model) (2007).

Table 8-2. Summary of Annual Effective Dose Equivalents Because of INL Site Operations (2007).

	Maximum Dose to an Individual[a] CAP-88PC[b]	Population Dose MDIFF
Dose	0.093 mrem (9.3×10^{-4} mSv)	0.32 person-rem (3.2×10^{-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	0.93 percent	No standard
Natural background	363 mrem (3.6 mSv)	106,031 person-rem (1,060 person-Sv)
Percentage of background	0.03 percent	0.0003 percent

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

b. Effective dose equivalent calculated using the CAP-88PC Version 3 code.

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.

Table 8-3. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue using INL Site Wastewater Disposal Ponds in 2007.[a]

Radionuclide	RTC Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
^{241}Am	3.99×10^{-4}	2.72×10^{-3}	0
^{60}Co	1.19×10^{-4}	0	0
^{137}Cs	1.47×10^{-2}	2.53×10^{-4}	0
Total Dose	$\mathbf{1.52 \times 10^{-2}}$	$\mathbf{2.97 \times 10^{-3}}$	**0**

a. Committed (50-yr) effective dose equivalent from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from EPA Federal Guidance Report No. 13 (EPA-402-R-99-001).

b. Doses are calculated on maximum radionuclide concentrations in different waterfowl collected at RTC and MFC wastewater disposal ponds, and are therefore worst case doses.

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 1976-1986 (Markham et al. 1982). Game animals collected at the INL Site during the past few years have shown much lower concentrations of radionuclides. Only one game animal collected during 2007 had a detectable concentration of ^{137}Cs in the muscle; none had a detectable concentration in liver tissue. Based on the concentration of ^{137}Cs found in the muscle of this game animal, the potential dose from consuming the muscle at the above weights was approximately 0.01 mrem (0.1 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

Introduction

The impact of environmental radioactivity at the INL on nonhuman biota was assessed using the graded approach procedure detailed in 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 (BCGs). A BCG 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 BCGs (the combined sum of fractions) is less than one, no negative impact to populations of plants or animals 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 in excess of 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 2007 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types (Figure 8-4). 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 that are also included in the graded approach (Table 8-4).

Table 8-4. Radionuclides That can Currently be Evaluated Using the Graded Approach (DOE 2003).

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.

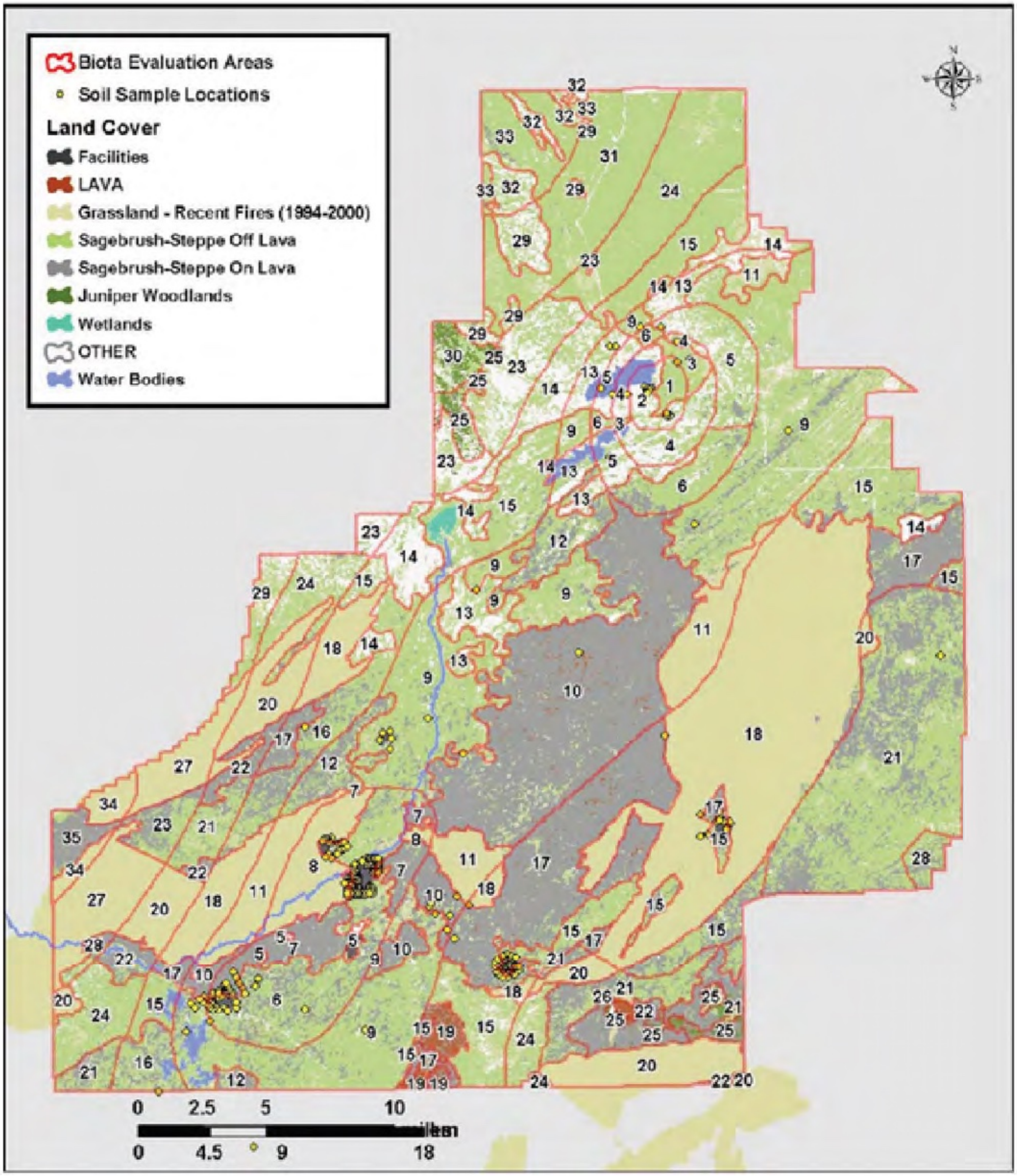

Figure 8-4. Evaluation Areas and Current Soil Sampling Locations on the INL. ***(Areas with the same number are in the same evaluation area.)*** **(Morris 2003).**

Aquatic Evaluation

For this analysis, maximum effluent data were used because actual pond water samples were not available. These 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 only available radionuclide-specific concentrations detected in 2007 were for ^{129}I and tritium in CFA effluents, and ^{241}Pu, uranium-233,234 (^{233,234}U) (assumed conservatively to be ^{234}U), and ^{238}U in the MFC Industrial Waste Pond (Table 8-5). Plutonium-241 was conservatively assumed to be in equilibrium with its daughter, ^{241}Am, which was input into the RESRAD-Biota code. These data were combined in a Site-wide general screening analysis. The combined sum of fractions was less than one (0.045) and passed the general screening test (see Morris 2003 for a detailed description of the assessment procedure).

Terrestrial Evaluation

For the initial terrestrial evaluation, we used maximum concentrations from the INL Site contractors 2006 soil sampling (see Morris 2003 for a detailed description of the assessment procedure). The combined sum of fractions was less than one (0.86) and passed the general screening test (Table 8-6).

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

Table 8-5. Biota Dose Assessment of Aquatic Ecosystems on the INL Site (2007).

Nuclide	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]				
AM-241	9.5E+00	4.4E+02	2.2E-02	0.0E+00	7.0E+05	0.0E+00	2.2E-02
H-3	4.7E+03	5.0E+09	9.3E-07	0.0E+00	7.0E+06	0.0E+00	9.3E-07
I-129	2.4E-01	1.0E+06	2.4E-07	0.0E+00	4.9E+05	0.0E+00	2.4E-07
U-234	3.6E+00	2.0E+02	1.8E-02	0.0E+00	3.1E+06	0.0E+00	1.8E-02
U-238	1.3E+00	2.2E+02	5.9E-03	0.0E+00	4.3E+04	0.0E+00	5.9E-03
				Combined Sum of Fractions[g]			**4.5E-02**

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 8-6. Biota Dose Assessment of Terrestrial Ecosystems on the INL Site (2007).

Nuclide	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]
Am-241	9.5E+00	2.0E+05	4.7E-05	1.2E-02	3.9E+03	3.1E-06	5.0E-05
Cs-137	0.0E+00	6.0E+05	0.0E+00	1.7E+01	2.1E+01	8.3E-01	8.3E-01
H-3	4.7E+03	2.3E+08	2.0E-05	0.0E+00	1.7E+05	0.0E+00	2.0E-05
I-129	2.4E-01	5.7E+06	4.1E-08	0.0E+00	5.7E+03	0.0E+00	4.1E-08
Pu-238	0.0E+00	1.9E+05	0.0E+00	5.9E-02	5.3E+03	1.1E-05	1.1E-05
Pu-239	0.0E+00	2.0E+05	0.0E+00	2.9E-02	6.1E+03	4.7E-06	4.7E-06
Sr-90	0.0E+00	5.5E+04	0.0E+00	7.1E-01	2.3E+01	3.2E-02	3.2E-02
U-234	3.6E+00	4.0E+05	9.0E-06	0.0E+00	5.1E+03	0.0E+00	9.0E-06
U-238	1.3E+00	4.1E+05	3.2E-06	0.0E+00	1.6E+03	0.0E+00	3.2E-06
				Combined Sum of Fractions[e]			**8.6E-01**

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.

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Chapter 9. Ecological and Meteorological Research at the Idaho National Environmental Research Park

R. Blew - S. M. Stoller Corporation

9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

9.1 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 for ecosystem preservation and study. This has been one of the few formal efforts to protect land for ecosystem preservation and study and to protect land on a national scale for research and education. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems.

There are five basic objectives guiding activities on the Research Parks. They are to:

1. Develop methods for assessing and documenting the environmental consequences of human actions related to energy development.
2. Develop methods for predicting the environmental consequences of ongoing and proposed energy development.
3. Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment.
4. Train people in ecological and environmental sciences.
5. Use the Research Parks for educating the public on environmental and ecological issues.

The 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 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.

Establishment of NERPs was not the beginning of ecological research at federal laboratories. Ecological research at the INL Site 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. Other long-term studies conducted on the Idaho NERP include the reptile monitoring study initiated in 1989, which is the longest continuous study of its kind in the world; as well as, the protective cap biobarrier experiment initiated in 1993, which evaluates the long-term performance of evapotranspiration caps and biological intrusion barriers.

Ecological research on the 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.

The Idaho NERP provides a coordinating structure for ecological research and information exchange at the INL Site. The Idaho NERP facilitates ecological research on the INL Site by attracting new researchers, providing background data to support new research project development, and providing logistical support for assisting researcher access to the INL Site. The Idaho NERP provides infrastructure support to ecological researchers through the Experimental Field Station and museum reference collections. The Idaho NERP tries to foster cooperation and research integration by encouraging researchers using the INL Site to collaborate, develop interdisciplinary teams to address more complex problems, and encourage data sharing, and by leveraging funding across projects to provide more efficient use of resources. The Idaho NERP has begun to develop a centralized ecological database to provide an archive for ecological data and facilitate retrieval of data to support new research projects and land management decisions. The Idaho NERP can also be a point of synthesis for research results that integrates results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho NERP also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act (NEPA) process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The following sections describe ecological research activities that took place at the Idaho NERP during 2007.

9.2 Monitoring Amphibian and Reptile Populations on the Idaho National Laboratory: Indicators of Environmental Health and Change

Investigators and Affiliations

Scott Cambrin, Graduate Student, Herpetology Laboratory, Department of Biological Sciences, Idaho State University (ISU), Pocatello, Idaho

Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, ISU, Pocatello, Idaho

Funding Sources
Idaho State University Graduate Student Research and Scholarship Committee

U.S. Department of Energy Idaho Operations Office

Background
Many amphibian and reptile species have characteristics that make them sensitive environmental indicators. The main research goal of this project is to provide indicators of environmental health and change by monitoring the distribution and population trends of amphibians and reptiles on the INL Site. This information is important to the DOE for several reasons: (1) as an indicator of environmental health and change; (2) for management of specific populations of sensitive species; (3) meeting NEPA requirements regarding the siting of future developments; (4) avoiding potentially dangerous snake-human interactions; and (5) providing a foundation for future research into the ecological importance of these species

Objectives
The main objective of this project is to monitor amphibian and reptile distribution on the INL Site. Specific objectives for 2007 included the following:

- Continue monitoring snake and lizard populations at the three main den complexes (Figure 9-1);
- Expand monitoring program to include a 170 km driving loop to complement the den data (Figure 9-1). This has been added because Denim Jochimsen's data showed that the proportion of gopher snakes on the roads is higher than at the main den sites;

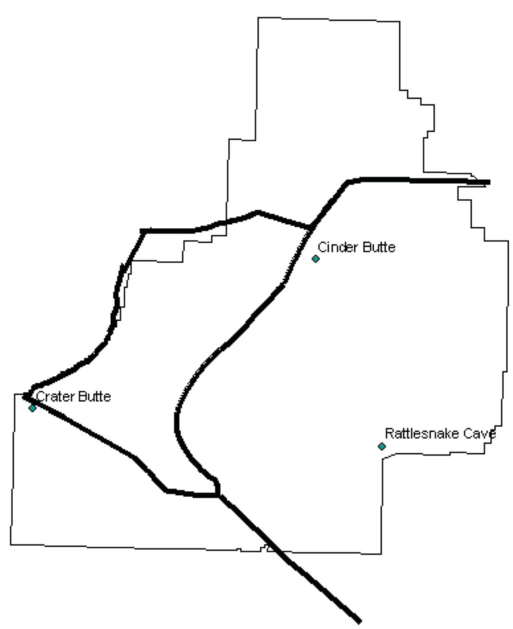

Figure 9-1. Map of the Idaho National Laboratories with the Three Main Den Complexes and the 170 km Drive Loop.

- Continue to monitor breeding sites for Great Basin Spadefoot “toads” (*Spea intermontana*)
- Continue entering current herpetological information into a geographic information system (GIS) tool database;
- Provide herpetological expertise, as needed;
- Provide snake safety workshops; and
- Provide educational opportunities for undergraduate and graduate students.

Accomplishments Through 2007

Specific accomplishments for 2007 include the following:

- We continued monitoring of snake populations at three den complexes (Cinder Butte, Crater Butte, and Rattlesnake Cave) allowed us to increase the total number of snakes captured by 481 snakes (Figure 9-2), 332 of which were new marks.
- We found 51 snakes during eight road cruising trips.
- We did not confirm spadefoot toad breeding activity at the Big Lost River sinks in 2007.
- In two man hours of searching we were not able to confirm the presence of Long-nosed Leopard Lizards (*Gambelia wislizenii*) on the INL Site in 2007.
- We conducted three snake safety talks in May of 2007 at the INL Site.

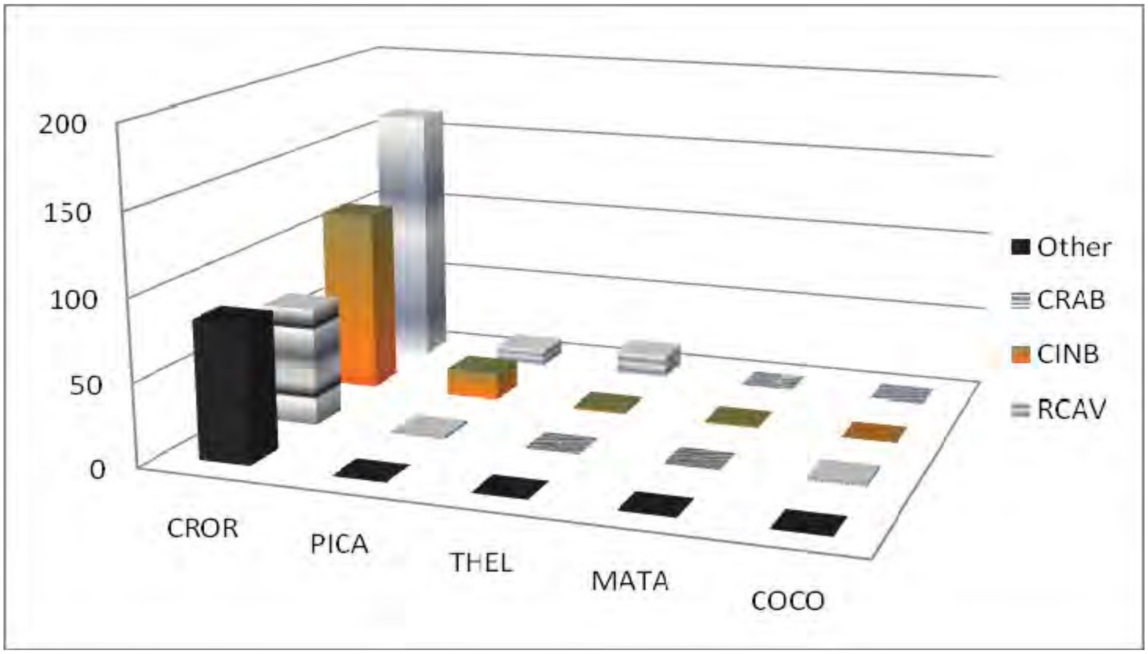

Figure 9-2. The Number of Captures from each Species Caught at Each Den Site Over the 2007 Field Season (CROR = Rattlesnakes, PICA = Gopher snakes. MATA = Striped-whipped snakes, COCO = Racer, CRAB = crater butte, CINB = cinder butter, RCAV = rattlesnake cave).

Results

The number of marked snakes on the INL Site was increased to 4,400 in 2007, which includes all snakes PIT-tagged since 1994 and marking data collected at Cinder Butte from 1989 to 1994

- We found that in 2007, 10 percent of females were gravid at Cinder Butte, 30 percent were gravid at Crater Butte, and 10 percent were gravid at Rattlesnake Cave.
- No observations of a leopard lizard (*Gambelia wislizenii*) were made at Circular Butte in 2007. Western skinks (*Eumeces skiltonianus*) were found in funnel traps at Rattlesnake Cave. Sagebrush lizards (*Sceloporus graciosus*) were found across the entire INL Site.
- We found 34 gopher snakes, 16 rattlesnakes, and one unidentifiable snake during our road cruising surveys (Figure 9-3).
- Spadefoot toad (*Spea intermontana*) breeding was not observed in the Big Lost River Sinks.
- We provided herpetological expertise in the form of snake safety talks for the INL Site, as well as, at the Idaho Falls Earth Day celebration and to elementary school children at different schools and libraries.
- Through the continuation of Scott Cambrin's masters research he has also started to look at some of the factors affecting body condition and pregnancy rates. Using the results from a laboratory study he has modeled neonate overwinter survival for the three main den sites (Figure 9-4).

Plans for Continuation

Scott Cambrin will complete a thesis and approximately two manuscripts will be submitted to peer reviewed scientific journals.

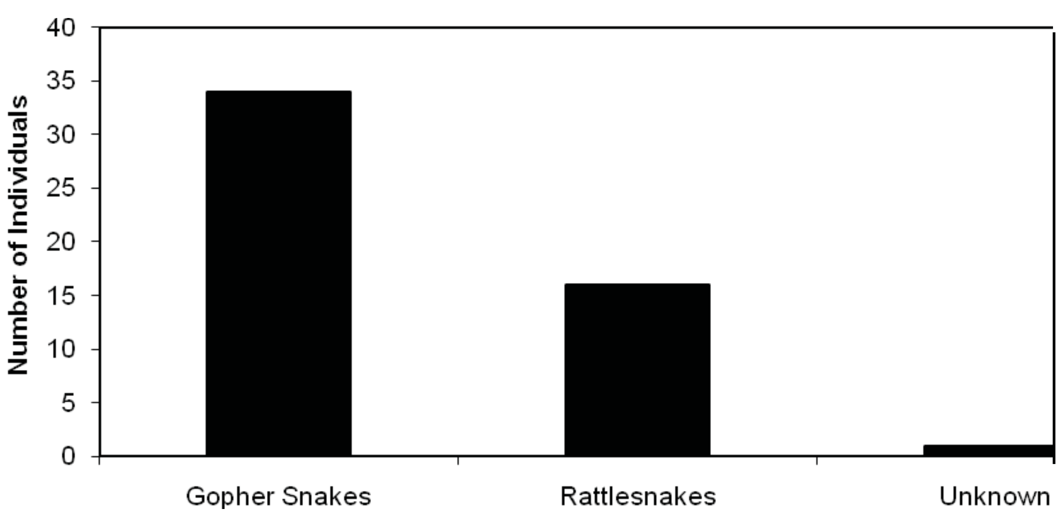

Figure 9-3. Number of Snakes Found During the Road Cruising Survey on the INL. All snakes were found dead.

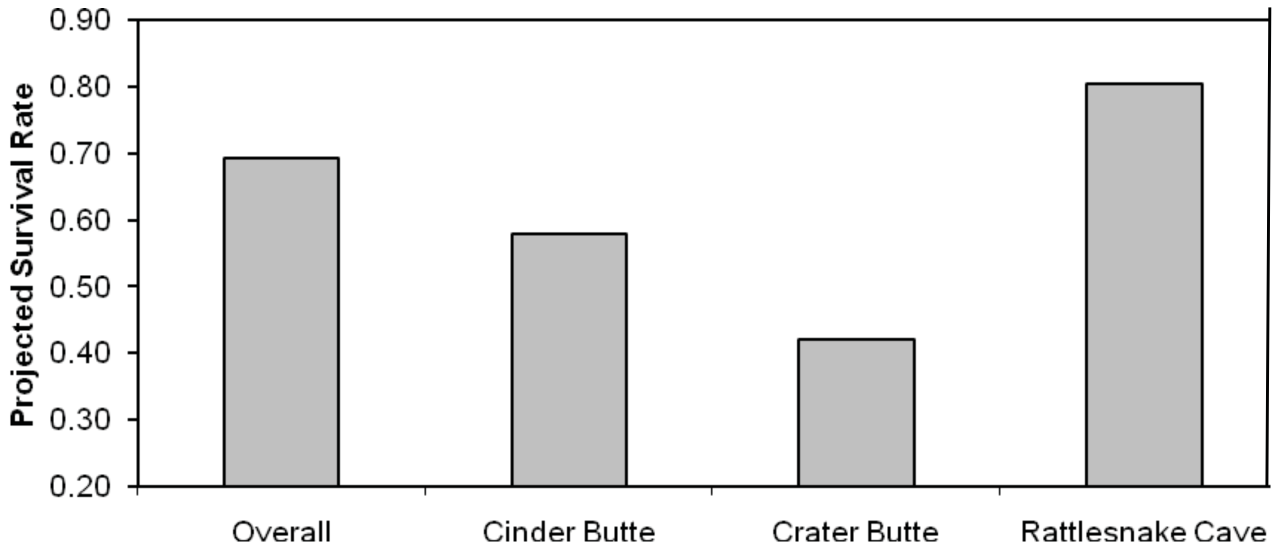

Figure 9-4. Estimated Survival Rates for Neonatal Rattlesnakes Overwinter at the Three Main Den Sites and Overall Based on Body Condition Estimates.

9.3 Developing a Conservation Management Plan for the Idaho National Laboratory

Investigators and Affiliations

Christopher L. Jenkins, Conservation Scientist, North America Program, Wildlife Conservation Society, Idaho Falls, Idaho

Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

The sagebrush steppe of western North America is one of the most endangered ecosystems in the world. Sagebrush steppe is threatened by soil disturbance (especially associated with overgrazing) that promotes invasion by exotic annual vegetation (such as cheatgrass, *Bromus tectorum*) which in turn alters natural fire regimes. These types of landscape changes are having significant effects on sagebrush steppe wildlife. Despite the widespread nature of the threats to sagebrush steppe, the INL Site has experienced only limited disturbance and is likely the most intact example of sagebrush steppe remaining.

Without an adequate management plan in place the biodiversity of sagebrush habitats on the INL Site are at a greater risk of being degraded. Localized threats to biodiversity on the INL Site include livestock grazing in peripheral areas, invasion by cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum*), fire, raven depredation, and road and facility development. In addition, complex interactions can exist between threats.

Developing a conservation management plan for the INL Site is important because it will help preserve one of the best remaining sagebrush steppe ecosystems in the world. A conservation management plan is also important to DOE because it will facilitate land use planning on the INL Site. For example, with a conservation management plan in place and an understanding of the distribution of important biological resources DOE will save time and money when planning projects such a new construction.

Objectives

The overall goal of the project is to conserve sagebrush steppe ecosystems while facilitating land use planning on the INL Site. Specific objectives include:

- Determine the distribution and abundance of pygmy rabbits on the INL Site.
- Determine the distribution and abundance of sage grouse on the INL Site.
- Conduct a biodiversity inventory of the INL Site.
- Develop a vegetation map for the INL Site.
- Set conservation priorities on the INL Site.
- Develop an interactive GIS tool for the INL Site.
- Prepare a conservation management plan for the INL Site.

Some of the objectives above will be focused on the entire INL Site (Pygmy Rabbit Studies, Sage Grouse Studies, and Vegetation Mapping) while the Biodiversity Inventory will be focused in two smaller areas in the south central part of the INL Site designated the Development Corridor and Development Zone (Figure 9-5). Thus, conservation priorities, the interactive planning tool, and the Conservation Management Plan (CMP) will only completely cover all important biological resources within these two areas.

Accomplishments Through 2007

Pygmy Rabbit Surveys. In 2007 we continued conducting ground surveys for pygmy rabbits. These surveys detected the presence of 422 burrow systems bringing the total number of burrow systems identified during the CMP project over 600.

Sage Grouse Surveys. In 2007 we conducted ground surveys for sage grouse leks. We found a total of two new leks during these surveys to bring the total number of new leks found during the CMP to six.

Biodiversity Inventory. As part of the biodiversity inventory we selected a suite of indicator taxa including vegetation, reptiles, passerine birds, raptors, bats, small mammals, mammalian mesocarnivores, and ungulates. Accomplishments in 2007 by taxa are as follows:

- *Vegetation.* We sampled approximately 50 modified Whitaker plots.

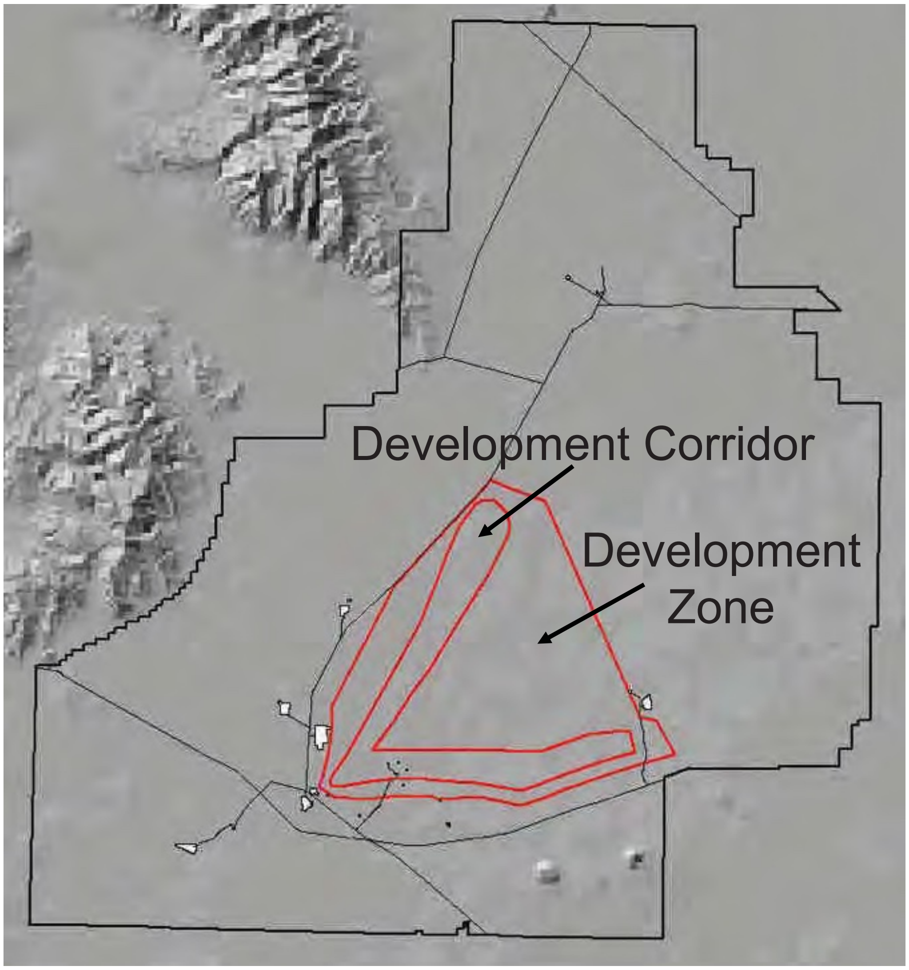

Figure 9-5. Map Displaying the Location of the Development Corridor and Development Zone on the INL.

- *Reptiles.* We sampled reptiles using 14 trapping arrays, >100 visual surveys, and a series of road surveys. We found over 1000 individual reptiles of six species. Sagebrush lizards and horned lizards were the most commonly sampled species.
- *Breeding Birds.* We sampled approximately 65 plots for breeding birds using point counts.
- *Raptors.* We sampled approximately 100 plots for raptors.
- *Small Mammals.* We sampled a total of approximately 50 plots for small mammals using Sherman live traps and Havahart traps.

Plans for Continuation
In 2008 we plan to continue surveys for pygmy rabbits, continue developing an abundance index for pygmy rabbits, and will be begin a movement and critical habitat study on sage grouse. Finally, we will continue a study on raven depredation of sage grouse nests that is primarily funded through a U.S. Bureau of Land Management (BLM) grant.

9.4 Historical Fire Regimes of Wyoming and Basin Big Sagebrush Steppe on the Snake River Plain

Investigators and Affiliations

Stephen C. Bunting, Professor of Rangeland Ecology, Department of Rangeland Ecology and Management, University of Idaho, Moscow, Idaho

Andréa L. Kuchy, Graduate student, 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 scarred by fire (e.g., western juniper (*Juniperus occidentalis*), ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*). These species, however, are largely not available for most of the Snake River Plain.

There is an urgent need for understanding the relationship between seasonal climate patterns and large fire potential in sagebrush steppe, as 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 (5000+ acres) and consecutive climatic conditions. The specific objectives of this research are to: 1) reconstruct the fire history (1960-2003) for sagebrush steppe ecosystems across three spatial scales of sagebrush-dominated steppe: a. Idaho National Laboratory Site, b. Snake River Plain, and c. portions of the Northern Basin and Range to include the Snake River Plain; 2) 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, ENSO and PDO); and 3) develop predictive models to assess how climate variation will affect fire frequency and size characteristics within sagebrush steppe ecosystems.

Accomplishments Through 2007

- Downloaded climate data (Daymet) for future analyses
- Secured vegetation coverage of area (GAP)
- Collected and compiled various historical fire data into a GIS layer
- Obtained and averaged climate data into monthly, seasonal divisions, and annual divisions
- Modified precipitation and temperature to use Western Regional Climate Center (WRCC) data to extend full range of dates of fire history (1960-2003)
- Compiled Palmer Drought Severity Index (PDSI) data for study areas into spreadsheet

Results

Because data collection was not initiated until 2007 and no data analyses have yet been compiled, no results are reported here.

Plans for Continuation

In 2008, we plan to complete the data analysis and report preparation. To investigate the probability of future regional fire years in sagebrush steppe in response to changes in climate, six hypothetical scenarios are currently being used, where each scenario is simulated as a departure from baseline mean temperature and precipitation. These six scenarios were derived using three downscaled general circulation models and the Intergovernmental Panel on Climate Change A2 and B1 scenarios, which simulate the upper and lower limits of projected greenhouse gasses, respectively. The probabilities of future regional fire years in sagebrush steppe under different climate scenarios are being examined.

Publications, Theses, Reports, etc.

No publications have resulted from this research at this time. We anticipate completion of M.S. thesis during this current year

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

Investigators and Affiliations

Lora Perkins, PhD student, Department of Natural Resources and Environmental Science, University of Nevada Reno, Nevada

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

Kimberly G. Allcock, Postdoctoral Associate, Department of Natural Resources and Environmental Science, University of Nevada, Reno, Nevada

Funding Sources
U.S. Department of Energy Idaho Operations Office

Nevada Arid Rangeland Initiative and the 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 has 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.

There are several characteristics of the eastern Snake River Plain that 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). 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 Pains also differ from most cheatgrass dominated areas. The relatively minor extent of cheatgrass invasion at the INL Site in comparison 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 tease out 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 dominated much of the landscape, to 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 INL Site which 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 and microbes) to community (vegetation and animal) to landscape (climate and land use patterns) to parameterize a structural equation model (SEM) (Grace 2006) and specifically test hypotheses about how site characteristics affect invasion success of cheatgrass.

SEM 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 SEM is that we can include variables based on 'expert opinion' rather than relying on strictly empirical data. This means we can include a wealth 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 2007

Comparative Surveys. The GIS data collected in 2006 was used to help identify potential sampling points. For our sites at INL Site, we selected areas with a diversity of vegetation type and fire history. In June 2007, we visited INL Site and sampled our first 100 sites. 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. In October 2007, we returned to INL Site and inserted resin capsules into the soil. These capsules will collect soil nutrients over the winter. We will collect the resin capsules when we return to INL Site in spring 2008. It is our hope that these resin capsules will decrease the amount of lab work required to characterize soil nutrients as well as provide a time integrated measure of soil nutrient availability.

In November 2007, over 150 field sites in Nevada were identified, visited and resin capsules inserted. Our Nevada sites are in two areas, one is located outside Midas in northwestern Nevada and the other about 40 miles north of Austin in the central part of the state. These sites offer a huge variation in land use patterns, fire history, vegetation types and climate variables.

The data collected is 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*, *Achnatherium hymenoides* or *Elymus elemoides*), late-season native species (*Pseudoroegneria spicata*, *Acnatherium 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 2000 seeds per m^2. 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 1/6 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 implementation of our experimental treatments until June 2007 in order 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, and clipped above-ground biomass, sorted by species. Samples are currently being oven-dried and weighed.

Results

Comparative Survey. We only have data from 100 of the anticipated 500+ sites in the comparative survey and are still processing the samples and data. Thus, preliminary results are not yet available.

Controlled Greenhouse Studies. We are processing the above-ground 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’. There did not appear to be any obvious visual effect of the planted species on cheatgrass density or biomass. There was no effect of planted species on soil water content (as measured by time domain reflectometry, [TDR]) in the top 10 cm of soil, and minimal effect of the watering treatments on surface soil water content 24 hours after the water pulses were applied.

Plans for Continuation

This project will continue through 2010. We will continue collecting field data for the comparative survey at INL Site and our other field sites in 2008 and 2009. A select number of sites at INL Site will be followed year to year; however, most sites for the comparative survey will only be visited once. SEMs require a large number of data points in order for the algorithms used to identify reliable parameter values (Tanaka 1987), and we plan on sampling approximately 500 sites through the course of this study.

