DOE/ID-12082(04)

ISSN 1089-5469
STOLLER-ESER-93

Idaho National Engineering and Environmental Laboratory Site Environmental Report Calendar Year 2004

Environmental Surveillance, Education and Research Program

U.S. Department of Energy Idaho Operations Office

October 2005

S. M. Stoller Corp.

This report was prepared for the
U.S. Department of Energy Idaho Operations Office
Under Contract DE-AC07-00ID13658
By the S. M. Stoller Corporation
Environmental Surveillance, Education and Research Program
1780 First Street
Idaho Falls, ID 83401

Idaho National Engineering and Environmental Laboratory's Environmental Policy

It is the policy of the U.S. Department of Energy (DOE) to conduct research, environmental remediation, and operations at the Idaho National Engineering and Environmental Laboratory (INEEL) in a manner that protects human health and the environment and is in full compliance with environmental laws and regulations.

The INEEL achieves this by integrating environmental requirements and pollution prevention into all work planning and execution, and by taking actions to minimize the environmental impacts of operations. Through employee involvement and management commitment to environmental excellence, the INEEL will:

- Protect the unique natural, biological, and cultural resources of the INEEL.
- Conduct operations and manage hazardous and radioactive materials and wastes in a safe, compliant, and cost-effective manner. This is done by establishing and communicating environmental responsibilities, by providing environmental training to the workforce, and by implementing controls to mitigate environmental hazards.
- Conduct environmental remediation to address contamination from legacy activities and minimize impacts on human health and the environment.
- Develop and deploy new and enhanced environmental technologies and share this expertise with other DOE sites, the local community, and external customers.
- Integrate pollution prevention into project planning, design, and construction to minimize toxicity and volume of waste generated; conserve natural resources and energy; and minimize environmental impacts.
- Conserve natural resources by reusing and recycling materials, purchasing recycled materials, and using recyclable materials.
- Promptly identify noncompliant conditions and encourage full disclosure and open discussion regarding compliance issues. Aggressively work to resolve identified issues.
- Establish documented environmental objectives and milestones, and update them as necessary to reflect the changing needs, missions, and goals of the INEEL.
- Consider the input of stakeholders when weighing options.
- Measure environmental performance and monitor impacts on the environment, and communicate the results to employees and stakeholders.
- Continuously improve the INEEL environmental management system through self assessment and corrective action.

This policy applies to all business units and all employees. Every employee and subcontractor is expected to follow this policy and to report environmental concerns to management. Managers shall promote environmental stewardship, take prompt action to address concerns and issues, and have zero tolerance for noncompliance.

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, Donald Rasch, and Jim Cooper with the U.S. Department of Energy (DOE) Idaho Operations Office;
- Leroy Knobel and Betty Tucker with the U.S. Geological Survey;
- W. Greg Bass with the DOE Chicago Operations Office Argonne Area Office;
- Neil Hukari, Kirk Clawson and Richard Eckman of the National Oceanic and Atmospheric Administration;
- Wendy Dixon of the DOE Pittsburgh Naval Reactors Office, Idaho Branch Office;
- Ron Brown, Mark Hutchinson, Shane Lowry, Jerry Knowles, and Kelly Willie of Bechtel Bettis Inc.;
- Brad Andersen, Ben Beus, Bryan Borsella, Teresa Brock, John Gill, Mike Lewis, Dennis McBride, Teresa Meachum, Maria Miles, Joan Neff, Erick Neher, Paul Ritter, Ron Rope, Chris Staley, Angela Stormberg, Leah Street, Amy Sumariwalla, Jim Tkachyk, Mark Verdoorn, Roger Wilhelmsen, Cheryl Whitaker, Tom Wood, and Jeff Einerson (statistician) with Bechtel BWXT Idaho, LLC;
- Maureen Finnerty of Argonne National Laboratory-West;
- Christopher Jenkins, Denim Jochimsen, Terence McGonigle, Nancy Glenn, Valerie Sheedy with the Idaho State University;
- 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, and Greg Studley 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 2004 for the environmental monitoring and surveillance programs conducted on and around the Idaho National Engineering and Environmental Laboratory (INEEL). During 2004, the Environmental Surveillance, Education and Research (ESER) Program was performed by a team led by the S. M. Stoller Corporation. This team collected 2004 data and prepared this report. During 2004, the INEEL was operated by Bechtel BWXT Idaho, LLC (BBWI). This report refers to BBWI as the Management and Operating (M&O) contractor. The M&O organization responsible for operating each facility conducted effluent and facility monitoring. The U.S. Geological Survey performed groundwater monitoring both on and off site. The M&O contractor also conducted some onsite groundwater monitoring related to waste management, clean-up/restoration, and environmental surveillance. The National Oceanic and Atmospheric Administration collected meteorological data.

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 INEEL operations.

Argonne National Laboratory-West (ANL-W), the Naval Reactors Facility (NRF) and the Advanced Mixed Waste Treatment Project (AMWTP) maintain separate monitoring programs. Each program collects similar data as the M&O and ESER contractors, but the data are specific to these facilities. ANL-W provides its information to the ESER contractor for incorporation into this annual report. AMWTP performs limited monitoring as a best management practice, and is not presented in this report. The M&O Environmental Monitoring Unit performs all regulatory and surveillance monitoring at this facility, which is presented here. The INEEL Oversight Program, under the Idaho Department of Environmental Quality, maintained independent sample locations and analysis capabilities both on and around the INEEL in 2004.

Facilities operated under the Naval Nuclear Propulsion Program, like the NRF, are exempt from the provisions for preparing an annual site environmental report. The Naval Nuclear Propulsion Program maintains a separate environmental protection program to ensure compliance with all applicable environmental laws and regulations. Monitoring data and information specific to NRF are provided in a separate annual environmental report issued by NRF. For completeness, data from onsite monitoring programs at NRF are referenced in this report.

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

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), 2003a, "Environmental Protection Program," DOE Order 450.1, January.

U.S. Department of Energy (DOE), 2003b, "Environment, Safety, and Health Reporting," DOE Order 231.1, August.

Executive Summary

M. Case - S. M. Stoller Corporation

Each year the U.S. Department of Energy (DOE) publishes the Idaho National Engineering and Environmental Laboratory (INEEL) site environmental report to summarize environmental data, information, and regulations, and highlight major environmental programs and efforts. In summary, the results of the monitoring programs for 2004 presented in this report indicate that radioactivity from current INEEL operations could not be distinguished from worldwide fallout and natural radioactivity in the region surrounding the INEEL. Radioactive material concentrations in the offsite environment were below State of Idaho and federal health protection guidelines. Potential doses to the maximally exposed individual and to the surrounding population were estimated to be well below the applicable regulatory limit and far less than doses resulting from background radiation.

Organization of the Report

Individual chapters of the report are designed to:

- Provide an overview of the INEEL site, mission, and history (*Chapter 1*);
- Summarize the status of INEEL compliance with environmental regulations (*Chapter 2*);
- Describe major activities and milestones in environmental restoration, waste management, and other environmental programs, and review INEEL environmental surveillance programs (*Chapter 3*);
- Present and evaluate results of environmental monitoring of air (*Chapter 4*);
- Present and evaluate results of monitoring of liquid effluent, drinking water, and storm water for compliance with applicable laws, regulations, and other requirements (*Chapter 5*);
- Present and evaluate results of environmental monitoring of groundwater, drinking water, and surface water (*Chapter 6*);
- Present and evaluate results of environmental monitoring of other media (*Chapter 7);*
- Discuss the potential radiation dose to the public and to biota (*Chapter 8*);
- Describe ecological research activities that took place on the INEEL (*Chapter 9*); and
- Discuss programs used to ensure environmental data quality (*Chapter 10*).

Chapter highlights are presented below.

Introduction (Chapter 1)

The Atomic Energy Commission created what is now the INEEL as the National Reactor Testing Station in 1949 as a site to build and test nuclear power reactors. The INEEL occupies approximately 2300 km^2 (890 mi^2) of the upper Snake River Plain in southeastern Idaho. Over the life of the INEEL, 52 types of reactors, associated research centers, and waste handling areas have been constructed and tested.

The INEEL serves as a multi-program national laboratory that delivers science and engineering solutions to the world's environmental, energy, and security challenges in four core areas:

- Science-based, engineered solutions to challenges of the DOE's mission areas, other federal agencies, and industrial clients.
- Completion of environmental cleanup at the INEEL.
- Enhancement of scientific and technical talent, facilities, and equipment to best serve national and regional interests.
- Leadership and support to the Environmental Management mission throughout the DOE complex.

There are nine primary facility areas and three smaller secondary facilities at the INEEL and in Idaho Falls. Six of the nine primary facilities and the three secondary facilities are operated by the INEEL Management and Operating (M&O) Contractor Bechtel BWXT Idaho, LLC. The University of Chicago, British Nuclear Fuels Limited, Inc., and Bechtel Bettis, Inc. operated the remaining three primary facilities at the INEEL in 2004.

Approximately 7000 people work at the INEEL, making it the largest employer in eastern Idaho and one of the top five employers in the State. The INEEL has a tremendous economic impact on eastern Idaho. The INEEL infuses more than $750 million dollars to the Idaho economy.

Environmental Compliance Summary (Chapter 2)

Table ES-1 presents a brief summary of the INEEL's status of compliance with federal acts in 2004.

Environmental Program Information (Chapter 3)

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

The major objectives of the environmental monitoring programs conducted at the INEEL 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

Table ES-1. Compliance with federal acts in 2004.

Act	What it Addresses	2004 Activities
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	This act provides specific procedures to assess and remediate areas where the release or potential of a release of hazardous substances has occurred.	Work on these sites continued in compliance with CERCLA requirements. More than 70% of CERCLA actions have been completed. A significant accomplishment was the remediation of WAG 4, the Central Facilities Area, in 2004.
Resource Conservation and Recovery Act (RCRA)	This act establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste.	In 2004 DOE received three Notices of Violation (NOVs) from the Idaho Department of Environmental Quality (DEQ). The NOV against British Nuclear Fuels Limited (BNFL) was dismissed. A consent order was negotiated and signed to address the two NOVs issued against the M&O contractor.
Federal Facility Compliance Act	This act requires the preparation of site treatment plans for the management of mixed wastes stored or generated at DOE facilities.	Three site treatment plan milestones were completed in 2004.
Clean Air Act	This act sets the standards for ambient air quality and for emission of hazardous air pollutants.	Compliance with the Idaho air quality program was primarily administered through the permitting process. The 2004 National Emission Standards for Hazardous Air Pollutants report documented a maximum annual individual dose to a member of the public from INEEL releases of 0.044 mrem/yr, well below the regulatory limit of 10 mrem/yr.
Clean Water Act	This act establishes goals to control pollutants discharged to surface waters of the U.S.	All discharges from INEEL Idaho Falls facilities were within permit limits in 2004. EPA Region 10 issued a letter in October 2003 with the determination that Idaho Nuclear Technology and Engineering Center (INTEC), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN) do not have a reasonable potential for discharge to U.S. waters. U.S. Department of Energy-Idaho Operations Office (DOE-ID) thus directed the M&O Contractor to cease stormwater monitoring at those facilities.
Safe Drinking Water Act	This act establishes primary and secondary standards for drinking water systems.	All drinking water systems were in compliance with U.S. Environmental Protection Agency (EPA) drinking water standards.
Toxic Substances Control Act	This act regulates industrial chemicals currently produced or imported into the U.S.	EPA Region 10 determined that the cleanup of PCBs[a] is complete at the INEEL.
National Environmental Policy Act (NEPA)	This act requires federal agencies to consider and evaluate potential environmental impacts as a result of federal activities and requires the study of alternatives to mitigate those impacts.	The DOE-ID issued the Annual NEPA Planning Summary in 2004 as required by DOE Order 451.18.
Emergency Planning and Community Right-to-Know Act (EPCRA)	This act provides the public with information about hazardous chemicals and establishes emergency planning and notification procedures to protect the public from chemical releases.	The EPCRA Section 311 and 312 Reports were issued as required in 2004.

a. PCBs = Polychlorinated biphenyls.

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 2004, the prime M&O contractor at the INEEL, Bechtel BWXT Idaho, LLC was responsible for onsite environmental monitoring. The Environmental Surveillance, Education and Research Program (ESER) contractor, which was a team led by the S. M. Stoller Corporation, was responsible for offsite environmental monitoring.

In May 2002, DOE, DEQ and the EPA signed a letter of intent formalizing an agreement to pursue accelerated risk reduction and cleanup at the INEEL. The intent of accelerating the cleanup of the INEEL yields two significant objectives: (1) risk reduction and continued protection of the Snake River Plain Aquifer and (2) consolidation of Environmental Management activities and reinvestment of savings into cleanup. Nine strategic initiatives were developed around these two objectives to accelerate cleanup. The INEEL made significant progress in 2004 toward accelerated cleanup.

The Environmental Restoration Program continued progress during 2004 toward final cleanup of contaminated sites at the INEEL. Since the Federal Facility Agreement and Consent Order was signed in December 1991, 22 Records of Decision (ROD) have been signed and are being implemented; three Remedial Investigation/Feasibility Studies are under development; closeout activities at Waste Area Group (WAG) 2, 4, and 8 have been completed. Only three investigations remain to be completed:

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

The overall goals of the Waste Management Program are to ensure that workers and the public are protected and the environment is not further impacted by waste operations at the INEEL. The Waste Management Program provides management services for facility waste streams. The following tasks were accomplished during 2004:

- Three Site Treatment Plan milestones were met.
- BNFL commenced Treatment Facility operations at the Advanced Mixed Waste Treatment facility in August 2004.
- Over 900 m^3 (1,177 yd^3) of mixed low-level waste was treated and disposed of in 2004.
- Approximately 6080 m^3 (7,953 yd^3) of legacy and newly generated waste was disposed in the subsurface disposal area (SDA) in 2004.
- The Transuranic Waste Program shipped 192 m^3 (251 yd^3) of transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.
- The INEEL accelerated efforts to decontaminate, decommission, and demolish aging, unnecessary buildings and structures. Over 29,203 m^2 (314,338 ft^2) of buildings and structures were demolished in 2004.

Environmental Monitoring Programs - Air (Chapter 4)

The INEEL environmental surveillance programs, conducted by the M&O contractor and the ESER contractor, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INEEL releases to receptors. The M&O contractor monitors airborne effluents at individual INEEL facilities and ambient air outside the facilities to comply with appropriate regulations and DOE orders. The ESER contractor samples ambient air at locations within, around, and distant from the INEEL.

An estimated total of 8,816 Ci of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2004. 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 (^{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 within historical measurements. Table ES-2 summarizes the results of radiological monitoring of environmental media, including air, sampled at INEEL boundary, onsite, and offsite locations.

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

Environmental Compliance Monitoring Programs (Liquid Effluent, Drinking Water, Surface Water) (Chapter 5)

One potential pathway for exposure (primarily to workers) to the contaminants released from the INEEL is through surface, drinking, and groundwater. The M&O contractor monitors liquid effluents, drinking water, groundwater, and storm water runoff at the INEEL to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., Wastewater Land Application Permit [WLAP] requirements). Argonne National Laboratory-West and the Naval Reactors Facility conduct their own WLAP and drinking water monitoring. The ESER contractor monitors drinking water and surface water at offsite locations.

During 2004, liquid effluent and groundwater monitoring was conducted in support of WLAP requirements for INEEL 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 DEQ. Additional parameters are also monitored in the effluent in support of surveillance activities. Most wastewater and groundwater regulatory and surveillance results were below applicable limits in 2004. Several metals detected in October 2004 samples taken from the INTEC New Percolation Ponds perched water compliance wells ICPP-MON-V-200 and ICPP-MON-V-212 were above their respective state of Idaho groundwater secondary constituent standards and therefore above the Wastewater Land Application Permit limits. Further evaluation indicated that the likely cause of the elevated metals were suspended solids from washed-in interbed material.

Table ES-2. Boundary, onsite, and offsite radiological environmental monitoring results for 2004 (data from Chapters 4, 5, 6, and 7).

Media	Sample Type	Analysis	Results
Air	Charcoal cartridge	Radioiodine	Iodine-131 (^{131}I) was not detected in any individual charcoal cartridge collected.
	Particulate filter	Gross alpha and gross beta activity, gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, plutonium-238 (^{238}Pu), and $^{239/240}$Pu.	In general, gross alpha and gross beta activities show levels and seasonal variations not attributable to INEEL releases. All measurements of specific radionuclides were well below Derived Concentrations Guide (DCG) for radiation protection and within historical results.
	Atmospheric moisture	Tritium	Tritium was detected in 14 of 62 samples. Measurements were well below the DCG and within historical concentrations.
	Precipitation	Tritium	Tritium was detected in 8 of 26 precipitation samples. Measurements were well below the DCG and within historical measurements made at the INEEL and within EPA Region 10 (ID, OR, WA, and AK).
Water	Surface water	Gross alpha and gross beta activity, and tritium	Gross alpha activity was not detected in any of 12 samples collected. Most samples had measurable gross beta activity below the EPA screening level. Tritium was detected in The highest level measured was below the EPA maximum concentration level (MCL).
	Drinking water	Gross alpha and gross beta activity, and tritium	Gross alpha activity was detected in one sample at a concentration below the EPA Maximum Contaminent Level (MCL). Gross beta activity was detected in most samples at levels within background levels and below the EPA screening level. Tritium was detected in eleven drinking water samples at a level below the EPA MCL.
Agricultural products	Milk, lettuce, wheat, potatoes, and sheep	Gamma-emitting radionuclides and ^{90}Sr	Some human-made radionuclides were detected in samples at levels consistent with historical measurements that appear to be attributable with past weapons testing fallout.
Game animals	Ducks, mule deer, elk, and pronghorn	Gamma-emitting radionuclides, ^{90}Sr and specific actinides. Iodine-131 in deer, elk, and pronghorn thyroids	Cesium-137 was detected in muscle and liver samples of pronghorn at levels consistent with fallout. The maximum dose estimated for ingestion of game animals is 0.008 mrem. Human-made radionuclides were detected in at least one tissue type in 6 waterfowl collected from INEEL wastewater ponds and control areas. The potential dose from consumption of ducks with the highest concentrations was calculated to be 0.005 mrem (0.001% of 352 mrem from background sources).
Soil	Offsite soil composite samples	Gamma-emitting radionuclides, ^{90}Sr and the same actinides analyzed in particulate filters	Radionuclide concentrations detected in soils collected at boundary and distant locations were not statistically different and were consistent with historical measurements. The concentrations are most likely due to weapons testing fallout.
Radiation exposure	Thermoluminescent dosimeters	Gamma radiation	Exposures at boundary and distant locations using environmental dosimeters were similar and showed levels consistent with previous years and background.

One TAN/Technical Support Facility (TSF) Sewage Treatment Plant monitoring well had concentrations of iron, manganese, and total dissolved solids that exceeded permit limits. Further evaluation is needed to determine the cause.

No EPA health-based drinking water or DOE regulatory limits were exceeded in INEEL drinking water in 2004.

Tritium continues to be measured in the groundwater under the INEEL. This radionuclide has not been detected off the INEEL since the mid-1980s. A maximum effective dose equivalent of 0.47 mrem/yr (4.7 µSv/yr), less than the 4 mrem/yr (40 µSv/yr) EPA standard for public drinking water systems, was calculated for workers at the Central Facilities Area on the INEEL in 2004.

As required by the General Permit for storm water discharges from industrial activities, visual examinations were made and samples were collected from selected locations. Visual examinations showed no deficiencies. As of December 2003, the DOE no longer conducts compliance activities associated with the Storm Water Pollution Prevention Plan for Industrial or Construction Activities at three INEEL facilities that do not have a reasonable potential to release storm water to U.S. waters, as determined by EPA.

Environmental Monitoring Program - Groundwater, Drinking Water and Surface Water (Chapter 6)

Results from a number of special studies conducted by the U.S. Geological Survey of the properties of the aquifer were published during 2004. Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells at the INEEL. Concentrations of organic compounds were below the state of Idaho groundwater primary and secondary constituent standards as well as EPA MCLs for these compounds. (Note: The MCL is used only for comparison because the MCL applies mainly to the distribution system).

Environmental Restoration groundwater monitoring continued for the Waste Area Groups on the INEEL in 2004. At Test Area North, activities continued to contain and restore groundwater contaminated with chlorinated solvents using in-situ bioremediation and pump and treat methods. At the Idaho Nuclear Technology and Engineering Center, monitoring indicates that the concentrations of most radionuclides are decreasing over time, with the possible exception of technetium-99. Monitoring at RWMC found some elevated concentrations of solvents (including carbon tetrachloride, toluene and trichloroethane, chromium, and uranium-235. Concentrations of contaminants at other Waste Area Groups were similar to expected and historical concentrations.

Drinking water samples were collected from 14 locations off the INEEL and around the Snake River Plain in 2004. One sample had measurable gross alpha, eleven samples had measurable tritium, and most samples had measurable gross beta activity. None of the samples exceeded the EPA Maximum Contaminant Level (MCL) for these constituents.

Eleven 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 one sample had measurable tritium. None of these constituents were above regulatory limits.

Table ES-2 summarizes the results of radiological monitoring of environmental media, including water, collected at INEEL boundary, onsite, and offsite locations.

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

To help assess the impact of contaminants released to the environment by operations at the INEEL, 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 INEEL in 2004.

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 INEEL.

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

Table ES-2 summarizes the results of radiological monitoring of environmental media, including biota and soil, collected at INEEL boundary and offsite locations.

Dose to the Public and Biota (Chapter 8)

Potential radiological doses to the public from INEEL 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 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 INEEL. The maximum calculated dose to an individual by either of the methods was well below the applicable radiation protection standard of 10 mrem/yr. The dose to the maximally exposed individual, as determined by the CAP-88, program was 0.044 mrem (0.44 µSv). The dose calculated by the MDIFF program was 0.031 mrem (0.31 µSv). The maximum potential population dose to the approximately 276,979 people residing within an 80-km (50-mi) radius of any INEEL facility was 0.368 person-rem (3.7×10^{-3} person-Sv), well below that expected from exposure to background radiation.

Potential doses to members of the public are summarized in Table ES-3.

The maximum potential individual doses from consuming waterfowl and big game animals, at the INEEL, based on the highest concentrations of radionuclides measured in samples of these animals, were estimated to be 0.005 mrem (0.05 µSv), and 0.008 mrem (0.08 µSv), respectively. These estimates are conservatively high.

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

Table ES-3. Summary of annual effective dose equivalents due to INEEL operations (2004).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF[c]
Dose	0.044 mrem 4.4×10^{-4} μSv	0.031 mrem 3.1×10^{-4} μSv	0.368 person-rem 3.7×10^{-3} person-Sv
Location	Frenchman's Cabin	Northwest of Mud Lake	Area within 80 km (50 mi) of any INEEL facility
Applicable radiation protection standard[d]	10 mrem (0.1 μSv)	10 mrem (0.1 μSv)	No standard
Percentage of standard	0.44 percent	0.31 percent	No standard
Natural background	363 mrem (3.6 μSv)	363 mrem (3.6 μSv)	102,183 person-rem (1022 person-Sv)
Percentage of background	0.01 percent	0.009 percent	0.0004 percent

a. Hypothetical dose to a maximally exposed individual residing near the INEEL.
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 modes is 100 mrem/yr as given in DOE Order 5400.5, DOE guidance states that DOE facilities will comply with the EPA standard for the airborne pathway of 10 mrem/yr.

Ecological Research at the Idaho National Environmental Research Park (Chapter 9)

The INEEL 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 INEEL 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 2004:

- The Effect of Landscape Change on the Life History of Western Rattlesnakes;
- Factors that Influence the Road Mortality of Snakes on the Eastern Snake River Plain;
- Behavior, Dispersal, and Survival of Captive-Raised Idaho Pygmy Rabbits Released onto the INEEL in Idaho;
- Fine-scale Movement Patterns of Coyotes on the INEEL in Idaho;
- Natural and Assisted Recovery of Sagebrush in Idaho's Big Desert;
- Phylogenetic Analysis of the *Abronic ammophilia* Green (Nyctaginaceae) Species Complex;
- Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater;
- The Protective Cap/Biobarrier Experiment; and
- Developing Advanced Scientific Methods for Landscape Level Management of Federal Facilities.

Quality Assurance (Chapter 10)

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 M&O and ESER contractors were addressed with the laboratories and resolved.

Helpful Information

M. Case - S. M. Stoller Corporation

Scientific Notation

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

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

Unit Prefixes

Units for very small and very large numbers are often expressed with a prefix. One common example is the prefix kilo (abbreviated k), which means 1000 of a given unit. One kilometer is, therefore, equal to 1000 meters. Table HI-1 shows fractions and multiples of units while, Table HI-2 provides useful conversions.

Table HI-1. Fractions and Multiples of Units

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

Units of Radioactivity, Radiation Exposure, and Dose

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

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

The concentration of radioactivity in air samples is expressed in units of microcuries per milliliter (µCi/mL) of air. For liquid samples, such as water and milk, the units are in picocuries per liter (pCi/L). Radioactivity in agricultural products is expressed in nanocuries per gram (nCi/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 1 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. Table HI-2 provides conversions from conventional to Système International units.

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 (±) the estimated sample standard deviation, s, that is obtained by propagating sources of analytical uncertainty in measurements. Analytical uncertainties are reported as 1s in this report, unless noted otherwise, for consistency with other INEEL 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.

Table HI-2. Conversion Table.

Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liquid qt-U.S.	0.946	L	L	1.057	liquid qt-U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
dpm	0.450	pCi	pCi	2.22	**dpm**
pCi	10^{-6}	µCi	µCi	10^{6}	pCi
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^{9}	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/mL (air)	µCi/mL (air)	10^{12}	pCi/m^3 (air)
Curie (Ci)	$3.7x10^{10}$	Becquerel (Bq)	Becquerel (Bq)	$27x10^{-12}$	Curie (Ci)
Rad (radiation absorbed dose)	0.01	Gray (Gy)	Gray (Gy)	100	Rad (radiation absorbed do
Rem (Roentgen equivalent man)	0.001	Sievert (Sv)	Sievert (Sv)	100	Rem (Roentgen equivalent m
mrem	10	µSv	µSv	0.1	mrem

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). Radionuclide symbols used in this report are shown in Table HI-3.

Table HI-3. Radionuclides and symbols used in this report.

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

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
AMWTP	Advanced Mixed Waste Treatment Plant
ANL-W	Argonne National Laboratory-West
ANOVA	Analysis of Variance
ARA	Auxiliary Reactor Area
ASME	American Society of Mechanical Engineers
BBI	Bechtel Bettis, Inc.
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
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	Comprehensive Environmental Response, Compensation, and Liability Act
CERT	Controlled Environmental Radioiodine Test
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CMS	Community Monitoring Station
COD	Chemical Oxygen Demand
CRMP	Cultural Resource Management Plan
CTF	Contained Test Facility
CWA	Clean Water Act
DCE	dichloroethene
DCE	Dichloroethene

DCG	Derived Concentration Guide
DD&D	Decontamination, Decommissiong and Demolition
DEQ	(Idaho) Department of Environmental Quality
DNA	Deoxyribonucleic Acid
DOE	U.S. Department of Energy
DOE-CH	U.S. Department of Energy - Chicago Operations Office
DOE-ID	U.S. Department of Energy - Idaho Operations Office
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
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

FFA/CO	Federal Facility Agreement and Consent Order
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	INEEL CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IFSF	Irradiated Fuel Storage Facility
IMPROVE	Interagency Monitoring of Protected Visual Environments
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRC	INEEL Research Center
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Standards Organization
ISU	Idaho State University
LDRD	Laboratory Directed Research and Development
LFR	Live Fire Range
LMWL	Local Meteoric Water Line
LTS	Long-Term Stewardship
M&O	Management and Operating

MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MNA	Monitored Natural Attenuation
MTR	Materials Test Reactor
NCER	National Center for Environmental Research
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	Nitrate 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
NOV	Notice of Violation
NO_x	Nitrogen Oxide
NPDES	National Pollutant Discharge Elimination System
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NSF	National Science Foundation

NWCF	New Waste Calcining Facility
NWQL	National Water Quality Laboratory (USGS)
NWCF	New Waste Calcining Facility
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment
PCE	Tetrachloroethene
PCS	Primary Constituent Standard
PE	Performance Evaluation
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
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
RFP	Request for Proposal
RH	Remote Handled
RI	Rapid Infiltration
RI/FS	Remedial Investigation/ Feasibility Study
RML	Radiological Measurements Laboratory (INEEL)
RPD	Relative Percent Difference
ROD	Record of Decision
RWMC	Radioactive Waste Management Complex

SAM	Sample and Analysis Management
SAR	Sodium Absorption Radio
SBW	Sodium Bearing Waste
SCS	Secondary Constituent Standard
SDA	Subsurface Disposal Area
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
STL	Severn Trent Laboratories
STP	Sewage Treatment Plant
TAN	Test Area North
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
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
VOL	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

Units

Btu	British thermal unit
Bq	becquerel
cfm	cubic feet per minute
Ci	curie
cm	centimeter
d	day
dpm	disintegrations per minute
ft	feet
g	gram
gal	gallon
gpd	gallons per day
Gy	gray
ha	hectare
hr	hour
in.	inch
KeV	kilo-electron-volts
kg	kilogram
km	kilometer
L	liter
Lpd	liters per day
lb	pound
m	meter
MeV	megaelectron Volt
mg	milligram
MG	million gallons
mi	mile
min	minute
mL	milliliter
mSv	millisievert
µ	micron
µCi	microcurie (10^{-6} curies)
µg	microgram
µm	micrometer
µS	microsiemens
mGy	milligray
mm	millimeters
mmhos/cm	millimhos per centimeter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mSv	millisievert
ng	nanogram
oz	ounce
pCi	picocurie (10^{-12} curies)
ppm	parts per million
qt	quart
rad	radiation absorbed dose
rem	roentgen equivalent man
R	roentgen
sec	second
Sv	seivert
x^2	unit squared
x^3	unit cubed
yd	yard
yr	year
<	lesser than
>	greater than

Chapter 1 - Introduction

Chapter Highlights

In 1949, the U.S. Atomic Energy Commission created what is now the Idaho National Engineering and Environmental Laboratory (INEEL) as the National Reactor Testing Station to build and test nuclear power reactors. The INEEL occupies approximately 2300 km^2 (890 mi^2) of the upper Snake River Plain in southeastern Idaho. Over the life of the INEEL, 52 types of reactors, associated research centers, and waste handling areas have been constructed and tested.

The INEEL serves as a multiprogram national laboratory that delivers science and engineering solutions to the world's environmental, energy, and security challenges in four core areas:

- Science-based, engineered solutions to the challenges of the U.S. Department of Energy's (DOE's) mission areas, other federal agencies, and industrial clients.
- Completion of environmental cleanup at the INEEL.
- Enhancement of scientific and technical talent, facilities, and equipment to best serve national and regional interests.
- Leadership and support to the DOE Office of Environmental Management mission throughout the DOE complex.

There are nine primary facility areas and three smaller secondary facilities at the INEEL and in Idaho Falls. During 2004, six of the nine primary facilities and the secondary facilities were operated by the INEEL Management and Operating contractor, Bechtel BWXT, Idaho, LLC. The University of Chicago, British Nuclear Fuels Limited, Inc. and Bechtel Bettis, Inc. operated three additional facilities on the INEEL.

Approximately 7000 people work at the INEEL, making it the largest employer in eastern Idaho and one of the top five employers in the State. The INEEL has a tremendous economic impact on eastern Idaho. The INEEL infuses more than $750 million dollars into the Idaho economy.

1. INTRODUCTION

This report presents the results and activities of organizations performing environmental monitoring on the Idaho National Engineering and Environmental Laboratory (INEEL) and surrounding areas for calendar year 2004. Environmental monitoring results are transmitted to the U.S. Department of Energy Idaho Operations Office (DOE-ID) and other government agencies.

The INEEL is owned by DOE and administered through its Idaho Operations Office. The INEEL Site occupies approximately 2300 km^2 (890 mi^2) of the upper Snake River Plain in southeastern Idaho (Figure 1-1). It is roughly equidistant from Salt Lake City, Utah (328 km [203 mi]); Butte, Montana (380 km [236 mi]); and Boise, Idaho (450 km [280 mi]). The communities closest to the INEEL are Atomic City (population 45), Arco (population 1026), Howe (population 33), Monteview (population 10), Mud Lake (population 270), and Terreton (population 100). The larger population centers of Idaho Falls (population 50,730), Blackfoot (population 10,419), and Pocatello (population 51,466) are at least 35 km (22 mi) from the nearest INEEL boundary (Figure 1-2). Ten Idaho counties are located in part or entirely within 80 km (50 mi) of the INEEL (Figure 1-2). The INEEL encompasses portions of five counties (Bingham, Bonneville, Butte, Clark, and Jefferson).

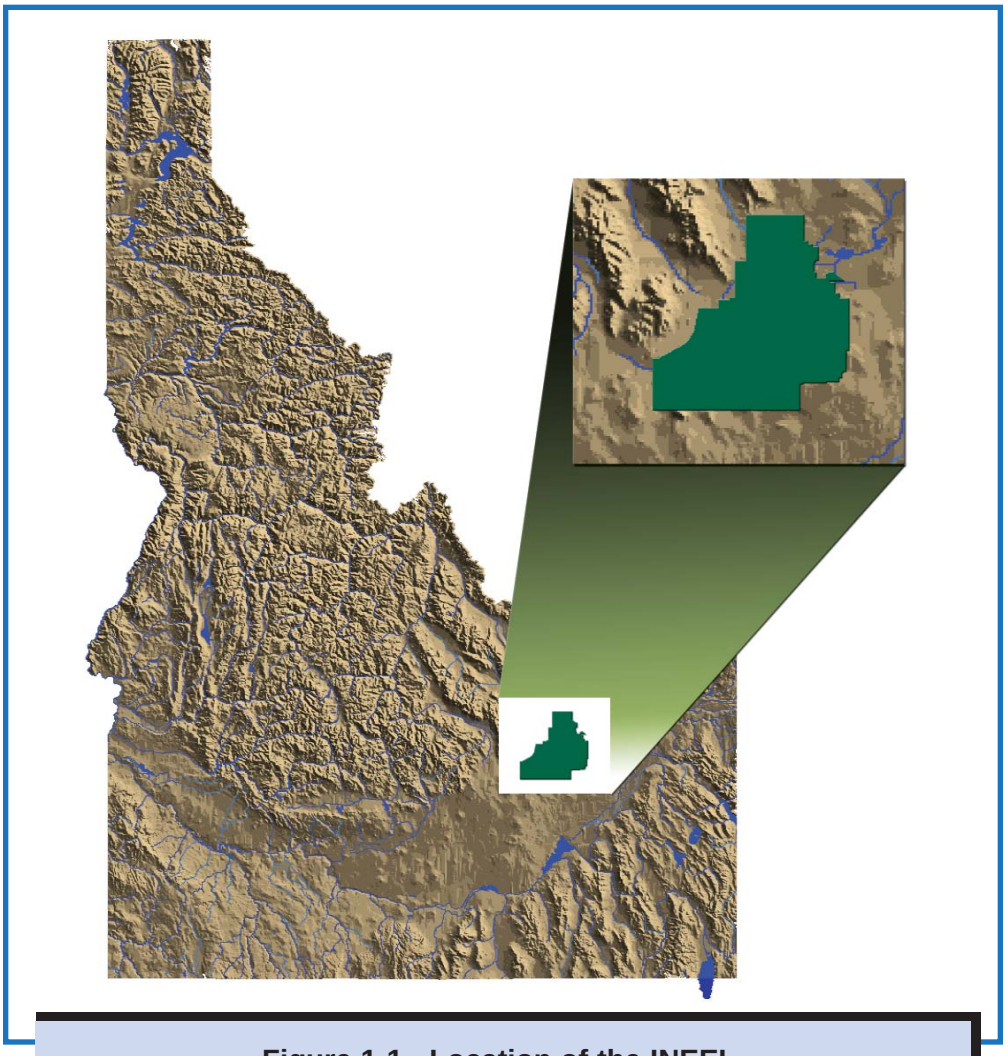


Figure 1-1. Location of the INEEL.

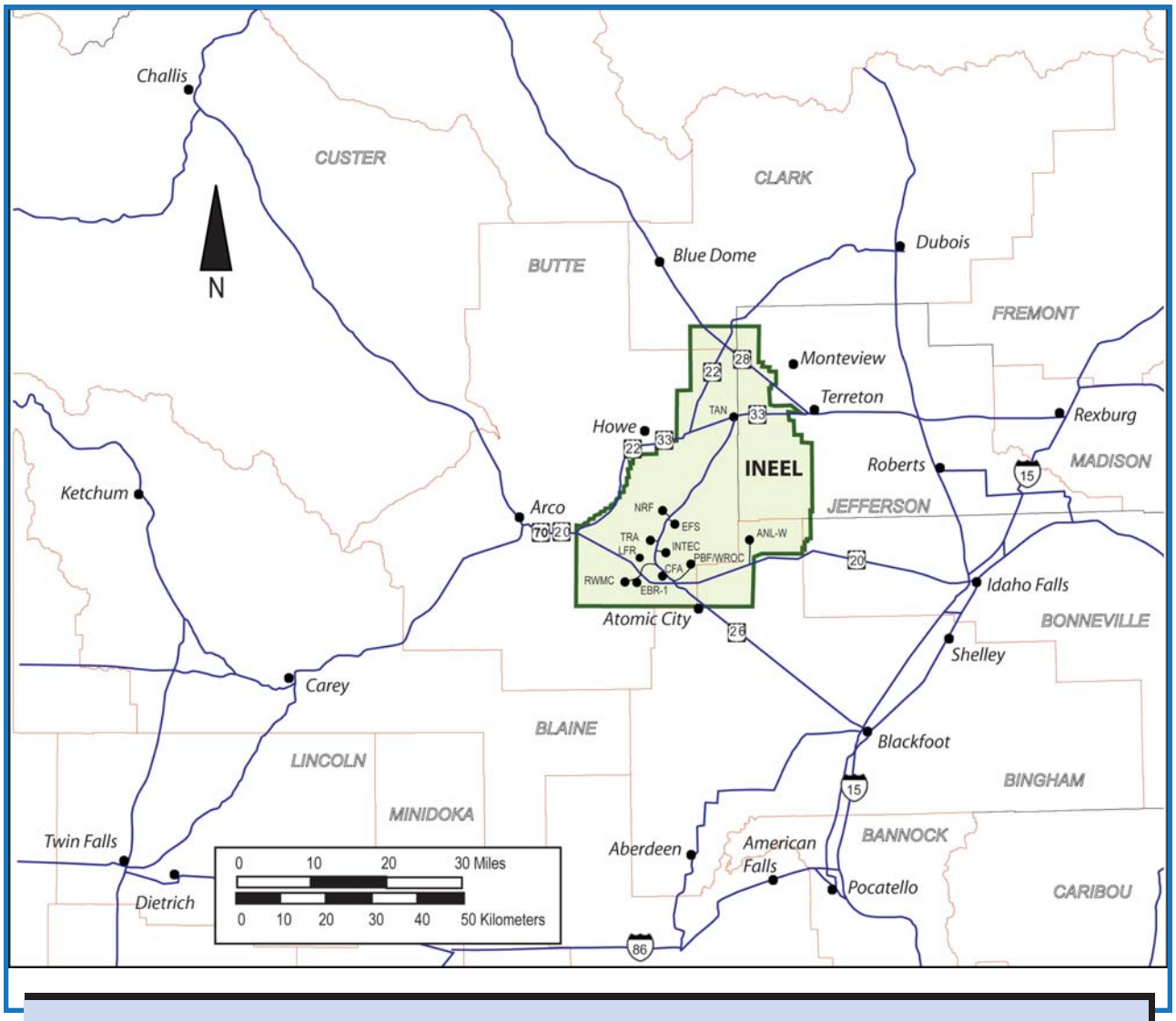


Figure 1-2. Map of INEEL and surrounding area showing facilities, counties, and cities.

1.1 INEEL Mission and Facilities

The INEEL's vision is to serve as a multi-program national laboratory that delivers science and engineering solutions to the world's environmental, energy, and security challenges. The mission of the INEEL can be divided into four core areas:

- Deliver science-based, engineered solutions to the challenges of DOE's mission areas, other federal agencies, and industrial clients;
- Complete environmental cleanup responsibly and cost effectively using innovative science and engineering capabilities;
- Provide leadership and support to optimize the value of the DOE Office of Environmental Management (EM) investments and strategic partnerships throughout the DOE complex; and

- Enhance scientific and technical talent, facilities, and equipment to best serve national and regional interests.

Over the years, various Management and Operating (M&O) contractors have operated the INEEL. During 2004, the INEEL M&O contractor was Bechtel BWXT Idaho, LLC (BBWI). The University of Chicago's Argonne National Laboratory, Bechtel Bettis, Inc. (BBI), and British Nuclear Fuels Limited, Inc. (BNFL) operated other facilities. The M&O operates facilities at the Site and in Idaho Falls, Idaho. There are nine primary facility areas and three smaller secondary facilities at the INEEL and in Idaho Falls (Figure 1-2). These facility areas are described below.

Argonne National Laboratory-West

Argonne National Laboratory-West (ANL-W) is the prime testing center in the United States for demonstration and proof-of-concept of nuclear energy technologies. Research is focused on areas of national concern relating to energy, nuclear safety, nonproliferation, decommissioning and decontamination, and remote handling of nuclear materials. In 2004, the University of Chicago operated ANL-W for the DOE Chicago Operations Office (DOE-CH). The DOE-CH Argonne Area Office (AAO) supports local operations.

Central Facilities Area

The Central Facilities Area (CFA) provides centralized support for the INEEL, including administrative offices, research laboratories, medical and fire services, security headquarters, warehouses, crafts, vehicle support, and a cafeteria.

Idaho Falls Facilities

Idaho Falls facilities include the INEEL Research Center (IRC), where researchers conduct fundamental and applied research in science and engineering areas crucial to DOE's national missions. Additional support personnel for the facilities at the INEEL are housed at the Willow Creek Building, Engineering Research Office Building, and other office buildings.

Idaho Nuclear Technology and Engineering Center

The primary mission of the Idaho Nuclear Technology and Engineering Center (INTEC) is to safely store spent nuclear fuel and prepare it for shipment to an offsite repository. The facility also developed technology for the safe treatment of high-level liquid radioactive wastes.

Naval Reactors Facility

The Naval Reactors Facility (NRF) is operated for the U.S. Naval Nuclear Propulsion Program 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.

Power Burst Facility/Critical Infrastructure Test Range

During its operation, the Power Burst Facility (PBF) supported numerous nuclear safety studies related to commercial nuclear power plants. Currently, the PBF is undergoing decontamination activities in preparation of dismantlement. The Critical Infrastructure Test Range (CITR) is home to the INEEL's National Security Programs division. This area provides space for numerous test programs and pilot-scale demonstrations related to Homeland and National security.

Radioactive Waste Management Complex

The Radioactive Waste Management Complex (RWMC) manages solid transuranic and low-level radioactive waste. The facility supports research projects dealing with waste retrieval and processing technology and provides temporary storage and treatment of transuranic waste destined for the Waste Isolation Pilot Plant (WIPP) in New Mexico. In 2004, BNFL Inc. operated the Advanced Mixed Waste Treatment Facility. 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 WIPP.

Test Area North

Located at the north end of the INEEL, 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 (SMC) Project, conducted at the TAN facility, manufactures protective armor for the U.S. Army M1-A1 and M1-A2 Abrams tanks. TAN personnel also manage cleanup of environmental contamination from prior 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 INEEL mission are demolished.

Test Reactor Area

The Test Reactor Area (TRA) is dedicated to nuclear technology research. The Advanced Test Reactor is used to study the effects of radiation on materials, test nuclear fuels, and to produce rare and valuable medical and industrial isotopes.

Secondary Facilities

Three secondary facilities at the INEEL include a national historic landmark, a former dairy farm, and a live-fire gun range. These three facilities provide the INEEL with public relations, an experimental field station, and firearms training areas. Each of these facilities is described in the following sections.

Experimental Breeder Reactor No. 1. The Experimental Breeder Reactor No. 1 (EBR-I) is a Registered National Historic Landmark located at the INEEL 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 9.7).

Live-Fire Range. The Live-Fire Range (LFR) has been used since 1990 for security force practice maneuvers, including small and large (machine gun and light-antitank weapons) arms target practice. The LFR includes a large firing range area surrounded on three sides by a 20-foot protective berm. This range also houses an interactive, indoor, live-fire range with computer controlled target simulations.

1.2 Physical Setting of the INEEL

The INEEL is located in a large, relatively undisturbed expanse of sagebrush steppe habitat. Approximately 94 percent of the land on the INEEL is open and undeveloped. The 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 (Figure 1-1). Lands immediately adjacent to the INEEL are open rangeland, foothills, or agricultural fields. Agricultural activity is concentrated in areas northeast of the INEEL. Approximately, sixty percent of the INEEL is open to livestock grazing.

The climate of the high desert environment of the INEEL is characterized by sparse precipitation (less than 22.8 cm/yr [9 in./yr]), warm summers (average daily temperature of 15.7°C [60.3°F]), and cold winters (average daily temperature of -5.2°C [22.6°F]) (DOE-ID 1989). The altitude, intermountain setting, and latitude of the INEEL 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 INEEL (Anderson et al. 1996). Vertebrate animals found on the INEEL 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 INEEL flows toward the northeast, ending in a playa area 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 INEEL, however, form a portion of the eastern Snake River Plain Aquifer, which stretches 267 km (165 mi) from St. Anthony to Bliss, Idaho, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 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 INEEL, the aquifer moves laterally to the southwest at a rate of 1.5 to 6 m/d (5 to 20 ft/d) (Lindholm 1996). The Snake River Plain Aquifer 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 INEEL

The geologic events that have shaped the modern Snake River Plain on and near the INEEL took place during the last 2 million years (Lindholm 1996, ESRF 1996). The plain, which arcs from far eastern Oregon across southern Idaho to Yellowstone National Park, marks the passage of the earth's crust over a plume of melted mantle material pressing upward. The resultant rhyolite volcanics are oldest in the western portion of the Snake River Plain and youngest on the Yellowstone Plateau, which overlies the thermal plume today. The plain is a 640 km (400 mi) trail made by the passage of the continent over this hot spot. The basalts that are visible on much of the plain today are younger than the rhyolites they cover. However, many of the rhyolite buttes have pushed up through the overlying basalts and, therefore, younger than the basalts. The flat basalt cap on Middle Butte is a good illustration of this process.

Humans first appeared on the Upper Snake River Plain approximately 11,000 years ago, likely descendants of people who crossed the Bering Strait land bridge. 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 to build 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 Snake River Plain 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, a reactor at the NRTS (EBR-I) became the first to produce useful electricity. The Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas. The NRTS was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory 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.

1.4 Regional Economic Impact

Approximately 7000 people work at the INEEL, making it the largest employer in eastern Idaho and one of the top five employers in the State. This number includes about 400 federal employees, most of who work for DOE-ID. The majority of the other 6600 employees work for the M&O contractor at the INEEL. During 2004, other employees worked for contractors at facilities operated by other DOE organizations, such as BBI at NRF, the University of Chicago at ANL-W, and BNFL, Inc. at the Advanced Mixed Waste Treatment Facility at the RWMC.

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

REFERENCES

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

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

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

Reynolds, T.D., Connelly, J.W., Halford, D.K., and Arthur, W.J., 1986, "Vertebrate Fauna of the Idaho National Environmental Research," *Great Basin Naturalist*, 46(3): 513-527.

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

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 Engineering and Environmental Laboratory (INEEL) are subject to numerous federal and state environmental statutes, executive orders, and 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 INEEL met all its regulatory commitments in 2004 and programs are in place to address areas for continued improvement.

The following paragraphs highlight the accomplishments made in 2004:

Under a Federal Facility Agreement/Consent Order, signed in 1991, the INEEL was divided into ten Waste Area Groups containing 25 operable units, which are areas with similar contamination. The INEEL 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 the following facilities: Test Area North PM2A Tank System, Test Area North 616 Treatment Subsystem, and Idaho Nuclear Technology and Engineering Center (INTEC) D-Cell Container Storage Unit.

DOE-ID submitted the *2004 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 INEEL Cultural Resource Management Plan was reviewed and approved by the Idaho State Historic Preservation Office and the Advisory Council on Historic Preservation became final.

The Idaho Department of Environmental Quality issued a new wastewater land application permit for the combined INTEC Sewage Treatment Plant effluent and service wastewater for disposal at the new INTEC percolation ponds.

No releases occurred during the year that required reporting to external agencies.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Engineering and Environmental Laboratory (INEEL) with environmental protection requirements. Section 2.1 discusses the compliance status of the INEEL 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 INEEL 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 INEEL 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 INEEL's compliance status with those regulations. Table 2-1 shows how the discussion is organized.

Table 2-1. Environmental compliance statutes.

Activity	Governing Statute or Order
Radiation Protection	DOE Order 5400.5, "Radiation Protection of the Public and the Environment"
Environmental Remediation and Protection	Comprehensive Environmental Response, Compensation, and Liability Act
	DOE Order 450.1, "Environmental Protection Program"
	Emergency Planning and Community Right-to-Know Act
	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 INEEL left behind contaminants that pose a potential risk to human health and the environment. The INEEL

was placed on the National Priorities List under CERCLA on November 29, 1989. The DOE 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 INEEL.

The INEEL 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 INEEL, 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 INEEL's placement on the National Priorities List. These same releases created the potential for injury to natural resources. DOE is liable under CERCLA for damages to natural resources resulting from releases of hazardous substances to the environment.

Although the ecological risk assessment is a separate effort from the Natural Resources Damage Assessment, it is anticipated that the ecological assessment performed for CERCLA remedial actions can be used to help resolve natural resource issues. Ecological risk assessments at the INEEL 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 INEEL) 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, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," 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 2004. 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 2004 by March 1, 2005. This report identified the types, quantities, and locations of hazardous and extremely hazardous chemicals stored at INEEL facilities that exceeded:

- 10,000 pounds (for Occupational Safety and Health Act hazardous chemicals);
- 500 pounds (for Extremely Hazardous Substances as defined in Title 40 Code of Federal Regulations (CFR), Part 355 [40 CFR 355]); or
- The Threshold Planning Quantity (TPQ),

whichever is less.

313 Report - The Toxic Chemical Release Inventory Report was transmitted to the EPA and the state of Idaho by July 1, 2005. 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 off-site waste storage and treatment, air emissions, recycling, and other activities. Eight reports were prepared at the INEEL during 2004 for toluene, ethylbenzene, lead and lead compounds, nitric acid, hydrochloric acid, naphthalene, propylene, 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 Manual (DOE-ID 2003). The DOE-ID NEPA Compliance Officer and NEPA Planning Board implement the process.

The DOE-ID issued the Annual NEPA Planning Summary in January 2004. 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 INEEL projects are described below.

Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (Idaho HLW & FD EIS) - This EIS evaluates 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.

In the final EIS, the state of Idaho (a cooperating agency) and DOE identified separate preferred alternatives for waste treatment but identified the same preferred alternative for facilities disposition. The State identified vitrification as its preferred waste treatment alternative, while DOE's preferred alternative is to select from among the options and technologies or one represented by those analyzed in the EIS. The selection would be based on performance factors such as demonstration-scale test data, technical maturity, cost and schedule, ability to meet compliance dates, and public input.

DOE conducted four workshops, in 2003, to inform the public about the five technologies that the DOE was considering for treatment of the sodium bearing waste (SBW) with the preferred disposition at the Waste Isolation Pilot Plant (WIPP). The five technologies were Direct Vitrification, Cesium Ion Exchange with a grout waste form, Calcination with Maximum Achievable Control Technology Upgrades, Direct Evaporation, and Steam Reforming. During the workshops and briefings, DOE informed the public that the DOE's strategy was to select one of the five technologies for treatment of the SBW. Subsequently, DOE changed this strategy by incorporating the requirement for a contractor to propose a treatment technology for SBW in a draft Request for Proposals (RFP) for the Idaho Cleanup Project (ICP) contract to complete the Environmental Management accelerated cleanup mission. Prior to the draft RFP being issued, DOE informed the public at public meetings of the Idaho Environmental Management Citizens Advisory Board, at public meetings conducted by the National Academy of Sciences in Idaho, and other meetings with local stakeholders, of the change in strategy and that the DOE would identify a preferred treatment technology for SBW after the contract was awarded. At these meetings, DOE also informed the public that they would have an opportunity to provide comments on the draft RFP.

DOE issued the draft RFP for the ICP contract for comment in February 2004. The draft RFP required bidders to propose technologies for treating SBW for disposal at WIPP and an alternative technical approach to prepare this waste for disposal as HLW in the geologic repository for HLW and spent nuclear fuel if this waste could not be disposed of at WIPP. In addition, the draft RFP included facilities disposition and HLW calcine requirements. DOE responded to comments received on the draft RFP and issued the final RFP in July 2004 with the anticipated award in early 2005.

DOE plans a phased decision making process. This first ROD focuses on SBW treatment, facilities disposition, excluding tank closure, and DOE's strategy for HLW calcine. An amended record of decision addressing closure of the INTEC Tank Farm Facility (the Tank Farm) 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 is scheduled for issuance in 2009.

Supplement Analysis of Spent Fuel EIS - In late 2004, DOE began preparation of a supplement analysis to compare projects in the 1995 DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impacts Statement with updated INEEL plans and prevailing environmental baseline conditions. The supplement analysis will be used as a basis for determining: whether the environmental impact statement record of decision should be amended; whether a supplemental EIS should be prepared; or that no further NEPA review is required. The supplement analysis is scheduled to be completed and made available to the public in June 2005.

Environmental Assessment for the Remote Treatment Project - The proposed action is to provide heavily shielded remote waste handling services for the Argonne National Laboratory-West (ANL-W) and INEEL 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. 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* 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 environmental assessment is scheduled for public comment in 2005.

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 INEEL. 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 INEEL: the threatened Bald eagle (*Haliaeetus leucocephalus*) and the Gray wolf (*Canis lupus*). Gray wolves found in the geographical region that includes the INEEL are identified as an experimental/nonessential population and treated as a threatened species. Bald eagles occasionally winter on part of the INEEL, 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 INEEL 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, K.N. and D.H. 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 INEEL 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, J.E and J.P. Rousseau 2003). A flood hazard report based on the geomorphological models was drafted and will undergo 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, the 100-year floodplain has been delineated in a United States 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 INEEL 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 INEEL 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 non-regulated sites with ecological, environmental, and future development significance. In 2004, 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 component of mixed waste at the INEEL. 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 one RCRA Part A permit for the INEEL and eight Part B permits. One additional Part B permit is pending. DOE, Bechtel BWXT Idaho, LLC (BBWI), British Nuclear Fuels Limited, Inc. (BNFL), and Idaho DEQ met quarterly to discuss RCRA-related issues.

Notices of Violation - Idaho DEQ conducted an inspection of INEEL in May 2004, resulting in issuance of a notice of violation (NOV). The NOV addresses alleged violations related to facilities operated by the management and operating (M&O) contractor and by BNFL, Inc. Three alleged violations were identified for failures to: properly prepare hazardous waste manifests, maintain a waste analysis plan, and maintain copies of facility inspection records. The violation against BNFL, Inc. was dismissed. A consent order was negotiated and signed to address the two M&O contractor violations, which were subsequently corrected.

RCRA Closure Plans - The state of Idaho approved closure plans for the following facilities in 2004:

- Test Area North (TAN) 2A Tank System.
- TAN 616 Treatment Subsystem.
- INTEC D-Cell Container Storage Unit.

RCRA Reports - As required by the state of Idaho, INEEL submitted the Idaho Hazardous Waste Generator Annual Report for 2004. The report contains information on waste generation, treatment, recycling, and disposal activities at INEEL facilities.

DOE-ID submitted the INEEL 2004 Affirmative Procurement Report to the EPA, as required by Section 6002 of RCRA and Executive Order 13101. This report provides information on the INEEL's procurement of products with recycled content.

The INEEL RCRA permit for the Hazardous Waste Storage Facility at the Central Facilities Area (CFA) and some areas at ANL-W requires submittal of an annual certification to Idaho DEQ that the INEEL has a waste minimization program in place to reduce the volume and toxicity of hazardous waste. The certification was submitted by July 1, 2004.

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 INEEL 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 INEEL mixed waste streams, called the "backlog," and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities.

The INEEL 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 INEEL. 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 2004 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 INEEL does not produce chemicals, compliance with TSCA at the INEEL is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls (PCBs).

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. INEEL activities related to this Order are discussed in Chapters 3 and 7.

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 on 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 Test Reactor Area Cold Waste Ponds, the Naval Reactors Facility Industrial Waste Ditch, and the ANL-W 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 INEEL. 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 2004, no Settlement Agreement milestones were scheduled.

As part of the Settlement Agreement, the state of Idaho received $30 million from DOE for economic development in eastern Idaho. Idaho awarded grants to the Regional Development Alliance and State universities and colleges to reduce economic dependence on the INEEL. These awards have created more than 2600 jobs.

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.

Modifications to Permits to Construct - Two modified permits were received from the Idaho DEQ in 2004. The INTEC/INEEL nitrogen oxide (NO_x) permit was modified to remove the NO_x ambient monitoring system and boilers that are no longer operational. The INTEC-606 Boiler permit was modified to remove the portable boiler that was permitted and used during installation of the INTEC-606 Boilers.

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 Operating Permit program.

The INEEL submitted the first Title V Air Operating Permit Application to the Idaho DEQ in 1995. An updated application was submitted to the DEQ in March 2001. The application included ten volumes: one for each of the nine operating areas at the INEEL and a sitewide volume that contains information and standards applicable to all areas. Idaho DEQ issued a draft permit that will undergo DOE-ID, EPA, and public comment before issuing a final permit. The Idaho DEQ expects to issue a final permit in 2005.

National Emission Standards for Hazardous Air Pollutants - DOE-ID submitted the *2004 INEEL 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 Clean Air Act Assessment Package-1988 (CAP-88) computer model to calculate the hypothetical maximum individual effective dose equivalent to a member of the public resulting from INEEL airborne radionuclide emissions. The 2004 calculations for this code are discussed further in Chapter 8, "Dose to the Public and Biota."

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, 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 INEEL 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 INEEL storm water corridor (63 FR 189); and
- NPDES General Permit for Storm Water Discharges from Construction Activities provides protective requirements for construction activities located within the INEEL storm water corridor (63 FR 31).

Clean Water Act Section 404 Permits - In October 1994, the U.S. Army Corps of Engineers granted a ten-year Section 404 permit that allows DOE-ID to dispose of material associated with the excavation of soil in Spreading Area B to the surrounding spreading area. This area is located southwest of the RWMC. Fill removal activities have since ceased in this area.

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 INEEL Idaho Falls facilities in 2004 were within compliance levels established on the acceptance forms.

Storm Water Discharge Permits for Industrial Activity - Revised requirements for the NPDES general permit for the discharge of storm water from industrial activities became effective in 2000. The INEEL met the requirements to continue operations under this general permit. A modified NPDES Storm Water Multi-sector General Permit for industrial activities was also published in 2000. The original *INEEL Storm Water Pollution Prevention Plan for Industrial Activities* was implemented in 1993. The most recent revision was completed in January 2001 (DOE-ID 2001). This plan provides for baseline and tailored controls and measures to prevent pollution of storm water from industrial activities at the INEEL. The storm water pollution prevention plan team conducts annual evaluations to determine compliance with the plan. The Environmental Monitoring Unit of the M&O contractor monitors storm water in accordance with the permit requirements. Chapter 5, Section 5.5 provides results from this monitoring in 2004.

The National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division provides identification and notification of storm events. Storm water pollution prevention training is provided to INEEL personnel in accordance with the permit requirements.

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 M&O contractor to cease storm water management activities at those locations and complete a technical analysis to determine if other locations at the INEEL also do not have a reasonable potential to discharge. The technical analysis is expected to be completed in February 2005.

Storm Water Discharge Permits for Construction Activity - INEEL'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 INEEL. 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 M&O contractor was also directed to cease storm water management activities associated with construction at INTEC, RWMC, and TAN in the December 2003 letter. Additional areas may be included based on the results of the technical analysis.

Spill Prevention, Control, and Countermeasure Plans - For most of 2004, TAN, INTEC, and RWMC required Spill Prevention, Control, and Countermeasure (SPCC) Plans. These INEEL facilities were evaluated in 2001 in accordance with 40 CFR 112. As a result of this evaluation, the current plans were found to inadequately address the current requirements. In 2003, the plans were updated to address the deficiencies. However, as with storm water regulations, the basis for SPCC regulations is the potential to discharge pollutants into waters of the United States, resulting in SPCC no longer being applicable at the INEEL. The December 2003 letter also directed the M&O contractor to cease application of SPCC regulation at the locations specified in the EPA letter.

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 INEEL drinking water supplies meet these criteria for public water systems and are classified as either nontransient noncommunity or transient noncommunity systems. The INEEL operates 12 active public water systems, two of which serve the Naval Reactors Facility and ANL-W. All INEEL facilities performed sampling of drinking water as required by the State and EPA. Chapter 5 “Compliance Monitoring Programs” 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 and amendments. The act requires that for any federal project that may have an adverse effect on historic property, the agency in charge of the project must take actions to mitigate those adverse effects. This is usually done through an agreement with the State Historic Preservation Office.

In 2004, the National Park Service approved the Historic American Engineering Record (HAER) reports for TAN and Power Burst Facility historic properties. These reports contain written and photographic documentation of buildings and structures and are prepared to mitigate the adverse effects associated with demolition of these historic properties. The two final HAER reports reside with the National Park Service and will soon have a permanent place in the Library of Congress.

Demolition of these structures and plans to accelerate decontamination, decommissioning, and demolition of many other structures have necessitated development of an integrated approach. Over the next several years, DOE-ID plans to inactivate approximately 50 percent of the INEEL buildings owned by the Office of Environmental Management through consolidation of personnel and functions. INEEL developed the Historic Architectural Properties Management Plan to provide a comprehensive, cost-effective, and time saving approach to manage facility inactivation and achieve compliance with the National Historic Preservation Act while preserving important elements of INEEL's past for future generations. The INEEL Historic Architectural Properties Management Plan is incorporated as Appendix D in the INEEL Cultural Resource Management Plan (CRMP), which was reviewed and approved by the Idaho State Historic Preservation Office and the Advisory Council on Historic Preservation. The CRMP became final in August 2004. The CRMP provides a tailored approach for the INEEL to Section 106 of the National Historic Preservation Act. A

Programmatic Agreement Concerning Management of Cultural Resources on the INEEL between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho State Historic Preservation Office, dated July 2004, formally implements the CRMP.

Native American Graves Protection and Repatriation Act

The INEEL is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-Bannock Tribes are major stakeholders in INEEL 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

No releases occurred in 2004 that required reporting to external agencies.

2.3 Permits

Table 2-2 summarizes permits applied for, and granted to, the INEEL through year-end 2004.

Table 2-2. Permit summary for the INEEL (2004).

Media/Permit Type	Issuing Agency	Active	Pending
Air			
Permit to Construct	State of Idaho	17	0
NESHAPs (Subpart H)[a]	EPA Region 10	1	0
Operating Permit	State of Idaho	0	1
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 Wastewater Acceptance	City of Idaho Falls	15	0
RCRA			
Part A	State of Idaho	1	0
Part B[b]	State of Idaho	8[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.

REFERENCES

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

40 CFR 355, 2002, "Emergency Planning and Notification," *Code of Federal Regulations*, Office of the Federal Register.

63 FR 189, 1998, "Final Modification of the National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities," *Federal Register*, U.S. Environmental Protection Agency, September 30, p. 52430.

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

Hortness, J.E., and Rousseau, J.P., 2003, *Estimating the magnitude of the 100-year peak flow in the Big Lost River at the Idaho National Engineering and Environmental Laboratory*, Idaho: U.S. Geological Survey Water-Resources Investigations Report 02-4299 DOE/ID 22181, 36 p.

Koslow, K.N. and VanHaaften D.H., 1986, *Flood Routing Analysis for a Failure of Mackay Dam*, EG&G EP-7184.

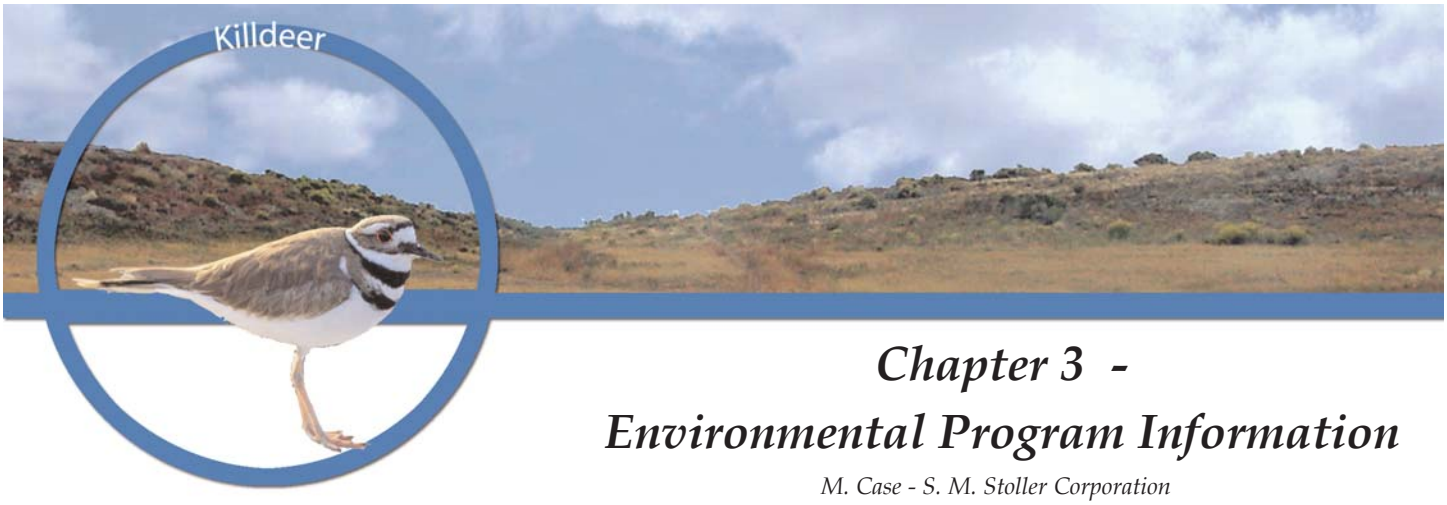
U.S. Department of Energy Idaho Operations Office (DOE-ID), 2001, *Idaho National Engineering and Environmental Laboratory Storm Water Pollution Prevention Plan for Industrial Activities*, DOE/ID-10431, Rev. 41, January.

U.S. Department of Energy Idaho Operations Office (DOE-ID), 1998, *Idaho National Engineering and Environmental Laboratory Storm Water Pollution Prevention Plan for Construction Activities*, DOE/ID-10425, Rev. 2, May.

U.S. Department of Energy Idaho Operations Office (DOE-ID), 2003, *Draft DOE-ID NEPA Planning and Compliance Program Manual*, ID M 451.A-1, August 5.

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

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



Chapter 3 - Environmental Program Information

M. Case - S. M. Stoller Corporation
B. Jonker - U.S. Department of Energy - Idaho Operations Office
L. Knobel and B. Tucker - United States Geological Survey
K. Clawson - National Oceanic and Atmospheric Administration

Chapter Highlights

There are many environmental monitoring programs that help implement the Environmental Compliance Policy for the Idaho National Engineering and Environmental Laboratory (INEEL). 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 INEEL 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 (DOE) commitments.

During 2004, responsibility for environmental monitoring onsite was with the prime Management and Operating contractor at the INEEL, Bechtel BWXT Idaho, LLC. The offsite environmental monitoring program was the responsibility of the Environmental Surveillance, Education and Research Program contractor who, during 2004, was a team led by the S. M. Stoller Corporation.

Environmental media sampled under these programs include ambient air; drinking, surface, and ground water; soils; vegetation; agricultural products; wildlife; and direct radiation. Samples are analyzed for a wide array of constituents ranging from pH, inorganics, volatile organics, gases, and gross alpha and beta activity to specific radionuclides, such as tritium, strontium-90, and plutonium isotopes.

In May 2002, DOE, the Idaho Department of Environmental Quality and the U.S. Environmental Protection Agency signed a letter of intent formalizing an agreement to pursue accelerated risk reduction and cleanup at the INEEL. The intent of accelerating the cleanup of the INEEL yields two significant objectives: (1) risk reduction and continued protection of the Snake River Plain Aquifer, and (2) consolidation of Environmental Management activities and reinvestment of savings into cleanup. Nine strategic initiatives were developed around these two objectives to accelerate cleanup.

Since the Federal Facility Agreement and Consent Order was signed in December 1991: 22 Records of Decision have been signed and are being implemented; three Remedial Investigation/Feasibility Studies are under development; and more than 70 percent of Comprehensive Environmental Response, Compensation, and Liability Act actions have been completed. Only three investigations remain to be completed:

- Buried waste at the Radioactive Waste Management Complex Waste Area Group-7 (WAG 7);
- Soil contamination at the Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm (WAG 3, Operable Unit [OU] 3-14);
- Snake River Plain Aquifer contamination (WAG 10, OU 10-8).

In a significant accomplishment, remediation of WAG 4, the Central Facilities Area, was completed in 2004.

Under the accelerated cleanup agreement, planning is underway to determine the end state and to work toward closure of many contaminated areas and buildings at the INEEL. Significant progress was made in accelerating cleanup and reducing risk.

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 INEEL. During 2004, three site treatment plan milestones were met.

The overall goal of the Advanced Mixed Waste Treatment Project is the treatment of alpha-containing low level mixed and transuranic wastes for final disposal. A contract for treatment services was awarded to British Nuclear Fuels Limited, Inc. in December 1996. They completed construction of the facility in December 2002 and commenced treatment operations in 2004.

Significant accomplishments were achieved during 2004 in the disposal of low-level and mixed waste stored and generated at the INEEL. Activities were highlighted by the treatment and disposal of 900 m^3 (1,177 yd^3) of mixed low-level waste. Approximately 6,080 m^3 (7,953 yd^3) of legacy and newly generated low-level waste was disposed at the Subsurface Disposal Area.

The Transuranic Waste Program continued transuranic waste shipments to the Waste Isolation Pilot Plant. A total 192 m^3 (251 yd^3) were shipped in 2004.

The INEEL Management and Operating contractor continued to make progress on the effort initiated in 1997 to develop and implement an INEEL-wide Environmental Management System (EMS). The Environmental Management System meets the requirements of International Standards Organization (ISO) 14001. The INEEL EMS received ISO 14001 registration in June 2002. A semiannual ISO 14001 surveillance performed in November 2004 found no nonconformances with the ISO standard.

The INEEL Citizens Advisory Board was formed in March 1994. During its tenure, the Citizens Advisory Board has provided recommendations on over 100 topics. In 2004, the Board provided recommendations on six critical topics.

3. ENVIRONMENTAL PROGRAM INFORMATION

This chapter highlights the Idaho National Engineering and Environmental Laboratory (INEEL) environmental programs that help implement the Environmental Policy for the INEEL (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 INEEL 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 they are found.

Effluent monitoring is conducted by various INEEL organizations. Airborne effluent measurements and estimates, required under the Idaho State Implementation Plan, are the responsibility of the regulated facilities. At the INEEL, these facilities include Argonne National Laboratory-West (ANL-W), Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Naval Reactors Facility (NRF), Power Burst Facility/Critical Infrastructure Test Range (PBF/CITR), Radioactive Waste Management Complex (RWMC), Test Area North/Specific Manufacturing Capability (TAN/SMC), and Test Reactor Area (TRA). The Liquid Effluent Monitoring Program and Storm Water Monitoring Program, conducted by the Management and Operating (M&O) contractor, are designed to demonstrate compliance with the Clean Water Act, Wastewater Land Application Permits (WLAP), and other associated permits.

Environmental surveillance is the major environmental monitoring activity conducted at the INEEL. 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 INEEL; 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 2004 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 2004 results on current ecological research programs at the INEEL.

Objectives of Environmental Monitoring

Operations of INEEL 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 INEEL facilities, where they could potentially impact the surrounding environment and the population living in these areas.

The major objectives of the various environmental monitoring programs conducted at the INEEL 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 INEEL is required by the U.S. Department of Energy (DOE) Order 450.1 (DOE 1993). 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, or other official DOE documents.

History of Environmental Monitoring

Environmental monitoring has been performed at the INEEL 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 INEEL. The Atomic Energy Commission's Health Services

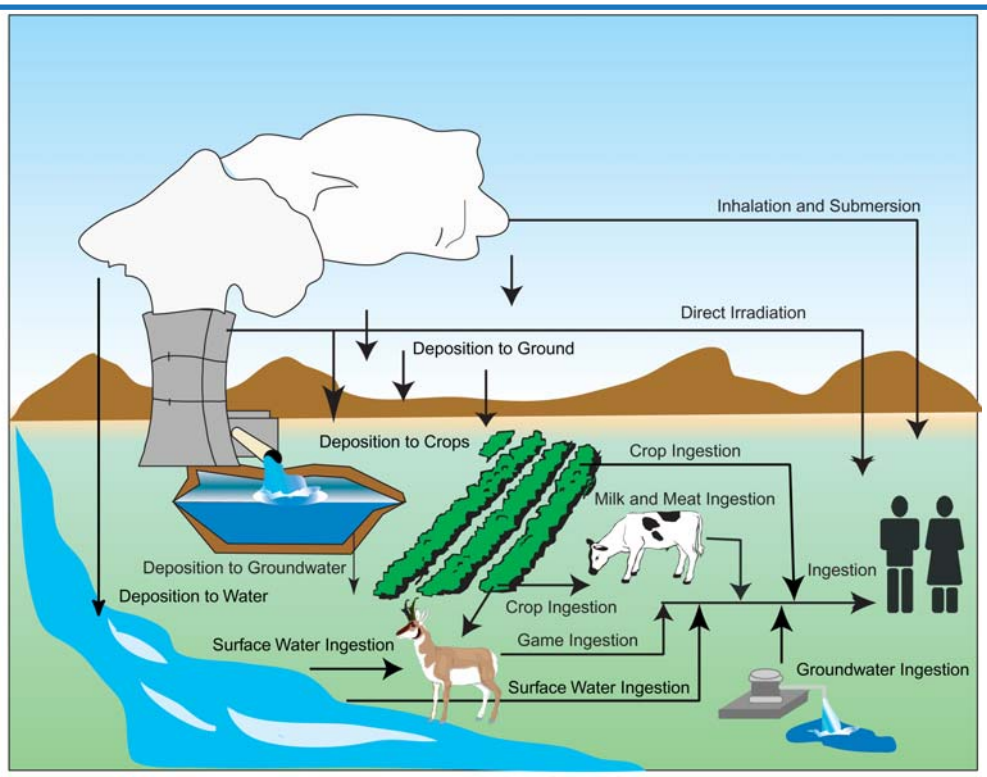


Figure 3-1. Potential exposure pathways to humans from the INEEL.

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 INEEL 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 INEEL facilities. Radionuclides were the major contaminants of concern because the INEEL 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 M&O contractors conducted sampling of liquid and airborne effluents from facilities to develop waste inventory information.

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

As a result of a site 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 M&O contractor. During 2004, Bechtel BWXT Idaho, LLC (BBWI) was the prime M&O contractor at the INEEL. The offsite monitoring program is performed by the Environmental Surveillance, Education and Research (ESER) Program contractor. During 2004, the ESER contractor and 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 operated on and in the vicinity of the INEEL 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-Müller 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.

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

Table 3-1. Historical low volume radiological air sampling locations and dates of operation.

Sampling Location	Dates of Operation
Distant Locations	
Aberdeen	1952–1957, 1960–1970
American Falls	1970
Blackfoot	1968–2001
Blackfoot Community Monitoring Station	1983–present
Carey	1961–1970
Craters of the Moon[a]	1973–present
Dubois	2001–present
Dietrich	1961–1970
Idaho Falls	1953–1955, 1956–present
Jackson	2001–present
Minidoka	1961–1970
Pocatello	1969–1980
Rexburg Community Monitoring Station	1983–present
Spencer	1953–1956
Boundary Locations	
Arco	1968–present
Atomic City	1953–1957, 1960–1970, 1973–present
Butte City	1953–1957, 1960–1973
Blue Dome	2001–present
Federal Aviation Administration Tower	1981–present
Howe	1958–present
Monteview	1958–present
Mud Lake	1958–present
Reno Ranch/Birch Creek	1958–2001
Roberts	1960–1970
Terreton	1953–1956, 1964–1965
INEEL Locations	
Argonne National Laboratory-West	1961–present
Aircraft Nuclear Propulsion Program	1953–1955, 1961–1963
Auxiliary Reactor Area	1966–present
Central Facilities Area	1953–present
East Butte	1953–1955
Experimental Breeder Reactor No. I	1952–1956, 1958–present
Experimental Field Station	1972–present
Fire Station #2	1958–1963
Gas-Cooled Reactor Experiment	1961–1963
Gate 4	2004
Idaho Nuclear Technology and Engineering Center	1953–1956, 1958–1970, 1981–present
Main Gate	1976–present
Mobile Low Power Reactor No. I	1961–1963
Naval Reactors Facility	1956, 1958–present
Organic Moderated Reactor Experiment	1957–1963
Power Burst Facility	1958–present
Radioactive Waste Management Complex	1973–present
Rest Area, Highway 20	2000–present
Stationary Low-Power Reactor No. I	1961–1963
Test Area North	1953–1955, 1956–present
Test Reactor Area	1953–1956, 1958–present
Van Buren Gate	1976–present

a. Designated as a boundary location 1973–1981.

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 INEEL 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-hour $PM_{2.5}$ 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 M&O contractors maintain a network of low volume air samplers to monitor for airborne radioactivity (Figure 3-2). The ESER contractor operates 12 samplers at offsite locations and three onsite samplers. The ESER contractor 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 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 M&O contractor maintains 16 onsite and four offsite sampling locations. Additional samplers were added at Specific Manufacturing Capability, Gate 4, and INTEC due to increased decontamination and dismantlement activity.

Each low-volume air sampler maintains an average airflow of 50 L/min (2 ft^3/min) 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 nine 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).

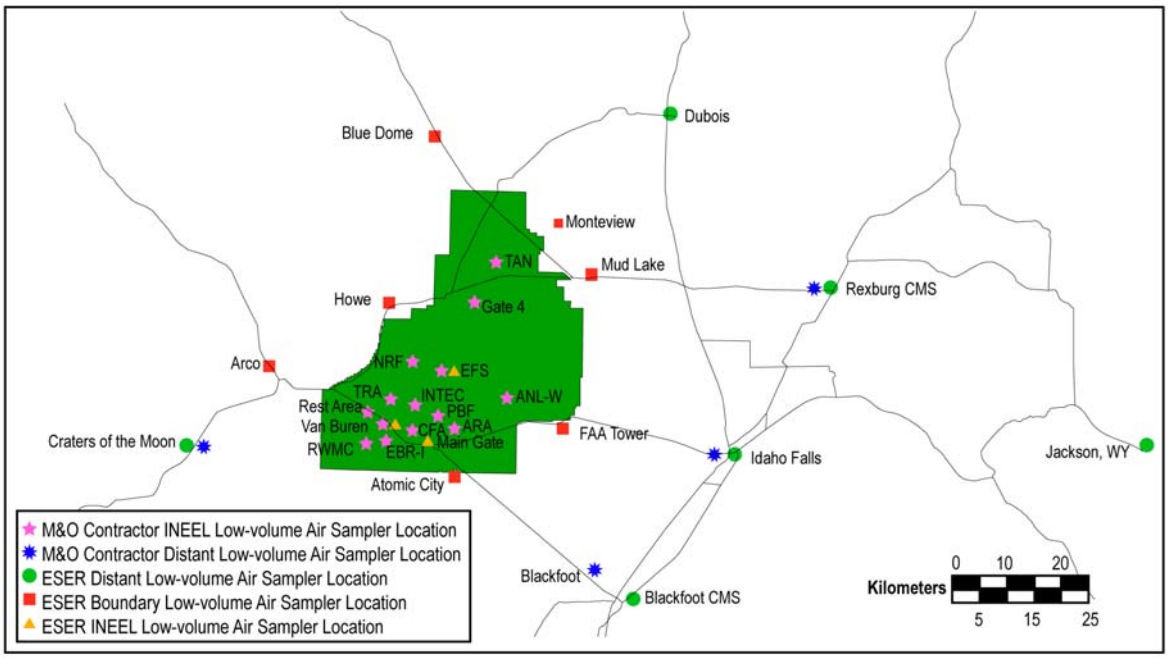


Figure 3-2. ESER and M&O contractor low-volume radiological air sampling locations.

Measurements of suspended particulates are also performed on the 1.2-µm pore membrane filters from the low-volume air samplers. The M&O contractor weighs their filters weekly before and after sampling to determine the amount of material collected. The ESER contractor also weighs their filters weekly before and after use. 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/hr (0.01-0.02 ft^3/hr). 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 INEEL monthly at CFA and weekly at the 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 INEEL since the Site's inception in 1949. The USGS was initially assigned the task to characterize water resources of the area. It has since maintained a groundwater quality and water level measurement program

on the INEEL to support research and monitor the movement of radioactive and chemical constituents in the Snake River Plain Aquifer. The first well, USGS 1, was completed and monitored in December 1949. USGS personnel have maintained an INEEL Project Office at CFA since 1958 (USGS 1998).

In 1993, the DOE Idaho Operations Office (DOE-ID) initiated a program to integrate all of the various groundwater monitoring programs on the INEEL. 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 analysis 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 INEEL led to a decrease in the number of sampling locations. In 1988, a centralized drinking water program was established. Each contractor participates in the INEEL Drinking Water Program. However, each contractor (BBWI, ANL-W and NRF) administers their own drinking water programs in place. 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. 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 maximum contaminant levels [MCLs] are not exceeded). 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 General Permit effective October 1, 1992, the INEEL 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 INEEL 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 analysis for two of the years during every five-year cycle at potential discharge locations. This usually occurs during years two and four; the INEEL 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 178 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 analysis of organic and inorganic substances.

The USGS also records water levels at 308 selected wells on schedules ranging from monthly to annually.

The USGS also conducts special studies of the groundwater resources of the Eastern Snake River Plain. The abstract of each study published in 2004 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 substances in the groundwater. One special USGS investigation of particular interest is the ongoing annual sampling effort in the area between the southern boundary of the INEEL 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 INEEL facilities could migrate through the Snake River Plain Aquifer to the Snake River in the Twin Falls/Hagerman area. The most recent results of this study are summarized in USGS Open File Report 03-168 (Twining et. al. 2003).

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 INEEL facility. The updated plan modifies groundwater monitoring recommendations in accordance with more recent information (i.e., requirements in records of decisions), relying on existing multiple groundwater programs rather than a single comprehensive program.

The M&O contractor conducts groundwater monitoring in support of state of Idaho Wastewater Land Application Permit (WLAP) requirements at INTEC, and TAN as well as surveillance monitoring at INTEC. ANL-W also performs groundwater surveillance monitoring in support of the Record of Decision (ROD) and a submitted state of Idaho Wastewater Land Application Permit.

The M&O contractor's Drinking Water Program monitors production and drinking water wells for radiological, chemical, and bacteriological contaminants at all their INEEL facilities. Currently, 17 wells and ten distribution systems are monitored. All analyses for the program are conducted using laboratories certified by the state of Idaho or laboratories certified in other states, where this certification is accepted by the state of Idaho. The NRF and ANL-W maintain separate programs for sampling drinking water based on the requirements applicable at their facilities. Radiological and bacteriological samples from ANL-W are sent to the M&O contractor for analysis. ANL-W conducts a separate program for chemical monitoring.

M&O personnel collect quarterly onsite drinking water samples from active systems for radiological analysis. General Engineering Laboratory, located in Charleston, South Carolina, performed these analyses during 2004. 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 monitoring and observation wells indicate this water may contain ^{90}Sr concentrations above background levels.

Microwise Laboratory, located in Idaho Falls, Idaho, analyzes drinking water monthly for coliform bacteria in 2004. 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 M&O contractor's Drinking Water Program also samples drinking water from wells and distribution systems at INEEL facilities for volatile organic compounds. 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.

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 a letter dated October 27, 2003, to the DOE-ID chief counsel, EPA Region 10 determined that three sites at the INEEL (RWMC, INTEC, and the north part of the INEEL 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). DOE-ID directed the M&O contractor to cease expending further resources on compliance with the Storm Water Pollution Prevention Plan for Industrial Activities, Storm Water Pollution Prevention Plan for Construction Activities, and Spill Prevention Control and Countermeasures Programs at the three sites discussed in the letter from EPA. The letter further directed the M&O contractor to conduct a technical analysis to determine any other areas under the M&O contractor's control that would also have the same or less potential to discharge storm water to waters of the United States. As a result of this direction by DOE-ID, construction and industrial storm water inspections, data collection, and reports have ceased for projects located at those facilities.

The remaining projects were evaluated through the technical analysis requested by DOE-ID to determine potential to discharge. 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 the preliminary technical analysis (to be finalized in early 2005), ceased.

The ESER contractor 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.

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 concern. Lettuce has been collected since 1977.

Current Programs - Milk samples are collected from both commercial and single-family dairies. A two-liter (0.5 gal) sample is obtained from each location monthly, except in Idaho Falls where a sample is collected weekly. Milk from each location is analyzed for ^{131}I, and one analysis for ^{90}Sr and tritium at each location is performed during the year.

Wheat samples are collected from farms or grain elevators in the region surrounding the INEEL. 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 INEEL, 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.

Prior to 2003, lettuce samples were obtained from private gardens in communities in the vicinity of the INEEL. A new sampling program was instituted in 2003 in which self-contained growing boxes were distributed throughout the region, usually at existing air monitoring locations. Lettuce was then grown from seed at each location and collected when mature. The use of self-contained growing boxes has allowed the collection of samples at areas on the INEEL (e.g., the Experimental Field Station) and at boundary locations where lettuce could not 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 M&O contractor annually collects perennial and grass samples from around the major waste management facilities. These samples are analyzed for gamma-emitting radionuclides. ANL-W personnel also collects vegetation samples annually from around the ANL-W Industrial Waste Pond and along the ANL-W Industrial Waste Ditch. These samples are analyzed for selected alpha, beta, and gamma radionuclides.

NRF personnel collect vegetation around the NRF facility and along the NRF Industrial Waste Ditch. These samples are analyzed for gamma radionuclides. Results are reported in Bechtel Bettis (2004).

Animal Tissue Monitoring

Historical Background - Monitoring of game animals has focused on research into 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 waste 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. Routine dove sampling as part of the environmental surveillance program was initiated in 1996. In 1998, 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 were also monitored biennially during the period 1978 to 1986.

Current Programs - Selected tissues (muscle, liver, and thyroid) are collected from game animals accidentally killed on INEEL 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 INEEL. Control samples are also taken in areas distant from the INEEL. Waterfowl samples are separated into an external portion (consisting of the skin and feathers); edible portion (muscle, liver, and gizzard tissue); and remainder 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 TRA waste ponds and from a control area distant to the INEEL. 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, ^{90}Sr, and transuranic radionuclides.

Marmots are collected from the vicinity of the RWMC and a control area distant to the INEEL, usually Pocatello, in some years. Marmot samples are separated into three portions: an external portion (consisting of the skin and fur); edible portion (muscle, liver, and gizzard tissue); and viscera portion (remaining internal organs). All samples are analyzed by gamma spectrometry. Selected samples are also analyzed for ^{90}Sr and transuranic 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 five-centimeters (two-inches) in depth from a one square meter (approximately ten square feet) 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 in even numbered years. Following collection, soil samples are dried for at least three hours at 120°C (250°F) and sieved. Only soil particles less than 500-µ in diameter (35 mesh) are analyzed. All offsite samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and transuranic radionuclides.

The M&O contractor now performs soil sampling on a two-year rotation. One hundred nine sites were sampled in 2004. 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 M&O contractor also performs annual sampling of the CFA sewage treatment plant irrigation spray field to show compliance with the WLAP soil loading limits.

ANL-W personnel collect soil samples annually at locations along the major wind directions and at crosswind locations around the ANL-W facility. Samples are analyzed for low-level gamma-emitting radionuclides, and uranium, plutonium, and thorium isotopes. Sufficient material to fill a 500 mL (16 oz.) wide mouth jar is collected from 0-5 cm (0-2 in.) depth within an approximately 1 m^2 (~11 ft^2) area.

NRF personnel collect soil samples around the NRF facility. These samples are analyzed for gamma radionuclides. Results are reported in Bechtel Bettis (2004).

Direct Radiation Monitoring

Historical Background - Measurements of radiation in the environment have been made on the INEEL 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 INEEL operations and other industrial processes.

At each location, a dosimeter holder containing four individual chips is placed one meter (three feet) above ground level. The M&O contractor maintains dosimeters at 13 offsite locations and 135 locations on the INEEL. The ESER contractor has dosimeters at 14 offsite locations. The dosimeter card at each location is changed semiannually, and cumulative gamma radiation is measured by the M&O contractor Dosimetry Unit.

In addition to TLDs, the M&O contractor uses a mobile global positioning system radiometric scanner arrangement to conduct gamma radiation surveys. Two plastic scintillation detectors and radiometric 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.

ANL-W personnel conduct annual surface radiation surveys of ANL-W wastewater ditches using hand-held portable beta-gamma meters. In addition to these surveys ANL-W also maintains a network of four high pressure ionization chambers (HPICs) to monitor ambient airborne radiation. The HPICs are oriented to the facility in the two major wind directions (northeast and southwest) and two cross-wind directions (north-northwest and southeast).

NRF has TLDs placed on the facility fence line at approximately one meter (three feet) above ground level. Results of TLD monitoring at NRF are reported in Bechtel Bettis (2004).

Meteorological Monitoring

Historical Background - The NOAA Air Resources Laboratory-Field Research Division (NOAA ARL-FRD) began work at the INEEL in 1948 as a Weather Bureau Research Station. The first meteorological observation station established to support the Site 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 INEEL. 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 located on the INEEL. Data are transmitted via radio and telephone to the NOAA ARL-FRD Idaho Falls facility, where they are stored in a computerized archive.

Monitoring and Surveillance Committee

The INEEL Monitoring and Surveillance Committee was formed in March 1997 and holds bimonthly meetings to coordinate activities between groups involved in INEEL-related onsite and offsite environmental monitoring. This standing committee brings together representatives of DOE (Idaho, Chicago, and Naval Reactors), INEEL contractors, ANL-W, NRF, Shoshone-Bannock Tribes, Idaho INEEL 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.

Monitoring Summary

Tables 3-2 through 3-5 present a summary of the environmental surveillance programs conducted by the ESER contractor, the M&O contractor, ANL-W, and the USGS, respectively, in 2004. Information concerning the environmental monitoring program for NRF can be found in Bechtel Bettis 2004.

