DOE/ID-12082(05)

ISSN 1089-5469
STOLLER-ESER-97

Idaho National Laboratory
Site Environmental Report
Calendar Year 2005

Environmental Surveillance, Education and Research Program

U.S. Department of Energy Idaho Operations Office

October 2006

This report was prepared for the
U.S. Department of Energy Idaho Operations Office
Under Contract DE-AC07-06ID14680
By the S. M. Stoller Corporation
Environmental Surveillance, Education and Research Program
1780 First Street
Idaho Falls, ID 83401

ACKNOWLEDGMENTS

The following people with the current Environmental Surveillance, Education and Research (ESER) contractor (S. M. Stoller Corporation) have provided primary authorship of portions of this report: Marilyn Case, Russell Mitchell and Roger Blew.

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:

- Mark Arenaz, Jack Depperschmidt, Betsy Jonker, Richard Kauffman, John Medema, Don Rasch, Tim Safford, Bob Starck, Bob Stump, Jerry Wells, Stephanie Woolf, Brian Edgerton, Shannon Brennan, Keith Lockie, Brett Bowhan, Dave Wessman, Kathleen Hain, Nolan Jensen, Richard Kimmel, Michael O'Hagan, Donald Rasch, and Jim Cooper with the U.S. Department of Energy (DOE) Idaho Operations Office;
- Leroy Knobel, Linda Davis and Betty Tucker with the U.S. Geological Survey;
- Neil Hukari, Kirk Clawson and Richard Eckman of the National Oceanic and Atmospheric Administration;
- Ron Brown, Mark Hutchinson, Shane Lowry, Jerry Knowles, and Kelly Willie of Bechtel Bettis Inc.;
- Brad Andersen, Mark Verdoorn, Robert P. Breckenridge, and Jeff Einerson with Battelle Energy Alliance;
- Dennis McBride, Erick Neher, and Roger Wilhelmsen, with CH2M-WG Idaho;
- Christopher Jenkins, Charles R. Peterson, Scott Cambrin, and Denim Jochimsen, with the Idaho State University;
- Maxine Dakins, University of Idaho.
- Robert Westra with the Washington State University;
- Mike Jaeger and Mike Ebinger with the Utah State University;
- Mike Pellant with the Idaho State Office of the Bureau of Land Management; and
- Alana Jensen, Brande Hendricks, Chris Vilord, Doug Halford, Amy Forman, Greg Studley, Sue White, and Wendy Purrington of the S. M. Stoller Corporation.





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 2005 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 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 conducted effluent and facility monitoring, as well as sitewide environmental surveillance on the INL. The cleanup operations, called the Idaho Cleanup Project (ICP), were managed separately by CH2M-WG Idaho (CWI). CWI performed environmental monitoring at and around waste management facilities involved in the ICP. The Environmental Surveillance, Education, and Research Program, managed by S. M. Stoller Corporation, performed 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 at the Radioactive Waste Management Complex, 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), 5400.5 (DOE 1993), and 414.1c (DOE 2005). 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 (BBI 2005).

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 (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), 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

M. Case - S. M. Stoller Corporation

Approximately 8000 people work at the INL Site, making it the largest employer in eastern Idaho and one of the top five employers in the State. The INL Site has a tremendous economic impact on eastern Idaho. The INL Site infuses more than $750 million dollars to the Idaho economy.

This Site Environmental Report summarizes environmental data, information, and regulations, and highlights major environmental programs and efforts during calendar year 2005 at the Idaho National Laboratory (INL) Site. The report is published annually in compliance with DOE Order 231.1A, Environment, Safety and Health Reporting (DOE 2004).

Calendar Year 2005 began with a series of major changes for the Idaho Site. February 1, 2005 marked a major milestone for the Site when the Idaho National Engineering and Environmental Laboratory was merged with Argonne National Laboratory-West to form the Idaho National Laboratory or INL. The newly-formed INL focuses on research and development missions in nuclear and national security programs. The Battelle Energy Alliance (BEA) was selected as the management and operations (M&O) contractor for the INL. Ongoing cleanup operations are now managed under a separate program called the Idaho Cleanup Project or ICP. In 2005, CH2M-WG Idaho, LLC (CWI) was selected to manage the ICP. Finally, management of the Advanced Mixed Waste Treatment Project was transferred from BNFL, Inc. to Bechtel BWXT Idaho, LLC.

Other contractors at the INL Site include Bechtel BWXT Idaho, LLC, which operates the Advanced Mixed Waste Treatment Project (AMWTP), and Bechtel Bettis, Inc., which manages the Naval Reactors Facility.

Environmental Program Information

Many environmental programs help implement the environmental compliance policy for the INL Site. Most of the regulatory compliance activity is performed through environmental monitoring programs, the signed Accelerated Cleanup Agreement, the Environmental Restoration Program, and the Waste Management Program.

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 2005, Battelle Energy Alliance (BEA) and CH2M-WG Idaho (CWI) had primary responsibility for environmental monitoring at the INL Site. The Environmental Surveillance,



Education and Research Program contractor, which was a team led by the S. M. Stoller Corporation, was 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 and beta activity, and specific radionuclides, such as tritium, strontium-90 (^{90}Sr), and plutonium isotopes.

The ICP continued progress during 2005 toward final cleanup of contaminated sites at the INL Sites. Examples of significant accomplishments during 2005 are:

- Cleanup activities at Waste Area Group 5 are complete;
- Over 7440 m^2 (80,082 ft^2) of buildings and structures were demolished;
- Approximately 6535 m^3 (230,780 ft^3) of legacy and newly generated waste was disposed in the Subsurface Disposal Area;
- The first shipment of treated transuranic waste was shipped to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico;
- The Transuranic Waste Program shipped a total 4267 m^3 (150,688 ft^3) transuranic waste to the WIPP.
- All scheduled Site Treatment Plan milestones were achieved.

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. The ICP contractor focuses on environmental surveillance of waste management facilities. The ESER contractor samples ambient air at locations within, around, and distant from the INL Site.

An estimated total of 6614 Ci of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2005. 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 well below regulatory standards and most were within historical measurements.

Nonradiological pollutants, including particulates, were monitored at select locations around the INL Site. All results were well 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 monitor 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 Land Application Permit [WLAP] requirements). The ESER contractor monitors drinking water and surface water at offsite locations.

During 2005, liquid effluent and groundwater monitoring were conducted in support of WLAP requirements for INL Site facilities that generate liquid waste streams covered under WLAP rules. The WLAPs 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 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 2005. Several high concentrations of metals were detected in samples taken from both aquifer and perched water wells associated with the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds. Further evaluation indicated that the elevated levels were below preoperational upgradient concentrations and were thus considered in compliance with the permit and Ground Water Quality Rule.

In January and February 2005, monthly total suspended solids (TSS) in the Technical Area North (TAN)/Technical Support Facility (TSF) Sewage Treatment Facility exceeded the permit limit of 100 mg/L. It was determined that the sanitary drain line from a former building was inadvertently filled with debris when the building was demolished in 2003. The debris was pushed downgradient when trailers were moved into the area and connected to the sanitary system in 2004. The lines were cleaned and TSS levels returned to levels well below the permit limit.

In 2005, total coliform bacteria was detected at the Main Gate, Experimental Breeder Reactor No. 1, and the Gun Range. Trichloroethylene (TCE) concentrations in the Radiactive Waste Management Complex (RWMC) public water system remain below EPA limits. TCE levels in drinking water from the TAN drinking water well remained below the EPA limit.

A maximum effective dose equivalent of 0.5 mrem/year (5.0 µSv/year), less than the 4 mrem/year (40 µSv/year) EPA standard for public drinking water systems, was calculated for workers at the Central Facilities Area on the INL Site in 2005.

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

Results from a number of special studies conducted by the USGS of the properties of the aquifer were published during 2005. 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 as well as EPA maximum contaminant levels (MCLs) for these compounds.



Groundwater surveillance monitoring continued for the Waste Area Groups on the INL Site in 2005. At TAN, a 24-month test was initiated to evaluate the effectiveness of the New Pump and Treat Facility in remediation of the a portion of the plume of TCE. Chromium was above the MCL in two wells at the Reactor Technology Complex. Monitoring at Central Facilities Area landfills detected nitrate and chromium levels above their respective MCLs. At the INTEC, four constituents exceeded their MCLs, but concentrations of most radionuclides are decreasing over time. Monitoring at the RWMC indicated some elevated concentrations of carbon tetrachloride near and sometimes in excess of the MCL.

Semiannual drinking water samples were collected from 14 locations off the INL Site and around the Snake River Plain in 2005. Eight samples had measurable tritium, and 19 samples had measurable gross beta activity. None of the samples exceeded the EPA MCL for these constituents.

Twelve offsite surface water samples were collected from five locations along the Snake River. No sample had measurable gross alpha activity. Most samples had measurable gross beta activity, while only two samples had measurable tritium. None of these constituents were above regulatory limits.

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, wheat, potatoes, and sheep), wildlife, and soil were sampled and analyzed for radionuclides. In addition, direct radiation was measured on and off the INL Site in 2005.

Some human-made radionuclides were detected in agricultural product, wildlife, and soil samples. For the most part, the results could not be directly linked to operations at the INL Site.

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 (CAP-88) computer code and the mesoscale diffusion (MDIFF) air dispersion model. CAP-88 is required by the EPA to demonstrate compliance with the Clean Air Act. The NOAA Air Resources Laboratory-Field Research Division developed MDIFF to evaluate dispersion of pollutants in arid environments such as those found at the INL Site. The maximum calculated dose to an individual by either of the methods was well below the applicable radiation protection standard of 10 mrem/year. The dose to the maximally exposed individual, as determined by the CAP-88 program, was 0.077 mrem (0.77 μSv). The dose calculated by the MDIFF program was 0.041 mrem (0.41 μSv). The dose from natural background radiation was estimated to be 0.358 mrem (3.6 μSv). The maximum potential population dose to the approximately 281,495 people residing within an 80-km (50-mi) radius of any INL facility was 0.565 person-rem



(5.7 x 10^{-3} person-Sv), well below that expected from exposure to background radiation (102,429 person-rem or 1024 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 0.19 mrem (1.9 μSv), and 0.005 mrem (0.05 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 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 2005:

- Survival rates of rattlesnakes in southeastern Idaho;
- Fine-scale movement patterns of coyotes (*Canis latrans*) on the INL Site in Idaho;
- Seasonal and landscape variation of snake mortality on the Upper Snake River Plain;
- The Protective Cap/Biobarrier Experiment;
- Spatial pattern of species diversity; and
- Employing unmanned aerial vehicles for monitoring habitat and species in sagebrush-steppe ecosystems.



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.

HELPFUL INFORMATION

Scientific Notation

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

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

Unit Prefixes

Units for very small and very large numbers are often expressed with a prefix. One common example is the prefix kilo (abbreviated k), which means 1000 of a given unit. One kilometer is, therefore, equal to 1000 meters. Table HI-1 shows fractions and multiples of units

Table HI-1. Fractions and Multiples of Units.

Multiple	Decimal Equivalent	Prefix	Symbol
10^{6}	1,000,000	mega-	M
10^{3}	1,000	kilo-	k
10^{2}	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	μ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.00000000000000001	atto-	a



Units of Radioactivity, Radiation Exposure, and Dose

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

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

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

The Système International is also used to express units of radioactivity and radiation dose. The basic unit of radioactivity is the Becquerel (Bq), which is equivalent to one nuclear disintegration per second. The number of curies must be multiplied by 3.7×10^{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 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.



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

Radionuclide	Symbol	Radionuclide	Symbol
Actinium-228	^{228}Ac	Neptunium-239	^{239}Np
Americium-241	^{241}Am	Nickel-59	^{59}Ni
Americium-243	^{243}Am	Nickel-63	^{63}Ni
Antimony-124	^{124}Sb	Niobium-94	^{94}Nb
Antimony-125	^{125}Sb	Niobium-95	^{95}Nb
Antimony-127	^{127}Sb	Potassium-40	^{40}K
Argon-41	^{41}Ar	Plutonium-238	^{238}Pu
Barium-133	^{133}Ba	Plutonium-239	^{239}Pu
Barium-137	^{137}Ba	Plutonium-239/240	$^{239/240}Pu$
Barium-139	^{139}Ba	Plutonium-240	^{240}Pu
Barium-140	^{140}Ba	Plutonium-241	^{241}Pu
Barium-141	^{141}Ba	Plutonium-242	^{242}Pu
Beryllium-7	^{7}Be	Praseodymium-144	^{144}Pr
Bismuth-214	^{214}Bi	Promethium-147	^{147}Pm
Carbon-14	^{14}C	Radium-226	^{226}Ra
Cerium-141	^{141}Ce	Radium-228	^{228}Ra
Cerium-144	^{144}Ce	Rubidium-88	^{88}Rb
Cesium-134	^{134}Cs	Rubidium-88d	^{88d}Rb
Cesium-137	^{137}Cs	Rubidium-89	^{89}Rb
Cesium-138	^{138}Cs	Ruthenium-103	^{103}Ru
Chromium-51	^{51}Cr	Ruthenium-106	^{106}Ru
Cobalt-58	^{58}Co	Samarium-151	^{151}Sm
Cobalt-60	^{60}Co	Scandium-46	^{46}Sc
Curium-242	^{242}Cm	Silver-110m	^{100m}Ag
Curium-244	^{244}Cm	Sodium-24	^{24}Na
Europium-152	^{152}Eu	Strontium-89	^{89}Sr
Europium-154	^{154}Eu	Strontium-90	^{90}Sr
Hafnium-181	^{181}Hf	Technetium-99	^{99}Tc
Tritium	^{3}H	Technetium-99m	^{99m}Tc
Iodine-125	^{125}I	Tellurium-125m	^{125m}Te
Iodine-129	^{129}I	Thorium-228	^{228}Th
Iodine-131	^{131}I	Thorium-230	^{230}Th
Iodine-132	^{132}I	Thorium-232	^{232}Th
Iodine-133	^{133}I	Tungsten-187	^{187}W
Iodine-134	^{134}I	Uranium-232	^{232}U
Iodine-135	^{135}I	Uranium-233	^{233}U
Iridium-192	^{192}Ir	Uranium-233/234	$^{233/234}U$
Iron-55	^{55}Fe	Uranium-234	^{234}U
Iron-59	^{59}Fe	Uranium-235	^{235}U
Krypton-85	^{85}Kr	Uranium-235/236	$^{235/236}U$
Krypton-85m	^{85m}Kr	Uranium-238	^{238}U
Krypton-87	^{87}Kr	Xenon-133	^{133}Xe
Krypton-88	^{88}Kr	Xenon-135m	^{135m}Xe
Lanthanum-140	^{140}La	Xenon-138	^{138}Xe
Lead-212	^{212}Pb	Yttrium-90	^{90}Y
Lead-214	^{214}Pb	Yttrium-91	^{91}Y
Manganese-54	^{54}Mn	Zinc-65	^{65}Zn
Mercury-203	^{203}Hg	Zirconium-95	^{95}Zr
Molybdenum-99	^{99}Mo		
Neptunium-237	^{237}Np		

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



ACRONYMS

AAO	Argonne Area Office (DOE-CH)
AEC	U.S. Atomic Energy Commission
AGL	Above Ground Level
AIC	Akaike's Information Criterion
AMWTP	Advanced Mixed Waste Treatment Project
ANL-W	Argonne National Laboratory-West
ANOVA	Analysis of Variance
ARA	Auxiliary Reactor Area
ARP	Accelerated Retrieval Project
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
BBI	Bechtel Bettis, Inc.
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
BEA	Battelle Energy Alliance
BLM	U.S. Bureau of Land Management
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
CAP-88	Clean Air Act Assessment Package, 1988
CERCLA	Comprehansive Environmental Response, Compensation, and Liability Act
CERT	Controlled Environmental Radioiodine Test
CES	Cascade Earth Science
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC/PBF	Critical Infrastructure Test Range Complex/Power Burst Facility



CMS	Community Monitoring Station
COD	Chemical Oxygen Demand
CRMP	Cultural Resource Management Plan
CTF	Contained Test Facility
CWA	Clean Water Act
CWI	CH2M-WG Idaho
DCE	dichloroethene
DCG	Derived Concentration Guide
DD&D	Decontamination, Decommissioning, and Demolition
DEQ	Department of Environmental Quality (state of Idaho)
DNA	Deoxyribonucleic Acid
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy - Headquarters
DOE-ID	U.S. Department of Energy - Idaho Operations Office
DOR	Dead on Road
EA	Environmental Assessment
EAL	Environmental Assessment Laboratory
EBR-I	Experimental Breeder Reactor - No. 1
ECF	Expended Core Facility
ECG	Environmental Concentration Guide
ECM	Electrical Conductivity Measurements
EDE	Effective Dose Equivalent
EDF	Experimental Dairy Farm
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
ERAMS	Environmental Radiation Ambient Monitoring System
ESER	Environmental Surveillance, Education, and Research
ESRPA	Eastern Snake River Plain Aquifer
ESRP	Eastern Snake River Plain
ET	Evapotranspiration
FAST	Fluorinel Dissolution Process and Fuel Storage Facility
FD	Facilities Disposition
FEIS	Final Environmental Impact Statement
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Regulations
FY	Fiscal Year
GAC	Granular Activated Carbon
GEL	General Engineering Laboratories
GEM	Glovebox Excavator Method
GIS	Geographic Information System
GPS	Global Positioning System
HAER	Historic American Engineering Record
HDR	Hydrogeological Data Repository
HLW	High-level Waste
HPIC	High Pressure Ionization Chamber
ICDF	INL CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IFF	Idaho Falls Facilities
IFSF	Irradiated Fuel Storage Facility
IMPROVE	Interagency Monitoring of Protected Visual Environments
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory



INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRA	Interim Risk Assessment
IRC	INL Research Center
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
ISU	Idaho State University
keV	Kilo-electron Volts
LDRD	Laboratory Directed Research and Development
LFR	Live Fire Range
LMWL	Local Meteoric Water Line
LOFT	Loss-of-Fluid Test
LTS	Long-Term Stewardship
M&O	Management and Operating
Ma	Million years before present
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MFC	Materials and Fuels Complex
MNA	Monitored Natural Attenuation
MTR	Materials Test Reactor
NCER	National Center for Environmental Research
NCRP	National Council on Radiation Protection and Measurements
ND	Non Detected
NEON	National Ecological Observatory Network
NEPA	National Environmental Policy Act



NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NH_3-N	Ammonia as Nitrogen
NIST	National Institute of Standards and Technology
NO_2-N	Nitrite as Nitrogen
NO_3-N	Nitrate as Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory - Field Research Division
NON	Notice of Non-Compliance
NOV	Notice of Violation
NO_x	Nitrogen Oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NSF	National Science Foundation
NWCF	New Waste Calcining Facility
NWQL	National Water Quality Laboratory (USGS)
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment
PCE	Tetrachloroethene
PCS	Primary Constituent Standard
PE	Performance Evaluation
PIDAS	Perimeter Intrusion Detection Access System



PM	Particulate Matter
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
RESRAD	Residual Radioactivity
RFP	Request for Proposal
RH	Remote Handled
RI	Rapid Infiltration
RI/FS	Remedial Investigation/Feasibility Study
RML	Radiological Measurements Laboratory (INL)
RPD	Relative Percent Difference
ROD	Record of Decision
RQ	Reportable Quantity
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SA	Supplement Analysis
SAM	Sample and Analysis Management
SAR	Sodium Absorption Radio
SBW	Sodium Bearing Waste
SCS	Secondary Constituent Standard
SDA	Subsurface Disposal Area
SHPO	State Historic Preservation Office



SI	International System of Units
SIP	State Improvement Plan
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level
SNF	Spent Nuclear Fuel
SNOTEL	Snowpack Telemetry
SP	Suspended Particle
SPCC	Spill Control and Countermeasures Plan
SRP	Snake River Plain
STL	Severn Trent Laboratories
STP	Sewage Treatment Plant
TAN	Test Area North
TBE	Teledyne Brown Engineering
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TIC	Total Integrated Concentration
TKN	Total Kjeldahl Nitrogen
TLD	Thermoluminescent Dosimeter
TNTC	Too Numerous to Count
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TPQ	Threshold Planning Quantity
TRA	Test Reactor Area
TRIGA	Training, Research, Isotopes, General Atomics
TRU	Transuranic (waste)
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TSS	Total Suspended Solids



UAV	Unmanned Aerial Vehicles
UFG	Upper Fremont Glacier
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
WAG	Waste Area Group
WIPP	Waste Isolation Pilot Plant
WLAP	Wastewater Land Application Permit
WRRTF	Water Reactor Research Test Facility
WSU	Washington State University
YSRP	Yellowstone-Snake River Plain



UNITS

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



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American Painted Lady

Chapter 1 - Introduction

M. Case - S. M. Stoller Corporation
B. Jonker - U.S. Department of Energy-Idaho Operations Office

Chapter Highlights

In 1949, the U.S. Atomic Energy Commission created what is now the Idaho National Laboratory (INL) Site as the National Reactor Testing Station to build and test nuclear power reactors. Approximately 2300 km^2 (890 mi^2) of the upper Snake River Plain in southeastern Idaho is occupied by the INL Site. For many years the INL Site was the location of the largest concentration of nuclear reactors in the world. Fifty-two types of reactors, associated research centers, and waste handling areas were constructed, including the Experimental Breeder Reactor No. 1 (EBR-I) which produced the first usable amounts of electricity from nuclear power, a reactor which was the first to provide electricity to a U.S. community, and the U.S. Navy's first prototype nuclear propulsion plant. During the 1970s, the laboratory's mission broadened into other areas, such as biotechnology, energy and materials research, conservation, and renewable energy. At the end of the Cold War, waste treatment and cleanup of previously contaminated sites became a priority.

With renewed interest in nuclear power the U.S. Department of Energy (DOE) announced in 2003 that Argonne National Laboratory-West (ANL-W) and the Idaho National Engineering and Environmental Laboratory (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 cleanup operation, the Idaho Cleanup Project (ICP) is now a separately managed effort.

The INL is focused on meeting the nation's energy, nuclear technology, science, and national and homeland security challenges. As such, it 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 multiprogram national laboratories. The INL contractor is Battelle Energy Alliance (BEA).

DOE contractors who operate environmental management facilities at the INL Site include the ICP, managed by CH2M-WG Idaho, and the Advanced Mixed Waste Treatment Project, managed by Bechtel BWXT Idaho. The ICP is charged with safely and cost-effectively completing the majority of cleanup work from past laboratory missions by 2012.

Other facilities located at the INL Site include the Naval Reactors Facility, operated for Naval Reactors by the Bechtel Bettis, Inc., and the Specific Manufacturing Capability, operated for the Department of Defense by BEA.

Approximately 8000 people work at the INL Site, making it the largest employer in eastern Idaho and one of the top five employers in the State. The INL Site has a tremendous economic impact on eastern Idaho. The INL Site infuses more than $750 million into the Idaho economy.

1. INTRODUCTION

This report provides an introduction to the Idaho National Laboratory (INL) Site, discusses site missions, and highlights the Site's various environmental-related programs. Included are sections discussing site compliance with local, state, and federal environmental laws and regulations; site operations including environmental restoration, waste management, and footprint reduction activities; effluent and emissions from Site facilities; onsite and offsite environmental monitoring activities; radiological doses to public and biota; and ecological research activities at the Site. The report describes INL'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.

In 2005, the Idaho National Engineering and Environmental Laboratory was merged with the Argonne National Laboratory-West to form the Idaho National Laboratory or INL. BEA, owned by Battelle Memorial Institute, is a limited liability company created to lead the new INL, transforming it into the preeminent, multi-program national laboratory envisioned by DOE as the vehicle for achieving the renaissance of nuclear energy and reshaping world's energy economy. BEA is comprised of the Battelle Memorial Institute, BWXT Services Inc., Washington Group International, the Electric Power Research Institute, and the Massachusetts Institute of Technology.

DOE awarded contracts to CH2M WG - Idaho (CWI) for the Idaho Cleanup Project and to Bechtel BWXT Inc. for the Advanced Mixed Waste Treatment Project. CWI is comprised of CH2M Hill, Washington Group International, and Premier Technology, Inc.

1.1 Idaho National Laboratory 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 the Site's cold-war legacy. DOE-ID receives implementing direction and guidance primarily from two DOE Headquarters offices, the Office of Nuclear Energy, Science and Technology (NE) and the Office of Environmental Management (EM). NE is the Lead Program Secretarial Officer 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 Officer. 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 Department of Energy's vision is for the INL to enhance the Nation's energy security by becoming the preeminent, internationally-recognized nuclear energy research, development and demonstration laboratory within ten years. The INL will also establish itself as a major center for national security technology development and demonstration.

The Idaho National Laboratory (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, multiprogram 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 based on the Advanced Test Reactor (ATR) and the Critical Infrastructure Test Range, piloting of an Advanced Fuel-Cycle Facility, demonstration of thermochemical/high-temperature hydrogen production, and expansion of the Center for Advanced Energy Studies. Applying critical mission enablers will propel the INL transformation. These enablers will include developing public trust and confidence in INL and nuclear energy; demonstrating world-leading safety, environmental, and operational performance; creating three modern laboratory campuses; developing, recruiting, and retaining a world-class work force; adopting best-in-class laboratory management systems and information technology; and establishing and leveraging new research centers.

Idaho Cleanup Project

The Idaho Cleanup Project (ICP) is charged with safely and cost-effectively completing the majority of cleanup work from past laboratory missions by 2012. In March 2005, DOE selected CH2M-WG (CWI) Idaho to lead the cleanup effort. The seven year, $2.9 billion project, funded through the DOE's Office of Environmental Management (EM), targets legacy waste generated from munitions testing, government-owned research and defense reactors, laboratory research, and defense missions at other DOE sites. Cleanup efforts include decommissioning and dismantlement of 215 excess EM facilities including three reactors, management of spent nuclear fuel, treatment and disposal of sodium-bearing waste, empty and dispose of all tank farm facility waste tanks and remediation of the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC).

Advanced Mixed Waste Treatment Project

British Nuclear Fuels Limited operated the Advanced Mixed Waste Treatment Project (AMWTP), until April 30, 2005. On May 1, 2005, Bechtel BWXT Idaho, assumed the operation of the AMWTP. This facility is used to retrieve mixed transuranic waste in temporary storage, treat the waste to meet disposal criteria, and package the waste for shipment to the Waste Isolation Pilot Plant (WIPP).

Primary INL Site Facilities

The primary facility areas (buildings and structures) are clusters of typically less than a few square miles each and separated from each other by miles of gently rolling sagebrush-covered semi-arid desert (Figure 1-1). The buildings and structures at the INL Site are clustered within these areas. 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. About fifty percent of INL's employees work in administration, scientific and engineering research, and nonnuclear laboratory programs having offices in Idaho Falls.



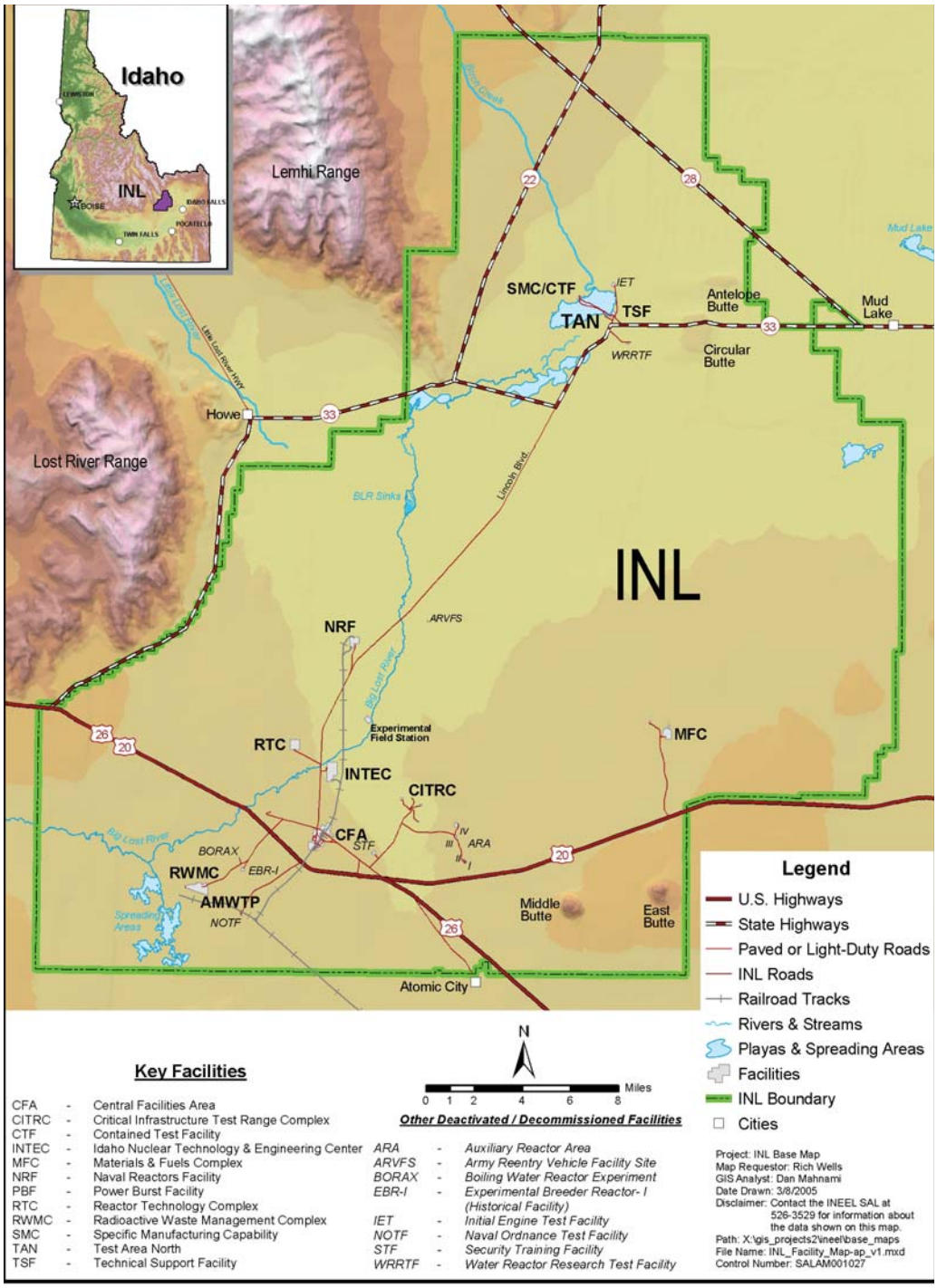

Figure 1-1. Location of the INL Site, showing Facilities.



Central Facilities Area - located centrally on the INL Site, 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 - The Critical Infrastructure Test Range Complex 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 is operated by CWI. Current operations at INTEC include management of sodium-bearing waste, nuclear material disposition, and demolition of excess facilities. CWI has four primary objectives for the INTEC facility: eliminate risks to the Snake River Plain Aquifer, continue safety and compliance in adherence to all regulatory requirements and commitments, expedite consolidation of EM's spent nuclear fuel from wet to dry storage, and substantial reduction of EM footprint and costs.

Materials and Fuels Complex - The Materials and Fuels Complex (formerly Argonne National Laboratory-West) located on the INL Site 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. Projected new construction will include a facility for preparing remote-handled waste for shipment to the Waste Isolation Pilot Plant in New Mexico. Depending on the feasibility of a key project, buildings will be constructed at this location to support manufacturing and assembling components for use in space applications. MFC operated by BEA.

Naval Reactors Facility - The Naval Reactors Facility (NRF) is operated for Naval Reactors by Bechtel Bettis, Inc. Developmental nuclear fuel material samples, naval spent fuel and irradiated reactor plant components/materials are examined at the Expended Core Facility (ECF). The knowledge gained from these examinations is used to improve current reactor designs and to monitor the performance of existing reactors. The naval spent fuel examined at ECF is critical to the design of longer-lived cores, which minimizes the creation of spent 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 450.1, 5400.5, and 414.1c. 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 2005).



Radioactive Waste Management Complex - 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, located in the southwest corner of the INL Site, encompasses 72 hectares (ha) (177 acres) and is operated by CWI. 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 WIPP in New Mexico.

The SDA, a 39-ha (97-acre) landfill located inside the RWMC, has been used for the disposal of low-level and transuranic wastes. The SDA contains an active shallow-land-burial area for the permanent disposal of solid, low-level waste in addition to pits and trenches that have been used to store radioactive waste for more than 50 years. Most of the transuranic waste buried in the SDA was received from the Rocky Flats Plant in Colorado between 1954 and 1970. A small portion of the transuranic waste inventory came from other sites in the DOE Complex as well as the INL Site.

To achieve 2012 cleanup goals for RWMC, CWI will

- Remove transuranic waste from the SDA,
- Dispose of 300,000 m^3 (1,059,440 ft^3) of low-level mixed waste,
- Dispose of 7500 m^3 (264,860 ft^3) of contact-handled transuranic waste,
- Dispose of 85 m^3 (3002 ft^3) of remote-handled transuranic waste, and
- Demolish 47 excess facilities.

CWI will remove targeted wastes that present the highest risks. The company plans (pending regulatory approval) to mitigate the remaining risk with an impermeable boundary and cap combination to prevent contaminant migration.

Reactor Technology Complex - The Reactor Technology Complex (formerly Test Reactor Area) is dedicated to research supporting DOE missions, including nuclear technology research. It will be the focal point for designing, testing and proving the new technologies of the nuclear renaissance. The new mission is broad, far-reaching, and encompasses large scope involving multiple technological options important to coming generations of nuclear power reactors. Facilities planned at this complex include buildings to house laboratory activities, offices, warehousing, and a cafeteria required to support the Advanced Test Reactor. A hot cell connected to the Advanced Test Reactor canal also will be included to support future materials and fuels development. Multicraft shop buildings will be constructed to enhance operational activities. RTC is operated by BEA.

Science and Technology Campus - The Science and Technology 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 Center for Advanced Energy Studies (CAES) are envisioned 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 - Located at the north end of the INL Site, Test Area North (TAN) was originally built to house the nuclear powered airplane project during the 1950s. Currently, the TAN facilities support two projects. The Specific Manufacturing Capability Project, operated for U.S. Department of Defense by BEA, manufactures protective armor for the U.S. Army M1-A1 and M1-A2 Abrams tanks. TAN personnel also manage cleanup of environmental contamination from previous operations. The TAN facility has gone through major changes in the last few years as cleanup projects are completed and buildings no longer needed for the INL mission are demolished. The cleanup mission at TAN is performed by CWI.

Secondary INL Site Facilities

Two secondary facilities at the INL Site include a national historic landmark and a former dairy farm. These facilities provide the INL with public relations and an experimental field station.

Experimental Breeder Reactor No. 1 - The Experimental Breeder Reactor No. 1 (EBR-I) is a Registered National Historic Landmark located at the INL Site off U.S. Highway 20/26. It is open to the public, free of charge, every summer from the Memorial Day weekend through Labor Day.

At 1:50 p.m., on December 20, 1951, the first usable amount of electricity from a nuclear power reactor was generated. EBR-I's real mission was not to show that electricity could be generated by a nuclear reactor, but it was to determine whether scientists' theoretical calculations on fuel breeding could actually be achieved. EBR-I was also successful in this task, breeding (creating) more fuel than it consumed.

Experimental Field Station - The Experimental Field Station (EFS), first called the Experimental Dairy Farm (EDF), was established to conduct Controlled Environmental Radioiodine Tests (CERTs). The first CERT at EDF was conducted on September 2, 1964. The CERTs at EDF ended in 1970. The EFS was established in 1973 as a major environmental monitoring site with high- and low-volume air samplers. Since that time, the EFS has served as a field station for various experiments, the longest running being the Protective Cap/Biobarrier Experiment (see Chapter 9.4).



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 it 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 sixty 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. 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. Surface water does not move 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 Snake River Plain is crop irrigation.

1.3 History of the INL

The geologic events that have shaped the modern Snake River Plain (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 million years, 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 that 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, 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 carrier. 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 INEEL in January 1997. 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 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 Idaho National Laboratory (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 multiprogram national laboratories.

The ICP is now a separately managed effort. The ICP is charged with safely and cost-effectively completing the majority of cleanup work from past laboratory missions by 2012. In March 2005, DOE selected CWI to lead the cleanup effort. The seven year, $2.9 billion project, funded through the U.S. Department of Energy's Office of Environmental Management, targets legacy waste generated from munitions testing, government-owned research and defense reactors, laboratory research, and defense missions at other DOE sites. Cleanup goals include decommissioning and dismantlement of 215 excess Environmental Management facilities including three reactors, management of spent nuclear fuel, treatment and disposal of sodium-bearing waste for disposal, emptying and disposing of all tank farm facility waste tanks and remediation of the SDA at the RWMC.

1.4 Regional Economic Impact

With 8000 scientists, researchers and support staff, the INL Site programs work with national and international governments, universities and industry partners to discover new science and develop technologies that underpin the nation's nuclear and renewable energy, national security and environmental missions. This number includes about 400 federal employees, most of whom work for DOE-ID. The majority of the other employees work for the INL contractor, BEA, and the ICP contractor, CWI, at the INL Site. During 2005, other employees worked for contractors at facilities operated by other DOE organizations, such the AMWTP at the RWMC, and at the NRF operated by Bechtel Bettis, Inc. for the Navy.

The INL Site infuses more than $750 million into the Idaho economy through the purchase of goods and services, corporately funded economic development, and contributions to the State and local tax base.



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Chapter 2 - Environmental Compliance Summary

B. Jonker - U.S. Department of Energy - Idaho Operations Office
M. Case - S. M. Stoller Corporation

Chapter Highlights

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and U.S. Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of nonpermitted hazardous materials to the environment must be documented. Overall, the INL Site met all its regulatory commitments in 2005 and programs are in place to address areas for continued improvement.

The following paragraphs highlight the accomplishments made in 2005.

Under a Federal Facility Agreement/Consent Order, signed in 1991, the INL Site was divided into ten Waste Area Groups containing 25 operable units, which are areas with similar contamination grouped within a single Record of Decision (ROD). The INL Site continues to make progress on remedial actions at operable units, as detailed in Chapter 3.

All Emergency Planning and Community Right-to-Know Act and Resource Conservation and Recovery Act reports were submitted as scheduled.

The state of Idaho approved closure plans for nine facilities.

The U. S. Department of Energy-Idaho Operations Office (DOE-ID) completed a Supplement Analysis of the 1995 Spent Fuel Environmental Impact Statement, concluding that the environmental restoration and waste management portion of the Environmental Impact Statement (EIS) was still adequate for informing DOE decision-makers and the public of the environmental risks and impacts of actions taken for existing environmental restoration and waste management operations at the INL Site.

DOE-ID submitted the *2004 INL National Emission Standards for Hazardous Air Pollutants-Radionuclides* report to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2005, in compliance with the Clean Air Act.

The state of Idaho issued a Tier I operating permit under Title V of the Clean Air Act with an effective date of June 28, 2005.

In December 2005, DOE issued a ROD for the Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement.

DOE-ID completed the Save America's Treasures matching funds grant for the Experimental Breeder Reactor-1, raising $320,000 to match the grant received from the National Park Service for preservation of this National Historic Landmark.

There are 59 active permits that have been granted to the INL Site from the City of Idaho Falls, State of Idaho, the U.S. Environmental Protection Agency, and the Corps of Engineers.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (INL) Site with environmental protection requirements. 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.

Table 2-1. Environmental Compliance Status.

Activity	Governing Statute or Order
Radiation Protection	DOE Order 450.1, "Environmental Protection Program"
	DOE Order 5400.5, "Radiation Protection of the Public and the Environment"
Environmental Remediation and Protection	Comprehensive Environmental Response, Compensation, and Liability Act
	Emergency Planning and Community Right-to-Know Act
	National Environmental Policy Act
	Endangered Species Act
	Executive Order 11988 – Floodplain Management
	Executive Order 11990 – Protection of Wetlands
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



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, in accordance with the FFA/CO, is conducting environmental restoration activities at the INL Site.

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's Site 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) provides the public with information about hazardous chemicals at a facility (such as the INL Site) and establishes emergency planning and notification procedures to protect the public from chemical releases. EPCRA also contains requirements for periodic reporting on hazardous chemicals stored and/or used at a facility. Executive Order 13148, "Greening the Government through Leadership in Environmental Management," requires all federal facilities to comply with the provisions of EPCRA.

311 Report – EPCRA Section 311 reports were submitted quarterly for those chemicals that met the threshold planning quantity. 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 2005. These quarterly reports satisfied the 90-day notice requirement for new chemicals brought onsite.

312 Report – Local and State planning and response agencies received the Emergency and Hazardous Chemical Inventory (Tier II) Report for 2005 by March 1, 2005. This report identified the types, quantities, and locations of hazardous and extremely hazardous chemicals stored at INL Site facilities that exceeded:

- 4536 kg (10,000 lbs) (for Occupational Safety and Health Act hazardous chemicals),
- 230 kg (500 lbs) (for Extremely Hazardous Substances as defined in Title 40 Code of Federal Regulations, Part 355 [40 Code of Federal Regulations (CFR 355)]), or
- the Threshold Planning Quantity, whichever is less.

313 Report – The Toxic Chemical Release Inventory Report was transmitted to the EPA and the state of Idaho July 1, 2006. The report identifies quantities of 313-listed toxic chemicals that were used/released above an activity threshold. Once these activity thresholds (for manufacturing, processing, or otherwise used) are exceeded, an EPA 313 Toxic Release Inventory Form R report must be completed for each specific chemical. Releases under EPCRA reporting include transfers to offsite waste storage and treatment, air emissions, recycling, and other activities. Ten reports were prepared at the INL Site during 2005 for toluene, ethylbenzene, lead and lead compounds, nitric acid, naphthalene, propylene, xylene, 1,2,4-trimethylbenzene, nickel, and polycyclic aromatic compounds. The 313 reports vary year-to-year depending upon the chemical processes at the Site.

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 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 NEPA Planning and Compliance Program Guidance (DOE-ID 2005). The DOE-ID NEPA Compliance Officer and NEPA Planning Board implement the process.

The DOE-ID issued the Annual NEPA Planning Summary in January 2005. That 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 will be issued 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 expected in calendar year 2006. An additional ROD for HLW calcine disposition and bin set closure is scheduled for issuance in 2009.

Supplement Analysis of Spent Fuel EIS – In late 2004, DOE began preparation of a supplement analysis (SA) to compare environmental restoration and waste management projects identified in Volume 2 of the 1995 DOE Programmatic Spent Nuclear Fuel Management and Idaho National Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impacts Statement (DOE 1995) with updated INL plans and prevailing environmental baseline conditions. The SA was completed in June 2005 and made available to the public. DOE concluded the environmental restoration and waste management portion of the 1995 EIS was still adequate for informing DOE



decision-makers and the public of the environmental risks and impacts of actions taken within the scope of Volume 2 and for existing environmental restoration and waste management operations at the INL Site. DOE also concluded that there were no new significant circumstances, information, or changes identified within the analysis of Volume 2 that would compel preparation of a new EIS or Supplemental EIS for current INL Site environmental restoration and waste management activities.

Environmental Assessment for the Remote Treatment Project - The proposed action is to provide heavily shielded remote waste handling services for the Materials and Fuels Complex and INL Site legacy and newly generated remote handled (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 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 2006.

Environmental Assessment for the Dynamic Test of PIDAS Elements and Protective Vehicles - The proposed action would be to conduct two security technology systems tests. The proposed project would consist of two explosive events conducted over an 18-month period. The draft EA was made available to the public in August 2005. The EA was subsequently cancelled. The proposed activities will be included in a new EA for a proposed project titled "Security Systems Test Range." Comments received on the draft Dynamic Test of PIDAS Elements and Protective Vehicles EA will be considered during the development of the new EA.

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.

The Environmental Surveillance, Education and Research Program conducts 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.

Two federally protected species may occasionally spend time on the INL Site: the threatened bald eagle (*Haliaeetus leucocephalus*) and the gray wolf (*Canis lupus*). 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. Bald eagles occasionally winter on part of the INL Site,



and there have been unsubstantiated sightings of gray wolves. Research and monitoring continued on several species of special biological, economic, and social concern, including Townsend's big-eared bat (*Corynorhinus townsendii*), sage grouse (*Centrocercus urophasianus),* elk (*Cervus elaphus*), and pronghorn antelope (*Antilocapra americana*).

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 Code of Federal Regulations (10 CFR 1022) contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures (10 CFR 1022). 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 directed that all proposed actions be reviewed to identify their location relative to the elevation of the 100-year flood indicated in *Flood Routing Analysis for a Failure of Mackay Dam* for purposes of the NEPA compliance (Koslow and VanHaaften 1986). This analysis involved a 100-year flood in conjunction with the Mackay Dam failure. This direction is considered to be interim and remains in effect until DOE-ID issues a final determination of the 100- and 500-year Big Lost River flood elevations. Projects to delineate the Big Lost River 100-year through 10,000-year floodplains using geomorphological models and hydrologic analysis to characterize and estimate the frequency and magnitude of Big Lost River floods on the INL Site have been conducted. The hydrologic analysis is published in *Estimating the Magnitude of the 100-Year Peak Flow in the Big Lost River at the Idaho National Engineering and Environmental Laboratory, Idaho* (Hortness and Rousseau 2003*).* A flood hazard report based on the geomorphological models was drafted and has undergone peer review in 2004. Evaluations of the determinations are ongoing and they will be analyzed by DOE-ID for implementation upon completion.

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 – Protection of Wetlands 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.

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 2005, no actions took place or had an impact on potentially jurisdictional wetlands on the Site, and, to date, 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. DOE-ID, Battelle Energy Alliance (BEA), CH2M-WG Idaho, Bechtel BWXT Idaho, and Idaho DEQ meet quarterly to discuss RCRA-related issues. Summaries of the meetings can be accessed at http://idahocleanupproject.inel.gov/PublicInfo/tabid/84/Default.aspx.

Notices of Violation/Non-compliance – On October 18-20, 2005, EPA conducted an inspection of DOE-ID owned and contractor operated petroleum underground storage tanks (UST) located at Idaho Falls Facilities (IFF) and the Materials and Fuels Complex (MFC). The EPA inspector issued a UST Field Notice of Non-compliance (NON) to BEA on October 20, 2005 for the following alleged non-compliance issues: (1) failure to provide 12 months of passing tank leak tests for a UST at MFC, (2) failure to verify adequate cathodic protection on piping by not testing and providing conductivity measurements every three years for a UST at MFC, and (3) failure to install vent piping in accordance with industry standards for a UST at MFC and a UST at an IFF building. BEA provided documentation to the EPA by the required due date and the EPA dismissed the NON.

RCRA Closure Plans – The state of Idaho approved closure plans for the following facilities in 2005:

- Reactor Technology Complex Test Reactor Area (TRA)-630 Catch Tank (revised closure plan)
- TAN PM2A Tanks ILRWMS Closure-Phase III
- INTEC CPP-603 Basin Water Treatment System
- INTEC VES SFE-106 Radioactive Solids and Liquid Waste Storage Vessel



- INTEC CPP-637/CPP-620 and VCO units INTEC-087 and INTEC-091
- INTEC INTEC-076 FAST Basin Water Aquaskid
- INTEC INTEC-049 PEWE Condensate System
- Reactor Technology Complex (RTC) TRA-002 TRA/ETR Hot Waste Tank System
- RTC TRA -023 TRA/ETR P-7 Experimental Water Loop System
- TAN TAN-020 HTRE-3 Mercury Spill at Loss-of Fluid Test (LOFT).

RCRA Reports – As required by the state of Idaho, the INL Site submitted the Idaho Hazardous Waste Generator Annual Report for 2005. The report contains information on waste generation, treatment, recycling, and disposal activities at INL Site facilities.

DOE-ID submitted the INL Site 2005 Affirmative Procurement Report to the EPA, as required by Section 6002 of RCRA and Executive Order 13101, *Greening the Government through Waste Prevention, Recycling, and Federal Acquisition*. This report provides information on the INL's Site procurement of products with recycled content.

The INL Site RCRA permit for the Hazardous Waste Storage Facility at the Central Facilities Area (CFA) and some areas at the MFC requires submittal of an annual certification to Idaho DEQ that the INL Site has a waste minimization program in place to reduce the volume and toxicity of hazardous waste. The certification was submitted by July 1, 2005.

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 2005 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 Clean Water Act, 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. One ballast had a release and the area was cleaned per regulatory requirements.

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 Wastewater Land Application Permits

DOE-ID has applied for state of Idaho Wastewater Land Application Permits (WLAP) for all existing land application facilities. Permit renewal applications for the CFA Sewage Treatment Plant and TAN/Technical Support Facility Sewage Treatment Plant are under consideration by Idaho DEQ. Until the renewal permits are finalized, Idaho DEQ has authorized continued use of these facilities under the terms and conditions of the original permits.

Idaho DEQ issued a new WLAP permit for the combined INTEC Sewage Treatment Plant effluent and service wastewater for disposal at the new INTEC percolation ponds in 2004. The combined discharge commenced in December 2, 2004, and the separate INTEC Sewage Treatment Plant WLAP and INTEC New Percolation Pond WLAP were terminated at that time. Idaho DEQ is reviewing permit applications for the TRA Cold Waste Ponds, the Naval Reactors Facility Industrial Waste Ditch, and the Argonne National Laboratory-West industrial and sanitary waste ponds.

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 makes Idaho the only state with a federal court-ordered agreement limiting shipments of DOE and Naval spent nuclear fuel into the State and setting milestones for shipments of spent nuclear fuel and radioactive waste out of the State.

In 2005, there were no scheduled Settlement Agreement milestones. Progress was made toward meeting future milestones, including waste and spent nuclear fuel shipments. In 2005, 4267 m^3 (150,688 ft^3) of transuranic waste were shipped out of Idaho and the INL Site received truck cask shipments containing a combined total of 0.0535 metric tons (118 lbs) heavy metal from State University of New York–Buffalo, Argonne National Laboratory–East, and the North Anna Power Plant.

On December 13, 2005, DOE issued a ROD for the Facilities Disposition Environmental Impact Statement. This ROD chose the steam reforming technology to treat the remaining sodium-bearing liquid waste in the INTEC Tank Farm. DOE plans on completing the treatment using this technology by December 31, 2012.



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 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, as described in the regulations, must be completed. If not deemed significant per PSD regulations, an application for only a PTC without the additional modeling and analyses is needed. All PTCs are applied for using the state of Idaho air regulations and guidelines.

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

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 interim approval of the Idaho Title V (Tier I) Operating Permit program. The INL Site was issued a Tier I operating permit with an effective date of June 28, 2005.

National Emission Standards for Hazardous Air Pollutants – DOE-ID submitted the *2005 INL National Emission Standards for Hazardous Air Pollutants-Radionuclides* report to EPA, DOE Headquarters, and state of Idaho officials in June. This statute requires the use of the CAP-88 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 2005 calculations for this code are discussed further in Chapter 7, "Dose to the Public."

Clean Water Act

The Clean Water Act (CWA), passed in 1972, established goals to control pollutants discharged to U.S. surface waters. Among the main elements of the CWA are effluent limitations, set by the EPA,



Table 2-2. Permit Summary for the INL Site (2005).

Media/Permit Type	Issuing Agency	Active	Pending
Air			
Permit to Construct	State of Idaho	15	0
NESHAPs (Subpart H)[a]	EPA Region 10	5	0
Operating Permit	State of Idaho	2	0
Groundwater			
Injection Well	State of Idaho	8	0
Well Construction	State of Idaho	1	0
Surface Water			
Wastewater Land Application Permit	State of Idaho	3	3
404 Permit	Corps of Engineers	1	0
Industrial Waste Acceptance	City of Idaho Falls	15	0
RCRA			
Part A	State of Idaho	2	0
Part B[b]	State of Idaho	7[b]	1[b]

a. NESHAPs = National Emissions Standards for Hazardous Air Pollutants (40 CFR 61, Subpart H, National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities).

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

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 from a point source into surface waters.

The INL Site complies with four CWA permits through the implementation of procedures, policies, and best management practices. The four permits are:

- Section 404 Permit for dredge and fill activities at Spreading Area B located southwest of the Radioactive Waste Management Complex (RWMC) requires elimination of pollutant discharges and reclamation in the area
- Discharges from Idaho Falls facilities to the City of Idaho Falls publicly owned treatment works
- NPDES General Permit for Storm Water Discharges from Industrial Activities provides protective requirements for facilities located within the INL Site storm water corridor (63 FR 189)
- 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. Twelve Idaho Falls facilities have associated Industrial Wastewater Acceptance Forms for discharges to the city sewer system.

The Industrial Wastewater Acceptance Forms for these facilities contain 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 2005 were within compliance levels established on the acceptance forms.

Storm Water Discharge Permits for Industrial Activity – The EPA issued a letter in October 2003, stating that they determined that INTEC, RWMC, and TAN do not have a reasonable potential to discharge storm water to waters of the United States. In December 2003, DOE-ID directed the Management and Operating contractor to cease storm water activities at those locations and complete a technical analysis based on the EPA statements to determine if other locations at the INL Site also do not have a reasonable potential to discharge. The technical analysis completed in 2005 determined that the industrial activities at the INL site do not have a potential to discharge because of the distance from the river and/or physical features that prevent discharges from reaching it. Notices of Termination for coverage under the Nationwide permit program were submitted to EPA Region 10.

Storm Water Discharge Permits for Construction Activity – INL Site's General Permit for Storm Water Discharges from Construction Sites was issued in June 1993. The permit has been renewed twice since issuance. The *INEEL Storm Water Pollution Prevention Plan for Construction Activities* was most recently revised in 1998 (DOE-ID 1998). The plan provides for measures and controls to prevent pollution of storm water from construction activities at the INL Site. Worksheets are completed for construction projects and are appended to the plan. Inspections of construction sites are performed in accordance with permit requirements.

The regulatory basis for storm water discharge from construction sites is the same as for industrial activities; therefore, the technical analysis also reduced the area under the purview of the Storm Water for Construction Activities program.

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 serve 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 of 1966, as amended. The Act requires that for any federal project that may have an adverse effect on a historic property, the agency in charge of the project must take actions to mitigate those adverse effects. This is usually done through a Memorandum of Agreement with the State Historic Preservation Office.

DOE-ID, the DOE Federal Preservation Officer, and the Idaho State Historic Preservation Office (SHPO) entered into a Memorandum of Agreement to mitigate the adverse effects of the proposed decontamination, decommissioning, and demolition of four INL Site "Signature Properties" located at TAN and the Reactor Technology Complex. Signature Properties as defined in the INL Site Cultural Resource Management Plan (CRMP), is a term coined by DOE-Headquarters that denotes its most historically important properties across the complex and/or those properties that are viewed as having tourism potential. The TAN Hot Shop (TAN-607), the LOFT Control and Equipment Building (TAN-630), LOFT Containment and Service Building (TAN-650), and the Materials Test Reactor Building (TRA-603) are slated for demolition as part of Environmental Management Idaho Cleanup Project.

DOE-ID submitted the draft Historic American Engineering Record (HAER) report for the Reactor Technology Complex to the National Park Service (NPS). The HAER report focuses on the Engineering Test Reactor and the Materials Test Reactor and contains written and photographic documentation of these historic reactor buildings. The report also contains written and photographic documentation for direct and indirect support buildings for the two reactor buildings.

The INL Site CRMP underwent its first revision in September 2005. The CRMP provides a tailored approach for the INL Site to comply with Section 106 of the National Historic Preservation Act. The 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 Idaho National Laboratory Site*, formally implements the CRMP.

DOE-ID completed the Save America's Treasures matching funds grant for Experimental Breeder Reactor No. 1 (EBR-I) National Historic Landmark. DOE-ID received the $320,000 grant in May 1999 from the NPS and entered into an Interagency Agreement with the NPS to receive the funds and agree upon preservation activities for EBR-I. The funds were used to repair/replace damaged brick on the exterior of the reactor building and for new interpretive displays on EBR-I history at the reactor building. The grand opening for the new displays was held May 24, 2005.

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.



2.2 Environmental Occurrences

In 2005, three releases were deemed reportable to external regulatory agencies:

- On December 1, 2005, 133 L (35 gal) of diesel fuel was released to soil near the INL CERCLA Disposal Facility gate at INTEC. The source of the spill was a fuel tank on a subcontractor-owned water truck that was punctured during demobilization. The spill exceeded the 94.6 L (25 gal) regulatory reportable quantity (RQ) limit for petroleum products and therefore was reported to the appropriate authorities within the state of Idaho according to regulatory requirements.

- On August 23, 2005, a spill of approximately 3.8 L (1.0 gal) petroleum-based hydraulic fluid was discovered near a pile of debris which had been the result of a recent test of decontamination and decommissioning equipment near the INTEC fence line. The spill residue stain was determined to be a release to the environment because the spill occurred on a gravel-over-soil outdoor surface. Cleanup of the spill was completed on August 24. Although the RQ for petroleum products (94.6 L [25 gal]) was not exceeded, the spill was not cleaned up within the 24-hour regulatory required period and was therefore reported to appropriate state of Idaho authorities.

- On August 30, 2005, an estimated quantity of 90.7-113.4 kg (200-250 lbs) of granular activated carbon (GAC) containing approximately 2 kg (4.5 lbs) of RCRA F001-listed volatile organic compounds (TCE, PCE, and TCA) was released to the gravel pad near the V tank treatment system at the TAN facility in response to a fire in the GAC bed. The INL Fire Department had to breach the GAC filter to fully extinguish the fire, causing the GAC to be released to the compacted dirt floor at the V-tank project area. Since the GAC had contacted F001 listed waste and the amount released was greater than the 0.45 kg (1 lb) RQ, notification was made to state of Idaho authorities as required by 40 CFR 265.196 (d)(1).

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 permits applied for, and granted to, the INL Site through year-end 2005.



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Monarch

Chapter 3 - Environmental Program Information

B. Jonker - U.S. Department of Energy - Idaho Operations Office
R. Mitchell - S. M. Stoller Corporation
B. Anderson and M. Verdoorn - Battelle Energy Alliance

Chapter Highlights

There are many environmental monitoring programs that help implement the Environmental Compliance Policy for the Idaho National Laboratory (INL) Site. Most of the regulatory compliance activity is performed through various environmental monitoring programs, the recently signed Accelerated Cleanup Agreement, the Environmental Restoration Program, and the Waste Management Program.

The major objectives of the various 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. 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 other U.S. Department of Energy commitments.

During 2005, Battelle Energy Alliance and CH2M-WG Idaho (CWI) had primary responsibility for environmental monitoring on the INL Site. The offsite environmental monitoring program was the responsibility of the Environmental Surveillance, Education and Research Program contractor who, during 2005, was a team led by the S. M. Stoller Corporation.

Environmental media sampled under these programs include ambient air; drinking water, surface water, and groundwater; soils; vegetation; agricultural products; wildlife; and direct radiation. Samples are analyzed for a wide array of constituents including but not limited to pH, inorganics, volatile organics, gases, and gross alpha and beta activity to specific radionuclides, such as tritium, strontium-90, and plutonium isotopes.

The Idaho Cleanup Project (ICP) continued to make significant progress toward meeting its goals. Examples of ICP environmental cleanup and waste management successes in 2005 are:

- Cleanup activities at Waste Area Group 5 are complete. This area supported two reactor facilities, the Power Burst Facility and the Auxiliary Reactor Area.
- A new cleanup contractor was procured to achieve cleanup mission goals through 2012. CWI took over operations on May 1, 2005;
- Over 7440 m^2 (80,082 ft^2) of buildings and structures were demolished;
- The first shipment of treated transuranic waste was sent from the Advanced Mixed Waste Treatment Project to the Waste Isolation Pilot Plant (WIPP) on May 31, 2005.
- Approximately 6535 m^3 (230,780 ft^3) of legacy and newly generated low-level waste was disposed at the Subsurface Disposal Area.
- The Transuranic Waste Program shipped a total 4267 m^3 (150,688 ft^3) transuranic waste to the WIPP.
- All scheduled Site Treatment Plan milestones were achieved.

3. ENVIRONMENTAL PROGRAM INFORMATION

This chapter highlights the Idaho National Laboratory (INL) Site environmental programs that help implement the Environmental Policy for the INL Site (see front matter of this report). Much of the regulatory compliance activity is performed through the various environmental monitoring programs (Section 3.1), the recently signed Accelerated Cleanup Agreement (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, 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), Naval Reactors Facility (NRF), Critical Infrastructure Test Range/Power Burst Facility (CITR/PBF), Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North/Specific Manufacturing Capability (TAN/SMC). The Liquid Effluent Monitoring Program, conducted by the Idaho Cleanup Project (ICP) contractor, is designed to demonstrate compliance with the Clean Water Act, Wastewater Land Application Permits (WLAPs), 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 2005 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 2005 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.

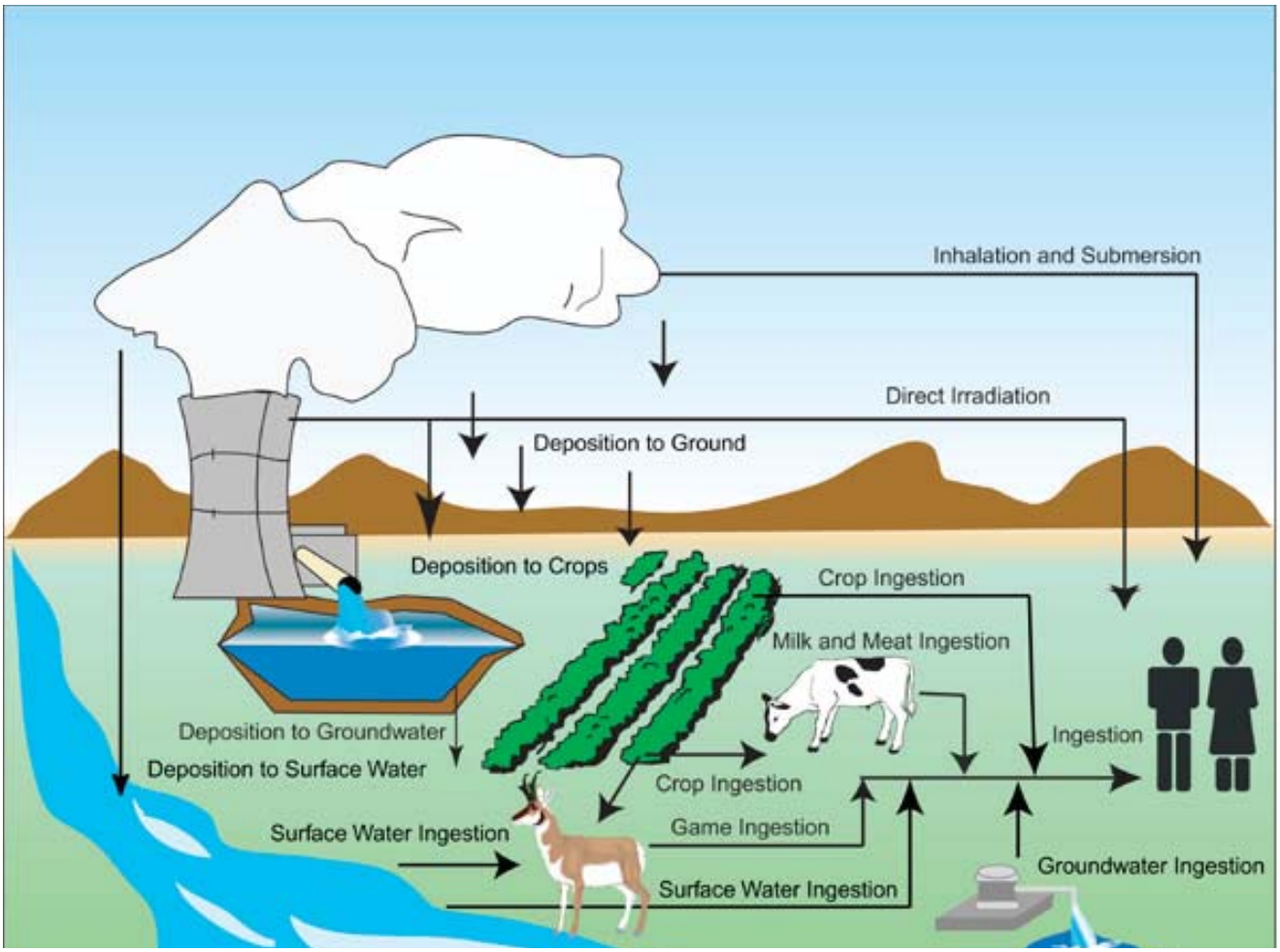

Figure 3-1. Potential Exposure Pathways to Humans from the INL Site.

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, 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 and Energy Research and Development Agency, 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 Atomic Energy Commission'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.

As a result of a large scale, comprehensive audit 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 2005, Battelle Energy Alliance (BEA) was the prime INL contractor. CH2M-WG Idaho (CWI) assumed responsibility for the ICP on May 1, 2005. The offsite monitoring program is performed by the Environmental Surveillance, Education and Research (ESER) Program contractor. During 2005, 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 offsite locations and three onsite samplers. ESER added a thirteenth offsite sampler in June 2001 at Jackson, Wyoming. Two samplers were also moved to new locations in July 2001 when the landlords



Table 3-1. Historical Low-Volume Radiological Air Sampling Locations and Date of Operations.

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
b. TRA = Test Reactor Area



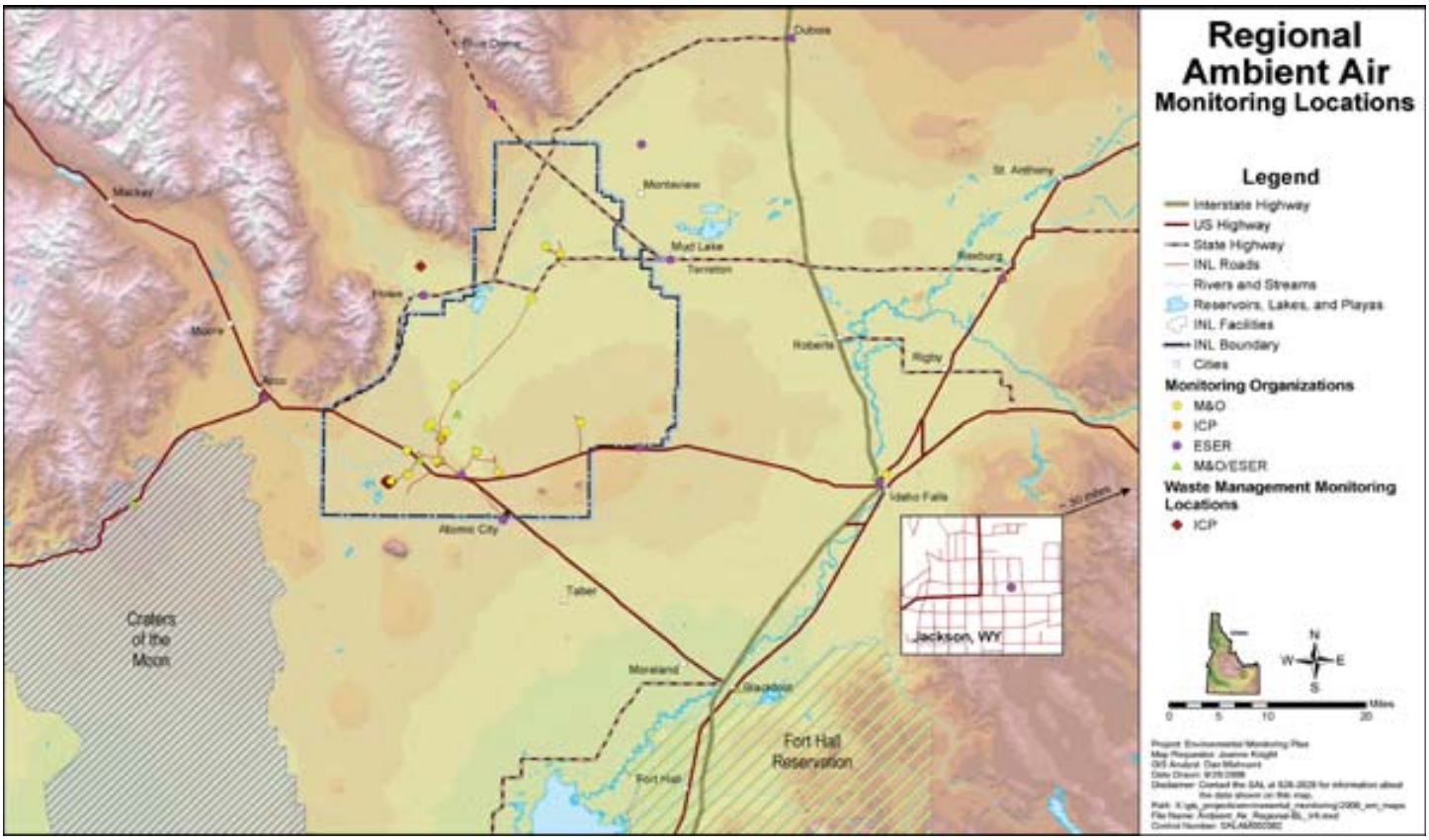

Figure 3-2. ESER and INL Contractor Low-Volume Radiological Air Sampling Locations.

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 SMC, Gate 4, the RTC and INTEC due to increased decontamination and dismantlement activity.

Each low-volume air sampler maintains an average airflow of 50 L/minute (1.8 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 ESER and the INL contractor weigh their 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 absorbs water vapor. Columns are changed when sufficient moisture to obtain a sample is absorbed (typically from one to three times per quarter). The absorbed water is removed from the desiccant through heat distillation. Tritium concentrations in air are then determined from the absorbed 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 ESRPA. The first well, USGS 1, was completed and monitored in December 1949. USGS personnel have maintained an INL Project Office since 1958 (USGS 1998). 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 Idaho National Engineering Laboratory (INEL) Site. This resulted in the development of the *INEL Groundwater Monitoring Plan* (DOE-ID 1993a) and the *INEL 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.

As one of the requirements of the National Pollutant Discharge Elimination System (NPDES) General Permit effective October 1, 1992, the INL Site was obligated to develop a storm water monitoring program. Sampling of snowmelt and rain runoff began in 1993, and it included 16 sites at eight INL Site facilities. Samples were collected from storms of at least 0.25 cm (0.1 in.) of precipitation preceded by a minimum of 72 hours without precipitation.

In September 1998, the EPA issued the "Final Modification of the National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities" (63 FR 189). The permit requires sample collection and laboratory analyses for two of the years during every five-year cycle at potential discharge locations. This usually occurs during years two and four; the INL Site last collected and analyzed storm water samples in 2003. The permit also required continued annual monitoring from coal piles at INTEC whenever there was a discharge to the Big Lost River System. In addition, quarterly visual monitoring was required at all other designated locations.

Current Programs – USGS personnel collect samples from 167 observation or production wells and auger holes and have them analyzed for selected organic, inorganic, and radioactive substances. Sampling is performed on schedules ranging from monthly to annually. These samples are submitted to the RESL at CFA for analysis of radioactive substances and to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analyses of organic and inorganic substances. The USGS also records water levels at 210 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 2005 is provided in Appendix C. These special studies provide more specific geological, chemical, and hydrological information on the characteristics of the aquifer and the movements of chemical and radiochemical contaminants in the groundwater. One special USGS investigation of particular interest was the ongoing annual sampling effort in the area between the INL Site's southern boundary and the Twin Falls/Hagerman area, known as the Magic Valley Study. This study was prompted by public concern that radiochemical and chemical constituents generated by INL Site facilities could migrate through the Eastern Snake River Plain Aquifer (ESRPA) to the Snake



River in the Twin Falls/Hagerman area. The final results of this study are summarized in USGS Open File Report 2005-1125 (Rattray et al. 2005).

The *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.

The INL contractor conducts sampling on the wastewater treatment systems at MFC, CFA, RTC, and SMC and monitors for nonradioactive and radioactive parameters in liquid waste effluents as required by the applicable WLAP and DOE environmental protection objectives. The INL contractor also is responsible for groundwater monitoring at MFC in support of the Record of Decision (ROD) and proposed monitoring associated with WLAP applications at MFC and RTC facilities. The ICP contractor owns and performs sampling on the wastewater treatment systems at INTEC and TAN. Monitoring is also performed for nonradioactive and radioactive parameters in liquid waste effluents generated at INTEC and TAN as required by their applicable WLAPs and DOE environmental protection objectives. The ICP contractor is also responsible for groundwater monitoring conducted at all other CERCLA site monitoring locations, WLAP compliance at INTEC and TAN, and RCRA closure monitoring at INTECs Waste Calcine Facility.

The INL contractor performs drinking water monitoring at all INL Site facilities except NRF. The INL contractor monitors 19 wells and 11 distribution systems across the INL Site for radiological and nonradiological parameters. Transient noncommunity water systems on the INL Site are EBR-I, the Gun Range, and the Main Gate. Nontransient water systems at the INL Site are INTEC, RWMC, CFA, RTC, TAN/Contained Test Facility, CITRC, and MFC.

Personnel collect quarterly onsite drinking water samples from active systems for radiological analysis. Each water sample is submitted for gross analyses for alpha- and beta-emitting radionuclides. Tritium analyses are also performed on all drinking water samples collected for radiological analysis. Strontium-90 analyses are performed on quarterly samples from CFA and INTEC because historical water quality data from some monitoring and observation wells indicate ^{90}Sr concentrations are above background levels.

Drinking water samples are analyzed monthly for microbiological contaminants, such as coliform bacteria. If indications of contamination by bacteria are found in a sample, that particular drinking water system is taken out of service until it can be disinfected, resampled, and tested again until it is clear of bacteria. Corrective actions to purify the water may vary among facilities.

The INL contractor's Drinking Water Program also samples drinking water from wells and distribution systems at INL Site facilities for volatile organic compounds. Environmental Health Laboratories (now Underwriters Laboratories) performs organic analyses. Chlorinated drinking water



systems are also monitored for total trihalomethanes (bromoform, bromodichloromethane, chloroform, and dibromochloromethane). Additional sampling is conducted for a variety of inorganic constituents, including metals, nitrates, and dissolved solids.

ESER collects drinking water samples semiannually from boundary and distant communities. Surface water samples are collected from springs in the Twin Falls/Hagerman area and the Snake River at Idaho Falls and Bliss. Each water sample is analyzed for gross alpha and gross beta activity and tritium.

Historically, storm water monitoring locations were based upon drainage patterns and proximity to potential sources of pollutants. The General NPDES Permit requires visual examinations of storm water for obvious indications of storm water pollution. In addition, visual examinations were conducted for surveillance purposes at some locations whether or not storm water discharged to the Big Lost River System.

In 2003, EPA Region 10 determined that three sites at the INL Site (RWMC, INTEC, and the north part of the INL Site near Birch Creek [area around TAN]) do not have a reasonable potential to discharge storm water to waters of the United States. As a result of this determination, construction and industrial storm water inspections, data collection, and reports have ceased for projects located at these facilities.

The remaining projects were evaluated through a technical analysis to determine any other areas under the INL Site's control that would also have the same or less potential to discharge storm water to waters of the United States. Required storm water inspections and reporting continued for these projects until October 2004. At that time, inspections and reports at any additional projects that had no reasonable potential to discharge to waters of the United States, as determined through a preliminary technical analysis (finalized in early 2005), ceased.

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 private gardens in communities in the vicinity of the INL Site. In addition, self-contained growing boxes are distributed throughout the region, usually at existing air monitoring locations. 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.

Sheep that have grazed onsite have been part of the routine monitoring program since a special study was conducted in 1975. 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 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 a 1 mi^2 (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 locations are sampled by the ESER Program 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 now performs soil sampling on a two-year rotation. One hundred seventy-five sites were sampled in 2005. All sites are analyzed in situ for gamma emitting radionuclides and ^{90}Sr. Approximately 10 percent of the sites have a physical sample collected for laboratory analysis of gamma-emitting and transuranic radionuclides. Samples are collected from 0–5 cm (0–2 in.) and sieved at the sample site with the 35-mesh fraction being collected. The INL contractor also performs annual sampling of the CFA sewage treatment plant irrigation spray field to show compliance with the WLAP 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 – The NOAA Air Resources Laboratory-Field Research Division (NOAA ARL-FRD) began work at the INL Site in 1948 as a Weather Bureau Research Station. The first meteorological observation station established to support the onsite activities began operation in 1949 at CFA. The network of stations expanded in the 1950s to provide more closely spaced data. The current mesonet was designed and constructed in the 1990s.

Current Programs – NOAA ARL-FRD currently maintains a network of 36 meteorological stations in the vicinity of the INL Site. These stations provide continuous measurements of a variety of parameters, including air temperature at two or three elevations, wind direction and speed, relative humidity, barometric pressure, solar radiation, and precipitation. In addition, continuous measurements of wind speed/direction and air temperature at various heights above the ground are taken using a radar wind profiling system and a radio acoustic sounding system. Data are transmitted via radio and telephone to the NOAA ARL-FRD Idaho Falls facility, where they are stored in a computerized archive.

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; 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 contractor, and the USGS, respectively, in 2005.

3.2 Accelerated Cleanup Agreement

In May 2002, DOE, the Idaho Department of Environmental Quality, and the EPA signed a letter of intent formalizing an agreement to pursue accelerated risk reduction and cleanup at the INL Site. The letter provides the foundation for a collaborative plan for the accelerated cleanup.

DOE-ID and its contractors, in consultation with the state of Idaho and EPA, developed a Performance Management Plan describing the approach to accelerate the reduction of environmental risk at the INL Site by completing its cleanup responsibility faster and more efficiently. The plan will fulfill the following two visions:

- By 2012, the INL Site will have achieved significant risk reduction and will have placed materials in safe storage ready for disposal.
- By 2020, the INL Site will have completed all active cleanup work with the potential to further accelerate cleanup to 2016.

The vision for accelerating cleanup results in two objectives: (1) risk reduction and continued protection of the ESRPA and (2) consolidation of Environmental Management (EM) activities and reinvestment of savings into cleanup.