Publications, Reports, Theses, etc.

We anticipate several peer reviewed publication 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 2009.

9.6 Development and Evaluation of a Monitoring Program for Pygmy Rabbits

Investigator and Affiliations

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Funding Sources

United States Department of Energy, Idaho Operations Office

Idaho Bureau of Land Management Challenge Cost Share Program (with Idaho Department of Fish and Game)

Background

The recent petition for Endangered Species Act (ESA) listing for pygmy rabbits was, in part, based on a perceived decline in the species, however, data to evaluate this supposition are not available. Efforts during the past 2-3 years have documented numerous new occurrences of the species in Idaho, which have helped to fill out the statewide distribution of pygmy rabbits. However, it is not known if populations of pygmy rabbits 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 first of these population criteria.

Monitoring burrow systems over the past six years in the Lemhi Valley has documented marked fluctuations in density of active burrows, which likely reflect fluctuations in population density of rabbits. Although burrow entrance counts are commonly used to estimate population abundance for semi-fossorial mammals, this relationship has not been evaluated for pygmy rabbits. Therefore this work will investigate the link between density of burrow systems and density of rabbits, and this information will be used to evaluate an index of rabbit abundance that could be employed by wildlife biologists to monitor changes in abundance of pygmy rabbit populations over time.

Objectives

The purpose of this research is to develop a standardized method to monitor abundance of pygmy rabbits and to gain an understanding of how pygmy rabbits affect their habitat. Specific objectives are to:

- Calibrate an index of abundance based on burrow systems by correlating the index with estimates of population density;
- Evaluate factors that affect the probability of detection during mark-resight exercises;

- Design standardized protocols for monitoring abundance; and,
- Evaluate the effect of pygmy rabbits on sagebrush shrubs around burrow systems

Accomplishments Through 2007

Project Design. Three sites were delineated for 2007 field work: two sites in the Lemhi Valley and one site at the INL Site. A census of all burrow systems and mark-resight exercises were completed at all three study sites. Census of burrow systems provide an evaluation of the density and activity status of rabbit burrows, and mark-resight exercises provide and estimate of abundance of rabbits. A second method for estimating abundance of rabbits based on observations of tracks at burrow systems immediately following snow fall will continue through the winter. Mark-resight and snow-track techniques will be used to evaluate and calibrate an index of abundance based on burrow systems.

Burrow Censuses. A complete census of burrow systems was conducted at two sites in the Lemhi Valley (Cedar Gulch and Rocky Canyon) and on one site on the INL Site (Atomic City). 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 classified based on sign/activity as described by Roberts (2001).

As expected, systematic censuses in the Lemhi Valley and on the INL Site indicate a difference in the number of burrow systems in each activity class and the density of burrow systems on each of the 3 study areas. Cedar Gulch had the lowest total number of burrow systems (131) and the lowest density of burrow systems, while Rocky Canyon had the largest number of burrow systems (505) and the highest density burrow systems. Atomic City fell in the middle with 449 total burrow systems (Figure 9-6).

Trapping and Radio-collaring. Trapping was conducted from 4-14 days on the 3 study sites. At sites in the Lemhi Valley a visual search and chase technique was the sole method used to capture animals; however, due to low success of this technique on the INL Site other methods were employed. Additional techniques used were: drift fences, spotlighting, and placing traps in active locations during daylight hours. Captured animals were fitted with 4.2 g radio transmitters (Holohil Inc., Toronto), PIT tags were implanted, and standard mammalian measurements were collected (weight, hind foot, ear length).

Trapping in the Lemhi Valley was conducted for approximately 12 days between the two study areas. On Cedar Gulch, 13 animals were fitted with radio-collars (5 males, 8 females) and on Rocky Canyon 14 animals were collared (6 males, 8 females). The day after capture we located rabbits to visually check collar fit

Trapping effort at Atomic City yielded only one animal captured. The visual technique used in the Lemhi Valley proved to be inefficient, and therefore other techniques were attempted. We set Tomahawk and Havahart traps at sites of active sign. Traps were set at sunrise and baited with apples, carrots or green beans, and checked at sunset. After several days without success, we constructed four drift fences (Burak 2006, Faulhaber et al. 2005) and placed them in areas where we had spotted rabbits previously. Traps were placed along the fences. Drift fences proved to be

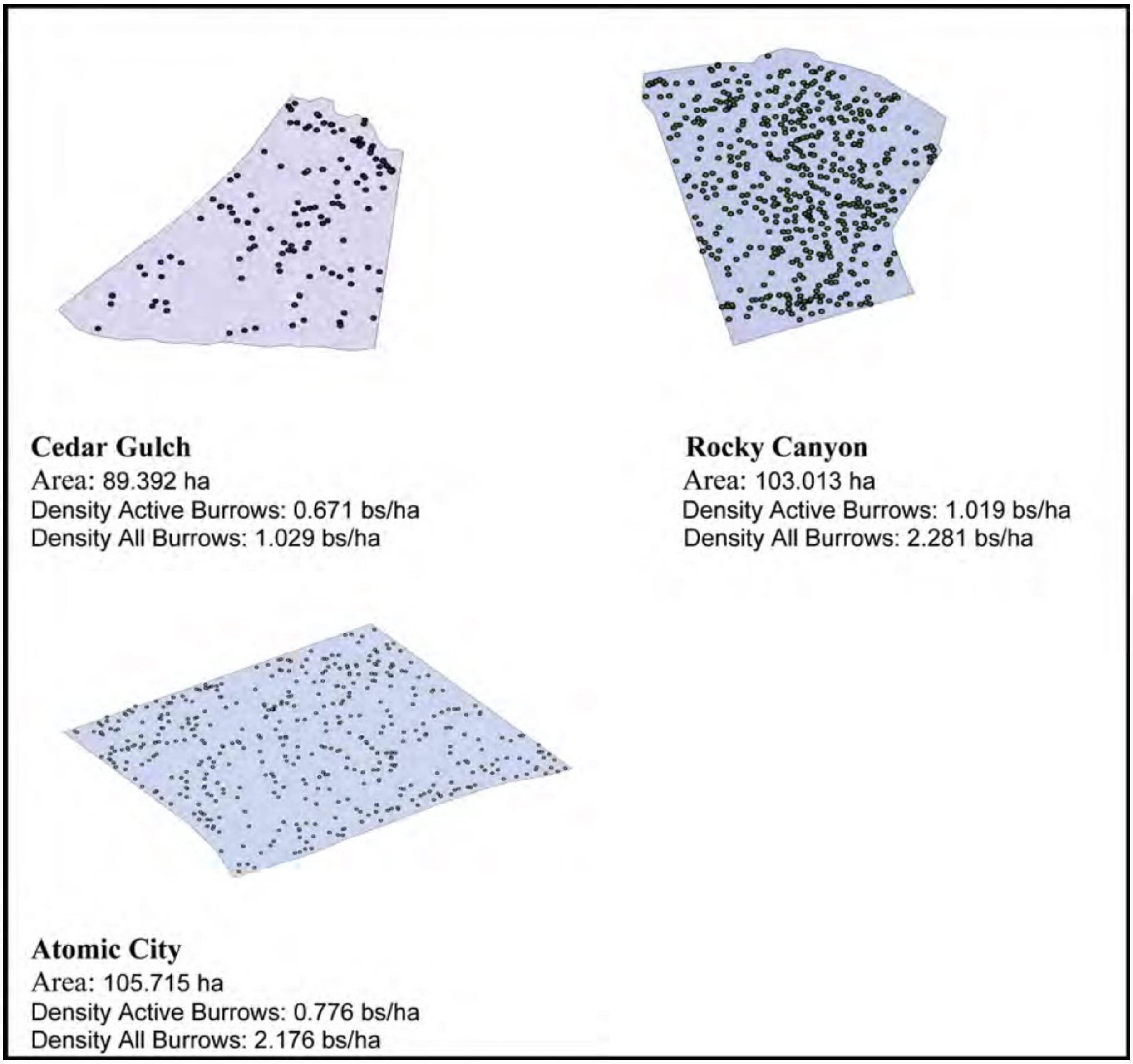

Figure 9-6. Maps of All Burrow Systems at Each Study Site Conducted September - November 2007. Density of all burrow systems and of active burrow systems was highest at Rocky Canyon and lowest at Cedar Gulch.

unsuccessful, but with some improvement might be a useful method in the future. The one rabbit that was successfully trapped (male) was caught by the visual technique, and remained in the same complex of burrows it was captured.

Mark-resight Work. Upon completion of trapping events, mark-resight surveys commenced. Animals were resighted by using maps and GPS to navigate to all burrow systems categorized as “active” or “recently active” during the previous burrow censuses. Using this technique allowed us to maximize resight probabilities of all animals. In the Lemhi Valley resight occasions were rotated every other day between Rocky Canyon and Cedar Gulch, for five resight days on Rocky Canyon and six resight days on Cedar Gulch. On the INL Site, resight events were conducted every day for five resight occasions.

Mark-resight surveys in the Lemhi Valley yielded a total of 25 collared and 44 uncollared rabbit sightings on Cedar Gulch over 6 days, and 25 collared, 22 uncollared rabbits on Rocky Canyon over five days. On several occasions one or two rabbits were documented offsite at both Rocky Canyon and Cedar Gulch, and thus were not available for resight (Table 9-1).

Mark-resight surveys at Atomic City yielded 10 sightings of rabbits over five occasions. The collared rabbit was observed three out of five occasions and a total of seven uncollared rabbits were recorded (Table 9-1). This information represents a preliminary summary. The mark-resight data will be analyzed using Program MARK to estimate numbers of rabbits using each site. Observations at Atomic City suggest that more burrow systems are used per rabbit at Atomic City where sagebrush appears much more continuous than in the Lemhi Valley. An understanding of factors that influence the relationship between rabbits and burrows is essential for developing an index based on burrow systems. To this end, we will be conducting vegetation measurements at each site.

Plans for Continuation

In 2008, we plan to conduct snow- track surveys as weather permits on the three established study areas. We also plan to establish further study sites on the INL Site, in the Lemhi Valley, and possibly Camas Prairie. Burrow censuses, mark- resight, and snow-track surveys will continue to be used in order to develop an index of rabbit abundance based on burrow systems. Additionally, vegetation analysis will be conducted over the summer months at the Lemhi sites to gain an understanding of pygmy rabbit use and impact on vegetation around their burrow systems.

Table 9-1. Summary of Results from Mark-resight Surveys on 3 Study Sites. Cedar Gulch (CG) had the largest number of resights, followed by Rocky Canyon (RC), then Atomic City (AT).

Study Area	# collared	# uncollared	# offsite	# Collared On-site	Total resights
CG	25	44	0-2	9-11	69
RC	25	22	0-1	13-14	47
AT	3	7	0	1	10

9.7 Landscape Genetics of Great Basin Rattlesnakes, *Crotalus Oreganus Lutosus*, on the Upper Snake River Plain

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Idaho State University Molecular Core Research Facility Seed Grant

Background

This project will model how landscape characteristics affect gene flow and population structure in Great Basin rattlesnakes, *Crotalus oreganus lutosus*. 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 exists on population size dynamics, reproduction, neonate survivorship, and disturbance effects, there has yet to be genetic component to this ongoing research. Genetic distance data can effectively ascertain landscape features influencing movement patterns and gene flow among sampling locations of animals (Bushar et al. 1998). The field of landscape genetics, made possible by GIS and microsatellite DNA imaging technologies, attempts to correlate habitat heterogeneity with patterns of gene flow and population structure (Manel et al., 2003, Storfer et al., 2006). This type of analysis is valuable for understanding the interplay between rattlesnake ecology and their physical environment, as well as lending insights to ways of avoiding the deleterious effects of habitat fragmentation, reproductive isolation, and genetic drift on genetic variability and population viability of snake species (Bushar et al. 1998).

Objectives

- To understand how landscape characteristics influence genetic connectivity among populations of Great Basin rattlesnakes from over-wintering sites (dens) in the shrub-steppe ecosystem of the Upper Snake River Plain in eastern Idaho.
- To understand the effects of natural and anthropogenically altered landscapes on gene flow among rattlesnake populations.

Accomplishments Through 2007

- 243 rattlesnakes from 13 geographically distinct denning locations have been captured and had a tissue sample collected for subsequent DNA analysis.
- DNA has been extracted from individuals captured at 10 geographically distinct denning locations.
- Of 17 potential microsatellite loci developed for genotyping use in other species of rattlesnake, six loci have been successfully amplified and used to genotype 180 Great Basin rattlesnakes.
- Digital geospatial data files for cover type, soils, geology, elevation, grazing, infrastructure, landownership, and burn status on the INL Site and surrounding BLM managed lands have been compiled and incorporated into a GIS.

Results

Initial results have shown that population genetic sub-structuring is highly likely among the rattlesnake dens on the INL Site, but are not reported due to insufficient sample size used in this preliminary analysis.

Plans for Continuation

- In-depth statistical analysis of genotype data will be performed.
- ArcMap will be used to make correlations between molecular and geospatial data to determine how landscape attributes affect gene flow and population connectively among the Great Basin rattlesnake dens on the INL Site.

Publications, Theses, Reports, etc.

Thesis research will be completed December 2008, and submitted for publication early 2009.

9.8 Modeling and Mapping Reptile Distributions on the Idaho National Laboratory Site

Investigators and Affiliations

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Funding Sources

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

Idaho State University, teaching assistantship.

Background

This study was designed for the purpose of understanding factors affecting reptile distribution and to make predictive distribution maps for individual species across the development zone (central 259 km^2) of the INL Site. This information will be used to help develop the conservation management plan for the INL Site, which will help the Department of Energy make decisions about future facility locations.

Objectives

The main objective of this project is to assist in development of a conservation management plan that will be used for future facility siting decisions: Specific objectives for the 2007 season included:

- Develop and apply a habitat-based sampling design for reptiles
- Determine the occurrence, distribution, and habitat relationships of reptiles on the development zone
- Develop a habitat model for each reptile species in the development zone
- Make and test predicted distribution maps.

Accomplishments Through 2007

Reptile data collection was completed and modeling procedures for six reptile species on the INL Site were developed. Three distribution modeling techniques were also completed: 1) Boolean Modeling, 2) Trapping and observational probability modeling, and 3) Mahalanobis Distance Modeling.

Results

- Incidental observation was the sampling technique that provided most reptile observations. However, skinks were not detected using this method.
- Visual Encounter Surveys produced the second highest number of reptile observations. All six species were detected.
- Trapping detected all species but in few numbers. However, the use of traps was required to sample for night snakes, which potentially occur in the study area.

Distribution Modeling. *Boolean Model.* Uses all positive data to determine in which environmental types each species occurs, then map all suitable environmental type polygons

Trapping / Observational Probability Model. Uses all positive and negative trapping and visual encounter survey data to calculate a probability of trapping or observing a particular species in a particular environmental type.

Mahalanobis Distance Model. Uses all positive data to create a habitat similarity index based on the characteristics of pixels in the GIS layers for sites where a species of interest is known to occur.

Model Ranking. We used our sample sizes, statistical analyses, and knowledge of species ecology to rank each model for each species. We also used this information to determine our relative confidence for the highest ranked model for each species.

Species Richness

- The species richness map was made by overlapping all of the boolean distribution model results.

- The number of species within the Development Zone varied from 2 to 6.
- The area with the highest reptile species richest is located on the southern end of the L shaped corridor where development is most likely to occur.
- The highest species richness areas are characterized by big sagebrush and no recent burns.

Plans for Continuation
Additional modeling approaches will be tried (e.g., DOMAIN and Maximum Entropy).

Publications, Theses, Reports, etc.
Thesis and publications are in progress.

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

Investigators and Affiliations
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Funding Sources
United States 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
- Development of habitat suitability models for predicting species occurrences, and
- Classifying areas for their importance in conservation management planning.

Previous vegetation maps of the INL Site are inadequate to serve these conservation management planning goals because they are outdated. The most recent effort was almost twenty years ago and does not capture important changes that have occurred since that time including fires, sagebrush die-off and invasion by non-native plants. Also, methodologies for vegetation classification and mapping have been refined and standardized since those earlier maps and will allow for continuity between classification on the INL Site and on neighboring lands managed by other agencies. Among others, those standards include the U.S. National Vegetation Classification System (USNVC) and the Federal Geographic Data Committee spatial data transfer and metadata standards.

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 research, and inventory and monitoring activities. It will also serve as an important background database for research on the National Environmental Research Park.

Objectives

The overall goal of vegetation community classification and mapping is to assess the distribution of plant communities on the INL Site. Specific objectives are to:

- Determine the community types present on the INL Site
- Determine the distribution of those community types on the landscape, and
- Conduct an accuracy assessment of the resulting map.

The approach planned includes two parallel processes (plant community classification and delineating mapping units) that are brought together in the final step to produce the map.

The plant community classification process includes collection of new field data from many locations representing distinct community types. The final classifications will be based on these field data analyzed using ordination and cluster analysis. These results will then be cross-walked to the USNVC vegetation associations.

The delineation and mapping process begins by collecting new color-infrared aerial imagery in a digital format. That imagery is then processed using image analysis software and other techniques to define areas of similarity in the imagery.

The next step will be to bring these two processes together by linking the community classifications to the mapping units derived from the aerial imagery. It is important to note that in some cases there may be more than one association linked to a single mapping unit and vice-versa. This allows for a consideration of vegetation associations that occur as a mosaic at a finer scale than can be delineated using this process.

Finally, we will conduct an accuracy assessment by selecting sites from the new map and collecting field data at those sites. The final products will include a report describing the plant community classes existing on the INL Site and a GIS database of plant communities on the INL Site at multiple geographic scales suitable for use with the Conservation Management Plan.

Accomplishments through 2007

The only activity scheduled in 2007 was the collection of new aerial imagery. Due to the extremely dry conditions across the INL Site this spring, the originally scheduled image acquisition was cancelled and postponed until spring of 2008. Following a few days of heavy consistent rainfall in June, we visited representative vegetation communities across the INL Site and determined that the influx of moisture resulted in a response in the vegetation that would likely assist with image classifications. On June 15, color-infrared digital imagery was collected at 1 m ground sample distance across the entire INL Site.

We began Quality Assurance/Quality Control (QA/QC) assessments of the imagery to determine that it met our data quality requirements. Following the initial spatial accuracy assessment, the imagery appears to have about 1 m or less horizontal accuracy.

Results

Because the project is in the initial data collection phase, results are not yet ready to be reported.

Plans for Continuation

In 2008, we plan to begin the two major efforts of classification and delineation. Using pre-existing data a preliminary vegetation community classification, necessary for the field data collection, is expected to be completed in May 2008. Field data collection is expected to occur in June, July, and August of 2008. Data analysis to define community classification is expected to begin in the fall of 2008.

The delineation effort is expected to start in the spring of 2008 and should be completed by spring 2009. Further refinements and additional delineations may occur following the accuracy assessment to produce the final map.

Linking the plant community classification to the delineated map is expected to occur in winter of 2009 with field accuracy assessments to occur in spring and summer of 2009. The final report and project completion is expected in 2010.

Publications, Reports, Theses, etc.

Because the project has just begun, no publications or reports have been produced.

9.10 Long-Term Vegetation Transects

Investigators and Affiliations

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9.24 INL Site Environmental Report

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Funding Sources
U.S. Department of Energy, Idaho Operations Office

Background

The Long-Term Vegetation (LTV) Transects and associated permanent vegetation plots (Figure 9-7) 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 Site. Samples of plant and animal tissues were also collected from these plots and analyzed for radionuclide concentrations on an annual basis for several years. The effort to collect 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 on a regular basis for nearly sixty years.

The data generated from the LTV Transects comprises 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 INL Site 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;

- Plant community classification and mapping,
- 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 NEPA processes,
- Making appropriate land management recommendations, and
- 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 involves a major effort in updating and describing the data archives. The second includes summarization and analysis of the 2006 and all previously collected abundance data.

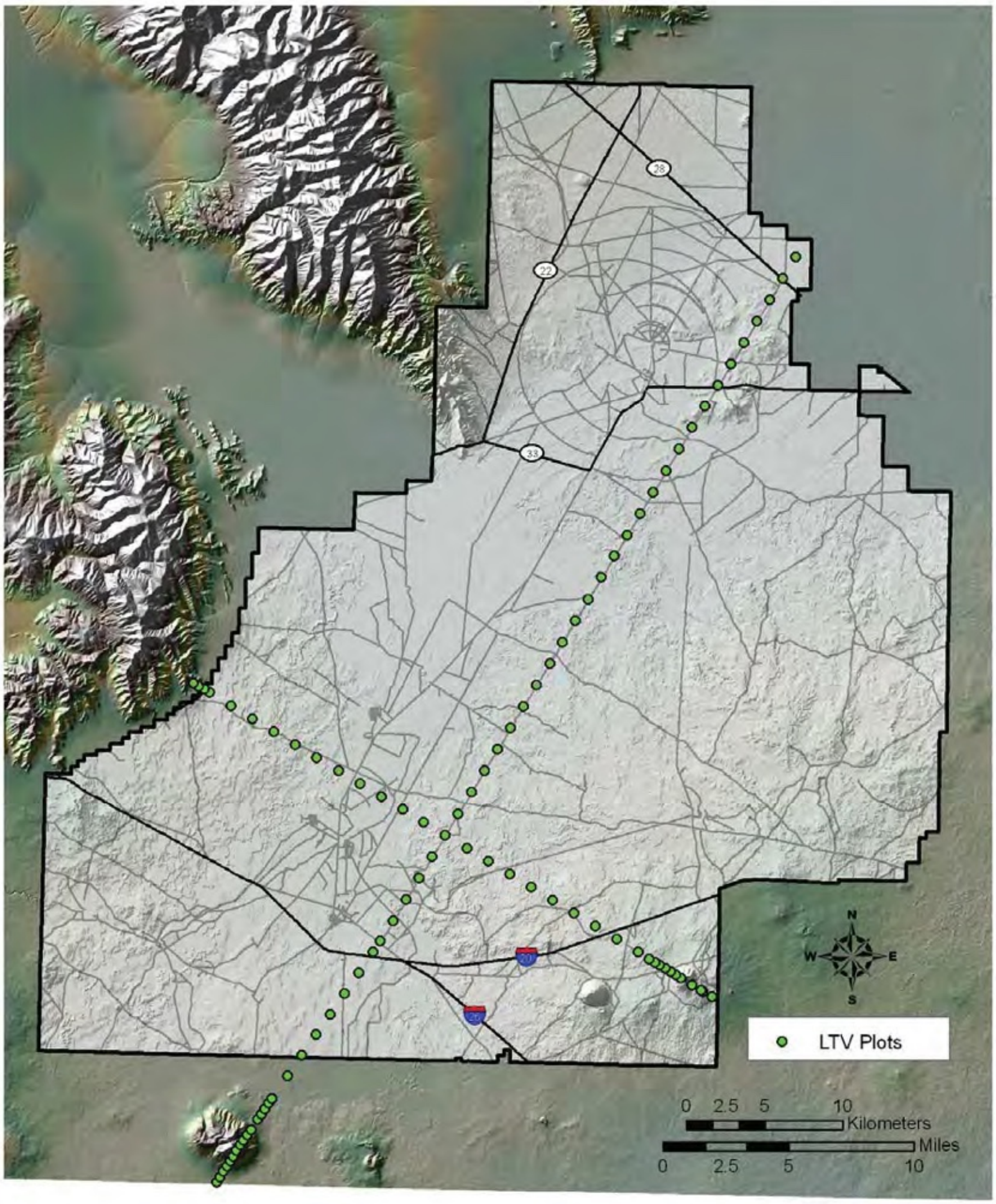

Figure 9-7. Map of the INL with Locations for Permanent LTV Plots Located Along Two Macro-transects.

The last attempt at organizing and archiving the LTV data was completed in the early 1980s. Although care has 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 entry and summary of the 2006 data includes designing and populating a relational database for all of the LTV data from 1950-2006. Additionally, a specific sampling protocol will be developed and a thorough history included for the LTV 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 group of analyses will concentrate 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 2007

Accomplishments through 2007 include collection of the 2006 data and completion of QA/QC procedures on that data set. The 2006 data were also summarized and formatted for inclusion in a comprehensive database. A specific protocol for use in collecting 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 will also expedite current and future analyses on the complete LTV data set. Incorporation of historical and 2006 LTV data into the database was mostly completed in 2007. Data verification and validation efforts were also completed primarily in 2007. Verification and validation processes were used to ensure the integrity and completeness, as well as to resolve issues associated with taxonomic classifications and scaling, of the historical data set as it was integrated into the new database.

Results

The database includes seven raw data and metadata tables. The general structure of the database is depicted in Figure 9-8. 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 data table can, and should be used for all future vegetation data collection on the INL Site. It contains standardized information for each vascular plant species documented to occur within or adjacent to the Site boundary. Information contained in the species information table will facilitate summarizing data into functional groups, and allows the definitions of functional groups to be easily changed. The species information table reconciles species codes traditionally used for data collection on the INL Site with a national standard (USDA, NRCS 2008). This data table can be readily updated in response to changes in taxonomy and contains unique numeric codes for each species so that a species is always identified correctly for summarization in current and historical data sets even though taxonomy and species codes have changed through time.

The plot information data table contains metadata about each permanent plot along the LTV macro-transects and several additional plots sampled in 1957 and 1965, referred to as the century series.

The plot information table contains data about the location and history of each 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. The data contained in the sample frequency table is not entirely unique. For example, determining whether all three types of abundance data were collected on a specific plot in a certain year can be accomplished by querying all three abundance data tables. However, running one query against the sample frequency table streamlines the process. The sample frequency table also houses information about sampling details (i.e. only 40 point frames were sampled on plot 36 in 1995 instead of the usual 50 frames). 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

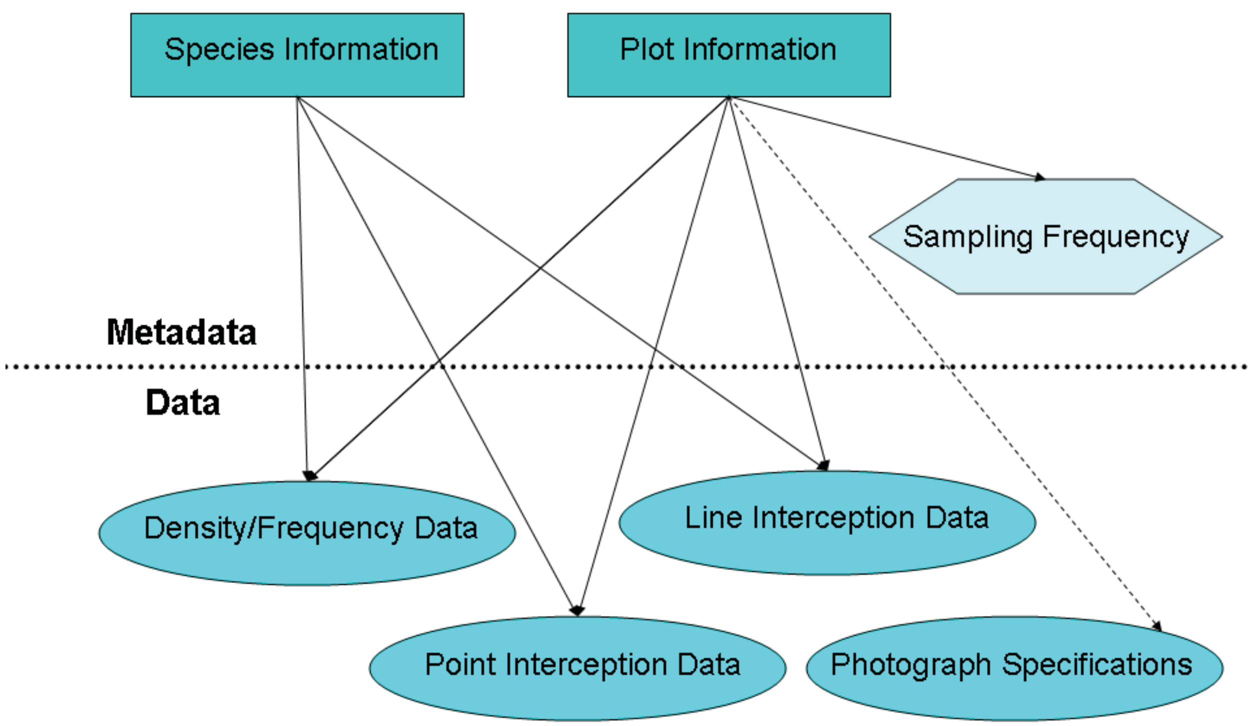

Figure 9-8. Flow Chart Showing Seven Data and Metadata Tables and the Relationships of Those Tables to One Another in the LTV Database.

possible; however, most of the historical data archives were summarized to some extent, which dictated the level of data summarization used in the actual database. The photograph specifications data table was designed to consolidate data associated with photos taken during LTV data collection efforts including, photo dates, exposure, aperture, camera angle, etc. The photo data was designed such that the record of each photo can include 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 will be completed for the 2006 LTV data during 2008. Two peer-reviewed publications containing results from the current LTV data set will also be prepared and submitted as time and funding allow.

9.11 The Protective Cap/Biobarrier Experiment

Investigators and Affiliations

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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 ground water 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 ground water (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 (ET) 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 four primary objectives which include; (1) comparing the hydrologic performance of four ET cap designs, (2) examining the effects of biobarriers on water movement throughout the soil profile of ET caps (3) assessing the performance of alternative ET cap designs under current and future climatic scenarios, and (4) evaluating the performance of ET 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 ET.

During the 2007 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 ET on plots planted with a native seed mix, (2) determine relative contribution by species to plot ET, and (3) determine if community dynamics have been shaped by either cap design or irrigation treatment.

Accomplishments Through 2007

Soil moisture and vegetation cover data from 1994-2006 were analyzed according to the 2007 report objectives listed above and the final report was published in February 2007. A copy of the report, entitled “PCBE Revisited: Long-Term Performance of Alternative Evapotranspiration Caps for Protecting Shallowly Buried Wastes under Variable Precipitation” (Janzen et al. 2007), is available at www.stoller-eser.com.

Two supplemental irrigation treatments were completed on the PCBE in 2007. A summer irrigation treatment was applied in fifty millimeter increments on a biweekly basis 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 during 2007 beginning in April through mid-October on a biweekly basis. Vegetation cover data were collected throughout the month of July and early August. Fine scale measurements in the form of photographs were taken on a monthly basis 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 Resource Conservation and Recovery Act (RCRA) cap types receiving summer irrigation at the end of July, August, and early October.

Results

Because data collection was initiated in 2007 for the new outlined objectives, limited data analysis has been completed, however, analysis on long-term community dynamics has been completed and results are presented below.

- Vegetative cover in RCRA cap types was generally lower than in all other cap types. 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 was lowest in the ambient treatment than in either of the irrigated treatments. Long-term trends in other diversity indices did not differ significantly among irrigation treatments.
- Species rank abundance was relatively similar among cap types with the exception of the shallow biobarrier cap types which had significantly different species ranks for *Ericameria nauseosus* and *Hedysarum boreale*.
- Species rank abundance varied among irrigation treatments. Plots receiving the ambient treatment generally had a higher species rank for forbs and the lowest species rank for *Agropyron cristatum* than either of the irrigation treatments.

Plans for Continuation

During the upcoming growing season we will continue to monitor vegetation cover and soil moisture as we continue to assess long-term alternative ET cap performance. Additionally, we will continue to collect fine scale vegetation cover measurements and direct transpiration measurements throughout the growing season in 2008. The measurements taken during the 2007 and 2008 field seasons will be used to better characterize and quantify the soil-plant water relationships on the PCBE, which will be useful for modeling long-term cap performance, as well as improving cap performance through directed revegetation design.

Publication, Reports, Theses, etc.

We anticipate that we will submit two manuscripts to peer reviewed journals in addition to the completion of a M.S. thesis in late 2008 or early 2009.

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

Investigators and Affiliations

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Dr. Nancy Huntly, 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 hostplants 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*. Development of 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 2007 were to:

- Determine the presence and relative density of *A. websteri* in 45 locations along 3 permanent INL Site Breeding Bird Survey (BBS) transects;
- Use counts of *A. websteri* on sagebrush branches to develop an estimate of *A. websteri* density and to calibrate trap efficiency;
- Characterize vegetation and other habitat attributes at each sampling location;
- Compile and analyze field data.

Accomplishments Through 2007

Project accomplishments for 2007 include the following:

- Insect traps were used to sample *A. websteri* in 40 locations along INL Site roads spanning portions of 2 permanent BBS transects;
- An inventory of *A. websteri* on branches collected from sagebrush in each of the 40 trapping locations was completed;

- Plant composition (relative abundance rank), distance from each trap to the nearest sagebrush, height, canopy width (in two compass directions) and distance to nearest neighbor were obtained at each location and non-target insect species captured in the traps were preserved;
- Temperature, precipitation, and wind-speed for all sampling dates were obtained from climatological monitoring stations at the Central Facilities Area (CFA) and the Materials and Fuels Complex (MFC).

Results

- *A. websteri* was captured in 11 (about 28 percent) of the sampled locations (Figure 9-9). A maximum of three individuals was captured in any location.
- Evidence of *A. websteri* was also found in sagebrush branches from only eight of the 40 sites (20 percent), which could account for the low numbers captured in traps;
- Although collection of 45 samples along three transects was planned, time constraints and habitat destruction associated with a wildfire that started on July 18, 2007, resulted in the elimination of sampling along the Twin Buttes BBS transect. An unintended consequence was that all sites with more than one sagebrush host species were eliminated.
- *A. websteri* and other specimens were preserved and are in the process of being sorted and mounted for identification.

Plans for Continuation

- To support an analysis of host-plant composition, sampling in 2008 will be conducted in a sagebrush community with two or more host-species (location to be determined).
- INL Site sites sampled in 2007 will be re-sampled (or sub-sampled) in 2008 to verify low *A. websteri* densities and to further quantify potential correlations with densities of *A. websteri* and other insects in grazed and un-grazed habitats.
- Combined data from 2007 and 2008 will be used to develop alternative models 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) most strongly predict the presence or absence and abundance of *A. websteri*.

Publications, Reports, Etc.

A manuscript documenting project results will be submitted for publication in a peer-reviewed journal in December 2008. Results also will be included as a chapter of my Ph.D. dissertation and will contribute to other integrated presentations and publications on the biology and outbreak dynamics of *A. websteri* and other insect pests of western rangelands.