3.2 Accelerated Cleanup Agreement

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

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 INEEL by completing its cleanup responsibility faster and more efficiently. The plan will fulfill the following two visions:

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

The vision for accelerating cleanup of the INEEL results in two objectives: (1) risk reduction and continued protection of the Snake River Plain Aquifer and (2) consolidation of the DOE Office of Environmental Management (EM) activities and reinvestment of savings into cleanup.

Table 3-2. ESER environmental surveillance program summary (2004).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	1×10^{-15} µCi/mL
	Gross beta	4 weekly[a]	14 weekly[a]	2×10^{-12} µCi/mL
	Specific gamma	4 quarterly[a]	14 quarterly[a]	3×10^{-16} µCi/mL
	^{238}Pu	1-2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	$^{239/240}Pu$	1-2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	^{241}Am	1-2 quarterly	7 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	1-2 quarterly	7 quarterly	6×10^{-17} µCi/mL
	^{131}I	4 weekly[a]	14 weekly[a]	2×10^{-15} µCi/mL
	Total particulates	4 quarterly[a]	14 quarterly[a]	10 µg/m^3
Air (high volume)[b]	Gross beta	None	1, twice per week	1×10^{-15} µCi/mL
	Gamma scan	None	If gross $\zeta > 1$ pCi/m^3	1×10^{-14} µCi/mL
	Isotopic U and Pu	None	1 annually	2×10^{-18} µCi/mL
Air (PM_{10})	Weighing filter	None	3 weekly	± 0.000001 g
Air (atmospheric moisture)	Tritium	None	4 locations, 2 to 4 per quarter	2×10^{-13} µCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[c]	1 monthly	100 pCi/L
Drinking Water	Gross alpha	None	13 semiannually	3 pCi/L
	Gross beta	None	13 semiannually	2 pCi/L
	Tritium	None	13 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			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 annually	0.1 pCi/g
	^{90}Sr	None	8 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	9 annually	0.1 pCi/g
	^{90}Sr	None	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	14 semiannually	5 mR

a. Onsite include three locations and a blank, offsite includes 13 locations and a blank.
b. Filter are collected by ESER personnel and sent to EPA for analysis. Data are reported by EPA's Environmental Radiation Ambient Monitoring System (ERAMS) at http://www.epa.gov/narel/erams/.
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 INEEL for at least two weeks before being sampled. Offsite animals have never grazed on the INEEL 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. M&O contractor site environmental surveillance program summary (2004).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	16 weekly	4 weekly	1×10^{-15} µCi/mL
	Gross beta	16 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	16 quarterly	4 quarterly	—[a]
	^{238}Pu	16 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{241}Am	16 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	16 quarterly	4 quarterly	2×10^{-14} µCi/mL
	Particulate matter	16 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[b]	—	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[b]	—	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	—	[a]
	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 INEEL roads[c]	—	NA

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

b. Onsite soil sampling is performed each year at different onsite facilities on a rotating two-year schedule.

c. Surveys are performed each year at different onsite facilities on a rotating three-year schedule. All INEEL roadways over which waste is transported are surveyed annually.

Table 3-4. ANL-W site environmental surveillance program summary (2004).

Medium Sampled	Type of Analysis	Frequency	Minimum Detectable Concentration
Airborne Effluents	Nitrogen oxides	Continuous	NA[a]
Airborne Effluents	Sulfur dioxide	Continuous	NA
Soil	Specific gamma	7 annually	0.7 pCi/g
	Pu, Th, U isotopes	7 annually	0.005 pCi/g
	Metals	1 annually	Varies by analyte
Vegetation	Specific gamma	8 annually	0.7 µCi/g
	Pu, Th, U isotopes	8 annually	0.005 µCi/g
Drinking Water	Gross alpha	1 quarterly	1 pCi/L
	Gross beta	1 quarterly	4 pCi/L
	Tritium	1 quarterly	1000 pCi/L
	Inorganics	1 every 9 years	Varies by analyte
	Lead/copper	20 triennially	3.0 µg/L/1.5 µg/L
	Nitrate	1 annually	0.1 mg/L
	Cyanide	1 triennially	10 µg/L
	Arsenic	1 triennially	1.7 µg/L
	Coliform bacteria	1 quarterly	Presence
	Volatile organics	1 every six years[b]	Varies by analyte
	Semivolatile organics	1 every six years[b]	Varies by analyte
Surface Water	Inorganics	1 annually	Varies by analyte
	Anions	2 annually	Varies by analyte
	Gross Alpha	3 monthly	3 pCi/L
	Gross Beta	3 monthly	2 pCi/L
	Gamma Spec	3 monthly	Varies by analyte
	Tritium	3 monthly	400 pCi/L
	Water Quality Parameters[c]	3 monthly	Varies by analyte
Groundwater	Inorganics	5 semiannually	Varies by analyte
	Anions (Cl, SO_4, NO_3)	5 semiannually	Varies by analyte
	TOC[d]	5 semiannually	260 µg/L
	TOX[d]	5 semiannually	2.4 µg/L
	Gross Alpha	5 semiannually	3 pCi/L
	Gross Beta	5 semiannually	2 pCi/L
	Uranium isotopes	5 semiannually	Varies by analyte
	Tritium	5 semiannually	400 pCi/L
	Water Quality Parameters[e]	5 semiannually	Varies by analyte
Direct Radiation Exposure (HPICs)[f]	Ionizing radiation	4 Continuous	10 µR
Direct Radiation Exposure (portable radiation survey)	Gamma radiation	1 annually	NA

a. NA = not applicable. This information is recorded as an instrument reading at the time of inspection.

b. Surface water quality parameters include pH, temperature, specific conductivity, dissolved oxygen, and turbidity/ total dissolved solids.

c. Monitoring is required triennially unless waiver obtained from the state.

d. TOC = Total Organic Carbon; TOX = Total Organic Halogens.

e. Groundwater quality parameters include pH, total alkalinity, bicarbonate alkalinity, carbonate alkalinity, total dissolved solids, and specific conductivity.

f. HPIC = High Pressure Ionization Chamber.

Table 3-5. U.S. Geological Survey monitoring program summary (2004).

Constituent	Groundwater		Surface water		Minimum Detectable Concentration
	Number of Sites	Number of Samples	Number of Sites	Number of Samples	
Gross Alpha	53	65	4	8	3 pCi/L
Gross Beta	53	65	4	8	3 pCi/L
Tritium	163	253	7	14	400 pCi/L
Specific Gamma	94	138	4	8	—[a]
Strontium-90	111	183	—[b]	—	5 pCi/L
Americium-241	21	36	—	—	0.05 pCi/L
Plutonium Isotopes	21	36	—	—	0.04 pCi/L
Specific Conductance	163	254	7	14	Not applicable
Sodium Ion	152	168	—	—	0.1 mg/L
Chloride Ion	163	254	7	14	0.1 mg/L
Nitrates (as nitrogen)	115	129	—	—	0.05 mg/L
Sulfate	108	120	—	—	0.1 mg/L
Chromium (dissolved)	91	121	—	—	0.005 mg/L
Purgeable Organic Compounds[c]	28	51	—	—	0.0002 mg/L
Total Organic Carbon	51	53	—	—	0.1 mg/L
Trace Elements	91	121	—	—	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.

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

- Accelerate Tank Farm Closure;
- Accelerate high-level waste calcine removal from Idaho;
- Accelerate consolidation of spent nuclear fuel to the 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;
- Transfer all EM-managed special nuclear material offsite;
- Remediate buried waste in the RWMC; and
- Accelerate consolidation of INEEL 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 high-level waste to a repository; and final dismantlement of remaining EM buildings. These activities will be complete by 2035 with the exception of some minor activities leading to long-term stewardship. Even with these continuing activities, the cleanup costs can be reduced by up to $19 billion, and the cleanup schedule can be completed decades earlier. The Performance Management Plan is a living document that will be revised and improved as necessary to reflect the decisions and progress made towards accelerated cleanup. INEEL made significant progress in 2004, most notably:

- Demolished over 29,203 m^2 (314,333 ft^2) of buildings and structures;
- Achieved the final end state condition for the Waste Experimental Reduction Facility, Mixed Waste Storage Facility, and the Power Burst Facility control areas;
- Removed debris and sludge from four aging spent nuclear fuel storage basins through the innovative use of underwater divers and dewatered the basins ahead of schedule;
- Treated and disposed of backlog mixed low-level waste two years ahead of schedule;
- Completed the glovebox excavator method project eight months ahead of schedule;
- Accelerated Retrieval Project facility was constructed and approved to initiate operations; and
- Commenced operations at the Advanced Mixed Waste Treatment Project's (AMWTP) treatment facility.

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 INEEL 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 the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). By the end of 2004:

- Twenty-two RODs have been signed and are being implemented;

- Three Remedial Investigation/Feasibility Studies (RI/FSs) are under development; and
- Closeout activities at Waste Area Groups (WAGs) 2, 4 and 8 have been completed.

By progressing on these cleanup projects, workers were able to significantly reduce risks posed by past contamination at INEEL facilities. Also, by reducing the number of unneeded buildings at the INEEL, 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 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 hold public comment meetings on the proposed cleanup alternative. Only three investigations remain to be completed:

- Buried waste at the RWMC (WAG 7);
- Soil contamination at the INTEC Tank Farm (WAG 3, Operable Unit [OU] 3-14); and
- Snake River Plain Aquifer contamination (WAG 10, OU 10-8).

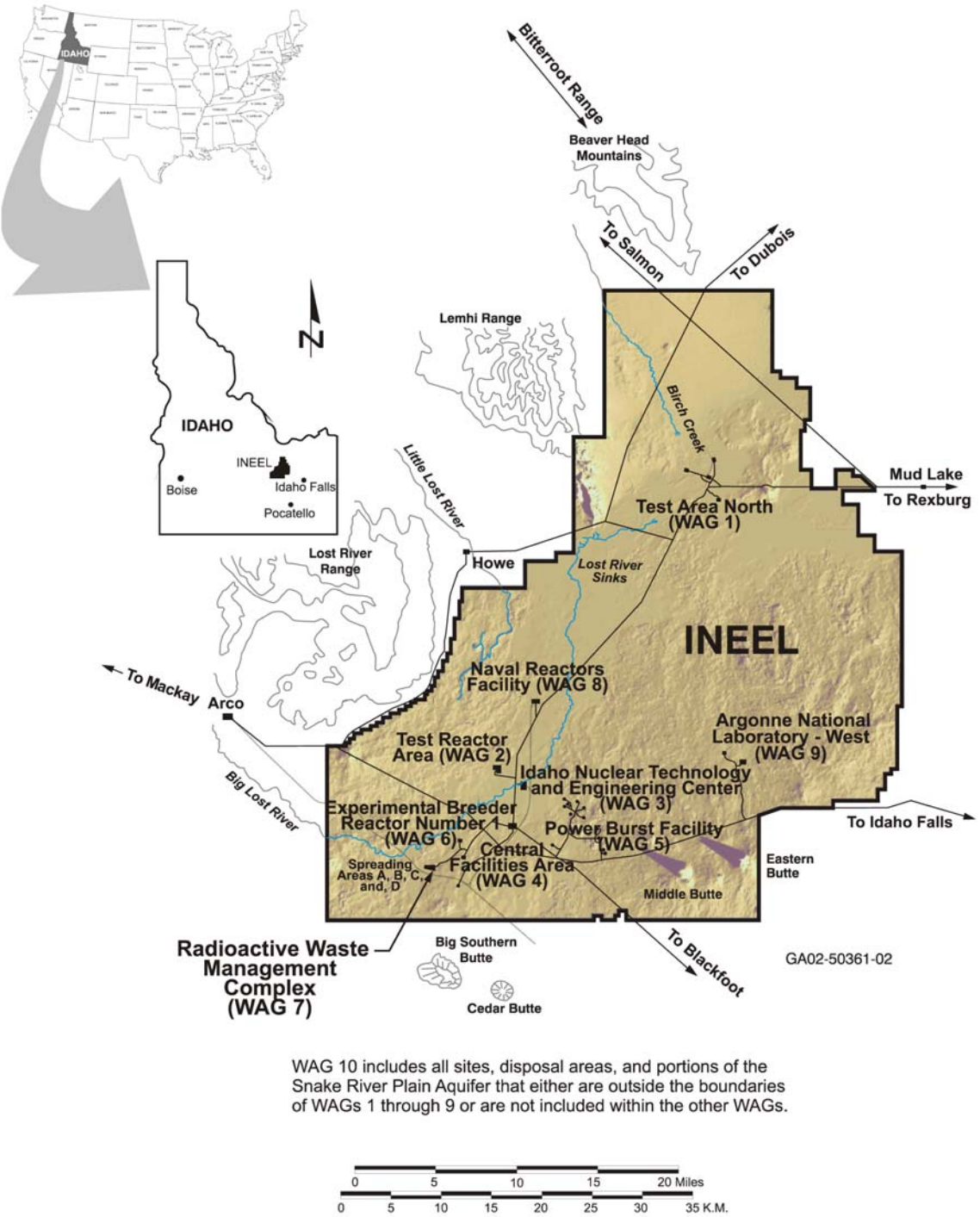
A complete catalog of documentation associated with the INEEL FFA/CO is contained in the CERCLA Administrative Record at http://ar.inel.gov/. The location of each WAG is shown on Figure 3-3.

Waste Area Group 1 - Test Area North

In 2004, the Agencies agreed on a remedy for the PM-2A and V-tanks waste. The V-tanks site consists of four underground storage tanks, related structures, and the surrounding contaminated soil. There are three out-of-service 37,854-L (10,000-gal) and one 1,514-L (400-gal) underground storage tanks. The contents are contaminated with radionuclides, heavy metals, and organic

compounds. The remedy is soil and tank removal, chemical oxidation/reduction with stabilization of the tank contents, and disposal. The major treatment activities will take place at the V-tanks site or in adjacent areas, as necessary.

Figure 3-3. Relief map of the INEEL showing locations of the facilities and corresponding waste area groups.



The remedy for the PM-2A tanks was also amended. The waste in the PM-2A tanks is similar to that of the V-tanks except that in the early 1980s an absorbent was added to the tanks in an attempt to solidify the waste. The 1999 ROD remedy for the PM-2A tanks specified that the tank contents would be removed from the tank by vacuum extraction, treated if necessary, and disposed on site. During the design of the remedy, it was determined that the tanks were structurally sound enough to be removed intact with the waste still inside. This alternate remedy reduces the potential for worker exposure during excavation and treatment.

Remediation of the two PM-2A tanks (V-13 and V-14) actually began in 2004. The two 189,265-L (50,000-gallon) tanks were removed from the ground and moved into the TAN-607 hi-bay for storage. The waste in the PM-2A tanks is a dried sludge contaminated with organics, metals, and radionuclides. V-13 does not require treatment and will be disposed of directly in the INEEL CERCLA Disposal Facility (ICDF). V-14 does require treatment for tetrachloroethylene. V-14 will be moved to the ICDF and be treated prior to disposal.

In addition to the V-tank work, the Operable Unit 1-07B Groundwater cleanup continued throughout 2004. The in-situ bioremediation nutrient injection system and the New Pump and Treatment Facility (NPTF) continued to reduce contaminate concentrations in the aquifer. The NPTF ran flawlessly with an operational uptime of 99 percent.

Waste Area Group 2 - Test Reactor Area

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 2004, all of these Institutional Controls were maintained.

Waste Area Group 3 - Idaho Nuclear Technology and Engineering Center

Operations continued at the ICDF during 2004, 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 site-wide INEEL CERCLA cleanup operations and segregates those wastes from potential migration to the aquifer, reducing risk to the public and environment. As of the end of 2004 about 138,221,389 Kg (152,363 tons) of contaminated soil and debris and about 476,456-L (125,870-gallons) of contaminated liquid had been disposed of at the ICDF. Progress was also made on constructing the Staging, Storage, Sizing, and Treatment Facility, which will provide the capability to treat soils that do not meet Land Disposal Restriction requirements, so that they can be disposed in the ICDF landfill. Other major accomplishments at WAG 3 include:

- Finalized the OU 3-14 Tank Farm RI/FS Draft Work Plan and began its implementation. The Remedial Investigation report, including the Baseline Risk Assessment, is expected to be completed during 2005.
- Completed field work for remediation of OU 3-13, Group 6 buried gas cylinders.
- Completed interim actions required for 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 - Power Burst Facility/Waste Reduction Operations Complex

This area supported two reactor facilities-the Power Burst Facility and the Auxiliary Reactor Area. Cleanup activities at WAG 5 are complete. A Remedial Action Report will be submitted to the regulators in 2005.

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

Ecological and groundwater monitoring continued in 2004. Work on the INEEL Sitewide Groundwater Model also continued. These activities are to prepare for the upcoming OU 10-08 RI/FS. The OU 10-04 Phase II Remedial Design and Remedial Action Work Plan was prepared and submitted to the agencies. The Phase I Remedial Action Report was also submitted.

Waste Area Group 7 - Radioactive Waste Management Complex

Waste Area Group 7 includes the Subsurface Disposal Area (SDA), a 39 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 (GEM) project 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 in New Mexico. Wastes retrieved during this successful excavation have been used to validate the characterization data generated by several non-invasive techniques and by ground probes. The ongoing Accelerated Retrieval Project is a larger-scale excavation (one-half acre) in Pit 4 using many of the safe operating concepts developed during the GEM project. Additional excavations are anticipated in future years as the retrieval approach is proven effective.

The following accomplishments were achieved at WAG 7 in 2004:

- Continued the Organic Contamination in the Vadose Zone Project, which vacuums solvent vapors that have escaped from buried waste. The vapors are brought to the surface and destroyed using thermal and catalytic processes. Since the beginning of operations in January 1996, about 191,730 lb (86,967 kg) of these contaminants have been removed and destroyed.
- GEM project waste excavation began in January 2004 and was completed, including backfilling the excavation pit, in April 2004.
- Construction began on the Accelerated Retrieval Project, the next phase of buried waste retrieval. This project is being performed as a CERCLA Removal Action.
- Performed in-situ grouting of beryllium blocks in the SDA as a CERCLA Removal Action in order to reduce the potential for future release of Beryllium into the subsurface.

Waste Area Group 8 - Naval Reactors Facility

The NRF is operated for the U.S. Naval Nuclear Propulsion Program by Bechtel Bettis, Inc., Bettis Atomic Power Laboratory-Idaho. Developmental nuclear fuel material samples, naval spent fuel, and irradiated reactor plan components/materials are examined at the Expended Core Facility (ECF). The knowledge gained from these examinations is used to improve current 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 results in the creation of less spent fuel requiring disposition. NRF is also preparing naval fuel for dry storage and eventual transportation to a repository. Remedial actions at NRF in 2004 included the following:

- Phase I Remedial Actions-Excavation of contaminated soil and pipe and removal of concrete structures were completed previously. The pipe and concrete have been sent offsite as low-level radioactive waste and the soil was consolidated onsite in preparation for containment within an engineered cover.
- Phase II Remedial Actions-Construction of three engineered covers over contaminated soil areas was completed in 2004.

Waste Area Group 9 - Argonne National Laboratory-West

All remediation activities for WAG 9 sites were completed and confirmation samples collected and analyzed in the fall of 2004. The final Remedial Action report will be submitted in June 2005.

3.4 Waste Management

The INEEL's waste management activities provide safe, compliant, and cost-effective management services for facility waste streams. 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 INEEL 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 INEEL which will be stored for one year or longer prior to treatment.

During 2004, the following Site Treatment Plan milestones were met:

- Commercial treatment/disposal of a backlog - 250.0 m^3 (8,828.7 ft^3);
- Sodium Components Maintenance Shop treatment backlog -- 2.0 m^3 (70.6 ft^3);
- Debris backlog treatment - 60.0 m^3 (2,118.9 ft^3).

Advanced Mixed Waste Treatment Project

The overall goal of the 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 INEEL waste streams and the flexibility to treat other INEEL 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 BNFL, Inc. in December 1996. They 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.

High-Level Waste and Facilities Disposition

In 1953, reprocessing of spent nuclear fuel began at the INTEC, resulting in the generation of liquid high-level waste and sodium-bearing liquid waste. Those wastes were placed into interim storage in underground tanks at the INTEC Tank Farm. Treatment of those wastes began in 1963 through a process called calcining. The resultant waste form, known as calcine, was placed in storage in stainless steel bins at the Calcine Solids Storage Facility. Processing of spent nuclear fuel was curtailed in 1992. The INEEL completed calcining of all nonsodium-bearing liquid high-level waste on February 20, 1998, four months ahead of the June 30, 1998 Idaho Settlement Agreement milestone. Calcining of remaining sodium-bearing liquid waste began immediately following completion of nonsodium liquid waste treatment, more than three years ahead of the Settlement Agreement milestone. Per that Agreement, all such waste is required to be calcined by the end of the year 2012.

The calciner was placed on standby in 2000 while DOE determines whether to upgrade and permit the facility to current standards or develop a new method of treating the remaining sodium-bearing liquid waste. Treatment alternatives for the remaining sodium-bearing liquid and calcined wastes were evaluated in the Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (see Chapter 2, National Environmental Policy Act). The remaining 3.4 million L (900,000 gal) of sodium-bearing liquid waste has been consolidated into three 1.14 million L (300,000 gal) underground tanks in the 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 of final closure. Decisions regarding the treatment technology for the sodium-bearing waste are expected with the award of the new Idaho Cleanup Project contract in 2005. In addition, work continues in 2004 and 2005 to investigate technologies for efficient retrieval of the existing high-level waste calcine from the calcine storage facilities. In the future, the high-level waste calcine will be retrieved, treated as necessary, and packaged for disposal at the national high-level waste repository.

Low-Level and Mixed Radioactive Waste

Under the Accelerated Cleanup initiative, INEEL embarked on an accelerated schedule to reduce a 2,250 m^3 (2,943 yd^3) backlog of mixed low-level waste. In 2004, INEEL treated and disposed of more than 900 m^3 (1,177 yd^3) of mixed low-level waste. The remaining backlog inventory was eliminated in 2004, two years ahead of schedule under an accelerated cleanup plan. Approximately 6,080 m^3 (7,953 yd^3) of legacy and newly generated low-level waste were disposed at the SDA in 2004.

Transuranic Waste

The Settlement Agreement requires that the INEEL must ship at least 6,000 m^3 (7,848 yd^3) of TRU waste out of Idaho between January 1, 2003, and December 31, 2005. In 2004, INEEL shipped a total of 192 m^3 (251 yd^3) of TRU waste out of Idaho.

Waste Minimization/Pollution Prevention

The mission of the INEEL 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 INEEL to incorporate pollution prevention into every activity. Pollution prevention is one of the key underpinnings of the INEEL EMS (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 INEEL is promoting the inclusion of pollution prevention into all planning activities as well as the concept that pollution prevention is integral to mission accomplishment. Noteworthy pollution prevention accomplishments in 2004 include:

- Five $^{241}Am/Be$ neutron sources were transferred to another project at the INEEL instead of being disposed of as radioactive waste.
- Six steam tanks from the decontamination, decommissioning, and demolition (DD&D) of Water Reactor Research Test Facility (WRRTF) reactor building were sold to a private company for reuse, generating proceeds for the INEEL. Because the reactor was never brought on line, the steam tanks were clean. The six steam tanks weighed a total of approximately 453,138 kg (997,000 lbs).
- Five sheets of lead from the DD&D of WRRTF reactor building were sent to the Nevada Test Site for reuse instead of being disposed of as hazardous waste. Because the reactor was never brought on line, the lead shielding was clean. Due to the size of the lead sheets, they could not be sent to a lead recycler. The largest piece was a 2.9 m (9.5 ft) square, clad in steel, that weighed 15,648 kg (34,500 lbs).
- A 200-ton compactor weighing 14,514 kg (32,000 lbs) was sent to a waste processing facility in Oak Ridge, Tennessee instead of being disposed of as low-level waste at the INEEL. As it was at the INEEL, the compactor will be used for volume reduction of low-level radioactive waste.

3.5 Environmental Management System

The INEEL M&O contractor continued to make progress on the effort initiated in 1997 to develop and implement an INEEL-wide EMS. The EMS meets the requirements of International Standards Organization (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 INEEL 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 INEEL facilities, which was received in June 2002. A semi-annual ISO 14001 audit conducted in November 2004, supporting maintenance of the registration, found no nonconformances with the ISO standard. The ISO 14001 Standard requires that the EMS be completely re-evaluated for registration every three years. Therefore, the next audit, scheduled for May 2005, will be a comprehensive re-registration audit.

3.6 Other Major Environmental Issues and Activities

Decontamination, Decommissioning, and Demolition Activities

INEEL greatly stepped up efforts to reduce the DOE Office of Environmental Management (EM) "footprint" through accelerated DD&D of EM-owned buildings and structures. This effort achieves cost and risk reduction by eliminating aging, unnecessary facilities and migrating toward consolidation of EM activities. In total, over 29,203 m^2 (314,338 ft^2) of buildings and structures were demolished in 2004. Specific projects at various facilities are described below.

Test Area North - The most dramatic transformation has occurred at TAN, where more than 26 EM-owned buildings and structures were demolished in 2004 accounting for the majority of demolition (18,839 m^2 or 202,784 ft^2) at the INEEL.

Power Burst Facility/Waste Reduction Operations Complex - Eleven Power Burst Facility buildings and structures were demolished ahead of schedule and the final end state condition was achieved for the Waste Experimental Reduction Facility, Waste Engineering Development Facility, Mixed Waste Storage Facility, and the Power Burst Facility control areas.

Test Reactor Area - Water from the Materials Test Reactor (MTR) canal was removed in support of MTR canal closure.

Idaho Nuclear Technology and Engineering Center - INTEC represented approximately 25 percent (7,482 m^2 or 80,543 ft^2) of the total DD&D in 2004. Accomplished in 2004 was the issuance of the CERCLA Non-time Critical Removal Action for demolition of the CPP-627 (old Remote Analytical Laboratory) was issued in 2004. This laboratory was part of the Spent Fuel Reprocessing mission terminated in 1992 and is one of the most contaminated facilities at INEEL. The demolition of CPP-627 is to be completed in 2005.

Spent Nuclear Fuel

Spent nuclear fuel (SNF) is defined as fuel that has been irradiated in a nuclear reactor, that has produced power, that has been removed from the reactor and that 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. At the INEEL, fuel is managed by Environmental Management at INTEC, by the Naval Propulsion Program at NRF, and by the Office of Nuclear Energy, Science, and Technology at the Test Reactor Area and the Argonne National Laboratory-West. Over 220 different types of SNF ranging in size from 2 lbs, to ½ ton are managed at the INEEL.

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 INEEL fuel be removed from the state of Idaho by 2035. The INEEL's goal is to begin shipping SNF to a monitored geologic repository by September 30, 2015.

In 2004, INEEL 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 INEEL SNF into standard canisters in dry storage, so that it can be ready for transport once a repository is completed. SNF storage facilities are described below. All EM-managed SNF was consolidated at INTEC in 2003.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666) - This INTEC facility, also called FAST, is divided into two parts: an SNF storage 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 the underwater storage pools and placed in dry storage in preparation for shipment to a repository. In 2004, the Advanced Test Reactor dispatched shipments of SNF to FAST for storage and TRIGA (Training Research Isotope General Atomics) SNF was transferred from the basins to dry storage in the Irradiated Fuel Storage Facility (IFSF).

Irradiated Fuel Storage Facility (CPP-603) - This INTEC facility 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. The wet side of the facility is no longer in use and will begin decontamination and decommissioning activities in 2005. The IFSF was approximately ½ full at the end of 2004 and will continue to receive SNF from the CPP-666 basin and foreign and domestic research reactors SNF in 2005.

TMI-2 Independent Spent Fuel Storage Installation (CPP-1774) - This INTEC facility, also called the ISFSI, is a Nuclear Regulatory Commission (NRC)-licensed dry storage area for SNF and debris from the Three Mile Island reactor accident. Fuel and debris were transferred to the TAN for examination, study, and storage following the accident. After 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 five paved 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 - 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.

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 INEEL 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; and
- Communicate findings to the citizens of Idaho in a manner that provides them the opportunity to evaluate these potential impacts.

The INEEL 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 www.deq.idaho.gov/inl_oversight/.

Citizens Advisory Board

The INEEL Citizens Advisory Board, one of the Environmental Management Site Specific Advisory Boards, was formed in March 1994. Its charter is to provide input and recommendations on DOE Environmental Management's strategic decisions that impact future use, risk management, economic development, and budget prioritization activities.

The Citizens Advisory Board has produced over 100 recommendations during its tenure. Currently, the Board is working on the following issues, in addition to numerous others:

- Risk-Based End State Vision for the INEEL;
- Modification to the Hazardous Waste Facility Permit for the Waste Isolation Pilot Plant;
- Environmental Management budget;
- Scoping for the Fast Flux Test Facility decommissioning environmental impact statement;

- Engineering evaluation and cost analysis for the CPP-603A basin; and
- Disposition for orphan waste at the INEEL.

More information about the Board's recommendations, membership, and meeting dates and topics can be found at http://www.inlemcab.org.

REFERENCES

63 FR 189, 1998, "Final Modification of the National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities," *Federal Register*, U.S. Environmental Protection Agency, September 30, p. 52430.

Bechtel Bettis, 2004, *2004 Environmental Monitoring Report for the Naval Reactor Facility*, NRFRC-EE-012.

DOE Order 450.1, 2003 "Environmental Protection Agency," U.S. Department of Energy, January.

Ryan, M., 2003, EPA Region 10, to A. E. Gross, DOE-ID, "Storm Water Compliance at the INEEL," CCN 46063, October 27, 2003.

Twining, B. V., Rattray, G., and Campbell, L. J., 2003, *Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagarman Area*, Idaho, 2001, U.S. Geological Survey Open-File Report 01-168, DOE/ID-22185, 32 p.

U.S. Department of Energy Idaho Operations Office (DOE-ID), 1991, *Idaho National Engineering Laboratory Historical Dose Evaluation*, Appendix E, Environmental Surveillance, DOE/ID-12119, Vol. 2, August.

U.S. Department of Energy Idaho Operations Office (DOE-ID), 1993a, *Idaho National Engineering Laboratory Groundwater Monitoring Plan*, DOE/ID-10441.

U.S. Department of Energy Idaho Operations Office (DOE-ID), 1993b, *Idaho National Engineering Laboratory Groundwater Protection Management Plan*, DOE/ID-10274, March.

USGS, 1998, http://water.usgs.gov/pubs/FS/FS-130-97/, April.

Chapter 4 - Environmental Monitoring Programs (Air)

M. Case - S. M. Stoller Corporation
M. Verdoorn - Bechtel/BWXT Idaho, LLC.
R. Wilhelmsen - Bechtel/BWXT Idaho, LLC

Chapter Highlights

The Idaho National Engineering and Environmental Laboratory (INEEL) environmental surveillance programs (conducted by the Management and Operating [M&O] contractor and the Environmental Surveillance, Education and Research Program [ESER] contractor) emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INEEL releases to receptors. The M&O contractor monitors airborne effluents at individual INEEL 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 INEEL.

An estimated total of 8,816 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2004. 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 INEEL and environmental concentrations measured offsite. All concentrations were well below regulatory standards and within historical measurements.

Nonradiological pollutants, including particulates, were monitored at select locations around the INEEL. 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 Engineering and Environmental Laboratory (INEEL) and offsite. Results from sampling conducted by the Management and Operating (M&O) contractor and the Environmental Surveillance, Education and Research (ESER) Program 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 INEEL 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 INEEL 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 INEEL environmental surveillance programs, conducted by the M&O 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 INEEL.

The M&O contractor monitors airborne effluents at individual INEEL facilities and ambient air outside the facilities to comply with applicable statutory requirements and DOE orders. The M&O contractor collected approximately 2,300 air samples (primarily on the INEEL) for analyses in 2004.

The ESER contractor collects samples from an approximately 23,309 km^2 (9000 mi^2) area of southeastern Idaho and Jackson, Wyoming, at locations on, around, and distant to the INEEL. The ESER Program collected approximately 2,200 air samples, primarily off the INEEL, for analyses in 2004. Section 4.2 summarizes results of air monitoring by the M&O and ESER contractors. Section 4.3 discusses air sampling performed by the M&O contractor in support of waste management activities.

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

Unless specified otherwise, the radiological results discussed in the following sections are those greater than three times the associated analytical uncertainty (see Appendix B for information on statistical methods). Each individual result is reported in tables as the measurement plus or minus one sigma (± 1s) analytical 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 (http://yosemite.epa.gov/r10/AIRPAGE.NSF/SIPs and http://www2.state.id.us/adm/adminrules/rules/idapa58/0101.pdf). Monitoring or estimating effluent data is the responsibility of programs associated with the operation of each INEEL facility and not the environmental surveillance programs.

Environmental surveillance of air pathways is the responsibility of the M&O contractor and the ESER contractor. Figure 4-1 shows the surveillance air monitoring locations for the INEEL environmental surveillance programs.

The INEEL environmental surveillance program contractors collect filters from a network of low-volume air monitors weekly. Air flows (at an average of about 57 L/min [2 cfm]) through a

Table 4-1. Air monitoring activities by organization.

Area/Facility[a]	Airborne Effluent Monitoring Programs	Air Monitoring 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
Argonne National Laboratory-West										
ANL-W	•				•					
Management and Operating Contractor										
INTEC	•									
TAN	•									
PBF/CITR	•									
INEEL Sitewide		•	•	•	•	•		•	•	
Naval Reactors Facility										
NRF[e]	•									
Environmental Surveillance, Education and Research Program										
INEEL/Regional		•	•	•	•	•	•	•	•	•[f]
National Oceanic and Atmospheric Administration										
INEEL/Regional						•	•	•	•	
INEEL Oversight Program (state of Idaho)										
INEEL/Regional		•	•	•	•	•	•		•	

a. ANL-W = Argonne National Laboratory-West, INTEC = Idaho Nuclear Technology and Engineering Center, TAN = Test Area North, PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range, and NRF = Naval Reactors Facility.

b. Facilities with stacks that required continuous monitoring during 2003 for compliance with Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H, National Emissions Standards for Hazardous Air Pollutants (NESHAP) Regulation. The exception is NRF. See footnote e.

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

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

e. NRF is not required to continuously monitor any stack for NESHAP compliance. However, NRF has a number of stacks and vents with emissions that are monitored and calculated by NRF for confirmation that emissions continue to be below regulatory limits. The NRF source terms are included in the INEEL's calculation of the annual dose to the public for NESHAP compliance (Chapter 7).

f. The IMPROVE samplers are operated by the National Park Service for the Environmental Protection Agency.

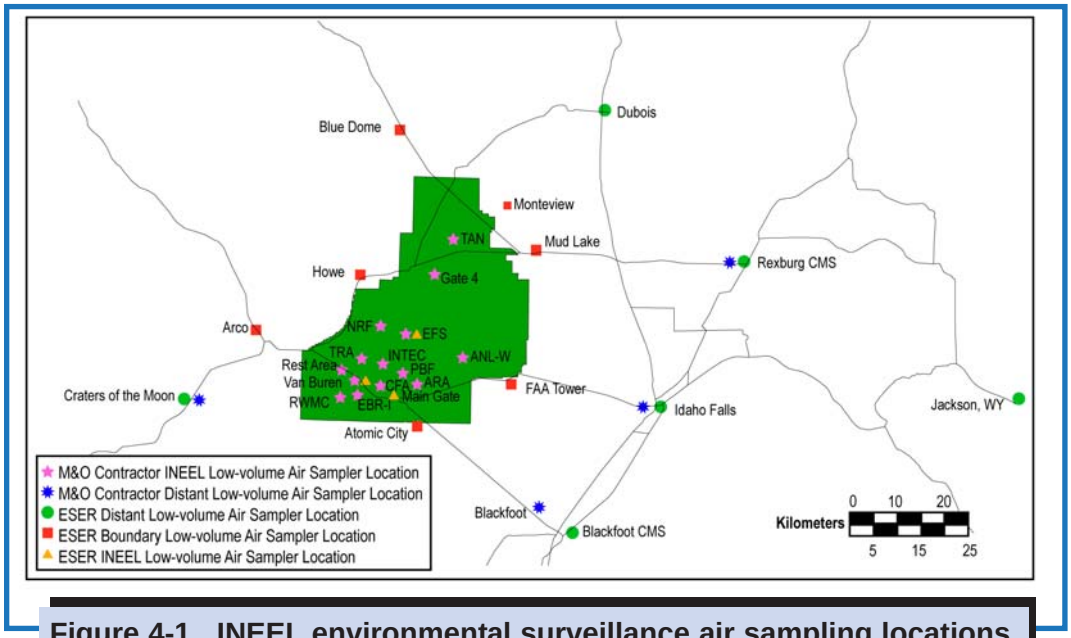


Figure 4-1. INEEL environmental surveillance air sampling locations.

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 INEEL, but the M&O and the ESER contractors monitor this to provide comparison information for other monitoring programs and to the DOE-Idaho Operations Office (DOE-ID). 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}), the respirable particle size, for comparison to EPA air quality standards.

Nitrogen dioxide was measured in past years to meet permit requirements for the New Waste Calcining Facility (NWCF). A permit modification was granted to the INEEL requiring that monitoring be conducted only during operation of the NWCF, which is currently shut down and did not operate in 2004. Therefore, the M&O contractor no longer monitors nitrogen dioxide.

Tritium in water vapor in the atmosphere is monitored by the M&O 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 2004, an estimated 8,816 Ci of radioactivity was released to the atmosphere from all INEEL sources. *The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Calendar Year 2004 INL Report for Radionuclides* (DOE-ID/2005) 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 INEEL dose (i.e., >1E-05 mrem) are listed in the NESHAP report. Table 4-2 only includes the screened NESHAP radionuclides with releases greater than 1 pCi/yr.

The largest facility contributions to the total emissions came from the Idaho Nuclear Technology and Engineering Center (INTEC) at more than 58 percent, Test Reactor Area (TRA) at approximately 15 percent, and Argonne National Laboratory-West (ANL-W) at approximately 27 percent (Table 4-2). Approximately 86 percent of the radioactive effluent was in the form of noble gases (argon, krypton, and xenon). Most of the remaining effluent (14 percent) was tritium.

Low-Volume Charcoal Cartridges

Both the ESER and M&O 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 2004, the ESER contractor analyzed 936 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 M&O contractor.

Low-Volume Gross Alpha

Particulates filtered from the air were sampled from 29 locations weekly as part of the INEEL environmental surveillance programs (see Figure 4-1). All were analyzed for gross alpha activity and gross beta activity. Gross alpha concentrations found in ESER contractor samples, both on and offsite, tended to be higher than those found in M&O 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 and offsite locations.

Weekly gross alpha concentrations in ESER contractor samples that exceeded their 3 sigma uncertainty ranged from a minimum of $(0.77 \pm 0.25) \times 10^{-15}$ µCi/mL at the Mud Lake Q/A-2 station during the week ending February 4, 2004, to a maximum of $(6.16 \pm 0.71) \times 10^{-15}$ µCi/mL during the week ending January 21, 2004, at Idaho Falls. Concentrations measured by the M&O contractor that exceeded their 3 sigma uncertainty ranged from a low of $(0.57 \pm 0.12) \times 10^{-15}$ µCi/mL collected at the Auxiliary Reactor Area (ARA) on January 14, 2004, to a high of $(12.9 \pm 0.14) \times 10^{-15}$ µCi/mL collected at the U.S. 20 Rest Area on January 21, 2004.

Table 4-2. Radionuclide composition of INEEL airborne effluents (2004).[a]

Nuclide[a]	Half-life	Airborne Effluent (Ci)[a,b]								
		ANL-W	CFA[c]	INTEC[d]	NRF[e]	PBF	RWMC[f]	TAN	TRA	TOTAL
Ag-110	24.6 s	--[g]	--	1.59E-19	--	--	--	2.93E-04	--	2.93E-04
Ag-110M	249.9 d	--	--	1.96E-07	--	3.60E-07	--	2.21E-20	6.78E-06	7.33E-06
Am-241	432.2 y	--	5.26E-10	6.41E-04	--	8.54E-08	2.73E-05	7.68E-06	3.44E-04	1.02E-03
Am-243	7380 y	--	4.00E-13	3.53E-10	--	--	1.05E-06	1.90E-15	2.60E-06	3.65E-06
Ar-41	1.827 h	1.47E+00	--	--	--	--	--	--	6.59E+02	6.60E+02
Ba-133	10.5 y	--	--	1.86E-14	--	--	--	--	2.42E-07	2.42E-07
Ba-140	12.74 d	--	--	--	--	--	--	1.51E-116	3.27E-06	3.27E-06
C-14	5730 y	--	--	1.96E-03	**5.49E-01**	--	8.81E-01	4.84E-12	3.72E-06	1.43E+00
Ce-144	284.3 d	--	--	1.92E-04	--	--	2.68E-13	1.46E-06	5.87E-06	1.99E-04
Cf-252	2.638 y	--	--	7.12E-29	--	--	--	1.28E-31	1.78E-04	1.78E-04
Cl-36	3.01E5 y	--	--	1.75E-10	--	--	1.32E-05	--	--	1.32E-05
Cm-242	162.8 d	--	--	2.20E-10	--	--	--	1.51E-06	8.36E-09	1.52E-06
Cm-243	28.5 y	--	--	4.75E-10	--	--	1.82E-07	1.31E-07	3.01E-12	3.13E-07
Cm-244	18.11 y	--	--	9.24E-09	--	--	2.69E-04	2.98E-07	2.90E-04	5.59E-04
Co-57	270.9 d	--	1.43E-09	1.78E-11	--	--	--	--	3.26E-07	3.28E-07
Co-58	70.8 d	--	--	3.01E-09	--	--	--	--	2.86E-05	2.86E-05
Co-60	5.271 y	--	2.59E-08	2.21E-04	**3.84E-07**	7.15E-08	5.90E-03	8.89E-05	9.43E-03	1.56E-02
Cr-51	27.704 d	--	--	1.48E-11	--	--	--	--	1.19E-01	1.19E-01
Cs-134	2.062 y	--	4.19E-09	2.96E-04	--	--	1.10E-12	2.44E-07	1.66E-05	3.13E-04
Cs-137	30.0 y	--	3.54E-08	1.44E-02	**1.51E-04**	3.36E-02	8.99E-04	3.34E-02	4.72E-02	1.30E-01
Cs-138	32.2 m	--	--		--	--	--	--	1.62E-02	1.62E-02
Eu-152	13.33 y	--	--	9.20E-05	--	--	--	4.50E-06	2.05E-04	3.01E-04
Eu-154	8.8 y	--	--	3.32E-04	--	1.90E-08	1.62E-04	3.84E-06	2.74E-03	3.24E-03
Eu-155	4.96 y	--	--	2.79E-05	--	2.21E-09	--	9.56E-07	2.54E-04	2.83E-04
Fe-55	2.7 y	--	1.59E-06	4.50E-08	--	1.14E-06	1.12E-14	8.61E-06	1.78E-02	1.79E-02
Fe-59	44.529 d	--	--	1.57E-10	--	--	--	--	4.91E-06	4.91E-06
H-3	12.35 y	1.42E+01	2.90E+00	6.26E+02	8.30E-02	1.80E-02	7.55E+01	2.88E+00	4.87E+02	1.21E+03
Hf-181	42.39 d	--	--	1.04E-11	--	--	--	--	1.31E-04	1.31E-04
Hg-203	46.6 d	--	--	1.52E-09	--	--	--	--	4.82E-06	4.82E-06
I-129	1.57E7 y	--	4.27E-05	1.07E-01	--	--	1.49E-09	5.27E-14	1.33E-04	1.07E-01
I-131	8.04 d	--	--	9.82E-10	**6.21E-06**	--	--	--	1.27E-03	1.28E-03
I-132	2.30 h	--	--	--	--	--	--	--	2.87E-04	2.87E-04

Table 4-2. Radionuclide composition of INEEL airborne effluents (2004).[a] (continued)

Nuclide[a]	Half-life	Airborne Effluent (Ci)[a,b]								
		ANL-W	CFA[c]	INTEC[d]	NRF[e]	PBF	RWMC[f]	TAN	TRA	TOTAL
I-133	20.8 h	--	--	--	--	--	--	--	7.99E-04	7.99E-04
I-134	52.6 m	--	--	--	--	--	--	--	2.49E-04	2.49E-04
I-135	6.61 h	--	--	--	--	--	--	--	2.56E-04	2.56E-04
In-113M	1.658 h	--	--	2.02E-12	--	--	--	--	2.78E-06	2.78E-06
Ir-192	74.02 d	--	--	2.14E-13	--	--	--	--	5.56E-07	5.56E-07
K-40	1.277E8 y	--	--	3.88E-07	--	--	4.14E-15	2.37E-04	2.92E-10	2.37E-04
Kr-85	10.72 y	2.26E+03	--	4.51E+03	--	--	6.78E-14	6.59E-09	6.28E-09	6.77E+03
Kr-85M	4.48 h	--	--	--	--	--	--	--	1.19E+01	1.19E+01
Kr-87	76.3 m	--	--	--	--	--	--	--	5.13E+00	5.13E+00
Kr-88	2.84 m	--	--	--	--	--	--	--	1.43E+01	1.43E+01
Mn-54	312.5 d	--	1.78E-09	8.65E-10	--	--	--	1.75E-07	1.44E-04	1.45E-04
Mo-99	66.0 h	--	--	2.97E-14	--	--	--	--	9.18E-07	9.18E-07
Na-24	15.0 h	--	--	--	--	--	--	--	2.32E-04	2.32E-04
Nb-93M	13.6 y	--	--	8.41E-09	--	--	--	7.68E-14	4.26E-06	4.27E-06
Nb-94	2.03E4 y	--	--	3.32E-09	--	--	3.14E-06	6.46E-06	1.19E-06	1.08E-05
Nb-95	35.15 d	--	--	2.58E-09	--	--	--	6.35E-07	6.62E-06	7.26E-06
Ni-59	7.5E4 y	--	--	2.06E-09	--	--	2.16E-05	4.84E-11	2.94E-05	5.10E-05
Ni-63	96 y	--	5.53E-07	2.85E-05	--	3.68E-07	3.81E-03	4.11E-04	2.22E-03	6.47E-03
Np-237	2.14E6 y	--	1.50E-13	1.02E-04	--	1.01E-09	--	2.48E-13	2.04E-05	1.22E-04
Np-239	2.355 d	--	--	5.02E-12	--	--	--	1.90E-15	5.88E-05	5.88E-05
Pm-147	2.6234 y	--	--	4.16E-03	--	--	2.70E-13	1.44E-04	9.68E-04	5.27E-03
Pu-238	87.74 y	--	6.67E-11	1.43E-03	--	8.66E-09	1.67E-05	3.08E-06	1.06E-05	1.46E-03
Pu-239	24065 y	4.51E-07	3.36E-06	2.98E-04	3.88E-06	5.09E-06	2.24E-06	7.63E-06	1.17E-04	4.38E-04
Pu-240	6537 y	--	--	7.40E-05	--	2.18E-08	4.70E-06	1.03E-06	8.56E-05	1.65E-04
Pu-241	14.4 y	--	--	1.22E-03	--	--	1.59E-09	3.64E-10	2.54E-04	1.47E-03
Ra-226	1600 y	--	7.01E-10	7.06E-07	--	7.01E-09	--	1.45E-05	1.90E-03	1.91E-03
Rb-89	15.2 m	--	--		--	--	--	--	8.00E-03	8.00E-03
Ru-103	39.28 d	--	--	3.05E-10	--	--	--	1.61E-69	6.08E-07	6.08E-07
Ru-106	368.2 d	--	--	4.95E-04	--	--	--	3.20E-06	1.03E-06	4.99E-04
Sb-124	60.2 d	--	--	7.61E-12	--	--	--	1.18E-51	5.82E-06	5.82E-06
Sb-125	2.77 y	--	--	1.05E-03	--	--	1.63E-14	5.26E-11	1.44E-05	1.06E-03
Sc-46	83.83 d	--	--	3.18E-13	--	--	--	--	7.44E-06	7.44E-06
Sm-151	90 y	--	--	2.66E-05	--	--	--	1.92E-09	8.66E-10	2.66E-05
Sn-113	115.09 d	--	4.43E-10	2.09E-12	--	--	--	--	3.60E-06	3.60E-06

Table 4-2. Radionuclide composition of INEEL airborne effluents (2004).[a] (continued)

Nuclide[a]	Half-life	Airborne Effluent (Ci)[a,b]								
		ANL-W	CFA[c]	INTEC[d]	NRF[e]	PBF	RWMC[f]	TAN	TRA	TOTAL
Sn-123	129.2 d	--	--	2.70E-25	--	--	--	4.79E-28	1.51E-06	1.51E-06
Sr-89	50.5 d	--	--	7.68E-15	--	--	1.63E-14	3.40E-06	6.07E-05	6.41E-05
Sr-90	29.12 y	6.47E-06	2.82E-05	3.92E-03	1.08E-04	2.06E-05	2.58E-04	2.46E-03	4.84E-03	1.16E-02
Tc-99	2.13E5 y	--	3.82E-07	1.63E-07	--	--	4.49E-06	3.27E-11	2.74E-07	5.30E-06
Tc-99M	6.02 h	--	--	--	--	--	--	--	3.25E-04	3.25E-04
Th-230	7.7E4 y	--	--	9.76E-08	--	4.24E-09	--	7.09E-15	6.80E-10	1.02E-07
Th-232	1.405E10 y	--	1.81E-13	8.08E-08	--	3.20E-09	2.92E-12	1.31E-21	7.26E-06	7.34E-06
U-232	72 y	--	2.50E-13	6.01E-08	--	--	8.81E-09	3.04E-15	8.78E-07	9.47E-07
U-233	1.585E5 y	--	--	5.05E-07	--	2.85E-08	1.01E-11	9.58E-06	1.36E-04	1.46E-04
U-234	2.457E5 y	--	1.30E-10	1.39E-04	--	3.14E-08	3.44E-09	7.09E-06	4.20E-06	1.51E-04
U-235	7.038E8 y	--	1.51E-14	9.87E-06	--	1.86E-09	3.42E-13	1.73E-05	4.08E-07	2.76E-05
U-238	4.468E9 y	--	5.06E-08	1.16E-04	--	1.25E-08	--	1.00E-03	1.82E-05	1.14E-03
W-187	23.9 h	--	--	--	--	--	--	--	2.20E-06	2.20E-06
Xe-133	5.245 d	--	--	--	--	--	--	--	8.60E+01	8.60E+01
Xe-135	9.09 h	--	--	--	--	--	--	--	5.92E+01	5.92E+01
Xe-135M	15.29 m	--	--	--	--	--	--	--	4.33E-01	4.33E-01
Xe-138	14.17 m	--	--	--	--	--	--	--	1.40E+00	1.40E+00
Y-91M	49.71 m	--	--	--	--	--	--	--	5.18E-05	5.18E-05
ZN-65	243.9 d	--	3.29E-09	9.02E-09	--	--	--	1.08E-06	2.27E-03	2.27E-03
ZR-95	63.98 d	--	--	3.19E-06	--	--	--	8.67E-08	5.48E-06	8.76E-06
Totals		2.28E+03	2.90E+00	5.13E+03	6.32E-01	5.16E-02	7.63E+01	2.92E+00	1.32E+03	8.82E+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
d. Most of the INTEC emissions are from the Three Mile Island Dry Fuel Storage Facility and are based on conservative calculations.
e. Values for ^{90}Sr and ^{239}Pu listed under NRF are actually gross beta and gross alpha results, respectively, but are listed as these radionuclides for ease of comparison. **NRF does not measure for ^{90}Sr or ^{239}Pu.**
f. RWMC = Radioactive Waste Management Complex.
g. A double dash signifies the radionuclide was not released to air from that facility during the calendar year.

Figure 4-2 displays the median weekly gross alpha concentrations for the ESER and M&O contractors at INEEL, boundary, and distant station groups. 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 M&O contractor for the distant group in the fourth quarter of 2004. The maximum median weekly gross alpha concentration was 4.7 x 10^{-15} µCi/mL and is below the DCG for the most restrictive alpha-emitting radionuclide in air [americium-241 (^{241}Am)] of 20 x 10^{-15} µCi/mL.

Annual median gross alpha concentrations calculated by the ESER contractor ranged from 1.09 x 10^{-15} µCi/mL at Blue Dome to 1.78 x 10^{-15} µCi/mL at Mud Lake (Table 4-3). Confidence intervals are not calculated for annual medians. Annual median gross alpha concentrations calculated by the M&O contractor ranged from 1.19 x 10^{-15} µCi/mL at Craters of the Moon to 1.92 x 10^{-15} µCi/mL at Rexburg.

In general, gross alpha concentrations were typical of those measured previously and well within the range of measurements observed historically from 1995 through 2004 (Figure 4-3).

Low-Volume Gross Beta

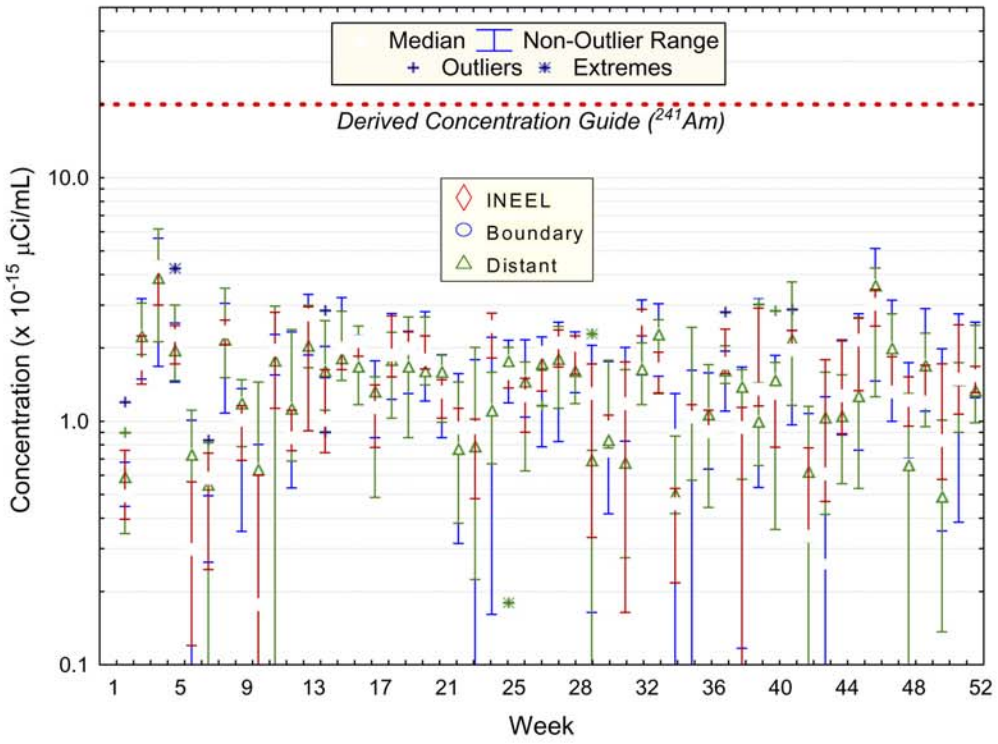
Gross beta concentrations in ESER contractor samples were fairly consistent with those found in M&O contractor samples.

Weekly gross beta concentrations in ESER contractor samples that exceeded their 3 sigma uncertainty ranged from a low of (0.29 ± 0.05) x 10^{-14} µCi/mL on March 10, 2004, at Idaho Falls to a high of (16.5 ± 0.29) x 10^{-14} µCi/mL at Mud Lake on January 21, 2004. Concentrations measured above 3 sigma by the M&O contractor ranged from a low of (0.22 ± 0.05) x 10^{-14} µCi/mL at ANL-W in March 10, 2004, to a high of (50.40 ± 3.34) x 10^{-14} µCi/mL at the EFS in January 2004.

Figure 4-4 displays the median weekly gross beta concentrations for the ESER and M&O contractors at INEEL, boundary, and distant station groups. 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 first quarter of 2004. Each median value was calculated using all measurements, including those less than the associated 3 sigma uncertainties. The maximum weekly median gross beta concentration was 10.0 x 10^{-14} µCi/mL and is significantly below the DCG of 300 x 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 2.27 x 10^{-14} µCi/mL at Dubois to 2.57 x 10^{-14} µCi/mL at the EFS. M&O contractor data indicated an annual median range of 2.00 x 10^{-14} µCi/mL at Craters of the Moon to 2.42 x 10^{-14} µCi/mL at Rexburg. In general, the levels of airborne radioactivity for the three groups (INEEL, 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 INEEL.

Weekly gross alpha concentrations (ESER contractor)



Weekly gross alpha concentrations (M&O contractor)

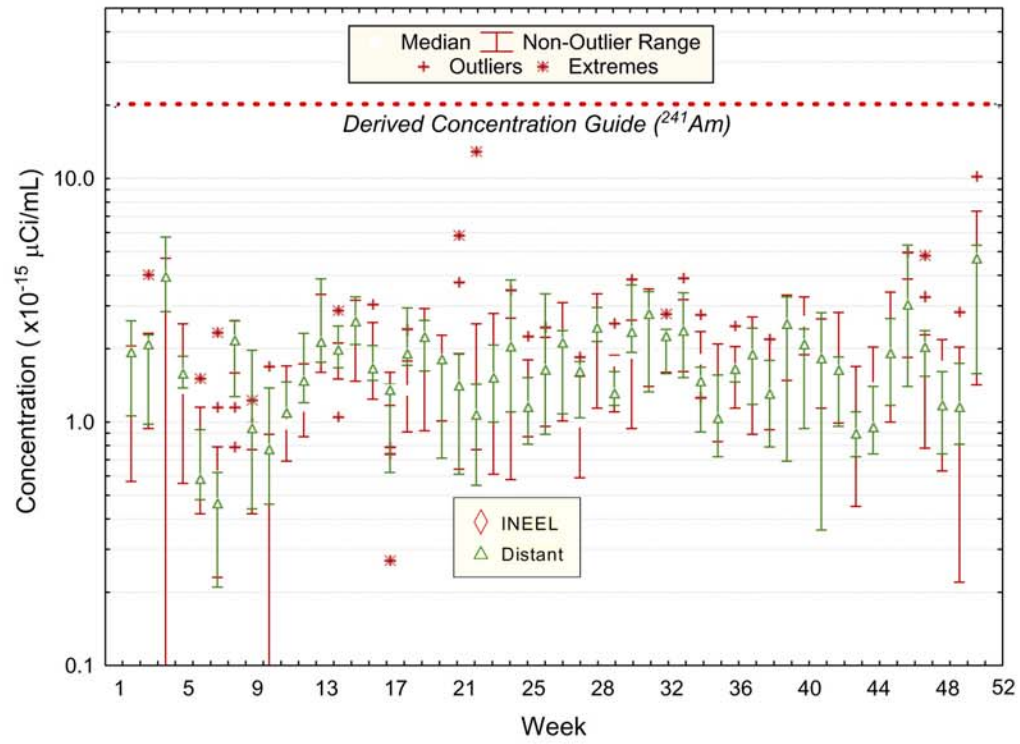


Figure 4-2. Median weekly gross alpha concentrations in air (2004).

Table 4-3. Median annual gross alpha concentrations in air (2004).[a]

ESER Contractor Data			Concentration[b]	
Group	Location	No. of Samples	Range of Samples	Annual Median
Distant	Blackfoot CMS[c]	104[d]	-0.41 – 4.95	1.30
	Craters of the Moon	50	-0.29 – 2.97	1.27
	Dubois	48	0.26 – 3.00	1.51
	Idaho Falls	51	-0.49 – 6.16	1.50
	Jackson	52	0.14 –3.02	1.30
	Rexburg CMS	52	0.43 – 4.13	1.59
			Distant Median:	**1.40**
Boundary	Arco	52	0.10 – 3.18	1.43
	Atomic City	51	0.08 – 3.51	1.25
	Blue Dome	52	-0.10 – 2.66	1.09
	Federal Aviation Administration Tower	51	-0.13 – 4.40	1.20
	Howe	52	0.18 – 5.61	1.51
	Monteview	52	0.04 – 4.67	1.57
	Mud Lake	101[c]	-0.04 – 5.64	1.78
			Boundary Median:	**1.52**
INEEL	EFS	52	-0.13 – 4.32	1.31
	Main Gate	52	0.04 – 4.56	1.34
	Van Buren	52	0.12 – 3.02	1.53
			INEEL Median:	**1.37**
M&O Contractor Data			**Concentration[a]**	
Group	Location	No. of Samples	Range of Samples	Annual Median
Distant	Blackfoot	50	0.36 – 5.74	1.62
	Craters of the Moon	50	0.44 – 2.84	1.19
	Idaho Falls	50	0.21 – 5.09	1.76
	Rexburg	48	0.62 – 5.33	1.92
			Distant Median	**1.65**
INEEL	ANL-W	49	0.69 – 4.11	1.64
	ARA	46	0.48 – 3.19	1.50
	CFA	50	0.54 – 4.03	1.64
	EBR-I[e]	47	-0.06 – 5.84	1.42
	EFS	49	0.31 – 10.20	1.75
	INTEC	50	0.22 – 3.26	1.67
	NRF	50	0.23 – 4.87	1.67
	PBF	50	0.27 – 5.00	1.42
	Rest Area	49	0.06 – 12.90	1.70
	RWMC	50	0.42– 3.41	1.62
	TAN	50	0.41 – 7.34	1.73
	TRA	50	0.36 – 3.94	1.68
	Van Buren	50	0.50 – 3.73	1.61
			INEEL Median	**1.65**

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 Station
d. Includes duplicate measurements at this station.
e. EBR-1 = Experimental Breeder Reactor-I

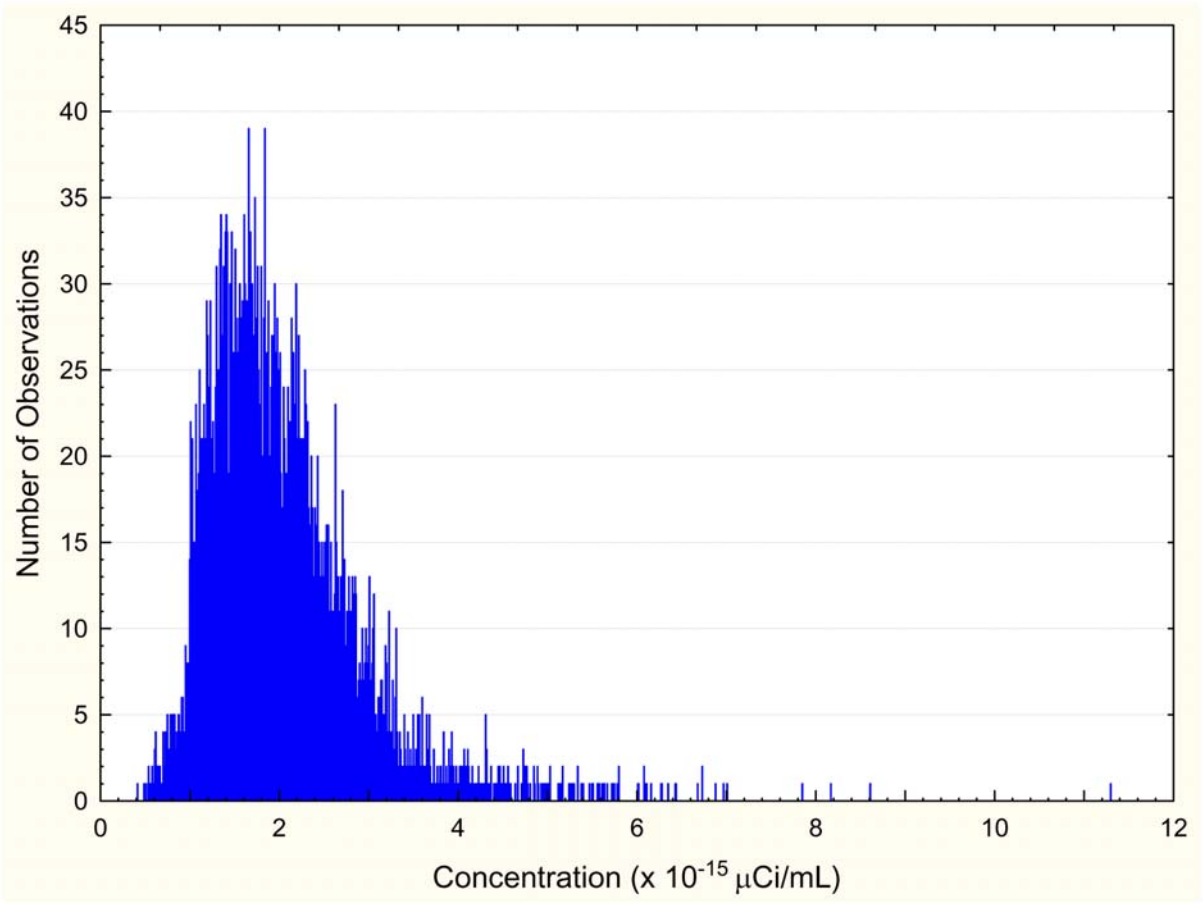


Figure 4-3. Frequency distribution of gross alpha activity detected above the 3 sigma level in air filters collected by the ESER contractor from 1995 through 2004 (valid samples greater than 7000 ft^3, recounts not included).

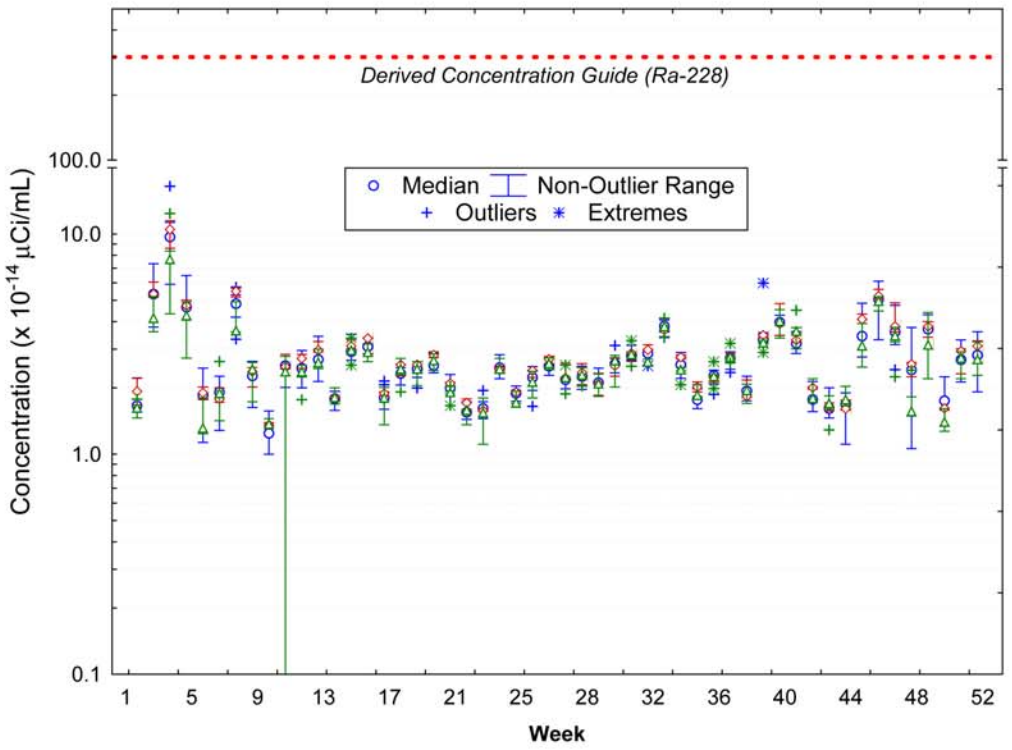
In addition, all results greater than 3 sigma reported by the ESER contractor are well within measurements taken within the last ten years (Figure 4-5). The maximum concentration detected in 2004 is within this range of results.

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 INEEL release.

Statistical comparisons were made using the gross beta radioactivity data collected from the onsite, boundary, and distant locations (see Appendix B for a description of statistical methods). Figure 4-6 is a graphical comparison of all gross beta concentrations measured during 2004 by the ESER contractor. The results are grouped by location (that is, INEEL, boundary and distant stations). Visually, there appeared to be no difference between locations. The figure also shows

Weekly gross beta concentrations (ESER contractor)



Weekly gross beta concentrations (M&O contractor)

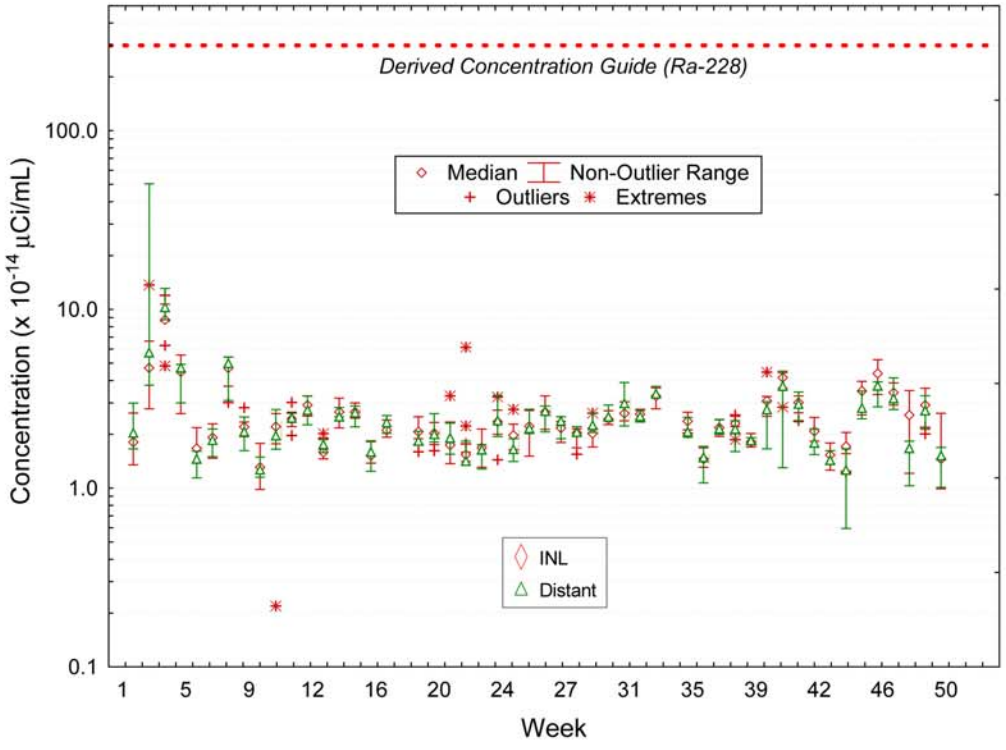


Figure 4-4. Median weekly gross beta concentrations in air (2004).

Table 4-4. Gross beta activity in air (2004).[a]

ESER Contractor Data			Concentration[b]	
Group	Location	No. of Samples	Range of Samples	Annual Median
Distant	Blackfoot CMS	104[c]	-0.06 – 11.20	2.38
	Craters of the Moon	50	1.24 – 6.08	2.38
	Dubois	48	1.29 – 4.54	2.27
	Idaho Falls	51	0.29 – 12.40	2.47
	Jackson	52	-0.02 – 7.72	2.31
	Rexburg CMS	52	1.27 – 8.37	2.52
			Distant Median:	**2.40**
Boundary	Arco	52	0.01 – 7.81	2.44
	Atomic City	51	1.23 – 10.10	2.45
	Blue Dome	52	1.00 – 5.91	2.29
	Federal Aviation Administration Tower	52	-0.01 – 8.75	2.28
	Howe	52	1.33 – 8.63	2.52
	Monteview	52	1.22 – 9.32	2.34
	Mud Lake	101[c]	1.28 – 16.50	2.52
			Boundary Median:	**2.43**
INEEL	EFS	52	1.34 – 11.50	2.57
	Main Gate	52	1.36 – 10.50	2.56
	Van Buren	52	1.39 – 8.62	2.53
			INEEL Median:	**2.56**
M&O Contractor Data			**Concentration[b]**	
Group	Location	No. of Samples	Range of Samples	Annual Median
Distant	Blackfoot	50	1.32 – 13.10	2.07
	Craters of the Moon	50	1.01 – 9.48	2.00
	Idaho Falls	50	1.20 – 11.20	2.27
	Rexburg	48	0.60 – 8.76	2.42
			Distant Median	**2.19**
INEEL	ANL-W	49	0.22 – 6.28	2.12
	ARA	46	0.99 – 8.77	2.12
	CFA	50	0.98 – 13.70	2.23
	EBR-I	47	1.21– 8.66	2.35
	EFS	49	1.29 – 12.00	2.35
	INTEC	50	1.30 – 8.74	2.26
	NRF	50	1.21 – 10.10	2.39
	PBF	50	1.04 – 9.60	2.17
	Rest Area	49	0.02 – 6.14	2.27
	RWMC	50	1.07 – 4.83	2.28
	TAN	50	1.31 – 10.70	2.09
	TRA	50	1.33 – 9.60	2.38
	Van Buren	50	1.25 – 8.60	2.34
			INEEL Median	**2.29**

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.

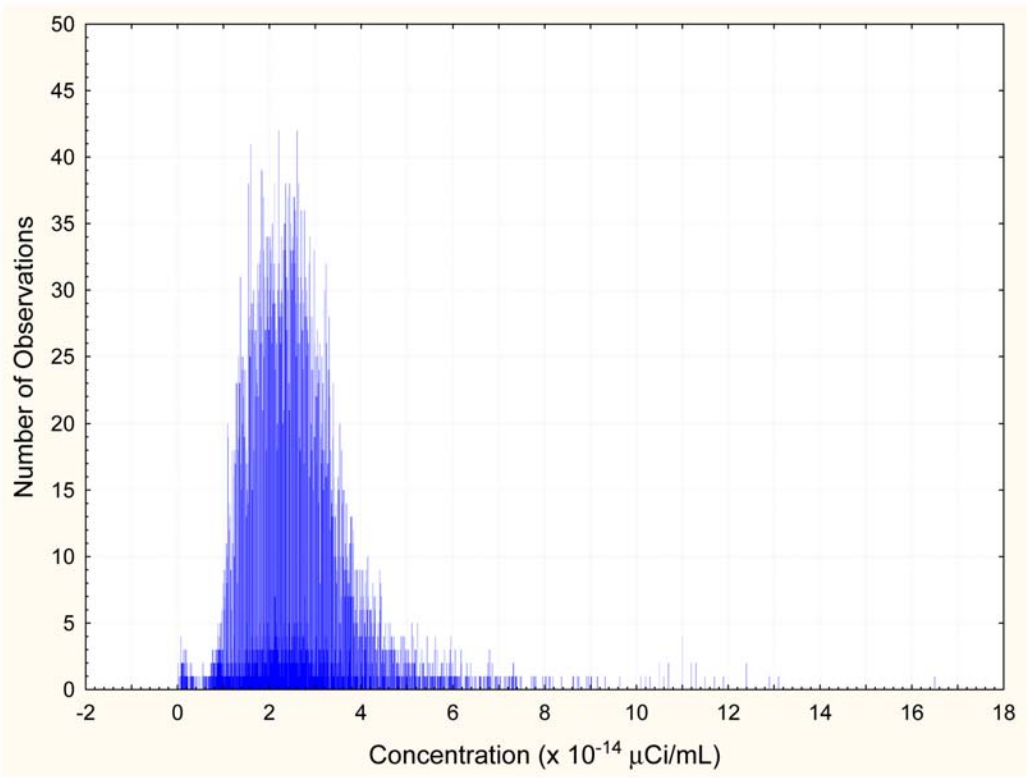


Figure 4-5. Frequency distribution of gross beta activity detected above the 3s level in air filters collected by the ESER contractor from 1995 through 2004 (valid samples > 7,000 ft^3, recounts not included).

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 INEEL 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 INEEL, boundary, and distant locations in 2004.

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2004. Concentrations collected during one week each 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 the August and September can be attributed to natural variation in the data. None of the weekly concentrations were greater at the distant locations when compared to the boundary locations.

The M&O contractor data were grouped into INEEL and distant data sets. There were no statistical differences between data obtained from INEEL and distant locations.

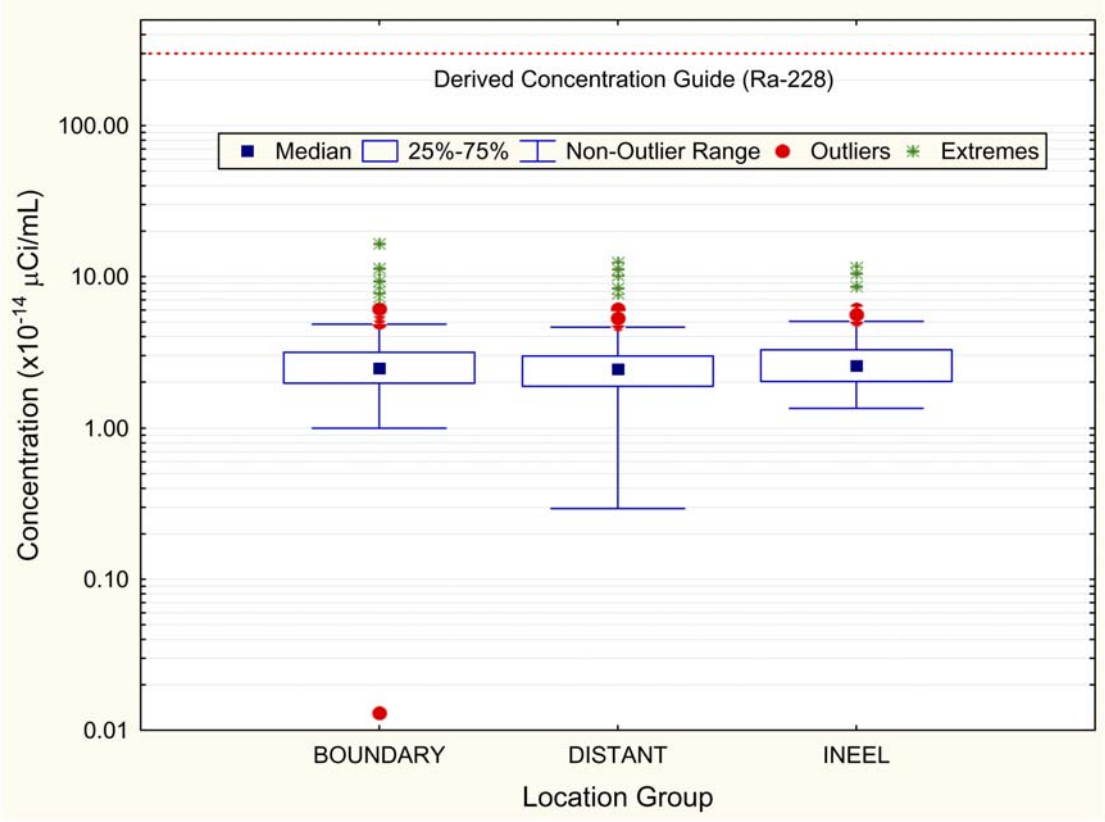


Figure 4-6. Comparison of gross beta concentrations measured in air at distant, boundary, and INEEL locations by the ESER contractor (2004).

Specific Radionuclides in Air

Human-made radionuclides were observed above 3 sigma values in some ESER contractor and M&O 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 four 2004 quarterly composite samples. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past eight years is shown in Figure 4-7. All results detected above the 3 sigma level during 2004 were within the range measured historically and are well below the ^{241}Am DCG of 20,000 x 10^{-18} µCi/mL.

Plutonium-238 (^{238}Pu) was not detected in any ESER sample in 2004. Plutonium-239/240 ($^{239/240}$Pu) was detected in two composite samples, one at Rexburg during the first quarter and one at Howe during the third quarter. Plutonium is a residual product of nuclear fission. All valid $^{239/240}$Pu levels were significantly below the $^{239/240}$Pu DCG of 20,000 x 10^{-18} µCi/mL. The concentrations measured in ESER samples are consistent with worldwide levels related to atmospheric nuclear weapons testing and are well within past measurements (Figure 4-8).

Table 4-5. Human-made radionuclides in ESER contractor quarterly composited air samples (2004).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}$Pu	^{90}Sr
First Quarter 2004					
Rexburg	ND[b]	ND	ND	ND	ND
Second Quarter 2004					
FAA Tower	ND	5.6 ± 1.7		ND	ND
Rexburg CMS	ND	4.9 ± 1.3	ND	21.2 ± 3.8	ND
Third Quarter 2004					
Blackfoot	ND	5.4 ± 1.4	ND	ND	ND
Monteview	ND	ND	ND	ND	33.5 ± 11.0
Mud Lake (Q/A-2)	ND	4.1 ± 1.3	ND	ND	ND
Fourth Quarter 2004					
Blackfoot	ND	ND	ND	ND	39.6 ± 12.0
Howe	ND	ND	ND	5.0 ± 1.3	ND

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 M&O contractor quarterly composited air samples (2004).

Location	^{137}Cs	^{241}Am	^{234}U/^{238}U	^{90}Sr
First Quarter 2004				
Van Buren (Q/A)	ND[b]	ND	NS[c]	114.0 ± 37.0
Second Quarter 2004				
EBR-1	ND	ND	NS	186.0 ± 56.0
Rest Area	ND	ND	NS	121.0 ± 40.0
TRA	2370.0 ± 328.0	ND	NS	103.0 ± 32.0
Third Quarter 2004				
ARA	ND	ND	NS	220.0 ± 60.0
TRA	ND	ND	NS	250.0 ± 70.0

a. Concentrations shown are: Result x 10^{-18} µCi/mL air ± 1s analytical uncertainty.
b. ND = Not detected. Result < 3s.
c. NS = Natural sources. Numerous detections of 234U, 234U, and 238U were obtained during this reporting period at levels and ratios that indicate they were from natural sources. Measurements ranged from 1.08 x 10^{-17} µCi/mL to 7.77 x 10^{-17} µCi/mL.

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

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

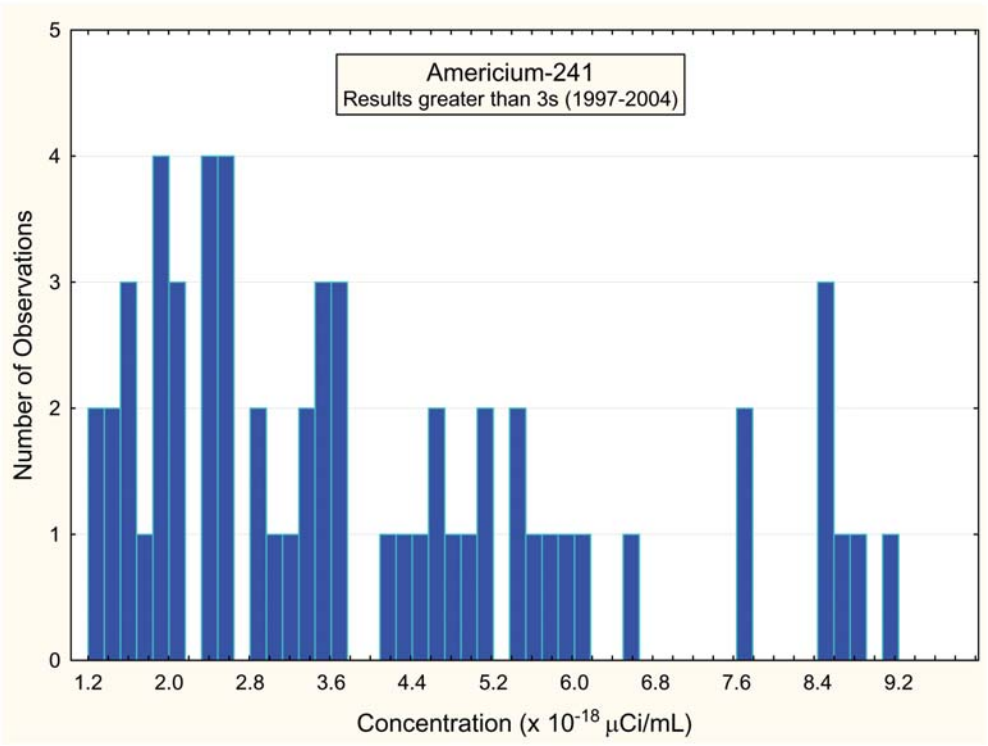


Figure 4-7. Frequency distribution of ^{241}Am concentrations detected above the 3s level in air filters collected by the ESER contractor from 1997 to 2004.

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

The M&O contractor reported no detections of ^{241}Am or ^{239,240}Pu.

Stontium-90 was detected in seven quarterly composites collected by the M&O contractor during 2004. The maximum result (250.0 ± 70.0) x 10-18 µCi/mL , is well below the DCG for 90Sr and within historical measurements.

Cesium-137 was detected in one M&O contractor sample. The measurement is within those made by the EPA at Idaho Falls from 1984 through 2004, as reported on the Environmental Radiation Ambient Monitoring System website (http://www.epa.gov/enviro/html/erams/).

Atmospheric Moisture

During 2004, the ESER contractor collected 62 atmospheric moisture samples from four locations (Atomic City, Blackfoot, Idaho Falls, and Rexburg) using silica gel and molecular sieve. Table 4-7 presents the range of values for each station by quarter.

Tritium was detected in 14 of the samples. Samples that exceeded the respective 3 sigma values ranged from a low at Atomic City (4.4 ± 1.3) × 10^{-14} µCi/mL collected on November 1, 2004, to a high (77.5 ± 18.0) × 10^{-14} µCi/mL at Rexburg collected on October 12, 2004.

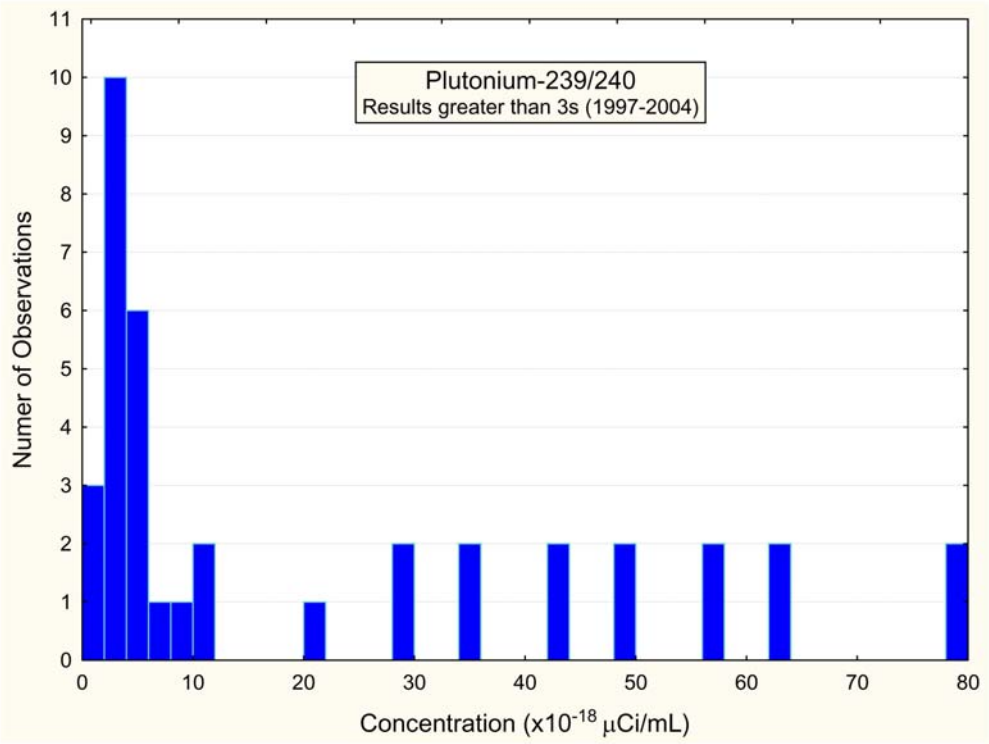


Figure 4-8. Frequency distribution of $^{239/240}$Pu concentrations detected above the 3s level in air filters collected by the ESER contractor from 1997 to 2004.

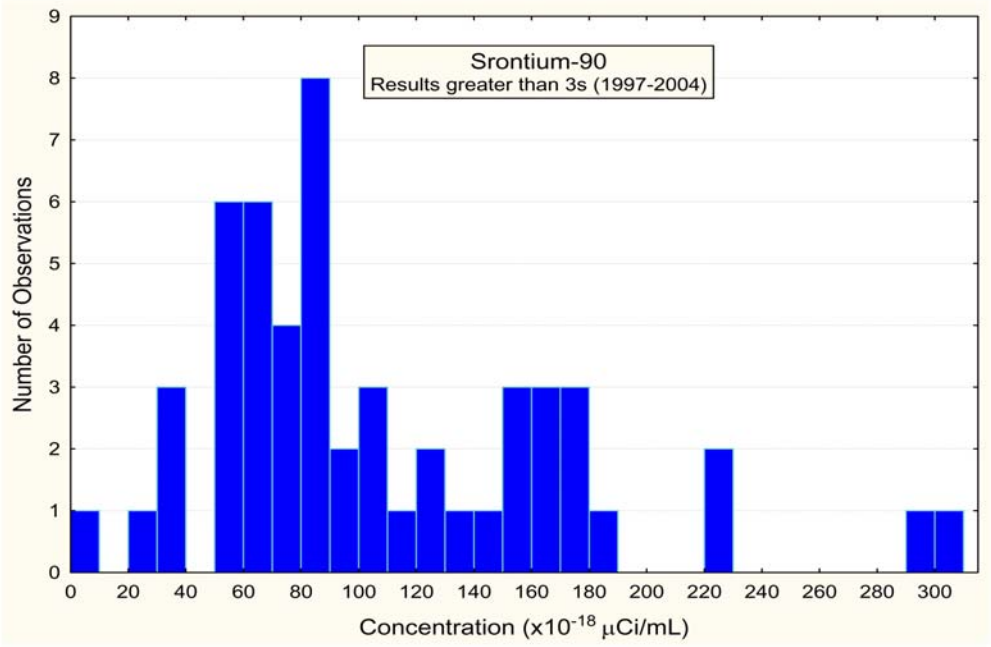


Figure 4-9. Frequency distribution of ^{90}Sr concentrations detected above the 3s level in air filters collected by the ESER contractor from 1997 to 2004.

Table 4-7. Tritium concentrations in ESER contractor atmospheric moisture samples (2004).

Location	Range[a] First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Atomic City	21.3 ± 4.3 – 43.6 ± 12.7	ND[b]	9.9 ± 1.9[c]	4.4 ± 1.9 – 8.7 ± 2.7
Blackfoot	ND	63.2 ± 14.6	73.6 ± 20.9	ND
Idaho Falls	ND	47.1 ± 10.6 – 67.0 ± 16.0	ND	5.5 ± 1.3 – 25.2 ± 2.2
Rexburg	ND	58.3 ± 12.5	57.7 ± 15.1	77.5 ± 18.0

a. All values are x 10^{-14} 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.

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 INEEL operations. The highest observed tritium concentration (from the fourth quarter at Rexburg) is more than five orders of magnitude below the DCG for tritium in air (as hydrogen tritium oxygen [HTO]) of 1×10^{-7} µCi/mL.