Nine strategic initiatives were developed around these objectives. They include:

- Accelerate Tank Farm Closure
- Accelerate high-level waste (HLW) calcine removal from Idaho
- Accelerate consolidation of spent nuclear fuel to INTEC
- Accelerate offsite shipments of transuranic waste stored in the transuranic waste storage area
- Accelerate remediation of miscellaneous contaminated areas
- Eliminate onsite treatment and disposal of low-level and mixed low-level waste



Table 3-2. ESER Environmental Surveillance Program Summary (2005).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	1 x 10^{-15} µCi/mL
	Gross beta	4 weekly	14 weekly	2 x 10^{-12} µCi/mL
	Specific gamma	4 quarterly	14 quarterly	3 x 10^{-16} µCi/mL
	^{238}Pu	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	$^{239/240}$Pu	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	^{241}Am	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	^{90}Sr	2 quarterly	7 quarterly	6 x 10^{-17} µCi/mL
	^{131}I	4 weekly	14 weekly	2 x 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 x 10^{-15} µCi/mL
	Gamma scan	None	If gross ζ > 1 pCi/m^3	1 x 10^{-14} µCi/mL
	Isotopic U and Pu	None	1 annually	2 x 10^{-18} µCi/mL
Air (PM_{10})	Weighing filter	None	3 weekly	± 0.000001 g
Air (atmospheric moisture)	Tritium	None	4 locations, 2 to 4 per quarter	2 x 10^{-13} µCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[c]	1 monthly	100 pCi/L
Drinking Water	Gross alpha	None	14 semiannually	3 pCi/L
	Gross beta	None	14 semiannually	2 pCi/L
	Tritium	None	14 semiannually	300 pCi/L
Surface Water	Gross alpha	None	5 semiannually	3 pCi/L
	Gross beta	None	5 semiannually	2 pCi/L
	Tritium	None	5 semiannually	300 pCi/L
Animal Tissue (sheep)	Specific gamma	4 annually[d]	2 annually	5 pCi/g
	^{131}I	4 annually	2 annually	3 pCi/g
Animal Tissue (game)	Specific gamma	Varies annually[e]	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 include three locations and a blank, offsite includes 13 locations and a blank.
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 are reported by ERAMS.
d. Onsite animals grazed on the INL for at least two weeks before being sampled. Offsite animals have never grazed on the INL Site and served as controls.
e. Only animals that are victims of road-kills or natural causes are sampled onsite. No controls are generally collected except for specific ecological studies (i.e., ducks).



Table 3-3. INL Site Contractors Environmental Surveillance Program Summary (2005)[a].

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite[b]	Offsite	
Air (low volume)	Gross alpha	17 weekly	4 weekly	1×10^{-15} µCi/mL
	Gross beta	17 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	17 quarterly	4 quarterly	—[c]
	^{238}Pu	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	$^{239/240}$Pu	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{241}Am	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	17 quarterly	4 quarterly	2×10^{-14} µCi/mL
	Particulate matter	17 quarterly	4 quarterly	10 µg/m^3
Air (atmospheric moisture)	Tritium	2 to 4 per quarter	2 to 4 per quarter	1×10^{-11} µCi/mL (water)
Soil	Specific gamma	Varies annually[d]	—	0.1 pCi/g
	Pu isotopes	Varies annually	—	0.003 pCi/g
	^{241}Am	Varies annually	—	0.003 pCi/g
	^{90}Sr	Varies annually	—	0.06 pCi/g
Vegetation	Specific gamma	Varies annually[d]	—	1×10^{-7} µCi/g
	^{238}Pu	Varies annually	—	1.2×10^{-8} µCi/g
	$^{239/240}$Pu	Varies annually	—	6×10^{-10} µCi/g
	^{241}Am	Varies annually	—	1.2×10^{-8} µCi/g
	^{90}Sr	Varies annually	—	1.2×10^{-8} µCi/g
Drinking Water	Gross alpha	12 quarterly	—	1 pCi/L
	Gross beta	12 quarterly	—	4 pCi/L
	Tritium	12 quarterly	—	1,000 pCi/L
	^{90}Sr	4 quarterly	—	2 pCi/L
	Other radionuclides	12 quarterly	—	—[c]
	Volatile organics	10 annually/ 4 quarterly	—	Varies by analyte
	Semivolatile organics	12 triennially	—	Varies by analyte
	Inorganics	12 triennially	—	Varies by analyte
Direct Radiation Exposure (TLDs)	Ionizing radiation	135 semiannually	13 semiannually	5 mR
Direct Radiation Exposure (mobile radiation surveys)	Gamma radiation	Facilities and INL Site roads[e]	—	NA

a. INL Site Contractors refers to both the iNL contractor (BEA) and the ICP contractor (CWI).

b. 17th sampler was added to the northeast corner of the RTC in October.

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

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 (2005).

Constituent	Groundwater		Surface water		Minimum Detectable Concentration
	Number of Sites	Number of Samples	Number of Sites	Number of Samples	
Gross Alpha	53	51	4	4	3 pCi/L
Gross Beta	53	51	4	4	3 pCi/L
Tritium	160	146	7	7	400 pCi/L
Specific Gamma	95	81	4	4	—[a]
Strontium-90	107	93	—[b]	—	5 pCi/L
Americium-241	31	28	—	—	0.05 pCi/L
Plutonium Isotopes	31	28	—	—	0.04 pCi/L
Specific Conductance	160	146	7	7	Not applicable
Sodium Ion	149	136	—	—	0.1 mg/L
Chloride Ion	160	146	7	7	0.1 mg/L
Nitrates (as nitrogen)	115	109	—	—	0.05 mg/L
Sulfate	105	92	—	—	0.1 mg/L
Chromium (dissolved)	92	84	—	—	0.005 mg/L
Purgeable Organic Compounds[c]	39	36	—	—	0.0002 mg/L
Total Organic Carbon	51	48	—	—	0.1 mg/L
Trace Elements	11	10	—	—	varies

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

b. No surface water samples collected for this constituent.

c. Each purgeable organic compound water sample is analyzed for 60 volatile organic compounds.



- Transfer all EM-managed special nuclear material offsite
- Remediate buried waste in the RWMC
- Accelerate consolidation of INL Site facilities and reduce the total building footprint.

At the 2020 end state, some activities will continue: shipment of spent nuclear fuel to a repository; retrieval, treatment, packaging, and shipment of calcined HLW to a repository; and final dismantlement of remaining EM buildings. These activities will be completed by 2035 with the exception of some minor activities leading to long-term stewardship. The accelerated cleanup vision is 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 2005, most notably:

- Procured a new cleanup contractor to achieve cleanup mission goals through 2012. CWI took over operations on May 1, 2005.
- Demolished over 7440 m^2 (80,082 ft^2) of buildings and structures.
- Approved a Mission Need Statement initiating a project to treat 3407 m^3 (900,000 gal) of radioactive liquid sodium-bearing waste currently stored in tanks at INTEC in January 2005.
    - Issued the HLW and Facility Disposition Environmental Impact Statement ROD to treat the sodium-bearing waste utilizing a steam reforming process in December 2005.
    - Completed construction of the landfill cell expansion at the INL Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) INL CERCLA Disposal Facility (ICDF) to bring the landfill to a total capacity of over 390,000 m^3 (1,377,270 ft^3).
    - Completed cleanup of three contaminated soil sites at the INTEC by excavating over 90,718,474 kg (100,000 tons) of contaminated soils and disposing of it in the ICDF landfill.
    - Emptied the INTEC special nuclear material vault, CPP-651, and made it available to support other DOE missions on July 5, 2005.
    - Completed moving all Training, Research, Isotopes, General Atomics (TRIGA) spent nuclear fuel from storage in CPP-666 to CPP-603 on January 29, 2005. This was the first wet-to-dry spent nuclear fuel campaign.
    - Placed the final Peach Bottom spent nuclear fuel shipment in the CPP-749 storage vaults on September 21, 2005.
    - In support of tank closure and sodium-bearing waste treatment activities at INTEC, efforts were concluded to ensure that newly generated liquid waste would no longer be transferred into the Tank Farm Facility. These efforts included continued minimization of liquid waste at INTEC, use of other existing tankage, and locking inlet valves to the Tank Farm tanks. The last transfer into the Tank Farm Facility occurred in August 2005.



- Completed retrieval of remote-handled transuranic waste drums from the RWMC Intermediate Level Transuranic Storage Facility and placement into interim above ground storage.
- Began exhumation and processing of targeted waste from the Accelerated Retrieval Project.
- Transmitted the draft Operable Unit (OU) 7-13/14 Remedial Investigation and Baseline Risk Assessment to EPA and the state of Idaho for their review.

Accelerated cleanup activities are further discussed through 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 CERCLA. By the end of 2005:

- Twenty-two RODs have been signed and are being implemented.
- Three Remedial Investigation/Feasibility Studies (RI/FSs) are under development.
- Closeout activities at Waste Area Groups (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 the cumulative risks for an entire WAG by assessing the combined impact of all release sites within that group.
- Review assumptions used in each previous investigation, including "No Further Action" sites, Track 1 and 2 limited field investigations, RI/FSs, and interim actions.
- Identify data gaps and recommend actions, such as field sampling or historical document research, to resolve questions.
- Perform feasibility studies to evaluate cleanup alternatives for the entire WAG.

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. Three investigations remain to be completed:

- Buried waste at the RWMC (WAG 7)
- Soil contamination at the INTEC Tank Farm (WAG 3, OU 3-14)
- Eastern Snake River Plain Aquifer contamination (WAG 10, OU 10-8).

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 2005, the remediation of the PM-2A tanks was completed and remediation of V-tanks 1, 2, 3, and 9 was initiated. This V-tanks site consists of four out-of-service underground storage tanks, related structures, and the surrounding contaminated soil. There are three 37,854 L (10,000 gal) and one 1514 L (400 gal) underground storage tanks. The contents are contaminated with radionuclides, heavy metals, and organic compounds. The remedy consists of soil and tank removal, treatment of tank contents using air sparging followed by stabilization, and disposal. The treatment activities taking place at the V-tanks site and adjacent areas were ongoing at the end of 2005.

Remediation of the two PM-2A tanks (V-13 and V-14) began in 2004. The two 190,000 L (50,000 gal) tanks were first removed from the ground. Tank V-13 did not require treatment and was then disposed directly in the ICDF. Tank V-14 was moved to the ICDF and its contents treated via air sparging to remove tetrachloroethene prior to disposal in the ICDF landfill.

In addition to the V-tank work, the OU 1-07B groundwater cleanup continued throughout 2005. The in situ bioremediation nutrient injection system continued to reduce contaminant concentrations in the aquifer. The New Pump and Treat Facility was placed on standby to test rebound of aquifer contamination levels. Significant rebound did not occur through the end of 2005.

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 2005, all of these Institutional Controls were maintained.



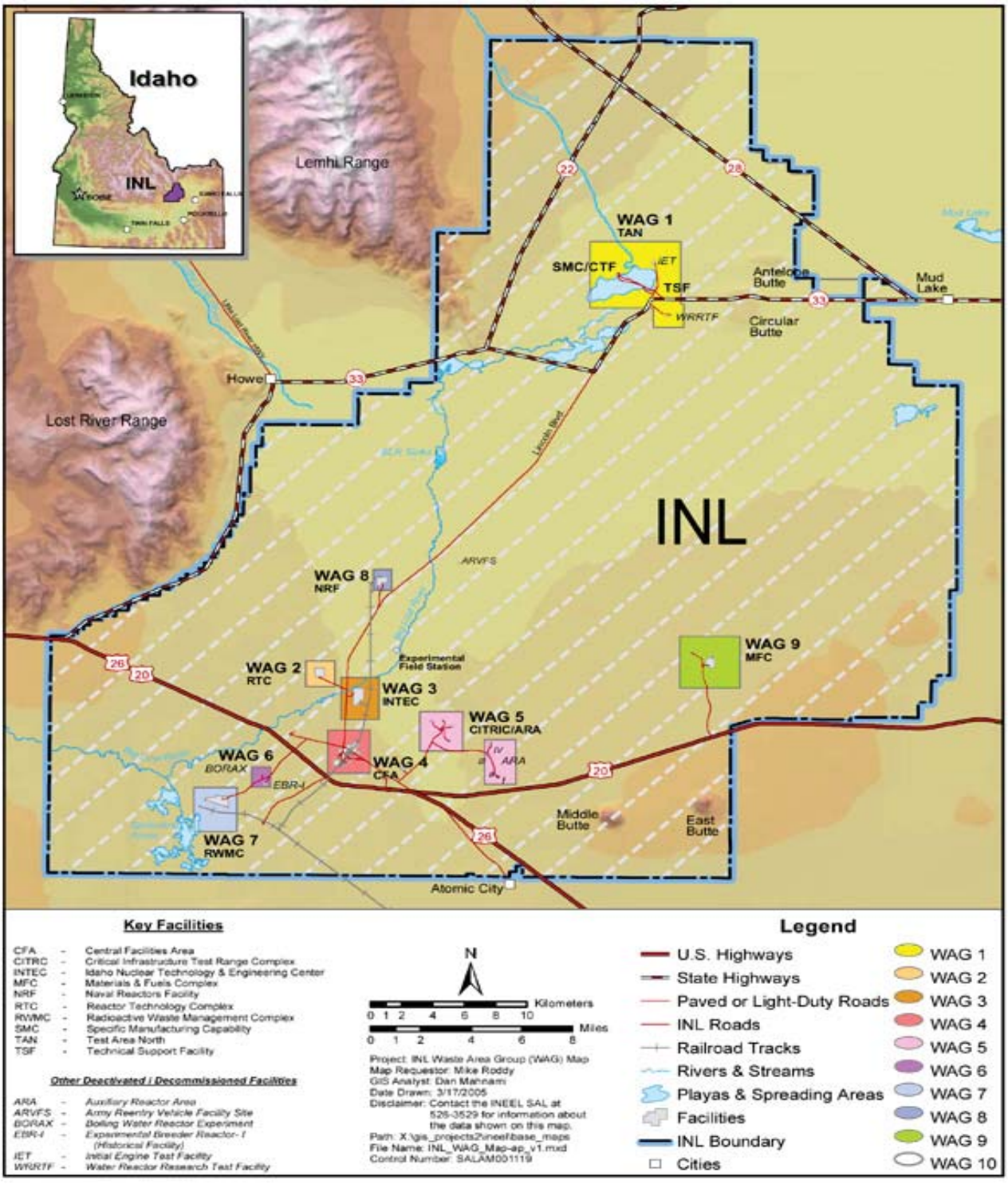

Figure 3-3. Relief Map of the INL Site Showing Locations of the Facilities and Corresponding WAGs.



Waste Area Group 3 – Idaho Nuclear Technology and Engineering Center

Operations continued at the ICDF during 2005, 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. During 2005, construction of the second phase of the ICDF landfill was completed and put into operation to bring the landfill to its full capacity of about 390,000 m^3 (13,772,721 ft^3). Construction of the Staging, Storage, Sizing, and Treatment Facility was also completed, which provides the capability to treat soils that do not meet Land Disposal Restriction requirements so that they can be disposed in the ICDF landfill. As of the end of 2005, treatment was ongoing of 403 metric tons (1216 tons) of mercury-contaminated soil staged on an asphalt pad in the ICDF area. The soil came from a cleanup project at CFA. Other major accomplishments at WAG 3 include:

- Completed the Draft RI/FS Study Reports and submitted them for review by regulatory agencies. Completion of these reports and issuance of a proposed cleanup plan is expected during 2006.
- Completed field work for remediation of OU 3-13, Group 3 soil contamination sites CPP-34A, CPP-34B, and CPP-97. The cleanup consisted of excavating over 90,000 metric tons (100,000 tons) of contaminated soil, disposing of it in the ICDF landfill, and backfilling the excavations with clean soil.
- 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 Power Burst Facility (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 2005. Work on the INL Site-wide groundwater model also continued. These activities are to prepare for the upcoming OU 10-08 RI/FS. The OU 10-04 ROD is being implemented in four phases. The Phase I Remedial Action Report, documenting implementation of institutional controls and ecological monitoring, was completed during 2005. The Phase II remedial design/remedial action (RD/RA) Work Plan to address remediation of TNT contaminated soils sites was completed during 2004. The Phase III RD/RA Work Plan was



completed during 2005. The Phase IV RD/RA Work Plan to address unexploded ordnance will be completed during 2006.

Waste Area Group 7 – Radioactive Waste Management Complex

Waste Area Group 7 includes the Subsurface Disposal Area (SDA), a 39 hectare (ha) (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 state, EPA, and DOE-ID agreed on a revised technical approach, the Glovebox Excavator Method project (GEM), to demonstrate retrieval from a small area of Pit 9. Workers remotely excavated wastes and examined them in a shielded confinement structure or glovebox. The waste is to be treated for shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Waste retrieved during this successful excavation has been used to validate the characterization data generated by several noninvasive techniques and by ground probes. The ongoing Accelerated Retrieval Project (ARP), and ARP-II project to be initiated during 2006, are larger-scale excavations (one-half acre) in Pits 4 and 6 using many of the safe operating concepts developed during the GEM project. These projects 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 2005:

- Continued the Organic Contamination in the Vadose Zone Project, a vacuuum 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 progressed through much of 2005. However, during November 2005, a drum that was in the process of being excavated ignited. The fire was quickly extinguished by covering the drum with soil. Retrieval excavations were discontinued while conducting an extensive evaluation to ensure continued excavations would be safe. Retrieval excavations are anticipated to be reinitiated for ARP and initiated for ARP-II during 2006.

Waste Area Group 9 – Materials and Fuels Complex

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

3.4 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.

Federal Facility Compliance Act

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

In accordance with the Site Treatment Plan, 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. The INL Site is storing the backlog of mixed waste in permitted storage at the Waste Reduction Operations Complex and INTEC. The Site Treatment Plan covers the treatment and disposal of legacy waste by means of a backlog schedule. Below is a list of backlog waste and amounts that were disposed in 2005 in accordance with the milestone schedules.

- HEPA Filter Leach – 28.6 m^3 (1010 ft^3)
- Commercial treatment/disposal of a backlog – 31.2 m^3 (1101.8 ft^3)
- Sodium Components Maintenance Shop treatment backlog – 2.1 m^3 (74.2 ft^3).

The Site Treatment Plan covers the development of a treatment facility for sodium-bearing waste and the research process to identify treatment options for calcine waste.

Advanced Mixed Waste Treatment Project

The overall goal of the Advanced Mixed Waste Treatment Project (AMWTP) is the treatment of alpha-containing low-level mixed and transuranic (TRU) mixed wastes for final disposal by a process that minimizes overall costs while ensuring safety. This will be accomplished through a private sector 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.

A contract for treatment services was awarded to British Nuclear Fuels Limited (BNFL), Inc. in December 1996. BNFL completed construction of the facility in December 2002, fulfilling a Settlement Agreement milestone. AMWTP retrieval operations commenced in March 2003 and treatment facility operations commenced in August 2004. The BNFL contract was terminated effective April 30, 2005, and BBWI assumed operations of AMWTP on May 1, 2005. Certification of the treatment facility was obtained in May 2005 allowing for certification and shipment of treated TRU waste to WIPP. The first shipment of treated TRU waste from AMWTP was sent to WIPP on May 31, 2005.



High-Level Waste (HLW) and Facilities Disposition

In 1953, reprocessing of spent nuclear fuel began at the INTEC, resulting in the generation of liquid HLW and sodium-bearing liquid waste (SBW). 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 spent nuclear fuel 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 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.

DOE issued, in October 2002, the Final Idaho HLW and Facilities Disposition Environmental Impact Statement (FEIS) that included alternatives other than calcination for treatment of the SBW. DOE issued a ROD for this FEIS on December 13, 2005. This ROD chose steam reforming technology to treat the remaining SBW in the tank farm. DOE plans on completing SBW treatment using this technology by December 31, 2012. The state of Idaho in a letter dated November 17, 2005, to the Honorable James A. Rispoli, Assistant Secretary for Environmental Management, U.S. Department of Energy, from Kathleen Trever, Administrator, Division of INL Oversight and Radiation Control, states: "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." 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. 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.

In addition, the final Idaho HLW and FEIS issued in October 2002 included analysis of alternatives for treatment of the calcined waste. Work continues to investigate technologies for efficient retrieval of the existing HLW calcine from the consolidated calcine storage facilities (bin sets). The ROD that will be issued by December 31, 2009, will provide for the treatment, if necessary, of the calcine waste to meet the completion date of December 31, 2035.

Low-Level and Mixed Radioactive Waste

In 2005, the INL Site treated and disposed offsite more than 830 m^3 (29,311 ft^3) of mixed low-level waste. Approximately 6535 m^3 (231,841 ft^3) of legacy and newly generated low-level waste were disposed at the SDA in 2005.



Transuranic Waste

In 2005, the INL Site shipped a total of 4267 m^3 (150,688 ft^3) of transuranic waste out of Idaho. This represents an increase of over 4000 m^3 (141,259 ft^3) from the volume shipped in 2004. The increase was the result of implementing efficiency, reliability, and maintainability improvements as well as increasing staffing levels. Since 1999, more than 10,000 m^3 (353,147 ft^3) of waste have been shipped offsite.

Waste Minimization/Pollution Prevention

The mission of the Pollution Prevention Program is to reduce the generation and release of wastes and pollutants by implementing cost-effective pollution prevention techniques, practices, and policies. Pollution prevention is required by various federal statutes including, but not limited to, the Pollution Prevention Act and the Resource Conservation and Recovery Act; Executive Order 13101, *Greening the Government through Waste Prevention, Recycling, and Federal Acquisition*, and Executive Order 13148, *Greening the Government through Leadership in Environmental Management*.

It is the policy of the INL Site to incorporate pollution prevention into every activity onsite and in the Idaho Falls facilities. Pollution prevention is one of the key underpinnings of the INL Site Environmental Management System (see Section 3.5). It functions as an important preventive mechanism because generating less waste reduces waste management costs, compliance vulnerabilities, and the potential for releases to the environment. The INL Site is promoting the inclusion of pollution prevention into all planning activities as well as the concept that pollution prevention is integral to mission accomplishment.

3.5 Environmental Management System

The INL contractor continued to make progress on the effort initiated in 1997 to develop and implement a sitewide Environmental Management System (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. In February and May of 2005, DOE brought two new contractors on board to run the future development of the INL (BEA) and the cleanup of legacy facilities and waste under the Idaho Cleanup Project (CWI), along with changing the operating contractor at the AMWTP from BNFL to BBWI. Because these contract changes occurred during the ISO 14001 registration audit period, the new contractors allowed the former system to lapse while focusing on a new system under the new contracts (for BEA and CWI; BBWI remained exempt under terms of the contract). In November 2005, both BEA and CWI successfully applied and passed the registration audit to regain ISO 14001 registration. In early December 2005, the DOE-ID Manager was able to certify to DOE Headquarters that a successful Environmental Management System was being implemented at the INL Site.

3.6 Other Major Environmental Issues and Activities

Decontamination, Decommissioning, and Demolition (DD&D) Activities

The INL Site continued with an aggressive approach to reducing the EM "footprint" through accelerated DD&D activities 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 total, 7440 m^2 (80,082 ft^2) of buildings and structures were demolished in 2005. Specific projects at various facilities are described below.

Test Area North – Only minor structures and buildings that no longer have a mission were demolished at TAN. In 2005 a total of 268 m^2 (2887 ft^2) of footprint reduction was achieved at TAN.

Critical Infrastructure Test Range/Power Burst Facility – Significant effort was placed on reducing the risks within the PBF Reactor. The PBF Reactor was placed in a cold, dark and dry state; the reactor in-pile tube was removed, water was pumped out of the reactor vessel, and two thirds of the shielding lead was removed from the facility. The PBF reactor evaporation tank was demolished in 2005. The footprint reduction reported for PBF was 465 m^2 (5010 ft^2); credit for work accomplished in the PBF Reactor facility will not be counted until facility DD&D is complete.

Reactor Technology Complex – Emphasis was placed on demolishing the Material Test Reactor and Engineering Test Reactor support facilities. A total of 2942 m^2 (31,665 ft^2) of buildings and structures was demolished in 2005. Decontamination work started in the Engineering Test Reactor to reduce personnel and environmental risks.

Idaho Nuclear Technology and Engineering Center – Significant effort was placed on completing the demolition of CPP-627 (Remote Analytical Laboratory), which was part of the Fuel Reprocessing Complex and represented one of the highest risk facilities at the INL Site. The CPP-627 along with several other buildings and structures, were decommissioned in 2005, resulting in a total footprint reduction of 3764 m^2 (40,520 ft^2).



Spent Nuclear Fuel

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 EM INTEC, by the Naval 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 monitored geologic 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 a monitored geologic repository by September 30, 2015.

In 2005, 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 into standard canisters, in dry storage, so that it can be ready for transport once a repository is licensed. SNF storage facilities are described below. All Environmental Management 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: a SNF storage 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. Eventually, all SNF will be removed from this underwater storage pool and placed in dry storage in preparation for shipment to a repository. In 2005, the Advanced Test Reactor (ATR) sent shipments of SNF to FAST for storage and aluminum-plate SNF was transferred from the basins to dry storage in the Irradiated Fuel Storage Facility.

Irradiated Fuel Storage Facility (CPP-603) – This INTEC facility, also called the IFSF, is the dry side of the Wet & Dry Fuel Storage Facility. It has 636 storage positions and has provided dry storage for SNF since 1973. In 2005, the DD&D of the old fuel storage basin was started. The IFSF was approximately 60% full at the end of 2005 and will continue to receive SNF from the CPP-666 basin, and foreign and domestic research reactors SNF in 2006.

TMI-2 Independent Spent Fuel Storage Installation (CPP-1774) – This INTEC facility, also called the ISFSI, is an NRC-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. This facility stores Peach Bottom fuel as well as other unirradiated fuels.

Fort Saint Vrain Independent Spent Fuel Storage Installation – The DOE-ID manages this offsite NRC-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 will be a monitored geologic repository.

Environmental Oversight and Monitoring Agreement

The 2000 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 Idaho National Laboratory 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 over 125 recommendations during its tenure. Currently, the Board is working on the following issues, in addition to numerous others:

- Cleanup and closure of RWMC, including the SDA
- Cleanup and Closure of INTEC
- Disposition of Calcined HLW
- Treatment of Liquid SBW
- Decommissioning the PBF Reactor Building.

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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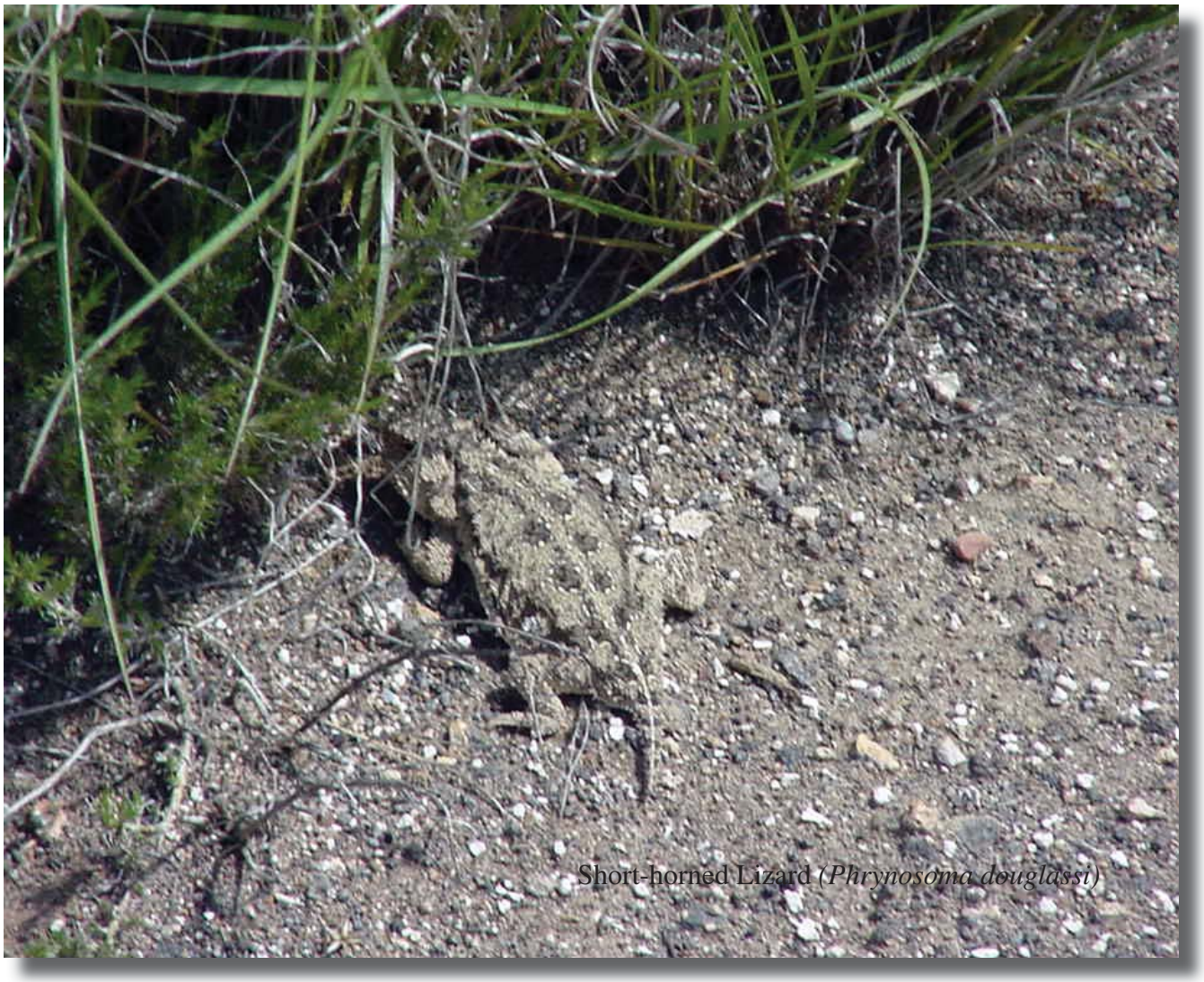
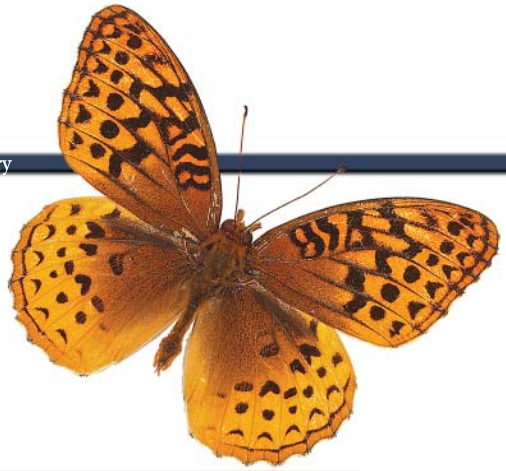


Short-horned Lizard (*Phrynosoma douglassi*)



Great Spangled Fritillary

Chapter 4 - Environmental Monitoring Programs - Air

M. Case - S. M. Stoller Corporation
M. Verdoorn - Battelle Energy Alliance
R. Wilhelmsen - CH2M-WG Idaho

Chapter Highlights

The Idaho National Laboratory (INL) onsite environmental surveillance programs are the primary responsibility of the INL contractor (Battelle Energy Alliance [BEA]) and the Idaho Cleanup Project (ICP) contractor (CH2M-WG Idaho [CWI]). The Environmental Surveillance, Education and Research (ESER) contractor who, during 2005, was a team led by the S. M. Stoller Corporation, is primarily responsible for the offsite environmental monitoring program. These programs emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to receptors. The INL and ICP contractors monitor airborne effluents at individual INL Site facilities and ambient air outside the facilities to comply with appropriate regulations and U.S. Department of Energy (DOE) Orders. The ESER contractor samples ambient air at locations within, around, and distant from the INL Site.

An estimated total of 6614 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2005. 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, strontium-90, iodine-131, cesium-137, plutonium-239/240, and americium-241. Results do not indicate any link between radionuclides released from the INL Site and environmental concentrations measured offsite. All concentrations were well below regulatory standards and most were within historical measurements.

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

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 (DOE) 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, conducted by the INL contractor, the ICP contractor, and the ESER contractor, emphasize measurement of airborne radionuclides because air has the potential to transport a large amount of activity 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 by each organization at the INL Site.

The INL contractor monitors airborne effluents at individual INL 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 2005.

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 2005. Section 4.2 summarizes results of air monitoring by the INL and ESER contractors. 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



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		•	•	•	•	•		•	•	
Environmental Surveillance, Education and Research Program										
INL/Regional		•	•	•	•	•	•	•	•	•[f]
National Oceanic and Atmospheric Administration										
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 2004 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. The IMPROVE samplers are operated by the National Park Service for the Environmental Protection Agency.



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 (SIP). 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.

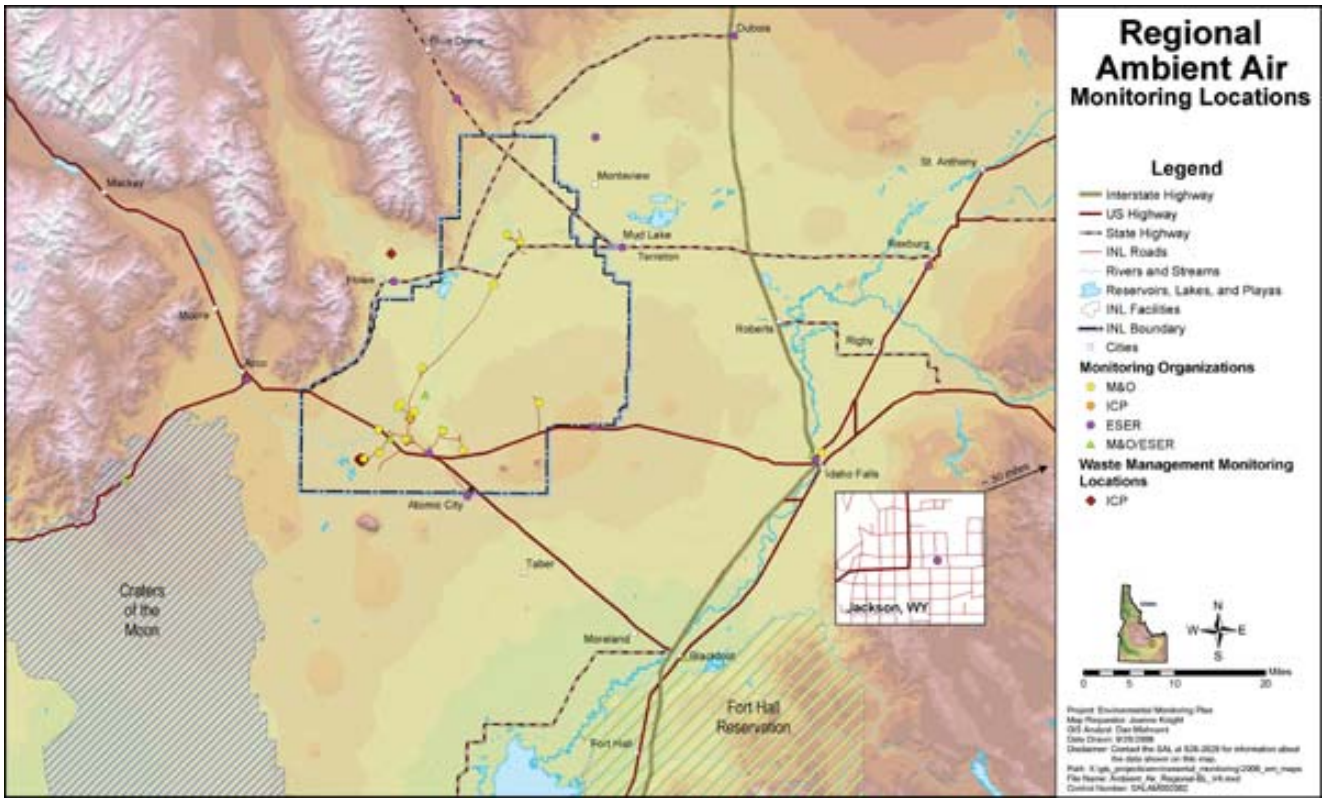


Figure 4-1. INL Site Environmental Surveillance Air Sampling Locations.



For onsite and offsite air surveillance monitoring, filters are collected from a network of low-volume air monitors weekly. 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 and ESER contractors monitor this to provide comparison information for 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.

Tritium in water vapor in the atmosphere 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 absorbs 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 2005, an estimated 6,614 Ci of radioactivity were released to the atmosphere from all INL Site sources. *The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Calendar Year 2005 INL Report for Radionuclides* (DOE-ID 2006) 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. Only radionuclides that are potentially significant contributors to the INL Site dose (i.e., >1E-05 mrem) are listed in the NESHAPs report. Table 4-2 only includes the screened NESHAPs radionuclides with releases greater than 1 pCi/year.



Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2005).[a]

		Airborne Effluent (Ci)[b]							
Nuclide	Half-life	CFA[c]	INTEC[c,d]	MFC[c]	CITRC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Ac-227	21.7 y	--[g]	5.16E-14	--	--	4.86E-12	--	--	4.91E-12
Ag-109M	39.6 s	--	1.24E-20	--	--	--	--	--	1.24E-20
Ag-110	24.6 s	--	1.31E-19	--	--	--	--	--	1.31E-19
Ag-110M	249.9 d	--	2.29E-06	--	--	3.32E-06	--	1.42E-03	1.43E-03
Am-241	432.2 y	5.26E-10	7.05E-05	--	--	1.93E-03	1.23E-04	1.41E-07	2.12E-03
Am-242	16 h	--	1.41E-13	--	--	3.09E-13	--	--	4.50E-13
Am-242M	152 y	--	1.41E-13	--	--	--	--	--	1.41E-13
Am-243	7380 y	4.00E-13	2.02E-10	--	--	2.85E-07	--	--	2.85E-07
Ar-41	1.827 h	--	--	3.50E+00	--	5.49E+02	--	--	5.53E+02
Ba-133	10.5 y	--	--	--	--	2.11E-09	--	--	2.11E-09
Ba-139	82.7 m	--	--	--	--	1.98E-04	--	--	1.98E-04
Ba-140	12.74 d	--	--	--	--	5.36E-06	--	--	5.36E-06
Ba-141	18.3 m	--	--	--	--	1.46E-09	--	--	1.46E-09
Be-7	53.3 d	--	--	--	--	--	4.42E-08	--	4.42E-08
Bi-210	5 d	--	2.76E-15	--	--	--	--	--	2.76E-15
Bi-211	2.1 m	--	4.62E-14	--	--	--	--	--	4.62E-14
Bi-212	60.6 m	--	1.97E-12	--	--	--	1.46E-12	--	3.43E-12
Bi-214	19.9 m	--	7.55E-13	--	--	--		--	7.55E-13
C-14	5730 y	--	7.64E-04	--	--	3.45E-04	9.38E-01	--	9.40E-01
Cd-115M	44.6 y	--	1.07E-62	--	--	--	--	--	1.07E-62
Ce-141	32.5 d	--	4.56E-80	--	--	1.12E-06	--	--	1.12E-06
Ce-144	284.3 d	--	1.81E-08	--	--	1.03E-05	1.48E-12	6.03E-07	1.09E-05
Cf-252	2.638 y	--	5.67E-29	--	--	3.67E-05	--	--	3.67E-05
Cl-36	3.01E5 y	--	--	--	--	2.62E-14	--	--	2.62E-14
Cm-242	162.8 d	--	5.67E-11	--	--	3.77E-08	--	1.86E-10	3.80E-08
Cm-243	28.5 y	--	5.67E-09	--	--	6.89E-15	--	7.35E-08	7.92E-08
Cm-244	18.11 y	--	4.95E-07	--	--	1.52E-06	2.95E-11	5.94E-08	2.08E-06
Cm-245	8500 y	--	2.21E-16	--	--	--	--	--	2.21E-16
Cm-246	4730 y	--	6.53E-18	--	--	--	--	--	6.53E-18
Cm-247	1.6E7 y	--	1.61E-24	--	--	--	--	--	1.61E-24
Cm-248	3.4E5 y	--	4.93E-25	--	--	--	--	--	4.93E-25
Co-57	270.9 d	1.43E-09	--	--	--	7.35E-08	--	--	7.49E-08
Co-58	70.8 d	--	1.05E-06	--	--	1.93E-06	--	9.78E-09	2.99E-06
Co-60	5.271 y	2.59E-08	5.95E-02	--	--	4.02E-03	9.65E-10	2.21E-05	6.35E-02
Cr-51	27.704 d	--	--	--	--	9.38E-02	--	--	9.38E-02
Cs-134	2.062 y	4.19E-09	4.94E-04	--	--	4.26E-05	6.08E-12	2.81E-08	5.37E-04
Cs-135	2.3E6 y	--	9.40E-11	--	--	--	--	--	9.40E-11
Cs-137	30.0 y	2.30E-08	9.40E-02	2.52E-03	6.00E-08	4.22E-03	2.20E-10	9.48E-02	1.95E-01
Cs-138	32.2 m	--	--	--	--	1.70E-02	--	--	1.70E-02
Eu-152	13.33 y	--	3.92E-01	--	--	8.68E-05	--	1.02E-06	3.92E-01
Eu-154	8.8 y	--	2.21E-01	--	--	8.96E-05	--	4.86E-07	2.21E-01
Eu-155	4.96 y	--	2.20E-02	--	--	2.29E-05	--	8.82E-08	2.20E-02
Fe-55	2.7 y	3.98E-10	1.31E-06	--	--	1.58E-02	6.19E-14	--	1.58E-02
Fe-59	44.529 d	--	--	--	--	2.23E-07	--	--	2.23E-07

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2005).[a] (continued)

		Airborne Effluent (Ci)[b]							
Nuclide	Half-life	CFA[c]	INTEC[c,d]	MFC[c]	CITRC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Fr-221	4.8 m	- -	1.29E-16	- -	- -	- -	- -	- -	1.29E-16
Fr-223	21.8 m	- -	7.13E-16	- -	- -	- -	- -	- -	7.13E-16
H-3	12.35 y	4.56E-02	5.08E+02	1.01E+01	6.04E-03	2.72E+02	1.00E+01	1.82E+00	8.02E+02
Hf-181	42.39 d	- -	- -	- -	- -	1.04E-05	- -	- -	1.04E-05
Hg-203	46.6 d	- -	- -	- -	- -	1.19E-05	- -	- -	1.19E-05
Ho-166	26.8 h	- -	2.43E-16	- -	- -	- -	- -	- -	2.43E-16
Ho-166M	1.2E3 y	- -	6.82E-15	- -	- -	1.59E-11	- -	- -	1.59E-11
I-125	60.1 d	- -	- -	- -	- -	2.11E-03	- -	- -	2.11E-03
I-129	1.57E7 y	- -	5.84E-02	- -	- -	1.28E-04	- -	1.17E-03	5.97E-02
I-131	8.04 d	- -	- -	- -	- -	2.83E-01	- -	- -	2.83E-01
I-132	2.30 h	- -	- -	- -	- -	3.83E-04	- -	- -	3.83E-04
I-133	20.8 h	- -	- -	- -	- -	6.68E-04	- -	- -	6.68E-04
I-134	52.6 m	- -	- -	- -	- -	9.61E-04	- -	- -	9.61E-04
I-135	6.61 h	- -	- -	- -	- -	1.75E-03	- -	- -	1.75E-03
In-115	5.2E15 y	- -	1.46E-20	- -	- -	- -	- -	- -	1.46E-20
Ir-192	74.02 d	- -	- -	- -	- -	6.28E-09	- -	- -	6.28E-09
K-40	1.277E8 y	- -	2.28E-07	- -	- -	- -	5.90E-08	5.99E-06	6.28E-06
Kr-85	10.72 y	- -	3.80E+03	1.38E+03	- -	2.49E-01	3.76E-07	- -	5.19E+03
Kr-85M	4.48 h	- -	- -	- -	- -	5.24E+00	- -	- -	5.24E+00
Kr-87	76.3 m	- -	- -	- -	- -	1.71E+00	- -	- -	1.71E+00
Kr-88	2.84 m	- -	- -	- -	- -	6.25E+00	- -	- -	6.25E+00
Mn-54	312.5 d	1.78E-09	6.07E-10	- -	- -	8.74E-05	- -	1.98E-08	8.74E-05
Mo-93	3.5E3 y	- -	- -	- -	- -	2.23E-09	- -	- -	2.23E-09
Mo-99	66.0 h	- -	- -	- -	- -	4.21E-05	- -	- -	4.21E-05
Na-22	2.6 y	- -	- -	- -	- -	5.64E-10	- -	- -	5.64E-10
Na-24	15.0 h	- -	- -	- -	- -	1.42E-04	- -	- -	1.42E-04
Nb-93M	13.6 y	- -	3.92E-11	- -	- -	5.30E-07	- -	- -	5.30E-07
Nb-94	2.03E4 y	- -	6.99E-04	- -	- -	3.34E-08	- -	8.63E-07	7.00E-04
Nb-95	35.15 d	- -	5.22E-08	- -	- -	4.44E-07	- -	4.56E-08	5.42E-07
Nb-95M	86.6 h	- -	4.65E-44	- -	- -	- -	- -	- -	4.65E-44
Ni-59	7.5E4 y	- -	1.60E-06	- -	- -	6.95E-06	- -	- -	8.56E-06
Ni-63	96 y	1.44E-09	4.37E-04	- -	1.18E-10	8.22E-04	1.96E-13	5.37E-05	1.31E-03
Np-237	2.14E6 y	1.50E-13	3.49E-06	- -	1.01E-12	9.18E-06	- -	1.59E-10	1.27E-05
Np-238	2.1 d	- -	1.93E-11	- -	- -	- -	- -	- -	1.93E-11
Np-239	2.355 d	- -	8.50E-13	- -	- -	5.76E-05	- -	- -	5.76E-05
Np-240	65 m	- -	7.05E-23	- -	- -	- -	- -	- -	7.05E-23
Np-240M	7.4 m	- -	6.41E-20	- -	- -	- -	- -	- -	6.41E-20
Pa-231	3.3E4 y	- -	1.76E-13	- -	- -	- -	- -	- -	1.76E-13
Pa-233	27 d	- -	1.11E-10	- -	- -	2.64E-11	- -	- -	1.38E-10
Pb-209	3.3 h	- -	1.22E-16	- -	- -	- -	- -	- -	1.22E-16
Pb-210	22.3 y	- -	2.76E-15	- -	- -	5.85E-11	1.33E-08	- -	1.34E-08
Pb-211	36.1 m	- -	4.63E-14	- -	- -	- -	- -	- -	4.63E-14
Pb-212	10.6 h	- -	2.09E-12	- -	- -	- -	1.46E-12	- -	3.55E-12
Pb-214	26.8 m	- -	9.25E-12	- -	- -	- -	- -	- -	9.25E-12

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2005).[a] (continued)

		Airborne Effluent (Ci)[b]							
Nuclide	Half-life	CFA[c]	INTEC[c,d]	MFC[c]	CITRC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Pd-107	6.5E6 y	- -	1.55E-11	- -	- -	- -	- -	- -	1.55E-11
Pm-147	2.6234 y	- -	2.01E-04	- -	- -	8.38E-04	1.50E-12	- -	1.04E-03
Pm-148	5.4 d	- -	1.00E-67	- -	- -	- -	- -	- -	1.00E-67
Pm-148M	41.3 d	- -	2.08E-66	- -	- -	- -	- -	- -	2.08E-66
Po-210	138.4 d	- -	2.56E-15	- -	- -	2.93E-11	- -	- -	2.93E-11
Po-218	3.05 m	- -	1.42E-14	- -	- -	- -	- -	- -	1.42E-14
Pr-144	17.3 m	- -	9.87E-12	- -	- -	- -	1.49E-12	- -	1.14E-11
Pr-144M	7.2 m	- -	6.40E-14	- -	- -	- -	- -	- -	6.40E-14
Pu-236	2.9 y	2.50E-13	4.40E-14	- -	- -	3.16E-13	- -	- -	6.10E-13
Pu-238	87.74 y	6.67E-11	5.46E-04	- -	- -	8.35E-06	6.36E-09	3.87E-07	5.55E-04
Pu-239	24065 y	1.40E-10	2.20E-03	5.05E-07	2.54E-10	7.97E-05	3.90E-04	5.97E-06	2.68E-03
Pu-240	6537 y	- -	3.75E-04	- -	- -	9.98E-05	8.70E-05	5.94E-06	5.68E-04
Pu-241	14.4 y	- -	1.50E-02	- -	- -	1.31E-04	8.82E-09	- -	1.51E-02
Pu-242	3.8E5 y	1.50E-13	6.09E-13	- -	- -	2.58E-08	5.70E-14	- -	2.58E-08
Pu-243	5 h	- -	1.61E-24	- -	- -	- -	- -	- -	1.61E-24
Pu-244	8.3E7 y	- -	6.42E-20	- -	- -	3.18E-11	- -	- -	3.18E-11
Ra-223	11.4 d	- -	5.12E-14	- -	- -	- -	- -	- -	5.12E-14
Ra-225	14.8 d	- -	1.29E-16	- -	- -	- -	- -	- -	1.29E-16
Ra-226	1600 y	- -	2.12E-06	- -	- -	9.66E-08	- -	5.05E-07	2.72E-06
Rb-87	4.7E10 y	- -	2.83E-14	- -	- -	- -	- -	- -	2.83E-14
Rb-88	17.8 m	- -	- -	- -	- -	2.55E-01	- -	- -	2.55E-01
Rb-89	15.2 m	- -	- -	- -	- -	1.10E-02	- -	- -	1.10E-02
Rh-103M	56.1 m	- -	7.14E-67	- -	- -	- -	- -	- -	7.14E-67
Ru-103	39.28 d	- -	7.15E-67	- -	- -	1.61E-08	- -	8.27E-08	9.88E-08
Ru-106	368.2 d	- -	1.53E-08	- -	- -	8.02E-08	- -	5.02E-07	5.98E-07
Sb-124	60.2 d	- -	5.24E-49	- -	- -	2.49E-06	- -	- -	2.49E-06
Sb-125	2.77 y	- -	6.04E-03	- -	- -	2.62E-06	9.04E-14	2.75E-08	6.04E-03
Sb-126	12.4 d	- -	5.23E-11	- -	- -	- -	- -	- -	5.23E-11
Sb-126M	19 m	- -	3.74E-10	- -	- -	- -	- -	- -	3.74E-10
Sb-127	3.9 d	- -	- -	- -	- -	6.25E-06	- -	- -	6.25E-06
Sc-46	83.83 d	- -	- -	- -	- -	6.09E-07	- -	- -	6.09E-07
Sm-147	1.1E11 y	- -	1.04E-14	- -	- -	- -	- -	- -	1.04E-14
Sm-151	90 y	- -	4.51E-04	- -	- -	- -	- -	- -	4.51E-04
Sn-113	115.09 d	4.43E-10	- -	- -	- -	1.86E-11	- -	- -	4.62E-10
Sn-123	129.2 d	- -	2.13E-25	- -	- -	- -	- -	- -	2.13E-25
Sn-126	1E5 y	- -	3.74E-10	- -	- -	5.40E-11	- -	- -	4.28E-10
Sr-89	50.5 d	- -	6.15E-11	- -	- -	4.69E-03	- -	- -	4.69E-03
Sr-90	29.12 y	4.21E-10	1.61E-01	1.24E-05	2.64E-07	1.85E-03	2.31E-07	3.01E-03	1.66E-01
Sr-91	9.5 h	- -	- -	- -	- -	2.77E-11	- -	- -	2.77E-11
Sr-92	2.7 h	- -	- -	- -	- -	3.36E-11	- -	- -	3.36E-11
Tb-160	72.3 d	- -	8.02E-43	- -	- -		- -	- -	8.02E-43
Tc-99	2.13E5 y	- -	8.73E-08	- -	- -	1.97E-08	- -	- -	1.07E-07
Tc-99M	6.02 h	- -	- -	- -	- -	1.27E-04	- -	- -	1.27E-04
Te-127	9.4 h	- -	2.36E-28	- -	- -		- -	- -	2.36E-28

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2005).[a] (continued)

Nuclide	Half-life	Airborne Effluent (Ci)[b] CFA[c]	INTEC[c,d]	MFC[c]	CITRC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Te-127M	109 d	--	2.40E-28	--	--	4.00E-12	--	--	4.00E-12
Te-129	69.6 m	--	1.70E-79	--	--	--	--	--	1.70E-79
Te-129M	33.6 d	--	2.71E-79	--	--	--	--	--	2.71E-79
Th-227	18.7 d	--	4.59E-14	--	--	--	--	--	4.59E-14
Th-230	7.7E4 y	--	6.54E-08	--	4.24E-09	1.87E-10	--	1.33E-13	6.98E-08
Th-231	25.5 h	--	4.07E-10	--	--	--	--	--	4.07E-10
Th-232	1.405E10	1.81E-13	1.06E-05	--	3.21E-09	1.73E-11	4.01E-13	--	1.06E-05
Tl-207	4.8 m	--	4.61E-14	--	--	--	--	--	4.61E-14
Tl-208	3.1 m	--	1.10E-12	--	--	--	5.23E-13	--	1.62E-12
Tl-209	2.2 m	--	2.66E-18	--	--	--	--	--	2.66E-18
U-232	72 y	2.50E-13	1.43E-12	--	--	8.41E-17	1.42E-12	--	3.10E-12
U-233	1.585E5 y	--	2.21E-07	--	--	5.31E-09	5.59E-11	1.10E-05	1.13E-05
U-234	2.457E5 y	1.30E-10	2.23E-04	--	8.46E-09	2.23E-07	3.17E-13	1.09E-05	2.34E-04
U-235	7.038E8 y	1.51E-14	9.28E-06	--	5.91E-10	9.85E-09	--	1.41E-06	1.07E-05
U-236	4.468E9 y	--	3.92E-07	--	--	4.43E-12	--	--	3.92E-07
U-237	6.8 d	--	--	--	--	9.38E-10	--	--	9.38E-10
U-238	4.5 E9 y	1.68E-07	1.12E-05	--	5.31E-09	5.99E-06	--	1.13E-06	1.85E-05
U-240	14.1 h	--	6.41E-20	--	--	--	--	--	6.41E-20
W-187	23.9 h	--	--	--	--	2.01E-05	--	--	2.01E-05
Xe-127	9.4 h	--	3.99E-81	--	--	--	--	--	3.99E-81
Xe-131M	11.8 d	--	6.80E-121	--	--	--	--	--	6.80E-121
Xe-133	5.245 d	--	--	--	--	2.61E+01	--	--	2.61E+01
Xe-133M	5.2 d	--	--	--	--	1.00E+00	--	--	1.00E+00
Xe-135	9.09 h	--	--	--	--	2.28E+01	--	--	2.28E+01
Xe-135M	15.29 m	--	--	--	--	2.08E+00	--	--	2.08E+00
Xe-138	14.17 m	--	--	--	--	3.01E+00	--	--	3.01E+00
Y-91	58.5 d	--	1.05E-45	--	--	--	--	--	1.05E-45
Y-91M	49.71 m	--	--	--	--	2.61E-04	--	--	2.61E-04
Zn-65	243.9 d	3.29E-09	8.74E-09	--	--	5.16E-05	--	6.73E-08	5.17E-05
Zr-93	1.5E6 y	--	2.17E-09	--	--	--	--	--	2.17E-09
Zr-95	63.98 d	--	3.17E-06	--	--	7.48E-07	--	4.52E-08	3.96E-06
Total		4.56E-02	4.31E+03	1.40E+03	6.04E-03	8.90E+02	1.10E+01	1.92E+00	6.61E+03

a. Radioactive release information provided by CH2M WG Idaho, LLC (CWI).
b. Includes only those radionuclides with a total Site release that potentially contribute >1E-05 mrem dose.
c. CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center , MFC = Materials and Fuels Complex, CITRC = Critical Infrastructure Test Range Complex, RTC = Reactor Technology Complex, RWMC = Radioactive Waste Management Area, TAN = Test Area North
d. Most of the INTEC emissions are from the Three Mile Island Dry Fuel Storage Facility and are based on conservative calculations.
e. A double dash signifies the radionuclide was not released to air from that facility during the calendar year.

The largest facility contributions to the total emissions came from the Idaho Nuclear Technology and Engineering Center (INTEC) at more than 65 percent, Reactor Technology Complex at approximately 13.5 percent, and Materials and Fuels Complex at approximately 21 percent (Table 4-2). Approximately 88 percent of the radioactive effluent was in the form of noble gases (argon, krypton, and xenon). Most of the remaining effluent (12 percent) was tritium.

Low-Volume Charcoal Cartridges

Both the ESER and INL 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 radionuclide were detected, the filters were individually analyzed. During 2005, the ESER contractor analyzed 1171 cartridges, looking specifically for ^{131}I. No ^{131}I was detected in any of the individual ESER samples. No iodine was detected in samples collected by the INL contractor.

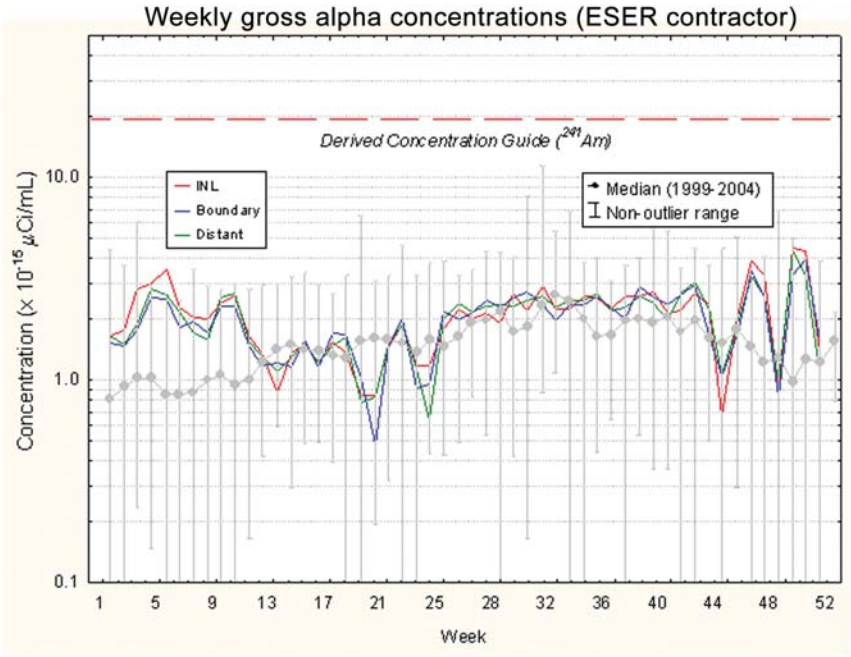
Low-Volume Gross Alpha

Particulates filtered from the air were sampled from 29 locations 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. Gross alpha concentrations found in INL contractor samples, both on and offsite, tended to be higher than those found in ESER contractor samples at common locations. Reasons for differences in concentrations measured at the same locations are likely caused by differences in laboratory analytical techniques and instrumentation, as different analytical laboratories were used. Both sets of data indicated gross alpha concentrations at onsite locations were generally equal to or lower than at boundary locations.

Weekly gross alpha concentrations detected in ESER contractor samples (i.e., measurements which exceeded their associated 3 sigma uncertainties) ranged from a minimum of 0.93×10^{-15} µCi/mL at the Howe Q/A-2 station during the week ending October 12, 2005, to a maximum of 4.53×10^{-15} µCi/mL during the week ending December 14, 2005, at Idaho Falls. Concentrations measured by the INL contractor that exceeded their 3 sigma uncertainty ranged from a low of 0.54×10^{-15} µCi/mL collected at Gate 4 on the INL Site on December 7, 2005, to a high of 7.37×10^{-15} µCi/mL collected at Blackfoot on November 2, 2005.

Figure 4-2 displays the median weekly gross alpha concentrations for the ESER and INL contractors at INL Site, boundary, and distant station groups. It also shows historical medians and ranges measured by the ESER contractor from 1999- 2004. 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 INL group in the fourth quarter of 2005. The maximum median weekly gross alpha concentration was 1.4×10^{-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.





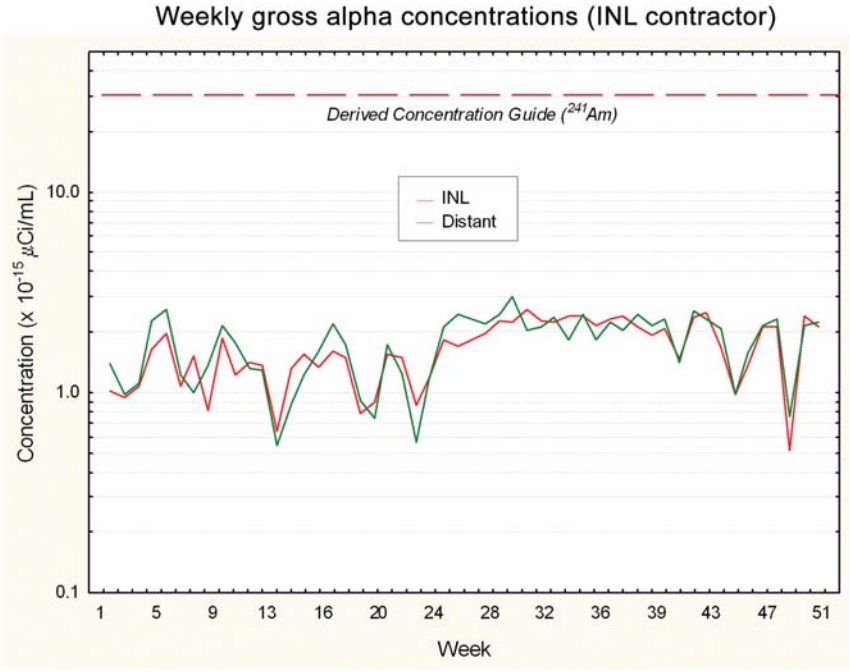


Figure 4-2. Median Weekly Gross Alpha Concentrations in Air (2005).



Annual median gross alpha concentrations calculated by the ESER contractor ranged from 0.85 x 10^{-15} µCi/mL at Blue Dome to 1.72 x 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 INL contractor ranged from 1.31 x 10^{-15} µCi/mL at Craters of the Moon to 2.05 x 10^{-15} µCi/mL at Rexburg.

In general, gross alpha concentrations were typical of those detected previously and well within the range of measurements observed historically for the ten-year period from 1996 through 2005 (Figure 4-3).

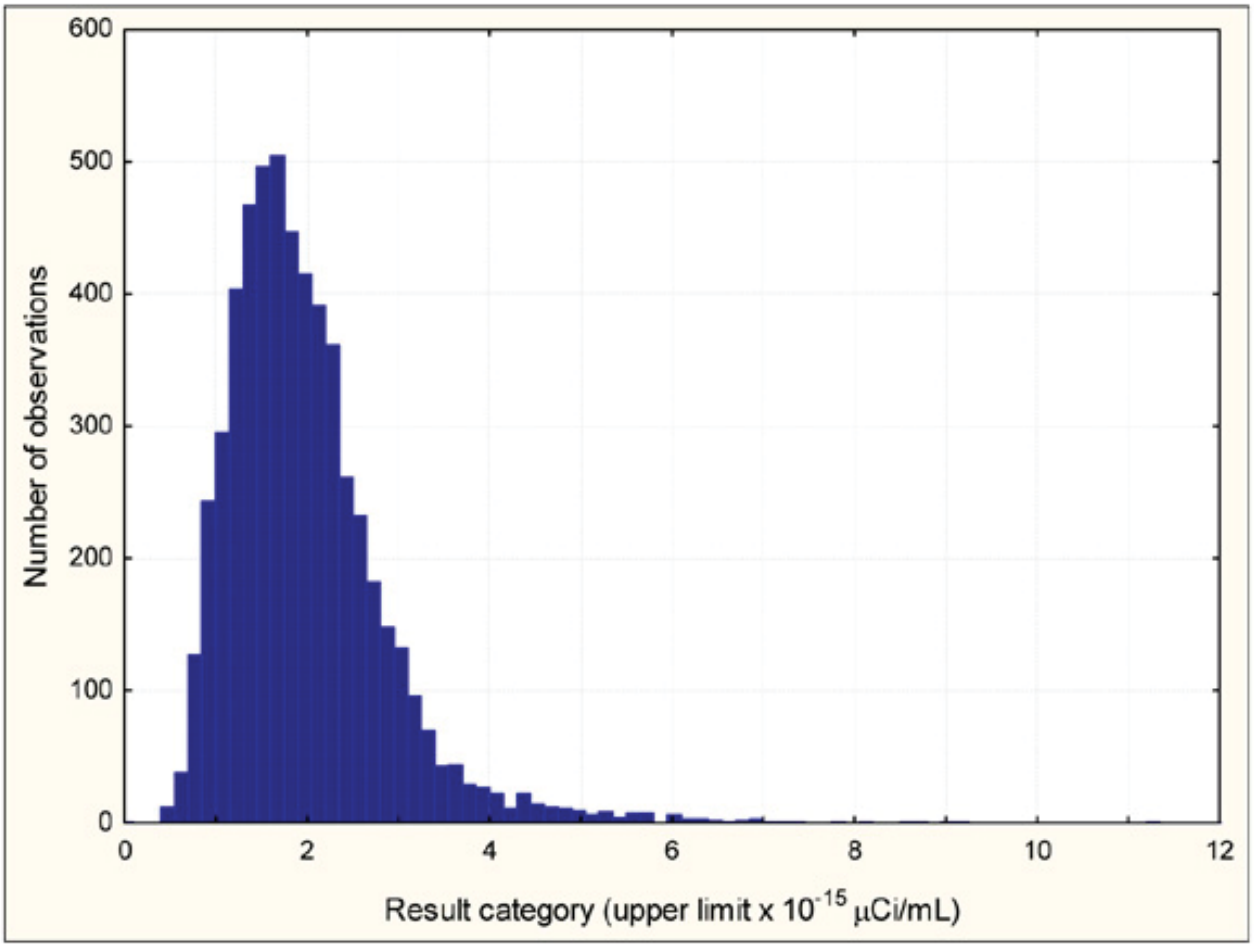


Figure 4-3. Frequency Distribution of Gross Alpha Activity Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1996 through 2005. (Valid samples greater than 7000 ft^3, recounts not included).



Table 4-3. Median Annual Gross Alpha Concentrations in Air (2005).[a]

ESER Contractor Data		Concentration[b]		
Group	Location[c]	No. of Samples	Range of Samples	Annual Median
Distant	Blackfoot CMS	52	-0.23 – 3.01	1.30
	Craters of the Moon	52	-0.66 – 2.43	1.08
	Dubois	49	-0.17 – 3.35	1.03
	Idaho Falls	52	0.25 – 4.53	1.72
	Jackson	52	-0.11 – 2.88	1.38
	Rexburg CMS	51	0.32 – 3.23	1.34
			Distant Median:	**1.32**
Boundary	Arco	49	-0.22 – 2.54	1.34
	Atomic City	52	-1.09 – 2.54	1.09
	Blue Dome	50	-0.32 – 3.22	0.85
	Federal Aviation Administration Tower	52	-0.42 – 2.73	1.10
	Howe	101[d]	-0.12 – 3.31	1.24
	Monteview	52	-0.04 – 2.98	1.16
	Mud Lake	51	-0.25 – 1.55	1.56
			Boundary Median:	**1.19**
INL Site	EFS	52	0.34 – 2.61	1.33
	Main Gate	104[d]	-0.16 – 3.34	1.31
	Van Buren	52	0.11 – 2.33	1.34
			INL Site Median:	**1.33**
INL Contractor Data			**Concentration[a]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	50	0.63 – 7.37	1.99
	Craters of the Moon	50	0.40 – 3.31	1.31
	Idaho Falls	50	0.42 – 5.05	1.80
	Rexburg	48	0.12 – 3.49	2.05
			Distant Median	**1.79**
INL Site	MFC (formerly ANL-W)	51	0.10 – 3.83	1.66
	ARA	51	0.55 – 2.53	1.64
	CFA	50	0.28 – 3.27	1.71
	CPP	50	0.02 – 5.79	1.46
	EBR-I[e]	50	0.42– 2.82	1.48
	EFS	51	0.24 – 3.14	1.93
	Gate 4	51	0.24 – 5.60	1.77
	INTEC	50	0.60 – 6.84	1.82
	NRF	51	0.41 – 3.87	1.84
	CITRC (formerly PBF)	49	0.34 – 3.68	1.73
	Rest Area	51	0.36 – 3.99	1.61
	RTC (NE corner)	11	0.48 – 5.67	Insufficient Data
	RWMC	50	0.00 – 3.72	1.60
	SMC	49	0.49 – 4.23	1.81
	TAN	50	0.30 – 3.70	1.78
	RTC (formerly TRA)	51	0.38 – 3.11	1.74
	Van Buren	51	0.52 – 4.59	1.76
			INL Site Median	**1.71**

a. All values are x 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. CMS = Community Monitoring Stations.
d. Includes duplicate measurements at this station
e. EBR-I = Experimental Breeder Reactor No. 1



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 0.71×10^{-14} µCi/mL on December 7, 2005, at Blackfoot to a high of 7.97×10^{-14} µCi/mL at Mud Lake on December 14, 2005. Concentrations measured above 3 sigma by the INL contractor ranged from a low of 0.82×10^{-14} µCi/mL at Rexburg on March 30, 2005, to a high of 7.75×10^{-14} µCi/mL at Test Area North on December 14, 2005.

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 1999-2004. 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 2005 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 6.3×10^{-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]).

Annual median gross beta concentrations are shown in Table 4-4. ESER contractor annual median gross beta concentrations ranged from 2.13×10^{-14} µCi/mL at Craters of the Moon to 2.65×10^{-14} µCi/mL at the EFS. INL contractor data indicated an annual median range of 2.27×10^{-14} µCi/mL at Van Buren to 2.79×10^{-14} µCi/mL at INTEC. In general, the levels of airborne radioactivity for the three groups (INL Site, boundary, and distant locations) tracked each other closely throughout the year. This indicates that the pattern of fluctuations occurred 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.

In addition, all results greater than 3 sigma reported by the ESER contractor are well within valid measurements taken within the last ten years (Figure 4-5) (this figure does not include recounts). The maximum concentration measured in 2005 is within this range of results.

Statistical Comparisons

Gross beta concentrations 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.



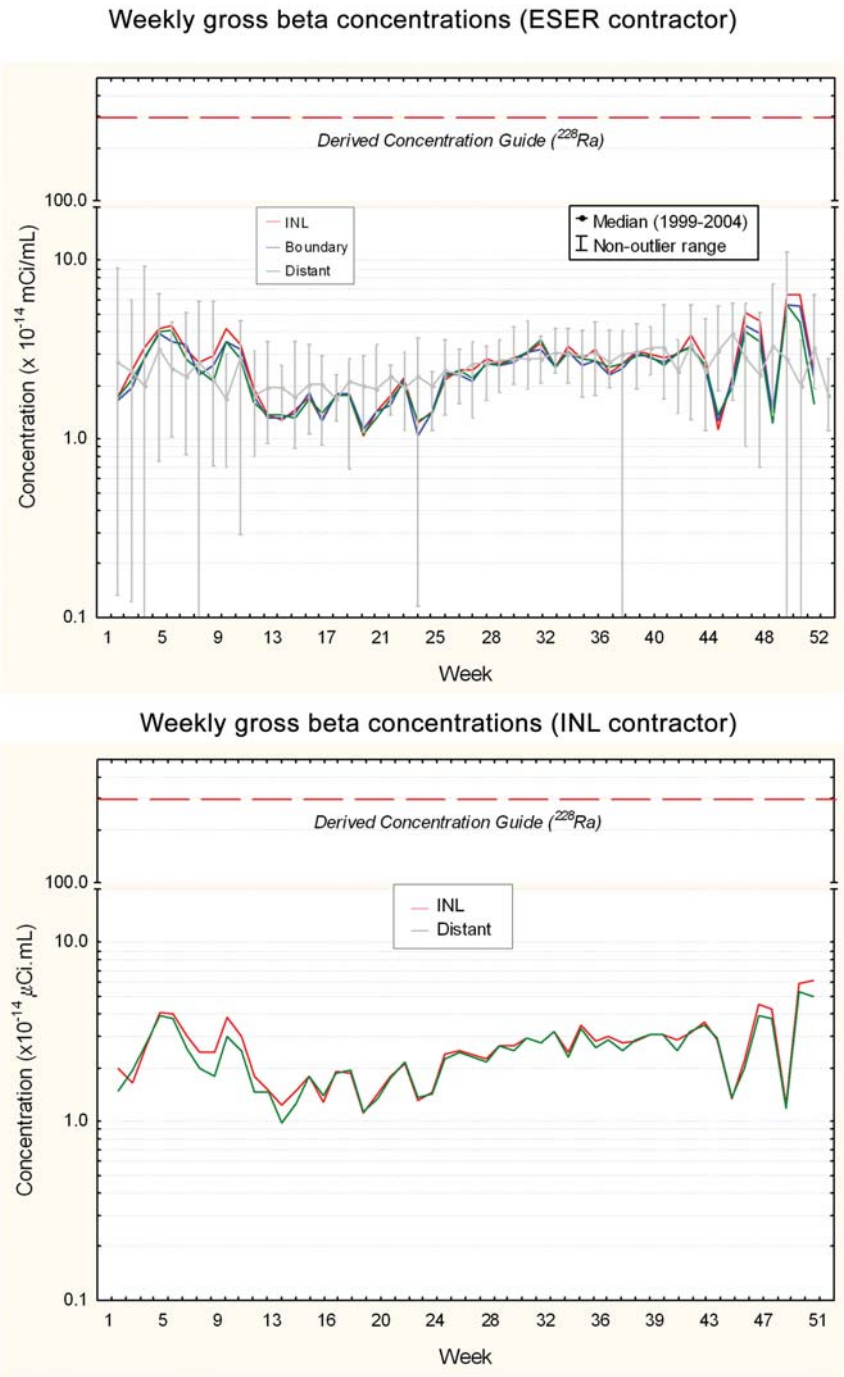


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2005).



Table 4-4. Median Annual Gross Beta Concentrations in Air (2005).[a]

ESER Contractor Data			Concentration[b]	
Group	**Location[c]**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS	52	0.71 – 6.66	2.53
	Craters of the Moon	52	0.91 – 4.07	2.13
	Dubois	49	1.16 – 5.23	2.43
	Idaho Falls	52	0.73 – 6.92	2.61
	Jackson	52	0.76 – 6.10	2.46
	Rexburg CMS	52	0.75 – 5.30	2.60
			Distant Median:	**2.47**
Boundary	Arco	49	0.99 – 6.29	2.34
	Atomic City	52	0.99 – 5.63	2.50
	Blue Dome	50	0.90 – 4.71	2.15
	Federal Aviation Administration Tower	52	1.01 – 4.97	2.26
	Howe	101[d]	0.93 – 6.58	2.51
	Monteview	52	1.15 – 6.34	2.51
	Mud Lake	52	0.98 – 7.97	2.60
			Boundary Median:	**2.40**
INL Site	EFS	52	1.04 – 6.91	2.65
	Main Gate	104[d]	0.96 – 6.45	2.62
	Van Buren	52	1.00 – 6.45	2.63
			INL Site Median:	**2.64**
INL Contractor Data			**Concentration[a]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	50	1.32 – 13.10	2.44
	Craters of the Moon	51	1.01 – 9.48	2.35
	Idaho Falls	51	1.20 – 50.40	2.51
	Rexburg	50	0.60 – 11.20	2.40
			Distant Median	**2.43**
INL Site	MFC (formerly ANL-W)	51	1.08 – 5.50	2.39
	ARA	51	1.12 – 6.31	2.38
	CFA	50	1.12 – 5.97	2.56
	CPP	50	0.02 – 6.37	2.51
	EBR-I	50	1.13 – 6.02	2.59
	EFS	51	1.14 – 6.51	2.58
	Gate 4	51	1.07 – 7.39	2.52
	INTEC	50	1.08 – 6.96	2.79
	NRF	51	1.09– 6.91	2.73
	CITRC (formerly PBF)	49	0.98 – 6.46	2.66
	Rest Area	51	0.99 – 6.21	2.47
	RTC (NE corner)	11	1.19 – 6.34	Insufficient Data
	RWMC	50	0.85 – 6.10	2.45
	SMC	49	1.00 – 7.26	2.49
	TAN	50	1.08 – 7.75	2.58
	RTC (formerly TRA)	51	0.92 – 6.46	2.52
	Van Buren	51	0.97 – 6.50	2.27
			INL Site Median	**2.53**

a. All values are x 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 duplicate measurements at this station.

d. Replicate samplers were used at this location.



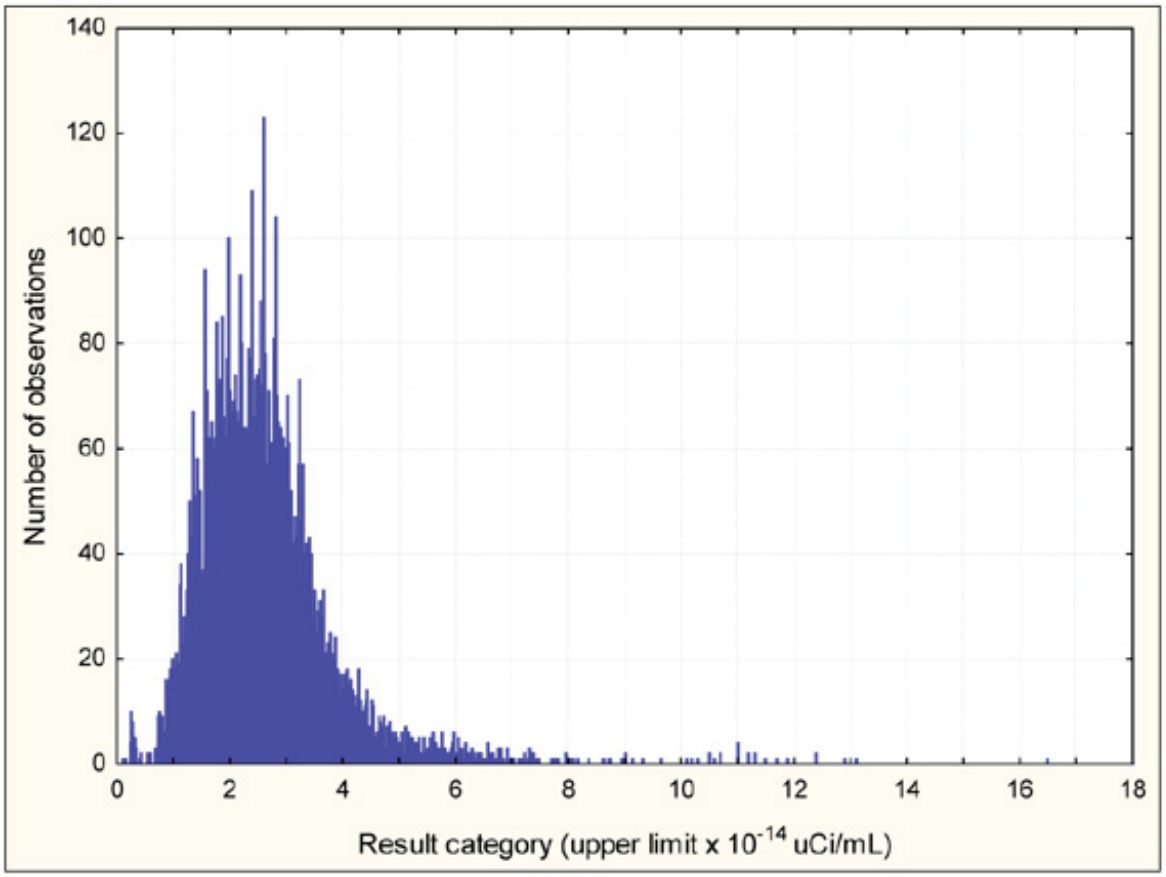


Figure 4-5. Frequency Distribution of Gross Beta Activity Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1996 through 2005.

