Idaho National Engineering
and Environmental Laboratory

Site Environmental Report
Calendar Year 2003

Environmental Surveillance, Education, and Research Program

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U.S. Department of Energy Idaho Operations Office

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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.

INEEL
Idaho National Engineering and Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

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[1] Randall Morris is with North Wind, Inc.

Preface

M. Case and C. Martin - S. M. Stoller Corporation

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 2003 for the environmental monitoring and surveillance programs conducted on and around the Idaho National Engineering and Environmental Laboratory (INEEL). During 2003, the Environmental Surveillance, Education and Research (ESER) Program was performed by a team led by the S. M. Stoller Corporation. This team collected 2003 data and prepared this report. During 2003, 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 Advance 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 2003.

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

U.S. Department of Energy, 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 2003 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 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. operate the remaining three primary facilities at 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 has infused 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 2003.

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.

Table ES-1. Compliance with federal acts in 2003.

Act	What it Addresses	2003 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.	The INEEL continues to make progress on remedial actions in compliance with CERCLA requirements. By the end of 2003 more than 70% of CERCLA actions are complete. The Agency for Toxic Substances and Disease Registry (ATSDR) released the draft public health assessment of the INEEL, as required by CERCLA, for public review and comment.
Resource Conservation and Recovery Act (RCRA)	This act establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste.	The Idaho Department of Environmental Quality (DEQ) conducted a RCRA inspection at the INEEL in August 2003. Two notices of violation (NOVs) were issued as a result. A Consent Order to resolve the NOVs was negotiated by the State of Idaho, Bechtel BWXT Idaho LLC, the DOE Idaho Operations Office and British Nuclear Fuels Limited, Inc. and the alleged violations were resolved. The State of Idaho approved RCRA closure plans for three facilities at the INEEL.
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.	Five site treatment plan milestones were met in 2003.
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 2003 National Emission Standards for Hazardous Air Pollutants report documented a maximum annual individual dose to a member of the public from INEEL releases of 0.035 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 United States.	EPA Region 10 issued a letter in October 2003 with the determination that INTEC, RWMC, and TAN do not have a reasonable potential for discharge to waters of the U.S. DOE-ID directed the M&O to cease stormwater activities at those facilities in December 2003.
Safe Drinking Water Act	This act establishes primary and secondary standards for drinking water systems.	No U.S. Environmental Protection Agency health-based drinking water regulatory limits were exceeded in 2003.
Toxic Substances Control Act	This act regulates industrial chemicals currently produced or imported into the United States.	The INEEL was in compliance with management of polychlorinated biphenyls in 2003.
National Environmental Policy Act	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 final Environmental Assessment to evaluate pre-fire planning, fire response, and post-fire restoration alternatives was issued in 2003, with a finding of no significant impact.
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 2003. The Toxic Chemical Release Inventory Report (313) was issued for eight chemicals used on the INEEL.

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 these contaminants on the public and the environment. This is accomplished though sampling and analysis of air; surface, subsurface, and drinking water; soil; wildlife; and vegetation, as well as measurement of direct radiation. During 2003, the prime Management and Operating (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, 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. The INEEL made significant progress in 2003 toward accelerated cleanup.

The Environmental Restoration Program continued progress during 2003 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 2 have been completed, 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 RWMC Waste Area Group-7 (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)

All requirements have been met and all Federal Facility Agreement and Consent Order-enforceable milestones related to the WAG 2 ROD have been completed. This is the first WAG at the INEEL be closed out and prepared for transition into Long-Term Stewardship management.

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 2003:

- Five Site Treatment Plan milestones were met.
- British Nuclear Fuels Limited, Inc. commenced retrieval operations at the Advanced Mixed Waste Treatment facility in March 2003.

- Over 900 m^3 (1177 yd^3) of mixed low-level waste was treated and disposed of in 2003.
- The Transuranic Waste Program shipped 384 m^3 (502 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 5574 m^2 (60,000 ft^2) of buildings and structures were demolished in 2003.

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 7796 Ci of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2003. 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. 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 nitrogen dioxide and particulates, were monitored at select locations around the INEEL. All results were well below regulatory standards.

Environmental Monitoring Programs - 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 2003, 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 Idaho Department of Environmental Quality. Additional parameters are also monitored in the effluent in support of surveillance activities. Most

Table ES-2. Boundary, onsite, and offsite radiological environmental monitoring results for 2003 (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, strontium-90 (^{90}Sr), and americium-241, plutonium 238, 239/240	In general, gross alpha and gross beta activities show levels and seasonal variations not attributable to INEEL releases. Five of the weekly gross beta results showed statistical differences between boundary and distant locations. In all cases the differences were attributed to natural variation or to inversion conditions. All measurements of specific radionuclides were well below Derived Concentration Guide (DCG) for radiation protection and within historical results.
	Atmospheric moisture	Tritium	Tritium was detected in 13 of 44 samples. Measurements were well below the DCG and within historical concentrations.
	Precipitation	Tritium	Tritium was detected in 13 of 53 precipitation samples. Measurements were well below the DCG and within historical measurements made at the INEEL and within U.S. Environmental Protection Agency (EPA) Region 10 (ID, OR, WA, and AK) historical levels.
Water	Surface water	Gross alpha and gross beta activity, and tritium	Gross alpha activity was detected in one sample. Nine of 12 samples had measurable gross beta activity. All were below the EPA screening level. Tritium was detected in one sample. The highest level measured was below the EPA Maximum Contaminant Level (MCL).
	Drinking water	Gross alpha and gross beta activity, and tritium	No EPA health-based drinking water or DOE regulatory limits were exceeded in 2003.
Agricultural products	Milk, lettuce, wheat, potatoes, and sheep	Gamma-emitting radionuclides and ^{90}Sr	Some human-made radionuclides were detected in agricultural samples. All concentrations were similar to historical measurements and appear to be attributable to 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 some muscle, thyroid, or liver samples of mule deer and pronghorn at levels consistent with past weapons testing fallout. Low levels of ^{137}Cs and ^{90}Sr were found in five marmots. Levels were below those from previous investigations. One or more human-made radionuclides were detected in at least one tissue type in 11 waterfowl collected from INEEL wastewater ponds and control areas. The potential dose from consumption of waterfowl with the highest concentrations was calculated to be 0.002 mrem (0.001 percent of 363 mrem from background sources).
Soil	Offsite soil composite samples	Gamma-emitting radionuclides, ^{90}Sr and the same actinides analyzed in particulate filters	Soil sampling was not conducted by the ESER contractor in 2002. Radionuclide levels in soils at 186 site surveillance locations near major INEEL facilities were measured by the M&O contractor using in situ gamma spectrometry. The results show concentrations above background at ARA and INTEC, but consistent with historical concentrations at these locations. Measurements at ANL-W, NRF, and the Large Grid were within background levels. 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' measurements and with background levels.

wastewater and groundwater regulatory and surveillance results were below applicable limits in 2003.

Samples from public water systems and wells continue to show measurable quantities of carbon tetrachloride at the Radioactive Waste Management Complex production well. The annual average of 2.8 µg/L was below the U.S. Environmental Protection Agency (EPA) established maximum contaminant level (MCL) of 5 µg/L. Trichloroethylene concentrations in samples from the Test Area North drinking water system during 2003 also remained below the MCL. Argonne National Laboratory-West and Naval Reactors Facility systems did not exceed any limits during 2003.

Tritium and strontium-90 continue to be measured in the groundwater under the INEEL. Neither of these radionuclides has been detected off the INEEL since the mid-1980s. A maximum effective dose equivalent of 0.88 mrem/yr (8.8 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 2003.

Drinking water samples were collected from 13 locations off the INEEL and around the Snake River Plain in 2003. No sample had measurable gross alpha, one had measurable tritium, and most samples (19 of 28) had measurable gross beta activity. None of the samples exceeded the EPA MCL for these constituents.

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. Total suspended solids, iron, and magnesium all exceeded benchmark levels in samples collected from the RWMC. Concentrations of these parameters have occurred above benchmark levels in the past. Examination of storm water flow paths showed no deficiencies in storm water protection.

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

Results from nine special studies conducted by the U.S. Geological Survey of the properties of the aquifer were published during 2003. 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 for comparison only as the MCL applies only to the distribution system and not the source well).

Offsite surface water was collected from five locations along the Snake River. One of 12 samples had measurable gross alpha activity. Nine of 12 samples had measurable gross beta activity, while only one sample had measurable tritium. None of these constituents were above regulatory limits. Onsite sampling of surface water runoff for waste management purposes showed no values 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 2003.

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 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 0.035 mrem (0.35 µSv). The dose calculated by the MDIFF program was 0.024 mrem (0.24 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 0.022 person-rem, 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, big game animals, and marmots at the INEEL, based on the highest concentrations of radionuclides measured in samples of these animals, were estimated to be 0.002 mrem (0.02 µSv), 0.045 mrem (0.45 µSv), and 0.006 mrem (0.06 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 (2003).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF
Dose	0.035 mrem (3.5×10^{-4} mSv)	0.024 mrem (2.4×10^{-4} mSv)	0.022person-rem (2.2×10^{-4} person-Sv)
Location	Frenchman's Cabin	Frenchman's Cabin	Area within 80 km (50 mi) of any INEEL facility
Applicable radiation protection standard[d]	10 mrem (0.1 mSv)	10 mrem (0.1 mSv)	No standard
Percentage of standard	0.35 percent	0.24 percent	No standard
Natural background	363 mrem (3.6 mSv)	363 mrem (3.6 mSv)	100,540 person-rem (1,005 person Sv)
Percentage of background	0.01 percent	0.007 percent	0.00002 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.

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 of 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 2003:

- Monitoring Amphibian and Reptile Populations on the INEEL;
- The Affect 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;
- Use of Genetic Markers as a Screening Tool for Ecological Risk Assessment at the INEEL: Microsatellite Mutation Rate of Burrowing Mammals;
- Crested Wheatgrass Rates of Spread into Native Sagebrush Steppe in Eastern Idaho;
- Experimental Remote Sensing of Vegetation on the INEEL;
- Natural and Assisted Recovery of Sagebrush in Idaho's Big Desert;
- Sagebrush Demography;
- Development of an Intregrated Watershed Information Tool for Long-term Facilities, Stewardship at the INEEL;
- Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater;
- The Protective Cap/Biobarrier Experiment;
- Assessing the Effects of Soil-forming Processes on Surface Caps; and
- Coupled Effects of Biointrusion and Precipitation on Soil Caps.

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.

Laboratories used by the ESER contractor met their quality assurance goals in 2003. Quality issues that arose with laboratories used by the M&O contractor were addressed with the laboratory and resolved.

Helpful Information

C. Martin and 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 P-1 shows fractions and multiples of units while, Table P-2 provides useful conversions.

Table P-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 P-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 P-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
d/m	0.450	pCi	pCi	2.22	d/m
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 dose)
Rem (Roentgen equivalent man)	0.001	Sievert (Sv)	Sievert (Sv)	100	Rem (Roentgen equivalent man)
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 P-3.

Table P-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
Curium-141	^{141}Cm	Ruthenium-106	^{106}Ru
Curium-144	^{144}Cm	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
ALSM	Airborn Laser Swath Mapping
ANL-W	Argonne National Laboratory-West
ANOVA	Analysis of Variance
ARA	Auxiliary Reactor Area
ASME	American Society of Mechanical Engineers
BBI	Bechtel Bettis, Inc.
BBS	Breeding Bird Survey
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
BDN	Bayesian Decision Network
BLM	U.S. Bureau of Land Management
BLR	Big Lost River
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERT	Controlled Environmental Radioiodine Test
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITR	Critical Infrastructure Test Range
CMS	Community Monitoring Station

COD	Chemical Oxygen Demand
CTF	Contained Test Facility
CWA	Clean Water Act
DCG	Derived Concentration Guide
DEM	Digital Elevation Model
DEQ	(Idaho) Department of Environmental Quality
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
EBTF	Engineered Barrier Test Facility
ECF	Expended Core Facility
EDF	Experimental Dairy Farm
EFS	Experimental Field Station
EIS	Environmental Impact Statement
EM	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
ESER	Environmental Surveillance, Education and Research
ESRF	Environmental Science and Research Foundation
ESRPA	Eastern Snake River Plain Aquifer
ESRP	Eastern Snake River Plain

ET	Evapotranspiration
FFA/CO	Federal Facility Agreement and Consent Order
GEL	General Engineering Laboratories
GIS	Geographic Information System
GPS	Global Positioning System
HDR	Hydrogeological Data Repository
HDS	Head Dissipation Sensors
ICP/AES	Inductively Coupled Plasma/Atomic Emission Spectroscopy
ICPP	Idaho Chemical Processing Plant
IDAPA	Idaho Administrative Procedures Act
IMPROVE	Interagency Monitoring of Protected Visual Environments
IMU	Inertia Mesurements Unit
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
IWIMT	Integrated Watershed Information Management Tools
LDRD	Laboratory Directed Research and Development
LFR	Live Fire Range
LTS	Long-Term Stewardship
M&O	Management and Operating
MCL	Maximum Contaminant Level

MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MNA	Monitored Natural Attenuation
MTR	Materials Test Reactor
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory - Field Research Division
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NWQL	National Water Quality Laboratory (USGS)
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment
PCS	Primary Constituent Standard
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct

QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
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
SCS	Secondary Constituent Standard
SD	System Dynamics
SDA	Subsurface Disposal Area
SMC	Specific Manufacturing Capability
SRPA	Snake River Plain Aquifer
STL	Severn Trent Laboratories
TAN	Test Area North
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TLD	Thermoluminescent Dosimeter
TRA	Test Reactor Area
TRU	Transuranic (waste)
TSA	Transuranic Storage Area
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility

TSS	Total Suspended Solids
USFWS	U.S. Fish and Wildlife Services
USGS	U.S. Geological Survey
WAG	Waste Area Group
WERF	Waste Experimental Reduction Facility
WLAP	Wastewater Land Application Permit
WSU	Washington State University

Units

Btu	British thermal unit	µCi	microcurie (10^{-6} curies)
Bq	becquerel	µg	microgram
cfm	cubic feet per minute	µm	micrometer
Ci	curie	µS	microsiemens
cm	centimeter	mmhos/cm	millimhos per centimeter
cpm	counts per minute	mph	miles per hour
d	day	mR	milliroentgen
dl	detection limit	mrem	millirem
dpm	disintegrations per minute	mSv	millisievert
ft	feet	ng	nanogram
g	gram	nm	nanometer
gal	gallon	oz	ounce
gpd	gallons per day	pCi	picocurie (10^{-12} curies)
ha	hectare	ppb	parts per billion
hr	hour	qt	quart
in.	inch	rem	roentgen equivalent man
KeV	kilo-electron-volts	R	roentgen
kg	kilogram	sec	second
km	kilometer	Sv	seivert
L	liter	x^2	unit squared
lb	pound	x^3	unit cubed
m	meter	yd	yard
mi	mile	yr	year
min	minute	<	lesser than
mL	milliliter	>	greater than

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Tables

Chapter 1 - Introduction

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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 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 secondary facilities are 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. operate 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 has infused 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 2003. 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.