The M&O contractor collected atmospheric moisture samples at the EFS and at Van Buren Boulevard on the INEEL and at Idaho Falls and Craters of the Moon off the INEEL. They collect from one to three samples at each location each quarter. One sample indicated an activity greater than its 3 sigma level. The sample was taken at EFS in the fourth quarter with a value of $(40.9 \pm 13.6) \times 10^{-14}$ µCi/mL. This value is consistent with ESER contractor results and is significantly less than the DCG for tritium in air.

Precipitation

The ESER contractor collects precipitation samples weekly at the EFS and monthly at the CFA and offsite in Idaho Falls. A total of 26 precipitation samples were collected during 2004 from the three sites. Tritium concentrations were measured above the 3 sigma uncertainty level in eight samples and results ranged from (79.9 ± 25.3) to (200.0 ± 28.1) pCi/L. Table 4-8 shows the maximum concentration by quarter for each location. The highest radioactivity was from a sample collected at CFA 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 INEEL. The maximum concentration measured since 1998 was (553 ± 78) pCi/L, measured at the EFS in 2000. The results are also well within measurements made by the EPA in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past ten years (http://www.epa.gov/enviro/html/erams/).

Table 4-8. Maximum tritium concentrations in ESER contractor precipitation samples (2004).

Location	Maximum Concentration[a]			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
CFA	ND[b]	—[c]	ND	117.0 ± 25.8
EFS	191.0 ± 55.7	ND	ND	200.0 ± 28.1
Idaho Falls	ND	ND	79.9 ± 25.3	176.0 ± 30.5

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
c. No samples collected during this quarter.

Suspended Particulates

In 2004, both the ESER and M&O 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 µg/m^3 at Craters of the Moon to 19.7 µg/m^3 at Blackfoot. In general, particulate concentrations were higher at distant locations than at the INEEL stations. This is mostly caused by agricultural activities in offsite areas.

The total suspended particulate concentrations measured by the M&O 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 INEEL 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 2004. A valid sample is one that has run for the proper length of time (24 hours continuously) and that has a beginning weight less than the ending weight (does not yield a negative weight). Concentrations of PM_{10} particulates collected at Rexburg ranged from 1.9 to 47.6 µg/m^3. At the Blackfoot CMS, 61 valid samples were collected from January through December. Concentrations ranged from 1.5 to 39.3 µg/m^3. At Atomic City, 61 valid samples were collected from January through December. Concentrations ranged from 0.0 to 84.5 µg/m^3. All measurements were less than the EPA standard for mean annual concentration.

Nitrogen Dioxide

Emissions from the Experimental Breeder Reactor II auxiliary boilers do not require continuous monitoring because they are below the state of Idaho's 250 million Btu/hr emission limit. 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. Potassium is also measured and may be derived from soils, but it is also a component of smoke.

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.

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 Management and Operating contractor in 2004. Samples were obtained from suspended particle (SP) monitors.

Suspended particle monitors had gross alpha measurements that exceeded their 3 sigma uncertainty ranging from a high of $(1.40 \pm 0.51) \times 10^{-15}$ µCi/mL in the first half of January at location SDA-6.3 to a low of $(1.50 \pm 0.50) \times 10^{-16}$ µCi/mL in the first half of October at location HOWE-400.3. The annual mean for gross alpha was 1.23×10^{-15} µCi/mL. SP gross beta levels ranged from a high of $(3.09 \pm 0.09) \times 10^{-13}$ µCi/mL in the first half of January at SDA-6.3 to a low of $(2.10 \pm 0.13) \times 10^{-15}$ µCi/mL at HOWE-400.3 in the second half of April. The gross beta annual mean was 3.71×10^{-14} µCi/mL.

Specific Radionuclides

Anthropogenic gamma-emitting radionuclides were detected in 2004 that exceeded the three-sigma uncertainty. In April, cobalt-57 $(8.50 \pm 0.88) \times 10^{-15}$ µCi/mL, cobalt-60 $(8.35 \pm 0.84) \times 10^{-15}$ µCi/mL, and manganese-54 $(4.52 \pm 0.89) \times 10^{-15}$ µCi/mL were detected at location HOWE-400.3. These isotopes are activated corrosion products generated from operation of nuclear reactors. Analysis of site surveillance samples from the same time period showed no contamination from these nuclides, which indicates no unmonitored release. Due to the short half-lives of cobalt-57 (about 272 days) and manganese-54 (about 312 days), they are unlikely to come from buried waste. Subsequent samples at this location indicated no recurring contamination. Antimony 124 was detected at location SDA-6.3 $(1.31 \pm 0.35) \times 10^{-15}$ µCi/mL at the Subsurface Disposal Area. This nuclide has a short half-life (about 60 days), and therefore it is doubtful that it is from current waste retrieval operations at the Subsurface Disposal Area, and the result is suspect. All gamma detections are significantly below their respective Derived Concentration Guides.

Radiochemical analysis detections for alpha- and beta-emitting radionuclides of greater than the 3 sigma uncertainty level are listed in Table 4-9.

During the first quarter, americium-241 was detected on several samples. These results were rejected because americium was detected in the blank sample. Contamination at the analytical laboratory is suspected.

Table 4-9. Waste management radiochemical results for air.

Quarter	Location	Isotope	Results[a]	1s Error	Units	Sample Date	MDA[b]
First	SDA-4.2	Pu-239/240	7.18E-18	± 1.94E-18	µCi/cc	3/31/2004	3.30E-18
Second	SDA-4.2	Sr-90	9.03E-16	± 1.58E-16	µCi/cc	6/30/2004	1.21E-16
Second	HOWE-400.3	Pu-239/240	1.11E-17	± 2.31E-18	µCi/cc	6/30/2004	4.73E-18
Second	SDA-4.3	Pu-239/240	3.67E-18	± 1.17E-18	µCi/cc	6/30/2004	9.94E-19
Fourth	SDA-4.3	Sr-90	3.98E-16	± 4.96E-17	µCi/cc	1/3/2005	1.11E-16
Fourth	SDA-2.3	Pu-239/240	2.05E-17	± 3.24E-18	µCi/cc	1/3/2005	4.79E-18
Fourth	SDA-2.3	Sr-90	2.23E-16	± 4.78E-17	µCi/cc	1/3/2005	1.19E-16

a. Results shown are those greater than 3 sigma error.
b. MDA = Minimum Detectable Activity.

Plutonium-239/240 was detected at location SDA-4.2 in the first quarter of 2004 and at location SDA-4.3 in the second quarter, and strontium-90 was detected at SDA 4.2 during the second quarter and at SDA-4.3 in the fourth quarter. These two monitors are collocated, and there were no detections for the same sample period at the collocated monitor. However, a sampler collecting a single particle with activity at this level is possible, and these results are considered valid without regard to field duplicate precision criteria.

Uranium-234, -235, and -238 were detected in numerous samples at levels that indicate their origin as naturally occurring radioisotopes.

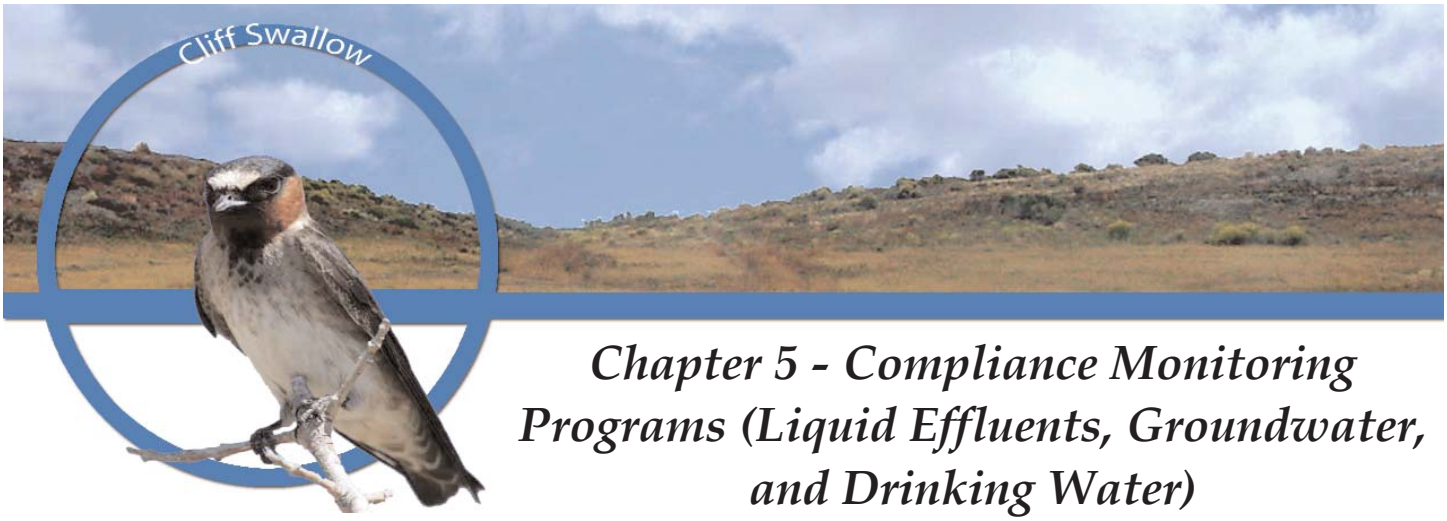
Results at these levels are well below the respective DCGs and consistent with previous years. The most probable cause of detections at the Subsurface Disposal Area is resuspension of contaminated soil. Loss of confinement integrity would give substantially higher results. No trends were detected based on analytical results from calendar year 2004.

REFERENCES

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

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

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2005, *National Emissions Standards for Hazardous Air Pollutants (NESHAPs) - Calendar Year 2004 INL Report for Radionuclides*, DOE/NE-ID-10890(05).



Chapter 5 - Compliance Monitoring Programs (Liquid Effluents, Groundwater, and Drinking Water)

R. Mitchell - S. M. Stoller Corporation
M. Lewis, B. Beus, B. Andersen, and D. McBride - Bechtel/BWXT Idaho, LLC
M. Finnerty - Argonne National Laboratory-West

Chapter Highlights

One potential pathway for exposure (primarily to workers) to contaminants released from the Idaho National Engineering and Environmental Laboratory (INEEL) is through the water pathway (surface water, drinking water, and groundwater). The Management and Operating contractor monitors liquid effluents, drinking water, groundwater, and storm water runoff at the INEEL to comply with applicable laws and regulations, U.S. Department of Energy (DOE) orders, and other requirements (e.g., Wastewater Land Application Permit [WLAP] requirements). Argonne National Laboratory-West and the Naval Reactors Facility conduct their own WLAP equivalent and drinking water monitoring.

During 2004, liquid effluent and groundwater monitoring was conducted in support of WLAP requirements for INEEL facilities that generate liquid waste streams covered under WLAP rules. The WLAP rules generally require compliance with the state of Idaho groundwater quality primary and secondary constituent standards in specified groundwater monitoring wells. The permits specify annual discharge volume, 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 also monitored in the effluent released in support of surveillance activities.

Results of most wastewater and groundwater samples taken in support of WLAPs were below applicable limits in 2004. Several metals detected in October 2004 samples taken from the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds perched water compliance wells ICPP-MON-V-200 and ICPP-MON-V-212 were above their respective state of Idaho groundwater secondary constituent standards and therefore, above the WLAP limits. Concentrations of aluminum, iron, and manganese in October 2004 samples collected from well ICPP-MON-V-200 and iron in the October 2004 sample collected from well ICPP-MON-V-212 were above the permit limits. For well ICPP-MON-V-212, this was the first time that a permit limit was exceeded. An evaluation was performed to determine the source of aluminum, iron, and manganese in INTEC New Percolation Ponds wells ICPP-MON-A-166, ICPP-MON-A-167, and ICPP-MON-V-200. The evaluation indicated that the majority of the metals found in these wells were from suspended solids. The evaluation further indicated that the likely cause of the suspended solids was from washed-in interbed material either near the well completion zones or from sediment in-filled fractures in the basalt. 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).

During the 2004 permit year, WLAP-required groundwater samples were collected in April and October from the INTEC STP monitoring wells. As in previous years, the concentrations of chloride and nitrate as nitrogen in USGS-052 were elevated compared to USGS-121 (an upgradient background well). Although the chloride and nitrate concentrations in samples collected from USGS-052 were higher than those found in the background well, all parameters in well USGS-052 were in compliance with permit limits during 2004.

The only TAN/TSF STP monitoring well that had constituents that were above permit limits was compliance well TAN-10A. The concentrations of iron, manganese, and total dissolved solids (TDS) in well TAN-10A exceeded the associated permit limits. Further evaluation is needed to determine what impacts the effluent, condition of the well, and past disposal practices are having on the constituent concentration in samples collected from well TAN-10A.

Monthly total nitrogen in the effluent from the INTEC STP exceeded the monthly average permit limit of 20 mg/L during February 2004, June 2004, and August 2004. With the termination of the INTEC STP WLAP (LA-000115-02) on December 2, 2004, the wastewater will no longer be discharged to the INTEC STP rapid infiltration (RI) trenches, and the combined effluent being discharged to the INTEC New Percolation Ponds is not expected to have the elevated concentrations associated with the INTEC STP effluent.

The December 2004 monthly total suspended solids (TSS) concentration in the TAN/TSF STP effluent exceeded the permit limit of 100 mg/L. Soil has washed into the manholes of the TAN/TSF collection system and has deposited in the sump where the effluent samples are collected. Removal of the soil is planned.

The M&O contractor Drinking Water Program monitors 10 onsite water systems, which include 17 wells. During 2004, 435 routine samples and 55 quality control samples were collected and analyzed from the INEEL. No U.S. Environmental Protection Agency (EPA) health-based drinking water or DOE regulatory limits were exceeded in 2004. In the Radioactive Waste Management Complex public water system, carbon tetrachloride remained below the EPA established maximum contaminant level (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 3.35 µg/L. The annual average for the production well of 4.88 µg/L was also below the MCL. Trichloroethylene concentrations in samples from the Test Area North drinking water Well #2 during 2004 also remained below the MCL.

Elevated levels of tritium continue to be measured in the groundwater at the INEEL. This radionuclide has not been detected off the INEEL since the mid-1980s. A maximum effective dose equivalent of 0.47 mrem/yr (4.7 µSv/yr), less than the four mrem/yr EPA standard for public drinking water systems, was calculated for workers at the Central Facilities Area at the INEEL in 2004.

As required by the General Permit for storm water discharges from industrial activity, visual examinations were conducted and samples were collected from selected locations. The visual

examinations performed in 2004 showed satisfactory implementation of the INEEL Storm Water Pollution Prevention Plan for Industrial Activities (DOE-ID 2002), and no corrective actions were required or performed during the year. An October 27, 2003, letter from the EPA Region 10 to the DOE, Idaho Operations Office (DOE-ID) chief counsel, determined that three sites at the INEEL (RWMC, INTEC, and the north part of the INEEL 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 a result, on December 15, 2003, the DOE-ID contract officer directed the M&O contractor Prime Contracts manager to cease compliance activities associated with the Storm Water Pollution Prevention Plan for Industrial Activities (SWPPP-IA), Storm Water Pollution Prevention Plan for Construction Activities (SWPPP-CA), and Spill Prevention Control and Countermeasures (SPCC) Programs at these three sites (Bauer 2003). The DOE-ID further directed the M&O contractor to:

- Conduct a technical analysis to evaluate what additional areas of the INEEL lack potential to discharge storm water to waters of the U.S;
- Conduct a regulatory analysis on the applicability of Clean Water Act (CWA) programs at the INEEL that still have a reasonable potential to discharge storm water run-off to these waters of the U.S.; and
- Define how applicable CWA programs will be communicated and implemented at the INEEL.

The storm water corridor technical analyses will be completed in early 2005, and may result in the cessation of compliance activities associated with additional monitoring locations.

5. COMPLIANCE MONITORING PROGRAMS

Operations at facilities located on the Idaho National Engineering and Environmental Laboratory (INEEL) release radioactive and nonradioactive constituents into the environment. These releases are in compliance with regulations, and monitoring of these releases ensures protection of the public and environment. This chapter presents results from radiological and nonradiological analyses of liquid effluent, groundwater, drinking water, and storm water samples taken at both onsite and offsite locations. Results from sampling conducted by the Management and Operating (M&O) contractor; Argonne National Laboratory-West (ANL-W), and the Naval Reactors Facility (NRF) 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 [DCG] for ingestion of water).

This chapter begins with a general overview of the organizations responsible for monitoring the various types of water at the INEEL in Section 5.1. Sections 5.2 and 5.3 describe liquid effluent and groundwater monitoring as required by the City of Idaho Falls and Wastewater Land Application Permit (WLAP) and effluent monitoring that is done for surveillance activities only.

The INEEL drinking water programs are discussed in Section 5.4. Section 5.5 describes storm water monitoring, while Section 5.6 summarizes onsite waste management water surveillance activities.

5.1 Summary of Monitoring Programs

The M&O contractor monitors liquid effluents, groundwater, drinking water, and storm water runoff at the INEEL to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., WLAP requirements).

The NRF monitors liquid effluent and drinking water to comply with applicable laws and regulations, proposed WLAP conditions, or as best management practices. Effluent samples were analyzed for radionuclides, inorganic constituents, and purgeable organic compounds, while drinking water parameters are covered by State and Federal regulations.

ANL-W also performs independent monitoring of liquid effluent and drinking water at its facility to comply with applicable laws and regulations, proposed WLAP conditions, or as best management practices. Industrial and sanitary liquid effluent samples are analyzed for gross activity (alpha and beta), tritium, inorganics, and water quality parameters. Drinking water parameters are covered under State and Federal regulations.

The INEEL Oversight Program collects split samples with the M&O and other INEEL contractors of liquid effluents, groundwater, drinking water, and storm water. Results of the Oversight programs monitoring are presented in annual reports prepared by that organization and are not reported here.

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

5.2 Liquid Effluent and Related Groundwater Compliance Monitoring

The M&O contractor monitors for nonradioactive and radioactive parameters in liquid waste effluent and groundwater. Wastewater is typically discharged to the 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/Technical Support Facility (TAN/TSF) Sewage Treatment Plant Disposal Pond, and Test Reactor Area (TRA) Cold Waste Pond;
- INTEC Sewage Treatment Plant infiltration trenches; and
- A sprinkler irrigation system at the Central Facilities Area (CFA) used during the summer months to land-apply industrial and treated sanitary wastewater.

Table 5-1. Water-related monitoring at the INEEL and surrounding area.

Area/Facility[a]	Media					
	Liquid Effluent (Permitted)	Liquid Effluent (Surveillance)	Groundwater	Drinking Water	Storm Water	Surface Water
Argonne National Laboratory-West						
ANL-W		•	•	•		
Management and Operating Contractor						
CFA[b]	•	•		•	•[c]	
INTEC	•	•	•	•		
TRA	•[d]	•		•		
TAN/TSF, CTF	•	•	•	•	•[c]	
RWMC				•		•
PBF				•	•	
IRC	•					
Naval Reactors Facility						
NRF		•	•	•		
Environmental Surveillance, Education and Research Program						
INEEL/Regional				•		
INEEL Oversight Program						
INEEL/Regional		•	•	•	•	

a. ANL-W = Argonne National Laboratory-West, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, TRA = Test Reactor Area, TAN = Test Area North, RWMC = Radioactive Waste Management Complex, PBF = Power Burst Facility, IRC = INEEL Research Center, and NRF = Naval Reactors Facility.
b. Includes Gun Range, EBR-I (Experimental Breeder Reactor-I), and Main Gate.
c. Storm water monitoring ceased in October 2004. Injection wells will continue to be monitored as required.
d. The Idaho DEQ has not issued a Wastewater Land Application Permit for TRA. However, TRA follows WLAP regulations for the applicable effluent.

Discharge of wastewater to the land surface is regulated under Idaho WLAP rules (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 INEEL facilities that generate liquid waste streams covered under WLAP rules. Table 5-2 lists the five facilities operated by the M&O contractor that require WLAPs and the current permit 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 and application rates and effluent quality limits. As required, an annual report is prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

Table 5-2. Current M&O Contractor Wastewater Land Application Permits.

Facility	Permit Status at end of 2004	Explanation
CFA Sewage Treatment Plant	WLAP expired	Idaho DEQ issued a letter authorizing continued operation under the terms and conditions of the original permit until a new permit is issued. Negotiation of a draft permit began in spring 2004.
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).
TAN/TSF Sewage Treatment Facility	WLAP expired	Idaho DEQ issued a letter authorizing continued operation under the terms and conditions of the original permit until a new permit is issued. Negotiation of a draft permit began in spring 2004.
TRA Cold Waste Pond	WLAP application submitted to Idaho DEQ	Idaho DEQ has not issued a WLAP. Idaho DEQ authorized INEEL 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].

During 2004, the M&O contractor conducted monitoring as required by the permits for each of the first four facilities listed in Table 5-2. The TRA 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 Order 5400.5 and 450.1 (DOE 1993, DOE 2003) environmental protection objectives. Section 5.3 discusses the results of liquid effluent surveillance monitoring for individual facilities operated by the M&O contractor and those additional facilities monitored by ANL-W (Industrial Waste Ditch and Pond, the ANL-W Sanitary Lagoons), and the NRF (Industrial Waste Ditch).

Idaho Falls Facilities

Description - The City of Idaho Falls is authorized by the *Clean Water Act*, National Pollutant Discharge Elimination System (NPDES) to set pretreatment standards for nondomestic wastewater discharges to publicly owned treatment works. The DOE - Idaho Operations (DOE-ID) Office and M&O contractor facilities in Idaho Falls are required to comply with the applicable regulations in Chapter 1, Section 8 of the Municipal Code of the City of Idaho Falls.

Industrial Wastewater Acceptance Forms were obtained for facilities that discharge process wastewater through the City of Idaho Falls sewer system. Twelve M&O 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 INEEL Research Center has specific monitoring requirements.

Wastewater Monitoring Results - Semiannual monitoring was conducted at the INEEL Research Center in April and October of 2004. Table 5-3 summarizes the 2004 semiannual monitoring results.

Table 5-3. Semiannual monitoring results for INEEL Research Center (2004).[a]

Parameter	INEEL Research Center		
	April 2004	October 2004[b]	Discharge Limit[c]
Cyanide	0.005 U[d]	0.005 U	1.04
Silver	0.0025 U	0.0025 U	0.43
Arsenic	0.0050 U	0.0050 U	0.04
Cadmium	0.0010 U	0.0010 U	0.26
Chromium	0.0026	0.0025 U	2.77
Copper	0.0484	0.0332/0.0330	1.93
Mercury	0.00020 U	0.00020 U	0.002
Nickel	0.0080	0.0025 U	2.38
Zinc	0.0423	0.0162/0.0153	0.90
Lead	0.00079	0.00085/0.00088	0.29
Conductivity (µS)	619.3/584.7[e]	646.3/562.7[e]	N/A
pH (standard units)	7.94/7.73[e]	8.06/7.96[e]	5.5-9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Regular and duplicate samples were collected in October. 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 eight-hour period during semiannual monitoring.

Central Facilities Area Sewage Treatment Plant

Description - The CFA Sewage Treatment Plant (STP) serves all major facilities at CFA. It is southeast of CFA, approximately 671 m (2,200 ft) downgradient of the nearest drinking water well.

A 1,500 L/min (400 gal/min) pump applies wastewater from a 0.2 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 25 acre-in./acre/yr from March 15 through November 15, and limits leaching losses to 8 cm/yr (3 in./yr).

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 2004. Effluent samples were collected from the pump pit (prior to the pivot irrigation system) starting in June 2004 and continued through October 2004 (the period of irrigation operation for 2004). All samples collected were 24-hr composites, except pH and coliform samples, which were collected as grab samples. Tables 5-4 and 5-5 summarize the results.

Table 5-4. CFA STP influent monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Biological Oxygen Demand (5-day)	20.3	158.0	49.74	NA[d]
pH (grab)	7.61	8.24	7.89	NA
Chemical Oxygen Demand	43.3	155.0	83.27	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.027	1.010	0.352	NA
Nitrogen, Total Kjeldahl	4.63	20.90	12.32	NA
Total Suspended Solids	25.1	161.0	55.91	NA

a. With the exception of pH, which is unitless, all values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were collected in February 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.
d. NA—Not applicable; no permit limit is set for this parameter.

Table 5-5. CFA STP effluent monitoring results (2004).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Biological Oxygen Demand (5-day)	1.00[c]	2.33	1.33	NA[d]
pH (grab)[e]	9.36	10.19	9.81	NA
Chemical Oxygen Demand	19.50	47.80	27.08	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.005[c]	0.012	0.006	NA
Total Phosphorus	0.078	0.315	0.169	NA
Nitrogen, Total Kjeldahl	0.411	1.070	0.630	NA
Total Suspended Solids	2.00[c]	25.60	7.62	NA
Fecal Coliform (colonies/100 mL)	0	2	1	NA
Total Coliform (colonies/100 mL)	1	21	7	NA

a. With the exception of pH, which is unitless, 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. NA—Not applicable; no permit limit is set for this parameter.
e. pH readings were collected on two separate days in July and are included in the summaries. The maximum pH reading was from one of these samples.

Discharge to the pivot irrigation area averaged less than 647,235 Lpd (171,000 gpd). Application rates ranged from 0.03 to 0.12 acre-in./day during the entire 2004 application period of June 28, 2004, through October 21, 2004.

The total volume of applied wastewater for 2004 was approximately 13.64 MG, which is significantly less than the design hydraulic loading of 40.5 MG. Hydraulic loading peaked in September. Nitrogen loading rates were significantly lower (0.8 lb/acre/yr) than the projected maximum loading rate of 32 lb/acre/yr. As a general rule, nitrogen loading should not exceed the amount necessary for crop utilization plus 50 percent. However, wastewater is applied to rangeland without nitrogen removal via crop harvest. To estimate nitrogen buildup in the soil under this condition, a nitrogen balance was prepared by Cascade Earth Science, Ltd., which estimated it would take 20 to 30 years to reach normal nitrogen agricultural levels in the soil (based on a loading rate of 32 lb/acre/year) (CES 1993). The extremely low 2004 nitrogen loading rate had a negligible effect on nitrogen accumulation.

The 2004 annual total chemical oxygen demand (COD) loading rate at CFA STP (35 lb/acre/year) was substantially less than state guidelines of 50 lb/acre/day (which is equivalent to 18,250 lb/acre/year).

The annual total phosphorus loading rate (0.237 lb/acre/year) was well below the projected maximum loading rate of 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 (BOD) and TSS achieved the projected efficiency of 80 percent, and COD was below the projected efficiency of 70 percent. During the 2004 permit year, the average REs indicate that treatment in the lagoons was sufficient to produce a good quality effluent for land application. A total of 6.83 acre-in./acre of wastewater was applied over approximately 7.4 acres during the 2004 permit year, which was 3.84 in. more than that applied in 2003. This total, when adjusted for irrigation efficiency and added to the total adjusted precipitation for the permit year, yields 12.37 acre-in./acre, which is well below the permit limit of 25 acre in./acre/year. This resulted in no leaching and, therefore, was well below the permit limit of 7.6 cm (3 in.) per year.

WLAP Groundwater Monitoring Results - The WLAP does not require groundwater monitoring at the CFA STP.

Idaho Nuclear Technology and Engineering Center New Percolation Ponds

Description - The Percolation Ponds receive only nonhazardous wastewater. Wastewater with the potential to contain hazardous constituents is disposed of in accordance with the applicable *Resource Conservation and Recovery Act* requirements. Sanitary wastes from restrooms and the INTEC cafeteria are either discharged to the INTEC STP or directed to onsite septic tank systems.

The INTEC New Percolation Ponds were placed into service August 26, 2002, and the INTEC Existing Percolation Ponds were isolated from further use. During normal operations, INTEC

generates an average of 1 to 2 MG per day of process wastewater (commonly called service waste) that is discharged to the New Percolation Ponds. The service waste system serves all major facilities at INTEC. This process-related wastewater from INTEC operations consists primarily of steam condensates, noncontact cooling water, reverse osmosis products, water softener and demineralizer regenerate, and boiler blowdown wastewater.

The new pond complex is a rapid infiltration system and is comprised of two ponds excavated into the surficial alluvium and surrounded by bermed alluvial material. Each pond is approximately 93 x 93 m (305 x 305 ft) at the top of the berm and is about 3 m (10 ft) deep. Each pond is designed to accommodate a continuous wastewater discharge rate of approximately 11 million Lpd (three MG per day).

During normal operation, wastewater is discharged to only one pond at a time. Periodically, the pond receiving the wastewater will be alternated to minimize algae growth and maintain good percolation rates. Ponds are routinely inspected, and the water depth is recorded via permanently mounted staff gauges.

The WLAP (LA-000130-03) for the INTEC New Percolation Ponds issued by DEQ was in effect through December 3, 2004. A request for a major permit modification to expand facility operations associated with the INTEC New Percolation Ponds by routing the sanitary wastewater from the INTEC STP (WLAP LA-000115-02) to the INTEC service waste system and discharge the combined effluent to the INTEC New Percolation Ponds was submitted to DEQ in 2003. The new WLAP (LA-000130-04) was issued and became effective on December 2, 2004, when the two wastewaters were combined for discharge to the INTEC New Percolation Ponds.

WLAP Wastewater Monitoring Results - The WLAP for the New Percolation Ponds requires effluent monitoring, as well as groundwater sampling. A 24-hr flow-proportional composite sample is collected monthly from the sample point in CPP-797 for all parameters except pH, which is taken as a grab sample as required by the permit. Table 5-6 summarizes the effluent results from the INTEC New Percolation Ponds. Table 5-7 shows the effluent results for December 2004 after the two waste streams were combined on December 2, 2004.

The permit for the INTEC New Percolation Ponds WLAP LA-000130-04 (effective as of December 2, 2004) specifies limits for TSS of 100 mg/L and 20 mg/L for total nitrogen. These limits were not exceeded in the December 2004 sample.

Prior to December 2004, the previous WLAP (LA-000130-03) did not specify concentration limits for the effluent to the ponds. However, to aid in monitoring plant efficiency, effluent concentrations were compared to the groundwater quality standards. When comparing the effluent concentrations to the groundwater quality standards as an indicator of plant efficiency, only chloride was above the standards and only during one month of the year (February 2004). However, because there are no permit limits for chloride in the effluent, the chloride concentration during February does not reflect a permit noncompliance. Historically, concentrations of total dissolved solids (TDS), chloride, and sodium have all been high in the service waste effluent and have been considered indicative of a problem with the CPP-606 water treatment system. Evaluations of design options to upgrade the water treatment system were ongoing during the 2004 permit year, and the new permit for the combined effluents (WLAP LA-

Table 5-6. Summary of INTEC New Percolation Ponds effluent monitoring results for January 2004 through November 2004 (prior to the two effluent waste streams being combined).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
pH (grab)	7.5	8.4	7.9	NA[c]
Nitrogen, Total Kjeldahl	0.08[d]	0.14[d]	0.09[e]	NA
Nitrogen, as Nitrate (mg-N/L)	0.81	1.08	0.94	NA
Nitrogen, as Nitrite (mg-N/L)	0.003[d]	0.023	0.007	NA
Phosphorus	0.0165	0.0350	0.0252	NA
Total Dissolved Solids	305.0	469.0	398.2	NA
Chloride	55.7	260.0	125.1	NA
Fluoride	0.19	0.23	0.21	NA
Aluminum	0.0032[d]	0.0149	0.0065	NA
Arsenic	0.00125[d]	0.00225[d]	0.00178[e]	NA
Cadmium	0.00015[d]	0.00020[d]	0.00018[e]	NA
Chromium	0.0032[d]	0.0067	0.0057	NA
Copper	0.0007[d]	0.0043	0.0020	NA
Iron	0.0041[d]	0.1240	0.0215	NA
Manganese	0.0001[d]	0.0009	0.0005	NA
Mercury	0.00004[d]	0.00004[d]	0.00004[e]	NA
Selenium	0.00175[d]	0.00225[d]	0.00203[e]	NA
Silver	0.00115[d]	0.00350[d]	0.00157[e]	NA
Sodium	40.4	102.0	77.0	NA
Total Nitrogen[f]	0.90[d]	1.18	1.03	NA

a. With the exception of pH, which is unitless, 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. NA—Not applicable; no permit limit is set for this parameter.
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, nitrate, and nitrite

Table 5-7. Summary of INTEC New Percolation Ponds effluent monitoring results for December 2004 (after the two effluent waste streams were combined).[a]

Parameter	Value[b]	Permit Limit
pH (grab)	7.85	NA[c]
Total Coliform (colonies/100 mL)	13	NA
Nitrogen, Total Kjeldahl	0.05[d]	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.958	NA
Total Phosphorus	0.135	NA
Biological Oxygen Demand (5-day)	1.0[d]	NA
Total Suspended Solids	2[d]	100
Total Dissolved Solids	423	NA
Chloride	114	NA
Conductivity (grab)(µS)	437	NA
Fluoride	0.239	NA
Aluminum	0.0125[d]	NA
Arsenic	0.00125[d]	NA
Cadmium	0.0005[d]	NA
Chromium	0.0053	NA
Copper	0.0025	NA
Iron	0.0681	NA
Manganese	0.00125[d]	NA
Mercury	0.0001[d]	NA
Selenium	0.001[d]	NA
Silver	0.00125[d]	NA
Sodium	68.9	NA
Total Nitrogen[e]	1.008	20

a. With the exception of pH, which is unitless, all values are in milligrams per liter (mg/L) unless otherwise noted.
b. The combined effluent began being discharged to the INTEC New Percolation Ponds on December 2, 2004. As a result only one sample was taken from the combined effluent during 2004, and the minimum, maximum, and averages are the same for each parameter.
c. NA—Not applicable; no permit limit is set for this parameter.
d. Sample result was less than the detection limit; value shown is half the detection limit.
e. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite.

000130-04) includes a compliance requirement to submit a salt loading corrective action plan and schedule to reduce salt loading to the INTEC New Percolation Ponds.

The flow volumes to the New Percolation Ponds were recorded daily from the flow meter located in CPP-797. Total flow discharged to the New Percolation Ponds in 2004 was approximately 1,647 million L (435.3 MG).

WLAP Groundwater Monitoring Results - To measure potential impacts to groundwater from the New Percolation Ponds, the permit requires that groundwater samples be collected semiannually from six monitoring wells:

- One background aquifer well (ICPP-MON-A-167) upgradient of the New Percolation Ponds;
- One background perched water well (ICPP-MON-V-191) north of the New Percolation Ponds and just south of the Big Lost River;
- Two aquifer wells (ICPP-MON-A-165 and -166) downgradient of the New Percolation Ponds; and
- Two perched water wells (ICPP-MON-V-200 and ICPP-MON-V-212) adjacent to the New Percolation Ponds. Well ICPP-MON-V-200 is north of the 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. Contaminant concentrations in the aquifer compliance wells are limited by the natural background concentrations in those wells. According to IDAPA 58.01.11.200.03, if the natural background level of a constituent exceeds the standard in this Section (i.e., IDAPA 58.01.11.200.01), the natural background shall be used as the standard. Because there were no natural background levels for the two perched wells listed as compliance points, these wells are limited by the groundwater PCS and SCS in IDAPA 58.01.11.200.01. All permit required samples are collected as unfiltered samples.

Table 5-8 shows the April and October 2004 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all parameters specified by the permit for aquifer wells. Table 5-9 presents similar information for the perched water wells. Samples were collected from wells ICPP-MON-A-165, ICPP-MON-A-166, ICPP-MON-A-167, ICPP-MON-V-200, and ICPP-MON-V-212. Perched water well ICPP-MON-V-191 was dry during both the April and October 2004 sampling events. Well ICPP-MON-V-191 is expected to remain dry until there is sufficient flow in the Big Lost River to recharge the perched water at this well.

The parameter concentrations in the aquifer wells remained below the preoperational natural background concentrations. The majority of the permit-required parameters in the two perched water wells were below their respective PCS or SCS during the 2004 permit year. However, exceedances were reported for three metals (aluminum, iron, and manganese).

Table 5-8. INTEC New Percolation Ponds aquifer well monitoring data (2004).

Depth to	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)				PCS/SCS[a]
Water Table (ft)	498.41	499.36	500.96	502.32	506.48	506.48	506.18	506.18	
Water Table Elevation (ft)	4,451.80	4,450.85	4,452.04	4,450.68	4,453.01	4,453.01	4,453.31	4,453.31	
Sample Date (units[b])	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	4/7/2004[c] (mg/L)	10/27/2004 (mg/L)	10/27/2004[c] (mg/L)	(mg/L)
pH	7.78	8.11	7.61	7.02	7.62	7.62	8.03	8.03	6.5–8.5
TKN[d]	0.10 U[e]	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA[f]
NO_3-N	0.67	0.55	0.69	0.69	0.36	0.36	0.31	0.32	10
NO_2-N	0.020 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	1
Total phosphorus	0.081 U	0.157	0.0453 U	0.05 U	0.0501 U	0.043 U	0.0402	0.0329	NA
TDS	227	240	226	248	170	185	202	205	500
Chloride	9.7	8.8	25.9	34.5	7.9	7.9	7.6	7.7	250
Fluoride	0.16	0.17	0.16	0.16	0.20	0.20	0.21	0.19	4
Aluminum	0.554	3.130	0.0176	0.0953	0.0855	0.0739	0.0609[g]	0.0541[g]	0.2
Aluminum (reanalysis)	—	2.530[h]	—	—	—	—	—	—	0.2
Aluminum-filtered	0.0202	0.0239	—	—	0.0200	0.0196	0.0191[g]	0.0176[g]	0.2
Arsenic	0.0018	0.0012	0.002	0.00091	0.0014	0.0011	0.0019 U	0.0021 U	0.05
Arsenic (reanalysis)	—	0.0017 U[h]	—	—	—	—	—	—	0.05
Arsenic-filtered	0.0022	0.0012	—	—	0.0017	0.0029	0.0023 U	0.0020 U	0.05
Cadmium	0.0001 U	0.00008 U	0.0001 U	0.00008 U	0.0001 U	0.0001 U	0.00008 U	0.00008 U	0.005
Cadmium (reanalysis)	—	0.00008 U[h]	—	—	—	—	—	—	0.005
Cadmium-filtered	0.0001 U	0.00008 U	—	—	0.0001 U	0.0001 U	0.00008 U	0.00008 U	0.005
Chromium	0.0118	0.0172[g]	0.0067	0.0071[g]	0.0075	0.0063	0.0088	0.0083	0.1
Chromium-filtered	0.0095	0.0079 R[i,j]	—	—	0.0057	0.0081	0.0089	0.0083	0.1
Copper	0.0024	0.0109	0.00089	0.0016	0.00049	0.00048	0.00044	0.00068	1.3
Copper (reanalysis)	—	0.0094[h]	—	—	—	—	—	—	
Copper-filtered	0.00087	0.0019	—	—	0.00039	0.0003 U	0.00070	0.00043	1.3

Table 5-8. INTEC New Percolation Ponds aquifer well monitoring data (2004) (continued).

Depth to	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)				PCS/SCS[a]
Water Table (ft)	498.41	499.36	500.96	502.32	506.48	506.48	506.18	506.18	
Water Table Elevation (ft)	4,451.80	4,450.85	4,452.04	4,450.68	4,453.01	4,453.01	4,453.31	4,453.31	
Sample Date (units[b])	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	4/7/2004[c] (mg/L)	10/27/2004 (mg/L)	10/27/2004[c] (mg/L)	(mg/L)
Iron	0.439	1.95	0.0457	0.139	0.0658	0.0508	0.0675 R[i,k]	0.0650 R[i,k]	0.3
Iron (reanalysis)	—	1.60[h]	—	—	—	—	0.0684 R[i,k]	0.0644 R[i,k]	0.3
Iron-filtered	0.0143 U	0.0148 U	—	—	0.0092 U	0.0069 U	0.0145 R[i,k]	0.0163 R[i,k]	0.3
Iron-filtered (reanalysis)	—	—	—	—	—	—	0.0143 R[i,k]	0.0160 R[i,k]	0.3
Manganese	0.0114	0.0395[g]	0.00062	0.0017[g]	0.0174	0.0142	0.0371	0.0365	0.05
Manganese-filtered	0.003	0.0113 R[i,j]	—	—	0.0144	0.021	0.0397	0.038	0.05
Mercury	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.002
Mercury (reanalysis)	—	0.0001 U[h]	—	—	—	—	—	—	0.002
Mercury-filtered	0.0001 U	0.0001 U	—	—	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.002
Selenium	0.0013	0.0017	0.0013	0.00097	0.00085 U	0.00085 U	0.0012	0.00092 U	0.05
Selenium (reanalysis)	—	0.0019[h]	—	—	—	—	—	—	0.05
Selenium-filtered	0.00098	0.00099	—	—	0.00085 U	0.0012	0.0015	0.0012	0.05
Silver	0.00015 U	0.00025 U	0.00015 U	0.00025 U	0.00015 U	0.00015 U	0.00025 U	0.00025 U	0.1
Silver (reanalysis)	—	0.00025 U[h]	—	—	—	—	—	—	0.1
Silver-filtered	0.00015 U	0.00025 U	—	—	0.00015 U	0.00015 U	0.00025 U	0.00025 U	0.1
Sodium	9.59	13.1	10.9	15.4	7.65	6.25	8.96	9.33	NA

Table 5-8. INTEC New Percolation Ponds aquifer well monitoring data (2004) (continued).

Depth to	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)				PCS/SCS[a]
Water Table (ft)	498.41	499.36	500.96	502.32	506.48	506.48	506.18	506.18	
Water Table Elevation (ft)	4,451.80	4,450.85	4,452.04	4,450.68	4,453.01	4,453.01	4,453.31	4,453.31	
Sample Date (units[b])	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	10/19/2004 (mg/L)	4/7/2004 (mg/L)	4/7/2004[c] (mg/L)	10/27/2004 (mg/L)	10/27/2004[c] (mg/L)	(mg/L)
Sodium (reanalysis)	—	13.1[h]	—	—	—	—	—	—	NA
Sodium-filtered	9.23	13.4	—	—	6.77	9.55	9.86	9.33	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. The units for all parameters listed are as shown except for pH which is unitless.
c. Duplicate sample.
d. TKN—Total Kjeldahl nitrogen.
e. U flag indicates that the result was reported as below the detection limit.
f. NA—Not applicable.
g. The initial result was rejected during validation due to quality control issues. A reanalysis was requested, and the result of that reanalysis is presented.
h. A reanalysis was requested due to higher than expected results for some metals associated with this data package. The result of that reanalysis is presented.
i. R flag indicates that the result was rejected during validation.
j. Because the filtered sample is not required by the permit, no reanalysis was requested.
k. The initial result was rejected during validation due to quality control issues. A reanalysis was requested for those specific parameters whose initial results were rejected during validation. Because both the initial result and the reanalysis result were rejected, both results are presented.

Table 5-9. INTEC New Percolation Ponds perched water well monitoring data (2004).

Depth to Water Table (ft)	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-200 (GW-013009) 103.00	ICPP-MON-V-200 (GW-013009) 112.27	ICPP-MON-V-212 (GW-013010) Not Taken[c]	ICPP-MON-V-212 (GW-013010) 233.69	PCS/SCS[a]
Water Table Elevation (ft)	—	—	4,850.02	4,840.75	Not Taken	4,724.69	
Sample Date (units[d])	April 2004 Not Sampled	October 2004 Not Sampled	4/7/2004 (mg/L)	10/11/2004 (mg/L)	4/7/2004 (mg/L)	10/11/2004 (mg/L)	(mg/L)
pH	—	—	7.81	7.96	7.44	7.87	6.5–8.5
TKN[e]	—	—	0.10 U[f]	0.10 U	0.10 U	0.10 U	NA[g]
NO_3-N	—	—	0.93	0.87	0.88	0.84	10
NO_2-N	—	—	0.02 U	0.02 U	0.02 U	0.02 U	1
Total phosphorus	—	—	0.0643 U	0.0906	0.0287 U	0.05 U	NA
TDS	—	—	425	406	427	432	500
Chloride	—	—	145	110	136	126	250
Fluoride	—	—	0.38	0.30	0.22	0.16	4
Aluminum	—	—	0.0191	7.120	0.0417	0.0615	0.2
Aluminum (reanalysis)	—	—	—	8.070[h]	—	0.0686[h]	0.2
Aluminum-filtered	—	—	0.0166	0.0296	—	—	0.2
Arsenic	—	—	0.0046	0.0032	0.001	0.0011	0.05
Arsenic (reanalysis)	—	—	—	0.0033 U[h]	—	0.0024 U[h]	0.05
Arsenic-filtered	—	—	0.003	0.0026	—	—	0.05
Cadmium	—	—	0.0001 U	0.00008 U	0.0001 U	0.00008 U	0.005
Cadmium (reanalysis)	—	—	—	0.00008 U[h]	—	0.00008 U[h]	0.005
Cadmium-filtered	—	—	0.0001 U	0.00008 U	—	—	0.005
Chromium	—	—	0.0056	0.0515[i]	0.0053	0.0083[i]	0.1
Chromium-filtered	—	—	0.004	0.0063 R[i]	—	—	0.1
Copper	—	—	0.0015	0.0146	0.00035	0.00081	1.3

Table 5-9. INTEC New Percolation Ponds perched water well monitoring data (2004) (continued).

Depth to Water Table (ft)	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-200 (GW-013009) 103.00	ICPP-MON-V-200 (GW-013009) 112.27	ICPP-MON-V-212 (GW-013010) Not Taken[c]	ICPP-MON-V-212 (GW-013010) 233.69	PCS/SCS[a]
Water Table Elevation (ft)	—	—	4,850.02	4,840.75	Not Taken	4,724.69	
Sample Date (units[d])	April 2004 Not Sampled	October 2004 Not Sampled	4/7/2004 (mg/L)	10/11/2004 (mg/L)	4/7/2004 (mg/L)	10/11/2004 (mg/L)	(mg/L)
pH	—	—	7.81	7.96	7.44	7.87	6.5–8.5
TKN[e]	—	—	0.10 U[f]	0.10 U	0.10 U	0.10 U	NA[g]
NO_3-N	—	—	0.93	0.87	0.88	0.84	10
NO_2-N	—	—	0.02 U	0.02 U	0.02 U	0.02 U	1
Total phosphorus	—	—	0.0643 U	0.0906	0.0287 U	0.05 U	NA
TDS	—	—	425	406	427	432	500
Chloride	—	—	145	110	136	126	250
Fluoride	—	—	0.38	0.30	0.22	0.16	4
Aluminum	—	—	0.0191	7.120	0.0417	0.0615	0.2
Aluminum (reanalysis)	—	—	—	8.070[h]	—	0.0686[h]	0.2
Aluminum-filtered	—	—	0.0166	0.0296	—	—	0.2
Arsenic	—	—	0.0046	0.0032	0.001	0.0011	0.05
Arsenic (reanalysis)	—	—	—	0.0033 U[h]	—	0.0024 U[h]	0.05
Arsenic-filtered	—	—	0.003	0.0026	—	—	0.05
Cadmium	—	—	0.0001 U	0.00008 U	0.0001 U	0.00008 U	0.005
Cadmium (reanalysis)	—	—	—	0.00008 U[h]	—	0.00008 U[h]	0.005
Cadmium-filtered	—	—	0.0001 U	0.00008 U	—	—	0.005
Chromium	—	—	0.0056	0.0515[i]	0.0053	0.0083[i]	0.1
Chromium-filtered	—	—	0.004	0.0063 R[i]	—	—	0.1
Copper	—	—	0.0015	0.0146	0.00035	0.00081	1.3

Table 5-9. INTEC New Percolation Ponds perched water well monitoring data (2004) (continued).

Depth to Water Table (ft)	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-191 (GW-013008) Dry[b]	ICPP-MON-V-200 (GW-013009) 103.00	ICPP-MON-V-200 (GW-013009) 112.27	ICPP-MON-V-212 (GW-013010) Not Taken[c]	ICPP-MON-V-212 (GW-013010) 233.69	PCS/SCS[a]
Water Table Elevation (ft)	—	—	4,850.02	4,840.75	Not Taken	4,724.69	
Sample Date (units[d])	April 2004 Not Sampled	October 2004 Not Sampled	4/7/2004 (mg/L)	10/11/2004 (mg/L)	4/7/2004 (mg/L)	10/11/2004 (mg/L)	(mg/L)
Sodium-filtered	—	—	63.4	76.2	—	—	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. ICPP-MON-V-191 is a perched well and was dry in April and October 2004 when permit-required sampling was performed. Therefore, the well could not be sampled.

c. Measurement could not be taken due to an obstruction in the well, which has since been removed.

d. The units for all parameters listed are as shown except for pH which is unitless.

e. TKN—Total Kjeldahl nitrogen.

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

g. NA—Not applicable.

h. A reanalysis was requested due to higher than expected results for some metals associated with this data package. The result of that reanalysis is presented.

i. The initial result was rejected during validation due to quality control issues. A reanalysis was requested, and the result of that reanalysis is presented.

j. R flag indicates that the result was rejected during validation. Because the filtered sample is not required by the permit, no reanalysis was requested.

Samples collected from perched water well ICPP-MON-V-200 in April 2004 were below the SCSs for aluminum, iron, and manganese in the unfiltered samples, but were well above the SCSs in the October 2004 unfiltered sample (Table 5-9). The concentration of iron in the unfiltered sample taken from well ICPP-MON-V-212 in October 2004 was above the SCS. This was the first time since sampling began for this well that any of these three metals were above the SCS in an unfiltered sample.

Previous sampling events have shown higher than expected concentrations of aluminum, iron, and manganese in wells ICPP-MON-A-167, ICPP-MON-A-166, and ICPP-MON-V-200. A study (Hull, et al. 2004) was performed to determine the source of the aluminum, iron, and manganese in these three wells. The study evaluated the following:

- Possible impacts to the groundwater from well construction materials and construction activities;
- Concentrations of aluminum, iron, and manganese in filtered versus unfiltered groundwater samples collected from the three wells; and
- Additional purging of the three wells prior to sampling.

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 effluent concentrations of these metals are significantly lower than the concentrations in the three wells addressed in the study and are below the respective SCSs.

Hull, Wright, and Street (2004) stated that there were significant concentrations of aluminum, iron, and manganese in the suspended solids from samples collected from wells ICPP-MON-A-166, ICPP-MON-A-167, and ICPP-MON-V-200. The study further indicated that if the suspended solids were removed by using a 0.45 µm filter during sample collection, the concentrations of the three metals would be below the SCSs. To date, all filtered sample results from wells ICPP-MON-A-166, ICPP-MON-A-167, and ICPP-MON-V-200 have been below the SCSs for aluminum, iron, and manganese.

The suspended solids were found to consist primarily of quartz and alumino-silicate minerals. The metals found in the sediments are consistent with the abundance of these metals in the earth's crust. It was concluded that the likely cause of the suspended solids was from washed-in interbed material either near the well completion zones or from sediment in-filled fractures in the basalt. Sediment infilling is a common occurrence in fractures, rubble zones, and void spaces in the Snake River Plain basalt flows (Hull et al. 2004).

Just prior to the April 2004 sampling event, wells ICPP-MON-A-166, ICPP-MON-A-167, and ICPP-MON-V-200 were purged for approximately 83 hours at the maximum rate possible for each well. Aluminum, iron, and manganese concentrations were significantly reduced in the April 2004 samples compared to the previous October 2003 sampling event for wells ICPP-MON-A-166 and ICPP-MON-A-167. For the October 2004 sampling event, these wells were purged to three well volumes as required by the permit instead of the extended purge time that was

performed in April 2004. The concentrations of these metals in ICPP-MON-A-167 (the upgradient well) and ICPP-MON-V-200 (a perched water well) increased in October 2004 compared to the April 2004 sample results with the extended purge time. Additional purge time will be considered for future sampling events.

Unlike wells ICPP-MON-A-167 and ICPP-MON-V-200, well ICPP-MON-A-166 did not show a significant increase in the metals concentrations between the April and October 2004 sampling events. Hull, Wright, and Street (2004) indicated that there was a potential that the bottom of the well screen in well ICPP-MON-A-166 might have been damaged by a pipe that had accidentally been dropped down the well bore. In addition, the turbidity in the well was not reduced during the extended purging in April 2004. Because of this, a sand/gravel pack was placed in well ICPP-MON-A-166 prior to the October 2004 sampling event. Approximately 0.6 m (2 ft) of silica sand was placed at the bottom of the well followed by a 0.6 m (2 ft)-thick layer of washed pea gravel. The sampling logbook indicates that the water cleared up quickly and remained clear during the October 2004 sampling. Future sampling events will determine whether the sand gravel pack was effective.

Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant

Description - The INTEC Sewage Treatment Plant (STP) was regulated under WLAP LA-000115-02 through December 2, 2004. A major permit modification request was submitted to the DEQ in 2003 to address the inability to maintain effluent total nitrogen, to eliminate a discharge in the area near INTEC, and to reduce the number of WLAPs. On December 2, 2004, coverage under WLAP LA-000115-02 was terminated when the INTEC STP effluent was combined with the INTEC service waste system wastewater and discharged to the INTEC New Percolation Ponds rather than to the INTEC STP rapid infiltration (RI) trenches. This discharge is now regulated under WLAP LA-000130-04.

The sewage system consists of seven lift stations, which pump the 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-000115-02, the INTEC STP consisted of:

- Two aerated lagoons (Cell Nos. 1 and 2);
- Two quiescent, facultative stabilization lagoons (Cell Nos. 3 and 4), with temporary surface aerators installed in Cell No. 3 in 2001;
- Four RI trenches; and
- Six control stations (weir boxes).

Since the INTEC STP permit (WLAP LA-000130-04) became effective on December 2, 2004, piping to the RI trenches was disconnected, the RI trenches were filled with soil, and the surface aerators were removed.

Automatic flow-proportional composite samplers are located at control stations CPP-769 (influent) and CPP-773 (wastewater from the Sewage Treatment Plant to the rapid infiltration trenches). The composite samplers collect 24 hr flow-proportional samples as required by the permit.

WLAP Wastewater Monitoring Results - The WLAP LA-000115-02 set effluent (CPP 773, wastewater from the STP to the RI trenches) limits for total nitrogen (total Kjeldahl nitrogen [TKN] + nitrogen, nitrate [NO_3] + nitrite [NO_2]) and TSS and required that the influent and effluent be sampled and analyzed monthly for these and several other parameters. 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 wastewaters 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 5-10 and 5-11. All samples are collected as 24 hour flow proportional composites, except the monthly total coliform grab samples and the pH grab samples at CPP-773 and CPP-797 under WLAP LA-000130-04 starting December 2, 2004.

Monthly effluent TSS concentrations remained below the limit (effective through December 1, 2004) of 100 mg/L for the reporting period. Monthly total nitrogen exceeded the monthly average limit (effective through December 1, 2004) of 20 mg/L during February 2004, June 2004, and August 2004. With the termination of the INTEC STP WLAP (LA-000115-02) on December 2, 2004, the wastewater will no longer be discharged to the INTEC STP RI trenches, and the combined effluent being discharged to the INTEC New Percolation Ponds is not expected to have the elevated concentrations associated with the INTEC STP effluent.

Total annual effluent flow to the trenches was 41.56 million L (10.98 MG) during 2004. This total includes estimated flow volumes for periods when the flow meter was out of service.

Table 5-10. Summary of INTEC Sewage Treatment Plant influent monitoring results (2004).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Biological Oxygen Demand (5-day)	83.00	379.00	204.33	NA[c]
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.020	1.050	0.116	NA
Total Phosphorus	3.26	7.85	5.88	NA
Nitrogen, Total Kjeldahl	11.20	50.40	34.24	NA
Total Suspended Solids	91.10	312.00	174.26	NA

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

Table 5-11. Summary of INTEC Sewage Treatment Plant effluent monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Biological Oxygen Demand (5-day)	10.20	427.00	72.28	NA[d]
Conductivity (composite) (µS)[e]	699	1087	872	NA
Chloride	94.00	179.00	129.25	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.005[f]	11.500	1.361	NA
Total Phosphorus	3.10	4.87	3.84	NA
Total Dissolved Solids	270	647	464	NA
Nitrogen, Total Kjeldahl	8.47	29.90	16.00	NA
Total Suspended Solids	2.00[f]	60.90	33.82	100
Total Coliform (colonies/100 mL)	220	80,000	10,091	NA
Total Nitrogen[g]	9.17	29.9	17.35	20

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. The 24-hour composite sample for September 2004 could not be taken due to low flows in the ponds.
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. NA—Not applicable; no permit limit is set for this parameter.
e. Conductivity readings were collected on two separate days in July and are included in the summaries. The maximum conductivity reading was from one of these samples.
f. Sample result was less than the detection limit; value shown is half the detection limit.
g. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite.

WLAP Groundwater Monitoring Results - To measure potential INTEC Sewage Treatment Plant impacts to groundwater, WLAP LA-000115-02 required collecting groundwater samples semiannually from three monitoring wells:

- One background aquifer well (USGS 121) upgradient of INTEC;
- One perched water well (ICPP-MON-PW-024) immediately adjacent to the Sewage Treatment Plant; and
- One aquifer well (USGS-052) downgradient of the Sewage Treatment Plant, which serves as the point of compliance.

Sampling was conducted semiannually (April and October) and included a list of specified parameters for analysis. Contaminant concentrations in USGS 052 were limited by the PCS and SCS specified in Idaho regulations (IDAPA 58.01.11, "Ground Water Quality Rule"). All permit required samples are collected as unfiltered samples.

During the 2004 permit year, groundwater samples were collected in April and October. Duplicate samples were collected from USGS-052 in April and October 2004. Table 5-12 shows water table elevations and depth to water table, determined prior to purging and sampling, and analytical results for all parameters required by the permit. Groundwater samples collected from USGS-052 were in compliance with all permit limits during 2004. As in previous years, concentrations of chloride and nitrate as nitrogen in USGS-052 were elevated compared to USGS-121.

Monitoring well ICPP-MON-PW-024 was constructed in the perched water zone approximately 21 m (70 ft) below the surface of the infiltration trenches. It is used as an indicator of treatment efficiency of the soil rather than serving as a point of compliance.

The TDS concentrations in well ICPP-MON-PW-024 typically have been above the SCS of 500 mg/L. For permit year 2004, the TDS concentration in this well increased from 516 mg/L in April to 617 mg/L in October.

Total nitrogen concentrations (comprised of nitrate as nitrogen [NO_3-N], nitrite as nitrogen [NO_2-N], and TKN) in the perched water closely followed those of the effluent prior to 1997, the difference being that nearly all the total nitrogen in the perched water was comprised of NO_3-N, while the effluent was primarily comprised of ammonia as nitrogen (NH_3-N). This suggests significant nitrification (a process whereby NH_3-N is converted to NO_3-N) by the soil but little denitrification to a gas. This can be seen in the April 2004 sample from well ICPP-MON-PW-024 where the NO_3-N concentration was above the PCS of 10 mg/L and in the October 2004 sample where the NO_3 N was just slightly below the PCS.

Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the data were rejected and the wells were resampled for total and fecal coliform in July 2004. Because a determination was made to reject the April 2004 coliform data, only the July and October 2004 sample results are presented in Table 5-12. Total coliform was detected in both the July and October 2004 samples from ICPP-MON-PW-024. In both instances, the laboratory reported the total coliform results as "too numerous to count" (TNTC). The analytical method allows the laboratory to report total coliform as TNTC when the count exceeds 200 colonies/100 mL. For comparison, the PCS for total coliform is 1 colony/100 mL.

Fecal coliform was also detected in both the July and October 2004 samples collected for well ICPP-MON-PW-024 at 197 colonies/100 mL and 2 colonies/100 mL, respectively. There is not a specific PCS or SCS for fecal coliform. Fecal coliform consists of various genera and species of coliform that are specifically associated with human and animal wastes. The treatment processes at the INTEC STP do not include disinfection of the wastewater. Therefore, the likely source of coliform bacteria in well ICPP-MON-PW-024 was the INTEC STP effluent percolating to the perched water zone in which this well is located.

With the termination of WLAP LA-000115-02, discharge to the RI trenches has been discontinued, and the perched water zone in which ICPP-MON-PW-024 is located is expected to dry up.

Table 5-12. INTEC Sewage Treatment Plant groundwater monitoring results (2004).

Depth to Water Table (ft)	ICPP-MON-PW-024 (GW-011502)		USGS-52 (GW-011501)				USGS-121 (GW-011503)		PCS/SCS[a]
	59.4	59.43	460.02	460.02	460.35	460.35	461.20	462.97	
Water Table Elevation (ft)	4,850.4	4,850.37	4,452.94	4,452.94	4,452.61	4,452.61	4,451.96	4,450.19	
Sample Date (units[e])	4/12/2004[b] (mg/L)	10/26/2004 (mg/L)	4/14/2004[c] (mg/L)	4/14/2004[c,d] (mg/L)	10/13/2004 (mg/L)	10/13/2004[d] (mg/L)	4/12/2004[b] (mg/L)	10/13/2004 (mg/L)	(mg/L)
TKN	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	NA[g]
Chloride	96.3	137	27.1	27.2	27.3	27.4	12.4	14.2	250
TDS	516	617	242	245	266	262	229	238	500
NO_3-N	15.6	9.8	3.1	3.1	2.9	2.9	0.78	0.79	10
NO_2-N	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	1
NH_4-N	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
BOD	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NA
Total phosphorus	1.62	2.13	0.0406 U	0.0382 U	0.05 U	0.05 U	0.0335 U	0.05 U	NA
Total coliform	TNTC[h]	TNTC	Absent	Absent	Absent	Absent	Absent	Absent	1 col/100 mL
Fecal coliform	197	2	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. Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the well was resampled for coliform on 7/19/2004.
c. Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the well was resampled for coliform on 7/20/2004.
d. Duplicate sample.
e. The units for all parameters listed are in mg/L except for total and fecal coliform, which are listed as colonies/100 ml.
f. U flag indicates that the result was reported as below the detection limit.
g. NA—Not applicable.
h. TNTC—Too numerous to count.

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

- A wastewater-collection manhole;
- An Imhoff tank;
- Sludge drying beds;
- A trickle filter and settling tank;
- A contact basin (currently not in use); and
- An infiltration disposal pond.

The TAN/TSF Disposal Pond was constructed in 1971; prior to that, treated wastewater was disposed of through an injection well. The TAN/TSF Disposal Pond consists of a primary disposal area and an overflow section, both of which are located within an unlined, fenced 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 3623 m^2 (39,000 ft^2) and 1338 m^2 (14,400 ft^2), respectively, for a combined area of approximately 4961 m^2 (53,400 ft^2). 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 wastes from restrooms, sinks, and showers. The sanitary wastewater goes to the TAN 623 Sewage Treatment Facility, and then to the TAN 655 Lift Station, which pumps to the TAN/TSF Disposal Pond.

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

WLAP Wastewater Monitoring Results - Total effluent to the TAN/TSF Disposal Pond for calendar year 2004 was approximately 45.7 million L (12.07 MG). This total does not include estimated flow volumes for two short periods when the flow meter was out of service. Using historical flow data for these periods would increase the annual total by less than 10 percent.

The permit for the TAN/TSF Sewage Treatment Facility also sets concentration limits for total suspended solids and total nitrogen measured in the effluent to the TAN/TSF Disposal Pond and

requires that the effluent be sampled and analyzed monthly for several parameters. During 2004, 24 hr composite samples (except fecal and total coliform, which were grab samples) were collected monthly from the TAN-655 lift station effluent.

Table 5-13 summarizes the effluent monitoring results for calendar year 2004. Monthly concentrations of TSS were below the permit limit (100 mg/L) with the exception of the December 2004 sample that had a concentration of 134 mg/L. Beginning with the October 2004 sample (89.8 mg/L), TSS in the effluent samples have shown a significant increase. Prior to October 2004, the previous highest concentration in 2004 was in the January sample at 25 mg/L.

Table 5-13. Summary of TAN/TSF Sewage Treatment Facility effluent monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Biological Oxygen Demand (5-day)	9.13	71.20	24.02	NA[d]
Chloride	21.30	302.00	95.78	NA
Fluoride	0.100[e]	0.557	0.271	NA
Nitrogen, as Ammonia	0.317	8.530	2.169	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	0.096	6.340	3.200	NA
Nitrogen, Total Kjeldahl	1.51	15.70	4.62	NA
Total Nitrogen[f]	2.26	19.40	7.78	20
Total Phosphorus	0.481	2.790	1.563	NA
Sulfate	33.80	55.20	41.93	NA
Total Dissolved Solids	163	797	406	NA
Total Suspended Solids	2.00[e]	134.00	35.54	100
Arsenic	0.0015[e]	0.006	0.003	NA
Barium	0.095	0.179	0.117	NA
Chromium	0.003	0.030	0.009	NA
Iron	0.144	2.860	0.820	NA
Lead	0.0002[e]	0.0115	0.0030	NA
Manganese	0.004	0.035	0.013	NA
Mercury	0.0001[e]	0.0007	0.0003	NA
Selenium	0.01[e]	0.01[e]	0.01[g]	NA
Sodium	9.15	186.00	58.93	NA
Zinc	0.028	0.440	0.120	NA
Fecal Coliform (colonies/100 mL)	1,727	59,000	24,905	NA
Total Coliform (colonies/100 mL)	23,000	160,000	79,083	NA

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

b. Duplicate samples were collected in July for all parameters (excluding 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. NA—Not applicable; no permit limit is set for this parameter.

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

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

g. 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.

It is believed that sediment has washed into the manholes of the TAN/TSF collection system and deposited in the sump where the effluent samples are collected. Removal of the sediment from these locations is planned.

All monthly total nitrogen (TKN + nitrogen, nitrite+nitrate) concentrations were below the permit limit of 20 mg/L, with the maximum monthly concentration of 19.4 mg/L reported in October 2004.

WLAP Groundwater Monitoring Results - To measure potential TAN/TSF Disposal Pond impacts to groundwater, the WLAP for the TAN/TSF Sewage Treatment Facility requires collecting groundwater samples semiannually from four monitoring wells:

- One background aquifer well (TANT MON-A-001) upgradient of the TAN/TSF Disposal Pond; and
- Three aquifer wells (TAN-10A, TAN 13A, and TANT-MON-A-002) that serve as permit points of compliance.

Sampling must be conducted semiannually and includes several specified parameters for analysis. Contaminant concentrations in TAN-10A, TAN-13A, and TANT-MON-A-002 are limited by the permit to the PCS and SCS levels in IDAPA 58.01.11, "Ground Water Quality Rule." All permit required samples are collected as unfiltered samples.

During the 2004 permit year, groundwater samples were collected in April and October. Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the April results were rejected, and the wells were resampled for total and fecal coliform in July 2004. Table 5-14 shows water table elevations and depth to water table, determined prior to purging and sampling, and analytical results for all parameters specified by the permit.

Iron concentrations exceeded the SCS of 0.3 mg/L in well TAN-10A in April and October 2004. Iron concentrations in additional filtered samples collected in April and October 2004 from well TAN 10A also exceeded the SCS. Elevated iron concentrations historically have been detected in the TAN WLAP monitoring wells.

Video log information gathered in 2001 on well TAN-10A showed that the carbon steel well casing appeared corroded most of the way to the water table, 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. The iron concentrations in well TAN-10A increased after the maintenance was performed in 2001 that replaced the galvanized riser pipe. The iron concentrations in well TAN-10A were above the SCS (0.3 mg/L) in both April 2003 (0.433 mg/L) and October 2003 (1.07 mg/L), but were lower then those in October 2002 (3.02 mg/L and 3.22 mg/L, duplicate). The iron results from April 2004 (1.05 mg/L) and October 2004 (0.872 mg/L) showed similar concentrations to October 2003 and were also above the iron SCS. The residual effects relating to the replacement of the galvanized riser pipe appear to have caused the temporary increase in the iron concentration in October 2002.

The majority of the iron in well TAN-10A appears to be in solution. Table 5-14 shows that the filtered (0.45 µm filter) iron concentrations in this well are similar to the concentrations in the

Table 5-14. TAN/TSF Sewage Treatment Facility groundwater monitoring results (2004).

Depth to Water	TANT-MON-A-001 (GW-015301)		TANT-MON-A-002 (GW-015304)				TAN-10A (GW-015303)		TAN-13A (GW-15302)		PCS/SCS[a]
Table (ft)	206.68	210.78	211.24	211.24	214.42	214.42	208.39	212.18	210.35	212.70	
Water Table Elevation (ft)	4,578.88	4,574.78	4,576.37	4,576.37	4,573.19	4,573.19	4,575.75	4,571.96	4,573.65	4,571.3	
Sample Date (units[e])	4/13/2004[b] (mg/L)	10/20/2004 (mg/L)	4/13/2004[b] (mg/L)	4/13/2004[b,c] (mg/L)	10/20/2004 (mg/L)	10/20/2004[c] (mg/L)	4/19/2004[d] (mg/L)	10/12/2004 (mg/L)	4/19/2004[d] (mg/L)	10/12/2004 (mg/L)	(mg/L)
TKN	0.10 U[f]	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.53 R[g]	0.10 U	0.77	0.10 U	NA[h]
BOD	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	7.6	6.6	2.0 U	2.0 U	NA
Chloride	11.7	11.1	3.9	4.0	3.9	3.9	99.5	106	4.3	4.2	250
TDS	208	243	171	169	211	210	476	501	174	188	500
Total phosphorus	0.0643 U	0.05	0.0477 U	0.0596 U	0.05 U	0.0524	0.0841	0.114	0.0292	0.05 U	NA
Sodium	7.58	7.82[i]	6.42	6.21	6.39[i]	6.35[i]	48.2	48.9	5.95	5.83[i]	NA
NO_3-N	0.95	0.87	0.58	0.58	0.52	0.51	0.02 U	0.02 U	0.67	0.41	10
NO_2-N	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	1
NH_4-N	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
Arsenic	0.003	0.0018	0.0026	0.0029	0.0017	0.0015	0.0014	0.00081	0.0022	0.0017	0.05
Arsenic (reanalysis)	—	—	—	—	—	—	—	0.0033 U[j]	—	—	0.05
Barium	0.080	0.0755	0.0785	0.0762	0.0719	0.0705	0.245	0.260	0.0748	0.0744	2
Barium (reanalysis)	—	—	—	—	—	—	—	0.233[j]	—	—	2
Chromium	0.0044	0.0047	0.0067	0.0064	0.0061	0.0058	0.00043 U	0.0002 U	0.0048	0.0047	0.1
Chromium (reanalysis)	—	—	—	—	—	—	—	0.0011[j]	—	—	0.1
Mercury	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.00022	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.002
Selenium	0.0016	0.0016	0.0016	0.0021	0.0014	0.0011	0.00085 U	0.00092 U	0.00099	0.0017	0.05
Selenium (reanalysis)	—	—	—	—	—	—	—	0.00092 U[j]	—	—	0.05
Fluoride	0.21	0.19	0.18	0.20	0.18	0.19	0.13	0.16	0.18	0.19	4
Iron	0.0067 U	0.0355 U	0.0495	0.0475	0.0504	0.0509	1.05	0.872	0.0349	0.0603	0.3
Iron (reanalysis)	—	—	—	—	—	—	—	0.754[j]	—	—	0.3
Iron (filtered)	—	—	—	—	—	—	0.744	0.930	—	—	0.3
Iron (filtered-reanalysis)	—	—	—	—	—	—	—	0.860[j]	—	—	0.3
Lead	0.0005 U	0.00055 U	0.0005 U	0.0005 U	0.00055 U	0.00055 U	0.0005 U	0.00055 U	0.0005 U	0.00055 U	0.015
Lead (reanalysis)	—	—	—	—	—	—	—	0.00055U[j]	—	—	0.015
Manganese	0.00002 U	0.00036	0.0019	0.0018	0.0013	0.0015	0.0099	0.423	0.0035	0.0011	0.05
Manganese (reanalysis)	—	—	—	—	—	—	—	0.371[j]	—	—	0.05
Sulfate	29.8	28.6	15.1	15.1	14.4	14.4	39.1	41.1	15.1	16.1	250

Table 5-14. TAN/TSF Sewage Treatment Facility groundwater monitoring results (2004) (continued).

Depth to Water	TANT-MON-A-001 (GW-015301)		TANT-MON-A-002 (GW-015304)				TAN-10A (GW-015303)		TAN-13A (GW-15302)		PCS/SCS[a]
Table (ft)	206.68	210.78	211.24	211.24	214.42	214.42	208.39	212.18	210.35	212.70	
Water Table Elevation (ft)	4,578.88	4,574.78	4,576.37	4,576.37	4,573.19	4,573.19	4,575.75	4,571.96	4,573.65	4,571.3	
Sample Date (units[e])	4/13/2004[b] (mg/L)	10/20/2004 (mg/L)	4/13/2004[b] (mg/L)	4/13/2004[b,c] (mg/L)	10/20/2004 (mg/L)	10/20/2004[c] (mg/L)	4/19/2004[d] (mg/L)	10/12/2004 (mg/L)	4/19/2004[d] (mg/L)	10/12/2004 (mg/L)	(mg/L)
Zinc	0.0443	0.0512	0.115	0.108	0.097	0.0937	0.0275	0.0140	0.140	0.153	5
Zinc (reanalysis)	—	—	—	—	—	—	—	0.0178[j]	—	—	5
Total coliform	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	1 col/100 mL
Fecal coliform	Absent	Absent	Absent	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. Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the well was resampled for coliform on 7/22/2004.

c. Duplicate sample.

d. Due to quality control issues associated with the April 2004 total and fecal coliform analyses, the well was resampled for coliform on 7/21/2004.

e. The units for all parameters listed are in mg/L except for total and fecal coliform, which are listed as colonies/100 ml.

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

g. R flag indicates that the result was rejected during validation and that the result was not used in any summaries.

h. NA—Not applicable.

i. The initial result was rejected during validation due to quality control issues. A reanalysis was requested, and the results of that reanalysis are presented.

j. A reanalysis was requested due to higher than expected results for some metals associated with this data package. The results of that reanalysis are presented.

unfiltered samples. It is unclear what impact the concentration of iron in the effluent is having on the iron concentrations in well TAN-10A. For 2004, iron concentrations in 8 of the 12 effluent samples were at or above the SCS of 0.3 mg/L. However, the effluent samples are all collected as unfiltered samples. Therefore, it is unknown whether the iron in the effluent is dissolved in solution. Further evaluation is needed to determine the impacts from the effluent, condition of the well, past disposal practices, and remediation activities are having on the iron concentration in samples collected from well TAN-10A.

For well TAN-10A, manganese was above the SCS of 0.05 mg/L in October 2004. The October 2004 manganese concentration was significantly higher than in April 2004 (Table 5-14) and in both April and October 2003. This is the first time since the original permit was issued that the manganese concentration in this well exceeded the groundwater quality standard, and no cause for the exceedance was identified. Manganese in well TAN-10A will continue to be monitored semiannually, and future groundwater quality standard exceedances will be investigated.

Well TAN-10A continues to have intermittent problems meeting the TDS SCS of 500 mg/L. The April 2004 TDS concentration in well TAN-10A was below the SCS, but the October 2004 concentration (501 mg/L) slightly exceeded the SCS. The condition of the well casing may be contributing to the TDS concentrations in this well. In addition, the TDS in the effluent may be impacting the concentrations in this well. TDS concentrations in th effluent have fluctuated over time, and have occasionally exceeded 500 mg/L.

Total and fecal coliform samples were collected in April and October 2004 as required by the TAN/TSF Sewage Treatment Facility WLAP. However, as stated earlier, due to quality control issues associated with the April 2004 total and fecal coliform analyses, the data were rejected, and the wells were resampled for total and fecal coliform in July 2004. Analytical results (Table 5-14) show that both total and fecal coliform were absent in all samples and wells during the 2004 permit year.

Test Reactor Area Cold Waste Pond

Description - The TRA 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 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 (TRA 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 (TKN + nitrogen, nitrite + nitrate) and total suspended solids 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 5.3.

Automated samplers are used to collect quarterly 24-hour time-proportional composite samples from TRA-764. Total suspended solids and total nitrogen results are summarized in Table 5-15. For 2004, all total suspended solids 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 2004 was 2.55 mg/L, which was significantly less than the regulatory limit of 20 mg/L.

Table 5-15. Summary of TRA Cold Waste Pond effluent monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit[d]
Total Suspended Solids	2[e]	2[e]	2[f]	100
Total Nitrogen[g]	0.4	2.55	1.38	20

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were taken in May and are included in the summaries.
c. 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.
d. Effluent limit specified in IDAPA 58.01.17.600.06B, Wastewater Land Application Permit Rules.
e. Sample result was less than the detection limit; value shown is half the detection limit.
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. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite.

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

5.3 Liquid Effluent Surveillance Monitoring

As stated in Section 5.2, additional radiological and nonradiological parameters specified in the Idaho groundwater quality standards also are monitored. The results of this additional monitoring are discussed by individual facility in the following sections. This additional monitoring is performed to comply with DOE Order 450.1 and 5400.5 environmental protection objectives.

Argonne National Laboratory-West

During 2004, the Industrial Waste Pond, Industrial Waste Ditch, and Secondary Sanitary Lagoon at ANL-W were monitored monthly for iron, sodium, chloride, fluoride, sulfate, pH, conductivity, total dissolved solids, turbidity, biological oxygen demand, gross alpha, gross beta, gamma spectrometry, and tritium. Additionally, the Secondary Sanitary Lagoon was also monitored monthly for total coliform. All chemical parameters for both ponds and the waste ditch were well below applicable limits. (Table 5-16)

Table 5-16. Summary of ANL-W liquid effluent surveillance monitoring results (2004).[a,b]

Parameter	Unit	min	max	avg
Industrial Waste Pond				
Chloride	ug/L	4.50E+03	6.10E+04	3.88E+04
Chromium	ug/L	2.75E+01	2.75E+01	2.75E+01
Fluoride	ug/L	1.00E+03	1.00E+03	1.00E+03
Gross Alpha	pCi/L	2.00E+01	6.00E+02	1.86E+02
Gross Beta	pCi/L	2.00E+01	2.00E+02	6.50E+01
Iron	ug/L	1.00E+02	6.70E+02	2.83E+02
Lead	ug/L	1.72E+00	1.72E+00	1.72E+00
Mercury	ug/L	4.70E-02	4.70E-02	4.70E-02
pH Measurement	pH	6.54E+00	8.89E+00	7.71E+00
Sodium	ug/L	2.51E+04	4.32E+04	3.11E+04
Sulfate	ug/L	2.00E+03	2.50E+04	1.78E+04
Tritium	pCi/L	3.50E+01	3.50E+01	3.50E+01
Industrial Waste Ditch				
Chloride	ug/L	1.00E+03	3.17E+05	8.42E+04
Fluoride	ug/L	2.90E+01	1.10E+03	9.03E+02
Gross Alpha	pCi/L	2.00E+01	6.00E+02	2.13E+02
Gross Beta	pCi/L	2.00E+01	2.00E+02	8.00E+01
Iron	ug/L	1.00E+02	1.50E+02	1.22E+02
Lead	ug/L	1.72E+00	1.72E+00	1.72E+00
Mercury	ug/L	4.70E-02	4.70E-02	4.70E-02
pH Measurement	pH	6.65E+00	7.70E+00	7.52E+00
Phosphate	ug/L	1.00E+03	1.40E+03	1.07E+03
Sodium	ug/L	2.04E+04	1.87E+05	5.41E+04
Sulfate	ug/L	1.40E+04	1.90E+04	1.74E+04
Tritium	pCi/L	3.50E+01	3.50E+01	3.50E+01
Secondary Sanitary Lagoon				
Chloride	ug/L	2.10E+04	2.74E+05	1.87E+05
Fluoride	ug/L	1.00E+03	1.00E+03	1.00E+03
Gross Alpha	pCi/L	2.00E+01	6.00E+02	1.86E+02
Gross Beta	pCi/L	2.00E+01	2.00E+02	7.14E+01
Iron	ug/L	1.00E+02	3.60E+02	1.78E+02
Lead	ug/L	1.72E+00	1.72E+00	1.72E+00
Mercury	ug/L	4.70E-02	4.70E-02	4.70E-02
pH Measurement	pH	6.23E+00	8.67E+00	7.57E+00
Phosphate	ug/L	1.00E+03	2.80E+04	1.69E+04
Sodium	ug/L	2.10E+03	1.99E+05	1.28E+05
Sulfate	ug/L	2.20E+03	9.40E+04	6.02E+04
Tritium	pCi/L	3.50E+01	3.50E+01	3.50E+01

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 5-17 summarizes the additional monitoring conducted during 2004 at the CFA Sewage Treatment Plant and shows those parameters with at least one detected result during the year. Additional monitoring is performed quarterly from the floor drains and vehicle maintenance areas of the Transportation Complex at CFA 696. During 2004, most additional parameters were within historical concentration levels.

Table 5-17. Summary of CFA liquid effluent surveillance monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Influent to CFA Sewage Treatment Plant Pond 1				
Conductivity (µS) (grab)	732	3,721	1,303	NA
Total Phosphorus	1.01	4.34	2.27	NA
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System				
Conductivity (µS) (grab)	1,282	1,644	1,406	NA
Chloride[d]	436	436	436	NA
Fluoride[d]	0.309	0.309	0.309	NA
Sulfate[d]	65.20	65.20	65.20	NA
Total Dissolved Solids[d]	1,020	1,020	1,020	NA
Arsenic[d]	0.003	0.003	0.003	NA
Barium[d]	0.117	0.117	0.117	NA
Copper[d]	0.058	0.058	0.058	NA
Iron[d]	0.105	0.105	0.105	NA
Manganese[d]	0.006	0.006	0.006	NA
Mercury[d]	0.0006	0.0006	0.0006	NA
Sodium[d]	173	173	173	NA
Zinc[d]	0.003	0.003	0.003	NA
Gross Beta[d,e]	6.46 ± 1.49	6.46 ± 1.49	6.46 ± 1.49	NA
Tritium[d,e]	5,650 ± 420	5,650 ± 420	5,650 ± 420	NA
Potassium-40[d,e]	147.00 ± 90.60	147.00 ± 90.60	147.00 ± 90.60	NA
Strontium-89[d,e]	0.33 ± 0.18	0.33 ± 0.18	0.33 ± 0.18	NA
Transportation Complex, CFA-696				
pH (standard units) (grab)	7.76	8.57	7.98	NA
Conductivity (µS) (grab)	699	979	832	NA
Total Oil and Grease	5.58	23.50	15.85	NA

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).

Idaho Nuclear Technology and Engineering Center

Wastewater Land Application Permits are in effect for the INTEC Sewage Treatment Plant and the INTEC New Percolation Ponds. Table 5-18 summarizes the additional monitoring conducted during 2004 at INTEC and shows those parameters with at least one detected result during the year.

During 2004, most additional parameters were within historical concentration levels. No parameters were analyzed for at the INTEC New Percolation Ponds beyond those required by the permit.

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 [^{89}Sr], strontium-90 [^{90}Sr], iodine-129 [^{129}I], and tritium, which are monitored annually]. Table 5-19 summarizes the results of this additional monitoring for those parameters with at least one detected result. During 2004, the concentrations of most additional parameters were within historical concentration levels.

Table 5-18. Summary of INTEC liquid effluent surveillance monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Influent to INTEC Sewage Treatment Plant				
Conductivity (µS)	674	1,084	874	NA
pH (standard units)	8.27	9.02	8.62	NA
Effluent from INTEC Sewage Treatment Plant				
pH (standard units) (grab)	7.30	8.83	8.21	NA
Conductivity (µS) (grab)	695	1,078	872	NA
Sulfate	40.80	40.80	40.80	NA
Barium	0.088	0.088	0.088	NA
Copper	0.003	0.003	0.003	NA
Iron	0.138	0.138	0.138	NA
Manganese	0.017	0.017	0.017	NA
Sodium	104	106	105	NA
Zinc	0.008	0.008	0.008	NA
Gross Beta[d]	6.76 ± 1.09	16.10 ± 2.62	8.43 ± 0.77	NA
Cobalt-60[d]	1.51 ± 0.89[e]	1.51 ± 0.89[e]	1.52 ± 0.85	NA

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. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
e. Maximum is based on detected results only. For cobalt-60, only one result was detected during the year. Therefore, the minimum and maximum are the same.

Table 5-19. Summary of TAN liquid effluent surveillance monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Effluent to TAN/TSF Disposal Pond				
Conductivity (µS) (grab)	451	1638	815	NA
pH (standard units) (grab)	7.47	9.52	8.22	NA
Aluminum	0.044	1.780	0.398	NA
Copper	0.005	0.097	0.033	NA
Nickel	0.0015[d]	0.005	0.002	NA
Gross Alpha[e]	1.27 ± 1.45[f]	2.99 ± 1.68	2.00 ± 1.10	NA
Gross Beta[e]	6.82 ± 1.51	41.90 ± 4.38	10.95 ± 1.22	NA
Cesium-137[e]	2.21 ± 2.80[f]	28.50 ± 7.80	5.21 ± 2.64	NA
Potassium-40[e]	68.00 ± 53.20	114.00 ± 56.00	89.82 ± 38.57	NA
Strontium-89[e]	-2.27 ± 0.51[f]	0.55 ± 0.36	0.01 ± 0.06	NA
Strontium-90[e]	0.47 ± 0.72[f]	17.40 ± 2.50	2.28 ± 0.20	NA
Uranium-235[e]	5.67 ± 29.60[f]	26.60 ± 17.58	18.94 ± 12.53	NA

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

Since strontium-90 exceeded the drinking water Maximum Contaminant Levels (MCLs) in January 2004, additional samples for strontium-90 were collected throughout the year, and none of the additional samples exceeded MCLs. It was subsequently determined that the presence of strontium-90 in the TAN-655 effluent is incidental to past processes, and no further evaluation or analyses are necessary (Hutten 2004)

Test Reactor Area

The effluent to the Cold Waste Pond receives a combination of process water from various TRA facilities. Additional monitoring for surveillance purposes is conducted quarterly for metal parameters and for radiological parameters. Table 5-20 summarizes the results of this additional monitoring for those parameters with at least one detected result. During 2004, the concentrations of the additional parameters were within historical levels.

The largest volume of wastewater received by the TRA Cold Waste Pond is secondary cooling water from the Advanced Test Reactor when it is in operation. During 2004, concentrations of sulfate and TDS were elevated in samples collected during reactor operation. These differences are due to 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

Table 5-20. Summary of TRA effluent surveillance monitoring results (2004).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Effluent from TRA Cold Waste Pond				
Conductivity (µS) (grab)	395	1,119	756	NA
pH (standard units) (grab)	7.65	8.13	7.86	NA
Chloride	10.20	33.60	22.60	NA
Fluoride	0.100[d]	0.394	0.174	NA
Nitrogen, Nitrate + Nitrite (mg-N/L)	0.301	2.390	1.232	NA
Sulfate	21.10	440.00	139.58	NA
Total Dissolved Solids	269	829	429	NA
Total Kjeldahl Nitrogen	0.0500[d]	0.161	0.100	NA
Antimony	0.0003[d]	0.0012	0.0005	NA
Arsenic	0.0015[d]	0.005	0.003	NA
Barium	0.047	0.121	0.068	NA
Chromium	0.003	0.011	0.005	NA
Copper	0.0005[d]	0.003	0.002	NA
Iron	0.049	0.109	0.070	NA
Sodium	7.71	24.60	12.65	NA
Zinc	0.0015[d]	0.003	0.002	NA
Gross Alpha[e]	2.70 ± 1.50	2.86 ± 1.58	2.78 ± 1.09	NA
Gross Beta[e]	9.78 ± 1.59	10.50 ± 2.06	10.05 ± 1.26	NA
Potassium-40[e]	9.35 ± 36.4[f]	36.90 ± 21.60	28.69 ± 16.07	NA

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.

release levels specific for the TRA 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.

5.4 Drinking Water Monitoring

In 1988, a centralized drinking water program was established. Each contractor (BBWI, ANL-W, and NRF) participates in the INEEL Drinking Water Program. However, during 2004, each contractor (BBWI, BNFL, NRF, ANL-W) administered their own drinking water program.

The Drinking Water Program was established to monitor drinking water wells, which are multiple use wells for industrial use, fire safety, and drinking water. According to the "Idaho Regulations for Public Drinking Water Systems" (IDAPA 58.01.08), INEEL drinking water systems are classified as either nontransient or transient, noncommunity water systems. The M&O 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 M&O 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 MCLs are not exceeded). The federal Safe Drinking Water Act also establishes requirements for the Drinking Water Program.

Because groundwater supplies the drinking water at the INEEL, information on groundwater quality was used to help develop the Drinking Water Program. The U.S. Geological Survey (USGS) and the various contractors monitor and characterize groundwater quality at the INEEL. Three groundwater contaminants have impacted M&O 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 (CFR) parts 141-143. State regulations also require the use of laboratories that are certified by the state of Idaho or certified by another state whose certification is recognized by the state of Idaho for their drinking water analyses. The DEQ oversees the certification program and maintains a listing of approved laboratories.

Currently, the M&O contractor Drinking Water Program monitors 10 onsite water systems, which include 17 wells. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Parameters with primary MCLs must be monitored at least once during every three-year compliance period. Parameters with secondary MCLs are monitored every three years based on a recommendation by the EPA. The three year compliance periods for the M&O contractor Drinking Water Program are 2002 to 2004, 2005 to 2007, 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 M&O 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 2004, no maximum contaminant level was exceeded at M&O contractor drinking water systems.

M&O Contractor Drinking Water Monitoring Results

During 2004, 435 routine samples and 55 quality control samples were collected and analyzed from CFA, EBR-I, Gun Range, INTEC, Main Gate, Power Burst Facility (PBF), RWMC, TAN/Contained Test Facility (CTF), TAN/TSF, and TRA. In addition to the routine sampling, the M&O contractor Drinking Water Program 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. Fifty requests for nonroutine sampling were received during 2004.

Analytical results of interest (carbon tetrachloride, trichloroethylene, and tritium) and nitrate (required to be monitored annually) results for 2004 are presented in Tables 5-21 and 5-22, respectively, and are discussed in the following subsections. EBR-I, Gun Range, INTEC, Main Gate, PBF, and TAN/CTF were well below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report.

Table 5-21. Monitored drinking water parameters of interest in 2004.

Parameter[a]	Location	Results[b]	MCL[b]
Carbon Tetrachloride	RWMC Distribution	3.35	5
	RWMC Well[c]	4.88	NA[d]
Trichloroethylene	RWMC Distribution	1.65	5
	RWMC Well[c]	2.15	NA
	TAN/TSF Distribution	1.40	5
	TAN/TSF #2 Well[c]	2.50	NA
Tritium	CFA Distribution	7,594 ± 201	20,000
	CFA #1 Well[c]	7,887 ± 205	NA
	CFA #2 Well[c]	6,942 ± 193	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 for surveillance purposes (not required by regulations to be sampled). The compliance point is the distribution system.
d. NA = Maximum contaminant level is not applicable to the well concentration.

Table 5-22. Nitrate results for M&O contractor and ANL-W water systems in 2004.