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 2005 by the ESER contractor. The results are grouped by location (that is, INL Site, boundary and distant stations). Visually, 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 x 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 INL Site, boundary, and distant locations in 2005.

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2005. Concentrations collected during one week each



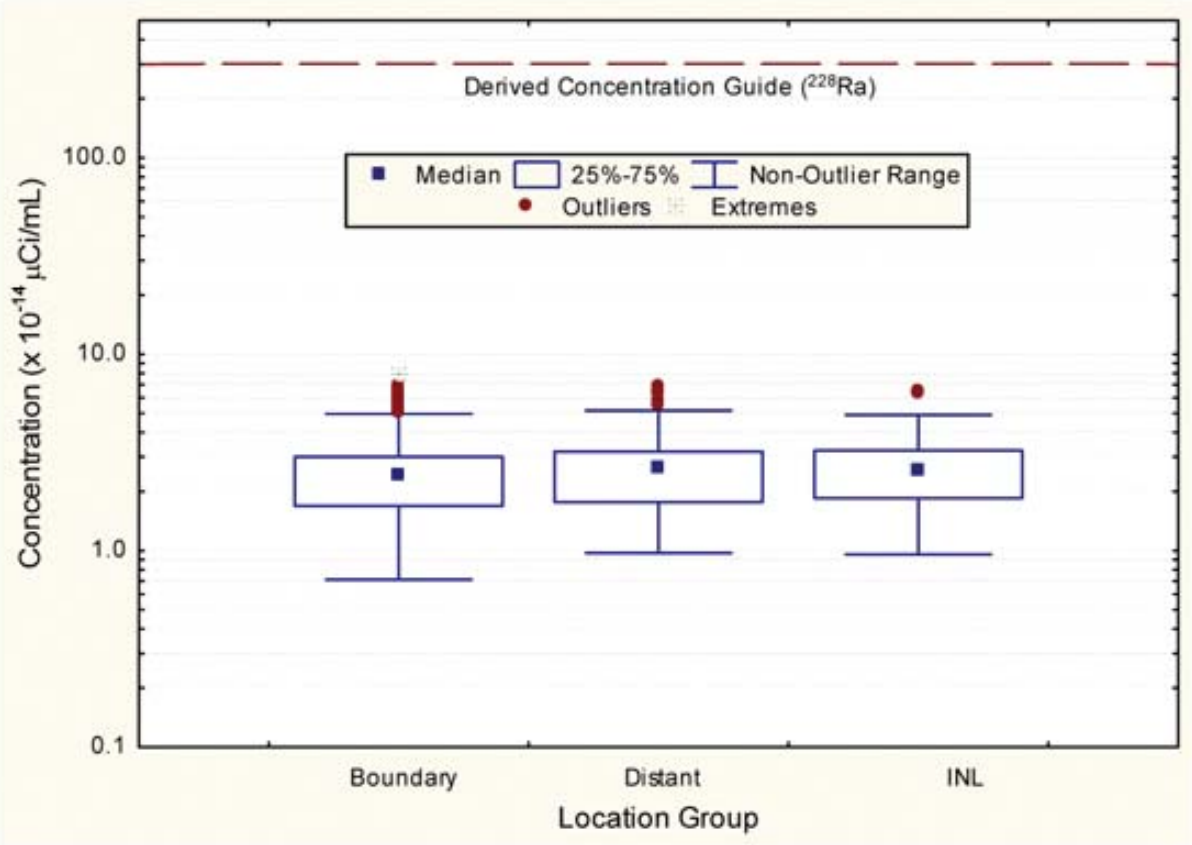


Figure 4-6. Comparison of Gross Beta Concentrations Measured in Air at Distant, Boundary, and INL Site Locations by the ESER Contractor (2005).

in February, August, and September were greater for the boundary group than for the distant group. The differences observed in February appear to be related to the influence of inversion conditions. The differences observed in August and September can be attributed to expected statistical variation in the data. None of the weekly concentrations were greater at the distant locations when compared to the boundary locations.

INL contractor onsite and distant data sets were compared and there were no statistical differences between data obtained from INL Site 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 the third quarter 2005 quarterly composite sample collected onsite at Van Buren Gate. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past nine years is shown in Figure 4-7. The result detected in 2005, 8.52×10^{-17}, is above the range measured historically, but is only 0.43 percent of the ^{241}Am DCG of 20,000 x 10^{-18} µCi/mL. The radionuclide concentration on the filter is considered an anomalous result. Windblown soil from the nearby Radioactive Waste Management Complex (RWMC) is an unlikely source as soil in this area also contains plutonium

Table 4-5. Human-made Radionuclides in ESER Contractor Quarterly Composited Air Samples (2005).[a]

Location	^{241}Am	^{90}Sr
Third Quarter 2005		
Arco	ND[b]	390 ± 123
Atomic City	ND	333 ± 99.5
Van Buren Gate	85.1 ± 5.9	ND
Fourth Quarter 2005		
Craters of the Moon	ND	118 ± 14.5

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

Table 4-6. Human-made Radionuclides in INL Contractor Quarterly Composited Air Samples (2005).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}PU$	^{90}Sr
First Quarter 2005					
Rexburg	ND[b]	ND	16.8 ± 3.47	ND	ND
ARA	ND	ND	10.1 ± 2.73	ND	ND
Location A	3630.0 ± 500.0	ND	ND	ND	ND
Second Quarter 2005					
ARA	3080.0 ± 625.0	ND	10.1 ± 2.73	7.35 ± 2.44[c]	ND
Fourth Quarter 2005					
INTEC	ND	ND	ND	ND	20.1 ± 5.42
SMC	ND	9.71 ± 3.15	ND	ND	ND

a. Concentrations shown are: Result x 10^{-18} µCi/mL air ± 1s analytical uncertainty.
b. ND = Not detected. Result < 3σ.
c. This result is considered suspect due to >3σ detection on field blank.



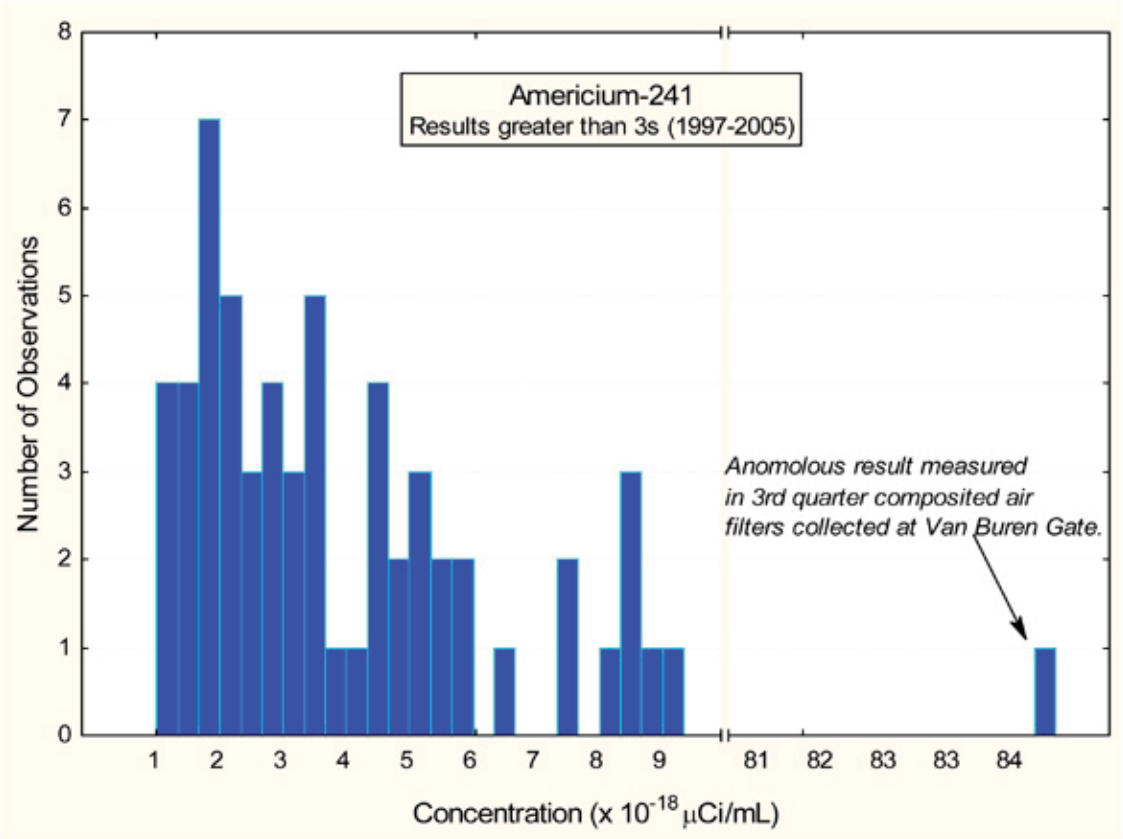


Figure 4-7. Frequency Distribution of ^{241}Am Concentrations Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2005.

radionuclides in fairly constant ratios with ^{241}Am. In addition, there was not enough particulate loading on the filter to indicate a windblown soil source. Finally, laboratory contamination is not indicated by either the field blank or laboratory blank.

Plutonium isotopes were not detected in any ESER sample in 2005. Valid $^{239/240}$Pu levels 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 three ESER samples. Two of the results were outside historical measurements (Figure 4-9). However, the values measured are much below the DCG of 9,000,000 x 10^{-18} µCi/mL.

Cesium-137 (^{137}Cs) was not detected in any ESER sample.

Isotopes of uranium (^{234}U, ^{235}U, or ^{238}U) were detected in numerous INL contractor quarterly composites at levels which indicate their origin as naturally occurring.



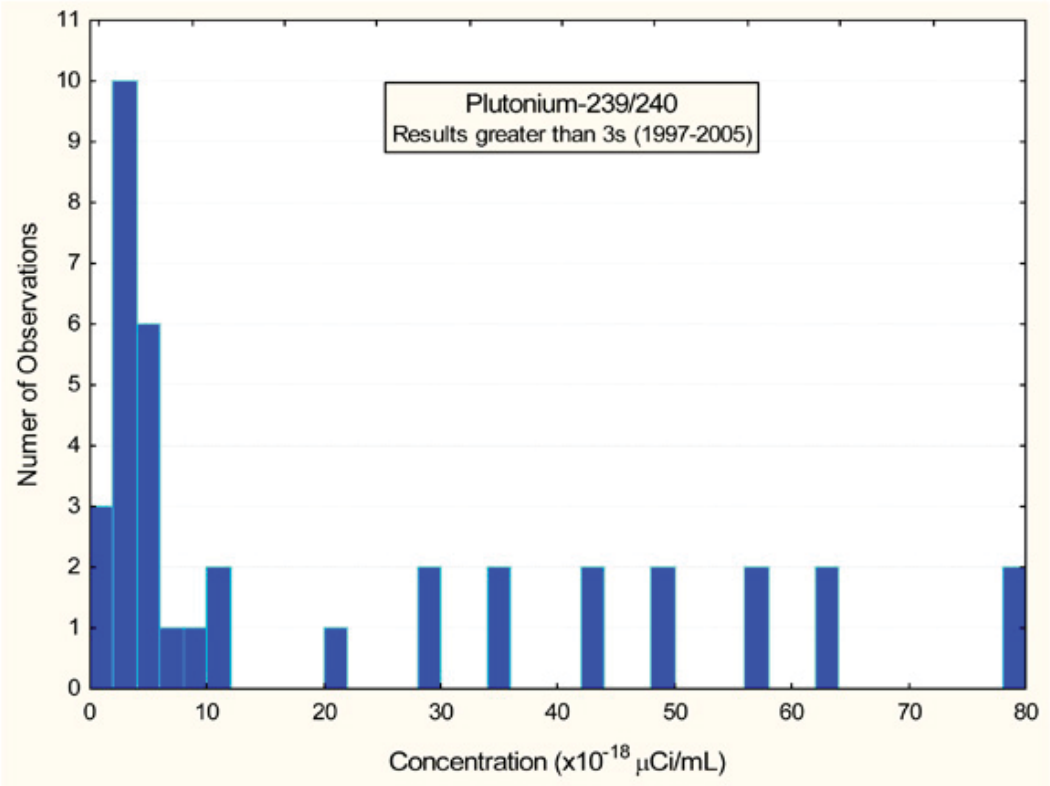


Figure 4-8. Frequency Distribution of $^{239/240}$Pu Concentrations Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2005.

The INL contractor reported one detection of ^{241}Am in one sample. Plutonium 239/240 was also detected in one sample. Plutonium-238 was detected in three samples. All were well within historical measurements.

Stontium-90 was detected in one quarterly composite collected by the INL contractor during 2005. The result is well below the DCG for ^{90}Sr and within historical measurements.

Cesium-137 was detected in two INL contractor samples. The measurements are within those made historically.

Atmospheric Moisture

During 2005, the ESER contractor collected 71 atmospheric moisture samples from four locations (Atomic City, Blackfoot, Idaho Falls, and Rexburg) using molecular sieve. Table 4-7 presents the range of values for each station by quarter.



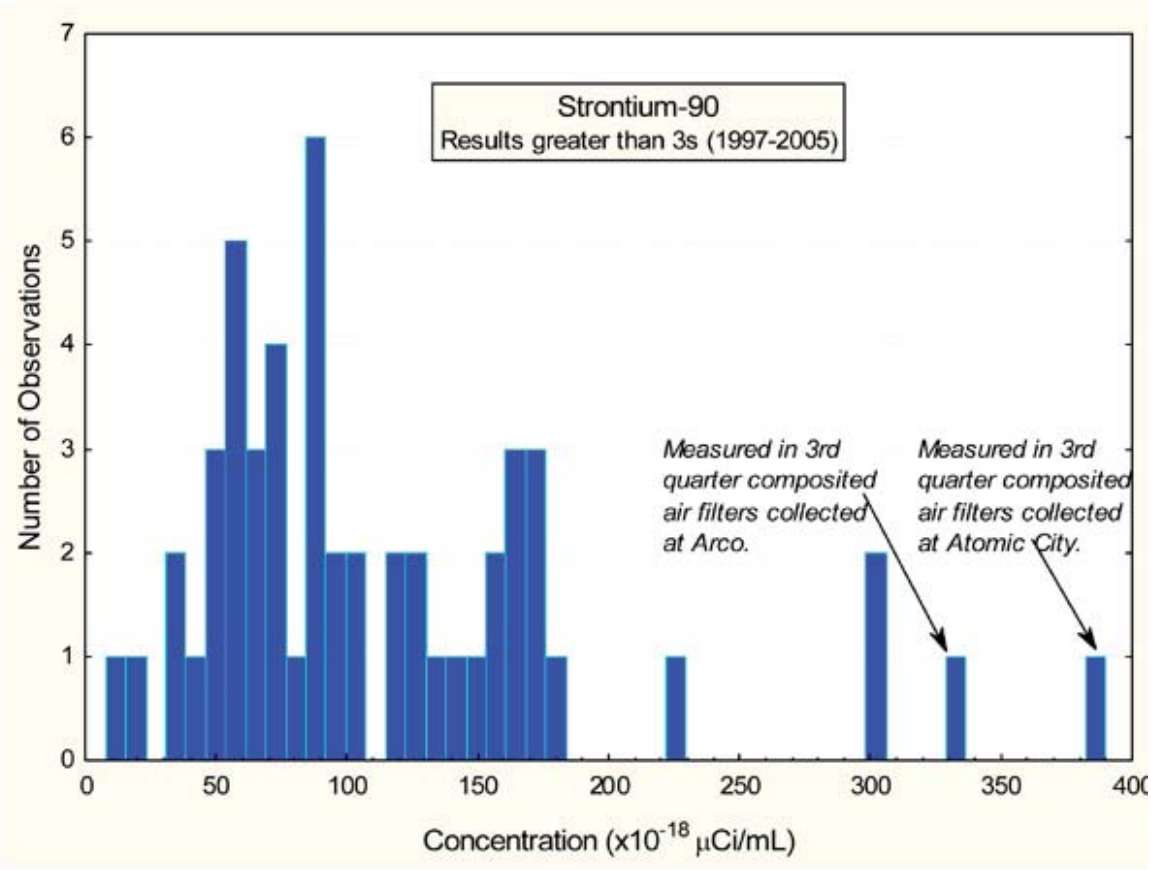


Figure 4-9. Frequency Distribution of ^{90}Sr Concentrations Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2005.

Table 4-7. Tritium Concentrations in ESER Contractor Atmospheric Moisture Samples (2005).

	Range[a]			
Location	**First Quarter**	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
Atomic City	5.4 ± 0.9 – 6.4 ± 1.0	5.1 ± 1.2 – 7.9 ± 1.5	ND[b]	7.7 ± 1.0 [c]
Blackfoot	1.0 ± 0.2	4.6 ± 1.3	5.8 ± 1.2 – 7.6 ± 2.0	9.8 ± 1.4
Idaho Falls	ND	4.5 ± 1.4 – 7.3 ± 1.4	ND	6.8 ± 1.5 – 10.1 ± 1.7
Rexburg	4.1 ± 0.5	1.5 ± 0.5	7.1 ± 2.2	4.9 ± 1.1

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s uncertainties.
b. ND = Not detected. Result <3s
c. When a single value is reported, tritium was detected in only one sample.



Tritium was detected in 21 of the samples. Samples that exceeded the respective 3 sigma values ranged from a low at Blackfoot of 1.0 x 10^{-13} µCi/mL collected on February 15, 2005, to a high of 10.1 x 10^{-13} µCi/mL at Idaho Falls collected on October 14, 2005.

These detected radioactive concentrations were similar at distant and boundary locations. This similarity suggests that the detections probably represent tritium from natural production in the atmosphere by cosmic ray bombardment, residual weapons testing fallout, and possible analytical variations, rather than tritium from INL Site operations. The highest observed tritium concentration (from the fourth quarter at Idaho Falls) is far below the DCG for tritium in air (as hydrogen tritium oxygen [HTO]) of 1 x 10^{-7} µCi/mL.

The INL contractor collected atmospheric moisture samples at the EFS and at Van Buren Boulevard on the INL and at Idaho Falls and Craters of the Moon off the INL. They collect from one to three samples at each location each quarter. During 2005, 41 samples were collected. Seven samples indicated an activity greater than its 3 sigma level. The samples ranged from a low of 4.8 ± x 10^{-13} µCi/mL at Craters of the Moon taken on March 9, 2005, to a high of 225 x 10^{-13} µCi/mL collected on June 15, 2005 (Table 4-8). All values are consistent with ESER contractor results and are less than the DCG for tritium in air.

Table 4-8. Tritium Concentrations in INL Contractor Atmospheric Moisture Samples (2005).

	Range[a]		
Location	**First Quarter**	**Second Quarter**	**Third Quarter**
Craters of the Moon	4.8 ± 1.0	ND[b]	ND
EFS	ND	7.5 ± 2.4	29.5 ± 1.8
Van Buren	ND	25.1 ± 3.8 – 225.0 ± 5.5	29.8 ± 5.1
Idaho Falls	ND	ND	11.3 ± 3.6

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s uncertainties.
b. ND = Not detected. Result <3s
c. When a single value is reported, tritium was detected in only one sample.



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 35 precipitation samples were collected during 2005 from the three sites. Tritium concentrations were measured above the 3 sigma uncertainty level in 11 samples and results ranged from 77.1 to 306.0 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 fourth quarter and is far below the DCG level for tritium in water of 2×10^6 pCi/L. The concentrations are well within the 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 4-9. Maximum Tritium Concentrations in ESER Contractor Precipitation Samples (2005).

	Maximum Concentration[a]	
Location	**Second Quarter**	**Fourth Quarter**
CFA	161.0 ± 31.0 – 202.0 ± 31.5	77.1 ± 25.5
EFS	90.5 ± 30.1 – 169.0 ± 30.5	93.5 ± 26.1 – 306.0 ± 31.2
Idaho Falls	185.0 ± 31.3	ND[b]

a. All values are in picocuries per liter (pCi/L) ± 1s and represent results greater than their associated 3s analytical uncertainties.

b. ND = Not detected. Results <3s

Suspended Particulates

In 2005, 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.

Particulate concentrations from ESER contractor samples ranged from 0.08 $\mu g/m^3$ at Craters of the Moon to 19.7 $\mu g/m^3$ at Blackfoot. In general, particulate concentrations were higher at distant locations than at the INL Site stations. This is mostly caused by agricultural activities in offsite areas.



The total suspended particulate concentrations measured by the INL contractor ranged from ~0.0 µg/m^3 at CFA, Craters of the Moon, and RWMC, to 161.0 µg/m^3 at EFS. Sample particulate concentrations were generally higher at distant locations than at the INL Site stations.

Filtered Particulates

The EPA's air quality standard is 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 are considered to be responsible for most of the adverse health effects associated with airborne particulate pollution. The air quality standards for PM_{10} are an annual average of 50 µg/m^3, with a maximum 24-hour concentration of 150 µg/m^3.

The ESER contractor collected 61 valid 24-hour samples at Rexburg from January through December 2005. 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 0.0 to 44.8 µg/m^3. At the Blackfoot Community Monitoring Station, 60 valid samples were collected from January through December. Concentrations ranged from 0.07 to 42.4 µg/m^3. At Atomic City, 59 valid samples were collected from January through December. Concentrations ranged from 0.1 to 52.5 µg/m^3. All measurements were less than the EPA standard for mean annual concentration.

Nitrogen Dioxide

Nitrogen dioxide is monitored at the Experimental Breeder Reactor II auxiliary boilers at MFC. Monitoring at this facility occurs monthly with a portable stack emission monitor as an efficiency check and to ensure nitrogen dioxide and sulfur dioxide emissions are below state-imposed standards.

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 25,103 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

Gross alpha and gross beta activity were determined on all waste management samples collected by the ICP contractor in 2005. Low-volume suspended particle (SP) monitors collected particulate material on 10-cm (4-in) membrance filters.

Samples had gross alpha measurements that exceeded their 3 sigma uncertainty ranging from a high of 4.87 x 10^{-15} µCi/mL in the first half of December at location Howe 400.3 to a low of 0.27 x 10^{-17} µCi/mL in the second half of March at location Subsurface Disposal Area (SDA) 4.3. The annual mean for gross alpha was 7.13 x 10^{-16} µCi/mL. SP gross beta levels ranged from a high of 7.33 x 10^{-14} µCi/mL in the first half of December at Howe 400.3 to a low of 1.95 x 10^{-15} µCi/mL at SDA 4.3 in the second half of March. The gross beta annual mean was 9.23 x 10^{-15} µCi/mL.

Specific Radionuclides

The only anthropogenic gamma-emitting radionuclide detected in 2005 that exceeded the three-sigma error was ^{137}Cs. In March, ^{137}Cs was found in the Location A , SDA, filter (3.6 x 10^{-15} µCi/mL) and in June at ARA (3.1 x 10^{-15} µCi/mL). This gamma detections were significantly below the DCG for air at 4.0 x 10^{-10} µCi/mL. This is consistent with what was seen in the past from resuspended soils containing activity due to fallout.

Radiochemical analysis showed no detections of alpha- and beta-emitting radionuclides greater than the 3 sigma error. No trends were detected based on analytical results from calendar year 2005.



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.

40 Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants," *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), 2006, *National Emissions Standards for Hazardous Air Pollutants (NESHAPs) – Calendar year 2005 INEL Report for Radionuclides,* DOE/NE-ID-10890(05).




Jutta Arctic

Chapter 5 - Environmental Monitoring Program - Water

R. Mitchell - S. M. Stoller Corporation
M. Lewis, D. Frederick, B. Beus, B. Andersen, and M. Verdoorn - Battelle Energy Alliance

Chapter Highlights

One potential pathway for exposure (primarily to workers) to contaminants released from the Idaho National Laboratory (INL) Site is through the water pathway (surface water, drinking water, and groundwater). INL Site contractors monitor liquid effluents, drinking water, groundwater, and storm water runoff to comply with applicable laws and regulations, U.S. Department of Energy orders, and other requirements (e.g., Wastewater Land Application Permit [WLAP] requirements). The Naval Reactors Facility conducts their own WLAP equivalent and drinking water monitoring.

During 2005, liquid effluent and groundwater monitoring was conducted in support of WLAP requirements for INL Site facilities that generate liquid waste streams covered under WLAP rules. The WLAPs generally require compliance with Idaho groundwater quality 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. Additional parameters are monitored in liquid effluent in support of surveillance activities.

Aluminum, iron, and manganese concentrations in unfiltered samples from both aquifer and perched water wells associated with the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds WLAP have exceeded the associated groundwater quality standards in the past. These high concentrations were detected in unfiltered preoperational groundwater samples taken from a downgradient aquifer well (ICPP-MON-A-166) and the upgradient aquifer well outside the zone of influence of the INTEC New Percolation Ponds (ICPP-MON-A-167) and have persisted since the INTEC New Percolation Ponds began receiving wastewater. For aquifer wells, the preoperational concentrations in the upgradient well (ICPP-MON-A-167) are considered the natural background level (IDAPA 58.01.11.200.03) and are used for determining compliance with the permit and the Ground Water Quality Rule. Because concentrations of these metals in aquifer wells during 2005 were below the preoperational upgradient concentrations, they are considered in compliance with the permit and the Ground Water Quality Rule.

The January and February 2005 monthly total suspended solids (TSS) concentration in the Test Area North (TAN)/Technical Support Facility Sewage Treatment Facility effluent exceeded the permit limit of 100 mg/L. It was suspected that the sanitary drain line from the former TAN-609 building was inadvertently filled with debris (gravel, silt, sediment) when the building was demolished in 2003, and then in late 2004, when trailers were moved into the area and placed on-line with the sanitary system, the effluent from restrooms began driving silt and sediment downgradient. Concentrations of TSS in the monthly samples returned to normal levels (below 20 mg/L) after the sediment traps and drain lines were cleaned, and remained well below the permit limit for the remainder of the year.

During 2005, 545 routine samples and 65 quality control samples were collected and analyzed from INL Site facilities. In 2005, total coliform bacteria was detected at the Main Gate, EBR-I, and Gun Range. In the Radioactive Waste Management Complex public water system, carbon tetrachloride remained below the U.S. Environmental Protection Agency (EPA) established maximum contaminant levels (MCL) of 5 µg/L. The MCL applies only at the compliance point, which is the distribution system. The annual average for the compliance point of the distribution system was 3.50 µg/L. The annual average for the production well was 5.18 µg/L. Trichloroethylene concentrations in samples from the TAN drinking water Well #2 remained below the MCL of 5 µg/L during 2005.

The estimated annual effective dose equivalent to a worker from consuming all their drinking water at the Central Facilities Area during 2005 was 0.50 mrem/year (5.0 µSv/year). The EPA standard for public drinking water systems is 4 mrem/year.

No storm water monitoring was conducted in 2005. A technical analysis was finalized that identified projects that had no reasonable potential to discharge to waters of the United States, and inspection and reporting for these activities ceased.

5. ENVIRONMENTAL MONITORING PROGRAM - WATER

This chapter presents results from radiological and nonradiological analyses of liquid effluent, groundwater, drinking water, and storm water samples taken at onsite locations. Results from sampling conducted by the INL and Idaho Cleanup Project (ICP) contractors are presented here. Results are compared to the appropriate regulatory limit (e.g., liquid effluent discharge permit limits, 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).

Sections 5.1 and 5.2 describe liquid effluent and groundwater monitoring as required by the City of Idaho Falls and Idaho Wastewater Land Application Permits (WLAP), and effluent monitoring that is done for surveillance activities only. The INL Site drinking water programs are discussed in Section 5.3. Section 5.4 describes storm water monitoring, while Section 5.5 summarizes onsite waste management water surveillance activities.

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

5.1 Liquid Effluent and Related Groundwater Compliance Monitoring

The INL contractor and the ICP contractor monitor nonradioactive and radioactive parameters in liquid waste effluent and groundwater. Wastewater (nonradioactive) is typically discharged to the



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

	Media					
Area/Facility[a]	Liquid Effluent (Permitted)	Liquid Effluent (Surveillance)	Liquid Effluent (Groundwater)	Drinking Water	Storm Water[b]	Surface Water
ICP Contractor: CH2M•WG Idaho, LLC. (CWI)						
INTEC	•	•	•	•		
TAN/TSF, CTF	•	•	•	•		
RWMC				•		•
INL Contractor: Battelle Energy Alliance (BEA)						
CFA[c]	•	•		•		
IRC	•					
MFC		•		•		
CITRC				•		
RTC	•[d]	•		•		
Environmental Surveillance, Education and Research Program (S. M. Stoller Corp.)						
INL/Regional				•		•

a. CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, 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, and IRC = INL Research Center

b. Storm water monitoring ceased in October 2004. Injection wells will continue to be monitored as required.

c. Includes Gun Range, EBR-I (Experimental Breeder Reactor-I), and Main Gate.

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

ground surface and evaporation ponds. Discharges to the ground surface are through infiltration ponds, trenches, or a sprinkler irrigation system at the following areas:

- Infiltration 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, and Reactor Technology Complex (RTC) Cold Waste Pond
- 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 WLAP rules (Idaho Administrative Procedures Act [IDAPA] 58.01.17). An approved WLAP will normally require monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater, as applicable. The



liquid effluent and groundwater monitoring programs support WLAP requirements for INL Site facilities that generate liquid waste streams covered under WLAP rules. Table 5-2 lists the current WLAP status of each facility.

The WLAPs generally require compliance with the Idaho groundwater quality primary constituent standards (PCS) and secondary constituent standards (SCS) in specified groundwater monitoring wells (IDAPA 58.01.11). The permits specify annual discharge volume, application rates, and effluent quality limits. As required, an annual report is prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2005, the contractors conducted monitoring as required by the permits for each of the first four facilities listed in Table 5-2. The RTC Cold Waste Pond has not been issued a permit; however, quarterly 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 5400.5 and 450.1 (DOE 1993, DOE 2003) 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, National Pollutant Discharge Elimination System, to set pretreatment standards for nondomestic wastewater discharges to publicly owned treatment works. The INL contractor and U.S. Department of Energy-Idaho Operations Office (DOE-ID) 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.

Industrial Wastewater Acceptance Forms were obtained for facilities that discharge process wastewater through the City of Idaho Falls sewer system. Twelve INL contractor facilities in Idaho Falls have associated Industrial Wastewater Acceptance Forms for discharges to the City sewer system. The Industrial Wastewater Acceptance Forms for these facilities contain special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters; however, only the INL Research Center has specific monitoring requirements.

Wastewater Monitoring Results – Semiannual monitoring was conducted at the INL Research Center in April and October of 2005. Table 5-3 summarizes the 2005 semiannual monitoring results.

Central Facilities Area Sewage Treatment Plant

Description – The CFA Sewage Treatment Plant serves all major facilities at CFA. It is southeast of CFA, approximately 671 m (2200 ft) downgradient of the nearest drinking water well.



Table 5-2. Status of Wastewater Land Application Permits (2005).

Facility	Permit Status at end of 2005	Explanation
CFA Sewage Treatment Plant	WLAP issued	Idaho DEQ reissued a permit in January 2005. The permit was modified on 10/19/05.
INTEC New Percolation Ponds	WLAP issued	A major modification request to route the sanitary wastewater from the INTEC Sewage Treatment Plant to the INTEC service waste system and then discharge to the INTEC New Percolation Ponds was submitted in 2003. A new WLAP was issued and became effective on December 2, 2004, when the two wastewaters were combined.
INTEC Sewage Treatment Plant	WLAP terminated	The INTEC Sewage Treatment Plant WLAP was terminated on December 2, 2004, when the discharge was routed to the INTEC service waste system (see INTEC New Percolation Ponds explanation above).
MFC Industrial Waste Pond	WLAP application submitted to Idaho DEQ	A WLAP application is being developed for Idaho DEQ.
TAN/TSF Sewage Treatment Facility	WLAP issued	Idaho DEQ reissued a permit in January 2005.
RTC Cold Waste Pond	WLAP application submitted to Idaho DEQ	Idaho DEQ has not issued a WLAP. Idaho DEQ authorized INL to operate the wastewater land application facility under the conditions and terms of State of Idaho WLAP rules and Idaho DEQ's Handbook for Land Application of Municipal and Industrial Wastewater until a permit is issued (Johnston 2001).

A 1500 L/minute (400 gal/minute) 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 46 MG (23 acre-in./acre/year) from April 1 through October 31.

WLAP 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 2005. Effluent samples were collected from the pump pit (prior to the pivot irrigation system) starting in June 2005 and continuing through September 2005 (the period of irrigation operation for 2005). All samples collected were flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables 5-4 and 5-5 summarize the results.



Wastewater was applied via the center pivot irrigation system on 53 days between June 2, 2005, and September 29, 2005. On the days it was operational, discharge to the pivot irrigation system ranged from 596,138 to 789,173 L/day (157,500-208,500 gal/day) and averaged 695,305 L/day (183,686 gal/day).

The total volume of applied wastewater for 2005 was approximately 9.94 MG (4.98 acre-in./acre/year), which is significantly less than the permit limit of 46 MG (23.0 acre-in./acre/year). Hydraulic loading was highest in June and lowest in September. Nitrogen loading rates were significantly lower at 2.59 kg/ha/year (2.31 lb/acre/year) than the projected maximum loading rate of 35.8 kg/ha/year (32 lb/acre/year). 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 35.8 kg/ha/year [32 lb/acre/

Table 5-3. Semiannual Effluent Monitoring Results for INL Research Center (2005).[a]

Parameter	INL Research Center			Discharge Limit[c]
	April 2005[b]		October 2005	
Arsenic	0.0050 U[d]	0.0050 U	0.0050 U	0.04
Cadmium	0.0010 U	0.0010 U	0.0010 U	0.26
Chromium	0.0025 U	0.0025 U	0.0025 U	2.77
Conductivity (µ/S) (grab)	885.0/641.7[e]		969.2/665.9[e]	NA
Copper	0.0314	0.0324	0.0305	1.93
Cyanide	0.005 U[d]	0.005 U	0.005 U	1.04
Lead	0.00080 U	0.00080 U	0.00053	0.29
Mercury	0.00020 U	0.00020 U	0.00020 U	0.002
Nickel	0.0025 U	0.0025 U	0.0025 U	2.38
pH (standard units) (grab)	7.89/7.81[e]		8.10/7.86[e]	5.5-9.0
Silver	0.0025 U	0.0025 U	0.0025 U	0.43
Zinc	0.0256	0.0289	0.0219	0.90

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Regular and duplicate samples were collected in April. For parameters with detected results, both, the regular and duplicate results are presented.
c. Limit as set in the applicable Industrial Wastewater Acceptance Forms.
d. U flag indicates that the result was below the detection limit.
e. Values represent the maximum and average for the five samples taken in April and October over an 8-hour period during semiannual monitoring.



Table 5-4. Summary of CFA Sewage Treatment Plant Influent Monitoring Results (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Biological oxygen demand (5-day)	19.6	514	100.6
Chemical oxygen demand	49.5	299	131.0
pH (standard units) (grab)	7.27	8.26	7.83
Nitrate+nitrite, as Nitrogen	0.019	1.35	0.81
Total Kjeldahl nitrogen	9.49	49.7	25.0
Total suspended solids	6.4	215	92.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were collected in August for all parameters (excluding pH) and the duplicate results are included in the summaries.
c. Annual average is determined from the average of the monthly values.

Table 5-5. Summary of CFA Sewage Treatment Plant Effluent Monitoring Results (2005).[a]

Parameter	Minimum	Maximum	Average[b]
Biological oxygen demand (5-day)	1.0[c]	2.01	1.25
Chemical oxygen demand	34.4	44.1	39.24
Fecal coliform (colonies/100mL)	0.5[c]	9	3.5
Nitrate+nitrite, as nitrogen	0.005[c]	0.0855	0.0251
pH (standard units) (grab)	7.83	9.34	8.78
Total coliform (colonies/100 mL)	0.5[c]	57	23
Total Kjeldahl nitrogen	1.49	2.51	2.03
Total phosphorus	0.339	1.21	0.598
Total dissolved solids	826	1170	992.75
Total suspended solids	2[c]	2[c]	2[d]

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
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.



year]) (CES 1993). The extremely low 2005 nitrogen loading rate had a negligible effect on nitrogen accumulation.

The 2005 annual total chemical oxygen demand (COD) loading rate at the CFA Sewage Treatment Plant 48.27 kg/ha/year (43.09 lb/acre/year) was substantially less than state guidelines of 20,443 kg/ha/year (18,250 lb/acre/year).

The annual total phosphorus loading rate of 0.87 kg/ha/year (0.78 lb/acre/year) was markedly below the projected maximum loading rate of 5.0 kg/ha/year (4.5 lb/acre/year). The small amount of phosphorus applied was probably removed by sorption reactions in the soil and utilized by vegetation, rather than lost to groundwater.

Removal efficiencies (REs) were calculated to estimate treatment in the lagoons. Average REs were higher than the previous year for all four parameters. Total nitrogen, biochemical oxygen demand and TSS achieved the projected efficiency of 80 percent, and COD was below the projected efficiency of 70 percent. During the 2005 permit year, the average REs indicate that treatment in the lagoons was sufficient to produce a good quality effluent for land application.

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

Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant

Description – 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 sewage system consists of seven lift stations, which pump waste into two main lift stations. Both of the two main lift stations contain a sewage grinder that the wastewater passes through before being pumped to the STP. Under WLAP LA-000130-04, the INTEC STP consists of:

- Two aerated lagoons (Cell Nos. 1 and 2)
- Two quiescent, facultative stabilization lagoons (Cell Nos. 3 and 4)
- Five control stations (weir boxes) (CPP-769, CPP-770, CPP-771, CPP-772, and CPP-773)
- A Lift station (CPP-2714) is used to pump the treated effluent to the service waste system.

Because the STP depends on natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) to treat the wastewater, the five control stations are used to direct the wastewater flow to the proper sequence of lagoons. After treatment in the lagoons, the effluent is then gravity fed to lift station CPP-2714 where it is pumped to the service waste system at manhole MAH-PHE-SW-106. 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). These composite samplers are connected to flow meters, thus allowing flow-proportional samples to be taken.

WLAP Wastewater Monitoring Results – Influent samples were collected from control station CPP-769, and effluent samples were collected from control station CPP-773. The WLAP (LA-000130-



04) for the combined wastewater discharged to the INTEC New Percolation Ponds still requires samples to be collected from these two locations. However, the new permit does not set limits for total nitrogen or TSS at control stations CPP-769 and CPP-773. The permit-required data are summarized in Tables 5-6 through 5-8. All samples are collected as 24-hour flow-proportional composites, except pH and total coliform, which are taken as grab samples as required by the permit.

WLAP 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):

- 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.

The permit requires that samples be collected semiannually during April and October and provides a specified list of parameters to be analyzed for in the groundwater samples. 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. 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 5-9 shows the April and October 2005 water table elevations and depth to water table, determined before purging and sampling, and the analytical results for all parameters specified by the permit for aquifer wells. Table 5-10 presents similar information for the perched water wells.

Aquifer well ICPP-MON-A-167 was dry during the October 2005 sampling. This is the first time this well could not be sampled because of insufficient volume. Since October 2002, when WLAP sampling began, the depth of water in this well has ranged from approximately 150.9 m (495 ft) to just less than 152.4 m (500 ft). In March 2004, routine maintenance was performed on this well and a new pump was installed. However, in April 2004, when samplers tried to obtain the permit-required sample, the new pump was inoperable and had to be replaced before taking the sample on April 7, 2005. In October 2005, when samplers tried to obtain the October permit-required sample, the water level had fallen below the intake of the pump, and a compliance sample could not be obtained. The pump is currently positioned near the bottom of this well and cannot be lowered farther. Unless the water level



Table 5-6. Summary of INTEC New Percolation Ponds Effluent Monitoring Results for January 2005 through December (2005).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Aluminum	0.0125[c]	0.0125[c]	0.0125[d]	NA[e]
Arsenic	0.00125[c]	0.0046	0.0018	NA
Biological oxygen demand (5-day)	1.0[c]	5.07	1.55	NA
Cadmium	0.0005[c]	0.0005[c]	0.0005[d]	NA
Chloride	78.2	266	139.6	NA
Chromium	0.0047	0.0064	0.0054	NA
Conductivity (µS) (grab)	176.1	1333	564	NA
Copper	0.0019	0.0053	0.0031	NA
Fluoride	0.1[c]	0.253	0.195	NA
Iron	0.051	0.122	0.088	NA
Manganese	0.00125[c]	0.00125[c]	0.00125[d]	NA
Mercury	0.0001[c]	0.0001[c]	0.0001[d]	NA
Nitrate+nitrite, as nitrogen	0.577	1.95	1.225	NA
pH (standard units) (grab)	7.16	8.08	7.69	NA
Selenium	0.001[c]	0.001[c]	0.001[d]	NA
Silver	0.00125[c]	0.00125[c]	0.00125[d]	NA
Sodium	62.5	147	86.3	NA
Total coliform (colonies/100 mL)	0.5[c]	96	21.0	NA
Total dissolved solids	359	716	483	NA
Total Kjeldahl nitrogen	0.142	0.758	0.474	NA
Total nitrogen[f]	0.964	2.633	1.7	20
Total phosphorus	0.0524	2.81	0.3523	NA
Total suspended solids	2.0[c]	2.0[c]	2.0[d]	100

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
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. NA—Not applicable; no permit limit is set for this parameter.
f. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.



Table 5-7. Summary of INTEC Sewage Treatment Plant Influent Monitoring Results (2005).[a]

Parameter	Minimum	Maximum	Average[b]
Biological oxygen demand (5-day)	65.1	714.0	244.6
Nitrate+nitrite, as nitrogen	0.0136	0.3150	0.0738
Total Kjeldahl nitrogen	21.2	85.4	48.9
Total phosphorus	3.4	13.2	6.7
Total suspended solids	32.2	686	229

a. All values are in milligrams per liter (mg/L).
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.

Table 5-8. Summary of INTEC Sewage Treatment Plant Effluent Monitoring Results (2005).[a]

Parameter	Minimum	Maximum	Average[b]
Biological oxygen demand (5-day)	6.44	31.60	16.01
Chloride	78.2	148.0	111.2
Conductivity (µS) composite	507.6	1064	748.8
Nitrate+nitrite, as nitrogen	0.0109	4.33	1.4826
pH (standard units) (grab)	6.92	8.93	8.38
Sodium	47.0	93.8	68.7
Total coliform (colonies/100 mL)	20	4200	969
Total dissolved solids	375	571	476
Total Kjeldahl nitrogen	7.16	43.20	17.84
Total nitrogen[c]	8.1253	43.959	19.318
Total phosphorus	2.08	7.10	4.03
Total suspended solids	7.00	84.60	30.35

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
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.



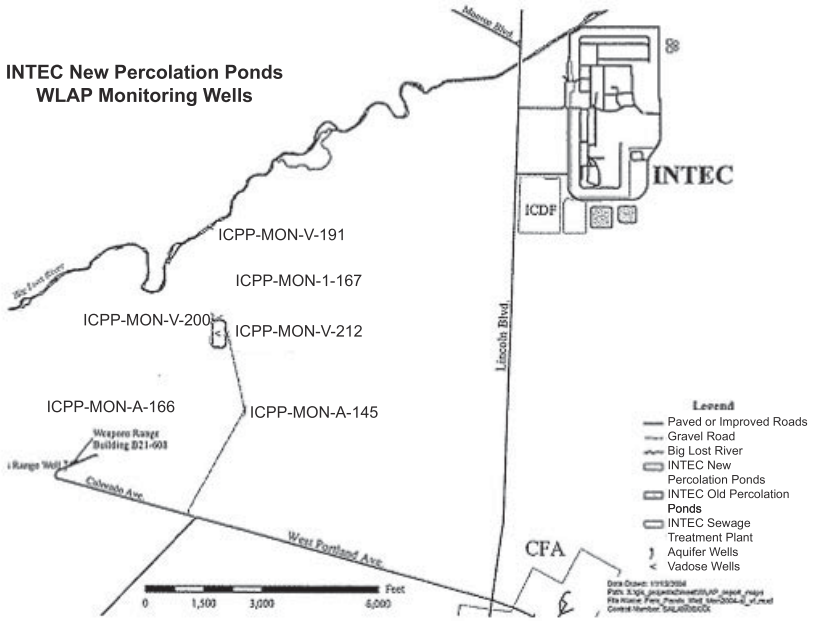


Figure 5-1. WLAP Monitoring Locations at INTEC.

rises above the pump intake, future WLAP samples cannot be collected from this well. Similarly, water levels in wells ICPP-MON-A-165 and ICPP-MON-A-166 have also been dropping (see Figure 5-2). All three aquifer wells will continue to be monitored semiannually, and analytical samples will be taken if sufficient water exists.

Perched water well ICPP-MON-V-191 was dry during both the April and October 2005 sampling events. The well is not expected to have sufficient volume to sample during the required April and October compliance periods unless there is extended flow in the Big Lost River to sufficiently recharge the perched water at this well. During 2005, there was flow in the river in the vicinity of the INTEC New Percolation Ponds for a 10-day period starting on May 31, 2005. Before then, the river had been dry since May 2000. While well ICPP-MON-V-191 did receive recharge from this event, insufficient volume existed in the well to obtain a sample.

Groundwater Quality Standard Exceedances Summary — Metals. Aluminum and iron concentrations in unfiltered samples taken from perched water well ICPP-MON-V-200 in April 2005 (McNeel 2005a) and iron concentrations in October 2005 (McNeel 2006b) exceeded the associated



Table 5-9. New Percolation Pond WLAP Groundwater Quality Data from Aquifer Wells for April 2005 and October 2005.

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)				ICPP-MON-A-166 (GW-013007)		PCS/SCS[a]
Sample Date	4/7/2005	October 2005	4/5/2005	4/5/2005[b]	10/6/2005	10/6/2005[b]	4/14/2005	10/4/2005	NA[c]
Depth to water table (ft)	498.53	Dry[d]	502.61	502.61	503.76	503.76	508.92	509.60	NA
Water table elevation at brass cap (ft)	4,451.60	—	4,450.30	4,450.30	4,449.15	4,449.15	4,450.58	4,449.90	NA
pH	7.80	—	7.98	7.98	7.89	7.89	7.69	7.85	6.5–8.5
Total Kjeldahl Nitrogen (mg/L)	0.10 U[e]	—	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA
Nitrate, as nitrogen (mg-N/L)	0.49	—	0.78	0.72	0.63 R[f]	0.63 R[f]	0.22	0.29	10
Nitrite, as nitrogen (mg-N/L)	0.02 U	—	0.02 U	0.02 U	0.02 U R[f]	0.02 U R[f]	0.02 U	0.02 U	1
Total phosphorus (mg/L)	0.318	—	0.0525	0.0573	0.0274	0.0274	0.0765	0.0421	NA
Biochemical oxygen demand (mg/L)	97.0	—	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NA
Total dissolved solids (mg/L)	185	—	259	256	262	268	196	192	500
Chloride (mg/L)	9.0	—	43.2	43.3	44.4	45.5	7.8	7.1	250
Fluoride (mg/L)	0.13	—	0.13	0.12	0.18	0.19	0.21	0.22	4
Aluminum (mg/L)	6.15	—	0.0328	0.0251	0.072 U	0.077 U	1.06	0.816	0.2
Aluminum-filtered (mg/L)	0.025 U	—	—	—	—	—	0.025 U	0.066 U	0.2
Arsenic (mg/L)	0.0075 U	—	0.0075 U	0.0075 U	0.0014	0.0014	0.0075 U	0.0017	0.05
Arsenic-filtered (mg/L)	0.0075 U	—	—	—	—	—	0.0075 U	0.0016	0.05
Cadmium (mg/L)	0.0025 U	—	0.0025 U	0.0025 U	0.001 U	0.001 U	0.0025 U	0.001 U	0.005
Cadmium-filtered (mg/L)	0.0025 U	—	—	—	—	—	0.0025 U	0.001 U	0.005
Chromium (mg/L)	0.0228	—	0.020	0.0202	0.020	0.018	0.0141	0.009	0.1
Chromium-filtered (mg/L)	0.0072	—	—	—	—	—	0.0055	0.006	0.1
Copper (mg/L)	0.0208	—	0.0034	0.0028	0.014 U	0.013 U	0.0035	0.010 U	1.3
Copper-filtered (mg/L)	0.0025 U	—	—	—	—	—	0.0025 U	0.008 U	1.3
Iron (mg/L)	3.82	—	0.302	0.278	0.066	0.076	0.802	0.566	0.3

Table 5-9. New Percolation Pond WLAP Groundwater Quality Data from Aquifer Wells for April 2005 and October 2005. (Continued)

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)				ICPP-MON-A-166 (GW-013007)		PCS/SCS[a]
Sample Date	4/7/2005	October 2005	4/5/2005	4/5/2005[b]	10/6/2005	10/6/2005[b]	4/14/2005	10/4/2005	NA[c]
Iron-filtered (mg/L)	0.0907	—	—	—	—	—	0.0748	0.3 U	0.3
Manganese (mg/L)	0.0849	—	0.0061	0.0059	0.005	0.005	0.028	0.046	0.05
Manganese-filtered (mg/L)	0.0263	—	—	—	—	—	0.0156	0.039	0.05
Mercury (mg/L)	0.0002 U	—	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Mercury-filtered (mg/L)	0.0002 U	—	—	—	—	—	0.0002 U	0.0002 U	0.002
Selenium (mg/L)	0.0025 U	—	0.0025 U	0.0025 U	0.0017 U	0.0016 U	0.0025 U	0.0009 U	0.05
Selenium-filtered (mg/L)	0.0025 U	—	—	—	—	—	0.0025 U	0.0006 U	0.05
Silver (mg/L)	0.0025 U	—	0.0025 U	0.0025 U	0.01 U	0.01 U	0.0025 U	0.01 U	0.1
Silver-filtered (mg/L)	0.0025 U	—	—	—	—	—	0.0025 U	0.01 U	0.1
Sodium (mg/L)	11.4	—	15.6	15.0	15.3	16.2	9.46	9.54	NA
Sodium-filtered (mg/L)	10.6	—	—	—	—	—	9.31	9.27	NA
Total coliform (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	Absent	R[g]	1 col/100 mL
Fecal coliform (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	Absent	Absent	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. Duplicate sample.
c. NA—Not applicable.
d. ICPP-MON-V-167 was dry in October 2005 when permit-required sampling was performed, and the pump is located at the bottom of the well and cannot be lowered further. Therefore, the well could not be sampled.
e. U flag indicates that the result was below the detection limit.
f. The reported result was rejected during validation because of missed holding times by the analytical laboratory.
g. The reported total coliform result was rejected during validation due to interferences with the noncoliform bacteria results reported as too numerous to count.

Table 5-10. New Percolation Pond Groundwater Quality Data from Perched Water Wells for April 2005 and October 2005.

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		PCS/SCS[a]
Sample Date	April 2005	October 2005	4/6/2005	10/12/2005	4/5/2005	10/11/2005	NA[b]
Depth to water table (ft)	Dry[c]	Dry[c]	112.86	111.12	233.80	233.39	NA
Water table elevation at brass cap (ft)	—	—	4,840.11	4,841.85	4,724.54	4,724.95	NA
pH	—	—	7.65	7.66	7.79	7.79	6.5–8.5
Total Kjeldahl nitrogen (mg/L)	—	—	0.1 U[d]	0.1 U	0.1 U	0.1 U	NA
Nitrate, as nitrogen (mg-N/L)	—	—	1.4	0.90	1.1	0.98	10
Nitrite, as nitrogen (mg-N/L)	—	—	0.2 U	0.02 U	0.2 U	0.02 U	1
Total phosphorous (mg/L)	—	—	0.0956	0.0494	0.0597	0.0298	NA
Biochemical oxygen demand (mg/L)	—	—	2.0 U	2.0 U	2.0 U	2.0 U	NA
Total dissolved solids (mg/L)	—	—	457	503	393	495	500
Chloride (mg/L)	—	—	138	173	112	157	250
Fluoride (mg/L)	—	—	0.24	0.27	0.13	0.17	4
Aluminum (mg/L)	—	—	0.539	0.125	0.025 U	0.087 U	0.2
Aluminum-filtered (mg/L)	—	—	0.025 U	0.061 U	0.025 U	0.091 U	0.2
Arsenic (mg/L)	—	—	0.0075 U	0.0029	0.0075 U	0.0013	0.05
Arsenic-filtered (mg/L)	—	—	0.0075 U	0.0029	0.0075 U	0.0013	0.05
Cadmium (mg/L)	—	—	0.0025 U	0.001 U	0.0025 U	0.001 U	0.005
Cadmium-filtered (mg/L)	—	—	0.0025 U	0.001 U	0.0025 U	0.001 U	0.005
Chromium (mg/L)	—	—	0.0106	0.006	0.0054	0.005	0.1
Chromium-filtered (mg/L)	—	—	0.0056	0.005	0.0051	0.005	0.1
Copper (mg/L)	—	—	0.003	0.013	0.0025 U	0.017	1.3
Copper-filtered (mg/L)	—	—	0.0025 U	0.013	0.0025 U	0.016	1.3
Iron (mg/L)	—	—	0.687	0.391	0.233	0.136	0.3

Table 5-10. New Percolation Pond Groundwater Quality Data from Perched Water Wells for April 2005 and October 2005. (Continued)

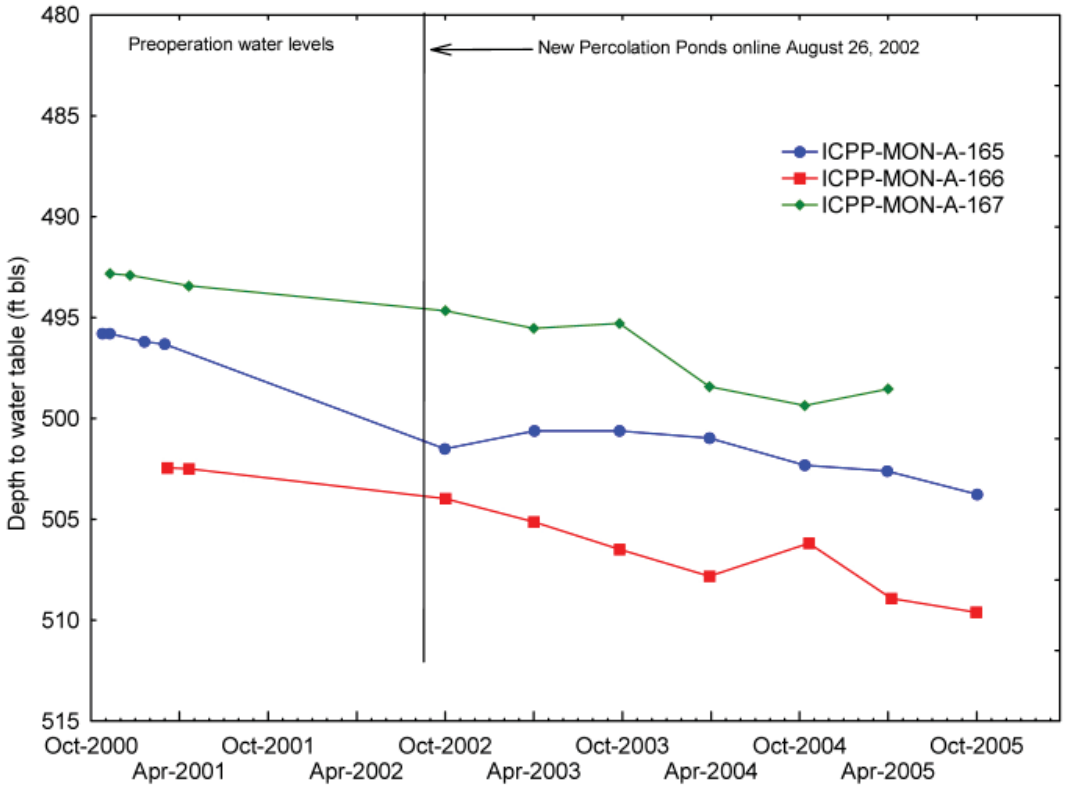
	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		PCS/SCS[a]
Sample Date	April 2005	October 2005	4/6/2005	10/12/2005	4/5/2005	10/11/2005	NA[b]
Iron-filtered (mg/L)	—	—	0.0623	0.3 U	0.0922	0.3 U	0.3
Manganese (mg/L)	—	—	0.0124	0.011	0.0025 U	0.006	0.05
Manganese-filtered (mg/L)	—	—	0.0025 U	0.006	0.0025 U	0.006	0.05
Mercury (mg/L)	—	—	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Mercury-filtered (mg/L)	—	—	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Selenium (mg/L)	—	—	0.0025 U	0.0014 U	0.0025 U	0.0013 U	0.05
Selenium-filtered (mg/L)	—	—	0.0025 U	0.0014 U	0.0025 U	0.0014 U	0.05
Silver (mg/L)	—	—	0.0025 U	0.010 U	0.0025 U	0.010 U	0.1
Silver-filtered (mg/L)	—	—	0.0025 U	0.010 U	0.0025 U	0.010 U	0.1
Sodium (mg/L)	—	—	80.0	96.6	38.9	51.0	NA
Sodium-filtered (mg/L)	—	—	79.0	99.3	39.2	49.9	NA
Total coliform (colonies/100 mL)	—	—	Absent	Absent	Absent	Absent	1 col/100 mL
Fecal coliform (colonies/100 mL)	—	—	Absent	Absent	Absent	Absent	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. NA—Not applicable.
c. ICPP-MON-V-191 is a perched well and was dry in April 2005 and October 2005 when permit-required sampling was performed. Therefore, the well could not be sampled.
d. U flag indicates that the result was below the detection limit.

groundwater quality standards. Aluminum, iron, and manganese concentrations in unfiltered samples from both aquifer and perched water wells associated with the INTEC New Percolation Ponds WLAP have exceeded the associated groundwater quality standards in the past. These high concentrations were detected in unfiltered preoperational groundwater samples taken from a downgradient aquifer well (ICPP-MON-A-166) and the upgradient aquifer well outside the zone of influence of the INTEC New Percolation Ponds (ICPP-MON-A-167) and have persisted since the INTEC New Percolation Ponds began receiving wastewater. For aquifer wells, the preoperational concentrations in the upgradient well (ICPP-MON-A-167) are considered the natural background level (IDAPA 58.01.11.200.03) and are used for determining compliance with the permit and the Ground Water Quality Rule. Because concentrations of these metals in aquifer wells during 2005 were below the preoperational upgradient concentrations, they are considered in compliance with the permit and the Ground Water Quality Rule.

Perched water well ICPP-MON-V-200 was first sampled in October 2002. Concentrations of aluminum and iron in the unfiltered samples from ICPP-MON-V-200 were first detected above SCSs in April 2003. During 2005, concentrations of both aluminum and iron in the unfiltered samples remained above the SCSs.

Figure 5-2. Depth of Water Table in the New Percolation Pond Aquifer Monitoring Wells.





Because of persistently high concentrations of these metals in unfiltered samples taken from both aquifer and perched water wells, several investigative and corrective actions have been taken. A study by Hull, Wright, and Street (2004) was conducted prior to the October 2004 permit-required sampling. The specific objectives of this investigation were to determine the source of suspended solids in the wells and to evaluate the relationship between the suspended solids and metals concentrations that exceed groundwater quality standards.

The study generally concluded that elevated concentrations of aluminum, iron, and manganese are directly attributable to undissolved, suspended solids in unfiltered groundwater samples. Composed mainly of quartz and alumino-silicate minerals, the solids may have originated from washed-in interbed material derived from the completion zones of the wells (from sedimentary interbeds or from sediment-infilled fractures). Sediment infilling is a common occurrence in fractures, rubble zones, and void spaces in the Snake River Plain basalt flows (Hull, Wright, and Street 2004). Such sediment, present as suspended solids in water samples, would result in high unfiltered concentrations of common elements in rock-forming minerals, particularly iron, aluminum, and manganese (Gibs et al. 2000). When the samples are filtered through a 0.45 μm filter, the metals concentrations fall below the respective groundwater quality standards.

Review of Effluent Concentrations. Hull, Wright, and Street (2004) did not specifically address the concentrations of aluminum, iron, and manganese in the effluent as a possible cause of the elevated levels of these metals in the INTEC New Percolation Ponds wells. However, the average concentrations of these metals in the effluent are significantly lower than the concentrations in the three wells addressed in their study and are below the respective SCSs. Average permit year concentrations of these metals are summarized in Table 5-11.

Groundwater Quality Standard Exceedances Summary — TDS. The concentration of TDS in well ICPP-MON-V-200 in October 2005 (503 mg/L) exceeded the SCS of 500 mg/L (McNeel 2006c). The concentrations of TDS, as well as chloride and sodium, in the perched water continue to be influenced by the concentrations of these parameters in the wastewater (CPP-797 effluent) discharged to the INTEC New Percolation Ponds (Figure 5-3), with little attenuation of these three parameters by the soil. A Salt Loading Corrective Action Plan and Schedule was submitted to DEQ and is currently being revised. Once approved and implemented, the planned corrective actions are intended to reduce salt loadings to the INTEC New Percolation Ponds.

Test Area North/Technical Support Facility 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



Table 5-11. Summary of Aluminum, Iron, and Manganese in the Effluent to New Percolation Ponds, by Permit Year.

	Average Permit Year Effluent Concentration				
Parameter	2002[a] (mg/L)	2003 (mg/L)	2004[b] (mg/L)	2005 (mg/L)	Groundwater Quality Standard (mg/L)
Aluminum	0.0068	0.006	0.0066	0.025 U[c]	0.2
Iron	0.0184	0.034	0.036	0.086	0.3
Manganese	0.0006	0.0008	0.0007	0.0025 U	0.05

a. The New Percolation Ponds became operational on August 26, 2002. Therefore, the 2002 permit year average is only based on the September and October monitoring results.

b. The 2004 permit year included through December 2, 2004, when the sanitary waste was combined with the service waste.

c. U flag indicates that all the results for the permit year were below the detection limit. The reported detection limit is shown.

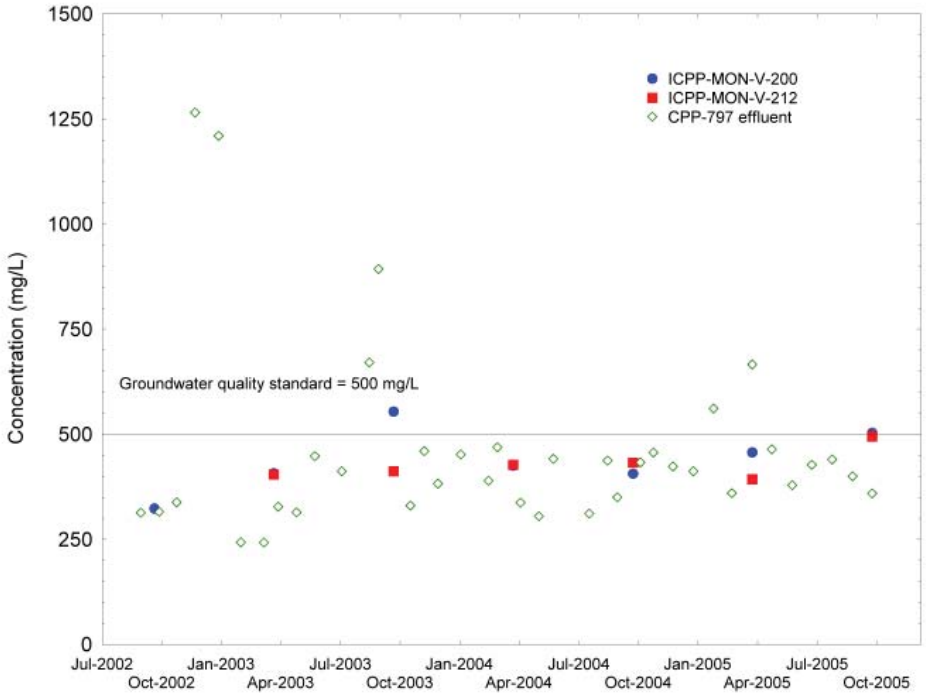


Figure 5-3. TDS Concentrations in Perched Water Wells ICPP-MON-V-200 and ICPP-MON-V-212, and the CPP-797 Effluent (July 2002 - October 2005).



- 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; before that, treated wastewater was disposed of through an injection well (TSF-05). The TAN/TSF Disposal Pond (TAN-740) consists of a primary disposal area and an overflow section, both of which are located within an unlined, fenced 14-ha (35-acre) area. 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.

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 Plant, 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; steam condensate; 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 combined with sanitary wastewater before being pumped to the TAN/TSF Disposal Pond.

WLAP Wastewater Monitoring Results – Total effluent to the TAN/TSF Disposal Pond for calendar year 2005 was approximately 44.7 million L (11.82 million gal).

The permit for the TAN/TSF Sewage Treatment Facility sets concentration limits for TSS and total nitrogen (measured at the effluent to the TAN/TSF Disposal Pond) and requires that the effluent be sampled and analyzed monthly for specific parameters. During 2005, 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.

Table 5-12 summarizes the effluent monitoring results for calendar year 2005. Monthly concentrations of TSS were below the permit limit (100 mg/L) with the exception of the January 2005 and February 2005 samples, which had a concentration of 248 and 103, respectively. It was suspected that the sanitary drain line from the former TAN-609 building was inadvertently filled with debris (gravel, silt, sediment) when the building was demolished in 2003, and then in late 2004, when trailers were moved into the area and placed on-line with the sanitary system, the effluent from the restrooms began driving silt and sediment downgradient. Concentrations of TSS in the monthly samples returned to normal levels (below 20 mg/L) after the sediment traps and drain lines were cleaned, and remained



Table 5-12. Summary of TAN/TSF Sewage Treatment Facility Effluent Monitoring Results (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Aluminum	0.0125[d]	1.4700	0.1949	NA[e]
Arsenic	0.00125[d]	0.0053	0.0031	NA
Barium	0.0911	0.1930	0.1117	NA
Beryllium	0.00025[d]	0.00025[d]	0.00025[f]	NA
Biological oxygen demand (5-day)	5.44	28.60	10.58	NA
Cadmium	0.0005[d]	0.0005[d]	0.0005[f]	NA
Chloride	17.00	517.00	172.58	NA
Chromium	0.00125	0.035	0.00613	NA
Fecal coliform (colonies/100 mL)[g]	273	400,000	43,552	NA
Fluoride	0.100[d]	0.309	0.228	NA
Iron	0.110	3.080	0.542	NA
Lead	0.0002[d]	0.0134	0.0019	NA
Manganese	0.0031	0.0329	0.0080	NA
Mercury	0.0001[d]	0.0011	0.0002	NA
Nitrogen, as ammonia	0.0119	3.64	1.9921	NA
Nitrate+nitrite, as nitrogen	2.73	6.03	3.78	NA
pH (standard units) (grab)	7.28	8.45	7.85	NA
Total Kjeldahl nitrogen	0.0869	7.18	3.1305	NA
Selenium	0.01[d]	0.01[d]	0.01[f]	NA
Sodium	9.18	317.00	101.94	NA
Sulfate	26.8	62.4	38.4	NA
Total coliform (colonies/100 mL)[g]	200	410,000	55,139[h]	NA
Total dissolved solids	142	1070	530	NA
Total nitrogen[i]	2.9969	10.13	6.9144	20
Total phosphorus	0.179	1.640	0.790	NA
Total suspended solids	2.00[d]	248.00	34.76	100
Zinc	0.0144	0.496	0.0825	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. Duplicate samples were collected in March for all parameters (excluding total coliform and fecal coliform) and the duplicate results are included in the summaries.

c. 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.

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

e. NA—Not applicable; no permit limit is set for this parameter.

f. 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.

g. No sample was taken in December 2005.

h. The reported average was calculated using estimated values for January and February because the Total Coliforms were too numerous to count at the performed dilutions. The values were estimated from a regression of Ln Total Coliforms on Ln Fecal Coliforms. The estimated values were 15,231 and 7412 for January and February, respectively.

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



well below the permit limit for the remainder of the year. All monthly total nitrogen (total Kjeldahl nitrogen + nitrate+nitrite, as nitrogen) concentrations were below the permit limit of 20 mg/L, with the maximum monthly concentration of 10.1 mg/L reported in January 2005.

WLAP Groundwater Monitoring Results – To measure potential TAN/TSF Disposal Pond impacts to groundwater, the permit requires that groundwater samples be collected from five monitoring wells (Figure 5-4):

- One background aquifer well (TANT-MON-A-001) upgradient of the TAN/TSF Disposal Pond
- Three aquifer wells (TAN-10A, TAN-13A, 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 specified parameters for analysis. As specified in Section F of the permit, parameter concentrations in wells TAN-10A (except for iron), TAN-13A, and TANT-MON-A-002 are limited to the PCSs and SCSs in IDAPA 58.01.11, "Ground Water Quality Rule." Section F of WLAP LA-000153-02 exempted the iron concentrations in well TAN-10A from the limits set forth in IDAPA 58.01.11.200.01.b. All permit-required samples are collected as unfiltered samples.

During the 2005 permit year, groundwater samples were collected in April and October. Table 5-13 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. Therefore, no analytical results are presented for this well.

Iron concentrations in well TAN-10A were above the SCS of 0.3 mg/L in April 2005 and October 2005. Elevated iron concentrations historically have been detected in the TAN WLAP monitoring wells. Because of increased iron concentrations in all four of the TAN WLAP monitoring wells in 1999, a corrosion evaluation (CORRPRO 2000) was performed at the TAN wells, and exhibited similar increases. This evaluation confirmed that the riser pipes at several TAN wells were significantly corroded. The riser pipes attached to the dedicated submersible pumps were replaced with stainless steel riser pipes in all four TAN WLAP monitoring wells during August 2001. Video log information gathered during the well maintenance showed that the stainless steel well casings in wells TAN-13A, TANT-MON-A-001, and TANT-MON-A-002 appeared relatively free of rust to the water table. While some residual effect of the well maintenance activities continued in 2002, iron concentrations have decreased in all three of these wells based on samples collected before the maintenance and those collected after the maintenance.

The April 2001 video log information gathered on well TAN-10A showed that the carbon steel well casing appeared corroded most of the way to the water table, with slime on the well casing below the water table, a partially plugged screen, and approximately a foot of sludge at the bottom of the well. Both total and dissolved iron concentrations in well TAN-10A increased immediately after the 2001 well maintenance was performed. While total iron concentrations have since dropped, concentrations



Table 5-13. TAN/TSF Treatment Facility Groundwater Data for April and October 2005.

	TANT-MON-A-001 (GW-015301)				TANT-MON-A-002 (GW-015304)		TAN-10A (GW-015303)		TAN-13A (GW-015302)		TSFAG-05 (GW-015306)		PCS/SCS[a]
Sample Date	4/13/05[b]	4/13/05[b,c]	10/13/05	10/13/05[c]	4/13/05[d]	10/13/05	4/11/05	10/11/05	4/12/05	10/11/05	April 2005	October 2005	NA[e]
Depth to Water table (ft)	210.64	210.64	213.85	213.85	213.91	217.61	211.56	214.92	213.32	215.37	Dry	Dry	NA
Water table Elevation at Brass Cap (ft)	4,572.11	4,572.11	4,568.90	4,568.90	4,570.95	4,567.25	4,572.61	4,569.25	4,570.65	4,568.60	—	—	NA
pH	7.78[b]	7.78[b]	7.89	7.89	7.70[d]	7.79	7.56	7.58	7.66	7.69	—	—	6.5–8.5
Total Kjeldahl Nitrogen (mg/L)	0.10 U[f]	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	—	—	NA
NH_3-N (mg/L)	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	—	—	NA
NO_3-N (mg/L)	0.92	0.91	0.91	0.91	0.55	0.55	0.02 U	0.02 U	0.40	0.37	—	—	10
NO_2-N (mg/L)	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.2 U	0.02 U	0.02 U	0.02 U	—	—	1
BOD (mg/L)	2.0 U	2.0 U	3 U	3 U	2.0 U	3 U	6.6 U	6.3	2.0 U	2.0 U	—	—	NA
Total phosphorous (mg/L)	0.0717	0.0621	0.0543	0.0176	0.0597	0.0396	0.0549	0.106	0.110	0.0494	—	—	NA
TDS (mg/L)	223	224	240	216	199	194	507	511	175	187	—	—	500
Aluminum (mg/L)	0.025 U	0.025 U	0.086 U	0.104 U	0.025 U	0.125 U	0.025 U	0.105 U	0.025 U	0.118 U	—	—	0.2
Arsenic (mg/L)	0.0075 U	0.0075 U	0.0028	0.0027	0.0075 U	0.0023	0.0075 U	0.0012	0.0075 U	0.0019	—	—	0.05
Barium (mg/L)	0.0761	0.0769	0.072	0.067	0.0733	0.070	0.260	0.238	0.0702	0.069	—	—	2
Beryllium (mg/L)	0.002 U	0.002 U	0.0003 U	0.0003 U	0.002 U	0.0003 U	0.002 U	0.0003 U	0.002 U	0.0003 U	—	—	0.004
Cadmium (mg/L)	0.0025 U	0.0025 U	0.001 U	0.001 U	0.0025 U	0.001 U	0.0025 U	0.001 U	0.0025 U	0.001 U	—	—	0.005
Chloride (mg/L)	11.5	11.6	11.7	11.8	3.8	3.8	107	108	3.6	3.4	—	—	250
Chromium (mg/L)	0.0042	0.0038	0.004	0.004	0.0056	0.006	0.0025 U	0.001 U	0.0038	0.004	—	—	0.1



Table 5-13. TAN/TSF Treatment Facility Groundwater Data for April and October 2005. (Continued)

Sample Date	TANT-MON-A-001 (GW-015301) 4/13/05[b]	TANT-MON-A-001 (GW-015301) 4/13/05[b,c]	TANT-MON-A-001 (GW-015301) 10/13/05	TANT-MON-A-001 (GW-015301) 10/13/05[c]	TANT-MON-A-002 (GW-015304) 4/13/05[d]	TANT-MON-A-002 (GW-015304) 10/13/05	TAN-10A (GW-015303) 4/11/05	TAN-10A (GW-015303) 10/11/05	TAN-13A (GW-015302) 4/12/05	TAN-13A (GW-015302) 10/11/05	TSFAG-05 (GW-015306) April 2005	TSFAG-05 (GW-015306) October 2005	PCS/SCS[a] NA[e]
Fluoride (mg/L)	0.18	0.20	0.21	0.20	0.18	0.22	0.14	0.16	0.16	0.20	—	—	4
Lead (mg/L)	0.0005 U	0.0005 U	0.001 U	0.001 U	0.0005 U	0.001 U	0.0005 U	0.001 U	0.0005 U	0.001 U	—	—	0.015
Iron (mg/L)	0.0809	0.0857	0.300 U	0.098	0.0725	0.053	0.992	1.14	0.0851	0.097	—	—	0.3
Iron (filtered) (mg/L)	—	—	—	—	—	—	0.874	0.934	—	—	—	—	0.3
Manganese (mg/L)	0.0025 U	0.0025 U	0.004	0.009	0.0025 U	0.005	0.474	0.467	0.0025 U	0.010	—	—	0.05
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.00007 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	—	—	0.002
Selenium (mg/L)	0.0025 U	0.0025 U	0.0016	0.0016	0.0025 U	0.0013 U	0.0025 U	0.0004 U	0.0025 U	0.0012 U	—	—	0.05
Sodium (mg/L)	7.01	7.17	7.49	5.66	5.85	6.16	50.9	53.3	5.81	5.86	—	—	NA
Sulfate (mg/L)	28.9	28.6	30.6	31.4	14.8	14.6	37.7	33.9	14.8	14.8	—	—	250
Zinc (mg/L)	0.0384	0.0394	0.030	0.138	0.096	0.109	0.0109	0.018	0.121	0.140	—	—	5
Total coliform (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	—	—	1 col/100 mL
Fecal coliform (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	—	—	NA

a. Primary constituent standards (PCSs) and secondary constituent standards (SCSs) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. For well TANT-MON-A-001, the coliform samples were collected on 4/20/2005, and the pH on 4/20/2005 was 7.98.
c. Duplicate sample.
d. For well TANT-MON-A-002, the coliform samples were collected on 4/26/2005, and the pH on 4/26/2005 was 7.80.
e. NA—not applicable.
f. U flag indicates that the result was reported as below the detection limit.