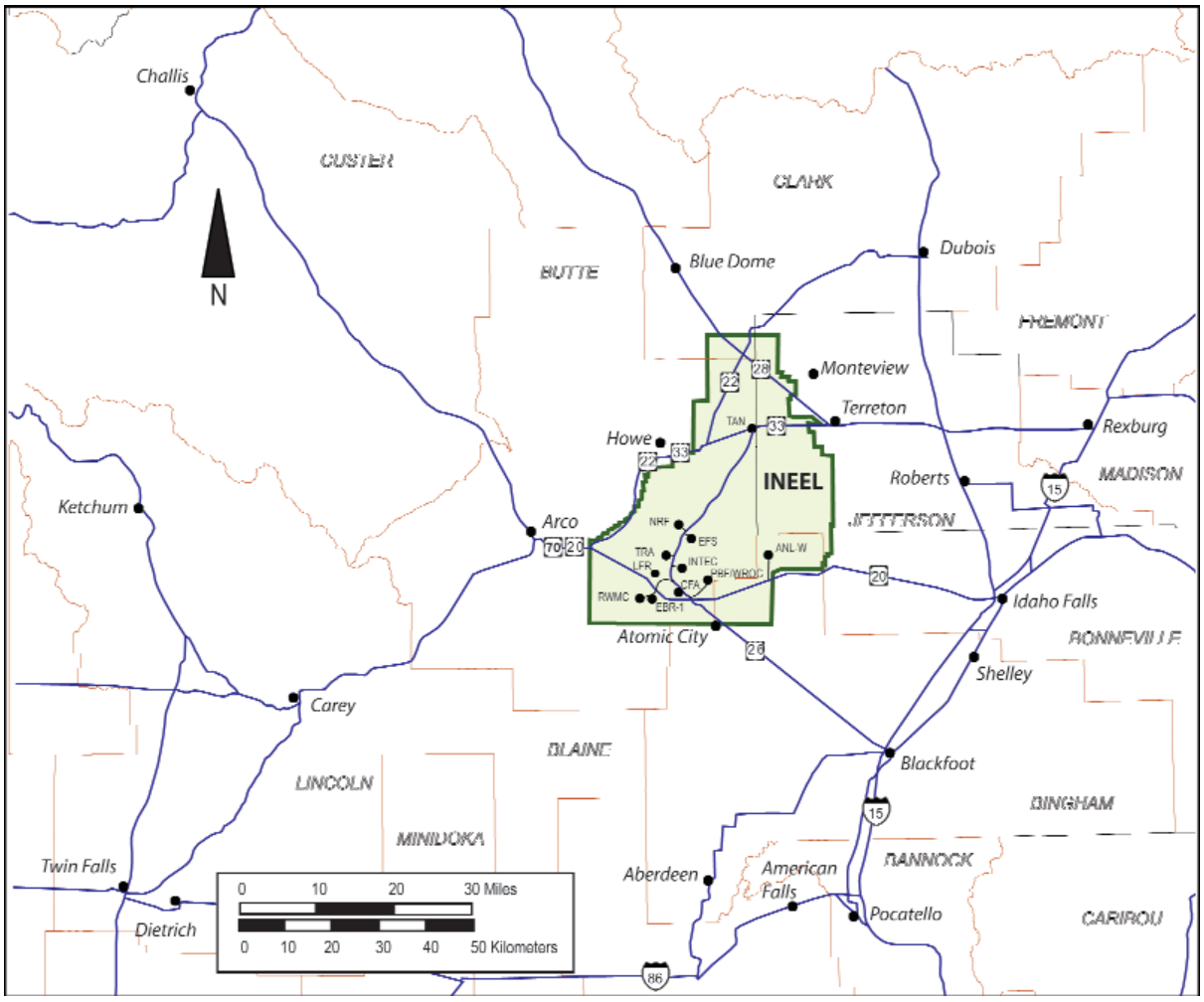

Figure 1-2. Map of INEEL and surrounding area showing facilities, counties, and cities.

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 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 (INEEL Mission/Vision 2001).

Over the years, various Management and Operating (M&O) contractors have operated the INEEL. During 2003, 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) operate 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. The University of Chicago operates 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, one DOE 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 BBI, Bettis Atomic Power Laboratory-Idaho. 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. BNFL, Inc. is currently preparing the Advanced Mixed Waste Treatment Facility for operation. This facility will 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 research technologies for the cleanup of environmental contamination from prior operations. This research includes alternatives such as biological remediation of organic solvents in groundwater.

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.

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, environmental 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 9.12).

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. Other employees work 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.

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Chapter 2 - Environmental Compliance Summary

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Chapter Highlights

Operations at the Idaho National Engineering and Environmental Laboratory (INEEL) are subject to numerous federal and state environmental statutes, executive orders, and U.S. Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of nonpermitted hazardous materials to the environment must be documented. Overall, the INEEL met all its regulatory commitments in 2003 and programs are in place to address areas for continued improvement.

The following paragraphs highlight the accomplishments made in 2003:

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 grouped within a single Record of Decision. The INEEL continues to make progress on remedial actions at operable units, as detailed in Chapter 3.

The Idaho Department of Environmental Quality conducted a Resource Conservation and Recovery Act inspection at the INEEL in August 2003. Two notices of violation were issued as a result of this inspection. The State of Idaho, Bechtel BWXT Idaho, LLC, the DOE Idaho Operations Office (DOE-ID), and British Nuclear Fuels Limited, Inc. negotiated a consent order and resolved the alleged violations.

The State of Idaho approved closure plans for the following facilities: Phase II of Tank Farm Facility Closure; TRA-630 Catch Tank; and TAN-647 Storage Unit.

The final Environmental Assessment to evaluate pre-fire planning, fire response, and post-fire restoration alternative was issued in April 2003, with a finding of no significant impact.

The Advanced Mixed Waste Treatment Facility commenced retrieval operations, meeting a Settlement Agreement milestone.

DOE-ID submitted the 2003 *INEEL National Emission Standards for Hazardous Air Pollutants-Radionuclides* report to U.S. Environmental Protection Agency, DOE Headquarters, and State of Idaho officials in June 2004, in compliance with the Clean Air Act.

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.

DOE Order 450.1, Environmental Protection Program

DOE issued this Order in January of 2003 with the purpose of consolidating all environmental protection activities under the umbrella of the Environmental Management System and ensuring that the Environmental Management System is integrated into each Site's Integrated Safety Management System. The INEEL's Integrated Safety Management System has successfully operated for several years and already includes an environmental component. In addition, the INEEL achieved registration under the international standard ISO 14001, Environmental Management Systems, in 2001 (see Chapter 3).

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

This Order establishes standards and requirements for operations of DOE sites with respect to protection of members of the public and the environment against undue risk from radiation. The standards and guides provided by DOE Order 5400.5 are presented in Appendix A. Concentrations of radionuclides measured by the INEEL environmental programs in 2003 were well below concentration guides established by this Order (see Chapters 4, 5, and 6). Potential doses to members of the public in the vicinity of the INEEL were also estimated to be well below the dose limits established by this order (see Chapter 8).

Table 2-1. Environmental compliance status.

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

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release of chemically hazardous and/or radioactive substances. Nuclear research and other operations at the 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 Management and Operating (M&O) 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) conducting environmental investigations 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. This information is presented to the public in a Proposed Plan. 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. After reviewing public comments, DOE-

ID, EPA, and the state reach a final decision, which is documented in a Record of Decision. 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 2003. 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 2003 by March 1, 2004. 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, 2004. The report identifies quantities of 313-listed toxic chemicals available on the INEEL that exceeded their TPQ. Once the TPQ is exceeded (for manufacturing, processing, or otherwise used), an EPA 313 Form R report must be completed for each specific chemical. These reports describe how the chemical is released to the environment. Releases under EPCRA reporting include transfers to offsite waste storage and treatment, air emissions, recycling, and other activities. Eight reports were prepared at the INEEL during 2003 for toluene, ethyl benzene, lead, nitric acid, chromium, naphthalene, propylene, and polyaromatic cyclic 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 2003. This 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 - 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. A phased decision-making process will be used to implement the proposed action and its preferred alternative. The technology selection phase will focus on four technologies analyzed in the EIS for implementation: calcination, steam reforming, cesium ion extraction, and evaporation to dryness.

Work on the record of decision (ROD) for the EIS is currently on hold pending resolution of legal uncertainties concerning classification of Sodium Bearing Waste and award of the INEEL cleanup contract. Upon resolution of the legal uncertainties and contract transition, DOE will establish a target for ROD issuance.

Wildland Fire Management Plan Environmental Assessment - In January 2001, the DOE-ID manager signed a determination to prepare an EA to evaluate pre-fire planning, fire response, and post-fire restoration alternatives. Actions to be analyzed include firebreak construction and maintenance, dust suppression, habitat rehabilitation, and impacts on cultural resources. DOE issued the final EA and finding of no significant impact in April 2003.

Nuclear Regulatory Commission NEPA Review - In addition to anticipated DOE actions at the INEEL that warrant NEPA review, the Nuclear Regulatory Commission (NRC) has separate NEPA authority over NRC-licensed activities forming a part of the INEEL mission. These activities currently include the Three Mile Island Unit 2 (TMI-2) Independent Spent Fuel Storage Installation (ISFSI) licensed under materials license SNM-2508 (located on the INTEC site) and the Fort St. Vrain ISFSI licensed under materials license SNM-2504 (located near Platteville, Colorado). NRC evaluates changes in or exemptions from license conditions/regulations under NEPA. NEPA reviews/actions are anticipated to occur (though infrequently) in the future as NRC regulatory requirements evolve.

In addition, Foster Wheeler Environmental Corporation submitted a license application (Docket #72-25) to the NRC on November 19, 2001, for a spent fuel storage facility to be constructed on the INEEL. The facility will be owned and operated by Foster Wheeler under a privatization contract with NE-ID. Issuance of the license by NRC to Foster Wheeler will be supported by the NRC Final EIS to be issued in late-2004. Issuance of the license (planned in 2004) constitutes the equivalent of a DOE ROD.

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 presented to the DOE-ID Natural Phenomenon Hazards Committee upon completion.

For facilities at Test Area North (TAN), the 100-year floodplain has been delineated in a 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 nonregulated sites with ecological, environmental, and future development significance. In 2003, 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.

DEQ has issued one RCRA Part A permit for the INEEL and seven Part B permits. Five additional Part B permits are pending. DOE, Bechtel BWXT Idaho, LLC (BBWI), British Nuclear Fuels Limited, Inc. (BNFL), and Idaho DEQ meet quarterly to discuss RCRA-related issues. Summaries of the meetings can be accessed at http://cleanup.inel.gov/publicdocuments/.

Notices of Violation - Idaho DEQ conducted an inspection of INEEL in August 2003, resulting in issuance of two notices of violation (NOV). One NOV addresses alleged violations related to facilities operated by the M&O contractor and the other addresses alleged violations at the Advanced Mixed Waste Treatment Project operated by BNFL, Inc. Most of the violations are

failures to correct in a timely manner deficiencies noted in routine operator inspection logs and reports. The state, BBWI, DOE-ID, and BNFL, Inc. negotiated a consent order and resolved the alleged violations.

RCRA Closure Plans - The State of Idaho approved closure plans for the following facilities in 2003:

- Phase II of Tank Farm Facility Closure
- TRA-630 Catch Tank
- TAN-647 Storage Unit.

RCRA Reports - As required by the State of Idaho, INEEL submitted the Idaho Hazardous Waste Generator Annual Report for 2003. The report contains information on waste generation, treatment, recycling, and disposal activities at INEEL facilities.

DOE-ID submitted the INEEL 2003 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 and some areas at Argonne National Laboratory-West 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, 2003.

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 2003 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 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, 4, 5, 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. Renewal permits have been submitted for the Central Facilities Area Sewage Treatment Plant, INTEC Sewage Treatment Plant, and Test Area North/Technical Support Facility Sewage Treatment Plant. 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 WLAP permit for the new INTEC percolation ponds for disposal of service wastewater in 2001. Idaho DEQ is reviewing permit applications for the Process Ponds at Test Area North, the Test Reactor Area Cold Waste Ponds, the Naval Reactors Facility Industrial Waste Ditch, and the Argonne National Laboratory-West industrial and sanitary waste ponds.

Idaho Settlement Agreement

On October 16, 1995, DOE, the U.S. Navy, and the State of Idaho entered into an agreement that guides management of spent nuclear fuel and radioactive waste at the 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. The Settlement Agreement milestones scheduled for 2003 were met as follows:

- Commence operation of the Advanced Mixed Waste Treatment Facility - the milestone was due on 3/31/03 and retrieval operations started on 3/27/03.

- Begin loading spent fuel into dry storage - the milestone was due on 7/1/03 and loading started on 7/10/97.

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.

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

Title V Operating Permit - Title V of the 1990 Clean Air Act Amendments required the EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state and/or local air pollution agencies. The EPA promulgated regulations in July 1992, that defined the requirements for state programs. Idaho has promulgated regulations and EPA has given interim approval of the Idaho Title V 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 and public comment before issuing a final permit.

National Emission Standards for Hazardous Air Pollutants - DOE-ID submitted the *2003 INEEL National Emission Standards for Hazardous Air Pollutants-Radionuclides* report to EPA, DOE Headquarters, and State of Idaho officials on June 4. This statute requires the use of the CAP-88 computer model to calculate the hypothetical maximum individual effective dose

Table 2-2. Permit summary for the INEEL (2003).

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	5	2
404 Permit	Corps of Engineers	1	0
Industrial Waste Acceptance	City of Idaho Falls	15	0
RCRA			
Part A	State of Idaho	1	0
Part B[b]	State of Idaho	7[b]	1[b]

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

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

equivalent to a member of the public resulting from INEEL airborne radionuclide emissions. The 2003 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 2003 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 2003.

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 Test Area North (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 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 2004.

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 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 2003, 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, so the December 2003 letter directed the M&O contractor to cease application of SPCC regulation at the locations specified in the EPA letter. This results in SPCC no longer being applicable at the INEEL.

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 Argonne National Laboratory-West. All INEEL facilities performed sampling of drinking water as required by the state and EPA. Chapter 5 contains details on drinking water monitoring results.

National Historic Preservation Act

Preservation of historic properties on lands managed by DOE is mandated under Section 106 of the National Historic Preservation Act 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.

DOE-ID and the Idaho State Historic Preservation Office (SHPO) implemented three memoranda of agreement in 2003 to deactivate, decontaminate, and decommission (D&D&D) multiple structures at the TAN and Power Burst Facility. Most of these structures were demolished in 2003; the remainder will be demolished in 2004. Demolition of these structures and plans to accelerate D&D&D 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). A Programmatic Agreement with the SHPO 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

In 2003, approximately 3028 L (800 gal) of demineralized rinse water were released to the soil at INTEC. The release occurred during the final water flush for the transfer line encasements to the WM-184 tank containment vault. Because the rinse water came in contact with the encasements and vault, it carries RCRA hazardous waste codes F001, F002, F005, and U134. This release was reported to external agencies as required. Release notifications are conducted in accordance with DOE, EPA, and State of Idaho requirements.

2.3 Permits

Table 2-2 summarizes permits applied for, and granted to, the INEEL through year-end 2003.

REFERENCES

3 CFR, 2002, "Superfund Implementation," *Code of Federal Regulations*, Office of the Federal Register.

10 CFR 1022, 2001, "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.

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Chapter 3 - Environmental Program Information

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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 2003, 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 2003, 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. Significant progress was made during 2003.

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, Operable Unit 10-8).

A review of all CERCLA remediations completed under the WAG 2 Record of Decision was completed in 2003. It was determined that all requirements have been met and all identified FFA/CO-enforceable milestones related to the WAG 2 ROD have been completed. This is the first WAG at the INEEL to be closed out and prepared to transition into Long-Term Stewardship management.

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.

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. The Waste Management Program provided presentations to the INEEL Citizens Advisory Board to explain issues related to the program. Stakeholders were also notified of the timeframes for regulatory-required public comment periods and where documents could be found for their review and participated in several tours of the INEEL that featured the mission and accomplishments of the Waste Management Program.

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 2003, five 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 retrieval operations in March 2003.

As of 2003, six 1.14 million liter (300,000 gallon) underground tanks in the INTEC Tank Farm have been emptied and one of the tanks has been cleaned to State-approved standards. This leaves only five of these initial six tanks to be emptied.

Significant accomplishments were achieved during 2003 in the disposal of low-level and mixed waste stored and generated at the INEEL. Activities were highlighted by the treatment and disposal of over 900 m^3 (1177 yd^3) of mixed low-level waste. Approximately 4000 m^3 (5232 yd^3) of legacy and newly generated low-level waste was disposed at the Subsurface Disposal Area in 2003.

The Transuranic Waste Program continued transuranic waste shipments to the Waste Isolation Pilot Plant. A total of 384 m^3 (502 yd^3) were shipped in 2003.

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. The Environmental Management System meets the requirements of International Standards Organization (ISO) 14001. The INEEL EMS received ISO 14001 registration in June 2002. A semi-annual ISO 14001 surveillance performed in November 2003, found no nonconformances with the ISO standard.

All 62 spent nuclear fuel storage racks, the coffins, the transfer cart adapter, and miscellaneous equipment that had been in wet storage at Test Area North was transferred to dry storage at Test Area North's spent nuclear fuel storage pad in 2003. Power Burst Facility fuels were transferred to the Irradiated Fuel Storage Facility in 2003.

The INEEL Citizens Advisory Board was formed in March 1994. During its tenure, the Citizens Advisory Board has produced recommendations on over 100 topics. In 2003, the Board provided recommendations on seven critical topics.