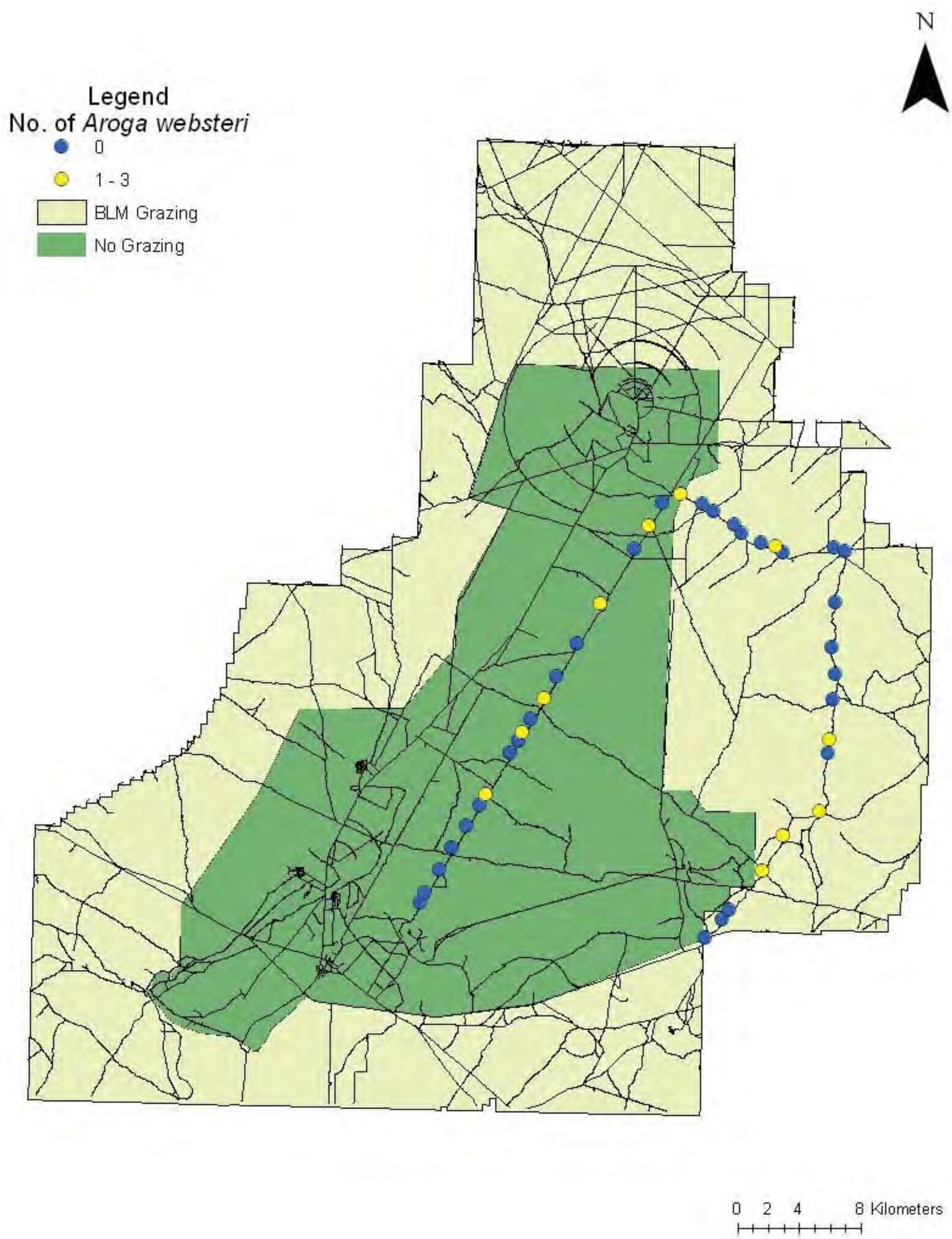

Figure 9-9. The Number of *A. websteri* Captured in 2007 at INL Sample Locations.

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

Investigators and Affiliations

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Funding Sources

INRA – Inland Northwest Research Alliance

NCALM – National Center for Airborne Laser Mapping

U.S. Department of Defense

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 non-agricultural 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 and vegetation controls on post-fire wind erosion potential.

Accomplishments Through 2007

We have 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.

We have submitted an abstract with our results on hydroclimatological controls on post-fire wind erosion to the International Grasslands Congress (IGC) in Huhot, China (July 2008).
We are preparing a manuscript based on the hydroclimatological results submitted to IGC.
NCALM collected a lidar data set for our INL Site study area in November 2007. We will use this data to investigate vegetation controls on post-fire wind erosion potential.

Results

Little saltation activity was detected and threshold could not be assessed at the unburned site. Threshold increased during the course of the study at the burned site (Figure 9-10a), suggesting that erodibility was highest immediately following fire and decreased throughout fall. Water, temperature, and relative humidity (Figure 9-10b, c, and d) were moderately-strongly correlated with threshold (Pearson's correlation = 0.70, -0.68, 0.76, respectively, all $p < 0.00$). A multiple regression model with relative humidity and water as predictors explained substantial variability in threshold (threshold = 6.92 * 0.02 relative humidity * 0.10 water, r2 = 0.75, p-values < 0.00).

Preliminary findings from this study suggest that wildland fire has the potential to increase wind erosion susceptibility in the semiarid rangeland environment we studied. Erodibility, as measured by daily mean threshold wind speed, appeared to be highest in the weeks immediately following fire. Both subsurface hydrology and boundary layer atmospheric conditions appear to be major controls on the dynamics of post-fire wind erosion.

Plans for Continuation

We intend to continue our monitoring work through at least fall/winter 2008.

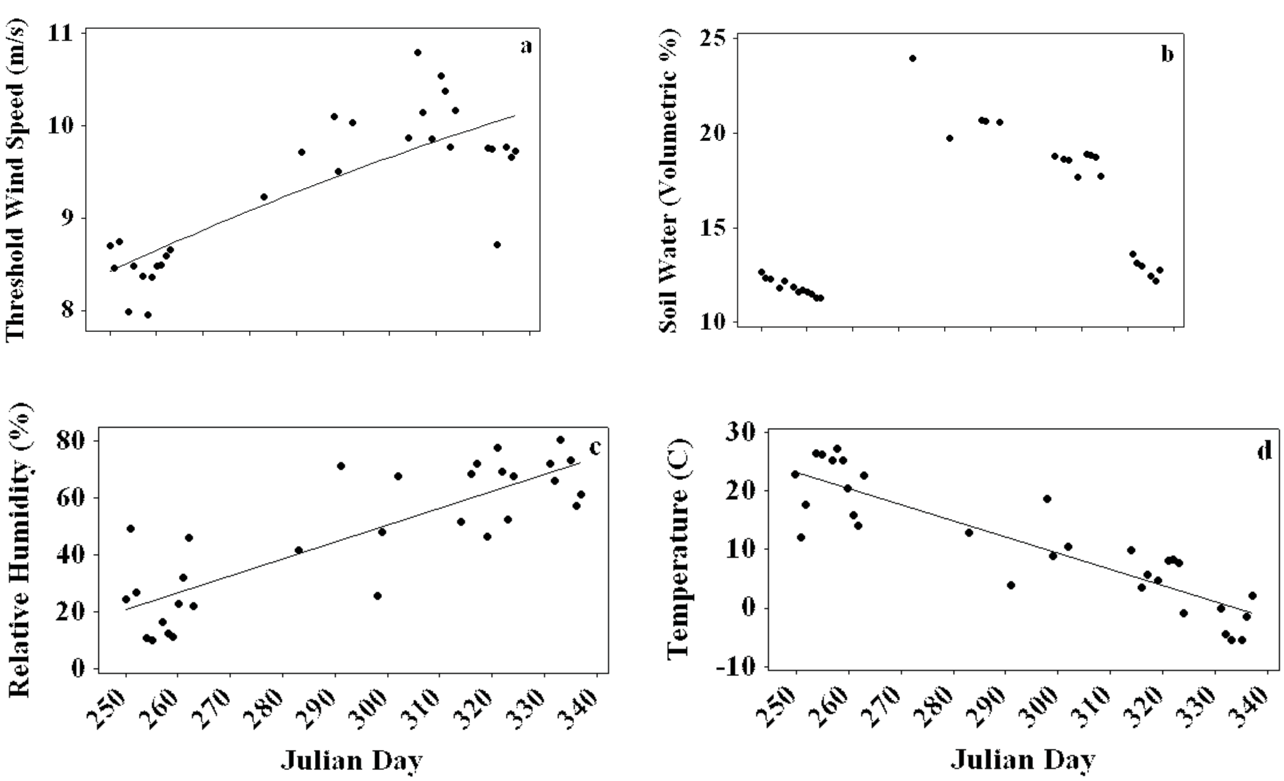

Figure 9-10. Daily Mean Threshold, Soil Water Content, Relative Humidity, and Air Temperature for Erosion Events Occurring After Summer Wildfire.

Publications, Theses, Reports, etc.

We have submitted an abstract with our results on hydroclimatological controls on post-fire wind erosion to the IGC in Huhot, China (July 2008). We are preparing a manuscript based on the hydroclimatological results submitted to IGC.

9.14 Improving Rangeland Monitoring and Assessment: Integrating Remote Sensing, GIS, and Unmanned Aerial Vehicle Systems

Investigators and Affiliations

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Maxine Dakins, Associate Professor, Environmental Sciences, University of Idaho, Moscow, Idaho

Steven Bunting, Professor, Department of Rangeland Ecology and Management, University of Idaho, Moscow, Idaho

Lee Vierling, Associate Professor, Department of Rangeland Ecology and Management, University of Idaho, Moscow, Idaho

Jerry Harbour, Manager, National Training Center, Albuquerque, New Mexico

Funding Source

United States Department of Energy, Idaho Operations Office

Accomplishments

This research was conducted as part of a doctoral program and has been completed

Dissertation Abstract

Creeping environmental changes are impacting some of the largest remaining intact parcels of sagebrush steppe ecosystems in the western United States, creating major problems for land managers. The INL Site, located in southeastern Idaho, is part of the sagebrush steppe ecosystem, one of the largest ecosystems on the continent. Scientists at the INL Site and the University of Idaho have integrated existing field and remotely sensed data with geographic information systems technology to analyze how recent fires on the INL Site have influenced the current distribution of terrestrial vegetation. Three vegetation mapping and classification systems were used to evaluate the changes in vegetation caused by fires between 1994 and 2003. Approximately 24 percent of the sagebrush steppe community on the INL Site was altered by fire, mostly over a 5-year period. There were notable differences between methods, especially for juniper woodland and grasslands. The Anderson system (Anderson et al. 1996) was superior for representing the landscape because it includes playa/bare ground/disturbed area and sagebrush steppe on lava as vegetation categories. This study found that assessing existing data sets is useful for quantifying fire impacts and should be helpful in future fire and land use planning. The evaluation identified that data from remote

sensing technologies is not currently of sufficient quality to assess the percentage of cover. To fill this need, an approach was designed using both helicopter and fixed wing unmanned aerial vehicles (UAVs) and image processing software to evaluate six cover types on field plots located on the INL Site. The helicopter UAV provided the best system compared against field sampling, but is more dangerous and has spatial coverage limitations. It was reasonably accurate for dead shrubs and was very good in assessing percentage of bare ground, litter and grasses; accuracy for litter and shrubs is questionable. The fixed wing system proved to be feasible and can collect imagery for very large areas in a short period of time. It was accurate for bare ground and grasses. Both UAV systems have limitations, but these will be reduced as the technology advances. In both cases, the UAV systems collected data at a much faster rate than possible on the ground. The study concluded that improvements in automating the image processing efforts would greatly improve use of the technology. In the near future, UAV technology may revolutionize rangeland monitoring in the same way GPS have affected navigation while conducting field activities.

9.15 Meteorological Research at the Idaho National Laboratory Site Improved Atmospheric Dispersion Modeling for the Idaho National Laboratory Site

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

National Oceanic and Atmospheric Administration, Air Resources Laboratory

Background

The Field Research Division of the National Oceanic and Atmospheric Administration Air Resources Laboratory (NOAA ARL-FRD) provides meteorological support to the INL Site. This includes maintaining the INL Site meteorological tower network (the INL Site Mesonet) and running atmospheric dispersion models for emergency response applications. For many years NOAA ARL-FRD has used a locally developed dispersion model called MDIFF to simulate potential hazardous releases from INL Site facilities. However, MDIFF has not been significantly upgraded in many years and is showing its age. Both INL Site and NOAA staff have requested new modeling capabilities that are not present in MDIFF. While MDIFF could in principal be upgraded, it is more cost effective to adopt a newer model that already has many of the requested capabilities.

The NOAA Air Resources Laboratory already has an advanced dispersion model called HYSPLIT that contains many of the features that have been requested for future INL Site applications. HYSPLIT is used operationally within NOAA for various applications including smoke forecasting from wildfires and forecasting the movement of ash plumes from volcanic eruptions. It is also used by the National Weather Service to produce plume forecasts for toxic releases.

NOAA ARL-FRD recommended several years ago that HYSPLIT be adopted for INL Site use, but funding restraints did not allow any efforts along these lines until 2007. Adoption of HYSPLIT benefits both INL Site and NOAA as a whole. INL Site benefits because HYSPLIT is a more modern model with new modeling and display capabilities. Unlike MDIFF, HYSPLIT also has broad support within NOAA, so the limited resources available locally can be leveraged through interactions with the broader HYSPLIT community within NOAA. The benefit to NOAA is that any improvements to HYSPLIT made for INL Site applications can feed back to the wider HYSPLIT community.

Objectives

The objectives of this work are to

- Transition INL Site dispersion modeling from MDIFF to HYSPLIT
- Develop more realistic wind fields that account for the local topography and changes in the wind with height
- Improve the dispersion model output so it is more useful to decision makers in the INL Site Emergency Operations Center
- Provide capability to forecast future plume movements using gridded atmospheric models
- Develop release scenarios for INL Site facilities that are compatible with the HYSPLIT model inputs

Accomplishments Through 2007

Many of the capabilities required for using HYSPLIT at INL Site actually coincide with the needs of other HYSPLIT users within NOAA. NOAA ARL-FRD has therefore collaborated with these other groups in adding many features. These include improving the model output so that it more useful for decision makers and adding a chemical database within HYSPLIT that is used in generating contours. Output from the model can be provided in a GIS format that allows it to be layered with other geographical data. A basic radiological dose calculation algorithm has also been added, although it is still undergoing testing.

NOAA ARL-FRD is running a version of the WRF gridded atmospheric weather prediction system with a horizontal grid spacing of 4 km over the INL Site region. The forecast winds from WRF can be used in HYSPLIT to create forecasts of future plume movements.

Results

HYSPLIT now has many of the capabilities that are needed for INL Site dispersion modeling. The main obstacle remaining is the development of a realistic three-dimensional wind field based on the INL Site Mesonet data, and this is discussed below.

Plans for Continuation

Unlike MDIFF, HYSPLIT requires a three-dimensional wind field that accounts for vertical changes in the winds and for terrain effects. This can already be done using the output from gridded models such as WRF, but it must be remembered that these gridded models are only producing forecast winds and not actual winds. These forecasts can fail just like the models used by the National

Weather Service in producing general weather forecasts. For this reason, it is not advisable to rely solely on forecast model winds when generating plume plots in an emergency-response environment.

NOAA ARL-FRD therefore plans to develop a capability to generate a three-dimensional HYSPLIT wind field based directly on the INL Site Mesonet data. Such a wind field is a “nowcast” rather than a forecast, since it involves current conditions rather than future conditions. MDIFF currently creates two-dimensional nowcasts simply by horizontally interpolating between Mesonet towers. The situation is more complicated with HYSPLIT because of the need to deal with vertical variations in the wind. In addition, it is highly desirable to have the HYSPLIT winds flow realistically over or around terrain obstacles and to obey mass continuity. Simple interpolation does not produce such results. NOAA ARL-FRD is therefore looking at either adopting or developing a so-called diagnostic wind-field model that matches the Mesonet observations as closely as possible while still obeying physical constraints such as terrain blockage and mass continuity. Once such a wind-field model is in place, the transition from MDIFF to HYSPLIT can be initiated.

9.16 Improving INL Wind Forecasting with Cluster Analysis of Wind Patterns

Investigators and Affiliations

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Jason D. Rich and Neil Hukari, Research Meteorologists, NOAA Air Resources Laboratory Field Research Division, Idaho Falls, Idaho

Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

NOAA ARL-FRD has provided INL Site climatology monitoring and specialized weather forecasting such as wind forecasts for nearly 60 years. Understanding wind patterns and forecasting winds are of interest at the INL Site for various applications. Short-term wind forecasts are used during emergency operations to track the potential transport of hazardous substances and in predicting the spread of wildfires. Wind forecasts are also important for the safety of personnel and the efficiency of many routine INL Site activities. For example, some operations at the INL Site can only be conducted when the wind speed remains under specific thresholds. Climatological wind patterns are also one factor that must be considered as part of INL Site’s efforts to ensure it meets regulatory requirements for public safety.

The meteorologists working at NOAA ARL-FRD have long known that a few typical wind patterns recur frequently across the INL Site and the surrounding area. For example, meteorologists have learned to expect northeast, down-valley winds on summer mornings and up-valley, southwesterly flows on summer afternoons. Cluster analysis is one mathematical approach used to identify common patterns in data. A cluster analysis of the NOAA INL Site Mesonet wind observations was completed to better understand the frequent wind patterns and to exploit them in weather forecasting.

This analysis identified eight clusters or typical wind patterns which seem to be well correlated to commonly observed meteorological conditions.

Objectives

The main objective of this project is to formally identify recurring wind patterns and create a method to categorize wind fields according to these patterns. Three goals of the project once these clusters are defined are to:

1. Understand how the wind fields evolve over time and obtain a better understanding of the physical processes driving the wind fields.
2. Improve wind forecasting, both short and long term at the INL Site.
3. Investigate whether the wind patterns are correlated with other factors such as precipitation coverage and wildfire frequency.

Accomplishments Through 2007

A cluster analysis was conducted using Mesonet data from November 1993 to February 1999 which identified eight wind field clusters. These were further refined by taking all data available from November 1993 to March 2006 and assigning them to clusters and refining the cluster centers. The clusters are numbered from 1 to 8, with 1 being the most common and 8 the least common. A number of statistics for each cluster were calculated including frequency of occurrence by season and time of day, average duration, times when each cluster was most likely to be observed, and the probability of transitions from one cluster to another. The evolution of the clusters has also been studied. A number of software tools have been developed that allow forecasters to examine current and historical wind fields in the context of which cluster they belong to and the expected changes in cluster membership over time.

Results

A detailed description of each cluster is beyond the scope of this report. As an example, Figure 9-11 shows the INL Site wind fields representing clusters 1 and 3. The left map shows the most frequent pattern at INL Site, namely a nocturnal drainage flow from the northeast. It is most common during summer nights and early mornings. The right map shows cluster 3, the third most frequent pattern representing moderate up-valley flow. It is often observed during summer afternoons. Overall, the first 5 clusters are more common and are related to normal diurnal trends due to terrain and atmospheric stability conditions. Clusters 6-8 occur less frequently and are associated with large-scale forcing from passing weather systems. People working at INL Site may be somewhat surprised that strong southwest winds are not the most common pattern. However, it must be remembered that most INL Site workers are at the site only during daylight hours, whereas the cluster analysis is based on data from all hours. Also, people usually remember extreme weather events more than the intervening quiescent periods. A more in-depth description of the cluster analysis is found in Clawson et al. (2007).

Plans for Continuation

We plan to continue improving our understanding of the physical processes, such as terrain effects, related to each wind cluster. We also plan to improve the cluster forecasting tools. This will allow us to incorporate the clusters into daily forecasting and also to work with the Pocatello National Weather Service in improving short term wind forecasting across SE Idaho and the INL Site.

Eventually we would like to look at whether the clusters are correlated with other spatial factors including precipitation and vegetation distributions and wildfire probability.

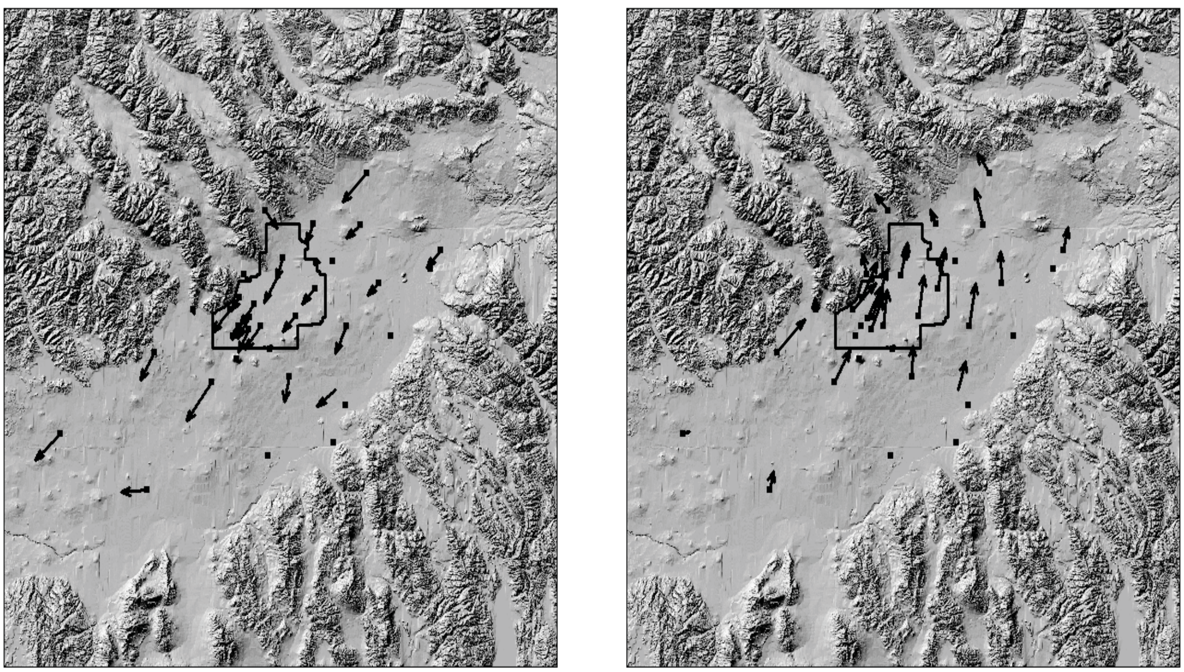

Figure 9-11. Example INL Site Wind Patterns From Cluster Analysis. The left map shows the most common cluster 1 (northeast flow mostly at night) and the right map is the third most common cluster 3 (moderate southwest flow during the day).

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House Wren on Nest

Chapter 10. Quality Assurance

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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 and QC program is to ensure precise, accurate, representative, and reliable results, and to maximize data completeness. Another key issue of a quality program is to ensure that data collected at different times are comparable to previously collected data.

Elements of typical quality assurance programs include, but are not limited to the following (ASME 2001, ASME 1989, EPA 1998):

- 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) Site contractors and subcontractors in 2007 used the following accredited laboratories:

- The Idaho Cleanup Project (ICP) used General Engineering Laboratories (GEL) and Sanford Cohen and Associates for radiological and inorganic analyses.
- The INL Site Drinking Water Program used GEL for radiological analyses, Microwise Laboratories (now Energy Laboratories) of Idaho Falls for inorganic and bacterial analyses, and Environmental Health Laboratories (now Underwriters Laboratory) for inorganic and organic analyses.
- The INL Site air monitoring program used Severn-Trent St. Louis.
- The Wastewater Reuse Permit (WRP) Liquid Effluent Program used Southwest Research Institute for some analyses.
- 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); Teledyne Brown Engineering of Knoxville, Tennessee, was used 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. Department of Energy's (DOE's) Radiological and Environmental Sciences Laboratory (RESL) performed radiological analyses for the U.S. Geological Survey (USGS).
- The USGS National Water Quality Laboratory conducted non-radiological analyses.

All these laboratories participated in a variety of programs to ensure the quality of their analytical data. Some of these programs are described below.

Quality Assessment Program/Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program (MAPEP) is administered by DOE's RESL. The 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. The MAPEP distribution (Series 18) scheduled for June was delayed due to RESL's involvement in an Outsourcing Competition during 2007. Series 18 was distributed in January 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 2007).

2007 MAPEP Results

Comparisons of the air and water MAPEP results for the laboratories used by INL Site environmental monitoring organizations in 2007 are presented in Figures 10-1 and 10-2 for gross alpha/beta and actinides. Results for all laboratories were qualified as "Acceptable" for these analyses, with two exceptions: the ICP Analytical Services result for ^{238}Pu in air and the Sanford Cohen result for ^{241}Am in air were classified as "Acceptable with Warning."

National Institute of Standards and Technology

The DOE RESL participates in a traceability program administered through the NIST. RESL 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 RESL to confirm their analytical capabilities. RESL maintained NIST certifications in both preparation and analysis in 2007.

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 analysis that range from ± 20 percent to ± 35 percent.

The Operational Dosimetry Unit of the INL contractor also conducts in-house quality assurance testing during monthly and quarterly environmental thermoluminescent dosimeter (TLD) processing periods. The QA test dosimeters were prepared by a QA program administrator. The delivered irradiation levels were blind to the TLD processing technician. The results for each of the QA tests have remained within the 20 percent acceptance criteria during each of the testing periods.

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 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 listing of approved laboratories. Where possible (i.e., the laboratory can perform the requested analysis) the contractors use such 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, the INL contractor, the ICP contractor, the USGS, and other contractors performing monitoring use a variety of quality control samples of different media. Quality control samples measure precision of sampling and analysis activities. Quality control samples include blind spike samples, duplicate samples, split samples, trip blanks, rinsate samples, equipment blanks, and field blanks.

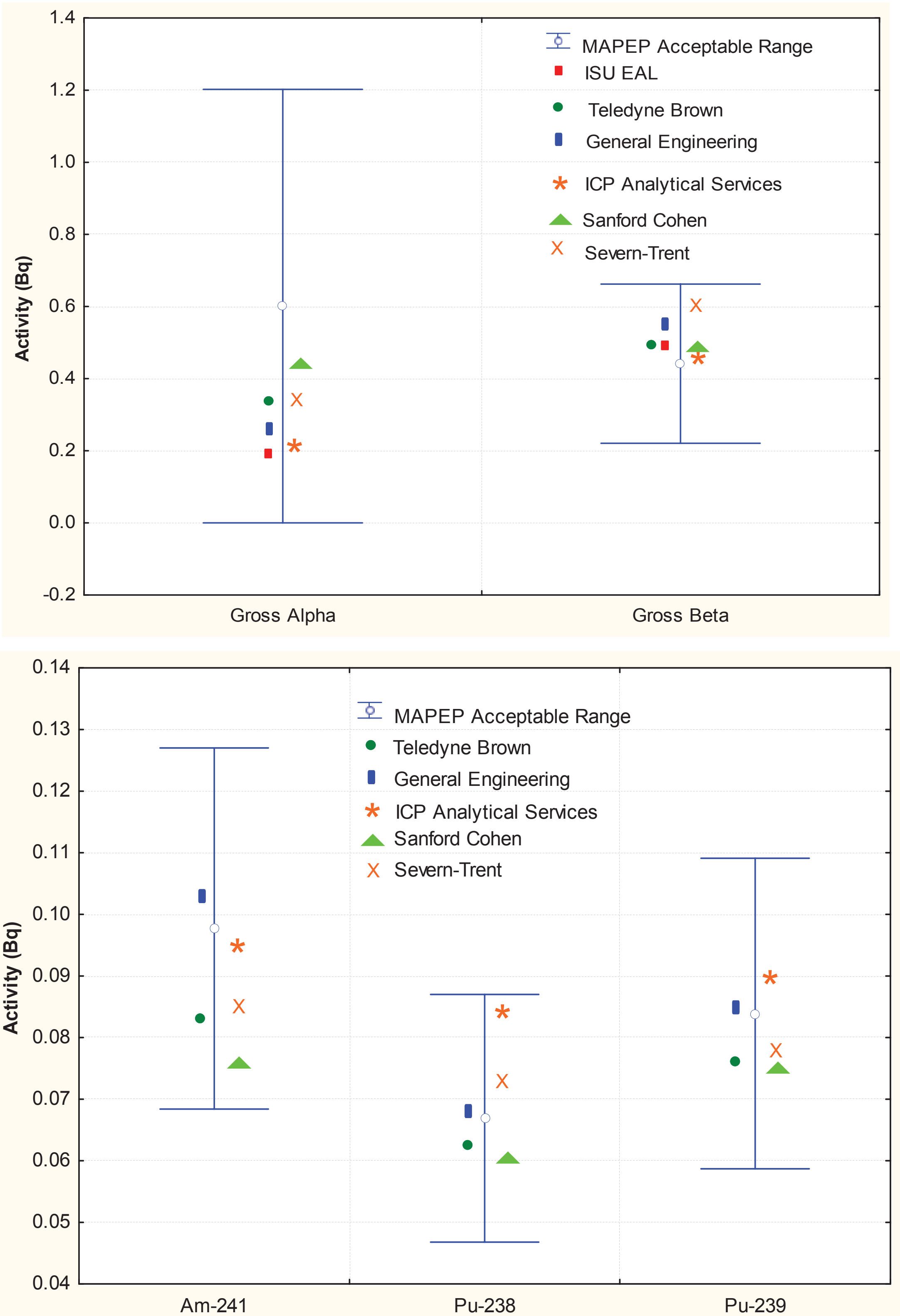
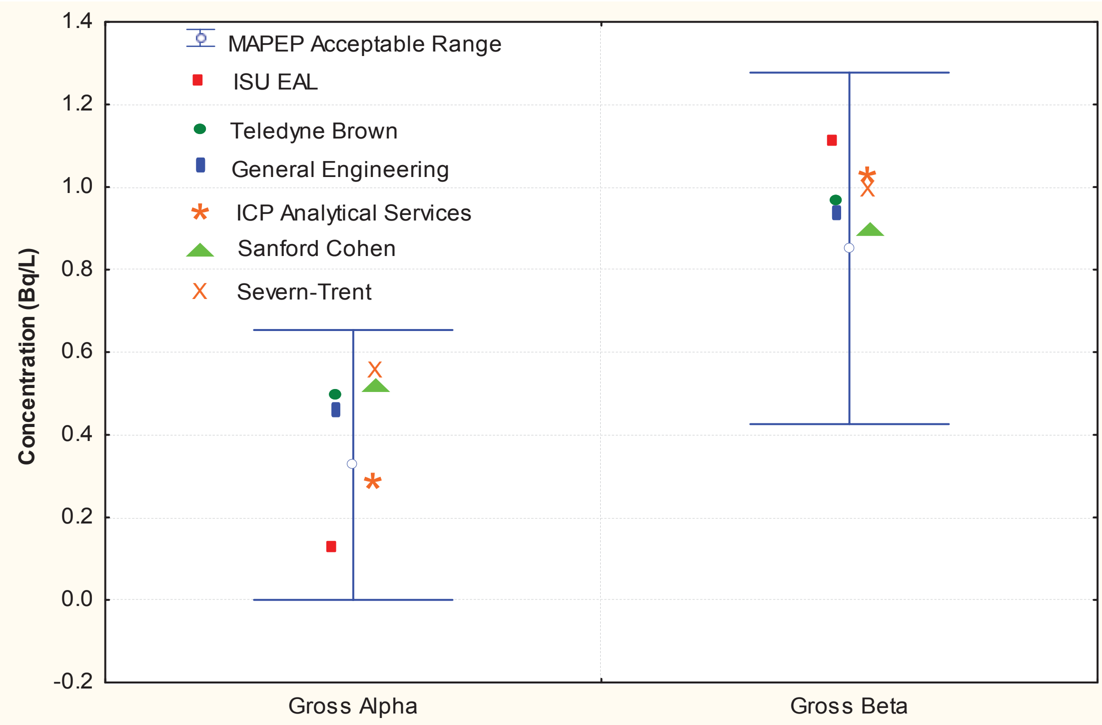


Figure 10-1. INL, ICP, and ESER Surveillance Laboratory Air Sampling Results From the MAPEP Intercomparisons (2007).



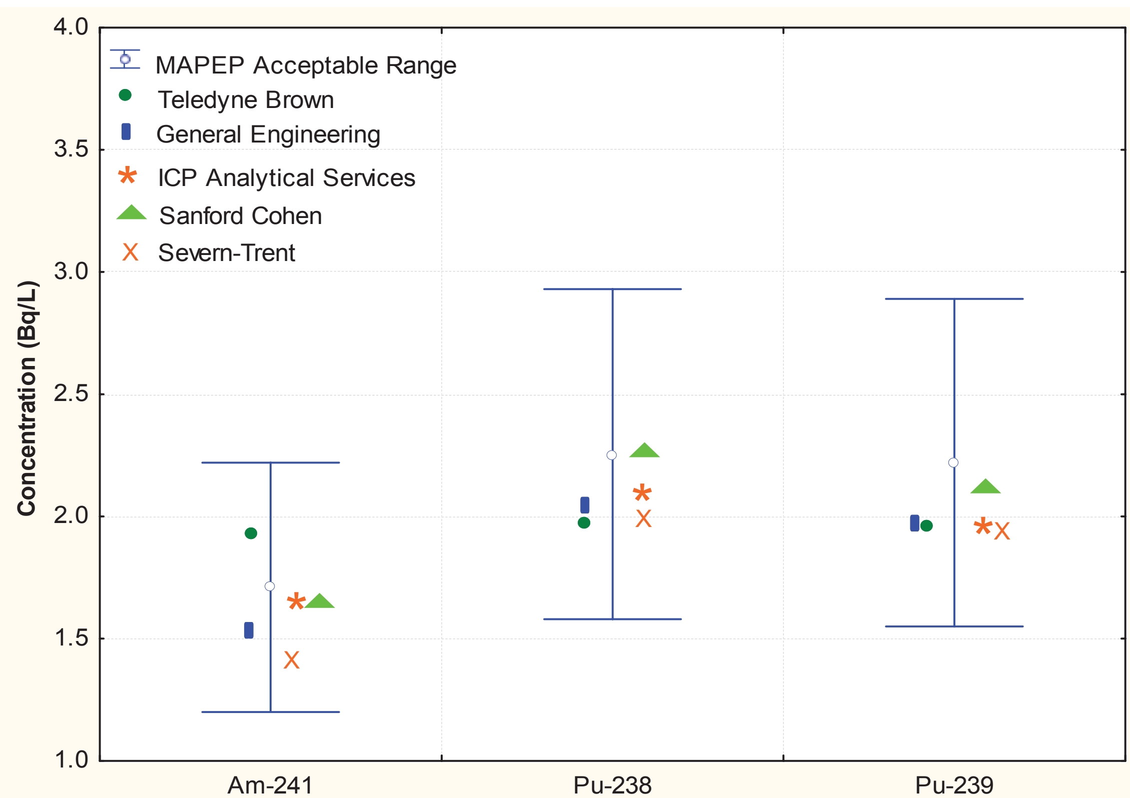


Figure 10-2. INL, ICP, and ESER Surveillance Laboratory Water Sampling Results From the MAPEP Intercomparisons (2007).

Blind Spikes—Used to assess the accuracy of the laboratories selected for analysis. Contractors purchase samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to the NIST. These samples are then submitted to the laboratories with regular field samples, with 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 Sampling—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 Sampling—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 activities.