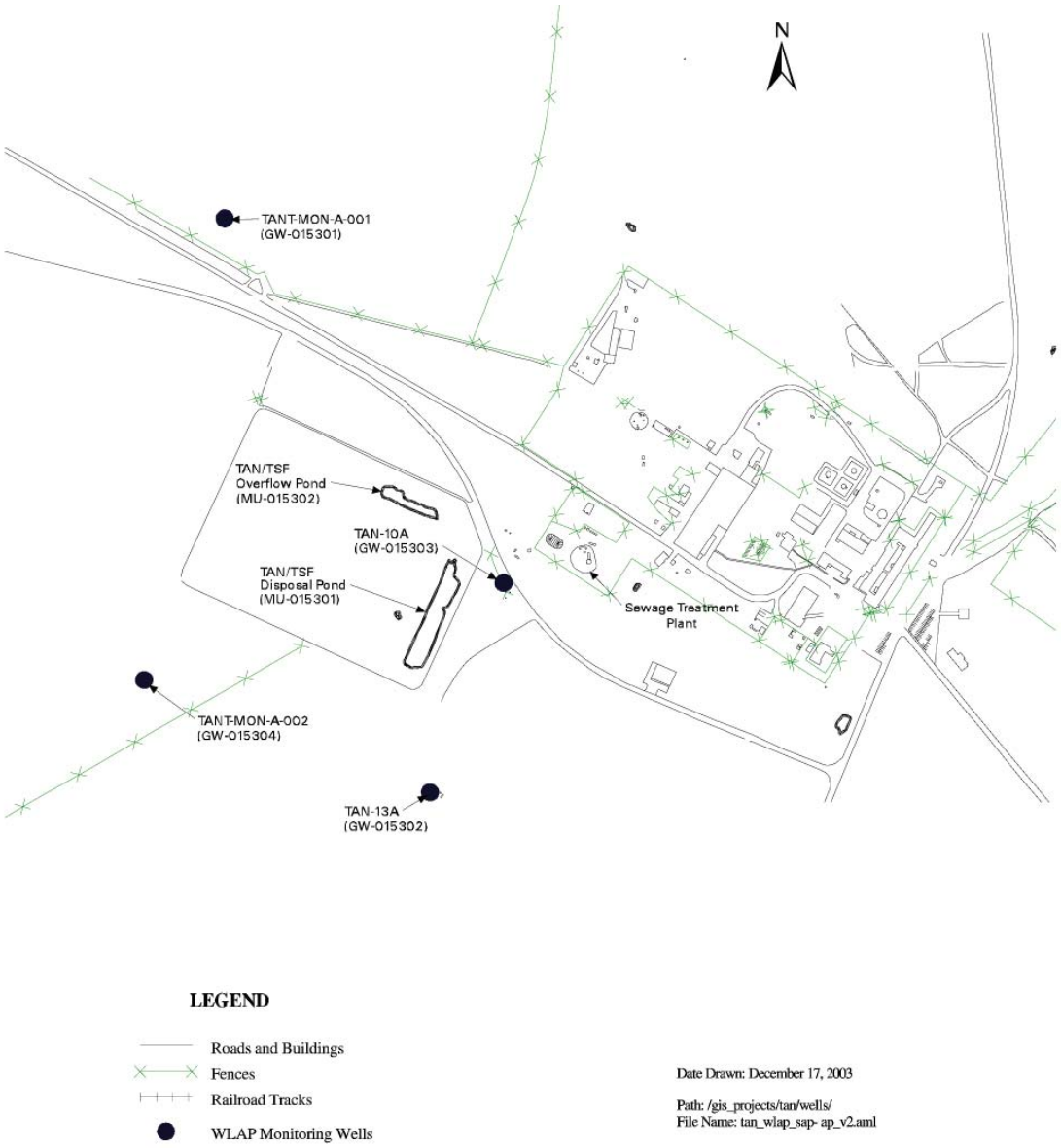


Figure 5-4. WLAP Monitoring Locations at TAN.

of dissolved iron have continued to increase, and concentrations of both have consistently remained above the SCS.

Item No. 1 of Compliance Activity CA-153-07 requires a groundwater investigation of the iron concentrations in the TAN/TSF STF area. The conclusions of that investigation show elevated total (unfiltered) iron in many area wells, increased concentrations of dissolved (filtered) iron in area wells impacted by ongoing remediation activities, and impacts of the carbon steel casing in TAN-10A on



the total (unfiltered) iron concentrations in that well (ICP 2006a). However, the investigation did not find that the elevated iron concentrations in TAN-10A were derived from iron discharged to the TSF Disposal Pond from the TAN/TSF STF effluent. The majority of the iron in well TAN-10A is dissolved iron, rather than solid phase iron, and the investigation did find that the increases in dissolved iron were correlated to the onset of in situ bioremediation operations in 1999. In situ bioremediation is being used to remediate the known trichloroethylene (TCE) hot spot that resulted from historical injections into injection well TSF-05.

However, because Section F of WLAP LA-000153-02 exempted the iron concentrations in well TAN-10A from the limits set forth in IDAPA 58.01.11.200.01.b, these exceedances do not represent permit noncompliances. Concentrations of both manganese and TDS in well TAN-10A also exceeded their SCSs (0.05 mg/L and 500 mg/L, respectively) during the permit year. None of the groundwater samples taken from the other permitted wells exceeded parameter concentrations during the 2005 permit year.

For well TAN-10A, concentrations of both manganese and TDS have periodically been above their SCSs. The peak TDS concentration occurred shortly after riser pipe replacement, and the condition of the well casing may still be contributing to the TDS concentrations in well TAN-10A. Figure 5-5 shows the historical TDS concentrations in the effluent and in well TAN-10A. While increases in well TAN-10A in early 2000 seem to follow earlier increases in the effluent, no pattern is visibly evident from 2000 forward, with increases in well TAN-10A occurring before increases in the effluent. Similarly, no visible pattern is evident for the concentrations of manganese in the effluent when compared to concentrations in well TAN-10A. Concentrations of TDS and manganese in well TAN-10A were also compared to available data from area wells located outside the hot spot of the TCE plume and wells outside the influence of the Disposal Pond, and reported concentrations of TDS and manganese were within the same concentration range as other area wells (ICP 2006b). ICP 2006b also found that concentrations of TDS and manganese in wells located within the vicinity of the TSF-05 injection well have increased as a result of the frequent amendment injections associated with the in situ bioremediation operations of the TCE hot spot, but were unable to determine if similar increases in TAN-10A were directly related to these activities.

The TAN/TSF WLAP requires semiannual monitoring of five wells in the vicinity of the TAN/TSF for a specific set of parameters. As specified in Section F of the WLAP, parameter concentrations in wells TAN-10A (except for iron), TAN-13A, and TANT-MON-A-002 are limited to the PCSs and SCSs. Concentrations of TDS (507 mg/L in April and 511 mg/L in October) and manganese (0.474 mg/L in April and 0.467 mg/L in October) in well TAN-10A exceeded the SCSs of 500 mg/L and 0.03 mg/L, respectively (McNeel 2005a and McNeel 2006c). Before 2005, the concentrations of these parameters in well TAN-10A first exceeded their respective SCSs in October 2004.

The peak TDS concentration occurred shortly after riser pipe replacement, and the condition of the well casing may still be contributing to the TDS concentrations in well TAN-10A. The periodic



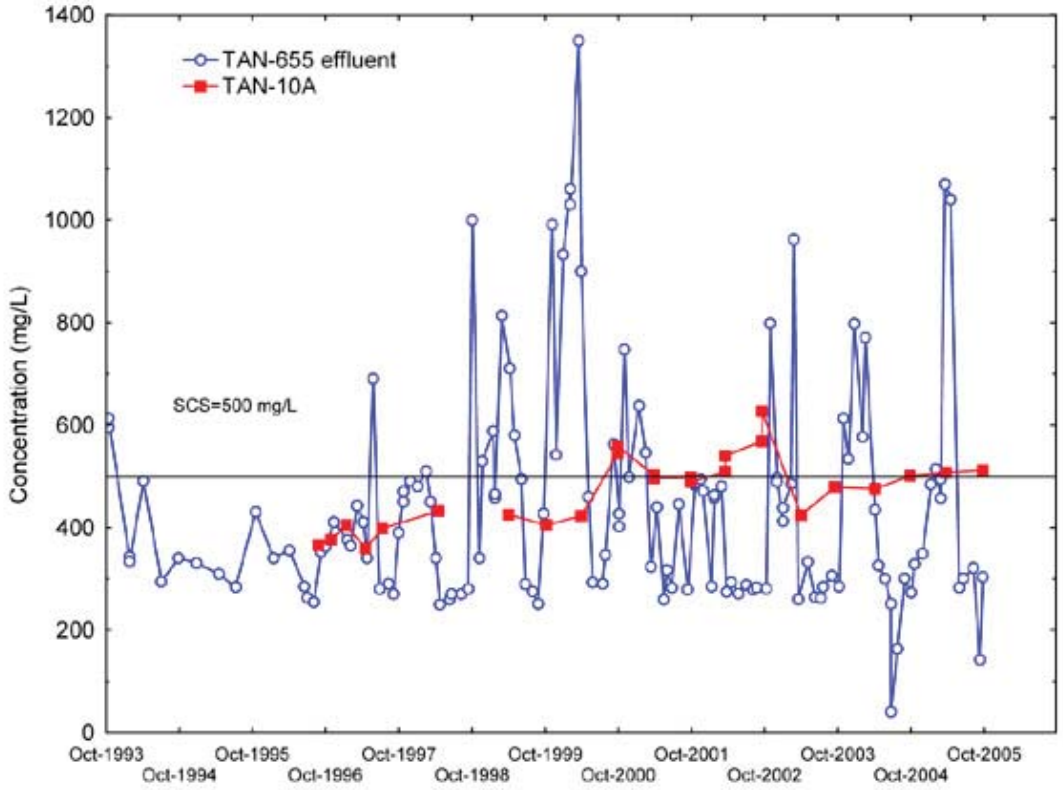


Figure 5-5. TDS Concentrations in TAN-655 Effluent and Well TAN-10A (October 1993-2005).

elevated concentrations in well TAN-10A of both TDS and manganese were investigated (ICP 2006b). The conclusions of that investigation were:

- Concentrations of TDS and manganese in well TAN-10A were within the same concentration range when compared to available data from area wells located outside the hot spot of the TCE plume and outside the influence of the Disposal Pond
- TDS and manganese concentrations detected in well TAN-10A do not appear to be derived from TDS or manganese in the effluent discharged to the Disposal Pond
- Both TDS and manganese concentrations in wells in the vicinity of the TSF-05 injection well have increased as a result of frequent amendment injections relating to the remediation of the TCE hot spot.

Concentrations of TDS and manganese in well TAN-10A, as well as other permitted wells, will continue to be monitored semiannually.



Reactor Technology Complex Cold Waste Pond

Description – The RTC Cold Waste Pond was constructed in 1982. The majority of wastewater received by the Cold Waste Pond is secondary cooling water from the Advanced Test Reactor (ATR) when it is in operation. Chemicals used in the cooling water are primarily commercial corrosion inhibitors and sulfuric acid to control pH. Other wastewater discharges to the Cold Waste Pond are nonhazardous and nonradioactive and include, but are not limited to: maintenance cleaning waste, floor drains, and yard drains.

The cold waste effluents collect at the cold waste well sump and sampling station (RTC-764) before being pumped to the Cold Waste Pond. The cooling tower system has a radiation monitor with an alarm that prevents accidental discharges of radiologically contaminated cooling water.

WLAP Wastewater Monitoring Results – A letter from the Idaho DEQ, issued in 2001, authorized the continued operation of the Cold Waste Pond under the terms and conditions of the WLAP regulations (Johnston 2001). As a result, total nitrogen (Total Kjeldahl Nitrogen + nitrogen, nitrite + nitrate) and TSS analyses were added in August 2001 to the list of parameters analyzed quarterly at the Cold Waste Pond. These are the only parameters required for compliance. Other parameters are sampled for surveillance purposes, which are discussed in Section 5.2.

Automated samplers are used to collect quarterly 24-hour time-proportional composite samples from TRA-764. TSS and total nitrogen results are summarized in Table 5-14. For 2005, all TSS results were below the laboratory's minimum detection level of 4 mg/L. The regulatory limit for TSS is 100 mg/L. The maximum total nitrogen concentration during 2005 was 3.812 mg/L, which was also significantly less then the regulatory limit of 20 mg/L.

WLAP Groundwater Monitoring Results – Currently, there are no groundwater monitoring requirements associated with the RTC Cold Waste Pond. However, groundwater monitoring is expected to be required when a permit is issued.

5.2 Liquid Effluent Surveillance Monitoring

As stated in Section 5.1, additional radiological and nonradiological parameters specified in the Idaho groundwater quality standards also are monitored. The following sections discuss results of this additional monitoring by individual facility. This additional monitoring is performed to comply with DOE Orders 450.1 and 5400.5 environmental protection objectives.

Central Facilities Area

Both the influent and effluent to the CFA Sewage Treatment Plant are monitored according to the WLAP issued for the plant. Table 5-15 summarizes the additional monitoring conducted during 2005 at the CFA Sewage Treatment Plant and shows those parameters which were detected in at least



Table 5-14. Summary of RTC Cold Waste Pond Effluent Monitoring Results (2005).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit[c]
Total suspended solids	2[d]	2[d]	2[e]	100
Total nitrogen[f]	1.076	3.812	1.983	20

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Annual average is determined from the average of the quarterly values. Half the reported detection limit was used in any calculation to estimate the average for those data reported as below the detection limit.
c. Effluent limit specified in IDAPA 58.01.17.600.06B, Wastewater Land Application Permit Rules.
d. Sample result was less than the detection limit; value shown is half the detection limit.
e. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.
f. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite.

one sample during the year. Additional monitoring is performed quarterly from the floor drains and vehicle maintenance areas of the Transportation Complex at CFA-696. During 2005, most additional parameters were within historical concentration levels.

Idaho Nuclear Technology and Engineering Center

A WLAP is in effect for the INTEC New Percolation Ponds. Table 5-16 summarizes the additional monitoring conducted during 2005 at INTEC and shows the analytical results for parameters which were detected in at least one sample during the year.

During 2005, most additional parameters were within historical concentration levels.

Materials and Fuels Complex

During 2005, the Industrial Waste Pond, Industrial Waste Ditch, and Secondary Sanitary Lagoon were sampled monthly for iron, sodium, chloride, fluoride, sulfate, pH, conductivity, TSS, turbidity, biological oxygen demand, gross alpha, gross beta, gamma spectrometry, and tritium. Additionally, a sample for selected metals is collected once a year, and the Secondary Sanitary Lagoon is sampled monthly for total coliform. The Secondary Sanitary Lagoon was not sampled in January, and the Industrial Waste Pond was dry for part of the year and was only sampled in March through August. Tables 5-17 through 5-19 summarize the analytical results for parameters which were detected in at least one sample.



Table 5-15. Summary of CFA Liquid Effluent Surveillance Monitoring Results (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Influent to CFA Sewage Treatment Plant Pond 1			
Total Phosphorus	1.56	8.96	3.80
Conductivity (µS) (grab)	839	2018	1220
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System			
Aluminum[d]	0.0296	0.0296	0.0296
Barium[d]	0.114	0.114	0.114
Chloride	317	317	317
Conductivity (µS) (grab)	1372	1634	1517
Copper[d]	0.0017	0.0017	0.0017
Flouride	0.505	0.505	0.505
Gross beta[d,e]	13.1 ± 2.26	13.1 ± 2.261	13.1 ± 2.26
Iodine-129[e,f]	0.172 ± 0.1246	0.172 ± 0.1246	0.172 ± 0.1246
Iron[d]	0.162	0.162	0.162
Manganese[d]	0.0122	0.0122	0.0122
Sodium[d]	130	130	130
Sulfate[d]	52.3	52.3	52.3
Tritium[e,f]	4610 ± 286	4610 ± 286	4610 ± 286
Zinc[d]	0.0038	0.0038	0.0038
Transportation Complex, CFA-696			
Conductivity (µS) (grab)	648	861	744
pH (standard units) (grab)	7.76	8.48	8.09
Total oil and grease	2[g]	29.3	12.68

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. 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.
d. Parameter was analyzed for in June only. Therefore, the minimum, maximum, and average are the same.
e. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
f. Parameter was analyzed for in August only. Therefore, the minimum, maximum, and average are the same.
g. Sample result was less than the detection limit; value shown is half the detection limit.



Table 5-16. Summary of INTEC Liquid Effluent Surveillance Monitoring Results (2005).[a]

Parameter	Minimum	Maximum	Average[b]
Effluent to INTEC New Percolation Ponds			
Cesium-137[c]	0.55 ± 2.58	3.62 ± 0.92	2.48 ± 0.57
Gross alpha[c]	1.00 ± 3.20[d]	9.24 ± 5.52	3.08 ± 1.87
Gross beta[c]	1.17 ± 7.34	36.8 ± 6.80	21.2 ± 1.71
Total strontium[c]	1.52 ± 4.86	4.44 ± 2.02	1.99 ± 0.60
Influent to INTEC Sewage Treatment Plant			
Conductivity (µS)	178.8	1,190	771.7
pH (standard units) (grab)	7.73	8.77	8.34
Effluent from INTEC Sewage Treatment Plant			
pH (standard units) (composite)	7.43	9.16	8.47
Conductivity (µS) (grab)	601	1,050	780
Gross alpha[c]	-1.22 ± 1.17[d]	3.57 ± 2.30	0.03 ± 0.76
Gross beta[c]	9.60 ± 2.18	14.0 ± 3.44	11.1 ± 0.99
Radium-226[c]	2.69 ± 5.64[d]	17.5 ± 10.5	6.01 ± 4.97
Silver-110m[c]	0.04 ± 2.72[d]	9.53 ± 8.96	1.15 ± 1.12
Total strontium[c]	0.67 ± 0.36[d]	1.39 ± 0.45	0.92 ± 0.24

a. Only parameters with at least one detected result are shown.
b. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
c. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
d. Result was a statistical nondetect.

Test Area North

The effluent to the TAN/TSF Disposal Pond receives a combination of process water from various TAN facilities and treated sewage waste. Additional monitoring for surveillance purposes is conducted monthly for metal parameters and quarterly for radiological parameters (with the exception of strontium-89, iodine-129, and tritium, which are monitored annually, and strontium-90, which was monitored monthly starting in March 2005). Table 5-20 summarizes the results of this additional monitoring for those parameters which were detected in at least one sample during the year.

During 2005, the concentrations of most additional parameters were within historical concentration levels.



Table 5-17. Summary of Analytical Results for Samples Collected from the MFC Industrial Waste Pond (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Arsenic[d]	0.0069	0.0069	0.0069
Barium[d]	0.117	0.117	0.117
Biological oxygen demand (5-Day)	1.0[e]	10.0	4.98
Chloride	13.0	90.5	35.3
Chromium[d]	0.0352	0.0352	0.0352
Conductivity[f] (µS)	323.5	806.5	522.4
Fluoride	0.333	0.629	0.514
Iron	0.732	10.6	3.9
Lead[d]	0.0016	0.0016	0.0016
Nitrate + nitrite, as nitrogen[f]	0.005[e]	0.333	0.089
Total Kjeldahl nitrogen	1.010	3.22	1.82
pH (standard units) (grab)	7.33	9.0	8.18
Sodium	12.3	71.3	29.2
Sulfate	52.8	179	106
Total dissolved solids[f]	301	590	391
Total phosphorus	0.145	0.362	0.251
Total suspended solids	12.7	67.8	38.0
Zinc[d]	0.0266	0.0266	0.0266
Gross alpha[g,h]	4.14 ± 2.02	9.02 ± 2.44	6.00 ± 0.422
Gross beta[g,h]	11.7 ± 1.578	19.8 ± 2.56	13.9 ± 0.474
Uranium-233/-234[d,g]	4.51 ± 0.798	4.51 ± 0.798	4.51 ± 0.798
Uranium-235[g,h]	-9.51 ± 18.78[i]	20.0 ± 19.9[i]	0.234 ± 0.0099
Uranium-238[d,g]	2.0 ± 0.442	2.0 ± 0.442	2.0 ± 0.442

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. 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.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Only analyzed in samples collected in April through August.
g. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
h. Only includes results for samples collected in April through August. The lab did not report the sample uncertainty for samples collected in March.
i. Result was a statistical nondetect.



Table 5-18. Summary of Analytical Results for Samples Collected from the MFC Industrial Waste Ditch (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Barium[d]	0.0434	0.0434	0.0434
Biological oxygen demand[f] (5-Day)	1.0[e]	6.03	2.20
Chloride	16.0	123	66
Conductivity[f] (µS)	421.4	742.6	557.8
Fluoride	0.5[e]	0.791	0.658
Iron	0.100	0.791	0.350
Lead[d]	0.0013	0.0013	0.0013
Nitrate + nitrite, as nitrogen	0.967	2.04	1.80
Total Kjeldahl nitrogen[f]	0.072[e]	1.99	0.657
pH (standard units) (grab)	7.05	8.45	7.92
Sodium	2.06	78.5	34.1
Sulfate	5.8	26.8	18.8
Total dissolved solids[f]	289	450	365
Total phosphorus	0.128	0.938	0.45
Total suspended solids[f]	2[e]	36.9	12.9
Zinc[d]	0.0221	0.0221	0.0221
Gross alpha[g,h]	-0.582 ± 1.98[i]	4.25 ± 1.812	2.39 ± 0.0882
Gross beta[g,h]	2.84 ± 1.788	40.3 ± 2.6	6.03 ± 0.1582
Cesium-137[g,h]	-2.25 ± 5.22[i]	4.59 ± 2.78	0.858 ± 0.372
Potassium-40[g,h]	5.96 ± 43.8[i]	112 ± 46	29.6 ± 64.4
Uranium-233/-234[d,g]	1.36 ± 0.368	1.36 ± 0.368	1.36 ± 0.368
Uranium-238[d,g]	0.604 ± 0.226	0.604 ± 0.226	0.604 ± 0.226

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. 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 uncertainly.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Only analyzed in samples collected in April through December.
g. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
h. Only includes results for samples collected in April through December. The lab did not report the sample uncertainty for samples collected in January through March.
i. Result was a statistical nondetect.



Table 5-19. Summary of Analytical Results for Samples Collected from the MFC Secondary Sanitation Lagoon (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Barium[d]	0.0568	0.0568	0.0568
Biological oxygen demand[e] (5-day)	9.28	69	29.9
Chloride	143	346	230
Conductivity[e] (µS)	1316	2401	1717
Fecal coliform	60	2100	495
Fluoride	0.209	0.5[f]	0.266
Iron	0.208	1.270	0.684
Lead[d]	0.00087	0.00087	0.00087
Nitrate + nitrite, as nitrogen[e]	0.005[f]	1.25	0.509
Total Kjeldahl nitrogen[e],	18.6	48.1	31.0
pH (standard units) (grab)	6.84	8.24	7.74
Sodium	99.7	267	172
Sulfate	20	113	63.6
Total dissolved solids[e]	739	1620	1133
Total phosphorus	1.32	16.5	13.0
Total suspended solids[e]	13	75.1	34.8
Zinc[d]	0.0327	0.0327	0.0327
Gross alpha[g,h]	-0.964 ± 2.48[i]	7.64 ± 2.32	1.45 ± 0.1278
Gross beta[g,h]	2.69 ± 1.084	101 ± 4.94	21.4 ± 0.388
Radium-226[g,h]	0.257 ± 5.28[i]	19.9 ± 7.38	4.46 ± 2.36
Potassium-40[g,h]	2.2 ± 75.6[i]	138 ± 69.8	57.5 ± 86.8
Uranium-233/-234[d,g]	0.39 ± 0.1826	0.39 ± 0.1826	0.39 ± 0.1826
Uranium-238[d,g]	0.31 ± 0.1588	0.31 ± 0.1588	0.31 ± 0.1588

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. 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.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Only analyzed in samples collected in April through December.
f. Sample result was less than the detection limit; value shown is half the detection limit.
g. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
h. Only includes results for samples collected in April through December. The lab did not report the sample uncertainty for samples collected in January through March.
i. Result was a statistical nondetect.



Table 5-20. Summary of TAN Liquid Effluent Surveillance Monitoring Results (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Effluent to TAN/TSF Disposal Pond			
Cesium-137[d]	-0.60 ± 2.72[e]	5.34 ± 3.02	1.45 ± 1.48
Conductivity (µS) (grab)	422.2	2193	869.9
Copper	0.0017	0.1360	0.0227
Gross alpha[d]	2.66 ± 1.63	3.50 ± 2.20	2.91 ± 0.96
Gross beta[d]	4.74 ± 1.47	21.2 ± 2.74	8.96 ± 0.96
Nickel	0.0032	1.2500	1.0584
Strontium-90[d]	-0.40 ± 0.72[e]	14.4 ± 1.17	0.10 ± 0.06

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. 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.
d. Radionuclide values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
e. Result was a statistical nondetect.

Reactor Technology Complex

The effluent to the Cold Waste Pond receives a combination of process water from various RTC facilities. Additional monitoring for surveillance purposes is conducted quarterly for metals and for radiological parameters. Table 5-21 summarizes the results of this additional monitoring for those parameters which were detected in at least one sample during the year.

The largest volume of wastewater received by the RTC Cold Waste Pond is secondary cooling water from the ATR when it is in operation. During 2005, 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 cooling water pH. Concentrations of sulfate and TDS exceeded the risk-based release levels specific for the RTC Cold Waste Pond during reactor operation but not during reactor outages. The annual average was below the risk-based release limit, which is the concentration predicted to degrade groundwater quality to above drinking water standards.



Table 5-21. Summary of RTC Effluent Surveillance Monitoring Results (2005).[a,b]

Parameter	Minimum	Maximum	Average[c]
Effluent from RTC Cold Waste Pond			
Antimony	0.0003[d]	0.0019	0.0008
Arsenic	0.00125[d]	0.0066	0.003
Barium	0.0482	0.194	0.091
Chloride	10.7	44	28.8
Chromium	0.0031	0.0138	0.0067
Conductivity (µS) (grab)	398	1279	750
Copper	0.0017	0.0046	0.0033
Fluoride	0.100[d]	0.559	0.287
Iron	0.044	0.195	0.111
pH (standard units) (grab)	7.47	8.01	7.80
Nitrate + nitrite, as nitrogen	0.975	3.640	1.796
Sodium	7.94	38.30	21.69
Sulfate	21.7	625	205.15
Total dissolved solids	248	1320	602
Total Kjeldahl nitrogen	0.101	0.332	0.187
Zinc	0.00125[d]	0.0027	0.0016
Europium-154[e]	-3.37 ± 7.52[f]	8.27 ± 5.48	2.32 ± 5.88
Gross alpha[e]	0.174 ± 1.254[f]	3.68 ± 1.70	2.10 ± 0.322
Gross beta[e]	0.565 ± 1.09[f]	12.20 ± 2.56	2.47 ± 0.274
Manganese-54[e]	-1.14 ± 7.74[f]	2.96 ± 1.06	1.97 ± 0.352

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. 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.
d. Sample result was less than the detection limit; value shown is half the detection limit.
e. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
f. Result was a statistical nondetect.

5.3 Drinking Water Monitoring

In accordance with 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 INL contractor transient, noncommunity water systems are at the Experimental



Breeder Reactor No. 1 (EBR-I), the Gun Range, and the Main Gate. The rest of the INL contractor water systems are classified as nontransient, noncommunity water systems, which have more stringent requirements than transient, noncommunity water systems.

The Drinking Water Program monitors drinking water to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations (that spell out MCLs). The federal Safe Drinking Water Act also establishes requirements for the Drinking Water Program.

Because groundwater supplies the drinking water at the INL Site, information on groundwater quality was used to help develop the Drinking Water Program. The U.S. Geological Survey and the various contractors monitor and characterize groundwater quality at the INL Site. Three groundwater contaminants have impacted INL contractor drinking water systems: tritium at CFA, carbon tetrachloride at the Radioactive Waste Management Complex (RWMC), and trichloroethylene at TAN/TSF.

As required by the state of Idaho, the 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* parts 141–143. State regulations also require the use of laboratories that either are certified by the state or by another state whose certification is recognized by Idaho. The DEQ oversees the certification program and maintains a listing of approved laboratories.

Currently, the INL contractor Drinking Water Program monitors 12 onsite water systems, which include 19 wells. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Parameters with primary maximum contaminant levels must be monitored at least once during every three-year compliance period. Parameters with secondary maximum contaminant levels are monitored every three years based on a recommendation by the EPA. The three-year compliance periods for the INL contractor Drinking Water Program are 2005 to 2007, 2008 to 2010 and so on. Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline.

Because of known contaminants, the INL contractor Drinking Water Program monitors certain parameters more frequently than required. For example, the program monitors for bacteriological analyses more frequently because of historical problems with bacteriological contamination. These past detections were probably caused by biofilm on older water lines and stagnant water. In 2005, total coliform bacteria was detected in the EBR-I, Gun Range, and Main Gate water systems.

INL Contractor Drinking Water Monitoring Results

During 2005, 545 routine samples and 65 quality control samples were collected and analyzed from CFA, EBR-I, Gun Range (Live Fire Test Range), INTEC, Main Gate, Materials and Fuels Complex (MFC), Critical Infrastructure Test Range Complex (CITRC), RWMC, TAN/Contained Test Facility (CTF), TAN/TSF, and RTC. In addition to the routine sampling, the INL contractor also collects nonroutine samples. A nonroutine sample is one collected after a water main breaks and is repaired, to determine if the water is acceptable for use before the main is put back into service. Twenty-four requests for nonroutine sampling were received during 2005.



Analytical results of interest (carbon tetrachloride, trichloroethylene, and tritium) and nitrate (required to be monitored annually) results for 2005 are presented in Tables 5-22 and 5-23, respectively, and are discussed in the following subsections. EBR-I, Gun Range, INTEC, Main Gate, CITRC, and TAN/CTF were markedly below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report.

In 2005, total coliform bacteria was detected at the Main Gate, EBR-I, and Gun Range water system. In the RWMC public water system, carbon tetrachloride remained below the EPA established MCL of 5 µg/L. The MCL applies only at the compliance point, which is the distribution system. The annual average for the compliance point of the distribution system was 3.50 µg/L. The annual average for the production well was 5.18 µg/L. TCE concentrations in samples from the TAN drinking water Well #2 remained below the MCL of 5 µg/L during 2005.

In 2005, total coliform bacteria were detected in the EBR-I, Gun Range and Main Gate water systems.

The EBR-I Historical site is only open from Memorial Day through Labor Day. Bacteria were detected at EBR-I during testing of the system prior to opening. This was likely the result of stagnant water in the distribution system. The water distribution system was flushed and retested on May 5, 2005, and no further bacteria were detected.

Bacteria were detected at the Gun Range water system when the water chlorination system was being repaired. After the chlorination system was back on-line no further bacteria were detected.

The bacteria detected at the Main Gate water system were found when the filters were plugged with sand. The filters were changed and no further bacteria were detected.

Central Facilities Area – The CFA water system serves approximately 900 people daily. Since the early 1950s, wastewater containing tritium was disposed of to the Snake River Plain Aquifer (SRPA) 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 2005, water samples were collected once from CFA #1 Well (at CFA-651), and quarterly from CFA-1603 (manifold) for compliance purposes. Since December 1991, the mean tritium concentration has been below the 20,000 pCi/L MCL at all three locations. In general, tritium concentrations in groundwater have been decreasing (see Figure 5-6) because of changes in disposal techniques, recharge conditions, and radioactive decay.

CFA Worker Dose – Because of the potential impacts to downgradient workers at CFA from radionuclides in the Eastern SRPA, the potential effective dose equivalent from radioactivity in water was calculated. CFA was selected because tritium concentrations found in these wells were the highest of any drinking water wells. The 2005 calculation was based on reported tritium and iodine-129 concentrations for the CFA distribution system.



Table 5-22. Monitored Drinking Water Parameters of Interest in 2005.

Parameter[a]	Location	Results[b]	MCL[b]
Carbon Tetrachloride	RWMC Distribution RWMC Well[c]	3.50 5.18	5 NA[d]
Trichloroethylene	RWMC Distribution RWMC Well[c] TAN/TSF Distribution TAN/TSF #2 Well[c]	1.78 2.53 1.08 2.08	5 NA 5 NA
Tritium	CFA Distribution CFA #1 Well[c] CFA #2 Well[c]	8,170 ± 268 8,310 ± 210 7,840 ± 215	20,000 NA NA

a. The parameters shown are known contaminants that the Drinking Water Program is tracking.
b. Results and maximum contaminant levels are in micrograms per liter (µg/L). Tritium is in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations). Results are an average of four quarters.
c. Sampled once for surveillance purposes (not required by regulations to be samples). The compliance point is the distribution system.
d. NA = Maximum contaminant level is not applicable to the well concentration.

Table 5-23. Nitrate Results for INL Contractor Water Systems in 2005.

Water System	PWS Number	Parameter	Concentration	MCL (mg/L)
CFA	6120008	Nitrate as nitrogen	2.80	10
CITRC	6120019	Nitrate as nitrogen	0.83	10
EBR-1	6120009	Nitrate as nitrogen	0.36	10
INTEC	6120012	Nitrate as nitrogen	0.67	10
Gun Range	6120025	Nitrate as nitrogen	0.84	10
Main Gate	6120015	Nitrate as nitrogen	0.57	10
MFC	6060036	Nitrate as nitrogen	1.70	10
RTC	6120020	Nitrate as nitrogen	0.86	10
RWMC	6120018	Nitrate as nitrogen	0.81	10
TAN/CTF	6120013	Nitrate as nitrogen	0.79	10
TAN/TSF	6120021	Nitrate as nitrogen	0.87	10



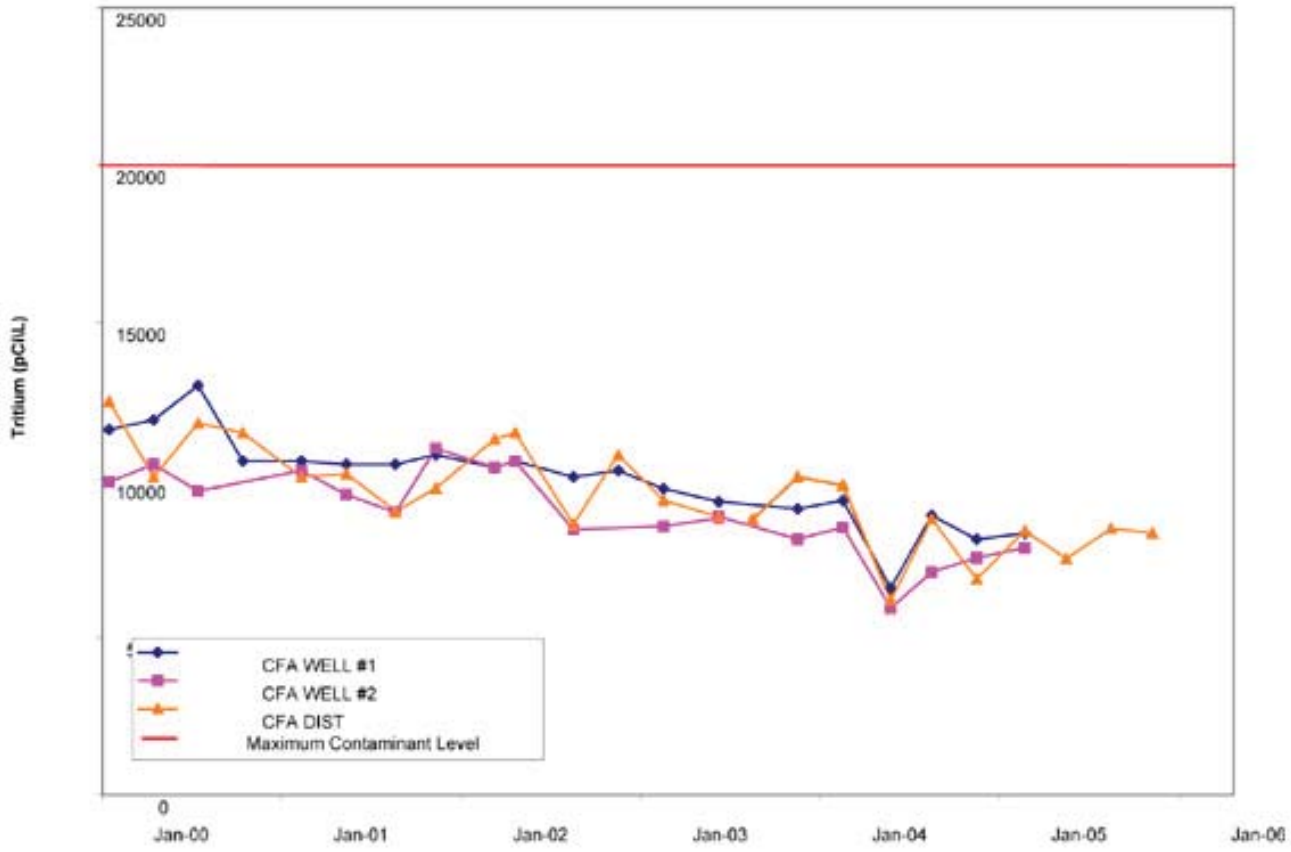


Figure 5-6. Tritium Concentrations in Two CFA Wells and CFA Distribution Systems (2000-2005).

For the 2005 dose calculation, it was assumed that each worker's total water intake came from the CFA drinking water distribution system. This assumption overestimates the 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 2005 was 0.50 mrem/year (5.0 µSv/year). The EPA standard for public drinking water systems is 4 mrem/year.

Radioactive Waste Management Complex – The RWMC production well is located in WMF-603 and supplies all of the drinking water for more than 300 people at the RWMC. The well was put into service in 1974. Water samples were collected at the wellhead and from the point of entry to the distribution system, which is the point of compliance, at WMF-604.



Since monitoring began at RWMC in 1988, there had been an upward trend in carbon tetrachloride concentrations until 1999 (see Figure 5-7). Since 1999, carbon tetrachloride concentrations have remained fairly constant. In October 1995, the carbon tetrachloride concentrations increased to 5.48 µg/L at the well. This was the first time the concentrations exceeded the maximum contaminant level of 5.0 µg/L. However, the maximum contaminant level for carbon tetrachloride is based on a four-quarter average and applies to the distribution system. The distribution system is the point from which water is first consumed and is the compliance point. Table 5-24 summarizes the carbon tetrachloride concentrations at the RWMC drinking water well and distribution system for 2005. The mean concentration at the well for 2005 was 5.18 µg/L, and the maximum concentration was 5.6 µg/L. The mean concentration at the distribution system was 3.50 µg/L, and the maximum concentration was 3.80 µg/L.

A potential source of the carbon tetrachloride is the estimated 334,630 L (88,400 gal) of organic chemical waste (including carbon tetrachloride, TCE, tetrachloroethylene, toluene, benzene, 1,1,1-trichloroethane, and lubricating oil) that were disposed of at the RWMC before 1970. High vapor-phase concentrations (up to 2700 parts per million vapor phase) of volatile organic compounds were measured in the zone above the water table. Groundwater models predict that volatile organic compound concentrations will continue to increase in the groundwater at the RWMC. Vapor vacuum extraction has been used since January 1996 to help mitigate the organic compound contamination.

Permanent chlorination was installed in 2003 because of a history of total coliform bacteria detection. Since permanent chlorination was installed, no coliform bacteria have been detected.

Test Area North/Technical Support Facility – In 1987, TCE was detected at both TSF #1 and #2 Wells, which supply drinking water to approximately 200 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 Well was taken offline, and TSF #2 Well 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 Well, no treatment (sparger air stripping system) is currently required. TSF #1 Well is used as a backup to TSF #2 Well. If TSF #1 Well must be used, the sparger system must be activated to treat the water.

Figure 5-8 illustrates the concentrations of trichloroethylene in both TSF wells and the distribution system from 2000 through 2005. Past distribution system sample exceedances are attributed to preventive maintenance activities interrupting operation of the sparger system.

Table 5-25 summarizes the trichloroethylene concentrations at TSF #2 Well and the distribution system. Regulations do not require sampling of TSF #2 Well; however, samples were collected to monitor trichloroethylene concentrations. The distribution system is the compliance point. TSF #1 Well was not sampled during 2005 because it was not required by the regulations. The mean



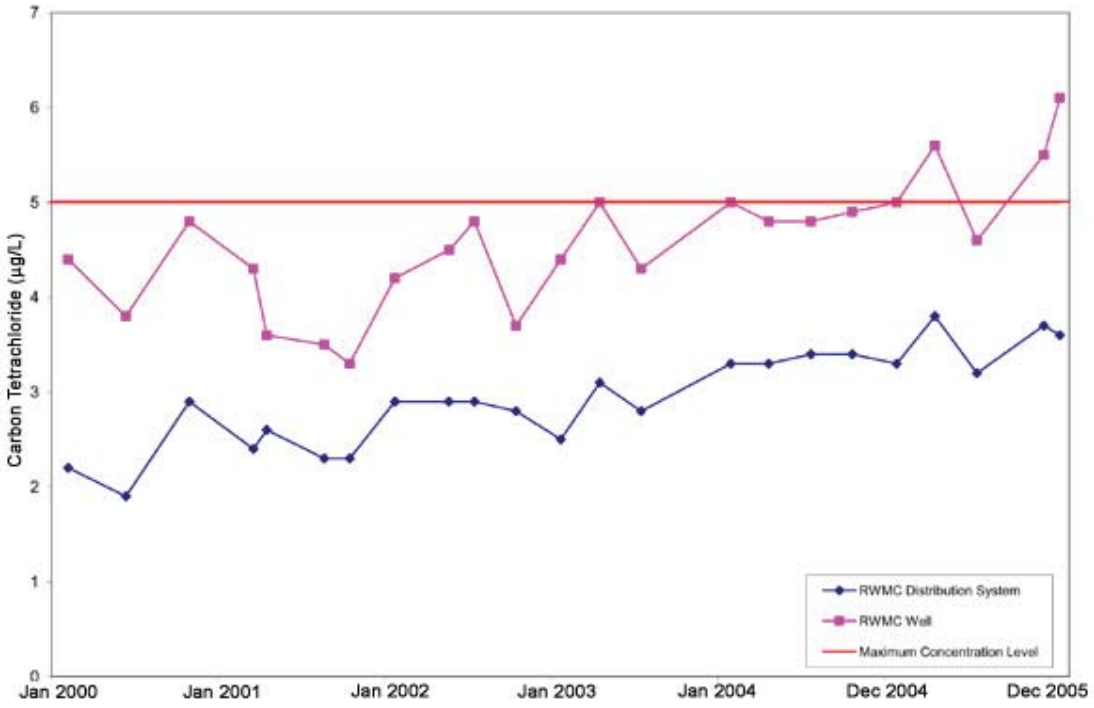


Figure 5-7. Carbon Tetrachloride Concentrations in the RWMC Drinking Water Well and Distribution System (2000-2005).

Table 5-24. Carbon Tetrachloride Concentrations in the RWMC Drinking Water Well and Distribution System (2005).

Location	Number of Samples	Carbon Tetrachloride Concentration [micrograms per liter (µg/L)]			
		Minimum	Maximum	Mean	MCL
RWMC WMF-603 Well	4	4.6	5.6	5.18	NA[a]
RWMC WMF-604 Distribution	4	3.2	3.8	3.50	5.0

a. NA = Not applicable. MCL applies to the distribution system only.



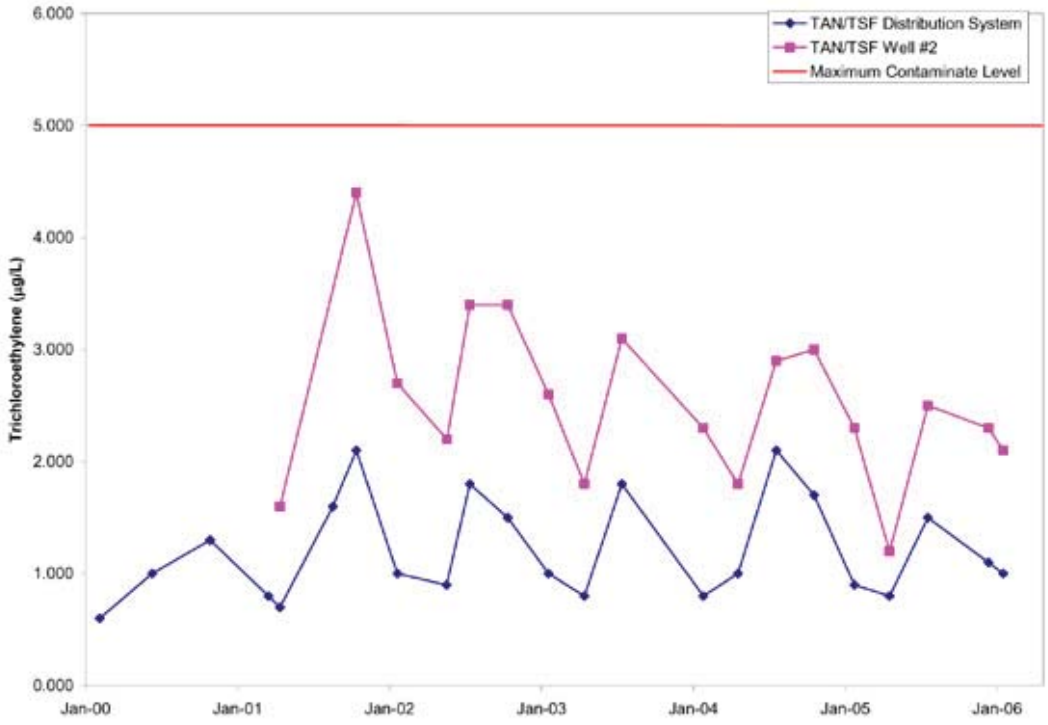


Figure 5-8. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2000-2005).

Table 5-25. Trichloroethylene Concentrations in TSF #2 Well and Distribution System (2005).

Location	Number of Samples	Trichloroethylene [micrograms per liter (µg/L)]			
		Minimum	Maximum	Mean	MCL
TAN/TSF #2 Well (612)[a]	4	1.2	2.5	2.08	NA[b]
TAN/TSF Distribution (610)	4	0.8	1.5	1.08	5.0

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



concentration of trichloroethylene at the distribution system for 2005 was 1.08 µg/L, which is below the MCL.

5.4 Storm Water Monitoring

The EPA National Pollutant Discharge Elimination System (NPDES) regulations for the point-source discharges of storm water to waters of the United States require permits for discharges from industrial activities (40 Code of Federal Regulations [CFR] 122.26 2003). Following these regulations, waters of the United States at the INL Site have been defined as the

- Big Lost River
- Little Lost River
- Birch Creek and Birch Creek Playa
- Spreading areas
- Big Lost River sinks
- Tributaries.

Together, the above locations comprise the Big Lost River System.

A Storm Water Monitoring Program was implemented in 1993 when storm water permits initially applied to the INL Site facilities. The program was modified as permit requirements changed, data were evaluated, and needs were identified. On September 30, 1998, the EPA issued the "Final Modification of the NPDES Storm Water Multi-Sector General Permit for Industrial Activities" (63 FR 189 1998) (referred to as the General Permit). The INL contractor implemented the analytical monitoring requirements of the 1998 General Permit starting January 1, 1999. Visual monitoring was implemented starting October 1, 1998, and continues to be performed quarterly.

The General Permit was reissued in October 2000. The *Idaho National Engineering and Environmental Laboratory Storm Water Pollution Prevention Plan for Industrial Activities* was revised in 2002 (DOE-ID 2001) to meet the requirements of the reissued General Permit. The Storm Water Monitoring Program meets the General Permit requirements by conducting permit-required monitoring. The General Permit requires visual monitoring during the first, third, and fifth years of the permit's duration and both analytical and visual monitoring on the second and fourth years. The General Permit requires that samples be collected and visually examined from rainstorms that accumulated at least 0.25 cm (0.1 in.) of precipitation preceded by at least 72 hours without measurable precipitation (< 0.25 cm [< 0.1 in.]) to allow pollutants to build up and then be flushed from the drainage basin.

In addition to the above-discussed NPDES permit-required monitoring, the program monitors storm water to deep injection wells (three at TAN, three at PBF, and one at CFA) to comply with



Idaho injection well permits. In 1997, responsibility for monitoring of storm water entering deep injection wells was transferred from the U.S. Geological Survey to the INL Site Storm Water Monitoring Program. Storm water data are reported as analytical data submitted to the EPA in a discharge monitoring report; as General Permit visual data and analytical data included in the annual revisions of the plan; or data for storm water discharged to deep injection wells reported to the Idaho Department of Water Resources.

Historically, storm water monitoring locations were based upon drainage patterns and proximity to potential sources of pollutants. The General Permit requires visual examinations of storm water for obvious indications of storm water pollution. In addition, visual examinations were conducted for surveillance purposes at some locations, whether or not storm water discharged to the Big Lost River System.

In 2003, EPA Region 10 determined that three sites at the INL Site (RWMC, INTEC, and the North part of the INL Site property near Birch Creek [area around TAN]) do not have a reasonable potential to discharge storm water to waters of the United States (Ryan 2003). As result of this determination, construction and industrial storm water inspections, data collection and reports have ceased for projects located at these facilities.

The remaining projects were evaluated through a technical analysis to determine any other areas under the INL Site's control that would also have the same or less potential to discharge storm water to waters of the United States. Required storm water inspections and reporting continued for these projects until October 2004. At that time, inspections and reports at any additional projects that had no reasonable potential to discharge to waters of the United States, as determined through a preliminary technical analysis (finalized in early 2005), ceased.

5.5 Waste Management Surveillance Water Sampling

In compliance with DOE Order 435.1, the ICP contractor collects surface water, as surface runoff, at the RWMC Subsurface Disposal Area (SDA) from the location shown in Figure 5-9. The control location for the RMWC/SDA is 1.5 km (0.93 mi) west from the Van Buren Boulevard intersection on U.S. Highway 20/26 and 10 m (33 ft) north on the T-12 Road.

Surface water is collected to determine if radionuclide concentrations exceed alert levels or if concentrations have increased significantly compared to historical data.

Radionuclides could be transported outside the RWMC boundaries via surface water runoff. Surface water runs off at the SDA only during periods of rapid snowmelt or heavy precipitation. At these times, water may be pumped out of the SDA 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.



Table 5-26. Surface Water Runoff Results (2005).

Location	Parameter	Maximum Concentration[a]	% DCG	Comment
SDA	Americium-241	0.213 ± 0.028	0.71	Comparable to historical concentrations
SDA	Plutonium-239/240	0.0600 ± 0.0166	0.20	Comparable to historical concentrations
SDA	Strontium-90	0.358 ± 0.033	0.04	Comparable to historical concentrations
Control	Strontium-90	1.74 ± 0.05	0.17	Comparable to historical concentrations
Control	Cs-137	2.89 ± 0.37[b]	0.10	Comparable to historical concentrations

a. All values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one sigma).
b. Cs-137 value is from the filtered portion of the sample.

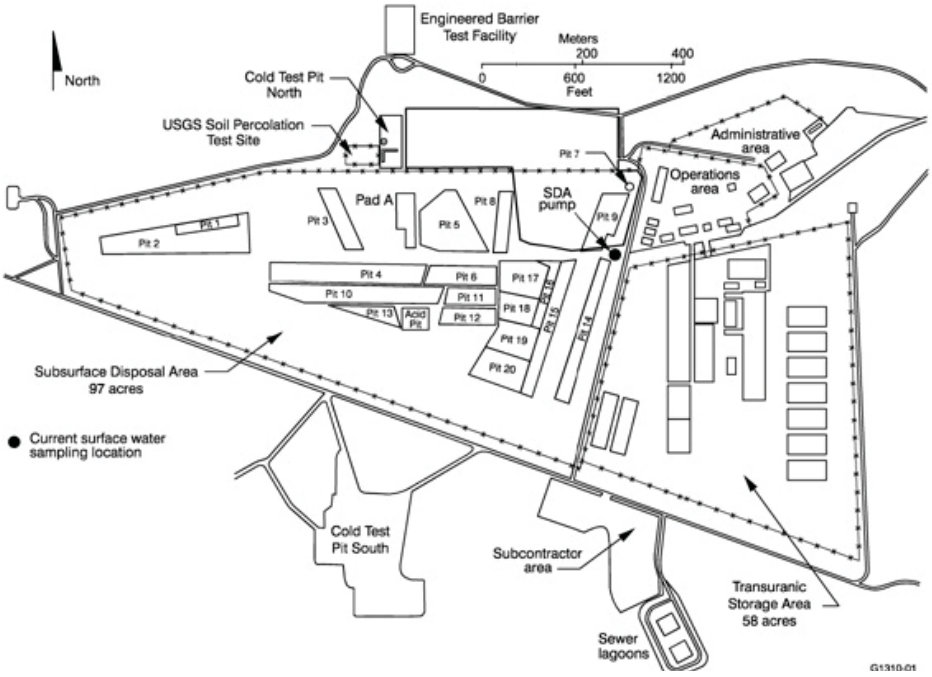


Figure 5-9. RWMC Surface Water Sampling Location.



Surface water runoff samples were collected at the RWMC/SDA during the first and second quarters of 2005. Table 5-26 summarizes the results of human-made radionuclides. All sample results were comparable to historical concentrations.

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Red Admiral

Chapter 6 - Environmental Monitoring Programs - Groundwater, Drinking Water and Surface Water

L. Knobel, L. Davis - U.S. Geological Survey
R. Mitchell - S. M. Stoller Corporation
T. Wood - Battelle Energy Alliance
M. Roddy , L. Nelson - CWI

Chapter Highlights

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the water pathway (surface water, drinking water, and groundwater). The Management and Operating contractor monitors groundwater, as well as liquid effluents, drinking water, and storm water runoff at the INL Site to comply with applicable laws and regulations, U.S. Department of Energy orders, and Wastewater Land Application Permit requirements. The Naval Reactors Facility conducts its own groundwater, effluent, and drinking water monitoring. The U.S. Geological Survey (USGS) INL Project Office performs groundwater monitoring, analyses, and studies of the Eastern Snake River Plain Aquifer (ESRPA) under and adjacent to the INL Site. The Environmental Surveillance, Education and Research program contractor monitors drinking water and surface water at offsite locations.

Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination in the ESRPA beneath the INL Site. These contaminated areas are monitored by the above-mentioned organizations and other various organizations.

Results from a number of special studies conducted by the USGS describing the hydrologic and geochemical properties of the aquifer were published during 2005. Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells at the INL Site. Concentrations of organic compounds meansured by the USGS were below the U.S. Environmental Protection Agency (EPA) maximum contaminant levels and state of Idaho groundwater primary and secondary constituent standards for these constituents.

Groundwater surveillance monitoring required in area specific Records of Decisions under the *Comprehensive Environmental Response, Compensation, and Liability Act* was performed in 2005. Contaminant concentrations were within expected or historical concentrations. At Test Area North, a 24-month test was initiated to evaluate the effectiveness of the New Pump and Treat Facility in remediation of a portion of the plume of trichloroethylene. Chromium was above the Maximum Contaminant Level (MCL) in two wells at the Reactor Technology Complex. At Idaho Nuclear Technology and Engineering Center, four constituents exceeded their MCLs but concentrations continue to decline over time. Monitoring at the Central Facilities Area landfills detected nitrate and chromium levels above their respective MCLs. At the Radioactive Waste Management Complex, only carbon tetrachloride is reported near and sometimes in excess of the MCL in sampling conducted by the INL contractor.

Semiannual drinking water samples were collected from 14 locations off the INL Site. One sample from Idaho Falls had measurable gross alpha activity. Eight samples had measurable tritium, and 19 samples had detectable gross beta activity. None of the samples exceeded the EPA MCL for these constituents.

A total of 12 offsite surface water samples were collected from five locations along the Snake River. Most of the samples had measurable gross beta activity attributed to natural radioactivity from geologic materials, while only two samples had measurable tritium. Neither of these constituents was above regulatory limits. Detectable gross alpha activity was not found in any sample.

6. ENVIRONMENTAL MONITORING PROGRAMS (GROUNDWATER, DRINKING WATER 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 and surface water samples taken at both onsite and offsite locations. Reported results from sampling conducted by the Idaho Cleanup Project (ICP) contractor; the U.S. Geological Survey (USGS); and the Environmental Surveillance, Education and Research (ESER) contractor are presented here. Results are compared to the state of Idaho groundwater primary and secondary constituent standards (PCS) 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.

Sections 6.1 and 6.2 present discussions of the hydrogeology of the INL Site and hydrogeologic data management, respectively. Section 6.3 describes aquifer studies related to the INL Site and ESRPA. Radiological and nonradiological monitoring of groundwater at the INL Site are discussed in Sections 6.4 and 6.5, respectively. Section 6.6 outlines the CERCLA groundwater activities performed in 2005. Section 6.7 describes offsite drinking and surface water monitoring.

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 River Plain (ESRP). Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2005, USGS personnel collected and analyzed over 1200 samples for radionuclides and inorganic constituents including trace elements and approximately 35 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). 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 are turned over to the Long-Term Stewardship program as an effort to consolidate monitoring activities.

The ESER contractor monitors offsite drinking and surface water. There were 30 drinking water and 12 surface water samples analyzed in 2005.



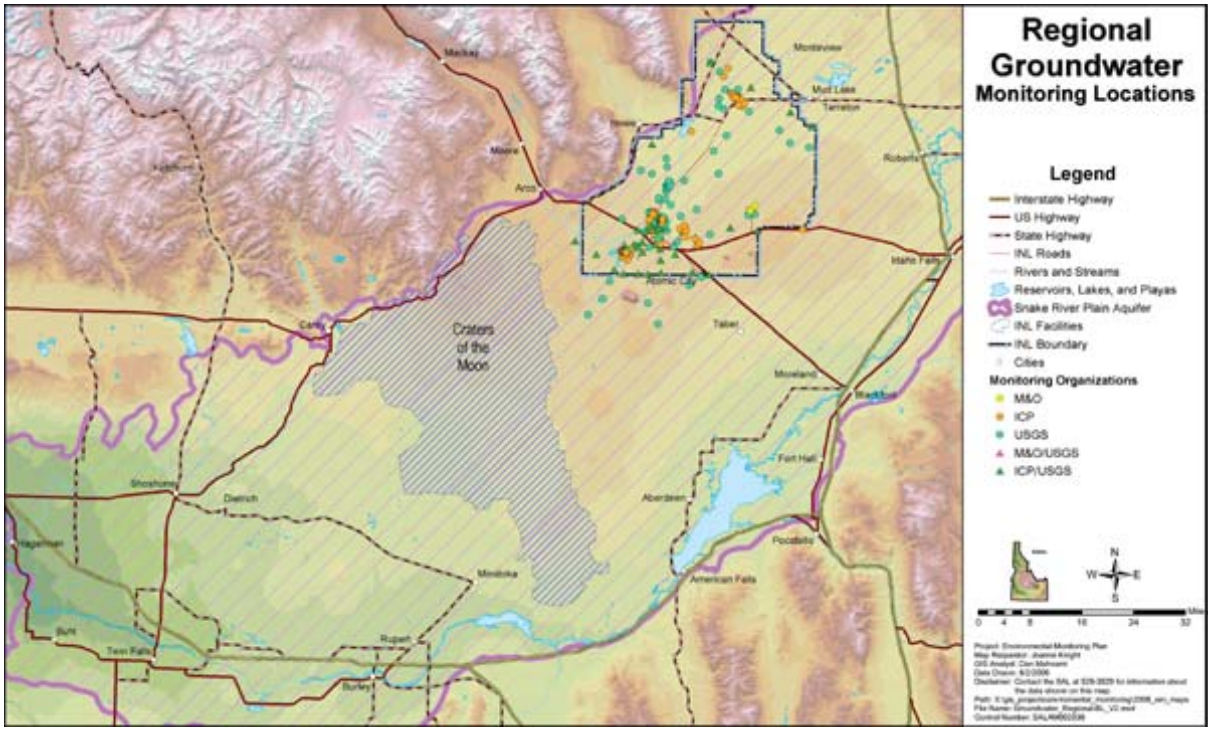

Figure 6-1. Regional Groundwater Monitoring Locations.

Table 6-1 presents the various groundwater and surface water monitoring activities performed on and around the INL Site.

6.1 Hydrogeology

The INL Site occupies 2300 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).



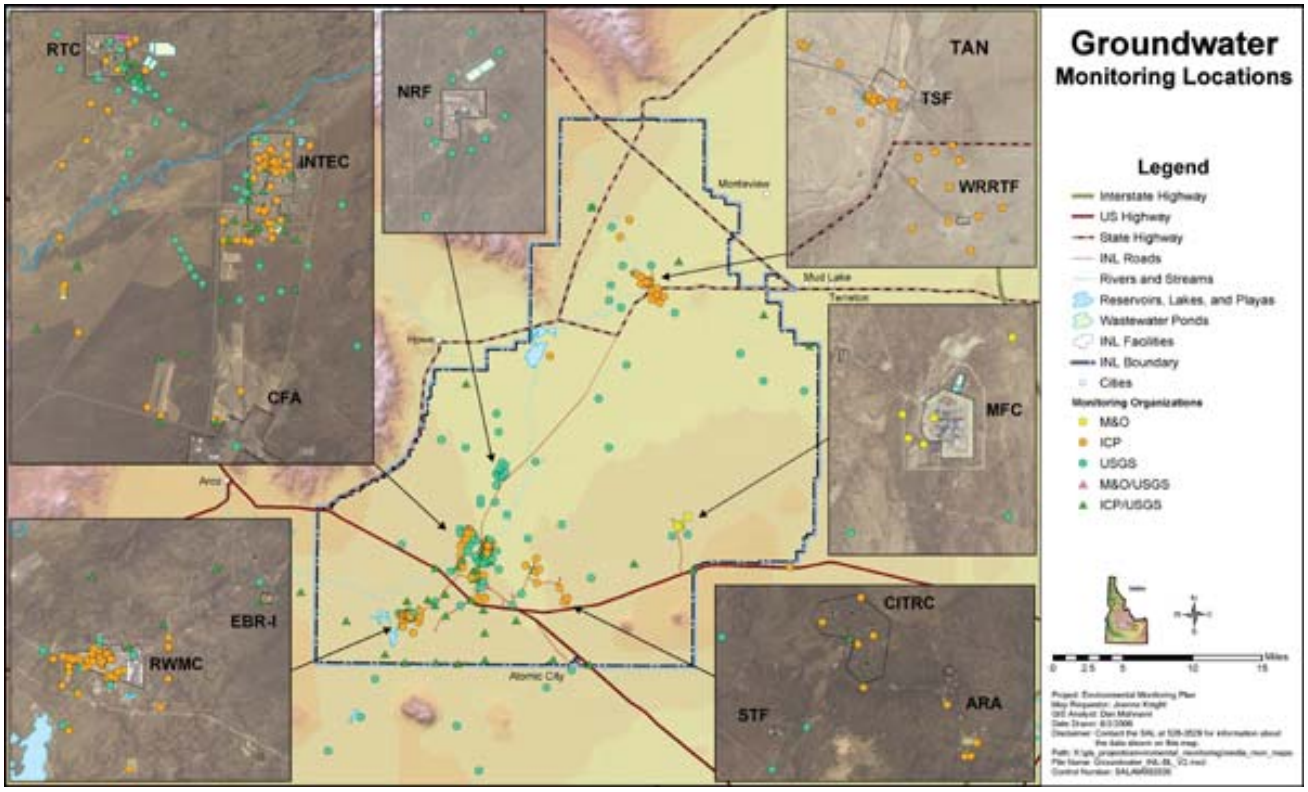

Figure 6-2. INL Site Groundwater Monitoring Locations.

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

The Big Lost Trough receives sediment primarily from Basin and Range fluvial systems of the Big Lost River, Little Lost River, and Birch Creek. The Big Lost trough contains a >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 1.5 to 6.1 m/day (5-20 ft/day). This is much faster than most studied aquifers and is attributed to the ESRP architecture and porous media.



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

	Media			
Area/Facility[a]	**Groundwater (Radiological)**	**Groundwater (Nonradiological)**	**Groundwater (CERCLA)**	**Surface Water**
INL/ICP Contractor				
CFA	•	•	•	•[b]
INTEC	•	•	•	
MFC	•	•	•	•
RTC	•	•	•	•[b]
TAN	•	•	•	•[b]
RWMC	•	•	•	•[b]
PBF/CITR				•[b]
Environmental Surveillance, Education and Research Program				
INL Site/Regional				•
U.S. Geological Survey				
INL Site/Regional	•	•		•[c]

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, IRC = INL Research Center, and NRF = Naval Reactors Facility.

b. See Chapter 5 for details of liquid effluent and storm water monitoring.

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



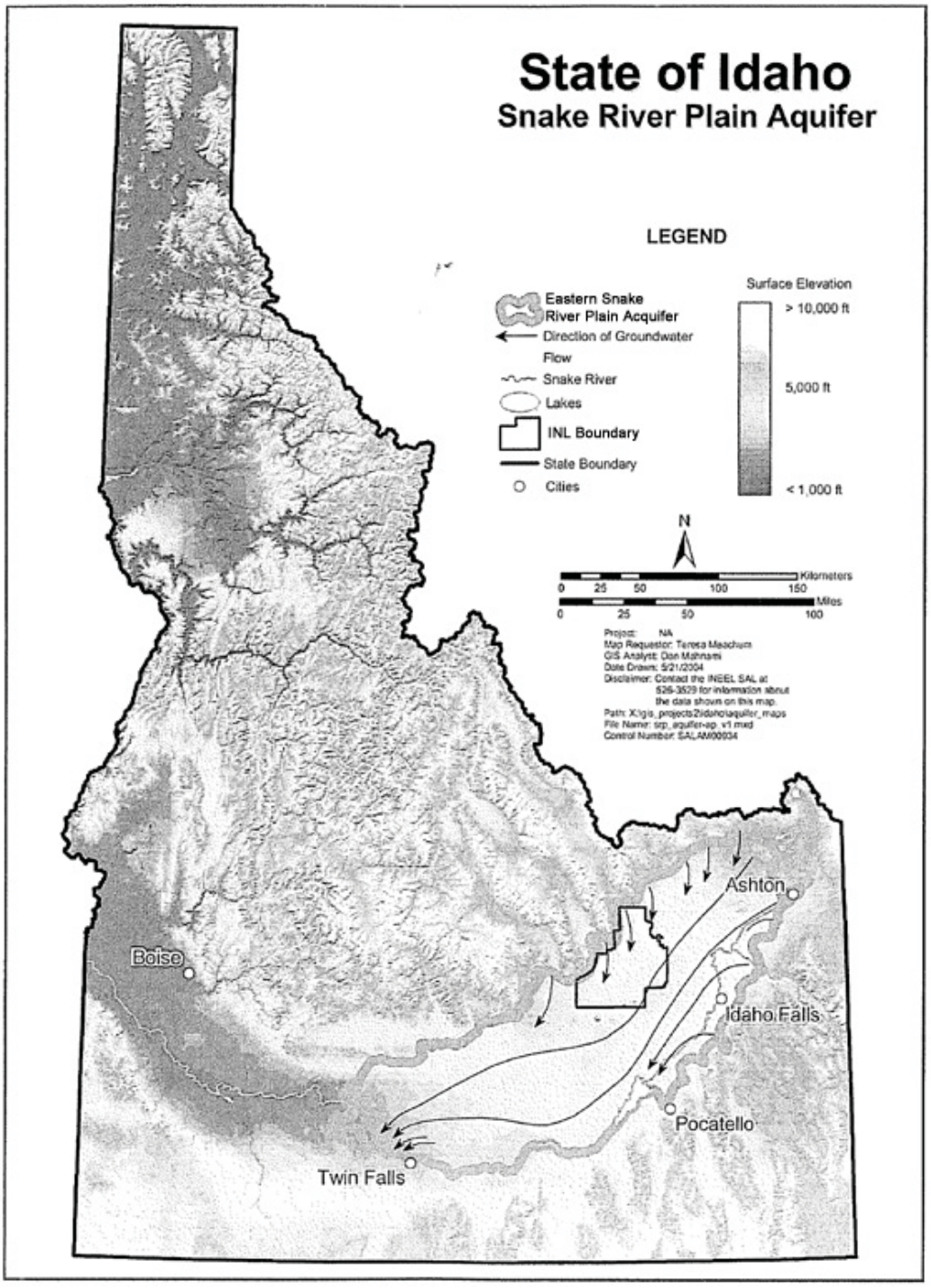

Figure 6-3. Location of the INL Site in Relation to the ESRP Aquifer.



Groundwater is removed from the ESRPA through pumping and as spring flows along the Snake River in the area between Twin Falls and Hagerman. Because of the high flow velocities, travel time from the INL Site to the Snake River through the ESRPA varies from 50 to 100 years.

Beyond the regional controls on flow in the ESRPA, the hydrogeology of the INL Site is controlled locally by surface water flows in the Big Lost River. Periods of high flow in the river have been shown to create temporary shifts in the local flow direction from northeast-southwest to north-south. The effect of these local changes has been to spread contamination related to INL Site operations over a larger area than would be expected. Other impacts of INL Site operations to the subsurface hydrogeology have been the formation of numerous perched water zones beneath waste ponds as a result of the seepage of pond water into the soils and the introduction of contaminants both directly (through injection) and indirectly (through vertical movement of water beneath ponds) to the ESRPA.

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site has been collected by a number of organizations, including the USGS, the ICP contractor, and other site contractors. 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, 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. Information from the HDR is available by request. A web site is being constructed that will allow open access to much of this information.

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 utilizes the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory.



6.3 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 these publications can be requested from the USGS INL Project Office by calling 208-526-2438. During 2005, personnel of the USGS INL Project Office published eight documents covering hydrogeologic conditions at the INL Site, on the ESRP, and in other areas of interest around the world. The abstracts to each of these reports are presented in Appendix C.

6.4 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. This wastewater contained high concentrations of both tritium and strontium-90 (^{90}Sr) and iodine-129 (^{129}I). Injection at the INTEC was discontinued in 1984 and the injection well sealed in 1990. When direct injection ceased, wastewater from INTEC was directed to a pair of 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 has 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 between 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 about 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 about 0.03 Ci of ^{90}Sr to the INTEC infiltration ponds (Bartholomay et al. 2000).

Presently, only ^{90}Sr continues to be detected by the ICP contractor 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 (2001), are shown in Figure 6-4 (Davis 2006). 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 (Well 65) and INTEC (Well 77) (see Figure 6-2) 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 Well 65 near RTC decreased from $(8.3 \pm 0.6) \times 10^3$ pCi/L in 2004 to $(7.2 \pm 0.3) \times 10^3$ pCi/L in 2005; the tritium concentration in Well 77 south of INTEC also showed a decrease, from $(12.9 \pm 1.2) \times 10^3$ pCi/L in 2004 to $(11.5 \pm 0.6) \times 10^3$ pCi/L in 2005.

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 Well 65 and Well 77 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, advective dispersion, 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 2006). The contamination originates from INTEC as a remnant of the earlier injection of wastewater. No ^{90}Sr in groundwater was detected in the vicinity of RTC during 2005. 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, 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.

Mean concentrations of ^{90}Sr in INL Site monitoring wells have remained at about the same concentrations since 1989. The annual average concentration in Well 65 at RTC was about the same in 2004 (1.0 ± 2.0 pCi/L) as in 2005 (1.0 ± 0.6 pCi/L). Concentrations in Well 77 south of INTEC decreased from 1.8 ± 0.4 pCi/L in 2004 to 0.6 ± 0.9 pCi/L in 2005. The PCS and MCL for ^{90}Sr in drinking water is 8 pCi/L.

The trend of ^{90}Sr over the past ten years in Wells 65 and 77 is shown in Figure 6-7. No clear trends are seen in the data with one (Well 65) increasing and the other (Well 77) decreasing; moreover, the statistical fit is weak. 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



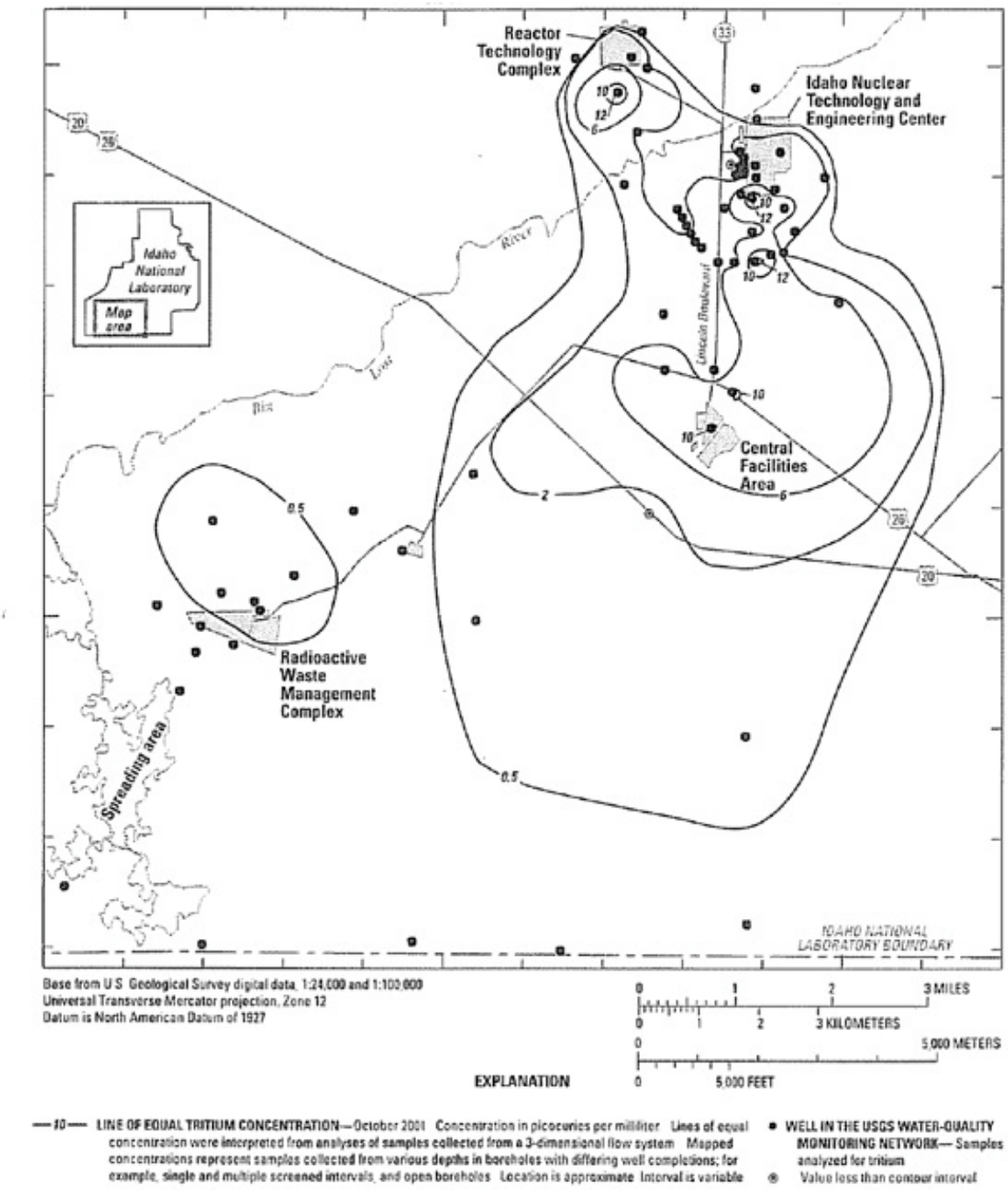

Figure 6-4. Distribution of Tritium in the Snake River Plain Aquifer on the INL Site (2001) (Davis 2006).



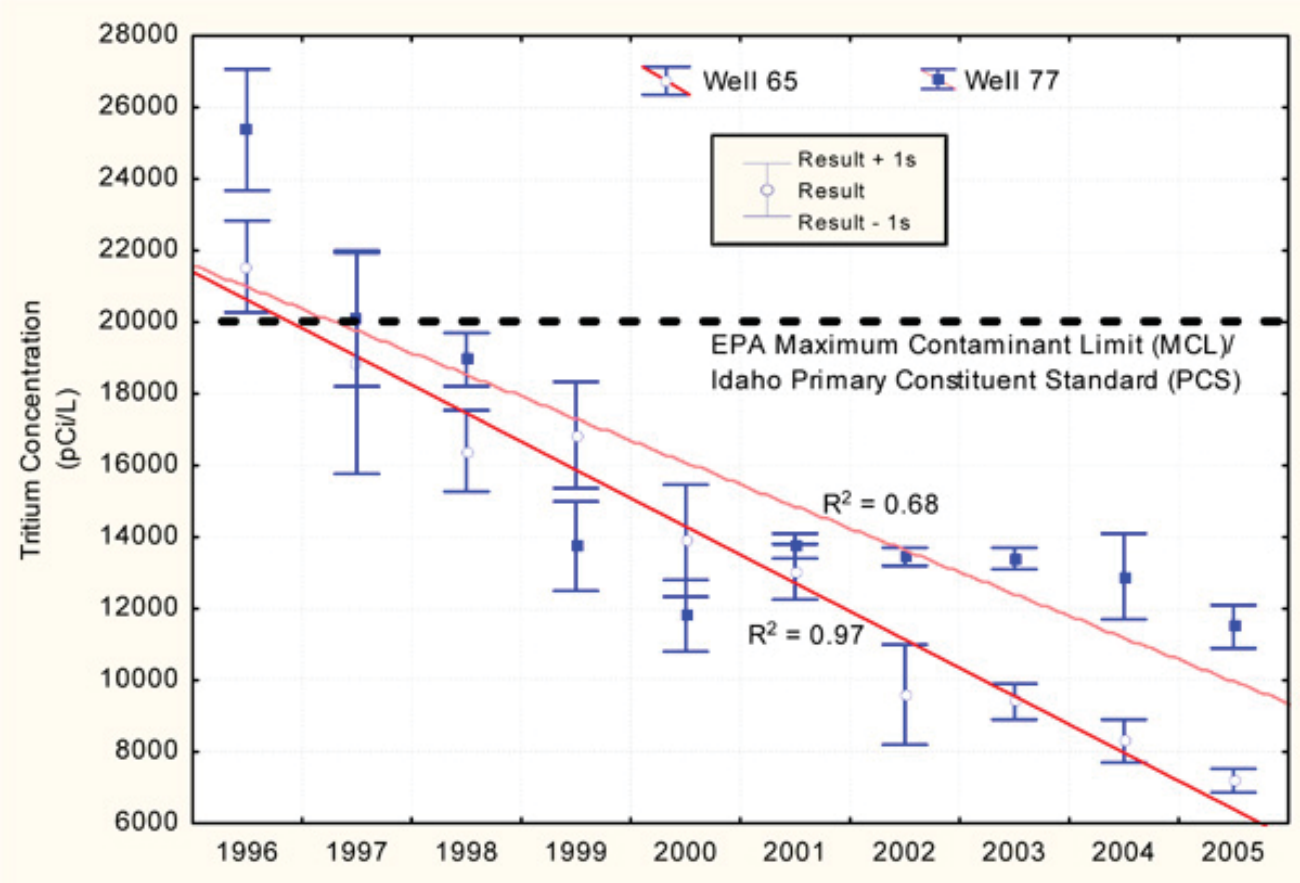

Figure 6-5. Long Term Trend of Tritium in USGS Wells 65 and 77 (1996-2005).

changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000).