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), INEEL Long-Term Stewardship Program (Section 3.4), Waste Management (Section 3.5), and Environmental Management System (Section 3.6). Section 3.7 summarizes 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). Descriptions of the airborne effluent monitoring programs are beyond the scope of this document and are not discussed. 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, 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 2003 and additional information on major programs can be found in Chapter 4 (air), Chapter 5 (compliance monitoring of water), Chapter 6 (surface and groundwater), and Chapter 7 (agricultural, wildlife, soil, and direct radiation). Chapter 9 presents 2003 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 5400.1 (DOE 1993). In January 2003 a new DOE order was established to cover environmental monitoring. DOE Order 450.1 was less prescriptive than the previous Order 5400.1 and created the requirement for DOE and contractor organizations to establish an Environmental Monitoring System (EMS). DOE is in the process of finalizing guidance on what constitutes a complete EMS, but many of the same components of Order 5400.1 remain (i.e., regular monitoring on environmental media).

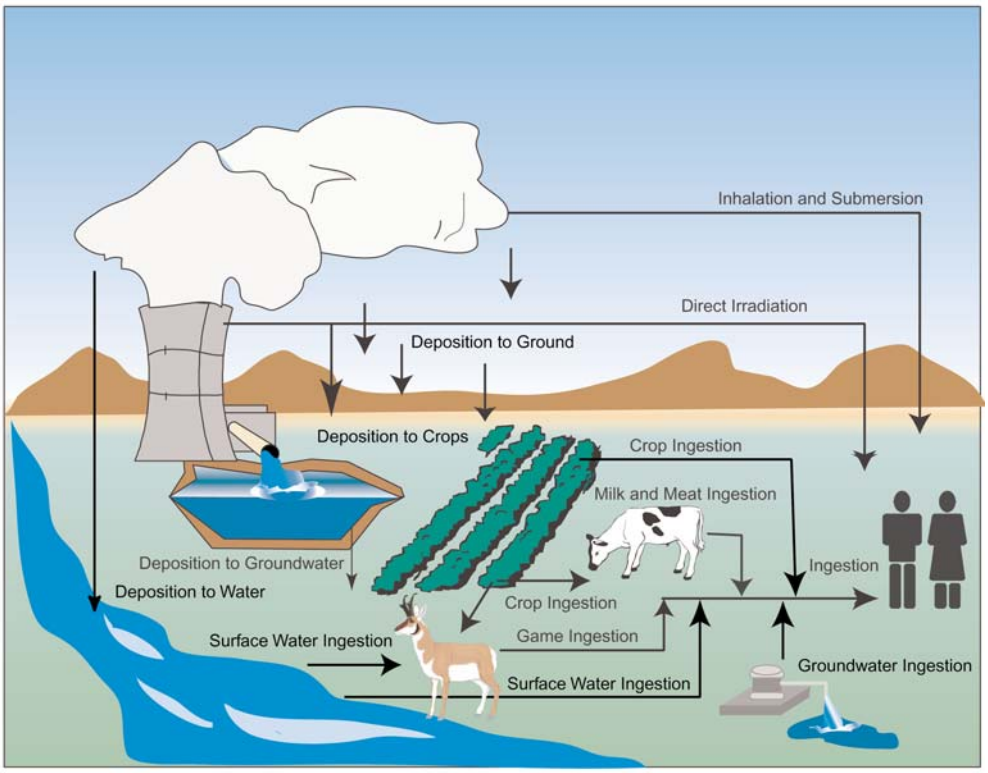

Figure 3-1. Potential exposure pathways to humans from the INEEL.

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 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 large scale, comprehensive 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 2003, Bechtel BWXT Idaho, LLC (BBWI) was the prime M&O contractor at the INEEL. The offsite monitoring program was transferred to the Environmental Surveillance, Education and Research Program (ESER) contractor. During 2003, 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 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 one station operated from 1989 through 2001 for sulfur dioxide.

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

Sampling Location	Dates of Operation
Distant Locations	
Aberdeen	1952–1957, 1960–1970
American Falls	1970
Blackfoot	1968–2001
Blackfoot Community Monitoring Station	1983–present
Carey	1961–1970
Craters of the Moon[a]	1973–present
Dubois	2001–present
Dietrich	1961–1970
Idaho Falls	1953–1955, 1956–present
Jackson	2001–present
Minidoka	1961–1970
Pocatello	1969–1980
Rexburg Community Monitoring Station	1983–present
Spencer	1953–1956
Boundary Locations	
Arco	1968–present
Atomic City	1953–1957, 1960–1970, 1973–present
Butte City	1953–1957, 1960–1973
Blue Dome	2001–present
Federal Aviation Administration Tower	1981–present
Howe	1958–present
Monteview	1958–present
Mud Lake	1958–present
Reno Ranch/Birch Creek	1958–2001
Roberts	1960–1970
Terreton	1953–1956, 1964–1965
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
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.

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 13 onsite and four offsite sampling locations.

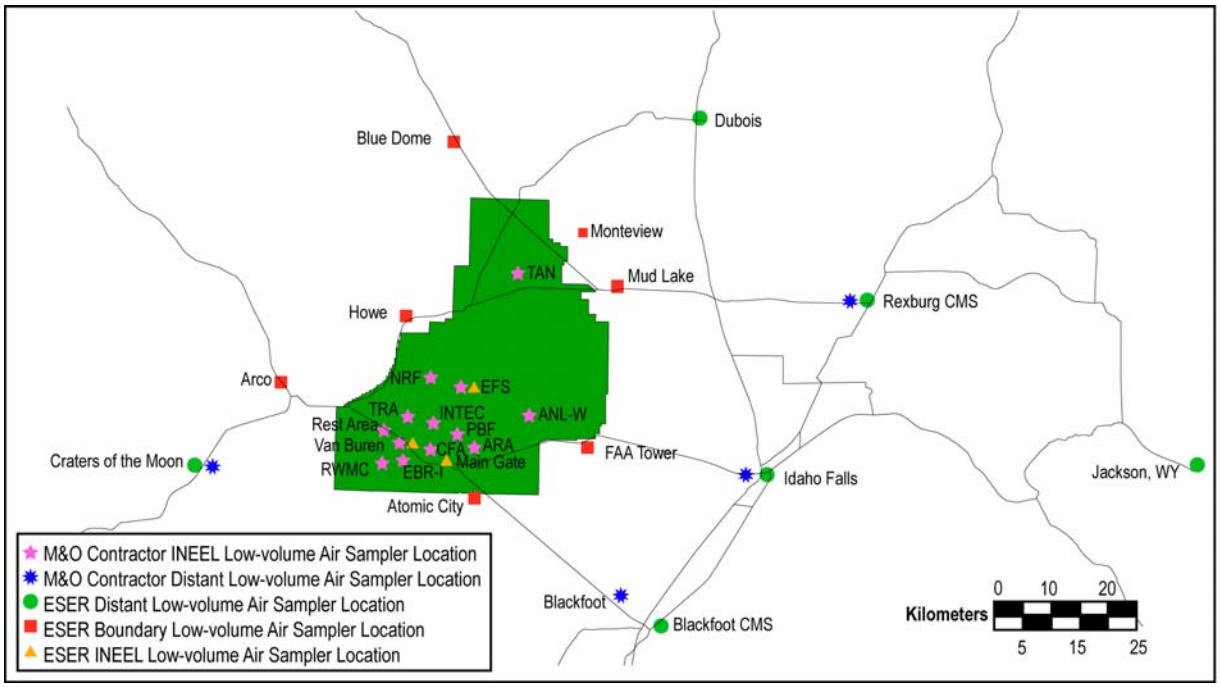

Figure 3-2. ESER and M&O contractor low-volume radiological air sampling locations.

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).

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 the 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 (0.6-1.0 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 in air 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.

Nitrogen oxides was monitored at the two stations on the INEEL (Van Buren Gate and EFS) through June 2003. Sulfur dioxide is no longer monitored at the one station (Van Buren Gate). Both these samplers have been placed on stand-by as the INEEL no longer releases either of these constituents. The IMPROVE sampler station at Craters of the Moon continued operation through 2003.

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) administer 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 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 (63 FR 189 1998).

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 1998). 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 2003 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 requirements at CFA, INTEC, and TAN as well as surveillance monitoring at INTEC. In 2003, Wastewater Land Application Permit required monitoring included collecting 231 groundwater samples yielding 700 parameter results. 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 2003. 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 2003. Previously the INEEL Environmental Hygiene Laboratory at CFA performed these analyses. However, in late 2002 this lab lost its state accreditation. The lab was moved from CFA to INTEC, but was still unable to regain its state accreditation. It was unlikely that any future effort would be made to regain accreditation. Bacteria samples will continue to be sent to Microwise in Idaho Falls. 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.

Storm water from the coal piles at INTEC did not discharge to the Big Lost River System in 2003; therefore, analytical monitoring was not required. Thus, monitoring in 2003 consisted only of quarterly visual monitoring at 22 locations and analytical monitoring at two RWMC locations and two locations at TAN.

In October 2003, the 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 directed M&O contractor to cease expending further resources on compliance 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 Programs at the three sites discussed in the letter from EPA (Bauer 2003). The letter further directed BBWI to conduct a technical analysis to determine any other areas at the M&O contractor INEEL 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 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 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 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 where 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., EFS) 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 also collects vegetation samples annually from around the Industrial Waste Pond and along the Industrial Waste Ditch. These samples are analyzed for selected alpha, beta, and gamma radionuclides.

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 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 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. 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 zero to five centimeters (0-5 cm) (zero to two inches [0-2 in.]) and five to ten centimeters (5-10 cm) (two to four inches [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 eighty-six sites were sampled in 2003. 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 Wastewater Land Application Permit soil loading limits.

ANL-W collects soil samples annually at locations along the major wind directions and at crosswind locations. 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 (~10-ft^2) area.

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 conducts annual surface radiation surveys of 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 to monitor ambient airborne radiation. The high pressure ionization chambers are oriented to the facility in the two major wind directions (northeast and southwest) and two cross-wind directions (north-northwest and southeast).

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 2003.

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.

Table 3-2. ESER environmental surveillance program summary (2003).

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^{-14} 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 gamma > 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)[c]	Specific gamma	4 annually	2 annually	5 pCi/g
	^{131}I	4 annually	2 annually	3 pCi/g
Animal Tissue (game)	Specific gamma	Varies annually[d]	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	11 annually	0.1 pCi/g
	^{90}Sr	None	11 annually	0.2 pCi/g
Agricultural Products (wheat)	Specific gamma	None	13 annually	0.1 pCi/g
	^{90}Sr	None	13 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 (2003).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	13 weekly	4 weekly	1×10^{-15} µCi/mL
	Gross beta	13 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	13 quarterly	4 quarterly	—[a]
	^{238}Pu	13 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{241}Am	13 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	13 quarterly	4 quarterly	2×10^{-14} µCi/mL
	Particulate matter	13 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)
Air	Nitrogen oxides	Continuous	—[b]	NA[c]
Air	Sulfur dioxide	Continuous	—	NA
Soil	Specific gamma	Varies annually[d]	—	0.1 pCi/g
	Pu isotopes	Varies annually	—	0.003 pCi/g
	^{241}Am	Varies annually	—	0.003 pCi/g
	^{90}Sr	Varies annually	—	0.06 pCi/g
Vegetation	Specific gamma	Varies annually[d]	—	1×10^{-7} µCi/g
	^{238}Pu	Varies annually	—	1.2×10^{-8} µCi/g
	$^{239/240}Pu$	Varies annually	—	6×10^{-10} µCi/g
	^{241}Am	Varies annually	—	1.2×10^{-8} µCi/g
	^{90}Sr	Varies annually	—	1.2×10^{-8} µCi/g
Drinking Water	Gross alpha	12 quarterly	—	1 pCi/L
	Gross beta	12 quarterly	—	4 pCi/L
	Tritium	12 quarterly	—	1,000 pCi/L
	^{90}Sr	4 quarterly	—	2 pCi/L
	Other radionuclides	12 quarterly	—	[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[e]	—	NA

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

b. Denotes that the M&O contractor does not collect samples from offsite locations for this parameter.

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

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

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

Table 3-4. ANL-W site environmental surveillance program summary (2003).

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 (2003).

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.

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 Environmental Management activities and reinvestment of savings into cleanup.

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 Environmental Management-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 Environmental Management buildings. These activities will be complete by 2035 with the exception of some minor activities leading to long-term stewardship (see Section 3.4). 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 2003, most notably:

- Demolished over 5,574 m^2 (60,000 ft^2) of buildings and structures;
- Completed physical remediation of Waste Area Group 4 (CFA);
- Completed excavation of Glovebox Excavation Method Project overburden;
- Began disposal of Comprehensive Environmental Response Compensation and Liability Act (CERCLA) soil in the INEEL CERCLA Disposal Facility (ICDF);
- Initiated decontamination and decommissioning activities at TAN and PBF; and
- Cleaned and sampled five Pillar and Panel high-level waste tanks at the INTEC.

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 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 CERCLA. By the end of 2003

- Twenty-two RODs have been signed and are being implemented;
- Three Remedial Investigation/Feasibility Studies (RI/FSs) are under development;
- Closeout activities at Waste Area Group 2 have been completed; and
- More than 70 percent of CERCLA actions are complete.

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 Waste Area Groups (WAGs) 1, 2, 3, 4, 5, 8, 9, and 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 remedial 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 the alternatives and recommending a preferred alternative After consideration of public comments DOE develops RODs selecting the alternative.

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 3-14); and
- Snake River Plain Aquifer contamination (WAG 10, Operable Unit 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 2003, the Agencies agreed on a new remedy for the V-tank 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 gallon) and one 1514 L (400 gallon) underground storage tanks. The contents are contaminated with radionuclides, heavy metals, and organic compounds. The out-of-state treatment remedy selected in the 1999 ROD is no longer available. The amended 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.

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 1980's 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.

Additional activities in 2003 include:

- Obtained approval to operate a landfill for uncontaminated construction and demolition debris resulting from dismantlement of structures at TAN;
- Submitted Operable Unit 1-10, Group 3 Draft Remedial Design/Remedial Action Work Plan;
- Submitted Operable Unit 1-07B New Pump and Treat Facility Draft Operations and Maintenance Plan; and
- Submitted Operable Unit 1-07B Monitoring Natural Attenuation Draft Remedial Design/Remedial Action Work Plan.

Waste Area Group 2 - Test Reactor Area

A review of all CERCLA remediations completed under the WAG 2 ROD was completed in 2003 and all requirements have been met. The review covered all WAG 2 CERCLA decision documents; operations, maintenance, and monitoring plans; identified sites investigated in each type of document (Track 1, Track 2, RI/FS, etc.); and closeouts of subcontracts, charge numbers, and total gathered costs. All identified FFA/CO-enforceable milestones related to the WAG 2

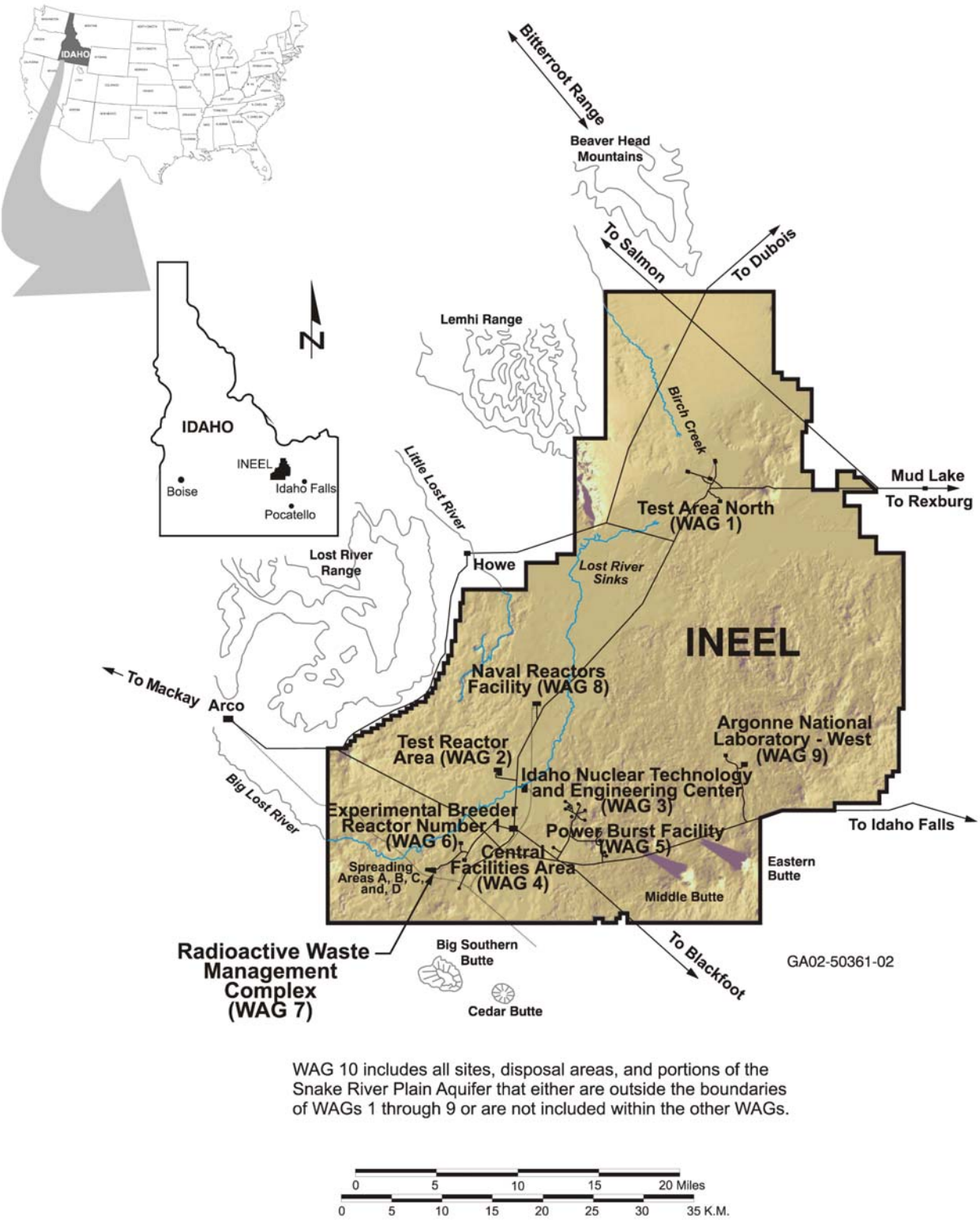

Figure 3-3. Relief map of the INEEL showing locations of the facilities and corresponding waste area groups.