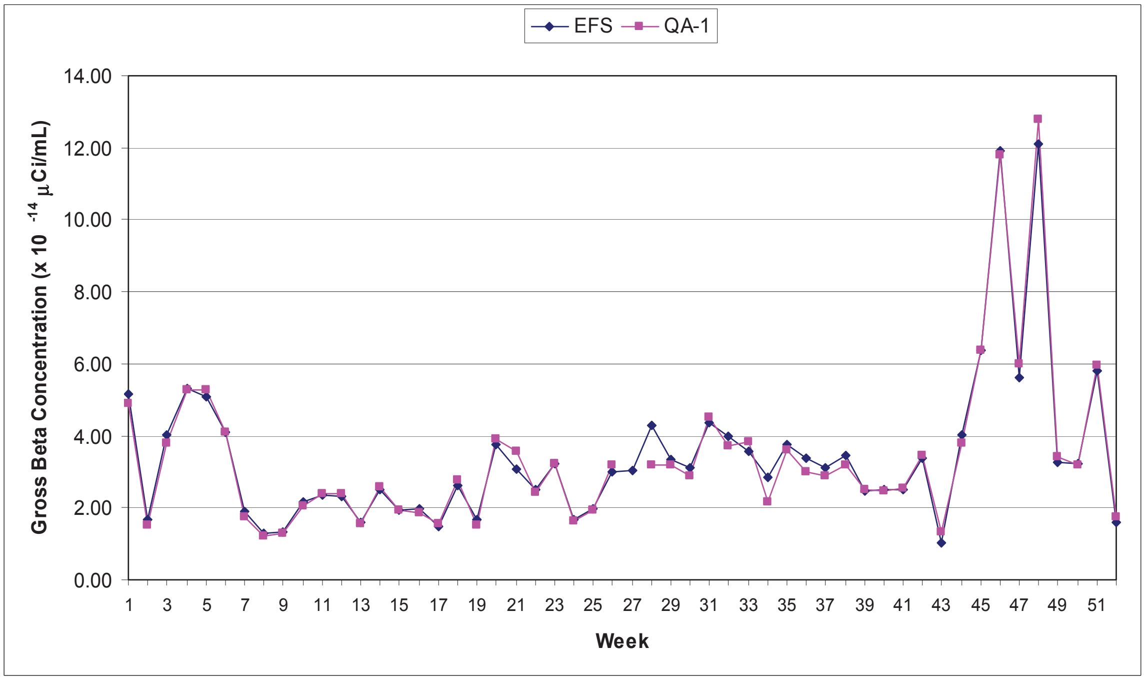
Duplicate Sampling within Organizations

Both the ESER contractor and the INL contractor maintained duplicate air samplers at two locations during 2007. The ESER contractor operated duplicate samplers at the locations in Mud Lake and at the Experimental Field Station (EFS) . The INL contractor duplicate samplers were located at the Test Area North (TAN) and at the Radioactive Waste Management Complex (RWMC). 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 tracked each other well.

Duplicate Sampling between Organizations

Another measure of data quality can be made 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 2007 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 EFS and Van Buren Boulevard Gate. Data from these sampling locations for gross beta show similar patterns over the course of the year and are shown in Figure 10-5.

The USGS routinely collects groundwater samples simultaneously with the INL Oversight Program. Comparison results from this sampling are regularly documented in reports prepared by the two organizations.



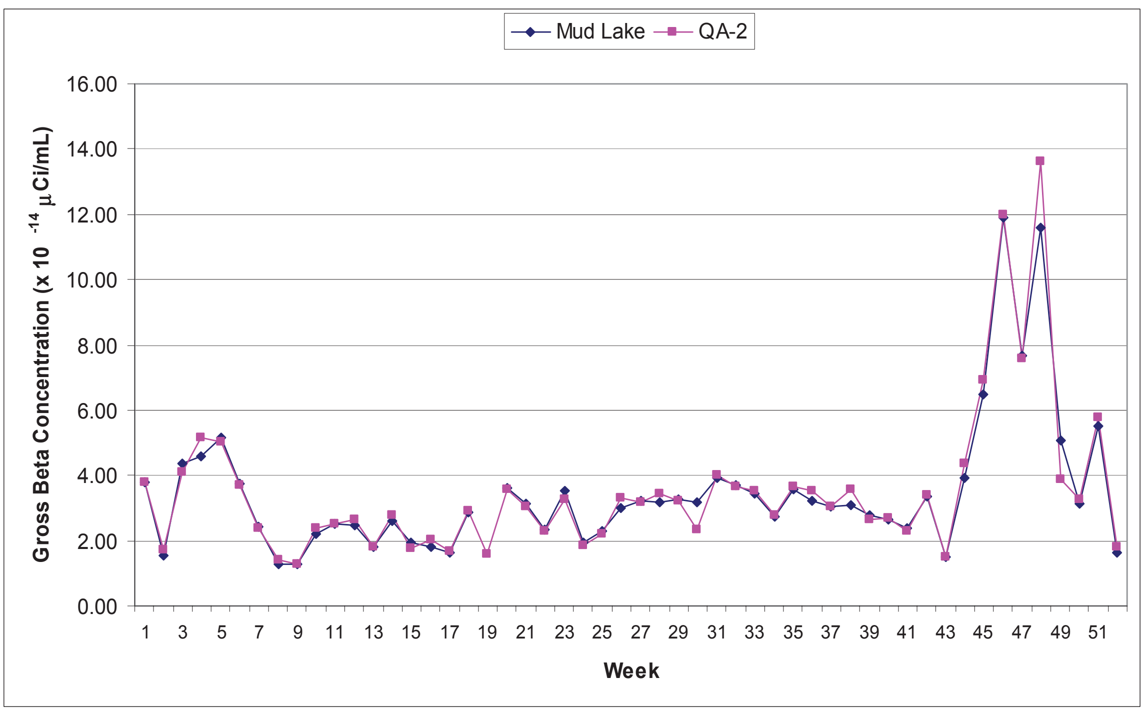
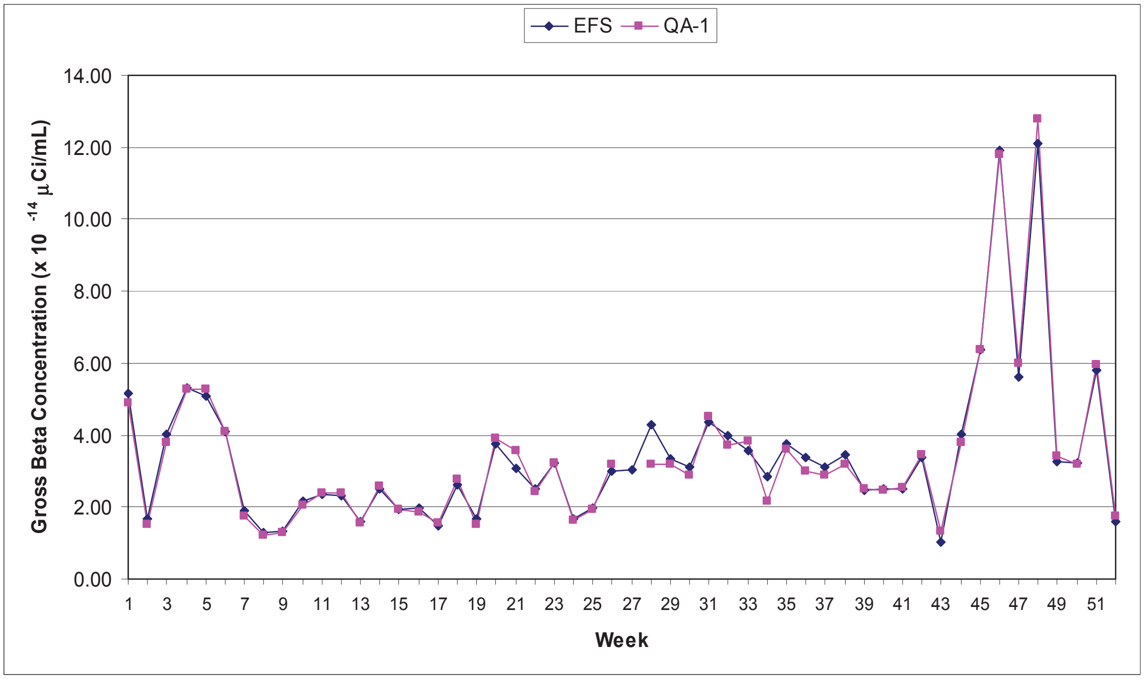


Figure 10-3. ESER Contractor Duplicate Air Sampling Gross Beta Results (2007).



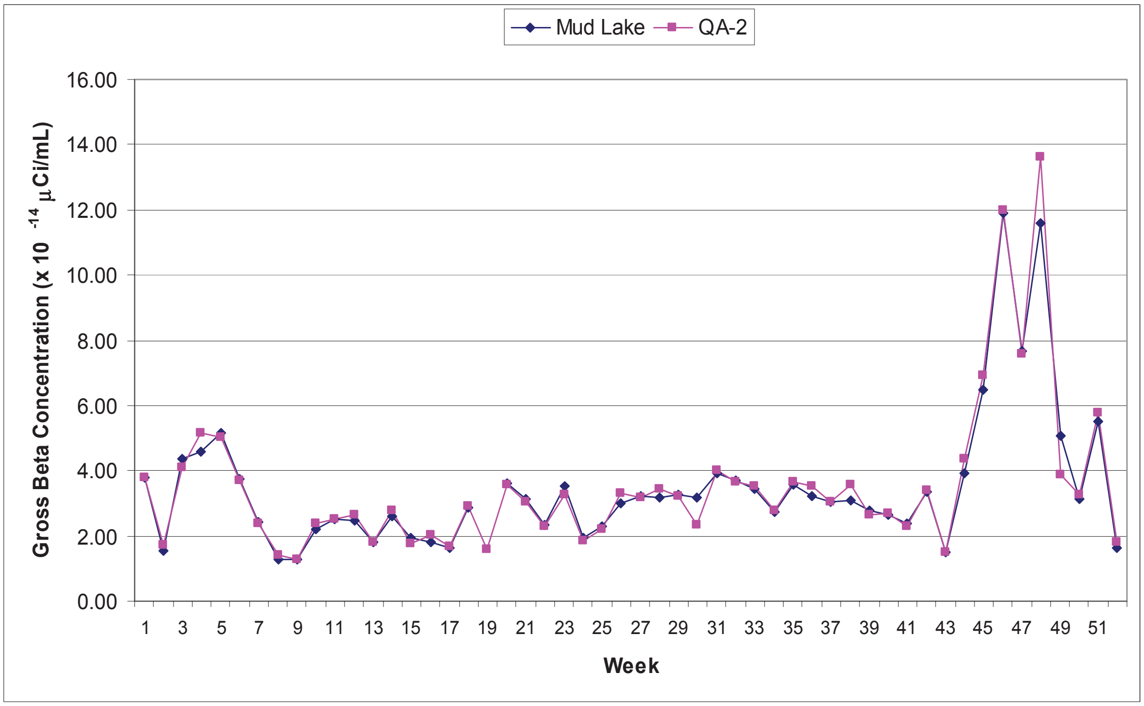
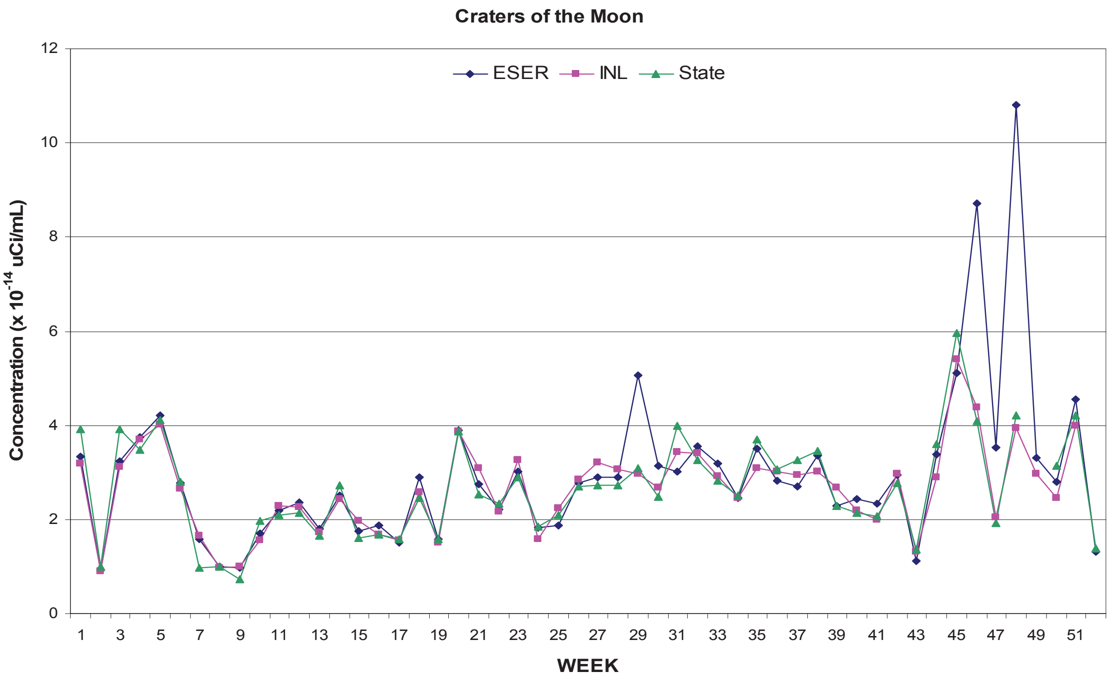


Figure 10-4. INL Contractor Duplicate Air Sampling Gross Beta Results (2007).



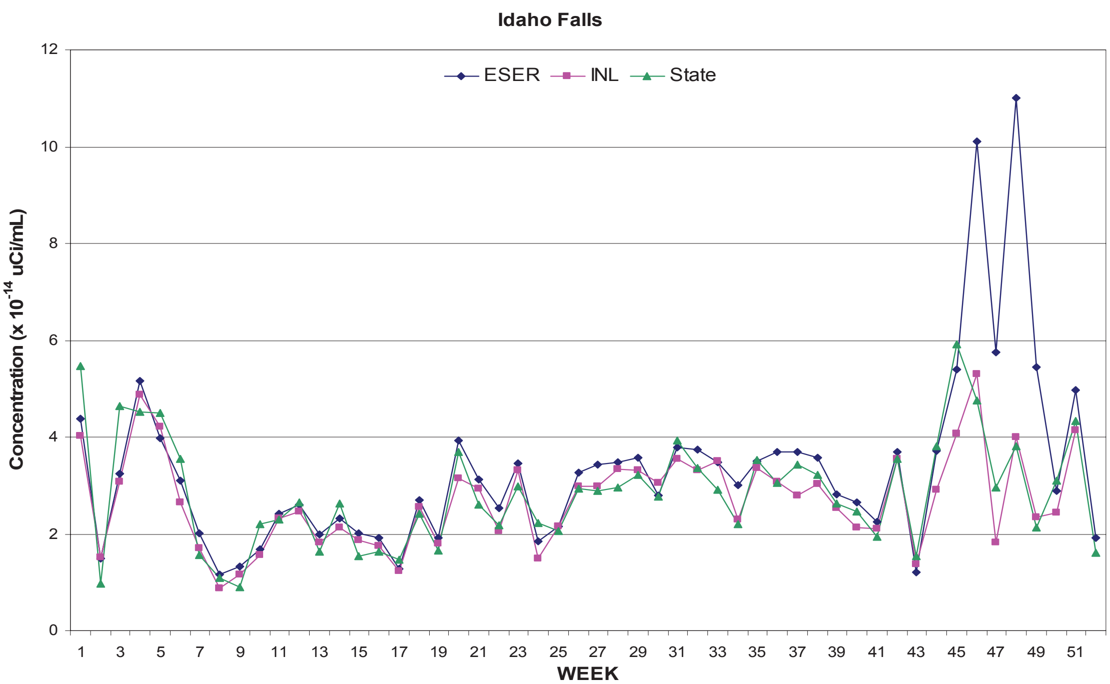
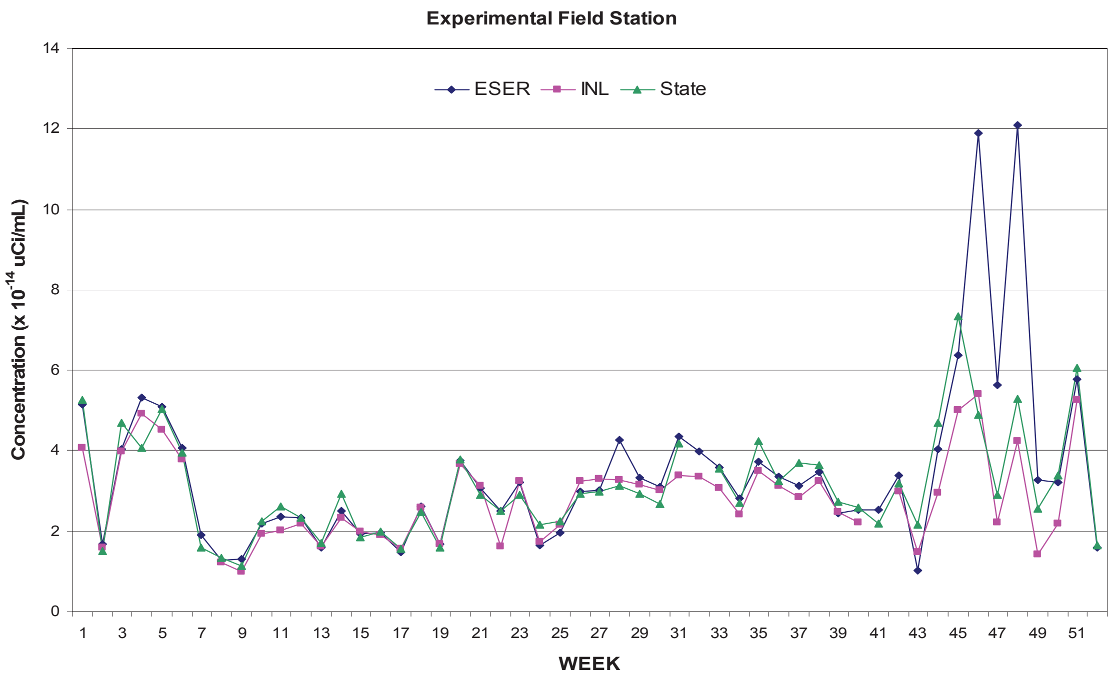


Figure 10-5. Comparison of Gross Beta Concentrations Measured by the ESER Contractor, the INL Contractor, and the State of Idaho (2007).



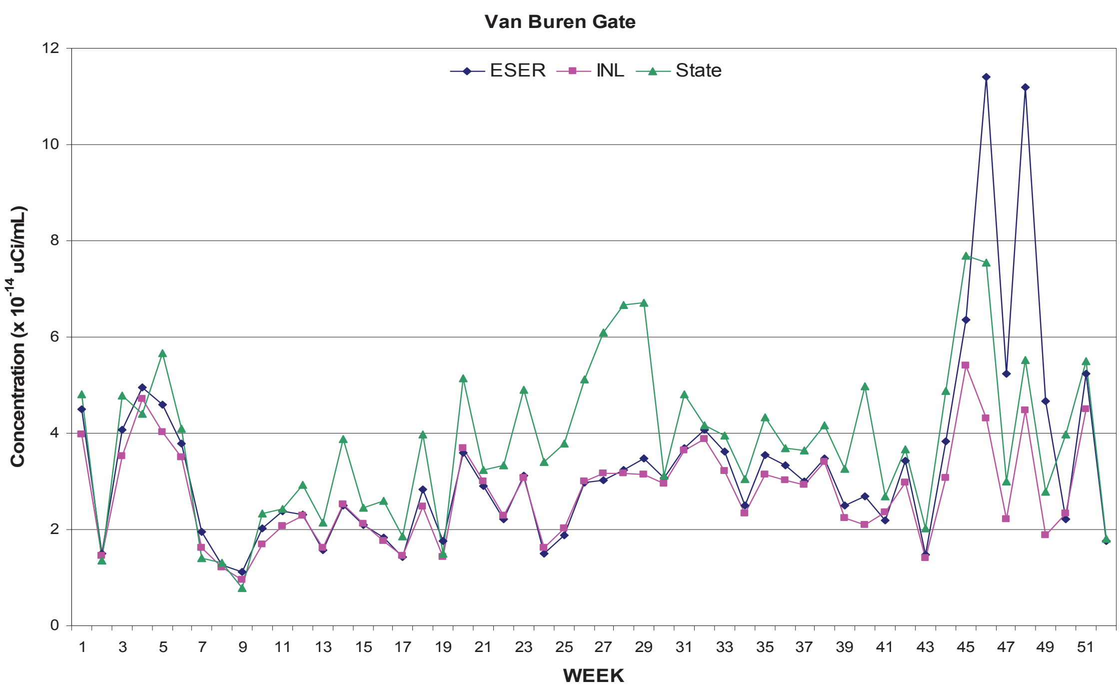


Figure 10-5. Comparison of Gross Beta Concentrations Measured by the ESER Contractor, the INL Contractor, and the State of Idaho (2007). (continued)

10.3 Program Quality Assurance

Liquid Effluent Program Quality Assurance/Quality Control

INL Contractor - The INL contractor's Liquid Effluent Monitoring Program has specific quality assurance/quality control objectives for analytical data. Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. The liquid effluent monitoring programs submit two types of quality control samples:

1) Performance evaluation samples (submitted as field blind spikes) are used to assess analytical data accuracy. At a minimum, performance evaluation samples are submitted quarterly.
2) Field duplicates (splits) provide information on analytical variability caused by sample heterogeneity, collection methods, and lab procedures. One duplicate sample is collected each year at each location.

During 2007, four sets of PE samples were submitted to the laboratory along with routine monitoring samples. The analytical results for the PE samples submitted in the first and second quarters were all within performance limits (range of concentrations considered acceptable by the laboratory that prepares the PE samples). The reported chemical oxygen demand in the third quarter PE sample was outside the performance limit. The reported concentration of total dissolved solids was outside the performance limit established for the fourth quarter PE sample; however, the reported result was only 13 percent higher than the spiked concentration

For non-radiological 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 the following equation:

$$RPD = \frac{|R_1 - R_s|}{(R_1 + R_s) / 2} \times 100$$

Where,
R_1 = concentration of analyte in the first sample
R_2= concentration of analyte in the duplicate sample

The INL contractor Liquid Effluent Monitoring Program requires that the relative percent difference from field duplicates should be ≤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:

$$|R_1 - R_s| \leq 3\,(\sigma_1^2 + \sigma_2^2)^{1/2}$$

Where,
R_1 = concentration of analyte in the first sample
R_2= concentration of analyte in the duplicate sample
s_1=sample standard deviation of the first sample
s_2=sample standard deviation of the duplicate sample
or,
the RPD was less than or equal to 35 percent.

Using the criteria outlined above, 98 percent of the non-radiological results and 98 percent of the radiological 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 2007.

ICP contractor - The ICP contractor Liquid Effluent Monitoring Program has specific QA/QC objectives for monitoring data. Effluent samples are collected as composites in a 5-gallon carboy and then poured into the sample bottles. All effluent sample results were usable, except for the September 2007 nitrate + nitrite, as nitrogen result, which was rejected due to missed holding time by the analytical laboratory (ICP 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 2007, PE samples were submitted to the laboratory along with routine monitoring samples on January 9, 2007, April, 25, 2007, August 15, 2007, and November 14, 2007. 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.

Field duplicates (splits) provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures. Duplicate samples were collected at TAN-655 on March 6, 2007, at CPP-769 and CPP-797 on June 20, 2007, at CPP-797 on July 25, 2007, and at CPP-773 on September 12, 2007. The RPD between the duplicate samples is used to assess data precision. Table 10-2 shows the results for 2007. 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 March 21, 2007, and at TAN-655 on July 19, 2007. The

Table 10-1. ICP Contractor Performance Evaluation Samples Outside Performance Acceptance Limits (2007).

Parameter	Number of Performance Evaluation Samples Outside Performance Acceptance Limits
Aluminum	1
Mercury	2
Nitrate+nitrite as nitrogen	1
Selenium	1
Silver	2

Table 10-2. Liquid Effluent Program Relative Percent Difference Results (2007).

Parameter	Relative Percent Difference Result
Inorganic and metals	82 percent of RPD results within program goal of ≤35 percent.
Radiological	Not applicable: duplicate results had no detectable quantities.
Note: The RPD is calculated only if both results are detected (greater than instrument's detection limit).	

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 2007, this goal was met.

Wastewater Land Application Permit Groundwater Monitoring Quality Assurance/Quality Control

The groundwater sampling activities associated with WRP compliance sampling follow established procedures and analytical methodologies.

During 2007, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center (INTEC) and TAN WRP monitoring wells that had sufficient water. Samples were not collected from aquifer well ICPP-MON-A-167, which was dry during April and October 2007, perched well ICPP MON-V-191, which was dry in April and October 2007, and perched well TSFAG-05, which was dry during both April and October 2007. All of the samples required for permit compliance were collected. All groundwater sample results were usable.

Field quality control samples were collected or prepared during the sampling activity in addition to regular groundwater samples. Laboratories qualified by the ICP Sample and Analysis Management Organization performed all ICP groundwater analyses during 2007. Because TAN and INTEC are regarded as separate sites, quality control 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, five percent of the total number of samples collected. Duplicates were collected using the same sampling techniques and preservation as regular groundwater samples. Duplicates have precision goals within 35 percent as determined by the RPD measured between the paired samples. Table 10-3 shows the RPD results. This high percentage (91 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 were used effectively to produce high quality data.

During the April 2007 groundwater sampling event, two PE samples were analyzed for total coliform and fecal coliform. These samples were within the QC Performance Acceptance Limits.

During the April 2007 sampling event, one PE sample was analyzed for metals. The results are shown in Table 10-4. The laboratory was notified of the results below the Performance Acceptance Limits, and the laboratory implemented corrective action.

During the October 2007 groundwater sampling event, one PE sample was analyzed for metals. The metals PE sample result was within the QC Performance Acceptance Limits.

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 and completeness at ≤35 percent for 90 percent of the analyses and 100 percent completeness, respectively. All Drinking Water Program analytical results with the exception of bacteria are validated following standard Environmental Protection Agency protocols. The Drinking Water Program submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and lab procedures.

Table 10-3. Groundwater Relative Percent Difference Results (2007).

	Relative Percent Difference Result
72 duplicate pairs	91 percent of RPD results within program goal of ≤35 percent.
Note: The RPD is calculated only if both results are detected (greater than instrument's detection limit).	

Table 10-4. Groundwater Performance Evaluation Sample Results for Metals (2007).

Parameter	Within Performance Acceptance Limits	Below Performance Acceptance Limits	Not Detected
Aluminum		X	
Arsenic	X		
Barium	X		
Beryllium		X	
Cadmium		X	
Chromium	X		
Iron	X		
Lead		X	
Manganese	X		
Mercury			X
Selenium	X		
Zinc	X		

For non-radiological 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 the following equation:

$$RPD = \frac{|R_1 - R_s|}{(R_1 + R_s) / 2} \times 100$$

Where,
R_1 = concentration of analyte in the first sample
R_2= concentration of analyte in the duplicate sample

The INL contractor Drinking Water Program requires that the relative percent difference from field duplicates should be ≤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 were reported as nondetects. For 2007, the INL contractor had four sets of inorganic and organic data with detectable quantities. Using the criteria outlined above, 100 percent of the inorganic and organic results for the duplicate samples were comparable to the original samples.

The precision of the radiological results were considered acceptable if:

$$|R_1 - R_s| \leq 3 (\sigma_1^2 + \sigma_2^2)^{1/2}$$

Where,
R_1 = concentration of analyte in the first sample
R_2= concentration of analyte in the duplicate sample
s_1=sample standard deviation of the first sample
s_2=sample standard deviation of the duplicate sample
or,
the RPD was less than or equal to 35 percent.

Relative percent difference was not calculated if either the sample or its duplicate were reported as nondetects. For 2007, the Drinking Water Program had seven sets of Radiological data with detectable quantities. Using the criteria outlined above, the 100 percent of the radiological data is comparable meeting the RPD goal ≤35 percent for 90 percent for 2007. This goal was met in 2007.

The INL contractor established a completeness goal is 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 2007.

ICP contractor - The ICP contractor Drinking Water Program's completeness goal is to collect, analyze, and verify 100 percent of all compliance samples. This goal was met during 2007.

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 2007 for all parameters.

The RPD between the duplicate samples is used to assess data precision. The ICP contractor met the precision goals for the Drinking Water Program in 2007, and results are shown in Table 10-5.

In 2007, four PE samples were analyzed for 524.2-regulated volatile organics. All results were within the QC Performance Acceptance Limits. Also, one PE sample was analyzed for nitrate as nitrogen, and the result was also within the QC Performance Acceptance Limits.

ESER Program Quality Assurance/Quality Control

The ESER program met its overall completeness goals for 2007, which is that 98 percent of scheduled samples are collected and analyzed. For air sampling, the number of scheduled samples that met the required volume to be considered a valid sample was slightly below 98 percent due to persistent power problems at two sites. Electrical work was undertaken to repair these problems. For most other sample types, 100 percent of samples were collected as scheduled.

Each analytical laboratory conducted an internal spike sample program using standards traceable to NIST and each laboratory participated in the MAPEP program. Precision was measured using duplicate and split samples and laboratory recounts. In 2007, 99.2 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 the presence of contamination through the sampling and analysis process. No problems were reported in 2007 for either field or laboratory blanks.

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 quality assurance programs, which verify all the methods used to analyze environmental samples.

Table 10-5. ICP Drinking Water Program Relative Percent Difference Results (2007).

Parameter	Relative Percent Difference Result
Inorganic and Organic	100 percent of RPD results within program goal of ≤35 percent
Radionuclide	100 percent of RPD results within program goal of ≤35 percent

Note: Relative percent difference was not calculated if either the sample or its duplicate were reported as nondetects.

The programs include the DOE MAPEP and the EPA National Center for Environmental Research (NCER) Quality Assurance Program. The laboratories met the performance objectives specified by the MAPEP and NCER.

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 as required with routine samples for analyses.

ICP Environmental Services Waste Management Surveillance Quality Assurance/Quality Control

The ICP contractor analytical laboratories analyzed all Waste Management Surveillance Program samples as specified in the statements of work. These laboratories participate in a variety of intercomparison quality assurance programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA NCER Quality Assurance Program. The laboratories met the performance objectives specified by the MAPEP and NCER.

All PE samples submitted to the contract laboratory for analysis in 2007 for the Waste Management Surveillance Program showed satisfactory agreement.

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 as required with routine samples for analyses. In 2007, the results for these samples were within the acceptable range.

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Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations are applicable, in whole or in part, on the Idaho National Laboratory (INL) or at the INL boundary:

- U.S. Environmental Protection Agency (EPA), "National Primary and Secondary Ambient Air Quality Standards," 40 CFR 50, 2007;
- U.S. Environmental Protection Agency (EPA), "National Emission Standards for Hazardous Air Pollutants," 40 CFR 61, 2007;
- U.S. Environmental Protection Agency (EPA), "Oil Pollution Prevention," 40 CFR 112, 2007;
- U.S. Environmental Protection Agency (EPA), "National Pollutant Discharge Elimination System," 40 CFR 122, 2007;
- U.S. Environmental Protection Agency (EPA), "National Interim Primary Drinking Water Regulations," 40 CFR 141, 2007;
- U.S. Environmental Protection Agency (EPA), "Hazardous Waste Management System: General," 40 CFR 260, 2007;
- U.S. Environmental Protection Agency (EPA), "Identifying and Listing of Hazardous Wastes," 40 CFR 261, 2007;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Generators of Hazardous Waste," 40 CFR 262, 2007;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Transporters of Hazardous Waste," 40 CFR 263, 2007;
- U.S. Environmental Protection Agency (EPA), "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 264, 2007;
- U.S. Environmental Protection Agency (EPA), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 265, 2007;
- U.S. Environmental Protection Agency (EPA), "Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities," 40 CFR 267, 2007;
- U.S. Department of Commerce, "Designated Critical Habitat," National Marine Fisheries Service, 50 CFR 226;
- U.S. Department of Energy (DOE), Order 450.1, " Environmental Protection Program," January 2003;
- U.S. Department of Energy (DOE), Order 5400.5, "Radiation Protection of the Public and the Environment," January 1993;
- U.S. Department of Energy (DOE), Order 435.1, "Radioactive Waste Management," August 2001;
- U.S. Department of Energy (DOE), Order 231.1A, 2003a, "Environment, Safety, and Health Reporting," August 2003;
- U.S. Department of the Interior (DOI), "Protection of Archeological Resources," National Park Service, 43 CFR 7;
- U.S. Department of the Interior (DOI), "Endangered and Threatened Wildlife and Plants," Fish and Wildlife Service, 50 CFR 17;

- U.S. Department of Interior (DOI), “Integrated Cooperation – Endangered Species Act of 1973 U.S. Amended,” Fish and Wildlife Service, 50 CFR 402;
- U.S. Department of the Interior (DOI), “Listing Endangered and Threatened Species and Designating Critical Habitat,” Fish and Wildlife Service, 50 CFR 424;
- U.S. Department of the Interior (DOI), “Endangered Species Exemption Process,” Fish and Wildlife Service, 50 CFR 450–453;
- U.S. Department of the Interior (DOI), “Curation of Federally-Owned and Administered Archeological Collections,” National Park Service, 43 CFR 79;
- Idaho Department of Environmental Quality (DEQ), “Rules and Regulations for the Control of Air Pollution in Idaho,” IDAPA 58.01.01;
- Idaho Department of Environmental Quality (DEQ), “Water Quality Standards and Wastewater Treatment,” IDAPA 58.01.02;
- Idaho Department of Environmental Quality (DEQ), “Individual/Subsurface Sewage Disposal,” IDAPA 58.01.03;
- Idaho Department of Environmental Quality (DEQ), “Hazardous Waste, IDAPA 58.01.05;
- Idaho Department of Environmental Quality (DEQ), “Solid Waste Management Rules and Standards,” IDAPA 58.01.06;
- Idaho Department of Environmental Quality (DEQ), “Idaho Regulations for Public Drinking Water Systems,” IDAPA 58.01.08;
- Idaho Department of Environmental Quality (DEQ), “Ground Water Quality Rules,” IDAPA 58.01.11;
- Idaho Department of Environmental Quality (DEQ), “Cleaning of Septic Tanks,” IDAPA 58.01.15;
- Idaho Department of Environmental Quality (DEQ), “Wastewater Rules,” IDAPA 58.01.16;
- Idaho Department of Environmental Quality (DEQ), “Wastewater Land Application Permits,” IDAPA 58.01.17;
- Executive Order 11988, “Floodplain Management,” May 1977;
- Executive Order 11990, “Protection of Wetlands,” May 1977;
- Executive Order 12580, “Superfund Implementation,” January 1987;
- Executive Order 12856, “Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements,” August 1993;
- Executive Order 12873, “Federal Acquisition, Recycling, and Waste Prevention,” October 1993; and
- Executive Order 13101, “Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition,” September 1998.