Water System	PWS Number	Parameter	Concentration (mg/L)	MCL (mg/L)
ANL-W	6060036	Nitrate as nitrogen	1.60	10
CFA	6120008	Nitrate as nitrogen	3.52	10
INTEC	6120012	Nitrate as nitrogen	0.68	10
EBR-I	6120009	Nitrate as nitrogen	0.34	10
Gun Range	6120025	Nitrate as nitrogen	0.85	10
Main Gate	6120015	Nitrate as nitrogen	0.59	10
PBF	6120019	Nitrate as nitrogen	0.89	10
RWMC	6120018	Nitrate as nitrogen	0.85	10
TAN/CTF	6120013	Nitrate as nitrogen	0.80	10
TAN/TSF	6120021	Nitrate as nitrogen	0.78	10
TRA	6120020	Nitrate as nitrogen	0.90	10

In 2004, total coliform and fecal coliform bacteria were absent in all M&O contractor-operated water systems at the INEEL. No MCL exceedances occurred during 2004 for any parameter.

Central Facilities Area - The CFA water system serves approximately 900 people daily. Since the early 1950s, wastewater containing tritium was disposed to the Eastern Snake River Plain Aquifer at INTEC and TRA through injection wells and infiltration ponds. These wastewaters migrated south southwest and are the suspected source of tritium contamination in the CFA water supply wells. The practice of disposing of wastewater through injection wells was discontinued in the mid-1980s.

In 2004, water samples were collected quarterly from CFA #1 Well (at CFA-651), CFA #2 Well (at CFA-642), and CFA-1603 (point of entry to the distribution system) for compliance purposes. Since December 1991, the mean tritium concentration has been below the MCL at all three locations. In general, tritium concentrations in groundwater have been decreasing (Figure 5-1) 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 aquifer, 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 2004 calculation was based on

- Mean tritium concentration for the CFA distribution system in 2004
- Measured concentration of Iodine-129 for the CFA distribution system.

For the 2004 dose calculation, the assumption was made 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 2004 was 0.47 mrem (4.7 µSv), below the EPA standard of 4 mrem/yr for public drinking water systems.

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 (Figure 5-2). 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 does not apply to the well. The distribution system is the point from which water is first consumed at RWMC and is the compliance point. Table 5-23 summarizes the carbon tetrachloride concentrations at the RWMC drinking water well and distribution system for 2004. The mean concentration at the well for 2004

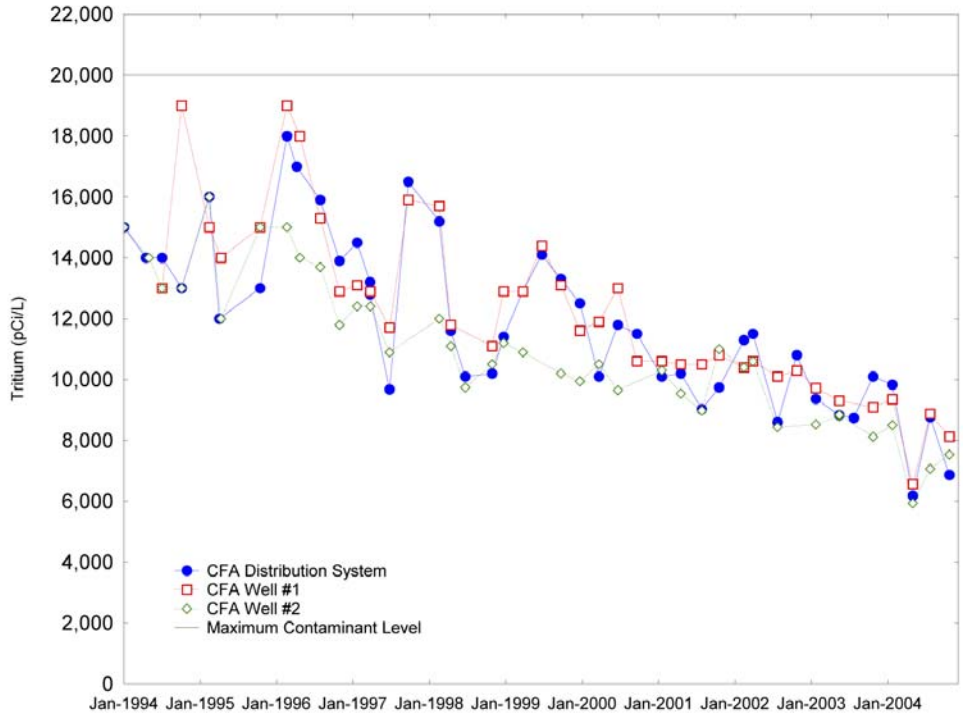


Figure 5-1. Tritium concentrations in two wells and one distribution system at the INEEL (1994-2004).

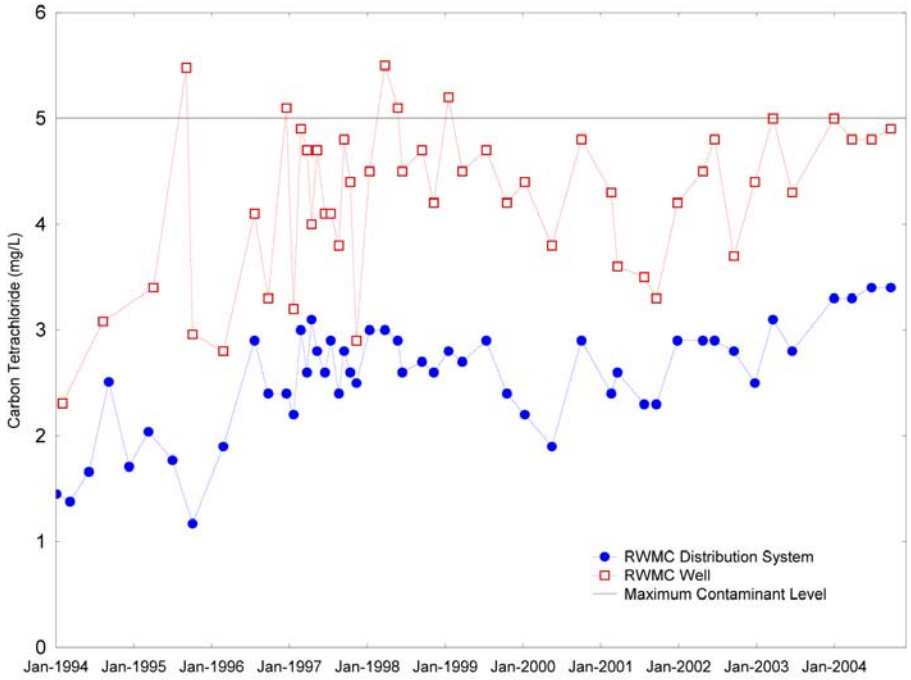


Figure 5-2. Carbon tetrachloride concentrations in the RWMC drinking water well and distribution system.

Table 5-23. Carbon tetrachloride concentrations in the RWMC drinking water well and distribution system (2004).

Location	Number of Samples	Carbon Tetrachloride Concentration [micrograms per liter (µg/L)]			
		Minimum	Maximum	Mean	MCL
RWMC WMF-603 Well	4	4.8	5.0	4.88	NA[a]
RWMC WMF-604 Distribution	4	3.3	3.4	3.35	5.0

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

was 4.88 µg/L, and the maximum concentration was 5.0 µg/L. The mean concentration at the distribution system was 3.35 µg/L, and the maximum concentration was 3.4 µg/L.

A potential source of the carbon tetrachloride is the estimated 334,630 L (88,400 gal) of organic chemical wastes (including carbon tetrachloride, trichloroethylene, 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 2,700 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.

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

Test Area North/Technical Support Facility - In 1987, trichloroethylene was detected at both TSF #1 and #2 Wells, which have supplied drinking water for up to 200 employees at TSF daily. 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 5-3 illustrates the concentrations of trichloroethylene in both TSF wells and the distribution system from 1994 through 2004. Past distribution system sample exceedances are attributed to preventive maintenance activities interrupting operation of the sparger system.

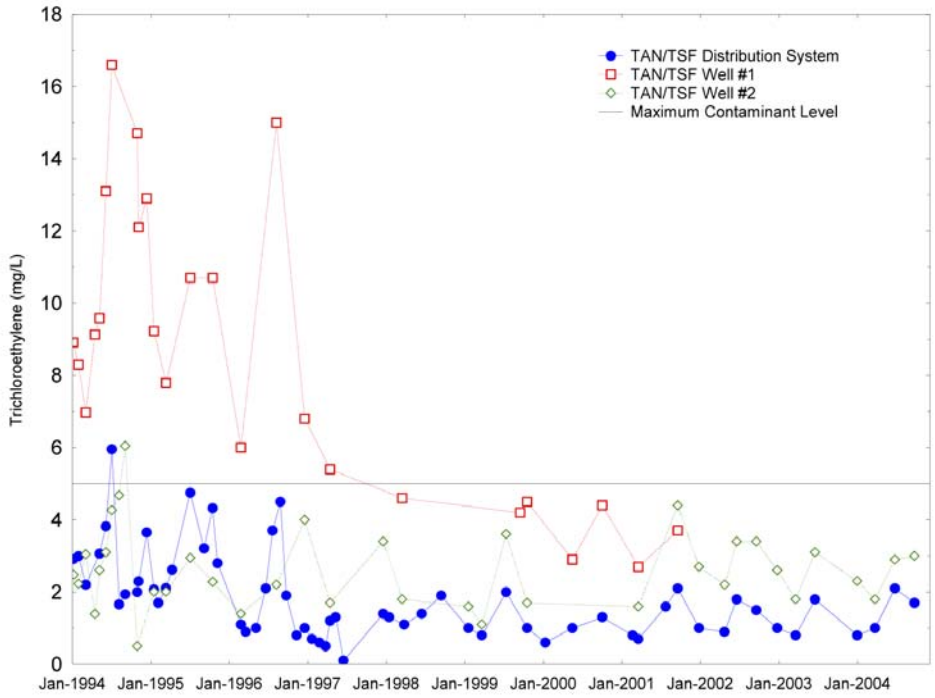


Figure 5-3. Trichloroethylene concentrations in TSF drinking water wells and distribution system.

Table 5-24 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 2004 because it was not required by the regulations and is not currently in use. The mean concentration of trichloroethylene at the distribution system for 2004 was 1.40 µg/L, which is below the MCL.

Table 5-24. Trichloroethylene concentrations at TSF #2 Well and distribution system (2004).

Location	Number of Samples	Trichloroethylene [micrograms per liter (µg/L)]			
		Minimum	Maximum	Mean	MCL
TAN/TSF #2 Well (612)[a]	4	1.8	3.0	2.50	NA[b]
TAN/TSF Distribution (610)	4	0.8	2.1	1.40	5.0

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

Argonne National Laboratory-West

During 2004, ANL-W analyzed quarterly water samples for gross alpha, gross beta, and tritium collected from a point prior to water entry to the drinking water distribution system, in accordance with the Safe Drinking Water Act. Values for both gross alpha concentration and gross beta concentration were well below MCLs. No detectable concentrations of tritium were reported.

ANL-W collected an annual nitrate sample as required by regulation. Results were below the EPA MCL (Table 5-22). ANL-W also tested its system quarterly for coliform bacteria with no positive results for the year.

Naval Reactors Facility

Drinking water samples were collected at a point before entering the distribution system. The samples were drawn from a sampling port immediately downstream from the NRF water softening treatment system. The water was monitored for nitrates, lead and copper. Radionuclides were sampled at each wellhead. Drinking water standards for these constituents were not exceeded at NRF.

No gross alpha, gross beta, gamma-emitters, or ^{90}Sr were measured in excess of natural background concentrations in 2004. Tritium values were not detected above the minimum detection levels. For more information see Bechtel Bettis 2004.

5.5 Storm Water Monitoring

The EPA NPDES regulations for the point-source discharges of storm water to waters of the United States require permits for discharges from industrial activities (40 CFR 122.26 2003). Following these regulations, the Army Corps of Engineers and EPA are likely to assert that the waters of the United States at the INEEL are the

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

Together, the above locations comprise the Big Lost River System (Figure 5-4).

A Storm Water Monitoring Program was implemented in 1993 when storm water permits initially applied to the INEEL 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 INEEL M&O 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 2002) 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 hrs 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 state of Idaho injection well permits. In 1997, responsibility for monitoring of storm water entering deep injection wells was transferred from the USGS to the M&O 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 a letter dated October 27, 2003, to the DOE-ID chief counsel, EPA Region 10 determined that three sites at the INEEL (RWMC, INTEC, and the north part of the INEEL 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). A subsequent letter on December 15, 2003, from the DOE-ID contract officer to the M&O Prime Contracts manager directed the M&O contractor to cease expending further resources on compliance with the Storm Water Pollution Prevention Plan for Industrial Activities, Storm Water Pollution Prevention Plan for Construction Activities, and Spill Prevention Control and Countermeasures Programs at the three sites discussed in the letter from EPA (Bauer 2003). The letter further directed the M&O contractor to conduct a technical analysis to determine any other areas under the M&O contractor's control that would also have the same or less potential to discharge storm water to waters of the United States. As a result of this direction by DOE-ID, construction and industrial storm water inspections, data collection, and reports have ceased for projects located at those facilities.

The remaining projects were evaluated through the technical analysis requested by DOE-ID to determine potential to discharge. 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 the preliminary technical analysis (to be finalized in early 2005), ceased.

During 2004, the Storm Water Monitoring Program monitored the following facilities or activities:

- Borrow sources (nonmetallic mineral mining, Sector J) - ceased monitoring in October 2004, and
- Landfills I, II, and III Extension at the CFA (Landfills, Sector L) - ceased monitoring in October 2004.

Storm Water Monitoring Results

During 2004, 2 visual storm water examinations were performed at two locations, and none performed at one location due to lack of storm water discharge. No discharge down any of the seven injection wells was observed; therefore, no visual examinations were performed or analytical samples collected at those locations.

The visual examinations performed in 2004 showed satisfactory implementation of the INEEL Storm Water Pollution Prevention Plan for Industrial Activities (DOE-ID 2002), and no corrective actions were required or performed during the year.

The General Permit does not contain numeric limitations for analytical parameters, except for pH limitations from runoff from coal piles, such as the one historically monitored at INTEC. Other parameters are compared to benchmark concentrations to help evaluate the quality of storm water discharges.

Analytical samples were collected for qualifying rain events that potentially discharged to waters of the United States at applicable monitoring locations. Discharge to waters of the United States from a qualifying storm occurred at the T-28 north gravel pit (TAN-MP-1/1 [inflow to gravel pit] and TAN-MP-2/1 [outflow from gavel pit]). Tables 5-25 and 5-26 summarize the 2004 results and permit benchmark concentrations for these two locations. No benchmark concentrations were exceeded at the T-28 north gravel pit. Monitoring of this location (along with other gravel pits, which never discharged and therefore were never sampled) ceased in October 2004 based on preliminary results of the technical analyses, which will be published in early 2005.

5.6 Waste Management Surveillance Water Sampling

In compliance with DOE Order 435.1, the M&O contractor collects surface water, as surface runoff, at the Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA). 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.

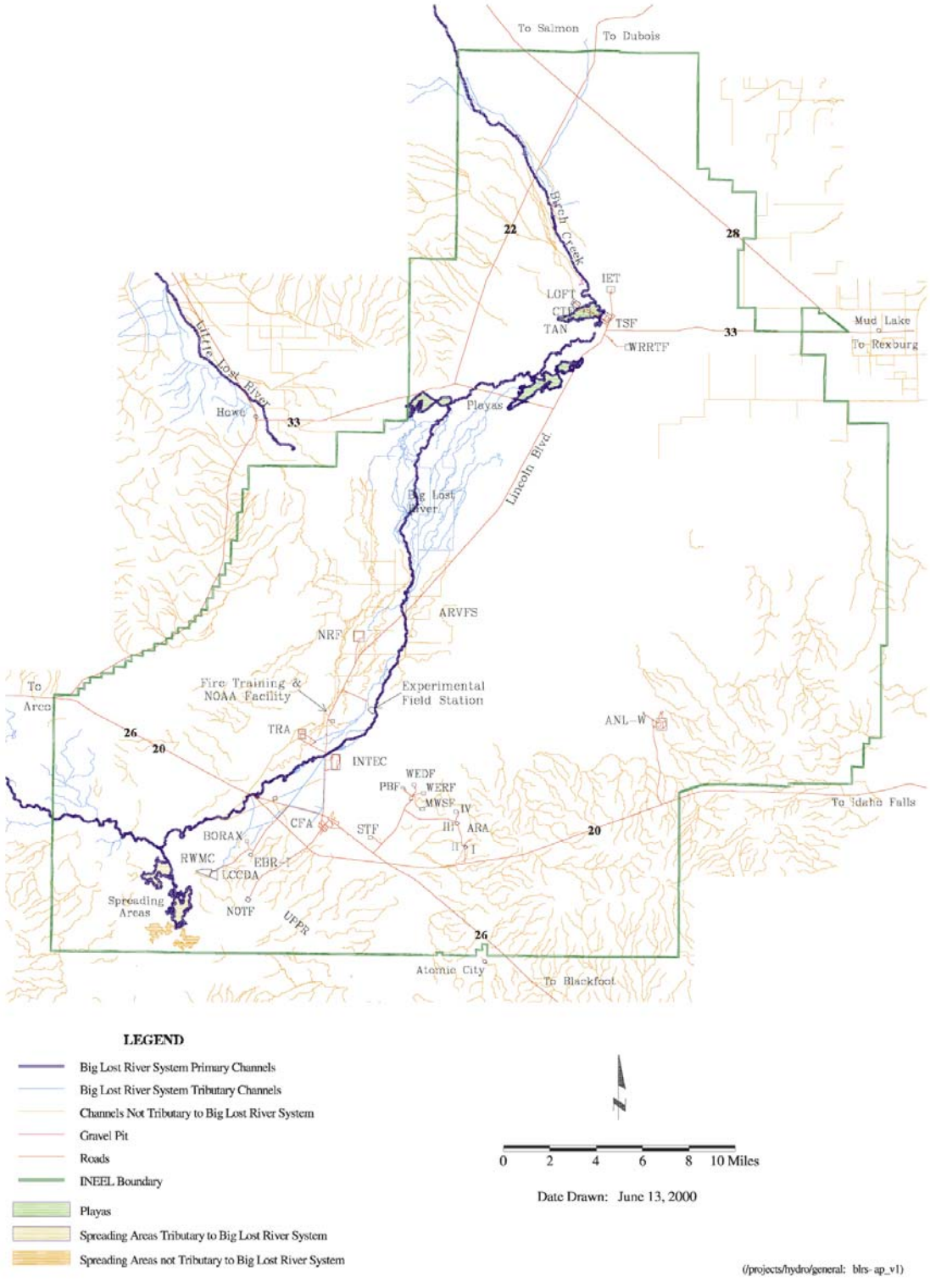


Figure 5-4. Big Lost River System.

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.

Because of drought conditions, no surface water runoff was available for sampling at the RWMC SDA during 2004.

Table 5-25. TAN-MP-1/1 (in flow) storm water results (2004).

Location	Sample Results	Limits for Comparison[a]
	Result ± 1s[a]	EPA MCL[b]
	Gross Alpha	
	May 2004	
Idaho Falls	4.58 ± 1.46	15
	Gross Beta	
	May 2004	
Aberdeen	5.80 ± 0.99	50[c]
Atomic City	3.00 ± 0.85	50
Fort Hall	7.85 ± 1.06	50
Idaho Falls	4.92 ± 0.95	50
Minidoka	3.22 ± 0.89	50
Monteview	5.17 ± 0.93	50
Moreland	6.48 ± 1.05	50
Mud Lake	3.69 ± 0.86	50
Duplicate	3.77 ± 0.84	50
Shoshone	3.47 ± 0.88	50
Taber	3.99 ± 0.97	50
	November 2004	
Aberdeen	5.12 ± 1.01	50
Atomic City	4.92 ± 0.89	50
Fort Hall	6.75 ± 1.10	50
Howe	5.12 ± 1.01	50
Minidoka	5.31 ± 0.93	50
Monteview	3.04 ± 0.97	50
Duplicate	3.75 ± 0.87	50
Moreland	4.18 ± 1.05	50
Mud Lake	4.22 ± 0.95	50
Roberts	2.99 ± 0.98	50

Table 5-25. TAN-MP-1/1 (in flow) storm water results (2004). (cont.)

Location	Sample Results	Limits for Comparison[a]
	Result ± 1s[a]	EPA MCL[b]
	Tritium	
	May 2004	
Howe	97.4 ± 29.8	20,000
Taber	78.0 ± 25.1	20,000
	November 2004	
Aberdeen	142.0 ± 30.2	20,000
Arco	137.0 ± 31.3	20,000
Atomic City	140.0 ± 30.8	20,000
Fort Hall	137.0 ± 31.2	20,000
Howe	142.0 ± 30.2	20,000
Monteview	139.0 ± 26.4	20,000
Mud Lake	78.8 ± 25.3	20,000
Taber	81.9 ± 25.6	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, DCG = derived concentration guide.
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.

Table 5-26. TAN-MP-2/1 (out flow) storm water results (2004).

Parameter[a]	Concentration	# Samples	# Detections[b]	Benchmark
Nitrogen, Nitrate + Nitrite	0.106	1	1	0.68
Total Suspended Solids	3.0	1	1	100
Conductivity (µS)	313.7	1	1	NA
pH (standard units)	8.40	1	1	6.0–9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. # Detections indicates the number of samples with results greater than the minimum detectable limit for that constituent.

REFERENCES

40 CFR 122.26, 2004, "Storm Water Discharges," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 141, 2004, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 142, 2004, "National Primary Drinking Water Regulations Implementation," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 143, 2004, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.

63 FR 189, 1998, "Final Modification of the National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities," Federal Register, U.S. Environmental Protection Agency, September 30, p. 52430.

Bauer, W., 2003, DOE-ID, to S. S. Crawford, BBWI "Actions in Regards to Environmental Protection Agency of the United States," CCN 46917, December 15, 2003.

Bechtel Bettis, 2004, *2004 Environmental Monitoring Report for the Naval Reactor Facility*, NRFRC-EE-012.

Cascade Earth Science (CES), 1993, *Soil Suitability Investigation for Land Application of Waste Water*, Central Facility Area, Idaho National Engineering Laboratory, July 8, 1993.

DEQ, 1995, “Wastewater Land Application Permit No. LA-000115-02 for ICPP Sewage Treatment Plant.”

Hull, L. C., K. E. Wright, and L. V. Street, letter report to M. G. Lewis, July, 8, 2004, “Analysis of Suspended Solids in INTEC Percolation Pond Monitoring Wells,” CCN 54400.

IDAPA 58.01.08, "Idaho Regulations for Public Drinking Water Systems," Idaho Administrative Procedures Act, State of Idaho Department of Health and Welfare, current revision.

IDAPA 58.01.11, "Ground Water Quality Rules," State of Idaho Department of Health and Welfare, current revision.

IDAPA 58.01.17, "Wastewater Land Application Permits," Idaho Administrative Procedure Act, State of Idaho Department of Health and Welfare, current revision.

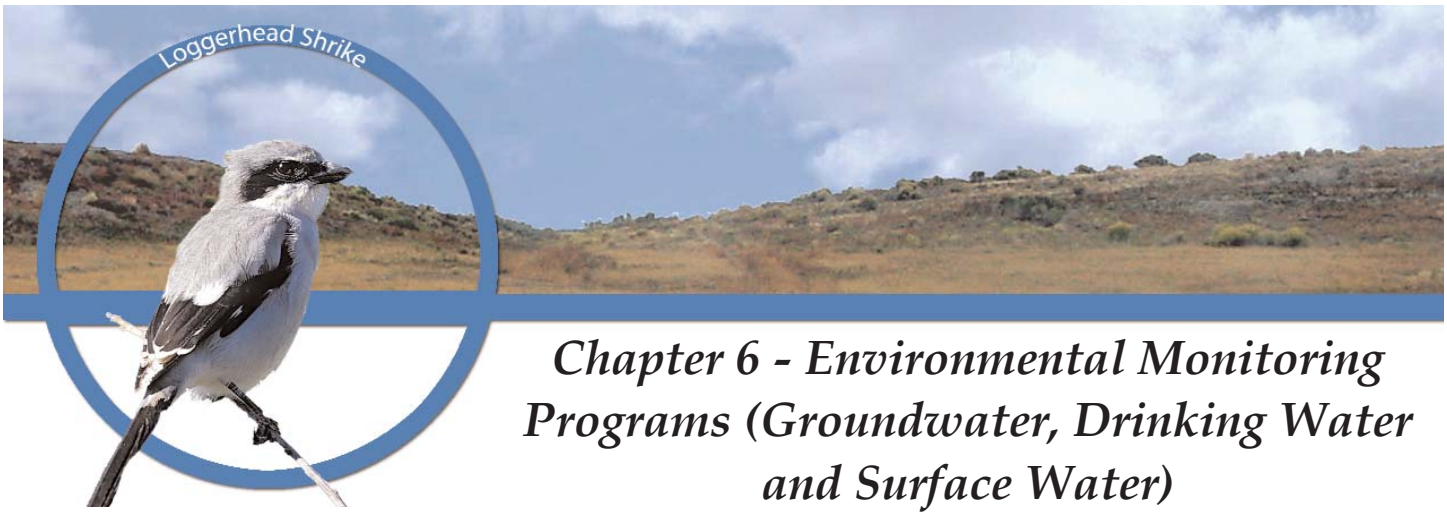
Johnston, J., 2001, DEQ, to Stacey Madson, DOE-ID, "INEEL Test Reactor Area (TRA) Cold Waste Pond and Water Reactor Test Facility (WRRTF) Wastewater Disposal Ponds," January 19, 2001.

Ryan, M., 2003, EPA Region 10, to A. E. Gross, DOE-ID, "Storm Water Compliance at the INEEL," CCN 46063, October 27, 2003.

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

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

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2002, *Idaho National Engineering and Environmental Laboratory Storm Water Pollution Prevention Plan for Industrial Activities*, DOE/ID-10431, Rev. 41, January.



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

R. Mitchell - S. M. Stoller Corporation
M. Roddy, T. Wood - Bechtel/BWXT Idaho, LLC
L. Knobel - United States Geological Survey
M. Finnerty - Argonne National Laboratory-West
S. Lowry - Naval Reactors Facility

Chapter Highlights

One potential pathway for exposure from contaminants released at the Idaho National Environmental and Engineering Laboratory (INEEL) 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 INEEL to comply with applicable laws and regulations, U.S. Department of Energy orders, and Wastewater Land Application Permit requirements. Argonne National Laboratory-West and the Naval Reactors Facility conduct their own groundwater, effluent, and drinking water monitoring. The U.S. Geological Survey (USGS) INEEL Project Office performs groundwater monitoring, analyses, and studies of the Eastern Snake River Plain Aquifer (ESRPA) under and adjacent to the INEEL. 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 INEEL. These contaminated areas are monitored by the above-mentioned organizations as well as various other organizations.

Results from a number of special studies conducted by the USGS of the properties of the aquifer were published during 2004. Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells at the INEEL. Concentrations of organic compounds were below the U.S. Environmental Protection Agency maximum contaminant levels and state of Idaho groundwater primary and secondary concentration 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 2004. No contaminant concentrations exceeded expected or historical concentrations.

Semiannual drinking water samples were collected from 14 locations off the INEEL. One sample from Idaho Falls had measurable gross alpha activity. Eleven samples had measurable tritium, and 21 samples had detectable gross beta activity. None of the samples exceeded the EPA MCL for these constituents.

A total of 11 offsite surface water samples were collected from five locations along the Snake River. Most of the samples had measurable gross beta activity, while only one sample had measurable tritium. Detectable gross alpha activity was not found in any sample. None of these constituents were above regulatory limits.

6. ENVIRONMENTAL MONITORING PROGRAMS (GROUNDWATER, DRINKING WATER AND SURFACE WATER)

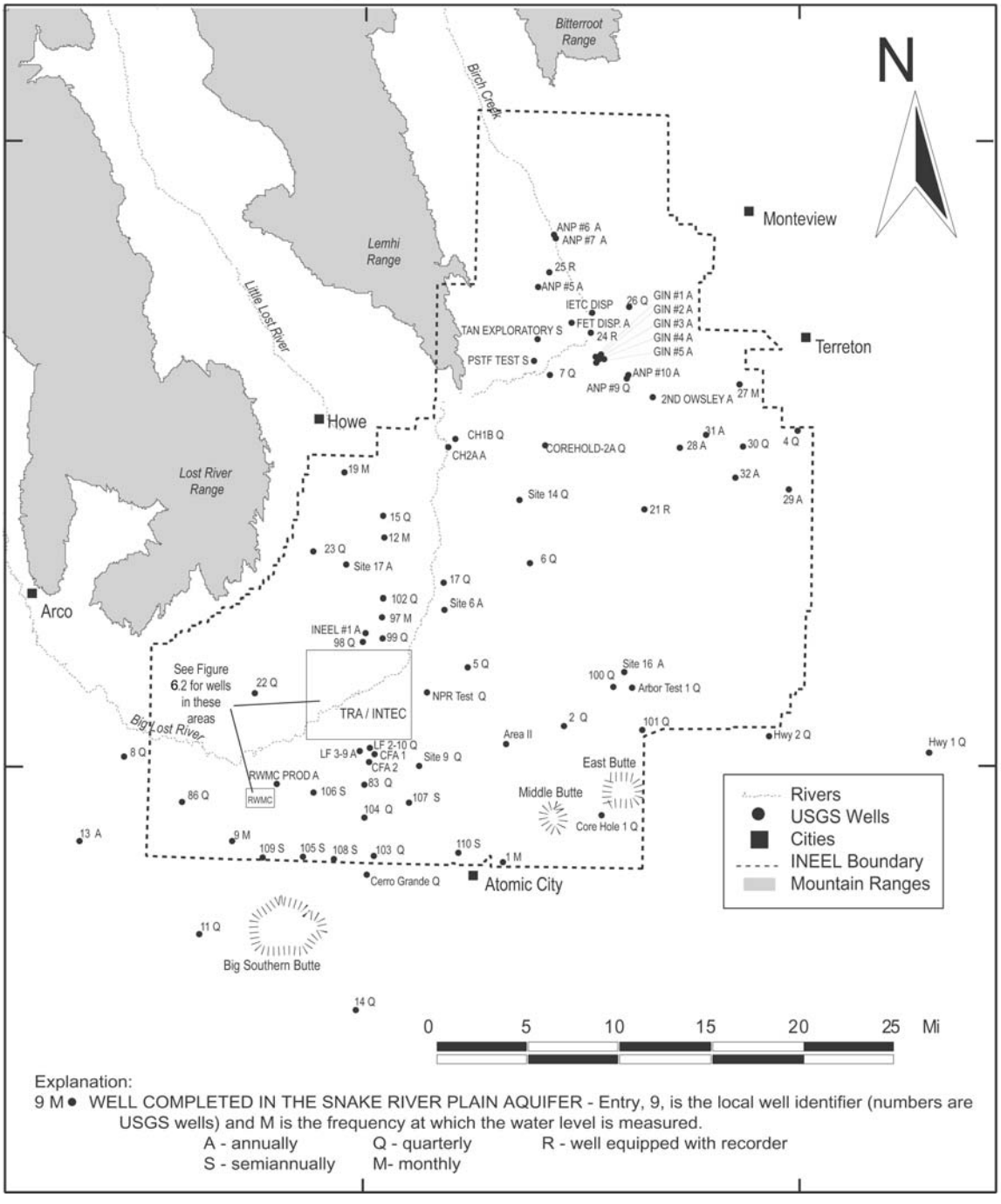
Operations at facilities located on the Idaho National Engineering and Environmental Laboratory (INEEL) release radioactive and nonradioactive constituents into the environment. These releases are in compliance with regulations, and monitoring of the releases ensures protection of the public and environment. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination in the Eastern Snake River Plain Aquifer (ESRPA) beneath the INEEL. These contaminated areas are monitored by various organizations.

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. Results from sampling conducted by the Management and Operating (M&O) contractor; Argonne National Laboratory-West (ANL-W); the U.S. Geological Survey (USGS); and the Environmental Surveillance, Education and Research Program (ESER) contractor are presented here. Results are compared to the state of Idaho groundwater primary and secondary constituents standards (PCS/SCS) of IDAPA 58.01.11 (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 (DCG) for ingestion of water.

This chapter begins with a general overview of the various organizations monitoring groundwater at the INEEL in Section 6.1. Sections 6.2 and 6.3 present discussions of the hydrogeology of the INEEL and hydrogeologic data management, respectively. Section 6.4 describes aquifer studies related to the INEEL and ESRPA. Radiological and nonradiological monitoring of groundwater at the INEEL are discussed in Sections 6.5 and 6.6, respectively. Section 6.7 outlines the CERCLA groundwater activities performed in 2004. Section 6.8 describes offsite drinking and surface water monitoring.

6.1 Summary of Monitoring Programs

The USGS INEEL Project Office performs groundwater monitoring, analyses, and studies of the ESRPA under and adjacent to the INEEL. This is done through an extensive network of strategically placed monitoring wells on the INEEL (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 2004, USGS personnel collected over 1,000 samples for radionuclides and inorganic constituents including trace elements and approximately 30 samples for purgeable organic compounds.



Explanation:

9 M ● WELL COMPLETED IN THE SNAKE RIVER PLAIN AQUIFER - Entry, 9, is the local well identifier (numbers are USGS wells) and M is the frequency at which the water level is measured.

A - annually Q - quarterly R - well equipped with recorder

S - semiannually M- monthly

Figure 6-1. USGS well locations (Bartholomay et al. 2000).

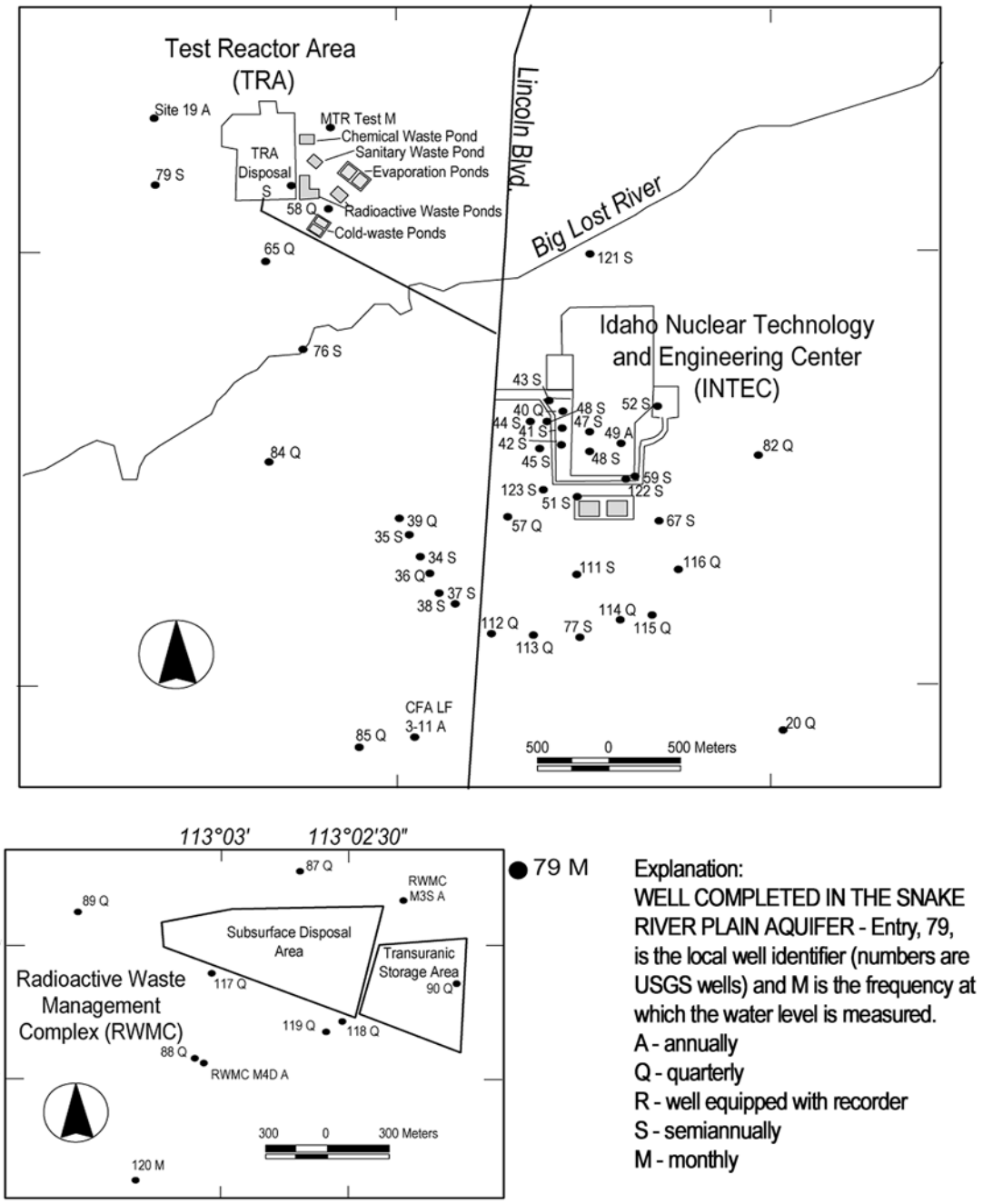


Figure 6-2. USGS well locations at the Idaho Nuclear Technology and Engineering Center, Test Reactor Area, and Radioactive Waste Management Complex (Bartholomay et al. 2000).

In addition to the above duties, the USGS performs groundwater monitoring activities for the Naval Reactors Facility (NRF) through an interagency agreement. As part of the 2004 NRF sampling program, the USGS performed sampling three times from nine NRF wells and four USGS wells, collecting a total of 45 samples. Samples were analyzed for radionuclides, inorganic constituents, and purgeable organic compounds.

ANL-W performs semiannual groundwater monitoring at one upgradient monitoring well, three downgradient monitoring wells, and one production well. Samples are analyzed for gross activity (alpha and beta), uranium isotopes, tritium, inorganics, and water quality parameters.

As detailed in Chapter 3, CERCLA activities at the INEEL are divided into ten Waste Area Groups (WAGs) (Figure 3-3). Each of these WAGs is addressing groundwater for its particular contaminants. WAG 10 has been designated as the site-wide WAG and addresses the combined impact of the individual contaminant plumes. As individual Records of Decision (RODs) are approved for each WAG, many of the groundwater monitoring activities are administratively turned over to the Long-Term Stewardship (LTS) program as an effort to consolidate monitoring activities.

The ESER contractor monitors offsite drinking and surface water. There were 30 drinking water and 11 surface water samples collected for analyses in 2004.

The INEEL Oversight Program collects split samples with the M&O and other INEEL contractors of groundwater from both compliance (discussed in Chapter 5) and surveillance wells. Results of the Oversight programs monitoring are presented in annual reports prepared by that organization and are not reported here.

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

6.2 Hydrogeology

The INEEL occupies 2300 km^2 (890 $mi^{2)}$ of the northwest side of the ESRP. The ESRP is a northeast-southwest oriented structural basin approximately 435 km (270 miles) long and 80 to 113 km (50 to 70 miles) wide. The ESRP is bounded by typical Basin and Range fault block mountains and valleys along the north edge and downwarping and faulting along the southern edge. Over time, the ESRP has been filled with basaltic and rhyolitic volcanic rocks related to the passage of the North American tectonic plate over the Yellowstone hotspot.

Sequences of basaltic rocks make up approximately the upper 550-1500 m (1800-4000 ft) of the fill material within the ESRP. Basalts were erupted over well defined cycles separated by long periods of no volcanic activity. Individual basalt flows range from 1.5 to 15 m (5 to 50 ft) in thickness and can cover tens of square miles. As newer basalt flows were erupted, they spread out across the landscape, covering previous basalt surfaces or accumulated soils which now form interflow zones and interbeds, respectively. Moving through these interflow zones is the water of the ESRPA.

The ESRPA is one of the largest, most productive aquifers in the United States. It has been estimated that there are 200 to 300 million acre-feet of water contained within the ESRPA. Presently, the aquifer is tapped to meet the demands of agriculture, industry, and the more than 280,000 people who live on and around the ESRPA. In 1990, the ESRPA was classified as a "sole-source aquifer" by the EPA. More recently the state of Idaho has implemented protections for the ESRPA under its groundwater quality regulations.

Table 6-1. Groundwater and surface water-related monitoring at the INEEL and surrounding area.

Area/Facility[a]	Media: Groundwater (Radiological)	Groundwater (Nonradiological)	Groundwater (CERCLA)	Surface Water
Argonne National Laboratory-West				
ANL-W	•	•	•	•[b]
Management and Operating Contractor				
CFA	•	•	•	•[b]
INTEC	•	•	•	
TRA	•	•	•	•[b]
TAN	•	•	•	•[b]
RWMC	•	•	•	•[b]
PBF/CITR				•[b]
Naval Reactors Facility				
NRF	•	•	•	
Environmental Surveillance, Education and Research Program				
INEEL/Regional				•
U.S. Geological Survey				
INEEL/Regional	•	•		•[c]
INEEL Oversight Program				
INEEL/Regional	•	•	•	•

a. ANL-W = Argonne National Laboratory-West, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, TRA = Test Reactor Area, TAN = Test Area North, RWMC = Radioactive Waste Management Complex, PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range, IRC = INEEL Research Center, and NRF = Naval Reactors Facility.

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

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

The water of the ESRPA originates as recharge from river waters of the upper Snake River Plain, such as the Henry's Fork, the south fork of the Snake River, and the Big and Little Lost Rivers (Figure 6-3). Other sources of recharge water include the flow of groundwater out of the surrounding mountain valleys (Birch Creek, Medicine Lodge Creek, Camas Creek), leakage from irrigation canals and ponds, and infiltration from precipitation and irrigation.

Once in the ESRPA, the water moves to the southwest at rates ranging from 1.5 to 6.1 m per day (5 to 20 ft per day). This is much faster than most aquifers and is attributed to the high permeability of the interflow zones.

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, estimated travel time from the INEEL 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 INEEL 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 INEEL operations over a larger area than would be expected. Other impacts of INEEL 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 and facilities) to the ESRPA.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INEEL has been collected by a number of organizations, including the USGS, the M&O, and other site contractors. One of the functions of the INEEL 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 INEEL. 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 INEEL, the ESRP, and the ESRPA beneath the INEEL. The HDR is also used to maintain the INEEL 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.

Another organization was also created at the INEEL to handle all laboratory analytical requests. The INEEL 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

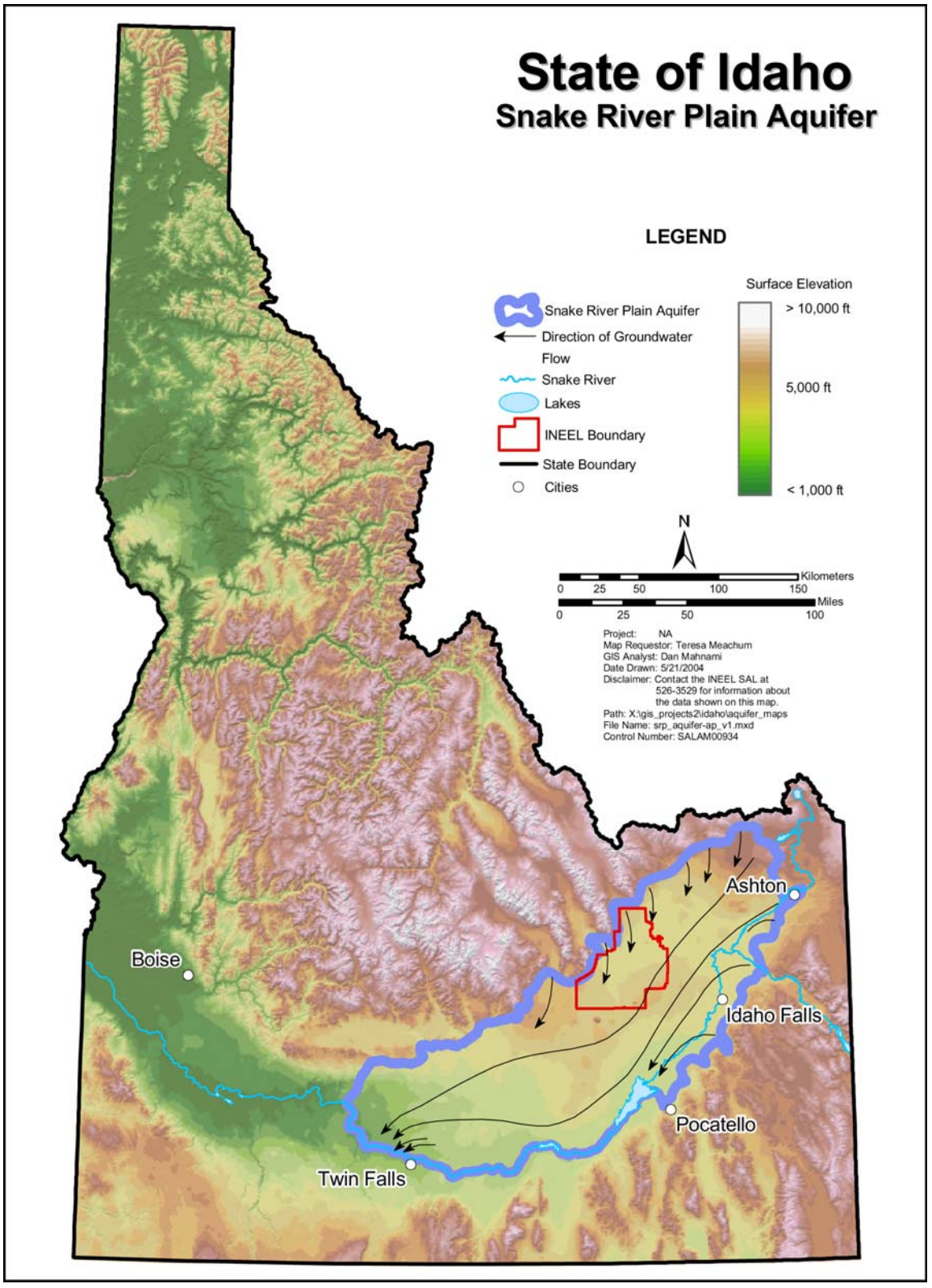


Figure 6-3. Location of the INEEL in relation to the Eastern Snake River Plain Aquifer is outlined.

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 INEEL. The SAM also participates in monitoring laboratory performance and annual onsite laboratory audits to ensure quality and compliance.

6.4 Aquifer Studies

The ESRPA, which underlies the ESRP and the INEEL, serves as the primary source for drinking water and crop irrigation in the Upper Snake River Basin. A description of the hydrogeology of the INEEL 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 INEEL Project Office by calling 208-526-2438. During 2004, personnel of the USGS INEEL project office published 11 documents covering hydrogeologic conditions at the INEEL, on the Eastern Snake River Plain and in other areas of interest around the world. The abstracts to each of these reports are presented in Appendix C.

6.5 Radiological Groundwater Monitoring

Historic waste disposal practices have produced localized areas of radiochemical contamination in the ESRPA beneath the INEEL. 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. Test Reactor Area (TRA) also discharged contaminated wastewater to a shallow percolation pond. The TRA 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 TRA and INTEC was highest between 1952 to 1983 (910 Ci/yr), decreased during 1984 to 1991 (280 Ci/yr), and continued to decrease during 1992 to 1995 (107 Ci/yr). From 1952 to 1998, the INEEL disposed about 93 Ci of ^{90}Sr at TRA and about 57 Ci at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the ESRPA at TRA; however, at INTEC a portion of the ^{90}Sr was injected directly to the ESRPA. From 1996 to 1998, the INEEL 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 M&O contractor and the USGS at levels above the Primary Constituent Standard (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. The configuration and extent of the tritium contamination area, based on the most recent published data (1998), are shown in Figure 6-4 (Bartholomay et al. 2000). 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.

Concentrations of tritium in the area of contamination have continued to decrease. 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.

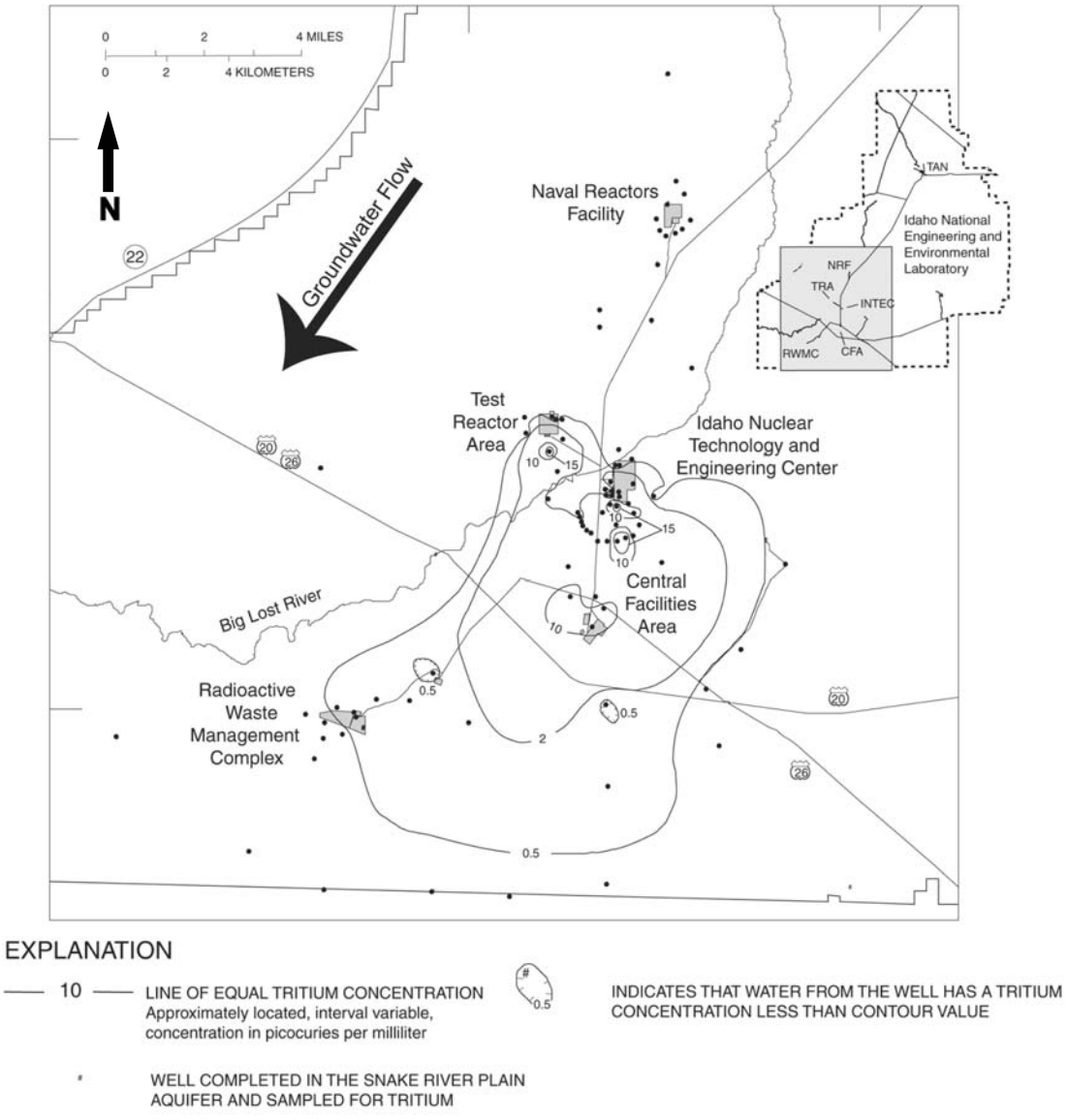


Figure 6-4. Distribution of tritium in the Snake River Plain Aquifer on the INEEL (1998) (Bartholomay et al. 2000).

Two monitoring wells downgradient of TRA (Well 65) and INTEC (Well 77) (see Figure 6-2) have continually shown high tritium activities in the aquifer over time. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer near TRA. The average tritium concentration in Well 65 near TRA decreased, from $(9.4 \pm 0.5) \times 10^3$ pCi/L in 2003 to $(8.3 \pm 0.6) \times 10^3$ pCi/L in 2004; the tritium concentration in Well 77 south of INTEC also showed a slight decrease, $(13.4 \pm 0.3) \times 10^3$ pCi/L in 2003 to $(12.9 \pm 1.2) \times 10^3$ pCi/L in 2004.

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

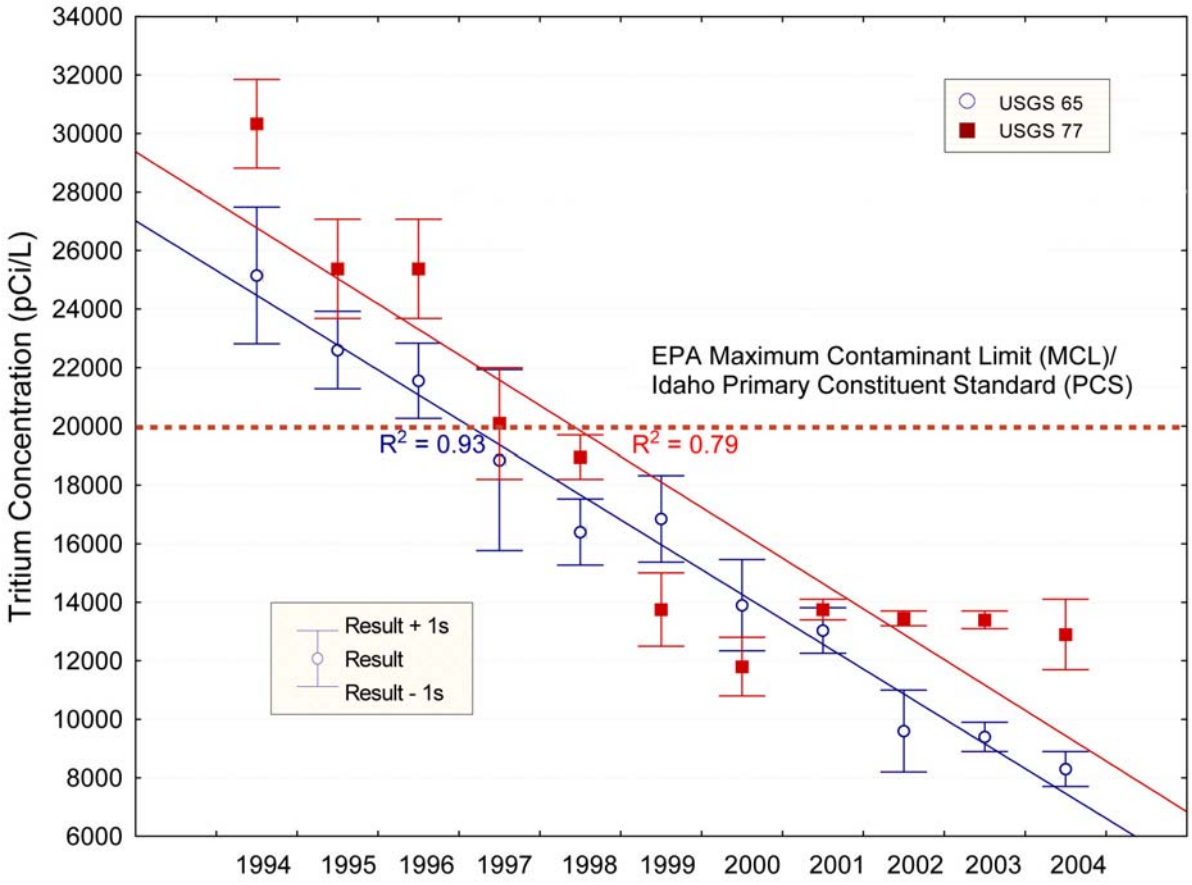


Figure 6-5. Long-term tend of tritium in USGS Well 65 and 77 (1994-2004). (Error bars are plus or minus one standard deviation [1s]).

Strontium-90 - The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2000). The contamination originates from INTEC as a remnant of the earlier injection of wastewater. No ^{90}Sr in groundwater has been detected in the vicinity of TRA. All ^{90}Sr at TRA was disposed to infiltration ponds in contrast to the direct injection that occurred at the INTEC. At TRA, ^{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.

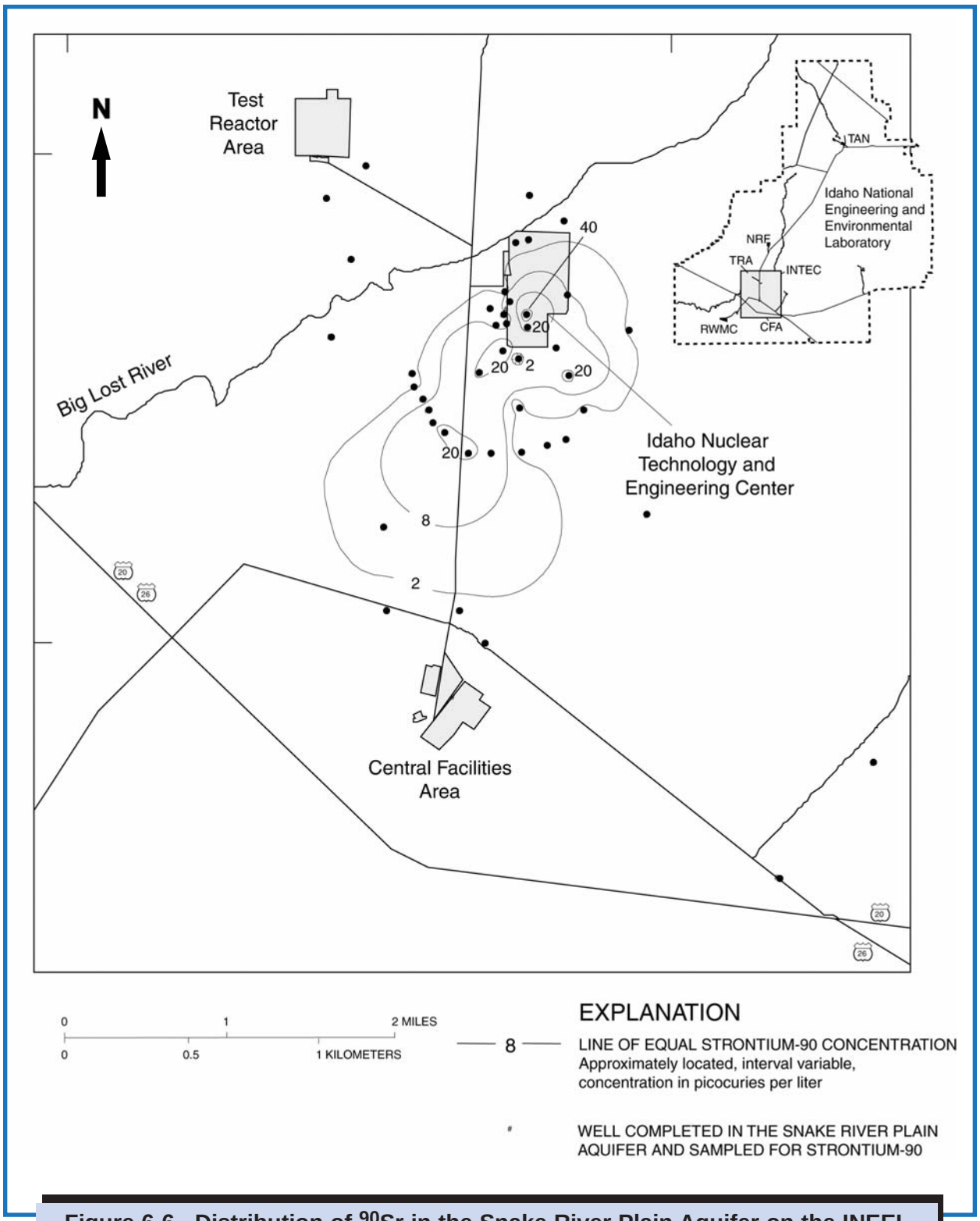


Figure 6-6. Distribution of ^{90}Sr in the Snake River Plain Aquifer on the INEEL (1998) (Bartholomay et al. 2000).

Mean concentrations of ^{90}Sr in wells have remained at about the same concentrations since 1989. The annual average concentration in well 65 decreased between 2003 (2.55 ± 0.58 pCi/L) and 2004 (1.0 ± 2.0 pCi/L). Concentrations in Well 77 remained the same at 1.8 ± 0.7 pCi/L in 2003 and 1.8 ± 0.4 pCi/L in 2004. The PCS and MCL for ^{90}Sr in drinking water is 8 pCi/L.

The trend of ^{90}Sr over the past ten years is shown in Figure 6-7. Although the trend is increasing, the statistical fit is weak (3 percent for Well 65 and 10 percent for Well 77). The uncertainties associated with ^{90}Sr are also larger. This increase over the last five years is thought to be due, in part, to a lack of recharge from the Big Lost River that would act to dilute the ^{90}Sr. Other reasons may also include an increase in the disposal of other chemicals into the INTEC percolation ponds that may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000).

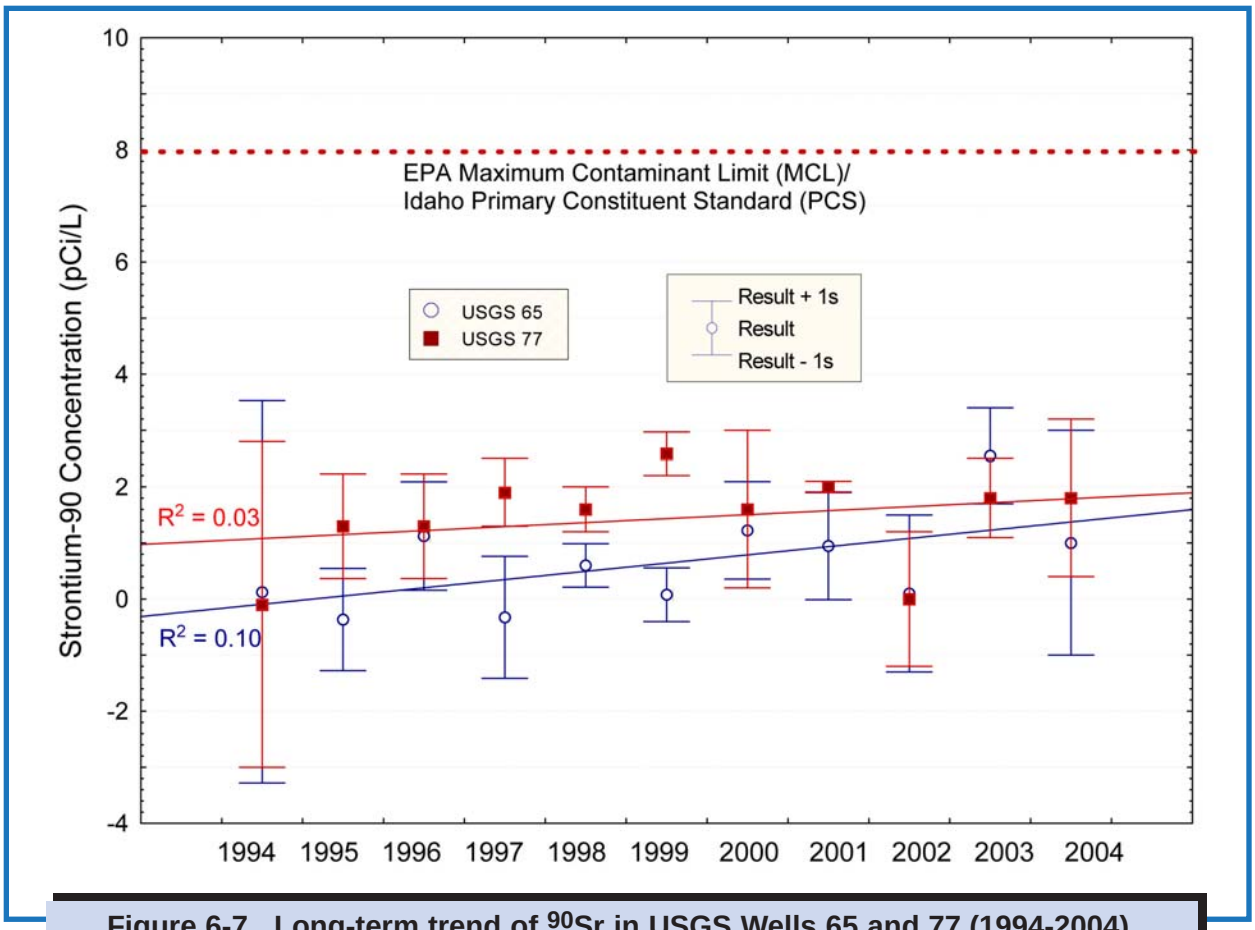


Figure 6-7. Long-term trend of ^{90}Sr in USGS Wells 65 and 77 (1994-2004).

Naval Reactors Facility

Groundwater samples around NRF are collected by the USGS under an interagency agreement. Groundwater monitoring did not detect any gross alpha or gross beta activity in excess of natural background concentrations. Measurements of tritium were at least a factor of 100 below PCS values. No ^{90}Sr or programmatic gamma-emitters were detected. For more information, see Bechtel Bettis 2004.

6.6 Nonradiological Groundwater Monitoring

U.S. Geological Survey

Sampling for purgeable (volatile) organic compounds in groundwater was conducted by the USGS at the INEEL during 2004. Water samples from an onsite production well and seven 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, Bartholomay et al. 2003). Ten purgeable organic compounds were detected at concentrations above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INEEL (Table 6-2). None of the measured constituents were above their respective PCS.

The Radioactive Waste Management Complex (RWMC) production well contained detectable concentrations of eight of these purgeable organic compounds. Annual average concentrations of these compounds in this well remained essentially unchanged from those observed in 2003, however, the 2004 average concentration for trichloroethene (2.66 µg/L) was slightly above the average concentration of 2003 (2.48 µg/L).

Naval Reactors Facility

Groundwater samples around NRF are collected by the USGS under an interagency agreement. Most volatile organic compounds, inorganic analytes, and water quality parameters were below the minimum detection levels. All of the target nonradiological constituent concentrations averaged below Idaho PCS/SCS and EPA MCLs, with the exception of chromium in well NRF-13. The high average value for chromium in NRF-13 is from a single anomalous value that appears to be the result of high suspended solids in the well. Groundwater monitoring wells are not used for drinking water supply. For more information, see Bechtel Bettis 2004.

6.7 CERCLA Groundwater Monitoring Activities

CERCLA activities at the INEEL are divided into WAGs that roughly correspond to the major facilities at the site plus the site-wide WAG 10 (Figure 6-8). The boundaries of the various WAGs are found on Figure 6-8. In 2004, a total of 192 aquifer monitoring wells were sampled to satisfy CERCLA requirements. The following sub-sections provide an overview of ground water sampling results. More detailed discussions of the CERCLA driven sampling can be found in the WAG specific monitoring reports.

Summary of WAG 1 Groundwater Monitoring Results

The objective of the operable unit (OU) 1 07B remedial action is to contain and restore the contaminated groundwater at Test Area North (TAN). The groundwater at TAN is contaminated with trichloroethene (TCE), tetrachloroethene (PCE), and dichloroethene (DCE). To facilitate this remedial action, the contaminated groundwater was divided into three zones. The locations of wells used in the definition of each zone are shown in Figure 6-9. The boundaries of each zone of the plume were based on TCE concentrations. The three zones are defined as follows:

Table 6-2. Concentrations of purgeable organic compounds in USGS well samples (2004). [a]

Well ID	Date	Bromo-dichloro-methane	Dibromo-chloro-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethene	Tetrachloro-ethene	Tetrachloro-methane	Tribromo-methane	1,1,1-Trichloro-ethane	Trichloro-ethene	Trichloro-methane
34 (SW of INTEC)	04/14	ND[b]	ND	ND	ND	ND	ND	ND[c]	0.10	ND	ND
38 (SW of INTEC)	04/21	ND	ND	0.11[d]	ND	ND	ND	ND	0.13	ND	ND
65 (S of TRA)	04/07	ND	ND	ND	ND	ND	ND	ND	0.19	ND	ND
77 (S of TRA)	10/20	ND	ND	0.11	0.16	ND	ND	ND	0.22	ND	ND
87 (N of RWMC)	04/08	ND	ND	0.14	ND	0.11	3.30	ND	0.19	0.68	0.15
88 (S of RWMC)	10/12	ND	ND	ND	ND	ND	0.87	ND	ND	0.38	0.51
120 (SW of RWMC)	10/14	ND	ND	ND	ND	ND	2.11	ND	0.17	0.53	0.30

Table 6-2. Concentrations of purgeable organic compounds in USGS well samples (2004).[a] (continued)

Well ID	Date	Bromo-dichloro-methane	Dibromo-chloro-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethene	Tetrachloro-ethene	Tetra-chloro-methane	Tribromo-methane	1,1,1-Trichloro-ethane	Trichloro-ethene	Trichloro-methane
RWMC PROD	01/15	ND	ND	ND	ND	0.23	6.27	ND	0.51	2.55	1.03
	02/12	ND	ND	ND	ND	0.24	6.19	0.12	0.52	2.78	1.16
	03/11	ND	ND	ND	ND	0.20	4.93	ND	0.47	2.34	1.11
	04/08	ND	ND	ND	ND	0.26	6.16	ND	0.52	2.75	1.32
	05/12	ND	ND	ND	ND	0.29	5.99	ND	0.49	2.95	1.36
	06/10	ND	ND	ND	ND	0.22	5.38	ND	0.47	2.43	1.06
	07/08	ND	ND	ND	ND	0.23	5.53	ND	0.49	2.54	1.22
	08/12	ND	ND	ND	ND	0.30	5.99	ND	0.51	2.98	1.29
	09/09	ND	ND	ND	ND	0.25	5.78	ND	0.48	2.77	1.28
	10/14	ND	ND	ND	ND	0.24	**5.83**	ND	0.48	2.40	1.10
	11/18	ND	ND	ND	ND	0.26	**6.24**	ND	0.53	2.67	1.20
	12/09	0.14	0.46	ND	ND	0.26	**6.30**	2.32	0.52	2.79	1.32
PCS[e]					**7.0[f]**	**5.0[g]**			**200**	**5[h]**	

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.

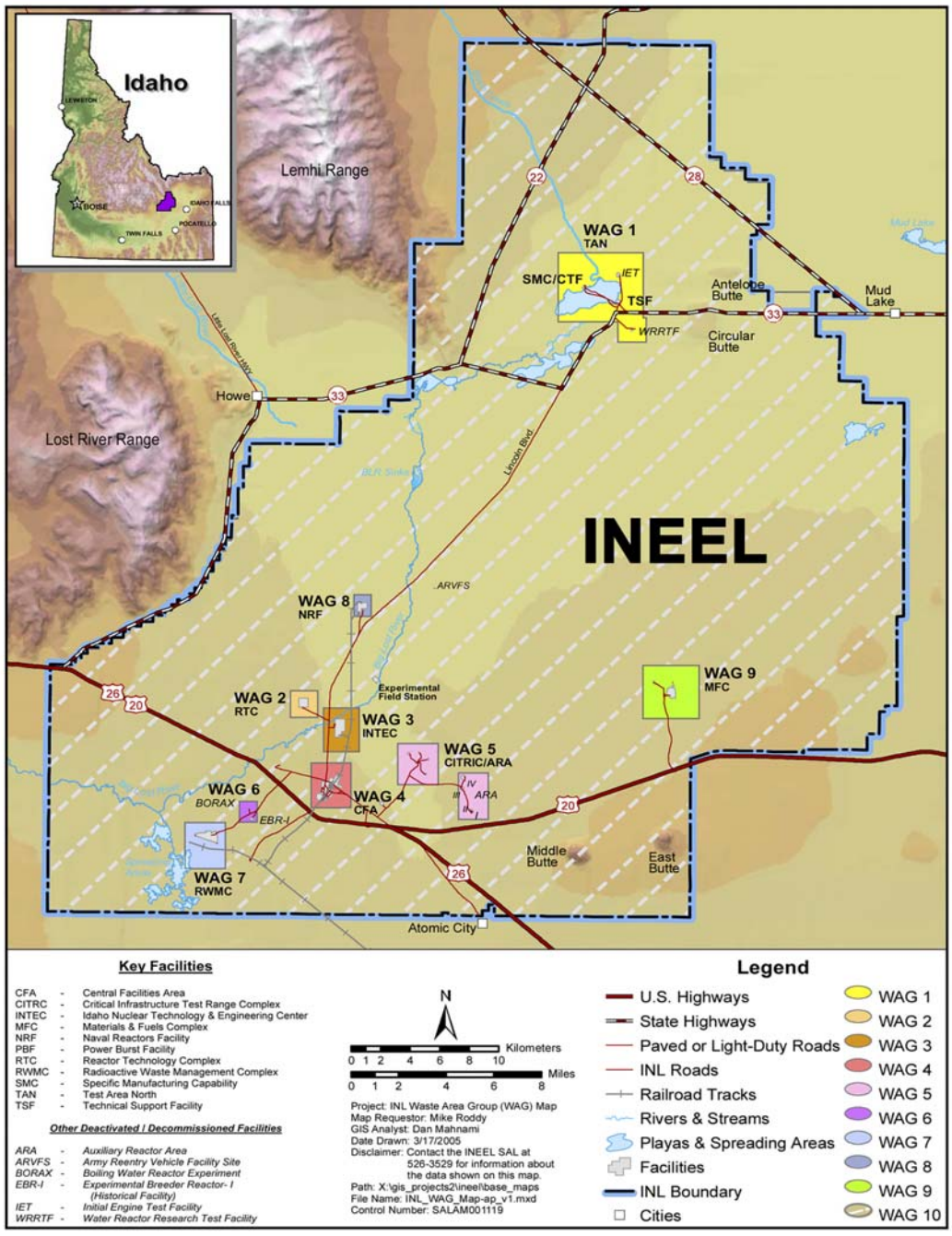


Figure 6-8. WAG 10 baseline, boundary, and guard wells sampled in June-July 2004.

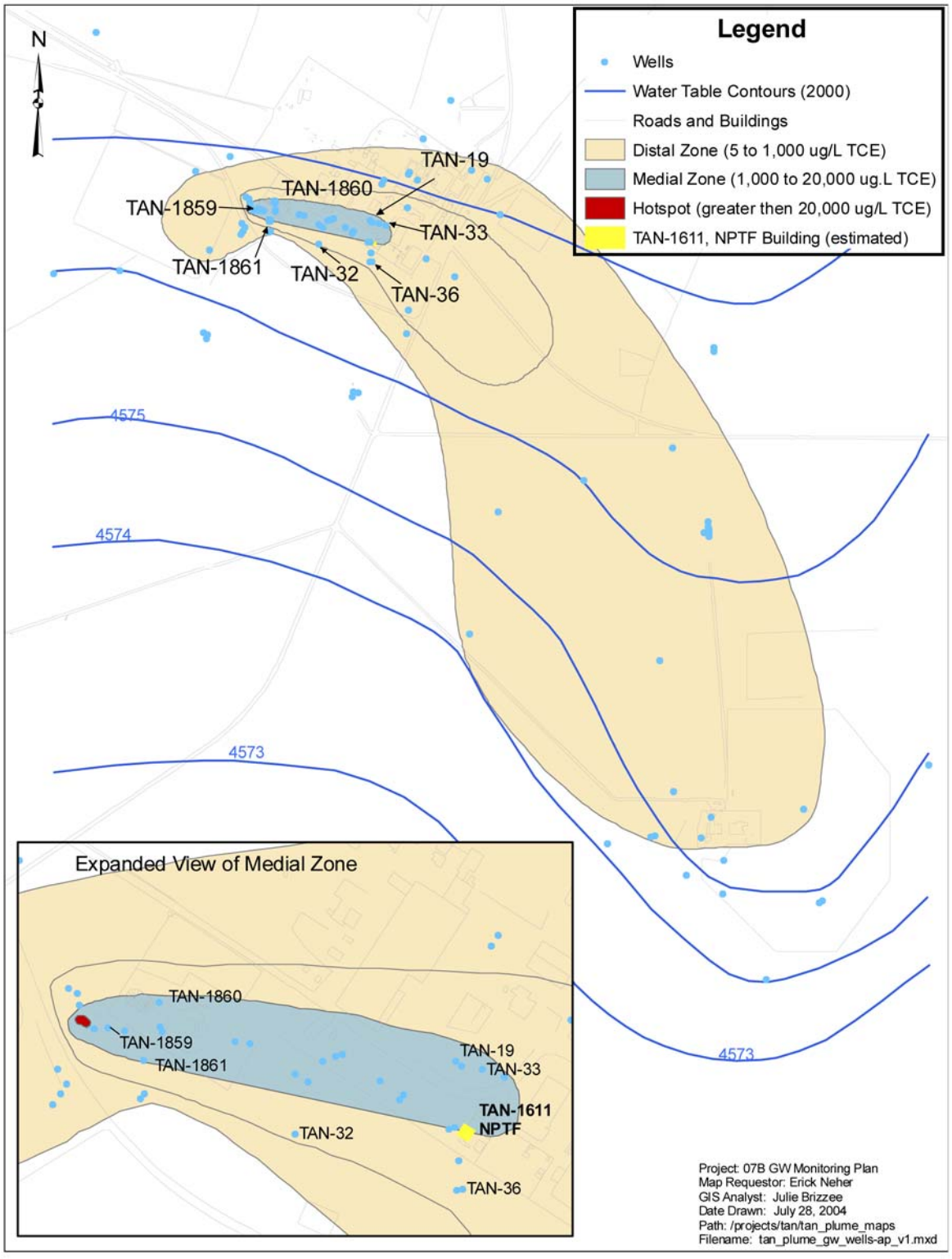


Figure 6-9. WAG 1 Well locations.

Hot Spot Zone (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 or sodium lactate) 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 2004 included periodic amendment injections (sodium lactate and whey), groundwater sampling and analysis, well-drilling activities, construction activities, and Alternate Electron Donor (AED) laboratory studies. Seven amendments were injected during the year, five into well TSF-05 and two into well TAN-1859. Whey powder was used for the last amendment during FY04. All other amendment injections were made with sodium lactate. Groundwater samples were collected monthly from 17 sampling locations in the treatment cell to track the progress of ISB in the hot spot zone.

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. Air stripping is a process that brings clean air into close contact with contaminated liquid, allowing the volatile organic contaminants to pass from the liquid into the air.

During 2004, all contaminant concentrations in water and air effluents from the New Pump and Treat Facility (NPTF) were below discharge limits and the influent contaminant concentrations continued to decrease. Water levels in several monitoring wells responded to extraction well startup (that is, pumping from extraction wells caused drawdown at these monitoring wells). Drawdown in wells TAN-19, -32, -33, and -36 indicates that the required plume capture width is achieved and that the NPTF is meeting its operational requirement to keep contaminated groundwater from migrating further downgradient.

Distal Zone (TCE concentrations between 5 and 1000 µg/L) - Monitored natural attenuation (MNA) has been selected as the treatment of choice for the distal zone of the plume. This process is the sum of the physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater.

Engineering and administrative controls are in place to protect current and future users from health risks associated with groundwater contamination. During the early part of the restoration timeframe, the contaminant plume may continue to increase slowly in size until the natural attenuation process overtakes it.

The primary MNA activities performed during 2004 were groundwater sampling and data analysis. Groundwater samples were collected for volatile organic compounds (VOCs) and radiological parameters from 17 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 2004 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, and uranium-234 (^{234}U), continue to be functional within the contaminant plume (DOE-ID 2003a). Groundwater monitoring in 2004 has shown no alarming increases in radionuclides, and 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 TAN OU 1-07B (DOE-ID 2003b).

Summary of WAG 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for WAG 2 during the calendar year 2004. The locations of the wells are shown on Figure 6-9, except for Highway 3 well, which is shown on Figure 6-16 for WAG 10. Six of the wells were sampled in both March and October of 2004, while Middle-1823 was only sampled in October 2004. Aquifer samples were analyzed for chromium (filtered and unfiltered), strontium-90, gamma spectroscopy, and tritium. The data for the March 2004 sampling event can be found in the FY04 Annual Report for WAG 2 (ICP 2004), and the data for the October 2004 sampling can be found in the FY05 annual report for WAG 2 (ICP 2005a). The data for the March 2004 and October 2004 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, with a maximum concentration of 136 µg/L in TRA-07 (Figure 6-10). Except for Highway-3, chromium concentrations were above background at all other aquifer wells sampled in WAG 2. The concentrations of chromium are declining in both USGS-065 and TRA-07.

Summary of WAG 3 Groundwater Monitoring Results

Groundwater samples (aquifer) were collected from 16 wells under CERCLA at WAG 3 in April, 2004 (DOE-ID 2005). Groundwater samples were analyzed for tritium, ^{90}Sr, Iodine-129 (^{129}I), uranium isotopes, plutonium isotopes, americium-241 (^{241}Am), mercury, gamma spectrometry, neptunium-237 (^{237}Np), technetium-99 (^{99}Tc), and gross alpha/beta activities. The sampling results are summarized in Table 6-4. Groundwater monitoring results for 2004 confirm

Table 6-3. WAG 2 groundwater quality summary for March and October 2004 sampling events.

Analyte	Background [a]	Maximum	Number of Wells with Detections above MCL	MCL
Strontium-90	<1	ND	0	8 pCi/L
Chromium (unfiltered)	2 to 3	146	2	100 µg/l
Chromium (unfiltered)		136	2	100 µg/l
Tritium	75 to 150	18 800	0	20,000 pCi/L

a. Background concentrations are from Knobel, Orr, and Cecil (1992).

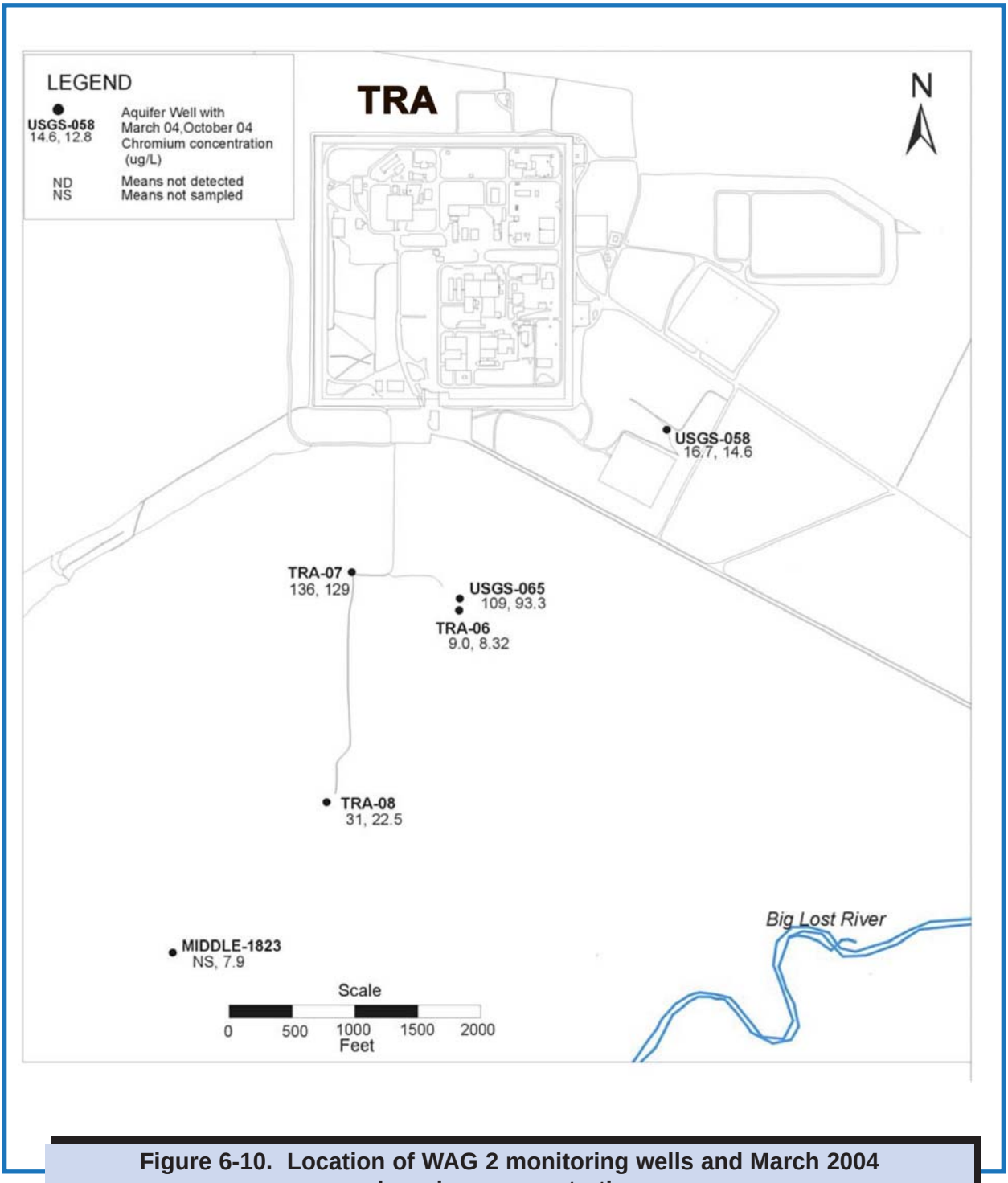


Figure 6-10. Location of WAG 2 monitoring wells and March 2004 chromium concentrations
(Note: Highway 3 well not shown on this map).

Table 6-4. Comparison of WAG 3 2004 sampling results in the ESRPA to regulatory levels.[a]

Analyte	Units	Maximum Detected Value	MCL or SMCL[a]	With Detections Above MCL or SMCL
Radionuclides				
Gross Beta	pCi/L	1380	NA	NA
Gross Alpha	pCi/L	178	15	2
Iodine-129	pCi/L	0.772	1	0
Technetium-99	pCi/L	2680	900	1
Strontium-90	pCi/L	35.4	8	9
Tritium	pCi/L	10500	20000	0
Carbon-14	pCi/L	10.4	2000	0
Cesium-137	pCi/L	11.4	200	0
Amercium-241	pCi/L	ND	15	0
Neptunium-237	pCi/L	0.178	15	0
Plutonium-238	pCi/L	ND	15	0
Plutonium-239/240	pCi/L	ND	15	0
Plutonium-241	pCi/L	20.6	300	0
Uranium-233/234	pCi/L	1.97	15	0
Uranium-235	pCi/L	0.344	15	0
Uranium-238	pCi/L	0.896	15	0
Anions				
Alkalinity-bicarbonate	mg/L	156	None	NA
Chloride	mg/L	140	*250*	0
Fluoride	mg/L	0.204	*2*	0
Nitrate/nitrite	mg-N/L	11.2	10	2
Sulfate	mg/L	44.9	*250*	0
Common Cations				
Calcium	mg/L	65,300	None	NA
Magnesium	mg/L	25,200	None	NA
Potassium	mg/L	5,220	None	NA
Sodium	mg/L	40,800	None	NA

previous observations that the concentrations of most radionuclides in groundwater continue to decline over time. One exception may be ^{99}Tc, whose concentrations appear to be slowly increasing at several monitoring well locations.

Strontium-90, ^{99}Tc, and gross alpha were detected in some wells above their respective MCLs. Tritium, ^{129}I, plutonium, uranium, and ^{137}Cs were also detected, but concentrations were below EPA maximum contaminant levels. Activities of $^{233/234}$U and ^{238}U isotopes were similar to background concentrations. Uranium-235 was detected in groundwater samples from three wells at levels slightly above natural background, but the concentrations were close to the detection limit and appear similar to those reported previously.

Table 6-4. Comparison of WAG 3 2004 sampling results in the ESRPA to regulatory levels (continued).[a]

Analyte	Units	Maximum Detected Value	MCL or SMCL[a]	Number of Wells With Detections Above MCL or SMCL
Inorganic Analytes				
Aluminum	mg/L	ND	*50–200*	0
Antimony	mg/L	ND	6	0
Arsenic	mg/L	3.38	50/10[b]	0
Barium	mg/L	141	2,000	0
Beryllium	mg/L	ND	4	0
Cadmium	mg/L	ND	5	0
Chromium	mg/L	20.2	100	0
Cobalt	mg/L	ND	None	NA
Copper	mg/L	2.31	1,300/*1,000*	0
Iron	mg/L	39	*300*	0
Lead	mg/L	ND	15[c]	0
Manganese	mg/L	7.32	50	0
Mercury	mg/L	0.149	2	0
Nickel	mg/L	37.5	None	NA
Selenium	mg/L	4.53	50	0
Thallium	mg/L	ND	2	0
Uranium	mg/L	ND	30	0
Vanadium	mg/L	8.5	None	NA
Zinc	mg/L	330	*5,000*	0
Perchlorate	mg/L	4.97	None	NA

a. Numbers in italics are for the **secondary MCL**.
b. The proposed new MCL for arsenic is 10 µg/L on 1/23/06.
c. The action level for lead is 15 µg/L.
NA = not applicable.
ND = not detected.

Strontium-90 concentrations are above the MCL (8 pCi/L) at nine of the 16 monitoring wells sampled in 2004 (Figure 6-11). However, ^{90}Sr levels have declined at most locations from the concentrations that were observed in 2001 and 2003. Strontium-90 was above its maximum contaminant level of 8 pCi/L in several wells near INTEC but was below its maximum contaminant level in the downgradient direction in wells at the CFA landfills. Tritium and ^{129}I concentrations were below MCLs in all wells sampled during 2003 and 2004. Iodine-129 concentrations increased slightly in several wells since 2001, but trends are inconclusive.