6.5 Nonradiological Groundwater Monitoring

U.S. Geological Survey

Sampling for purgeable (volatile) organic compounds in groundwater was conducted by the USGS at the INL Site during 2005. Water samples from an onsite production well and five groundwater monitoring wells were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 28 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996,



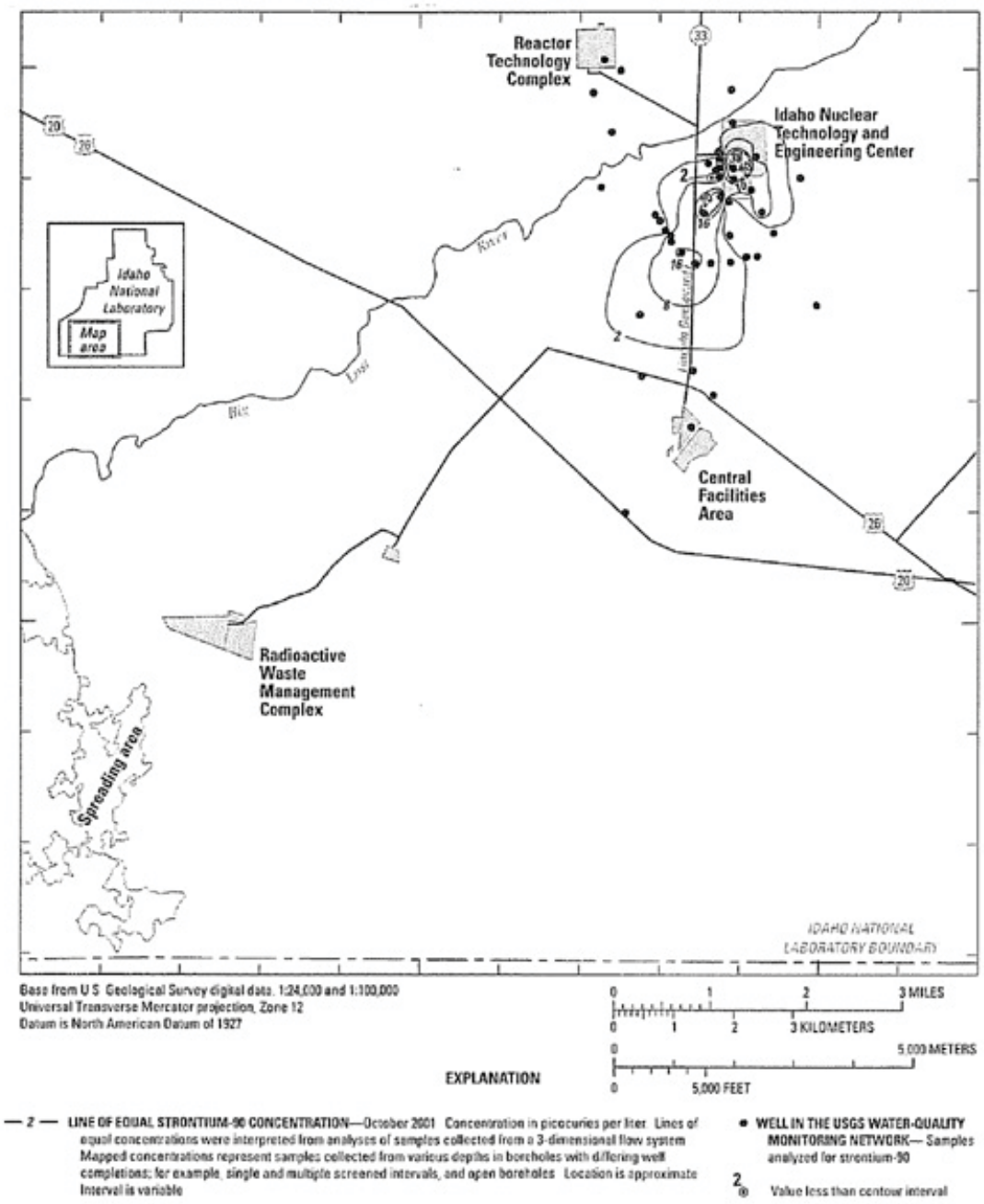

Figure 6-6. Distribution of ^{90}Sr in the Snake River Plain Aquifer on the INL Site (2001) (Davis 2006).



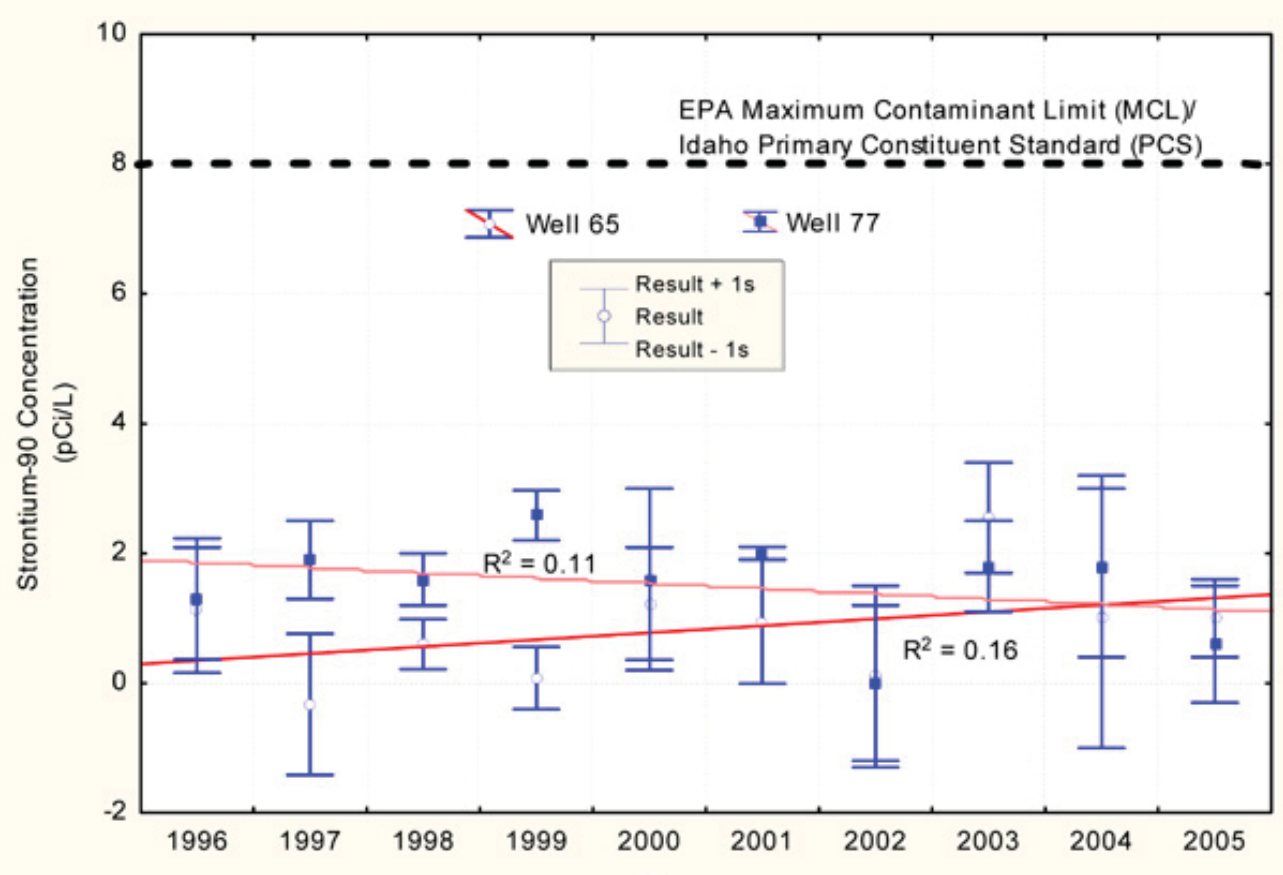

Figure 6-7. Long Term Trend of ^{90}Sr in USGS Wells 65 and 77 (1996-2005).

Bartholomay et al. 2003). Eleven 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). None of the measured constituents were above their respective PCS.

The RWMC production well contained detectable concentrations of nine of these purgeable organic compounds. Annual average concentrations of these compounds in this well remained essentially unchanged from those observed in 2004; however, the 2005 average concentration for trichloroethene (2.97 µg/L) was slightly above the average concentration of 2004 (2.66 µg/L).



Table 6-2. Concentrations of Purgeable Organic Compounds in USGS Well Samples (2005).[a]

Well ID	Date	Bromodichloromethane	Dibromochloromethane	Dichlorodifluoromethane	1,1-Dichloroethene	Tetrachloroethene	Tetrachloromethane	Tribromomethane	1,1,1-Trichloroethane	Trichloroethene	Trichloromethane	Xylenes
38 (SW of INTEC)	04/06	ND[b]	ND	ND	ND	ND	ND	ND[c]	0.11	ND	ND	ND
65 (S of RTC)	04/14	ND	ND	ND	ND	ND	ND	ND	0.14	ND	ND	ND
77 (S of RTC)	10/11	ND	ND	0.14[d]	0.17	ND	ND	ND	0.20	ND	ND	ND
87 (N of RWMC)	04/14	ND	ND	0.99	ND	ND	2.78	ND	0.16	0.56	0.15	ND
88 (S of RWMC)	10/04	ND	ND	ND	ND	ND	0.69	ND	ND	0.42	0.42	ND
RWMC PROD	01/13	ND	ND	ND	ND	0.23	5.36	ND	0.45	2.67	1.25	ND
	02/10	ND	ND	ND	ND	0.22	5.54	ND	0.49	2.56	1.25	ND
	03/10	ND	ND	ND	ND	0.27	5.80	ND	0.50	2.57	1.15	ND
	04/14	ND	ND	ND	ND	0.25	5.41	ND	0.45	2.55	1.28	ND
	05/12	ND	ND	ND	ND	0.33	8.72	ND	0.67	4.04	1.83	ND
	06/09	0.16	0.39	ND	ND	0.21	4.75	0.91	0.40	2.41	1.33	ND
	07/14	ND	ND	ND	ND	0.24	5.21	ND	0.42	2.57	1.04	ND
	08/11	ND	ND	ND	ND	0.28	6.29	ND	0.50	2.92	1.42	ND
	09/15	ND	ND	ND	ND	0.30	7.76	0.40	0.59	3.49	1.65	ND
	10/13	ND	ND	ND	ND	0.31	6.73	0.20	0.56	3.44	1.64	ND
	11/09	ND	0.23	ND	ND	0.30	6.28	0.39	0.55	3.25	1.58	ND
	12/08	0.33	0.73	ND	ND	0.28	6.25	1.64	0.52	3.16	1.67	0.20
PCS[e]					**7.0[f]**	**5.0[g]**			**200**	**5[h]**		**10**

a. All values are in micrograms per Liter (µg/L).
b. ND = Not Detected.
c. Not Detect value for tribromomethane is 0.2 µg/L for all samples.
d. Values for dichloro-difluoromethane are laboratory estimates.
e. PCS = Primary constituent standard values from IDAPA 58.01.11.
f. Value is for the related compound 1,1- dichloroethylene.
g. Value is for the related compound tetrachloroethylene.
h. Value is for the related compound trichloroethylene.

6.6 Summary of CERCLA Groundwater Monitoring Activities for Calendar Year 2005

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

Summary of WAG 1 Groundwater Monitoring Results

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 2005 included periodic whey injections, groundwater sampling and analysis, well maintenance, and minor construction activities. Groundwater samples were collected monthly from 18 sampling 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-192).

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 reinjection 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 1, 2005, the New Pump and Treat Facility (NPTF) was placed into standby mode to conduct a 24-month medial zone rebound test. The purpose of this test is to evaluate the effectiveness of the NPTF in remediating the medial zone of the plume. A performance monitoring strategy has been implemented to assess the degree of rebound in trichloroethene (TCE) concentrations while the NPTF is in standby mode. The test will be dynamic in the sense that data analysis and interpretation following each sampling event will be used to determine if the NPTF needs to be re-started to treat TCE concentrations that have reached a pre-determined restart concentration criteria before the end of the 24-month test. Based on modeling, the rebound test will not have an adverse effect on the on-going remedial action. The NPTF will resume operations no later than March 1, 2007 (ICP 2005a).

Distal Zone (TCE concentrations between 5 and 1000 μg/L) – Monitored natural attenuation (MNA) is the treatment for the distal zone of the plume. MNA is the sum of the physical, chemical,



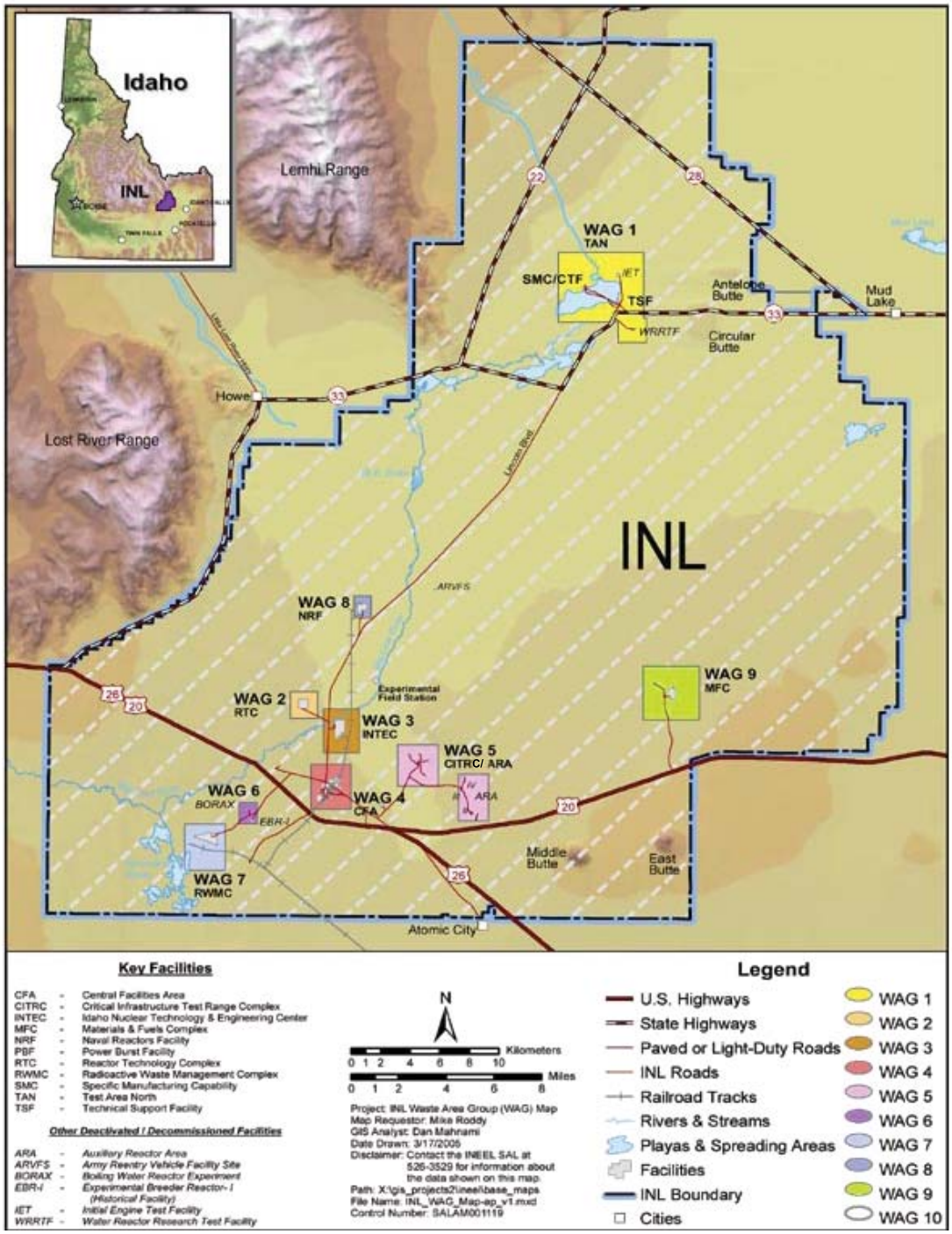

Figure 6-8. Map of the INL Showing Locations of the Facilities and Corresponding WAGs.



and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Engineering and administrative controls are in place to protect current and future users from health risks associated with groundwater contamination. During the early part of the restoration time frame, the contaminant plume may continue to increase slowly in size until the natural attenuation process overtakes it.

The primary MNA activities performed during 2005 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 2005 indicates that the natural attenuation mechanisms, as defined in the MNA Remedial Action Work Plan for the radionuclides tritium, Cesium-137 (^{137}Cs), ^{90}Sr, Uranium-234 (^{234}U), continue to be functional within the contaminant plume (DOE-ID 2003a). Future groundwater monitoring, as outlined in the MNA Operations, Monitoring, and Maintenance Plan, will be sufficient to track the progress of the MNA remedy for radionuclides at Test Area North Operable Unit (OU) 1-07B (RPT-199).

Summary of WAG 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for WAG-2 during calendar year 2005. The locations of the wells are shown on Figure 6-9, except for Highway 3 well (a public access potable water well), which is shown on the figure for WAG 10 sampling locations. Six of the wells were sampled in both March and October of 2005, while Middle-1823 was only sampled in October 2005. Aquifer samples were analyzed for chromium (filtered and unfiltered), ^{90}Sr, gamma-emitting radionuclides and tritium. The data for the March 2005 sampling event can be found in the Fiscal Year 2005 Annual Report for WAG 2 (ICP 2005b) and the data for the October 2005 sampling will be in the Fiscal Year 2006 annual report for WAG 2 (not yet published). The data for the March 2005 and October 2005 sampling events are summarized in Table 6-3. Chromium was the only constituent detected above its MCL. Chromium concentrations in wells TRA-07 and USGS-065 were greater than the 100 µg/L MCL in at least one sampling event, with a maximum filtered concentration of 136 µg/L in TRA-07 (Figure 6-9). Except for the Highway-3 well, chromium concentrations were above background at all other aquifer wells sampled in WAG 2. Chromium concentrations are declining in both USGS-065 and TRA-07.

Summary of WAG 3 Groundwater Monitoring Results

Groundwater samples (aquifer) were collected from 22 wells under CERCLA at WAG 3 in April 2005 (DOE-ID 2006a). Groundwater samples were analyzed for tritium, ^{90}Sr, ^{129}I, uranium isotopes, plutonium isotopes, Americium-241 (^{241}Am), mercury, gamma-emitting radionuclides, Neptunium-237 (^{237}Np), Technetium-99 (^{99}Tc), and gross alpha/beta activities. The sampling results are summarized in Table 6-4.



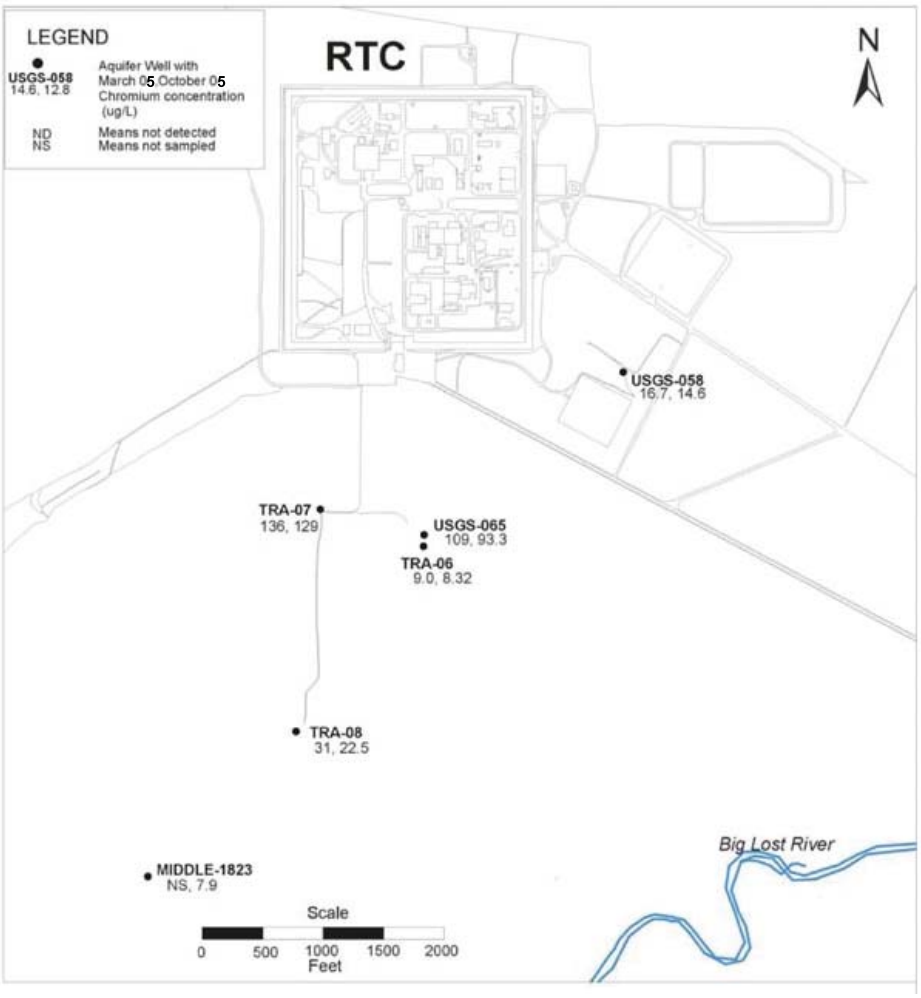

Figure 6-9. Location of WAG 2 Monitoring Wells and Chromium Concentrations for 2005. (Note: Highway 3 Well not Shown on this Map.)

Groundwater monitoring results for 2005 confirm previous observations that the concentrations of most radionuclides in groundwater continue to decline over time. During 2005, ^{90}Sr, ^{99}Tc, ^{129}I, and nitrate exceeded their respective drinking water MCLs in one or more of the monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. The ^{90}Sr concentrations remain above the MCL (8 pCi/L) at 9 of the 22 monitoring wells sampled in 2005, but ^{90}Sr levels have declined at most locations during 2001–2005.

Strontium-90 concentrations are above the MCL (8 pCi/L) at ten monitoring wells sampled in 2005 for ^{90}Sr (Figure 6-10). However ^{90}Sr levels have declined at most locations from the concentrations that were observed in 2001 and 2003. Although ^{90}Sr was above its maximum contaminant level of 8



Table 6-3. WAG 2 Groundwater Quality Summary for March and October 2005 Sampling Events.

Analyte	Background[a]	Maximum	Number of Wells with Detections above MCL	MCL
Strontium-90	<1	7,280[b]	2	8 pCi/L
Chromium Filtered	2 to 3	132	2	100 µg/l
Chromium (unfiltered)		193	2	100 µg/l
Tritium	75 to 150	17,100	0	20,000 pCi/L

a. Background concentrations are from Knobel, Orr, and Cecil (1992).
b. The high Sr-90 concentration is suspect since Sr-90 was below detection limits in previous samples from this well and another well above the MCL showed a non-detect after being re-sampled.

pCi/L in several wells near INTEC, it was below its maximum contaminant level in the downgradient direction in a well at the CFA landfills (Figure 6-10).

In 2005, only one well exceeded the ^{129}I MCL of 1 pCi/L (USGS-47; 1.23 pCi/L). During the previous two years (2003 and 2004), none of the INTEC aquifer wells exceeded the ^{129}I MCL. Since 2001, it appears that ^{129}I concentrations have increased slightly in several wells, but trends are inconclusive. Tritium concentrations have been below the MCL in all wells sampled during 2003–2005 and continue to decline in trend.

Technetium-99 was detected above the MCL (900 pCi/L) in two wells, ICPP-MON-A-230 and ICPP-2021, within INTEC, but concentrations were below the MCL at all other locations. The occurrence of elevated ^{99}Tc in groundwater is believed to be the result of past leaks from underground pipelines and valve boxes at the INTEC tank farm.

Cesium-137 was present in a groundwater sample (10.9 pCi/L) from a monitoring well near the former injection well, but the concentration was far below the MCL of 200 pCi/L.

Plutonium-239/240 was reported in groundwater samples from the USGS-42 (0.045J pCi/L) and USGS-67 (0.0428J pCi/L) wells. These concentrations were below the MCL (15 pCi/L). Plutonium-241 was detected in just one well (USGS-48; 20.6 pCi/L). This concentration was below the derived MCL (300 pCi/L). Americium-241 was not detected in any of the samples, and ^{237}Np was only detected in a single well at a concentration close to the detection limit. Neither ^{237}Np nor ^{241}Am was detected in any of the groundwater samples collected during 2005.

Uranium-238 was detected in groundwater at all sampling locations; however, with the possible exception of the ICPP-MON-A-230 well, the reported concentrations of ^{238}U are generally consistent with background concentrations reported for total uranium in the ESRPA elsewhere. Uranium-233/234 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 was detected in groundwater from 8 of the 22 wells, but concentrations were similar in upgradient and downgradient wells.



Table 6-4. Comparison of WAG 3 2005 Sampling Results in the ESRPA to Regulatory Levels.

Analyte	Units	Maximum Detected Value	MCL or SMCL[a]	Number of Wells With Detections Above MCL or SMCL
Radionuclides				
Gross Beta	pCi/L	649	NA	NA
Gross Alpha	pCi/L	4.02	15	0
Iodine-129	pCi/L	1.23	1	1
Technetium-99	pCi/L	2,900	900	2
Strontium-90	pCi/L	35.3	8	9
Tritium	pCi/L	8740	20000	0
Cs-137	pCi/L	10.9	200	0
Amercium-241	pCi/L	ND	15	0
Neptunium-237	pCi/L	ND	15	0
Plutonium-238	pCi/L	ND	15	0
Plutonium-239/240	pCi/L	0.045	15	0
Plutonium-241	pCi/L	8.58	300	0
Uranium-233/234	pCi/L	2.46	15	0
Uranium-235	pCi/L	0.201	15	0
Uranium-238	pCi/L	1.25	15	0
Anions				
Alkalinity-bicarbonate	mg/L	191	None	NA
Chloride	mg/L	153	*250*	0
Fluoride	mg/L	0.371	*2*	0
Nitrate/nitrite	mg-N/L	13.2	10	1
Sulfate	mg/L	40.8	*250*	0
Inorganic Analytes				
Calcium	mg/L	73,200	None	NA
Magnesium	mg/L	26,200	None	NA
Potassium	mg/L	5,460	None	NA
Sodium	mg/L	41,500	None	NA
Mercury	mg/L	0.149	2	0

a. Numbers in italics are for the SMCL.
NA = not applicable.
ND = not detected.

Dissolved mercury was detected at a single location in the groundwater sample from the USGS-47 well (0.077 µg/L), which is below the MCL of 2 µg/L. The detection of mercury in groundwater samples from USGS-47 is consistent with the presence of mercury in the service waste previously discharged to the former injection well located about 750 ft upgradient of this well.

Nitrate was detected in all of the wells sampled during 2005. The highest concentrations were reported at the ICPP-2021 new aquifer well (13.2 mg/L as N), ICPP-MON-A-230 (7.7 mg/L), and MW-18-4 (7.3 mg/L). All of these wells are located relatively close to the tank farm, and all show



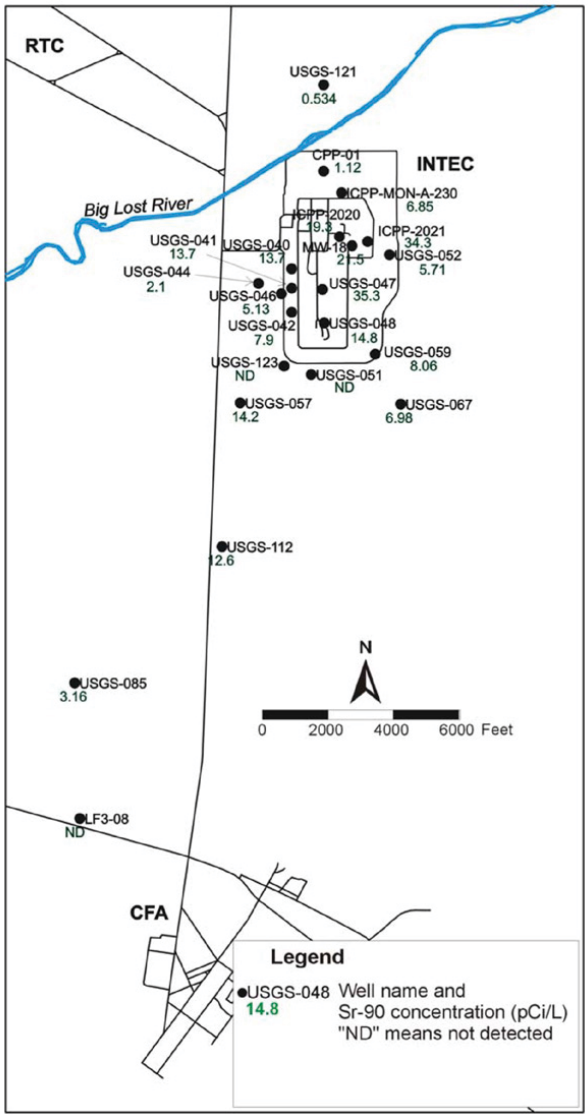

Figure 6-10. WAG 3 Locations of Wells Sampled and Distributed of ^{90}Sr (pCi/L) in the ESRPA in April 2005.

groundwater quality impacts attributed to past tank farm liquid waste releases. The nitrate-nitrogen at ICPP-2021 slightly exceeds the MCL for nitrate-nitrogen of 10 mg/L (as N).

Gross beta results generally mirrored the results for ^{90}Sr and ^{99}Tc. Gross alpha activity in groundwater samples were all below the MCL.

Depth-specific groundwater samples were collected, using a packer-isolation method, from monitoring wells USGS-041, USGS-044, USGS-046, USGS-047, USGS-048, USGS-52 and USGS-



059 to investigate variations in groundwater quality with depth in the aquifer. The results generally show that concentrations of the principal radionuclides decrease with depth below the water table, with the highest concentrations of ^{90}Sr, ^{99}Tc, ^{129}I, and tritium observed at the USGS-47 well, which is located approximately 229 m (750 ft) downgradient of the former injection well. None of the packer samples exceeded the 5 pCi/L ^{129}I action level established in the Explanation of Significant Differences (DOE-ID 2004a), and none of the packer samples collected below the HI sedimentary interbed exceeded the 1 pCi/L ^{129}I MCL.

Summary of WAG 4 Groundwater Monitoring Results

Groundwater monitoring for the CFA landfills consisted of sampling nine wells for volatile organic compounds, metals, and anions in October 2005. Because of falling water levels in the aquifer, only nine of the thirteen wells WAG 4 wells had sufficient water for sampling. Groundwater samples were not collected from LF2-08, LF2-09, LF2-11 and LF3-10. The locations of the CFA monitoring wells are shown on Figure 6-11. Analytes detected in groundwater are compared to regulatory levels in Table 6-5. A full description of the groundwater sampling and results is contained in (RPT-196).

Nitrate and chromium are the only constituents found to exceed their groundwater MCLs during the 2005 CFA landfill monitoring effort. Nitrate exceeded its MCL in two wells, CFA-MON-A-002 and CFA-MON-A-003. Although nitrate concentrations increased in CFA-MON-A-003 in the 2005 sampling event, nitrate concentrations in CFA-MON-A-002 and -003 had been relatively consistent since monitoring started in 1995. The occurrence of chromium above its MCL in LF3-09 could be due to suspended soil or rock particles in the unfiltered sample.

Groundwater gradients and groundwater 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

Groundwater monitoring for WAG 5 in 2005 was completed in November–December 2005 in accordance with the WAG 5 ROD (DOE-ID 2000), the Groundwater Monitoring Plan (DOE-ID 2004b) and recommendations from the first 5-year review (DOE-ID 2005). Eight of nine wells were sampled with only well ARA-MON-A-002 not being sampled due to malfunctioning equipment. The locations of the WAG 5 wells are shown on Figure 6-12. Three wells were sampled for volatile organic compounds and eight wells were sampled for select metals. Specific metals requested included arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver and zinc. The results are summarized below and on Table 6-6. The complete listing of results can be found in RPT-220. Overall, most analyte concentrations appear to be consistent with historical results and do not indicate the influence of contaminants from the surface of the Auxiliary Reactor Area (ARA) or Critical Infrastructure Test Range Complex (CITRC) areas.



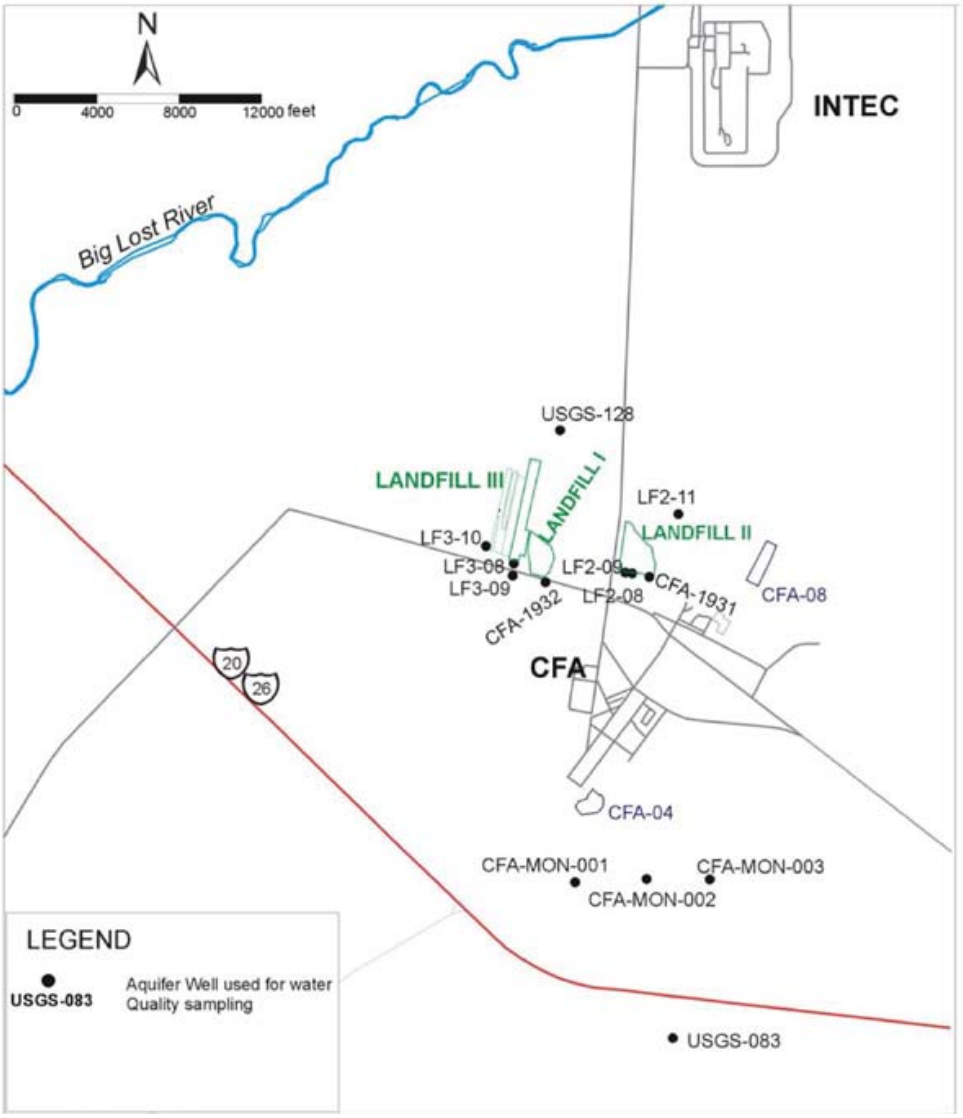

Figure 6-11. Location of WAG 4/CFA Monitoring Wells for 2005.

All constituents analyzed from the groundwater samples collected during the November–December 2005 sampling event were below MCLs. Lead concentrations, which had been above the action level for lead in several wells in the past, were all below the action level in November–December 2005. The 2005 sampling event represents the fourth consecutive year that the lead concentrations have not exceeded the action level. Replacement of galvanized pipe with stainless steel pipe appears to have removed the source of the lead.



Table 6-5. Comparison of 2005 WAG 4 Results to Regulatory Levels.

Compound	Units	Maximum Detected Value	MCL or SMCL[a]	Number of Wells With Detections Above MCL or SMCL
Anions				
Alkalinity-bicarbonate	mg/L	141	None	NA
Chloride	mg/L	146	*250*	0
Fluoride	mg/L	0.274	*2*	0
Nitrate/nitrite	mg-N/L	24	10	2
Sulfate	mg/L	37.9	*250*	0
Organic Analytes				
Toluene	µg/L	3.2	1,000	0
Chloroform	µg/L	0.73	100	0
Inorganic Analytes				
Arsenic	µg/L	5.4	50/10[b]	0
Barium	µg/L	91.5	2,000	0
Beryllium	µg/L	ND	4	0
Cadmium	µg/L	ND	5	0
Chromium	µg/L	176	100	1
Copper	µg/L	14.2	1,300/*1,000*	0
Lead	µg/L	4.2	15[c]	0
Mercury	µg/L	0.05	2	0
Nickel	µg/L	775	None	NA
Selenium	µg/L	ND	50	0
Vanadium	µg/L	12.1	None	NA
Zinc	µg/L	551	*5,000*	0

a. Numbers in italics are for the SMCL.
b. The proposed new MCL for arsenic is 10 µg/L.
c. The action level for lead is 15 µg/L.
NA = not applicable.
ND = not detected.

Summary of WAG 7 Groundwater Monitoring Results

Fifteen aquifer-monitoring wells were sampled semiannually under operable unit (OU) 7-13/14 and analyzed for a variety of radionuclide, inorganic, and organic contaminants (RPT-171). In addition to the wells monitored by OU 7-13/14, the USGS routinely samples eight wells in the vicinity of the RWMC. The location of the aquifer monitoring wells sampled at the RWMC are shown on Figure 6-13.

In the aquifer near the RWMC, carbon tetrachloride was the only analyte consistently detected at concentrations near and occasionally exceeding the primary drinking water MCL in Fiscal Year 2005



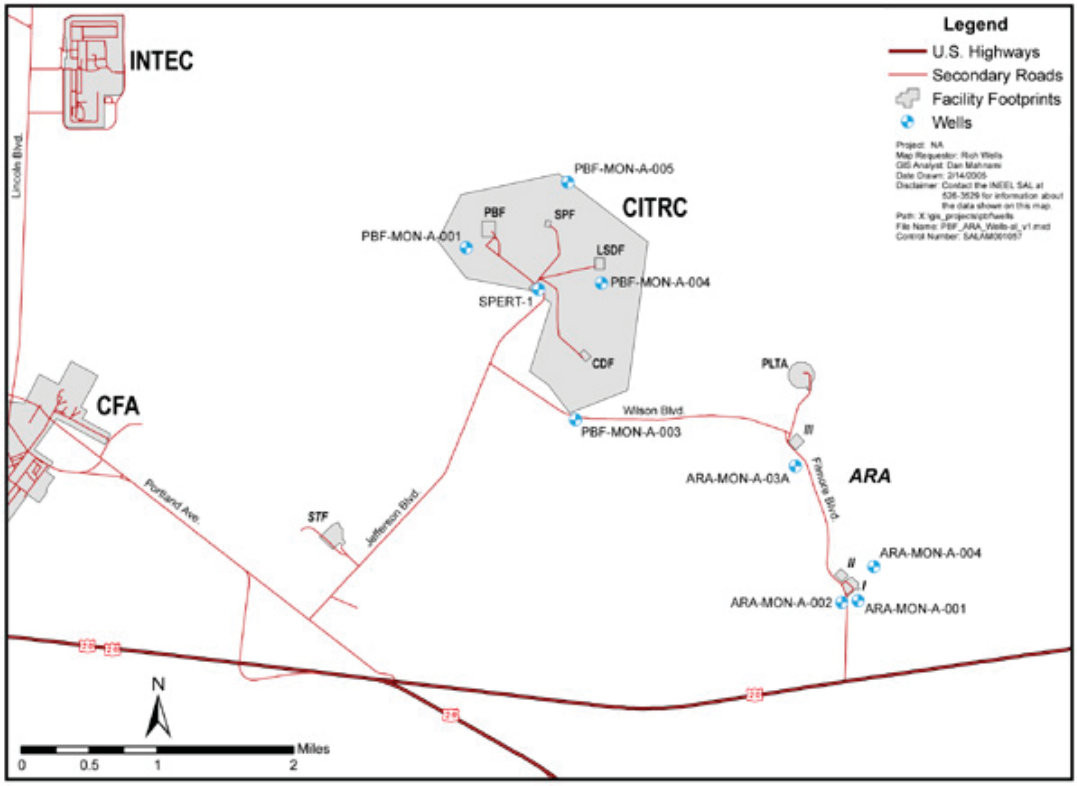

Figure 6-12. Wells Sampled for WAG 5.

(Table 6-7). Trichloroethene was also detected, but it occurred at concentrations less than its MCL. Tritium was consistently detected in the aquifer north of the RWMC; however, concentrations are substantially below the drinking water MCL. The source of the small, isolated tritium plume in the aquifer at the RWMC has been identified as being from upgradient facilities, primarily INTEC, and not from the SDA.

Summary of WAG 9 Groundwater Monitoring Results

MFC samples five wells (four monitoring and one production) (Figure 6-14) 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 (ANL-W, 1998). The analytical results for 2005 are summarized in Table 6-8.

Summary of WAG 10 Groundwater Monitoring Results

The groundwater sampling for WAG 10 consisted of sampling 27 wells in June-July, 2005. The wells were sampled for volatile organic compounds (target analyte list), metals (filtered), anions (including alkalinity), and radionuclides (^{129}I, tritium, ^{99}Tc, gross alpha, gross beta, gamma-emitting



Table 6-6. Comparison of Detected Analytes at WAG 5 with MCLs/SMCLs (2005).

Analyte	Background[a]	Maximum	Number of Wells with Detections above MCL	MCL or SMCL[b]
Inorganics				
Arsenic (µg/L)	2 to 3	2.3	0	50[c]
Barium (µg/L)	50 to 70	93.5	0	2,000
Chromium (µg/L)	2 to 3	25.6	0	100
Cadmium (µg/L)	<1	0.26	0	5
Lead (µg/L)	1 to 5	11.6	0	15[d]
Selenium (µg/L)	<1	1.7	0	50
Silver (µg/L)	<1	ND	0	100
Zinc (µg/L)	10.5 to 54	1120	0	*5,000*
Organics				
Trichloroethene (µg/L)	—[e]	0.16	0	5

a. Background concentrations are from Knobel, Orr, and Cecil (1992).
b. Numbers in italics are for the SMCL.
c. As of 1/23/06, the MCL for arsenic will be 10 µg/L.
d. Concentration represents the EPA-defined action level for this contaminant.
e. Volatile organic compounds are considered to be absent from background.
ND = not detected

radionuclides, uranium-isotopes, and ^{90}Sr). The locations of the wells are shown in Figure 6-15. The results are summarized on Table 6-9 and briefly described below. The complete results can be found in the WAG 10 RI/FS Annual Report (DOE-ID, 2006b).

Detected VOCs include toluene and acetone. Toluene was detected in seven wells at concentrations ranging from 0.18 to 18 µg/L. Toluene detections are notably beneath the MCL of 1000 µg/L.

Lead and antimony were reported above their respective MCLs in the duplicate sample from USGS-027, but both metals were considerably below their respective MCLs in the original sample from this well. All other metals were below there respective MCLs. Nitrate continues to be elevated in USGS-004 relative to other WAG 10 wells and probably represents off-site agricultural influences upgradient of the INL Site. Off-site influence was also indicated by elevated specific conductivity values for USGS-004 and USGS-027.

Tritium, gross alpha, gross beta, uranium isotopes were the primary radiological analytes detected. Gross alpha, gross beta, and uranium isotopes were at background concentrations. Tritium was detected in two wells south of CFA at concentrations less than 1000 pCi/L or well below the MCL of 20,000 pCi/L.



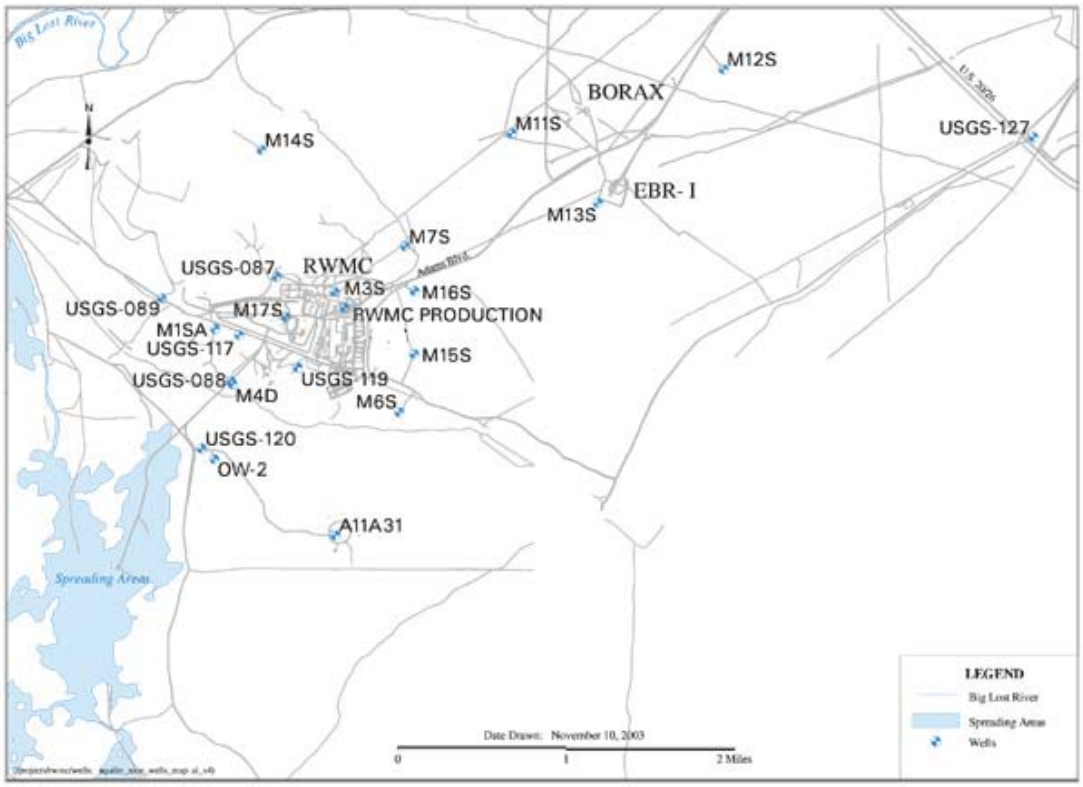

Figure 6-13. Locations of Aquifer-Monitoring Wells at RWMC WAG 7.

6.7 Offsite Water Sampling

Offsite Drinking Water Sampling

As part of the offsite monitoring performed by the ESER contractor, radiological analyses are performed on drinking water samples taken at offsite locations. In 2005, the ESER contractor collected 30 drinking water samples from 14 offsite locations.

Gross alpha activity was detected in one sample from Idaho Falls in May. The measured concentration of 7.84 ± 1.45 pCi/L was below the EPA MCL of 15 pCi/L.

As in years past, measurable gross beta activity was present in most offsite drinking water samples (19 of the 30 samples). Detectable concentrations ranged from 2.62 ± 0.86 pCi/L to 13.50 ± 1.15 pCi/L (Table 6-10). The upper value of this range is appreciably below the EPA screening level for drinking water of 50 pCi/L. Concentrations in this range are normal and cannot be differentiated from the natural decay products of thorium and uranium that dissolve into water as the water passes through the basalt terrain of the Snake River Plain.



Table 6-7. Comparison of Analytes Detected in Samples from the ESRPA at WAG 7 with MCLs (2005).

Relevant Analyte	Number Monitoring Wells Sampled	Number of Detections	Maximum Concentration (pCi/L ± 1σ) unless otherwise noted	Wells with Detections >MCL
Am-241	15	0	NA	0
C-14	15	0	NA	0
Cl-36	15	0	NA	0
Cs-137	15	0	NA	0
H-3	15	19	1,440 ± 91	0
I-129	15	0	NA	0
Nb-94[a]	15	0	NA	0
Np-237	15	0	NA	0
Pb-210[a]	NA	NA	NA	NA
Pu-238	15	0	NA	0
Pu-239/240	15	0	NA	0
Ra-226[a]	15	0	NA	0
Ra-228[a]	NA	NA	NA	NA
Sr-90[a]	15	0	NA	0
Tc-99	15	0	NA	0
Th-228[a]	NA	NA	NA	NA
U-233/234[b]	15	0	NA[b]	0
U-235/236[b]	15	0	NA[b]	0
U-238[b]	15	0	NA[b]	0
Total Uranium[c]	15	0	NA	0
Carbon tetrachloride	16	22	6.5 µg/L	M7S, RWMC Production
1,4-Dioxane	NA	NA	NA	NA
Methylene chloride	16	0	NA	0
Nitrate[b]	15	0	NA	0
Tetrachloroethene	16	0	NA	0
Trichloroethene	16	12	2.6 µg/L	0

a. Monitoring is not performed directly for some analytes.
-Niobium-94 is not a target analyte for groundwater, and is therefore analyzed indirectly by gamma spectrometric analyses.
-Radium-226 is not a target analyte for groundwater, and is therefore analyzed indirectly by gamma spectrometric analyses.
- Strontium-90 is monitored indirectly via gross beta screening analyses.
b. Uranium-234, -235, and -238, and nitrate are naturally occurring in the environment, and the number of detections shown are for results that exceeded background upper concentration limits.
-Background upper tolerance levels for U-233/234, U-235/236, and U-238 are 1.92, 0.15 and 0.90 pCi/L, respectively; and for nitrate the applied upper background concentration level is 5 mg/L.
c. Total uranium derived by converting isotopic uranium results (pCi/L) to mass units (µg/L) and summing the results.
NA = not applicable



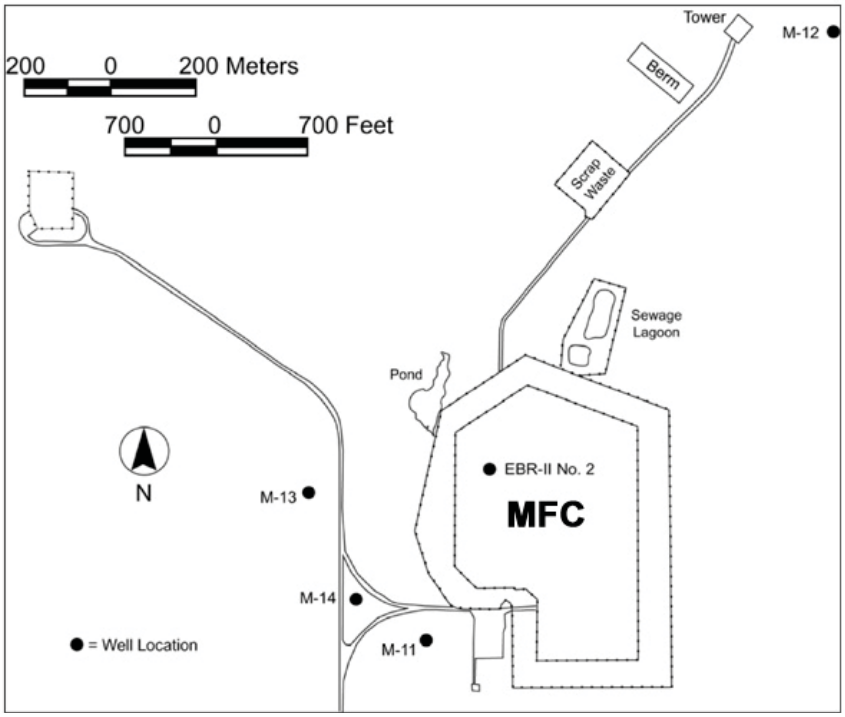

Figure 6-14. WAG 9 MFC Well Monitoring Locations.

Tritium was measured in eight drinking water samples during 2005, ranging from 78.6 ± 25.1 pCi/L at Idaho Falls in May to 223.0 ± 31.4, also at Idaho Falls, in November (Table 6-11). The maximum level is still significantly below the EPA MCL of 20,000 pCi/L for tritium in water. These levels can be explained by natural variability.

Offsite Surface Water Sampling

As part of the offsite monitoring performed by the ESER contractor, radiological analyses are performed on surface water samples taken at offsite locations. Locations outside of the INL Site boundary are sampled twice a year for gross alpha, gross beta, and tritium. In 2005, the ESER contractor collected 12 surface water samples from five offsite locations.

Gross alpha activity was not detected in any surface water samples during 2005.

Tritium was detected in two offsite surface water samples during 2005. The November surface water sample collected at Idaho Falls had a concentration of 231.0 ± 31.0 pCi/L and the November duplicate sample collected in the Hagerman area had a concentration of 384.0 ± 32.9 pCi/L (Table 6-11). These concentrations were well below the PCS and EPA MCL of 20,000 pCi/L.

Gross beta activity was measured in 11 of the 12 offsite surface water samples. Detectable concentrations ranged from 3.22 ± 0.90 pCi/L to 7.09 ± 0.96 pCi/L at Hagerman and Bliss,



Table 6-8. Comparison of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parentheses (2005).

Well		M-11		M-12		M-13		M-14		EBR-II No. 2		
Sample Date		5/23/2005	11/21/2005	5/23/2005	11/21/2005	5/23/2005	11/21/2005	5/24/2005	11/21/2005	5/24/2005	11/22/2005	MCL/SMCL[a]
Parameter	Units	Radionuclides[b]										
Gross Alpha	pCi/L	<1.03±0.77 (<2.19±0.91)	<1.06±0.79 (<-0.22±0.64)	2.71±0.82	<1.47±0.91	<1.86±0.67	<1.86±0.74	<0.21±0.64	<1.10±0.68	3.43±0.92	<0.93±0.87	15
Gross Beta	pCi/L	<1.38±0.7 (2.69±0.77)	2.96±0.69 (3.55±0.69)	2.48±0.63	4.48±0.76	2.90±0.75	3.74±0.68	3.36±0.72	3.04±0.72	3.74±0.75	3.93±0.72	50[c]
U-233/234	pCi/L	1.33±0.13 (1.39±0.15)	1.11±0.11 (1.39±0.13)	1.20±0.12	1.37±0.13	1.13±0.12	1.25±0.12	1.50±0.15	1.42±0.13	1.37±0.15	1.22±0.12	—
U-235	pCi/L	0.057±0.028 (<0.041±0.026)	0.06±0.026 (0.00±0.00)	<0.048±0.027	0.022±0.019	<0.049±0.027	0.035±0.024	<0.014±0.02	0.011±0.016	0.00±0.00	0.031±0.02	NE[d]
U-238	pCi/L	0.525±0.074 (0.624±0.091)	0.409±0.062 (0.689±0.085)	0.696±0.089	0.546±0.074	0.578±0.081	0.51±0.074	0.670±0.095	0.466±0.068	0.511±0.082	0.562±0.076	NE
Metals												
Aluminum	µg/L	<50 (<50)	<48 (<48)	<50	<53	37	<92	<50	<69	56	<41	200
Barium	µg/L	34 (34)	33.3 (33.2)	39	40	35	35	34	35.2	34	34.6	2000
Calcium	mg/L	37.9 (37.3)	38.9 (39.4)	39.3	42.2	38	41	37.3	39.2	37.4	40	NE
Chromium	µg/L	11 (6)	4 (3)	2	2	9	12	3	8	2	2	100
Copper	µg/L	<10 (<10)	<11 (<12)	<10	<11	12	<13	<10	<11	20	<13	1300
Iron	µg/L	423 (254)	297 R[e] (328 R)	52	80 R	805	580 R	42	1040 R	38	62 R	300
Lead	µg/L	<42 (<42)	<1 (<1)	<42	<1	<42	<1	<42	<1	1.97	<1	15
Magnesium	mg/L	12.4 (12.2)	11.6 (11.7)	11.7	11.2	12.2	11.9	12.1	11.8	12.2	11.8	NE
Manganese	µg/L	6 (7)	5 (5)	4	5	39	18	4	24	5	4	50
Potassium	mg/L	3.1 (3.13)	3.28 (3.3)	3.56	3.69	3.1	3.35	3.15	3.36	3.12	3.32	NE

Table 6-8. Comparison of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parentheses (2005). (Continued)

Well		M-11		M-12		M-13		M-14		EBR-II No.2		MCL/SMCL[a]
Sample Date		5/23/2005	11/21/2005	5/23/2005	11/21/2005	5/23/2005	11/21/2005	5/24/2005	11/21/2005	5/24/2005	11/22/2005	
Parameter	Units											
Sodium	mg/L	17.5 (17.3)	17.8 (18)	17.9	17.8	17.8	18.4	17.5	17.8	18	18.6	NE
Thallium	µg/L	<0.3 (<0.3)	<0.3 (<0.3)	<0.3	<0.6	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2
Vanadium	µg/L	<8 (<8)	6 (5)	<8	8	<8	6	<8	6	<8	6	NE
Zinc	µg/L	<20 (<20)	<3 (<5)	<20	<6	<20	<4	<20	<9	38	<10	5000
Anions												
Chloride	mg/L	18.9 (19.2)	19.8 (20)	17.3	18.5	18	18.7	18.2	18.9	18.5	18.8	250
Nitrate	mg/L	1.8 (1.8)	1.93 (1.92)	1.7	1.78	1.7	1.81	1.7	1.82	1.7	1.85	10
Sulfate	mg/L	16.5 (16.4)	16.5 (16.5)	15.3	15.5	17	16.8	16.9	16.5	16.9	17.4	250
Water Quality Parameters												
Bicarbonate Alkalinity	mg/L	138 (136)	131 (136)	136	150	140	130	139	134	138	136	NE
Total Dissolved Solids	mg/L	238 (238)	193 (163)	235	211	236	202	211	182	233	893	500
Total Organic Carbon	mg/L	<1 R (<1 R)	0.75 (0.54)	0.47 R	0.69	0.44 R	0.59	<1 R	0.56	<1 R	0.53	NE
Total Organic Halogen	µg/L	36.3 R (36.4 R)	19.2 (10.5)	108 R	6.8	55.6 R	7.5	54.5 R	8.5	26.3 R	4.8	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.

e. R=result was rejected.

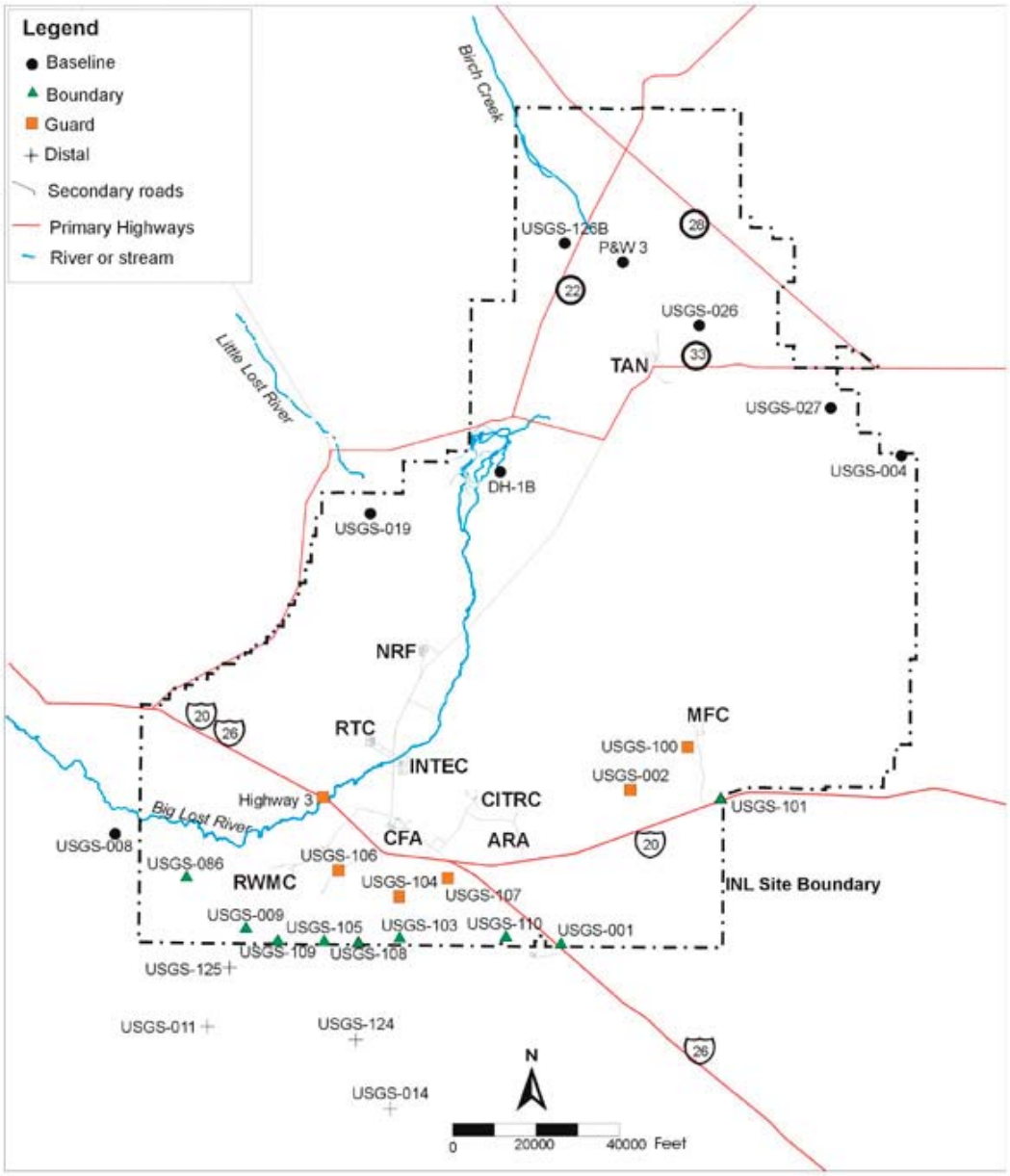

Figure 6-15. WAG 10 Baseline, Boundary, and Guard Wells Sampled in June-July 2005.



Table 6-9. Comparison of Detected Analytes with MCLs or SMCLs for WAG 10 (2005).

Analyte	Sample Units	Max Concentration	MCL or SMCL[a]	Detections above MCL or SMCL
Radionuclides				
Gross Beta	pCi/L	6.52	NA	NA
Gross Alpha	pCi/L	13.2[b]	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	1090	20000	0
Cs-137	pCi/L	2.74	200	0
C-14	pCi/L	ND	2000	0
Uranium-233/234	pCi/L	2.66	15	0
Uranium-235	pCi/L	0.506	15	0
Uranium-238	pCi/L	1.44	15	0
VOCs				
Toluene	µg/L	18	1,000	0
Acetone	µg/L	0.22	5	0
Anions				
Alkalinity	mg/L	269	None	NA
Chloride	mg/L	52.4	*250*	0
Fluoride	mg/L	0.89	*2*	0
Nitrate/Nitrite as N	mg/L	4.8	10	0
Sulfate	mg/L	38	*250*	0
Common Cations				
Calcium	µg/L	67,900	None	NA
Magnesium	µg/L	23,700	None	NA
Potassium	µg/L	6,990	None	NA
Sodium	µg/L	47,900	None	NA
Metals				
Aluminum	µg/L	42.6	*50 to 200*	0
Antimony	µg/L	9.1	6	1[b]
Arsenic	µg/L	3.8	50/10[c]	0
Barium	µg/L	142	2,000	0
Beryllium	µg/L	ND	4	0
Cadmium	µg/L	ND	5	0
Chromium	µg/L	11.2	100	0
Cobalt	µg/L	ND	None	NA
Copper	µg/L	1.6	1,300/*1,000*	0
Iron	µg/L	180	*300*	0
Lead	µg/L	116	15[d]	1
Manganese	µg/L	19.5	*50*	0
Mercury	µg/L	0.12	2	0
Nickel	µg/L	3.5	None	NA
Selenium	µg/L	ND	50	0
Silicon	µg/L	18,500	None	NA
Silver	µg/L	ND	None	NA
Strontium	µg/L	319	None	NA
Thallium	µg/L	0.36	2	0
Uranium	µg/L	4	30	0
Vanadium	µg/L	7.4	None	NA
Zinc	µg/L	352	*5,000*	0

a. Numbers in italics are for secondary maximum contaminant level.
b. Highest value is from a duplicate sample, sample value was 6.67 pCi/L.
c. The proposed new MCL for arsenic of 10 µg/L takes effect 1/23/06.
d. The action level for lead is 15 mg/L.
NA = not applicable
ND = not detected



Table 6-10. ESER Contractor Offsite Drinking Water Results (2005).

	Sample Results	Limit for Comparison
Location	Result ± 1s[a]	EPA MCL[b]
	Gross Alpha	
	May 2005	
Idaho Falls	7.84 ± 1.45	15
	Gross Beta	
	May 2005	
Aberdeen	4.89 ± 1.11	50[c]
Carey	3.18 ± 0.84	50
Fort Hall	13.00 ± 1.16	50
Idaho Falls	2.84 ± 0.88	50
Minidoka	2.63 ± 0.86	50
Monteview	4.68 ± 0.96	50
Shoshone	13.50 ± 1.15	50
Taber	3.53 ± 0.94	50
	November 2005	
Aberdeen	4.79 ± 1.01	50
Atomic City	3.57 ± 0.90	50
Carey	2.73 ± 0.89	50
Fort Hall	7.29 ± 1.05	50
Fort Hall (Duplicate)	8.57 ± 1.05	50
Idaho Falls	2.80 ± 0.91	50
Monteview	5.39 ± 0.97	50
Moreland	3.57 ± 1.02	50
Mud Lake	4.94 ± 0.91	50
Shoshone	2.62 ± 0.86	50
Taber	3.33 ± 0.92	50
	Tritium	
	May 2005	
Carey	170.0 ± 27.2	20,000
Idaho Falls	78.6 ± 25.1	20,000
	November 2005	
Carey	130.0 ± 31.8	20,000
Fort Hall	140.0 ± 30.3	20,000
Idaho Falls	223.0 ± 31.4	20,000
Minidoka	121.0 ± 30.4	20,000
Moreland	121.0 ± 30.4	20,000
Shoshone	80.3 ± 26.5	20,000

a. All values shown are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation [1s]).

b. MCL = maximum contaminant level.

c. The MCL for gross beta is established as a dose of 4 mrem/yr. A screening concentration of 50 pCi/L is used to simplify comparison.



respectively. The maximum concentration is below the EPA screening level for gross beta in drinking water of 50 pCi/L. Concentrations in this range are consistent with those measured in the past and cannot be differentiated from natural decay products of thorium and uranium that dissolve into water as the water passes through the surrounding basalts of the Snake River Plain.

Table 6-11. ESER Contractor Offsite Surface Water Detections (2005).

	Sample Results[a]	Limits for Comparison[b]	
Location	**Result ± 1s**	**PCS[c]**	**EPA MCL[d]**
	Gross Beta		
	May 2005		
Bliss	3.70 ± 0.92	4 mrem/yr	50
Bliss (duplicate)	5.54 ± 0.97	4 mrem/yr	50
Buhl	3.38 ± 0.94	4 mrem/yr	50
Hagerman	3.22 ± 0.90	4 mrem/yr	50
Twin Falls	6.23 ± 1.05	4 mrem/yr	50
	November 2005		
Bliss	7.09 ± 0.96	4 mrem/yr	50
Buhl	4.82 ± 0.89	4 mrem/yr	50
Hagerman	3.88 ± 0.83	4 mrem/yr	50
Hagerman (duplicate)	4.76 ± 0.86	4 mrem/yr	50
Idaho Falls	3.70 ± 0.82	4 mrem/yr	50
Twin Falls	4.07 ± 1.13	4 mrem/yr	50
	Tritium		
	November 2005		
Hagerman (duplicate)	384.0 ± 32.9	20,000	20,000
Idaho Falls	231.0 ± 31.0	20,000	20,000

a All values shown are in picocuries per liter (pCi/L), plus or minus one standard deviations (± 1s) unless otherwise noted.

b. Values shown are in picocuries per liter (pCi/L), unless otherwise noted. These limits are shown for comparison purposes only and do not apply to the surface water samples.

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

d. MCL = maximum contaminant level



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Tiger Swallowtail

Chapter 7 - Environmental Monitoring Programs - Agricultural, Biota, Soil and Direct Radiation

M. Case - S. M. Stoller Corporation
D. Broderick - Battelle Energy Alliance

Chapter Highlights

To help assess the impact of contaminants released to the environment by operations at the Idaho National Laboratory (INL) Site, agricultural products (milk, lettuce, wheat, potatoes, and sheep); wildlife (waterfowl and large mammals) and soil were sampled and analyzed for radionuclides. In addition, direct radiation was measured on and off the INL Site in 2005.

Some human-made radionuclides were detected in agricultural products and soil samples. However, the results could not be directly linked to operations at the INL Site. Concentrations of radionuclides detected in agricultural products and soil samples were consistent with fallout levels from atmospheric weapons testing. The maximum levels for these radionuclides were all well below regulatory health-based limits for protection of human health and the environment. Some human-made radionuclides were also detected in samples of wildlife during 2005 but concentrations were similar to those found in samples taken off the INL Site.

Direct radiation measurements made at offsite, boundary, and onsite (except in the vicinity of some INL Site facilities) locations were consistent with background levels. The measured annual dose equivalent from external exposure was 124 mrem. Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex were greater than background levels but consistent with those made historically at that location.

7. ENVIRONMENTAL MONITORING PROGRAMS - AGRICULTURAL PRODUCTS, 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 populations.

The INL and Idaho Cleanup Project (ICP) contractors monitored soil, vegetation, and direct radiation on the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The contractors collected 418 soil, vegetation, and direct radiation samples for analysis in 2005.

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 (9000 mi^2) of southeastern Idaho at locations on, around, and distant to the INL Site. The ESER contractor collected approximately 225 agricultural products, wildlife, and direct radiation samples for analysis in 2005.

Section 7.1 presents the agricultural products and wildlife 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.

7.1 Agricultural Products and Biota Sampling

Milk

During 2005, 152 milk samples were collected under the ESER Program. All of the samples were analyzed for gamma-emitting radionuclides including iodine-131 (^{131}I). During the second and fourth quarters, nine samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine-131 was not detected in any sample in 2005. Cesium-137 (^{137}Cs) was detected in one sample collected in Idaho Falls in July. The result, 3.1 pCi/L, is well below the DOE derived concentration guide (DCG) for ^{137}Cs in water of 3000 pCi/L.

Strontium-90 was detected in eight out of nine samples, ranging from 0.3 pCi/L at Moreland to 1.2 pCi/L at Carey. 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 DCG for ^{90}Sr in water of 1000 pCi/L.

Tritium was not detected in any of the nine samples analyzed.



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

Area/Facility[a]	Media			
	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.

Lettuce

ESER Program personnel collect lettuce samples every year from the areas 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 added two prototype lettuce planters in conjunction with other sampling locations at Atomic City and the Experimental Field Station (EFS) on the INL Site. These locations are relatively remote and have no access to water, requiring that a self-watering system be developed. This method allows for the placement and collection of lettuce at areas previously unavailable to the public (i.e., on the INL Site). The boxes are set out in the spring



with the lettuce grown from seed. This new method also allows for the accumulation of deposited radionuclides on the plant surface throughout the growth cycle.

Seven lettuce samples, including one duplicate, were collected from regional private gardens at Arco, Blackfoot, Howe, Idaho Falls, Mud Lake, and Pocatello (Figure 1). One sample was collected from the portable lettuce garden placed at Atomic City. The lettuce crop at EFS failed due to yellow jackets nesting in the soil.

Strontium-90 was detected above the 3s level in the sample collected from Pocatello in 2005. 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 concentration of 9.3×10^{-2} pCi/g was within concentrations detected historically (Table 7-2) and was most likely from weapons testing fallout.

Wheat

None of the 12 wheat samples (including one duplicate) collected during 2005 contained a measurable concentration of ^{90}Sr above the 3s uncertainty level. No other anthropogenic radionuclides were detected (Table 7-3).

Potatoes

Ten potato samples, including one duplicate, were collected during 2005: six samples and one duplicate from distant locations; three samples from boundary locations; and one sample from an out-of-state location (Colorado) (Figure 7-1). The nine Idaho samples were collected from Aberdeen, Arco, Blackfoot, Fort Hall, Idaho Falls, Monteview, Rupert, Terreton, and Taber. Strontium-90 was detected in three of the Idaho samples at levels ranging from 0.8 pCi/kg at Idaho Falls to 1.1 pCi/kg at Fort Hall. Strontium-90 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.

Sheep

Certain areas of the INL Site are open to grazing under lease agreements managed by the U.S. Bureau of Land Management. Every year, during the second quarter, ESER personnel collect samples from sheep grazed in these areas, either just before or shortly after they leave the INL Site. Muscle, liver, and thyroid samples were collected from each animal. For the calendar year 2005, six sheep were sampled. Four were from INL Site land, and two were from Dubois to serve as control samples. Cesium-137 was detected above 3s in the muscle tissue of one onsite sample at a level of 4.9 pCi/kg, but was not detected in offsite muscle samples. Cesium-137 was also detected in the liver tissue sample from one onsite animal at a level of 5.5 pCi/kg. Cesium-137 was not measured above the 3s uncertainty in any control sheep in 2005. All ^{137}Cs concentrations measured in 2005 were similar to those found in both onsite and offsite sheep samples in previous years and are within historical values.



Table 7-2. Strontium-90 Concentrations in Garden Lettuce (2000-2005).[a,b,c]

Location	2000	2001	2002	2003	2004	2005
Distant Group						
Blackfoot	80 ± 15	160 ± 55	116 ± 81	228 ± 83	97 ± 56	-17 ± 15
Carey	295 ± 70	144 ± 55	283 ± 79	220 ± 180	97 ± 66	NS[d]
Idaho Falls	61 ± 25	114 ± 55	41 ± 25	254 ± 170	328 ± 110	26 ± 24
Pocatello	89 ± 30	59 ± 50	NS	NS	135 ± 110	93 ± 26
Grand Mean[e]	**131 ± 20**	**119 ± 27**	**145 ± 39**	**234 ± 87**	**164 ± 44**	**35 ± 15**
Boundary Group						
Arco	81 ± 20	88 ± 55	93 ± 23	126 ± 160	154 ± 85	111 ± 37
Atomic City[f]	NS	110 ± 55	NS	282 ± 130	155 ± 130	57 ± 30
Howe	88 ± 24	21 ± 55	65 ± 28	25 ± 81	NS	49 ± 25
Monteview	NS	74 ± 55	85 ± 22	214 ± 140	NS	NS
Mud Lake (Terreton)	51 ± 26	41 ± 55	109 ± 26	NS	148 ± 79	55 ± 26
Grand Mean[e]	**73 ± 14**	**67 ± 25**	**88 ± 12**	**162 ± 66**	**152 ± 58**	**68 ± 15**
INL Site						
Experimental Field Station[f]	NS	NS	NS	442 ± 130	225 ± 86	SD[g]

a. Analytical results are x 10^{-3} times 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 x 10^{-4} pCi/g dry weight.
d. NS indicates no sample collected or sample was lost before analysis.
e. Uncertainty calculated as $\left(\sqrt{\sum_{i=1}^{n} s_i^2}\right)\Big/ n$ where s_i is the standard deviation of sample i and n is the number of samples within the group.
f. Portable lettuce garden used in 2003 - 2005.
g. SD indicates that the sample was destroyed, in this case, by yellow jackets.



Table 7-3. Strontium-90 Concentrations in Wheat (2000-2005). [a,b]

Location	2000	2001[c]	2002	2003	2004	2005
Distant Group						
Aberdeen[d] (American Falls)	4.9 ± 1.3	-20 ± 15	36 ± 130	84 ± 62	-1 ± 25	12 ± 18
					32 ± 29	
Blackfoot[d]	5.7 ± 2.9	61 ± 45	69 ± 66	NS	16 ± 25	16 ± 25
			81 ± 130			
Carey	NS[e]	50 ± 90	28 ± 66	-53 ± 47	65 ± 27	NS
Dietrich	5.6 ± 2.2	NS	NS	NS	17 ± 17	-27 ± 17
Idaho Falls[d]	5.3 ± 1.5	-37 ± 132	50 ± 82	121 ± 64	46 ± 22	15 ± 24
					26 ± 27	
Minidoka	6.2 ± 2.1	218 ± 145	0 ± 97	61 ± 48	NS	4 ± 24
Roberts (Menan)[d]	NS	193 ± 115	19 ± 65	54 ± 55	NS	7 ± 16
		29 ± 95				-11 ± 18
Rockford	NS	NS	-220 ± 130	195 ± 68	NS	NS
Rupert (Burley)[d]	NS	-69 ± 101	90 ± 130	-26 ± 52	NS	NS
Taber	6.1 ± 1.9	NS	111 ± 150	NS	NS	NS
Grand Mean[f]	5.6 ± 0.8	53 ± 36	26 ± 35	62 ± 22	29 ± 9	-0.9 ± 7
Boundary Group						
Arco[d]	6.3 ± 2.2	96 ± 130	41 ± 190	2 ± 55	16 ± 25	109 ± 38
		59 ± 44				
Howe	NS	NS	18 ± 76	-19 ± 49	-4 ± 19	5 ± 18
Monteview	2.4 ± 1.1	50 ± 49	220 ± 98	NS	NS	-41 ± 22
Mud Lake	4.8 ± 1.9	20 ± 37	54 ± 87	8 ± 56	21 ± 18	-5 ± 20
Terreton	3.2 ± 1.7	64 ± 65	86 ± 99	5 ± 43	-6 ± 22	NS
Grand Mean[f]	4.2 ± 0.9	58 ± 33	84 ± 52	-1 ± 26	7 ± 11	17 ± 13

a. Concentrations are picocuries per kilogram.
b. Analytical Results are for dry weight, plus or minus 1 standard deviation (± 1s).
c. Approximate MDC of ^{90}Sr in wheat through 2000 was 4 pCi/kg dry weight. After 2001, the MDC increased to 20 pCi/kg dry weight.
d. Samples were collected from multiple locations in this area during certain years.
e. NS = no sample collected.
f. Uncertainty calculated as $\left(\sqrt{\sum_{i=1}^{n} s_i^2}\right)/n$, where s is the standard deviation of sample i and n is the number of samples in the group.