The Derived Concentration Guides (DCGs) are based on the U.S. Department of Energy (DOE) standard (DOE 1993) and have been calculated using DOE models and parameters for internal (DOE 1988a) and external (DOE 1988b) exposure. These are shown in Table A-1. The most restrictive guide is listed when there is a difference between the soluble and insoluble chemical forms. The DCGs consider only the inhalation of air, the ingestion of water, and submersion in air. The principal standards and guides for release of radionuclides at the INL are those of DOE Order 5400.5, "Radiation Protection of the Public and the Environment." The DOE standard is shown in Table A-2 along with the EPA statute for protection of the public, airborne pathway only.

Ambient air quality statutes are shown in Table A-3. Water quality statutes are dependent on the type of drinking water system sampled. Tables A-4 through A-7 are a list of maximum contaminant levels set by the EPA for public drinking water systems in 40 CFR 141 (EPA 2002) and the Idaho groundwater quality values from IDAPA 58.01.11 (2003).

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}Pu	1×10^{-12}	2×10^{-6}
^{106}Ru	3×10^{-11}	6×10^{-6}	^{241}Am	2×10^{-14}	3×10^{-8}

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 DOE 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. EPA 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. EPA 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. EPA 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. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards 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. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards Secondary Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Aluminum	0.05 to 0.2	0.2
Chloride	250	250
Color	15 color units	15 color units
Corrosivity	Non-corrosive	
Foaming agents	0.5	0.5
Iron	0.3	0.3
Manganese	0.05	0.05
Odor	3 threshold odor number	3.0 threshold odor number
pH	6.5 to 8.5	6.5 to 8.5
Silver	0.1	0.1
Sulfate	250	250
Total dissolved solids (TDS)	500	500
Zinc	5	5

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

REFERENCES

Environmental Protection Agency (EPA), 2002, "National primary drinking water regulations," Code of Federal Regulations, 40 CFR 141, Office of the Federal Register.

IDAPA 58.01.08, 2003, "Idaho Regulations for Public Drinking Water Systems," Idaho Administrative Procedures Act, State of Idaho Department of Health and Welfare, current revision.

U.S. Department of Energy (DOE) Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," U.S. Department of Energy, January 7.

U.S. Department of Energy (DOE), 1988a, Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, July.

U.S. Department of Energy (DOE), 1988b, External Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0070, July.

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

Appendix B. 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.

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.

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 which could invalidate the result include insufficient sample volume, torn filters, 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.

Reporting Levels

It is the goal of the ESER program 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 (USGS) 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 B-1 illustrates these terms.

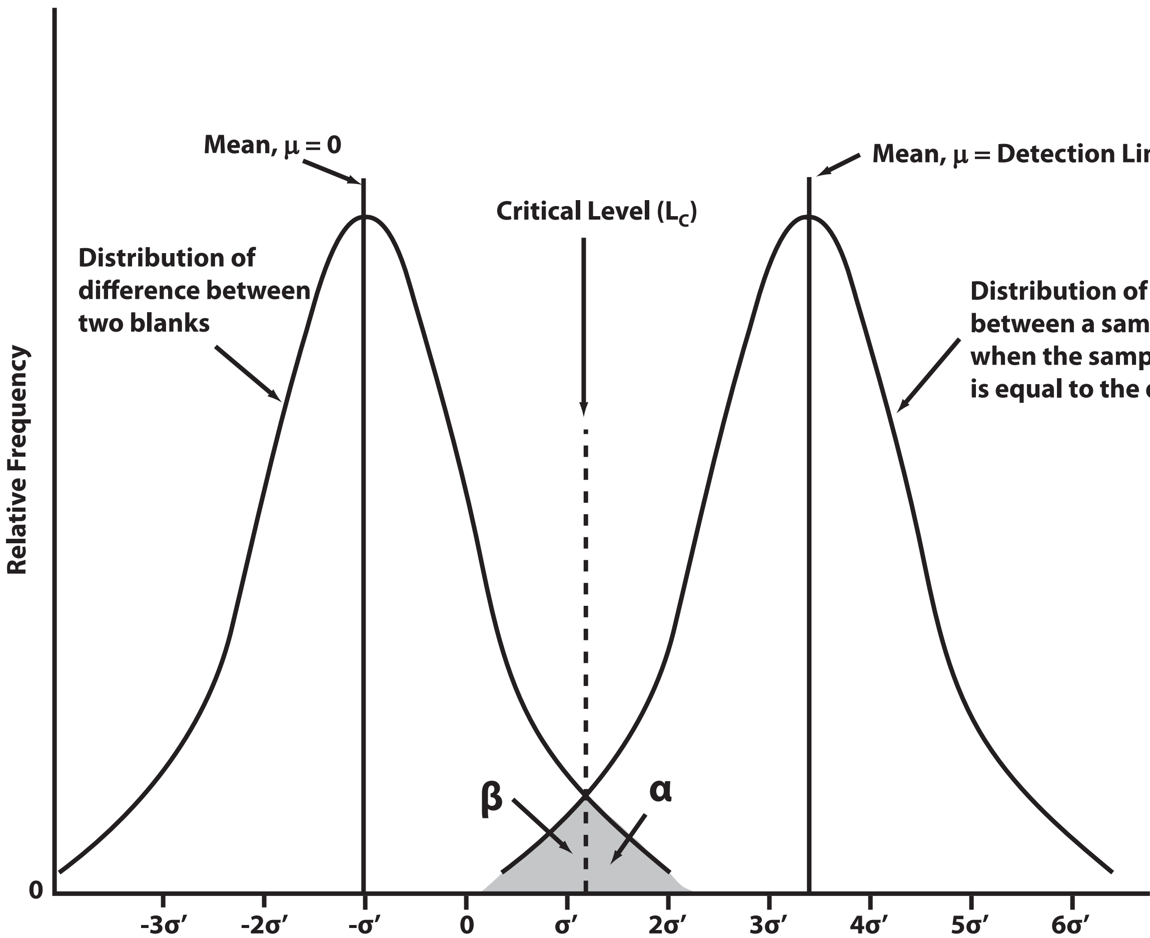

Figure B-1. Illustration of the Relation of the Criterion of Detection (Critical Level) and the Limit of Detection (Detection Limit). Errors of the First Kind (False Negatives) are Represented by the Value of α, Whereas Errors of the Second Kind (False Positives) are Represented by the Value of β. (from Currie 1988)

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 comparison of 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 five 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 (MDC), 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 five 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 $2\sigma_s$ and $3\sigma_s$ are considered to be “questionable” detections. Each result is reported with the associated $1\sigma_s$ uncertainty value for consistency with other INL reports.

Statistical Tests Used to Assess Data

An example dataset is presented here to illustrate the statistical tests used to assess data collected by the ESER contractor. The dataset 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 and air monitoring stations throughout the Snake River Plain (SRP). The perimeter locations are termed “boundary” and the SRP locations are termed “distant.” There are seven boundary locations: Arco, Atomic City, Birch Creek, FAA Tower, Howe, Monteview, and Mud Lake; and five distant locations: 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 dataset 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.

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 B-2) presents such a graphical look along with the results of the Shapiro-Wilk W Test. The data used for the illustration are the five years of weekly gross beta 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 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 B-3 presents this test of lognormality. The W statistic is not significant ($p=0.80235$) indicating that the data are lognormal.

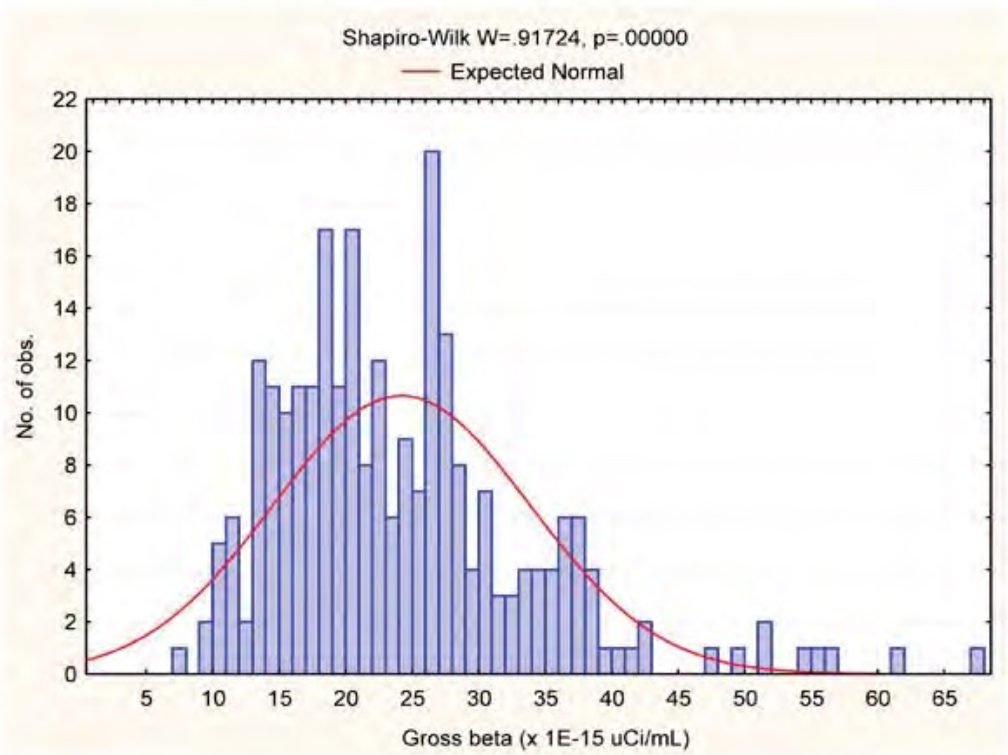

Figure B-2. Test of Normality for Arco Gross Beta Data.

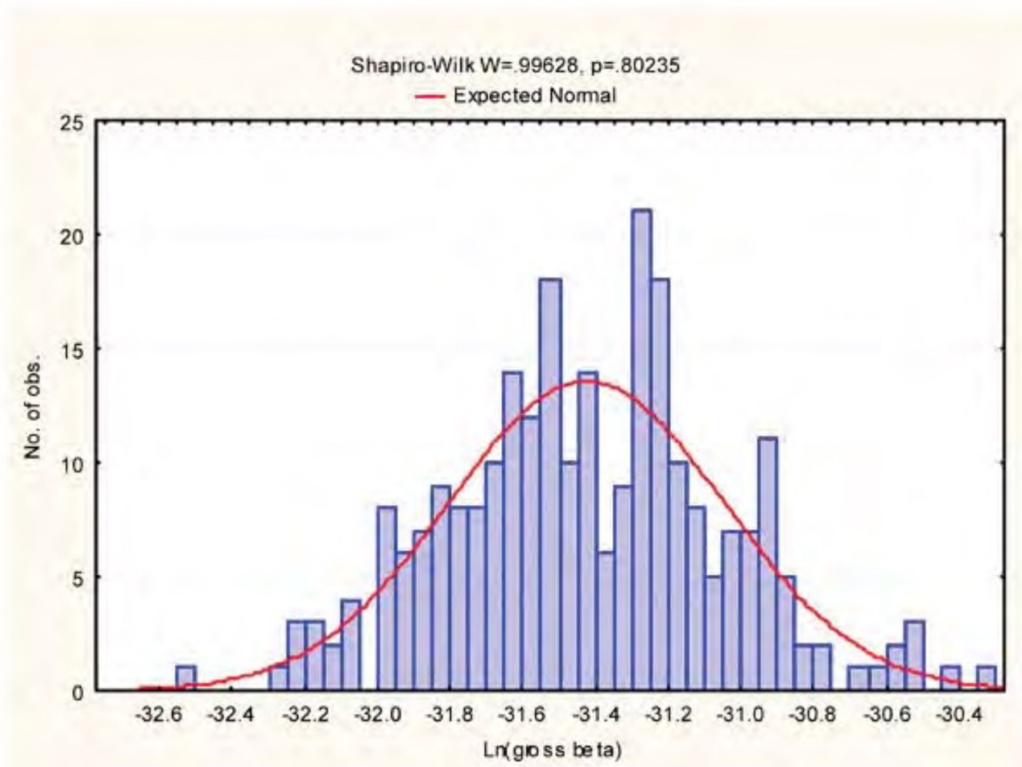

Figure B-3. Test of Lognormality for Arco Gross Beta.

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 such comparisons are made. Table B-1 presents the results of the Shapiro-Wilk W-Test for each of the seven boundary locations.

From Table B-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.

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.

Table B-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

Suppose we wish to compare all boundary locations to all distant locations. Figure B-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 B-4 indicate 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 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.

Comparison of Many Groups

Now suppose we wish to compare the boundary locations amongst themselves. In the parametric realm, this is done with an 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

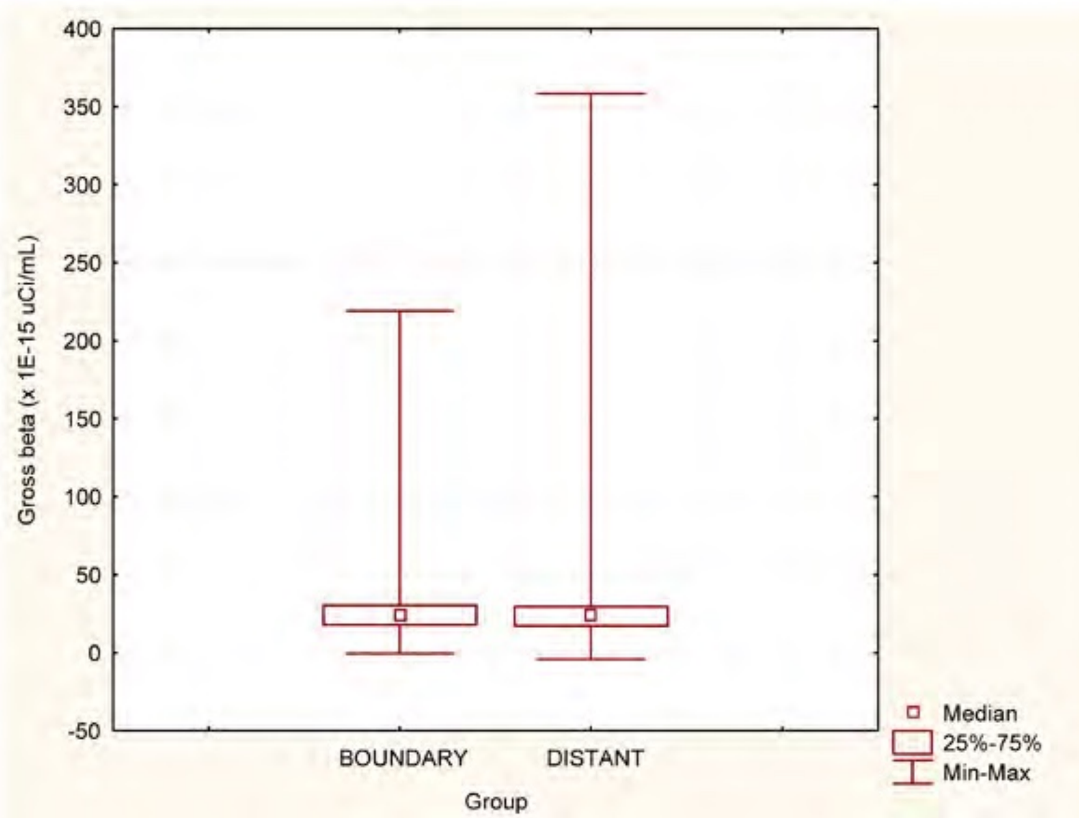

Figure B-4. Box Plot of Gross Beta Data from Boundary and Distant Locations.

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 B-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 amongst the seven boundary locations. Table B-2 gives the number of samples, medians, minimums, and maximums for each boundary location. The Kruskal-Wallis ANOVA only indicates that significant 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 that a significant difference does not exist between gross beta results at Arco and Atomic City. Other pairs can similarly be tested, but with the caution given above.

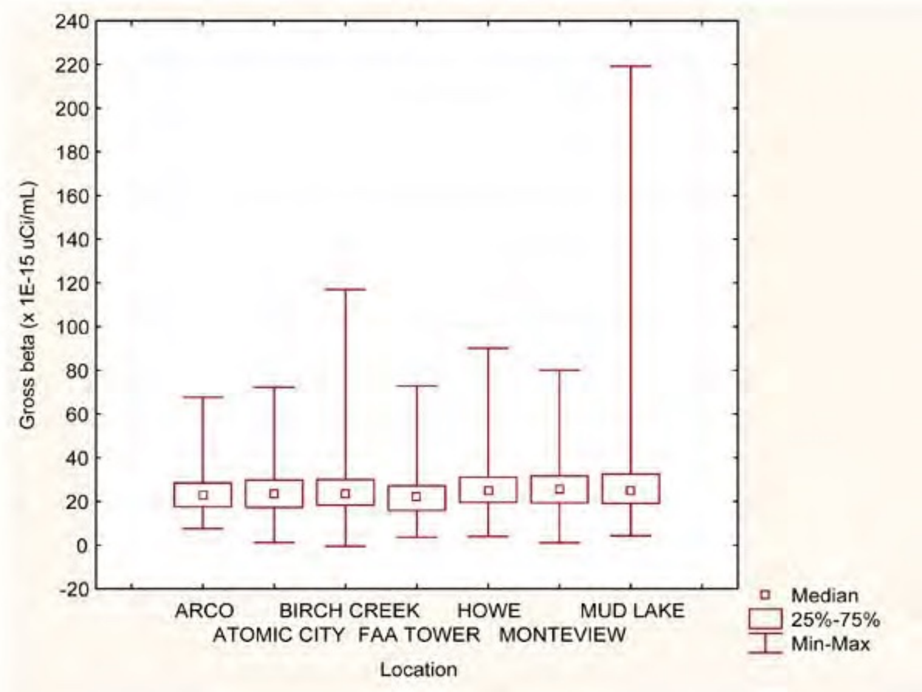

Figure B-5. Box Plot of Gross Beta Data for Each Boundary Location.

Table B-2. Summary Statistics for Boundary Locations.[a]

Location	Number of Samples	Median	Minimum	Maximum
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

a. All values are × 10^{-15} microcuries per milliliter (µCi/mL).

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 B-6 presents a scatterplot of the boundary data with the fitted regression line superimposed. Figure B-7 presents the same for the distant data. Table B-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 B-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.

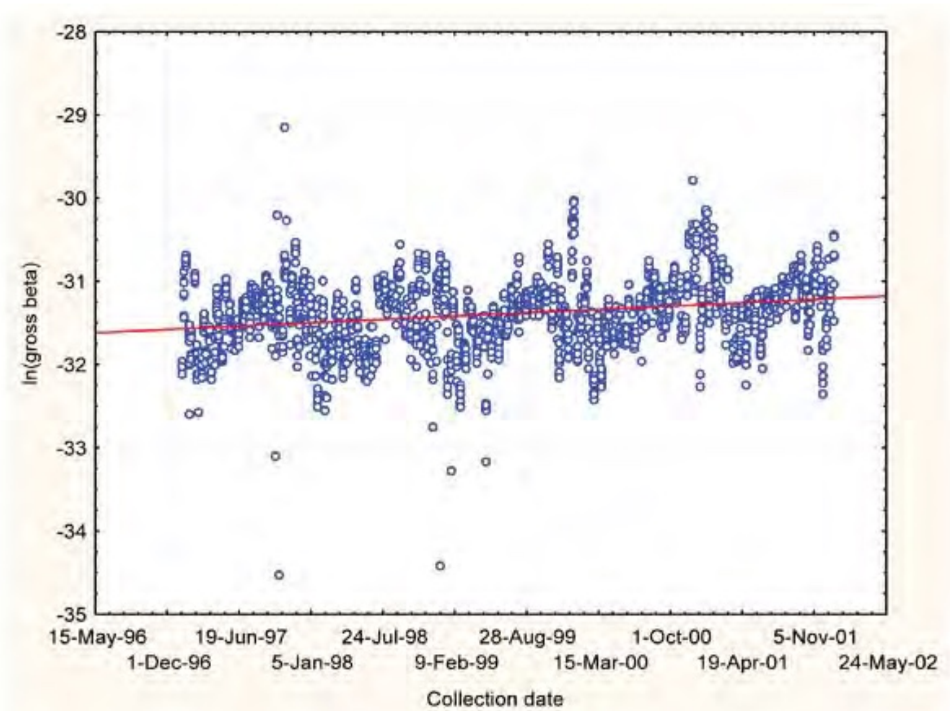

Figure B-6. Scatter Plot and Regression Line for ln(Gross Beta) From Boundary Locations.

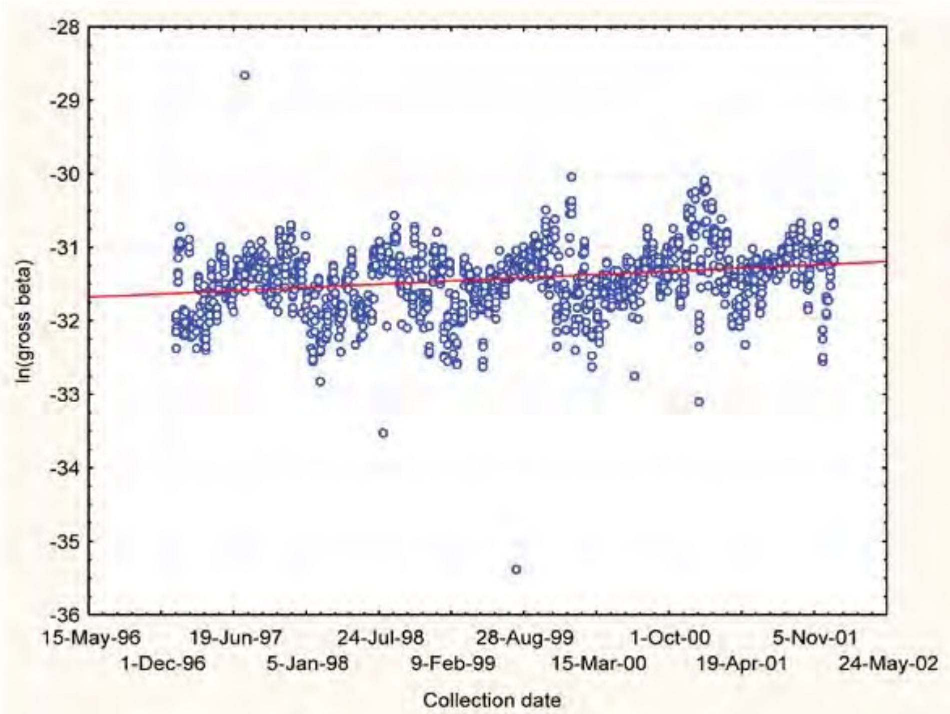

Figure B-7. Scatter Plot and Regression Line for ln(Gross Beta) From Distant Locations.

Table B-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

Another important point of note in Figures B-6 and B-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. Since the regression analysis performed above is over several years, we are still able to detect a positive trend over time 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 time period may erroneously conclude a significant positive or negative trend, when in fact, it is a portion of the cyclical trend.

Comparison of Slopes

A comparison of slopes between the regression lines for the boundary locations and distant locations will 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, we can conclude 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

$$b - t_{0.025,n-2}s_b \leq \beta \leq b + t_{0.025,n-2}s_b$$

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 B-4 gives the values used in constructing the confidence intervals and the resulting confidence intervals. As seen in the fifth column of Table B-4, the confidence intervals for the slope overlap and we can conclude that there is no difference in the rate of change in gross beta measurements for the two location groupings, boundary and distant.

Table B-4. Ninety-five Percent Confidence Intervals on the True Slope.

Sample group	b	z[a]	s_b	95% C.I.[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. C.I. = confidence interval.

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Appendix C. U.S. Geological Survey 2007 INL Publication Abstracts

Hydraulic Characteristics of Bedrock Constrictions and Evaluation of One- and Two-Dimensional Models of Flood Flow on the Big Lost River at the Idaho National Engineering and Environmental Laboratory, Idaho *(Charles Berenbrock, Joseph P. Rousseau, and Brian V. Twining)*

A 1.9-mile reach of the Big Lost River, between the Idaho National Engineering and Environmental Laboratory (INEEL) diversion dam and the Pioneer diversion structures, was investigated to evaluate the effects of streambed erosion and bedrock constrictions on model predictions of water-surface elevations. Two one-dimensional (1-D) models, a fixed-bed surface-water flow model (HEC-RAS) and a movable-bed surface-water flow and sediment-transport model (HEC-6), were used to evaluate these effects. The results of these models were compared to the results of a two-dimensional (2-D) fixed-bed model (Transient Inundation 2-Dimensional [TRIM2D]) that had previously been used to predict water-surface elevations for peak flows with sufficient stage and stream power to erode floodplain terrain features (Holocene inset terraces referred to as BLR#6 and BLR#8) dated at 300 to 500 years old, and an unmodified Pleistocene surface (referred to as the saddle area) dated at 10,000 years old; and to extend the period of record at the Big Lost River streamflow-gaging station near Arco for flood-frequency analyses. The extended record was used to estimate the magnitude of the 100-year flood and the magnitude of floods with return periods as long as 10,000 years.

In most cases, the fixed-bed TRIM2D model simulated higher water-surface elevations, shallower flow depths, higher flow velocities, and higher stream powers than the fixed-bed HEC-RAS and movable-bed HEC-6 models for the same peak flows. The HEC-RAS model required flow increases of 83 percent (100 to 183 cubic meters per second [m^3/s]), and 45 percent (100 to 145 m^3/s) to match TRIM2D simulations of water-surface elevations at two paleoindicator sites that were used to determine peak flows (100 m^3/s) with an estimated return period of 300 to 500 years; and an increase of 13 percent (150 to 169 m^3/s) to match TRIM2D water-surface elevations at the saddle area that was used to establish the peak flow (150 m^3/s) of a paleoflood with a return period of 10,000 years. A field survey of the saddle area, however, indicated that the elevation of the lowest point on the saddle area was 1.2 feet higher than indicated on the 2-ft contour map that was used in the TRIM2D model. Because of this elevation discrepancy, HEC-RAS model simulations indicated that a peak flow of at least 210 m^3/s would be needed to initiate flow across the 10,000-year old Pleistocene surface.

HEC-6 modeling results indicated that to compensate for the effects of streambed scour, additional flow increases would be needed to match HEC-RAS and TRIM2D water-surface elevations along the upper and middle reaches of the river, and to compensate for sediment deposition, a slight decrease in flows would be needed to match HEC-RAS water-surface elevations along the lower reach of the river.

Differences in simulated water-surface elevations between the TRIM2D and the HEC-RAS and HEC-6 models are attributed primarily to differences in topographic relief and to differences in the channel and floodplain geometries used in these models. Topographic differences were sufficiently large that it was not possible to isolate the effects of these differences on simulated water-surface elevations from those attributable to the effects of supercritical flow, streambed scour, and sediment deposition.

Property-Transfer Modeling to Estimate Unsaturated Hydraulic Conductivity of Deep Sediments at the Idaho National Laboratory, Idaho *(Kim S. Perkins and Kari A. Winfield)*

The unsaturated zone at the Idaho National Laboratory is complex, comprising thick basalt flow sequences interbedded with thinner sedimentary layers. Understanding the highly nonlinear relation between water content and hydraulic conductivity within the sedimentary interbeds is one element in predicting water flow and solute transport processes in this geologically complex environment. Measurement of unsaturated hydraulic conductivity of sediments is costly and time consuming, therefore use of models that estimate this property from more easily measured bulk-physical properties is desirable.

A capillary bundle model was used to estimate unsaturated hydraulic conductivity for 40 samples from sedimentary interbeds using water-retention parameters and saturated hydraulic conductivity derived from (1) laboratory measurements on core samples, and (2) site-specific property transfer regression models developed for the sedimentary interbeds. Four regression models were previously developed using bulk-physical property measurements (bulk density, the median particle diameter, and the uniformity coefficient) as the explanatory variables. The response variables, estimated from linear combinations of the bulk physical properties, included saturated hydraulic conductivity and three parameters that define the water-retention curve.

The degree to which the unsaturated hydraulic conductivity curves estimated from property-transfer-modeled water-retention parameters and saturated hydraulic conductivity approximated the laboratory-measured data was evaluated using a goodness-of-fit indicator, the root-mean-square error. Because numerical models of variably saturated flow and transport require parameterized hydraulic properties as input, simulations were run to evaluate the effect of the various parameters on model results. Results show that the property transfer models based on easily measured bulk properties perform nearly as well as using curve fits to laboratory-measured water retention for the estimation of unsaturated hydraulic conductivity.

Basalt stratigraphy of corehole USGS-132 with correlations and petrogenetic interpretations of the B flow group, Idaho National Laboratory, Idaho *(Myles Miller)*

New geochemical and petrological data from corehole USGS-132 and surficial eruptive centers within the Arco-Big Southern Butte Volcanic Rift Zone were assessed to refine basalt stratigraphy in the southwest region of the Idaho National Laboratory. The stratigraphy of USGS-132 is subdivided into fourteen flow groups, several of which correlate to previously identified flow groups.

Butte 5206 and Butte 5159 basalts correlate to the B flow group, indicating eruptions from closely-spaced comagmatic vents. Teakettle Butte and Lavatoo Butte basalts correlate to the E and lower F flow groups, respectively.

The petrogenesis of the B flow group, interpreted using mass balance and thermodynamic models, demonstrate magma evolution by fractional crystallization of relatively primitive magmas at multiple crustal levels and by magma mixing in a shallow reservoir prior to eruption. A single sample of chemically anomalous Shadow Butte basaltic andesite provides additional evidence of magma mixing on the eastern Snake River Plain.

Effect of soil disturbance on recharging fluxes: Case study on the Snake River Plain, Idaho National Laboratory, Idaho *(John R. Nimmo and Kim S. Perkins)*

Soil structural disturbance influences the downward flow of water that percolates deep enough to become aquifer recharge. Data from identical experiments in an undisturbed silt-loam soil and in an adjacent simulated waste trench composed of the same soil material, but disturbed, included (1) laboratory- and field-measured unsaturated hydraulic properties and (2) field-measured transient water content profiles through 24 h of ponded infiltration and 75 d of redistribution. In undisturbed soil, wetting fronts were highly diffuse above 2 m depth, and did not go much deeper than 2 m. Darcian analysis suggests an average recharge rate less than 2 mm/year. In disturbed soil, wetting fronts were sharp and initial infiltration slower; water moved slowly below 2 m without obvious impediment. Richards' equation simulations with realistic conditions predicted sharp wetting fronts, as observed for disturbed soil. Such simulations were adequate for undisturbed soil only if started from a post-initial moisture distribution that included about 3 h of infiltration. These late-started simulations remained good, however, through the 76 d of data. Overall results suggest the net effect of soil disturbance, although it reduces preferential flow, may be to increase recharge by disrupting layer contrasts.

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Lava Outcrop at INL

Appendix D. Onsite Dosimeter Measurements and Locations

Table D-1. Environmental Dosimeter Measurements at the Materials and Fuels Complex (MFC) (2007).

Location	Exposure[a]
MFC 7	137 ± 10
MFC 8	125 ± 9
MFC 9	145 ± 10
MFC 10	133 ± 9
MFC 11	138 ± 10
MFC 12	107 ± 7
MFC 13	131 ± 9
MFC 14	123 ± 8
MFC 15	134 ± 9
MFC 16	145 ± 10
MFC 17	126 ± 9
MFC 18	143 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

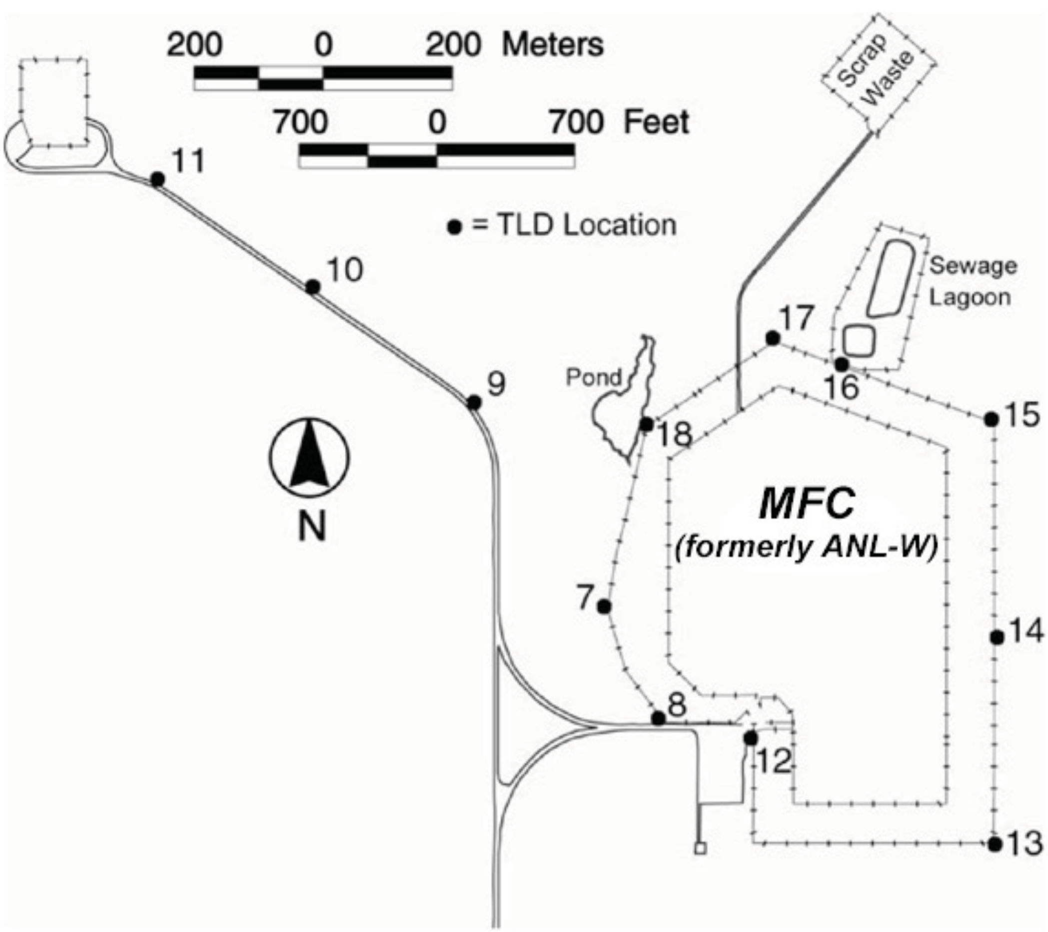

Figure D-1. Environmental Dosimeter Locations at the MFC (2007).

Table D-2. Environmental Dosimeter Measurements at the Auxiliary Reactor Area (ARA) (2007).