Groundwater from monitoring well ICPP-MON-A-230 located north of the INTEC tank farm contained elevated ^{99}Tc concentrations that exceeded the MCL (900 pCi/L) by a factor of approximately three. This was the only well that exceeded the ^{99}Tc MCL during 2004. The occurrence of elevated ^{99}Tc at this location is believed to be the result of past leaks from

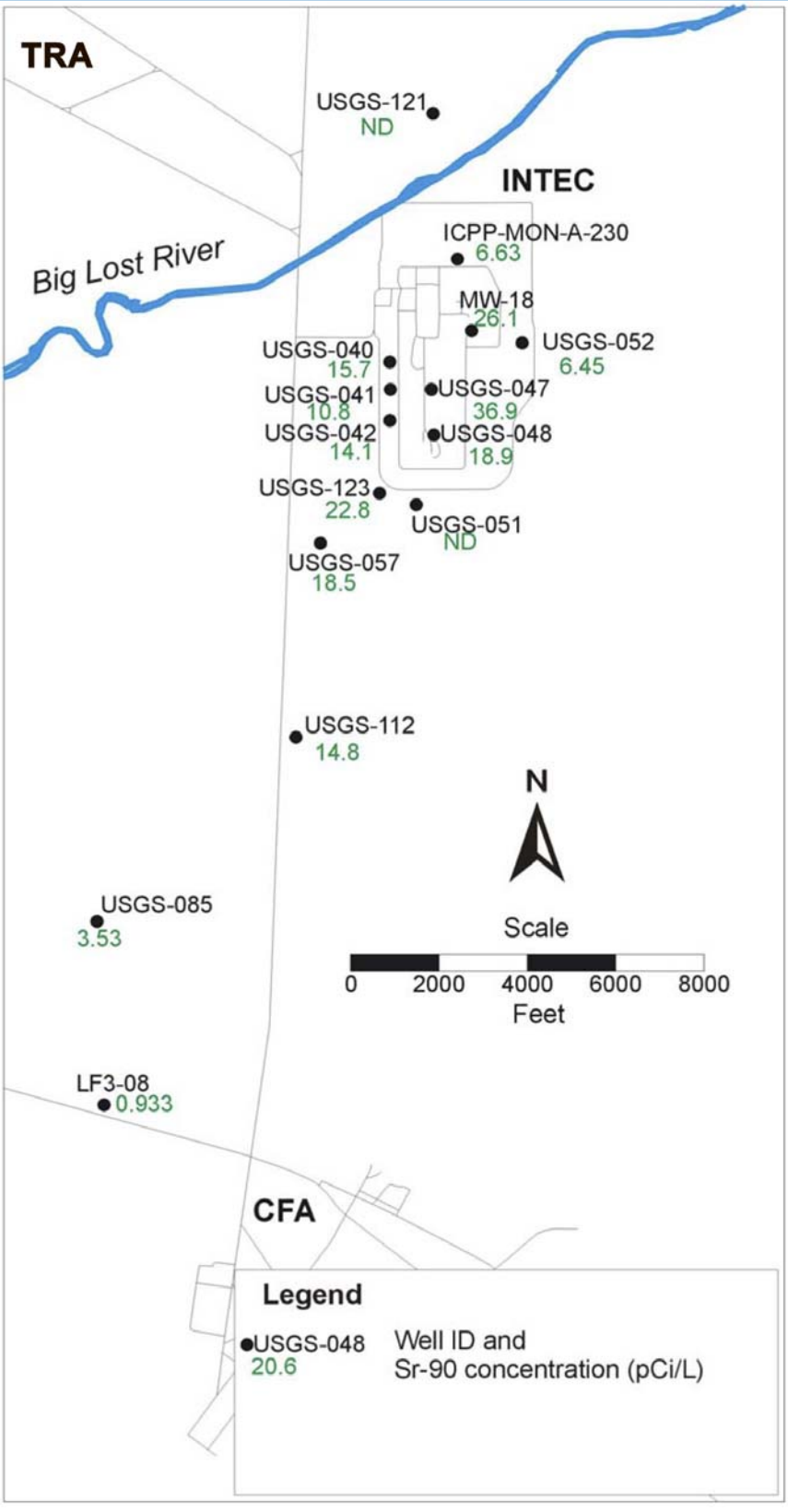


Figure 6-11. WAG 3 locations of wells sampled and distribution of ^{90}Sr (pCi/L) in the ESRPA in May- August 2004.

underground pipelines and valve boxes at the INTEC tank farm. Tc-99 concentrations in groundwater appear to have increased slightly at several locations downgradient of INTEC (DOE-ID 2004).

Gross beta results generally mirrored the results for ^{90}Sr and ^{99}Tc. Gross alpha activity in groundwater exceeded the MCL (15 pCi/L) in two wells located within INTEC. Gross alpha levels in wells located downgradient of INTEC were all below the MCL.

Cesium-137 was present in groundwater samples from two of the monitoring wells near the former injection well, but the concentrations were far below the MCL of 200 pCi/L.

Plutonium-241 was the only plutonium isotope detected in WAG 3 aquifer samples during 2004, and 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.

Mercury was detected in two wells during 2004, but the concentrations were below the MCL of 2 µg/L. Nitrate concentrations in groundwater slightly exceeded the MCL at two of the wells within INTEC. The elevated nitrate levels probably result from vadose zone sources. Elevated chloride concentrations that persist in wells near to and downgradient of the former percolation ponds are attributed to the elevated salinity of the service waste previously discharged to the percolation ponds.

Summary of WAG 4 Groundwater Monitoring Results

Groundwater monitoring for the CFA landfills consisted of sampling eleven wells for volatile organic compounds, metals, and anions. The locations of the wells sampled are shown on Figure 6-12. Because of falling water levels in the aquifer, only seven wells had sufficient water for sampling. Groundwater samples were not collected from LF2-08, LF2-09, LF2-11 and LF3-10. 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 ICP 2005b. The groundwater data indicated that nitrate was the only analyte above a maximum contaminant level. Nitrate was detected above its maximum contaminant level of 10 mg/L in well CFA-MON-A-002 (15.3 mg/L). Although previously above the MCL, the nitrate concentration in CFA-MON-A-03 (8.3 mg/L) dropped below the MCL in 2004. Nitrate concentrations in CFA-MON-A-002 and 003 dropped in 2004, but these concentrations are still within their historic ranges. Groundwater gradients and groundwater flow directions indicate that nitrate concentrations will not migrate to the Central Facilities Area production wells.

Iron was detected above its secondary maximum contaminant level of 300 µg/L in four samples, and aluminum was detected above its secondary maximum contaminant level of 200 µg/L in one sample. Because the pH of the groundwater is between 7 and 8 and has a high dissolved oxygen content, both the iron and aluminum are probably due to suspended particulates.

Summary of WAG 5 Groundwater Monitoring Results

WAG 5 FY-05 Groundwater monitoring was completed during October 2004 in accordance with the requirements delineated in the WAG 5 ROD (DOE-ID 2000a) and the Groundwater Monitoring Plan (DOE-ID 2000b). Nine wells were sampled, and the locations of these wells are

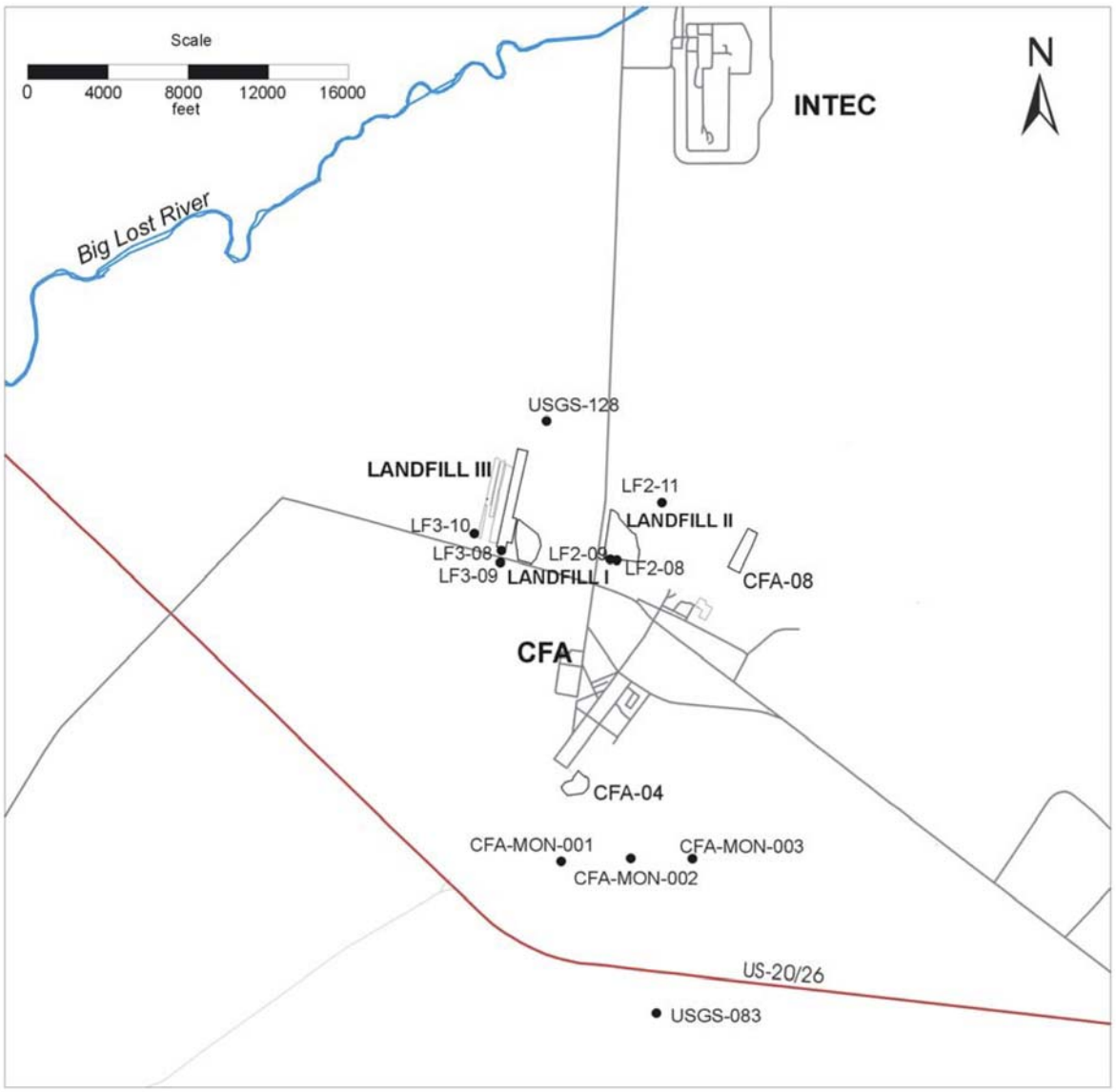


Figure 6-12. Location of WAG 4/CFA monitoring wells.

shown on Figure 6-13. Samples were analyzed for volatile organic compounds, select metals, anions and radionuclides. Specific metals requested included arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Radionuclide analyses included gross alpha and beta, gamma spectrometry, tritium, and ^{129}I. The results are summarized below, and the complete listing of results can be found in ICP (2005d).

All constituents analyzed from the October 2004 sampling event were below MCLs. The data are summarized in Table 6-6. There were three detections of toluene and one detection of trichloroethene. Toluene was detected in three wells at concentrations less than 1 µg/L up to 76.1 µg/L, with the highest concentration occurring at ARA-MON-A-004. Other BTEX (benzene, toluene, ethyl benzene, and xylene) components or hydrocarbon TICs (tentatively identified compounds) were not associated with toluene at the three locations where toluene was detected.

Table 6-5. Comparison of 2004 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	152	None	NA
Chloride	mg/L	111	*250*	0
Fluoride	mg/L	0.203	*2*	0
Nitrate/nitrite	mg-N/L	15.3	10	1
Sulfate	mg/L	39.5	*250*	0
Common Cations				
Calcium	µg/L	62,300	None	NA
Magnesium	µg/L	22,800	None	NA
Potassium	µg/L	4,360	None	NA
Sodium	µg/L	41,200	None	NA
Organic Analytes				
Toluene	µg/L	3.2	1,000	0
Inorganic Analytes				
Aluminum	µg/L	562	*50–200*	1
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	42.4	100	0
Copper	µg/L	ND	1,300/*1,000*	0
Iron	µg/L	924	*300*	4
Lead	µg/L	ND	15[c]	0
Manganese	µg/L	29.9	50	0
Mercury	µg/L	0.05	2	0
Nickel	µg/L	112	None	NA
Selenium	µg/L	4.8	50	0
Vanadium	µg/L	8.5	None	NA
Zinc	µg/L	210	*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.

The source of the toluene detections is uncertain, but the lack of other hydrocarbons at the locations of the toluene detections is not consistent with fuel migration. The occurrence of toluene may be a laboratory artifact. All detections were well below the toluene MCL of 1,000 µg/L. Trichloroethene were detected at a concentration less than 1 µg/L and well below its MCL of 5 µg/L. Lead concentrations, which had been above its action level of 15 µg/L in several wells in the past, were all below the action level in October 2004. Replacement of galvanized riser pipe with stainless steel riser pipe appears to have removed the source of lead in the wells. Consequently, lead concentrations have declined to background concentrations.

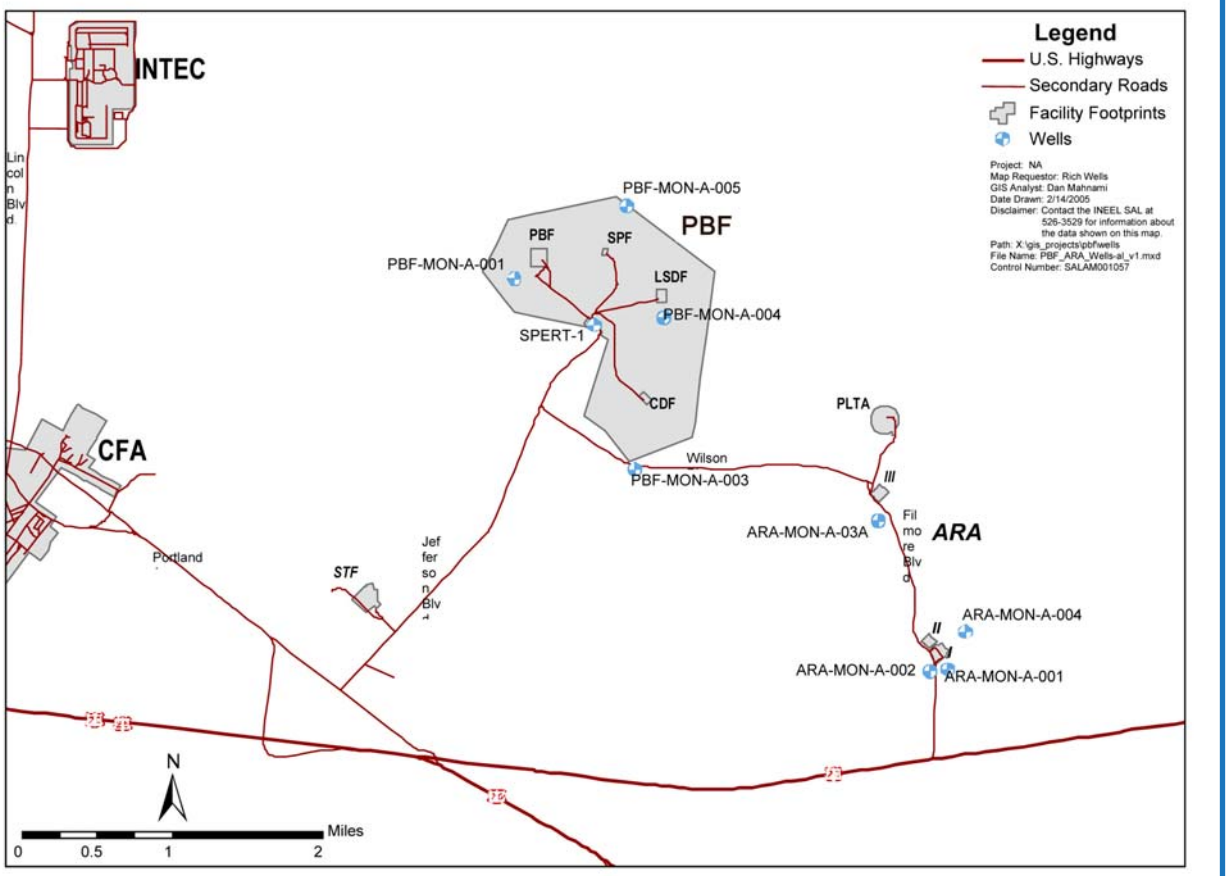


Figure 6-13. Wells sampled for WAG 5.

Gross alpha and gross beta concentrations were similar to background. Antimony-125 (^{125}Sb)was detected in Well PBF-MON-A-001 at a concentration of 16.8 ± 0.984 pCi/L, but this result is near the minimum detectable activity of 13.7 pCi/L for this analysis. Ruthenium-106 (^{106}Ru) was detected in PBF-MON-A-004 at 38.1 pCi/L but was flagged "J" during validation and was less than the minimum detectable activity of 41.4 pCi/L. In addition, these results are questionable for three other reasons. First, no other gamma-emitting radionuclides were reported in the samples, especially cobalt-60 and ^{137}Cs, which would be expected in the presence of the two isotopes in question. Second, both ^{125}Sb and ^{106}Ru have short half-lives (2.77 and 1.01 years, respectively) and if actually present would indicate a short travel time to the well from the source. However, no activities have taken place in the vicinity of the Auxiliary Reactor Area or the Critical Infrastructure Test Range in the last 20 years that could have contributed to the presence of these isotopes in the environment. Third, neither of these isotopes have been detected historically in samples from these two wells.

Summary of WAG 7 Groundwater Monitoring Results

Fifteen aquifer-monitoring wells were sampled under OU 7-13/14 and analyzed for a variety of radionuclide, inorganic, and organic contaminants (ICP, 2005c). Historically, aquifer samples

Table 6-6. Comparison of 2004 detected analytes at WAG 5 with MCLs.

Analyte	Background[a]	Maximum	Number of Wells with Detections above MCL	MCL or SMCL
Radionuclides				
Gross beta (pCi/L)	0 to 7	5.85	0	4 mrem/yr
Gross alpha (pCi/L)	0 to 3	4.54	0	15
Ruthenium-106(pCi/L)	—[b]	38.1	0	
Antimony-125 (pCi/L)	—[b]	16.8	0	
Inorganics				
Arsenic (µg/L)	2 to 3	7.9	0	50[c]
Barium (µg/L)	50 to 70	54.6	0	2,000
Chromium (µg/L)	2 to 3	11.6	0	100
Cadmium	<1	0.74	0	5
Lead (µg/L)	1 to 5	ND	0	15[d]
Fluoride (mg/L)	0.2 to 0.5	0.528	0	4[e]
Chloride (mg/L)	16 to 27	26.6	0	250[f]
Nitrate (mg/L)	1 to 2	1.35	0	10
Selenium	<1	9.4	0	50
Sulfate (mg/L)	24 to 31	23.8	0	250[g]
Organics				
Toluene (µg/L)	—[f]	76.1	0	1,000
2-Hexanone (µg/L)	—[f]	1.6	0	—

a. Background concentrations are from Knobel, Orr, and Cecil (1992).
b. Ru-106 and Sb-125 are considered to be absent from background.
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. For fluoride, a 2-mg/L secondary standard exists in addition to the MCL.
f. Concentration represents the EPA-defined secondary standard for this contaminant.
g. Volatile organic compounds are considered to be absent from background.
"—" = no data
MCL = maximum contaminant level
ND = not detected
SMCL = secondary maximum contaminant level.

have been collected quarterly; however, because years of monitoring data continued to show consistently low and unchanging detection rates of contaminants, the monitoring frequency was reduced to semiannually in August 2004. In addition to the wells monitored by OU 7-13/14, the USGS routinely samples eight wells in the vicinity of the RWMC. Figure 6-14 shows the location of the aquifer monitoring wells sampled at the RWMC.

During analyses of WAG 7 groundwater samples, carbon tetrachloride, tritium, chromium, and nitrate (as nitrogen) are consistently detected above aquifer background levels in some wells.

Contaminants detected in the aquifer beneath the RWMC in 2004 are summarized below:

- Elevated concentrations of carbon tetrachloride, toluene, and tricholroethene were detected in monitoring wells located east and southeast of the RWMC. Carbon tetrachloride concentrations regularly exceed the MCL in Well M7S.
- Chromium concentrations are elevated and steadily increasing in Wells M1SA, M6S, M11S, and M15S. The MCL was recently exceeded in Well M15S.
- Some chemical constituents of magnesium chloride brine or buried waste may have been detected in aquifer wells east and southeast of the RWMC.
- Neptunium-237 was detected in one sample from Well M11S at a concentration slightly above the method detection limit.
- Uranium-233/234 found in the aquifer was mostly at background levels, although the maximum concentration (i.e., 2.08 pCi/L) was slightly above the upper background tolerance limit of 1.92 pCi/L.
- Uranium-235 concentrations in Wells M12S and M13S are gradually increasing, and an upward trend is evident.
- Tritium is consistently detected at low concentrations in RWMC wells located in the northeast corner of the Subsurface Disposal Area (SDA).

Tritium was detected in the vadose zone and aquifer beneath the RWMC, but significant detections also occurred upgradient of the RWMC. It is speculated that some of the tritium is from upgradient facilities, primarily TRA; however, it is also likely that some of the tritium beneath the RWMC comes from sources in the SDA. Uranium detections in aquifer wells located around the RWMC are representative of natural uranium; however, indications of very low concentrations of anthropogenic uranium were found in two upgradient RWMC wells. The environmental data appear to warrant further investigation.

Summary of WAG 9 Groundwater Monitoring Results

ANL-W samples five wells (four monitoring and one production) (Figure 6-15) twice a year for selected radionuclides, metals, total organic carbon, total organic halogens, and water quality parameters as required under the WAG 9 ROD (ANL-W, 1998). Gross alpha, gross beta, and certain uranium isotopes were measured in groundwater during 2004. Uranium isotopes (i.e., natural uranium, uranium-235, uranium-238), and gross alpha and gross beta activity have been measured in these wells in the past. The concentrations are consistent with concentrations attributable to natural sources of uranium- and thorium-series radionuclides and the concentrations are statistically the same for both upgradient and downgradient wells, implying a natural source for this radioactivity. Table 6-7 gives the values for the measured radionuclides.

The common metals aluminum, calcium, iron, magnesium, potassium, and sodium were detected at levels consistent with past years. Barium, chromium, copper, manganese, vanadium, and zinc also were measured (Table 6-7). Anions and water quality parameters were within ranges of past values.

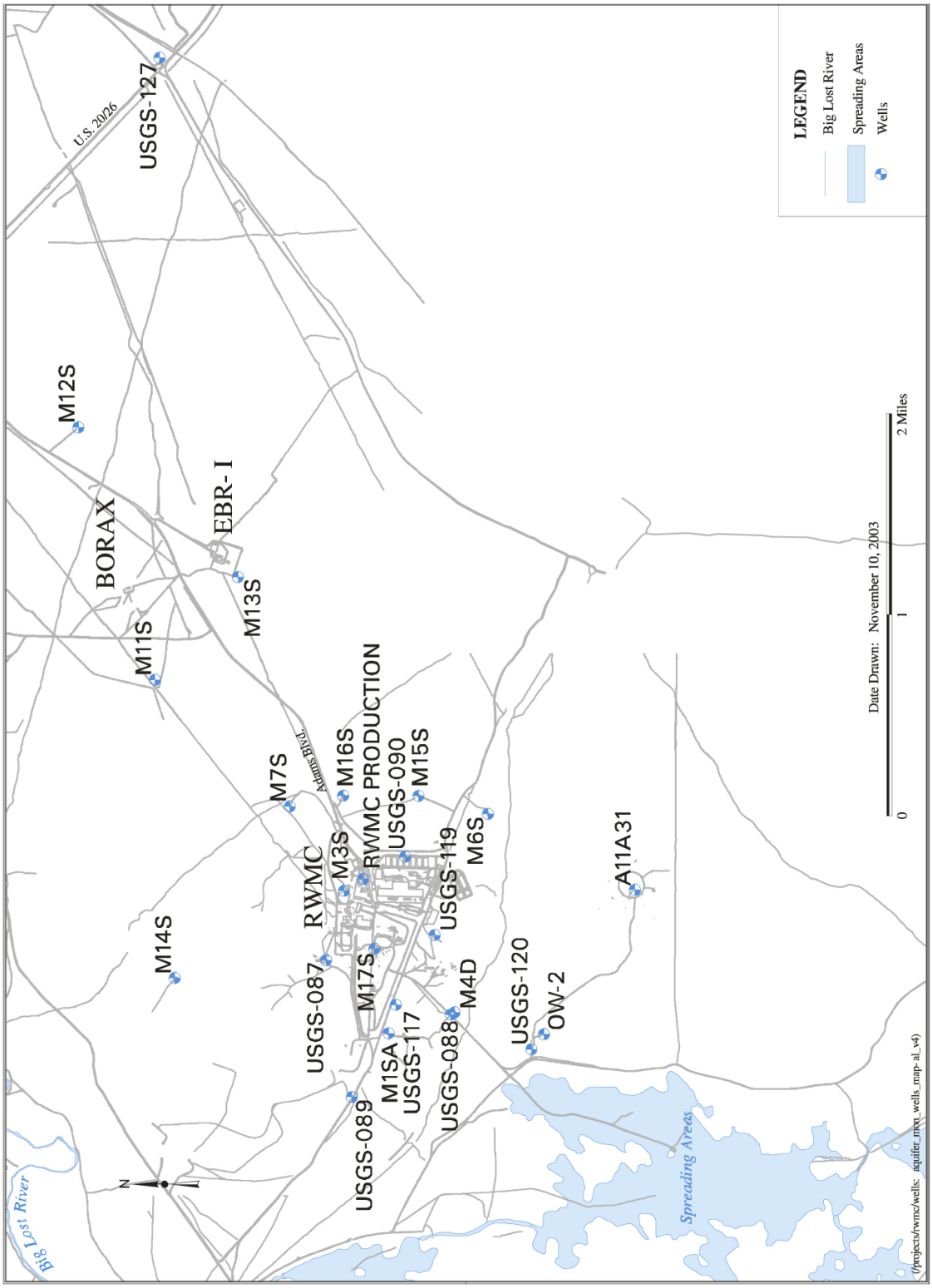


Figure 6-14. Locations of aquifer-monitoring wells at the Radioactive Waste Management Complex.

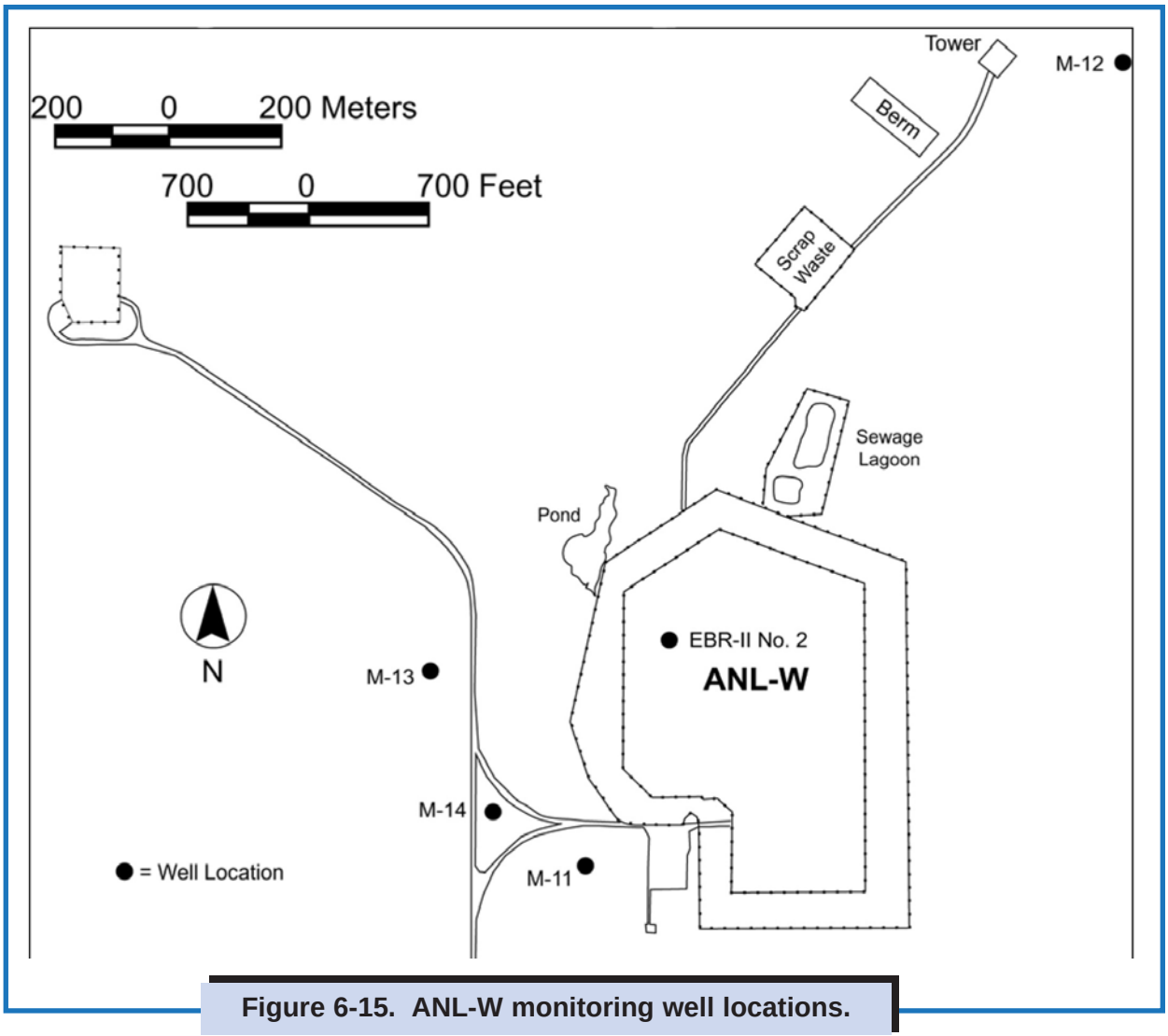


Figure 6-15. ANL-W monitoring well locations.

Summary of WAG 10 Groundwater Monitoring Results

The WAG 10 2004 groundwater sampling consisted of a sampling event in June-July, 2004. Twenty-two wells were sampled in June-July 2004. The wells were sampled for volatile organic compounds, metals (filtered), anions (including bicarbonate), and radionuclides (^{129}I, tritium, ^{99}Tc, gross alpha, gross beta, gamma spec, uranium-isotopes, and ^{90}Sr). The locations of the wells are shown in Figure 6-16. The results are summarized on Table 6-8 and briefly described below. The complete results can be found in DOE-ID 2005.

Methylene chloride was detected above the MCL in one well, but its occurrence is doubtful since this compound is a common laboratory contaminant and it was also detected in the laboratory blank. Other detected VOCs include trichloroethene, carbon tetrachloride, bromomethane, and carbon disulfide.

Table 6-7. Summary of metals and water quality parameters in ANL-W monitoring wells (2004).

Well	M-11		M-12		M-13		M-14		
Sample Date	4/20/2004	10/25/2004	4/20/2004	10/25/2004	4/20/2004	10/25/2004	4/20/2004	10/25/2004	PCS/SCS[a]
Parameter									
Radionuclides[b]									
Gross Alpha	--	1.28	1.86	3.19	1.75	2.70	1.38	-0.871	15
Gross Beta	--	1.69	2.98	4.08	4.06	2.52	3.46	0.367	50[c]
Uranium-233/234	--	1.66	--	1.40	1.29	1.35	0.878	0.035	[d]
Uranium-235/236	--	0.54	--	0.011	0.056	0.053	0.079	0.016	NE[e]
Uranium-238	--	0.91	--	0.379	0.709	0.699	0.364	0.039	NE
Metals[f]									
Aluminum	35.9	--	12.4	--	--	--	5.32	--	200
Barium	0.709	18.6	42.3	42.2	--	35.3	35.9	35.5	2,000
Calcium ($\times 10^4$)	0.032	--	3.97	--	3.81	--	3.83	--	NE
Chromium	1.57	1.57	3.04	3.50	5.36	--	5.09	3.50	100
Copper	1.80	--	1.80	--	4.99	--	1.91	3.50	1,300
Iron	68.0	--	183	--	363	--	153	--	300
Lead	4.99	3.76	1.94	1.72	1.94	--	1.94	1.72	150
Magnesium ($\times 10^4$)	0.10	--	1.10	--	1.13	--	1.10	--	NE
Manganese	1.54	--	2.84	--	2.65	--	0.468	--	50
Potassium ($\times 10^3$)	0.076	--	3.70	--	3.26	--	3.23	--	NE
Sodium ($\times 10^4$)	0.113	--	1.71	--	1.77	--	1.77	--	NE
Thallium	0.020	--	0.305	--	0.020	--	0.020	--	2
Vanadium	--	--	5.71	--	5.72	--	5.72	--	NE
Zinc	--	--	4.71	--	--	--	--	--	5,000

Table 6-7. Summary of metals and water quality parameters in ANL-W monitoring wells (2004) (cont.).

Well	M-11		M-12		M-13		M-14		
Sample Date	4/20/2004	10/25/2004	4/20/2004	10/25/2004	4/20/2004	10/25/2004	4/20/2004	10/25/2004	PCS/SCS[a]
Anions[g]									
Chloride	--	18.7	6.63	1.02	18.5	20.0	18.6	13.1	250
Nitrate	--	1.18	1.95	1.12	0.760	-0.047	1.26	-0.048	10
Sulfate	--	--	5.03	8.35	16.9	18.1	16.1	--	25
Bicarbonate Alkalinity	--	--	--	--	136	132	134	--	NE
Total Alkalinity	--	--	128	63.6	137	133	135	--	NE
Total Dissolved Solids	--	372	--	154	--	375	--	--	500
Total Organic Carbon	0.361	0.887	1.52	1.40	0.618	0.895	--	--	NE
Total Organic Halogen	0	--	--	0	--	3.05	--	--	NE

a. PCS/SCS = Primary constituent standard/Secondary constituent standard values as detailed in IDAPA 58.01.11.
b. All radionuclide values are in picocuries per liter (pCi/L) plus or minus 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. The MCL for total uranium is a concentration (30 µg/L) instead of an activity (pCi/L).
e. NE = not established. A primary or secondary constituent standard has not yet been established for this constituent.
f. All metal values are in micrograms per liter (µg/L), unless otherwise noted.
g. All anions and water quality parameter values are in milligrams per liter (mg/L), unless otherwise noted.

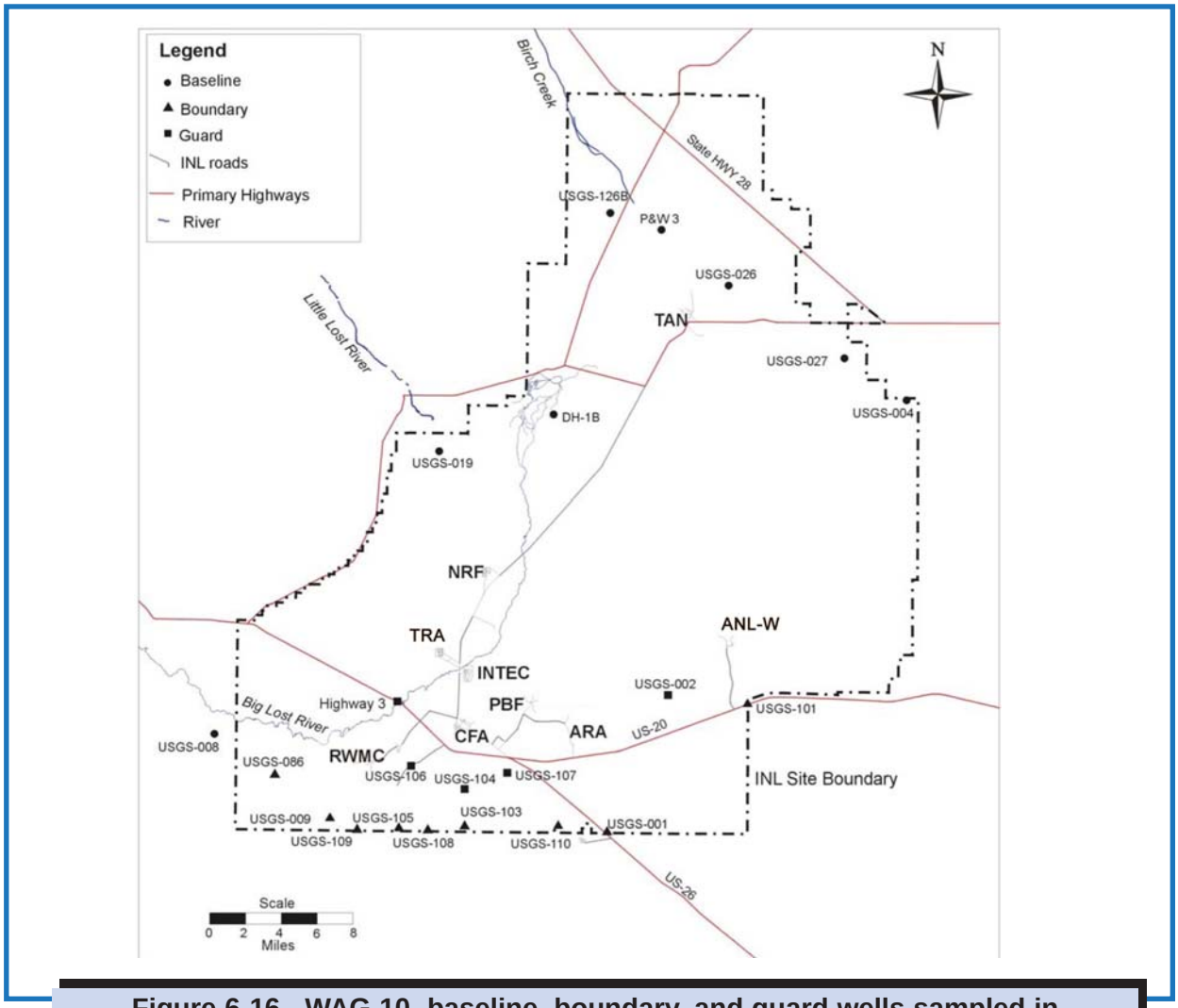


Figure 6-16. WAG 10 baseline, boundary, and guard wells sampled in June-July 2004.

None of the metals were measured above their respective MCL. Nitrate is elevated in USGS-004 relative to other WAG 10 wells and probably represents off-site agricultural influences upgradient of the INEEL. Off-site influence was also indicated by elevated specific conductivity values for USGS-004 and USGS-27.

Tritium, gross alpha, gross beta, and 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 at concentrations less than 1,000 pCi/L or well below the MCL of 20,000 pCi/L.

6.8 Offsite Water Sampling

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 2004, the ESER contractor collected 30 drinking water samples from 14 offsite locations.

Table 6-8. Comparison of detected analytes with MCLs or SMCLs for WAG 10.

Analyte	Sample Units	Maximum Concentration	MCL or SMCL[a]	Detections above MCL or SMCL
Radionuclides				
Gross Beta	pCi/L	6.89	NA	NA
Gross Alpha	pCi/L	9.32	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	1,090	20,000	0
Cesium-137	pCi/L	2.74	200	0
Carbon - 14	pCi/L	ND	2,000	0
Uranium-233/234	pCi/L	2.65	15	0
Uranium-235	pCi/L	0.454	15	0
Uranium-238	pCi/L	1.48	15	0
VOCs				
Bromomethane	ug/L	1.4	100	0
Trichloroethene	ug/L	0.22	5	0
Methylene chloride	ug/L	26	5	1[b]
Carbon tetrachloride	ug/L	0.24	5	0
Carbon disulfide	ug/L	2.4	none	NA
Anions				
Alkalinity	mg/L	159	None	NA
Bicarbonate	mg/L	159	None	NA
Carbonate	mg/L	U	None	NA
Chloride	mg/L	56.8	*250*	0
Fluoride	mg/L	0.98	*2*	0
Nitrate/Nitrite as N	mg/L	3.8	10	0
Sulfate	mg/L	37.4	*250*	0
Common Cations				
Calcium	ug/L	63,400	None	NA
Magnesium	ug/L	22,800	None	NA
Potassium	ug/L	6,740	None	NA
Sodium	ug/L	49,500	None	NA
Metals				
Aluminum	ug/L	43.6	*50 to 200*	0
Antimony	ug/L	U	6	0
Arsenic	ug/L	3.2	50/10[c]	0
Barium	ug/L	135	2,000	0
Beryllium	ug/L	U	4	0
Cadmium	ug/L	U	5	0
Chromium	ug/L	12.6	100	0

Table 6-8. Comparison of detected Analytes with MCLs or SMCLs for WAG 10 (continued).

Analyte	Sample Units	Maximum Concentration	MCL or SMCL[a]	Detections above MCL or SMCL
Metals (cont.)				
Cobalt	ug/L	U	None	NA
Copper	ug/L	U	1,300/*1,000*	0
Iron	ug/L	150	*300*	0
Lead	ug/L	U	15[d]	0
Manganese	ug/L	22.4	*50*	0
Mercury	ug/L	U	2	0
Nickel	ug/L	U	None	NA
Selenium	ug/L	4	50	0
Silicon	ug/L	18100	None	NA
Silver	ug/L	U	None	NA
Strontium	ug/L	292	None	NA
Thallium	ug/L	0.91	2	0
Uranium	ug/L	19.2	30	0
Vanadium	ug/L	6.1	None	NA
Zinc	ug/L	335	*5,000*	0

a. Numbers in italics are for secondary maximum contaminant level.

b. Methylene chloride is a common laboratory contaminant.

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.

MCL = maximum contaminant level

NA = not applicable

ND = not detected

SMCL = secondary maximum contaminant level

Gross alpha activity was detected in one sample from Idaho Falls. The measured concentration of 4.58 ± 1.46 pCi/L was significantly below the EPA MCL of 15 pCi/L.

As in years past, measurable gross beta activity was present in most offsite drinking water samples (21 of the 30 samples). Detectable concentrations ranged from 2.99 ± 0.98 pCi/L to 7.85 ± 1.06 pCi/L (Table 6-9). The upper value of this range is 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.

Tritium was measured in ten drinking water samples during 2004, ranging from 78.0 ± 25.1 pCi/L at Taber in May to 142.0 ± 30.2 at Aberdeen and Howe in November (Table 6-9). The maximum level is still well below the DOE's DCG of 2.0 x 10^6 pCi/L and 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 INEEL boundary are sampled twice a year for gross alpha, gross beta, and tritium. In 2004, the ESER contractor collected 11 surface water samples from five offsite locations.

Gross alpha activity was not detected in any sample during 2004.

Tritium was detected in one offsite surface water sample during 2004. The November surface water sample collected in the Hagerman area had a concentration of 86.8 ± 35.8 pCi/L (Table 6-10). This sample was well below the PCS and EPA MCL of 20,000 pCi/L. These levels can be attributed to natural variability.

Gross beta activity was measured in 8 of the 11 offsite surface water samples. Detectable concentrations ranged from 2.90 ± 0.92 pCi/L to 7.14 ± 0.98 pCi/L at Hagerman and Bliss, respectively (Table 6-10). The maximum concentration is well 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 6-9. 2004 ESER contractor offsite drinking water results.

Location	Sample Results	Limits for Comparison[a]
	Result ± 1s[a]	EPA MCL[b]
Gross Alpha		
May 2004		
Idaho Falls	4.58 ± 1.46	15
Gross Beta		
May 2004		
Aberdeen	5.80 ± 0.99	50[c]
Atomic City	3.00 ± 0.85	50
Fort Hall	7.85 ± 1.06	50
Idaho Falls	4.92 ± 0.95	50
Minidoka	3.22 ± 0.89	50
Monteview	5.17 ± 0.93	50
Moreland	6.48 ± 1.05	50
Mud Lake	3.69 ± 0.86	50
Duplicate	3.77 ± 0.84	50
Shoshone	3.47 ± 0.88	50
Taber	3.99 ± 0.97	50
November 2004		
Aberdeen	5.12 ± 1.01	50
Atomic City	4.92 ± 0.89	50
Fort Hall	6.75 ± 1.10	50
Howe	5.12 ± 1.01	50
Minidoka	5.31 ± 0.93	50
Monteview	3.04 ± 0.97	50
Duplicate	3.75 ± 0.87	50
Moreland	4.18 ± 1.05	50
Mud Lake	4.22 ± 0.95	50
Roberts	2.99 ± 0.98	50
Tritium		
May 2004		
Howe	97.4 ± 29.8	20,000
Taber	78.0 ± 25.1	20,000
November 2004		
Aberdeen	142.0 ± 30.2	20,000
Arco	137.0 ± 31.3	20,000
Atomic City	140.0 ± 30.8	20,000
Fort Hall	137.0 ± 31.2	20,000
Howe	142.0 ± 30.2	20,000
Monteview	139.0 ± 26.4	20,000
Mud Lake	78.8 ± 25.3	20,000
Taber	81.9 ± 25.6	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, DCG = derived concentration guide.

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.

Table 6-10. 2004 ESER contractor offsite surface water detections.

Location	Sample Results[a]	Limits for Comparison[b]		
	Result ± 1s	PCS[c]	EPA MCL[d]	DOE DCG[e]
Tritium				
November 2004				
Hagerman	86.8 ± 25.8	20,000	20,000	2,000,000
Gross Beta				
May 2004				
Bliss	4.65 ± 0.93	4 mrem/yr	50	100[f]
Buhl	4.89 ± 0.94	4 mrem/yr	50	100
Hagerman	4.25 ± 0.89	4 mrem/yr	50	100
Twin Falls	6.94 ± 1.04	4 mrem/yr	50	100
November 2004				
Bliss	7.14 ± 0.98	4 mrem/yr	50	100
Buhl	3.85 ± 0.88	4 mrem/yr	50	100
Hagerman (duplicate)	2.90 ± 0.92	4 mrem/yr	50	100
Twin Falls	3.34 ± 1.06	4 mrem/yr	50	100

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
e. DCG = Derived Concentration Guide.
f. Value based on the most conservative beta emitter (Radon-226).

REFERENCES

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

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

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

Bechtel Bettis, 2004, *2004 Environmental Monitoring Report for the Naval Reactor Facility*, NRFRC-EE-0012.

ICP, 2004, *Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2004*, ICP/EXT-04-00369, Rev. 0, September 2004.

ICP, 2005a, *Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2005*, ICP/EXT-05-00967, Rev. 0, August 2005.

ICP, 2005b, *Central Facilities Area Landfills I, II, and III Annual Monitoring Report (2004)*, ICP/EXT-05-00915, Rev. A, June 2005.

ICP, 2005c, *Fiscal Year 2004 OU 7-13/14 Environmental Monitoring Report for the Radioactive Waste Management Complex*, ICP/EXT-05-00795, May 2005.

ICP, 2005d, *Annual Groundwater Monitoring Status Report for Waste Area Group 5 Fiscal Year 2005*, INEEL/EXT-05-00901, Rev. 0, June 2005.

IDAPA 58.01.11, "Ground Water Quality Rules," State of Idaho Department of Health and Welfare, current revision.

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

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2000a, *Final Record of Decision for Power Burst Facility and Auxiliary Reactor Area*, DOE/ID-10700.

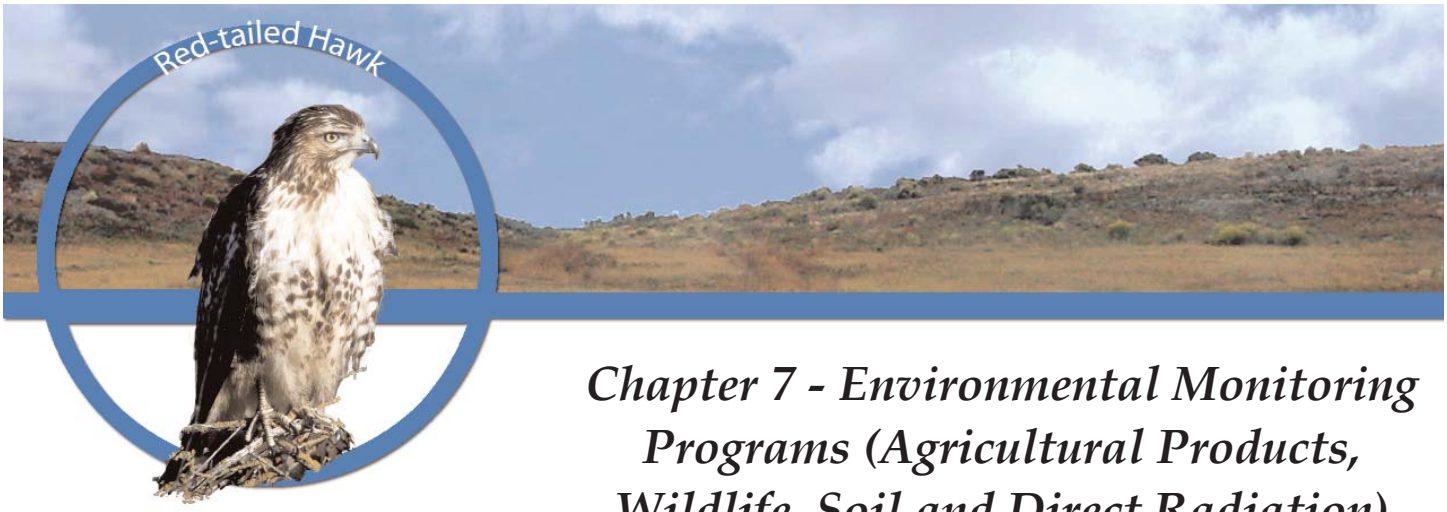
U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2000b, *Groundwater Monitoring Plan for the Waste Area Group 5, Remedial Action*, DOE/ID-10779, Revision 0.

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2003a, *Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B*, DOE/ID-11055, Revision 0.

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

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2004, *Annual INTEC groundwater monitoring report for Group 5-Snake River Plain Aquifer (2004)*, DOE/ID-11222, Rev 0. May 2005.

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2005, *Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Annual report (FY-2004)*, DOE/ID-11198, Rev 0. March 2005.



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

R. Mitchell - S. M. Stoller Corporation
R Wilhelmsen and D. McBride - Bechtel/BWXT Idaho, LLC
M. Finnerty - Argonne National Laboratory-West

Chapter Highlights

To help assess the impact of contaminants released to the environment by operations at the Idaho National Engineering and Environmental Laboratory (INEEL), 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 INEEL in 2004.

Some human-made radionuclides were detected in agricultural products and soil samples. However, the results could not be directly linked to operations at the INEEL. 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 2004 but concentrations were similar to those found in samples taken off the INEEL.

Direct radiation measurements made at offsite, boundary, and onsite (except in the vicinity of some INEEL facilities) locations were consistent with background levels. The measured annual dose equivalent from external exposure was 122 mrem. Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INEEL 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)

7.1 Organization of Monitoring Programs

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

The Management and Operating (M&O) contractor monitored soil, vegetation, and direct radiation on the INEEL to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The M&O contractor collected 418 soil, vegetation, and direct radiation samples for analysis in 2004.

Argonne National Laboratory-West (ANL-W) and the Naval Reactors Facility (NRF) also conduct monitoring of soil, vegetation, and direct radiation. These programs are to show compliance with DOE orders but are limited in scope to their specific facilities.

The Environmental Surveillance, Education and Research Program (ESER) contractor conducted offsite environmental surveillance and collected samples from an area of approximately 23,308 km^2 (9,000 mi^2) of southeastern Idaho at locations on, around, and distant to the INEEL. The ESER contractor collected approximately 225 agricultural products, wildlife, and direct radiation samples for analysis in 2004.

Section 7.2 presents the agricultural products and wildlife surveillance results sampled under the ESER Program. Section 7.3 presents the results of soil sampling by both the ESER contractor and the M&O contractor. The direct radiation surveillance results are presented in Section 7.4. Results of the waste management surveillance activities are discussed in Section 7.5.

The INEEL Oversight Program, conducted by the state of Idaho, collects split samples with the M&O and other INEEL contractors of some agricultural products and soil, and maintains collocated direct radiation monitors. Results of the Oversight Program's monitoring are presented in annual reports prepared by that organization and are not reported here.

The analytical results reported in the following surveillance sections are those that are greater than three times the analytical uncertainty (see Appendix B for information on statistical methods). Analytical uncertainties reported in text and tables are plus or minus one standard deviation (± 1s) uncertainty for the radiological analysis.

Table 7-1. Other environmental monitoring activities at the INEEL.

Area/Facility[a]	Media				
	Agricultural Products	Wildlife	Soil	Vegetation	Direct Radiation
Argonne National Laboratory-West					
ANL-W			•	•	•
Management and Operating Contractor					
CFA			•		•
RWMC			•	•	•
PBF/CITR					•
Sitewide[b]			•		•
Naval Reactors Facility					
NRF			•	•	•
Environmental Surveillance, Education and Research Program					
INEEL/Regional	•	•	•	•	•
INEEL Oversight Program					
INEEL/Regional	•[c]		•		•

a. ANL-W = Argonne National Laboratory-West, CFA = Central Facilities Area, RWMC = Radioactive Waste Management Complex, PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range, and NRF = Naval Reactors Facility

b. Sitewide includes thermoluminescent dosimeters located at major facilities (e.g., CFA, NRF, and ANL-W).

c. The only agricultural product collected by the INEEL Oversight Program is milk.

7.2 Agricultural Products and Wildlife Sampling

Milk

During 2004, 152 milk samples were collected by the ESER Program. All of the samples were analyzed for gamma-emitting radionuclides including iodine-131 (^{131}I). During the second and fourth quarters, selected samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine-131 was not detected in any sample in 2004. Strontium-90 was detected in three out of nine samples ranging from 0.6 ± 0.2 pCi/L at Idaho Falls to 1.2 ± 0.2 pCi/L in a sample from Roberts. 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 lower than the DOE derived concentration guide (DCG) for ^{90}Sr in water of 1,000 pCi/L.

Tritium was detected in four of nine samples with a maximum concentration of 107 ± 27 pCi/L at Blackfoot. This value is well below the DOE DCG of 20,000 pCi/L for water.

Lettuce

ESER Program personnel collect lettuce samples every year from the areas adjacent to the INEEL. The collection of lettuce from home gardens around the INEEL 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 INEEL. 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 INEEL). 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. Figure 7-1 shows the seven locations where lettuce was collected in 2004.

Seven lettuce samples, including one duplicate, were collected from regional private gardens and two were collected from the portable lettuce gardens placed at Atomic City and EFS. No anthropogenic radionuclides were detected above the 3s level in 2004 (Table 7-2). Strontium-90 and Cesium-137 (^{137}Cs) in lettuce results from plant uptake of these isotopes in soil as well as deposition from airborne dust containing ^{90}Sr and ^{137}Cs. Strontium-90 and ^{137}Cs are present in soil as a residual of fallout from aboveground nuclear weapons testing, which took place between 1945 and 1980. The quantities detected historically were most likely from weapons testing fallout.

Wheat

None of the 13 wheat samples (including one duplicate) collected during 2004 contained a measurable concentration of ^{90}Sr above the 3s uncertainty level. No other anthropogenic radionuclides were detected (Table 7-3).

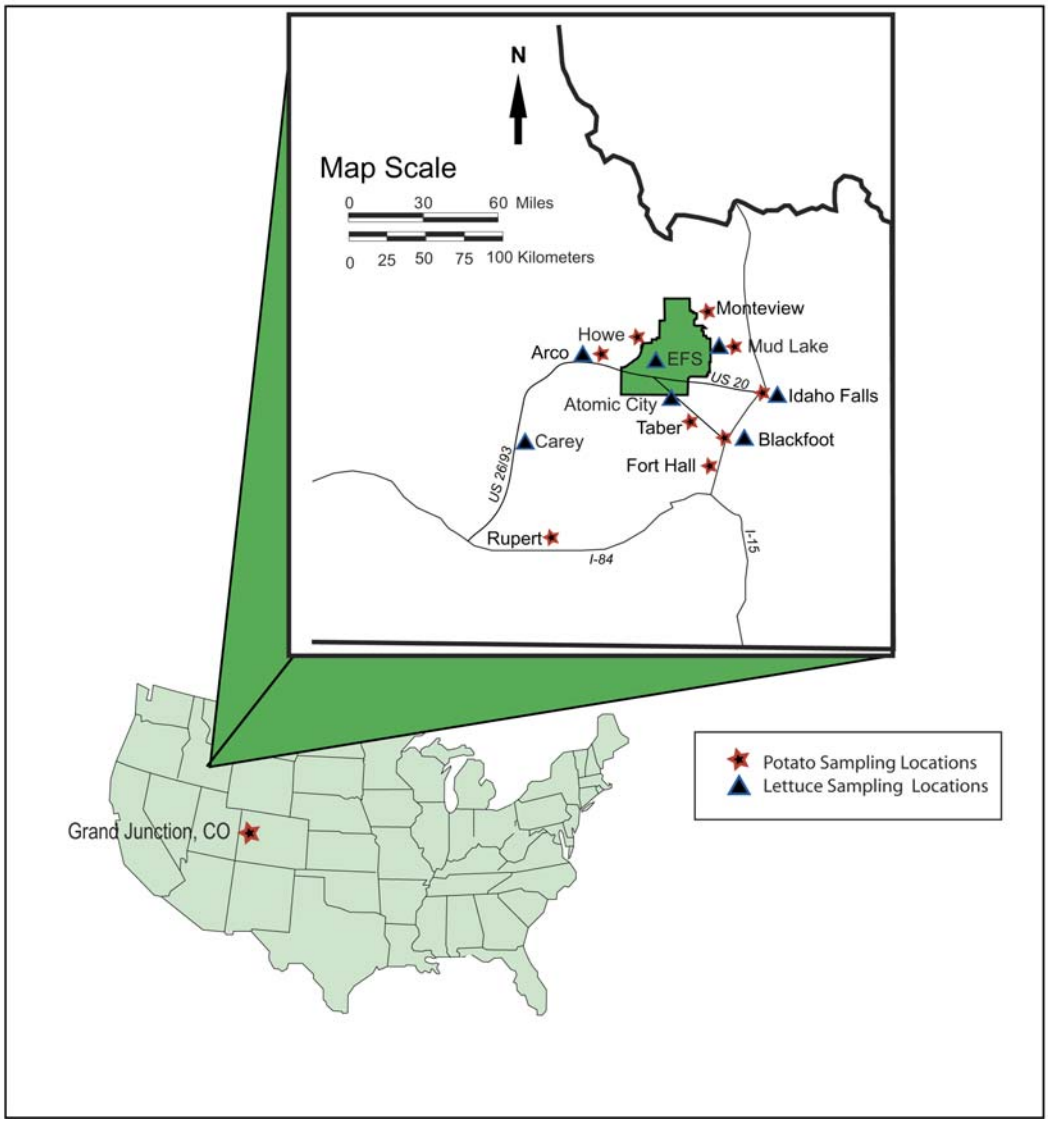


Figure 7-1. Locations of lettuce and potato samples taken during 2004.

Potatoes

Eleven potato samples, including one duplicate, were collected during 2004: five samples from distant locations, four samples and one duplicate from boundary locations, and one sample from an out-of-state location (Colorado) (Figure 7-1). The nine Idaho samples were collected from Arco, Blackfoot, Fort Hall, Howe, Idaho Falls, Monteview, Rupert, Terreton, and Taber. Strontium-90 was detected in two of the Idaho samples at levels of $(2.4 \pm 0.8) \times 10^{-1}$ pCi/g at Monteview and $(2.7 \pm 0.8) \times 10^{-1}$ pCi/g 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.

Table 7-2. Strontium-90 concentrations in garden lettuce (1999-2004).[a,b]

Location	1999	2000	2001	2002[c]	2003	2004
Distant Group						
Blackfoot	130 ± 30	80 ± 15	160 ± 55	116 ± 81	228 ± 83	97 ± 56
Carey	122 ± 38	295 ± 70	144 ± 55	283 ± 79	220 ± 180	97 ± 66
Idaho Falls	57 ± 20	61 ± 25	114 ± 55	41 ± 25	254 ± 170	328 ± 110
Pocatello	NS[d]	89 ± 30	59 ± 50	NS	NS	135 ± 110
Grand Mean[e]	**103 ± 15**	**131 ± 20**	**119 ± 27**	**147 ± 39**	**234 ± 87**	**164 ± 44**
Boundary Group						
Arco	116 ± 22	81 ± 20	88 ± 55	93 ± 23	126 ± 160	154 ± 85
Atomic City[f]	86 ± 19	NS	110 ± 55	NS	282 ± 130	155 ± 130
Howe	57 ± 34	88 ± 24	21 ± 55	65 ± 28	25 ± 81	NS
Monteview	225 ± 100	NS	74 ± 55	85 ± 22	214 ± 140	NS
Mud Lake (Terreton)	155 ± 40	51 ± 26	41 ± 55	109 ± 26	NS	148 ± 79
Grand Mean[e]	**128 ± 23**	**73 ± 14**	**67 ± 25**	**88 ± 12**	**162 ± 66**	**152 ± 58**
INEEL						
Experimental Field Station[f]	NS	NS	NS	NS	442 ± 130	225 ± 86

a. Analytical results are times 10^{-3} picocuries per gram (pCi/g).
b. Analytical results are for dry weight plus or minus one standard deviation (± 1s).
c. Approximate minimum detectable concentration (MDC) of ^{90}Sr in lettuce is 2 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 and 2004.

Sheep

Certain areas of the INEEL 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 INEEL. Muscle, liver, and thyroid samples were collected from each animal. For the calendar year 2004, six sheep were sampled. Four were from INEEL 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 (4.0 ± 1.3) x 10^{-3} pCi/g but was not detected in offsite muscle samples. Cesium-137 was also detected in the liver tissue sample from two onsite animals at levels of (4.3 ± 1.3) x 10^{-3} pCi/g and (4.8 ± 1.2) x 10^{-3} pCi/g. Cesium-137 was not measured above the 3s uncertainty in any control sheep in 2004. However, all ^{137}Cs concentrations measured in 2004 were similar to those found in both onsite and offsite sheep samples in previous years and are within historical values. Cesium-137 concentrations in both sheep liver and muscle have been

Table 7-3. Strontium-90 concentrations in wheat (1999-2004).[a,b]

Location	1999	2000	2001[c]	2002	2003	2004
Distant Group						
Aberdeen[e] (American Falls)	5.9 ± 2.5	4.9 ± 1.3	-20 ± 15	36 ± 130	84 ± 62	-1 ± 25
						32 ± 29
Blackfoot[e]	4.5 ± 2.3	5.7 ± 2.9	61 ± 45	69 ± 66	NS[d]	16 ± 25
				81 ± 130		
Carey	8.1 ± 1.7	NS	50 ± 90	28 ± 66	-53 ± 47	65 ± 27
Dietrich	4.8 ± 1.9	5.6 ± 2.2	NS	NS	NS	17 ± 17
Idaho Falls[e]	7.8 ± 2.8	5.3 ± 1.5	-37 ± 132	50 ± 82	121 ± 64	46 ± 22
						26 ± 27
Minidoka	4.0 ± 1.3	6.2 ± 2.1	218 ± 145	0 ± 97	61 ± 48	NS
Roberts (Menan)[e]	NS	NS	193 ± 115	19 ± 65	54 ± 55	NS
			29 ± 95			
Rockford	NS	NS	NS	-220 ± 130	195 ± 68	NS
Rupert (Burley)	NS	NS	-69 ± 101	90 ± 130	-26 ± 52	NS
Tabor	8.1 ± 3.0	6.1 ± 1.9	NS	111 ± 150	NS	NS
Grand Mean[f]	6.2 ± 0.9	5.6 ± 0.8	53 ± 36	26 ± 35	62 ± 22	29 ± 9
Boundary Group						
Arco[e]	5.2 ± 1.4	6.3 ± 2.2	96 ± 130	41 ± 190	2 ± 55	16 ± 25
			59 ± 44			
Howe	NS	NS	NS	18 ± 76	-19 ± 49	-4 ± 19
Monteview	5.7 ± 2.3	2.4 ± 1.1	50 ± 49	220 ± 98	NS	NS
Mud Lake	2.5 ± 1.4	4.8 ± 1.9	20 ± 37	54 ± 87	8 ± 56	21 ± 18
Terreton	4.6 ± 2.0	3.2 ± 1.7	64 ± 65	86 ± 99	5 ± 43	-6 ± 22
Grand Mean[g]	4.5 ± 0.9	4.2 ± 0.9	58 ± 33	84 ± 52	-1 ± 26	7 ± 11

a. Concentrations are 10^{-3} picocuries per gram.
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 x 10^{-3} pCi/g dry weight. After 2001, the MDC increased to 20 x 10^{-3} pCi/g dry weight.
d. NS = no sample collected.
e. Samples were collected multiple locations in this area during certain years.
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.

essentially the same (error bars overlap) since 1998 (DOE-ID 2004) (Figure 7-2). Iodine-131 did not exceed the 3s uncertainty in any sample.

Game Animals

Muscle, liver, and thyroid samples were collected from six mule deer, five pronghorn, and two elk, which were accidentally killed on INEEL roads or died from natural causes. There was detectable ^{137}Cs radioactivity above 3s in the muscle of two different pronghorn, and in the liver of one pronghorn taken on or near the INEEL. No tissue samples contained detectable ^{131}I above 3s (Table 7-4).

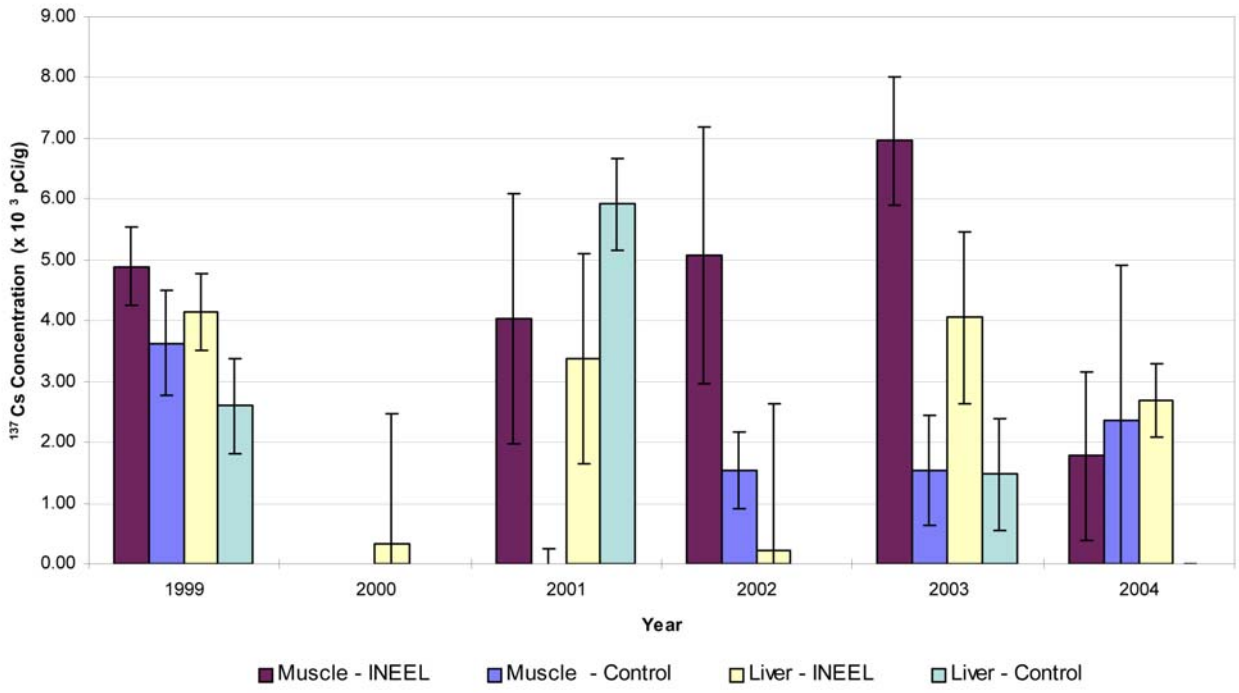


Figure 7-2. Average Cesium-137 concentrations in muscle and liver of sheep collected from the INEEL and control areas. Error bars represent ± 1s.

Table 7-4. Detectable concentrations of ^{137}Cs in game tissue on and near the INEEL in 2004.[a]

Tissue	Type	Location	Detected Value
Muscle	Pronghorn	Lincoln Boulevard	$(4.0 \pm 1.1) \times 10^{-3}$
Muscle	Pronghorn	U.S. Highway 26	$(5.8 \pm 1.5) \times 10^{-3}$
Liver	Pronghorn	U.S. Highway 26	$(8.1 \pm 1.6) \times 10^{-3}$

a. Concentrations in picocuries per gram ± 1 standard deviation.

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 ± 1.5) x 10^{-3} to (15 ± 0.2) x 10^{-3} pCi/g.

Muscle results from animals sampled in 2004 were within this range, from (4.0 ± 1.1) x 10^{-3} to (5.8 ± 1.5) x 10^{-3} pCi/g. The 2004 values were also within the range of historical values. Cesium-137 was also found in the liver of one pronghorn at (8.1 ± 1.6) x 10^{-3} pCi/g. 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.

Marmots are hunted and consumed by the Shoshone-Bannock Tribes. No marmots were collected during 2004. During 1998, 2000, 2002, and 2003, a total of 15 marmots were collected from the Radioactive Waste Management Complex (RWMC) and 11 from control areas. During 1998 and 2000, marmots were collected at random locations near the RWMC. During 2002 and 2003, marmots were collected at known contaminated areas at RWMC (primarily near the Subsurface Disposal Area [SDA] and Pit 9), which biased the results toward higher concentrations. Muscle, viscera, and fur/bone samples were collected from each, sent to a commercial radiochemistry laboratory, and analyzed for Americium-241 (^{241}Am), Plutonium-238 (^{238}Pu), Plutonium-239/240 ($^{239/240}$Pu), ^{90}Sr, and gamma-emitting radionuclides.

Analyses indicated that analytes were generally below detectable levels in all tissues from control animals. One animal collected from RWMC contained low levels of ^{137}Cs in all three tissue types. The ^{137}Cs concentrations detected in 2002 and 2003 were approximately one order of magnitude higher than those detected in marmots collected around the RWMC in 1998 (DOE-ID 2004). However, the ^{137}Cs concentrations observed in the 2002/2003 animals were below those observed in other wildlife species collected previously at the SDA as well as in control animals collected for an older study (Arthur and Janke 1986).

Strontium-90 levels followed a similar pattern to ^{137}Cs (both are also worldwide fallout products) in external tissues. However, muscle tissue collected in 2002 and 2003 showed a decrease from the 1998 concentrations. The animals sampled in 2002 and 2003 were collected from the Pit 9 area which contains higher concentrations. Again, these concentrations were well below ^{90}Sr levels detected in animals in previous studies at the subsurface disposal area (SDA) (Arthur and Janke 1986).

Six waterfowl were collected during 2004: four control samples from Market Lake and two from the Test Reactor Area (TRA) Radioactive Disposal Ponds. Samples of the viscera, edible portions, and the remainder (18 samples total plus one duplicate) of all these waterfowl were analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu. Six radionuclides had at least one detectable value above 3s. Total radionuclide concentrations for those samples are summarized in Table 7-5. The potential dose from consuming these ducks is discussed in Chapter 8.

Mourning doves were not collected in 2004.

Table 7-5. Radionuclide concentrations in waterfowl using INEEL wastewater disposal ponds and waterfowl from background locations (2004)[a].

Nuclide	Waterfowl Species and Location					
	Coot TRA	Coot TRA	Coot Market Lake	Coot Market Lake	Coot Market Lake	Coot Market Lake
Edible						
Cesium-137	198±22	76±20	--[b]	--	--	--
Exterior (Feathers and Gut)						
Cesium-137	64±10	41±10	--	--	--	--
Cobalt-60	59±11	39±12	--	--	--	--
Remainder (Bones, Remaining Organs, Residual Muscle)						
Cesium-137	29±6	37±5	--	--	--	--
Zinc-65	103±16	53±10	--	--	--	--
Americium-241	--	--	--	--	5.1±1.5	--
Plutonium-239/240	--	--	--	--	--	7.4±1.6
Strontium-90	72±8	17±5	31±5	63±9	18±5	63±9

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.

7.3 Soil Sampling

Soils are sampled to determine if long-term deposition of airborne materials released from the INEEL have resulted in a buildup of radionuclides in the environment and to support the Wastewater Land Application Permit (WLAP) for the Central Facilities Area (CFA) Sewage Treatment Plant. Samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and certain actinides. Above-ground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world. Of these, ^{137}Cs, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, all of which potentially could be released from INEEL operations, are of particular interest because of their abundance from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment because of long half-lives (e.g., $^{239/240}$Pu with a half-life of 24,390 years). All of these radionuclides were detected in one or more soil samples collected during 2004. However, if INEEL inputs had contributed significantly to these concentrations, it would be expected that boundary concentrations would be higher than distant locations. There were no differences (using independent sample t-tests and $\alpha = 0.05$) between boundary and distant group concentrations for any of these radionuclides.

The ESER contractor collects offsite soil samples every two years (in even years, except for 1975); thus, soil sampling was conducted in 2004. Results from 1975 to 2004 are presented in Figure 7-3. The geometric means were used because the data were log-normally skewed. The shorter-lived radionuclides (^{90}Sr and ^{137}Cs) show overall decreases through time.

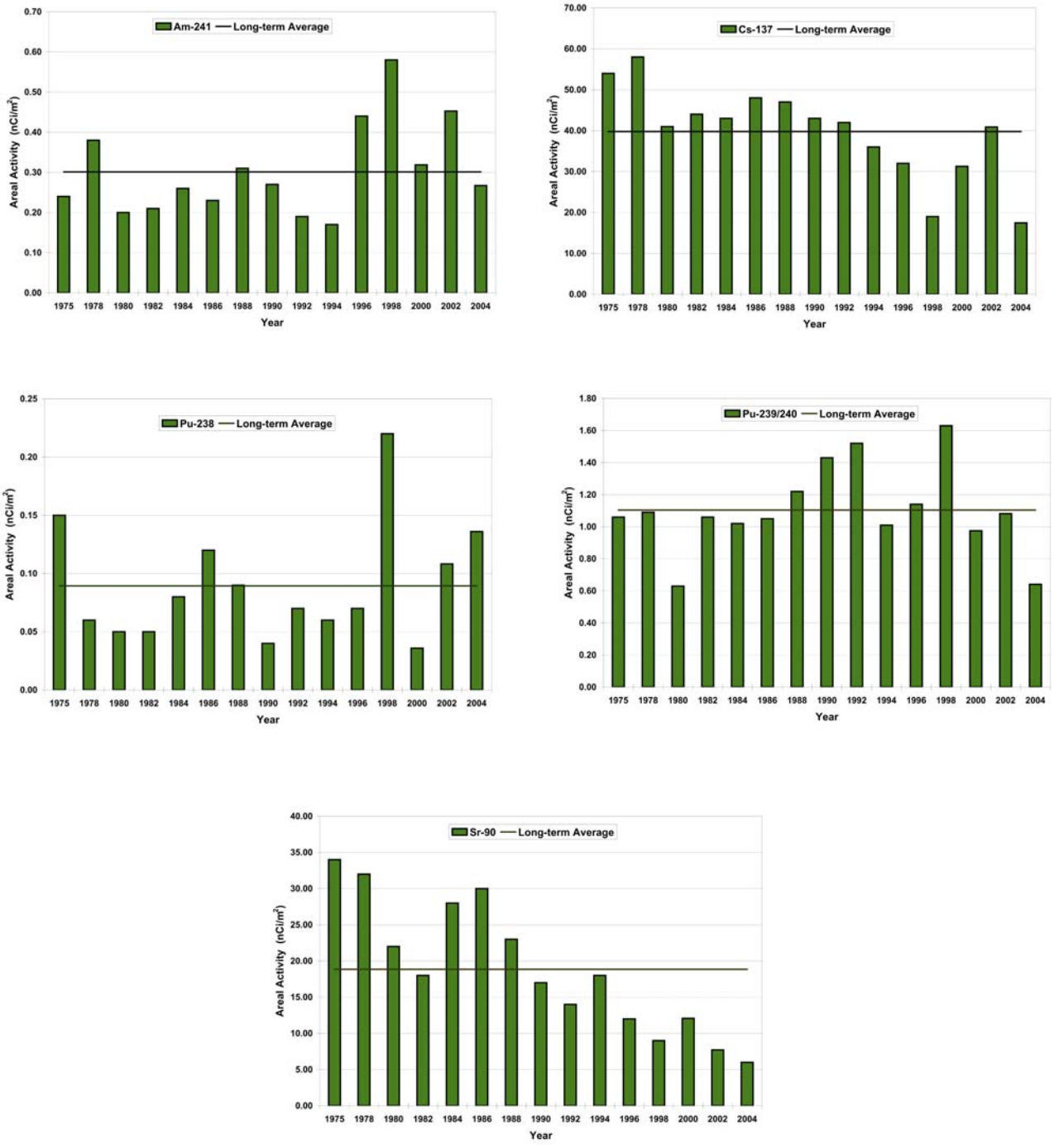


Figure 7-3. Geometric mean areal activity in offsite surface (0 to 5 cm [0 to 2 in.]) soils (1975 to 2004).

Radionuclide levels in soils at 109 site surveillance locations near major INEEL facilities were measured by the M&O contractor in 2004 using in situ gamma spectrometry with 13 additional grab samples collected from 0 to 5 cm (0 to 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.

Table 7-6. In situ soil gamma results measured by the M&O contractor (2004).

Location[a]	Radionuclide	Concentration (picocuries per gram ±1s) Minimum	Maximum	Mean	Comment
PBF	Cesium-137	0.21 ± 0.01	0.62 ± 0.04	0.44	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
RWMC	Cesium-137	0.24 ± 0.07	0.89 ± 0.10	0.56	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
TAN	Cesium-137	0.12 ± 0.02	2.06 ± 0.06	0.52	The mean concentrations are within background for the INEEL and surrounding areas and attributable to past fallout. However, maximum concentrations are above background for the INEEL, but consistent with historical concentrations at TRA and TAN.
TRA	Cesium-137	0.42 ± 0.08	2.19 ± 0.07	1.06	

a. In situ data were collected outside the fenced facility areas by the M&O contractor.
b. TAN = Test Area North

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). Soils are sampled from the CFA land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.) and 30 to 61 cm (12 to 24 in.) at each location and composited, yielding two composite 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 resulting in detrimental changes in soil quality. These results are presented in Table 7-8. Preapplication data collected by Cascade Earth Sciences, Ltd. in 1993 are presented for comparison purposes in Table 7-8.

Soil pH has remained fairly constant during the application period (Table 7-8). Percent organic matter has varied around preapplication concentrations; however, it is expected to take several years for decomposed vegetation to be incorporated into the soil profile.

Table 7-7. Site surveillance soil sampling laboratory results measured by the M&O contractor (2004).

Location	Radionuclide	Minimum Concentration (picocuries per gram ±1s)	Maximum Concentration (picocuries per gram ±1s)	%ECG[a] (picocuries per gram)
PBF	Cesium-137	0.38 ± 0.02	0.55 ± 0.04	9.17
	Americium-241	0.00583 ± 0.00144	0.00598 ± 0.00148	0.01
	Plutonium-239/240	0.0136 ± 0.0025	0.0189 ± 0.0023	0.02
	Strontium-90	0.0843 ± 0.0091	0.145 ± 0.011	2.42
RWMC	Cesium-137	0.34 ± 0.02	0.56 ± 0.07	9.33
	Americium-241	0.0088 ± 0.0020	0.235 ± 0.016	0.59
	Plutonium-239/240	0.0192 ± 0.0039	0.0695 ± 0.0050	0.09
	Strontium-90	0.0756 ± 0.0065	0.193 ± 0.014	3.22
TAN	Cesium-137	0.26 ± 0.03	0.71 ± 0.10	11.83
	Plutonium-239/240	0.0662 ± 0.0019	0.0123 ± 0.0025	0.02
	Strontium-90	0.0659 ± 0.0101	0.0854 ± 0.0195	1.42
TRA	Cesium-137	0.63 ± 0.05	0.73 ± 0.05	12.17
	Americium-241	0.0073 ± 0.0016	0.0074 ± 0.0017	0.02
	Plutonium-239/240	0.0082 ± 0.0020	0.0188 ± 0.0038	0.02
	Strontium-90	0.0636 ± 0.0119	0.119 ± 0.014	1.98

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

The soil salinity averages are within acceptable ranges based on electrical conductivity results. Soil salinity levels between 0 to 2 mmhos/cm are generally accepted to have negligible effects on plant growth (Bohn et al. 1985). During 2004, the electrical conductivity in both the 0 to 30 cm (0 to 12 in.) and the 30 to 61 cm (12 to 24 in.) intervals were above historical levels but remained well below the recommended 2 mmhos/cm maximum. Soils with sodium adsorption ratios (SARs) below 15 are generally classified as not having sodium or salinity problems (Bohn et al. 1985). During 2004, SARs were elevated at the upper depth relative to preapplication SARs, but 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 unfertilized, background agricultural soils.

In 2004, available phosphorus concentrations remained below preapplication concentrations and less than that considered adequate for range and pasture crop growth (EPA 1981).

Table 7-8. CFA Sewage Treatment Plant land application area soil monitoring results (2004).

Parameter	Preapplication Period[a] Depth (in.)	1993	Application Period Depth (in.)	1995 through 2003 Minimum	Maximum	Average	2004
pH	0–6	7.6	0–12	7.6[b]	8.4[b]	8.1[b]	7.83
	6–16	8.0	12–24	7.6[b]	8.6[b]	8.2[b]	7.96
	16–30	8.1					
Electrical Conductivity (mmhos/cm)	0–6	0.6	0–12	0.36	1.22	0.77	1.51
	6–16	0.7	12–24	0.20	1.64	0.76	1.33
	16–30	0.6					
Organic Matter (%)	0–6	2.2	0–12	0.63[b]	3.09[b]	1.73[b]	1.26
	6–16	1.6	12–24	0.56[b]	2.29[b]	1.19[b]	0.70
	16–30	1.4					
Nitrate as Nitrogen (ppm)	0–6	16	0–12	0.68[c]	6.00	2.86[d]	6.13
	6–16	6	12–24	0.43[c]	5.20	1.86[d]	1.24
	16–30	3					
Ammonium Nitrogen (ppm)	0–6	7.9	0–12	0.81 U[e]	6.10	2.63[d]	1.31
	6–16	7.6	12–24	0.84 U	6.00	2.32[d]	0.50 U
	16–30	7.4					
Phosphorus (ppm)[f]	0–6	29	0–12	3.69	12.00	7.92[d]	10.6
	6–16	18	12–24	2.00 U	10.20	3.57[d]	2.85
	16–30	12					
Sodium Adsorption Ratio	0–6	1.0	0–12	0.35	6.72	3.45	3.27
	6–16	1.4	12–24	0.31	9.12	2.69	1.09
	16–30	2.6					

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

c. 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.

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

e. 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.

f. 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. The total phosphorus reported for 1995 is not included in the summary statistics presented.

Based on these results, the application of wastewater at the CFA does not appear to adversely affect soil chemistry. However, sampling and analysis will continue, as required by the WLAP, to evaluate potential long-term effects.

Argonne National Laboratory-West

ANL-W collects four soil samples annually, two from the predominant wind direction and two from the crosswind directions. Sufficient material to fill a 500 mL (16 oz) wide mouth jar is collected from 0-5 cm (0-2 in.) depth within an approximately 1 m^2 (approximately 10 ft^2) area.

Samples are analyzed for low-level gamma-emitting radionuclides, and uranium, plutonium, and thorium isotopes. Table 7-9 presents the results of the 2004 sampling effort.

Naval Reactors Facility

Naval Reactors Facility personnel also sample soil and vegetation annually for programmatic radionuclides. For detailed information see Bechtel Bettis 2005.

Table 7-9. Soil radiochemistry results reported by ANL-W (2004).

Radionuclide	Concentrations[a]			Location of Maximum Result
	Minimum	Maximum	Average	
		Human-Made		
^{137}Cs	0.019	0.648	0.210	IW Pond[b]
^{238}Pu	-0.002	0.012	0.003	IW Pond
$^{239/240}Pu$	-0.002	0.045	0.013	IW Pond
		Naturally Occurring		
^{228}Ac	1.06	1.46	1.21	Air Monitor #3
^{7}Be	0.066	1.05	0.344	Air Monitor #4
^{214}Bi	0.900	1.39	1.100	Air Monitor #3
^{214}Pb	1.04	1.48	1.26	Air Monitor #4
^{40}K	18.1	22.1	20.1	Air Monitor #3
^{226}Ra	0.900	1.39	1.10	Air Monitor #3
^{228}Th	1.08	1.46	1.29	Air Monitor #1
^{230}Th	1.06	1.51	1.31	Air Monitor #2
^{232}Th	1.05	1.54	1.26	Air Monitor #3
$^{233/234}U$	0.679	1.42	0.904	IW Pond
$^{235/236}U$	0.033	0.061	0.047	Air Monitor #3
^{238}U	0.846	1.11	0.941	IW Pond

a. All concentrations are in picocuries per gram (pCi/g).
b. IW Pond refers to the ANL-W Industrial Waste Pond.

7.4 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures to ambient ionizing radiation. The TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. The TLDs are sensitive to beta energies greater than 200 kilo-electron volts (keV) and to gamma energies greater than 10 keV. The TLD packets contain four lithium fluoride chips and are placed about 1 m (approximately 3 ft) above the ground

at specified locations. 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 2004 were from November 2003 through April 2004 (spring) and from May 2004 through October 2004 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2003 through October 2004 is shown in Table 7-10 for two adjacent sets of dosimeters maintained by the ESER and M&O contractors. For purposes of comparison, annual exposures from 2000-2003 are also included for each location.

The mean annual exposures from distant locations in 2004 were 118 ± 3 milliroentgens (mR) as measured by both the ESER and M&O 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 M&O contractor dosimeters. Using both ESER and M&O data, the average dose equivalent of the distant group was 122 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 123 mrem.

In addition to TLDs, the M&O 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/hr (5 mph) to collect survey data (see Section 7.5, Waste Management Surveillance Sampling).

Onsite TLDs maintained by the M&O 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 2004 was 333 ± 23 mR at location RWMC 41. This dosimeter is located near active waste storage and management areas. The 2004 exposure is similar to that of previous years.

Locations TRA 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 TRA 2 and 3 have been reduced to less than one third of the values in 2002 (DOE-ID 2004).

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 2004 were all comparable to historical exposures.

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

Table 7-10. Annual environmental radiation exposures (2000-2004).[a]

Distant Group	2000		2001		2002		2003		2004	
	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O
Distant Group										
Aberdeen	144 ± 14	133 ± 9	152 ± 11	137 ± 10	141 ± 10	126 ± 9	123 ± 4	122 ± 9	130 ± 9	127 ± 9
Blackfoot[b]	138 ± 14	126 ± 9	145 ± 10	136 ± 9	125 ± 9	119 ± 9	117 ± 4	111 ± 8		109 ± 8
Blackfoot (CMS)[c]	114 ± 11		134 ±7		113 ± 8		101 ± 4		108 ± 8	
Craters of the Moon	126 ± 13	121 ± 9	137 ± 10	136 ± 9	121 ± 9	124 ± 9	116 ± 4	122 ± 9	118 ± 8	NS[d]
Dubois[e]					109 ± 8		98 ± 3		105 ± 7	
Idaho Falls	129 ± 13	123 ± 9	147 ± 10	127 ± 9	126 ± 9	112 ± 8	126 ± 9	111 ± 8	124 ± 9	114 ± 8
Jackson[e]					97 ± 7		97 ± 7		100 ± 7	
Minidoka	118 ± 12	111 ± 8	131 ± 9	122 ± 9	111 ± 8	107 ± 8	111 ± 8	104 ± 7	108 ± 8	107 ± 7
Rexburg	148 ± 15	120 ± 8	155 ± 11	131 ± 9	144 ± 10	115 ± 8	136 ± 5	116 ± 8	137 ± 10	118 ± 8
Roberts	137 ± 14	139 ± 10	157 ± 11	144 ± 11	134 ± 13	132 ± 9	126 ± 4	133 ± 9	133 ± 9	132 ± 9
Mean	**132 ± 5**	**125 ± 4**	**146 ± 4**	**133 ± 4**	**120 ± 3**	**119 ± 3**	**114 ± 2**	**117 ± 3**	**118 ± 3**	**118 ± 3**
Boundary Group										
Arco	128 ± 13	121 ± 9	143 ± 10	134 ± 9	126 ± 9	120 ± 9	113 ± 4	118 ± 8	124 ± 9	126 ± 9
Atomic City	131 ± 13	128 ± 9	147 ± 10	137 ± 9	130 ± 9	124 ± 9	120 ± 4	124 ± 9	132 ± 9	NS
Blue Dome[e]					106 ± 8		103 ± 4		104 ± 7	
Howe	118 ± 12	114 ± 9	133 ± 9	130 ± 9	121 ± 9	NS[d]	109 ± 4	110 ± 8	121 ± 8	114 ± 8
Monteview	122 ± 12	116 ± 9	134 ± 10	120 ± 8	118 ± 8	115 ± 8	106 ± 4	112 ± 8	119 ± 8	116 ± 8
Mud Lake	140 ± 14	126 ± 9	151 ± 11	140 ± 10	136 ± 10	129 ± 9	124 ± 4	122 ± 8	130 ± 9	133 ± 9
Birch Creek Hydro	118 ± 12	108 ± 8	114 ± 8	107 ± 8	110 ± 8	104 ± 7	105 ± 4	105 ± 7	112 ± 8	108 ± 8
Mean	**126 ± 5**	**119 ± 4**	**137 ± 4**	**128 ± 4**	**124 ± 4**	**118 ± 4**	**113 ± 2**	**115 ± 3**	**120 ± 3**	**119 ± 4**

a. All values are in milliroentgens with ± 1 standard deviation.
b. The ESER contractor discontinued Blackfoot location in 2004.
c. The M&O 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. Calculated effective dose equivalent from background sources (2004).

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 terrestrial portion of natural background radiation exposure is based on concentrations of naturally occurring radionuclides found in soil samples collected in 1976 (the last time a comprehensive background study was completed). 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/yr, respectively, for a total of 76 mrem/yr (Table 7-11). 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/yr. For 2004, this resulted in a corrected dose of 70 mrem/yr 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 INEEL at approximately 1,500 m (4,900 ft) (NCRP 1987). Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2004 was 118 mrem (Table 7-11). This is slightly below the 122 mrem measured at distant locations by ESER and M&O 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 INEEL 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 INEEL 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.

Naval Reactors Facility

The NRF also has TLDs placed around the perimeter fence of the facility and at distant locations to measure cumulative exposure. For detailed information see Bechtel Bettis 2005.

7.5 Waste Management Surveillance Sampling

Vegetation, soil, and direct radiation sampling are performed at RWMC and direct radiation sampling is performed at the 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 7-4. Russian Thistle is collected in even-numbered years. Control samples were collected near Frenchman's cabin (Figure 7-5). Because of recontouring and construction activities at the RWMC, Russian Thistle was available for sampling only on Pad A in 2004. The vegetation samples were analyzed for gamma-emitting radionuclides. No gamma-emitting radionuclides were detected. Americium-241, and ^{90}Sr results are shown in Table 7-12. The concentrations were all within the background range for the INEEL and surrounding areas and are attributable to past fallout.

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 2004.

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.