ROD have been completed. New sites that were identified after the ROD was signed are addressed in the OU 10-08 ROD. Most importantly, the review concluded that the selected remedies were protective of human health and the environment. This is the first WAG at the INEEL to be closed out and prepared for transition into Long-Term Stewardship management.

Waste Area Group 3 - Idaho Nuclear Technology and Engineering Center

Operations at the ICDF commenced in 2003, disposing of over 18,000 tons of contaminated soil and materials. This site consolidates low-level contaminated soils and debris from sitewide INEEL cleanup operations and segregates those wastes from potential migration to the aquifer, reducing risk to the public and environment. Other major accomplishments at WAG 3 include:

- Submitted the Operable Unit 3-14 Tank Farm RI/FS Draft Work Plan;
- Completed Phase I of the Operable Unit 3-13 Tank Farm Interim Action (evaporation pond liner and drainage ditches) identified in the 2002 Notice of Violation;
- Completed field work on Operable Unit 3-13 Group 6, Buried Gas Cylinders CPP-94 site remediation;
- Submitted Operable Unit 3-13 Group 7 Draft Remedial Design/Remedial Action Work Plan; and
- Submitted Operable Unit 3-13 Group 3 WAG 3 Soils Draft Remedial Design/Remedial Action Work Plan.

Waste Area Group 4 - Central Facilities Area

In 2003, the Agencies agreed to change the remedy for CFA-04, a pond that was contaminated with mercury from experiments that took place in the Chemical Engineering Laboratory. Based on new EPA guidelines, the final remediation goal for the pond soil is increased and the requirement to backfill the pond with clean soil is eliminated. Soil that exceeds the remediation goal of 8.4 mg/kg was excavated as deep as 3 m (10 ft) below ground surface or to basalt, depending on the depth of contamination. The excavated soil was disposed at the ICDF or the CFA landfill. Excavated soil that met the characteristics for hazardous waste for mercury was stabilized with concrete before disposal.

An FFA/CO-enforceable milestone was achieved with the submittal of the Operable Unit 4-13 CFA-04 Draft Remedial Design/Remedial Action Work Plan.

Waste Area Group 5 - Power Burst Facility/Waste Reduction Operations Complex

This area supported two reactor facilities-the PBF and the Auxiliary Reactor Area (ARA). Cleanup activities at WAG 5 are nearly complete. Soil contamination in the ARA will be remediated in 2004.

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

The following accomplishments were achieved at WAG 6/10 in 2003:

- Submitted Operable Unit 10-04 Draft Remedial Design/Remedial Action Work Plan for Sitewide Institutional Controls and Ecological Monitoring; and
- Issued the Long-Term Ecological Monitoring Plan for the INEEL to determine that the long-term INEEL-wide ecological impact of the contamination left in place is within acceptable limits.

Waste Area Group 7 - Radioactive Waste Management Complex

Waste Area Group 7 includes the Subsurface Disposal Area (SDA), a 39-hectare (97-acre) disposal area containing buried hazardous and radioactive waste. Organic solvents contained in this waste are a source of groundwater contamination and are being removed by an ongoing cleanup action. Projects are currently underway to gain more information about the contents of the pits and trenches of the SDA to aid decision-makers in determining the best treatment technology. The State, EPA, and DOE-ID agreed on a revised technical approach, the Glovebox Excavator Method project or GEM, to demonstrate retrieval from a small area of Pit 9. Workers will remotely excavate wastes and examine them in a shielded confinement structure or glovebox. The glovebox operates under negative air pressure to prevent contamination from escaping. The waste will be treated for shipment to the Waste Isolation Pilot Plan in New Mexico. The following accomplishments were achieved at WAG 7 in 2003:

- 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, more than 88,128 kg (194,289 lb) of these contaminants have been removed and destroyed.
- GEM operations commenced with removal of the soil overburden. Waste excavation will begin in 2004.

Waste Area Group 8 - Naval Reactors Facility

The Naval Reactors Facility (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. 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 Expended Core Facility 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 2003 included the following:

- Phase I Remedial Actions which included the excavation of contaminated soil and pipe and removal of concrete structures was completed. The pipe and concrete have been sent offsite (away from NRF) as low-level radioactive waste and the soil was consolidated onsite in preparation for containment within an engineered cover; and

- Phase II Remedial Actions including the construction of three engineered covers over contaminated soil areas continued. This effort will be completed in 2004.

Waste Area Group 9 - Argonne National Laboratory-West

DOE received post-phytoremediation soil sampling results from four sites at ANL-West. The results showed that remediation goals were met at the cesium-contaminated Interceptor Canal Mound site (ANL-09), and the Main Cooling Tower Blowdown Ditch (ANL-01A). Small areas of residual metals contamination were detected in two sites, Ditch A (ANL-01), and the Industrial Waste Discharge Ditch (ANL-35). A Scope of Work was developed to excavate these localized areas of residual contamination. The total amount of residual contaminated soil to be excavated is less than 76 m^3 (100 yd^3). Excavation work is scheduled for August 30, 2004.

CERCLA Public Health Assessment

The Agency for Toxic Substances and Disease Registry (ATSDR) has conducted a public health assessment of the INEEL as required by CERCLA for all sites on the National Priorities List. The focus of the public health assessment is to provide information about the impact of past activities on the health of citizens living near the INEEL. ATSDR released the draft public health assessment for public review and comment in 2003.

3.4 INEEL Long-Term Stewardship Program

Completing the remediation activities at the INEEL in compliance with the regulatory agreements governing them will result in residual contamination remaining at some locations onsite. The sites where residual contaminants remain will require long-term stewardship (LTS) to prevent unacceptable contact between waste residue and the public, and to initiate subsequent cleanup activities in the event of an unforeseen increase in contaminant transport through the soil or groundwater. The term LTS refers to all activities necessary to protect human health and the environment following completion of remediation, disposal, or stabilization of a site or a portion of a site. The INEEL considers the scope of LTS to also include conserving ecological and cultural resources and maintaining awareness of changes in technology, regulations, and policy affecting these stewarded sites.

While LTS activities such as monitoring groundwater, conducting surveillance of remedies and maintenance of caps and landfills, and restricting access to residually contaminated sites have been conducted for years at the INEEL under the auspices of several different programs, DOE recognized that management advantages could be gained by consolidating these similar activities into one program. In fiscal year 2000, DOE-ID developed a schedule for creating an INEEL LTS Plan to describe the strategic and tactical elements of a consolidated LTS Program at the INEEL.

Creation of an LTS Program represents a management consolidation of post-remediation responsibilities, regardless of what law or agreement governs the remedy. Consolidating these activities does not change any agreed-upon obligations for the operation, maintenance, monitoring, institutional control, or post-closure care identified in RODs, Hazardous Waste Management Act/Resource Conservation Recovery Act (RCRA) closure plans, or other agreements. Rather, creation of the INEEL LTS Program is a way to implement post-remediation responsibilities agreed to under a variety of regulations in a more efficient and focused manner.

Development of INEEL LTS Plan

The INEEL LTS Plan consists of two parts: (1) a strategic portion, in which the overall vision, mission, objectives, and goals of the program will be captured and (2) a tactical portion, which will document the specific activities and schedules necessary to achieve the vision, mission, objectives, and goals.

Regulators, environmental advocates, state and local governments, federal and state land and resource management agencies, the Shoshone-Bannock Tribes, and the general public developed the vision, mission, and objectives of the INEEL LTS Program that forms the foundation of the INEEL LTS Strategic Plan published in 2002. The INEEL LTS Implementation Plan published in 2003 describes specific long-term stewardship activities that meet the objectives of the LTS Strategic Plan and also identifies additional activities and modifications to current systems needed to meet Strategic Plan objectives. Combined, the two documents constitute the INEEL LTS Plan. Both Plans can be accessed at http://cleanup.inel.gov/stewardship/.

3.5 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.

In accordance with the Site Treatment Plan, the INEEL began receiving offsite mixed waste for treatment in January 1996. The INEEL received mixed waste from other sites within the DOE complex including Hanford, Los Alamos, Paducah, Pantex, Sandia, and six locations managed by the Office of Naval Reactors. The INEEL is storing the backlog of mixed waste in permitted storage at the Waste Reduction Operations Complex and INTEC. The Site Treatment Plan requires that disposal of the backlog of mixed waste will occur by no later than 2006; under the INEEL's accelerated cleanup initiative, the backlog will be eliminated in 2004, two years earlier than the scheduled milestone.

During 2003, the following Site Treatment Plan milestones were met:

- Commercial treatment/disposal of a backlog -- 120 m^3 (157 yd^3);
- Sodium Components Maintenance Shop treatment backlog -- 2.0 m^3 (70.6 ft^3);
- High-efficiency particulate air filter leach treatment -- 0.9 m^3 (31.8ft^3);
- Debris backlog treatment -- 52 m^3 (1836 ft^3); and
- Advanced Mixed Waste Treatment Project commence operations.

Advanced Mixed Waste Treatment Project

The overall goal of the Advanced Mixed Waste Treatment Project is the treatment of alpha-containing low-level mixed and transuranic (TRU) 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 British Nuclear Fuels Limited, Inc. in December 1996. They completed construction of the facility in December 2002, fulfilling a Settlement Agreement milestone. Advanced Mixed Waste Treatment Plant retrieval operations commenced in March 2003.

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 3.7 million L (one million gal) of sodium-bearing liquid waste is stored in up to eleven 1.14 million L (300,000 gal) underground tanks in the Tank Farm. Six of these tank farm tanks

have been emptied, cleaned, and removed from service in preparation of final closure. The other five tank farm tanks remain in service to store the sodium-bearing waste. 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 2250 m^3 (2943 yd^3) backlog of mixed low-level waste. In 2003, INEEL treated and disposed of more than 900 m^3 (1177 yd^3) of mixed low-level waste. By calendar year-end, more than half the backlog was removed from Idaho with just under 1150 m^3 (1504 yd^3) remaining that requires treatment and disposal. The remaining backlog inventory will be eliminated in 2004, two years ahead of schedule under an accelerated cleanup plan. Approximately 4000 m^3 (5232 yd^3) of legacy and newly generated low-level waste were disposed at the SDA in 2003.

Transuranic Waste

The Settlement Agreement requires that the INEEL must ship at least 6000 m^3 (7848 yd^3) of TRU waste out of Idaho between January 1, 2003 and December 31, 2005. In 2003, INEEL shipped a total of 384 m^3 (502 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 also required by various federal statutes, including but not limited to, the Pollution Prevention Act; RCRA; Executive Order 12856; and Executive Order 12873 (Federal Acquisition, Recycling, and Waste Prevention).

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 Environmental Management System (see Section 3.6). 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 2003 include:

- 91,685 kg (202,130 lb) of office paper and corrugated cardboard were recycled through a local company, saving $156,000.
- An alternative in-situ process to chemically treat 45,000 gallons of low-level liquid radioactive waste containing potassium permanganate was used, saving approximately $270,000.

3.6 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 Environmental Management System (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 2003, supporting maintenance of the registration, found no nonconformances with the ISO standard and generated high praise for INEEL personnel.

3.7 Other Major Environmental Issues and Activities

Decontamination, Decommissioning, and Demolition Activities

INEEL greatly stepped up efforts to reduce the EM "footprint" through accelerated decontamination, decommissioning, and demolition 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 5574 m^2 (60,000 ft^2) of buildings and structures were demolished in 2003. Specific projects at various facilities are described below.

Test Area North - The most dramatic transformation has occurred at TAN, where more than 20 EM-owned buildings and structures were demolished in 2003. Miscellaneous laboratory, maintenance, storage, and equipment buildings as well as tanks and related structures were documented in compliance with the National Historic Preservation Act and removed according to three Memoranda of Agreement with the Idaho State Historic Preservation Office.

Power Burst Facility/Waste Reduction Operations Complex - Decontamination and dismantlement of the Waste Experimental Reduction Facility (WERF) was completed in 2003 with removal of the WERF auxiliary building, dismantlement of the North Stack Area, and dismantlement of the Highbay Room. Several other PBF structures were removed, shutdown, or abandoned in place including the PBF cooling tower.

Test Reactor Area - The Materials Test Reactor (MTR) canal high-radiation materials were cut and segregated for disposition in the MTR canal cask in support of MTR canal closure.

Security Training Facility - The reactor vessel was dismantled and removed. More than 63 tons of carbon and stainless steel were removed from the project site.

Spent Nuclear Fuel

Spent nuclear fuel (SNF) is defined as fuel that has been withdrawn from a nuclear reactor following irradiation and the constituent elements have not been separated. Upon removal, SNF contains some unused enriched uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. A large amount of DOE's spent nuclear fuel is from national defense and other programmatic missions. Most of the fuel stored at the INEEL is at the INTEC.

For several years, spent nuclear fuel was reprocessed so recovered fissile material could be reused. However, the need for fuel grade uranium and plutonium decreased. A 1992 decision to stop reprocessing left a large quantity of spent nuclear fuel in storage.

DOE's spent nuclear fuel is stored in both wet and dry storage. Dry storage is preferred because it reduces concerns about corrosion and is less expensive to monitor. An effort is underway to put spent nuclear fuel in temporary dry storage so that it can be quickly readied for transport once a repository is completed. The INEEL's goal is to begin shipping spent nuclear fuel to a national repository by September 30, 2015. The Idaho Settlement Agreement, and a similar agreement with the state of Colorado, requires that all spent nuclear fuel must be out of Idaho by January 1, 2035. A significant accomplishment was achieved in 2003 when the last of the INEEL's aging wet storage basins at the PBF and TAN were emptied of spent nuclear fuel.

Spent nuclear fuel transfers and storage facilities are described below.

Fluorinel Dissolution Process and Fuel Storage Facility - This INTEC facility, also called FAST, is divided into two parts: a spent fuel storage area and the Fluorinel Dissolution Facility. This facility went operational in 1983. The storage area consists of six storage pools where spent nuclear fuel is stored under about 11 million L (3 million gal) of water, which provides protective shielding and cooling. Fuel formerly managed in the three storage pools at CPP-603 has been transferred to the newer underwater storage pools at FAST or to dry storage. Eventually, all spent nuclear fuel will be removed from underwater storage pools and placed in a dry storage system in preparation for shipment to a repository. In 2003, the Advanced Test Reactor dispatched 21 shipments of spent nuclear fuel to FAST for storage.

Irradiated Fuel Storage Facility - The Irradiated Fuel Storage Facility (IFSF), the dry side of the Wet & Dry Fuel Storage Facility (CPP-603), provides dry storage for spent nuclear fuel. The original facility (the wet side - basins) went operational in 1953. The IFSF was added later and went operational in 1973. The facility has 636 storage positions and is over half full. The majority of the spent nuclear fuel stored at the IFSF came from the Fort St. Vrain commercial reactor in Colorado. In the largest single fuel shipment of spent nuclear fuel ever made in the U.S., the DOE West Valley site in New York shipped 125 assemblies in two casks to the INEEL in July 2003 for storage at IFSF. INEEL also received fuel shipments from DOE Oak Ridge, General Atomics, Cornell University, and Japan. In addition, all remaining MTR and PBF fuel was shipped to the IFSF for interim storage.