Location	Exposure[a]
ARA 1	137 ± 10
ARA 2	132 ± 9
ARA 3	[b]
ARA 4	[b]

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. These TLD locations were eliminated due to D&D activities.

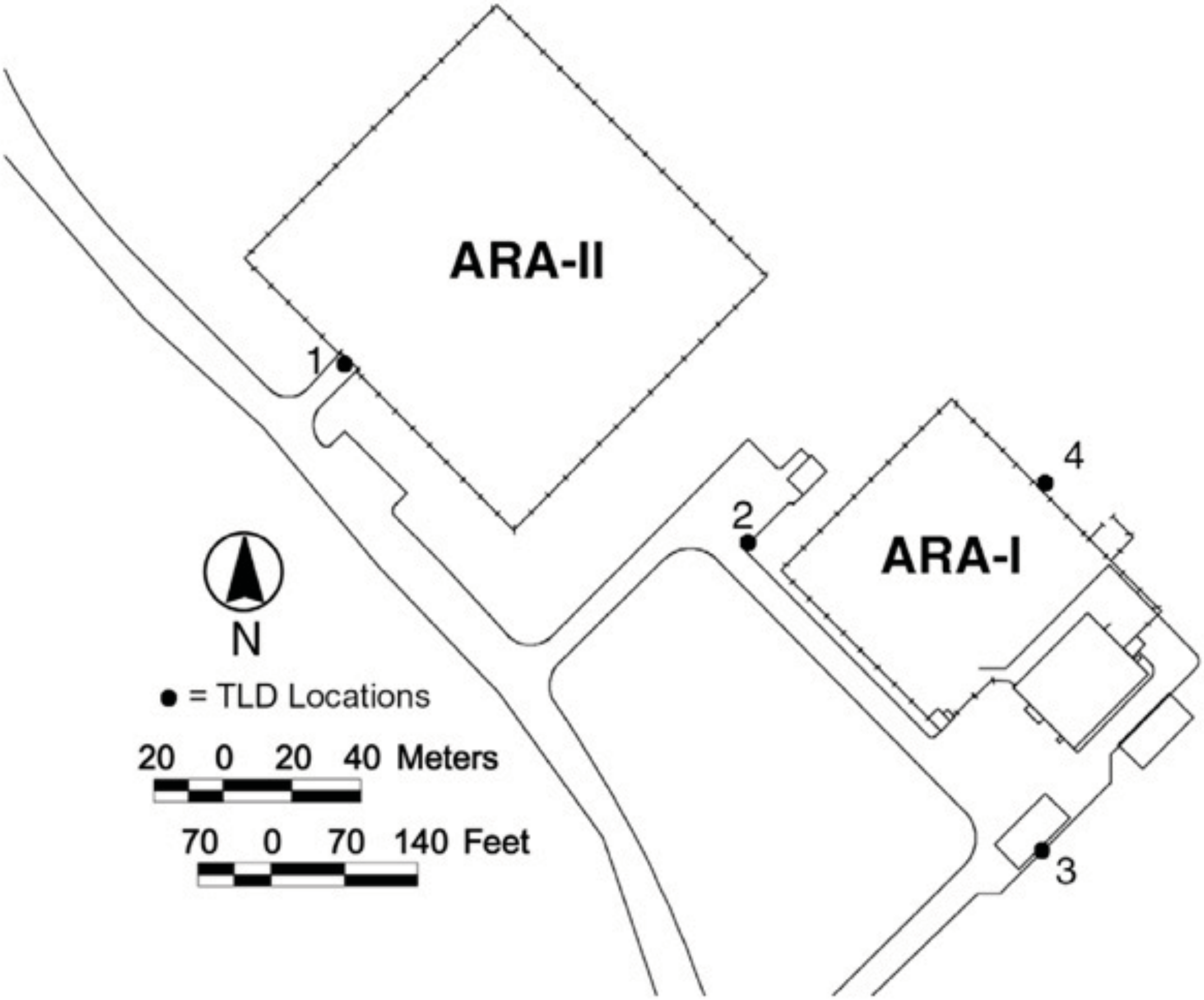

Figure D-2. Environmental Dosimeter Locations at the ARA (2007).

Table D-3 Environmental Dosimeter Measurements at the Central Facilities Area (CFA) (2007).

Location	Exposure[a]
CFA 1	136 ± 9
CFA 2	118 ± 8
CFA 3	141 ± 9
CFA 4	128 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

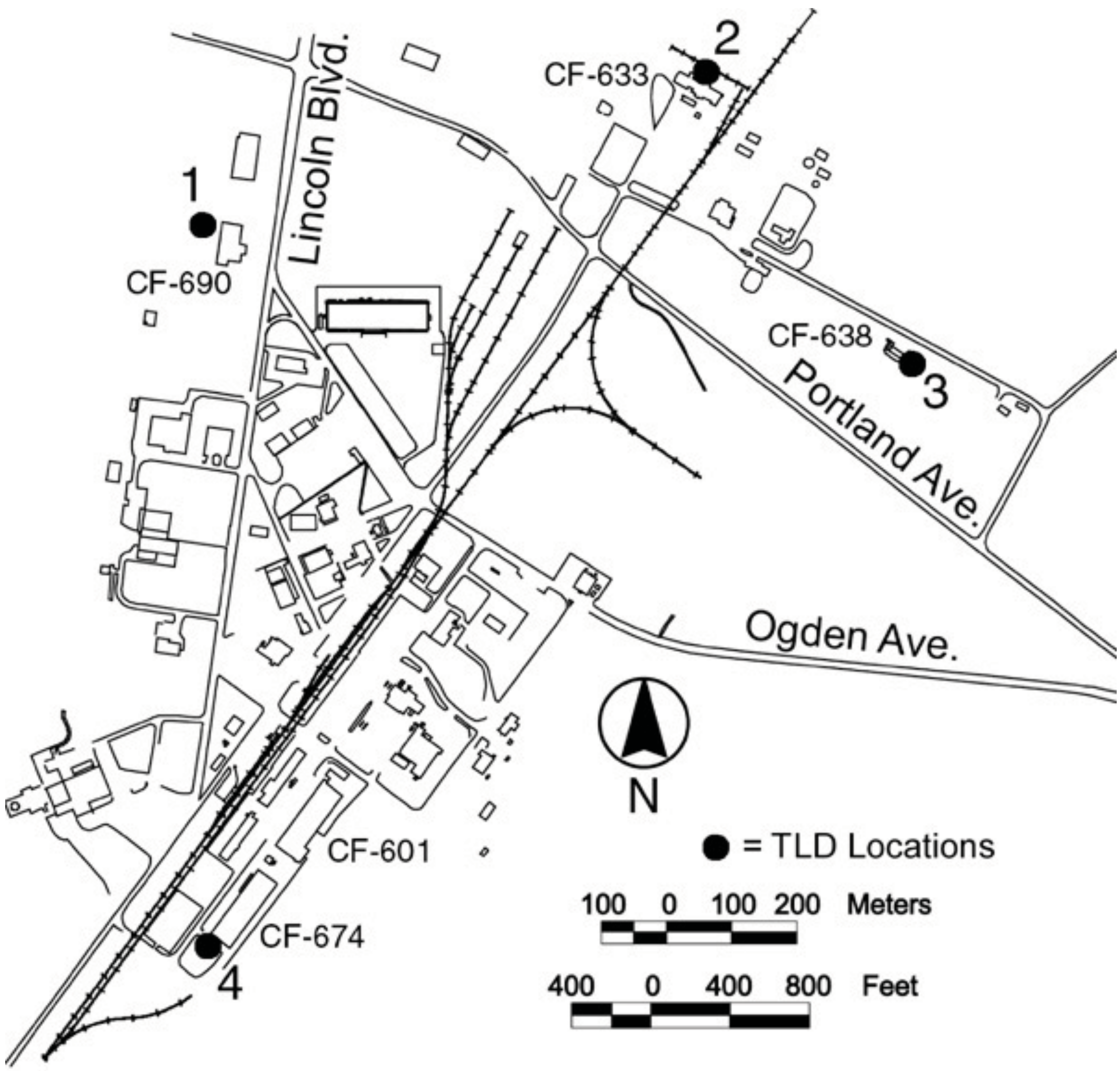

Figure D-3. Environmental Dosimeter Locations at the CFA (2007).

Table D-4. Environmental Dosimeter Measurements at the Idaho Nuclear Technology and Engineering Center (INTEC) (2007).

Location	Exposure[a]
INTEC 1	163 ± 11
INTEC 9	177 ± 12
INTEC 14	150 ± 10
INTEC 15	167 ± 12
INTEC 16	182 ± 13
INTEC 17	142 ± 10
INTEC 18	126 ± 9
INTEC 19	144 ± 10
INTEC 20	287 ± 20
INTEC 21	194 ± 13
INTEC 22	231 ± 16
INTEC 23	165 ± 11
INTEC 24	141 ± 10
INTEC 25	135 ± 9
INTEC 26	132 ± 9
TREE FARM 1	197 ± 14
TREE FARM 2	166 ± 12
TREE FARM 3	173 ± 12
TREE FARM 4	222 ± 15

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

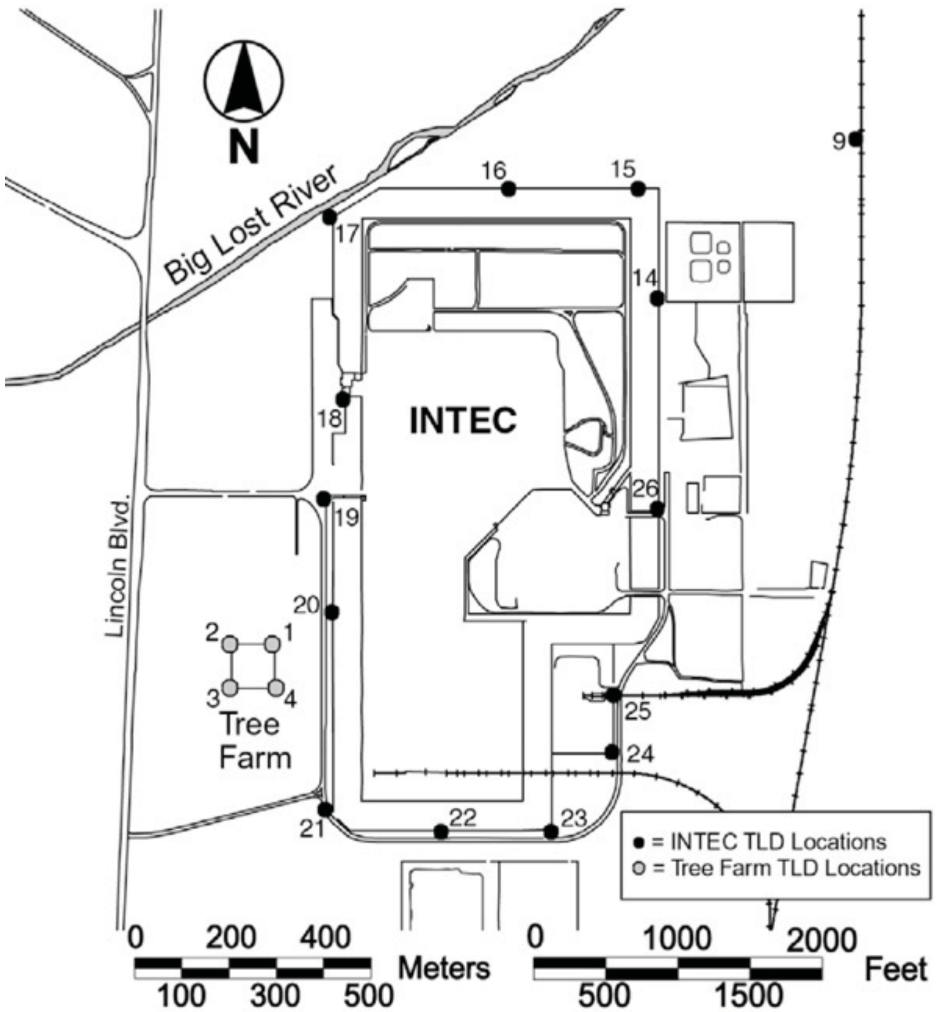

Figure D-4. Environmental Dosimeter Locations at the INTEC (2007).

Table D-5. Environmental Dosimeter Measurements at the Naval Reactors Facility (NRF) (2007)[a]

Location	Exposure[b]
NRF 4	139 ± 10
NRF 5	144 ± 10
NRF 11	140 ± 10
NRF 12	131 ± 9
NRF 13	138 ± 10
NRF 16	139 ± 10
NRF 17	--[c]
NRF 18	141 ± 10
NRF 19	143 ± 10
NRF 20	140 ± 10
NRF 21	--[c]

a. The INL contractor (BEA) manages dosimeters at NRF.
b. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
c. These locations were eliminated by construction activities.

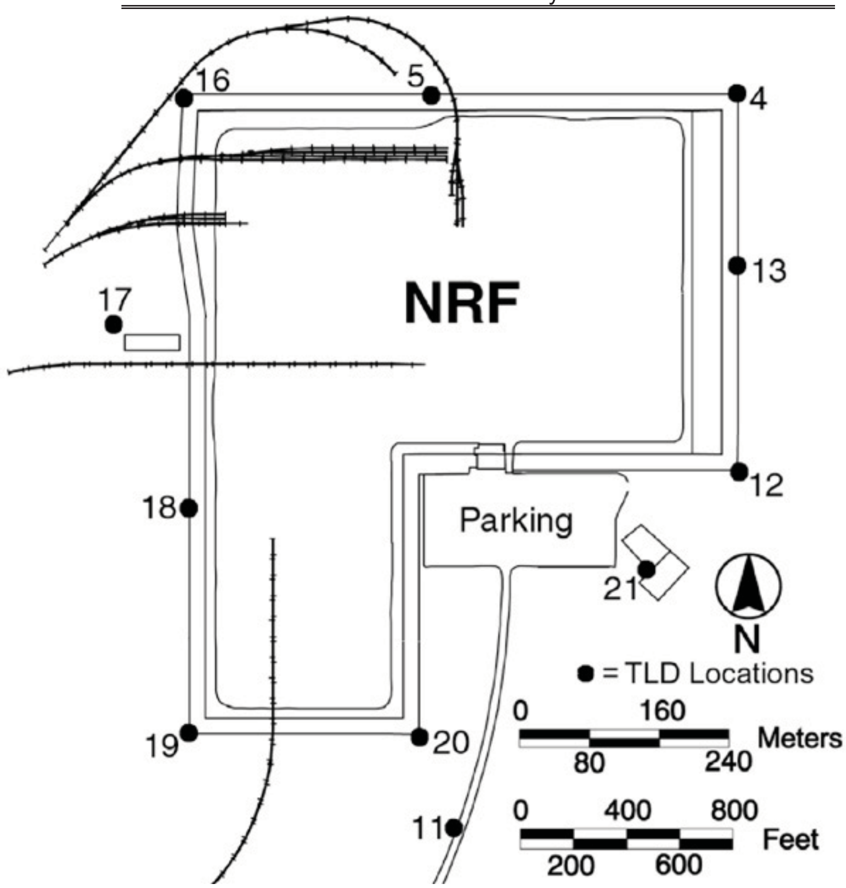

Figure D-5. Environmental Dosimeter Locations at the NRF (2007).

Table D-6. Environmental Dosimeter Measurements at the Critical Infrastructure Test Range Complex (CITRC) (2007).

Location	Exposure[a]
CITRC/SPERT 1	131 ± 9
CITRC/SPERT 2	136 ± 9
CITRC/SPERT 3	137 ± 9
CITRC/SPERT 4	142 ± 10
CITRC/SPERT 5	137 ± 10
CITRC/SPERT 6	145 ± 10
CITRC/WERF1	135 ± 9
CITRC/WERF2	118 ± 8
CITRC/WERF3	131 ± 9
CITRC/WERF4	145 ± 10
CITRC/WERF5	136 ± 9
CITRC/WERF6	128 ± 9
CITRC/WERF7	140 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

SPERT = Special Power Excursion Reactor Test

WERF = Waste Experimental Reduction Facility.

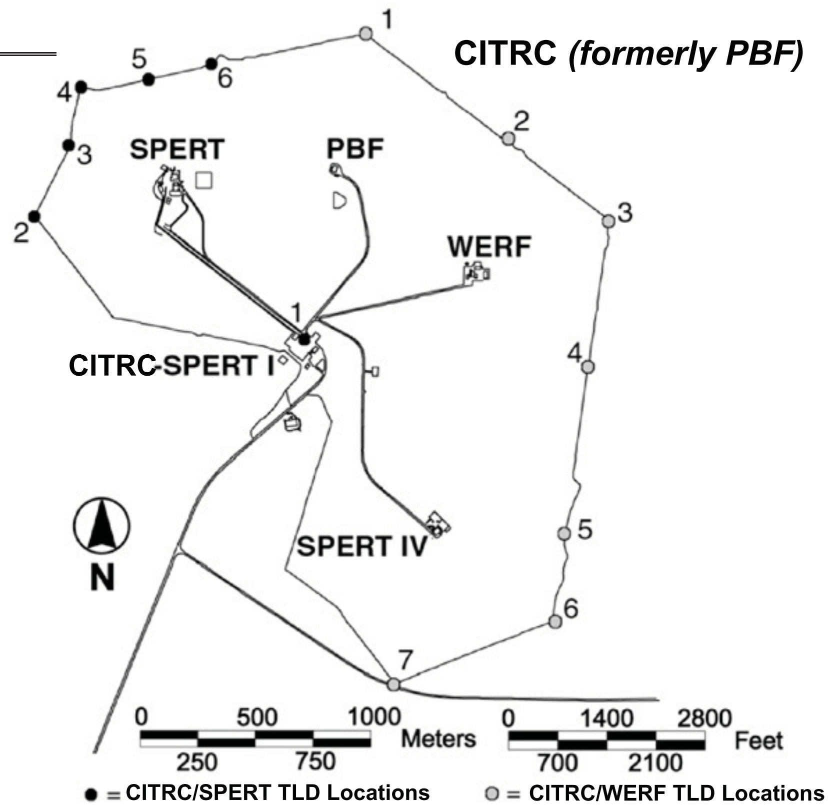

Figure D-6. Environmental Dosimeter Locations at the CITRC (2007).

Table D-7. Environmental Dosimeter Measurements at the Radioactive Waste Management Complex (RWMC) (2007).

Location	Exposure[a]
RWMC 3a	134 ± 9
RWMC 5a	132 ± 9
RWMC 7a	136 ± 9
RWMC 9a	160 ± 11
RWMC 11a	146 ± 10
RWMC 13a	142 ± 10
RWMC15a	135 ± 9
RWMC 17a	138 ± 10
RWMC 19a	129 ± 9
RWMC 21a	142 ± 10
RWMC 23a	139 ± 10
RWMC 25a	153 ± 11
RWMC 27a	225 ± 17
RWMC 29a	359 ± 28
RWMC 31a	237 ± 17
RWMC 37a	129 ± 9
RWMC 39	140 ± 10
RWMC 40	146 ± 10
RWMC 41	813 ± 56
RWMC 42	145 ± 10
RWMC 43	135 ± 9
RWMC 45	152 ± 11
RWMC 46	132 ± 9
RWMC 47	126 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

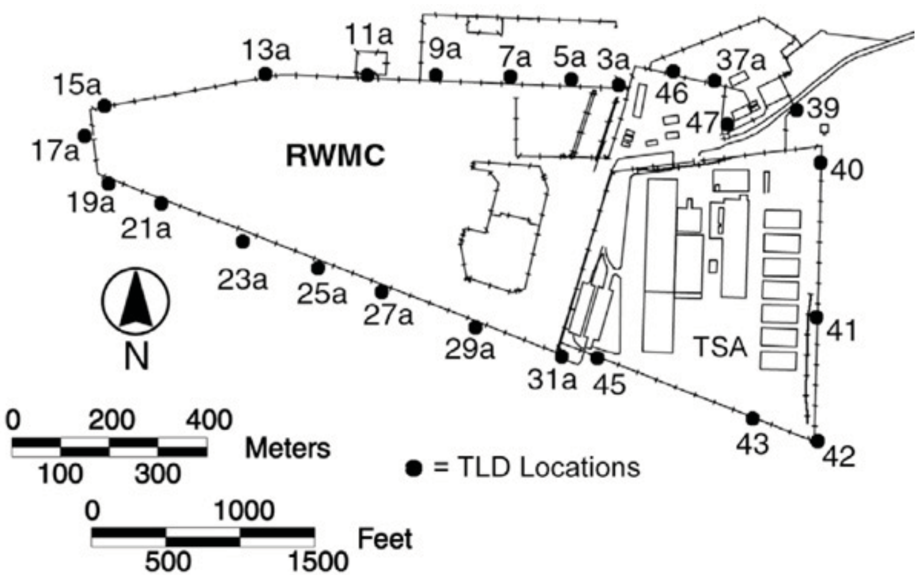

Figure D-7. Environmental Dosimeter Locations at the RWMC (2007).

Table D-8. Environmental Dosimeter Measurements at the Test Area North (TAN) (2007).

Location	Exposure[a]
TAN/TSF 1	113 ± 8
TAN/TSF 2	136 ± 9
TAN/TSF 3	113 ± 8
TAN/TSF 4	--[b]
TAN/LOFT 1	134 ± 9
TAN/LOFT 2	144 ± 10
TAN/LOFT 3	113 ± 8
TAN/LOFT 4	116 ± 8
TAN/LOFT 5	124 ± 9
TAN/LOFT 6	142 ± 10
TAN/LOFT 7	143 ± 10
TAN/WRRTF1	129 ± 9
TAN/WRRTF2	125 ± 9
TAN/WRRTF3	124 ± 9
TAN/WRRTF4	122 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.
TSF = Technical Support Facility
LOFT = Loss of Fluid Test Facility
WRRTF = Water Reactor Research Test Facility

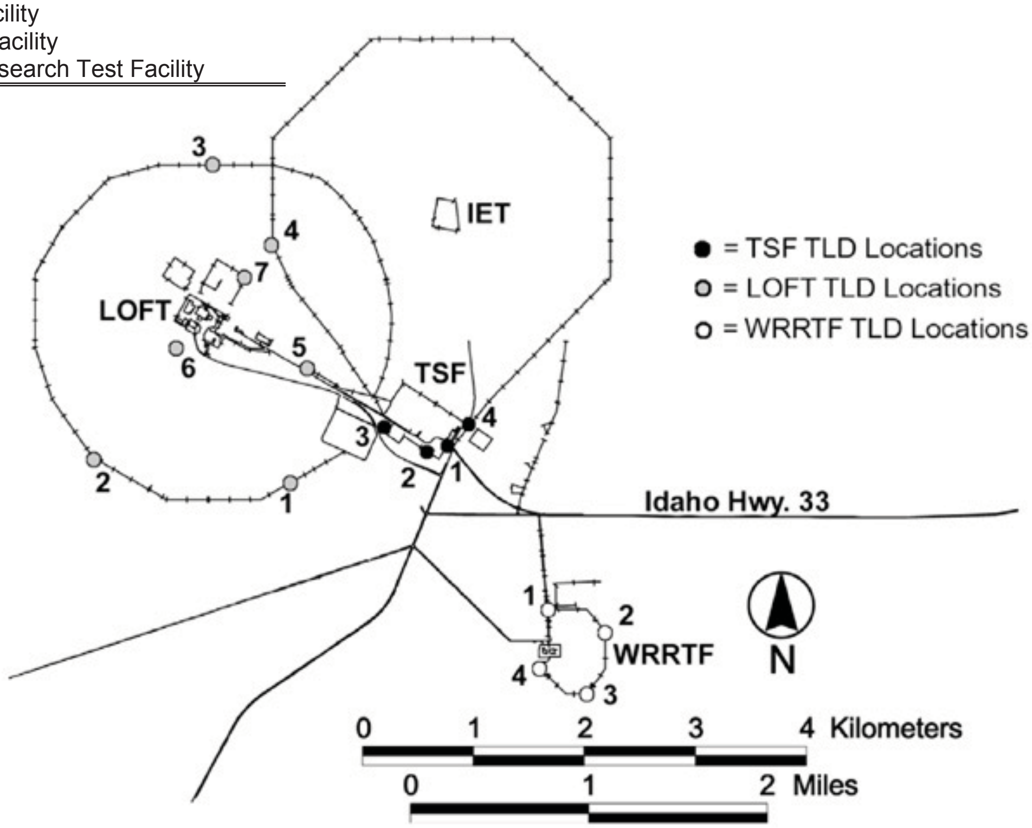

Figure D-8. Environmental Dosimeter Locations at the TAN (2007).

Table D-9. Environmental Dosimeter Measurements at the Reactor Technology Complex (RTC) (2007).

Location	Exposure[a]
RTC 1	148 ± 10
RTC 2	161 ± 11
RTC 3	157 ± 11
RTC 4	176 ± 12
RTC 5	158 ± 11
RTC 6	141 ± 10
RTC 7	140 ± 10
RTC 8	164 ± 11
RTC 9	149 ± 10
RTC10	160 ± 11
RTC11	165 ± 11
RTC12	163 ± 11
RTC13	159 ± 11

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

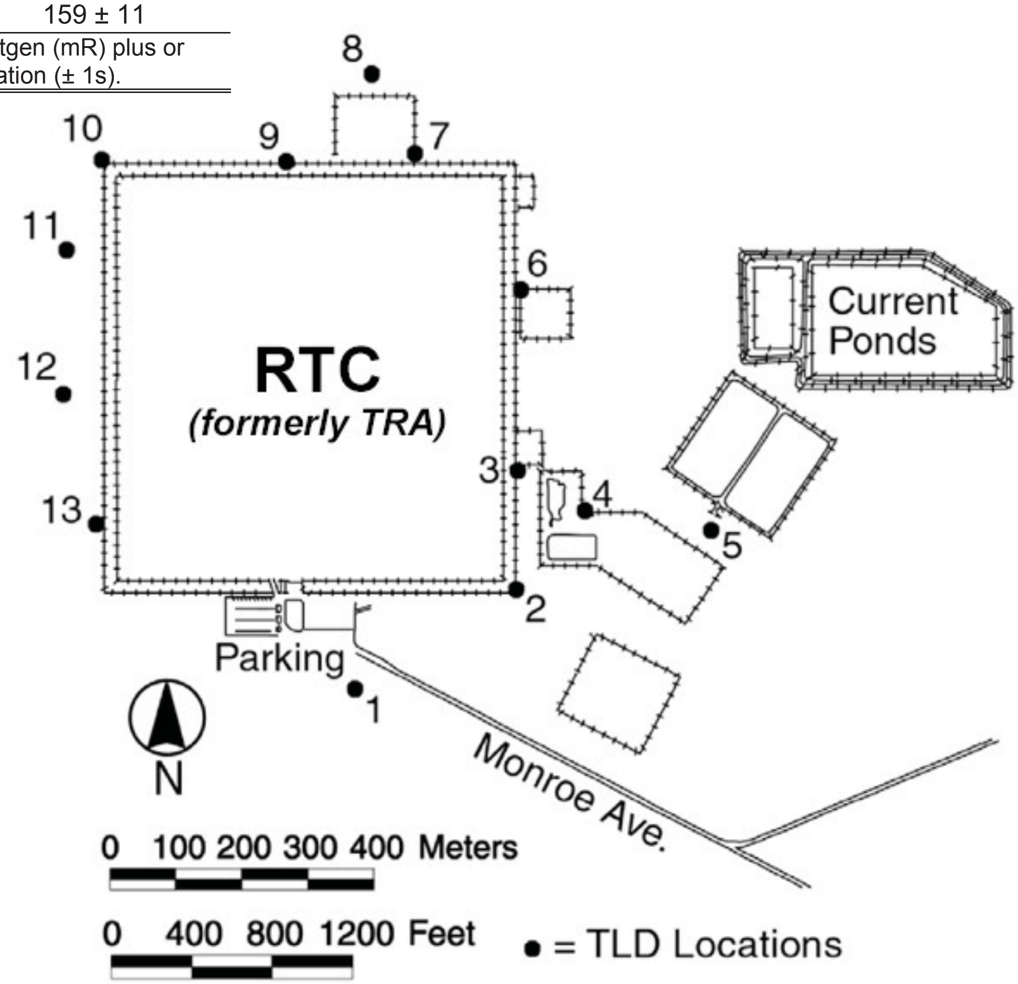

Figure D-9. Environmental Dosimeter Locations at the RTC (2007).

Table D-10. Environmental Dosimeter Measurements Along Lincoln Blvd. and US Highway 20 (2007).

Location	Exposure[a]
LINCOLN BLVD 1	135 ± 9
LINCOLN BLVD 3	152 ± 11
LINCOLN BLVD 5	148 ± 10
LINCOLN BLVD 7	145 ± 10
LINCOLN BLVD 9	145 ± 10
LINCOLN BLVD 11	141 ± 10
LINCOLN BLVD 13	142 ± 10
LINCOLN BLVD 15	144 ± 10
LINCOLN BLVD 17	144 ± 10
LINCOLN BLVD 19	133 ± 9
LINCOLN BLVD 21	127 ± 9
LINCOLN BLVD 23	128 ± 9
LINCOLN BLVD 25	134 ± 9
HWY 26-266	139 ± 10
HWY 26-268	135 ± 9
HWY 26-270	136 ± 9
HWY 20-264	131 ± 9
HWY 20-266	123 ± 9
HWY 20-268	131 ± 9
HWY 20-270	137 ± 9
HWY 20-272	125 ± 9
HWY 20-274	114 ± 8
HWY 20-276	130 ± 9
EBR 1	120 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

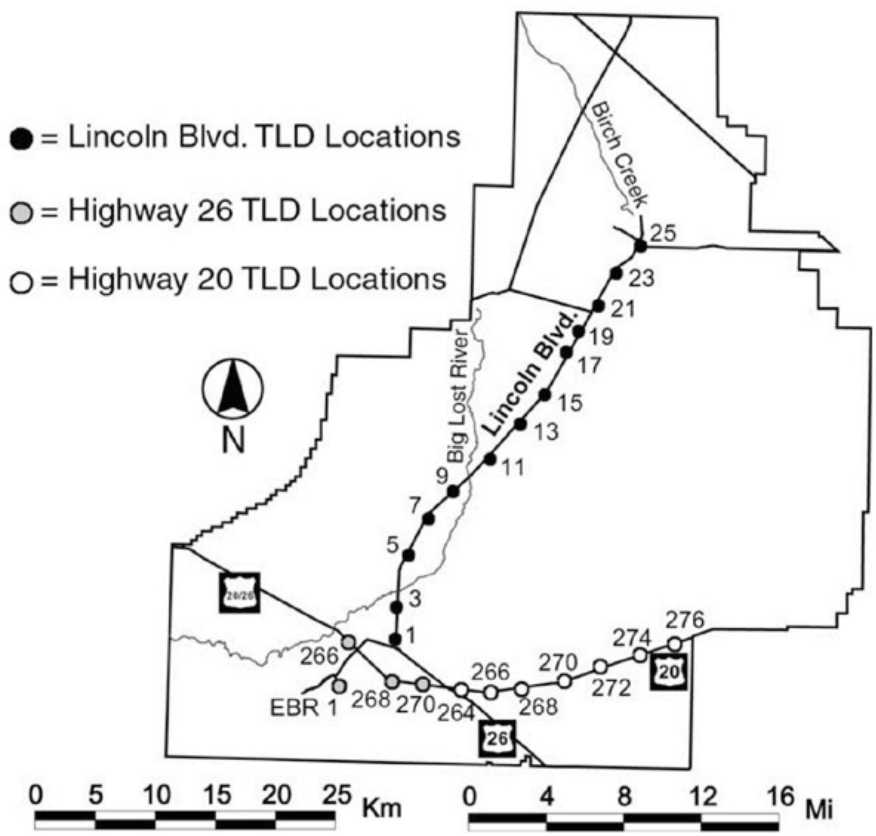

Figure D-10. Environmental Dosimeter Locations Along Lincoln Blvd. and US Highway 20 (2007).

Appendix E. Field Measurements of Gamma Radiation and Radionuclides in Surface Soil

INTRODUCTION

The Environmental Monitoring group at the Idaho National Laboratory (INL) is responsible for performing annual radiation measurements at the INL. The large size of the site (890 mi^2) and long distances between facilities necessitates the use of field-portable and mobile radiation measurement systems. In 2007, the Environmental Monitoring group performed 343 field-based gamma spectroscopy measurements. The mobile radiation measurement system results are discussed in Chapter 7. The measurements made using field-portable gamma-ray spectrometry systems are detailed in this appendix.

FIELD MEASUREMENTS

The gamma-ray spectrometry measurements were performed using p-type and n-type, high-purity germanium (HpGe) detectors connected to commercially available, state-of-the-art digital spectrometers, as shown in Figure E-1. These measurements follow the protocols of the U.S. Department of Energy Environmental Measurements Laboratory (EML). The EML is now under the purview of the U.S. Department of Homeland Security.

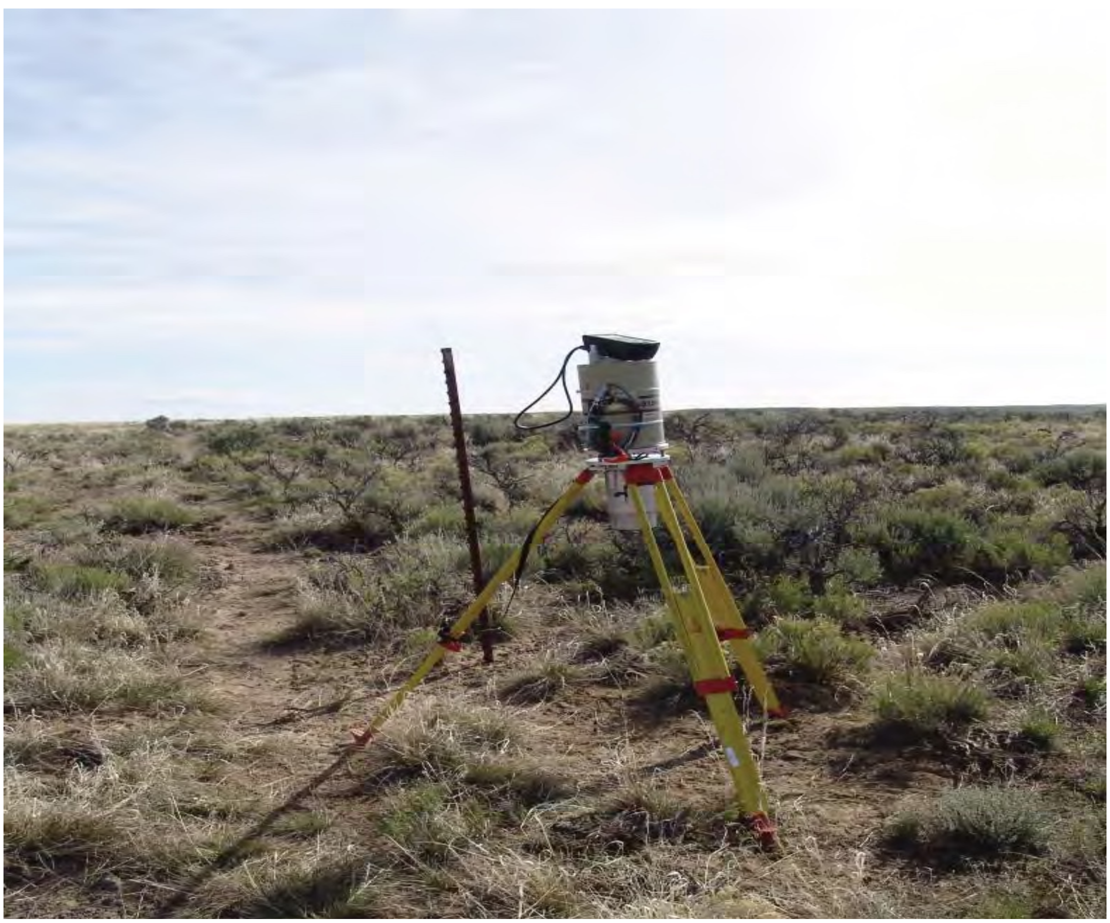

Figure E-1. High Purity Germanium Field Measurement System.