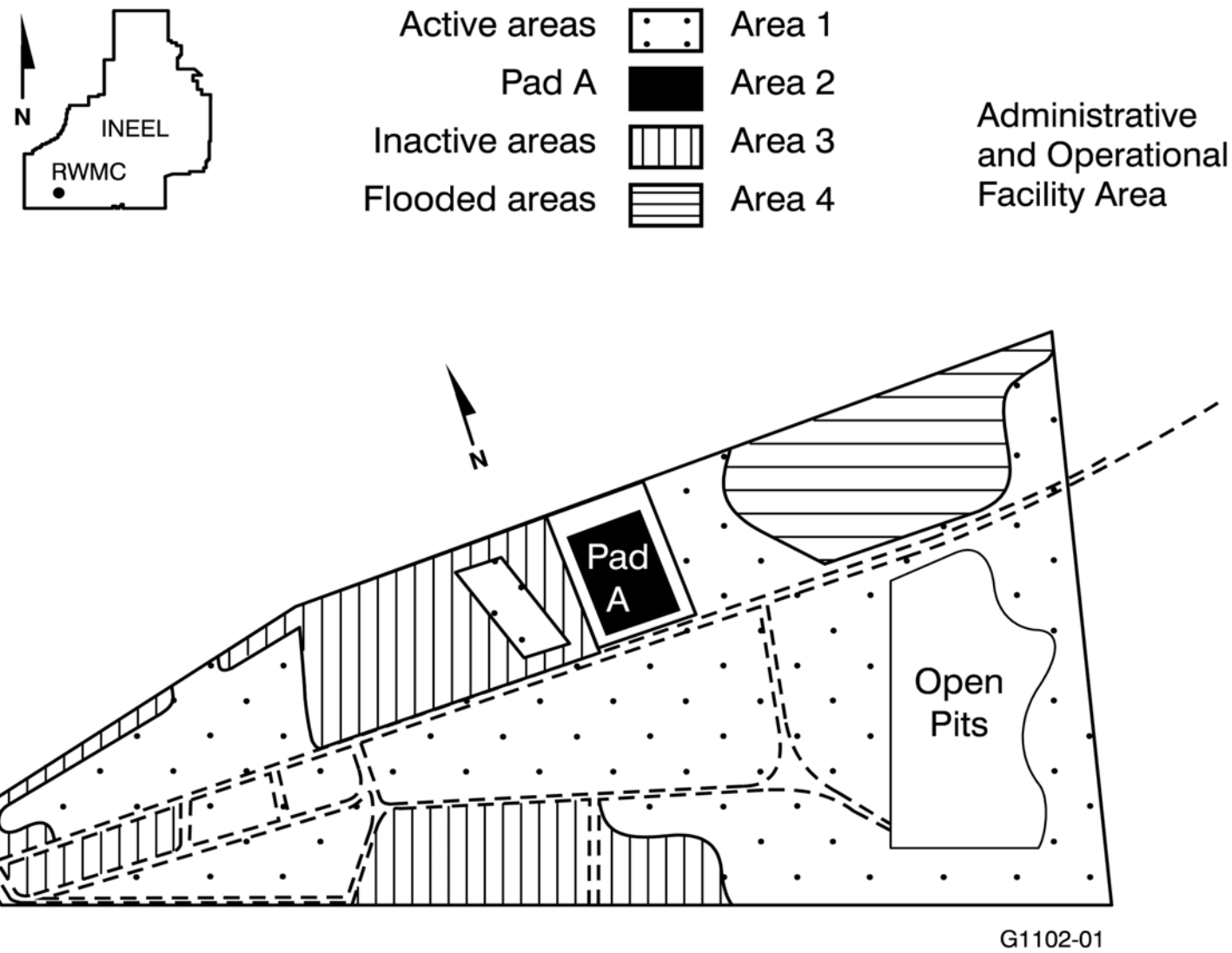


Figure 7-4. Four major areas of the RWMC used for M&O waste management vegetation collection.

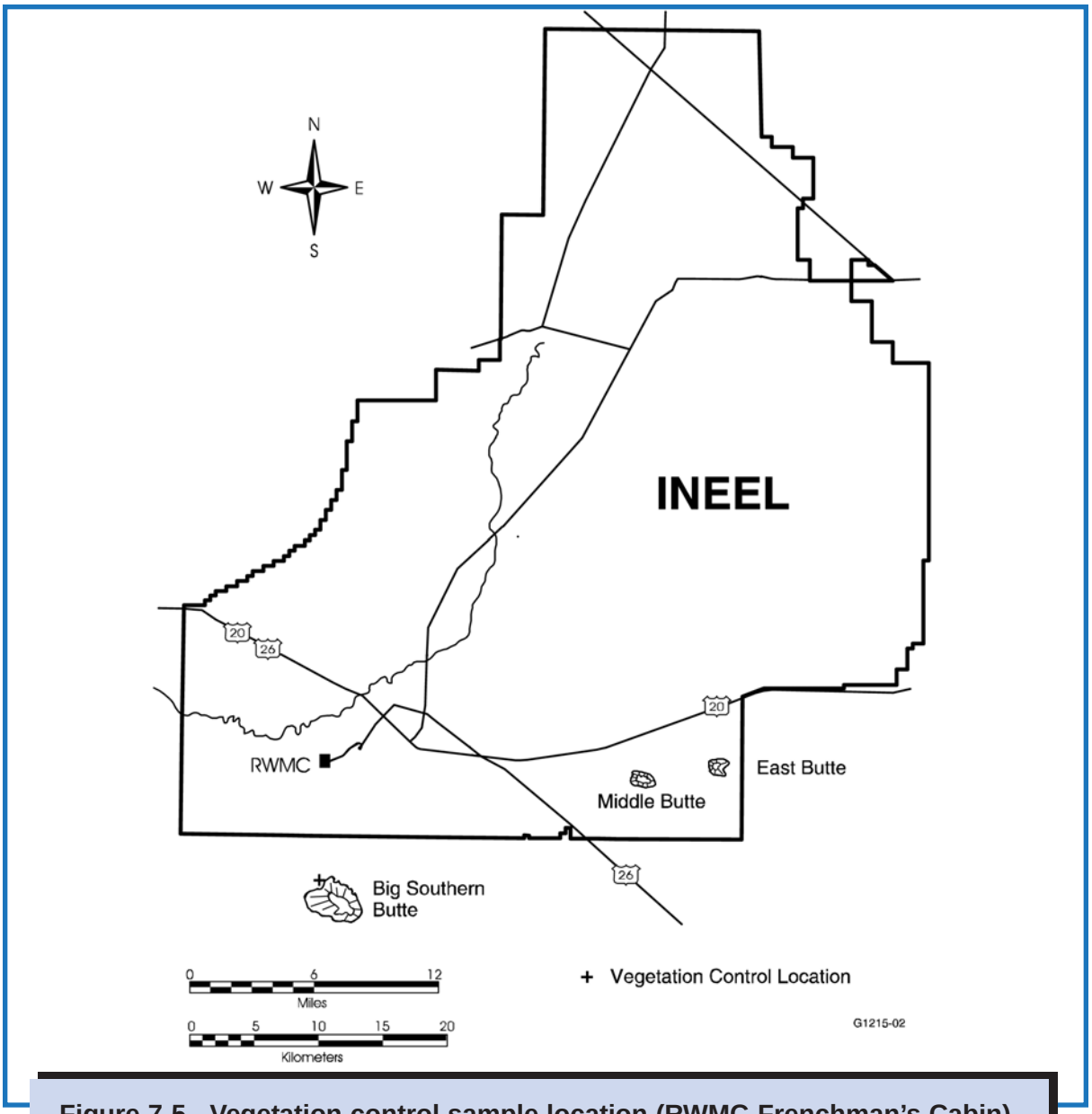


Figure 7-5. Vegetation control sample location (RWMC-Frenchman's Cabin).

Table 7-12. RWMC vegetation sampling results (2004).

Parameter	Minimum Concentration (picocuries per gram ±1s)	Maximum Concentration (picocuries per gram ±1s)
Americium-241	0.00130 ± 0.00030	0.00396 ± 0.00052
Strontium-90	0.0138 ± 0.0009	0.0674 ± 0.0053

Figure 7-6 shows the radiation readings from the 2004 RWMC annual survey. The survey around the active low-level waste pit was comparable to, or lower than, historical measurements for that area. No new elevated readings were identified during the survey. The maximum activity was 25,600 counts per second and was located at the west end of Trench 58. Although readings varied slightly from year to year, the results are comparable to previous years' measurements taken at the same locations.

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

7.6 Additional Surveillance Conducted by Argonne National Laboratory - West

ANL-W measures direct background radiation through the use of four continuously running high pressure ion chambers (HPICs). In addition, it surveys the facility area annually with a portable radiation survey meter.

ANL-W also collects random vegetation samples from predominant wind directions and other areas of concern. Vegetation is sampled at the same locations as soil samples. 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 7-13 presents the 2004 vegetation results for ANL-W.

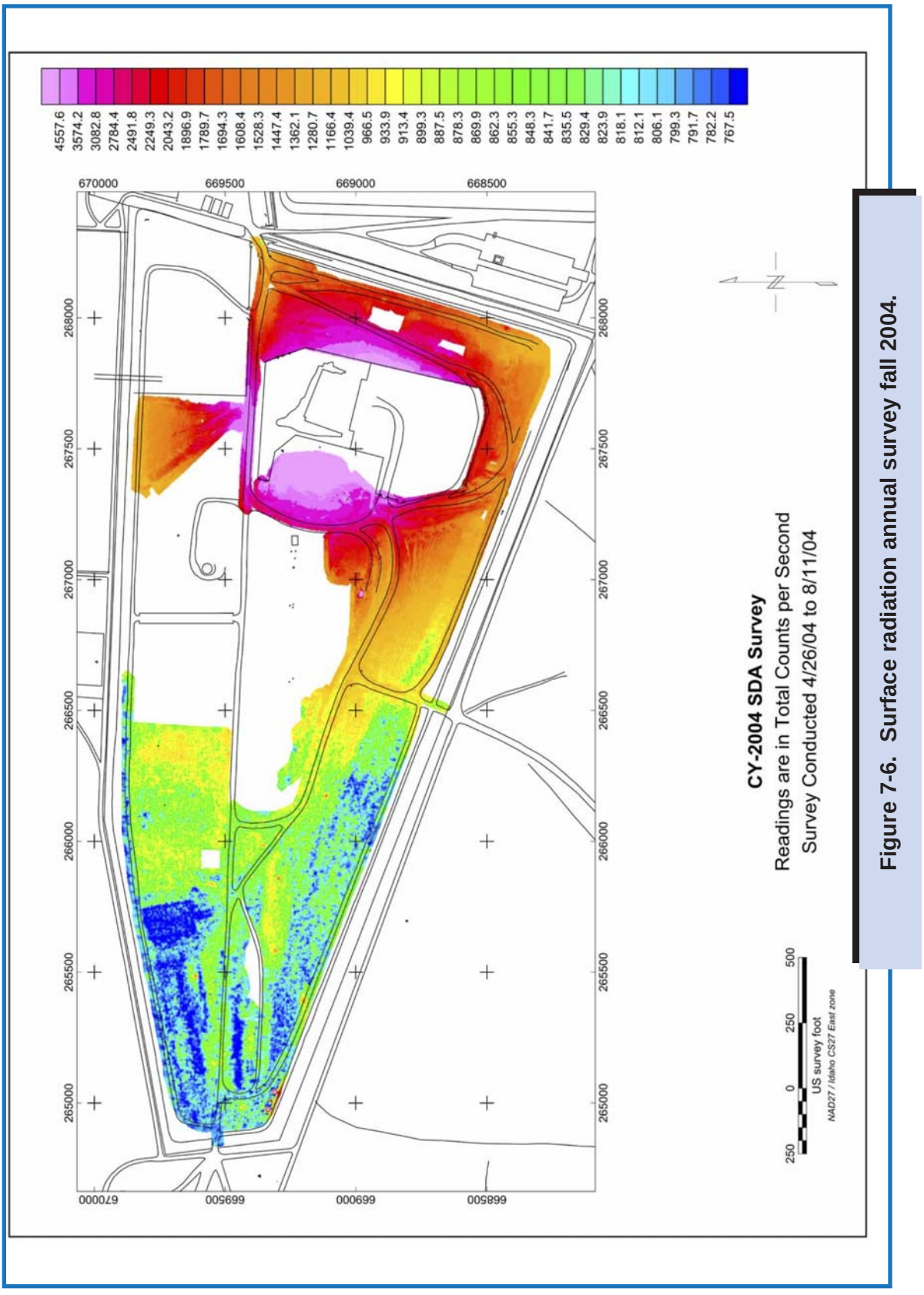


Figure 7-6. Surface radiation annual survey fall 2004.

Table 7-13. Vegetation radiochemistry results reported by ANL-W (2004).

Radionuclide	Concentrations[a]			Location of Maximum Result
	Minimum	Maximum	Average	
Human-Made				
Cesium-137	0.007	0.080	0.048	Air Monitor #2
Plutonium-238	-0.001	0.001	0.00001	Air Monitor #3
Plutonium-239/240	-0.0003	0.010	0.003	IW Pond[b]
Naturally Occurring				
Actinium-228	0.005	0.476	0.184	PPA
Beryllium-7	2.92	7.54	5.15	Air Monitor #2
Bismuth-214	0.050	0.211	0.142	
Lead-214	0.023	0.201	0.110	Air Monitor #2
Potassium-40	9.03	31.9	18.0	PPA[c]
Radium-226	0.050	0.211	0.142	PPA
Thorium-228	0.013	0.073	0.044	Air Monitor #2
Thorium-230	0.013	0.094	0.048	Air Monitor #2
Thorium-232	0.004	0.226	0.063	IW Pond
Uranium-233/234	0.009	0.083	0.037	Air Monitor #2
Uranium-235/236	0.0002	0.005	0.002	Air Monitor #3
Uranium-238	0.009	0.082	0.037	Air Monitor #4

a. Concentrations are in picocuries per gram.
b. IW = Industrial Waste
c. PPA = Property Protection Area

REFERENCES

Arthur, W.J. and Janke, D.H., 1986, "Radionuclide Concentrations in Wildlife Occurring at the Solid Radioactive Waste Disposal Area," *Northwest Science*, 60 (3): 154-159.

Bechtel Bettis, 2005, *2004 Environmental Monitoring Report for the Naval Reactors Facility*, NRFRC-EE-012.

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

EG&G, 1986, *Development of Criteria for Release of Idaho National Engineering Laboratory Sites Following Decontamination and Decommissioning*, EGG 2400, August.

EPA, 1995, *Environmental Radiation Data Reports 79 82*, July 1994-June 1995.

EPA, 1981, *Process Design Manual for Land Treatment of Municipal Wastewater*, EPA 625/1-81-013, Table 4-26.

IDEQ, 2000, Letter to J. Graham, "INEEL Central Facilities Area (CFA)," September 18.

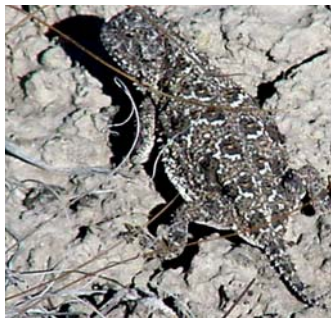
NCRP, 1987, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report No. 94, December 30.

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

U.S. Department of Energy (DOE), 2001, "Radioactive Waste Management," DOE Order 435.1, August 28.

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2004, *Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar-Year 2003*, DOE/ID-12082 (03).

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 1999, Letter to Idaho Division of Environmental Quality, "Wastewater Land Application Permit #LA-000141 Renewal Application and Report for the Central Facilities Area Sewage Treatment Plant," U.S. Department of Energy, Idaho Operations Office, February 9.



Chapter 8 - Dose to the Public and Biota

M. Case, 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 Engineering and Environmental Laboratory (INEEL) operations was evaluated to determine compliance with pertinent regulations and limits. Two different computer models were used to estimate doses: Clean Air Act Assessment Package, 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 INEEL. The maximum calculated dose to an individual by either of the methods was well below the applicable radiation protection standard of 10 mrem/yr. The dose to the maximally exposed individual, as determined by the CAP-88 program, was 0.044 mrem (0.44 µSv). The dose calculated using the MDIFF values was 0.031 mrem (0.31 µSv). The maximum potential population dose to the approximately 281,495 people residing within a 80-km (50-mi) radius of any INEEL facility was 0.368 person-rem (3.7×10^{-3} person-Sv), well below that expected from exposure to background radiation.

Using the maximum radionuclide concentrations in collected waterfowl, game animals, and marmots, a maximum potential dose from ingestion of these was calculated. The maximum potential dose for each was estimated to be 0.005 mrem (0.05 µSv) for waterfowl, 0.008 mrem (0.08 µSv) for game animals, and 0.006 mrem (0.06 µSv) for marmots.

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 INEEL 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 cultural and ecological 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 2004). 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 2004 radionuclide concentrations from operations at the Idaho National Engineering and Environmental Laboratory (INEEL).

8.1 General Information

Individual radiological impacts to the public surrounding the INEEL remain too small to be measured by available monitoring techniques. To show compliance with federal regulations established to ensure public safety, the dose from INEEL operations was calculated using the reported amounts of radionuclides released during the year from INEEL facilities (see Chapter 4) and appropriate air dispersion computer codes. During 2004, 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; and
- The collective effective dose equivalent (population dose) for the population within 80 km (50 mi) of any INEEL 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 each exposure pathway. 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 was 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 INEEL 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 INEEL and no radionuclides from the INEEL 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/yr (40 CFR 61). 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 INEEL 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 INEEL and the Hanford Site in eastern Washington). The MDIFF curves are more appropriate for estimating dose to the public caused by INEEL 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 has been in use for almost 40 years to calculate total integrated concentrations (TICs) that are then used to calculate the dose to members of the public residing near the INEEL. 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 INEEL 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 INEEL airborne releases of radionuclides calculated to demonstrate compliance with NESHAP are published in the *National Emissions Standards for Hazardous Air Pollutants-Calendar Year 2004 INEEL Report for Radionuclides* (DOE-ID 2005). 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 INEEL. 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 0.044 mrem (0.44 µSv) was calculated. The facilities making the largest contributions to this dose were the Idaho Nuclear Technology and Engineering Center (INTEC) at 62 percent, the Test Reactor Area (TRA) at 20 percent and the Radioactive Waste Management Complex (RWMC) at 10 percent. The dose of 0.044 mrem (0.44 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 INEEL and the MDIFF model, the NOAA ARL-FRD prepares a mesoscale map (Figure 8-1) showing the calculated 2004 time integrated concentrations. These TICs are based on a unit release rate weighted by percent contribution for each of eight INEEL facilities (Argonne National Laboratory-West [ANL-W], Central Facilities Area [CFA], INTEC, Naval Reactors Facility [NRF], Power Burst Facility [PBF], RWMC, TRA, 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 $(8760\ hr)^2$ or $7.67 \times 10^7\ hr^2$. This does not account for plume depletion, radioactive decay, or in-growth or decay of radioactive progeny.

The average air concentration calculated by MDIFF were input into a Microsoft Excel spreadsheet program developed by ESER to calculate doses using methods outlined in NRC (1977) and dose conversion factors provided by 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/sec to 0.035 m/sec, 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

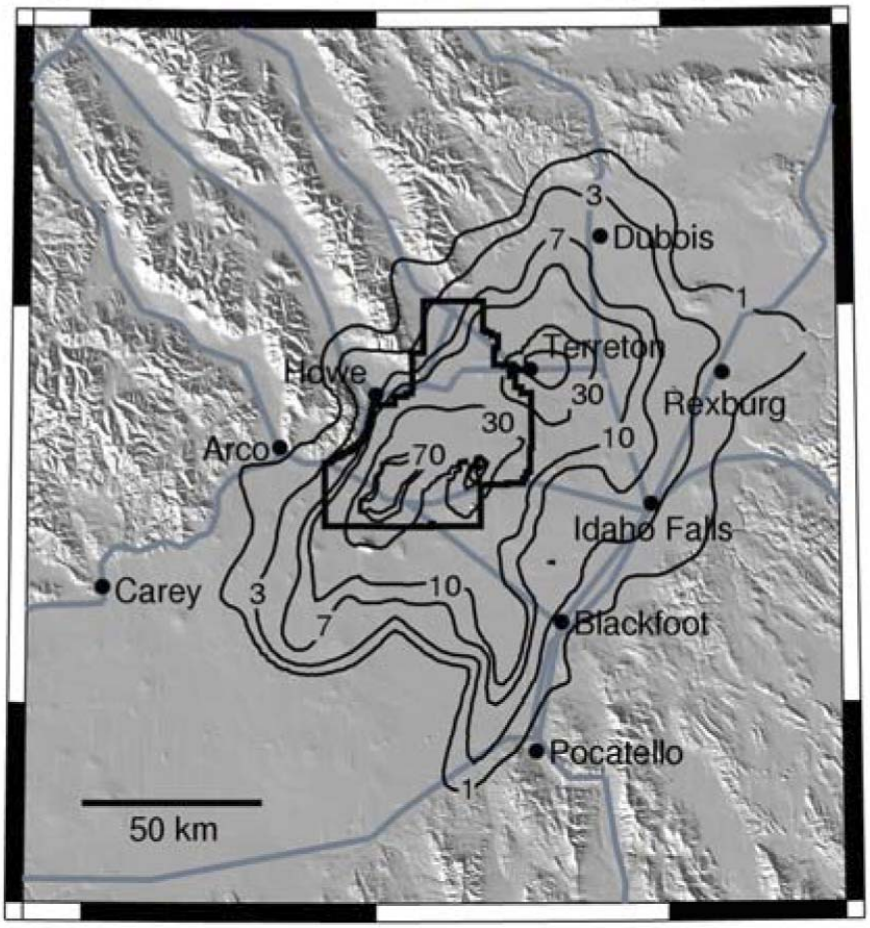


Figure 8-1. Average mesoscale isopleths of total integrated concentrations at ground level normalized to unit release rate from all INEEL facilities. Concentrations are times 10^{-9} hours squared per meter cubed (x 10^{-9} hr^2/m^3).

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 2004 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.

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 0.031 mrem (0.31 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.

Table 8-1. Total integrated concentration (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)
ANL-W	2.52×10^{-8}	1.86	30.2 (18.8)
CFA	3.23×10^{-8}	2.31	46.5 (28.9)
INTEC	2.88×10^{-8}	2.81	42.5 (26.4)
NRF	4.41×10^{-8}	2.14	35.5 (22.0)
PBF	3.51×10^{-8}	2.58	41.5 (25.8)
RWMC	2.78×10^{-8}	3.16	54.4 (33.8)
TAN	2.31×10^{-7}	0.50	10.4 (6.5)
TRA	2.72×10^{-8}	2.45	42.9 (26.7)

Table 8-2. Maximum individual effective dose equivalent as calculated from MDIFF model results (2004).

Radionuclide[a]	Radionuclide Concentration in Air at Maximum Offsite Location[b] (Ci/m^3)	Maximum Effective Dose Equivalent mrem	mSv
^{226}Ra	7.18×10^{-19}	5.99×10^{-3}	5.99×10^{-5}
^{137}Cs + D[c,d]	1.39×10^{-16}	5.83×10^{-3}	5.83×10^{-5}
^{129}I[c]	1.73×10^{-17}	5.70×10^{-3}	5.70×10^{-5}
^{90}Sr + D[d]	1.08×10^{-17}	3.25×10^{-3}	3.25×10^{-5}
^{241}Am	3.96×10^{-19}	2.64×10^{-3}	2.64×10^{-5}
^{238}Pu	5.56×10^{-19}	2.28×10^{-3}	2.28×10^{-5}
^{239}Pu	1.83×10^{-19}	9.61×10^{-4}	9.61×10^{-6}
^{244}Cm	2.01×10^{-19}	7.46×10^{-4}	7.46×10^{-6}
^{238}U	3.06×10^{-18}	7.10×10^{-4}	7.10×10^{-6}
^{41}Ar	9.26×10^{-14}	7.03×10^{-4}	7.03×10^{-6}
^{241}Pu	5.48×10^{-19}	6.68×10^{-4}	6.68×10^{-6}
^{240}Pu	6.30×10^{-20}	3.51×10^{-4}	3.51×10^{-6}
^{3}H (tritium)	4.50×10^{-13}	2.47×10^{-4}	2.47×10^{-6}
All Others	NA	4.03×10^{-4}	4.03×10^{-6}
Total		**3.06×10^{-2}**	**3.06×10^{-4}**

a. Table includes only radionuclides that contribute a dose of 1.0×10^{-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.

For 2004, the ingestion pathway was the primary route of exposure and accounted for 55 percent of the total dose, followed by inhalation at 42 percent, and immersion at 3 percent. Deposition accounted for only 0.02 percent of the dose.

Radionuclide releases for 2004 are presented in Figure 8-2. The noble gas krypton-85 (^{85}Kr) accounted for approximately 77 percent of the total release, followed by tritium with 14 percent, and argon-41 (^{41}Ar) at 7 percent of the total. The noble gases xenon-133 (^{133}Xe) and -135 (^{135}Xe) contributed 1.0 and 0.7 percent, followed by krypton-88 (^{88}Kr) at 0.2 percent. However, because these are noble gases, they contribute very little to the cumulative dose (affecting immersion only). Other than ^{41}Ar and tritium, the radionuclides contributing to the overall dose were 0.003 percent of the total radionuclides released.

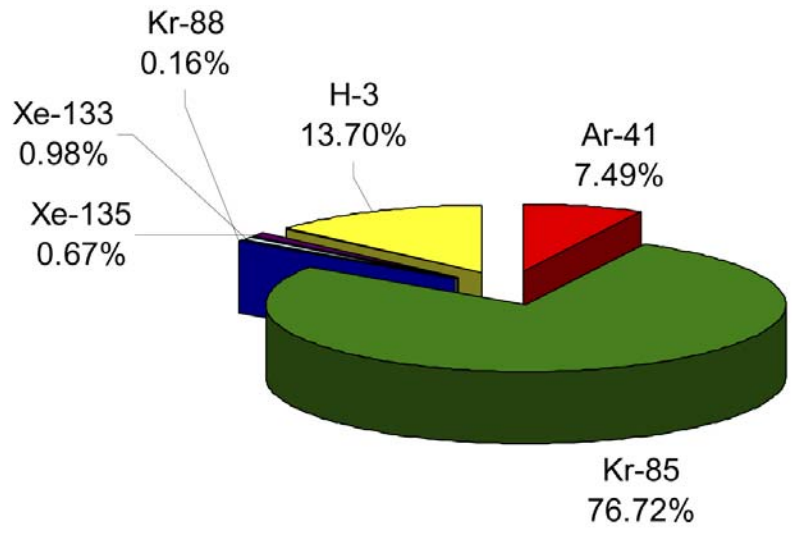


Figure 8-2. Radionuclides released to the environment (2004).

The largest contributor to the MEI dose was radium-226 (^{226}Ra), accounting for 19.6 percent of the total dose. This was followed by cesium-137 (^{137}Cs) at 19.1 percent, iodine 129 (^{129}I) at 18.6 percent, strontium-90 (^{90}Sr) at 10.9 percent, and americium-241 (^{241}Am) at 8.6 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 13.95 percent to the dose (Figure 8-3).

The respective contribution to the overall dose by facility is as follows: INTEC (35 percent), TRA (33 percent), TAN (27 percent), and PBF and RWMC (2 percent). NRF contributed approximately 0.15 percent of the 2004 total dose, while ANL-W and CFA contributed about 0.05 percent each.

The calculated maximum dose resulting from INEEL 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).

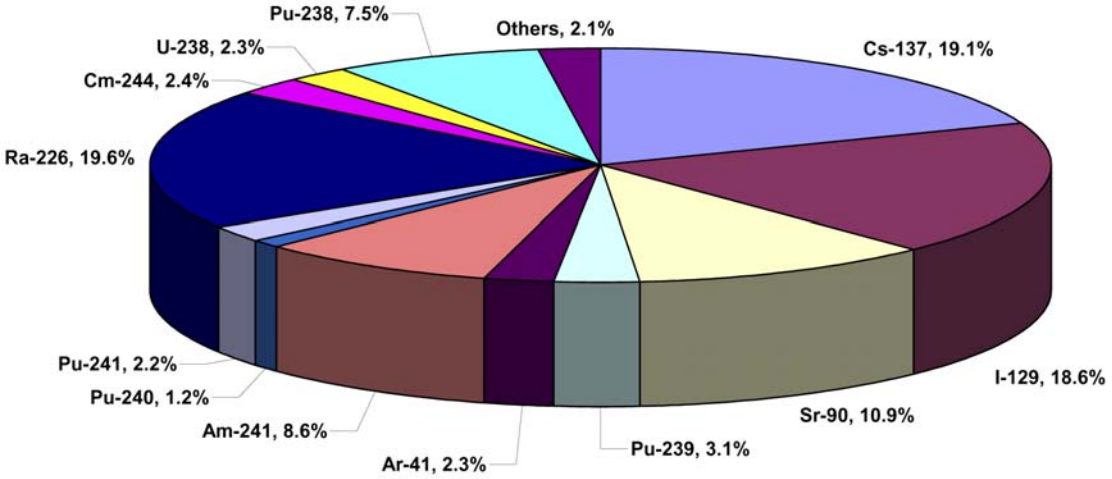


Figure 8-3. Radionuclides contributing to maximum individual dose (as calculated using the MDIFF air dispersion model) (2004).

Table 8-3 summarizes the calculated annual effective dose equivalents for 2004 from INEEL 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 population within an 80 km (50 mi) radius of any INEEL 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 INEEL. This collective dose included all members of the public within 80 km (50 mi) of an INEEL 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).

Table 8-3. Summary of annual effective dose equivalents because of INEEL operations (2004).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF
Dose	0.044 mrem (4.4×10^{-4} µSv)	0.031 mrem (3.1×10^{-4} µSv)	0.368 person-rem (3.7×10^{-3} person-Sv)
Location	Frenchman's Cabin	Northwest of Mud Lake	Area within 80 km (50 mi) of any INEEL facility
Applicable radiation protection standard[d]	10 mrem (0.1 µSv)	10 mrem (0.1 µSv)	No standard
Percentage of standard	0.44 percent	0.31 percent	No standard
Natural background	363 mrem (3.6 µSv)	363 mrem (3.6 µSv)	102,183 person-rem (1,022 person-Sv)
Percentage of background	0.01 percent	**0.009 percent**	0.0004 percent

a. Hypothetical dose to the maximally exposed individual residing near the INEEL.
b. Effective dose equivalent calculated using the CAP-88 code.
c. Effective dose equivalent calculated using the MDIFF air dispersion model. MDIFF calculations do not consider occupancy time or shielding by buildings.
d. Although the DOE standard for all exposure models is 100 mrem/yr as given in DOE Order 5400.5, DOE guidance states that DOE facilities will comply with the EPA standard for the airborne pathway of 10 mrem/yr.

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 (ANL-W) 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 2004 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 0.37 person-rem (3.7×10^{-3} person-Sv) to a population of approximately 281,495. When compared with an approximate population dose of 102,183 person-rem (1,022 person-Sv) from natural background radiation, this represents an increase of only about 0.0004 percent. The dose of

Table 8-4. Dose to population within 80 km (50 mi) of the INEEL facilities (2004).

Census Division[a]	Population[b]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,387	1.01×10^{-3}	1.01×10^{-5}
Alridge	659	6.51×10^{-5}	6.51×10^{-7}
American Falls	3,382	4.45×10^{-4}	4.45×10^{-6}
Arbon (part)	30	1.13×10^{-5}	1.13×10^{-7}
Arco	2,382	2.47×10^{-2}	2.47×10^{-4}
Atomic City (division)	3,325	1.88×10^{-2}	1.88×10^{-4}
Blackfoot	13,352	1.12×10^{-2}	1.12×10^{-4}
Carey (part)	1,087	1.04×10^{-3}	1.04×10^{-5}
East Clark	73	8.22×10^{-5}	8.22×10^{-7}
Firth	3,415	1.99×10^{-3}	1.99×10^{-5}
Fort Hall (part)	1,979	2.43×10^{-3}	2.43×10^{-5}
Hailey-Bellevue (part)	5	3.21×10^{-11}	3.21×10^{-13}
Hamer	2,340	3.97×10^{-2}	3.97×10^{-4}
Howe	336	8.25×10^{-3}	8.25×10^{-5}
Idaho Falls	79,313	8.06×10^{-2}	8.06×10^{-4}
Idaho Falls, west	1,832	6.21×10^{-3}	6.21×10^{-5}
Inkom (part)	586	1.20×10^{-4}	1.20×10^{-6}
Island Park (part)	83	8.22×10^{-5}	8.22×10^{-7}
Leadore (part)	4	5.64×10^{-8}	5.64×10^{-10}
Lewisville-Menan	4,088	1.29×10^{-2}	1.29×10^{-4}
Mackay (part)	1,139	2.99×10^{-6}	2.99×10^{-6}
Moody (part)	4,902	2.36×10^{-3}	2.36×10^{-5}
Moreland	9,621	3.44×10^{-2}	3.44×10^{-4}
Pocatello (part)	80,060	3.96×10^{-2}	3.96×10^{-4}
Rigby	12,322	1.72×10^{-2}	1.72×10^{-4}
Ririe	1,507	4.16×10^{-4}	4.16×10^{-6}
Roberts	1,713	9.03×10^{-3}	9.03×10^{-5}
Shelley	7,414	7.60×10^{-3}	7.60×10^{-5}
South Bannock (part)	298	1.19×10^{-4}	1.19×10^{-6}
St. Anthony (part)	2,279	2.72×10^{-3}	2.72×10^{-5}
Sugar City	5,546	1.06×10^{-2}	1.06×10^{-4}
Swan Valley (part)	5,211	3.16×10^{-4}	3.16×10^{-6}
Thornton	20,742	2.16×10^{-2}	2.16×10^{-4}
Ucon	5,947	1.05×10^{-2}	1.05×10^{-4}
West Clark	1,236	1.69×10^{-3}	1.69×10^{-5}
Totals	**281,495**	**0.368**	**3.7×10^{-3}**

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

b. Population based on 2000 Census Report for Idaho and updated to 2005 based on county population growth from 1960 to 2000.

0.37 person-rem can also be compared to the following estimated population doses for the same size population: 33,790 person-rem for medical diagnostic procedures, about 970 person-rem from exposure to highway and road construction materials, or 2.8 person-rem from nuclear power generation. The largest collective doses are found in the Idaho Falls and Hamer census divisions. Idaho Falls is high because of its greater population; Hamer is relatively high because most of this division lies in the predominant wind direction from the INEEL.

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 INEEL. Such studies include the potential dose to individuals who may eat (a) waterfowl that reside briefly at waste disposal ponds at TRA, INTEC, and ANL-W that are used for the disposal of low-level radioactive wastes and (b) game birds and game animals that may reside on or migrate across the INEEL.

Waterfowl

A study was initiated in 1994 to obtain data on the potential doses from waterfowl using INEEL waste disposal ponds. This study focused on the two hypalon-lined evaporation ponds at TRA that replaced the percolation ponds formerly used for disposal of wastes at that facility (Warren et al. 2001).

In the fall of 2004, two ducks were collected from the TRA waste ponds and four were collected from an offsite location (Market Lake, Idaho) as controls. The maximum potential dose from eating 225 g (8 oz) of meat from ducks collected in 2004 is presented in Table 8-5.

Table 8-5. Maximum annual potential dose from ingestion of edible waterfowl tissue using INEEL waste disposal ponds in 2004.[a]

Radionuclide	Maximum Dose [b] (mrem/yr)	Background Dose [c] (mrem/yr)
^{241}Am	1.06×10^{-3}	1.93×10^{-3}
^{134}Cs	1.06×10^{-4}	2.10×10^{-4}
^{137}Cs	2.23×10^{-3}	4.70×10^{-5}
^{238}Pu	0	3.88×10^{-4}
$^{239/240}Pu$	1.41×10^{-3}	1.41×10^{-3}
^{90}Sr	1.91×10^{-4}	6.03×10^{-5}
All others	3.83×10^{-4}	6.50×10^{-4}
Total Dose	**5.37×10^{-3}**	**4.70×10^{-3}**

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 two different waterfowl collected at INEEL waste disposal ponds and are therefore worst case doses.

c. Background doses calculated from maximum background concentrations to maintain comparability of data.

Radionuclide concentrations determining these doses are reported in Table 7-6. Doses from consuming waterfowl are based on the assumption that ducks are eaten immediately after leaving the ponds.

The maximum potential dose of 0.005 mrem (0.05 µSv) from these waterfowl samples is substantially below the 0.89 mrem (8.9 µSv) committed effective dose equivalent estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001).

Mourning Doves

No mourning doves were collected in 2004.

Big Game Animals

A conservative estimate of the potential whole-body dose that could be received from an individual eating the entire muscle (26,000 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 INEEL from 1976-1986 (Markham et al. 1982). Game animals collected at the INEEL during the past few years have shown much lower concentrations of radionuclides. Based on the highest concentration of radionuclides found in a game animal during 2004, the potential dose was approximately 0.008 mrem (0.08 µSv). This includes the maximum dose from ^{60}Co and ^{137}Cs in muscle and liver tissue from a single pronghorn collected on US Highway 26 on the INEEL (see Table 7-4).

Yellow-bellied Marmots

No marmots were collected in 2004. The potential dose from eating 225 g (8 oz.) of the most contaminated edible portions of the marmots collected in 2003 was 0.006 mrem (0.06 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 INEEL, and most of the animals that do migrate from the INEEL 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 INEEL 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/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured 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; and
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 2003 biota dose assessment is the division of the INEEL 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 INEEL that are also included in the graded approach (Table 8-6).

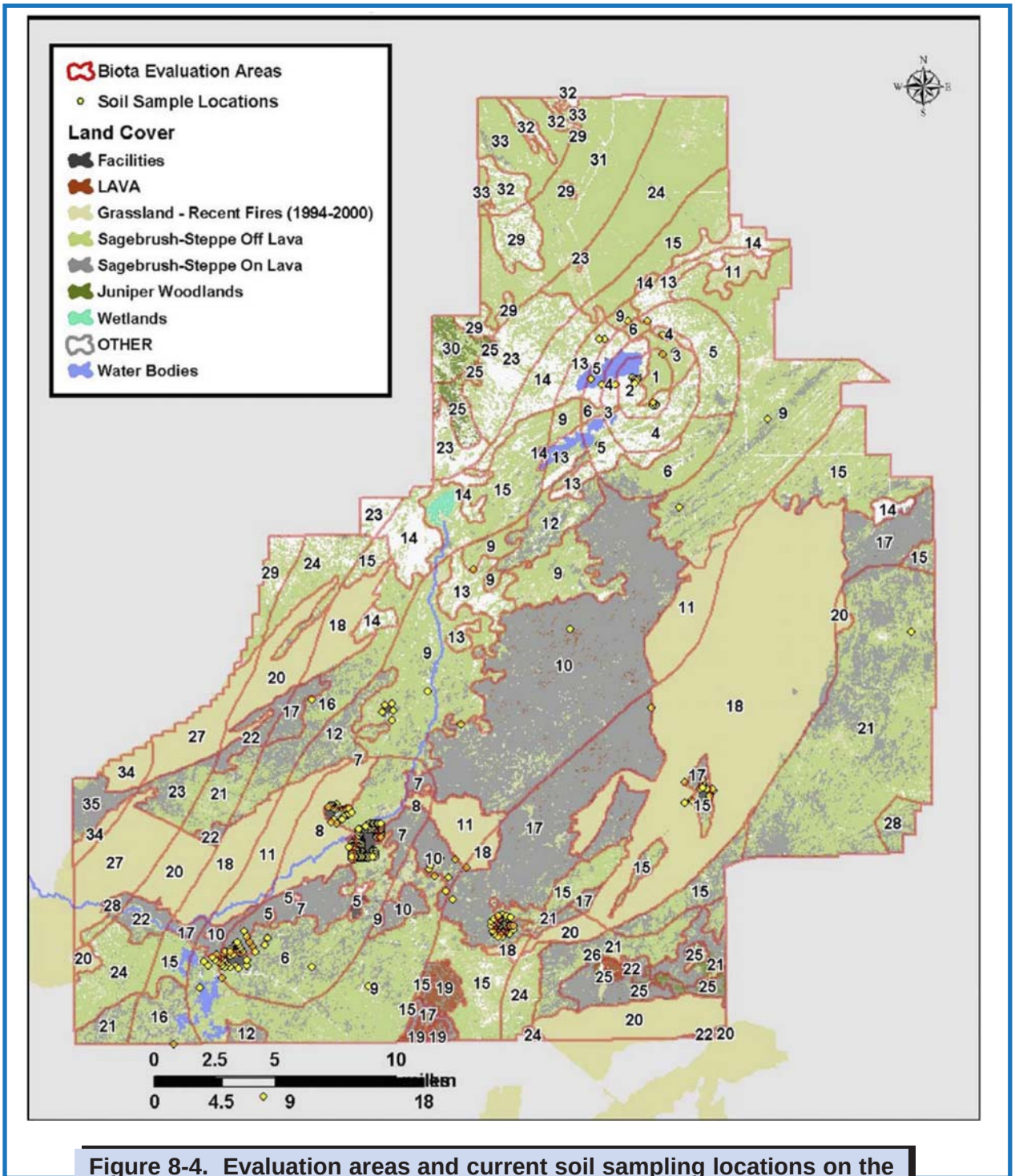


Figure 8-4. Evaluation areas and current soil sampling locations on the INEEL.

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 INEEL in 2003 and 2004.

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 when 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 2004 were for iodine-129 (^{129}I) in INTEC effluents, tritium (^{3}H) in the ANL-W industrial waste pond and ^{90}Sr in TAN effluents (Table 8-7) (see DOE 2002 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 less than one and passed the screening test (Table 8-7).

Table 8-7. Biota dose assessment of aquatic ecosystems on the INEEL (2004).

Nuclide	Water BCG[a] (pCi/L)	Maximum Effluent Concentration (pCi/L)	Partial Fraction[b]	Sediment BCG (pCi/g)	Sediment Concentration[c] (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
^{60}Co	3.76×10^{3}	1.51×10^{0}	4.02×10^{-4}	1.46×10^{3}	1.51×10^{0}	1.03×10^{-3}	1.43×10^{-3}
^{137}Cs	4.26×10^{1}	2.85×10^{1}	6.68×10^{-1}	3.12×10^{3}	1.43×10^{1}	4.56×10^{-3}	6.73×10^{-1}
^{3}H	2.65×10^{8}	5.65×10^{3}	2.13×10^{-5}	3.74×10^{5}	5.65×10^{-3}	1.51×10^{-8}	2.13×10^{-5}
^{90}Sr	2.78×10^{2}	1.74×10^{1}	6.25×10^{-2}	5.82×10^{2}	5.22×10^{-1}	8.9×10^{-4}	6.34×10^{-2}
^{235}U	2.17×10^{2}	2.66×10^{1}	1.22×10^{-1}	3.73×10^{3}	1.33×10^{0}	3.57×10^{-4}	1.22×10^{-1}
					Combined Sum of Fractions[f]		**8.60×10^{-1}**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Calculated by the RadBCG spreadsheet based on the effluent concentration.
d. Calculated sediment concentration/sediment BCG.
e. Sum of the partial fractions.
f. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

Terrestrial Evaluation

For the initial terrestrial evaluation, we used maximum concentrations from the management and operating (M&O) contractor 2003 and 2004 soil sampling (Figure 8-4, Table 8-8) (see DOE 2002 for a detailed description of the assessment procedure). These concentrations failed the initial screen (Table 8-8, First Screening) because of high ^{137}Cs concentrations in single samples from evaluation Areas 6 and 15 (Figures 8-5 and 8-6). For this reason, Areas 6 and 15 were sequentially removed from the analysis and the remaining maximum soil concentrations used (Table 8-8, Second and Third Screenings). Evaluation of potential harm to nonhuman terrestrial biota from maximum detected soil and water concentrations over the entire INEEL, with the exception of evaluation Areas 6 and 15, resulted in a combined sum of fractions less than one.

Areas 6 and 15 were evaluated separately. Because they are very large areas (Figure 8-4) with wide variation in soil concentrations and few samples with high concentrations (Figures 8-5 and 8-6), it was determined that to use the average soil concentrations was more

Table 8-8. Biota dose assessment of terrestrial ecosystems on the INEEL.

Nuclide	Water BCG[a] (pCi/L)	Maximum Effluent Concentration (pCi/L)	Partial Fraction[b]	Soil BCG (pCi/g)	Maximum Soil Concentration (pCi/g)	Partial Fraction[c]	Sum of Fractions[d]
First Screening[e]							
^{241}Am	2.02×10^{5}			3.89×10^{3}	2.35×10^{-1}	6.03×10^{-5}	6.03×10^{-5}
^{60}Co	1.19×10^{6}	1.51×10^{0}	1.26×10^{-6}	6.92×10^{2}			1.26×10^{-6}
^{137}Cs	5.99×10^{5}	2.85×10^{1}	4.76×10^{-5}	2.08×10^{1}	2.36×10^{1}	1.14×10^{0}	1.14×10^{0}
^{3}H	2.31×10^{8}	5.65×10^{3}	2.45×10^{-5}	1.74×10^{5}			2.45×10^{-5}
^{239}Pu	2.00×10^{5}			6.11×10^{3}	7.74×10^{-2}	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra	8.11×10^{3}			5.06×10^{1}	2.28×10^{-1}	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	5.45×10^{4}	1.74×10^{1}	3.19×10^{-4}	2.25×10^{1}	1.93×10^{-1}	8.58×10^{-3}	8.90×10^{-3}
^{232}Th	5.36×10^{4}			1.51×10^{3}	8.11×10^{-1}	5.38×10^{-4}	5.38×10^{-4}
^{234}U	4.04×10^{5}			5.13×10^{3}	7.67×10^{-1}	1.49E-04	1.49×10^{-4}
^{235}U	4.19×10^{5}	2.66×10^{1}	6.34×10^{-5}	2.77×10^{3}	1.23×10^{-1}	4.44×10^{-5}	1.08×10^{-4}
^{238}U	4.06×10^{5}			1.58×10^{3}	6.42×10^{-1}	4.07×10^{-4}	4.07×10^{-4}
				Combined sum of fractions[f]			**1.15×10^{0}**
Second Screening (Area 15 removed)[e]							
^{241}Am	2.02×10^{5}			3.89×10^{3}	2.35×10^{-1}	6.03×10^{-5}	6.03×10^{-5}
^{60}Co	1.19×10^{6}	1.51×10^{0}	1.26×10^{-6}	6.92×10^{2}			1.26×10^{-6}
^{137}Cs	5.99×10^{5}	2.85×10^{1}	4.76×10^{-5}	2.08×10^{1}	2.30×10^{1}	1.11×10^{0}	1.11×10^{0}
^{3}H	2.31×10^{8}	5.65×10^{3}	2.45×10^{-5}	1.74×10^{5}			2.45×10^{-5}
^{239}Pu	2.00×10^{5}			6.11×10^{3}	7.74×10^{-2}	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra	8.11×10^{3}			5.06×10^{1}	2.28×10^{-1}	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	5.45×10^{4}	1.74×10^{1}	3.19×10^{-4}	2.25×10^{1}	1.93×10^{-1}	8.58×10^{-3}	8.90×10^{-3}
^{232}Th	5.36×10^{4}			1.51×10^{3}	8.11×10^{-1}	5.38×10^{-4}	5.38×10^{-4}
^{234}U	4.04×10^{5}			5.13×10^{3}	7.67×10^{-1}	1.49×10^{-4}	1.49×10^{-4}
^{235}U	4.19×10^{5}	2.66×10^{1}	6.34×10^{-5}	2.77×10^{3}	1.23×10^{-1}	4.44×10^{-5}	1.08×10^{-4}
^{238}U	4.06×10^{5}			1.58×10^{3}	6.42×10^{-1}	4.07×10^{-4}	4.07×10^{-4}
				Combined sum of fractions[f]			**1.12×10^{0}**
Third Screening (Area 6 removed)[e]							
^{241}Am	2.02×10^{5}			3.89×10^{3}	2.35×10^{-1}	6.03×10^{-5}	6.03×10^{-5}
^{60}Co	1.19×10^{6}	1.51×10^{0}	1.26×10^{-6}	6.92×10^{2}			1.26×10^{-6}
^{137}Cs	5.99×10^{5}	2.85×10^{1}	4.76×10^{-5}	2.08×10^{1}	1.34×10^{1}	6.46×10^{-1}	6.46×10^{-1}
^{3}H	2.31×10^{8}	5.65×10^{3}	2.45×10^{-5}	1.74×10^{5}			2.45×10^{-5}
^{239}Pu	2.00×10^{5}			6.11×10^{3}	7.74×10^{-2}	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra	8.11×10^{3}			5.06×10^{1}	2.28×10^{-1}	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	5.45×10^{4}	1.74×10^{1}	3.19×10^{-4}	2.25×10^{1}	1.93×10^{-1}	8.58×10^{-3}	8.90×10^{-3}
^{232}Th	5.36×10^{4}			1.51×10^{3}	8.11×10^{-1}	5.38×10^{-4}	5.38×10^{-4}
^{234}U	4.04×10^{5}			5.13×10^{3}	7.67×10^{-1}	1.49×10^{-4}	1.49×10^{-4}
^{235}U	4.19×10^{5}	2.66×10^{1}	6.34×10^{-5}	2.77×10^{3}	1.23×10^{-1}	4.44×10^{-5}	1.08×10^{-4}
^{238}U	4.06×10^{5}			1.58×10^{3}	6.42×10^{-1}	4.07×10^{-4}	4.07×10^{-4}
				Combined sum of fractions[f]			**6.61×10^{-1}**

a. Biota Concentration Guide.
b. Effluent Concentration/Water BCG.
c. Calculated Soil Concentration/Soil BCG.
d. Sum of the Partial Fractions.
e. See the text for the rationale for the various screenings.
f. Sum of the Sums of Fractions. If the Combined Sum of Fractions <, the site passes the screening evaluation.

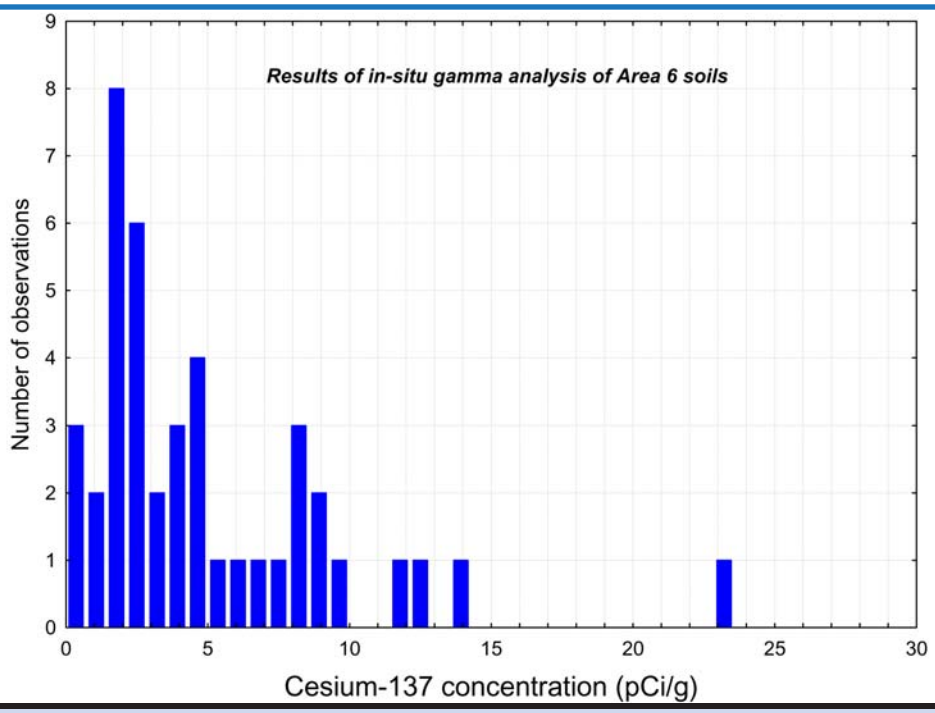


Figure 8-5. Frequency distribution of ^{137}Cs concentrations measured by in situ gamma spectroscopy of soils in evaluation area 6.

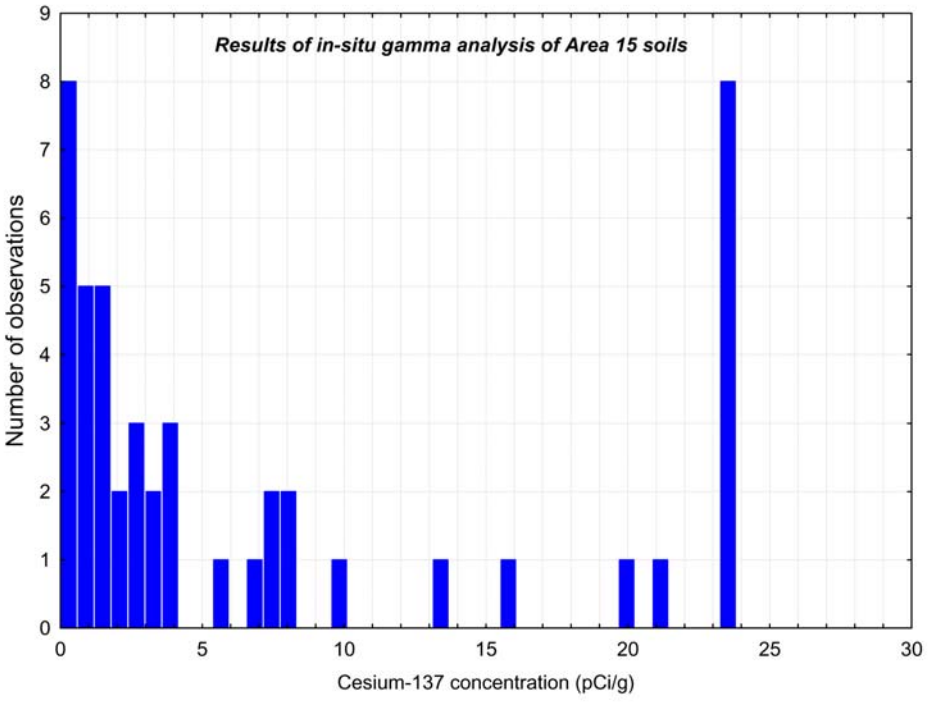


Figure 8-6. Frequency distribution of ^{137}Cs concentrations measured by in situ gamma spectroscopy of soils in evaluation area 15.
(Note: Measurements made in 2004 were assumed to not exceed 23.6 pCi/g, according to remediation soil concentration guidelines)

appropriate in this assessment rather than maxima. The average soil concentrations resulted in combined sums of fractions less than one (Table 8-9 and 8-10) (see DOE 2002 for a detailed description of the assessment procedure).

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

Table 8-9. Biota dose assessment of evaluation area 6 on the INEEL using spatially averaged soil concentrations (2004).

Nuclide	Water BCG[a] (pCi/L)	Effluent Concentration (pCi/L)	Partial Fraction[b]	Soil BCG (pCi/g)	Soil Concentration (pCi/g)	Partial Fraction[c]	Sum of Fractions[d]
^{241}Am	2.02×10^{5}			3.89×10^{3}	1.00×10^{-1}	2.57×10^{-5}	2.57×10^{-5}
^{60}Co	1.19×10^{6}	1.51×10^{0}	1.26×10^{-6}	6.92×10^{2}			1.26×10^{-6}
^{137}Cs	5.99×10^{5}			2.08×10^{1}	4.96×10^{0}	2.39×10^{-1}	2.39×10^{-1}
^{3}H	2.31×10^{8}	5.65×10^{3}	2.45×10^{-5}	1.74×10^{5}			2.45×10^{-5}
^{239}Pu	2.00×10^{5}			6.11×10^{3}	4.20×10^{-2}	6.87×10^{-6}	6.87×10^{-6}
^{226}Ra	8.11×10^{3}			5.06×10^{1}	1.27×10^{-1}	2.51×10^{-3}	2.51×10^{-3}
^{90}Sr	5.45×10^{4}			2.25×10^{1}	9.50×10^{-2}	4.22×10^{-3}	4.22×10^{-3}
^{232}Th	5.36×10^{4}			1.51×10^{3}	1.39×10^{-1}	9.23×10^{-5}	9.23×10^{-5}
^{234}U	4.04×10^{5}			5.13×10^{3}	1.34×10^{-1}	2.61×10^{-5}	2.61×10^{-5}
^{235}U	4.19×10^{5}			2.77×10^{3}	2.00×10^{-2}	7.22×10^{-6}	7.22×10^{-6}
^{238}U	4.06×10^{5}			1.58×10^{3}	9.10×10^{-2}	5.77×10^{-5}	5.77×10^{-5}
				Combined sum of fractions[f]			**2.46×10^{-1}**

a. Biota Concentration Guide.
b. Effluent Concentration/Water BCG.
c. Calculated Soil Concentration/Soil BCG.
d. Sum of the Partial Fractions.
e. See the text for the rationale for the various screenings.
f. Sum of the Sums of Fractions. If the Combined Sum of Fractions <, the site passes the screening evaluation.

Table 8-10. Biota dose assessment of evaluation area 15 on the INEEL using spatially averaged soil concentrations (2004).

Nuclide	Water BCG[a] (pCi/L)	Effluent Concentration (pCi/L)	Partial Fraction[b]	Soil BCG (pCi/g)	Average Soil Concentration (pCi/g)	Partial Fraction[c]	Sum of Fractions[d]
^{241}Am	2.02×10^{5}			3.89×10^{3}	1.00×10^{-1}	2.57×10^{-5}	2.57×10^{-5}
^{60}Co	1.19×10^{6}			6.92×10^{2}			
^{137}Cs	5.99×10^{5}			2.08×10^{1}	7.60×10^{0}	3.66×10^{-1}	3.66×10^{-1}
^{3}H	2.31×10^{8}			1.74×10^{5}			
^{239}Pu	2.00×10^{5}			6.11×10^{3}	2.50×10^{-3}	4.09×10^{-7}	4.09×10^{-7}
^{226}Ra	8.11×10^{3}			5.06×10^{1}	1.27×10^{-1}	2.51×10^{-3}	2.51×10^{-3}
^{90}Sr	5.45×10^{4}			2.25×10^{1}	9.50×10^{-2}	4.22×10^{-3}	4.22×10^{-3}
^{232}Th	5.36×10^{4}			1.51×10^{3}	1.39×10^{-1}	9.23×10^{-5}	9.23×10^{-5}
^{234}U	4.04×10^{5}			5.13×10^{3}	1.34×10^{-1}	2.61×10^{-5}	2.61×10^{-5}
^{235}U	4.19×10^{5}			2.77×10^{3}	2.00×10^{-2}	7.22×10^{-6}	7.22×10^{-6}
^{238}U	4.06×10^{5}			1.58×10^{3}	9.10×10^{-2}	5.77×10^{-5}	5.77×10^{-6}
					Combined sum of fractions[f]		**3.73×10^{-1}**

a. Biota Concentration Guide.
b. Effluent Concentration/Water BCG.
c. Calculated Soil Concentration/Soil BCG.
d. Sum of the Partial Fractions.
e. See the text for the rationale for the various screenings.
f. Sum of the Sums of Fractions. If the Combined Sum of Fractions <, the site passes the screening evaluation.

REFERENCES

Cahki, S. and Parks, B., 2000, *CAP88-PC*, Version 2.1, September.

Chew, E.W. and Mitchell, R.G., 1988, *1987 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082(87), May.

Eckerman, K.F., Ryman, J.C, 1993, *External Exposure to Radionuclides in Air, Water*, Federal Guidance Report 12, EPA-402-R-93-081, September.

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

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

Environmental Protection Agency (EPA), 2001, "National Emission Standards For Hazardous Air Pollutants," *Code of Federal Regulations*, 40 CFR 61, Office of the Federal Register.

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

Hoff, D.L., Chew, E.W., and Rope, S.K., 1987, *1986 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082(86), May.

Hoff, D.L., Mitchell, R.G., and Moore, R., 1989, *1988 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE/ID-12082 (88), June.

ISCORS, 2004. RESRAD-BIOTA: A tool for implementing a graded approach to biota dose evaluation. ISCORS Technical Report 2004-02; DOE/EH-0676. Springfield, VA: National Technical Information Service. Available from: http://homer.ornl.gov/oepa/public/bdac/.

Lewellen, W.S., Sykes, R.I., Parker, S.F., and Kornegay, F.C., 1985, *Comparison of the 1981 INEL Dispersion Data with Results from a Number of Different Models*, NUREG/CR-4159, U.S. Nuclear Regulatory Commission, Washington, D.C.

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

Morris, R.C., 2003, Biota Dose Assessment Guidance for the INEEL, NW ID 2003-062, September.

Sagendorf, J.F., and Fairobent, J.E., 1986, *Appraising Atmospheric Transport and Diffusion Models for Emergency Response Facilities*, NUREG/CR-4603, U.S. Nuclear Regulatory Commission, Washington, D.C., May.

Sagendorf, J.F., Carter, R.G., and Clawson, K.L., 2001, *MDIFF Transport and Diffusion Model, NOAA Air Resources Laboratory*, NOAA Technical Memorandum OAR ARL 238, February.

Start, G.E., Cate, J.H., Sagendorf J.F., Ackerman, G.R., Dickson, C.R., Hukari, N.H., and Thorngren, L.G., 1985, *1981 Idaho Field Experiment, Volume 3, Comparison of Trajectories, Tracer Concentration Patterns and MESODIF Model Calculations*, NUREG/CR-3488,Vol. 3, U.S. Nuclear Regulatory Commission, Washington, D.C., February.

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

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

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

U.S. Department of Energy Idaho Operations Office (DOE-ID), 2004, *National Emissions Standards for Hazardous Air Pollutants (NESHAPS) - Calendar Year 2003 INEEL Report for Radionuclides*, DOE/ID 10890(03), June.

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

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

Chapter 9 - Ecological Research at the Idaho National Environmental Research Park

Chapter Highlights

The Idaho National Engineering and Environmental Laboratory (INEEL) 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 for training researchers and introducing the public to ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

Ecological research at the INEEL 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 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 activities took place at the Idaho NERP during 2004:

- The Effect of Landscape Change on the Life History of Western Rattlesnakes *(Crotalus oreganus)*;
- Fine-scale Movement Patterns of Coyotes *(Canis latrans)* on the INEEL in Idaho;
- Behavior, Dispersal, and Survival of Captive-raised Idaho Pygmy Rabbits *(Brachylagus idahoensis)* Released onto the INEEL in Idaho;
- Phylogenetic Analysis of the *Abronia ammophila* Green (Nyctaginaceae) Species Complex;

- Factors that Influence the Road Mortality of Snakes on the Eastern Snake River Plain;
- Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater;
- The Protective Cap/Biobarrier Experiment;
- Natural and Assisted Recovery of Sagebrush *(Artemisia tridentata)* in Idaho's Big Desert: Effects of Seeding Treatments and Livestock Grazing on Successional Trajectories of Sagebrush Communities; and
- Developing Advanced Scientific Methods for Landscape Level Management of Federal Facilities.

9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

The Idaho National Engineering and Environmental Laboratory (INEEL) 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. This has been one of the few formal efforts to protect land on a national scale for research and education. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems.

There are five basic objectives guiding activities on the Research Parks. They are to:

- Develop methods for assessing and documenting the environmental consequences of human actions related to energy development.
- Develop methods for predicting the environmental consequences of ongoing and proposed energy development.
- Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment.
- Train people in ecological and environmental sciences.
- 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 U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

Establishment of NERPs was not the beginning of ecological research at federal laboratories. Ecological research at the INEEL 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, identification of 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 INEEL. The Idaho NERP facilitates ecological research on the INEEL by attracting new researchers, providing background data to support new research project development, and providing logistical support for assisting researcher access to the INEEL. 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 INEEL 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 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 2004.

9.1 The Effect of Landscape Change on the Life History of Western Rattlesnakes (*Crotalus oreganus*).

Investigators and Affiliations

Christopher L. Jenkins, Graduate Student, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID

Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

Idaho Department of Fish and Game

Bureau of Land Management

Idaho State University (ISU)

U.S. Department of Energy Idaho Operations Office

Background

This project was designed to assess the impact of landscape disturbance on western rattlesnakes by examining trophic interactions among habitat, small mammals, and snakes. The synergistic effect of livestock grazing, invasive plants and fire is changing sagebrush steppe ecosystems in the Upper Snake River Plain. It is hypothesized that this phenomenon is affecting the prey base of top-level predators in the system. The main research goal is to determine if changes in habitat are altering prey availability and subsequently life history characteristics of western rattlesnakes.

Information from this project is important to the Department of Energy for several reasons: (1) as an indicator of how habitat change is influencing small mammal biomass; (2) as an indicator of how trophic interactions affect western rattlesnakes; (3) providing recommendations for the management and conservation of predators on the INEEL; (4) for utilizing a long term mark recapture data set gathered by the Idaho State University Herpetology Laboratory to further an understanding of community ecology on the INEEL; (5) assisting in the training of graduate and undergraduate students in environmental research.

Objectives

The overall goal of this project is to determine if current landscape patterns in habitat and prey on the INEEL are influencing rattlesnake life histories. Specific objectives for 2004 included the following:

- Quantifying spatial variation in rattlesnake life histories.

- Determine if spatial variation in rattlesnake life histories correlate with coarse scale patterns in habitat and small mammal biomass.
- Determine if rattlesnakes are selecting habitats with greater small-mammal biomass.
- Determine if disturbance to sagebrush steppe systems affects small-mammal biomass.
- Determine if changes in small mammal communities influence body condition of female rattlesnakes.

Accomplishments through 2004

Specific accomplishments for 2004 include the following:

- Found significant variation in life history characteristics among three den complexes on the INEEL (Table 9-1). More specifically, it was found that snakes at one den complex, Rattlesnake Cave, had life history characteristics that would indicate higher fitness.
- Found that biological soil crust cover; grass cover; and small-mammal species richness, abundance, and biomass were significantly higher and shrub height was significantly lower at Rattlesnake Cave (Table 9-2). Although these results are preliminary, future analyses will examine this issue in greater detail.
- Found that small-mammal biomass was greater in snake core activity areas than in either migration corridors or random locations (Figure 9-1).
- Found that small-mammal biomass was highest in habitats characterized by relatively tall shrub cover, low grass cover, and high biological soil crust cover (Table 9-3).
- Found that average small-mammal biomass within the core area of a rattlesnake's home range had significant influence on the snake's seasonal weight gain (Figure 9-2).

Plans for Continuation

Future plans include placing out a series of data logging stations to monitor the thermal environments available to rattlesnakes (Summer 2005). Specifically, stations will be placed in disturbed and undisturbed sites at both Crater Butte and Rattlesnake Cave. Using the information provided by these stations in combination with small mammal trapping data, a series of potential activity and growth models will be developed. In addition, field and laboratory data collected over the past four years will be analyzed. Analysis of the data set will culminate in a doctoral dissertation (anticipated Spring 2006) and approximately three manuscripts that will be submitted to peer reviewed scientific journals.

Presentations 2004

1. Jenkins, C. L. and C. R. Peterson. Linking landscape disturbance to life history variation among western rattlesnake (*Crotalus oreganus*) populations. Presented at the Idaho Herpetological Society, Boise, ID.

Table 9-1. Life history characteristics calculated from western rattlesnakes captured between 1994-2002 at three den locations in southeastern Idaho. Condition of young and adult females is calculated as the residual mass (i.e., residual values of the regression of mass to length). Highlighted values represent the values that we presume to be the most advantageous relative to the other den locations.

	Den Location		
Life History Characteristics	Cinder Butte	Crater Butte	Rattlesnake Cave
Age at Maturity	4	6	**3**
Proportion of Females Pregnant	**0.25**	0.20	0.24
Number of Young	5.20 ± 0.32	4.40 ± 0.30	**5.92 ± 0.28**
Condition of Young	-0.83 ± 0.14	-0.54 ± 0.15	**1.08 ± 0.22**
Female Body Condition	-6.08 ± 4.80	-6.16 ± 2.54	**11.88 ± 4.76**
Ecdysis (sheds/year)	1.66 ± 0.15	1.68 ± 0.18	**2.41 ± 0.23**
Growth (cm/year)	5.50 ± 0.96	3.60 ± 0.69	**5.95 ± 1.14**

Table 9-2. Proportion of area disturbed and average available habitat and prey characteristics at the Crater Butte and Rattlesnake Cave hibernacula. Habitat cover was measured using the line intercept method and small mammal factors we estimated from results of small mammal trapping. Results should be considered preliminary. For example, averages are calculated across all sampling plots at a given hibernacula and future analyses will examine patterns at a finer level (e.g., examining differences between disturbed and undisturbed sites within and between hibernacula).

Factor	Crater Butte	Rattlesnake Cave
Disturbance		
Proportion Grazed	1.00	0.52
Proportion Burned	0.58	0.41
Habitat Cover (cm)		
Cryptogamic Crust	57.11 ± 8.64	**115.41 ± 19.06**
Rock	544.37 ± 61.70	390.57 ± 44.80
Bare Soil	1348.93 ± 81.44	1383.13 ± 57.55
Litter	489.88 ± 36.19	349.93 ± 25.89
Shrub	310.88 ± 27.85	349.95 ± 27.48
Grass	255.46 ± 14.98	**334.09 ± 23.89**
Forb	71.67 ± 5.19	63.36 ± 8.74
Shrub Height (cm)	**47.88 ± 2.5**	38.35 ± 2.12
Shrub Dispersion (cm)	123.23 ± 9.62	118.05 ± 15.27
Rabbit Scat Index (0-3)	1.17 ± 0.13	**1.36 ± 0.11**
Small Mammal		
Species Richness	0.76 ± 0.08	**1.18 ± 0.08**
Abundance	1.44 ± 0.19	**2.17 ± 0.20**
Biomass (g)	35.35 ± 5.28	**55.02 ± 5.74**

2. Jenkins, C. L. and C. R. Peterson. Linking landscape disturbance to life history variation among western rattlesnake (*Crotalus oreganus*) populations. Presented at the Rattlesnake Biology Symposium, Loma Linda, CA.

3. Jenkins, C. L. and C. R. Peterson. Using geostatistical techniques to model the distribution and abundance of amphibians and reptiles. Presented at the Snake Ecology Group Meetings, Carbondale, IL.

4. Jenkins, C. L. and C. R. Peterson. Complementary methods for monitoring amphibian and reptile populations. Presented at the Savannah River Ecology Laboratory (U. S. Department of Energy and University of Georgia).

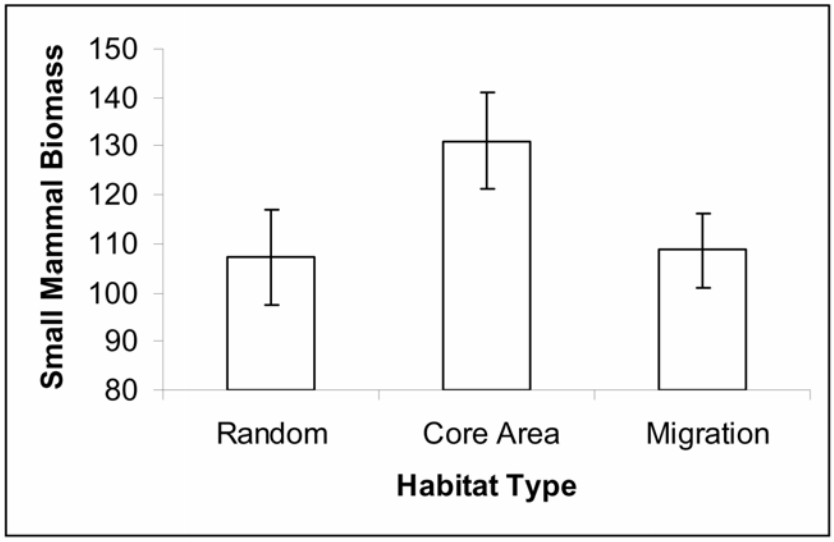


Figure 9-1. Average small mammal biomass found in random areas, core areas of snake activity, and migration corridors used by snakes during summer 2003. Error bars represent 1 standard error.

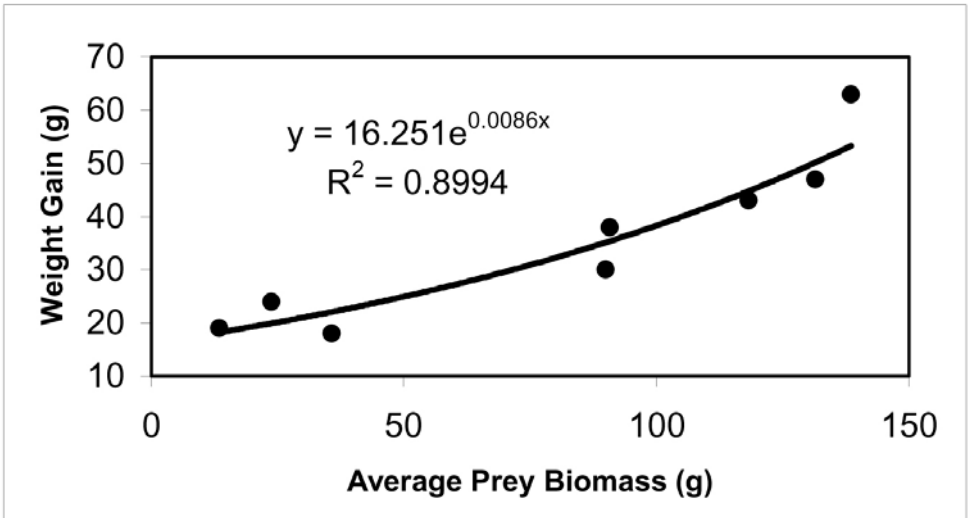


Figure 9-2. The relationship between prey biomass within a snake's home range and seasonal weight gain.

Table 9-3. The best model for predicting small mammal biomass in our study area, during the summer active period of snakes (May through September) 2003. The overall R^2 for the model was 0.26.

Variable	Coefficient	t-value	p-value
Intercept	1.70	6.78	<0.0001
Crust Cover	0.11	3.67	0.0003
Grass Cover	-0.20	-2.28	0.0236
Shrub Height	0.36	4.63	<0.0001

9.2 Fine-scale Movement Patterns of Coyotes (*Canis latrans*) on the INEEL in Idaho.

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 (Kernohan 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 5 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 ranges, paying special attention to the temporal component of the dataset. The 2004 year represents the first field season for this project, and specific goals for the year included the following:

- Capture and radio-collar 30-40 coyotes that reside in several contiguous territories in the study area on the INEEL.
- Test four new drop-off Global Positioning System (GPS) Lotek collars and analyze the data from retrieved collars to determine the appropriate sampling scheme necessary to gather meaningful fine-scale (temporal) data.
- Using the information from objective # 2, recapture resident coyotes and deploy 16 GPS collars to gather fine-scale data.
- Test the efficacy of new collaring scheme that increases the success of recapturing specific animals via helicopter net gunning.

Accomplishments through 2004

- Thirty adult coyotes (16 females/14 males) were opportunistically captured during late January 2004 via helicopter and net-gun. Each coyote was processed and fitted with a 65 gram VHF radio collar. Two pairs of coyotes from adjacent packs were also fitted with a GPS collars set to record locations every 5 minutes. Figure 9-3 shows the distribution of territories monitored during the 2004 season.
- The testing of the GPS collars showed exceptional accuracy (avg. error < 25 meters) and performance with an average acquisition success in the high 90th percent. Most missing locations were preceded and followed by accurate locations very near den sites, suggesting that the animals were underground and out of satellite view.
- Given the roughly inverse relationship between the absolute number of locations and the sampling interval of the collars, the data were sub-sampled to determine which interval provided the best data set for future sampling periods. It was concluded that although collecting locations every 5 minutes utilizes battery life rather-quickly, it also provides the most accurate and useful data for the question of interest (i.e. fine-scale space-use and movements). Even the most conservative re-sample (i.e. every 10 minutes) frequently resulted in interactions between coyotes and re-visitation to point locations being missed. Figure 9-4 shows the difference in total straight-line distance traveled for a single coyote at different sampling intervals during a single sampling period. Figure 9-5 shows an example of how different sampling intervals change the shape of an individual's movement path.
- The use of two separate collars (one VHF and GPS) is a rather new approach to monitoring wildlife species. The idea is to keep radio contact with animals after the GPS collars drop-off, and to increase the probability and efficiency of recapturing specific coyotes multiple times by homing in on the VHF frequencies with the helicopter during capture. The second

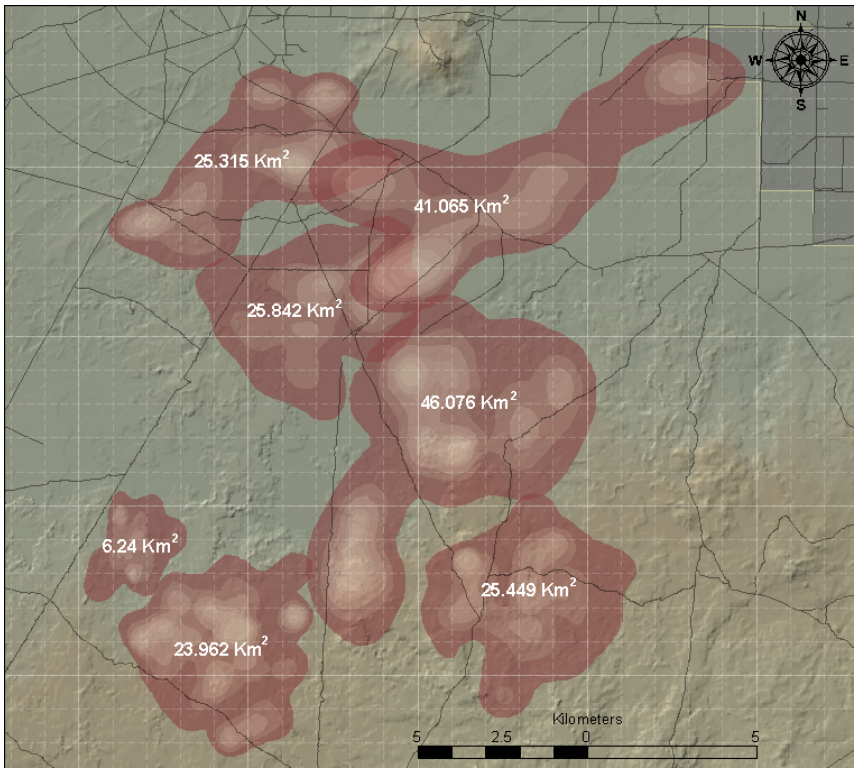


Figure 9-3. Home ranges for coyote packs monitored with GPS radio collars during 2004. Home ranges are calculated by the adaptive kernel (LSCV) method with the outer boundary representing the 90 percent isopleth.

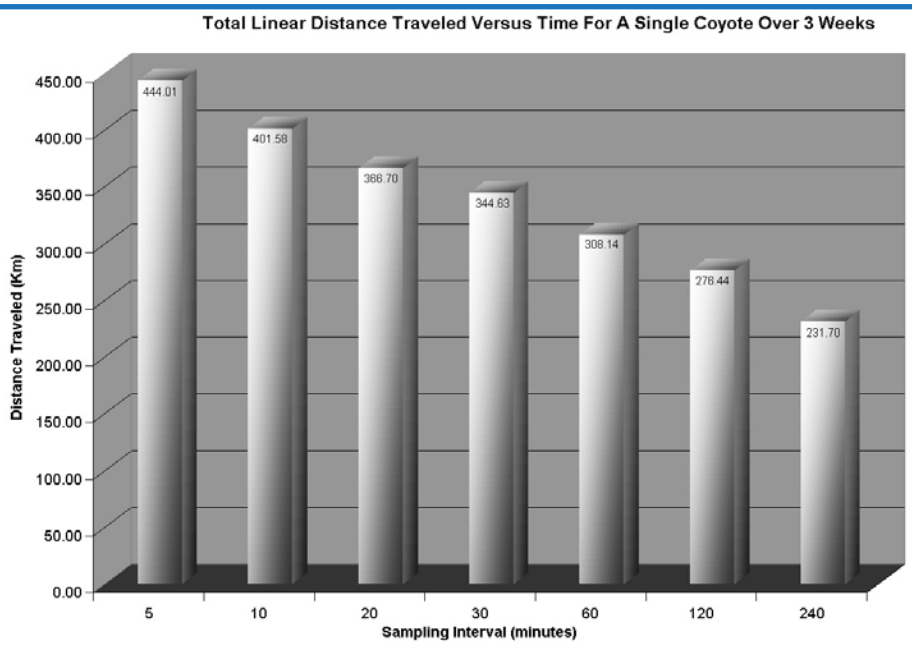


Figure 9-4. Total distance traveled for a single coyote for a period of three weeks at seven different sampling intervals. Notice that the distance traveled at the largest sampling interval (every 4 hours) is nearly half the distance traveled at 5-minute intervals.

capture in early December 2004 showed the success of such an approach. With 16 GPS collars available for deployment, 12 collared animals were able to be recaptured. GPS only had to be deployed on four unknown animals (three of which proved to be pack associates of previously collared animals).

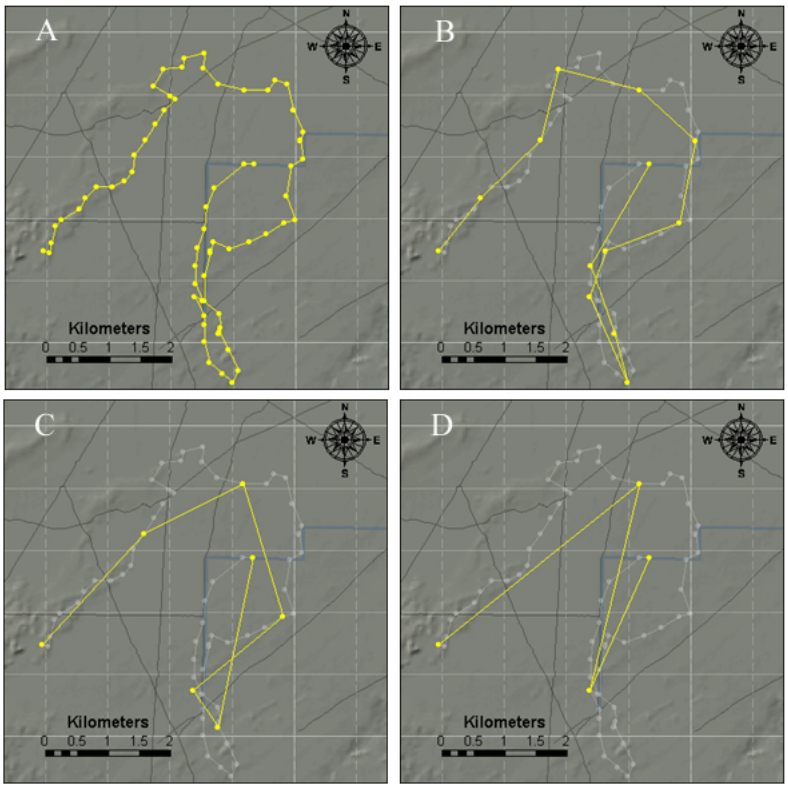


Figure 9-5. A continuous movement path shown at various sampling intervals. The yellow dots represent actual GPS locations and the yellow line represents the straight-line travel path between locations. The sampling intervals shown are: a) 5-minute, b) 30-minute, c) 1-hour, and d) 2-hours. Notice how the yellow line differs from the faded white line (5-minute interval) for frames b-d.

Results

The project is still in the data collection phase, although a few preliminary results have been provided below for those interested.

- Home ranges for coyotes on the INEEL site appear to be relatively large compared to previous studies. While this trend is true for most territories monitored, one pair of elderly coyotes (approximately 10 years old) appear to be an exception with their comparatively small home range (see Figure 9-3).

- Using serial locations to examine coyote movement patterns allows one to visualize how coyotes actually travel within their home ranges. Figure 9-6 shows the 5-minute GPS data (approximately 12,000 locations) and travel paths superimposed on the home range for a

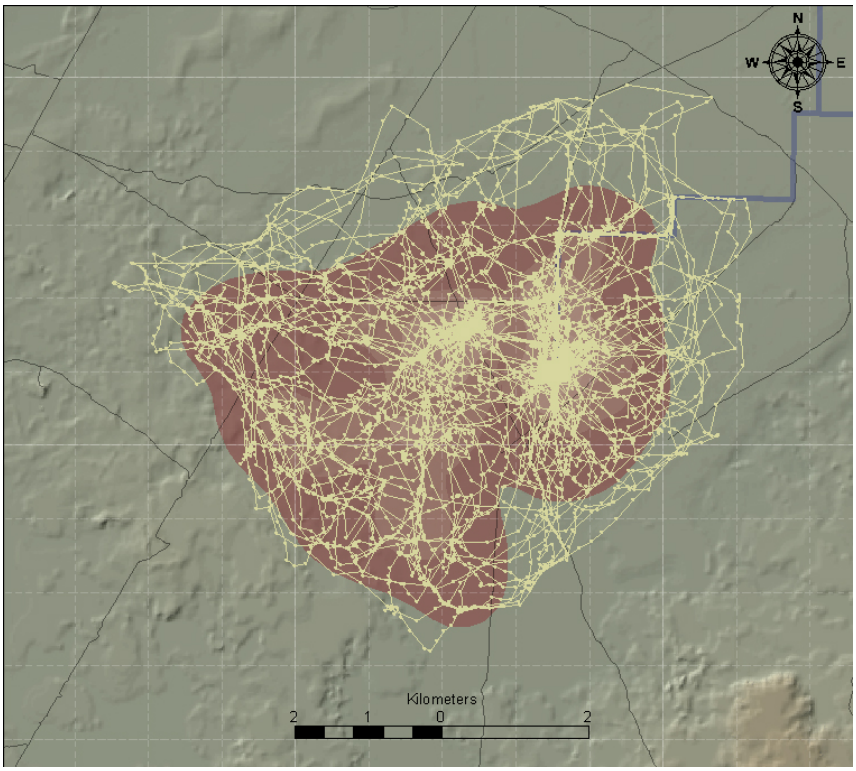


Figure 9-6. 5-minute GPS locations for a single coyote overlaid on the adaptive kernel home range polygon. One can see that while there are definite areas of concentration, the entire home range is being used and most of the travel paths represent novel movements rather than travel on fixed routes.

single coyote. A computer algorithm was used to divide locations into either "stationary" or "moving." This allows us to group locations into unique continuous "movement paths" and "resting spots" for further analyses (See Figure 9-7).

Plans for Continuation

- Two additional captures are scheduled for 2005 (Spring and Fall/Winter) with plans to deploy between 16 and 24 GPS collars during each period. This should generate roughly 500,000 coyote locations.

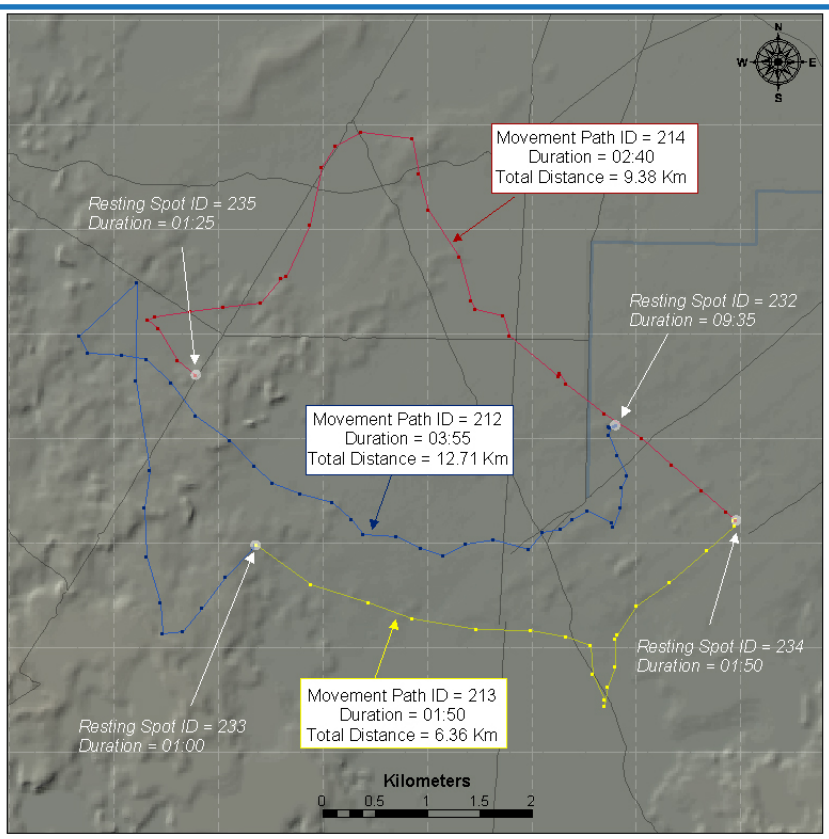


Figure 9-7. Three consecutive "movement paths" for a single coyote. Each movement path represents continuous movement by a coyote. By definition each movement path begins and ends with "resting spots" represented by a white circles on the map.

9.3 Behavior, Dispersal, and Survival of Captive-Raised Idaho Pygmy Rabbits *(Brachylagus idahoensis)* Released onto the INEEL in Idaho

Investigators and Affiliations

Rodney D. Sayler, Assoc. Professor, Department of Natural Resource Sciences, Washington State University, Pullman, WA

Robert Westra, Graduate Student, Department of Natural Resource Sciences, Washington State University, Pullman, WA

Lisa A. Shipley, Assoc. Professor, Department of Natural Resource Sciences, Washington State University, Pullman, WA

Funding Sources

Washington Department of Fish and Wildlife

Background

The pygmy rabbit *(Brachylagus idahoensis)* is the smallest rabbit in North America, a sagebrush foraging specialist, and one of only two North American rabbits to dig its own burrow. The long-isolated and genetically unique population of Columbia Basin pygmy rabbits located in eastern Washington State has declined precipitously to dangerously low levels and the U.S. Fish and Wildlife Service recently listed the Washington pygmy rabbits as an endangered population segment under the *Endangered Species Act*. Because little is known about successful captive-rearing and methods for restoring pygmy rabbits back into vacant natural habitats, reintroduction techniques in southeastern Idaho are being tested to develop protocols for the eventual restoration of endangered pygmy rabbits in Washington State. Idaho pygmy rabbits are propagated in captivity at Washington State University (WSU) and elsewhere and released into the wild in southeastern Idaho. The Idaho Fish and Game Department supervises these releases to determine whether selected captive rearing and release methods influence the behavior, dispersal, and survival of pygmy rabbits reintroduced into suitable sagebrush habitat.

Objectives

- Develop techniques to enhance the survival of captive-bred Idaho pygmy rabbits released into natural habitats for the purpose of establishing new local populations of pygmy rabbits.
- Test the effects of captive-rearing and release methods on the resulting behavior, dispersal, and survival of reintroduced pygmy rabbits.
- Develop recommended protocols for restoring pygmy rabbits in areas of vacant, suitable sagebrush habitat, and model the numbers of captive-bred animals and survival rates needed to establish new local breeding populations.

Accomplishments through 2004

A total of 42 pygmy rabbits were released from 2002-2004 at the INEEL to study behavior and survival of reintroduced animals. Rabbits originating from a source population in Idaho were raised in captivity at WSU, fitted with radio collars weighing < 2 percent of body weight, and released into temporary, weld-wire containment pens on the INEEL. The temporary pens surrounded the two openings of 3.0 to 4.5 m (10 to 15 ft) long plastic drainage tube burrows dug into the soil about 0.75 to 1.0 m (2.5 to 3.5 ft) deep in the center. The plastic-tubing burrows were used to partially replicate a natural pygmy rabbit burrow system and provide both thermal buffering and some protection against digging predators. Another goal of the artificial burrow system was to reduce premature dispersal of rabbits away from the release site selected in good sagebrush habitat. Released rabbits were monitored almost daily to record behavior, dispersal and habitat use.

Results

All released rabbits readily adapted to the small, temporary holding cages surrounding their burrow openings and continued normal feeding on provided foods (i.e., sagebrush tips, spinach,

lettuce, pellet food). All containment pens were removed from the burrows by the fourth day, allowing free movement and dispersal of the animals.