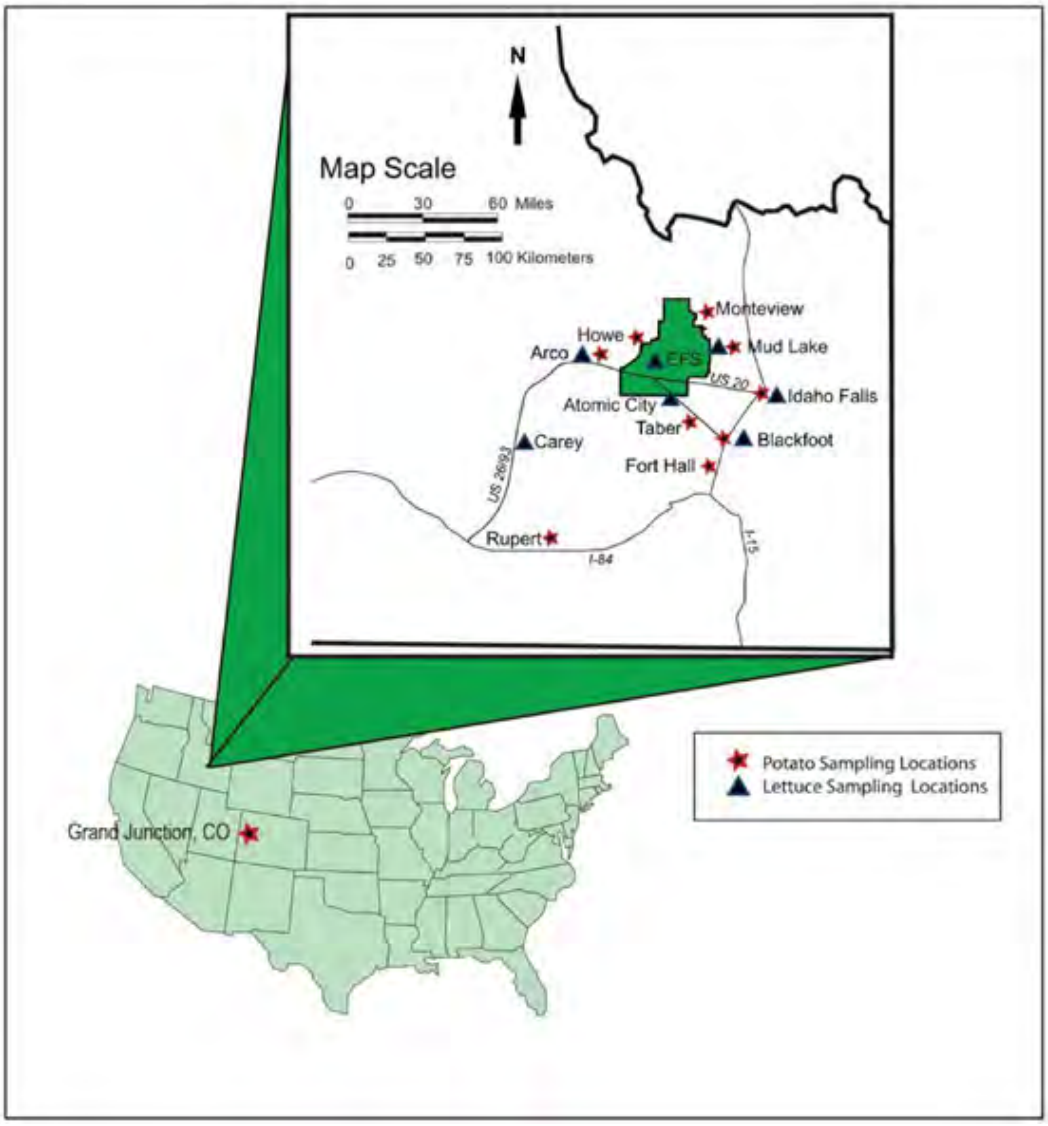

Figure 7-1. Locations of Potato and Lettuce Samples Taken During 2005.

Cesium-137 concentrations in both sheep liver and muscle have been essentially the same (error bars overlap) since 2000 (Figure 7-2).

Levels of ^{131}I are of particular interest in thyroids because of this organ's ability to accumulate iodine. Iodine-131 did not exceed the 3s uncertainty in any sample.



Game Animals

Muscle, liver, and thyroid samples were collected from three pronghorn and two mule deer which were accidentally killed on INL Site roads or died from natural causes. There was detectable ^{137}Cs radioactivity above 3s in the muscle of one pronghorn taken on or near the INL Site. The result was 4.0 pCi/kg. No tissue samples contained detectable ^{131}I above 3s.

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 2005 was below this range. The 2005 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.

No marmots were collected during 2005.

Nine ducks were collected during 2005. Three were collected from wastewater ponds located at the Reactor Technology Complex (RTC) facility, three came from wastewater ponds near the Materials and Fuels Complex (MFC) facility, and three control samples were collected near Firth. 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, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am. Concentrations of radionuclides measured in edible tissues 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, Cobalt-60 (^{60}Co), Manganese-54 (^{54}Mn), Plutonium-239 (^{239}Pu), $^{239/240}Pu$, ^{90}Sr, and Zinc-65 (^{65}Zn). Of these eight, five (^{137}Cs, ^{60}Co, ^{90}Sr, ^{241}Am, and ^{65}Zn) were found in the edible tissues. Two radionuclides, ^{241}Am and ^{90}Sr, were detected in the birds from the MFC ponds, however these detections are within historical levels attributable to fallout . No manmade radionuclides were found in the control samples.

Since manmade radionuclides were only found 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 higher than those found in the previous few years, but still 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 as they were observed in the area for about two weeks prior to collection. Ducks collected in previous years were sampled later during the hunting season and did not reside at the ponds (i.e., were migrating).



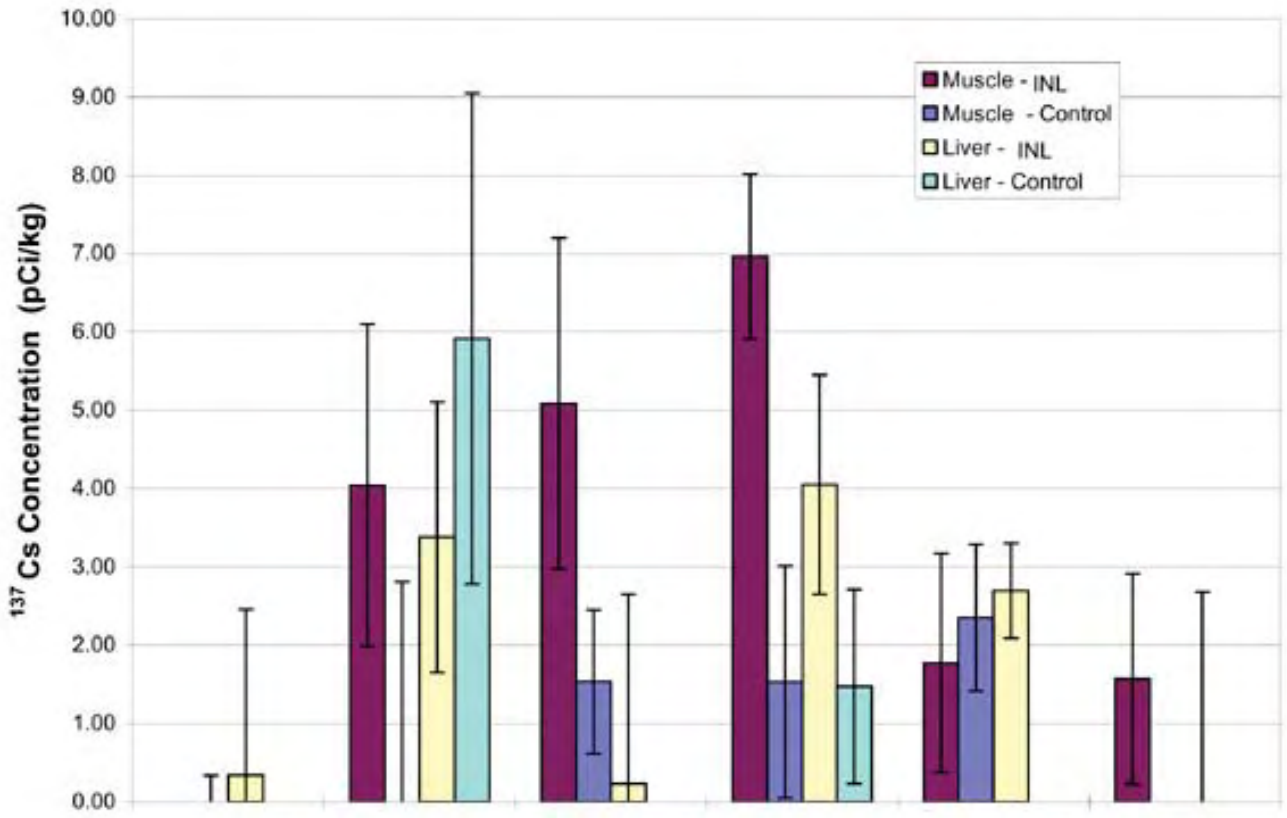

Figure 7-2. Average Cesium-137 Concentrations in Muscle and Liver of Sheep Collected from the INL Site and Control Areas.

RTC Evaporation Pond effluent data for several years were examined as a potential explanation for the increase in waterfowl radionuclide concentrations. Radionuclide amounts in effluent were cumulated to determine the pond source term for each year from 2003 through 2005. The RTC Evaporation Pond source terms for ^{137}Cs (the radionuclide responsible for 98 percent of the calculated doses) over this time period do not correlate with the increased dose estimated for 2005 ducks. There was no significant increase between 2004 and 2005, as one would expect if the increased radionuclide concentrations are correlated with a source term increase (the maximum concentration of ^{137}Cs in any of the waterfowl tissues sampled was 0.2 pCi/g in 2004 and 16.6 pCi/g in 2005). However, that does not preclude the sediment or vegetation, where radionuclides can accumulate, as a source of ^{137}Cs.

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 (average 225 g). The maximum potential dose from eating 225 g (8 oz) of meat from the most contaminated waterfowl collected in 2005 was estimated to



Table 7-4. Radionuclide Concentrations in Waterfowl at INL Site and Control Locations (2005).[a]

	Waterfowl Location								
Nuclide	**RTC**	**RTC**	**RTC**	**MFC**	**MFC**	**MFC**	**Firth**	**Firth**	**Firth**
				Edible					
Cesium-137	16600±84	2430±31	85±15	--[b]	--	--	--	--	--
Cobalt-60	540±17	--	23±7	--	--	--	--	--	--
Zinc-65	361±44	--	--	--	--	--	--	--	--
Americium-241	--	1.4±0.3	--	--	--	--	--	--	--
Strontium-90	19±2.5	3.6±1.1	--	7.3±1.9	7.1±2.2	--	--	--	--
				Exterior (feathers and gut)					
Cesium-137	1730±29	44430±116	411±38	--	--	--			
Cobalt-60	361±14	3020±28	183±23	--	--	--			
Zinc-65	821±56	578±41	657±39						
Americium-241	--	--	1.3±0.3	--	--	--			
Plutonium-239/240	1.9±0.4	--	--						
				Remainder (bones, remaining organs, residual muscle)					
Cesium-137	9880±42	845±10	44±4	--	--	--			
Cobalt-60	688±11	19±3	--						
Zinc-65	1310±34	--	--	--	--	--			
Americium-241	7.1±0.8	--	--	--	--	1.7±0.3			
Plutonium-239/240	--	--	--	--	--	7.4±1.6			
Strontium-90	526±29	498±36	12±2	--	--	38±10	7±2		

a. All values are $\times 10^{-3}$ picocuries per gram ± 1 standard deviation.

b. A double dash (--) indicates the radionuclide was not detected in the sample.

be 0.19 mrem (.0019 mSv) (Chapter 8). Although higher than in recent years, this dose was within expected variability when dealing with biological (and unpredictable) media. This dose is not the maximum dose ever estimated. 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).

Three mourning dove samples were collected in 2005. One came from the MFC facility, and two were from offiste locations. None of the samples contained detectable manmade radionuclides.

Vegetation Sampling

MFC also collects random vegetation samples (at the same locations as the soil samples) and other areas of concern. Vegetation is sampled and is used to determine windblown deposition and changes in plant uptake. Approximately 1 kg (2.2 lb) of mixed vegetation is collected and dried. The dried material is then powdered and analyzed for various radionuclides. Table 7-5 presents the 2005 vegetation results for MFC.

7.2 Soil Sampling

Soils are sampled to determine if long-term deposition of airborne materials from the INL have resulted in a buildup of radionuclides. The sampling also supports the Wastewater Land Application Permit (WLAP) 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 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 facilities are consistent with fallout levels. Soil sampling locations are shown in Figure 7-3.

The ESER contractor collects offsite soil samples every two years (in even years); thus, soil sampling was not conducted in 2005. Results from 1975 to 2004 are presented in Figure 7-4. 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.

Radionuclide levels in soils at 175 site surveillance locations near major INL facilities were measured by the INL and ICP contractors in 2005 using in situ gamma spectrometry, with 20 additional grab samples collected from 0-5 cm (0-2 in.) at selected locations. Table 7-6 summarizes the in situ gamma results, and Table 7-7 summarizes the analytical laboratory gamma and radiochemistry results. Uranium isotopes were detected in all samples at levels that indicated they were from natural sources.



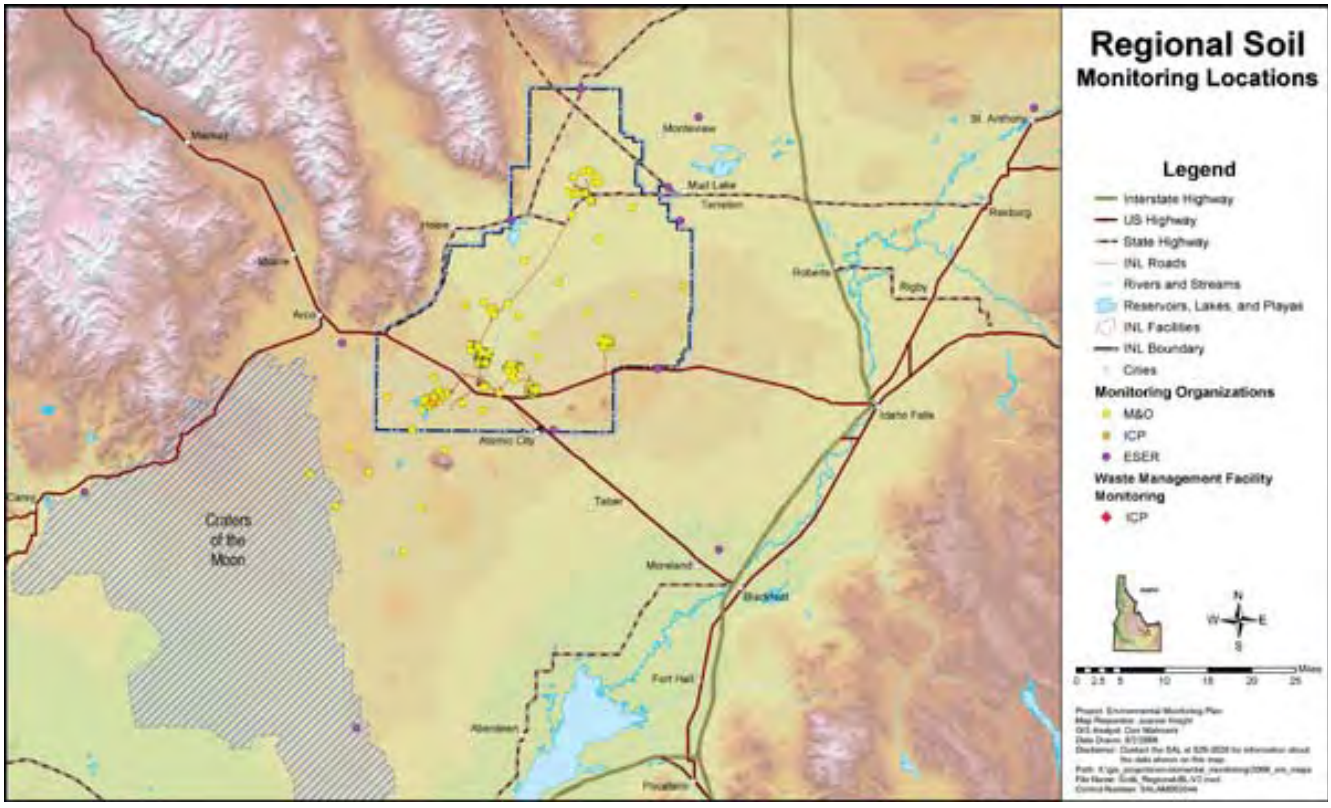

Figure 7-3. Soil Sampling Locations.

At MFC, seven locations and one duplicate were sampled and analyzed for low-level gamma-emitting radionuclides and for uranium, plutonium, and thorium isotopes. Table 7-8 presents the results of the 2005 sampling effort.

Wastewater Land Application Permit Soil Sampling at CFA

The WLAP for the CFA Sewage Treatment Plant allows for nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation (DOE-ID 1999, IDEQ 2000, Johnston 2005). Soils are sampled at ten locations within the CFA land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.), 30 to 61 cm (12 to 24 in.), and 61-91 cm (24 to 36 in.) at each location and composited for each depth interval, yielding three samples, one from each depth. These samples are analyzed for pH, electrical conductivity, sodium absorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the WLAP, to determine whether wastewater application is adversely affecting soil chemistry. The analytical results for the soil samples are summarized in Table 7-9. The 61-91



Table 7-5. Vegetation Sample Results Measured at MFC (2005).

Parameter	Minimum Concentration[a]	Maximum Concentration[a]	Average Concentration
		Human-Made	
Am-241	ND[b]	ND	ND
Co-60	ND	ND	ND
Cs-137	ND	ND	ND
Pu-238	ND	ND	ND
Pu-234/240	0.0247	0.0625	0.038
		Naturally Occurring	
Ac-228	0.139	0.785	0.579
Be-7	0.979	9.19	3.583
Bi-214	0.325	0.325	0.325
Pb-214	0.322	0.797	0.559
Ra-226	0.325	0.669	0.497
Th-228	0.176	0.444	0.090
Th-230	0.116	0.477	0.031
U-233/234	0.024	0.0625	0.038
U-235/236	0.002	0.008	0.006
U-238	0.012	0.033	0.022

a. Units are picocuries per gram
b. ND=Not Detected

cm (24 to 36 in.) depth interval is a new permit requirement for 2005; therefore no historical data are available for this interval. Data collected by Cascade Earth Sciences, Ltd. in 1993, prior to wastewater application, is presented in Table 7-9 for comparison purposes.

During 2005, pH levels were similar to the 1995-2004 historical averages at the 0-30 cm (0-12 in.) and 30-61 cm (12-24 in.) depths (no historical data is available for 61-91 cm [24-36 in.] depth). Percent organic matter was below the 1995 to 2004 historical average levels at 0-30 cm (0-12 in.) and 30-91 cm (12-24 in.) depths.



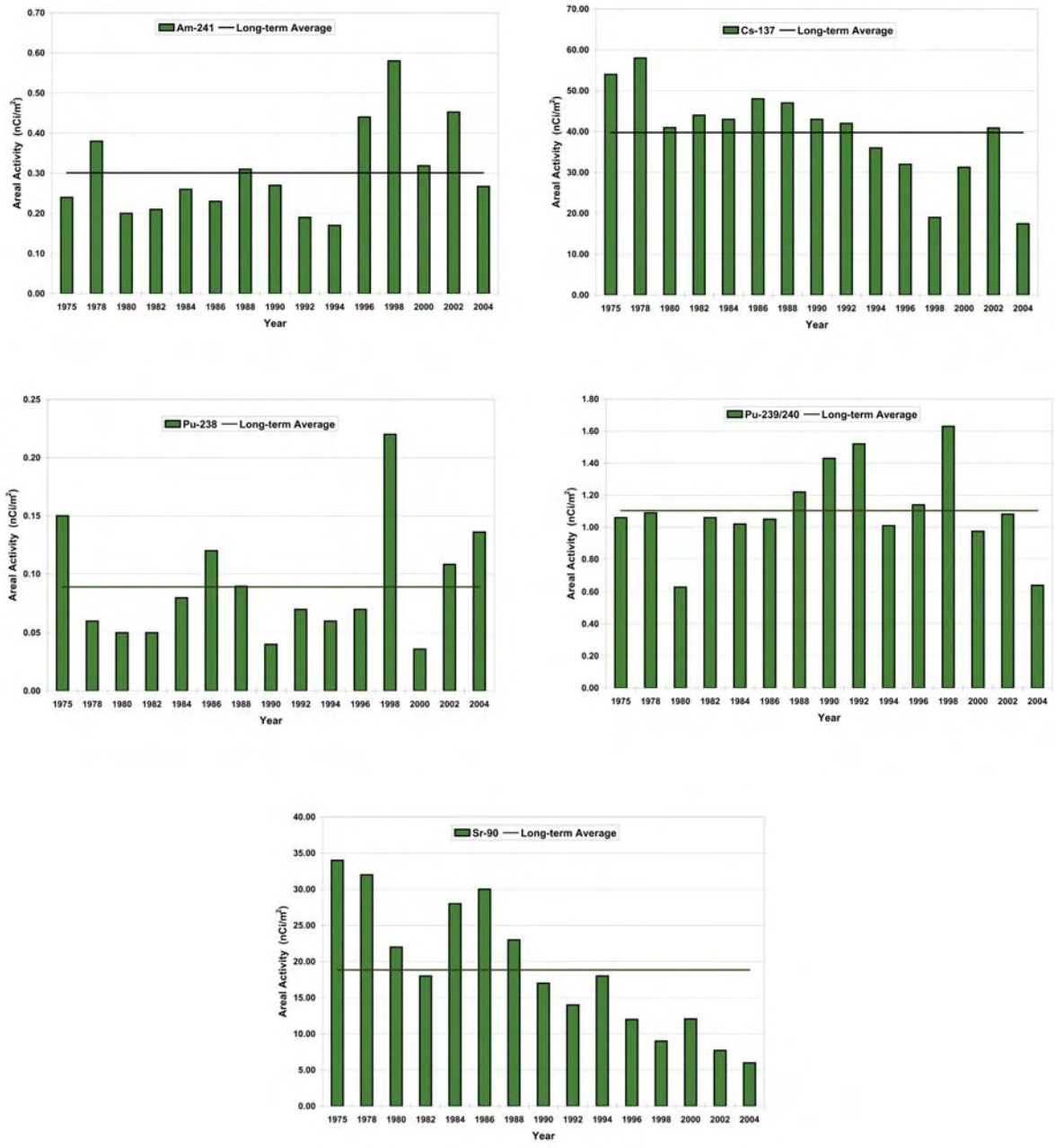

Figure 7-4. Geometric Mean Areal Activity in Offsite Surface (0-5 cm [0-2 in.]) Soils (1975-2004).



Table 7-6. In Situ Soil Gamma Results Measured by the INL and ICP Contractors (2005).

Location[a]	Radionuclide	Concentration (picocuries per gram ±1s) Minimum	Maximum	Mean	Comment
MFC	Cesium-137	0.111 ± 0.004	0.176 ± 0.003	0.11	Concentrations within background measurements for the INL Site and surrounding areas and attributable to past fallout.
ARA	Cesium-137	0.168 ± 0.030	8.1 ± 0.2	1.33	The mean concentrations are within background measurements for the INL Site and surrounding areas and attributable to past fallout. However, maximum concentrations are above background measurements for the INL Site, but consistent with historical concentrations at ARA.
INTEC	Cesium-137	0.466 ± 0.005	10.8 ± 0.1	2.65	Concentrations are above background for the INL Site, but consistent with historical concentrations at INTEC.
Large Grid	Cesium-137	0.051 ± 0.003	0.472 ± 0.019	0.27	Concentrations within background for the INL and surrounding areas and attributable to past fallout.
NRF	Cesium-137	0.080 ± 0.005	0.217 ± 0.009	0.13	Concentrations within background for the INL and surrounding areas and attributable to past fallout.

a. In situ data were collected outside the fenced facility areas by the ICP contractor.

Soil salinity levels between 0 to 2 mmhos/cm are generally accepted to have negligible effects on plant growth (Bohn et al. 1985). During 2005, the electrical conductivity represented the historic highs at both the 0 to 30 cm (0 to 12 in.) and the 30 to 61 cm (12 to 24 in.) intervals, and it was near or above the 2 mmhos/cm at all three depths. Soils with sodium adsorption ratios (SARs) below 15 are generally classified as not having sodium or salinity problems (Bohn et al. 1985). During 2005, SARs were elevated at the upper depth relative to preapplication SARs; however, both depths remain well below the ratio generally indicating a sodium problem in soil.

Nitrogen data suggest negligible nitrogen accumulation from wastewater application. The low soil-available nitrogen (ammonium-nitrogen and nitrate-nitrogen) concentrations suggest that the native sagebrush 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 utilizes plant available nitrogen. The ammonium and nitrate nitrogen concentrations are comparable to those of nonfertilized agricultural soils.

In 2005, available phosphorus concentrations exceeded the historical high at the 0-30.5 cm (0-12 in.) depth interval; however, concentrations remained below preapplication levels and less than that considered adequate for range and pasture crop growth (EPA 1981).

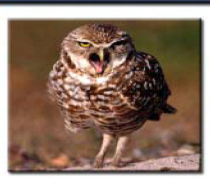
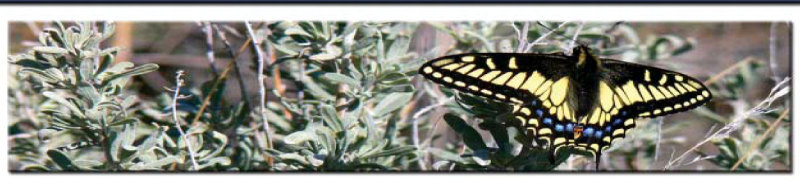
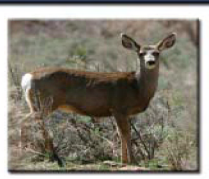

Table 7-7. Site Surveillance Soil Sampling Laboratory Results Measured by INL and ICP Contractors (2005).

Location	Radionuclide	Minimum Concentration[a]	Maximum Concentration[a]	%ECG[b]
MFC	Cesium-137	0.37 ± 0.02	0.91 ± 0.04	15.17
	Americium-241	0.0043 ± 0.0014	0.012 ± 0.0017	0.03
	Plutonium-239/240	0.015 ± 0.0021	0.029 ± 0.0035	0.04
INTEC	Cesium-137	3.56 ± 0.12	6.43 ± 0.27	107.17
	Americium-241	0.0061 ± 0.002	0.0081 ± 0.0017	0.02
	Plutonium-238	0.043 ± 0.0022	0.025 ± 0.0033	0.03
	Plutonium-239/240	0.011 ± 0.0012	0.029 ± 0.0039	0.04
	Strontium-90	0.49 ± 0.075	0.71± 0.076	11.83
NRF	Cesium-137	0.17 ± 0.01	1.12 ± 0.05	18.67
	Americium-241	0.0043 ± 0.0014	0.0097 ± 0.0017	0.02
	Plutonium-239/240	0.0057 ± 0.0016	0.016 ± 0.029	0.02
ARA	Cesium-137	0.82 ± 0.03	3.92 ± 0.14	65.33
	Americium-241	0.0055 ± 0.0012	0.0085 ± 0.0016	0.02
	Plutonium-238	NA	0.0039 ± 0.0012	0.00
	Plutonium-239/240	0.013 ± 0.0023	0.018 ± 0.0024	0.02
	Strontium-90	0.21 ± 0.033	0.37 ± 0.034	6.18
Large Grid[c]	Cesium-137	0.32 ± 0.02	0.61 ± 0.03	10.17
	Americium-241	0.0037 ± 0.0012	0.0076 ± 0.0016	0.02
	Plutonium-238	0.0033 ±0.0011	0.0040 ± 0.0012	< 0.01
	Plutonium-239/240	0.010 ± 0.0018	0.025 ± 0.0042	0.03
	Strontium-90	NA	0.11 ± 0.033	1.78

a. Units are picocuries per gram ±1s.

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

c. Large Grid = A 24-mile radius around INTEC.



Table 7-8. Soil Sample Results Measured at MFC (2005).

Parameter	Minimum Concentration[a]	Maximum Concentration[a]	Average Concentration
		Human-Made	
Am-241	1.14	1.69	1.34
Co-60	0.005	0.03	0.017
Cs-137	0.005	0.913	0.388
Pu-238	0.002	0.022	0.013
Pu-234/240	0.009	0.033	0.018
		Naturally Occurring	
Ac-228	0.114	1.69	1.34
Be-7	0.008	0.76	0.286
Bi-214	1.03	1.6	1.27
Pb-214	1.18	1.45	1.40
Ra-226	1.03	1.6	1.27
Th-228	1.03	1.77	1.45
Th-230	1.07	1.4	1.25
U-233/234	0.783	0.837	0.816
U-235/236	0.05	0.111	0.077
U-238	0.755	0.895	0.835

a. Units are picocuries per gram

Soil sampling and analysis will continue, as required by the WLAP, to evaluate the impacts of wastewater application on soil chemistry.

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



Table 7-9. CFA Sewage Treatment Plant Application Area Soil Monitoring Results (2005).

Parameter	Preapplication Period[a] Depth (in.)	1993	Application Period Depth (in.)[b]	1995 through 2004 Minimum	Maximum	Average	2005
pH	0–6	7.6	0–12	7.6[c]	8.4[c]	8.0[c]	8.02
	6–16	8.0	12–24	7.6[c]	8.6[c]	8.1[c]	7.94
	16–30	8.1	24-36	NA	NA	NA	8.03
Electrical Conductivity (mmhos/cm)	0–6	0.6	0–12	0.36	1.51	0.90	1.93
	6–16	0.7	12–24	0.20	1.64	0.80	2.86
	16–30	0.6	24-36	NA	NA	NA	2.1
Organic Matter (%)	0–6	2.2	0–12	0.63[c]	3.09[c]	1.7[c]	1.49
	6–16	1.6	12–24	0.56[c]	2.29[c]	1.1[c]	0.79
	16–30	1.4	24-36	NA	NA	NA	0.46
Nitrate as Nitrogen (ppm)	0–6	16	0–12	0.68[d]	6.13	3.2[e]	5.44
	6–16	6	12–24	0.43[d]	5.20	1.8[e]	1.66
	16–30	3	24-36	NA	NA	NA	1.73
Ammonium Nitrogen (ppm)	0–6	7.9	0–12	0.81 U[f]	6.10	2.5[e]	0.49 U
	6–16	7.6	12–24	0.5 U	6.00	2.1[e]	0.48 U
	16–30	7.4	24-36	NA	NA	NA	0.49 U
Phosphorus (ppm)[g]	0–6	29	0–12	3.69	12.00	8.2[e]	13.1
	6–16	18	12–24	2.00 U	10.20	3.5[e]	3.26
	16–30	12	24-36	NA	NA	NA	1.72
Sodium Adsorption Ratio	0–6	1.0	0–12	0.35	6.72	3.4	5.64
	6–16	1.4	12–24	0.31	9.12	2.5	3.94
	16–30	2.6	24-36	NA	NA	NA	3.12

a. Preapplication sample results were based on a composite of three representative samples taken at each depth. Preapplication soil depths and locations differ from permit samples.

b. The 24-36 in. depth interval was first collected in October 2005 per new permit requirements; therefore, there are no minimum, maximum, or average values.

c. The summary statistics shown do not reflect a result from 1995. While samples were collected in 1995, the analytical laboratory failed to analyze them.

d. The minimum shown is the minimum of the detected results. For the 0–12 in. depth, a result of less than 25 ppm was reported in 1997. For the 12–24 in. depth, a result of less than 1 ppm was reported in 1999, a result of less than 2.25 ppm was reported in both 2000 and 2001, and a result of less than 2.5 ppm was reported in 1997.

e. Where applicable, half the reported detection limit was used to calculate the average.

f. U flag indicates that the reported value for the minimum shown is below the detection limit. In addition, for the 12–24 in. depth, a result of less than 1 ppm was reported in 1998.

g. Available phosphorus was analyzed rather than the total phosphorus analysis specified in the permit. DEQ indicated that plant available phosphorous is the appropriate soil-monitoring constituent (Rackow 2003a). The total phosphorus reported for 1995 is not included in the summary statistics presented.



contain four lithium fluoride chips and are placed about 1 m (approximately 3 ft) above the ground at specified locations. 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 2005 were from November 2004 through April 2005 (spring) and from May 2005 through October 2005 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2004 through October 2005 is shown in Table 7-10 for two adjacent sets of dosimeters maintained by the ESER and Site contractors. For purposes of comparison, annual exposures from 2001-2004 are also included for each location.

The mean annual exposures from distant locations in 2005 were 121 ± 3 milliroentgens (mR) as measured by the ESER dosimeters and 119 ± 3 mR as measured by the Site contractor dosimeters (Table 7-10). For boundary locations, the mean annual exposures were 120 ± 3 mR as measured by ESER contractor dosimeters and 119 ± 4 mR as measured by INL Site contractor dosimeters. Using both ESER and INL Site contractors' data, the average dose equivalent of the distant group was 124 millirem (mrem), when a dose equivalent conversion factor of 1.03 was used to convert from milliroentgens to millirem in tissue (NRC 1997). The average dose equivalent for the boundary group was 120 mrem.

In addition to TLDs, the ICP contractor uses a global positioning radiometric scanner system to conduct gamma radiation surveys. The global positioning radiometric scanner is mounted on a four-wheel drive vehicle. The two plastic scintillation detectors of the radiometric scanner measure gross gamma in counts per second with no coincidence corrections or energy compensation. Elevated count rates suggest possible areas of contamination or elevated background areas. Both global positioning system and radiometric data are continuously recorded. The vehicle is driven at approximately 8 km/hour (5 mph) to collect survey data (see Section 7.4, Waste Management Surveillance Sampling).

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. The results are expressed in mR ± 1 standard deviation. Onsite dosimeters were 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 2005 was 333 ± 23 mR at location RWMC 41. This dosimeter is located near active waste storage and management areas. The 2005 exposure is similar to that of previous years.

Locations Reactor Technology Complex (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 third of the values in 2002 (DOE-ID 2005).

The Idaho Nuclear Technology and Engineering Center (INTEC) 20 TLD is located near a radioactive material storage area with an exposure of 280 ± 19 mR. Exposures at INTEC 20 and the INTEC Tree Farm for 2005 were all comparable to historical exposures.



Table 7-10. Annual Environmental Radiation Exposures (2001-2005).[a]

Distant Group	2001		2002		2003		2004		2005	
	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors
Distant Group										
Aberdeen	152 ± 11	137 ± 10	141 ± 10	126 ± 9	123 ± 4	122 ± 9	130 ± 9	127 ± 9	124 ± 7	130 ± 9
Blackfoot[b]	145 ± 10	136 ± 9	125 ± 9	119 ± 9	117 ± 4	111 ± 8		109 ± 8	129 ± 9	113 ± 8
Blackfoot (CMS)[c]	134 ±7		113 ± 8		101 ± 4		108 ± 8		117 ± 2	
Craters of the Moon	137 ± 10	136 ± 9	121 ± 9	124 ± 9	116 ± 4	122 ± 9	118 ± 8	NS[d]	138 ± 8	122 ± 8
Dubois[e]			109 ± 8		98 ± 3		105 ± 7		117 ± 5	
Idaho Falls	147 ± 10	127 ± 9	126 ± 9	112 ± 8	126 ± 9	111 ± 8	124 ± 9	114 ± 8	122 ± 2	116 ± 8
Jackson[e]			97 ± 7		97 ± 7		100 ± 7		106 ± 7	
Minidoka	131 ± 9	122 ± 9	111 ± 8	107 ± 8	111 ± 8	104 ± 7	108 ± 8	107 ± 7	116 ± 3	112 ± 8
Rexburg	155 ± 11	131 ± 9	144 ± 10	115 ± 8	136 ± 5	116 ± 8	137 ± 10	118 ± 8	152 ± 2	121 ± 8
Roberts	157 ± 11	144 ± 11	134 ± 13	132 ± 9	126 ± 4	133 ± 9	133 ± 9	132 ± 9	126 ± 11	NS
Mean	**146 ± 4**	**133 ± 4**	**120 ± 3**	**119 ± 3**	**114 ± 2**	**117 ± 3**	**118 ± 3**	**118 ± 3**	**121 ± 3**	**119 ± 3**
Boundary Group										
Arco	143 ± 10	134 ± 9	126 ± 9	120 ± 9	113 ± 4	118 ± 8	124 ± 9	126 ± 9	124 ± 9	120 ± 8
Atomic City	147 ± 10	137 ± 9	130 ± 9	124 ± 9	120 ± 4	124 ± 9	132 ± 9	NS	132 ± 9	NS
Blue Dome[e]			106 ± 8		103 ± 4		104 ± 7		104 ± 7	
Howe	133 ± 9	130 ± 9	121 ± 9	NS[d]	109 ± 4	110 ± 8	121 ± 8	114 ± 8	121 ± 8	116 ± 8
Monteview	134 ± 10	120 ± 8	118 ± 8	115 ± 8	106 ± 4	112 ± 8	119 ± 8	116 ± 8	119 ± 8	121 ± 8
Mud Lake	151 ± 11	140 ± 10	136 ± 10	129 ± 9	124 ± 4	122 ± 8	130 ± 9	133 ± 9	130 ± 9	130 ± 8
Birch Creek Hydro	114 ± 8	107 ± 8	110 ± 8	104 ± 7	105 ± 4	105 ± 7	112 ± 8	108 ± 8	112 ± 8	NS
Mean	**137 ± 4**	**128 ± 4**	**124 ± 4**	**118 ± 4**	**113 ± 2**	**115 ± 3**	**120 ± 3**	**119 ± 4**	**120 ± 3**	**119 ± 4**

a. All values are in milliroentgens with ± 1 standard deviation.
b. The ESER contractor discontinued the Blackfoot location in 2005.
c. The INL contractor does not sample at the Blackfoot Community Monitoring Station (CMS).
d. Dosimeter was missing at one of the collection times.
e. These stations were added by the ESER contractor in 2002.

Table 7-11 summarizes the calculated effective dose equivalent an individual receives on the Snake River Plain from various background radiation sources.

The terrestrial portion of natural background radiation exposure 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 are not expected to 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 (Table 7-10). 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 2005, this resulted in a corrected dose of 70 mrem/year because of snow cover, which ranged from 2.54 to 25.4 cm (1 to 10 in.) in depth with an average of 17.7 cm (6.99 in.) over 78 days with recorded snow cover.

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 approximately 1500 m (4900 ft) (NCRP 1987). Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Table 7-11. Calculated Effective Dose Equivalent from Background Sources (2005).

Source of Radiation Dose Equivalent		Total Average Annual Dose[a]	
		Calculated	Measured
External			
	Terrestrial	70	NA[b]
	Cosmic	48	NA
	Subtotal	118	122
Internal			
	Cosmogenic	1	
	Inhaled Radionuclides	200	
	^{40}K and others	39	
	Subtotal	240	
Total		**358**	

a. All values are in millirem.
b. NA indicates terrestrial and cosmic radiation parameters were not measured individually.



The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2005 was 118 mrem (Table 7-11). This is slightly below the 127 mrem measured at distant locations by ESER and INL TLDs after conversion from mR to mrem in tissue. Measured values are very close and within normal variability, of the calculated background doses (Tables 7-10 and 7-11). 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 7-11 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 358 mrem shown in Table 7-11 and will vary from one location to another.

7.4 Waste Management Surveillance Sampling

Vegetation, soil, and direct radiation sampling are performed at RWMC, and direct radiation sampling is performed at Waste Experimental Reduction Facility in compliance 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 7-5. Crested wheatgrass and perennials are collected in odd-numbered years. Control samples are collected near Frenchman's Cabin (Figure 7-6). Due to recontouring and construction activities at the RWMC, perennials were not available for sampling in 2005.

The vegetation samples were analyzed for gamma-emitting radionuclides, ^{90}Sr and alpha-emitting transuranics. Americium-241 was detected in four samples, with the maximum activity of 0.0033 pCi/g measured at the control location. Plutonium-239/240 was detected in one sample collected on the SDA with an activity of 0.001 pCi/g. The concentrations were all within the background range for the INL Site and surrounding areas and are attributable to past fallout. No gamma-emmitting radionuclides were detected.



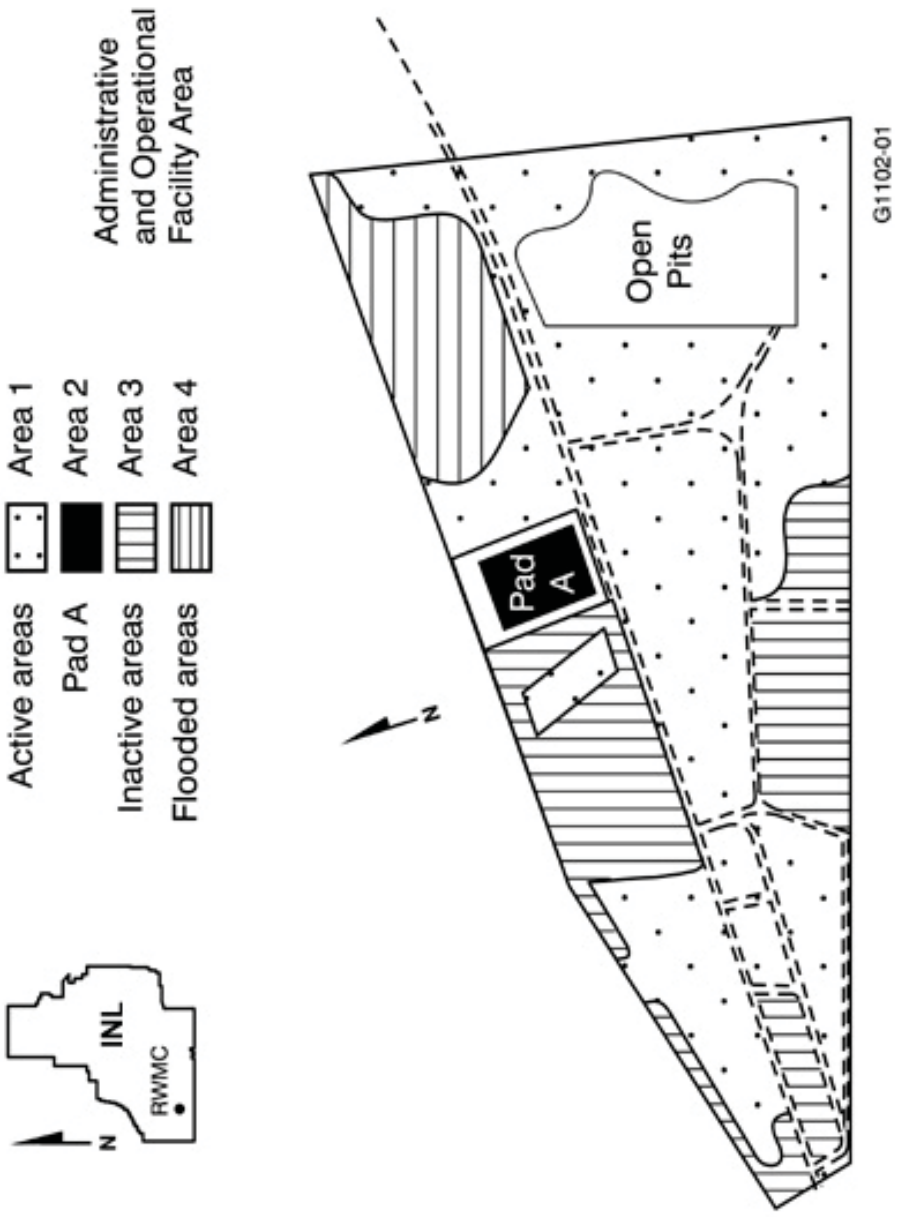

Figure 7-5. Four Major Areas of the RWMC used for ICP Waste Management Vegetation Collection.



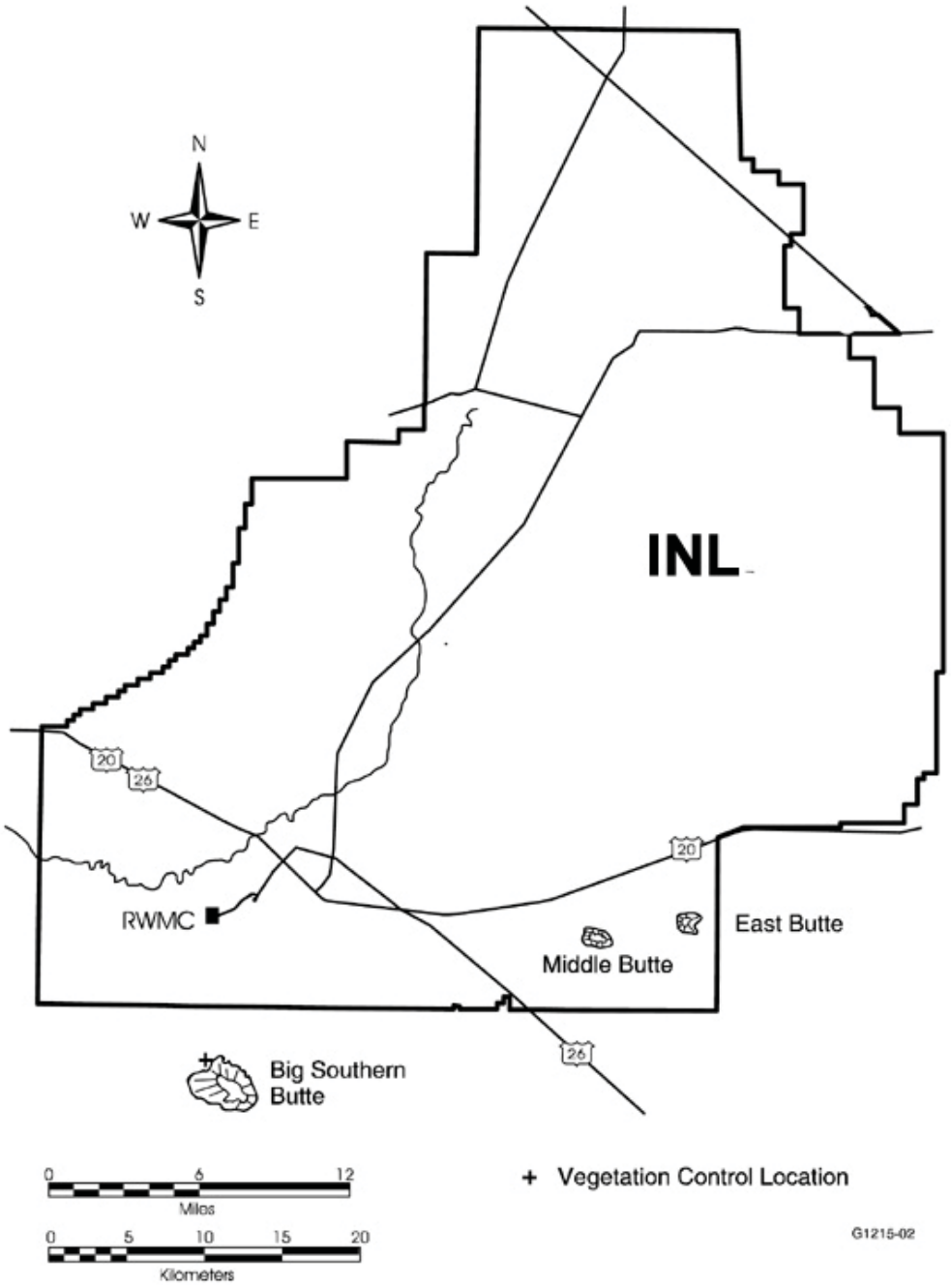

Figure 7-6. Vegetation Control Sample (RWMC—Frenchman's Cabin).



Soil Sampling

Soil samples are collected every three years at the RWMC. Soil samples were collected during 2003; thus, no RWMC soil samples were collected in 2005.

Direct Radiation

The radiometric scanner system was used to conduct soil surface radiation (gross gamma) surveys at the SDA to complement soil sampling. The global positioning radiometric scanner is mounted on a four-wheel drive vehicle. The system includes two plastic scintillators that measure gross gamma in counts per second with no coincidence corrections or energy compensation (elevated count rates indicate possible areas of contamination or elevated background). Both the global positioning system and radiometric data are continuously recorded.

Figure 7-7 shows the radiation readings from the 2005 RWMC annual survey. The maximum activity was 30,200 cps and located near the west perimeter of the active pit. The readings around the active pit ranged from 2100 to 30,200 cps (see Table 7-12), which are higher than historical measurements for that area, and are due to increased waste handling at the active Accelerated Retrieval Project, and the Intermediate Level Transuranic Storage Facility. The maximum activity at the west end of the Trench #58 was 24,800 counts per second (cps) and is comparable to previous years' measurements.

Pad A cannot be surveyed via the global positioning radiometric scanner because of driving restrictions.

Table 7-12. RWMC Radiation Survey, 2002-2005.

Location	CY 02[a]	CY 03[a]	CY 04[a]	CY 05[a]
Trench #58	34,200	30,000	25,600	24,800
Active Pit	1700 to 23,000	1900 to 13,800	1900 to 15,000	2100 to 30,200

a. Units in counts per second.



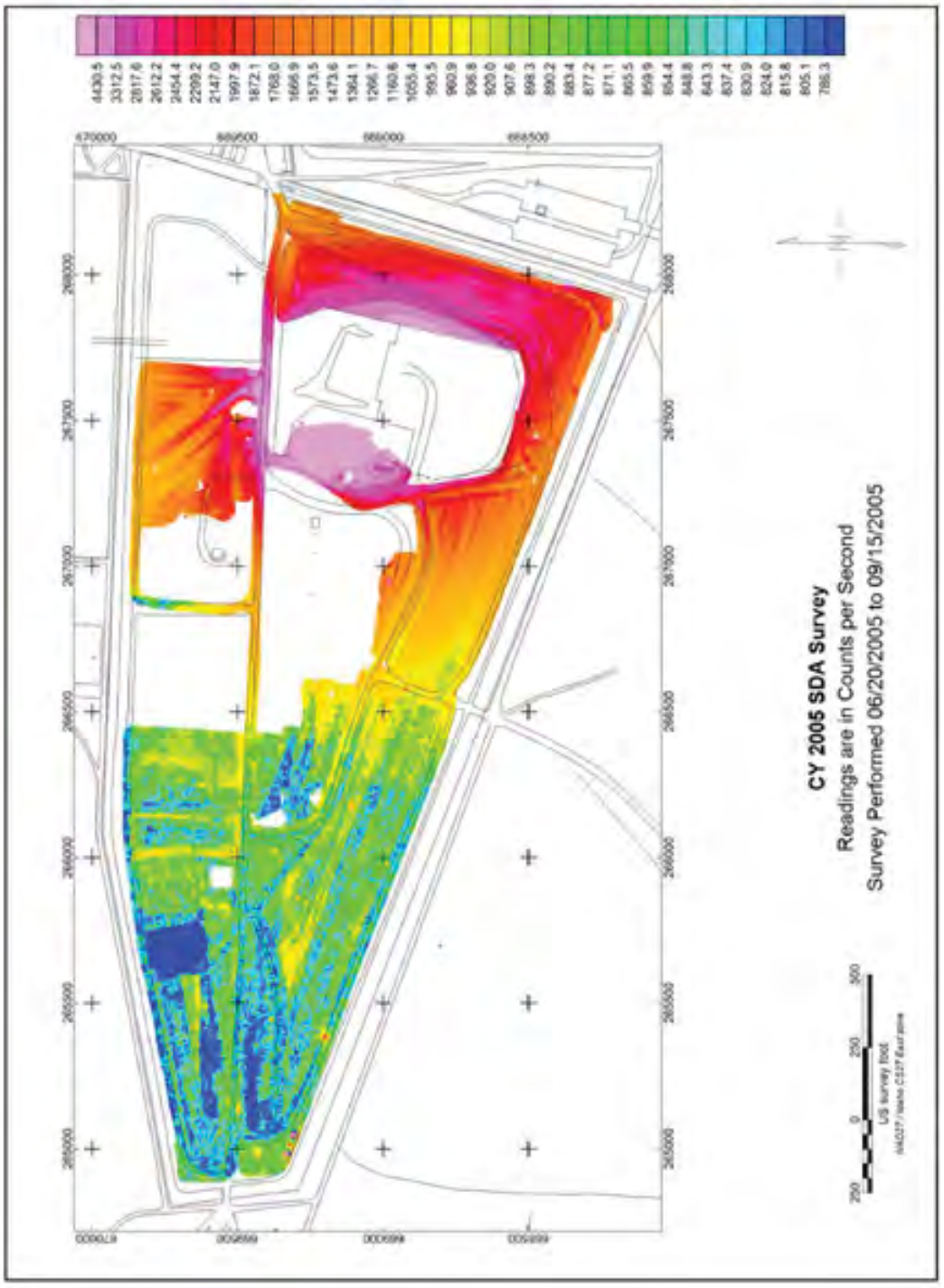

Figure 7-7. RWMC Surface Radiation Survey 2005.



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Chapter 8 - Dose to the Public and Biota

M. Case and R. Mitchell - S. M. Stoller Corporation
R. Eckman - National Oceanic and Atmospheric Administration Air Resources Laboratory, Field Research Division

Chapter Highlights

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. Two different computer models were used to estimate doses: Clean Air Act Assessment Program 1988 (CAP-88) and the mesoscale diffusion (MDIFF) air dispersion model. CAP-88 is required by the U.S. Environmental Protection Agency to demonstrate compliance with the Clean Air Act. The National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division developed MDIFF to evaluate dispersion of pollutants in arid environments such as those found at the INL Site. The maximum calculated dose to an individual by either of the methods was well below the applicable radiation protection standard of 10 mrem/year. The dose to the maximally exposed individual, as determined by the CAP-88 program, was 0.077 mrem (0.77 μSv). The dose calculated using the MDIFF values was 0.041 mrem (0.41 μSv). The maximum potential population dose to the approximately 281,495 people residing within a 80-km (50-mi) radius of any INL Site facility was 0.565 person-rem (5.7×10^{-3} person-Sv), well below that expected from exposure to background radiation.

Using the maximum radionuclide concentrations in collected waterfowl, game animals, and doves, a maximum potential dose from ingestion was calculated. The maximum potential dose was estimated to be 0.19 mrem (1.9 μSv) for waterfowl and 0.005 mrem (0.05 μSv) for game animals. No potential dose would result from consuming doves collected in 2005.

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

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 2005 radionuclide concentrations from operations at the Idaho National Laboratory (INL) Site.

8.1 General Information

Individual radiological impacts to the public surrounding the INL Site remain 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 2005, this was accomplished for the radionuclides summarized in Table 4-2.

The following estimates were calculated:

- 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, 1988 (CAP-88) computer code as required by the regulation (Cahki and Parks 2000)
- The effective dose equivalent to the MEI residing offsite using dispersion values from the mesoscale diffusion (MDIFF) model (Sagendorf et al. 2001) to comply with DOE Orders
- The collective effective dose equivalent (population dose) for the population within 80 km (50 mi) of any INL Site facility to comply with DOE Order 5400.5. The estimated population dose was based on the effective dose equivalent calculated from the MDIFF air dispersion model for the MEI.

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. U.S. Environmental Protection Agency (EPA) dose conversion factors and a 50-year integration period were used in calculations in combination with the MDIFF air dispersion model for internally deposited radionuclides (Eckerman et al. 1988) and for radionuclides deposited on the ground surface



(Eckerman and Ryman 1993). The CAP-88 computer code uses dose and risk tables developed by the EPA. 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. The CAP-88 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.

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, the MEI dose is determined through the use of computer codes of atmospheric dispersion of airborne materials.

8.2 Maximum Individual Dose - Airborne Emissions Pathway

Summary of Computer Codes

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 the code CAP-88 as recommended in 40 CFR 61 to demonstrate NESHAP compliance.

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 curves are more appropriate for estimating dose to the public caused by INL Site emissions than those used by the CAP-88 code. The MDIFF code is a dispersion model only and does not account for plume depletion and radioactive decay.

The MDIFF model is used to calculate total integrated concentrations (TICs) that are then used to calculate the dose to members of the public residing near the INL Site. In previous years, doses calculated from the MDIFF TICs have been somewhat higher than doses calculated using CAP-88. 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-88 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 may not agree 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).

CAP–88 Computer Code

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 2005 INL Report for Radionuclides* (DOE-ID 2006). For these calculations, 63 potential maximum locations were evaluated. The CAP-88 computer code predicted the highest dose to be at Frenchman's Cabin, located at the southern boundary of the INL Site. 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 0.077 mrem (0.77 μSv) was calculated. The dose of 0.077 mrem (0.77 μSv) is well below the whole body dose limit of 10 mrem (100 μSv) for airborne releases of radionuclides established by 40 CFR 61.

MDIFF Model

Using data gathered continuously at 36 meteorological stations on and around the INL Site and the MDIFF model, the NOAA ARL-FRD prepares a mesoscale map (Figure 8-1) showing the calculated 2005 time integrated concentrations (TICs). These TICs are based on a unit release rate weighted by percent contribution for each of eight INL Site facilities: Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Naval Reactors Facility (NRF), Critical Infrastructure Test Range Complex (CITRC), Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN). To create the isopleths shown in Figure 8-1, the TIC values are contoured. Average air concentrations (in curies per cubic meter [Ci/m^3]) for a radionuclide released from a facility are estimated from a TIC isopleth (line of equal air concentration) in Figure 8-1. To calculate the average air concentration, the TIC is 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 $(8760 \text{ hour})^2$ or $7.67 \times 10^7 \text{ hour}^2$. This does not account for plume depletion, radioactive decay, or in-growth or decay of radioactive progeny.

The average air concentrations calculated by MDIFF were input into a Microsoft Excel spreadsheet program developed by the Environmental Surveillance, Education and Research (ESER) Program



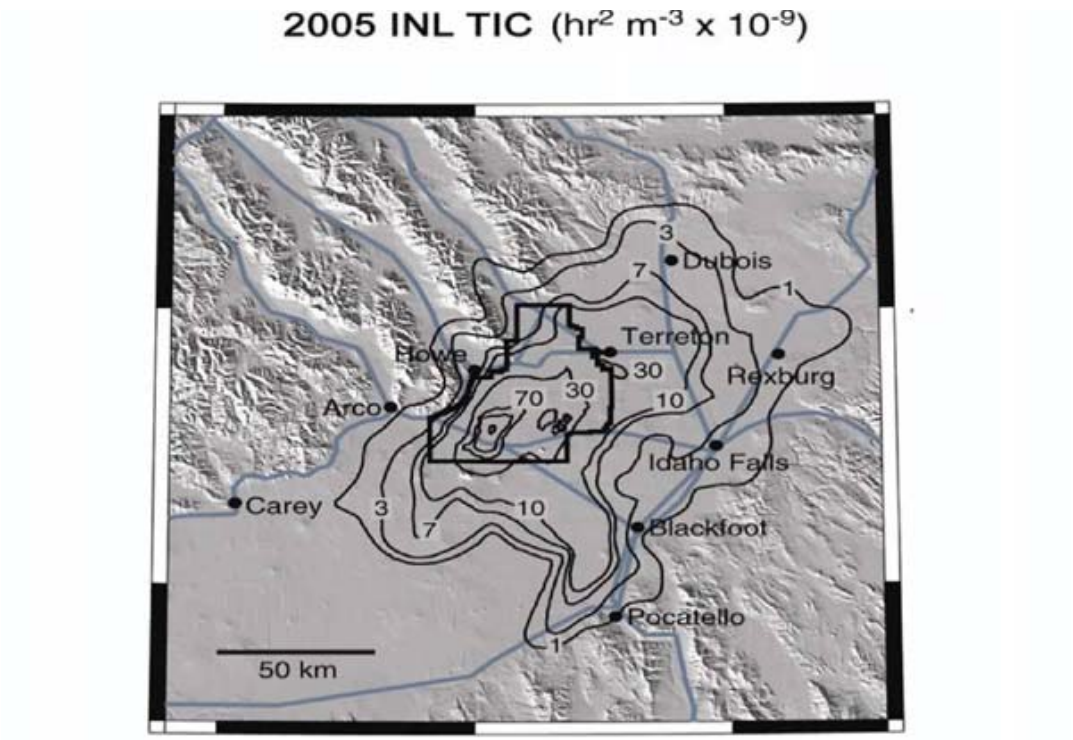

Figure 8-1. Average Mesoscale Isopleths of Total Integrated Concentrations at Ground Level Normalized to Unit Release Rates from all INL Site Facilities.

to calculate doses using methods outlined in U.S. Nuclear Regulatory Commission (NRC 1977) and dose conversion factors provided by EPA (EPA 2002). In 2000, a revision to the methods and values used for the calculation of the MEI dose using the MDIFF TIC values was undertaken. Values for the deposition and plant uptake rates of radionuclides, most noticeably radioiodines, were modified to reflect present operations and current values in use. The most notable change, mathematically, is the increase of the iodine-129 (^{129}I) deposition velocity from 0.01 m/second (0.03 ft/second) to 0.035 m/second (0.11 ft/second), as the emitted radioiodines went from predominantly organic in nature to elemental. These changes resulted in a mathematical increase in the amount of radionuclides deposited on the ground and available for plant uptake. This increase in deposited radionuclides leads to a corresponding net increase in the ingestion dose.

The MDIFF model predicted that the highest TIC for radionuclides in air at a location with a year-round resident during 2005 would have occurred northwest of Mud Lake. The maximum hypothetical dose was calculated for an adult resident at that location from inhalation of air, submersion in air, ingestion of radioactivity on leafy vegetables, and exposure because of deposition of radioactive particles on the ground. The calculation was based on data presented in Table 4-2 and the grid used to produce Figure 8-1.



Table 8-1. TIC, Travel Time, and Distance from Each Facility to the MEI Location.

Facility	Total Integrated Concentration (hr^2/m^3)	Travel Time hours	Distance km (miles)
CFA	2.59×10^{-8}	2.40	47.0 (29.2)
INTEC	2.18×10^{-8}	2.64	43.0 (26.7)
MFC	2.39×10^{-8}	1.61	30.0 (18.6)
NRF	4.84×10^{-8}	2.00	34.4 (21.4)
CITRC	2.74×10^{-8}	2.81	41.7 (25.9)
RTC	2.60×10^{-8}	2.35	44.3 (27.5)
RWMC	2.32×10^{-8}	3.29	55.0 (34.2)
TAN	2.71×10^{-7}	0.68	10.7 (6.7)

Using the largest calculated TIC for each facility (Table 8-1) at the location inhabited by a full-time resident, and allowing for radioactive decay and plume depletion during the transit of the radionuclides from each facility to the location of the MEI (northwest of Mud Lake), the potential annual effective dose equivalent from all radionuclides released was calculated to be 0.041 mrem (0.41 μSv) (Table 8-2). This dose is well below the whole body dose limit of 10 mrem set in the 40 CFR 61 for airborne releases of radionuclides.

For 2005, the ingestion pathway was the primary route of exposure and accounted for 72 percent of the total dose, followed by inhalation at 26 percent, and immersion at 2 percent. Deposition accounted for only 0.22 percent of the dose.

Radionuclide releases for 2005 are presented in Figure 8-2. The noble gas krypton-85 (^{85}Kr) accounted for approximately 78 percent of the total release, followed by argon-41 (^{41}Ar) with 9 percent, and tritium at 8 percent of the total. The noble gases xenon-133 (^{133}Xe) and -135 (^{135}Xe) contributed 0.4 and 0.3 percent, respectively. However, because these are noble gases they contribute very little to the cumulative dose (affecting immersion only). Other than ^{41}Ar and tritium (^{3}H), the radionuclides contributing to the overall dose were 0.02 percent of the total radionuclides released.

The largest contributor to the MEI dose was cesium-137 (^{137}Cs), accounting for 37.3 percent of the total dose (Figure 8-3). This was followed by strontium-90 (^{90}Sr) at 21.6 percent and americium-241 (^{241}Am) at 11.6 percent. Isotopes of plutonium (plutonium-238 [^{238}Pu], plutonium-239 [^{239}Pu], plutonium-240 [^{240}Pu], and plutonium-241 [^{241}Pu]) contributed a total of 15.1 percent to the dose.

The respective contribution to the overall dose by facility is as follows: TAN (45 percent), INTEC (35 percent), RTC (16 percent), and RWMC (3 percent). NRF contributed approximately 0.13 percent



Table 8-2. Maximum Individual Effective Dose Equivalent as Calculated from MDIFF Model Results (2005).

Radionuclide[a]	Radionuclide Concentration in Air at Maximum Offsite Location[b] (Ci/m^3)	Maximum Effective Dose Equivalent	
		mrem	mSv
^{137}Cs + D[c,d]	3.64 x 10^{-16}	1.53 x 10^{-2}	1.53 x 10^{-4}
^{90}Sr + D[d]	5.71 x 10^{-17}	8.89 x 10^{-3}	8.89 x 10^{-5}
^{241}Am	7.12 x 10^{-19}	4.75 x 10^{-3}	4.75 x 10^{-5}
^{239}Pu	7.95 x 10^{-19}	3.83 x 10^{-3}	3.83 x 10^{-5}
^{129}I[c]	8.95 x 10^{-18}	2.77 x 10^{-3}	2.77 x 10^{-5}
^{240}Pu	1.88 x 10^{-19}	1.00 x 10^{-3}	1.00 x 10^{-5}
^{152}Eu	1.11 x 10^{-16}	8.21 x 10^{-4}	8.21 x 10^{-6}
^{241}Pu	4.31 x 10^{-18}	6.74 x 10^{-4}	6.74 x 10^{-6}
^{154}Eu	6.28 x 10^{-17}	6.55 x 10^{-4}	6.55 x 10^{-6}
^{238}Pu	1.59 x 10^{-19}	6.52 x 10^{-4}	6.52 x 10^{-6}
^{41}Ar	7.70 x 10^{-14}	5.84 x 10^{-4}	5.84 x 10^{-6}
^{131}I	9.51 x 10^{-17}	5.03 x 10^{-4}	5.03 x 10^{-6}
^{60}Co	1.84 x 10^{-18}	1.70 x 10^{-4}	1.70 x 10^{-6}
^{3}H (tritium)	2.49 x 10^{-13}	1.37 x 10^{-4}	1.37 x 10^{-6}
All Others	NA	2.78 x 10^{-4}	2.78 x 10^{-6}
Total		**4.11 x 10^{-2}**	**4.11 x 10^{-4}**

a. Table includes only radionuclides that contribute a dose of 1.0 x 10^{-4} mrem or more.
b. Estimate of radioactive decay is based on a transport time from each facility using the distance to MEI location and the average wind speed in that direction from each facility.
c. Concentration adjusted for plume depletion.
d. When indicated (+D), the contribution of progeny decay products was also included in the dose calculations.

of the 2005 total dose, while MFC contributed about 0.11 percent. CFA and CITRC each accounted for less than 0.01 percent of the total 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 358 mrem (Table 7-12).



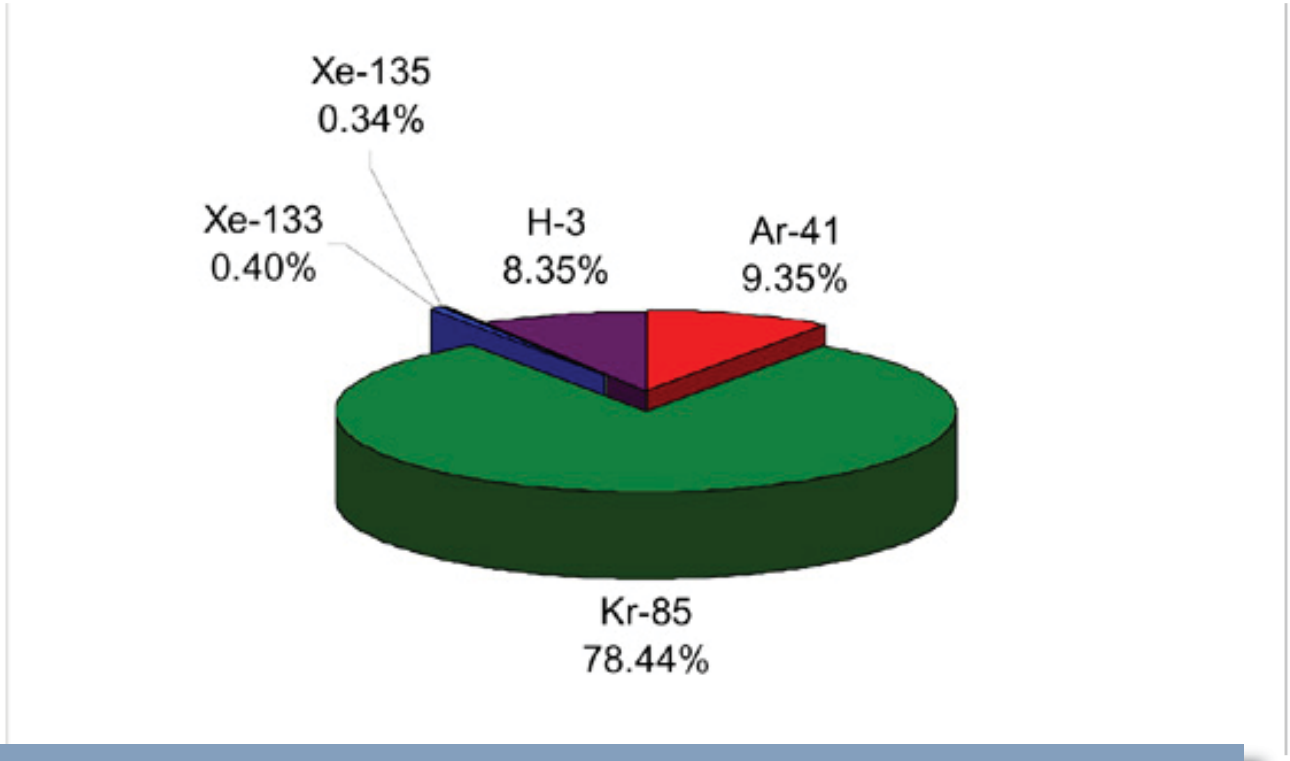

Figure 8-2. Radionuclides Released to the Environment (2005).

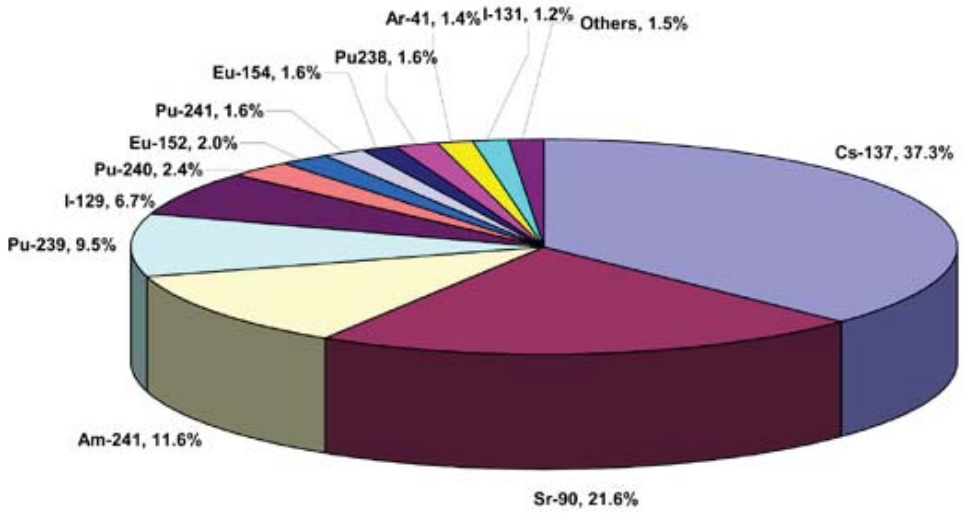

Figure 8-3. Radionuclides Contributing to Maximum Individual Dose (as calculated using the MDIFF air dispersion model) (2005).



Table 8-3 summarizes the calculated annual effective dose equivalents for 2005 from INL Site operations using both the CAP-88 and MDIFF air dispersion computer codes. A comparison is shown between these doses and the EPA airborne pathway standard and the estimated dose from natural background. The reasons for the disparity in the MDIFF and CAP-88 doses are a result of the changes made to the calculations discussed above.

8.3 80 Kilometer (50 Mile) Population Dose

As with the calculation of the maximum individual dose, the determination of the population dose also underwent changes in 2000. Using the power of a geographical information system (ArcView), annual population no longer needs to be distributed using growth estimations and a specialized computer code. In addition to this simplification, the population dose is now calculated for the

Table 8-3. Summary of Annual Effective Dose Equivalents Due to INL Site Operations (2005).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF[c]
Dose	0.077 mrem 7.7×10^{-4} mSv	0.041 mrem 4.1×10^{-4} mSv	0.565 person-rem 5.7×10^{-3} person-Sv
Location	Frenchman's Cabin	Northwest of Mud Lake	Area with 80 km (50 mi) of any INL Site facility
Applicable radiation protection standard[d]	10 mrem (0.1 mSv)	10 mrem (0.1 mSv)	No standard
Percentage of standard	0.77 percent	0.41 percent	No standard
Natural background	358 mrem (3.6 mSv)	358 mrem (3.6 mSv)	102,439 person-rem (1024 person-Sv)
Percentage of background	0.022 percent	0.011 percent	0.0006 percent

a. Hypothetical dose to a maximally exposed individual residing near the INL Site.
b. Effective dose equivalent calculated using the CAP-88 code.
c. Effective dose equivalent calculated using MDIFF air dispersion model dispersion coefficients.
d. Although the DOE standard for all exposure models is 100 mrem/year 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.



population within an 80 km (50 mi) radius of any INL Site facility. This takes into account the changes in facility operations, in that the INTEC is not always the single largest contributor of radionuclides released.

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 an INL Site facility. 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 8-4).

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 2005 MDIFF TIC 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 8-4). The estimated potential population dose was 0.565 person-rem (5.7×10^{-3} person-Sv) to a population of approximately 286,144. When compared with an approximate population dose of 102,439 person-rem (1024 person-Sv) from natural background radiation, this represents an increase of only about 0.0005 percent. The largest collective doses are found in the Idaho Falls and Pocatello census divisions due to their greater populations.

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, INTEC, 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.



Table 8-4. Dose to Population within 80 Kilometers (50 Miles) of INL Site Facilities (2005).

Census Division[a]	Population[b]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3418	2.24×10^{-3}	2.24×10^{-5}
Alridge	687	9.77×10^{-5}	9.77×10^{-7}
American Falls	3539	7.48×10^{-4}	7.48×10^{-6}
Arbon (part)	30	3.14×10^{-5}	3.14×10^{-7}
Arco	2383	3.29×10^{-2}	3.29×10^{-4}
Atomic City (division)	3383	3.10×10^{-2}	3.10×10^{-4}
Blackfoot	13,403	1.59×10^{-2}	1.59×10^{-4}
Carey (part)	1143	1.16×10^{-3}	1.16×10^{-5}
East Clark	74	1.14×10^{-4}	1.14×10^{-6}
Firth	3463	2.40×10^{-3}	2.40×10^{-5}
Fort Hall (part)	1967	3.09×10^{-3}	3.09×10^{-5}
Hailey-Bellevue (part)	5	8.32×10^{-11}	8.32×10^{-13}
Hamer	2347	4.93×10^{-2}	4.93×10^{-4}
Howe	340	1.18×10^{-2}	1.18×10^{-4}
Idaho Falls	80,314	1.00×10^{-1}	1.00×10^{-3}
Idaho Falls, west	1839	6.47×10^{-3}	6.47×10^{-5}
Inkom (part)	593	3.41×10^{-4}	3.41×10^{-6}
Island Park (part)	83	1.08×10^{-4}	1.08×10^{-6}
Leadore (part)	4	1.05×10^{-7}	1.05×10^{-9}
Lewisville-Menan	4176	1.77×10^{-2}	1.77×10^{-4}
Mackay (part)	1143	4.22×10^{-6}	4.22×10^{-8}
Moody (part)	5055	2.70×10^{-3}	2.70×10^{-5}
Moreland	9703	7.08×10^{-2}	7.08×10^{-4}
Pocatello (part)	80,990	1.11×10^{-1}	1.11×10^{-3}
Rexburg (part)	21,391	2.96×10^{-2}	2.96×10^{-4}
Rigby	12,879	2.55×10^{-2}	2.55×10^{-4}
Ririe	1528	5.04×10^{-4}	5.04×10^{-6}
Roberts	1731	1.10×10^{-2}	1.10×10^{-4}
Shelley	7487	9.56×10^{-3}	9.56×10^{-5}
South Bannock (part)	302	3.33×10^{-4}	3.33×10^{-6}
St. Anthony (part)	2298	2.91×10^{-3}	2.91×10^{-5}
Sugar City	5720	1.13×10^{-2}	1.13×10^{-4}
Swan Valley (part)	5291	3.71×10^{-4}	3.71×10^{-6}
Ucon	6126	1.14×10^{-2}	1.14×10^{-4}
West Clark	1309	2.45×10^{-3}	2.45×10^{-5}
Totals	**286,144**	**0.565**	**5.7×10^{-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 2006 based on county population growth from 1960 to 2000.