The HpGe measurements and analysis are conducted following the EML HASL-300 method for Field Gamma-ray Spectrometry. Gamma-emitting radionuclides are identified by the specific energies of the gamma-rays which they emit. These gamma-rays interact in the detector and are converted to electronic signals, proportional to the energy of the initial gamma-ray. These electronic pulses are then registered as spectral peaks in the instrumentation. The total number of electronic pulses that are recorded for each spectral peak for a given time period (i.e., the peak count rate) is related to the full absorption of unscattered gamma rays. If the detector is properly calibrated, the activities per unit mass of any radionuclide, in this case Cesium-137 (^{137}Cs), can be derived from the peak count rate using parameters that describe the soil characteristics (i.e., density) and the depth profile of the distribution. The in situ technique is particularly well suited for monitoring work such as this, because it quickly determines levels and types of contamination over large areas.

The measurements were performed by placing a detector on a tripod such that the detector was one meter above the ground surface. At this height, the detector has a circular field of view with a diameter of approximately 60 ft. In this configuration, each measurement provides a radionuclide concentration that is a weighted average over the detector field of view. The HpGe detector system was positioned at each measurement location and set to count the radioactivity in the soil. Count times for all field measurement points ranged from 1,800 seconds to 3,600 seconds. For each site facility, approximately 10 percent of the points were recounted for 3,600 seconds in order to perform quality assurance (QA) checks.

High resolution gamma-ray spectroscopy measurements were performed at 343 locations across the INL. The locations included points which border INL facilities, and a set of regional points that cover onsite and offsite locations from the southwest to northeast of the INL boundaries.

A series of soil samples were collected at select locations at each facility. These samples were collected at 33 locations according to a specific sampling pattern which encompassed the field-of-view of a detector at that location. Soil samples were collected using a split spoon sampler at 1-inch intervals to a depth of 12 inches. Soils were packaged into pucks, analyzed using conventional laboratory based gamma spectroscopy systems, and the ^{137}Cs depth profiles were determined.

RESULTS AND DISCUSSION

Analysis of the in situ measurement data show that ^{137}Cs is the only anthropogenic, gamma-emitting radionuclide that is measurable above background. Table E-1 and Figures E-2 through E-10 show the results of the radiation measurements for each of the eight major facilities and the large grid points for 2007. The 2007 soil puck results indicate that the ^{137}Cs depth profile at all INL sites was exponentially distributed. In Table E-1 INL sites and large grid results are reported in units of pCi/g and the mean 2007 ^{137}Cs concentration is 1.0 +/- 2.8 pCi/g.

Table E-1. 2007 InSitu Gamma Scan Results for INL Sites and Large Grid.

Facility surveyed:	MFC	NRF	CITRC	RTC	RWMC	Large Grid	TAN-SMC	ARA	INTEC	Overall
Number of measurements:	18	5	16	24	47	42	18	78	96	343
Descriptive statistics										
Distribution [a]	N	N	N	NP	NONE	G	NP	L	NP	NP
Mean	1.80E-01	6.00E-01	2.20E-01	5.30E-01	2.90E-01	2.80E-01	3.10E-01	1.48E+00	1.88E+00	1.02E+00
Median	1.80E-01	4.70E-01	2.20E-01	4.50E-01	2.60E-01	2.70E-01	2.50E-01	7.80E-01	1.02E+00	4.20E-01
Minimum	9.00E-02	4.60E-01	1.60E-01	2.20E-01	1.80E-01	1.10E-01	1.40E-01	1.70E-01	2.00E-02	2.00E-02
Maximum	2.40E-01	9.30E-01	2.90E-01	1.30E+00	1.00E+00	5.60E-01	1.20E+00	9.20E+00	4.90E+01	4.90E+01
Standard deviation	5.00E-02	2.00E-01	4.00E-02	2.60E-01	1.20E-01	9.00E-02	2.50E-01	1.63E+00	4.99E+00	2.84E+00
Variance	0.00E+00	4.00E-02	0.00E+00	7.00E-02	1.00E-02	1.00E-02	6.00E-02	2.66E+00	2.49E+01	8.04E+00
Coefficient of variation	2.60E-01	3.40E-01	1.70E-01	4.90E-01	4.30E-01	3.20E-01	7.90E-01	1.10E+00	2.65E+00	2.79E+00
Upper 95% UCL [b]	2.00E-01	7.90E-01	2.30E-01	6.30E-01	3.20E-01	3.00E-01	5.70E-01	1.95E+00	4.10E+00	1.69E+00
Comparison of 2006 and 2007 results:										
Mean (2006)	NA[c]	NA	NA	2.00E-01	1.10E-01	8.00E-02	1.40E-01	2.28E+00	8.80E-01	9.50E-01
% difference in means [d]	NA	NA	NA	1.66E+02	1.60E+02	2.46E+02	1.24E+02	-3.50E+01	1.14E+02	1.21E+02
Upper 95% UCL (2007)	NA	NA	NA	2.30E-01	1.20E-01	1.50E-01	1.80E-01	3.80E+00	1.60E+00	8.30E-01
% difference in UCLs) [e]	NA	NA	NA	1.74E+02	1.67E+02	1.00E+02	2.17E+02	-4.87E+01	1.56E+02	1.04E+02

a. N = normal, NP = nonparametric, G = gamma, L = lognormal

b. UCL = upper confidence limit

c. NA = Not applicable. Measurements made in 2006 for this facility are not comparable due to a difference in the reported unit.

d. $(\text{mean}_{2007} - \text{mean}_{2006}) * 100$

e. $(\text{UCL}_{2007} - \text{UCL}_{2006}) * 100$

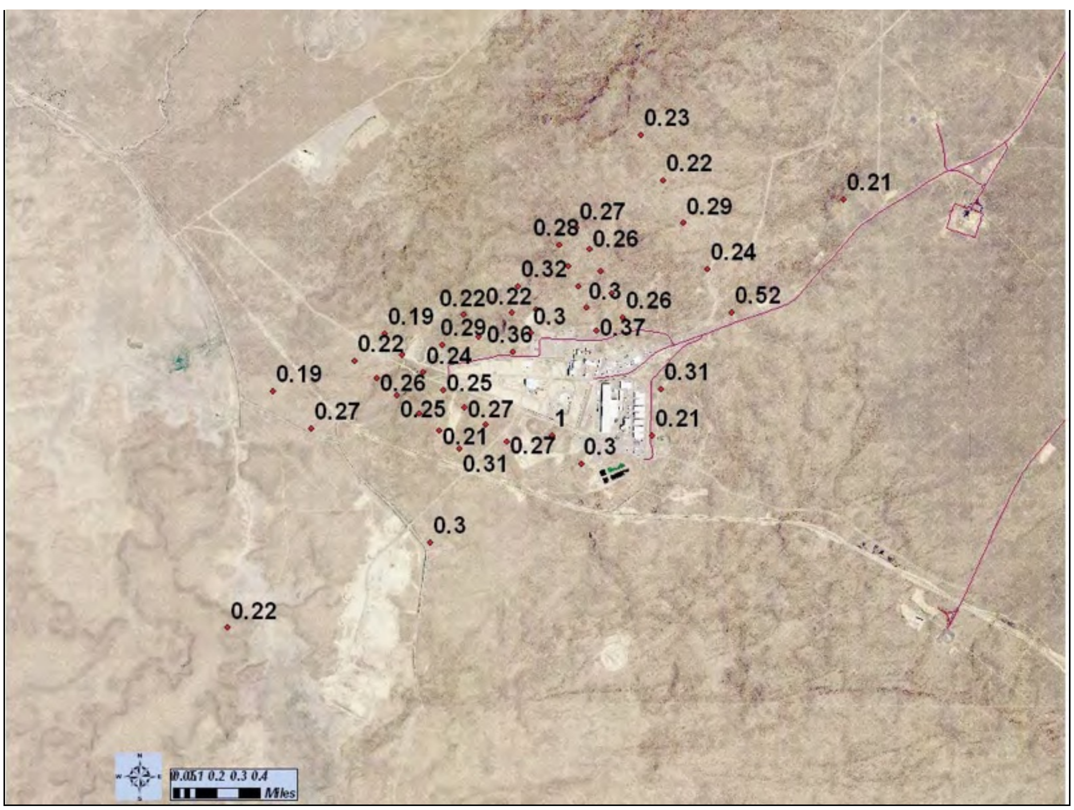

Figure E-2. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at the RWMC. Shallow exponential distribution, all values in pCi/g.

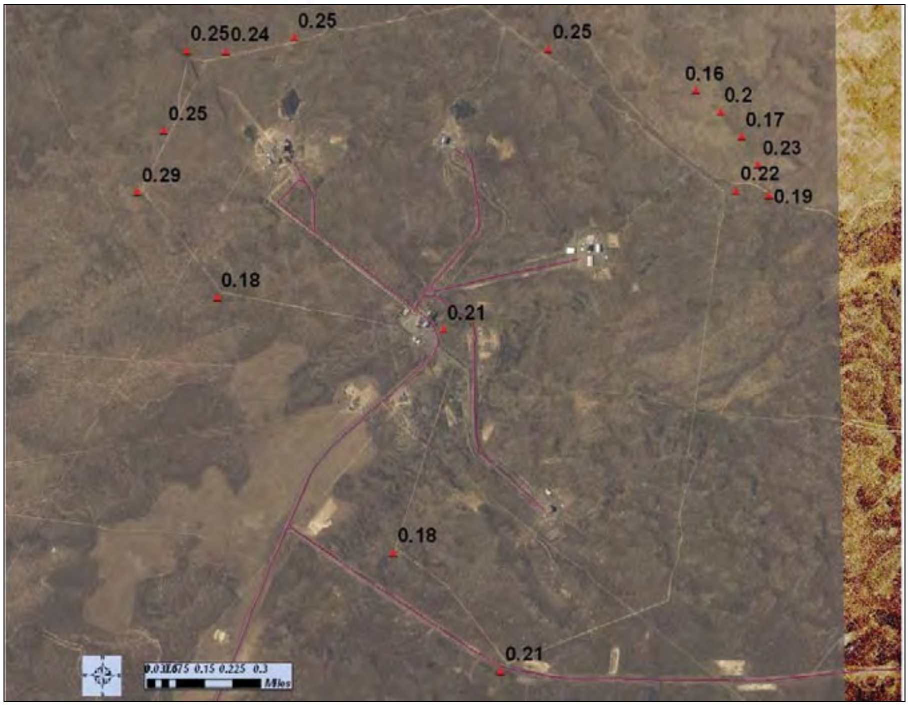

Figure E-3. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at CITRIC.

Figure E-4. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at INTEC.

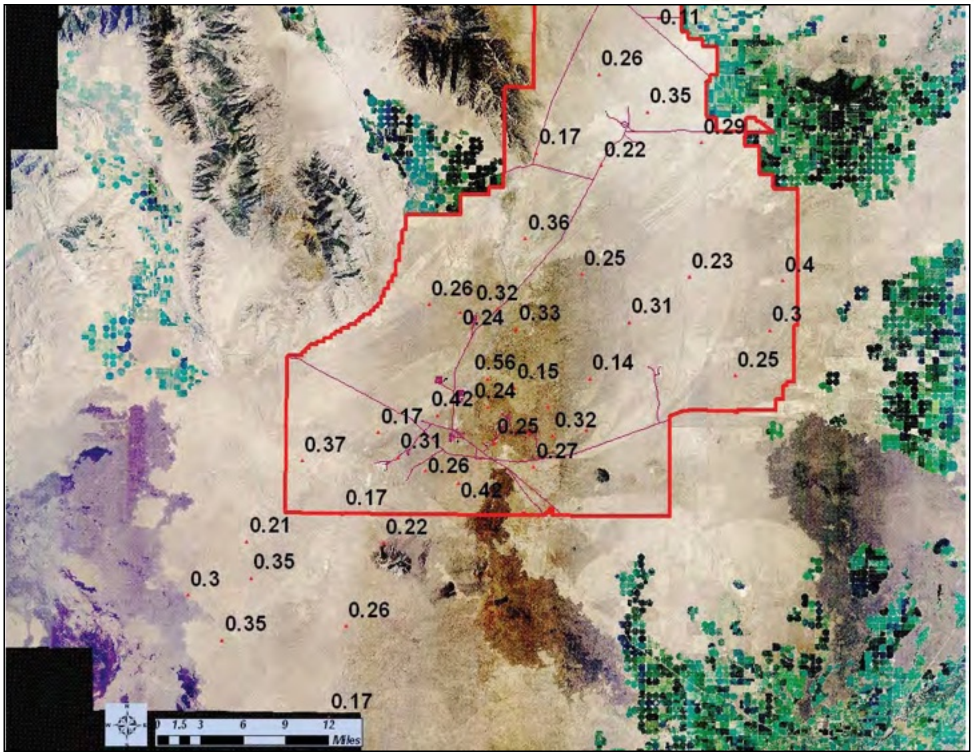

Figure E-5. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs on Large Grid.

Figure E-6. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at NRF.

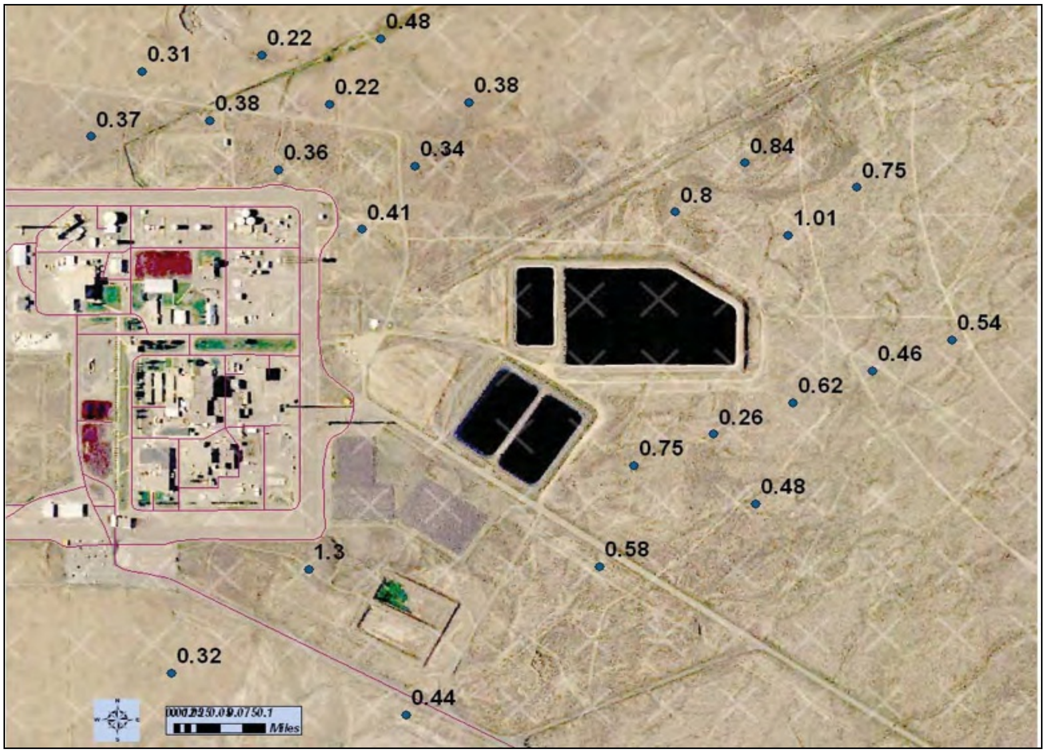

Figure E-7. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at RTC.

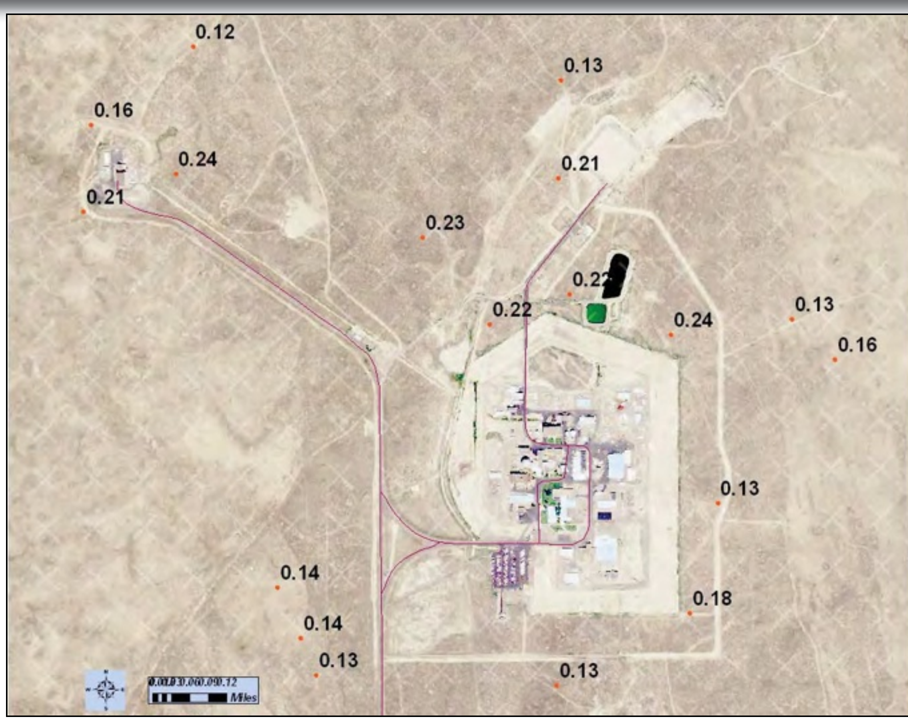

Figure E-8. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at MFC.

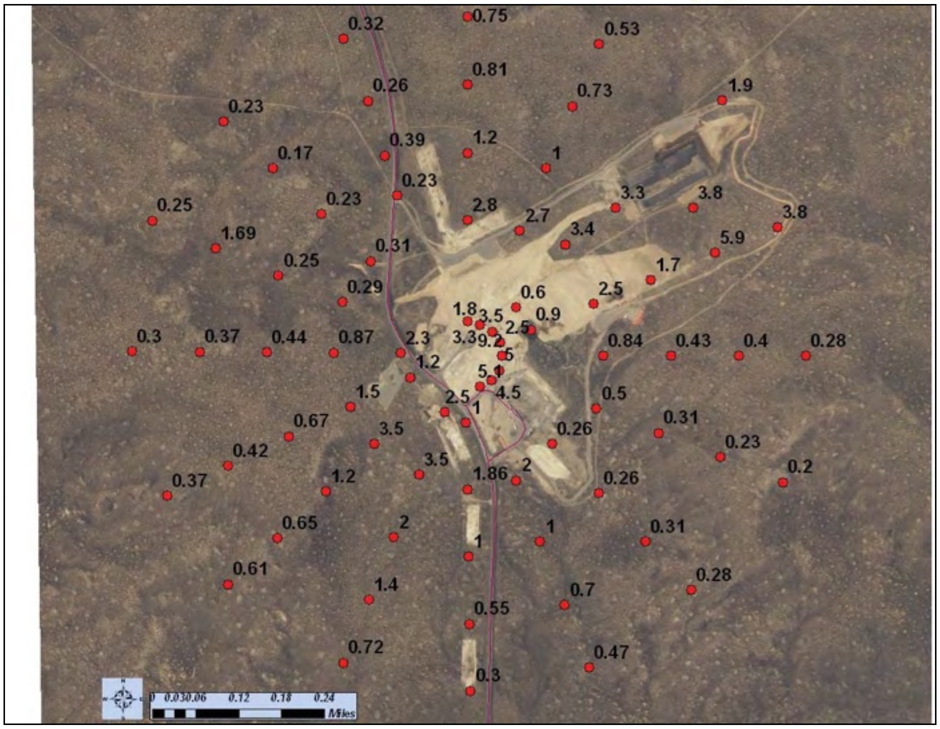

Figure E-9. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at ARA.

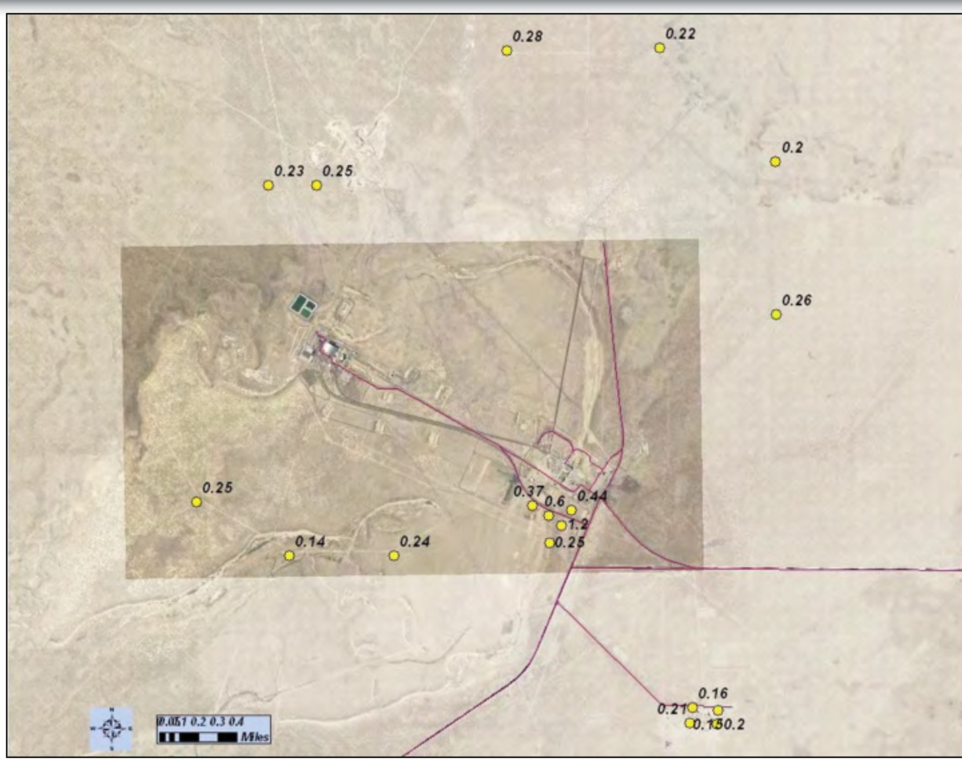

Figure E-10. 2007 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at TAN/SMC.

The ^{137}Cs data were further characterized in order to determine the relevant upper confidence limit (UCL) values. In order to accomplish this, the program ProUCL 4.0 (EPA 2004) was used. This program performs two main functions: (1) the data are first examined in order to determine the correct probability distribution, and (2) the UCL values are then calculated using an appropriate statistical calculation. The statistical distribution determination results for sites with shallow exponential ^{137}Cs distributions are shown in Table E-1. The 95 percent UCL values range from 0.2 to 4.1 pCi/g.

For comparison, the mean INL site background value for ^{137}Cs, based on Rood et al. (2004), is 0.44 pCi/g, and the 95 percent UCL is 0.82 pCi/g. A significance test on the overall 2007 site mean data, 1.02 pCi/g, indicates a strongly statistically significant difference between the 2007 site mean ^{137}Cs concentration in soil and the historical ^{137}Cs soil concentration in the 1994 report (p=.0002). Comparison between the 2006 and 2007 overall site means shows the two data sets to be not statistically different at the 95 percent confidence level (p= 0.78).

In 2006, the MFC, NRF, and CITRC data sets were calculated using a surface distribution model whereas in 2007, all site data results were calculated using the actual site specific exponential depth profiles based on soil core sampling results. Therefore, for the MFC, NRF, and CITRC sites, it is not possible to compare 2006 and 2007 results directly. For all other sites except ARA, the mean and 95 percent UCL values increased from 2006 to 2007 as shown in Table E-1. The largest increase in the mean ^{137}Cs concentration was noted for the large grid and the largest increase in the 95 percent UCL was for the TAN-SMC site.

QUALITY CONTROL

At 27 locations a second quality control check measurement was performed using in situ gamma spectroscopy. These results are shown in Table E-2. For each INL site, about 8 percent of the points were chosen in order to perform this second measurement. The percent differences between the initial and quality control measurements for both anthropogenic ^{137}Cs and naturally occurring Potassium-40 (^{40}K) are shown. The mean percent difference for ^{137}Cs is -3.6 ± 14.7 percent and the mean difference for ^{40}K is -.18 ± 9.0 percent. The percent differences for both ^{137}Cs and ^{40}K were both tested and found to be statistically insignificant (p=0.79 for ^{137}Cs, p=0.86 for ^{40}K).

Table E-2. Quality Control Results for In Situ Gamma Spectroscopy

POINT	EAST	NORTH	^{137}Cs QC	^{137}Cs Orig.	Uncer QC	Uncer-Orig	^{40}K QC	^{40}K Orig.	Uncer QC	Uncer Orig	alpha/rho	^{137}Cs %diff	^{40}K %Diff
L2-76QC	505935.57	803496.06	0.24	0.23	0.05	0.02	12.00	11.30	0.30	0.30	0.40	4.35	6.19
IET-6QC	519821.41	799954.99	0.27	0.26	0.03	0.01	15.10	16.80	0.30	0.30	0.40	3.85	-10.12
EBRII-10Q	526492.03	705600.40	0.19	0.21	0.01	0.01	15.10	16.80	0.30	0.30	0.68	-9.52	-10.12
EBR16QC	524288.28	701668.20	0.14	0.14	0.01	0.04	15.70	14.00	0.30	0.20	0.68	0.00	12.14
ARA-16QC	482471.10	673990.39	0.98	1.00	0.01	0.03	14.60	13.80	0.30	0.80	0.33	-2.00	5.80
ARA-57QC	481411.98	676553.49	0.21	0.23	0.01	0.01	12.70	13.00	0.30	0.30	0.33	-8.70	-2.31
ARA-52QC	479603.97	676366.76	0.24	0.25	0.01	0.01	10.60	9.60	0.30	0.30	0.33	-4.00	10.42
ARA-14QC	483590.52	673631.47	0.26	0.28	0.01	0.01	11.60	12.50	0.30	0.30	0.33	-7.14	-7.20
ARA-36QC	480884.89	674365.29	1.06	1.20	0.01	0.01	10.90	10.30	0.30	0.30	0.33	-11.67	5.83
INT-B29QC	449412.96	694312.02	0.69	0.50	0.03	0.02	18.00	16.00	0.40	0.30	0.40	38.00	12.50
INT-B17QC	449913.02	694811.65	0.81	0.70	0.02	0.03	18.30	16.70	0.50	0.40	0.40	15.71	9.58
INT-A49QC	455412.09	697312.30	2.90	3.40	0.01	0.03	14.40	15.00	0.40	0.40	0.40	-14.71	-4.00
INT-B62QC	449413.87	692812.08	0.71	0.85	0.02	0.01	15.60	16.70	0.40	0.30	0.40	-16.47	-6.59
INT-B84QC	449413.87	692811.83	0.82	1.00	0.04	0.03	16.00	16.30	0.40	0.50	0.40	-18.00	-1.84
INT-A47QC	451413.40	693311.77	3.45	3.80	0.02	0.02	15.40	15.50	0.30	0.20	0.40	-9.21	-0.65
INT-B94QC	449913.37	691312.08	1.04	1.20	0.03	0.01	14.60	15.70	0.24	0.20	0.40	-13.33	-7.01
PBF-1QC	475037.92	688169.57	0.20	0.21	0.01	0.01	15.40	16.40	0.30	0.30	0.27	-4.76	-6.10
WRF800EQ	475037.92	688169.57	0.22	0.19	0.02	0.01	9.50	11.30	0.20	0.30	0.27	15.79	-15.93
RW7-76Q	418471.12	669805.98	0.22	0.22	0.02	0.01	14.70	13.80	0.50	0.03	0.32	0.00	6.52
RW8-4QC	417399.77	668165.98	0.19	0.27	0.02	0.02	16.00	14.90	0.40	0.60	0.32	-29.63	7.38
RW4-1QC	427685.14	670987.51	0.50	0.52	0.01	0.02	15.10	16.00	0.30	0.40	0.32	-3.85	-5.63
RW6-2QC	421668.40	668252.31	0.26	0.22	0.01	0.02	13.70	12.60	0.40	0.30	0.32	18.18	8.73
RW2-1QC	425732.70	667987.28	0.20	0.21	0.04	0.01	13.70	12.60	0.40	0.30	0.32	-4.76	8.73
NRF-6QC	459077.84	723146.26	0.91	0.93	0.02	0.01	17.40	16.00	0.40	0.40	2.80	-2.15	8.75
TRA-A3.3Q	445592.50	701938.35	0.41	0.36	0.03	0.02	15.30	15.20	0.50	0.40	0.28	13.89	0.66
TRA-6.2Q	445764.92	699462.08	1.02	1.30	0.02	0.03	13.80	16.90	0.30	0.60	0.28	-21.54	-18.34
LG24-7	572844.47	737776.02	0.30	0.40	0.08	0.02	15.60	17.80	0.30	0.50	0.28	-25.00	-12.36

REFERENCES

Environmental Protection Agency (EPA). 2004. ProUCL 3.0. (2004). A Statistical Software. National Exposure Research Lab, EPA, Las Vegas Nevada, October 2004.

Rood et al; 1994; INEL-94/0250, “Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory.”

Coyote

Appendix F. Chapter 5 Addendum

Table F-1. Summary of CFA Sewage Treatment Facility Influent Monitoring Results (2007).[a,b,c]

Parameter	Minimum	Maximum	Median[d]
Biochemical oxygen demand (5-day)	18.8	463	54.8
pH (grab)	6.85	9.05	7.58
Chemical oxygen demand	35.9	313	85.7
Nitrogen, nitrate+nitrite (mg-N/L)	0.611	2.41	1.125
Nitrogen, total Kjeldahl	11.2	35	17.8
Total suspended solids	13.3	323	60.9

a. With the exception of pH, which is unitless, all values are in milligrams per liter (mg/L) unless otherwise noted.

b. Duplicate samples were collected in May for all parameters (excluding pH) and the duplicate results are included in the summaries.

c. There are no permit limits set for these parameters.

d. Annual median is calculated the average of the duplicate samples collected in May.

Table F-2. Summary of CFA Sewage Treatment Plant Effluent Monitoring Results (2007).[a]

Sample Date	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as Nitrogen (mg/L)	Biochemical Oxygen Demand (mg/L)	Chemical Oxygen Demand (mg/L)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	pH	Total Phosphorus (mg/L)	Fecal Coliform[b] (/100 mL)	Total Coliform[b] (/100 mL)
6/12/07	2.21	0.452	2 U[c]	37.2	1280	4 U	9.57	0.23	1 U	5
8/8/07	2.22	0.05 U	2 U	40.5	1120	4 U	8.74	0.124	1	1
8/8/07 (duplicate)	2.12	0.05 U	2 U	39.9	1130	4 U	NA	0.166	NA	NA

a. There are no permit limits for these parameters.

b. Grab samples.

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

Table F-3. INTEC Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2007).[a,b]

Parameter	Minimum	Maximum	Average[c]
	(mg/L)		
Biochemical oxygen demand (5-day)	90.8	373.0	208.9
Nitrate+nitrite, as nitrogen	0.025[d]	3.040	0.456
Total Kjeldahl nitrogen	39.2	136.0	75.6
Total phosphorus	4.37	14.80	8.82
Total suspended solids	43.1	760.0	204.7

a. Duplicate samples were collected in June for all parameters. Duplicate results are included in the summaries.

b. No permit limits are set for these parameters.

c. 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.

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

Table F-4. INTEC Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2007).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Biological oxygen demand (5-day) (mg/L)	12.0[e]	32.3	19.4
Chloride (mg/L)	33.5	95.0	71.8
Conductivity (µS/cm) (composite)	512	979	788.9
Nitrate+nitrite, as nitrogen (mg/L)	0.0025[d]	3.12	1.4467
pH (standard units) (grab)	7.96	9.18	8.50
Sodium (mg/L)	20.2	77.9	53.8
Total coliform (colonies/100 mL)	25	2,500	540.1[f]
Total dissolved solids (mg/L)	274	580	470
Total Kjeldahl nitrogen (mg/L)	7.73	33.90	19.28
Total phosphorus (mg/L)	2.73	7.05	4.46
Total suspended solids (mg/L)	4.40	96.80	35.81

a. Duplicate samples were collected in June all parameters (excluding conductivity, pH, and total coliform), and the duplicate results are included in the summaries.

b. Sample collected on May 23, 2007, was from a grab sample because seepage test in progress.

c. NA—Not applicable; no permit limit set for this parameter.

d. 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.

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

f. The average was calculated using the censored value of 200 colonies/100 mL. The May and December sample colonies were too numerous to count.

Table F-5. INTEC New Percolation Ponds Effluent Monitoring Results at CPP-797 (2007).[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.0125[c]	0.0125[d]
Arsenic (mg/L)	0.00125[c]	0.0025[c]	0.0015
Biochemical oxygen demand (5-day) (mg/L)	1.0[c]	12.8	2.0
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	75	1,210	262.9
Chromium	0.0039	0.0059	0.0050
Conductivity (µS/cm) (composite)	605	3,930	1,179.8
Copper (mg/L)	0.0016	0.0086	0.0039
Fluoride (mg/L)	0.204	0.256	0.231
Iron (mg/L)	0.0125[c]	0.1210	0.0742
Manganese (mg/L)	0.00125[c]	0.00125[c]	0.00125[d]
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrate+nitrite, as nitrogen (mg/L)	0.869	1.71	1.195
pH (grab)	7.32	8.93	7.94
Selenium (mg/L)	0.001[c]	0.0015	0.0012
Silver (mg/L)	0.00125[c]	0.00125[c]	0.00125[d]
Sodium (mg/L)	36.7	516	156
Total coliform (colonies/100 mL)	0.5[c]	200	54.4[e]
Total dissolved solids (mg/L)	359	2,180	648
Total Kjeldahl nitrogen (mg/L)	0.369	1.2	0.698
Total nitrogen[f] (mg/L)	1.459	2.470	1.893
Total phosphorus (mg/L)	0.0238	0.4500	0.1468
Total suspended solids (mg/L)	2.0[c]	5.5	2.3

a. Duplicate samples were collected in June for all parameters except biochemical oxygen demand (5-day), chloride, fluoride, total dissolved solids, and total suspended solids. Due to limited sample volume available in June, duplicate samples for those parameters were collected in July. 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. The average was calculated using the censored value of 200 colonies/100 mL. The July sample colonies were too numerous to count.