Rabbits moved an average of 54.1 m (177.5 ft) from their initial release burrow during their first week after soft release. Most rabbits remained fairly localized on the release site. Mean movement distances did not vary significantly among the first, second, or third week after soft release. Most captive-bred, dispersing animals selected an appropriate habitat consisting of relatively tall, dense big sagebrush with relatively good grass and forb availability. Released animals appeared to adapt to natural local forage quickly and appeared to use a high proportion of grass and forbs until colder weather in fall and winter, which prompted greater use of sagebrush.

Predation was the main source of mortality for released pygmy rabbits. Of the 42 released animals, approximately 26 percent were censured from the study (primarily because radio signals were lost and because of one collar malfunction), 42 percent were lost to predators, 19 percent were lost to unknown mortality factors, and 12 percent were alive at the end of the project. Eighteen of the 27 documented mortalities were caused by predators. Four mortalities were caused by raptors; northern harriers *(Circus cyaneus)* were directly observed in two predation events. Twelve animals were killed by long-tailed weasels *(Mustela frenata)* and two were confirmed coyote *(Canis latrans)* kills.

Survival - Total survivorship for the release population was 0.138 (Standard Error ± 0.085). This survivorship translates to an annual survival rate of 32 percent. Age and sex did not significantly influence survival, although the ability to detect such differences was limited. Males and females had similar survivorship; however, females experienced a higher mean survival time (175.7 days) than males (83.6 days). Annual survival rate was 18 percent for males and 30 percent for females.

Survival varied significantly among seasons (i.e., release groups). The annual survival rate was 0 percent for July, 24 percent for August, 32 percent for September, and 18 percent for February. However, the February release group had 50 percent of the rabbits released from the soft-release cages survive until the breeding season.

Survival quantiles for the released rabbits show a 76 percent survivorship for the first six days post soft-release, declining to 28 percent by day 95. Survivorship did not drop below 25 percent until day 260.

Reproduction of Reintroduced Pygmy Rabbits - At least two of the surviving released females appear to have given birth on the INEEL release site. One of the females was observed in 2003 and one in 2004. Consequently, it appears that surviving females will produce litters in the first spring after their release.

Plans for Continuation

This study on the INEEL has been a major research component of the recovery program for the endangered Columbia Basin pygmy rabbit in Washington, but will also provide valuable information in the event that local reintroductions are ever needed for populations of Idaho

pygmy rabbits. The study was terminated on the INEEL and two graduate theses were completed at WSU in summer 2004, to finish the research project. Technical research publications currently are being prepared from the theses for publishing in scientific journals. Interested parties may contact the investigators for more information.

9.4 Phylogenetic Analysis of the *Abronia ammophila* Green (Nyctaginaceae) Species Complex

Investigators and Affiliations

N. Elizabeth Saunders, Graduate Student, Southern Illinois University Carbondale, Carbondale, IL

Sedonia D. Sipes, Assistant Professor, Southern Illinois University Carbondale, Carbondale, IL

Funding Sources

Southern Illinois University

Wyoming Native Plant Society

Background

Abronia ammophila Greene and *Abronia mellifera* Dougl. ex Hook have a disputed taxonomic status. *Abronia ammophila* is thought endemic to Yellowstone National Park, and *Abronia mellifera* is thought to enjoy a more widespread distribution in Utah, Wyoming, Idaho, Washington and Oregon. Although the most recent morphological studies separate them into two species, some local botanists disagree with the determination. In fact, some taxonomists lump both species in with the even more widespread congener, *Abronia fragrans* Nutt. ex Hook, which is thought to range from Texas through Utah.

The existing taxonomy is based on morphological characters. Unfortunately, *Abronia* species in general tend to show incredible plasticity in morphological characters of interest for taxonomic determination. Indeed, among these two species the most informative characters overlap such that definitive determination to species is nearly impossible. This study was designed to collect molecular characters to build a phylogeny for the *Abronia ammophila* species complex with the hope that a molecular-based approach would succeed where a morphological approach has resulted in ambiguous and often subjective species determinations for individual plants.

Objectives

The overall objective of this research is to resolve the taxonomy of the *Abronia ammophila* species complex. Specifically, the research objectives are:

- Collect leaf material and voucher specimens from *Abronia ammophila* Greene, *Abronia*

mellifera Dougl. Ex Hook, and *Abronia fragrans* Nutt. Ex Hook for molecular analysis;

- Investigate the use of molecular characters to build a phylogenetic tree of the species complex.

Accomplishments through 2004

Leaf material was collected from representative samples of *Abronia ammophila* from Yellowstone National Park, from *A. mellifera* at Big Piney, WY, and INEEL, ID, and from *A. fragrans* from Texas and Utah. Leaf material was brought back to the lab at Southern Illinois University for analysis. Deoxyribonucleic acid (DNA) was extracted from all samples. Several regions of the nuclear and chloroplast genomes have been amplified and sequenced in order to find regions evolving at a sufficient rate as to differentiate closely related species. To date, the internal transcribed spacer regions of the ribosomal gene family (ITS I and 2) have been sequenced. These genes exhibit little variation among the *Abronia* species. However, we are going to evaluate several additional DNA regions that have shown potential in recent studies for resolving species-level relationships.

9.5 Factors that Influence the Road Mortality of Snakes on the Eastern Snake River Plain

Investigators and Affiliations

Denim M. Jochimsen, MS student, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID.

Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID.

Funding Sources

ISU Biological Sciences Department

ISU Graduate Student Research Committee

BBW Bechtel and the INEEL - ISU Education Outreach Program

ISU Biology Youth Research Program

National Science Foundation (NSF) GK-12 project

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 US, 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 variables that are highly correlated with snake mortality. These correlations could then be used to identify areas 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 five objectives: (1) quantify the road mortality of snakes on the eastern Snake River Plain; (2) identify any variation of mortality with respect to species, season, sex, age, traffic volume; (3) examine the spatial pattern of mortality across the survey route; (4) evaluate the importance of various landscape factors influencing this pattern; (5) develop a logistic regression model to predict road sections with intense mortality.

Accomplishments

- Successful completion of the 2003 and 2004 field seasons including 333 total road observations of snakes along the survey route in over 10,000 kilometers driven.
- Performed spatial and statistical analyses of the data, as well as identification of important landscape and habitat features that influence where snakes cross roads.

- Presented general findings of this research at the Intermountain Herpetological Rendezvous in Logan, Utah (2004), Society for Northwest Vertebrate Biology meeting in Corvallis, Oregon (February, 2005), and at the International conference on Ecology and Transportation in San Diego, California (September 2005).
- Successfully defended a master's thesis based on this work.
- Generated a poster publication to be used for subsequent presentation.

Results

Road mortality of snakes was quantified by road cruising (driving slowly in a vehicle and recording all snakes observed on a road surface) a 170-kilometer route from May through October of 2003. The survey route is located within the northeastern portion of the Snake River Plain and covers portions of US Highways 20, 26, 20/26, 22/33, Franklin Boulevard, and Lincoln Boulevard. Sampling consisted of 55 total trips along this route, and resulted in 9,350 total kilometers traveled over the 2003 field season (Table 9-4).

Table 9-4. Summary of sampling effort and snake observations from road-cruising surveys conducted across the INEEL in 2003 and 2004. EXTRAS denote specimens observed either while measuring habitat variables of noncrossing points, or off the survey route.

Year	Route Type / Length	Total km surveyed	No. Snakes Observed	Snakes / km	% Total Mortality	DOR[a]/ km
2003	Survey / 183 km	10,248	253	0.025	93%	0.023
2004	Survey / 183 km	2,013	35	0.017	97%	0.017
2004	Repeated / 10 km	746	80	0.107	74%	0.079
2003 - 2004	EXTRAS		23		96%	
Total		*> 13,000*	*391*	*0.03*	*90%*	*0.027*

a. DOR = Dead on Road

A total of 253 snakes were observed on roads along the survey route and across the entire survey period; 93 percent of these animals were found dead on the road surface (kill rate of 0.023 individuals/km surveyed). Spatial visualization and analyses indicate that these observations are clustered along the survey route (Figure 9-8). We documented the road mortality of 4 species belonging to families Colubridae and Viperidae. However, the majority of observations belonged to 2 species, *Pituophis catenifer* (gophersnake) and *Crotalus oreganus lutosus* (Great Basin rattlesnake). We observed gophersnakes most often on roads, comprising 74 percent of all road records, and rattlesnakes were observed more frequently than the remaining two species,

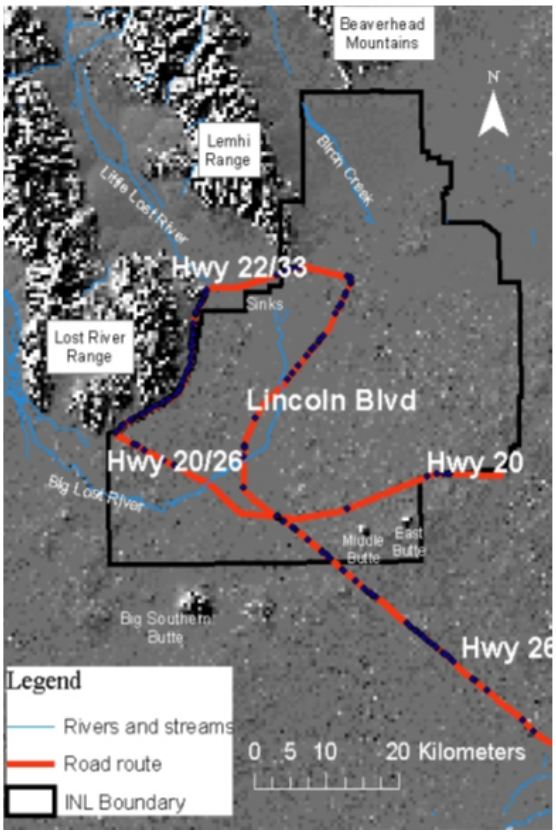


Figure 9-8. Spatial visualization of snake occurrences (n = 253) along the survey route from May - September 2003 generated in Arc GIS.

comprising 18 percent of all road records (Figure 9-9). Furthermore, we observed more adult males dead on roads for both these species than any other sex or age class. Juvenile observations comprised only 28 percent of total gophersnakes, and 17 percent of total rattlesnake road mortality.

Monitoring data indicate that rattlesnakes are the most abundant species based on hand and drift fence captures at dens. In fact, rattlesnakes made up 85 percent of captured snakes (n=2,459), with gophersnakes representing most of the remaining percentage of snakes (n=372) over a ten-year sampling period. This raises an interesting question, are gophersnakes more susceptible to road mortality on the Eastern Snake River Plain? This species is a habitat generalist and is perhaps more vagile than rattlesnakes, indicating that individuals would encounter roads more often, exposing them to the risk of road mortality.

The road mortality of snakes was documented in all months surveyed and seasonal patterns were evident. The mean number of snakes observed per route while road cruising was highest during the fall season, with a secondary peak in spring. These differences were significant (analysis of variance [ANOVA], $F = 3.638$, $P = 0.033$). The total number of sampling days without snake observations (11 total) was highest in late July and early August. There were also significant differences across season based on sex and age in gophersnakes (Figure 9-10).

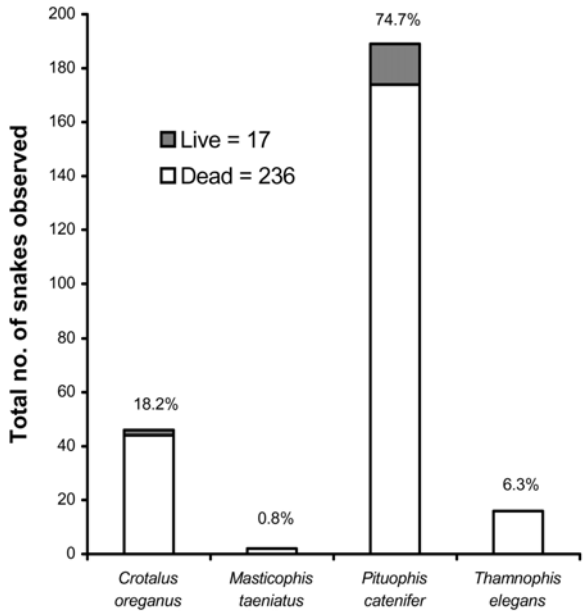


Figure 9-9. Road mortality accounted for 93% (n = 236) of all snake observations. Although racers and night snakes occur within the study region in low densities, none were observed during road surveys.

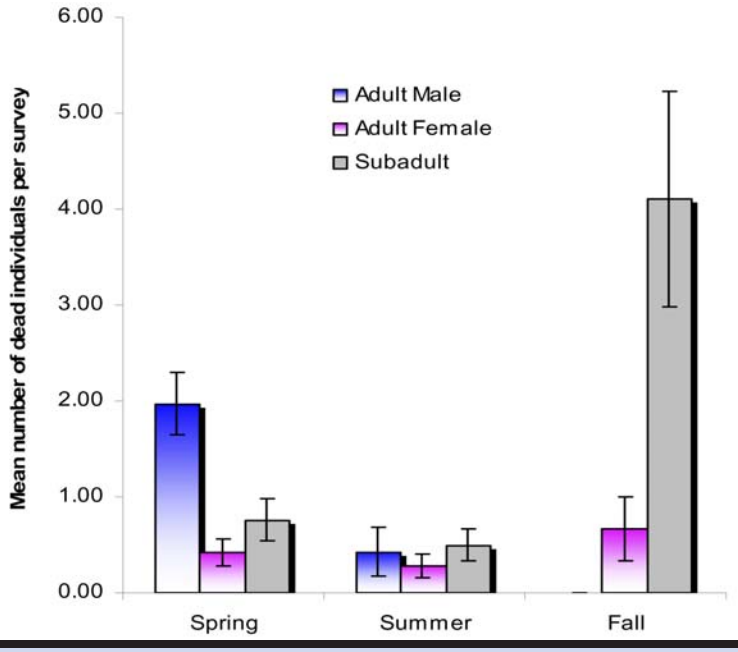


Figure 9-10. Seasonal comparison of mean numbers of adult male, adult female, and subadult road casualties for gophersnakes (*Pituophis catenifer*) observed along a 183 km route located on the INEEL surveyed in 2003. Bars represent one standard error above and below each mean.

Specifically, more males were killed in spring, whereas more subadults were dead in fall (results based on Kruskal-Wallis test). The higher numbers of certain age and sex classes with respect to seasons indicates that individuals may be more susceptible to road mortality during specific movements. Methods designed to ameliorate the road mortality of snakes should therefore coincide with these activity periods to be effective.

In addition to the systematic surveys, a 10 km segment of the route along State Highway 22/33 (running north/south) located on the western most edge of the study area was road-cruised in 2004. These surveys were designed to assess the probability of a snake successfully crossing the road. In attempts to address this, the shortened segment was driven between June and October in 2004, during periods of peak snake activity. Twelve of these routes were surveyed, covering 746 km and 80 snakes were observed (rate 0.107 snakes/km surveyed). Of these 80 snakes, 59 were observed killed. Similar to the 2003 surveys, 74 percent of observations were gophersnakes and 23 percent were rattlesnakes. This high mortality rate occurred in low traffic, and it appears that a traffic volume of less than ten vehicles per hour was sufficient to cause 100 percent mortality on some nights.

To assess the effect of road and landscape variables on snake mortality, several relevant variables were measured at each observation location from 2003, as well as an equal number of randomly chosen non-crossing points along the route. The variables measured were road slope, percent vegetation and major cover type within 10 meters of the road, distance to nearest vegetation, distance to nearest shrub, presence of burrows, presence of basalt, mean distance to dens (including those identified in this research), solar radiation, and major cover type at 50, 100, and 500 meters from the road (based on a geographic information system [GIS] coverage). A multiple logistic regression analysis was used to determine those variables significantly associated with road crossing locations. Finally, only gophersnake locations were used in this analysis as this was the only species with enough sample locations. Four variables were consistently included in each significant model. These were the grass major cover type (positively associated with snake crossing), percent vegetation cover within 10 meters (positively associated), presence of basalt (positively associated), and mean distance to den (positively associated). These results were surprising because it was expected that snake presence would be correlated with shrubs and would be negatively associated with den distance (i.e. the closer a den was to the road, the more mortality would be expected). A possible explanation for the positive association of grass cover type with snakes on roads is that this habitat is less suitable. If this is unsuitable habitat, individual snakes may move more to find more suitable habitat, and this increased movement would increase the likelihood of encountering a road. Second, if increased proximity of dens to a road actually reduces the probability of a snake encounter, then this likely indicates a population effect of road mortality. Specifically, this means that dens near roads either have reduced numbers of individuals or that snakes from those dens are not moving towards roads. Either way, this could influence population connectivity and ultimately, population persistence.

9.6 Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater

Investigators

Roger D. Blew, Amy D. Forman, Sue J. Vilord, and Jackie R. Hafla - Environmental Surveillance, Education and Research Program, S.M. Stoller Corporation, Idaho Falls, ID

Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

In 1995, the INEEL began disposing of treated wastewater at the Central Facilities Area (CFA) by applying it to the surface of soils and native vegetation using a center pivot irrigation system. Research conducted on this disposal method at the INEEL provides an opportunity to determine the benefits and/or hazards of disposal of wastewater on native vegetation in arid and semi-arid regions. Results will be applicable to a wide range of municipal, industrial and agricultural wastewater disposal needs. Because permits to dispose of agricultural and industrial wastewater may have restriction on application to prevent deep percolation, this research may refine some of the models used to predict the maximum rate of wastewater application possible without percolation below the rooting zone.

The wastewater land application facility at CFA covers approximately 29.5 ha (73 acres). The permit for operating this system limits the application rate to 63.5 cm (25 in.) water per year, which must be applied such that no more than 7.6 cm (3 in.) of water leach through the root zone toward groundwater. The 63.5 cm (25 in.) maximum application rate is more than two and one-half times the average annual precipitation and depending on the timing of application, plants may not be able to deplete this in one growing season to prevent leaching. Most of the precipitation in this cool desert biome occurs in the winter and spring, and soil moisture recharge occurs in the spring with snowmelt and rainfall. Therefore, wastewater application must be timed to avoid spring recharge to minimize deep percolation of wastewater. The wastewater also contains organic carbon, nitrogen, other nutrients, and trace metals that may have impacts on the proper functioning of native soil-plant systems.

Different plant species respond differently to addition of water and nutrient elements, especially if those additions come at times of the year that are normally dry. These differences in response can result in some species being favored and others discouraged. Changes in plant community structure can be expected. For example, in arid and semi-arid regions grasses are known to dominate where precipitation occurs mostly in the summer and shrubs tend to dominate in areas where moisture occurs as snow. Summer irrigation may lead to decreases in shrub dominance and increases in grasses.

Changes in plant community structure also mean changing habitats for other organisms such as small mammals, birds, insects, and big game animals. Because the area is relatively small, it

is unlikely that decreased habitat quality would have significant impacts on wildlife populations on the INEEL. Increases in habitat quality, however, could have substantial impacts on wildlife use pattern in and near this small area.

Objectives

The primary objective of the research study was to determine the ecological benefits or hazards of applying wastewater on native vegetation in semiarid regions. Specific objectives were to determine the potential for impacts on rangeland quality, resident wildlife populations, and soil water balance.

Accomplishments through 2004

Plant cover surveys were completed in 39 study plots within the three distinct plant community types (sagebrush steppe, crested wheatgrass, and a transition type) on the application area and in control areas adjacent to the wastewater application area. Soil moisture data was collected once every two weeks at 19 sites in the wastewater application area and 20 control sites throughout the growing season (beginning mid-March and ending mid-October), and a breeding bird survey was conducted according to United States Geological Survey (USGS) guidelines on and around the study site to determine any differences between irrigated and non-irrigated areas in bird usage. Additionally a complete ecological impacts report detailing results from the 2002 growing season was completed in early 2004.

Results

Spring wetting fronts in 2004 ranged from 0.4 m to 1.0 m and did not differ substantially between irrigated and control plots. Subsequent to infiltration, soil moisture decreased steadily throughout the wetted profile through the summer as a result of evapotranspiration. Soils began to approach the lower limit of extraction by early July in 2004. The soil moisture profiles do not indicate an increase in soil moisture at 20 cm or deeper due to wastewater application. If irrigation were to affect soil moisture, it would be expected to see either small wetting fronts in the profile throughout the summer (in the case of pulses in application), or it would be expected that soil moisture in at least some portion of the top of the soil profile to remain elevated (in the case of relatively steady application of water). Neither of these patterns is apparent in the irrigated soil profiles. In fact, those profiles dried down throughout the summer in a manner very similar to that of the control soil profiles. Thus, most of the additional water received by a soil profile through wastewater application was evaporated or transpired before it percolated to a depth of 20 cm within the soil profile. The soil moisture dynamics described here were similar across all plant communities on the application area. Therefore, the probability of water percolating through the rooting zone and continuing to move downward was essentially the same for the wastewater application area and control locations during the 2004 growing season.

9.7 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 aboveground foliage (Arthur 1982, Hakonson et al. 1992, Bowerman and Redente 1998). Likewise, percolation of water through the waste zone may transport contaminants into ground water (Fisher 1986, Bengtsson et al. 1994).

In semiarid regions, where potential evapotranspiration greatly exceeds precipitation, it is theoretically possible to preclude water from reaching interred wastes by (i) providing a sufficient cap of soil to store precipitation that falls while plants are dormant and (ii) 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, INEEL 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

- 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 caps;

- 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;
- To evaluate the performance of caps receiving higher precipitation than expected under either the present climate or that anticipated in the foreseeable future; and
- 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 2004 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 2004

Two supplemental irrigation treatments were completed on the PCBE in 2004. Fifty millimeters 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. Two hundred millimeters of water was applied to the fall/spring irrigated plots during a two week period at the end of September. Soil moisture measurements were collected once every two weeks from mid-March through mid-October. Vegetation cover data were collected throughout the month of July and into August.

Soil moisture and vegetation data collected in 2004 were archived. Soil moisture data were compiled and summarized, and soil moisture profiles were completed for each cap, irrigation and vegetation treatment.

Several presentations pertaining to alternative landfill cover designs and the PCBE were given in 2004. An invited talk detailing the ecological approach to revegetation design utilized on the PCBE was presented at the Design, Building, and Regulating Evapotranspiration (ET) Landfill Covers Conference sponsored by the U.S. Environmental Protection Agency, Remediation Technology Development Forum Program. A similar presentation was given as an invited talk at the 2004 Sediment Control/Wetlands Workshop conducted by the Idaho Department of Environmental Quality. Finally, a poster discussing the use of native vegetation for water extraction on landfill covers was presented at the Ecological Society of America 89th Annual Meeting.

Results and Discussion

Initial data analyses from the 2004 soil moisture data indicated that the spring infiltration event was deeper and more variable than it was in 2003 on the ambient and summer irrigated plots. The wetting front ranged from 40 cm to 160 cm in depth on those plots. Spring infiltration

extended below the biobarrier on many of the shallow biobarrier caps, and extended into the biobarrier, but not below the biobarrier on many of the deep biobarrier caps. On the fall irrigated plots, the soil profile became saturated subsequent to the October 2003 irrigation and remained at field capacity until the following spring. Thus, any water entering the soil profile during spring infiltration in 2004 likely percolated through the cap and into the soil below.

Over the ten year study period, the widespread cap failure that occurred in response to the fall irrigation treatment of 2003 marks the first event of this type under the experimental treatment conditions. Similar cap failures occurred on all cap designs and vegetation types with fall irrigation again in 2004. 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 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 and 2004 were a random and reversible occurrence.

Plans for Continuation

Soil moisture and plant community composition and cover were still experiencing important changes in 2004, as evidenced by the cap failures in response to the fall irrigation treatment. 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 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.

9.8 Natural and Assisted Recovery of a Sagebrush *(Artemisia tridentata)* in Idaho's Big Desert: Effects of Seeding Treatments and Livestock Grazing on Successional Trajectories of Sagebrush Communities

Investigators and Affiliations

Mike Pellant, Idaho State Office of the Bureau of Land Management, Boise, ID

Roger D. Blew, Amy D. Forman and Jackie Hafla, Environmental Surveillance, Education and Research Program, S. M. Stoller Corporation, Idaho Falls, ID

Robert Jones, U.S. Department of Energy Idaho Operations Office, Idaho Falls, ID

Greg White, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, ID

Alan Sands, The Nature Conservancy, Boise, ID

Funding Sources

Bureau of Land Management

U.S. Department of Energy Idaho Operations Office

The Nature Conservancy

Background

Averaged over the last 10 years, approximately 95,000 ha (235,000 acres) of lands managed by the Bureau of Land Management (BLM) in Idaho have burned annually. The BLM and other managers of Idaho rangelands, including the INEEL, must decide whether the burned areas need stabilization and rehabilitation treatments to prevent soil erosion and inhibit the invasion of exotic species such as cheatgrass *(Bromus tectorum)*. Most of these rangelands have historically been dominated by big sagebrush *(Artemisia tridentata)*, which does not resprout after fire. Sagebrush provides critical food and habitat for sage grouse, a species proposed for listing under the *Endangered Species Act*. With the accelerating loss of native sagebrush communities and habitat for sage grouse and other sagebrush-obligate species, sagebrush reseeding following fire has become an important consideration, as has the issue of livestock grazing impacts on recovering native vegetation and seeded areas. In the last three years, approximately 70 percent of the sage grouse habitat in eastern Idaho's Big Desert has been burned by wildfire. Fire suppression and rehabilitation costs are rising, and the threats to human life and property are increasing in eastern Idaho.

This study has been divided into three components to address management concerns relative to: (1) native plant recovery in good ecological condition rangeland, (2) success of aerial seeding sagebrush, and (3) whether livestock grazing affects recovery on sagebrush steppe rangelands.

These three components will provide new scientific information that addresses current management concerns relative to wildfire impacts and rehabilitation treatments on the eastern Snake River Plain. These studies are designed to establish long-term, replicated monitoring sites that can be reread in the future to provide additional information to managers about post-fire recovery and rehabilitation success. These studies will also provide insight into restoring sagebrush and understory herbaceous species for sage grouse and other sagebrush obligate wildlife species and domestic livestock in the Great Basin.

Objectives

The overall objectives of this research project are to examine some of the key factors that influence trajectories of community diversity and structure following wildfire in sagebrush-steppe ecosystems. Specifically, the factors that influence the recovery of these systems following fire and the replacement of native plant communities with vegetation dominated by cheatgrass *(B. tectorum)* will be examined. The three basic research objectives were to:

- Describe post-wildfire trajectories in community composition and structure in areas in good ecological condition;
- Compare sagebrush recruitment on areas that have been aerially seeded to areas relying on natural recruitment processes; and
- Determine whether trajectories of community composition and structure differ between areas returned to grazing after fire and areas where grazing is excluded.

Accomplishments through 2004

The trend in seedling density measured in 2003 on the 1994 burn pointed to the role of wind in seed dispersal and therefore it was determined to collect better data on that distribution pattern. To collect that data, six, 1000 m transects were used extending downwind from the upwind edge of the fire. Fifteen meter radius plots were surveyed at 50 m intervals along those transects. The center of the first plot on each transect was set 20 m from the fire edge. These surveys were conducted in burns from 1994, 1995, 1996, 1999 and 2000. This data will be used to look for changes in that distribution pattern with age since fire, possibly allowing us to determine a rate of spread into the burn.

Because those fires cover a period spanning from relative wet conditions through the current drought, this data can be used to further test the idea that sagebrush establishment is controlled by climatic conditions and not seed dispersal alone.

To address the first and third objectives, paired research plots were established in a portion of the area burned by the 2000 Tin Cup Fire. Grazing exclosure fences were constructed around one plot from each pair. The exclosed plot will be used to address questions related to recovery of vegetation in ungrazed sagebrush steppe rangeland. The unfenced plot will be used to examine the role of livestock grazing on that recovery. In all of these plots, plant cover, species richness and diversity were measured. Permanent photoplots and photopoints were established and photographed.

To address the first objective further, plots for addressing plant density and species richness in some of the older burned areas on the INEEL were established.

Grazing treatments were initiated in 2003 so utilization measurements were initiated at that time. Utilization was measured with the Ocular Estimate Method. Key species (one grass and one forb) were selected for each plot. Selection criteria included consideration of the most abundant species that had actually been grazed and for which there were sufficient numbers of individuals in the plot to obtain a reasonable sample.

Results

Heterogeneity chi-square tests were used to determine whether seedling counts were evenly, or uniformly, distributed among the twenty positions along each transect line. Overall, seedling counts were not uniformly distributed among the twenty plot positions along each transect for 27 of the 29 transects. Seedling counts were not comparable at the same position along each transect line within each burn, or stated differently, seedling count patterns were different along each transect within a burn. Thus, the highest seedling counts in any single transect did not necessarily occur at positions near the burn edge. In fact, the positions with the highest seedling counts were quite variable from one transect to the next.

A Poisson distribution was calculated for the frequency of occurrence of seedling counts among the 120 plots for each burn. The calculated Poisson distribution was then statistically compared to the actual frequency of occurrence of seedling counts among the plots using a Chi-Square Goodness of Fit Test to determine whether or not sagebrush seedlings occur randomly within the burned area. If the actual frequency of seedling occurrence among plots departed significantly from a random distribution, a variance to mean ratio was calculated to determine whether the seedling spatial pattern was clumped or uniform. However, there was already certainty the distribution would not be uniform because the possibility had been ruled out by the heterogeneity analysis. The variance to mean ratio for the sagebrush seedlings/plot on the all burns indicated either clumped or highly clumped distributions.

Species Richness, Density and Frequency - A total of 79 plant species were encountered in the ten pairs of plots (20 plots). Three species found in 2003 were not found in 2004. All three were perennials and two were native species. Twelve species not found in 2003 were found in 2004. Seven of those twelve were present in 2002, but not in 2003. Five were species not previously found in these plots. All of the species added in 2004 were native and ten of those were annuals.

Coefficient of Community is the percentage of total species that the two communities have in common. It was calculated here as to compare the two plots of each pair for similarity in terms of the species present. Coefficient of Community varied from 0.72 to 0.90. The Coefficient of Community went up in all but one plot pair (Plot 10).

Species/area curves were plotted based on the species counted in the nested plots. The y-intercept and slope increased in nearly all of the species/area curves. This is likely due to the increases in species richness and frequency.

Utilization - Utilization of grasses on each plot ranged from 0.0 to 1.4 percent with an average utilization of 0.26 percent. Forb utilization ranged from 0.0 to 6.7 percent with an average utilization of 1.9 percent. These numbers are obviously very low and indicate that the needed grazing treatment was not achieved on these plots in the spring of 2004.

Plant Cover - Mean total cover was 11.7, 13.6 and 20.1 percent in 2002, 2003 and 2004 respectively. Native perennial grass basal cover increased from 1.5 percent in 2002 to 2.3 percent in 2003 and remained unchanged through 2004. Percent aerial cover of native perennial forbs remained relatively stable with a high of 4.1 in 2003 and a low of 3.6 in 2004. Cover by introduced species (primarily annual forbs) was 0.6, 0.3 and 1.9 percent in 2002, 2003 and 2004 respectively. Aerial cover by native annual and biennial forbs was 0.6, 0.0 and 3.2 percent in 2002, 2003 and 2004 respectively. The increase in cover by annual and biennial species in 2004 may have been the result of higher precipitation in May and June of 2004 compared to 2002 and 2003.

Shannon-Weiner Diversity Indices for each plot ranged from 1.20 to 2.75. The diversity index went up on most of the plots between 2003 and 2004. The Morisita's Similarity Indices for comparing plots within a pair ranged from 62.62 to 98.52. The similarity index went up on four pairs of plots (2, 4, 7 and 9) and went down on six plot pairs (1, 3, 5, 6, 8 and 10).

Older Burned Area Plots - Of the 32 plots planned for this study, surveys were completed on 18 during 2003 and the remainder was surveyed in 2004. A total of 101 species were encountered on the 32 plots. There were more species of annual forbs in 2004 than 2003 and they were present in higher densities in 2004. There is a trend for big sagebrush density and frequency to be higher in the older burns than the more recent ones. Green rabbitbrush density and frequency varied greatly from plot to plot and from fire to fire with no apparent relationship to fire age. Cheatgrass frequency averaged about 0.5, but the density rarely exceeded 10 plants m^{-2}. There was no relationship between cheatgrass density or frequency with fire age. Halgeton density and frequency were higher on the areas burned in 1994 and 1996.

Project Conclusions

Natural Sagebrush Seedling Recovery - Sagebrush seedling spatial distribution was clumped in all five of the burns sampled. The 1994 and 2000 burns most closely approximate the exponential decay model that has been proposed for seedling distribution from the edge of a burn scar; those burns also have the highest variance to mean ratios, indicating the more strongly clumped distributions (likely driven by plots with higher seedling counts close to the burn edge). However, all of the burns sampled exhibited clumped seedling distributions, indicating that seedlings establish in clusters in burns that do not show a strong edge effect. Additionally, groups of seedlings may become established several hundred meters from the burn edge, as seen in all burns sampled except the 2000 burn. The clustered pattern may be influenced by seed from remnant islands. The clustered pattern may also reflect soils, topography, and microclimate.

The mechanism is likely a combination of remnant islands and an appropriate microhabitat, though the relative importance of each factor is unclear at this point. Most importantly, sagebrush seed does appear to become dispersed and seedlings established the interior of the burn scars that

were sampled in substantial numbers and within a relatively short time frame. However, the presence of sagebrush seedlings in the interior of burn scars does not necessarily indicate a short recovery period; it simply indicates that initial seed dispersal and establishment may not be as limited as previously thought. These results also demonstrate that there must be seed dispersal from the fire edge well into the burn area (something greater than 1000 m). That annual seed rain may be important for providing seed each year far into the burn to take advantage of a climate-driven establishment event.

Natural Recovery Trajectory - Consistent increases in cover by native species have been observed during each year of the study. This happened concurrent with a severe drought. Total annual precipitation since the fire in 2000 ranged from 110 to 155 mm while the long term mean annual precipitation at the INEEL is 220 mm. It was also interesting to see the return of native annuals in 2004 acting as ephemerals responding to summer conditions that were wetter than normal. During 2004, the plots received a substantial portion of the total annual precipitation during late spring. This is in contrast to 2003 when there was no precipitation between early May and late August. At this time, it appears that none of the plots are at risk of a recovery trajectory to anything other than communities dominated by native perennial species.

When that trajectory is extended by considering the data collected in the older burn plots a similar pattern is seen. It was interesting to find no sagebrush on the survey plots in an area that burned more than 55 years ago. This along with previous data collected at the INEEL indicate that natural recovery times for Wyoming big sagebrush may be much longer than previously estimated. Similarly the lack of an apparent relationship between time since burn and green rabbitbrush frequency and density suggests that the assumption that rabbitbrush acts as a successional species may need to be reconsidered.

Recovery Trajectory With Livestock Grazing - Unfortunately, meaningful grazing treatments were not achieved during 2004. Cattle were released onto the allotment around July 1, 2004, and removed in early August. When it was found that some of the plots would be grazed, albeit later than expected, it was attempted to capture as much information as possible about that event. It was hoped to be able to extend the study for at least one more year in an effort to determine if livestock grazing has an effect. To that end, utilization was re-measured on the ten pairs of plots on August 10, 11 and 12, 2004. In addition, six new grazed plots were established in an area that had received moderate to heavy utilization. Utilization was measured on those plots as well. A plan is in place to continue surveying the ten paired plots and the newly established plots should funding come available.

9.9 Developing Advanced Scientific Methods for Landscape Level Management of Federal Facilities

Investigators and Affiliations

Jerry L. Harbour, Robert P. Breckenridge, Randy D. Lee, Idaho National Engineering and Environmental Laboratory

Funding Sources

Idaho National Engineering and Environmental Laboratory

Background

Many Federal lands are subject to creeping environmental problems that often go unnoticed on a site-specific basis but, when reviewed from a landscape level, can have dramatic impacts on natural resource management (i.e., threatened and endangered species, invasive weeds, and fire).

This Laboratory Directed Research and Development (LDRD) project is researching the use of advanced concepts in landscape ecology and remote sensing to develop a unified theory for management of federal lands. Development of a unified theory that takes advantage of advanced technologies for identification and mapping of landscape features will enhance resource management to meet appropriate regulations, facilitate future facility sighting, and enhance the scientific basis for evaluating options for future management of these lands.

Objectives

Technical objectives for fiscal year 2004:

- Develop a theoretical model for land cover and land use on and around the INEEL.
- Evaluate ecological health indicators needed to support end state planning and risk assessment.
- Develop advanced methods to monitor conditions of sagebrush steppe vegetation using unmanned aerial technology for improving monitoring approached.
- Define the long-term research niche for the INEEL in understanding sagebrush steppe ecosystems.

Accomplishments through 2004

Development of theoretical model. In fiscal year 2004, the project team completed a report titled "Conducting Landscape Level Analysis: A Focus on Remote Sensing and GIS" that identifies the data and remote sensing imagery that can be incorporated into a theoretical modeling approach for the INEEL. The theoretical model being developed evaluates the framework for addressing end state planning and could help DOE achieve two aspects of its mission in managing lands in Idaho. These two aspects are 1) to understand the future use for

sagebrush ecosystems, and 2) to take actions to ensure that future DOE offices Nuclear Energy and Environmental Management and clean-up missions are achieved as efficiently as possible.

Evaluation of ecological health indicators. An extensive amount of ecological data has been collected over the many years that work has been conducted on the INEEL. Some data sets, such as the long-term vegetation plots, have records that go back over 50 years. The available data have been cataloged and, where appropriate, incorporated into a GIS format. These data will be used to support identification of the most appropriate indicators for evaluation of ecological health. The research team has been invited by the Sustainable Rangeland Executive Committee to join their group in identifying criteria and indicators for sustainable rangeland management. Current activities have focused on identifying critical linkages between ecological parameters, and how these will support long-term risk management for rangeland systems. A list of 64 criteria and indicators has been identified. This list is under evaluation to identify those parameters most appropriate for the INEEL.

Evaluate vegetation using Unmanned Aerial Vehicles (UAV's). Analysis of vegetation by traditional ground methods is very labor intensive. Evaluations are being conducted to determine if there are alternative aerial approaches`` for collecting data about the amount of vegetative cover present on the INEEL that are comparable to ground based methods, Two different UAV platforms (fixed wing and rotary) are being evaluated with both fixed and video cameras to determine if they are capable of assessing creeping environmental problems (Figure 9-11 and Figure 9-12). This includes identification of species to the life form (shrub, grass, forb and bare ground) to determine if it is possible to evaluate large tracks of land at one time, resulting in cost savings and improved safety from reduced fieldwork.

Long-term research niche for INEEL. A series of meetings and conference calls have been held with senior representatives from the U.S. Department of Interior, USGS, Fish and Wildlife Service, and Nature Conservancy to evaluate long-term uses for INEEL as a sagebrush steppe research facility. The National Academy of Science also has recently endorsed the creation of an ambitious network of ecological research stations that the NSF has been advocating for the past six years. INEEL, along with university collaborators, will pursue involvement of the INEEL in the National Ecological Observatory Network (NEON). During fiscal year 2005 the research team will meet with NSF and other collaborators to help identify INEEL's potential role in supporting the NEON concept.

A number of accomplishments were made this year. This LDRD resulted in a presentation on conceptual models for monitoring rangelands made to the Sustainable Rangeland Roundtable meeting in Spokane, Washington. Contacts also were made with the U.S. Department of the Interior (Dr. Jim Tate, science advisor) during discussions about applying state-and transition-modeling approaches for landscape management of federal lands. A conceptual model of a landscape management approach was also presented to Jon Sandavol, chief of staff, Idaho Division of Environmental Quality. The project team discussed the scientific basis for land management of federal lands with Dr. Steve Bunting (University of Idaho) and Dr. Mike Scott, a senior scientist for USGS. An abstract titled "Development of Ecological Indicators for Sustainable Management of Semiarid Ecosystems" was presented on October 2003 at the Sustainable Rangeland Roundtable in Boise, Idaho.

Results

Field data will be collected during the spring/summer of 2005. Results will be compiled and presented at appropriate professional meetings and published in the scientific literature.

Plans for Continuation

INEEL UAV program will continue to grow with continued interest in using the technology to support developing National Security and Nuclear missions. The UAV technology is in its developmental stages, system improvements are being evaluated and tested to determine if this approach will provide a viable alternative to conventional monitoring methods. UAVs and other remote sensing technologies will continue to be pursued, because they provide an opportunity to extend our ability to collect data on ecological resources across the vast landscape of INEEL that otherwise may not be accessible.

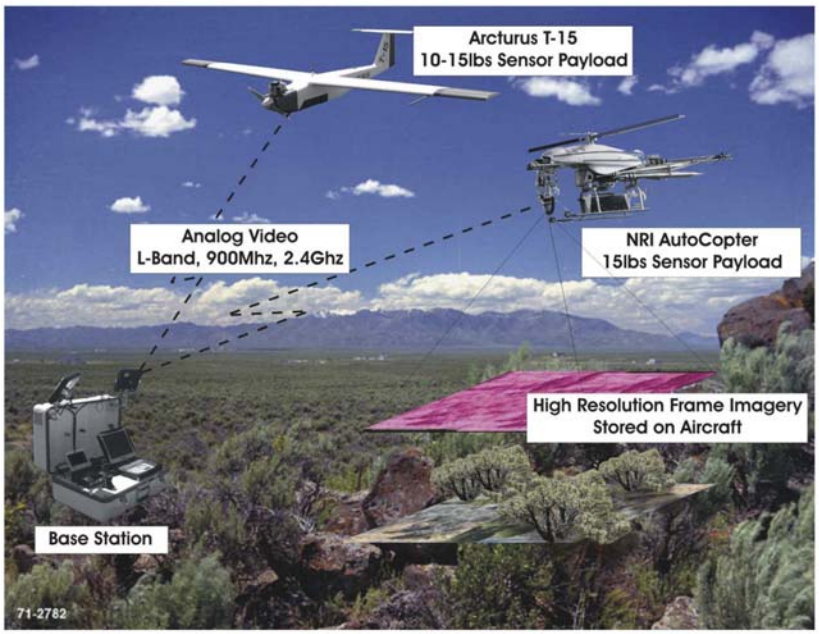


Figure 9-11. Unmanned Aerial Vehicle (UAV) technologies being evaluated in this project.

Figure 9-12. Remote controlled helicopter being tested for aerial photography.

REFERENCES

Arthur, W. J. 1982. "Radionuclide concentrations in vegetation at a solid radioactive waste disposal area in southeastern Idaho." *Journal of Environmental Quality,* 11:394-399.

Bengtsson, L., D. Bendz, W. Hogland, H. Rosqvist, and M. Akesson. 1994. "Water balance for landfills of different age." *Journal of Hydrology,* 158:203-217.

Bowerman, A. G., and E. F. Redente. 1998. "Biointrusion of protective barriers at hazardous waste sites." *Journal of Environmental Quality,* 27:625-632.

Cobb V.A. 1994. *The ecology of pregnancy in free-ranging Great Basin Rattlesnakes (Crotalus viridis lutosus),* Ph.D. dissertation. Idaho State University, Pocatello ID.

Daniel, D. E., and B. A. Gross. 1995. *Caps*. National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia.

Fisher, J. N. 1986. *Hydrogeologic factors in the selection of shallow land burial for the disposal of low-level radioactive waste.*

Gregory, P.T., Macartney, J.M. and Larsen, K.W. 1987. "Spatial patterns and movements." Pp. 366-395 In: R.A. Seigel, J.T. Collins, and S.S. Novak (eds.). *Snakes-ecology and evolutionary biology*. New York: Macmillan.

Hakonson, T. E., L. J. Lane, and E. P. Springer. 1992. "Biotic and abiotic processes." Pages 101-146 in C. C. Reith and B. M. Thomson, editors. *Deserts as dumps? The disposal of hazardous materials in arid ecosystems*. University of New Mexico Press, Albuquerque, New Mexico.

Jackson S.D. 1999. "Overview of transportation related wildlife problems." Pp. 1-4 In: G.L. Evink, P. Garrett, D. Zeigler and J. Berry (eds.). *Proceedings of the International Conference on Wildlife Ecology and Transportation*. State of Florida Department of Transportation, Tallahassee, Florida. FL-ER-73-99.

Kernohan, B. J., R. A. Gitzen, and J. J. Millspaugh. 2001. "Analysis of animal space use and movements." Pages 125-166 in J. J. Millspaugh and J. M. Marzluff, editors. *Radio Tracking and Animal Populations*. Academic Press, San Diego, California, USA.

King F.B. and D. Duvall. 1990. "Prairie rattlesnake seasonal migrations: episodes of movement, vernal foraging and sex differences." *Animal Behaviour,* 39: 959-935.

Nativ, R. 1991. "Radioactive Waste Isolation in Arid Zones." *Journal of Arid Environments*, 20:129-140.

Nyhan, J. W., T. E. Hakonson, and B. J. Drennon. 1990. "A water balance study of two landfill cover designs for semiarid regions." *Journal of Environmental Quality,* 19:281-288.

Rosen, P. C. and C. H. Lowe. 1994. "Highway mortality of snakes in the Sonoran Desert of southern Arizona." *Biological Conservation,* 68:143-148.

Rudolph, D. C., S. J. Burgdorf , R. N. Conner and R. R. Schaefer. 1999. "Preliminary evaluation of the impact of roads and associated vehicular traffic on snake populations in eastern Texas." 8 pp In: G.L. Evink, P. Garrett, D. Zeigler and J. Berry (eds.). *Proceedings of the International Conference on Wildlife Ecology and Transportation*. State of Florida Department of Transportation, Tallahassee, Florida. FL-ER-73-99.

Suter, G. W. I. I., R. J. Luxmoore, and E. D. Smith. 1993. "Compacted soil barriers at abandoned landfill sites are likely to fail in the long term." *Journal of Environmental Quality,* 22:217-226.

Chapter 10 - Quality Assurance

Russ 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.

10.1 Quality Assurance Programs

The purpose of a quality assurance and quality control program is to ensure precise, accurate, representative, and reliable results, and 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; and
- Data verification and validation programs.

10.2 Laboratory Intercomparison Program

Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. In 2004, the Management and Operating (M&O) contractor used the Idaho National Engineering and Environmental Laboratory (INEEL) Radiological Measurements Laboratory (RML) and General Engineering Laboratories (GEL) for radiological and inorganic analyses. The M&O Drinking Water Program used GEL for radiological analysis, 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) and Severn-Trent Laboratories (STL) of Richland, Washington, 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 Quality Assessment Program (QAP), administered by the DOE Environmental Measurements Laboratory (EML) in Brookhaven, New York, was a performance evaluation program that tested the quality of DOE contractor and subcontractor laboratories in performing environmental radiological analyses. The EML prepared samples containing known amounts of up to 15 radionuclides in four media: simulated air filters, soil, vegetation, and water. These were distributed to participating laboratories in March and September. Participants could use any method for each analysis, and they were required to report their results within 90 days. The EML issued quality assessment reports twice per year in which the identities of participating laboratories, their results, and comparison to EML results were presented. These reports are available, along with a searchable database of results, on the Internet at http://www.eml.doe.gov/qap/reports/ (DOE 2004a). The QAP was discontinued following the March 2004 distribution.

The Mixed Analyte Performance Evaluation Program (MAPEP) (DOE 2004b) 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 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.inel.gov/resl/mapep/reports.html (DOE 2004b).

2004 QAP/MAPEP Results

Comparisons of the air and water results for the laboratories used by INEEL environmental monitoring organizations in 2004 are presented in Figures 10-1 and 10-2. QAP results are for June 2004 and MAPEP results were reported for November 2004. All results for all laboratories were qualified as acceptable with the following exceptions. For the June air analysis, the DOE EML qualified the ^{238}U and gross beta results from GEL as "acceptable with warning." For November, STL received a "not acceptable" rating for its actinides in air analyses.

For water results in the June QAP report, GEL and STL each received an "acceptable with warning" rating for ^{241}Am. Severn-Trent also received a "not acceptable" rating for gross alpha and gross beta in water. For the November MAPEP report, Severn -Trent received a "not acceptable" rating for ^{241}Am and ^{90}Sr.

National Institute of Standards and Technology

The DOE RESL participates in a traceability program administered through the NIST. RESL prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards, generally in liquid media, for analysis by RESL to confirm their analytical capabilities. RESL maintained NIST certifications in both preparation and analysis in 2004.

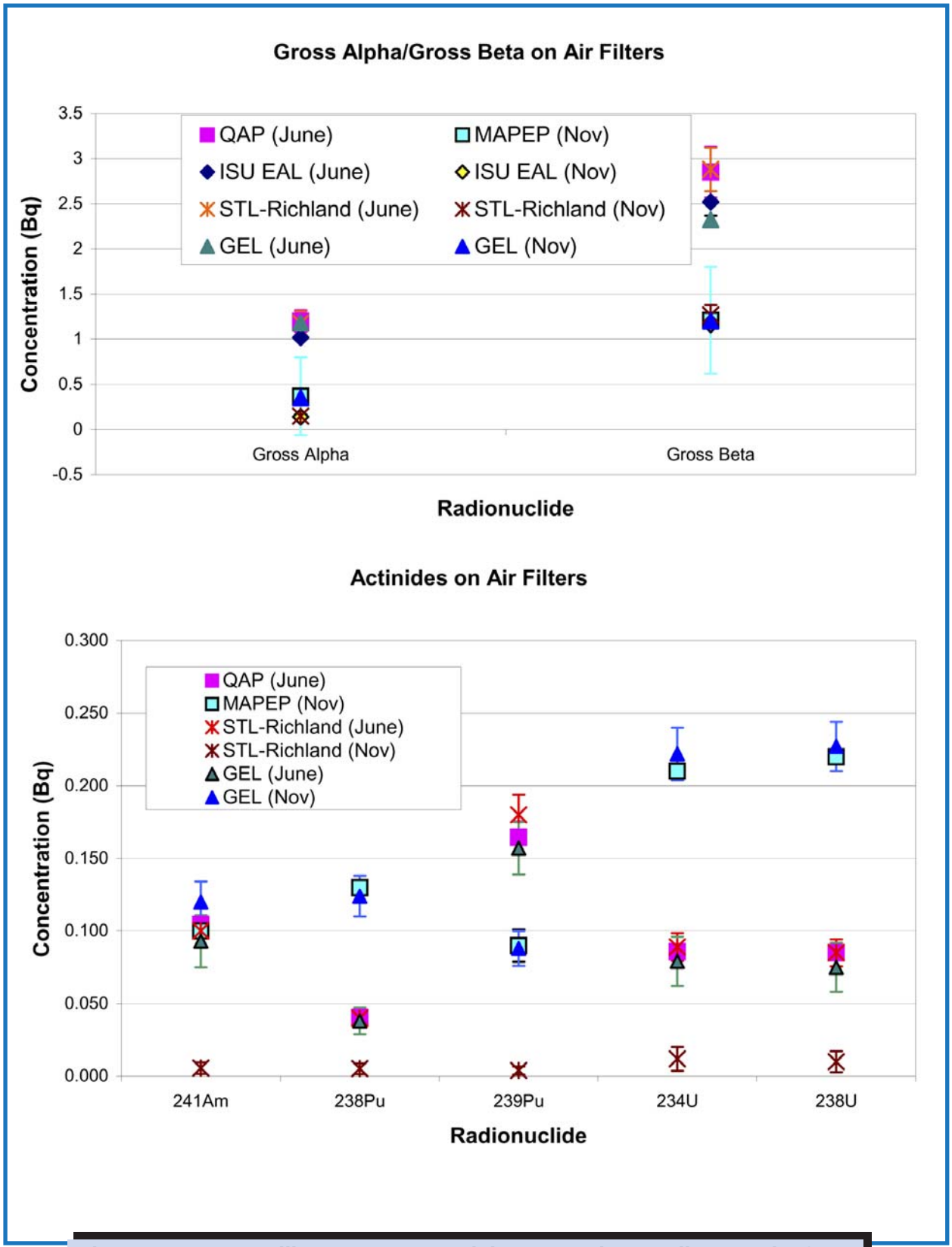
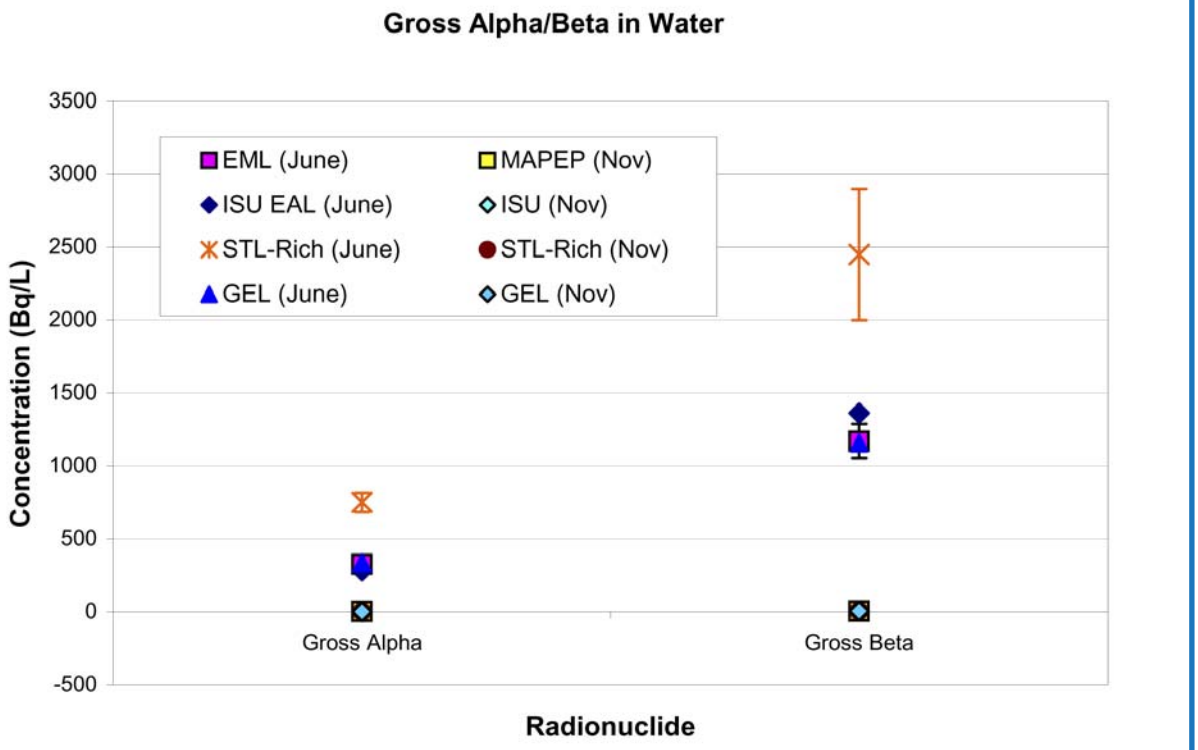


Figure 10-1. Surveillance contractor laboratory air sampling results from the QAP/MAPEP intercomparisons (2004).



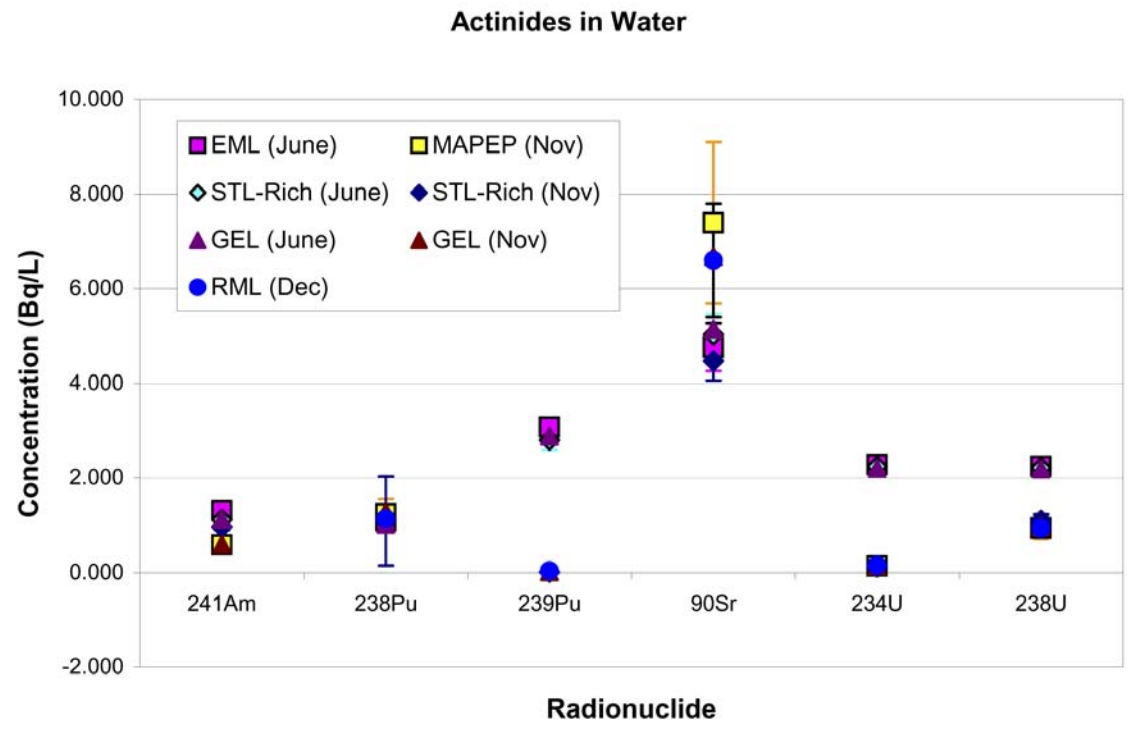


Figure 10-2. Surveillance contractor laboratory water sampling results from the QAP/MAPEP intercomparisons (2004).

Dosimetry

To verify the quality of the environmental dosimetry program conducted by the M&O 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. During 2004, the International Environmental Dosimeter Intercomparison Study was not offered for participation.

The Operational Dosimetry Unit of the INEEL M&O 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 during calendar year 2004. At no time during QA testing did any test exceed ± 10 percent.

Other Programs

INEEL 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.

10.3 Data Precision and Verification

As a measure of the quality of data collected, the ESER contractor, the M&O 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 M&O contractor maintained duplicate air samplers at two locations during 2004. The ESER contractor operated duplicate samplers at the locations in Blackfoot and Mud Lake. The M&O contractor duplicate samplers were located at Argonne National Laboratory-West 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 M&O contractor, and the State of Idaho's INEEL Oversight Program collected air monitoring data throughout 2004 at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls, and on the INEEL 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 INEEL Oversight Program at five locations in the Magic Valley area and two shared locations near the INEEL. Table 10-1 contains intercomparison results of the gross alpha, gross beta, and tritium analyses for the 2004 samples taken from these locations. The paired results were statistically the same for 98 percent (40 of 41) of the comparisons made.

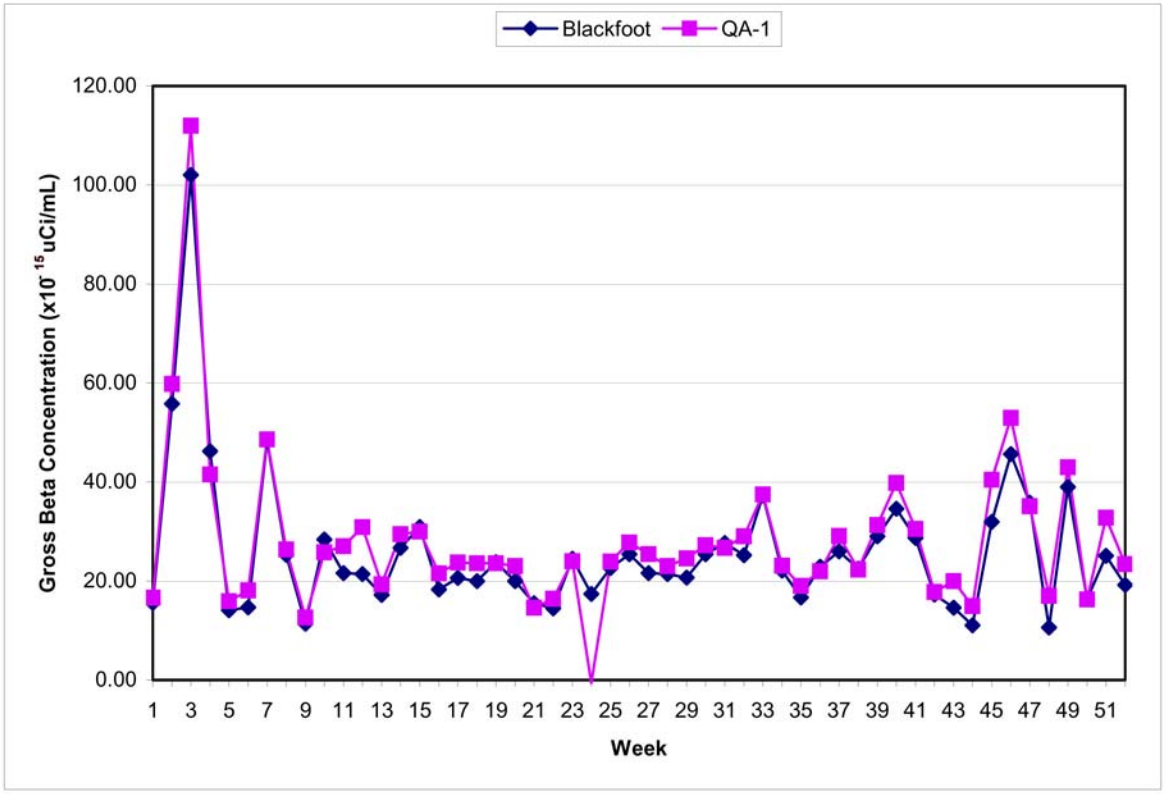
The USGS routinely collects groundwater samples simultaneously with the INEEL Oversight Program. Comparison results from this sampling are regularly documented in reports prepared by the two organizations.

10.4 Program Quality Assurance

Liquid Effluent Program Quality Assurance/Quality Control

The M&O 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. This section applies to all surveillance groundwater and effluent monitoring.

Performance evaluation samples (submitted as field blind spikes) are required to assess analytical data accuracy. At a minimum, performance evaluation samples are required quarterly.



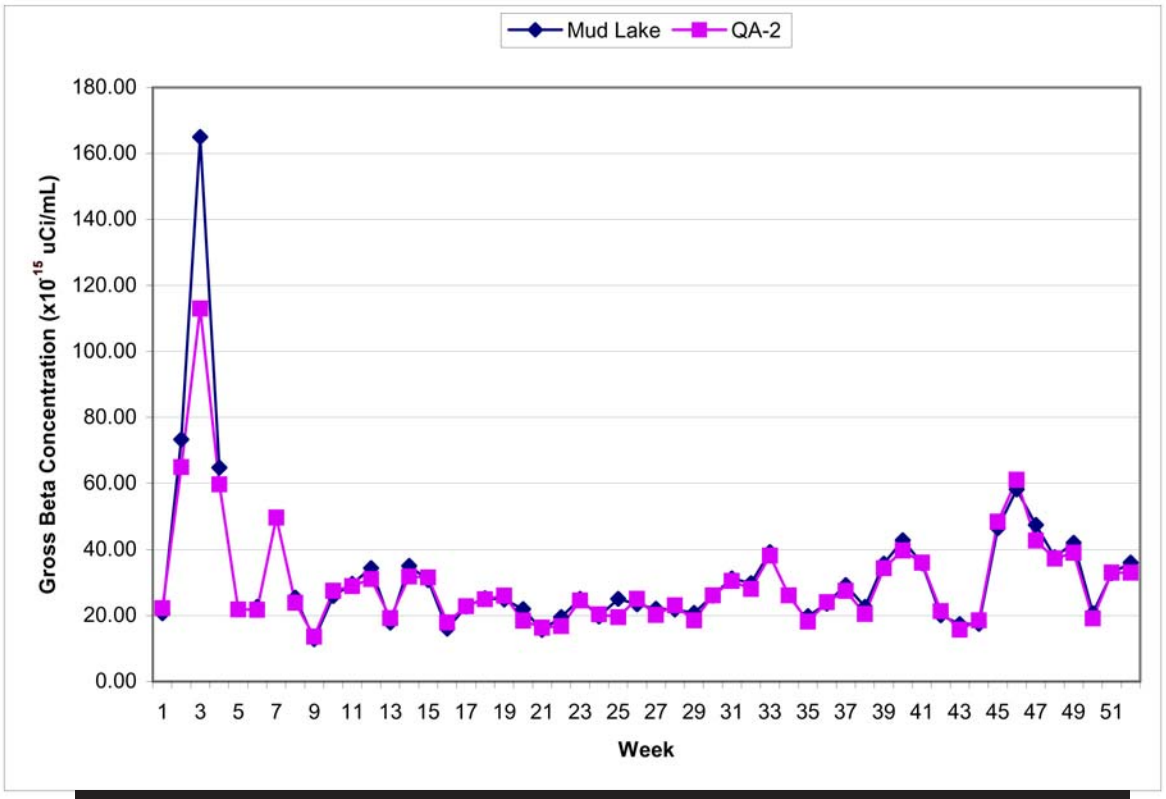
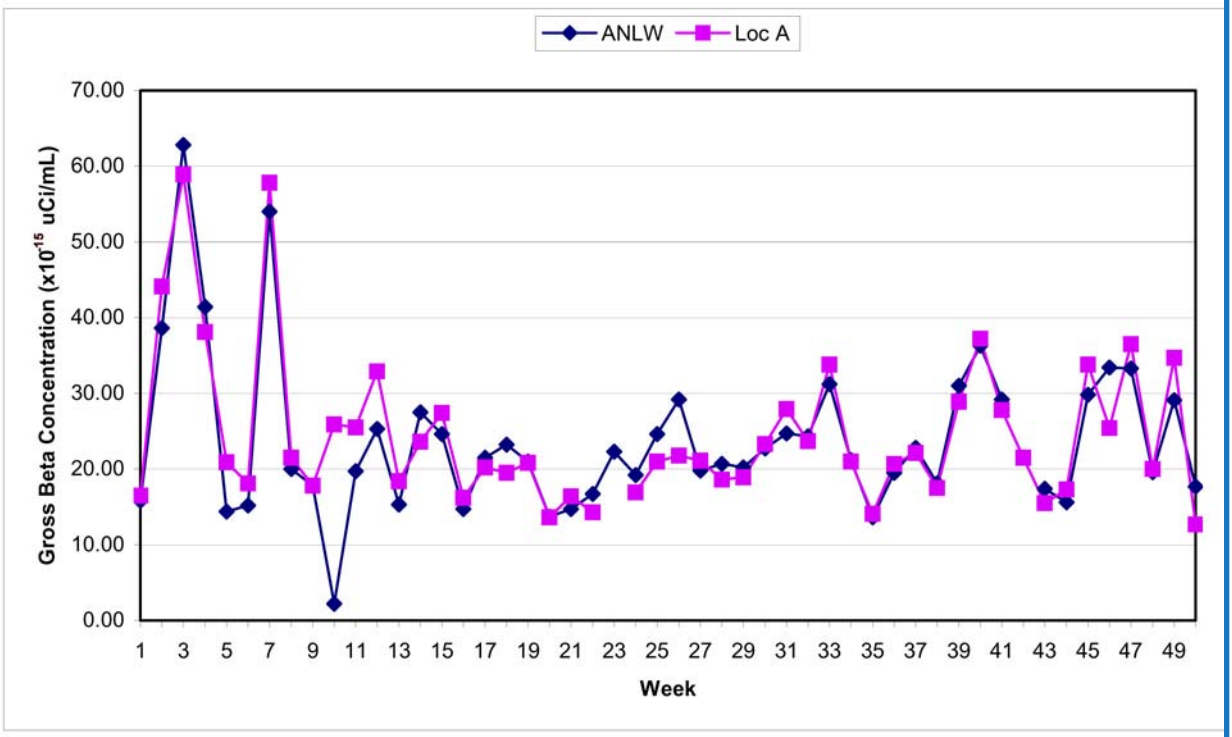


Figure 10-3. ESER contractor duplicate air sampling gross beta results (2004).



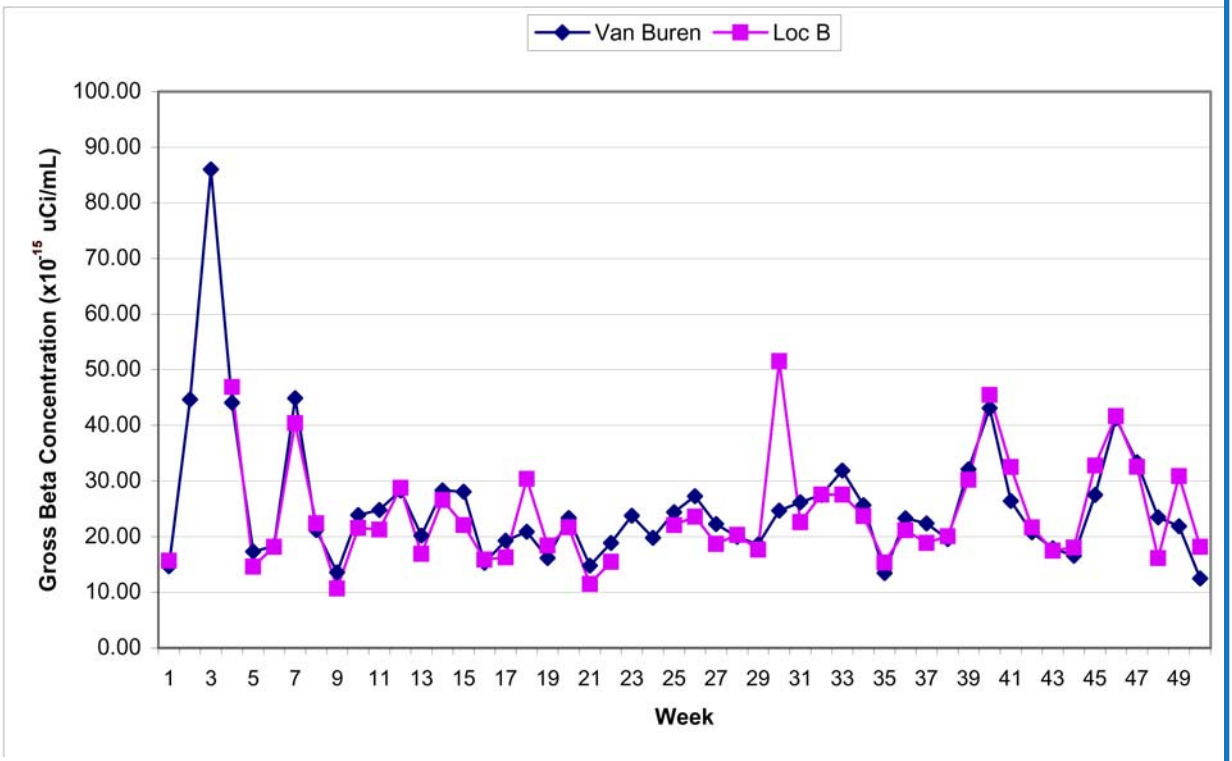


Figure 10-4. M&O contractor duplicate air sampling gross beta results (2004).

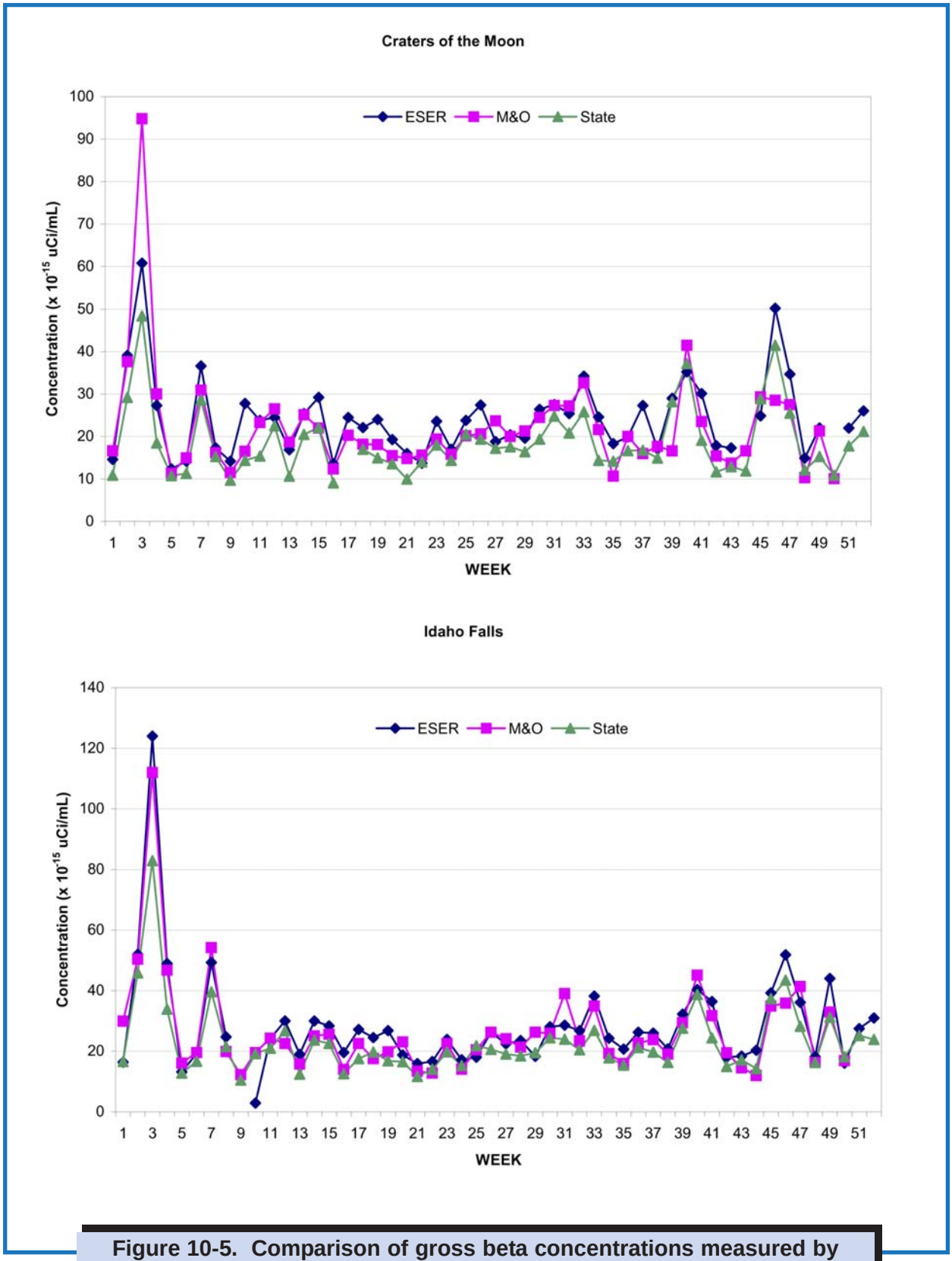
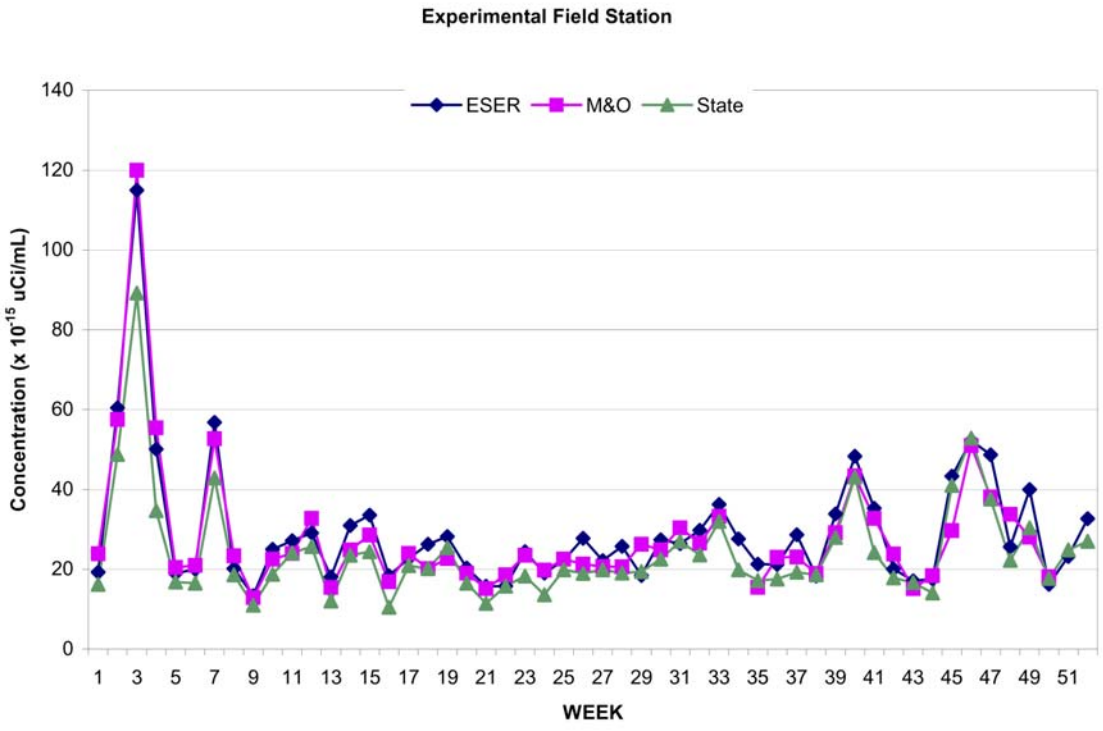


Figure 10-5. Comparison of gross beta concentrations measured by ESER contractor, M&O contractor, and State of Idaho (2004).



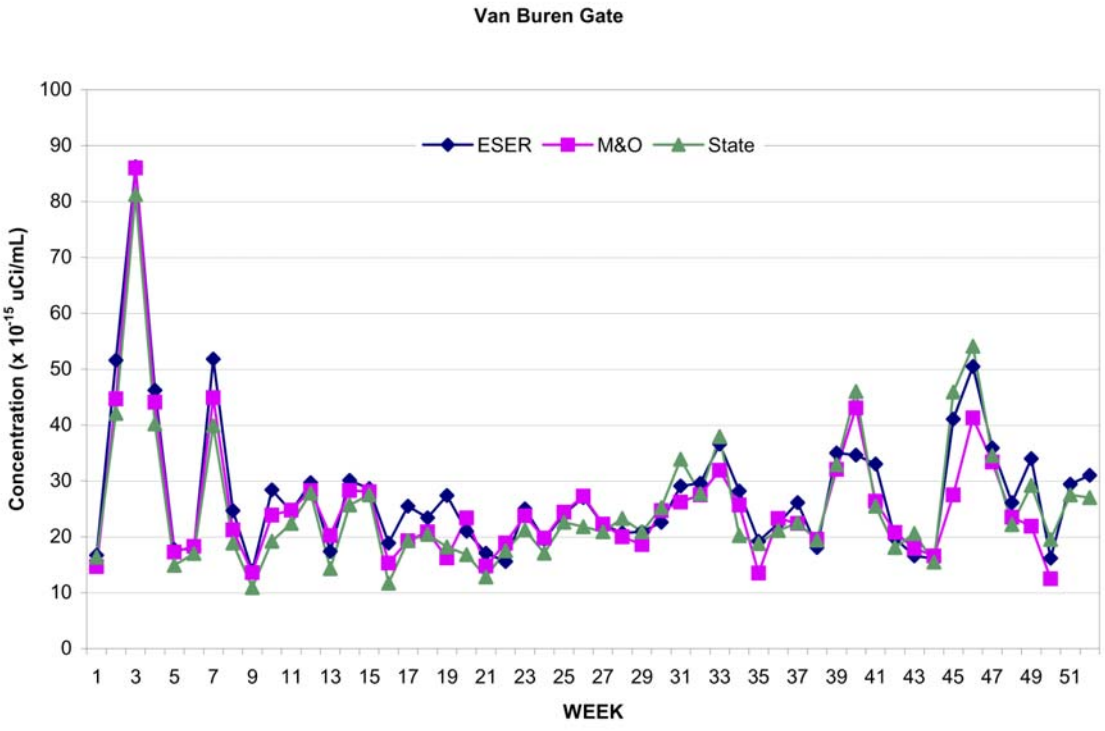


Figure 10-5. Comparison of gross beta concentrations measured by ESER contractor, M&O contractor, and State of Idaho (2004). (continued)

Table 10-1. Comparison of ESER and INEEL Oversight Program water monitoring results (2004).[a]

Location	Date	Gross Alpha (pCi/L) ESER	Gross Alpha (pCi/L) State	Gross Beta (pCi/L) ESER	Gross Beta (pCi/L) State	Tritium (pCi/L) ESER	Tritium (pCi/L) State
Drinking Water							
Atomic City	05/12	-0.15 ± 0.81	0.3 ± 0.8	3.00 ± 0.85	1.3 ± 0.5	15 ± 23	-50 ± 35
	11/10	1.15 ± 0.81	-0.3 ± 1.0	4.92 ± 0.89	2.0 ± 0.5	140 ± 31	-40 ± 40
Minidoka	05/11	0.87 ± 1.12	2.5 ± 0.95	3.22 ± 0.89	1.8 ± 0.55	53 ± 30	0 ± 35
	11/11	0.58 ± 0.78	-0.5 ± 0.95	5.31 ± 0.93	2.5 ± 0.5	1 ± 25	0 ± 40
Mud Lake	05/12	-1.77 ± 0.57	-0.2 ± 0.4	3.69 ± 0.86	2.4 ± 0.25	8 ± 23	20 ± 35
	11/10	0.62 ± 0.62	-1.0 ± 0.55	4.22 ± 0.95	2.8 ± 0.45	79 ± 25	-80 ± 40
Shoshone	05/11	-0.36 ± 0.91	-0.6 ± 1.0	3.47 ± 0.84	2.6 ± 0.6	40 ± 24	60 ± 35
	11/09	0.94 ± 0.86	-0.5 ± 0.9	2.81 ± 0.95	1.7 ± 0.45	-14 ± 23	0 ± 35
Surface Water							
Buhl	05/11	1.71 ± 1.23	-0.6 ± 1.1	4.89 ± 0.94	3.6 ± 0.55	6 ± 23	45 ± 25
	11/09	0.70 ± 0.86	0.5 ± 1.05	3.85 ± 0.88	2.1 ± 0.5	-47 ± 23	-60 ± 35
Hagerman	05/11	0.07 ± 0.89	0.7 ± 0.9	4.25 ± 0.89	2.9 ± 0.5	28 ± 23	10 ± 35
	11/09	-0.42 ± 0.75	-0.1 ± 0.95	1.44 ± 0.89	2.1 ± 0.5	87 ± 26	-10 ± 40
Twin Falls	05/11	-0.44 ± 1.40	-0.4 ± 1.25	6.94 ± 1.04	4.7 ± 0.6	46 ± 24	90 ± 35
	11/09	-0.20 ± 1.18	-1.4 ± 1.3	3.34 ± 1.06	4.8 ± 0.6	-17 ± 24	No Result

a. Values are shown as the result ± 1 standard deviation, where the standard deviation is the total uncertainty.

During 2004, five sets of performance evaluation samples were submitted to the laboratory along with routine monitoring samples. With the exception of total Kjeldahl nitrogen (TKN), no blind spike parameters routinely missed the performance acceptance limits. Out of five field blind spikes submitted for TKN, four were less than the lower performance acceptance limit (the laboratory value was less than the true value). For blind spike results below the lower performance acceptance limit, the concern is that all the reported concentrations associated with that blind spike result could be biased in the same direction and could result in an unreported permit limit exceedance. For blind spike results that are above the performance acceptance limit, the concern is that all the associated reported concentrations could again be biased in the same direction as the blind spike results and could result in the appearance of a permit limit exceedance when in fact none has occurred. The contract laboratory was contacted in November 2004 regarding the TKN results that fell outside of the performance acceptance limits. The laboratory apparently has resolved the issue because the subsequent (and most recent results from December 2004) were well within the performance acceptance limits. Blind spikes will continue to be submitted regularly to ensure laboratory performance.

Relative percent difference (RPD) between the duplicate samples is used to assess data precision. Table 10-2 shows the results for 2004.

Table 10-2. RPD results.

Parameter	RPD Result
Inorganic and metals	90% within the program goal of less than or equal to 35%.
Radiological parameters	Only five sets of duplicate results had detectable quantities. Of those, 4 or 80% met the program goal of less than or equal to 35%.

Note: The RPD is only calculated if both results are detected (greater than instrument detection limit).

The goal for completeness is to collect 100 percent of all required compliance samples. During 2004, this goal was met.

Validation performed on analytical results from the 2004 sampling efforts resulted in one rejected sample. The January total suspended solids result for CPP-773 (Idaho Nuclear Technology and Engineering Center [INTEC] effluent) was rejected for exceeding the hold time.

In addition two biochemical oxygen demand (BOD) results were not reported. Although October BOD samples for Central Facilities Area (CFA) influent and effluent were collected and delivered to the analytical laboratory, the laboratory did not report the results due to an analyst overlooking the end of the 5-day incubation period, which resulted in erratic sample results.

No other sampling or validation issues were identified during Calendar Year 2004.

Wastewater Land Application Permit Groundwater Monitoring Quality Assurance/Quality Control

The groundwater sampling activities associated with Wastewater Land Application Permit compliance sampling follow established procedures and analytical methodologies.

During 2004, groundwater samples were collected from all of the INTEC and Test Area North (TAN) Wastewater Land Application Permit monitoring wells (with the exception of perched well ICPP-MON-V-191, which was dry during both April 2004 and October 2004). All of the samples required for permit compliance were collected. Some of the 2004 analytical results were rejected as unusable during data validation because of quality control issues. The quality control issues were with the April coliform results from all wells, the April TKN result from one well, and some of the October metals results from several wells. Because all of the April coliform results were rejected, the impacted wells were resampled for coliform in July, and none of the July sample results were rejected. All other rejected results were attributed to either matrix spike or matrix spike duplicate recovery problems, both of which could be an issue with the analytical laboratory or could be the result of interference in the sample matrix, which is outside the laboratory's control. If this continues to be a problem, blind samples could be submitted to the laboratory for matrix spike analyses.

Field quality control samples were collected or prepared during the sampling activity in addition to regular groundwater samples. Laboratories qualified by the INEEL Sample and Analysis Management Organization performed all M&O groundwater analyses during 2004. 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 2004, for the 68 duplicate pairs with detectable results, 92 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.

Performance evaluation (PE) samples for fecal and total coliform were submitted to the contract laboratory in July and October of 2004. The PE coliform samples either had a certified value of <1 colony/100 ml or had a set QC Performance Acceptance Limits range associated with a certified result (reported in colonies/100 ml). For four toal coliform and two fecal coliform PE samples submitted in July of 2004, the laboratory reported the results as too numberous to count (TNTC). While the methods for coliform analyses allow the laboratory to report the results as TNTC when the count is greater than 200 colonies/100 mL, this made it impossible to compare the results of these six samples to the QC Performance Acceptance Limits. The laboratory was contacted and a request made to report the remainder of the July 2004 PE sample results as colonies/100 mL. The remaining four PE samples were analyzed in July 2004 for fecal coliform. These four samples were within the QC Performance Acceptance Limits.

During the October 2004 groundwater sampling event, four PE samples were analyzed for total coliform, and four PE samples were analyzed for fecal coliform. Only one sample (total coliform) did not meet the QC Performance Acceptance Limit or <1 colony/100 mL criteria. Ther result reported by the laboratory fell below the acceptable range. Additional PE samples for coliform analyses will be submitted in Calendar Year 2005 to ensure the laboratory meets the performance standards.

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.

Storm Water Monitoring Quality Assurance/Quality Control

The two samples collected at the Radioactive Waste Management Complex and the two samples collected at the T-28 north gravel pit were collected as unfiltered grab samples. No trip blanks or duplicate samples were collected. Sample containers and preservation methods were used according to internal procedures. The data were reviewed according to internal procedures.

Visual examination reports were checked for accuracy against logbook entries before submittal to the industrial storm water coordinator.

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 2004.

The Drinking Water Program requires that 10 percent of the samples (excluding bacteria) collected be quality assurance/quality control samples to include duplicates, field blanks, trip blanks, blind spikes, and splits. This goal was met in 2004 for all parameters.

The Drinking Water Program's precision goal states that the relative percent difference determined from duplicates must be 35 percent or less for 90 percent of all duplicates. That goal was met for 2004. The relative percent difference was less than the required 35 percent for 97 percent of all duplicates (for those with both results detected). Relative percent difference 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 2004, which requires that 98 percent of scheduled samples are collected and analyzed. For air sampling, less than 1.2 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 2004, samples of air, water, milk, and soil 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 2004, over 97 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 2004.

Environmental Surveillance Program Quality Assurance/Quality Control

The M&O 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.

The Environmental Surveillance Program met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. The Waste Management Surveillance Program submitted duplicate, blank, and control samples as required with routine samples for analyses.

PE samples were submitted for soils and vegetation and results received met all of the agreement criteria.

PE samples were also submitted for both 2-in. and 4-in. air samples. The trip blank from the 2-in. third quarter composites indicated ^{90}Sr at greater than 3 sigma error with similar levels on most the samples in that batch. The batch was reanalyzed, and the results did not confirm the original data. The second set of analytical results is being reported; however, the contract laboratory has continued to show poor performance on ^{90}Sr on air and other media.

PE samples were submitted to the contract laboratory for analysis in June 2004 (second quarter) and February 2005 (fourth quarter) for both waste management and site surveillance programs. For the PE samples submitted for analysis with the second quarter composites, the laboratory met the required agreement criteria on all nuclides using gamma spectrometry. For the fourth quarter PE samples, the laboratory met the required agreement criteria on all nuclides using gamma spectrometry with the exception of cobalt-60 (^{60}Co) on one 4-in. sample. The laboratory result was biased high (141 percent). Two other PE samples showed agreement with the known activity for ^{60}Co. Radiochemical analytical results showed warnings for ^{90}Sr on all three PE samples submitted. Two of the ^{90}Sr results were biased high, and one was biased low. All other radiochemical results on the PE samples showed satisfactory agreement.

Based on the results of these PE samples, ^{90}Sr and ^{60}Co results may be biased high, all three sigma results are being reported. The M&O contractor will submit additional PE samples in Calendar Year 2005 to monitor the contract laboratory's performance.

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), 2004a, Environmental Measurements Laboratory, Quality Assurance Program, http://www.eml.doe.gov/qap/reports/.