TAN Hot Shop/Manufacturing & Assembly Facility - TAN Hot Shop/Manufacturing & Assembly Facility, TAN-607, contains a hot shop (for handling spent nuclear fuel), and a spent fuel storage basin. TAN-607 went operational in 1955. Loss-of-Fluid Test, commercial, and test reactor SNF (totaling 3.6891 metric tons - heavy metal [MTHM] [4.06 tons]) was transferred from wet storage in the basin, dried, placed within casks, and the casks relocated to the storage pad, TAN-791, in 2002. A new pad, CPP-2707, is under construction at INTEC to which the casks will be transferred in 2004. All 62 spent nuclear fuel storage racks, the coffins, the transfer cart adapter, and miscellaneous equipment were removed from the TAN-607 storage basin in 2003. The basin water will be removed and disposed at the TRA evaporation pond.

TMI-2 Independent Spent Fuel Storage Installation - The Independent Spent Fuel Storage Installation (ISFSI), CPP-1774, is an NRC-licensed dry storage area for spent fuel 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 spent fuel and debris were transferred to the ISFSI. The ISFSI provides safe, environmentally secure, aboveground storage for the spent fuel and debris, which is kept in metal casks inside concrete vaults.

Power Burst Facility - The PBF, built in 1970, supported DOE and NRC studies of reactor fuel during normal and off-normal operating conditions. The PBF operated as a one-of-a-kind facility, with the ability to subject fuel samples to extraordinary power surges in milliseconds, causing the fuel to fail in an isolated, contained system. The NRC then used that information in developing safe operating limits for the commercial nuclear power industry. In 1985, the PBF reactor was placed on stand-by status and was eventually placed in shutdown status in 1998. PBF fuels were transferred to the IFSF in 2003.

Peach Bottom Fuel Storage Facility - The Peach Bottom Fuel Storage Facility, CPP-749, consists of below ground vaults for the dry storage of spent nuclear fuel. 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 totally below grade and are accessed from the top using equipment specifically designed for this use. This facility stores Peach Bottom fuel as well as other unirradiated fuels.

Fort Saint Vrain Independent Spent Fuel Storage Installation - The DOE manages this offsite NRC-licensed dry storage facility containing about two-thirds of the spent nuclear fuel generated at the Fort Saint Vrain reactor in Colorado.

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 http://www.oversight.state.id.us/.

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:

- End State Vision for the INEEL;
- Long-Term Stewardship Implementation Plan for the INEEL;
- Engineering Evaluation and Costs Analyses for CPP-603, CPP-637 and other facilities;
- Environmental Assessments of the ETR and MTR;
- Impacts of the New Mission on INEEL Cleanup;
- Cleanup of Pit 4; and
- Waste streams with no current disposition path.

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Chapter 4 - Environmental Monitoring Programs (Air)

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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 7796 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2003. 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 nitrogen dioxide and 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 Guide (DCG) 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 pathways (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 3400 air samples (primarily on the INEEL) for analyses in 2003.

The ESER contractor collects samples from an approximately 23,309 km^2 (9000 mi^2) area of southeastern Idaho at locations on, around, and distant to the INEEL. The ESER Program collected approximately 2600 air samples, primarily off the INEEL, for analyses in 2003. 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.

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 standard deviation (± 1s) uncertainty for that radiological analysis.

4.2 Air Sampling

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

Environmental surveillance of air pathways is the responsibility of the M&O contractor (specifically, the Environmental Services Program) 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 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.

Table 4-1. Air monitoring activities by organization.

Area/Facility[a]	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs									
	Airborne Effluents[b]	Low-Volume Charcoal Cartridges (iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation	Suspended Particulates	Filtered Particulates (PM_{10})[d]	Nitrogen Dioxide	IMPROVE samplers
Argonne National Laboratory-West											
ANL-W	•				•						
Management and Operating Contractor											
INTEC	•										
TAN	•										
PBF/CITR	•										
INEEL		•	•	•	•	•		•	•	•	
Naval Reactors Facility											
NRF[f]	•										
Environmental Surveillance, Education and Research Program											
INEEL/Regional		•	•	•	•	•	•	•	•		•[e]
National Oceanic and Atmospheric Administration											
INEEL/Regional						•	•	•	•		
INEEL Oversight Program Environmental Surveillance Program[g]											
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 require continuous monitoring for compliance with 40 Code of Federal Regulations (CFR) 61, Subpart H, National Emissions Standards for Hazardous Air Pollutants (NESHAP) Regulation. The exception is NRF. See footnote f.

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

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

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

f. 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).

g. This program, administered by the state of Idaho, generates data that can be used to verify and supplement the results reported by the Management and Operating Contractor and the Environmental Surveillance, Education and Research Program. The data are reported separately by the state of Idaho and are not reported in this report.

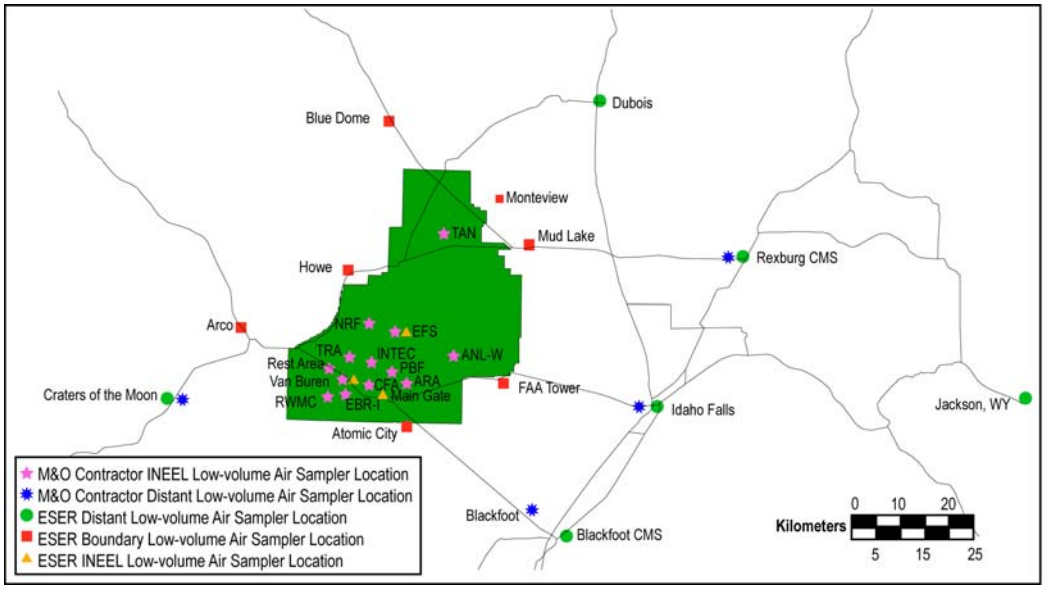

Figure 4-1. INEEL environmental surveillance air sampling locations.

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}) to comply with EPA air quality standards.

Sulfur dioxide measurements were recorded in past years to confirm that the INEEL does not release significant amounts of sulfur dioxide with respect to national ambient air quality standards. The M&O contractor no longer monitors sulfur 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 (silica gel or 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 2003, an estimated 7796 Ci of radioactivity was released to the atmosphere from all INEEL sources. *The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Calendar Year 2003 INEEL Report for Radionuclides* (DOE-ID 2003) 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. The NESHAP document reports only the first category results, whereas all three categories are included in Table 4-2 of this report.

The largest facility contributions to the total emissions came from the Idaho Nuclear Technology and Engineering Center (INTEC) at more than 77 percent, Test Reactor Area (TRA) at approximately 15 percent, and Argonne National Laboratory-West (ANL-W) at approximately 7 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 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 2003, the ESER contractor analyzed 841 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 the 3s uncertainty ranged from a minimum of $(0.51 \pm 0.16) \times 10^{-15}$ µCi/mL at the Rexburg Community Monitoring Station (CMS) during the week ending November 25, 2003, to a maximum of $(11.3 \pm 1.1) \times 10^{-15}$ µCi/mL during the week ending August 13, 2003, at Monteview. The latter measurement represents a bounding calculation of the true concentration. The exact volume of the sample collected is uncertain because the filter was so clogged when collected that the vacuum pressure was exceptionally high. The pressure is used in the calculation of the volume and assumes a steady increase in pressure over time. Because a hay harvest was in progress during collection, it was postulated that the particulates from the harvest may have been responsible and that the filter clogging occurred just prior to collection. If this is true, the actual

Table 4-2. Radionuclide composition of INEEL airborne effluents (2003).[a]

Radionuclide	Half-Life	Airborne Effluent (Ci)[a,b] AMWTP	ANL-W	CFA	INTEC[c]	NRF[d]	PBF	RWMC	TAN	TRA	Total
Ar-41	1.83 h	--[e]	1.41E+00	--	--	--	--	--	--	8.20E+02	**8.21E+02**
Kr-85	10.7 yr	2.14E-13	5.34E+02	--	5.30E+03	--	4.20E-06	--	9.77E-04	4.87E-06	**5.84E+03**
Kr-85m	4.4 h	--	--	--	--	--	--	--	--	2.31E+00	**2.31E+00**
Kr-87	--	--	--	--	--	--	--	--	--	1.62E+00	**1.62E+00**
Kr-88	--	--	--	--	--	--	--	--	--	3.92E+00	**3.92E+00**
Xe-133	5.25 d	--	--	--	--	--	--	--	--	1.48E+01	**1.48E+01**
Xe-135	--	--	--	--	--	--	--	--	--	1.23E+01	**1.23E+01**
Xe-135m	--	--	--	--	--	--	--	--	--	5.36E-01	**5.36E-01**
Xe-138	9.10 h	--	--	--	--	--	--	--	--	2.99E+00	**2.99E+00**
H-3	--	2.75E-04	3.29E+00	3.25E+00	7.12E+02	5.80E-02	2.27E-02	5.01E+01	2.05E+00	3.25E+02	**1.10E+03**
C-14	5,700 yr	2.48E-06	--	--	8.40E-04	3.70E-01	1.26E-06	8.64E-01	1.55E-08	2.37E-05	**1.23E+00**
Ag-110m	--	--	--	--	1.34E-09	--	3.12E-13	--	2.21E-20	1.97E-06	**1.97E-06**
Am-241	458 yr	3.81E-09	--	--	1.90E-07	--	1.04E-11	2.00E-10	5.14E-06	2.70E-04	**2.76E-04**
Am-243	--	--	--	--	2.95E-12	--	5.12E-15	--	1.90E-15	1.23E-16	**1.23E-06**
Ba-133	--	--	--	--	1.40E-15	--	--	--	--	7.58E-15	**7.58E-05**
Ba-137m	30.2 yr	--	--	--	5.70E-08	--	--	--	--	1.02E-03	**1.02E-03**
Ba-139	--	--	--	--	--	--	--	--	--	1.24E-04	**1.24E-04**
Ba-140	--	--	--	--	--	--	--	--	--	8.10E-07	**8.10E-07**
Ba-141	--	--	--	--	--	--	--	--	--	2.05E-09	**2.05E-09**
Ce-141	--	--	--	--	--	--	--	--	--	2.22E-07	**2.22E-07**
Ce-144	--	8.45E-13	--	--	4.53E-11	--	1.09E-12	--	1.01E-14	1.63E-06	**1.63E-06**
Cm-242	--	--	--	--	--	--	2.03E-15	--	3.07E-28	1.02E-06	**1.02E-06**
Cm-244	--	1.68E-11	--	--	--	--	1.55E-13	--	1.03E-14	2.44E-04	**2.44E-04**
Co-58	--	--	--	--	9.38E-10	--	1.04E-12	--	--	9.12E-05	**9.12E-05**
Co-60	--	3.12E-12	--	--	4.51E-04	2.30E-07	2.60E-07	--	2.41E-05	6.85E-02	**6.89E-02**
Cr-51	5.27 yr	--	--	--	3.92E-09	--	3.88E-13	--	--	1.97E-02	**1.97E-02**
Cs-134	--	3.46E-12	--	--	9.36E-06	--	1.76E-11	--	4.36E-08	3.11E-05	**4.05E-05**
Cs-137	--	7.05E-11	--	3.90E-07	4.46E-0	2.10E-04	5.83E-04	--	2.11E-01	2.00E-02	**2.76E-01**
Cs-138	30.2 yr	--	--	--	--	--	--	--	--	8.72E-03	**8.72E-03**
Eu-152	--	--	--	--	8.77E-05	--	3.81E-11	--	7.51E-10	0.00107	**1.16E-03**
Eu-154	12.7 yr	--	--	--	2.42E-04	--	5.76E-11	--	7.11E-08	1.27E-03	**1.51E-03**

Table 4-2. Radionuclide composition of INEEL airborne effluents (2003).[a] (continued)

Effluent Type[b]	Radionulide	Half-Life	Airborne Effluent (Ci)c AMWTP	ANL-W	CFA	INTEC	NRF	PBF	RWMC	TAN	TRA	Total
	Eu-152	--	--	--	--	8.77E-05	--	3.81E-11	--	7.51E-10	0.00107	**1.16E-03**
	Eu-154	12.7 yr	--	--	--	0.000242	--	5.76E-11	--	7.11E-08	0.001272	**1.51E-03**
	Eu-155	16 yr	--	--	--	0.000105	--	2.64E-11	--	6.81E-08	0.000442	**5.47E-04**
	Fe-55	--	3.53E-14	--	--	1.15E-08	--	1.20E-10	--	3.09E-07	0.00179	**1.79E-03**
	Fe-59	--	--	--	--	4.86E-12	--	2.23E-14	--	--	1.15E-05	**1.15E-05**
	Hf-181	--	--	--	--	1.07E-10	--	2.56E-13	--	--	3.02E-05	**3.02E-05**
	Hg-203	--	--	--	--		--	--	--	--	1.22E-05	**1.22E-05**
	I-125	--	--	--	--	2.27E-05	--	0.000197	--	--	--	**2.20E-04**
	I-129	--	--	--	--	0.071776	--	4.82E-05	--	1.82E-06	0.00028	**7.21E-02**
	I-131	1.6*10^7 yr	--	--	--	6.55E-09	5.90E-06	1.53E-08	--	--	0.207078	**2.07E-01**
	I-132	8.04 d	--	--	--	--	--	--	--	--	0.0004	**4.00E-04**
	I-133	--	--	--	--	--	--	--	--	--	0.000277	**2.77E-04**
	I-134	--	--	--	--	--	--	--	--	--	0.00129	**1.29E-03**
	I-135	--	--	--	--	--	--	--	--	--	0.000483	**4.83E-04**
	Ir-192	--	--	--	--	6.15E-18	--	--	--	--	0.000228	**2.28E-04**
	K-40	--	--	--	--	--	--	--	--	--	--	**1.20E-08**
	La-140	--	--	--	--	--	--	--	--	1.50E-116	1.90E-06	**1.90E-06**
	Mn-54	--	--	--	--	1.45E-10	--	6.85E-13	--	--	9.34E-05	**9.34E-05**
	Mo-99	--	--	--	--	--	--	--	--	--	0.000791	**7.91E-04**
	Na-24	--	--	--	--	--	--	--	--	--	0.000217	**2.17E-04**
	Nb-94	--	--	--	--	1.10E+10	--	6.46E-13	--	8.38E-11	2.02E-06	**2.02E-06**
	Nb-95	--	--	--	--	1.34E-09	--	2.76E-12	--	2.73E-44	1.48E-06	**1.48E-06**
	Ni-59	--	--	--	--	1.24E-10	--	2.55E-12	--	1.49E-09	5.12E-06	**5.13E-06**
	Ni-63	--	1.11E-13	--	--	0.00033	--	3.56E-10	--	1.49E-07	0.000803	**1.13E-03**
	Np-239	--	--	--	--	1.54E-12	--	5.03E-15	--	1.90E-15	6.49E-05	**1.13E-03**
	Pb-212	--	--	--	--	--	--	--	--	--	--	**6.49E-05**
	Pm-147	--	8.52E-13	--	--	0.000422	--	6.57E-09	--	0.409158	0.000257	**0.409838**
	Pr-144	--	8.49E-13	--	--	--	--	--	--	--	--	**1.94E-11**
	Pu-238	--	3.62E-09	--	--	0.000171	--	3.65E-11	--	1.03E-07	9.16E-06	**0.000181**