Waterfowl

A study was initiated in 1994 to obtain data on the potential doses from waterfowl using INL Site wastewater disposal ponds. This study focused on the two hypalon-lined evaporation ponds at RTC that replaced the percolation ponds formerly used for disposal of wastewater at that facility (Warren et al. 2001).

In the summer of 2005, three ducks were collected from the RTC wastewater ponds, three were collected from wastewater ponds at the MFC, and three were collected from an offsite location (near Firth, Idaho) as controls. The maximum potential dose from eating 225 g (8 oz) of meat from ducks collected in 2005 is presented in Table 8-5. Radionuclide concentrations used to determine these doses are reported in Table 7-4. Doses from consuming waterfowl are based on the assumption that ducks are eaten immediately after leaving the ponds.

The maximum potential dose of 0.19 mrem (1.9 µSv) from these waterfowl samples, while higher than those in the past few years, 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-

Table 8-5. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue using INL Site Wastewater Disposal Ponds in 2005.[a]

Radionuclide	RTC Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)
^{241}Am	0	2.40×10^{-4}
^{60}Co	1.53×10^{-3}	0
^{137}Cs	1.87×10^{-1}	0
^{90}Sr	4.36×10^{-4}	1.68×10^{-4}
^{65}Zn	1.19×10^{-3}	0
Total Dose	**1.91×10^{-1}**	4.08×10^{-4}

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

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



lined radioactive wastewater ponds but from the adjacent sewage lagoons. However, the birds likely used the radioactive wastewater ponds during the approximate two-week period they were observed in the area.

Mourning Doves

No manmade radionuclides were found in any of the three mourning dove samples collected in 2005. Therefore, there was no potential dose from manmade radionuclides received from eating these doves.

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 2005 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 was approximately 0.005 mrem (0.05 µSv).

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

8.5 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 general 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:

(1) Consider using mean concentrations of radionuclides rather than maxima

(2) Consider refining the evaluation area

(3) Consider using site-specific information for lumped parameters, if available

(4) Consider using a correction factor other than 100 percent for residence time and spatial usage in favor of more realistic assumptions

(5) Consider developing and applying more site-specific information about food sources, uptake, and intake

(6) 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 2005 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 (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 8-6).



Table 8-6. Radionuclides that can currently be evaluated using the graded approach (DOE 2003) compared to those detected in soil or water on the INL.

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.



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 for 2005 were for ^{129}I and tritium in CFA effluents, ^{226}Ra in INTEC effluents, ^{226}Ra, ^{137}Cs, and uranium isotopes in the MFC industrial waste pond ditch and sanitation lagoon, and ^{90}Sr in TAN effluents (Table 8-7) (see Morris 2003 for a detailed description of the assessment procedure). These data were combined in a Site-wide general screening analysis. The combined sum of fractions was greater than one and failed the first screening test due to the high concentration of ^{226}Ra.

Assuming dilution in the pond, the scenario was re-evaluated using an average concentration of radionuclides in the effluent rather than a maximum. This value (1.54) also failed the screen.

A "riparian animal" was identified as the critical organism. Although the ponds are typically lined and not attractive to riparian animals, and are surrounded by chain link fencing, it was conservatively assumed that a raccoon frequents the ponds at night approximately 50 percent of the time. The resulting estimate (0.77) passed the third screen.

Terrestrial Evaluation

For the initial terrestrial evaluation, we used maximum concentrations from the management and operating (M&O) contractor 2005 soil sampling (see Morris 2003 for a detailed description of the assessment procedure). These concentrations passed the initial screen (Table 8-8).

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



Table 8-7. Biota Dose Assessment of Aquatic Ecosystems on the INL.

Nuclide	Water BCG[a] (pCi/L)	Effluent Concentration (pCi/L)	Partial Fraction[b]	Sediment BCG (pCi/g)	Sediment Concentration[c] (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
First Screening[f]							
Cs-137	4.59E+00	4.26E+01	1.08E-01	2.30E+00	3.12E+03	7.34E-04	1.09E-01
H-3	4.61E+03	2.65E+08	1.74E-05	4.61E-03	3.74E+05	1.23E-08	1.74E-05
I-129	1.72E-01	3.84E+04	4.47E-06	1.72E-03	2.86E+04	6.01E-08	4.53E-06
Ra-226	1.91E+01	4.08E+00	4.69E+00	1.34E+00	1.01E+02	1.32E-02	4.70E+00
Sr-90	1.44E+01	2.78E+02	5.17E-02	4.32E-01	5.82E+02	7.42E-04	5.24E-02
U-233/234	4.51E+00	6.76E+02	6.67E-03	2.26E-01	5.28E+03	4.27E-05	6.71E-03
U-238	2.00E+00	7.56E+02	2.65E-03	1.00E-01	2.49E+03	4.02E-05	2.69E-03
						Combined Sum of Fractions	**4.87E+00**
Second Screening[f]							
Cs-137	2.48E+00	4.27E+01	5.81E-02	1.24E+00	3.13E+03	3.96E-04	5.85E-02
H-3	4.61E+03	2.65E+08	1.74E-05	4.61E-03	3.75E+05	1.23E-08	1.74E-05
I-129	1.72E-01	3.85E+04	4.47E-06	1.72E-03	2.86E+04	6.01E-08	4.53E-06
Ra-226	6.01E+00	4.08E+00	1.47E+00	4.21E-01	1.01E+02	4.16E-03	1.47E+00
Sr-90	1.00E-01	2.79E+02	3.59E-04	3.00E-03	5.83E+02	5.15E-06	3.64E-04
U-233/234	4.51E+00	6.77E+02	6.66E-03	2.26E-01	5.28E+03	4.27E-05	6.70E-03
U-238	2.00E+00	7.57E+02	2.64E-03	1.00E-01	2.49E+03	4.02E-05	2.68E-03
						Combined Sum of Fractions	**1.54E+00**
Third Screening (assume limiting organism is racoon foraging at night)[f]							
Cs-137	1.24E+00	4.27E+01	2.90E-02	2.48E-01	3.13E+03	7.92E-05	2.91E-02
H-3	2.31E+03	2.65E+08	8.70E-06	9.22E-04	3.75E+05	2.46E-09	8.70E-06
I-129	8.60E-02	3.85E+04	2.23E-06	3.44E-04	2.86E+04	1.20E-08	2.25E-06
Ra-226	3.01E+00	4.08E+00	7.37E-01	8.41E-02	1.01E+02	8.33E-04	7.37E-01
Sr-90	5.00E-02	2.79E+02	1.79E-04	6.00E-04	5.83E+02	1.03E-06	1.80E-04
U-233/234	2.26E+00	6.77E+02	3.33E-03	4.51E-02	5.28E+03	8.54E-06	3.34E-03
U-238	1.00E+00	7.57E+02	1.32E-03	2.00E-02	2.49E+03	8.03E-06	1.33E-03
						Combined Sum of Fractions[g]	**7.71E-01**

a. Biota concentration guide.
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.



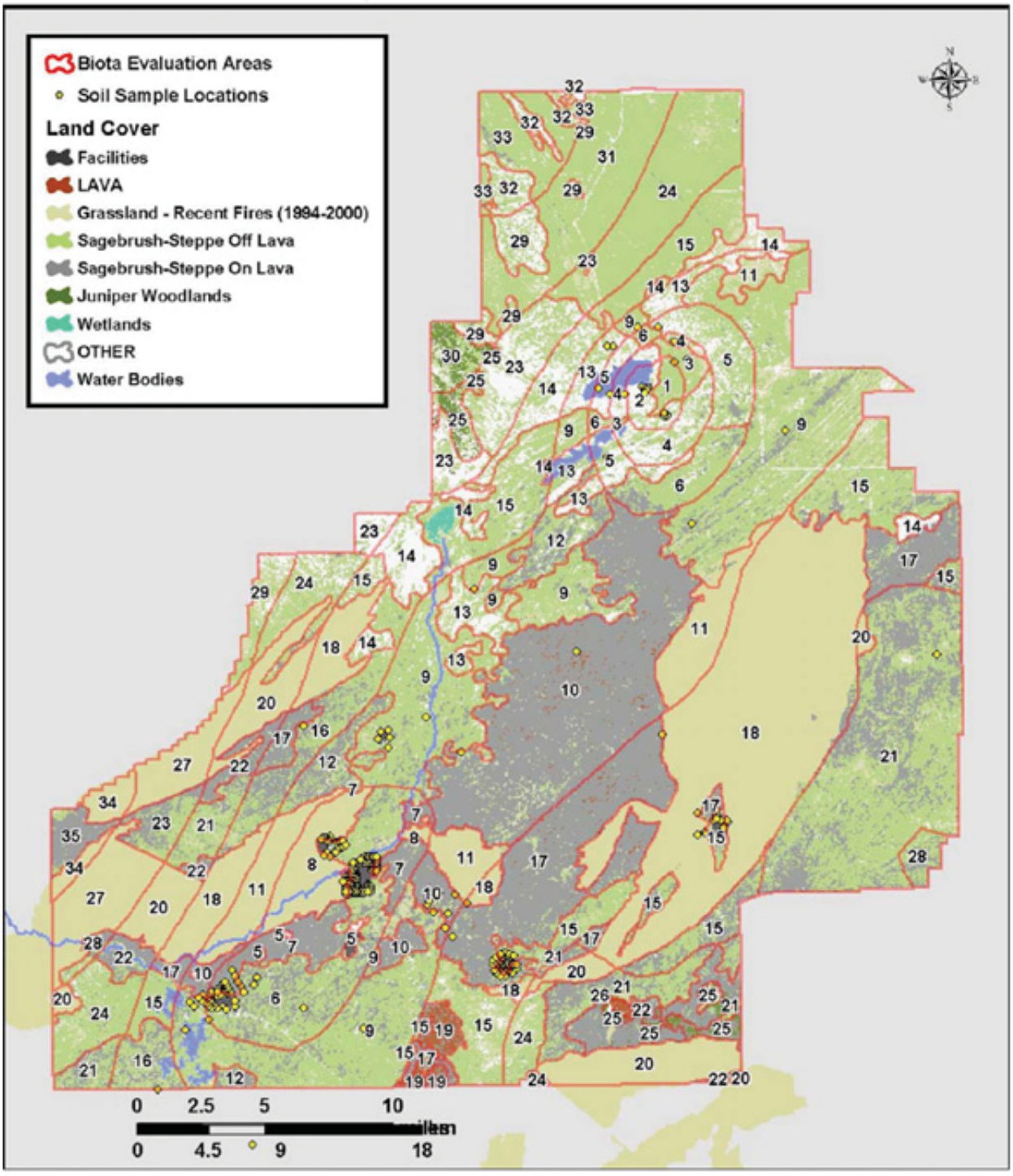

Figure 8-4. Evaluation Areas and Current Soil Sampling Locations on the INL. Areas with the same number are in the same evaluation area (Morris 2003).



Table 8-8. Biota Dose Assessment of Terrestrial Ecosystems on the INL.

Nuclide	Water BCG[a] (pCi/L)	Effluent Concentration (pCi/L)	Partial Fraction[b]	Soil BCG[c] (pCi/g)	Soil Concentration (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
Am-241	2.02E+05	0.00E+00	0.00E+00	3.89E+03	1.20E-02	3.08E-06	3.08E-06
Cs-137	5.99E+05	4.59E+00	7.67E-06	2.08E+01	6.43E+00	3.10E-01	3.10E-01
H-3	2.31E+08	4.61E+03	2.00E-05	1.74E+05	0.00E+00	0.00E+00	2.00E-05
I-129	5.70E+06	1.72E-01	3.02E-08	5.67E+03	0.00E+00	0.00E+00	3.02E-08
Pu-238	1.89E+05	0.00E+00	0.00E+00	5.27E+03	2.50E-02	4.74E-06	4.74E-06
Pu-239	2.00E+05	0.00E+00	0.00E+00	6.11E+03	2.90E-02	4.74E-06	4.74E-06
Ra-226	8.11E+03	1.91E+01	2.36E-03	5.06E+01	0.00E+00	0.00E+00	2.36E-03
Sr-90	5.45E+04	1.44E+01	2.64E-04	2.25E+01	7.10E-01	3.16E-02	3.19E-02
U-233	4.01E+05	4.51E+00	1.13E-05	4.83E+03	0.00E+00	0.00E+00	1.13E-05
U-238	4.06E+05	2.00E+00	4.93E-06	1.58E+03	0.00E+00	0.00E+00	4.93E-06
						Combined Sum of Fractions[e]	**3.44E-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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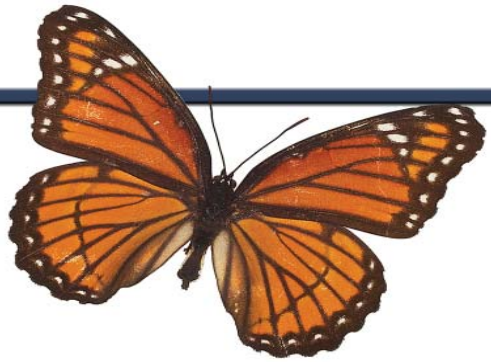
Western Meadowlark




Viceroy

Chapter 9 - Ecological Research at the Idaho National Laboratory Site

R. Blew and M. Case - S. M. Stoller Corporation

Chapter Highlights

The Idaho National Laboratory (INL) was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems. The NERPs provide rich environments for training researchers and introducing the public to ecological sciences. NERPs have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

Ecological research at the INL 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 better land use planning, 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 activities took place at the Idaho NERP during 2005:

- Survival rates of rattlesnakes in southeastern Idaho
- Fine-scale movement patterns of coyotes (*Canis latrans*) on the INL
- Seasonal and landscape variation of snake mortality on the Upper Snake River Plain
- The Protective Cap/Biobarrier Experiment
- Spatial patterns of species diversity
- Employing unmanned aerial vehicles for monitoring habitat and species in sagebrush-steppe ecosystems

9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

The Idaho National Laboratory (INL) Site was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in response to recommendations from citizens, scientists and members of Congress to set aside land 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 scaled 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 NERPs 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 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 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 oldest vegetation data sets in the West. 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. The Idaho NERP facilitates ecological research on the INL by attracting new researchers, providing background data to support new research project development, and providing logistical support for assisting researcher access to the INL. 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 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 2005.

9.1 Survival Rates of Rattlesnakes in Southeastern Idaho.

Investigators and Affiliations

Scott Cambrin, Graduate Student, Herpetology Laboratory, Department of Biological Sciences, Idaho State University (ISU), Pocatello, ID

Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, ISU, Pocatello, ID

Funding Sources

Idaho State University Graduate Student Research and Scholarship Committee

U.S. Department of Energy Idaho Operations Office

Background

This project was designed to find the survival rates of rattlesnakes on the INL. A study of survival on the INL will determine what survival rates should be in a pristine sagebrush-steppe ecosystem. More detail is needed on neonatal rattlesnakes as they have been the hardest age class to calculate an accurate survival estimate. The main goal of this project is to determine survival rates at each den site and compare the three main dens to look for variation and potential causes of that variation.



Information from this project is important to the U.S. Department of Energy (DOE) for several reasons: (1) it will produce actual survival rates for each den site and for different age classes for the rattlesnakes on the INL; (2) it will look at the causes of mortality over winter; and (3) it can be used in conjunction with two other projects to create a population viability analysis of the rattlesnakes on site, which will give a good indication on how these populations are persisting.

Objectives

The objective of this study is to determine overwinter survival in neonatal rattlesnakes. Because rattlesnakes are relatively long-lived species and have been shown to have low mortality rates as adults, it was hypothesized that overwinter survivorship will be lower in neonatal rattlesnakes than in adults. Because animals with higher body conditions tend to store more energy, they can survive longer periods without food. It was hypothesized that neonatal rattlesnakes with higher body conditions will have higher survivorship.

Accomplishments through 2005

Data were collected through 2005 from snakes returning to the den (Figures 9-1, 9-2, 9-3, and 9-4). The snakes do not leave the den sites again until late spring, therefore, no results have been calculated.

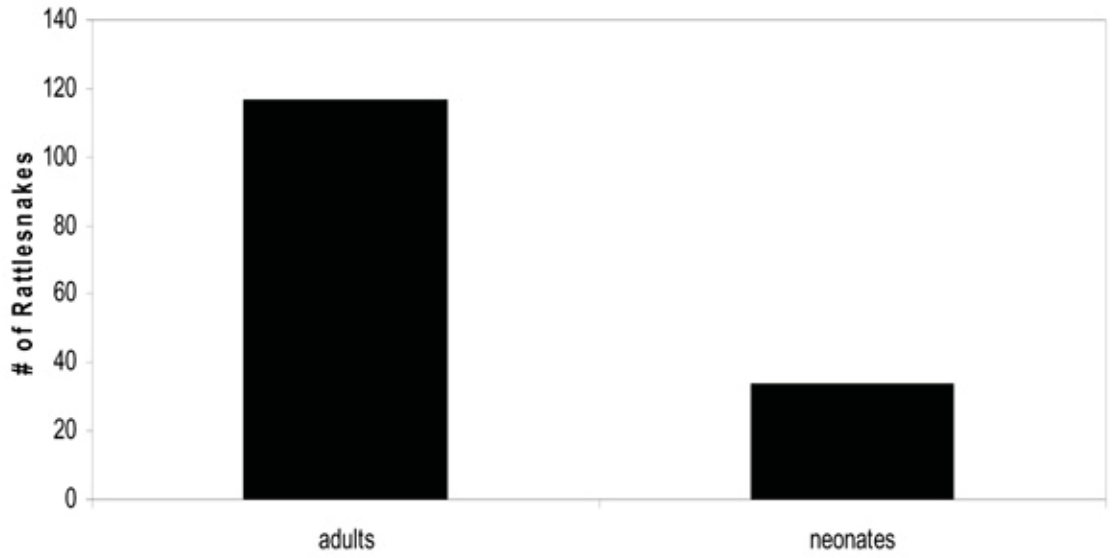


Figure 9-1. Number of Adult and Neonatal Rattlesnakes Caught in Fall 2005.



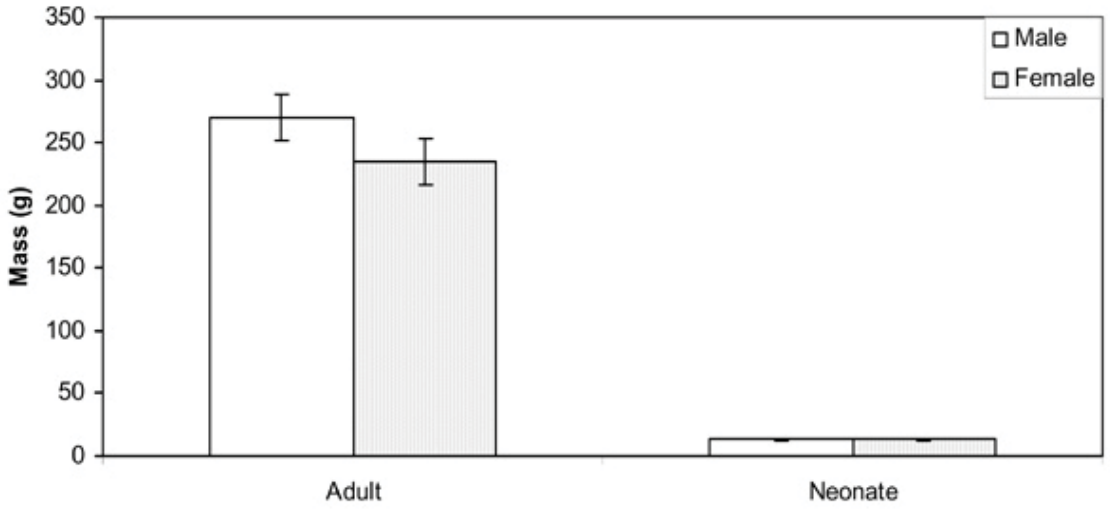


Figure 9-2. Mean Mass for Each Sex and Age Class of Rattlesnake Found in Falls 2005 (+/- SE).

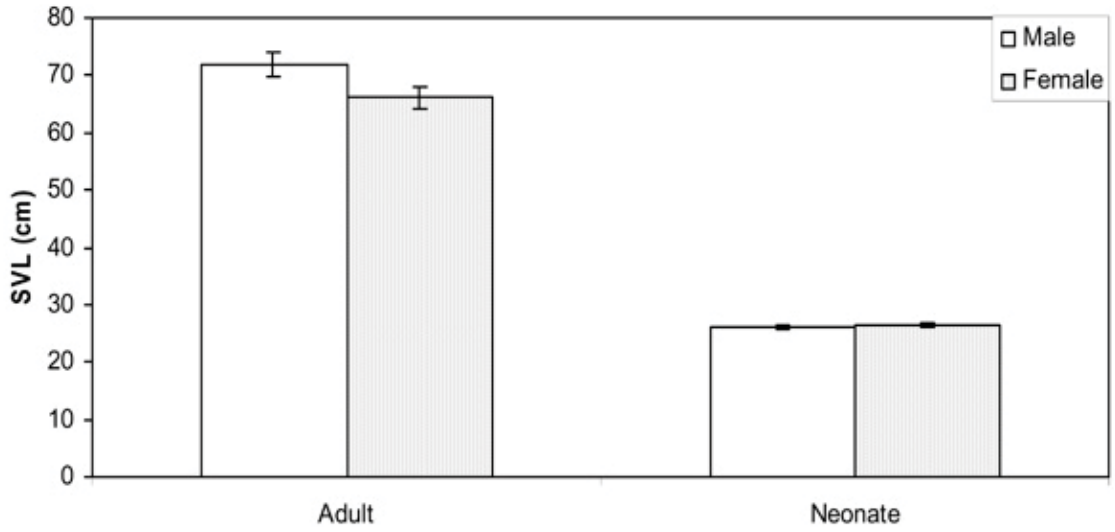


Figure 9-3. Mean Snout to Vent Length for Each Sex and Age Class of Rattlesnake Found in Fall 2005 (+/- SE).



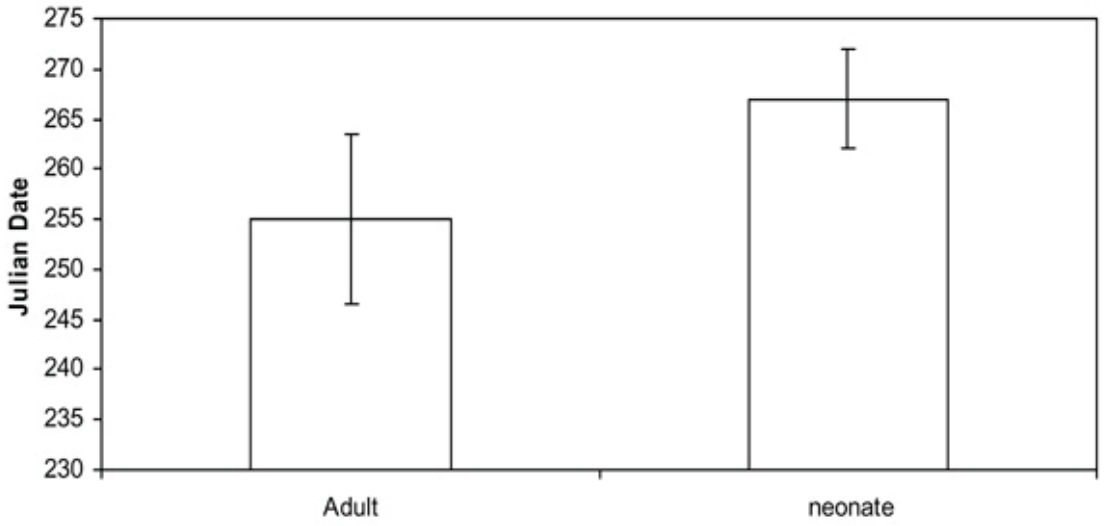


Figure 9-4. Mean Day of Year +/- 1 SD of Ingress for Adult and Neonatal Rattlesnakes for Fall 2005.

Results

Figures 9-1, 9-2, 9-3, and 9-4 show brief summary results from the fall field season.

Plans for Continuation

Future plans include intensive trapping in the spring and fall of 2006 and the spring of 2007 and analyzing the data to determine the survival (summer 2006 and 2007). Gravid females will be captured to perform a simulated hibernation study in the lab (summer 2006) and approximately two manuscripts will be submitted to peer reviewed scientific journals.

9.2 Fine-Scale Movement Patterns of Coyotes (*Canis latrans*) on the INL.

Investigators and Affiliations

Mike Ebinger, graduate student, Department of Forestry, Range, and Wildlife Science, Utah State University, Logan, UT.

Mike Jaeger, Research Zoologist, USDA/APHIS/WS/National Wildlife Research Center, Predator Ecology Field Station, Logan, UT.



Funding Sources

USDA/APHIS/WS/National Wildlife Research Center, Ft. Collins, Colorado.

Background

Coyote depredation has been a persistent problem to the livestock industry in the intermountain west for decades. As a pest species, they can also pose problems to species other than domestic livestock, such as game and sensitive species. While current depredation mitigation programs are effective and clearly needed, a more complete understanding of how coyotes move and use space provides a more solid framework for managers to alter current techniques to increase efficiency and effectiveness. Therefore, advancing our understanding of coyote space-use and movement patterns is a crucial step in the management of this intractable predator.

Traditional methods for understanding space-use and movement patterns of coyotes (and other medium- to large-sized carnivores) have relied on VHF radio telemetry and quantitative techniques for home range estimation. This approach has been criticized due to the fact that home range estimation often does not examine meaningful hypotheses about an animal's movements and behavior (Kernohn et al. 2001). Recent advancements in technology now provide the means to record fine-scale location data on coyotes at a rate (e.g., every five minutes) and volume (e.g., 12,000 locations/coyote/sampling period) that only a few years ago were unattainable. This new approach provides a unique dataset that allows for more meaningful investigations into coyote movement patterns and the internal anatomy of their home ranges.

Objectives

The overall goal of this project is to better understand how coyotes actually move within their home rages, paying special attention to the temporal component of the dataset. The objectives for 2005 included:

(1) Recapture coyotes and deploy global positioning system (GPS) collars during courtship/mating and whelping periods for coyotes in contiguous territories.

(2) Recover collars from each period and download data into database.

(3) Develop a novel spatiotemporal analysis technique to analyze movement data at different spatial and temporal scales.

(4) Deploy GPS collars on a few transient coyotes (opportunistically) to see the difference between resident and transient coyotes.

Accomplishments through 2005

Fifteen of the deployed collars were recovered from the courtship period (January/February) and 11 of 13 collars from the whelping period (May/June). This produced roughly 315,000 five-minute



locations. Two transient animals were collared during the May/June phase which showed dramatically different space-use in comparison to resident animals. Transients covered a much larger area than residents and focus their movements in the interstices between established territories. As a result the fine-scale tracking shows the existence of territories where we were unable to capture animals (see Figure 9-5).

A new conceptual approach was developed to look at spatiotemporal patterns of movement paths. This approach is based on the hypothesis that coyotes employ a space-use strategy that is most easily described as "avoiding areas in their home range that they have recently visited." To test this hypothesis, a raster based approach using the Interactive Data Language programming language and a newly designed statistic (i.e., index) was developed. The program compares the actual data (index summary for movement paths) against the same statistics for randomized datasets where the movement paths are "shuffled" in time but not in space. The large size of the data set prevents exact randomization tests (i.e., all permutations) and approximate randomization procedures are used to create a reference distribution.

Results

Analysis is currently under way and should be completed midway through 2006.

Plans for Continuation

A graduate thesis from this research will be completed in 2006. Continuation of the project beyond 2006 is contingent on future funding.

9.3 Seasonal and Landscape Variation of Snake Mortality on the Upper Snake River Plain

Investigators and Affiliations

Denim M. Jochimsen, MS student, Herpetology Laboratory, Department of Biological Sciences, ISU, Pocatello, ID.

Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, ISU, Pocatello, ID.

Funding Sources

ISU Biological Sciences Department

ISU Graduate Student Research Committee

BBWI Bechtel and the INL-ISU Education Outreach Program

ISU Biology Youth Research Program



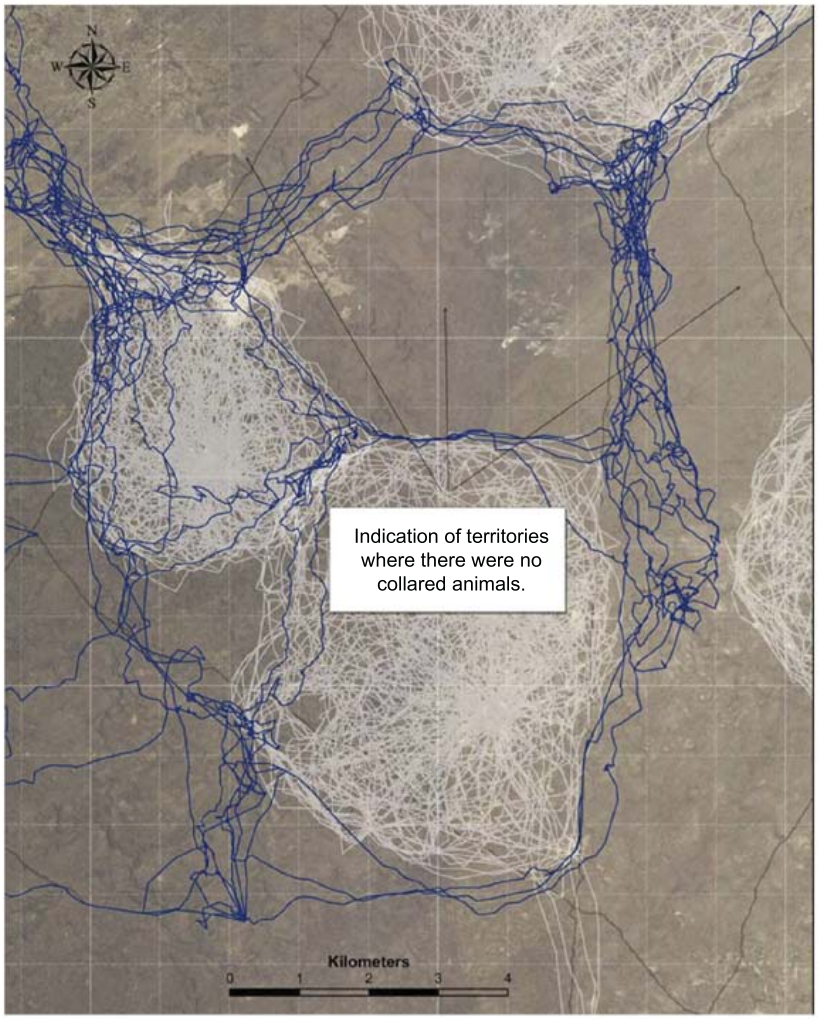


Figure 9-5. Fine-Scale Tracking Reveals Existence of Territories by Coyotes Not Captured During the Study.

Background

Transportation lies at the center of our society, linking destinations, and is ever expanding. A vast network of roads stretches across our landscape affecting ecosystem processes in myriad ways. Roads transform existing vegetation into a compacted earthen surface with altered thermal and moisture characteristics, and generate an array of ecological effects that disrupt ecosystem processes and wildlife movement.

Researchers have conducted surveys along roads in attempts to quantify the most conspicuous effect that roads impose on wildlife, mortality inflicted by vehicles. In reviewing the literature, it became apparent that rigorous studies concerning road mortality of snakes are scarce. Furthermore,



studies tend to be focused in the southeast and southwestern United States, with only three studies conducted in northern latitudes.

However, northern temperate snakes possess several characteristics that increase their susceptibility to road mortality. They migrate seasonally to locate specific resources (Gregory et al. 1987; King and Duvall 1990) such as refuge, mates, prey, and egg-laying habitat (for oviparous species). These resources tend to be located in distinct habitats that are patchily distributed across the landscape. Many large-bodied snake species make a loop-like migration from a communal hibernaculum (overwintering den site) to summer foraging habitats (King and Duvall 1990). Seasonal movements are defined by three distinct phases: 1) egress, or rapid movement away from the hibernacula, 2) stationary, or periods of short-distance movements associated with foraging, gestation, or ecdysis, and 3) ingress, or long-distance movements toward the hibernacula as described by Cobb (1994). The overlap of these movement corridors with the road network may result in high mortality. Publications tend to report numbers of fatalities according to species, but rarely explore the relationship of mortality with season, sex, or age of individuals.

Road mortality of snakes is a conservation issue that needs to be addressed. Future research must question if this mortality has the potential to severely reduce snake populations to a level where reproductive output cannot replace road-killed individuals (Rosen and Lowe 1994; Rudolph et al. 1999). The adverse effects of roads can be minimized, but the correct placement of mitigation efforts is critical. Ultimately, this research seeks to identify landscape and road variable that are highly correlated with snake mortality. These correlations could then be used to identify area that may represent high risks for snake road mortality. Studies suggest that mitigation success is dependent on correct placement of efforts (Jackson 1999) by identifying high-risk sites.

Objectives

This study was designed to address three objectives:

(1) Quantify the road mortality of snakes on the Upper Snake River Plain.

(2) Examine the variation of this mortality with respect to species, sex, age class, season, and traffic volume.

(3) Identify the landscape factors that influence the spatial pattern of road mortality.

Accomplishments

Presented general findings of this research at an invited symposium at the 2005 Society for the Northwest Vertebrate Biology / Oregon Chapter of the Wildlife Society annual meeting in Corvallis, Oregon. Investigator received the Les Eberhardt Award for the best student presentation.

Successful defense of Masters Thesis on June 15, 2005

Contributed an oral presentation regarding this research at the International Conference on Ecology and Transportation 2005 held from August 29 through September 2 in San Diego, California. In



addition, the results of this research were published in the final proceedings of the Conference.

Thesis Abstract

Roads fragment our landscape, altering natural flows and wildlife movement. The issue of vertebrate mortality on roads was first emphasized in the 1920s and the voluminous literature that has accumulated thereafter raised concern regarding species conservation. This concern has fostered a discipline known as "road ecology," which seeks to understand the myriad effects of roads on living organisms. There have been numerous reviews and a recent text published on this topic, yet reptiles and amphibians tend to be underrepresented. A literature review was conducted to specifically address the effect of roads on these taxa. This review indicated that mortality of herpetofauna can be quite high in some areas, and that snakes tend to form a large proportion of road-killed reptiles and amphibians. In addition, there exist potential mitigation options if specific locations of high road mortality can be identified.

This review also identified the need for research (1) across a greater expanse of geographic areas, particularly in high latitudes, (2) that analyzes the factors influencing road mortality, (3) that investigates the links between mortality and population effects, and (4) that evaluates the efficacy of mitigation structures. These findings motivated the choice for the research for this thesis. Specifically, this study documents the magnitude of road mortality on snake species that occur in sagebrush-steppe habitat, provides insight into how susceptibility to this mortality differs among species as well as by sex and age class of individuals, and examines how different landscape variables influence road-kill aggregations.

Data were collected by conducting road surveys along a 183 km route on the upper Snake River Plain in southeastern Idaho from May through October of 2003 and 2004. Fifty-six total routes were conducted in 2003, traveling 10,248 km (6368 mi) and encountering a total of 253 snakes (0.025 snakes/km) over the six-month survey period; 93 percent of these animals were found dead on the road (DOR) surface. In 2004, 11 surveys were conducted between May 4 and August 28, traveled 2013 km (1250 mi), and encountered 35 snakes; all but one were dead. The road mortality of four snake species belonging to families Colubridae and Viperidae were recorded. However, the majority of observations belonged to two species with gophersnakes (*Pituophis catenifer*) comprising 75 percent of all road records, and western rattlesnakes (*Crotalus oreganus*) comprising 18 percent of all road records. Repeated surveys of a short section indicated that very few snakes are able to successfully cross roads, even with low traffic levels.

Road mortality of snakes exhibited a bimodal trend, with an initial peak during spring/early summer (May and June) and a second peak in late summer/early fall (September), with peaks related to movement patterns of individuals. Specifically, road mortality varied seasonally by age and sex classes for both gophersnakes and western rattlesnakes. A greater number of adult male gophersnakes were encountered DOR in May and June, while the death of adult females did not exhibit a trend. A significant pulse of subadult mortality during the month of September was documented. The seasonal trends in mortality of western rattlesnakes differed from gophersnakes. Mortality of individuals



peaked later than that of gophersnakes, during the month of June. The comparison of the monthly mean numbers of road-kills among groups was only marginally significant in June, and was attributed to a greater number of adult males discovered DOR than adult females.

The spatial analysis of the data indicated that the observations were clustered across the survey route. A logistic regression model was used to identify which landscape factors (distance to hibernacula, habitat type, percent cover, elevation, and road slope) influenced the spatial pattern of road mortality. Using Akaike's information criterion (AIC) to evaluate the best model, road observations were positively correlated with percent grass cover within 10 m (32.8 ft) of the road, percent total vegetative cover within 10 m, presence of basalt piles, and mean distance to known hibernacula.

This research has raised several interesting questions which could direct future studies. Monitoring data from three of the largest snake hibernacula on the INL, indicated that western rattlesnakes were the most abundant snake species, comprising 50 percent of all captures at trapping arrays since 1994. However, the data collected during road surveys in 2003 and 2004 suggest otherwise. Are gophersnakes more susceptible to road mortality due to higher vagility, or are current monitoring efforts ineffective at estimating their populations? In addition, the positive association with grasses, which are mostly invasive cheatgrass and crested wheatgrass, suggests that habitat conversion may be increasing the likelihood of road mortality as opposed to sagebrush dominated areas. Furthermore, this research indicates that individuals may be more susceptible to road mortality during specific movements, such as mating or migration. Knowledge of predictable movements and their relationship with landscape features could help guide effective placement of mitigation efforts.

9.4 The Protective Cap/Biobarrier Experiment

Investigators and Affiliations

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

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). Presence of water may cause plant roots to grow into the waste zone and transport toxic materials to above ground 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 water storage reservoir of the soil.

The Protective Cap/Biobarrier Experiment (PCBE) was established in 1993 at the Experimental Field Station, INL 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

(1) To compare the performance of caps having biobarriers (capillary breaks) with that of that of soil-only caps and that of caps based on U.S. Environmental Protection Agency recommendations for Resource Conservation and Recovery Act (RCRA) caps

(2) To examine the effects of biobarriers as capillary breaks placed at different depths within the soil profile on water percolation, water storage capacity, plant rooting depths, and water extraction patterns

(3) To evaluate the performance of caps receiving higher precipitation than expected under either the present climate or that anticipated in the foreseeable future

(4) To compare the performance of a community of native species on ET caps to that of caps vegetated with a monoculture of crested wheatgrass.

Specific tasks for the PCBE in 2005 included maintenance of the study plots, continuation of the irrigation treatments, and collection of soil moisture and plant cover data. The data will be analyzed according to the four major objectives listed above and analyses will focus on long-term cap performance. The PCBE has one of the most complete, long-term data sets for ET caps, which makes it a model system for studying ET cap longevity. Long-term performance issues that will be addressed with the PCBE include changes in plant community composition, species invasion, and changes in soil moisture dynamics as the caps continue to age and the biological communities associated with the caps continue to develop.



Accomplishments through 2005

One supplemental irrigation treatment was completed on the PCBE in 2005. Fifty mm (1.97 in.) of water was applied to the summer irrigated plots once every other week from the end of June through the beginning of August for a total of 200 mm (7.87 in.). The fall/spring supplemental irrigation treatment was initiated in late September. Half of the fall/spring irrigated plots received 200 mm (7.87 in.) of water during a one week period. Irrigation on the other half of the fall/spring irrigated plots could not be completed due to a failure of the deep well. Repairs to the deep well and the completion of the fall/spring irrigation were scheduled for April of 2006. Soil moisture measurements were collected once every two weeks from beginning of April through mid-October. Vegetation cover data were collected throughout the month of July and into August.

Soil moisture and vegetation data collected in 2005 were archived. Soil moisture data were compiled and summarized, and soil moisture profiles were completed for each cap, irrigation and vegetation treatment. Historical vegetation data on the PCBE were reorganized and reformatted in 2005. Data files were reorganized such that multiple, duplicate files were reconciled and archived in one location and vegetation data within those files were reformatted to be more accessible and easier to use for future data analysis on the PCBE, specifically for analyses pertaining to vegetation community development and associated changes in landfill cover performance.

Results and Discussion

Initial data analyses from the 2005 soil moisture data indicated that the wetting front from the spring infiltration event was quite variable among soil only caps. On the ambient and summer irrigated subplots, the spring wetting front ranged from 0.8 m (2.6 ft) to 1.6 m (5.3 ft) in depth. The wetting front reached the bottom of the soil only caps on all of the fall/spring irrigated subplots, indicating that the soil only plots are failing under fall/spring irrigation. The spring wetting front extended through the biobarrier on two of the ambient subplots plots and on all of the fall/spring irrigated subplots within the shallow biobarrier plots. The wetting front reached the bottom of two of the fall/spring irrigated subplots under fall/spring irrigation. On the deep biobarrier caps, the spring wetting front did not extend below the biobarrier on any of the subplots even under the fall/spring irrigation treatment. The spring wetting front reached the flexible membrane liner on all of the subplots of the RCRA caps regardless of irrigation or vegetation treatment. Figure 9-6 shows representative soil moisture profiles for soil only, shallow biobarrier, and deep biobarrier plots under fall/spring irrigation in 2005.

Over the ten-year study period, a widespread cap failure occurred in response to the fall irrigation treatment of 2003; this failure was especially apparent during the natural spring infiltration event of 2004. This marks the first event of this type under the experimental treatment conditions. Although some fall/spring irrigated caps, especially the soil only caps, failed again in response to the spring infiltration event of 2005, other caps, primarily the deep biobarrier caps, performed very well in response to the infiltration event.

Soil moisture data will be closely compared with vegetation cover data to determine possible causes of the cap failure. Continued irrigation and soil moisture measurements will be critical over



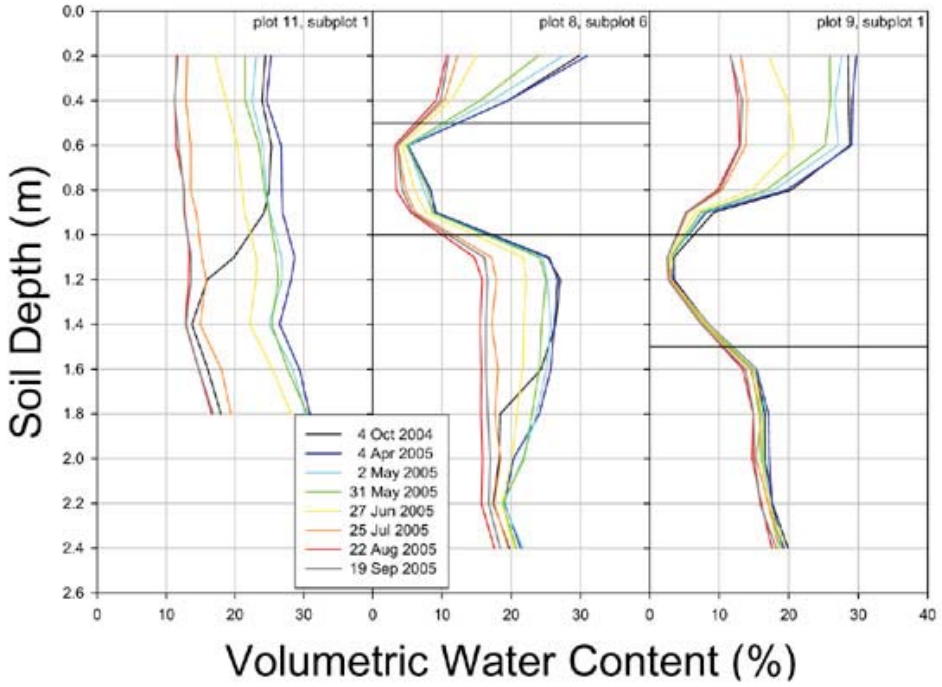


Figure 9-6. Soil Moisture Profiles for a Soil Only, a Shallow Biobarrier, and a Deep Biobarrier Cap on the Protective Cap/Biobarrier Experiment. The subplots were planted with a native vegetation mix and subjected to the fall/spring irrigation treatment.

the next few years to gauge whether cap failure under fall irrigation will continue to be a regular event, or whether the cap failures in 2003 were a random and reversible occurrence. As the caps continue to age, more specific differences in performance of various cap designs are becoming apparent, especially under the fall/spring irrigation treatment. The emerging differences will be closely documented and continue to be assessed to determine which cap designs will best withstand climate variability in the future.

Plans for Continuation

Soil moisture and plant community composition and cover were still experiencing important changes in 2005, as evidenced by the cap failures in response to the fall irrigation treatment and summer infiltration event. The PCBE should continue to be monitored at least until cap failure occurs on the fall/spring irrigated caps consistently or until the caps recover and the ecological and soil moisture parameters stabilize and long-term fluctuations can be characterized.

Additional recommended research for the PCBE includes studies pertaining to long-term maintenance issues such as plant community change, response to fire, invasive plant species, erosion,



and the role of soil microbiota in cap function. Research on specific uptake parameters and soil moisture distributions associated with native vegetation species will also be useful in optimizing water use by native vegetation, allowing cap revegetation plans and species recommendations to be designed specifically to address various capping issues.

9.5 Spatial Patterns of Species Diversity

Investigators and Affiliations

Anne-Marie Hoskinson, Ph.D. Student, University of Minnesota, St Paul, MN.

Funding Sources

Thesis writing was supported by National Science Foundation grant # DGE-0440517.

Background

Recent attempts to understand biodiversity may be inadequate for conservation management because they focus on just one species or population and because they are more concerned with the processes influencing biodiversity than the patterns of biodiversity. The research that has been done on biodiversity patterns is often weakened by inferences not supported by empirical or experimental results or results are extrapolated from small scales to large. This study contributes to our knowledge of biodiversity patterns in three important ways: (1) by empirically investigating the presence and nature of scale dependent biodiversity patterns; (2) by contributing an empirical foundation for scale-specific investigations of processes on patterns in biodiversity; and (3) by developing a model that tests the sensitivity of biodiversity patterns to processes thought to cause those patterns. These aspects were investigated using the method of additive partitioning on a long-term vegetation data set from the sagebrush steppe of Idaho, USA. Understanding the patterns of biodiversity, and forming an empirical basis for understanding the processes that cause and maintain those patterns, is fundamental to biodiversity conservation.

Objectives

The objective of this study is to use additive partitioning on long-term vegetation data from a sagebrush steppe to test for scale dependence in vascular plant species diversity.

Accomplishments

This research was conducted as part of a doctoral program and has been completed.

Thesis Abstract

The method of hierarchical additive partitioning to address three sets of questions relating vascular plant species to the space they inhabit: how species diversity patterns develop in space, how land use affects spatial and temporal diversity, and how species diversity, functional groups, and space are



related. First, to develop the explanatory and predictive power of species-area relationships (SARs), additive partitioning was applied to vascular vegetation diversity (richness, Simpson's, and Shannon's) on data collected over 50 year from a large region of sagebrush-steppe in Idaho. The power form of the SAR described this pattern well. Species subgroups varied in their match to the log-log SAR. Shrubs derived most of their diversity at the smallest extents, while forbs and perennial grass diversity have strong regional components. Next, diversity among land use types were compared and used the results of hierarchical partitioning was used to distinguish among possible drivers of those differences by comparing diversity components of common and rare species between land use types. It was concluded that land use, not environmental heterogeneity, was the stronger driver of spatial diversity pattern differences between the two regions. Finally, partitioning to regional productivity in order to determine whether species diversity within functional groups was as important to maintaining productivity as the number of functional groups themselves. It was determined that species diversity within perennial grasses mattered more at the regional extent than did diversity within shrubs. From this work, four main conclusions were drawn: (1) conservation efforts must be targeted to specific taxonomic groups in order to preserve a region's total diversity, (2) land use changes affect diversity patterns and should be considered in effects of land use planning on diversity concerns, (3) species, productivity, and space are related in complex ways, underscoring the need for explicit links between ecosystem ecology and landscape ecology, (4) additive partitioning with significance testing is shown to be a powerful and simple tool for both ecologists and land use planners who need to describe spatial and temporal patterns of species diversity. Additive partitioning can be used with sampling designs limited in extent or scope, and its usefulness is not constrained to particular taxa or biomes.

9.6 Employing Unmanned Aerial Vehicles for Monitoring Habitat and Species in Sagebrush-Steppe Ecosystems

Investigators and Affiliations

Robert P. Breckenridge, Manager, Ecological Science Department, Idaho National Laboratory, P.O. Box 1625, Idaho Falls, Idaho

Dr. Maxine Dakins, Associate Professor, Environmental Science, University of Idaho, 1776 Science Center Drive, Idaho Falls, Idaho.

Funding Sources

This research was part of a laboratory-directed research and development (LDRD) project titled "Development of the Scientific Basis for Landscape Management of Federal Lands."

Background

Monitoring vegetative cover in vast, semi-arid ecosystems is a difficult task that is often expensive, requires large amounts of time in the field and presents safety hazards. This task is made more difficult as there are not enough resource specialists or funds available to conduct quality ground surveys to support restoration activities.



Resource specialists managing sagebrush-steppe ecosystems are concerned about vegetation condition and habitat losses due to drought, fire, and land conversions. Vegetative cover data provide important information relative to ecological structure and processes such as nutrient cycling (Carroll et al. 1999, Pyke et al. 2002), soil development, and desertification (Mouat and Hutchinson 1995). Improved methods are needed to monitor these habitats to ensure quality data are available in a timely manner to make resource management decisions.

The INL, in conjunction with the University of Idaho, is evaluating a novel approach for monitoring biotic resources on western lands using Unmanned Aerial Vehicles (UAVs) as a quick, safe and cost effective method. We established seven macro field plots, each with four 12 m^2 (3 x 4 m [9.8 x 13.1 ft]) subplots on the INL west of Idaho Falls, Idaho in areas with varying vegetative types and amounts of cover. In this project, we used two types of UAV platforms, fixed wing and rotocopter. Each UAV was equipped with cameras to collect still frame and video imagery to assess cover in sagebrush-steppe ecosystems.

Objectives

The purpose of our project is to evaluate the feasibility of collecting imagery with a UAV and processing the imagery to estimate total percent cover and percent cover by selected type (shrub, forbs, grass, dead shrub, litter and bare ground), and compare the accuracy of results from these approaches to standard field methods.

Accomplishments through 2005

The fixed wing UAV is an APV3 RNR aircraft with about a 3-m (9.8-ft) wing span that flew using an autonomous navigation system and carried an 8 M pixel, full-size camera and video feed and flew 76, 152 and 305 m (250, 500 and 1000 ft) above ground level (AGL). Due to concerns during turning operations, the plane could not be flown below 250 ft AGL The rotocopter is made by Miniature Aircrafts and is a X-Cell model that carried a 4 M pixel micro camera and flew between 10.7 - 15.2 m (35-50 ft) AGL. Because of its size, the fixed wing UAV was capable of collecting many more images over a much larger area during a single flight. The main limitation for collecting imagery was camera storage capacity and navigation system battery life. The rotary UAV is capable of flying at a much lower level and has the potential to collect better imagery. However, it has limitation with fuel capacity (i.e., air time), requires a more skilled pilot, has landing location limitations, and weather condition restrictions (mostly winds).

Vegetative cover was evaluated in the field using a point frame method with 50 percent of each subplot read. The imagery from the UAV's is being evaluated using the processing software Sample Point being developed by the Agriculture Research Service (Booth et al. 2005). Sample Point lays a grid (typically 10 x 10 lines) over an image with its size and alignment adjusted to best fit the Sample Point frame. Three different observers trained together to learn the software and calibrate their observations. An evaluation of how the three sets of results compare against each other and the field data is currently ongoing and will be reported in the literature in the near future. Data from both the



field and sample point evaluations are being compiled into a database that will allow for comparison of accuracy between the two UAVs and field methods and among observers.

Plans for Continuation

Evaluation of vegetative cover is an important factor for maintaining the sustainability of many biotic resources; especially those associated with sage grouse populations. Vegetative cover is a critical indicator evaluated during ecological restoration activities (Pyke et al. 2002). Improved methods for assessing cover at the life form level that are accurate and cost-effective could revolutionize how biotic resources are monitored on vast area of western lands. Natural resource managers and specialists may be able to use UAV approaches to address some monitoring tasks when either people or funds are limited for conducting surveys of these lands.

Acknowledgements

Sincere thanks to, Mark McKay and Matt Anderson the main UAV pilots, Randy Lee (INL), Anthony Piscitella and Katherine Schoellenbach (students) for assistance in reading imagery, Terry Booth and Sam Cox (USDA-ARS) for developing and assisting in using Sample Point and Dr.'s Jerry Harbour, Steve Bunting, Lee Vierling, Don Crawford and the Stoller-ESER Program for technical guidance and assistance.

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Wood Nymph

Chapter 10 - Quality Assurance

R. Mitchell - S. M. Stoller Corporation

Chapter Highlights

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 to maximize data completeness. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, the laboratories participate in a number of laboratory quality check programs.

All contractors conducting environmental monitoring programs maintain specific quality assurance/quality control objectives for data. These programs use a number of quality control samples, including duplicate samples, split samples, spike samples, and field blanks to demonstrate that data are meeting the established objectives.

10. QUALITY ASSURANCE

Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses.

The purpose of a quality assurance and quality control 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. In 2005, the INL contractor used General Engineering Laboratories (GEL) 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 bacteriological analyses, and Environmental Health Laboratories (now Underwriters Laboratories) for inorganic and organic analyses.



The Environmental Surveillance, Education and Research Program (ESER) contractor used the Environmental Assessments Laboratory (EAL) located at Idaho State University (ISU) for gross radionuclide analyses (gross alpha, gross beta, and gamma spectrometry). Severn-Trent Laboratories (STL) of Richland, Washington, and Teledyne Brown Engineering (TBE) of Knoxville, TN were 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 (NWQL) conducted nonradiological 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. Both radiological and nonradiological constituents are included in the program. Results can be found at http://www.inl.gov/resl/mapep/reports.html (DOE 2005).

2005 MAPEP Results

Comparisons of the air and water MAPEP results for the laboratories used by INL Site environmental monitoring organizations in 2005 are presented in Figures 10-1 and 10-2 for gross alpha/beta and actinides. All results for all laboratories were qualified as acceptable with the following exceptions. For water results in the May MAPEP report, STL received a "not acceptable" rating for its gamma spectrometry analyses and an "acceptable with warning" for its ^{90}Sr analysis.

National Institute of Standards and Technology

The DOE RESL participates in a traceability program administered through the National Institute of Standards and Technology (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 2005.



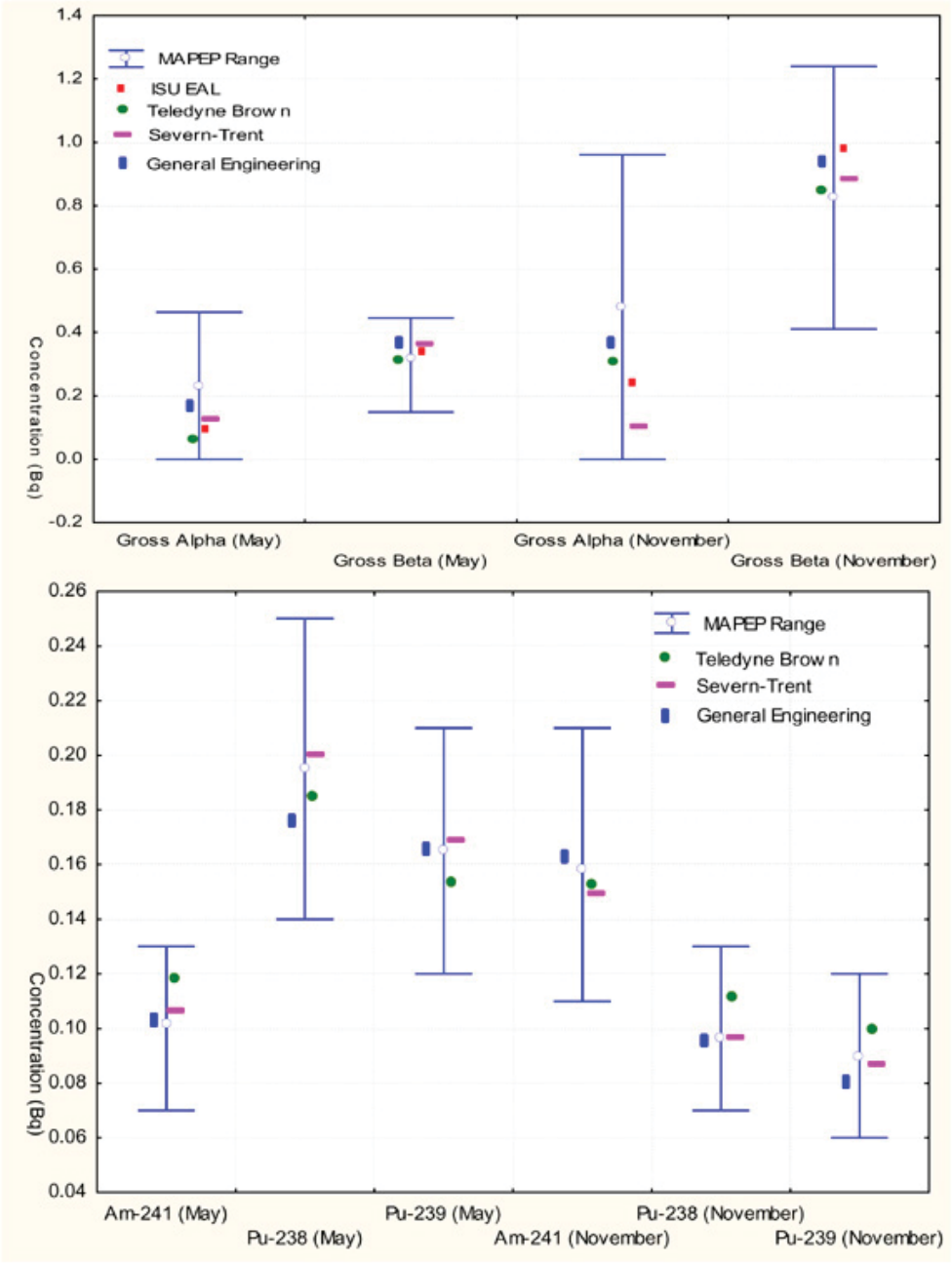
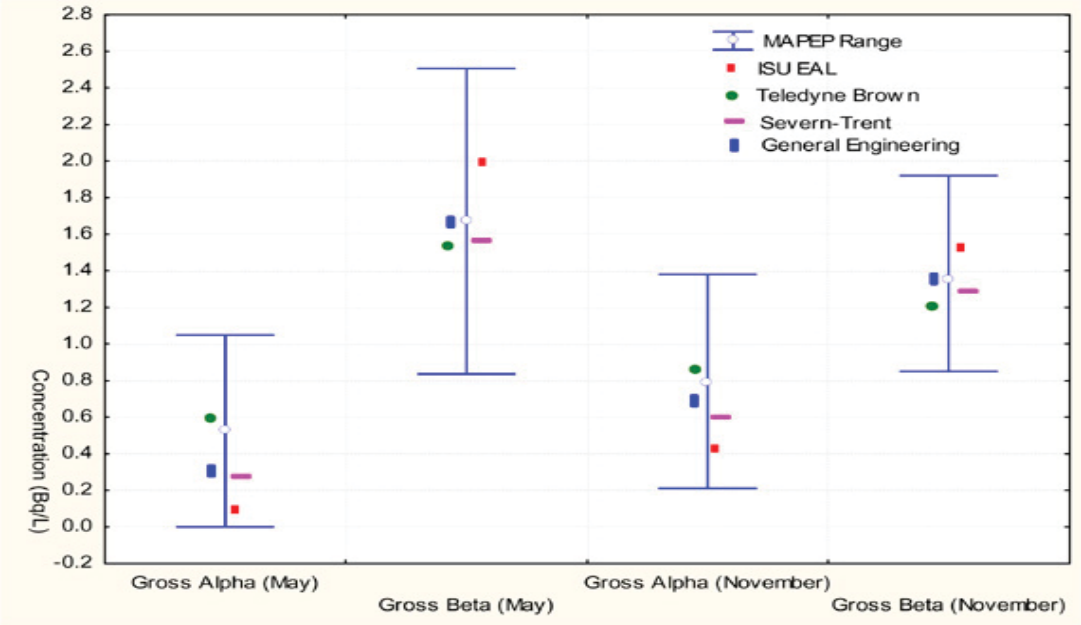


Figure 10-1. Surveillance Contractor Laboratory Air Sampling Results from the MAPEP Intercomparisons (2005).





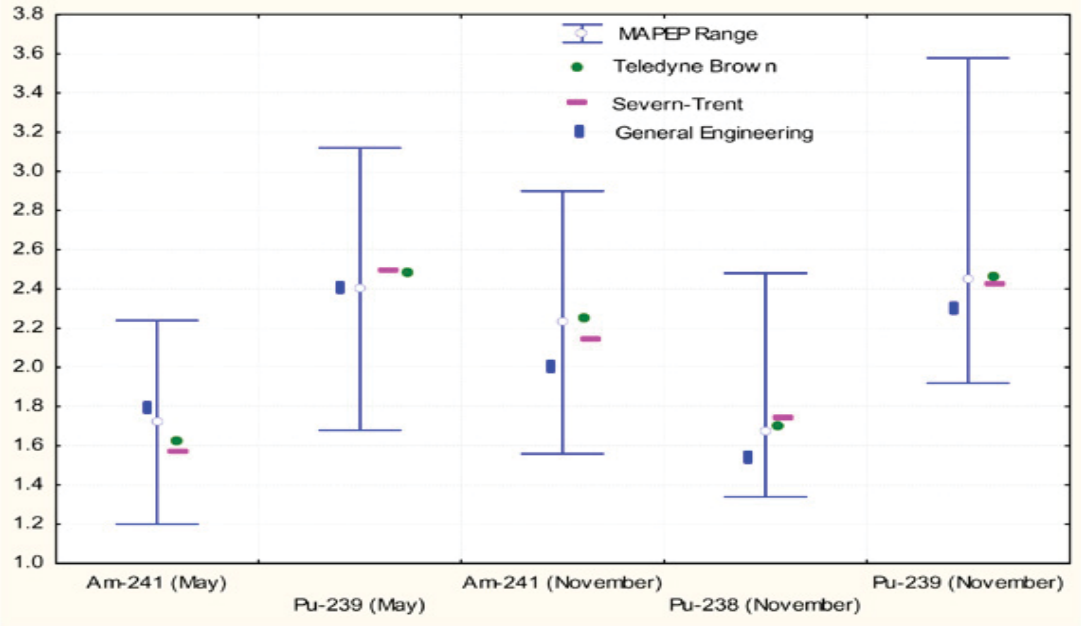


Figure 10-2. Surveillance Contractor Laboratory Water Sampling Results from the MAPEP Intercomparisons (2005).



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 quality assurance (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 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 Idaho Cleanup Project (ICP) contractor, the USGS, and other contractors performing monitoring use a variety of quality control samples of different media. Quality control samples include blind spike samples, duplicate samples, and split samples.

Blind Spikes

Groups performing environmental sampling use blind spikes 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 within Organizations

Monitoring organizations also collect a variety of quality control samples as a measure of the precision of sampling and analysis activities. One type is a duplicate sample, where two samples are



taken from a single location at the same time. A second type is a split sample, where a single sample is taken and later divided into two portions that are analyzed separately. Contractors specify in quality assurance plans the relative differences expected to be achieved in reported results for both types of quality assurance samples.

Both the ESER contractor and the INL contractor maintained duplicate air samplers at two locations during 2005. The ESER contractor operated duplicate samplers at the locations in Howe and at the INL Site Main Gate. The INL contractor duplicate samplers were located at the Materials and Fuels Complex and at the Van Buren Boulevard Gate. 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 2005 at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls, and on the INL Site at the Experimental Field Station and Van Buren Boulevard Gate. Data from these sampling locations for gross beta compared favorably and are shown in Figure 10-5.

The ESER contractor collects semiannual samples of drinking and surface water jointly with the INL Oversight Program at five locations in the Magic Valley area and two shared locations near the INL Site. Table 10-1 contains intercomparison results of the gross alpha, gross beta, and tritium analyses for the 2005 samples taken from these locations. The paired results were statistically the same for 90 percent (37 of 41) of the comparisons made.

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.

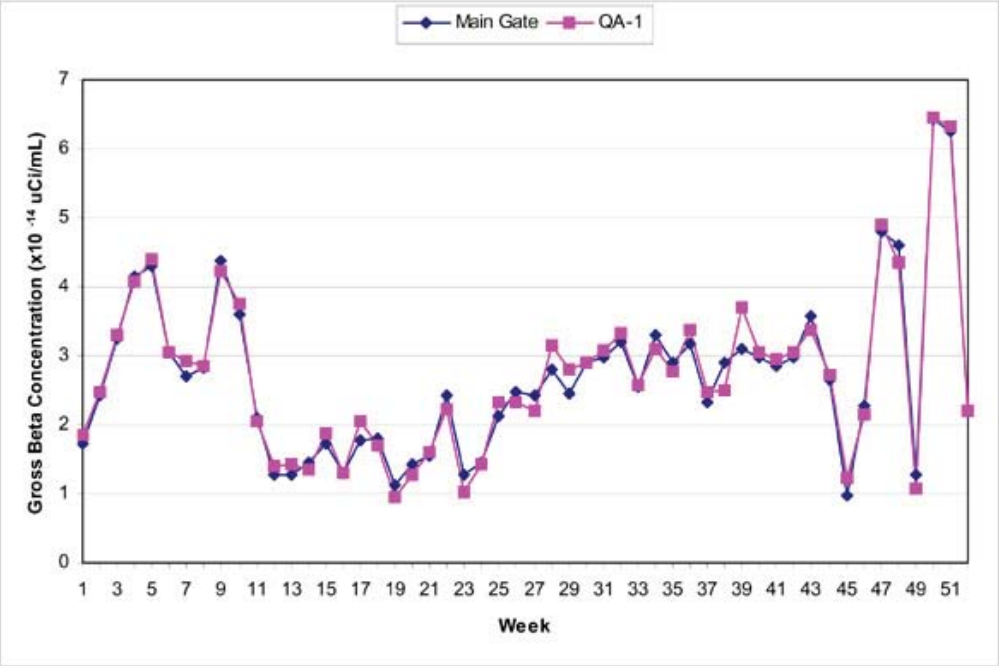
10.3 Program Quality Assurance

Liquid Effluent Program Quality Assurance/Quality Control

The ICP contractor's Liquid Effluent Monitoring Program has specific quality assurance/quality control objectives for monitoring data. Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. The liquid effluent monitoring programs submits three types of quality control samples:

(1) Performance evaluation samples (submitted as field blind spikes) are required to assess analytical data accuracy. At a minimum, performance evaluation samples are required quarterly.





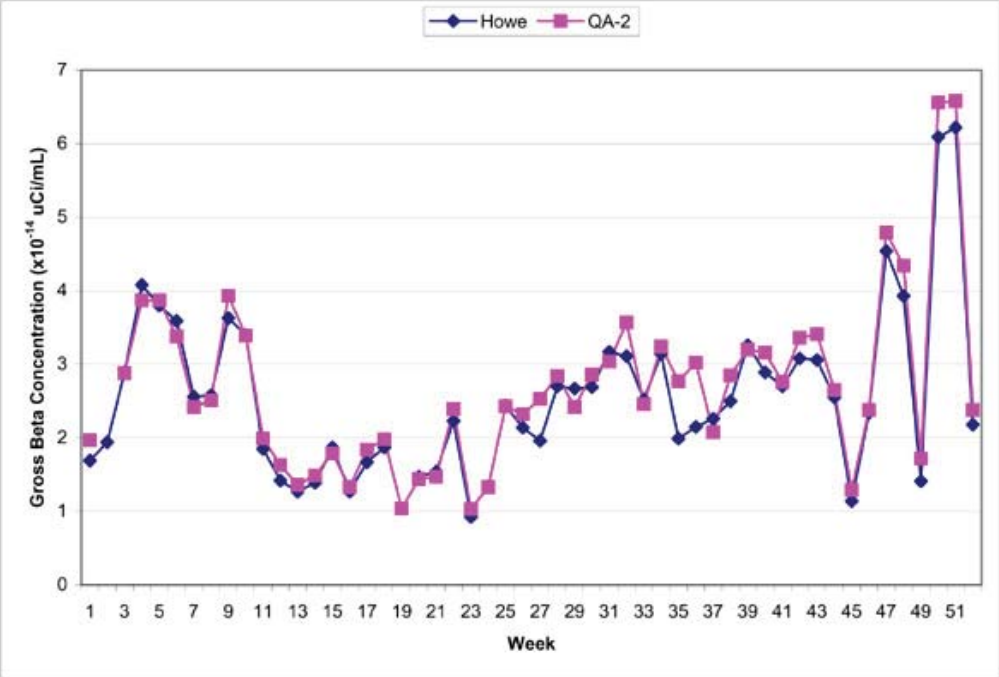
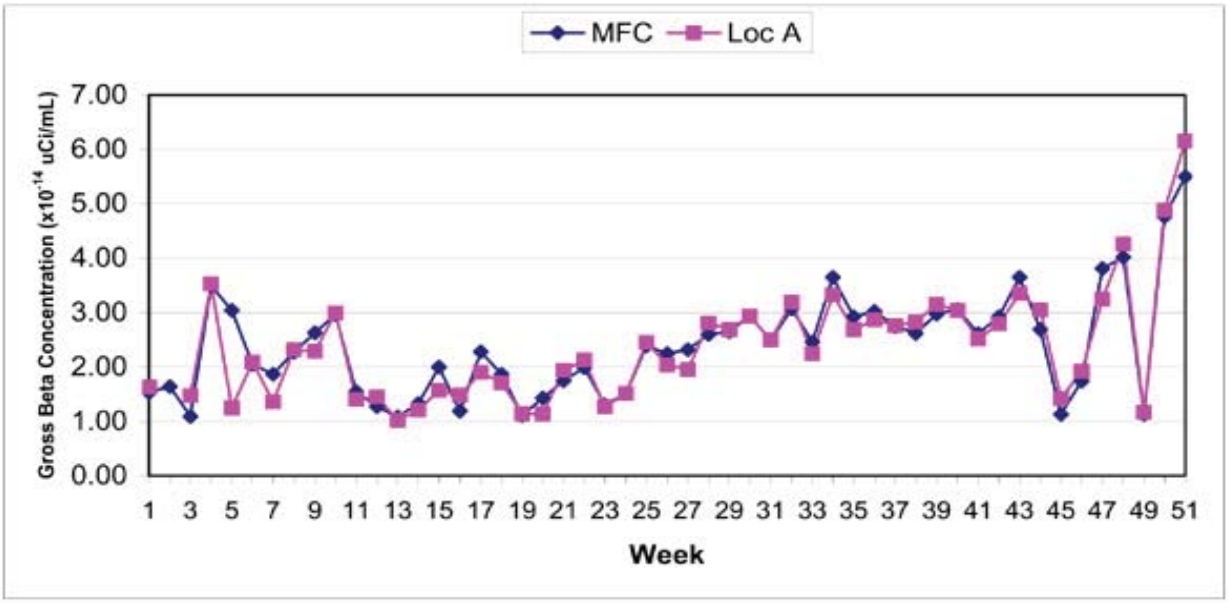


Figure 10-3. ESER Contractor Duplicate Air Sampling Gross Beta Results (2005).



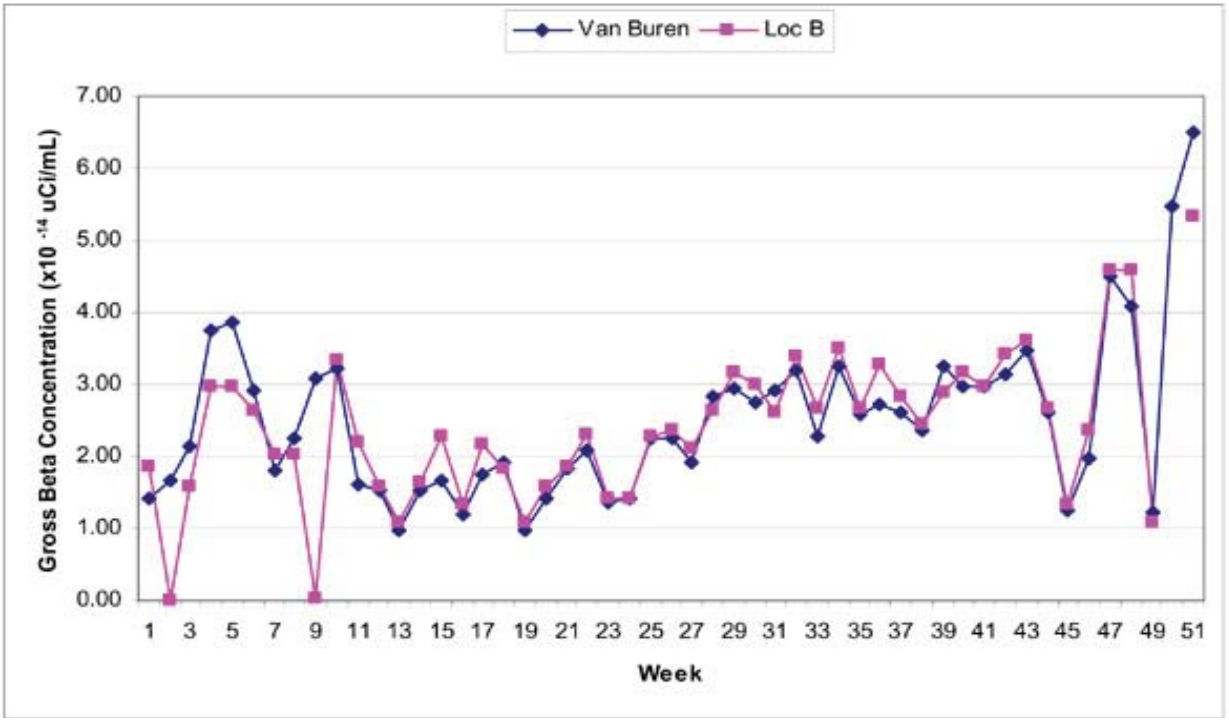


Figure 10-4. INL Contractor Duplicate Air Sampling Gross Beta Results (2005).



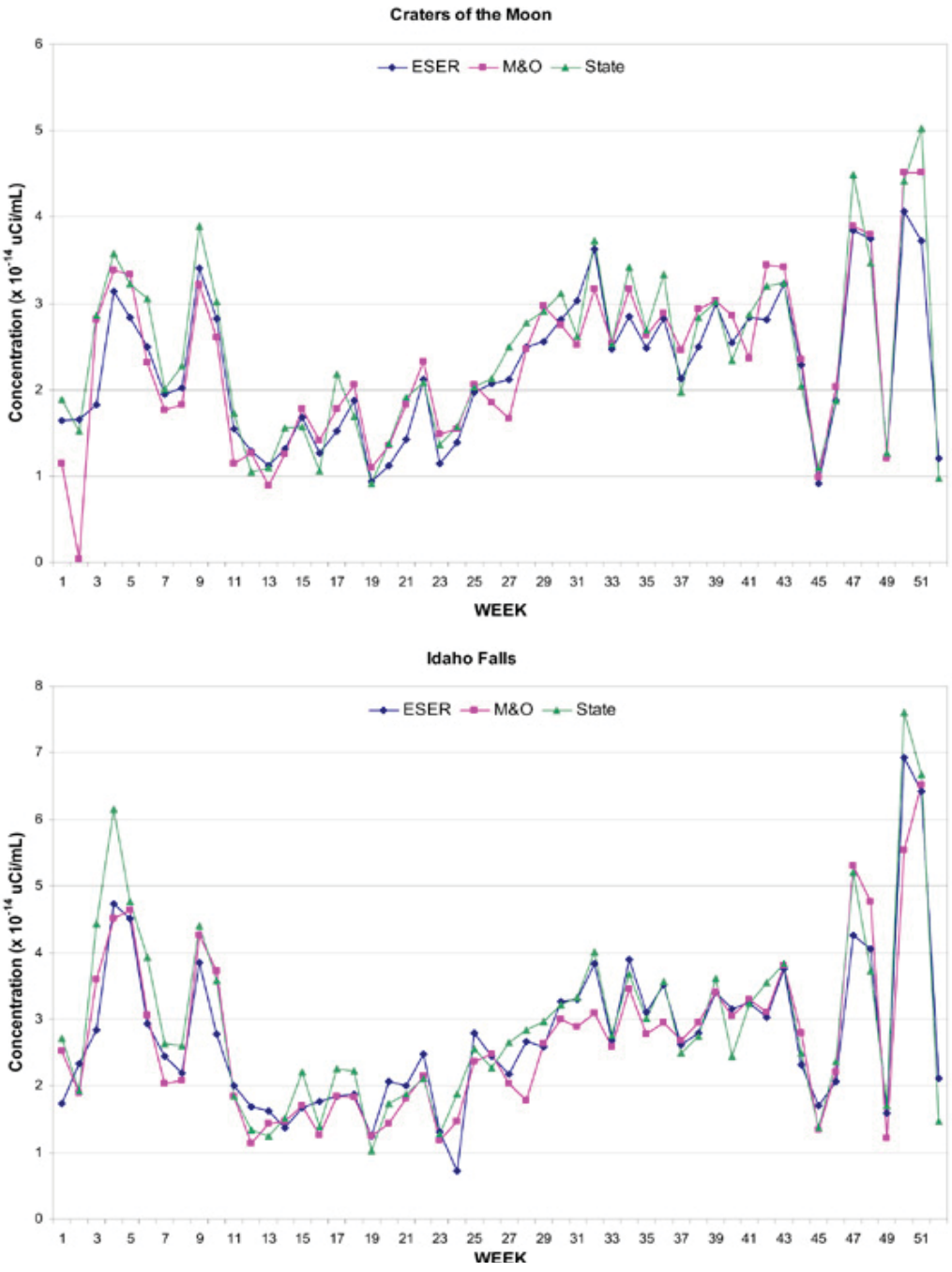
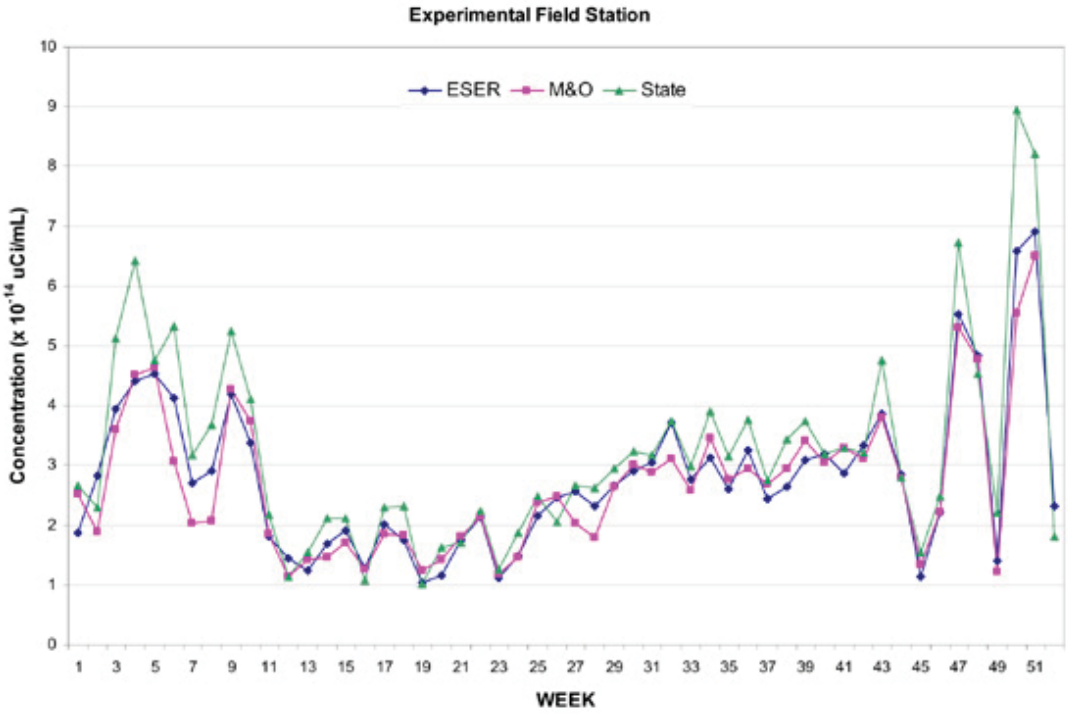


Figure 10-5. Comparison of Gross Beta Concentrations Measured by ESER Contractor, INL Contractor, and State of Idaho (2005).