U.S. Department of Energy (DOE), 2004b, Mixed Analyte Performance Evaluation Program, http://www.inel.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 Engineering and Environmental Laboratory (INEEL) or at the INEEL boundary:

- U.S. Environmental Protection Agency (EPA), "National Primary and Secondary Ambient Air Quality Standards," 40 CFR 50, 2001;
- U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants," 40 CFR 61, 2001;
- U.S. Environmental Protection Agency, "Oil Pollution Prevention," 40 CFR 112, 2001;
- U.S. Environmental Protection Agency, "National Pollutant Discharge Elimination System," 40 CFR 122, 2001;
- U.S. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," 40 CFR 141, 2001;
- U.S. Environmental Protection Agency, "Hazardous Waste Management System: General," 40 CFR 260, 2001;
- U.S. Environmental Protection Agency, "Identifying and Listing of Hazardous Wastes," 40 CFR 261, 2001.
- U.S. Environmental Protection Agency, "Standards Applicable to Generators of Hazardous Waste," 40 CFR 262, 2001;
- U.S. Environmental Protection Agency, "Standards Applicable to Transporters of Hazardous Waste," 40 CFR 263, 2001;
- U.S. Environmental Protection Agency, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 264, 2001;
- U.S. Environmental Protection Agency, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 265, 2001;
- U.S. Environmental Protection Agency, "Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities," 40 CFR 267, 2001;
- U.S. Department of Commerce, "Designated Critical Habitat," National Marine Fisheries Service, 50 CFR 226;
- U.S. Department of Energy, Order 450.1, "Environmental Protection Program," January 2003;

- U.S. Department of Energy Order 5400.5, "Radiation Protection of the Public and the Environment," January 1993;
- U.S. Department of Energy Order 435.1, "Radioactive Waste Management," August 2001;
- DOE Order 231.1, 2003a, "Environment, Safety, and Health Reporting," August 2003.
- U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plants," Fish and Wildlife Service, 50 CFR 17;
- U.S. Department of the Interior, "Listing Endangered and Threatened Species and Designating Critical Habitat," Fish and Wildlife Service, 50 CFR 424;
- U.S. Department of the Interior, "Endangered Species Exemption Process," Fish and Wildlife Service, 50 CFR 450-453;
- U.S. Department of the Interior, "Protection of Archeological Resources," National Park Service, 43 CFR 7;
- U.S. Department of the Interior, "Curation of Federally-Owned and Administered Archeological Collections," National Park Service, 43 CFR 79;
- Idaho Department of Environmental Quality, "Rules and Regulations for the Control of Air Pollution in Idaho," 1972, as amended through May 1990;
- Idaho Department of Environmental Quality, "Ground Water Quality Rules," 58.01.11, March 1997;
- Idaho Department of Environmental Quality, "Wastewater Land Application Permits," 58.01.17, November 1992;
- Idaho Department of Environmental Quality, "Idaho Regulations for Public Drinking Water Systems," 58.01.08, October 1993;
- 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 INEEL 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.

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 an effective dose equivalent of 100 mrem/yr.
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)	0.06	
Trihalomethanes (Chloroform)	0.08	0.1

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

Table A-6. EPA maximum contaminant levels for public drinking water systems and State of Idaho groundwater quality standards synthetic organic contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Alachlor	0.002	0.002
Aldicarb	0.003	
Aldicarb sulfoxide	0.004	
Aldicarb sulfone	0.002	
Atrazine	0.003	0.002
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-D	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (Silvex)	0.05	0.05
Benzo (a) pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di (2-ethylhexyl) adipate	0.4	0.4
Di (2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (Vydate)	0.2	0.2
Picrolam	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

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

Table A-7. EPA maximum contaminant levels for public drinking water systems and State of Idaho groundwater quality standards secondary contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Aluminum	0.05 to 0.2	0.2
Chloride	250	250
Color	15 color units	15 color units
Corrosivity	Non-corrosive	
Foaming agents	0.5	0.5
Iron	0.3	0.3
Manganese	0.05	0.05
Odor	3 threshold odor number	3.0 threshold odor number
pH	6.5 to 8.5	6.5 to 8.5
Silver	0.1	0.1
Sulfate	250	250
Total dissolved solids (TDS)	500	500
Zinc	5	5

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

REFERENCES

Environmental Protection Agency (EPA), 2002, "National primary drinking water regulations," *Code of Federal Regulations*, 40 CFR 141, Office of the Federal Register.

IDAPA 58.01.11, "Ground Water Quality Rules," State of Idaho Department of Health and Welfare, current revision.

U.S. Department of Energy (DOE) Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," U.S. Department of Energy, January 7.

U.S. Department of Energy, 1988a, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, July.

U.S. Department of Energy, 1988b, *External Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0070, July.

Appendix B - Statistical Methods used in the Idaho National Engineering and Environmental Laboratory Annual Site Environmental Report

M. Case - S. M. Stoller Corporation
J. Einerson - Bechtel/BWXT Idaho, LLC.

Relatively simple statistical procedures are used to analyze the data collected by the Idaho National Engineering and Environmental Laboratory (INEEL) 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 INEEL releases, meteorological data, and worldwide events that might conceivably have an effect on the INEEL environment.

Initial 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:

- the uncertainty is too high to be accepted by the analyst;
- the radionuclide has no supporting photopeaks to make a judgment;
- the photopeak width is unacceptable by the analyst;
- the 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; and
- the 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 something is not present 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

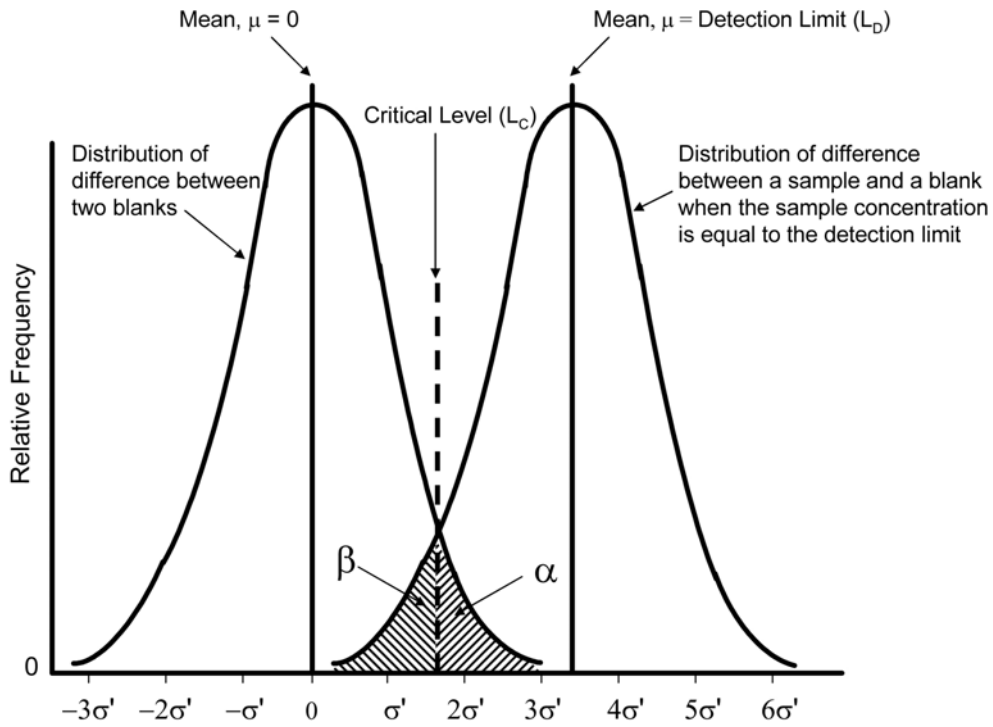


Figure B-1. Illustration of the relation of the criterion of detection (critical level) and the limit of detection (detection limit). Errors of the first kind (false negatives) are represented by the value of α, whereas errors of the second kind (false positives) are represented by the value of β. (from Currie 1984)

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, the probability distribution of possible outcomes, when the true net signal is zero, intersects L_C such that the fraction 1-α, where α is the error of the first kind (false positive), corresponds to the correct decision "not detected". Typically α, is set equal to 0.05. Using algorithms in Currie (1984) that are appropriate for our data, the L_C is 1.65s or approximately 2s. At this level, there is about a 95 percent probability that the correct decision—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentrations 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 Curries (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 radionuclides 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 equal to or above 3s are considered to be detected with confidence. Results between 2s and 3s are considered to be "questionable" detections. Results less than or equal to 2s are reported as “undetected.” Each result is reported with the associated 1s uncertainty value for consistency with other INEEL reports.

Statistical Tests used to Assess Data

An example set of data are presented here to illustrate the statistical tests used to assess data collected by the ESER contractor. The dataset used are 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 INEEL and air monitoring stations throughout the Snake River Plain. The perimeter locations are termed "boundary" and the Plain 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 data set will be used. The purpose of this task is to evaluate and illustrate the various statistical procedures, and not a complete analysis of the data.

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, S.S. and M.B. 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, S.S. et al. 1968). If the W statistic is significant ($p<0.00001$), then the hypothesis that the respective distribution is normal should be rejected.

Graphical depictions of the data should be a part of any evaluation of normality. The following histogram (Figure B-2) presents such a graphical look along with the results of the Shapiro-Wilk W test. The data used for the illustration are the five years of weekly gross beta measurements for the Arco boundary location. The W statistic is highly significant ($p<0.0001$) indicating that the data are not normally distributed. The histogram shows that the data are asymmetrical with right skewness. This suggests that the data may be lognormally distributed. The Shapiro-Wilk W test can be used to test this distribution by taking the natural logarithms of each measurement and calculating the W statistic. Figure B-3 presents this test of lognormality. The W statistic is not significant ($p=0.80235$) indicating that the data are lognormal.

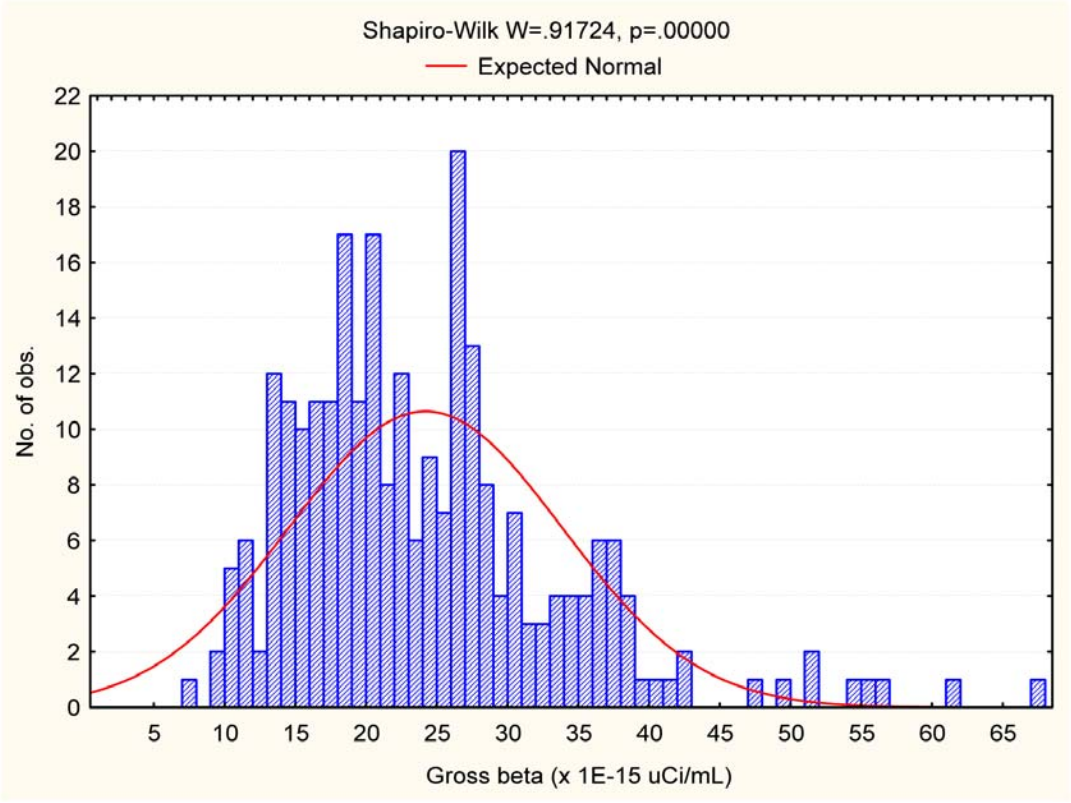


Figure B-2. Test of normality for Arco gross beta data.

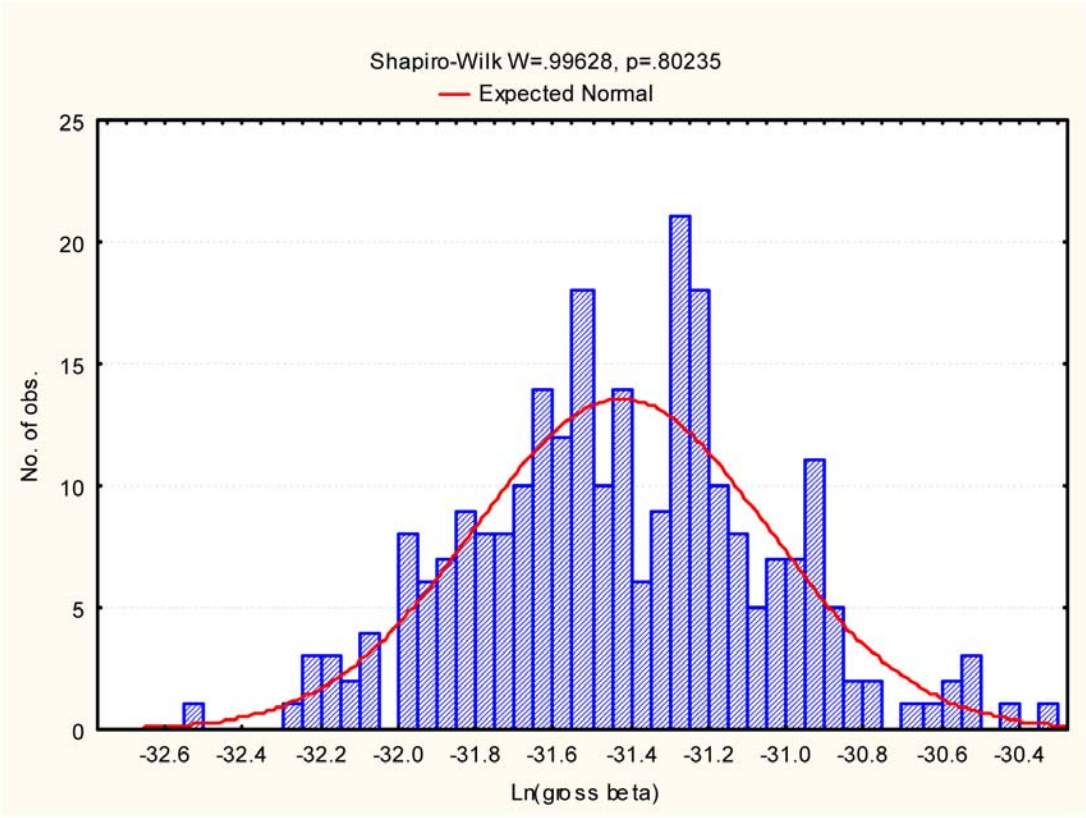


Figure B-3. Test of log normality for Arco gross beta.

To perform parametric tests of significance such as Student's T Test or One-Way Analysis of Variance (ANOVA), it is required that all data be normally (or lognormally) distributed. Therefore, if one desires to compare gross beta results of each boundary location, tests of normality must be performed before such comparisons are made. Table B-1 presents the results of the Shapiro-Wilk W Test for each of the seven boundary locations.

From Table B-1, none of the locations consist of data that are normally distributed and only some of the data sets are lognormally distributed. This is a typical result and a common problem when one desires to use a parametric test of significance. When many comparisons are to be made, attractive alternatives are nonparametric tests of significance.

Comparison of Two Groups

For comparison of two groups, the Mann-Whitney U Test (Hollander, M. and D.A. Wolfe 1973) is a powerful nonparametric alternative to the Student's T Test. In fact, the U Test is the most powerful (or sensitive) nonparametric alternative to the T Test for independent samples; in some instances it may offer even greater power to reject the null hypothesis than the T Test. The interpretation of the Mann-Whitney U Test is essentially identical to the interpretation of the Student's T Test for independent samples, except that the U Test is computed based on rank sums rather than means. Because of this fact, outliers do not present the serious problem that they do when using parametric tests.

Table B-1. Tests of normality for boundary locations.

Location	Normal		Lognormal	
	W statistic	p-value	W statistic	p-value
Arco	0.9172	<0.0001	0.9963	0.8024
Atomic City	0.9174	<0.0001	0.9411	<0.0001
Birch Creek	0.8086	<0.0001	0.9882	0.0530
FAA Tower	0.9119	<0.0001	0.9915	0.1397
Howe	0.8702	<0.0001	0.9842	0.0056
Monteview	0.9118	<0.0001	0.9142	<0.0001
Mud Lake	0.6130	<0.0001	0.9704	<0.0001

Suppose we wish to compare all boundary locations to all distant locations. Figure B-4 presents the box plots for the two groups. The median is the measure of central tendency most commonly used when there is no assumed distribution. It is the middle value when the data are ranked from smallest to largest. The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile and 75 percent of the measurements are less than the 75th percentile. The large distance between the medians and the maximums seen in Figure B-4 indicate the presence of outliers. It is apparent that the medians are

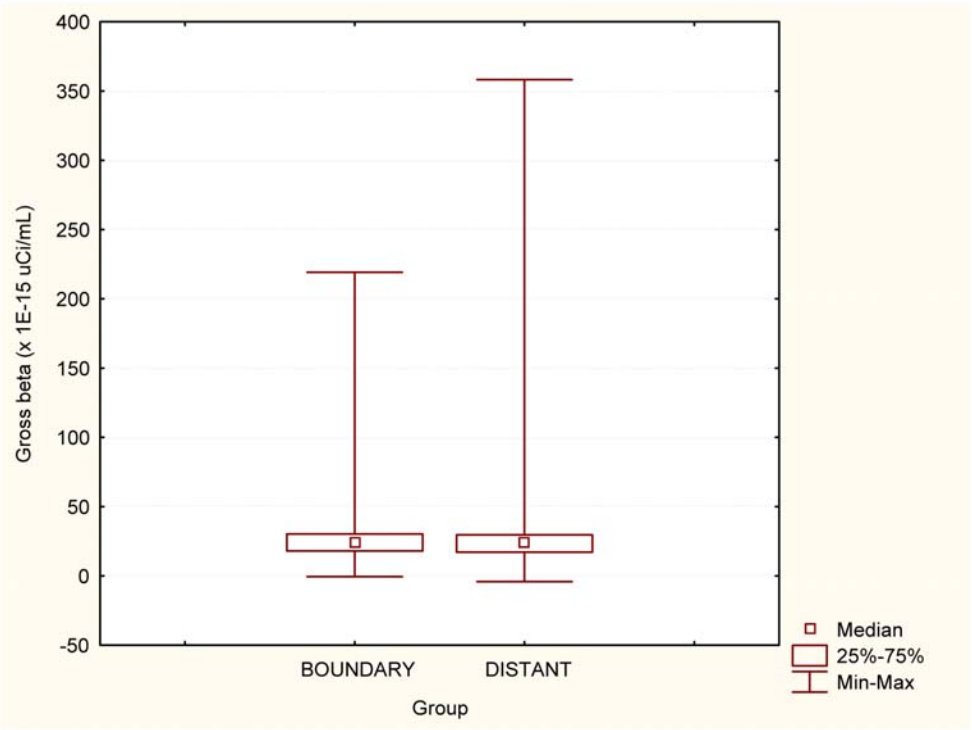


Figure B-4. Box plot of gross beta data from boundary and distant locations.

of the same magnitude indicating graphically that there is probably not a significant difference between the two groups.

The Mann-Whitney U test compares the rank sums between the two groups. In other words, for both groups combined, it ranks the observations from smallest to largest. Then it calculates the sum of the ranks for each group and compares these rank sums. A significant p-value ($p<0.05$) indicates a significant difference between the two groups. The p-value for the comparison of boundary and distant locations is not significant ($p=0.0599$). Therefore, the conclusion is that there is not strong enough evidence to say that a significant difference exists between boundary and distant locations.

Comparison of Many Groups

Now suppose we wish to compare the boundary locations amongst themselves. In the parametric realm, this is done with a One-Way ANOVA. A nonparametric alternative to the One-Way ANOVA is the Kruskal-Wallis ANOVA (Hollander, M. and D.A. 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 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.

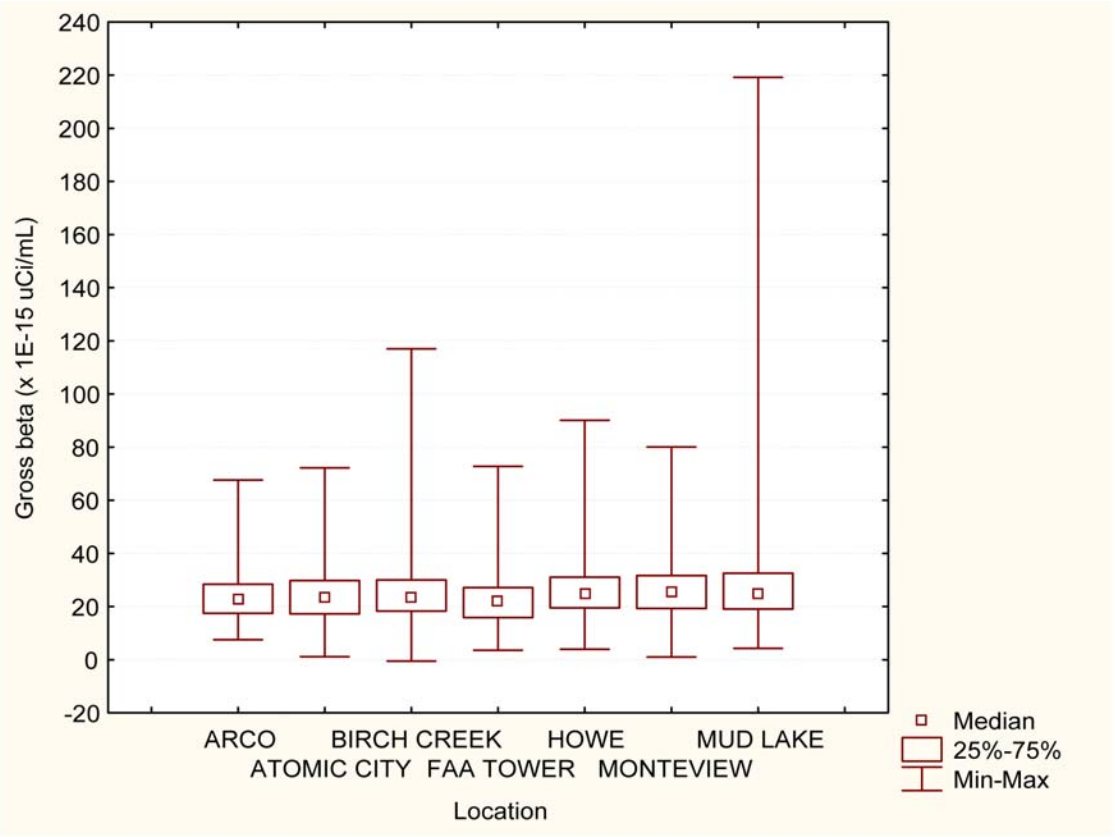


Figure B-5. Box plot of gross beta data for each boundary location.

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.

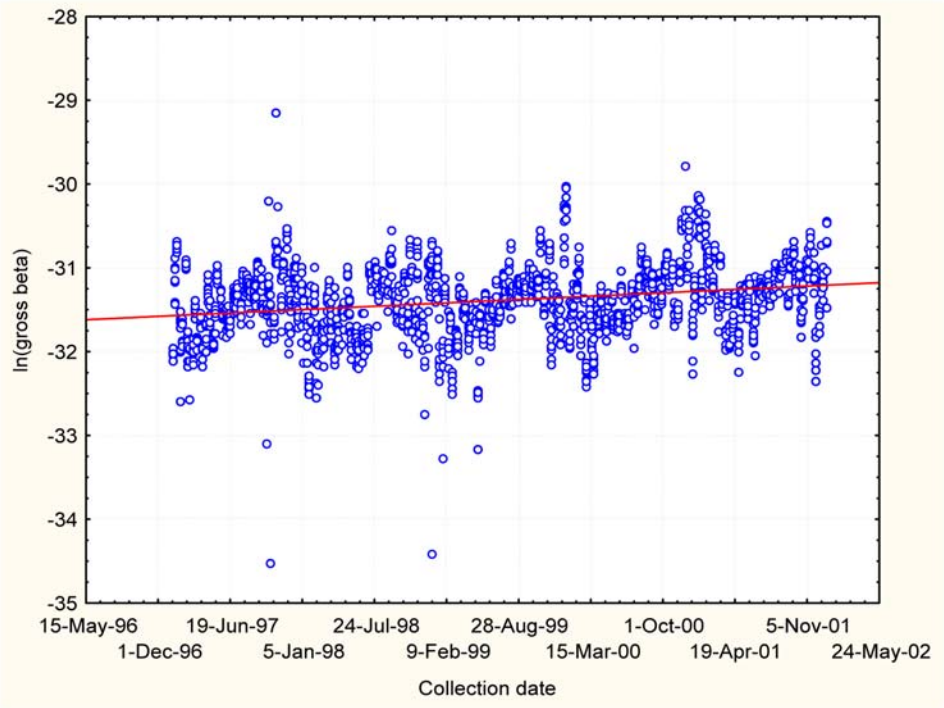


Figure B-6. Scatter plot and regression line for ln(gross beta) from boundary locations.

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 trend, when in fact, it is just a portion of the cyclical trend.

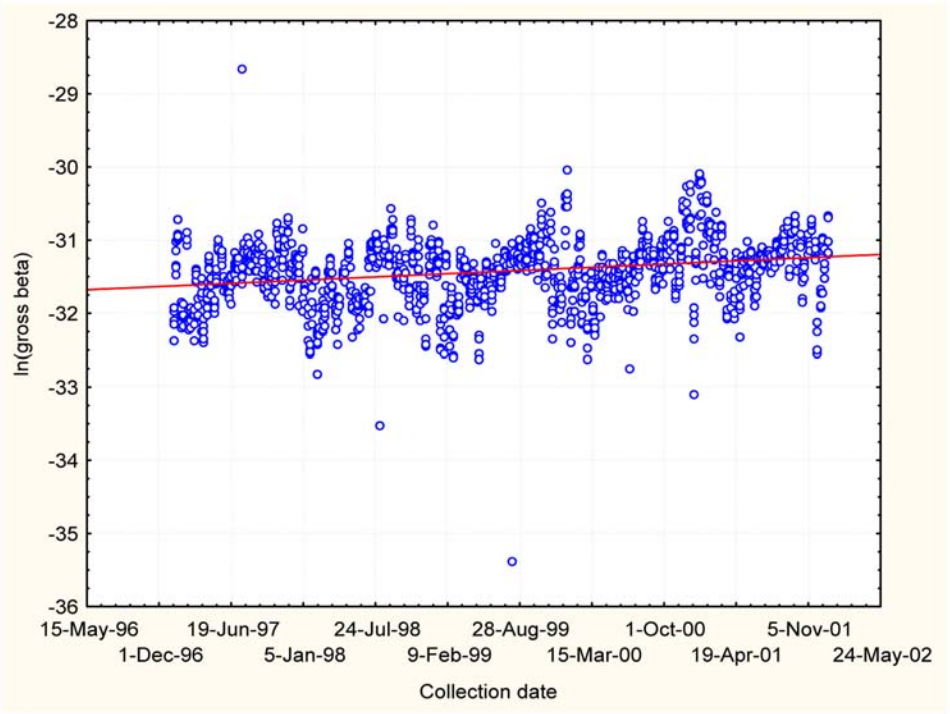


Figure B-7. Scatter plot and regression line for ln(gross beta) from distant locations.

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, J. and W. 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
ß	=	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.

REFERENCES

Bartholomay, R.C., B.J. Tucker, L.C. Davis, and M.R. Greene, 2000, Hydrological Conditions and Distribution of Selected Constituents in water, Snake River Plain Aquifer, Idaho National Engineering and Environmental Laboratory, Idaho, 1996 Through 1998, U.S. Geological Survey, DOE/ID-22167. September 2000.

Currie, L.A., 1984, Lower Limit of Detection-Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements: U.S. Nuclear Regulatory Commission NUREG/CR-4007.

Hollander, M., and Wolfe, D. A., 1973, *Nonparametric Statistical Methods*, New York: John Wiley and Sons, Inc.

Neter, J. and Wasserman, W., 1974, *Applied Linear Statistical Models*, Homewood, Illinois: Richard D. Irwin, Inc.

Shapiro, S. S., and Wilk, M. B., 1965, "An Analysis of Variance Test for Normality (complete samples)," *Biometrika*, 52, 591-611.

Shapiro, S. S., Wilk, M. B., and Chen, H. J., 1968, "A Comparative Study of Various Tests of Normality," *Journal of the American Statistical Association*, 63, 1343-1372.

Appendix C - U.S. Geological Survey 2004 INEEL Publication Abstracts

L. Knobel - United States Geological Survey

Association between atmospheric circulation patterns and firn-ice core records from the Inilchek glacierized area, central Tien Shan, Asia *(Vladimir B. Aizen, Elena M. Aizen, John M. Melack, Karl J Kreutz, and L. DeWayne Cecil)*

Glacioclimatological research in the central Tien Shan was performed in the summers of 1998 and 1999 on the South Inilchek Glacier at 5100-5460 m. A 14.36 m firn-ice core and snow samples were collected and used for stratigraphic, isotopic, and chemical analyses.The firn-ice core and snow records were related to snow pit measurements at an event scale and to meteorological data and synoptic indices of atmospheric circulation at annual and seasonal scales. Linear relationships between the seasonal air temperature and seasonal isotopic composition in accumulated precipitation were established. Changes in the $\delta^{18}O$ air temperature relationship, in major ion concentration and in the ratios between chemical species, were used to identify different sources of moisture and investigate changes in atmospheric circulation patterns. Precipitation over the central Tien Shan is characterized by the lowest ionic content among the Tien Shan glaciers and indicates its mainly marine origin. In seasons of minimum precipitation, autumn and winter, water vapor was derived from the arid and semiarid regions in central Eurasia and contributed annual maximal solute content to snow accumulation in Tien Shan. The lowest content of major ions was observed in spring and summer layers, which represent maximum seasonal accumulation when moisture originates over the Atlantic Ocean and Mediterranean and Black Seas.

Development of a Local Meteoric Water Line for southeastern Idaho, western Wyoming, and south-central Montana *(Lyn Benjamin, LeRoy L. Knobel, L. Flint Hall, L. DeWayne Cecil, and Jaromy R. Green)*

Linear regression analysis was applied to stable hydrogen (H) and oxygen (O) isotope data in 72 snow-core and precipitation samples collected during 1999-2001 to determine the Local Meteoric Water Line (LMWL) for southeastern Idaho, western Wyoming, and south-central Montana.

On the basis of (1) residuals from the regression model, (2) comparison of study-area deuterium-excess (*d*-excess) values with the global range of *d*-excess values, and (3) outlier analysis by means of Chauvenet's Criterion, values of four samples were excluded from final regression analysis of the dataset. Regression results for the 68 remaining samples yielded a LMWL defined by the equation $\delta^2H = 7.95\ \delta^{18}O + 8.09$ ($r^2 = 0.98$).

This equation will be useful as a reference point for future studies in this area that use stable isotopes of H and O to determine sources of ground-water recharge, to determine water-mineral exchange, to evaluate surface-water and ground-water interaction, and to analyze many other geochemical and hydrologic problems.

Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers *(L. DeWayne Cecil, Jaromy R. Green, and Lonnie G. Thompson)*

The earth is in a state of constant physical, chemical, and biological change on a global scale. Global environmental alterations have occurred throughout the existence of the earth and will invariably happen in the next millennium and beyond. Global change can have immediate as well as future consequences that could affect all life on earth. As a result, the importance of understanding current and potential global environmental change has radically increased.

Numerous global environmental change studies are currently underway. From monitoring ongoing natural events such as earthquakes and volcanoes to delineating potential anthropogenic effects from industrial chemical fallout from the atmosphere, all studies focus on understanding the immediate and potential environmental change and monetary impacts associated with such events. The study of global environmental change caused by anthropogenic influences requires knowing how and when the influences occurred and what effects the environment will suffer. Once these are known, the resultant future climactic and environmental changes can be projected. Additionally, studies of natural climactic and environmental alterations require the knowledge of long-term historical changes in order to predict or understand future shifts. Knowledge of past changes can only be acquired by studying and analyzing preserved environmental records that act as archives of these changes.

Preserved archives of past climactic and environmental conditions do exist in nature. For example, glaciers, ice caps, and ice sheets around the world can be repositories of climactic and environmental change. Ice cores from the polar regions have provided the scientific community with an unprecedented picture of past environmental change through chemical, isotopic, and stratigraphic data. High-resolution ice core records have also been obtained from high altitude sites in the tropics. However, weather patterns and climate changes affect high-latitude regions of the world differently than mid- to low-latitude areas. In addition, the majority of the world's population, at least 85 percent, lives between 50^{o} N and 50^{o} S. Therefore, understanding potential environmental change in mid- and low-latitude regions is of prime importance and could be accomplished by utilizing ice cores collected from selected alpine areas.

Research on temperate ice cores faces the challenge of several commonly held beliefs about ice cores in "warm" environments. First, that the influence of meltwater percolation - which tends to smooth glaciochemical variations in the glacier forming firn and snow- precludes the use of isotopic and chemical tracers. Second, that the high accumulation rates typical for temperate glaciers and ice sheets limit the length of the record to at most, a few centuries. Third, that the availability of other climate proxies, such as pollen and tree-ring records, makes temperate ice cores unnecessary.

Research at several mid-latitude sites worldwide has shown that these common beliefs are not warranted. Glacial research has already proven that ice cores collected from mid-latitude glaciers preserve the isotopic record with surprising accuracy and, for some glaciers, represents thousands of years of record. In addition, ice cores archive not only natural variations in climate and the environment but anthropogenic influences introduced over the last two centuries as well. Such additional anthropogenic information can aid in distinguishing between natural and human

additions to the environment and thus further refine the understanding of future global, environmental, and climate change.

There is now a small army of diverse researchers worldwide turning to the archived environmental record in mid- and low-latitude ice cores to answer diverse questions from natural and anthropogenic influences on climate change to rates of glacial retardation and growth. With the advent of ultra-sensitive analytical methods such as accelerator mass spectrometry and the experiences of diverse research teams, glaciers worldwide, with their environmental records and markers locked in, are becoming accessible.

These new scientific tools and their application to understanding our influence on global environmental processes are the focus of this book. In the field of glacial research and the associated global impacts on humans there is no set of handy formulas into which various parameters can be substituted to obtain answers for the complex problems facing the world's population. This book was designed with that fact in mind.

The papers collected here represent some of the leading research and methods development in the growing scientific field of documenting global climactic and environmental changes using records archived at mid- and low-latitude sites; historically, presently, and in the future. It is hoped that current researchers and students will find the introductory "how-to" methods section useful in their work. Additionally, with a good solid grounding in the methods utilized in bringing ice core records from remote, harsh environments to the laboratory for analyses and interpretation, students will be prepared to appreciate the significance of any glacial research they may find in the literature.

L. DeWayne Cecil
U.S. Geological Survey
Idaho Falls, Idaho U.S.A.

Development of an AMS method to study oceanic circulation characteristics using cosmogenic ^{39}Ar *(Ph. Collon, M. Bichler, J. Caggiano, L. DeWayne Cecil, Y. El Masri, R. Golser, C.L. Jiang, A. Heinz, D. Henderson, W. Kutschera, B.E. Lehmann, P. Leleux, H.H. Loosli, R.C. Pardo, M. Paul, K.E. Rehm, P. Schlosser, R.H. Scott, W.M. Smethie, Jr. and R. Vondrasek)*

Initial experiments at the ATLAS facility resulted in a clear detection of cosmogenic ^{39}Ar signal at the natural level. The present paper summarizes the recent developments of ^{39}Ar AMS measurements at ATLAS: the use of an electron cyclotron resonance (ECR) positive ion source equipped with a special quartz liner to reduce ^{39}K background, the development of a gas handling system for small volume argon samples, the acceleration of $^{39}Ar^{8+}$ ions to 232 MeV, and the final separation of ^{39}Ar from ^{39}K in a gas-filled spectrograph. The first successful AMS measurements of ^{39}Ar in ocean water samples from the Southern Atlantic ventilation experiment (SAVE) are reported.

Methods of Mid- and Low-Latitude Glacial Record Collection, Analysis, and Interpretation *(Jaromy R. Green, L. DeWayne Cecil, and Shaun K. Frape)*

The credibility of collecting, analyzing, interpreting and "dating" mid- and low-latitude glacial ice samples depends primarily on the methods used. Due to the wide variety of characteristics among mid- and low-latitude glaciers (such as location, altitude, precipitation, size, movement, and archived history), the methods used to study such glaciers vary from site to site and must be chosen with care. Of benefit to many of today's researchers is the ability to build upon the knowledge of past studies of mid- and low-latitude glaciers. In the 1970s and 80s, research was performed on such places as the Quelccaya Ice Cap in the Andes mountains of Peru, the Dunde Ice Cap within the Tibetan Plateau, and the Colle Gnifetti in the Alps. Past and present studies of these glacial sites allow current day researchers to more correctly identify and use those methods that are logistically, scientifically, and statistically sound to research additional mid- and low-latitude glacial sites. The following chapter details some of the methods used in current research.

A high resolution record of chlorine-36 nuclear-weapons-tests fallout from central Asia *(J.R. Green, L.D. Cecil, H.-A. Synal, J. Santos, K.J. Kreutz, and C.P. Wake)*

The Inilchek Glacier, located in the Tien Shan Mountains, central Asia, is unique among mid-latitude glaciers because of its relatively large average annual accumulation. In July 2000, two ice cores of 162 and 167 meters (m) in length were collected from the Inilchek Glacier for chlorine-36 (^{36}Cl) analysis as part of a collaborative international effort to study the environmental changes archived in mid-latitude glaciers worldwide. The average annual precipitation at the collection site was calculated to be 1.6 m. In contrast, the reported average annual accumulations at the high-latitude Dye-3 glacial site, Greenland, the mid-latitude Guliya Ice Cap, China, and the mid-latitude Upper Freemont Glacier, Wyoming, USA, were 0.52, 0.16, and 0.76 m, respectively. The resolution of the ^{36}Cl record in one of the Inilchek ice cores was from 2 to 10 times higher than the resolution of the records at these other sites and could provide an opportunity for detailed study of environmental changes that have occurred over the last 150 years.

Despite the differences in accumulation among these various glacial sites, the ^{36}Cl profile and peak concentrations for the Inilchek ice core were remarkably similar in shape and magnitude to those for ice cores from these other sites. The ^{36}Cl peak concentration from 1958, the year during the mid-1900s nuclear-weapons-tests period when ^{36}Cl fallout was largest, was preserved in the Inilchek core at a depth of 90.56 m below the surface of the glacier (74.14-m-depth water equivalent) at a concentration of 7.7×10^5 atoms of ^{36}Cl/gram (g) of ice. Peak ^{36}Cl concentrations from Dye-3, Guliya, and the Upper Freemont glacial sites were 7.1×10^5, 5.4×10^5, and 0.7×10^5 atoms of ^{36}Cl/g of ice, respectively. Measurements of ^{36}Cl preserved in ice cores improve estimates of historical worldwide atmospheric deposition of this isotope and allow the sources of ^{36}Cl in ground water to be better identified.

Event to decadal-scale glaciochemical variability on the Inilchek Glacier, Central Tien Shan *(Karl J. Kreutz, Cameron P. Wake, Vladimir B. Aizen, L. DeWayne Cecil, Jaromy R. Green, and Hans-Arno Synal)*

Glaciochemical records developed from mid- and low-latitude Asian ice cores provide a unique archive of past atmospheric conditions, and can be used for high-resolution reconstructions of climactic and environmental variability. To realize the full potential of chemical signals preserved in ice cores, detailed modern proxy calibration studies must be undertaken to understand the effects of local deposition noise and the relationships between meteorological conditions and time-series chemical variability. Previous work in the Tien Shan mountains of Central Asia has demonstrated the usefulness of stable water isotopes and soluble ions for investigating temperature, moisture flux, atmospheric circulation, and dust loading on different timescales. On a seasonal basis, a good correlation between $\delta^{18}O$ ratios and site temperature has previously been demonstrated. Alternatively, a 1996 worker interpreted fresh snow event isotope data in terms of moisture source and transport pathway. For soluble ions, the strong influence of dust derived from surrounding arid regions has been noted in snow, firn core, and aerosol studies. Here we present new fresh snow and snowpit results from the Inilchek Glacier, Central Tien Shan collected during July/August 2000. During the 2000 field season, two deep ice cores were also recovered, and are being used to develop high-resolution stable isotope and soluble ion records of the past 200-500 years. Our goal in this chapter is to assess local-scale spatial chemical variability in the Inilchek basin and the relation between time series chemical variability and regional meteorological parameters. Such knowledge is critical for the proper interpretation of high-resolution records developed from deep ice cores, particularly at sites such as the Inilchek where relatively high accumulation rates may allow reconstructions on seasonal or sub-seasonal timescales.

Variations between $\delta^{18}O$ in recently deposited snow and on-site air temperature, Upper Fremont Glacier, Wyoming *(David L. Naftz, David D. Susong, L. DeWayne Cecil, and Paul F. Schuster)*

Oxygen isotopic ratios ($\delta^{18}O$) in ice cores have been used extensively to reconstruct past climate trends. Recent investigations have documented positive correlations between site-specific $\delta^{18}O$ values in snow and ice to on-site average air temperature (T_A) during snow accumulation events in polar regions.

To date (2003), only limited observations link the $\delta^{18}O$ values in ice and snow samples to on-site air temperature at high-altitude, mid- and low-latitude ice-coring sites. In 2002, our team developed a series of site-specific transfer functions between on-site air temperature and $\delta^{18}O$ values in snow deposited at a mid-latitude ice coring site established at over 4,000 m above sea level (masl) on Upper Fremont Glacier (UFG), Wyoming. The site-specific transfer functions developed from this site were used in conjunction with $\delta^{18}O$ values from ice cores obtained from UFG to reconstruct changes in air temperature since the early 1700s.

Because UFG is a remote, high-altitude site, it is not possible to physically collect discrete snow samples from individual storm events for $\delta^{18}O$ analysis. Instead, the site was visited one to three times per year and snow pits were excavated and used to sample the accumulated snowpack. The timing and amount of each snow accumulation event in the excavated snow pits

on UFG was determined from snow pillow data from Cold Springs SNOTEL site, approximately 22 km northeast from UFG, and used in the development of site-specific transfer functions. This method of determining the timing and relative amounts of accumulation events on UFG relied on the following assumptions: (1) snow redeposition from wind events and melting was minimal after each accumulation event; (2) the same storms impact both sites with the same relative intensities; and (3) all precipitation on the UFG is in the form of snow and, therefore, accumulates and can be used as a proxy for cumulative precipitation. None of these assumptions were valid 100 percent of the time.

To better record the on-site snow accumulation and redeposition on UFG during 1999-2000, an hourly record of snow depth was obtained using an ultrasonic sensor. Instead of relying on the SNOTEL data as a proxy record for snow accumulation on UFG, on-site data were possible. The objectives of this chapter are to: (1) investigate and model the transfer function between $\delta^{18}O$ values in snow and the corresponding air temperature using the continuous, on-site snow-depth and air temperature monitoring equipment installed on UFG; (2) compare the transfer function developed from the on-site snow-depth sensor to transfer functions developed using off-site snow accumulation data; and (3) reconstruct and compare air temperatures from $\delta^{18}O$ values in UFG ice cores using both transfer functions.

Hydraulic and geochemical framework of the Idaho National Engineering and Environmental Laboratory vadose zone *(John R. Nimmo, Joseph P. Rousseau, Kim S. Perkins, Kenneth G. Stollenwerk, Pierre D. Glynn, Roy C. Bartholomay, and LeRoy L. Knobel)*

Questions of major importance for subsurface contaminant transport at the Idaho National Engineering and Environmental Laboratory (INEEL) include (i) travel times to the aquifer, both average or typical values and the range of values to be expected, and (ii) modes of contaminant transport, especially sorption processes. The hydraulic and geochemical framework within which these questions are addressed is dominated by extreme heterogeneity in a vadose zone and aquifer consisting of interbedded basalts and sediments. Hydraulically, major issues include diverse possible types of flow pathways, extreme anisotropy, preferential flow, combined vertical and horizontal flow, and temporary saturation or perching. Geochemically, major issues include contaminant mobility as influenced by redox conditions, the concentration of organic and inorganic complexing solutes and other local variables, the interaction with infiltrating waters and with the contaminant source environment, and the aqueous speciation of contaminants such as actinides. Another major issue is the possibility of colloid transport, which inverts some of the traditional concepts of mobility, as sorbed contaminants on mobile colloids may be transported with ease compared with contaminants that are not sorbed. With respect to the goal of minimizing aquifer concentrations of contaminants, some characteristics of the vadose zone are essentially completely favorable. Examples include the great thickness (200 m) of the vadose zone, and the presence of substantial quantities of fine sediments that can retard contaminant transport both hydraulically and chemically. Most characteristics, however, have both favorable and unfavorable aspects. For example, preferential flow, as promoted by several notable features of the vadose zone at the INEEL, can provide fast, minimally sorbing pathways for contaminants to reach the aquifer easily, but it also leads to a wide dispersal of contaminants in a large volume of subsurface material, thus increasing the opportunity for dilution and sorption.

Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman Area, Idaho, 2002 *(Gordon W. Rattray and Linford J. Campbell)*

The U.S. Geological Survey, Idaho Department of Water Resources, and the State of Idaho INEEL Oversight Program, in cooperation with the U.S. Department of Energy, sampled water from 17 sites as part of the sixth round of a long-term project to monitor water quality of the eastern Snake River Plain aquifer from the southern boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman area. The samples were collected from eight irrigation wells, three domestic wells, one stock well, one dairy well, one commercial well, one observation well, and two springs and analyzed for selected radiochemical and chemical constituents. One quality-assurance sample, a sequential replicate, also was collected and analyzed.

Many of the radionuclide and inorganic-constituent concentrations were greater than the reporting levels and most of the organic-constituent concentrations were less than the reporting levels. However, none of the reported radiochemical- or chemical-constituent concentrations exceeded the maximum contaminant levels for drinking water established by the U.S. Environmental Protection Agency. Statistical evaluation of the replicate sample pair indicated that, with 95 percent confidence, 132 of the 135 constituent concentrations of the replicate pair were equivalent.

Evidence of Abrupt Climate Change and the Development of an Historic Mercury Deposition Record Using Chronological Refinement of Ice Cores at Upper Fremont Glacier *(Paul F. Schuster, David L. Naftz, L. DeWayne Cecil , and Jaromy R. Green)*

Paleoclimatic and paleoenvironmental ice-core records are not common from mid-latitude locations in the contiguous U.S.A. Although excellent paleo-records exist for the high latitudes, ice-core records from polar regions may be considered proxy indicators of climactic and environmental change in the mid latitudes. Unlike polar ice cores which are more likely to preserve visual, chemical and isotopic stratigraphy with sub-annual resolution, visual stratigraphy and sub annual isotopic resolution are generally not apparent in mid-latitude ice cores. In addition, meltwater percolation can influence chemical and isotopic stratigraphy of alpine glaciers from mid-latitude ice cores by "damping" the environmental signal. Despite these problems, through chemical lines of evidence, several investigators indicated that the Upper Fremont Glacier (UFG) in the Wind River Range, Wyoming, U.S.A., (43° 07' 37" N, 109° 36' 54" W) is suitable for reconstruction of isotopic and chemical paleoclimate and environmental change records.

For a temperate glacier, the UFG has a combination of qualifications conducive to preserving paleoenvironmental signals. The drill-site elevation is 4100 m. Minimum, maximum and average annual air temperatures during 5 years of record were -36°C, 13°C, and -7°C respectively. Temperature profiles from snow pits, conducted on an intermittent basis on the UFG, indicated that the snow pack was typically isothermal at 0°C during the summer months. During the winter months, the snow pack was below 0°C, ranging from -7°C to -2°C. The net accumulation rate is 96 cm snow weq/yr, based on the vertical position of the 1963 tritium (^{3}H) fallout record. The glacial surface gradient is nearly level, reducing crevassing and fracturing of

the ice strata. These characteristics reduce the potential for meltwater to alter any paleoenvironmental signal. Because the remoteness of the site limits the influence of local sources of atmospheric mercury (Hg) deposition to the UFG, the location is favorable for measuring historical regional and global deposition of Hg and other chemical constituents from the atmosphere.

A grasshopper leg was recovered in 1991 near the base (152-m depth) of the UFG which yielded a carbon-14 (^{14}C) age of 221 ± 95 years before present. Based on present-day accumulation and ablation rates, ice deposited near the bottom of the glacier formed from snow which fell between about A.D. 1716 and 1820. This chronology, albeit informative, did not provide the accuracy needed to date abrupt climate change or interpret paleoenvironmental signals on, at least, a decadal time scale during the last 270 years.

Further study, direct current electrical conductivity measurements (ECM), scanning electron microscopy (SEM), and energy dispersion analysis (EDA) were performed, Hg concentrations were measured, and isotopic and chemical data were reexamined to: (1) identify volcanic fallout in the ice cores from historical volcanic eruptions, (2) support and refine previous low-resolution chronological estimates of the UFG ice cores, (3) constrain the time of the Little Ice Age (LIA) transition in alpine regions of Central North America, and (4) reconstruct an historical record of atmospheric Hg deposition. The results discussed here will, hopefully, increase awareness and urgency of recovering ice cores from mid-latitude alpine glaciers for paleoclimate studies before these records disappear or are severely compromised by meltwater effects in response to a warming climate. With the addition of the ECM and the Hg data, the UFG ice core data set is the most extensive of its kind from a glacier in the contiguous U.S.

To underscore the urgency to recover these unique records, increasing global temperatures are threatening the existence and integrity of mid- and low-latitude glaciers, which are receding rapidly. Thus, any future research involving mid-latitude glaciers must be prompt. Key to the advancement of understanding environmental change on a global scale through the interpretation of mid-latitude ice-core data is the establishment of global linkage with ice cores from other regions of the world. If recession continues at these rates, the Dinwoody Glacier, about 3 kilometers north of the UFG, will be gone in about 20 years. Other estimates indicate that the remaining glaciers in Glacier National Park, Montana will no longer exist in 50 to 70 years and high alpine glaciers in the Andes of South America (i.e. Quelccaya) will be severely compromised by meltwater processes. These irreplaceable paleoenvironmental resources may literally melt away in the near future releasing an additional and potentially large reservoir of Hg and other contaminants trapped in snow and ice to the environment.

REFERENCES

Aizen, V. B., Aizen, E. M., Melack, J. M., Kreutz, K. J., and Cecil, L. D., 2004, "Association between atmospheric circulation patterns and firn-ice core records from the Inilchek glacierized area, central Tien Shan," *Asia: Journal of Geophysical Research*, v. 109, D08304, p. 1-18.

Benjamin, Lyn, Knobel, L. L., Hall, L. F., Cecil, L. D., and Green, J. R., 2004, "Development of a Local Meteoric Water Line for southeastern Idaho, western Wyoming, and south-central Montana": *U.S. Geological Survey Scientific Investigations Report* 2004-5126, 17 p.

Cecil, L. D., Green, J. R., and Thompson, L. G., editors, 2004, "Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers in Developments in paleoenvironmental research 9": *Kluwer Academic Publishers*, The Netherlands, 249 p.

Collon, Ph., Bichler, M., Caggiano, J., Cecil, L. D. El Masri, Y., Golser, R., Jiang, C. L., Heinz, A., Henderson, D., Kutschera, W., Lehmann, B. E., Leleux, P., Loosli, H. H., Pardo, R. C., Paul, M., Rehm, K. E., Schlosser, P., Scott, R. H., Smethie, W. M., Jr., and Vondrasek, R., 2004, "Development of an AMS method to study oceanic circulation characteristics using cosmogenic ^{39}Ar: Nuclear Instruments and Methods in Physics Research", B223-224, p. 428-434.

Green, J. R., Cecil, L. D., and Frape S. K., 2004, "Methods of Mid- and Low-Latitude Glacial Record Collection, Analysis, and Interpretation: chapter in Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers", Cecil, L. D., Green, J. R., and Thompson, L. G., editors, Kluwer Academic Publishers, The Netherlands, 249 p.

Green, J. R, Cecil, L. D, Synal, H. A., Santos, J., Kreutz, K. J., and Wake, C. P., 2004, "A high resolution record of chlorine-36 nuclear-weapons-tests fallout from central Asia": Nuclear Instruments and Methods in Physics Research, B223-224, p. 854-857.

Kreutz, K. J., Wake, C. P., Aizen, V. B., Cecil, L. D., Green, J. R., and Synal, H. A., 2004, "Event to decadal-scale glaciochemical variability on the Inilchek Glacier, Central Tien Shan: chapter in Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers Cecil, L. D., Green, J. R., and Thompson, L. G., editors, Kluwer Academic Publishers, The Netherlands, 249 p.

Naftz, D. L., Susong, D. D., Cecil, L. D., and Schuster, P. F., 2004, "Variations between δ18O in recently deposited snow and on-site air temperature, Upper Fremont Glacier, Wyoming": chapter in Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers Cecil, L.D., Green, J.R., and Thompson, L.G., editors, Kluwer Academic Publishers, The Netherlands, 249 p.

Nimmo, J. R., Rousseau, J. P., Perkins, K. S., Stollenwerk, K. G., Glynn, P. D., Bartholomay, R. C., and Knobel, L. L., 2004, "Hydraulic and geochemical framework of the Idaho National Engineering and Environmental Laboratory vadose zone": *Vadose Zone Journal*, v. 3, p. 6-34.

Rattray, G. W., and Campbell, L. J., 2004, "Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman Area, Idaho", 2002: U.S. Geological Survey Open-File Report 2004-1004, 22 p.

Schuster, P. F., Naftz, D. L., Cecil , L. D., and Green, J. R., 2004, "Evidence of Abrupt Climate Change and the Development of an Historic Mercury Deposition Record Using Chronological Refinement of Ice Cores at Upper Fremont Glacier": chapter in Earth paleoenvironments: Records preserved in mid- and low-latitude glaciers Cecil, L. D., Green, J. R., and Thompson, L. G., editors, Kluwer Academic Publishers, The Netherlands, 249 p.

Appendix D - Onsite Dosimeter Measurements and Locations

Table D-1. Environmental dosimeter measurements at Argonne National Laboratory West (2004).

Location	Exposure[a]
ANL 7	158 ± 11
ANL 8	130 ± 9
ANL 9	151 ± 10
ANL 10	134 ± 9
ANL 11	130 ± 9
ANL 12	--[b]
ANL 13	127 ± 9
ANL 14	125 ± 9
ANL 15	153 ± 11
ANL 16	154 ± 11
ANL 17	125 ± 9
ANL 18	155 ± 11

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.

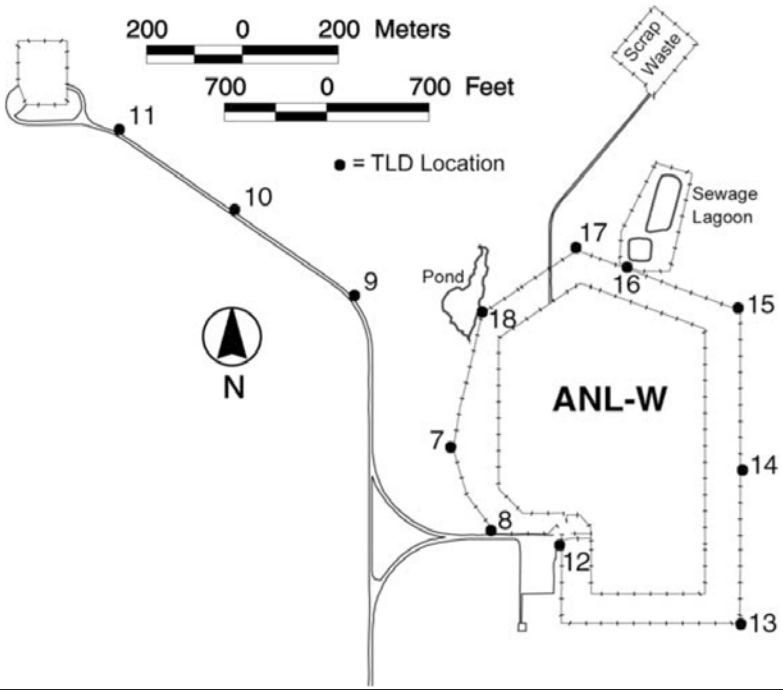


Figure D-1. Environmental dosimeter locations at Argonne National Laboratory West (2004).

Table D-2. Environmental dosimeter measurements at the Auxiliary Reactor Area (2004).

Location	Exposure[a]
ARA 1	[b]
ARA 2	142 ± 7
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.

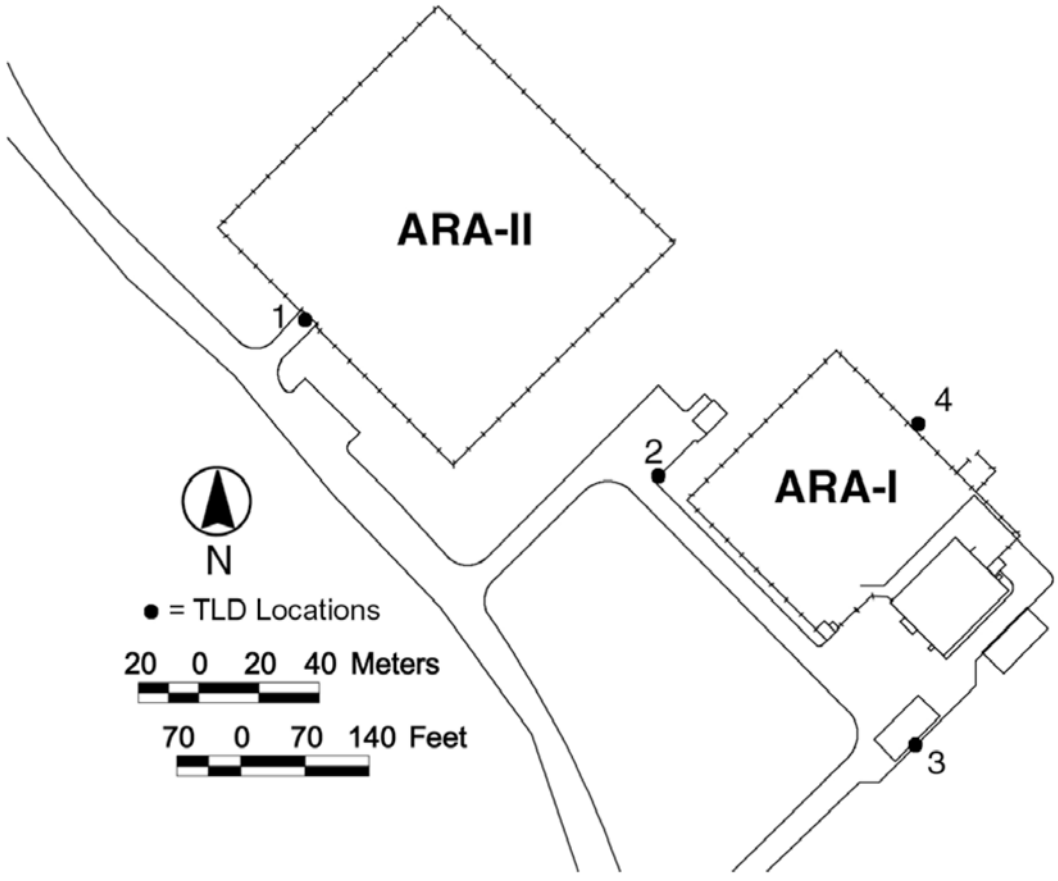


Figure D-2. Environmental dosimeter locations at Auxiliary Reactor Area (2004).

Table D-3. Environmental dosimeter measurements at the Central Facilities Area (2004).

Location	Exposure[a]
CFA 1	126 ± 9
CFA 2	117 ± 8
CFA 3	132 ± 9
CFA 4	126 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

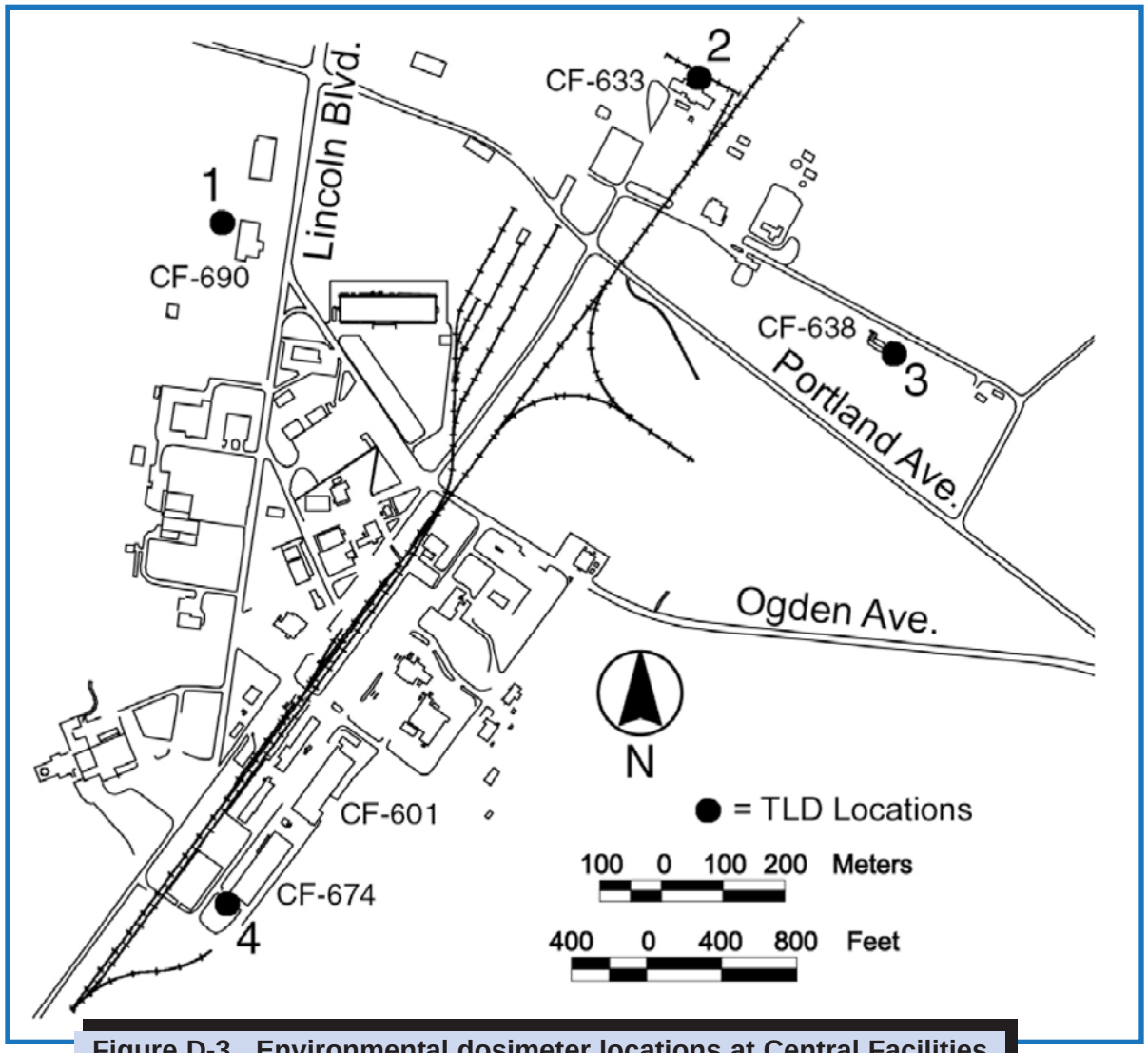


Figure D-3. Environmental dosimeter locations at Central Facilities Area (2004).

Table D-4. Environmental dosimeter measurements at the Idaho Nuclear Technology and Engineering Center (2004).

Location	Exposure[a]
INTEC 1	150 ± 10
INTEC 9	173 ± 12
INTEC 14	134 ± 9
INTEC 15	145 ± 10
INTEC 16	--[b]
INTEC 17	132 ± 9
INTEC 18	--[b]
INTEC 19	141 ± 10
INTEC 20	249 ± 17
INTEC 21	161 ± 11
INTEC 22	190 ± 13
INTEC 23	144 ± 10
INTEC 24	131 ± 9
INTEC 25	123 ± 9
INTEC 26	130 ± 9
TREE FARM 1	184 ± 13
TREE FARM 2	157 ± 11
TREE FARM 3	139 ± 10
TREE FARM 4	194 ± 13

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

b. Dosimeter missing at one of the collection times.

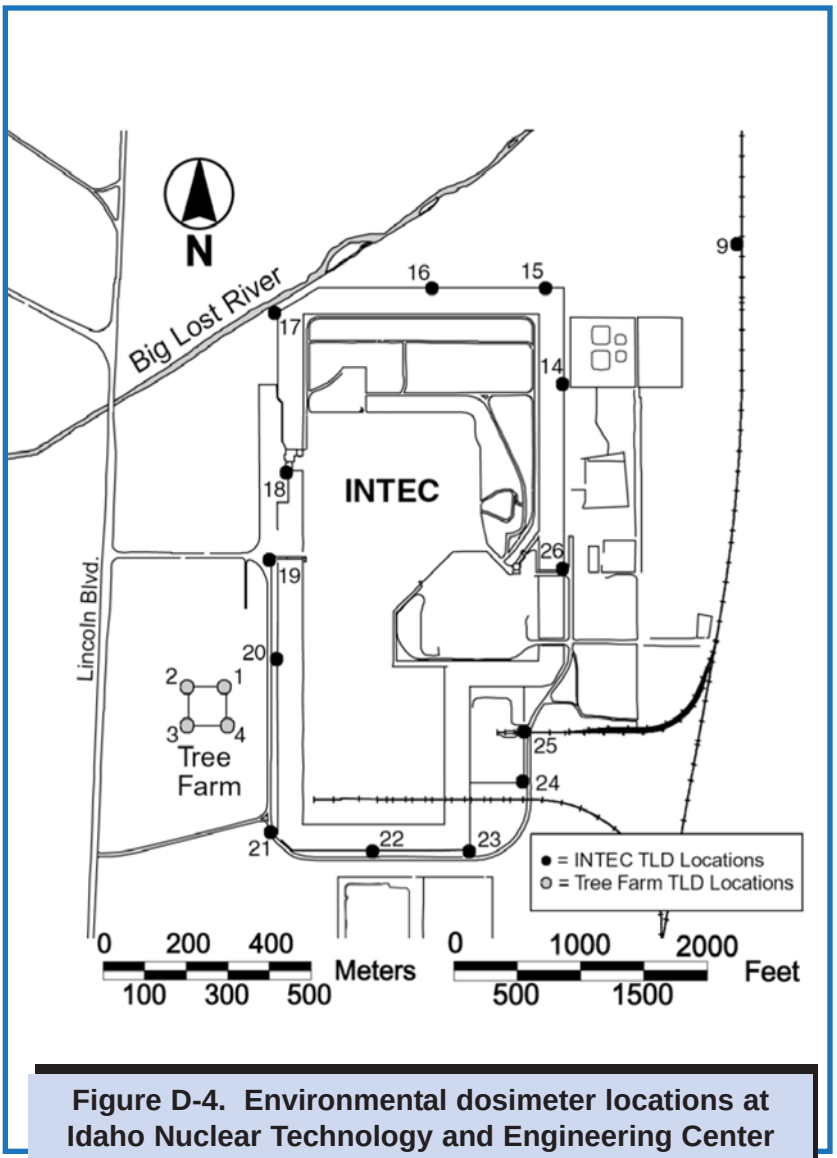


Figure D-4. Environmental dosimeter locations at Idaho Nuclear Technology and Engineering Center (2004).

Table D-5. Environmental dosimeter measurements at the Naval Reactors Facility (2004).

Location	Exposure[a]
NRF 4	132 ± 9
NRF 5	138 ± 10
NRF 11	136 ± 9
NRF 12	133 ± 9
NRF 13	132 ± 9
NRF 16	127 ± 9
NRF 17	--[b]
NRF 18	134 ± 9
NRF 19	132 ± 9
NRF 20	135 ± 9
NRF 21	--[b]

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. These locations were eliminated by construction activities.

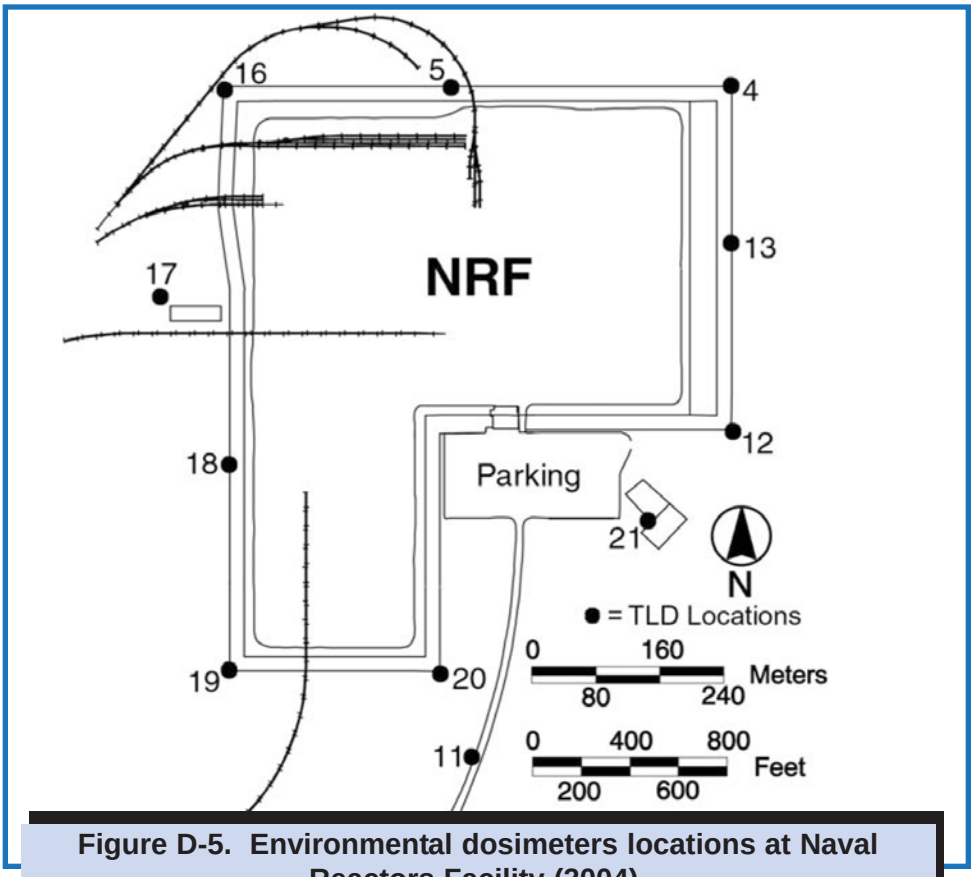


Figure D-5. Environmental dosimeters locations at Naval Reactors Facility (2004).

Table D-6. Environmental dosimeter measurements at the Power Burst Facility (2004).

Location	Exposure[a]
PBF/SPERT 1	127 ± 9
PBF/SPERT 2	126 ± 9
PBF/SPERT 3	130 ± 9
PBF/SPERT 4	137 ± 10
PBF/SPERT 5	132 ± 9
PBF/SPERT 6	134 ± 9
PBF/WERF1	128 ± 9
PBF/WERF2	114 ± 8
PBF/WERF3	125 ± 9
PBF/WERF4	136 ± 9
PBF/WERF5	126 ± 9
PBF/WERF6	129 ± 9
PBF/WERF7	132 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

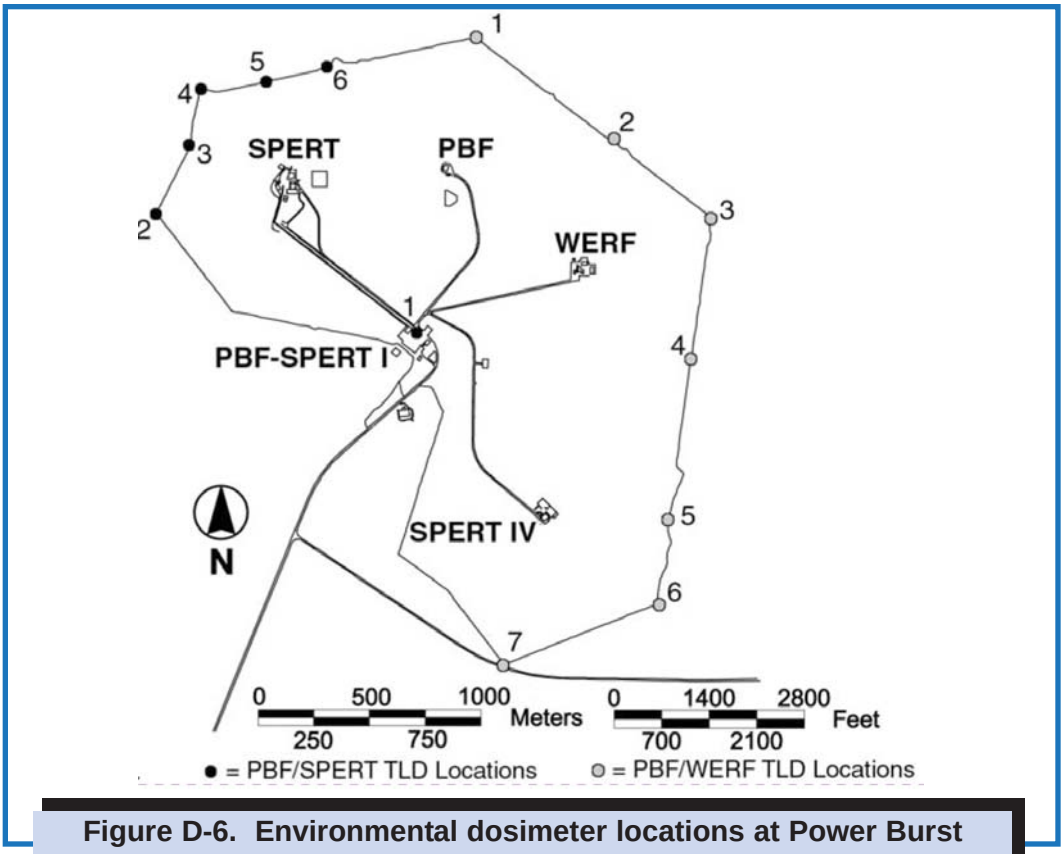


Figure D-6. Environmental dosimeter locations at Power Burst Facility (2004).

Table D-7. Environmental dosimeter measurements at the Radioactive Waste Management Complex (2004).

Location	Exposure[a]
RWMC 3a	133 ± 9
RWMC 5a	136 ± 9
RWMC 7a	146 ± 10
RWMC 9a	151 ± 10
RWMC 11a	146 ± 10
RWMC 13a	139 ± 10
RWMC15a	134 ± 9
RWMC 17a	131 ± 9
RWMC 19a	126 ± 9
RWMC 21a	138 ± 10
RWMC 23a	137 ± 9
RWMC 25a	147 ± 10
RWMC 27a	204 ± 14
RWMC 29a	222 ± 15
RWMC 31a	169 ± 12
RWMC 37a	127 ± 9
RWMC 39	133 ± 9
RWMC 40	151 ± 11
RWMC 41	333 ± 23
RWMC 42	140 ± 10
RWMC 43	131 ± 9
RWMC 45	147 ± 10
RWMC 46	140 ± 10
RWMC 47	126 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

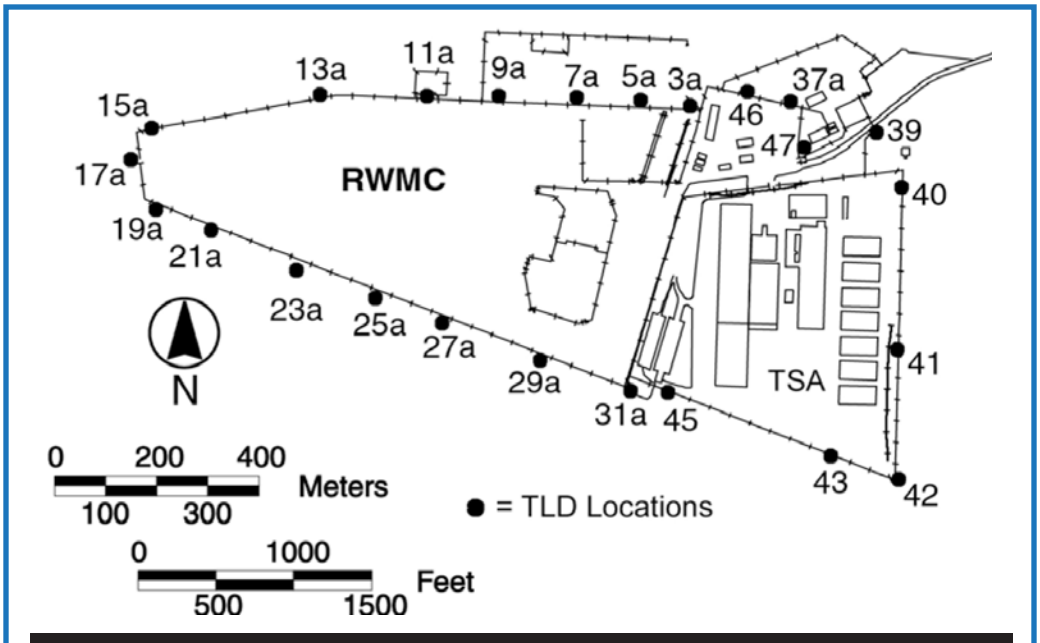


Figure D-7. Environmental dosimeter locations at Radioactive Waste Management Complex (2004).

Table D-8. Environmental dosimeter measurements at the Test Area North (2004).

Location	Exposure[a]
TAN/TSF 1	111 ± 8
TAN/TSF 2	144 ± 10
TAN/TSF 3	115 ± 8
TAN/TSF 4	125 ± 9
TAN/LOFT 1	127 ± 9
TAN/LOFT 2	137 ± 9
TAN/LOFT 3	109 ± 8
TAN/LOFT 4	110 ± 8
TAN/LOFT 5	117 ± 8
TAN/LOFT 6	134 ± 9
TAN/LOFT 7	138 ± 10
TAN/WRRTF1	125 ± 9
TAN/WRRTF2	115 ± 8
TAN/WRRTF3	119 ± 8
TAN/WRRTF4	115 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

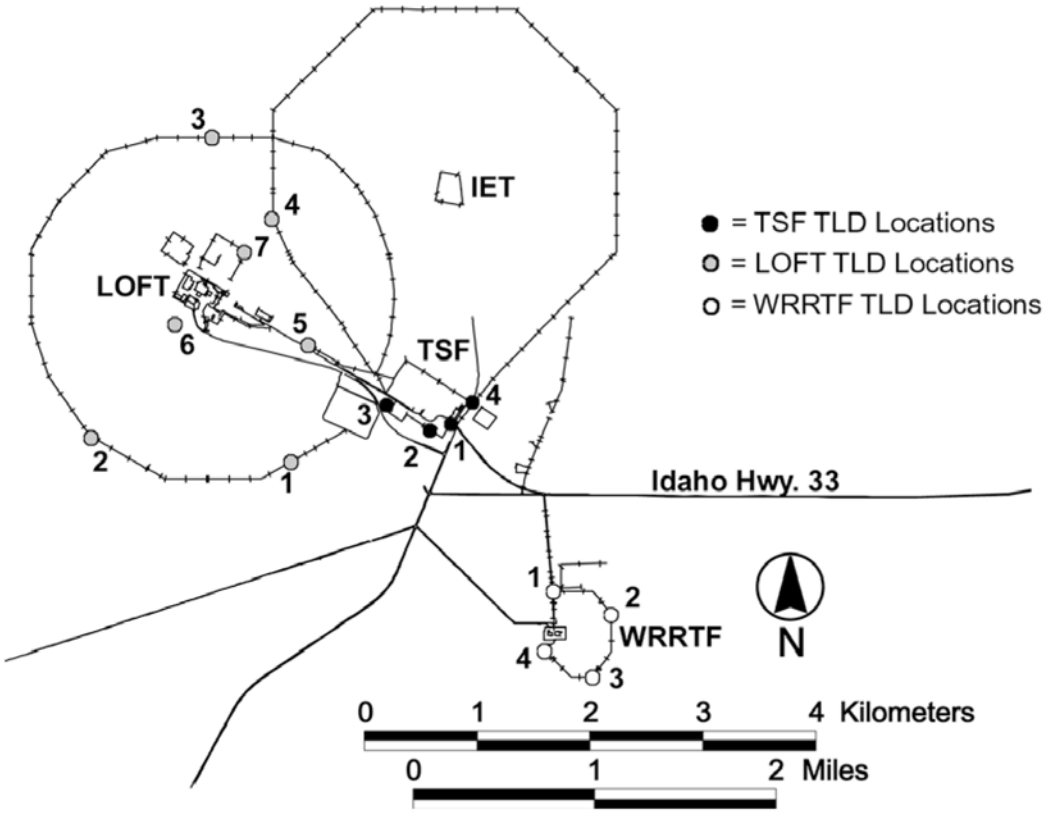


Figure D-8. Environmental dosimeter locations at Test Area North (2004).

Table D-9. Environmental dosimeter measurements at the Test Reactor Area (2004).

Location	Exposure[a]
TRA 1	139 ± 10
TRA 2	193 ± 14
TRA 3	218 ± 15
TRA 4	172 ± 12
TRA 5	147 ± 10
TRA 6	127 ± 9
TRA 7	132 ± 9
TRA 8	153 ± 11
TRA 9	138 ± 10
TRA10	140 ± 10
TRA11	154 ± 11
TRA12	152 ± 11
TRA13	153 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

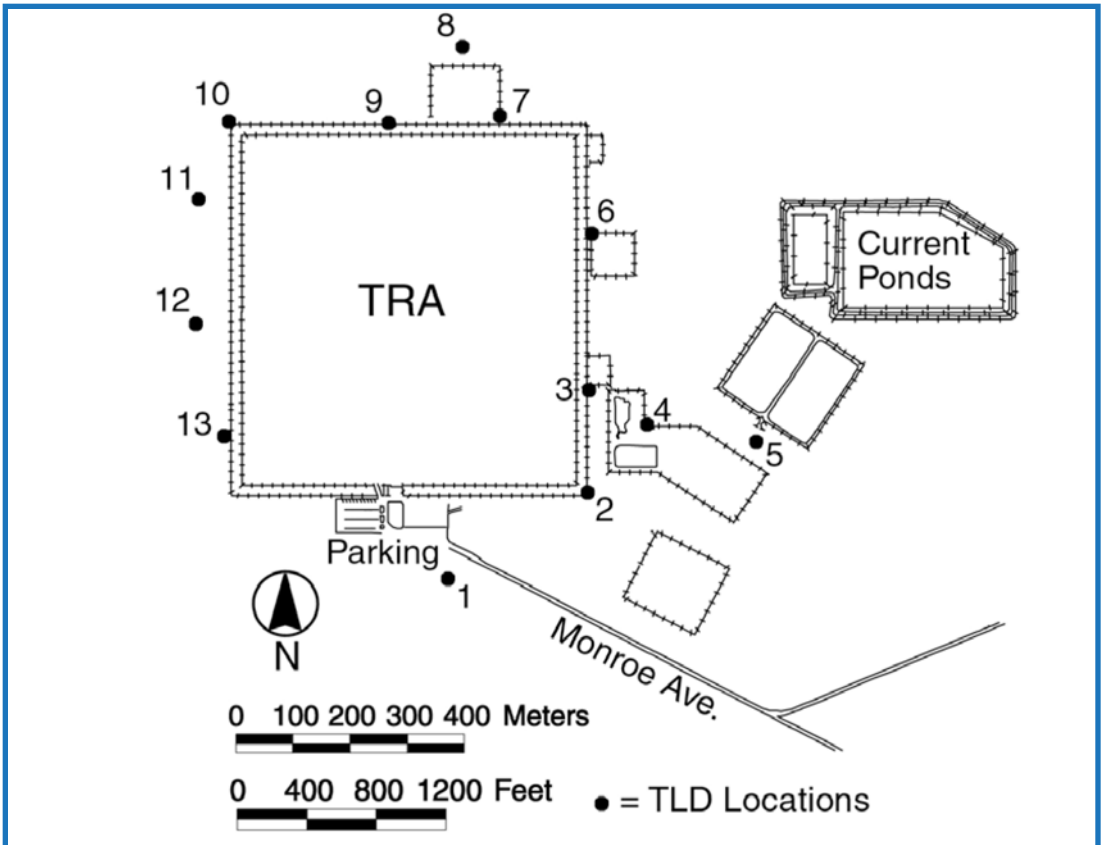


Figure D-9. Environmental dosimeter locations at Test Reactor Area (2004).

Table D-10. Environmental dosimeter measurements along Lincoln Blvd. and US Highway 20 (2004).

Location	Exposure[a]
LINCOLN BLVD 1	129 ± 9
LINCOLN BLVD 3	146 ± 10
LINCOLN BLVD 5	136 ± 9
LINCOLN BLVD 7	135 ± 9
LINCOLN BLVD 9	136 ± 9
LINCOLN BLVD 11	127 ± 9
LINCOLN BLVD 13	136 ± 9
LINCOLN BLVD 15	133 ± 9
LINCOLN BLVD 17	133 ± 9
LINCOLN BLVD 19	123 ± 9
LINCOLN BLVD 21	121 ± 8
LINCOLN BLVD 23	123 ± 9
LINCOLN BLVD 25	124 ± 9
HWY 26-266	128 ± 9
HWY 26-268	128 ± 9
HWY 26-270	129 ± 9
HWY 20-264	123 ± 8
HWY 20-266	118 ± 8
HWY 20-268	119 ± 8
HWY 20-270	123 ± 9
HWY 20-272	113 ± 8
HWY 20-274	102 ± 7
HWY 20-276	126 ± 9
EBR 1	119 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

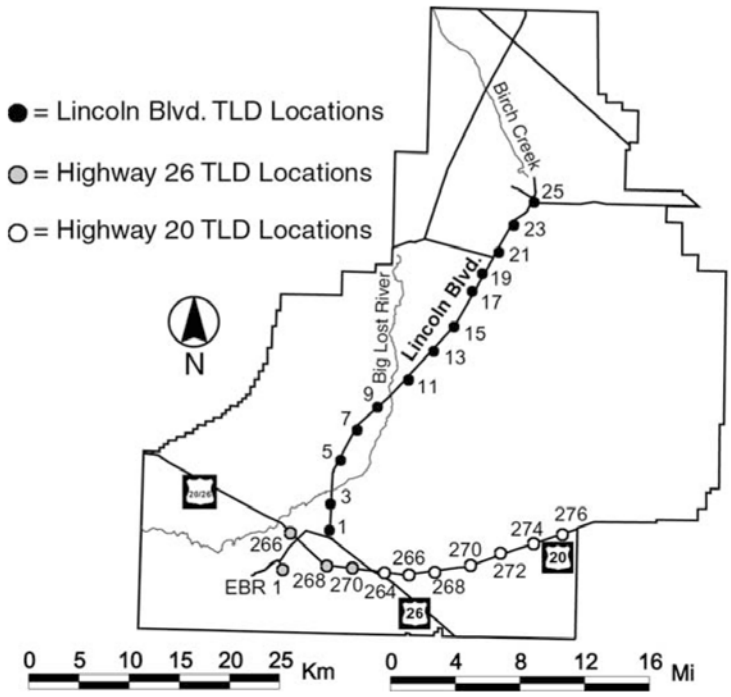


Figure D-10. Environmental dosimeter locations along Lincoln Blvd. and US Highway 20 (2004).

Appendix E - Glossary

A

Advanced Mixed Waste Treatment Facility: Opened in 2003, this facility is located on the INEEL 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 only an inch or so. 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.

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. All references to quantities of radioactive material in this report are made in curies (Ci), followed in parentheses by the equivalent in becquerels. There 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 if the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in an individual's custody if the item is (1) in the physical possession of that person, (2) within direct view of that person, or (3) placed in a secured area or container by that person.

collective effective dose equivalent: A measure of health risk to a population exposed to radiation. It is the sum of the total effective dose equivalents of all individuals within a defined population. The unit for collective effective dose equivalent is person-rem or person-sieverts.

committed effective dose equivalent: The total effective dose equivalent received over a 50-year period following the internal deposition of a radionuclide. It is expressed in rem or sieverts.

comparability: A measure of the confidence with which one data set or method can be compared to another.

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected, under optimum conditions.

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).

confidence interval: A numerical range within which the true value of a measurement or calculated value lies. In this report, radiological values are shown 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 INEEL, 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 INEEL analytical results to those in areas that could not have been impacted by INEEL 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 that 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 transformations in a radioactive series. A decay product may be either radioactive or stable.

deposition velocity: An empirical rate constant that relates the concentration of a radionuclide in air to that on ground or plant surfaces.

derived concentration guide (DCG): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation/ immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The U.S. Department of Energy, through Order 5400.5, "Radiation Protection of the Public and the Environment" has established these values.

diffuse sources: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

dilution: The process of lowering a constituent's concentration by increasing the volume of the media in which it occurs (e.g., adding water to a drink concentrate).

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 INEEL 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. A 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. Duplicates samples are analyzed independently as an indication of gross errors in sampling techniques.

E

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 or tissues 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 aboveground nuclear weapons testing that has been deposited on the Earth's surface.

field blank: A blank used to provide information about contamination that may be introduced

during sample collection, storage, and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Material capable of starting and sustaining a nuclear chain reaction.

fission: The nuclear reaction resulting from the splitting of atoms.

flood plain: Lowlands bordering a river that are subject to flooding. 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 radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See alpha radiation.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See beta radiation.

groundwater: Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water 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 of 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 Engineering and Environmental Laboratory (INEEL): Known locally as the Site or the INEEL, 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 INEEL, has recently been renamed the Idaho National Laboratory. Over the life of the INEEL, 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 single element possess almost identical chemical properties. An example of isotopes are plutonium-238, plutonium-239, plutonium-240, and plutonium-241, each acts chemically like plutonium but have 144, 145, 146, and 147 neutrons, respectively.

L

laboratory blank: A sample that is intended to contain none of the analytes of interest, usually deionized water, that is subjected to the same analytical or measurement process as other samples to establish a zero baseline or 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 gasses in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any state or local government, any foreign government, or any Indian tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Performance evaluation samples are prepared by adding a known amount of a U.S. Environmental Protection Agency reference compound to reagent water and submitting them to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of a 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, ingestion, inhalation, or assimilation into any 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 Contigency 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 of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{(x_1 - x_2)}{0.5x(x_1 - x_2)} \times 100$$

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 and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

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 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 flows out into the Snake River in the Thousand Springs area between Twin Falls and King Hill.

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 and 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 INEEL, 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 event 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 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 noncommunity water system: A water system that is not a community water system, and serves as 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, americium-241, 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 INEEL.

V

vadose zone: That part of the subsurface between the ground surface and the water table.

W

Waste Isolation Pilot Plant (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 such as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.