Table 4-2. Radionuclide composition of INEEL airborne effluents (2003).[a] (continued)

		Airborne Effluent (Ci)[a,b]									
Radionuclide	Half-Life	AMWTP	ANL-W	CFA	INTEC[c]	NRF[d]	PBF	RWMC	TAN	TRA	Total
Ra-226	--	--	--	--	--	--	--	--	--	--	**1.50E-07**
Rb-88	--	--	--	--	--	--	--	--	--	2.70E-01	**2.70E-01**
Rb-89	--	--	--	--	--	--	--	--	--	3.58E-02	**3.58E-02**
Ru-106	--	--	--	--	--	--	--	--	--	--	**9.78E-09**
Sb-124	--	--	--	--	3.04E-12	--	--	--	1.18E-51	7.78E-06	**7.78E-06**
Sb-125	--	5.15E-14	--	--	3.52E-05	--	1.09E-11	--	1.45E-08	4.62E-07	**3.57E-05**
Sb-127	2.73 yr	--	--	--	--	--	--	--	--	9.55E-06	**9.55E-06**
Sc-46	--	--	--	--	5.37E-12	--	--	--	--	1.06E-06	**1.06E-06**
Sm-151	--	--	--	--	5.61E-04	--	2.89E-11	--	1.97E-09	2.00E-08	**5.61E-04**
Sr-89	--	--	--	--	1.35E-14	--	7.08E-15	--	3.41E-55	5.93E-05	**5.93E-05**
Sr-90	--	6.30E-11	3.28E-06	3.36E-07	3.35E-0	9.40E-05	1.71E-04	--	5.83E-03	1.37E-03	**4.10E-02**
Tc-99m	28.6 yr	--	--	--	--	--	--	--	--	5.00E-04	**5.00E-04**
Te-125m	--	--	--	--	--	--	--	--	--	--	**2.42E-09**
Th-232	2.73 yr	2.28E-13	--	--	--	--	--	--	--	--	**1.02E-08**
U-232	--	8.11E-13	--	2.00E-10	--	--	--	--	--	--	**1.23E-07**
U-233	--	3.18E-11	--	--	1.43E-06	--	--	--	--	--	**5.77E-07**
U-234	--	1.80E-13	--	3.20E-06	1.20E-06	--	1.24E-08	--	7.84E-09	1.29E-06	**5.94E-06**
U-235	--	--	--	1.00E-06	1.82E-07	--	3.34E-11	--	1.85E-09	2.14E-08	**1.09E-06**
U-238	--	--	--	5.10E-06	--	--	1.21E-08	--	4.46E-08	7.96E-08	**5.42E-06**
W-187	--	--	--	--	1.07E-07	--	--	--	--	1.61E-05	**1.61E-05**
Y-90	--	--	--	--	2.02E-10	--	--	--	1.66E-03	1.84E-04	**1.84E-04**
Zn-65	28.6 yr	--	--	--	3.12E-06	--	3.41E-13	--	--	3.42E-04	**3.42E-04**
Zr-95	--	--	--	--	--	--	1.85E-12	--	--	8.99E-07	**4.02E-06**
Totals	--	**2.77E-04**	**5.39E+02**	**3.25E+00**	**6.02E+03**	**4.28E-01**	**2.37E-02**	**5.09E+01**	**2.68E+00**	**1.18E+03**	**7.80E+04**

a. Radioactive release information provided by BBWI, June 2003.

b. Includes only those radionuclides with releases greater than 1E-07 Ci.

c. Most of the INTEC emissions are from the Three Mile Island Dry Fuel Storage Facility and are based on conservative calculations.

d. Values for ^{90}Sr and ^{239}Pu reported by NRF are actually gross beta and gross alpha results, respectively, but are reported as these radionuclides for ease of comparison.

e. A double dash signifies the radionuclide was not released to air from that facility during the calendar year.

volume was probably greater and the concentration lower. The individual filter was analyzed for gamma-emitting radionuclides and for specific alpha-emitting radionuclides. No radionuclides of concern were detected. As such, it was concluded that the true concentration of alpha activity was probably lower due to a higher actual volume collected. Concentrations measured by the M&O contractor that exceeded the 3s uncertainty ranged from a low of $(0.25 \pm 0.04) \times 10^{-15}$ µCi/mL collected at TRA on November 3, 2003, to a high of $(7.3 \pm 0.8) \times 10^{-15}$ µCi/mL collected at TRA on October 8, 2003.

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 the associated 3s uncertainties. These data are typical of the annual natural fluctuation pattern for gross alpha concentrations in air. According to Figure 4-2, the highest median weekly concentration of gross alpha was measured by the ESER contractor for the distant group in the third quarter of 2003. The maximum median weekly gross alpha concentration was 4.0×10^{-15} µCi/mL and is below the DCG for the most restrictive alpha-emitting radionuclide in air (americium-241 [^{241}Am]) of 20×10^{-15} µCi/mL.

Annual median gross alpha concentrations calculated by the ESER contractor (Table 4-3) ranged from 1.29×10^{-15} µCi/mL at Craters of the Moon to 2.1×10^{-15} µCi/mL at Idaho Falls. M&O contractor data indicated an annual median range of 0.79×10^{-15} µCi/mL at Naval Reactor Facility (NRF) and Experimental Breeder Reactor-1 (EBR-I) to 1.80×10^{-15} µCi/mL at Auxiliary Reactor Area (ARA) (Table 4-3). Confidence intervals are not calculated for annual medians.

In general, gross alpha concentrations were typical of those measured previously and well within the range of measurements observed historically. Gross alpha activity measured in filters by the ESER contractor from 1995 through 2003 at levels greater than the 3s uncertainty ranged from a minimum of $(0.1 \pm 0.03) \times 10^{-15}$ to $(33.9 \pm 1.1) \times 10^{-15}$ µCi/mL (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 the 3s uncertainty ranged from a low of $(0.3 \pm 0.04) \times 10^{-14}$ µCi/mL on June 4, 2003, at Idaho Falls to a high of $(5.8 \pm 0.1) \times 10^{-14}$ µCi/mL at Jackson on December 23, 2003. Concentrations measured above 3s by the M&O contractor ranged from a low of $(0.2 \pm 0.01) \times 10^{-14}$ µCi/mL at Test Area North (TAN) in November 2003 to a high of $(5.7 \pm 0.3) \times 10^{-14}$ µCi/mL at the EFS in January 2003.

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 was detected in the fourth quarter of 2003. Each median value was calculated using all measurements, including those less than the associated 3s uncertainties. The maximum weekly median gross beta concentration was 6.0×10^{-14} µCi/mL and is significantly below the DCG of 300×10^{-14} µCi/mL for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

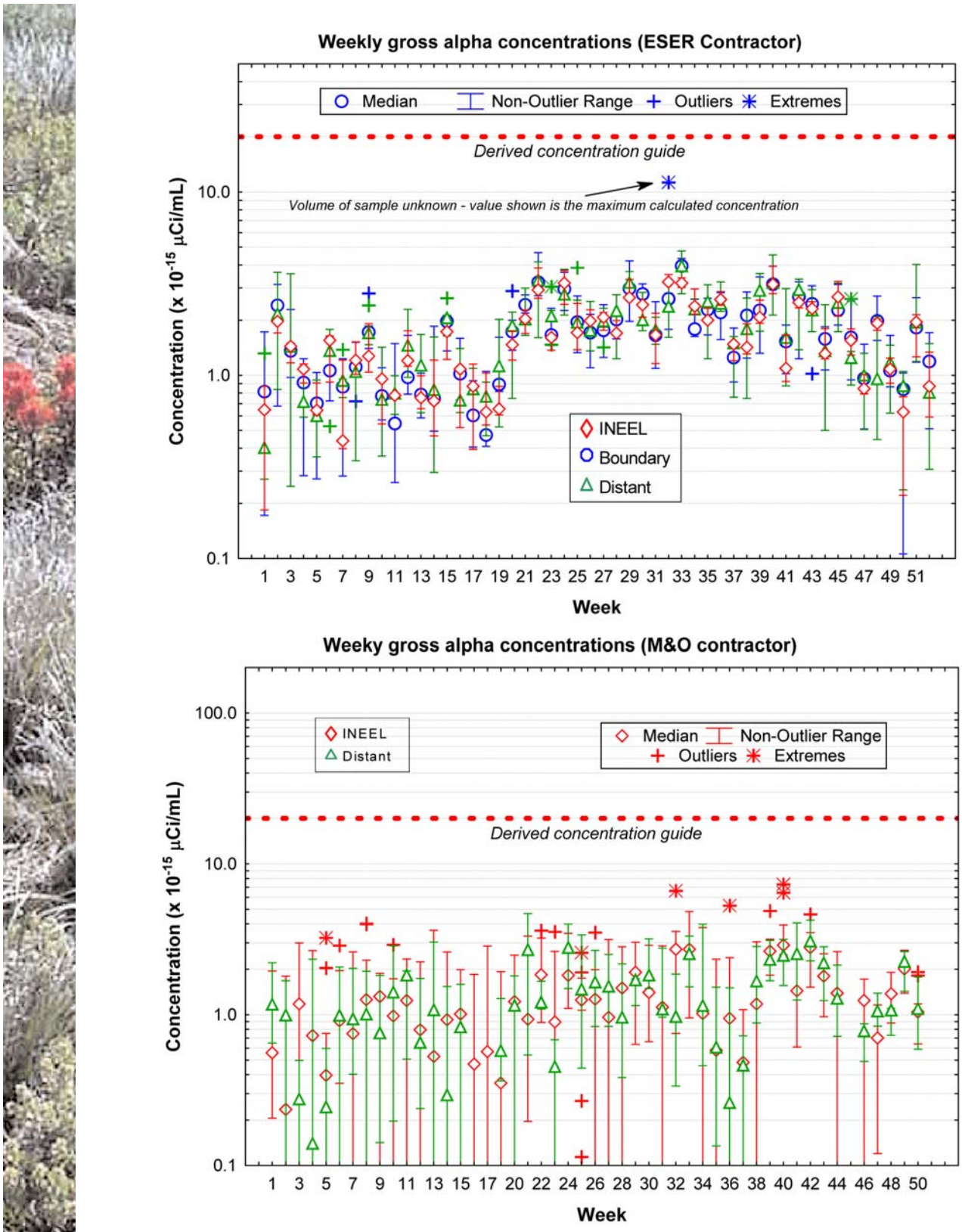

Figure 4-2. Median weekly gross alpha concentrations in air (2003).

Table 4-3. Median annual gross alpha concentrations in air (2003).[a]

ESER Contractor Data			Concentration[b]	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS	100[c]	-0.18 – 3.93	1.66
	Craters of the Moon	52	-5.10 – 3.84	1.29
	Dubois	52	0.14 – 25.20	1.58
	Idaho Falls	52	0.27 – 4.16	2.10
	Jackson	51	0.25 –4.02	1.49
	Rexburg CMS	52	0.41 – 4.73	1.88
			Distant Median:	**1.65**
Boundary	Arco	52	0.11 – 3.34	1.46
	Atomic City	52	-0.43 – 4.45	1.58
	Blue Dome	52	0.17 – 3.95	1.35
	Federal Aviation Administration Tower	52	-0.99 – 6.88	1.65
	Howe	52	0.41 – 4.31	1.81
	Monteview	52	0.55– 11.30	1.91
	Mud Lake	104[c]	0.04 – 4.75	1.87
			Boundary Median:	**1.67**
INEEL	EFS	52	0.18 – 3.85	1.72
	Main Gate	52	0.40 – 3.40	1.51
	Van Buren	52	0.22 – 3.93	1.57
			INEEL Median:	**1.58**
M&O Contractor Data			**Concentration[a]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	45	-1.49 – 3.38	1.10
	Craters of the Moon	49	-1.76 – 3.46	0.88
	Idaho Falls	48	-0.79 – 4.68	1.19
	Rexburg	48	-0.18 – 4.23	1.63
			Distant Median	**1.15**
INEEL	ANL-W	47	0.20 – 4.83	1.74
	ARA	48	-0.27 – 5.28	1.80
	CFA	47	-0.55 – 4.63	1.02
	EBR-I	48	-0.84– 4.88	0.79
	EFS	46	-2.30 – 154.00	0.85
	INTEC	48	-0.63– 3.01	1.27
	NRF	48	-0.56– 3.42	0.79
	PBF	47	-0.27 – 3.25	1.14
	Rest Area	48	-0.10 – 2.74	1.32
	RWMC	48	-0.63– 3.61	0.95
	TAN	48	-0.14– 3.09	1.02
	TRA	46	-0.73 – 3.78	1.48
	Van Buren	46	-1.25 – 6.64	1.36
			INEEL Median	**1.18**

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. Includes duplicate measurements at this station.

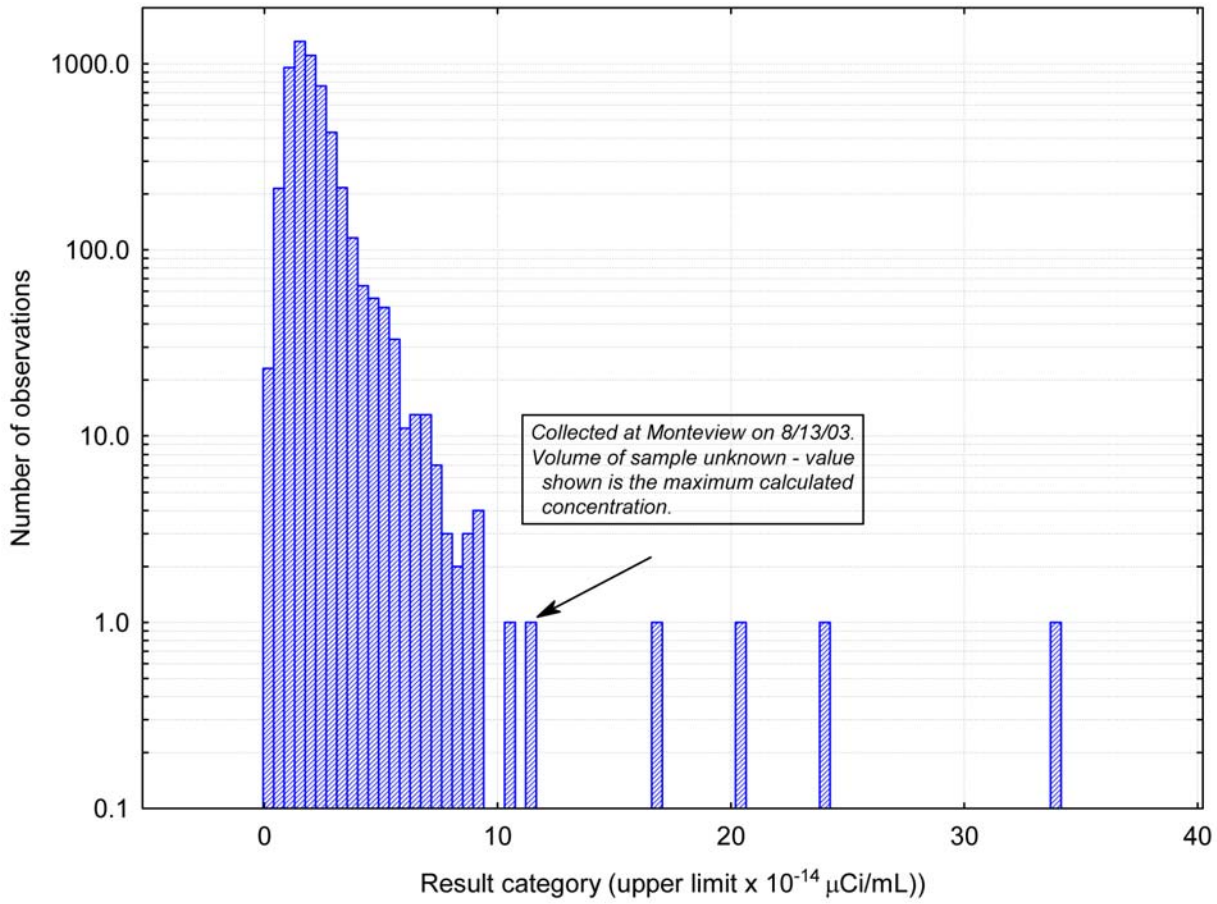

Figure 4-3. Frequency distribution of gross alpha activity detected above the 3s level in air filters collected by the ESER contractor from 1995 through 2003.