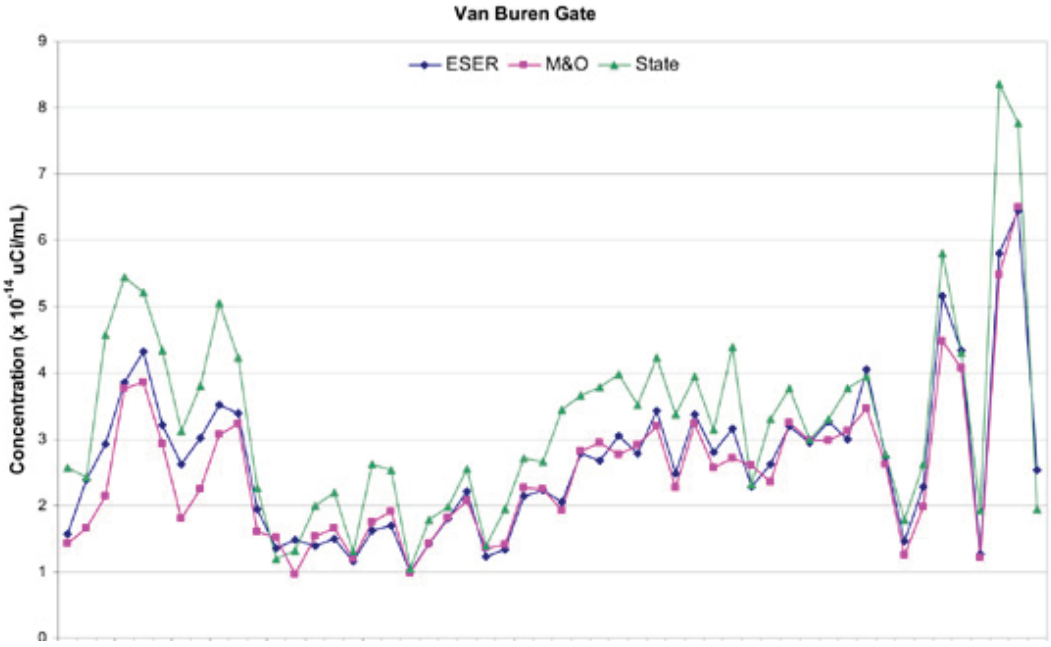


Figure 10-5. Comparison of Gross Beta Concentrations Measured by ESER Contractor, INL Contractor, and State of Idaho (2005). (Continued)



Table 10-1. Comparison of ESER and INL Oversight Program Water Monitoring Results (2005).[a]

Location	Date	Gross Alpha (pCi/L)		Gross Beta (pCi/L)		Tritium (pCi/L)	
		ESER	State	ESER	State	ESER	State
Drinking Water							
Atomic City	05/16	-0.9 ± 0.9	1.0 ± 0.9	1.4 ± 0.9	4.7 ± 0.5	54 ± 30	0 ± 35
	11/09	0.4 ± 0.7	-2.0 ± 1.1	3.6 ± 0.9	2.6 ± 0.5	52 ± 25	0 ± 40
Minidoka	05/10	-0.4 ± 0.8	2.2 ± 1.0	2.6 ± 0.9	3.5 ± 0.5	17 ± 24	-20 ± 35
	11/08	-0.4 ± 0.8	-1.4 ± 1.3	2.5 ± 0.9	3.0 ± 0.5	121 ± 30	20 ± 40
Mud Lake	05/17	-1.5 ± 0.7	0.8 ± 0.6	2.5 ± 0.9	4.2 ± 0.5	15 ± 29	-20 ± 35
	11/09	-0.9 ± 0.5	-1.4 ± 0.8	4.9 ± 0.9	3.5 ± 0.5	28 ± 24	30 ± 40
Shoshone	05/10	1.3 ± 0.9	1.0 ± 1.0	13.5 ± 1.2	2.3 ± 0.5	42 ± 25	-20 ± 40
	11/08	1.2 ± 0.7	2.6 ± 1.2	2.6 ± 0.9	2.8 ± 0.5	80 ± 27	50 ± 40
Surface Water							
Buhl	05/10	-0.6 ± 0.7	3.4 ± 1.1	3.4 ± 0.9	4.8 ± 0.5	7 ± 23	20 ± 40
	11/08	-0.2 ± 0.6	2.4 ± 1.5	4.8 ± 0.9	5.0 ± 0.6	-4 ± 25	70 ± 40
Hagerman	05/10	0.6 ± 0.7	1.6 ± 0.8	3.2 ± 0.9	3.5 ± 0.5	54 ± 25	-10 ± 40
	11/08	0.6 ± 0.6	-0.4 ± 1.1	3.9 ± 0.8	2.4 ± 0.5	18 ± 25	40 ± 45
Twin Falls	05/10	1.8 ± 1.1	3.6 ± 1.2	6.2 ± 1.1	6.6 ± 0.6	52 ± 30	10 ± 35
	11/08	-1.7 ± 1.1	2.3 ± 1.7	4.1 ± 1.1	8.1 ± 0.7	73 ± 29	No Result

a. Values are shown as the result ± 1 standard deviation, where the standard deviation is the total uncertainty.

(2) Field duplicates (splits) provide information on analytical variability caused by sample heterogeneity, collection methods, and lab procedures. One duplicate sample is collected each quarter at a randomly selected location.

(3) Rinsate samples are collected to evaluate the efficacy of equipment decontamination. One rinsate sample is collected each year.

During 2005, four sets of performance evaluation (PE) samples were submitted to the laboratory along with routine monitoring samples. The reported concentration of total Kjeldahl nitrogen and silver in two of the spikes were outside the performance acceptance limits. The reported concentration of biological oxygen demand, antimony, and thallium were outside the performance acceptance limit in only one of the PE samples. The laboratory was notified of the results so they could evaluate whether corrective action was required.



The relative percent difference (RPD) between the duplicate samples is used to assess data precision. Table 10-2 shows the results for 2005. 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.

The analytical results for the equipment blank sample indicated that decontamination procedures are adequate.

The goal for completeness is to collect 100 percent of all required compliance samples. During 2005, this goal was met.

Table 10-2. Liquid Effluent Program Relative Percent Difference Results.

Parameter	RPD result
Inorganic and metals	88% within the program goal of less than or equal to 35%.
Radiological parameters	Only two sets of duplicate results had detectable quantities. Of those, one met the program goal of less than or equal to 35%
Note: The RPD is only calculated if both results are detected (greater than instruments detection limit).	

Wastewater Land Application Permit Groundwater Monitoring Quality Assurance/Quality Control

The groundwater sampling activities associated with Wastewater Land Application Permit (WLAP) compliance sampling follow established procedures and analytical methodologies.

During 2005, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center (INTEC) and Test Area North (TAN) WLAP monitoring wells (with the exception of aquifer well ICPP-MON-A-167, which was dry during October 2005, and perched wells ICPP-MON-V-191 and TSFAG-05, which were dry during both April 2005 and October 2005). All of the samples required for permit compliance were collected. Some of the 2005 analytical results were rejected as unusable during data validation because of quality control issues. The quality control issues were with the October Nitrate as nitrogen and Nitrite as nitrogen from one well and total coliform from another well. The rejected Nitrate as nitrogen and Nitrite as nitrogen were attributed to missed holding times by the analytical laboratory, and the reported total coliform result was rejected due to interferences with the noncoliform bacteria results reported as too numerous to count.



Field quality control samples were collected or prepared during the sampling activity in addition to regular groundwater samples. Laboratories qualified by the INL Sample and Analysis Management Organization performed all INL groundwater analyses during 2005. 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 the potential for any bias introduced by analytical laboratories. 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 requirements as regular groundwater samples. Duplicates have precision goals within 35 percent as determined by the relative percent difference measured between the paired samples. In 2005, for the 46 duplicate pairs with detectable results, 93 percent had RPDs less than 35 percent. This high percentage of acceptable duplicate results indicates little problem with laboratory contamination 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 decontamination activities. They were collected by pouring analyte-free water through the sample port manifold after decontamination and before subsequent use. Again, results from the equipment blanks did not indicate improper 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 2005 groundwater sampling event, two PE samples were analyzed for total coliform and fecal coliform. These samples were within the quality control (QC) Performance Acceptance Limits.

During the October 2005 groundwater sampling event, two PE samples were analyzed for total coliform and fecal coliform and one sample was analyzed for metals. One fecal coliform sample did not meet the QC Performance Acceptance Limit; the result was outside the range by 1/100 mL criteria. The metal PE sample results were within the QC Performance Acceptance Limits with the exception of barium, beryllium, cadmium, chromium, lead, manganese, and zinc; the results were slightly lower than the QC Performance Acceptance limits.

Drinking Water Program Quality Assurance/Quality Control

The Drinking Water Program's completeness goal is to collect, analyze, and verify 100 percent of all compliance samples. This goal was met during 2005.

The Drinking Water Program requires that 10 percent of the samples (excluding bacteria) collected be QA/QC samples to include duplicates, field blanks, trip blanks, blind spikes, and splits. This goal was met in 2005 for all parameters.



The RPD between the duplicate samples is used to assess data precision. The INL contractor met the precision results for the Drinking Water Program in 2005 and results are shown in Table 10-3. 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. The RPD was not calculated if either the sample or its duplicate were reported as nondetects.

ESER Program Quality Assurance/Quality Control

The ESER program met its completeness goals for 2005, which requires that 98 percent of scheduled samples are collected and analyzed. For air sampling, less than 1.3 percent of scheduled samples did not meet the required volume to be considered a valid sample, due to equipment malfunctions and power outages. For most sample types, 100 percent of samples were collected as scheduled.

Spike samples were used to test the accuracy of the laboratories performing analyses for the program. During 2005, samples of air, water, and milk were submitted to each of the analytical laboratories and analyzed for gross alpha/beta, tritium, gamma-emitting radionuclides, actinides, and ^{90}Sr. Each laboratory also conducted an internal spike sample program using standards traceable to NIST.

Precision was measured using duplicate and split samples and laboratory recounts. In 2005, over 99 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 major problems were reported in 2005.

Table 10-3. Drinking Water Program Relative Percent Difference Results.

Parameter	RPD result
Inorganic, Organic, and Radionuclide	Over 90% within the program goal of less than or equal to 35%.
Note: The RPD is only calculated if both results are detected (greater than instruments detection limit).	



Environmental Surveillance Program Quality Assurance/Quality Control

The INL contractor analytical laboratories analyzed all Environmental 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 National Center for Environmental Research (NCER) Quality Assurance Program. The laboratories met the performance objectives specified by the MAPEP and NCER.

PE samples were submitted for soils, and vegetation and results received met all of the agreement criteria.

The Environmental Surveillance 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.

PE samples were submitted to the contract laboratory for analysis in February 2005 for site surveillance programs. Results on the PE samples showed satisfactory agreement.

REFERENCES

American Society of Mechanical Engineers (ASME), 1989, "NQA-3-1989: Quality Assurance Requirements for the Collection of Scientific and Technical Information for Site Characterization of High-Level Nuclear Repositories, Supplement SW-1," American National Standard; New York.

American Society of Mechanical Engineers (ASME), 2001, "NQA-1-2000: Quality Assurance Requirements for Nuclear Facility Applications, Part I," American National Standard; New York.

U.S. Department of Energy (DOE), 2005, Mixed Analyte Performance Evaluation Program, http://www.inl.gov/resl/mapep/reports.html.

U.S. Environmental Protection Agency (EPA), 1998, EPA QA/G-5, *EPA Guidance for Quality Assurance Project Plans*, Appendix B, EPA/600/R-98/018, February.



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, 2005;
- U.S. Environmental Protection Agency (EPA), "National Emission Standards for Hazardous Air Pollutants," 40 CFR 61, 2005;
- U.S. Environmental Protection Agency (EPA), "Oil Pollution Prevention," 40 CFR 112, 2005;
- U.S. Environmental Protection Agency (EPA), "National Pollutant Discharge Elimination System," 40 CFR 122, 2005;
- U.S. Environmental Protection Agency (EPA), "National Interim Primary Drinking Water Regulations," 40 CFR 141, 2005;
- U.S. Environmental Protection Agency (EPA), "Hazardous Waste Management System: General," 40 CFR 260, 2005;
- U.S. Environmental Protection Agency (EPA), "Identifying and Listing of Hazardous Wastes," 40 CFR 261, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Generators of Hazardous Waste," 40 CFR 262, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Transporters of Hazardous Waste," 40 CFR 263, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 264, 2005;
- U.S. Environmental Protection Agency (EPA), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 265, 2005;
- U.S. Environmental Protection Agency (EPA), "Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities," 40 CFR 267, 2005;
- 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 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}Am	2×10^{-14}	3×10^{-8}
^{106}Ru	3×10^{-11}	6×10^{-6}			

a. Derived concentration guides (DCGs) are from DOE Order 5400.5 and are based on committed effective dose equivalent of 100 mrem/yr for ingestion or inhalation of radionuclide during one year.
b. All values are in microcuries per milliliter (µCi/mL).
c. Based on the most restrictive alpha emitter (^{241}Am).
d. Based on the most restrictive beta emitter (^{228}Ra).
e. Submersion in a cloud of gas is more restrictive than the inhalation pathway.
f. An "m" after the number refers to a metastable form of the radionuclide.



Table A-2. Radiation Standards for Protection of the Public in the Vicinity of 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.



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.



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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 guidelines 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 saying reporting constituents absent in a sample population when it actually is, to the extent that is reasonable and practicable. 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.

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

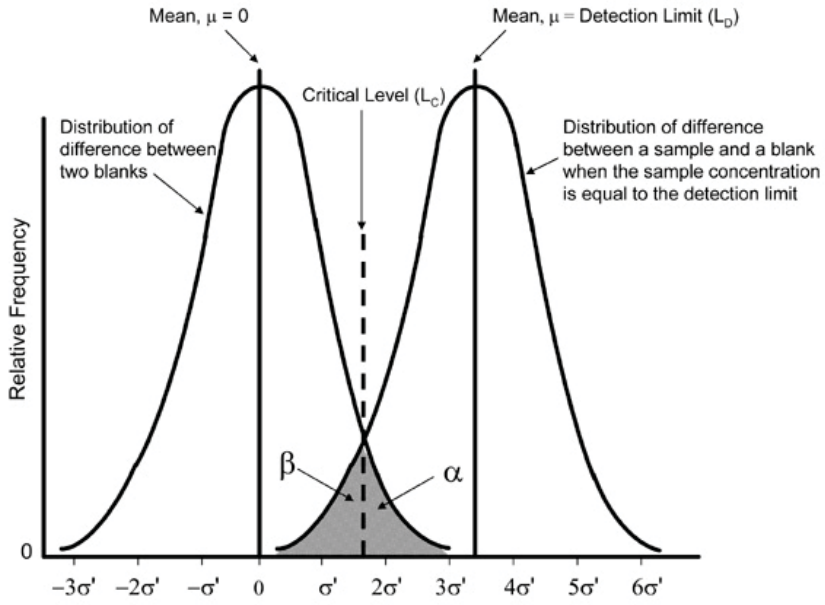

Figure B-1. Ilustration of the Relation of the Criterion of Detection (Critical Level) and the Limit of Detection (Detection Limit). Errors of the First Kind (False Negatives) are Represented by the Value of α, Whereas Errors of the Second Kind (False Positives) are Represented by the Value of β. (from Currie 1988)



error of the first kind (false positive), corresponds to the correct decision "not detected." Typically, α is set equal to 0.05. Using algorithms in Currie (1984) that are appropriate for our data, the L_C is 1.65s or approximately 2s. At this level, there is about a 95-percent probability that the correct decision—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentration larger than or equal to 2s, which were concluded as being detected, might not contain the radionuclide (i.e., a false positive).

Once the critical level has been defined, the minimum detectable concentration (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 5 percent of the samples that contain true concentrations at the minimum detectable concentration of 3s. These are referred to as false negatives or errors of the second kind.

True radionuclide concentrations between 2s and 3s have larger errors of the second kind. That is, there is a larger-than-five-percent probability of false negative results for samples with true concentrations between 2s and 3s. Although the radionuclide might have been detected, such detection may not be considered reliable; at 2s, the probability of a false negative is about 50 percent.

In this report, radionuclide concentrations less than 3s are considered to be below a "reporting level." Concentrations above 3s are considered to be detected with confidence. Results between $2\sigma_S$ 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, 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.

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.

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



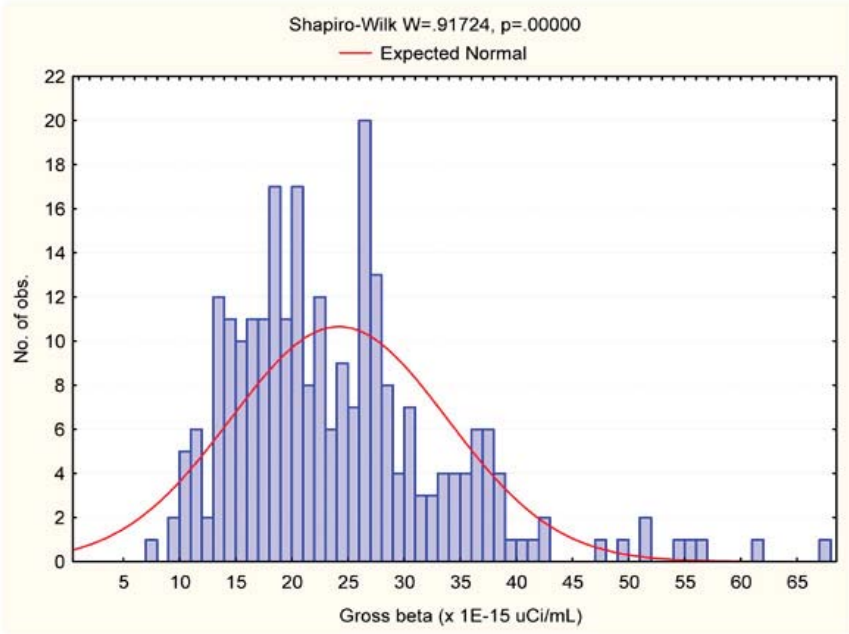

Figure B-2. Test of Normality for Arco Gross Beta Data.

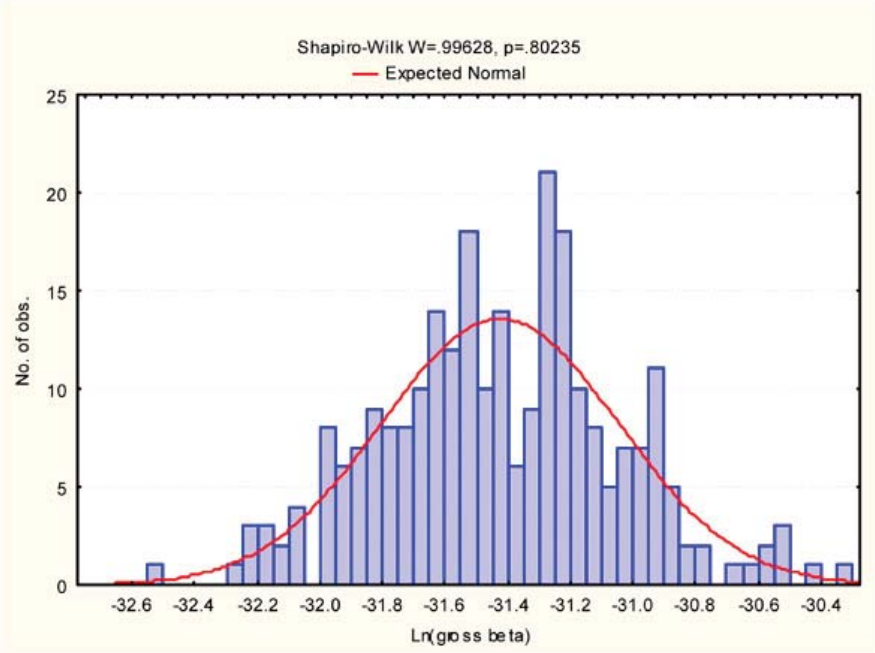

Figure B-3. Test of Lognormality for Arco Gross Beta.



Comparison of Two Groups

For comparison of two groups, the Mann-Whitney U-Test (Hollander and Wolfe 1973) is a powerful nonparametric alternative to the Student's T-Test. In fact, the U-Test is the most powerful (or sensitive) nonparametric alternative to the T-Test for independent samples; in some instances it may offer even greater power to reject the null hypothesis than the T-Test. The interpretation of the Mann-Whitney U-Test is essentially identical to the interpretation of the Student's T-Test for independent samples, except that the U-Test is computed based on rank sums rather than means. Because of this fact, outliers do not present the serious problem that they do when using parametric tests.

Suppose 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.

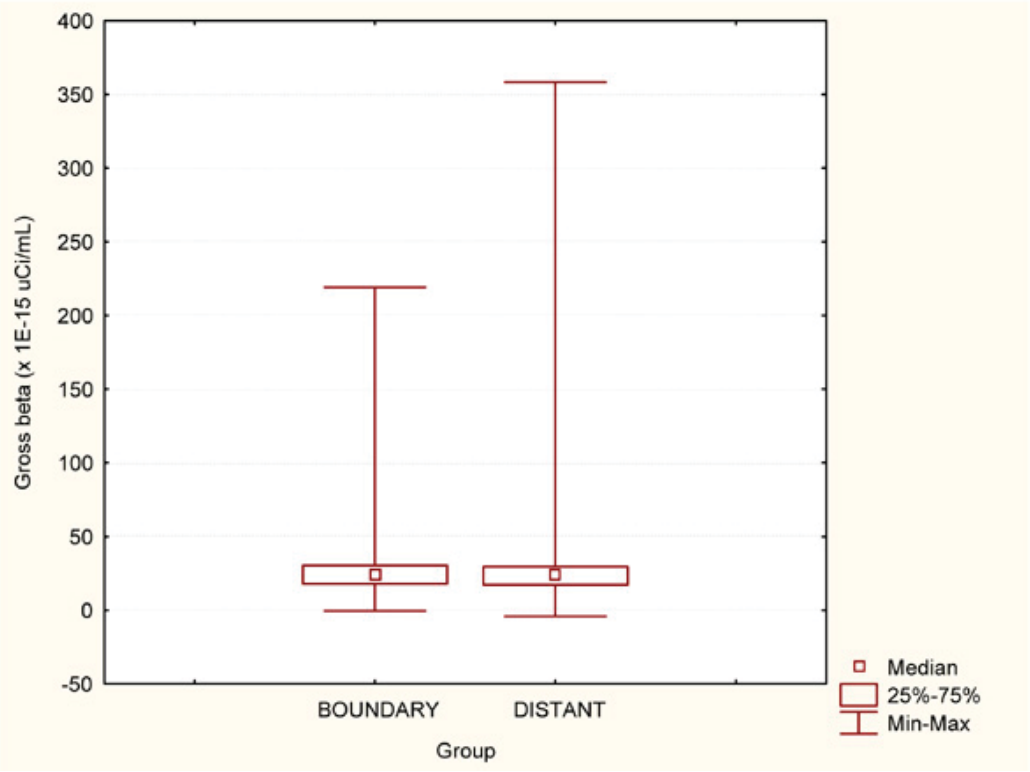

Figure B-4. Box Plot of Gross Beta Data from Boundary and Distant Locations.



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 a One-Way ANOVA. A nonparametric alternative to the One-Way ANOVA is the Kruskal-Wallis ANOVA (Hollander and Wolfe 1973). The test assesses the hypothesis that the different samples in the comparison were drawn from the same distribution or from distributions with the same median. Thus, the interpretation of the Kruskal-Wallis ANOVA is basically identical to that of the parametric One-Way ANOVA, except that it is based on ranks rather than means.

Figure 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

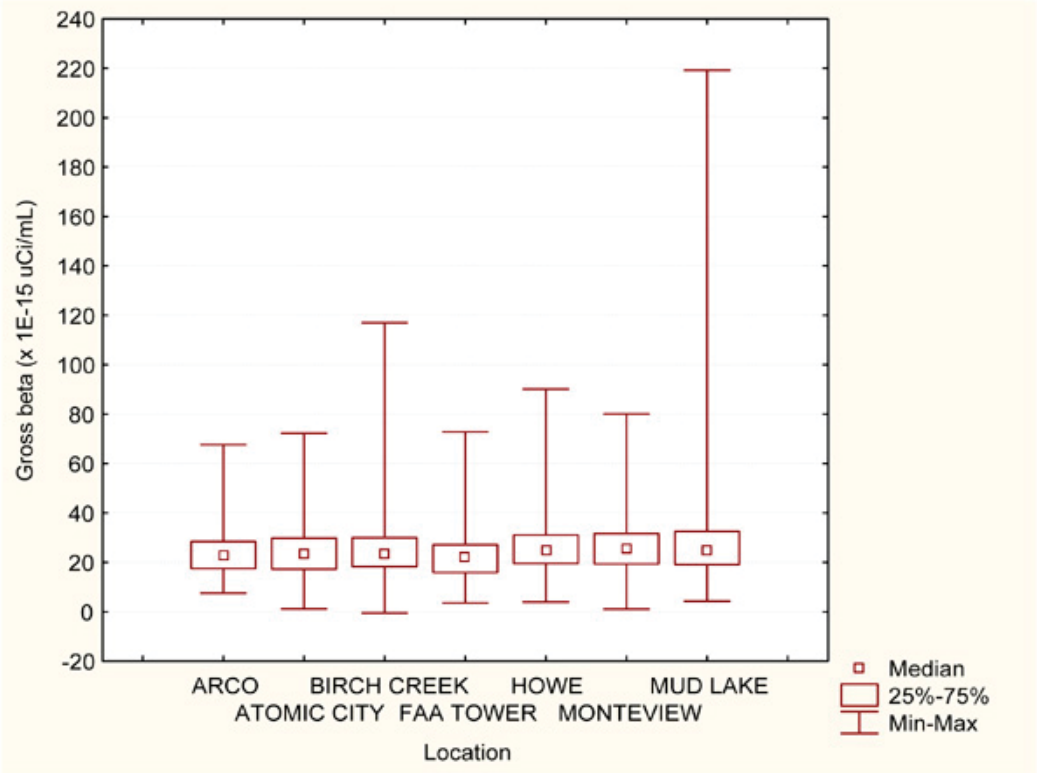

Figure B-5. Box Plot of Gross Beta Data for Each Boundary Location.



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.

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.

Table B-2. Summary Statistics for Boundary Locations.

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).



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.

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.

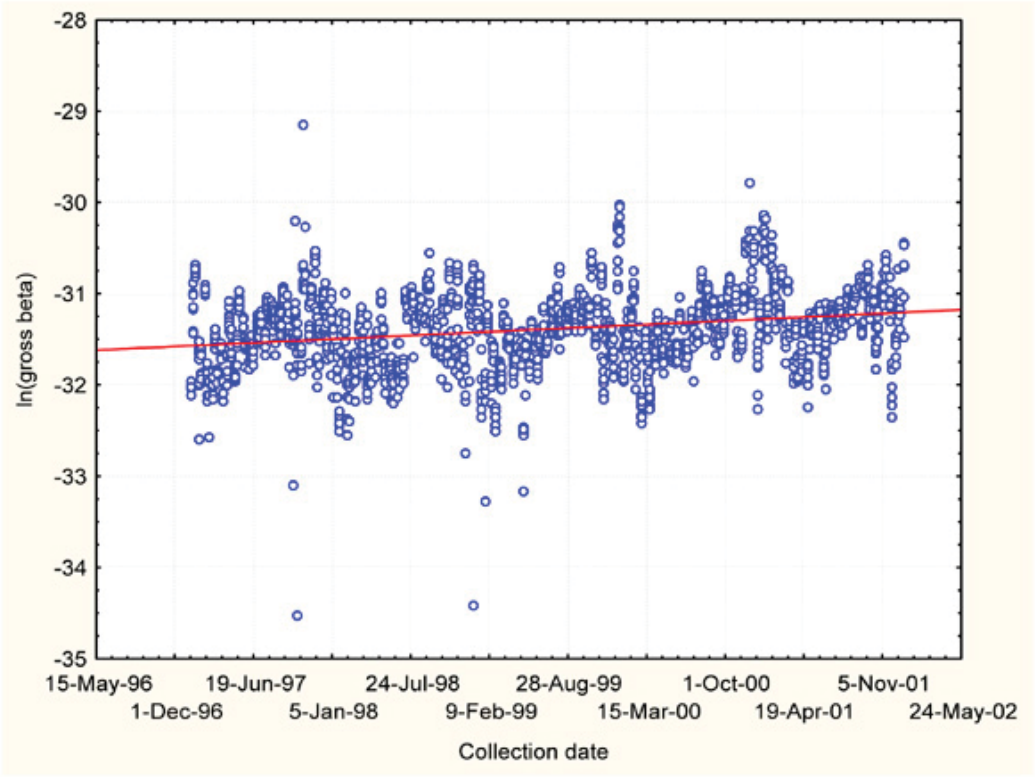

Figure B-6. Scatter Plot and Regression Line for ln(Gross Beta) from Boundary Locations.



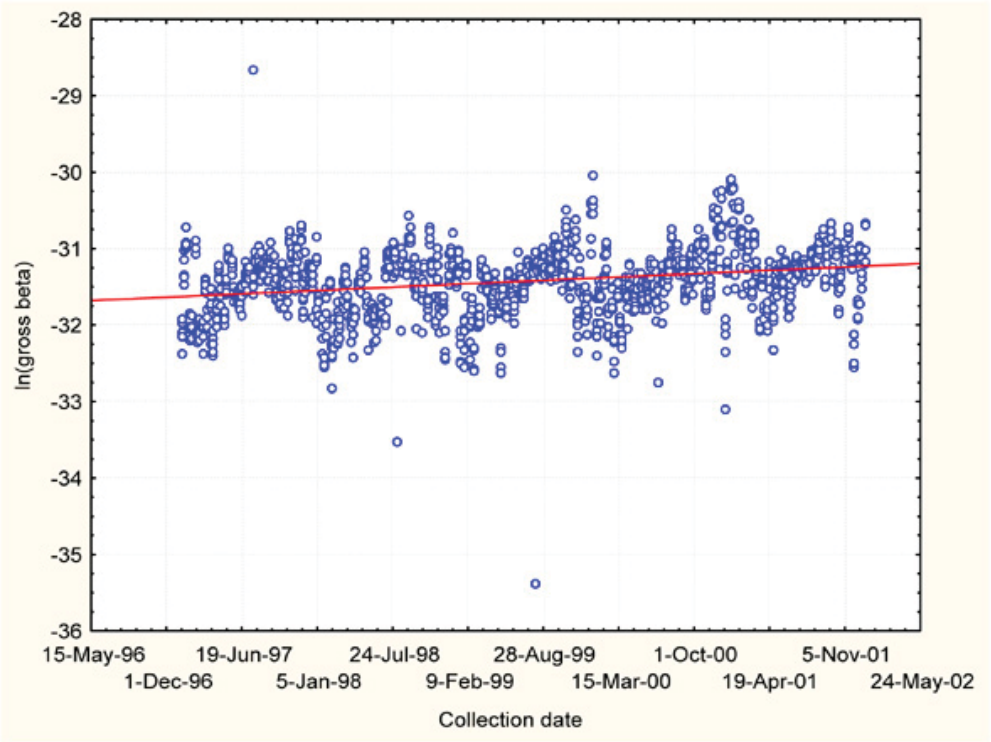

Figure B-7. Scatter Plot and Regression Line for ln(Gross Beta) from Distant Locations.

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



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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LeRoy L. Knobel - United States Geological Survey

Water Resources Data, Idaho, 2005: Volume 1. Surface Water Records *(T.S. Brennan, A.K. Lehmann, and O'Dell, I.)*

Water resources data for the 2005 water year for Idaho consists of records of stage, discharge, and water quality of streams; stage, contents, and water quality of lakes and reservoirs; discharge of irrigation diversions; and water levels and water quality of groundwater. The two volumes of this report contain discharge records for 204 stream-gaging stations and 9 irrigation diversions; stage only records for 5 stream-gaging stations; stage only for 6 lakes and reservoirs; contents only for 13 lakes and reservoirs; water-quality for 26 stream-gaging stations and partial record sites, 19 lakes sites, and 450 groundwater wells; and water levels for 465 observation network wells. Additional water data were collected at various sites not involved in the systematic data collection program and are published as miscellaneous measurements.

Water Resources Data, Idaho, 2005: Volume 2. Ground Water Records *(A.M. Campbell, S.N. Conti, I. O'Dell)*

Water resources data for the 2005 water year for Idaho consists of records of stage, discharge, and water quality of streams; stage, contents, and water quality of lakes and reservoirs; discharge of irrigation diversions; and water levels and water quality of groundwater. The two volumes of this report contain discharge records for 204 stream-gaging stations and 9 irrigation diversions; stage only records for 5 stream-gaging stations; stage only for 6 lakes and reservoirs; contents only for 13 lakes and reservoirs; water-quality for 26 stream-gaging stations and partial record sites, 19 lakes sites, and 450 groundwater wells; and water levels for 465 observation network wells. Additional water data were collected at various sites not involved in the systematic data collection program and are published as miscellaneous measurements.

Petrogenesis of an evolved olivine tholeiite and chemical stratigraphy of cores USGS 127, 128, and 129, Idaho National Engineering and Environmental Laboratory *(Claire Grimm Chadwick)*

The eastern Snake River Plain (ESRP) volcanic province has been dominated by basaltic volcanism for at least 3.2 Ma. Basalt core from three boreholes , USGS 127, 128, and 129, drilled at the Idaho National Engineering and Environmental Laboratory (INEEL) are used to document the subsurface chemostratigraphy of ESRP basalts and to understand the origin of their chemical variability. The stratigraphy of these coreholes was defined by detailed geochemical analysis of individual lava flows combined with paleomagnetic inclination data. Lava flows with similar chemistry and paleomagnetic inclination were identified and correlated between the three cores to refine the subsurface stratigraphy in this region.

One lava flow group from these cores, known as the "high K" flow group, is distinguished from typical olivine tholeiites on the ESRP by unusually high concentrations of incompatible elements and unusually low Sr isotopic ratios. The major element, trace element, and isotopic characteristics of this flow group were studied in detail in order to explain its petrogenetic history. Mass-balance modeling indicates that fractionation of plagioclase, olivine, magnetite, and apitite from a plausible olivine tholeiite parent magma could produce the high K flow group lavas. However, thermodynamic modeling of fractionation of the parent magma under higher redox conditions could not reproduce the required mineral assembledge. Another mechanism for the removal of magnetite and apitite in addition to olivine and plagioclase from the high K flow group parent magma is required. The high K flow group may be part of a chemically continuous series of lavas that includes the underlying lava flow group, designated here as flow group 4.

Historical Development of the U.S. Geological Survey Hydrologic Monitoring and Investigative Programs at the Idaho National Engineering and Environmental Laboratory, Idaho, 1949 to 2001
(LeRoy L. Knobel, Roy C. Bartholomay, and Joseph P. Rousseau)

This report is a summary of the historical development, from 1949 to 2001, of the U.S. Geological Survey's (USGS) hydrologic monitoring and investigative programs at the Idaho National Engineering and Environmental Laboratory. The report covers the USGS's water-level monitoring program, water-quality sampling program, geophysical program, geologic framework program, drilling program, modeling program, surface-water program, and unsaturated-zone program. The report provides physical information about the wells, and information about the frequencies of sampling and measurement. Summaries of USGS published reports with U.S. Department of Energy (DOE) report numbers also are provided in an appendix. This report was prepared by the USGS in cooperation with the DOE.

Genetic controls on basalt alteration within the eastern Snake River Plain aquifer system, Idaho
(John Mazurek)

This study examines the origin of basalt alteration that correlates with the sharp, but irregular boundary between active and deeper, much less conductive portions of the eastern Snake River Plain (ESRP) aquifer system. I specifically investigate three hypotheses for the origin of the boundary: (1) that basalt alteration took place *in-situ*, post-emplacement, while the basalt was within the ESRP aquifer system under ambient aquifer temperature and aqueous geochemical conditions, (2) that basalt alteration took place *in-situ*, post-emplacement, while the basalt was within the ESRP aquifer system under elevated temperature and different aqueous geochemical conditions, and (3) that basalt altered syn-emplacement, during the peperitization process.

A majority of altered basaltic units in borehole Middle 1823 also exhibit prominent syn-emplacement, peperitic intermingling between the molten basalt and wet sediment. Peperitization of



basalts is distinguished from subaerially or palagonitized basalt by zones of intermingled basalt and sediment displaying amoeboid-shaped basalt clasts with fluidal, oxidized margins intermingling with sediment at glass-rich contact regions between basalt and sediment, as well as clastic dikes of sediment and sediment amygdules within basalt flows. Thus some alteration occurred during the peperitization of the basalt, which was later overprinted by *in-situ* alteration.

Fluid inclusion microthermometry indicates that *in-situ* alteration-associated calcite precipitated at temperatures 7-20 ^{o}C higher than the present day temperatures. This is substantially higher than expected ambient variability within the aquifer and supports hypothesis # 2. Transient inputs of warm, reactive hydrothermal groundwater from depth (McLing et al., 1997; McLing et al., 2002; Morse and McCurry, 2002; Morse, 2002) with local variations in extent, magnitude, and flux, best explain the 3 dimensional variations in the morphology of the contact between the active portion and the base of the ESRP aquifer.

Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Laboratory to the Hagerman Area, Idaho, 2003 *(Gordon W. Rattray, Amy J. Wehnke, L. Flint Hall, and Linford J. Campbell)*

The U.S. Geological Survey and the Idaho Department of Water Resources, in cooperation with the U.S. Department of Energy, sampled water from 14 sites as part of an ongoing study to monitor the water quality of the eastern Snake River Plain aquifer between the southern boundary of the Idaho National Laboratory (INL) and the Burley-Twin Falls-Hagerman area. The State of Idaho, Department of Environmental Quality, Division of INL Oversight and Radiation Control cosampled with the U.S. Geological Survey and the Idaho Department of Water Resources and their analytical results are included in this report. The samples were collected from four domestic wells, two dairy wells, two springs, four irrigation wells, one observation well, and one stock well and analyzed for selected radiochemical and chemical constituents. Two quality-assurance samples, sequential replicates, also were collected and analyzed.

None of the concentrations of radiochemical or organic-chemical constituents exceeded the maximum contaminant levels for drinking water established by the U.S. Environmental Protection Agency. However, the concentration of one inorganic-chemical constituent, nitrate (as nitrogen), in water from site MV-43 was 20 milligrams per liter which exceeded the maximum contaminant level for that constituent. Of the radiochemical and chemical concentrations analyzed for in the replicate-sample pairs, 267 of the 270 pairs (with 95 percent confidence) were statistically equivalent.

Review of the Transport of Selected Radionuclides in the Interim Risk Assessment for the Radioactive Waste Management Complex, Waste Area Group 7 Operable Unit 7-13/14, Idaho National Engineering and Environmental Laboratory, Idaho *(Joseph P. Rousseau, Edward R. Landa, John R. Nimmo, L. DeWayne Cecil, LeRoy L. Knobel, Pierre D. Glynn, Edward M. Kwicklis,*



Gary P. Curtis, Kenneth G. Stollenwerk, Steven R. Anderson, Roy C. Bartholomay, Clifford R. Bossong, and Brennon R. Orr)

The U.S. Department of Energy (DOE) requested that the U.S. Geological Survey conduct an independent technical review of the Interim Risk Assessment (IRA) and Contaminant Screening for the Waste Area Group 7 (WAG-7) Remedial Investigation, the draft Addendum to the Work Plan for Operable Unit 7-13/14 WAG-7 comprehensive Remedial Investigation and Feasibility Study (RI/FS), and supporting documents that were prepared by Lockheed Martin Idaho Technologies, Inc.

The purpose of the technical review was to assess the data and geotechnical approaches that were used to estimate future risks associated with the release of the actinides americium, uranium, neptunium, and plutonium to the Snake River Plain aquifer from wastes buried in pits and trenches at the Subsurface Disposal Area (SDA). The SDA is located at the Radioactive Waste Management Complex in southeastern Idaho within the boundaries of the Idaho National Engineering and Environmental Laboratory. Radionuclides have been buried in pits and trenches at the SDA since 1957 and 1952, respectively. Burial of transuranic wastes was discontinued in 1982.

The five specific tasks associated with this review were defined in a "Proposed Scope of Work" prepared by the DOE, and a follow-up workshop held in June 1988. The specific tasks were (1) to review the radionuclide sampling data to determine how reliable and significant are the reported radionuclide detections and how reliable is the ongoing sampling program, (2) to assess the physical and chemical processes that logically can be invoked to explain true detections, (3) to determine if distribution coefficients that were used in the IRA are reliable and if they have been applied properly, (4) to determine if the transport model predictions are technically sound, and (5) to identify issues needing resolution to determine technical adequacy of the risk assessment analysis, and what additional work is required to resolve those issues.

Development of Property-Transfer Models for Estimating the Hydraulic Properties of Deep Sediments at the Idaho National Engineering and Environmental Laboratory, Idaho *(Kari A. Winfield)*

Because characterizing the unsaturated hydraulic properties of sediments over large areas or depths is costly and time consuming, development of models that predict these properties from more easily measured bulk-physical properties is desirable. At the Idaho National Engineering and Environmental Laboratory, the unsaturated zone is composed of thick basalt flow sequences interbedded with thinner sedimentary layers. Determining the unsaturated hydraulic properties of sedimentary layers is one step in understanding water flow and solute transport processes through this complex unsaturated system. Multiple linear regression was used to construct simple property-transfer models for estimating the water-retention curve and saturated hydraulic conductivity of deep sediments at the Idaho National Engineering and Environmental Laboratory. The regression models were developed from 109 core



sample subsets with laboratory measurements of hydraulic and bulk-physical properties. The core samples were collected at depths of 9 to 175 meters at two facilities within the southwestern portion of the Idaho National Engineering and Environmental Laboratory¿the Radioactive Waste Management Complex, and the Vadose Zone Research Park southwest of the Idaho Nuclear Technology and Engineering Center. Four regression models were developed using bulk-physical property measurements (bulk density, particle density, and particle size) as the potential explanatory variables. Three representations of the particle-size distribution were compared: (1) textural-class percentages (gravel, sand, silt, and clay), (2) geometric statistics (mean and standard deviation), and (3) graphical statistics (median and uniformity coefficient). The four response variables, estimated from linear combinations of the bulk-physical properties, included saturated hydraulic conductivity and three parameters that define the water-retention curve.

For each core sample,values of each water-retention parameter were estimated from the appropriate regression equation and used to calculate an estimated water-retention curve. The degree to which the estimated curve approximated the measured curve was quantified using a goodness-of-fit indicator, the root-mean-square error. Comparison of the root-mean-square-error distributions for each alternative particle-size model showed that the estimated water-retention curves were insensitive to the way the particle-size distribution was represented. Bulk density, the median particle diameter, and the uniformity coefficient were chosen as input parameters for the final models. The property-transfer models developed in this study allow easy determination of hydraulic properties without need for their direct measurement. Additionally, the models provide the basis for development of theoretical models that rely on physical relationships between the pore-size distribution and the bulk-physical properties of the media. With this adaptation, the property-transfer models should have greater application throughout the Idaho National Engineering and Environmental Laboratory and other geographic locations.



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Table D-1. Environmental Dosimeter Measurements at the Materials and Fuels Complex (MFC) (2005).

Location	Exposure[a]
ANL 7	140 ± 10
ANL 8	142 ± 10
ANL 9	148 ± 10
ANL 10	132 ± 9
ANL 11	144 ± 10
ANL 12	124 ± 9
ANL 13	129 ± 9
ANL 14	128 ± 9
ANL 15	170 ± 12
ANL 16	161 ± 11
ANL 17	--[b]
ANL 18	152 ± 11

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.

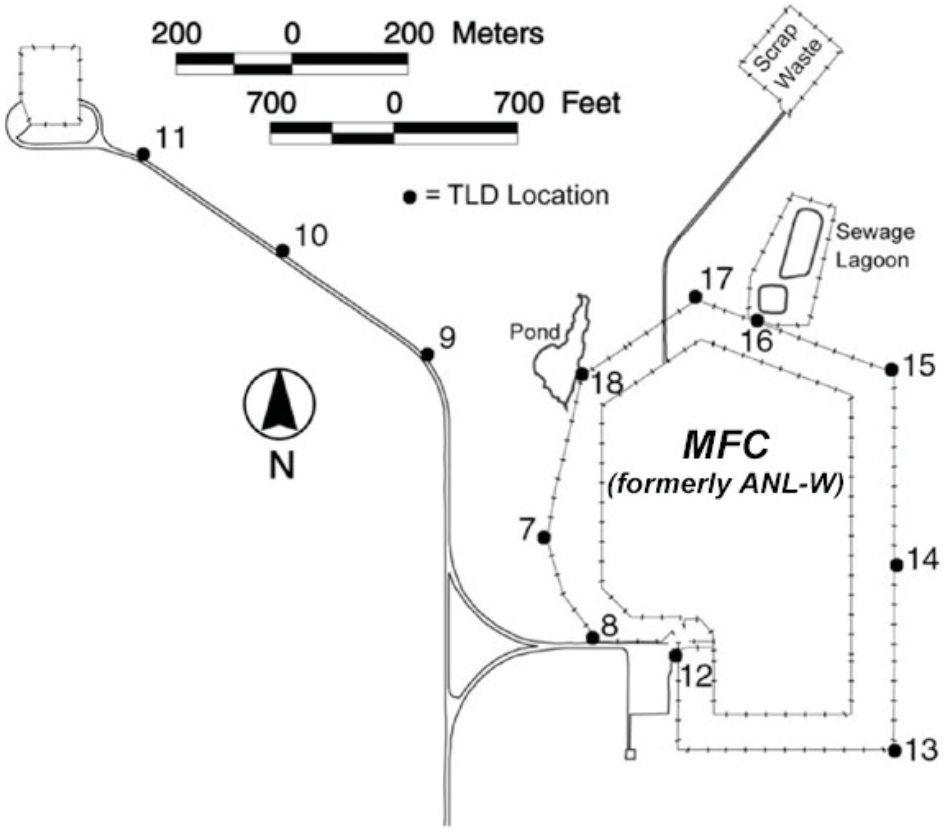

Figure D-1. Environmental Dosimeter Locations at MFC (2005).

Table D-2. Environmental Dosimeter Measurements at the Auxiliary Reactor Area (ARA) (2005).

Location	Exposure[a]
ARA 1	[b]
ARA 2	140 ± 10
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.

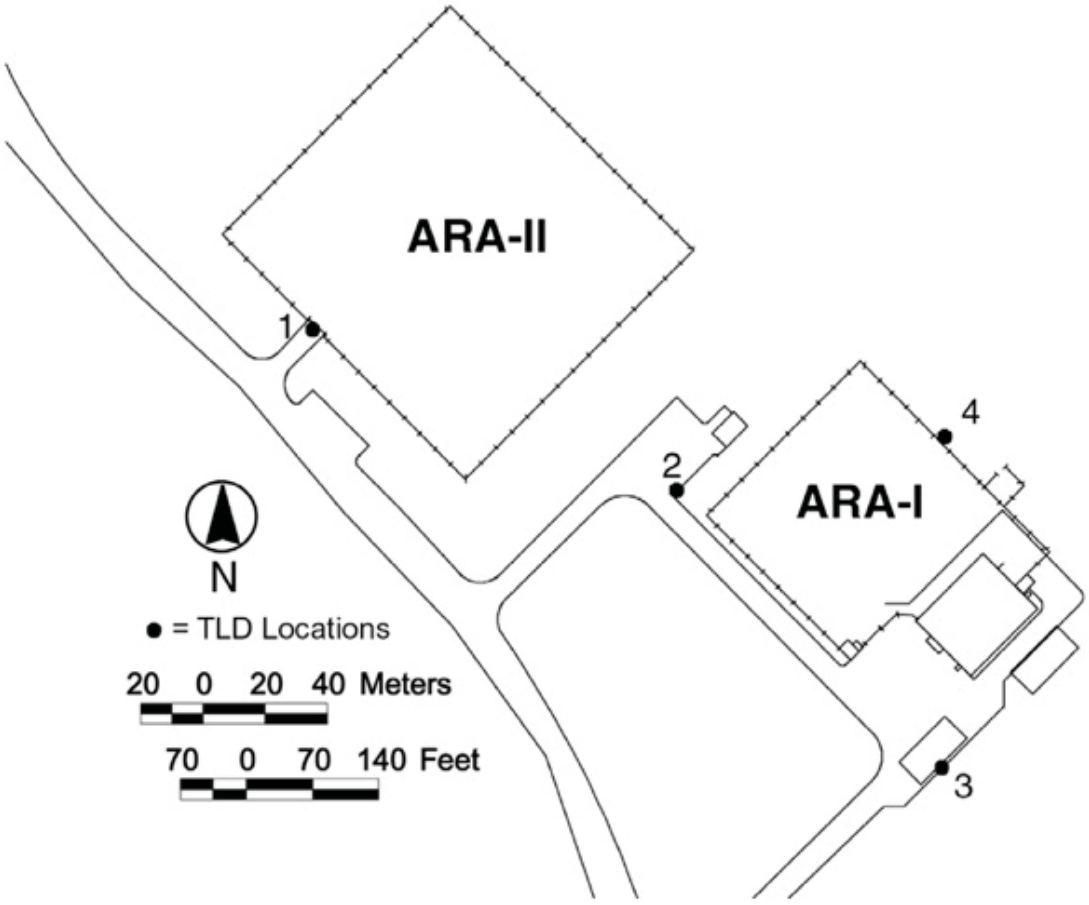

Figure D-2. Environmental Dosimeter Locations at ARA (2005).



Table D-3. Environmental Dosimeter Measurements at the Central Facility Area (CFA) (2005).

Location	Exposure[a]
CFA 1	134 ± 9
CFA 2	119 ± 8
CFA 3	141 ± 10
CFA 4	132 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

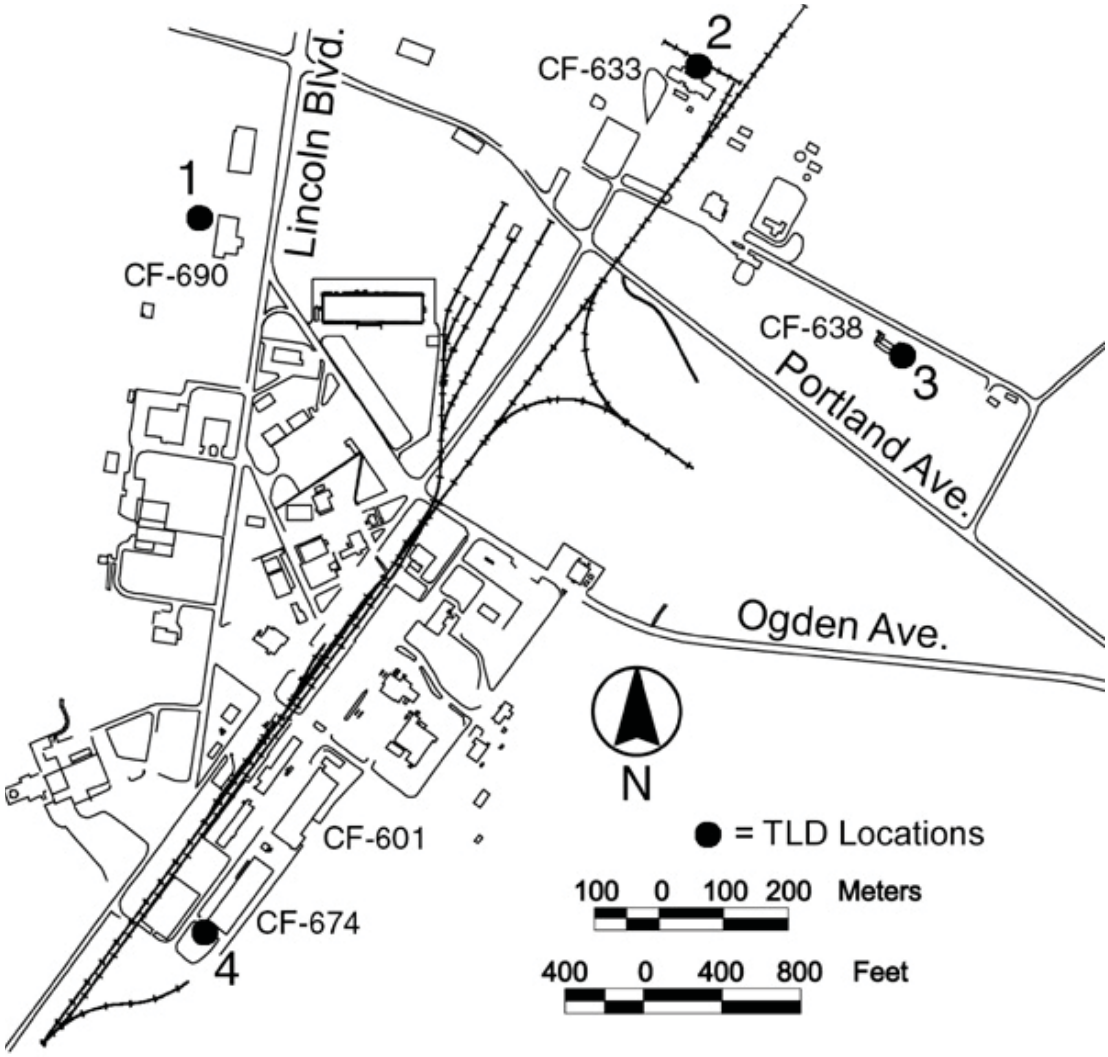

Figure D-3. Environmental Dosimeter Measurements at the CFA (2005).



Table D-4. Environmental Dosimeter Measurements at the Idaho Nuclear Technology and Engineering Center (INTEC) (2005).

Location	Exposure[a]
INTEC 1	160 ± 11
INTEC 9	175 ± 12
INTEC 14	150 ± 10
INTEC 15	153 ± 11
INTEC 16	137 ± 9
INTEC 17	134 ± 9
INTEC 18	--[b]
INTEC 19	146 ± 10
INTEC 20	246 ± 17
INTEC 21	176 ± 12
INTEC 22	200 ± 14
INTEC 23	147 ± 10
INTEC 24	139 ± 10
INTEC 25	127 ± 9
INTEC 26	140 ± 10
TREE FARM 1	183 ± 13
TREE FARM 2	157 ± 11
TREE FARM 3	163 ± 11
TREE FARM 4	202 ± 14

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

b. Dosimeter missing at one of the collection times.

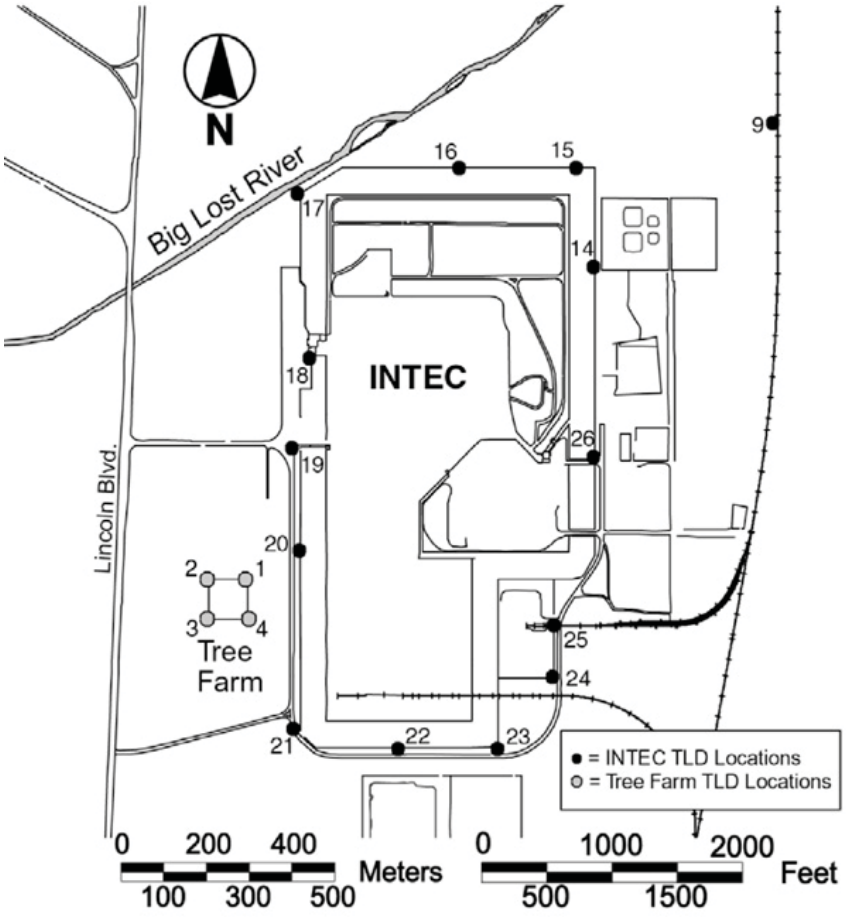

Figure D-4. Environmental Dosimeter Measurements at the INTEC (2005).



Table D-5. Environmental Dosimeter Measurements at the Naval Reactors Facility (NRF) (2005).[a]

Location	Exposure[b]
NRF 4	136 ± 9
NRF 5	137 ± 10
NRF 11	138 ± 10
NRF 12	--[c]
NRF 13	135 ± 9
NRF 16	131 ± 9
NRF 17	--[d]
NRF 18	139 ± 10
NRF 19	143 ± 10
NRF 20	145 ± 10
NRF 21	--[d]

a. The INL contractor (BEA) manages dosimeteres at NRF.
b. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
c. Dosimeter missing at one of the collection times.
d. These locations were eliminated by construction activities.

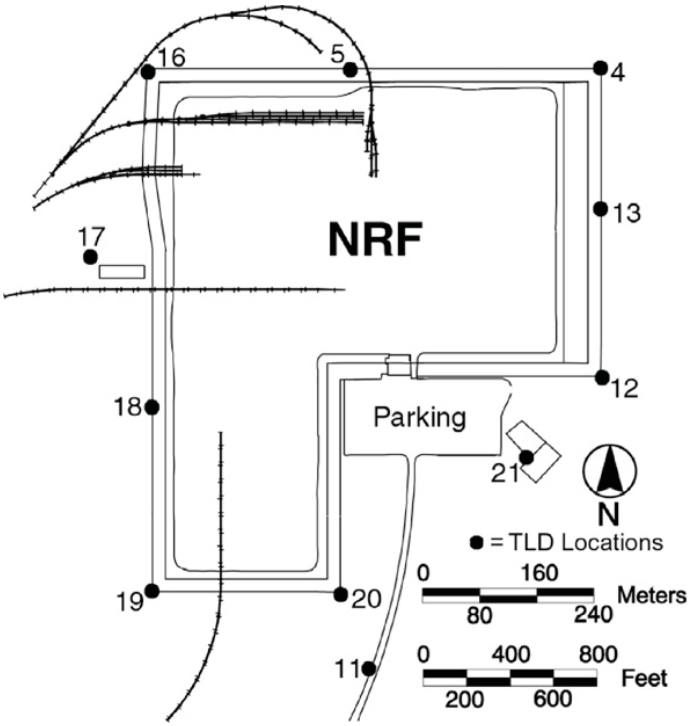

Figure D-5. Environmental Dosimeter Measurements at the NRF (2005).



Table D-6. Environmental Dosimeter Measurements at the Critical Infrastructure Test Range Complex (CITRC) (2005).

Location	Exposure[a]
CITRC/SPERT 1	131 ± 9
CITRC /SPERT 2	132 ± 9
CITRC /SPERT 3	137 ± 10
CITRC /SPERT 4	138 ± 10
CITRC /SPERT 5	136 ± 9
CITRC /SPERT 6	139 ± 10
CITRC /WERF 1	139 ± 10
CITRC /WERF 2	116 ± 8
CITRC /WERF 3	127 ± 9
CITRC /WERF 4	132 ± 9
CITRC /WERF 5	134 ± 9
CITRC /WERF 6	130 ± 9
CITRC /WERF 7	140 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

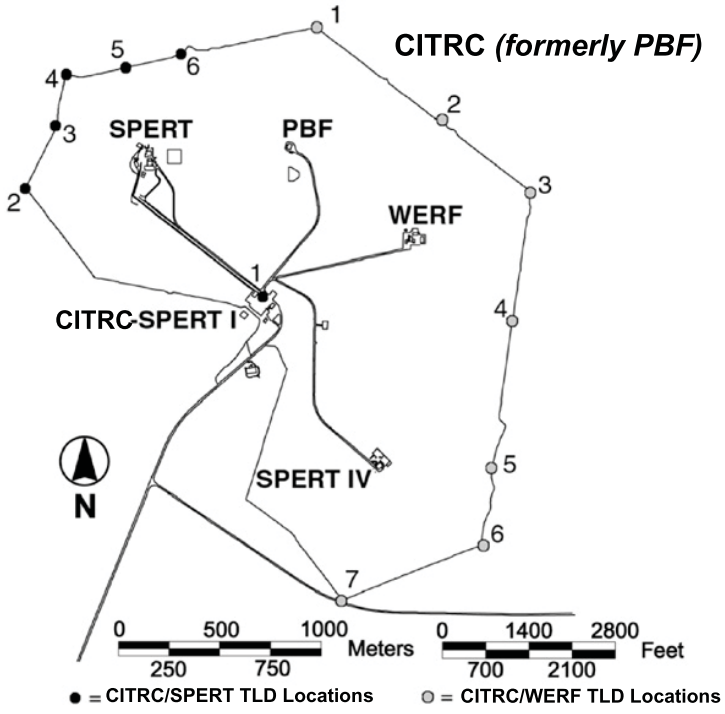

Figure D-6. Environmental Dosimeter Measurements at the CITRC (2005).



Table D-7. Environmental Dosimeter Measurements at the Radioactive Waste Management Complex (RWMC) (2005).

Location	Exposure[a]
RWMC 3a	137 ± 9
RWMC 5a	143 ± 10
RWMC 7a	145 ± 10
RWMC 9a	150 ± 10
RWMC 11a	141 ± 10
RWMC 13a	135 ± 9
RWMC15a	130 ± 9
RWMC 17a	132 ± 9
RWMC 19a	123 ± 9
RWMC 21a	136 ± 9
RWMC 23a	137 ± 9
RWMC 25a	155 ± 11
RWMC 27a	202 ± 14
RWMC 29a	243 ± 17
RWMC 31a	216 ± 15
RWMC 37a	126 ± 9
RWMC 39	137 ± 10
RWMC 40	152 ± 11
RWMC 41	344 ± 24
RWMC 42	137 ± 10
RWMC 43	138 ± 10
RWMC 45	200 ± 14
RWMC 46	136 ± 9
RWMC 47	121 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

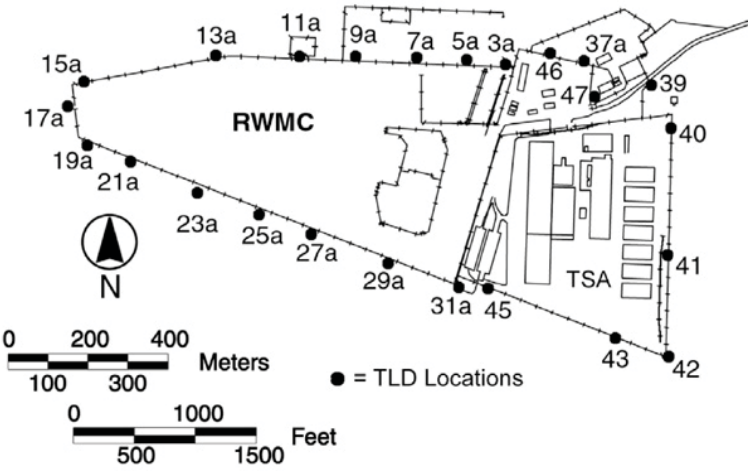

Figure D-7. Environmental Dosimeter Measurements at the RWMC (2005).



Table D-8. Environmental Dosimeter Measurements at the Test Area North (TAN) (2005).

Location	Exposure[a]
TAN/TSF 1	113 ± 8
TAN/TSF 2	142 ± 10
TAN/TSF 3	114 ± 8
TAN/TSF 4	124 ± 9
TAN/LOFT 1	134 ± 9
TAN/LOFT 2	--[b]
TAN/LOFT 3	114 ± 8
TAN/LOFT 4	116 ± 8
TAN/LOFT 5	120 ± 8
TAN/LOFT 6	141 ± 10
TAN/LOFT 7	144 ± 10
TAN/WRRTF1	131 ± 9
TAN/WRRTF2	123 ± 8
TAN/WRRTF3	--[b]
TAN/WRRTF4	119 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.

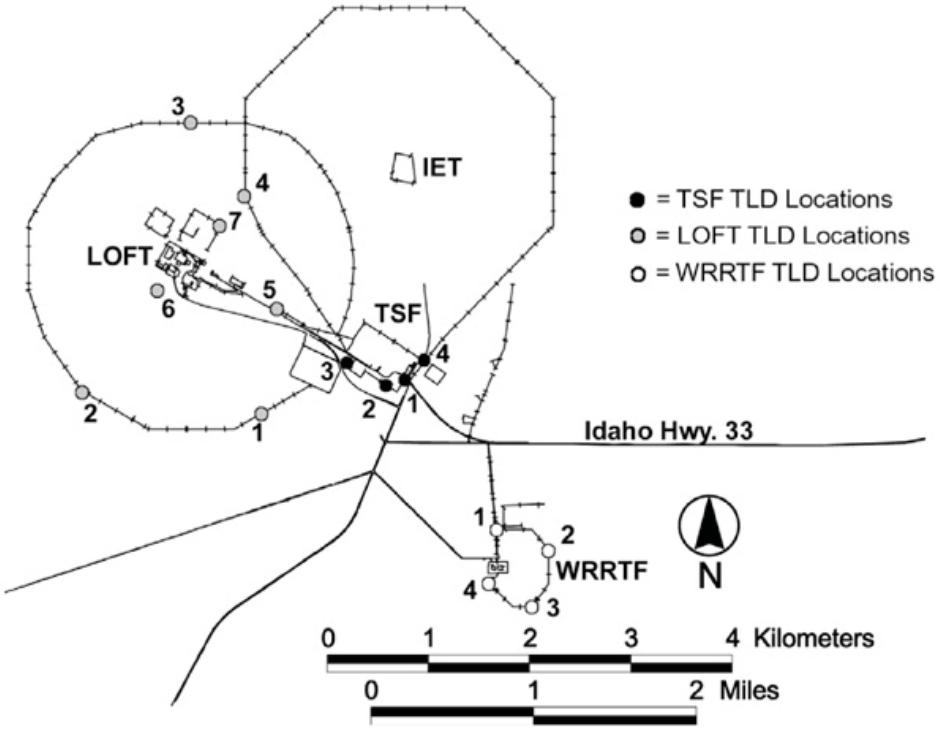

Figure D-8. Environmental Dosimeter Measurements at the TAN (2005).



Table D-9. Environmental Dosimeter Measurements at the Reactor Technology Complex (RTC) (2005).

Location	Exposure[a]
TRA 1	143 ± 10
TRA 2	162 ± 11
TRA 3	166 ± 11
TRA 4	165 ± 11
TRA 5	143 ± 10
TRA 6	130 ± 9
TRA 7	134 ± 9
TRA 8	152 ± 11
TRA 9	147 ± 10
TRA10	148 ± 10
TRA11	146 ± 10
TRA12	154 ± 11
TRA13	142 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

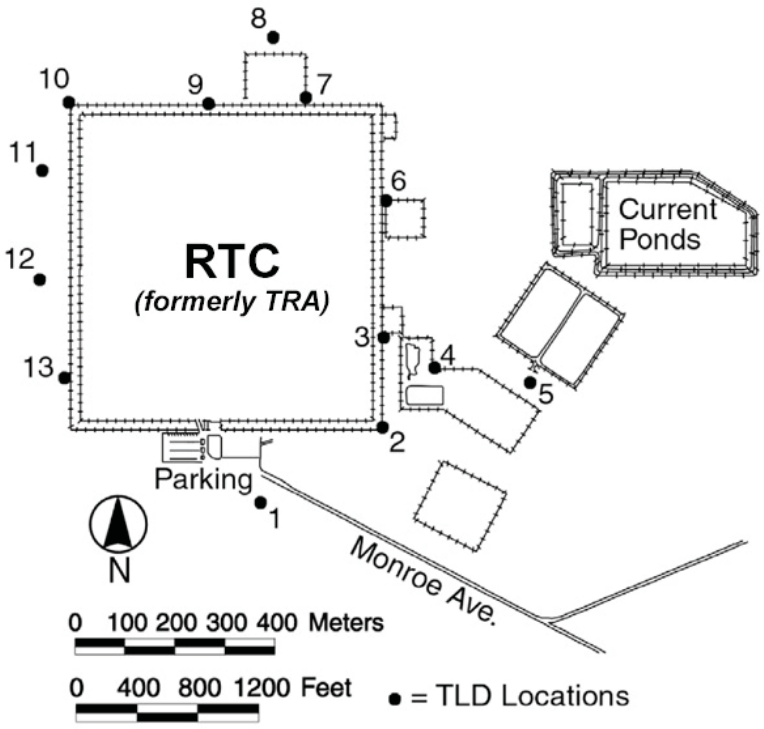

Figure D-9. Environmental Dosimeter Measurements at the RTC (2005).



Table D-10. Environmental Dosimeter Measurements along Lincoln Blvd. and US Highway 20 (2005).

Location	Exposure[a]
LINCOLN BLVD 1	127 ± 9
LINCOLN BLVD 3	141 ± 10
LINCOLN BLVD 5	133 ± 9
LINCOLN BLVD 7	134 ± 9
LINCOLN BLVD 9	133 ± 9
LINCOLN BLVD 11	128 ± 9
LINCOLN BLVD 13	135 ± 9
LINCOLN BLVD 15	133 ± 9
LINCOLN BLVD 17	139 ± 10
LINCOLN BLVD 19	129 ± 9
LINCOLN BLVD 21	127 ± 9
LINCOLN BLVD 23	122 ± 8
LINCOLN BLVD 25	124 ± 9
HWY 26-266	129 ± 9
HWY 26-268	129 ± 9
HWY 26-270	127 ± 9
HWY 20-264	128 ± 9
HWY 20-266	119 ± 8
HWY 20-268	124 ± 9
HWY 20-270	124 ± 9
HWY 20-272	114 ± 8
HWY 20-274	108 ± 7
HWY 20-276	124 ± 9
EBR 1	108 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

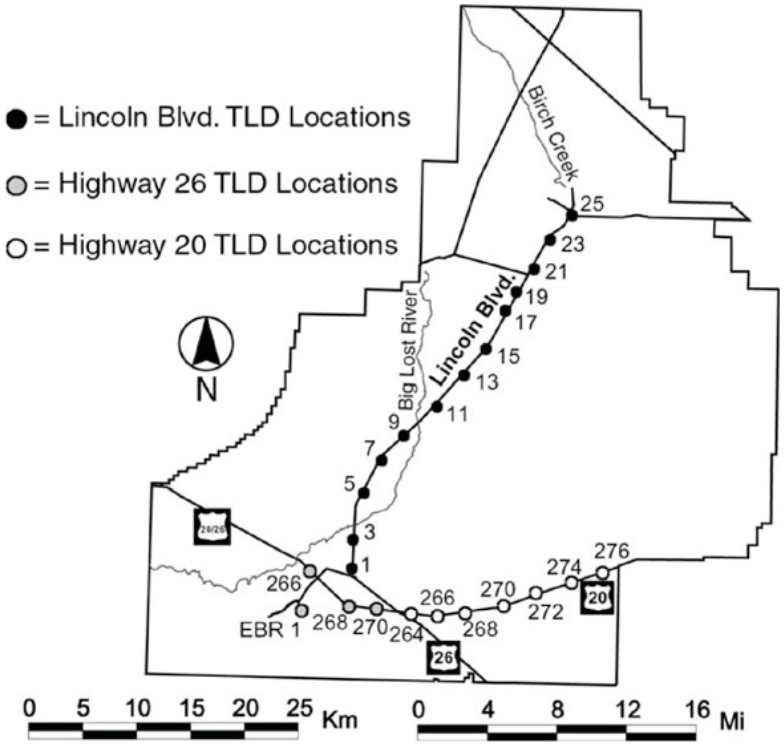

Figure D-10. Environmental Dosimeter Measurements along Lincoln Blvd. and US Highway 20 (2005).



A

Advanced Mixed Waste Treatment Facility: Opened in 2003, this facility is located on the Idaho National Laboratory (INL) Site at the Radioactive Waste Management Complex. Its purpose is the retrieval, preparation, and shipping of stored low-level transuranic waste to the Waste Isolation Pilot Plant.

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 make up 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. Naturally occurring radioactive elements such as radon emit alpha radiation.

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 ground water 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: A fine-grained dark igneous rock.

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, but 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 blank and laboratory 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 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 numerical range within which the true value of a measurement or calculated value lies. Typically, radiological values are reported with a 95 percent confidence interval (i.e., there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range).

contaminant: Any physical, chemical, biological, radiological substance, or matter in a location or concentration that is not naturally occurring.

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 Bq equals one nuclear decay per second. One curie of activity is equal to 3.7×10^{10} Bq.

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, though 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 reserves in the United States, it lies beneath the Snake River plain. Water comes from rivers surrounding the plain (the Snake River, Henry's Fork, Big Lost River, Little Lost River, Birch Creek, and Camas Creek) and from rain and snow that soaks down through the soils and rock. This water moves through the cracks in the rocks of the Snake River plain and flow out into the Snake River in the Thousand Springs area between Twin Falls and King Hill.

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 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 Communications), 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

Idaho National Laboratory (INL): Known locally as the INL Site, it was created as the National Reactor Testing Station by the U.S. Atomic Energy Commission in 1949 to build and test nuclear power reactors. The Testing Station was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory in January 1997. The INL was renamed the Idaho National Laboratory in 2005. Over the life of the INL Site, an assembly of 52 reactors, associated research centers, and waste handling areas have been constructed and tested.

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): The primary contractor responsible for management (human resources, staffing, and budget control) and day-to-day operations (system operations, building maintenance, process monitoring, and trash removal) of a facility or site.

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 non-community water system is either a transient non-community water system or a nontransient non-community 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 that 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 (0-7) indicates an acid condition; a high pH (7-14) 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:

$$RPD = \frac{(x_1 - x_2) \times 100}{0.5x(x_1 - x_2)}$$

where X_1 and X_2 are 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 fine grained light-brown to gray igneous rock.

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.

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

Snake River Plain: A wide (64 to 12 km [40 to 80 mi]) plain of rolling topography extended some 308 km (191 mi) from Ashton to King Hill/Twin Falls. The plain was formed by repeated volcanic eruptions that were the result of the passage of a geologic hot spot beneath the Earth's crust.

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.



U

U.S. Department of Energy (DOE): The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. DOE has responsibility for the national laboratories and the science and research conducted at these laboratories, including the INL Site.

V

vadose zone: That part of the subsurface between the ground surface and the water table.

W

Waste Isolation Pilot Plan (WIPP): Located in Carlsbad, New Mexico, this is the permanent repository for government-owned low-level transuranic waste.

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.