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

Table F-6. New Percolation Pond Wastewater Land Application Permit Groundwater Quality Data from Aquifer Wells for the 2007 Reporting Year.

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)				ICPP-MON-A-166 (GW-013007)						
Sample Date	April 2007	Oct 2007	4/3/2007	4/26/2007	5/2/2007[a]	10/2/2007	4/4/2007	4/4/2007[b]	5/3/2007[a]	5/3/2007[a,b]	10/2/2007	10/2/2007[b]	PCS/SCS[c]
Depth to water table (ft)	Dry[d]	Dry[d]	501.31	501.7	502.39	502.7	509.15	509.15	509.55	509.55	510	510	NA[e]
Water table elevation at brass cap (ft)	—	—	4,451.60	4,451.21	4,450.52	4,450.30	4,462.0	4,462.0	4,461.60	4,461.60	4,449.49	4,449.49	NA
Aluminum (mg/L)	—	—	0.0966 U[f]	—	—	0.0250 U	0.169 U	0.168 U	—	—	1.160[g]	1.100[g]	0.2
Aluminum-filtered (mg/L)	—	—	0.0734 U	—	—	0.0250 U	0.0635 U	0.0631 U	—	—	0.0250 U	0.0250 U	0.2
Arsenic (mg/L)	—	—	0.00115 U	—	—	0.0050 U	0.00154 U	0.00118 U	—	—	0.0050 U	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	—	0.00107 U	—	—	0.0050 U	0.00134 U	0.00122 U	—	—	0.0050 U	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	—	—	4.74	—	—	2.0 U[i]	2.25	1.09	—	—	2.0 U[i]	2.0 U[i]	NA
Cadmium (mg/L)	—	—	0.00018 U	—	—	0.0025 U	0.00018 U	0.00118 U	—	—	0.0025 U	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	0.00018 U	—	—	0.0025 U	0.00018 U	0.00018 U	—	—	0.0025 U	0.0025 U	0.005
Chloride (mg/L)	—	—	63.6	—	—	72.9	7.55	7.48	—	—	8.36	8.32	250
Chromium (mg/L)	—	—	0.0498	—	—	0.0741	0.00534	0.00528	—	—	0.0117	0.0117	0.1
Chromium-filtered (mg/L)	—	—	0.00508	—	—	0.0063	0.00491	0.00496	—	—	0.0045	0.0060	0.1
Coliform, fecal (colonies/100 mL)	—	—	—	Absent[h]	—	Absent[i]	Absent	Absent	—	—	Absent[i]	Absent[i]	NA
Coliform, total (colonies/100 mL)	—	—	—	Absent[h]	—	Absent[i]	Absent	Absent	—	—	Absent[i]	Absent[i]	1 col/100 mL
Copper (mg/L)	—	—	0.00268 U	—	—	0.0030	0.00098 U	0.00104 U	—	—	0.0027	0.0031	1.3
Copper-filtered (mg/L)	—	—	0.00170 U	—	—	0.0025 U	0.00051 U	0.00098 U	—	—	0.0025 U	0.0025 U	1.3
Fluoride (mg/L)	—	—	0.220	—	—	0.222	0.261	0.266	—	—	0.276	0.278	4
Iron (mg/L)	—	—	0.533[g]	—	—	0.884[g]	0.123	0.136 U	—	—	0.800[g]	0.781[g]	0.3
Iron-filtered (mg/L)	—	—	0.0670 U	—	—	0.145	0.0407 U	0.0417 U	—	—	0.0250 U	0.0250 U	0.3
Iron-filtered (mg/L)[j]	—	—	0.0565 U	—	—	—	0.0427 U	0.0416 U	—	—	—	—	0.3
Manganese (mg/L)	—	—	0.00479	—	—	0.0102	0.0257	0.0266	—	—	0.0356	0.0346	0.05
Manganese-filtered (mg/L)	—	—	0.00302	—	—	0.0050	0.0251	0.0241	—	—	0.0148	0.0157	0.05
Mercury (mg/L)	—	—	0.0000406 U	—	—	0.00020 U	0.0000406 U	0.0000406 U	—	—	0.00020 U	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	0.0000406 U	—	—	0.00020 U	0.0000777	0.0000406 U	—	—	0.00020 U	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	—	—	0.844	—	—	0.933[i]	0.318	0.307	—	—	0.262[i]	0.268[i]	10
Nitrite, as nitrogen (mg/L)	—	—	0.00 U	—	—	0.0500 U[i]	0.00 U	0.00 U	—	—	0.0500 U[i]	0.0500 U[i]	1
pH	—	—	7.88	8.02	7.85	8.03	7.77	7.77	7.84	7.84	8.03	8.03	6.5–8.5
Selenium (mg/L)	—	—	0.00104 U	—	—	0.00092	0.00118 U	0.00114 U	—	—	0.00065	0.00078	0.05
Selenium-filtered (mg/L)	—	—	0.00107 U	—	—	0.0012	0.00117 U	0.00097 U	—	—	0.00064	0.00066	0.05
Silver (mg/L)	—	—	0.00004 U	—	—	0.0025 U	0.00004 U	0.00004 U	—	—	0.0025 U	0.0025 U	0.1
Silver-filtered (mg/L)	—	—	0.00016 U	—	—	0.0025 U	0.00015 U	0.00004 U	—	—	0.0025 U	0.0025 U	0.1
Sodium (mg/L)	—	—	19.2	—	—	21.4	9.40	9.28	—	—	9.47	9.52	NA
Sodium-filtered (mg/L)	—	—	20.4	—	—	21.4	9.61	9.31	—	—	9.25	9.29	NA
Total dissolved solids (mg/L)	—	—	—	—	308	363[i]	—	—	197	190	198[i]	197[i]	500
Total Kjeldahl nitrogen (mg/L)	—	—	0.022 U	—	—	1.50	-0.138 U	-0.13 U	—	—	0.291	0.100 U	NA
Total phosphorus (mg/L)	—	—	0.016 U	—	—	0.0227	0.024	0.018 U	—	—	0.0510	0.0508	NA

a. Samples recollected because analytical laboratory failed to analyze April 2007 sample for total dissolved solids.
b. Duplicate sample.
c. 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.
d. ICPP-MON-A-167 was dry in April and October 2007 when permit-required sampling was performed, and the pump is located at the bottom of the well and cannot be lowered farther. Therefore, the well could not be sampled.
e. NA—Not applicable.
f. U flag indicates the result was below the detection limit.
g. Exceedance of primary constituent standard or secondary constituent standard. However, these exceedances are below the preoperational concentrations and are considered in compliance with the permit and the "Ground Water Quality Rule."
h. Samples recollected on 4/26/2007 due to shipping carrier problem.
i. Samples recollected on 10/3/2007 due to shipping carrier problem.
j. Extra iron sample collected in April 2007. Not required by the permit.

Table F-7 New Percolation Pond Groundwater Quality Data from Perched Water Wells for the October 2007 Reporting Year.

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)			
Sample Date	April 2007	October 2007	4/18/2007	10/3/2007	4/25/2007	5/10/2007[a]	10/1/2007	PCS/SCS[b]
Depth to water table (ft)	Dry[c]	Dry[c]	101.87	110.51	232.71	232.96	234.33	NA[d]
Water table elevation at brass cap (ft)	—	—	4,851.1	4,842.46	4,725.63	4,725.38	4,724.05	NA
Aluminum (mg/L)	—	—	0.0563 U	0.0250 U	**1.04**[e]	—	0.0250 U	0.2
Aluminum-filtered (mg/L)	—	—	0.0563 U	0.0250 U	0.0563 U	—	0.0250 U	0.2
Arsenic (mg/L)	—	—	0.00175 U	0.0050 U	0.00195 U	—	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	—	0.00136 U	0.0050 U	0.00165 U	—	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	—	—	0.798 U	2.0 U	1.28	—	2.0 U	NA
Cadmium (mg/L)	—	—	0.00021 U	0.0025 U	0.00021 U	—	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	0.00037	0.0025 U	0.00051	—	0.0025 U	0.005
Chloride (mg/L)	—	—	165	**253**[e]	131	—	179	250
Chromium (mg/L)	—	—	0.00365 U	0.0124	0.0181	—	0.0038	0.1
Chromium-filtered (mg/L)	—	—	0.00317 U	0.0064	0.00628	—	0.0038	0.1
Coliform, fecal (colonies/100 mL)	—	—	Absent	Absent	Absent	—	Absent	NA
Coliform, total (colonies/100 mL)	—	—	Absent	Absent	Absent	—	Absent	1 col/100 mL
Copper (mg/L)	—	—	0.00492	0.0029	0.00257	—	0.0025 U	1.3
Copper-filtered (mg/L)	—	—	0.00480	0.0025 U	0.00139	—	0.0025 U	1.3
Fluoride (mg/L)	—	—	0.278	0.291	0.242	—	0.227	4
Iron (mg/L)	—	—	0.0925	0.247	**1.19**[e]	—	0.0406	0.3
Iron-filtered (mg/L)	—	—	0.00729 U	0.117	0.00729 U	—	0.0250 U	0.3
Iron-filtered (mg/L)	—	—	0.00729 U	—	0.00729 U	—	—	0.3
Manganese (mg/L)	—	—	0.00230	0.0025 U	0.0201	—	0.0025 U	0.05
Manganese-filtered (mg/L)	—	—	0.00131 U	0.0025 U	0.00131 U	—	0.0025 U	0.05
Mercury (mg/L)	—	—	0.0000406 U	0.00020 U	0.0000406 U	—	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	0.0000406 U	0.00020 U	0.0000406 U	—	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	—	—	1.20	0.975	1.28	—	1.13	10
Nitrite, as nitrogen (mg/L)	—	—	0.00 U	0.185	0.00 U	—	0.113	1
pH	—	—	7.70	7.58	7.84	—	7.61	6.5–8.5
Selenium (mg/L)	—	—	0.00037 U	0.00080	0.00097	—	0.0013	0.05
Selenium-filtered (mg/L)	—	—	0.00037 U	0.0010	0.00037 U	—	0.0013	0.05
Silver (mg/L)	—	—	0.00004 U	0.0025 U	0.00004 U	—	0.0025 U	0.1
Silver-filtered (mg/L)	—	—	0.00004 U	0.0025 U	0.00004 U	—	0.0025 U	0.1
Sodium (mg/L)	—	—	97.2	144	56.4	—	67.2	NA
Sodium-filtered (mg/L)	—	—	94.2	144	55.0	—	67.1	NA
Total dissolved solids (mg/L)	—	—	**517**[e]	**626**[e]	—	**520**[e]	**618**[e]	500
Total Kjeldahl nitrogen (mg/L)	—	—	-0.069 U	0.426	-0.044 U	—	0.514	NA
Total phosphorous (mg/L)	—	—	0.078 U	0.0617	0.093	—	0.0185	NA

a. Samples recollected because analytical laboratory failed to analyze April 2007 sample for total dissolved solids.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.
c. ICPP-MON-V-191 is a perched well and was dry in April and October 2007.
d. NA—Not applicable.
e. **Bold** - Exceedance of groundwater quality standard.

Table F-8. Summary of TAN/TSF Sewage Treatment Facility Effluent Monitoring Results at TAN-655 (2007).[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.2430	0.0796
Arsenic (mg/L)	0.00125[c]	0.00370	0.00215
Barium (mg/L)	0.0830	0.1190	0.0959
Beryllium (mg/L)	0.00025[c]	0.00025[c]	0.00025[d]
Biochemical oxygen demand (5-day) (mg/L)	2.00	313.00	31.81
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	14.5	20.7	17.3
Chromium (mg/L)	0.00125[c]	0.00800	0.00328
Fecal coliform (colonies/100 mL)	0.5[c]	880.0	236.4
Fluoride (mg/L)	0.222	0.273	0.241
Iron (mg/L)	0.154	0.661	0.2735
Lead (mg/L)	0.0002[c]	0.0015	0.0005
Manganese (mg/L)	0.00125[c]	0.01220	0.00555
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrogen, as ammonia (mg/L)	0.0562	4.3700	1.7897
Nitrate+nitrite, as nitrogen (mg/L)	1.31	9.18	4.69
pH (standard units) (grab)	7.29	8.59	7.70
Total Kjeldahl nitrogen (mg/L)	0.749	5.690	2.764
Selenium (mg/L)	0.000990	0.00210	0.00134
Sodium (mg/L)	7.12	12.7	9.68
Sulfate (mg/L)	31.0	37.8	33.8
Total coliform (colonies/100 mL)	200	4,700	1,656
Total phosphorus (mg/L)	0.005[c]	1.640	0.916
Total dissolved solids (mg/L)	226	337	289.8
Total nitrogen[e] (mg/L)	2.059	12.52	7.451
Total suspended solids (mg/L)	2.0[c]	46.9	15.6
Zinc (mg/L)	0.0132	0.0727	0.0311

a. Duplicate samples were collected in March for all parameters (excluding total coliform and fecal 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.

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 F-9 Effluent Monitoring Results from Sewage Treatment Plant TAN-623 (2007).[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.0343	0.0198
Antimony (mg/L)	0.0003[c]	0.0003[c]	0.0003[d]
Arsenic (mg/L)	0.00125[c]	0.0037	0.0027
Barium (mg/L)	0.0856	0.0971	0.0905
Beryllium	0.00025[c]	0.00025[c]	0.00025[d]
Biochemical oxygen demand (5-day)	4.02	9.47	6.43
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	15.5	17.5	16.2
Chromium (mg/L)	0.00125[c]	0.00300	0.00183
Conductivity (µS/cm) (grab)	460	504	480
Copper (mg/L)	0.0025	0.0035	0.0030
Fluoride (mg/L)	0.224	0.240	0.232
Gross alpha (pCi/L ± 2s uncertainty)	2.51 ± 0.73	3.50 ± 2.58	2.58 ± 0.70
Gross beta (pCi/L ± 2s uncertainty)	3.95 ± 1.67	5.65 ± 1.10	4.96 ± 0.85
Iron (mg/L)	0.144	0.200	0.167
Lead (mg/L)	0.0002[c]	0.0002[c]	0.0002[d]
Manganese (mg/L)	0.00125[c]	0.00370	0.00252
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nickel (mg/L)	0.00125[c]	0.00125[c]	0.00125[d]
Nitrogen, as ammonia (mg/L)	1.53	3.82	2.68
Nitrate+nitrite, as nitrogen (mg/L)	3.04	5.91	4.59
pH (standard units) (grab)	7.71	7.87	7.78
Potassium-40 (pCi/L ± 2s uncertainty)	3.42 ± 31.4	105 ± 62.4	22.9 ± 22.4
Total Kjeldahl nitrogen (mg/L)	2.31	4.67	3.54
Selenium (mg/L)	0.001[c]	0.001[c]	0.001[d]
Silver (mg/L)	0.00125[c]	0.00125[c]	0.00125[d]
Sodium (mg/L)	9.61	10.60	10.02
Sulfate (mg/L)	32.3	32.8	32.5
Thallium (mg/L)	0.0002[c]	0.0002[c]	0.0002[d]
Total dissolved solids (mg/L)	276	290	284.3
Total nitrogen[e] (mg/L)	7.71	8.44	8.12
Total phosphorus (mg/L)	1.02	1.44	1.18
Total suspended solids (mg/L)	2.0[c]	5.2	30.5
Zinc (mg/L)	0.0151	0.0480	0.0305

a. Samples collected in January, February, and March 2007.

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. 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 F-10. TAN/TSF Groundwater Data for the 2007 Reporting Year.

	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	4/24/2007	5/8/2007[a]	10/9/2007	4/24/2007	4/24/2007[b]	5/8/2007[a]	5/8/2007[a,b]	10/9/2007	10/9/2007[b]	4/4/2007	5/7/2007[a]	10/17/2007	4/4/2007	5/8/2007[a]	10/29/2007	April 2007	Oct 2007	4/4/2007	5/8/2007[a]	10/29/2007	PCS/SCS[c]
Depth to water table (ft)	214.35	214.34	218.38	218.54	218.54	218.96	218.96	222.03	222.03	215.91	215.86	219.62	217.79	217.76	220.27	Dry[d]	Dry[d]	217.00	217.38	221.93	NA[e]
Water table elevation at brass cap (ft)	4,568.40	4,568.41	4,564.36	4,566.32	4,566.32	4,565.90	4,565.90	4,562.85	4,562.85	4,568.26	4,568.31	4,564.52	4,566.18	4,566.30	4,563.73	—	—	4,567.69	4,567.31	4,562.76	NA
Aluminum (mg/L)	0.0563 U[f]	—	0.0737	0.182 U	0.0641	—	—	**0.203**[g]	0.0534	0.157 U	—	0.0250 U	0.121 U	—	0.0250 U	—	—	0.142 U	—	0.0025 U	0.2
Ammonia-nitrogen (mg/L)	-0.06 U	—	0.050 U	-0.074 U	-0.037 U	—	—	0.050 U	0.050 U	-0.10 U	—	0.050 U	-0.045 U	—	0.050 U	—	—	-0.19 U	—	0.050 U	NA
Arsenic (mg/L)	0.0025	—	0.0050 U	0.0023	0.0024	—	—	0.0050 U	0.00050 U	0.0014 U	—	0.0050 U	0.0024 U	—	0.0050 U	—	—	0.0023 U	—	0.0050 U	0.05
Barium (mg/L)	0.0703	—	0.0798	0.0675	0.0650	—	—	0.0761	0.0744	0.301	—	0.302	0.0702	—	0.0686	—	—	0.0828	—	0.0796	2
Beryllium (mg/L)	0.00004 U	—	0.0025 U	0.00004 U	0.00004 U	—	—	0.0025 U	0.0025 U	0.00014 U	—	0.0025 U	0.00004 U		0.0025 U	—	—	0.00004 U	—	0.0025 U	0.004
Biochemical oxygen demand (mg/L)	3.11	—	2.0 U	64.1	4.78	—	—	2.0 U	2.0 U	0.00975 U	—	2.00 U	0.820 U	—	2.00 U	—	—	2.39	—	2.00 U	NA
Cadmium (mg/L)	0.00021 U	—	0.0025 U	0.00026	0.00021 U	—	—	0.0025 U	0.0025 U	0.0003 U	—	0.0025 U	0.0002 U	—	0.0025 U	—	—	0.0003 U	—	0.0025 U	0.005
Chloride (mg/L)	11.4	—	11.8	3.46	0.00 U	—	—	3.73	3.71	120	—	126	3.04	—	3.20	—	—	5.34	—	5.55	250
Chromium (mg/L)	0.0047	—	0.0063	0.0066	0.0061	—	—	0.0098	0.0082	0.0010 U	—	0.0025 U	0.0055	—	0.0044	—	—	0.0071	—	0.0059	0.1
Coliform, fecal (colonies/100 mL)	Absent	—	Absent	Absent	Absent	—	—	Absent	Absent	Absent	—	Absent	Absent	—	Absent	—	—	Absent	—	Absent	NA
Coliform, total (colonies/100 mL)	Absent	—	Absent	Absent	Absent	—	—	Absent	Absent	Absent	—	**28.0**[g]	Absent	—	Absent	—	—	Absent	—	Absent	1 col/100 mL
Fluoride (mg/L)	0.276	—	0.259	0.269	0.00 U	—	—	0.251	0.249	0.209	—	0.193	0.238	—	0.236	—	—	0.242	—	0.243	4
Iron (mg/L)	0.0426 U	—	0.213	0.132 U	0.119	—	—	**0.320**[g]	0.164	2.86[h]	—	3.56[h]	0.0679 U	—	0.110	—	—	0.197 U	—	0.108	0.3
Iron-filtered (mg/L)	0.00729 U	—	0.0921	0.00993	0.00729 U	—	—	0.0709	0.0808	2.89[h]	—	3.46[h]	0.0601 U	—	0.0766	—	—	0.236 U	—	0.0917	0.3
Iron-filtered (mg/L)	0.00729 U	—	—	0.00729 U	0.00729 U	—	—	—	—	2.70[h]	—	—	0.0424 U	—	—	—	—	0.0447 U	—	—	0.3
Lead (mg/L)	0.00005 U	—	0.00039	0.00020	0.00016	—	—	0.00046	0.00025 U	0.00015 U	—	0.00025 U	0.00007 U	—	0.00025 U	—	—	0.00036	—	0.00025 U	0.015
Manganese (mg/L)	0.00131 U	—	0.0034	0.00460	0.00717	—	—	0.0105	0.0025 U	**0.926**[g]	—	**0.960**[g]	0.00264	—	0.0031	—	—	0.00182	—	0.0025 U	0.05
Mercury (mg/L)	0.0000406 U	—	0.00020 U	0.0000406 U	0.0000406 U	—	—	0.00020 U	0.00020 U	0.0000406 U	—	0.00020 U	0.0000406 U	—	0.00020 U	—	—	0.0000406 U	—	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	0.875	—	0.888	0.562	0.570	—	—	0.565	0.565	0.00 U	—	0.050 U	0.414	—	0.418	—	—	0.668	—	0.630	10
Nitrite, as nitrogen (mg/L)	0.00 U	—	0.0500 U	0.00 U	0.00 U	—	—	0.0500 U	0.0500 U	0.00 U	—	0.050 U	0.00 U	—	0.050 U	—	—	0.00 U	—	0.050 U	1
pH	8.12	7.85	7.85	7.96	7.96	7.73	7.73	7.66	7.66	7.52	7.66	7.73	7.68	7.74	7.91	—	—	8.08	7.90	8.24	6.5–8.5
Selenium (mg/L)	0.0005	—	0.0019	0.0005	0.0004 U	—	—	0.0014	0.0015	0.0004 U	—	0.0020 U	0.0004 U	—	0.0014	—	—	0.0009 U	—	0.0019	0.05
Sodium (mg/L)	6.65	—	7.27	5.54	6.39	—	—	6.03	5.96	56.1	—	55.7	6.02	—	5.22	—	—	6.22	—	5.81	NA
Sulfate (mg/L)	32.0	—	31.0	14.2	0.00 U	—	—	14.5	14.6	37.6	—	37.1	13.8	—	14.9	—	—	15.6	—	23.6	250
Total dissolved solids (mg/L)	—	239	240	—	—	200	193	203	200	—	**537**[g]	**575**[g]	—	191	179	—	—	—	200	199	500
Total Kjeldahl nitrogen (mg/L)	0.042	—	0.486	-0.051 U	-0.041 U	—	—	0.128	0.241	0.030	—	0.539	-0.082 U	—	0.191	—	—	-0.174 U	—	0.484	NA
Total phosphorous (mg/L)	0.074	—	0.0389	0.064	0.066	—	—	0.0351	0.0327	0.051	—	0.0690	0.014 U	—	0.0230	—	—	0.035	—	0.0372	NA
Zinc (mg/L)	0.0290 U	—	0.400	0.0896 U	0.0843	—	—	0.163	0.102	0.0412	—	0.0285	0.0726	—	0.0558	—	—	0.0920	—	0.0214	5

a. Samples recollected because analytical laboratory failed to analyze April 2007 sample for total dissolved solids.
b. Duplicate sample.
c. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11. d. Well TSFAG-05 was dry in April and October 2007.
e. NA—Not applicable.
f. U flag indicates the result was below the detection limit.
g. **Bold** text indicates exceedance of primary constituent standard or secondary constituent standard.
h. Iron concentrations in Well TAN-10A are exempt from the limit, and therefore, these exceedances do not represent permit noncompliances.

Table F-11. Summary of CFA Liquid Influent and Effluent Surveillance Monitoring Results (2007).[a,b,c]

Parameter	Minimum	Maximum	Median[c]
Influent to CFA Sewage Treatment Plant			
Conductivity (µS/cm) (grab)	529	1404	935
Total Phosphorus	0.01 U[d]	3.65	2.69
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System			
Conductivity (µS/cm) (grab)	1645	1790	Not calculated
Chloride[e]	422	422	Not calculated
Fluoride[e]	0.582	0.585	Not calculated
Sulfate[e]	73.2	74.1	Not calculated
Aluminum[e]	0.025 U	0.0371	Not calculated
Antimony	0.0003	0.0003	Not calculated
Arsenic[e]	0.0043	0.0047	Not calculated
Barium[e]	0.0262	0.0282	Not calculated
Copper[e]	0.0083	0.009	Not calculated
Iron[e]	0.152	0.167	Not calculated
Selenium[e]	1.6	1.7	Not calculated
Sodium[e]	182	182	Not calculated
Gross beta[e,f]	4.23 ± 1.09	4.46 ± 0.577	Not calculated
Tritium[e,f]	4540 ± 481	4660 ± 492	Not calculated
Iodine-129[e,f]	0 ± 0.0404 U	0.235 ± 0.0269	Not calculated

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. Annual median was calculated using the average of the duplicate samples.
d. U flag indicates the result was below the detection limit.
e. Parameter was only analyzed for in the original and duplicate samples collected in August,; therefore, the median was not calculated.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Table F-12. INTEC Liquid Influent and Effluent Surveillance Monitoring Results (2007).

Parameter[a]	Minimum	Maximum	Average[b]
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	673	2,170	1,055
pH (standard units) (grab)	8.00	8.86	8.50
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	502	998	769.6
Gross alpha (pCi/L ± 2s uncertainty)	0.32 ± 1.58[c]	1.21 ± 0.83	1.02 ± 0.73
Gross beta (pCi/L ± 2s uncertainty)	9.86 ± 2.66	19.5 ± 3.02	14.1 ± 2.00
pH (standard units) (composite)	8.36	9.25	8.62
Effluent to INTEC New Percolation Ponds (CPP-797)			
Gross alpha (pCi/L ± 2s uncertainty)	-0.56 ± 2.77[c]	38.1 ± 7.50	5.08 ± 1.13
Gross beta (pCi/L ± 2s uncertainty)	1.02 ± 5.48[c]	48.3 ± 7.34	23.9 ± 2.02
U-234 (pCi/L ± 2s uncertainty)	1.59 ± 0.72[c]	1.59 ± 0.72	1.59 ± 0.72
U-238 (pCi/L ± 2s uncertainty	0.50 ± 0.37[c]	0.50 ± 0.37	0.50 ± 0.37

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 F-13. Summary of Analytical Results for Samples Collected from MFC Industrial Waste Pond (2007).[a,b]

Parameter	Minimum	Maximum	Median[c]
Aluminum[d]	2.72	2.72	Not calculated
Arsenic[d]	0.086	0.086	Not calculated
Barium[d]	0.103	0.103	Not calculated
Biochemical oxygen demand (5-Day)	2 U[e]	6.32	2 U
Chloride	44.7	136	74
Chromium[d]	0.0645	0.0645	Not calculated
Conductivity (µS/cm)	445	773.9	570
Copper	0.0128	0.0128	Not calculated
Fluoride	0.404	0.835	0.671
Iron	0.056	2.97	1.14
Lead[d]	0.0024	0.0024	Not calculated
Nickel[d]	0.0044	0.0044	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.0122	2.83	0.6415
Nitrogen, total Kjeldahl	0.43	1.94	1.21
pH (standard units)	7.19	9.03	8.04
Selenium[d]	0.0011	0.0011	Not calculated
Sodium	34.2	65.8	44.1
Sulfate	17.1	70.55	30.5
Total dissolved solids	294	504	343
Total phosphorus	0.01 U	0.475	0.247
Total suspended solids	4 U	75.4	18.7
Zinc[d]	0.0472	0.0472	Not calculated
Gross alpha[f]	1.5 ± 1.05 U	10.7 ± 2.46	Not calculated
Gross beta[f]	4.69 ± 1.19	55.4 ± 5.15	Not calculated
Tritium[f]	-68.8 ± 107 U	795 ± 130	Not calculated
Plutonium-241[d,f]	9.47 ± 2.64	9.47 ± 2.64	Not calculated
Uranium-233/234[d,f]	3.62 ± 0.351	3.62 ± 0.351	Not calculated
Uranium-238[d,f]	1.31 ± 0.165	1.31 ± 0.165	Not calculated

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. Annual median was calculated using the average result of the duplicate samples.
d. Parameter was analyzed in July only; therefore, the minimum and maximum are the same.
e. U flag indicates the result was below the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Table F-14. Summary of Analytical Results for Samples Collected from the MFC Industrial Waste Ditch (2007).[a,b]

Parameter	Minimum	Maximum	Median[c]
Arsenic[d]	0.0031	0.0036	Not calculated
Barium[d]	0.039	0.0392	Not calculated
Biochemical oxygen demand (5-Day)	2 U[e]	17.5	2 U
Chloride	44.1	132	66.8
Conductivity (µS/cm)	335	756.4	543.4
Copper[d]	0.0164	0.017	Not calculated
Fluoride	0.59	0.746	0.664
Iron	0.025 U	1.55	0.136
Lead[d]	0.00044	0.00048	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	1.58	2.32	1.96
Nitrogen, total Kjeldahl	0.171	1.49	0.367
pH (standard units)	6.97	8.38	7.71
Sodium	33	76.9	47.125
Sulfate	17.1	70.55	30.5
Total dissolved solids	299	481	343
Total phosphorus	0.01 U	0.596	0.277
Total suspended solids	4 U	5.6	4 U
Zinc[d]	0.0186	0.0197	Not calculated
Gross alpha[f]	0.566 ± 0.635 U	7.8 ± 2.17	Not calculated
Gross beta[f]	1.39 ± 1.15 U	23.5 ± 2.67	Not calculated
Tritium[f]	-68.8 ± 107 U	795 ± 130	Not calculated
Silver-108m[d,f]	-2.11 ± 1.74 U	4.18 ± 1.22	Not calculated
Uranium-233/234[d,f]	1.43 ± 0.158	1.63 ± 0.193	Not calculated
Uranium-238[d,f]	0.614 ± 0.0918	0.713 ± 0.111	Not calculated

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. Annual median was calculated using the average result of the duplicate samples.
d. Parameter was only analyzed in the original and duplicate samples collected in July.
e. U flag indicates the result was below the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Table F-15. Summary of Analytical Results for Samples Collected from the MFC Secondary Sanitary Lagoon (2007).[a,b]

Parameter	Minimum	Maximum	Median[c]
Arsenic[d]	0.0037	0.0037	Not calculated
Barium[d]	0.0211	0.0211	Not calculated
Biochemical oxygen demand (5-Day)	11	132	56.3
Chloride	110	350	198.5
Conductivity (µS/cm)	938	1934	1457.5
Copper[d]	0.0027	0.0027	Not calculated
Fluoride	0.1 U[e]	0.435	0.225
Iron	0.0502	0.485	0.195
Lead[d]	0.00038	0.0038	Not calculated
Manganese[d]	0.0049	0.0049	Not calculated
Nickel[d]	0.0037	0.0037	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.0125	1.04	0.27
Nitrogen, total Kjeldahl	16.2	71.8	29.25
pH (standard units)	6.98	9.84	8.4
Selenium[d]	0.0013	0.0013	Not calculated
Sodium	86.3	272	197
Sulfate	37.9	91.6	71.3
Total dissolved solids	559	1310	1065
Total phosphorus	0.027	15.8	8.035
Total suspended solids	17.2	195	44.75
Zinc[d]	0.0059	0.0059	Not calculated
Gross alpha[f]	-0.773 ± 0.526 U	5.99 ± 1.86	Not calculated
Gross beta[f]	12 ± 1.49	90 ± 6.48	Not calculated
Tritium[f]	309 ± 116 U	1760 ± 143	Not calculated
Potassium-40[f]	0 ± 24.6 U	163 ± 37.2	Not calculated
Uranium-233/234[d,f]	0.246 ± 0.0512	0.246 ± 0.0512	Not calculated
Uranium-238[d,f]	0.123 ± 0.0351	0.123 ± 0.0351	Not calculated

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. Annual median was calculated using the average result of the duplicate samples.
d. Parameter was only analyzed in July; therefore the minimum and maximum are the same.
e. U flag indicates the result was below the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Table F-16. Summary of TAN/TSF Liquid Effluent Surveillance Monitoring Results (2007).

Parameter[a]	Minimum	Maximum	Average[b]
Conductivity (µS/cm) (grab)	422	622	481.8
Copper (mg/L)	0.0014	0.0163	0.0058
Gross alpha (pCi/L ± 2s)	1.23 ± 1.76[c]	5.04 ± 3.02	2.13 ± 1.00
Gross beta (pCi/L ± 2s)	4.14 ± 2.68	12.1 ± 4.18	6.53 ± 1.33
Nickel (mg/L)	0.00125[d]	0.00125[d]	0.00125[e]
Strontium-90 (pCi/L ± 2s)	-0.20 ± 0.25	1.39 ± 0.61	-0.00 ± 0.10

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.

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 limits from each of the monthly values.

Table F-17. Summary of Analytical Results for Samples Collected from the RTC Cold Waste Pond (2007).[a,b]

Parameter	Minimum	Maximum	Median[c]
Aluminum	0.025 U[d]	0.025 U	0.025 U
Antimony	0.00025 U	0.000995[e]	0.00025 U
Arsenic	0.0025 U	0.0064	0.003475
Barium	0.0479	0.157	0.0509
Chloride	10.4	38.6	11.35
Chromium	0.0025 U	0.0092	0.00315
Conductivity (µS/cm)	400.2	1336	451.2
Copper	0.0013	0.0083	0.00275
Fluoride	0.167	0.456	0.2135
Iron	0.025 U	0.311	0.1185
Lead	0.00025 U	0.00084	0.00025 U
Manganese	0.0025 U	0.0037	0.0025 U
Nitrogen, nitrate + nitrite (mg-N/L)	0.902	3.58	1.005
Nitrogen, total Kjeldahl	0.1 U	0.524	0.2355
pH (standard units)	6.74	7.97	7.475
Selenium	0.001	0.0046	0.0011
Sodium	7.91	33.1	8.925
Sulfate	22.7	595	30.4
Total dissolved solids	237	1110	271
Zinc[d]	0.0025 U	0.0047	0.0025 U
Gross alpha[f]	1.865 ± 1.43 U	7.2 ± 2.26	Not calculated
Gross beta[f]	0.0952 ± 1.09 U	19.7 ± 2.76	Not calculated
Strontium-90[f]	-0.846 ± 0.224 U	1.29 ± 0.222	Not calculated

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. Annual median was calculated using the average result of the duplicate samples.
d. U flag indicates the result was below the detection limit.
e. Average of duplicate samples.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Townsend's Ground Squirrel

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.

Liliaceae Calonchortus Macrocarpus
Sagebrush Mariposa Lily

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