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 Craters of the Moon to 2.86 x 10^{-14} µCi/mL at the INEEL Main Gate. M&O contractor data indicated an annual median range of 1.84 x 10^{-14} µCi/mL at the RWMC to 2.82 x 10^{-14} µCi/mL at EFS. 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.

In addition, all results greater than 3s reported by the ESER contractor are well within measurements taken within the last seven years (Figure 4-5). The maximum concentration measured in 2003 is within this range of results.

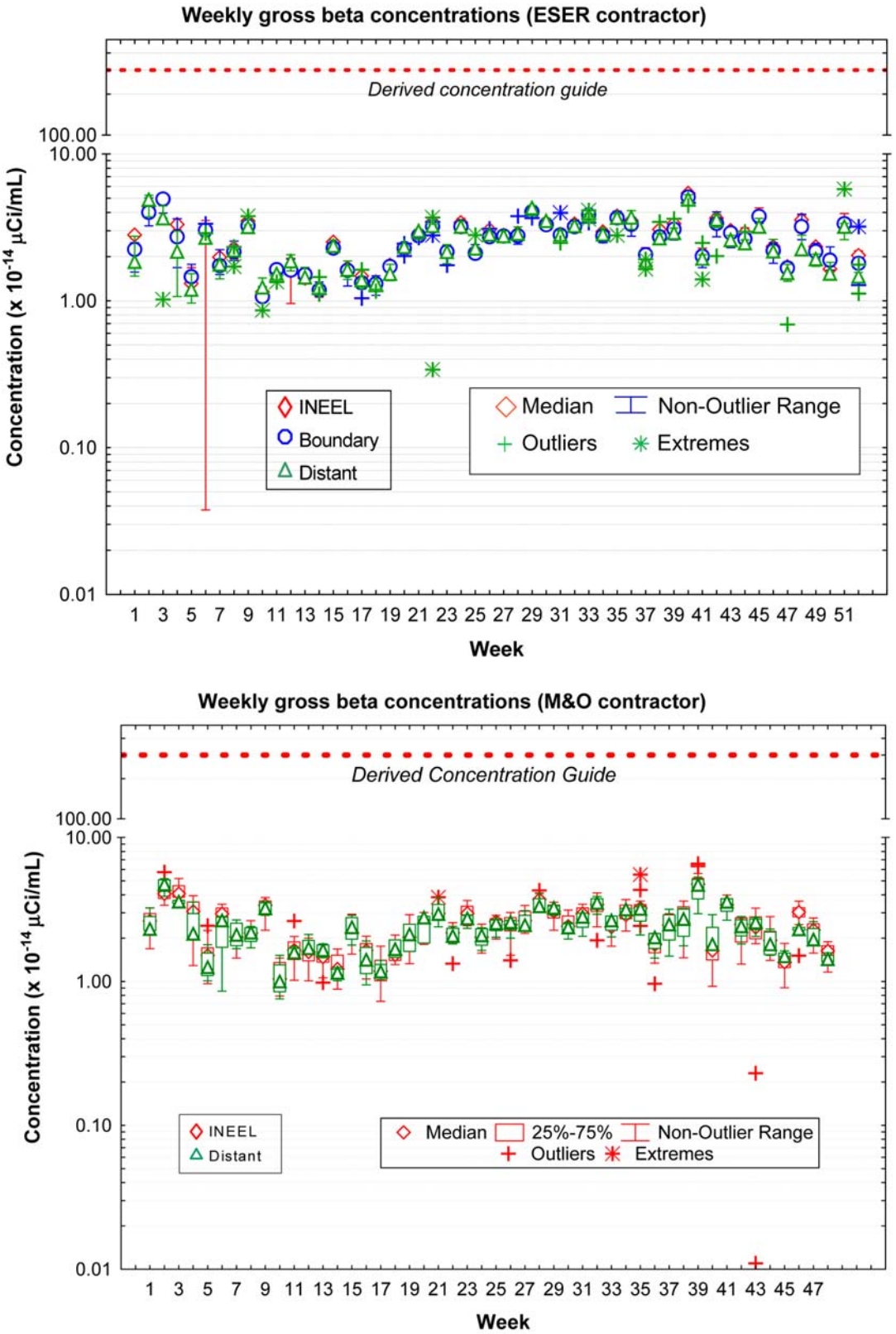

Figure 4-4. Median weekly gross beta concentrations in air (2003).

Table 4-4. Gross beta activity in air (2003).

ESER Contractor Data			Concentration[a]	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS	100[b]	0.89 – 5.72	2.56
	Craters of the Moon	51	0.86 – 4.44	2.27
	Dubois	48	1.20 – 4.84	2.70
	Idaho Falls	52	0.34 – 5.01	2.67
	Jackson	51	0.97 – 5.76	2.48
	Rexburg CMS	52	0.68 – 5.28	2.51
			Distant Median:	**2.52**
Boundary	Arco	52	1.07 –5.06	2.56
	Atomic City	52	-0.04 – 5.23	2.62
	Blue Dome	52	1.00 – 5.22	2.42
	Federal Aviation Administration Tower	51	1.14 – 5.05	2.53
	Howe	52	1.04 – 11.00	2.74
	Monteview	51	1.25 – 5.04	2.72
	Mud Lake	102[b]	1.19 – 5.40	2.85
			Boundary Median:	**2.67**
INEEL	EFS	52	1.11 – 5.37	2.85
	Main Gate	52	1.21 – 5.67	2.86
	Van Buren	52	0.04 – 5.39	2.79
			INEEL Median:	**2.84**
M&O Contractor Data			**Concentration[a]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	45	1.01 – 4.56	2.60
	Craters of the Moon	49	0.76 – 3.90	1.88
	Idaho Falls	48	1.08 – 5.17	2.44
	Rexburg	48	0.86 – 5.30	2.36
			Distant Median	**2.31**
INEEL	ANL-W	47	1.27 – 4.74	2.37
	ARA	48	1.16 – 5.52	2.40
	CFA	47	0.87 – 4.84	2.29
	EBR-I	48	0.01 – 4.68	2.39
	EFS	46	1.04 – 5.74	2.82
	INTEC	48	0.81 – 5.18	2.43
	NRF	48	0.73– 4.84	2.08
	PBF	47	0.90 – 4.72	2.28
	Rest Area	48	1.03 – 4.63	2.42
	RWMC	48	0.79 – 4.75	1.84
	TAN	48	0.23 – 4.51	2.22
	TRA	46	0.88 – 5.20	2.57
	Van Buren	46	0.95 – 4.12	2.60
			INEEL Median	**2.38**

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

b. Includes duplicate measurements at this station.

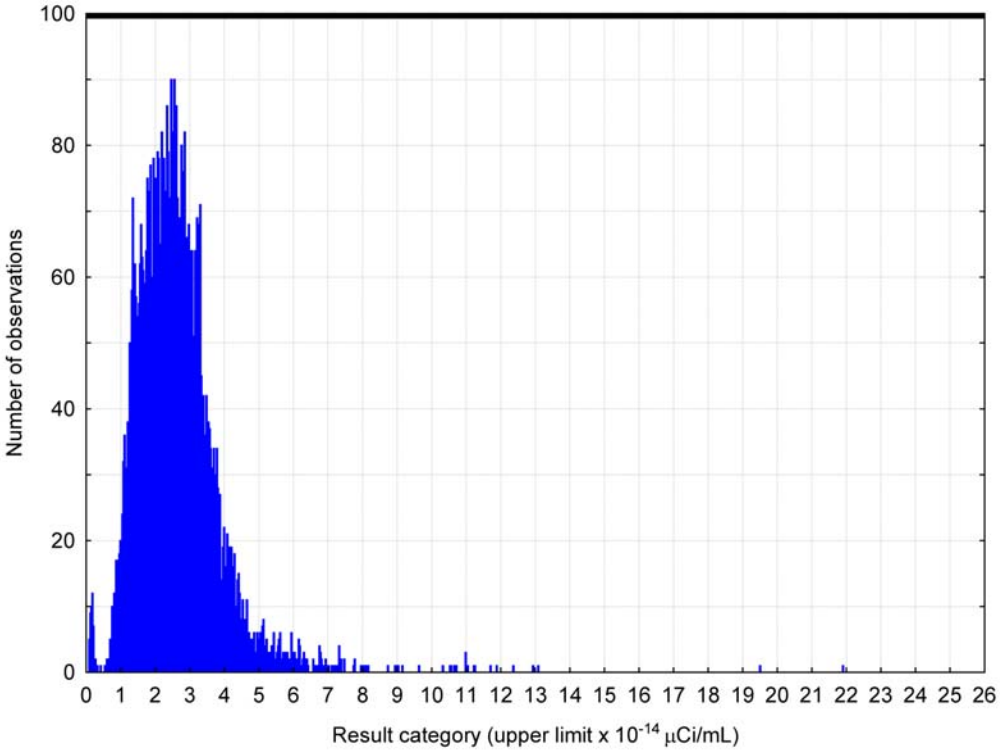

Figure 4-5. Frequency distribution of gross beta activity detected above the 3s level in air filters collected by the ESER contractor from 1995 through 2003.

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 2003 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 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 2003.

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2003. Concentrations collected during one week in January and two weeks each in November and December were greater for the boundary group than for the distant group. Results measured for the distant group were greater

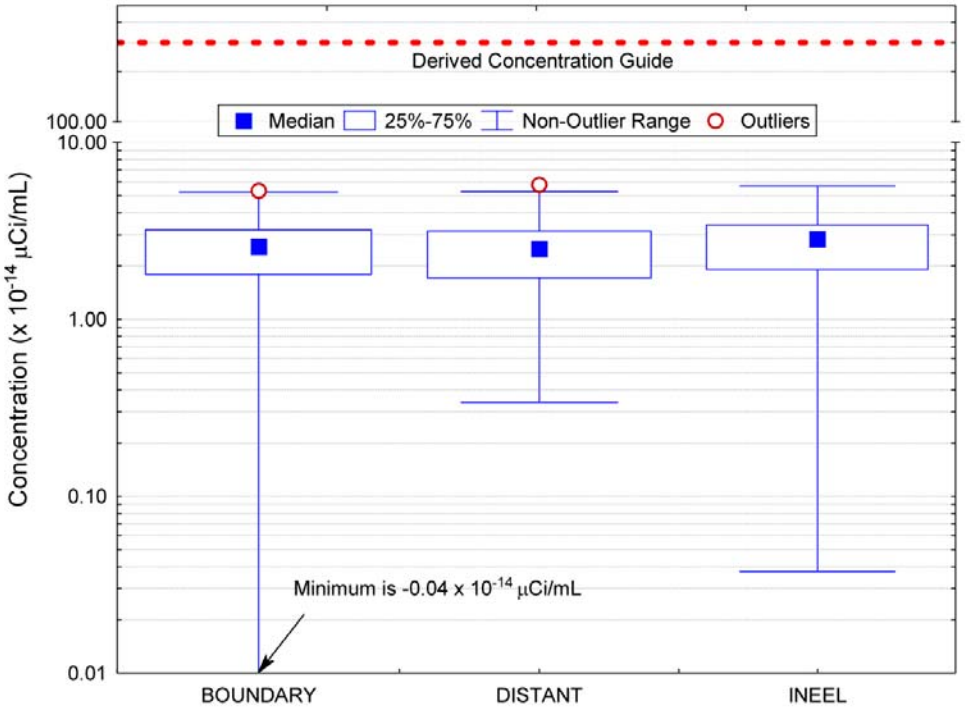

Figure 4-6. Comparison of gross beta concentrations measured in air at distant, boundary, and INEEL locations by the ESER contractor (2003). (Terms are defined in Appendix B.)

than boundary results during one week in July and one week in August. The differences observed in the winter months are associated with northern boundary locations (Howe, Monteview, and Mud Lake) and appear to be related to wind-driven suspension of particulates from surrounding fields and to the influence of inversion conditions. The differences observed in the summer months are attributed to natural variation in the data.

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.

Specific Radionuclides in Air

Human-made radionuclides were observed above 3s 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 air samples, although there has been no discernable pattern with respect to time or location. Americium-241 was again detected in five 2003 quarterly composite samples. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past seven years is shown in Figure 4-7. All results detected

Table 4-5. Human-made radionuclides in ESER contractor quarterly composited (2003).[a]

Location	^{241}Am	^{238}Pu	$^{239/240}$Pu	^{90}Sr
First Quarter 2003				
Rexburg	ND[b]	ND	8.3 ± 1.9	ND
Third Quarter 2003				
Craters of the Moon	6.5 ± 1.9	ND	ND	ND
Dubois	ND	ND	ND	62.3 ± 20.5
Howe	ND	9.1 ± 2.8	AR[c]	ND
Idaho Falls	8.6 ± 2.7	ND	ND	ND
Monteview	7.7 ± 2.2	ND	ND	ND
Mud Lake (Q/A-2)	ND	ND	ND	60.2 ± 17.5
Rexburg CMS	9.21 ± 2.5	ND	ND	ND
Fourth Quarter 2003				
Blackfoot	8.5 ± 1.9	ND	ND	ND

a. Concentrations shown are: Result x 10^{-18} µCi/mL air ± 1 standard deviation.
b. ND = Not detected. Result < 3s.
c. AR = Anomalous result. Result was unusually high for location. See text for discussion.

Table 4-6. Human-made radionuclides in M&O contractor quarterly composited air samples (2003).

M&O Contractor Samples[a]					
Location	^{125}Sb	^{137}Cs	^{241}Am	^{234}U/^{238}U	^{90}Sr
Second Quarter 2003					
Rexburg	ND[b]	ND	ND	36.3 ± 10.5/ 34.7 ± 9.6	ND
Third Quarter 2003					
CFA	ND	ND	7.4 ± 2.2	ND	ND
Van Buren Gate	ND	ND	ND	ND	224.0 ± 61.1
Fourth Quarter 2003					
CPP	ND	ND	ND	ND	111.0 ± 32.7
EFS	1,200.0 ± 399.0	ND	ND	ND	ND
Idaho Falls	ND	ND	ND	ND/53.9 ± 17.0	ND
Rexburg	ND	ND	ND	18.6 ± 5.8/ 23.5 ±5.7	ND
RWMC	ND	2590.0 ± 489.0	ND	ND	ND
TAN	ND	ND	ND	ND/14.2 ± 4.2	ND

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

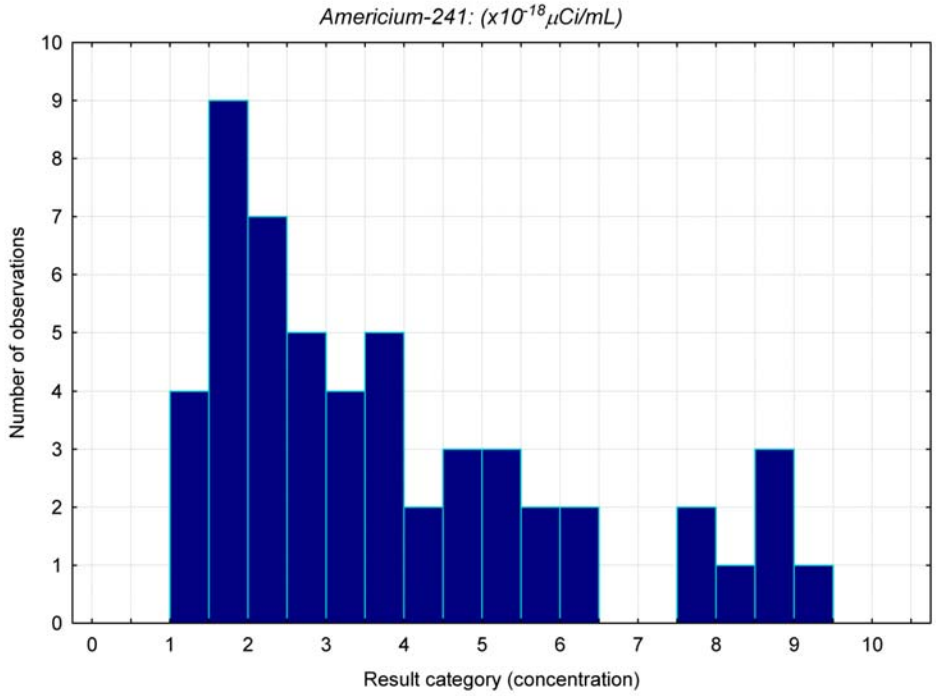

Figure 4-7. Frequency distribution of ^{241}Am concentrations detected above the 3s level in air filters collected by the ESER contractor from 1997 to 2003.

above the 3s level during 2003 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 detected in one ESER sample at a level significantly below the DCG of 30,000 x 10^{-18} µCi/mL and well within the range measured historically by EPA at Idaho Falls. Plutonium-239/240 ($^{239/240}$Pu) was also detected in two composite samples, with one anomalous result observed at Howe during the third quarter. The anomalous result was similar to that of a spiked sample, leading to the conclusion that the sample was probably contaminated during preparation of the spiked sample, and is not representative of levels normally seen in environmental samples; therefore, the result is considered invalid. 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).

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

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

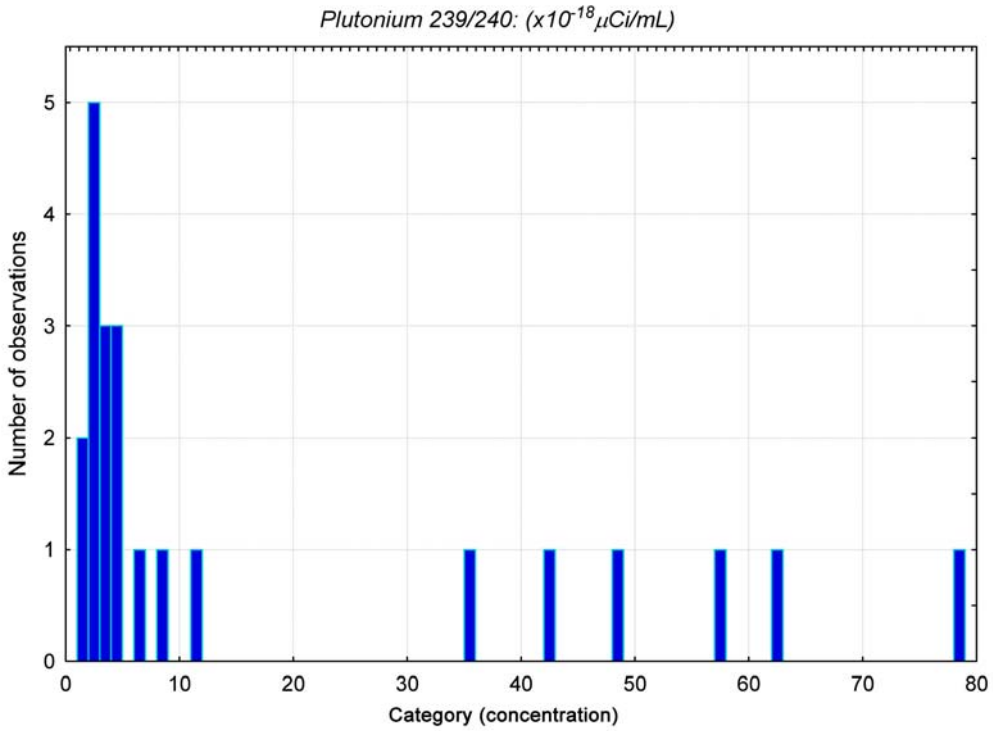

Figure 4-8. Frequency distribution of $^{239/240}$Pu concentrations detected above the 3s level in air filters collected by the ESER contractor from 1997 to 2003. (Note: An unusually high result was detected in 2003; however, it is considered to be anomalous and is not included in this figure. See text for discussion.)

Isotopes of uranium (^{234}U and/or ^{238}U) were detected in six M&O contractor quarterly composites. The maximum ^{234}U concentration was (36.3 ± 10.5) x 10^{-18} µCi/mL, well below the DCG of 90,000 x 10^{-18} µCi/mL. The maximum ^{238}U concentration was (53.9 ± 17.0) x 10^{-18} µCi/mL, far below the DCG of 100,000 x 10^{-18} µCi/mL. These concentrations are well within historical measurements measured by the EPA at Idaho Falls from 1984 through 2003, as reported on the Environmental Radiation Ambient Monitoring System website (http://www.epa.gov/enviro/html/erams/). The maximum ^{238}U concentration reported by EPA was (70.6 ± 6.8) x 10^{-18} µCi/mL. The maximum ^{238}U concentration reported by EPA was (75.3 ± 7.1) x 10^{-18} µCi/mL.

The M&O contractor reported one detection of ^{241}Am in the third quarter composites collected at CFA. The result, (7.4 ± 2.2) x 10^{-18} µCi/mL, is far less than the DCG for ^{241}Am of 20,000 x 10^{-18} µCi/mL and historical measurements.

Strontium-90 was detected in quarterly composites collected by the M&O contractor at CFA and Van Buren Boulevard during the fourth quarter of 2003. The maximum result (224.0 ± 61.1) x 10^{-18} µCi/mL, is well below the DCG for ^{90}Sr and within historical measurements.

Atmospheric Moisture

During 2003, the ESER contractor collected 44 atmospheric moisture samples from four locations (Atomic City, Blackfoot, Idaho Falls, and Rexburg) using silica gel. Table 4-7 presents the range of values for each station by quarter. Atmospheric moisture samples were also collected at these locations using drierite (primarily $CaSO_4$) during the first two quarters of 2003. However, it was determined that the material contains a contaminant that is released during the extraction process and this contaminant interferes with the liquid scintillation analysis. For this reason, the drierite results are considered to be invalid and the material is no longer used as a collection medium.

Tritium was detected in 13 of the samples. Samples that exceeded the respective 3s values ranged from a low at Atomic City $(1.9 \pm 0.5) \times 10^{-13}$ µCi/mL collected on July 30, 2003, to a high $(49.0 \pm 5.1) \times 10^{-13}$ µCi/mL at Atomic City collected on August 11, 2003.

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 Atomic City) is more than nine orders of magnitude below the DCG for tritium in air (as 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. They collected from one to three samples at each location each quarter. Laboratory analyses indicated that all samples were below the detection limit of 1×10^{-11} µCi/mL.

Table 4-7. Tritium concentrations in ESER contractor atmospheric moisture samples (2003).

	Range[a]			
Location	**First Quarter**	**Second Quarter**	**Third Quarter**	**Fourth Quarter**
Atomic City	—[b]	—[b]	1.9 ± 0.5 – 49.1 ± 5.1	6.8 ± 2.1
Blackfoot	—[b]	—[b]	—[c]	—[c]
Idaho Falls	3.3 ± 0.9	—[b]	8.3 ± 1.6 – 9.4 ± 2.2	3.4 ± 1.1
Rexburg	5.5 ± 1.6	—[b]	—[b]	5.2 ± 1.5

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s uncertainties.
b. No result was greater than its 3s uncertainty.
c. No sample collected during this quarter.

Precipitation

The ESER contractor collects precipitation samples weekly at the EFS and monthly at the CFA and offsite in Idaho Falls. A total of 53 precipitation samples were collected during 2003 from the three sites. Tritium concentrations were measured above the 3s level in thirteen samples and results ranged from 3.3 ± 0.9 to 292.0 ± 29.4 pCi/L. Table 4-8 shows the maximum

Table 4-8. Maximum tritium concentrations in ESER contractor precipitation samples (2003).

Location	Maximum Concentration[a]			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
CFA	292.00 ± 29.4	—[b]	—[b]	4.4 ± 1.0[b]
EFS	184.0 ± 54.5	—[b]	7.2 ± 2.1 [b]	13.4 ± 2.3[b]
Idaho Falls	—[b]	—[b]	3.3 ± 0.9[b]	—[b]

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

b. No results greater than ± 3s.

concentration by quarter for each location. The highest radioactivity was from a sample collected at CFA during the first 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/).

Suspended Particulates

In 2003, 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 8.02 µg/m^3 at Blue Dome to 48.3 µg/m^3 at the Rexburg CMS. 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 TAN to 84.0 µg/m^3 at Rexburg. 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}) (Title 40 Code of Federal Regulations [CFR] Part 50.6 2001). 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 60 valid 24-hour samples at Rexburg from January through December 2003. A valid sample is one that has run for the proper length of time (24 hours continuously) and that has a beginning weight less than the ending weight (does not yield a negative weight). Concentrations of PM_{10} particulates collected at Rexburg ranged from 0.42 to 153.9 µg/m^3. At the Blackfoot CMS, 60 valid samples were collected from January through December. Concentrations ranged from 1.3 to 173.7 µg/m^3. At Atomic City, 59 valid samples were collected from January through December. Concentrations ranged from 0.07 to 73.0 µg/m^3. The samples collected at the Blackfoot CMS location and at the Rexburg CMS on October 23, 2003, exceeded the EPA standard for a maximum 24-hour concentration. Atomic City, Blackfoot, and Rexburg sustained unusually high wind speeds (gusts from 40 to 50 mph) (see http://www.noaa.inel.gov) on October 23 implicating exceptionally high airborne dust concentrations. However, all annual averages (19.8, 16.9, and 14.8 µg/m^3 for Rexburg, Blackfoot, and Atomic City, respectively) were less than the EPA standard for mean annual concentration.

Nitrogen Dioxide

The M&O contractor monitored ambient nitrogen dioxide continuously at Van Buren Boulevard throughout 2003 and during the first and second quarters of 2003 at EFS. At Van Buren Boulevard, quarterly mean concentrations ranged from 2.9 to 3.9 parts per billion (ppb), with an annual mean of 3.5 ppb. These concentrations are significantly lower than the EPA national primary ambient air quality standard of 54 ppb (40 CFR 50.4 2001). The maximum 24-hour concentration measured was 10.4 ppb on August 25, 2003.

Quarterly means at EFS ranged from 7.4 ppb in the first quarter to 10.7 ppb in the second quarter. Because of equipment failure no data were collected in the third and fourth quarters of 2003. For the two quarters collected, the mean concentration was 9.1 ppb, again well below the EPA standard of 54 ppb. The maximum 24-hour average concentration was 10.7 ppb on May 25, 2003.

All quarterly concentrations in 2003 remained below 50 percent of the annual standard throughout the period of monitoring.

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 NO_x and SO_2 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 the two southeast Idaho sites. Selenium, in the 0.1 ng/m^3 range at Craters of the Moon, is a tracer of emissions from coal-fired plants. At Mammoth Cave in Kentucky, annual selenium concentrations of 1.4 ng/m^3 from natural sources have been reported.

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 was determined on all waste management samples collected by the Environmental Services Project in 2003. Samples were obtained from both suspended particle (SP) monitors and PM_{10} monitors.

For the PM_{10} monitors, gross alpha measurements ranged from a high of $(4.85 \pm 0.94) \times 10^{-14}$ µCi/mL in the second half of November at location SDA 2.3 to a low of $(-5.76 \pm 2.37) \times 10^{-16}$ µCi/mL in the first half of March at location SDA 4.2. The annual mean for gross alpha was 1.47×10^{-15} µCi/mL. PM_{10} gross beta levels ranged from a high of $(6.57 \pm 0.30) \times 10^{-13}$ µCi/mL in the second half of November at location SDA 2.3 to a low of $(5.98 \pm 4.72) \times 10^{-16}$ µCi/mL at WERF Building 614.3 in the first half of March. The gross beta annual mean was 2.66×10^{-14} µCi/mL.

Suspended Particle monitors had gross alpha measurements ranging from a high of $(2.79 \pm 0.58) \times 10^{-15}$ µCi/mL in the second half of August at location SMC 101 to a low of $(2.58 \pm 2.37) \times 10^{-16}$ µCi/mL in the second half of March at location SDA 2.0 with an annual mean of 1.23×10^{-15} µCi/mL. SP gross beta levels ranged from a high of $(4.60 \pm 0.15) \times 10^{-14}$ µCi/mL in the first half of January at SMC 104 to a low of $(9.94 \pm 0.71) \times 10^{-15}$ µCi/mL at SDA 2.0 in the second half of April. The gross beta annual mean was 2.10×10^{-14} µCi/mL. As previously noted, SP monitors were removed from service in October of 2003.

Previous reports have included statistical analysis of co-located SP and PM_{10} samplers and a comparison of activity levels over the year. A review of this past and current data was conducted to determine if this detailed analysis was required for these measurements. Since this review has shown the same general cyclic behavior over several years, a detailed statistical review was not conducted on waste management data for 2003. This review also indicated no significant change in airborne radioactivity concentration from previous years. If future reviews indicate and change from historical levels, a detail analysis will be performed to determine the source of the change and any corrective actions that need to occur.

Specific Radionuclides

Two sample results indicated human-made gamma emitting radionuclides that exceeded the three-sigma error in 2003. Both detections were at location 4.3 on the SDA. In November, cobalt-60 was detected at $(4.37 \pm 0.356) \times 10^{-15}$ µCi/mL, which is 0.0055 percent of the DCG, and in December niobium-95 was detected at $(4.37 \pm 0.24) \times 10^{-15}$ µCi/mL, which is 0.000029 percent of the DCG. These detections were not confirmed by analysis from a co-located sampler (SDA 4.2); therefore, these results can be considered suspect. Also, with an 86.6-hour half-life it is unlikely that niobium-95 would be present in any sample from a waste storage site.

Radiochemical analysis indicated twelve detections (> 3s uncertainty). These results are summarized on Table 4-9.

During the third quarter, uranium-235 was detected at HOWE 400.3, which is a background sampler. Uranium-235 is a naturally occurring isotope of uranium, and detection at this level is not uncommon. Americium-241 was also detected in three samples in the third quarter. Both SDA locations have co-located monitors with no americium-241 detections. In addition, the blank filter submitted with the samples indicated a true positive result; therefore, these results are considered suspect.

The highest ^{241}Am detection on a non-blank sample represents 0.045 percent of the DCG; uranium-235 represents 0.000064 percent, and the highest ^{90}Sr number represents 0.41 percent of the DCG. Numerous detections of uranium-234 and -238 occurred during 2003 at levels that indicate they were from naturally occurring sources.

Except as noted for uranium-235 above, results at these levels are most likely due to resuspension of contaminated soil on the SDA. Loss of confinement integrity would give substantially higher results. No trends were detected based on analytical results from calendar year 2003.

Table 4-9. Waste management radiochemical results for air.[a]

Location	Isotope	Results		1s Error	Units	Quarter	MDA[b]	% DCG[c]
SDA 2.0	AM-241	6.52E-18	±	1.38E-18	uCi/cc	2	3.34E-19	0.03260%
SDA 2.0	AM-241	5.53E-18	±	1.07E-18	uCi/cc	3	1.31E-18	0.02765%
SDA 4.3	AM-241	6.84E-18	±	1.96E-18	uCi/cc	3	4.82E-18	0.03420%
SDA 11.3	SR-90	4.40E-17	±	1.20E-17	uCi/cc	3	1.60E-17	0.00049%
SDA 12.3	AM-241	1.39E-17	±	3.02E-18	uCi/cc	3	7.74E-18	0.06950%
EBR 15.0	SR-90	8.60E-17	±	2.00E-17	uCi/cc	3	4.90E-17	0.00096%
TSA 22.3	AM-241	7.72E-18	±	2.23E-18	uCi/cc	3	6.09E-18	0.03860%
CTRL 603.3	SR-90	7.40E-17	±	2.00E-17	uCi/cc	3	2.70E-17	0.00082%
SMC 105	SR-90	7.04E-16	±	1.66E-16	uCi/cc	3	4.31E-16	0.00782%
HOWE 400.3	U-235	6.40E-18	±	1.71E-18	uCi/cc	3	3.30E-18	0.00640%
SDA 1.3	AM-241	9.00E-18	±	2.88E-18	uCi/cc	4	2.44E-18	0.04500%
SDA 9.3	SR-90	8.20E-17	±	2.50E-17	uCi/cc	4	7.20E-17	0.00091%

a. Results shown are those greater than 3s error.

b. MDA = Minimum Detectable Activity

c. DCG = Derived Concentration Guide

REFERENCES

40 Code of Federal Regulations 50.6, 2001, "National Primary and Secondary Ambient Air Quality Standards for Particulate Matter," *Code of Federal Regulations*, Office of the Federal Register.

40 Code of Federal Regulations 50.4, 2001, "National Primary Ambient Air Quality Standards for Nitrogen Oxides," *Code of Federal Regulations*," Office of the Federal Register.

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U.S. Department of Energy-Idaho Operations Office, 2003, *National Emissions Standards for Hazardous Air Pollutants (NESHAPs) - Calendar Year 2003 INEEL Report for Radionuclides*, DOE/ID-10890(02), June.

Chapter 5 - Compliance Monitoring Programs

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Chapter Highlights

One potential pathway for exposure (primarily to workers) to contaminants released from 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 liquid effluents, drinking water, groundwater, and storm water runoff at the INEEL to comply with applicable laws and regulations, U.S. Department of Energy orders, and other requirements (e.g., Wastewater Land Application Permit [WLAP] requirements). Argonne National Laboratory-West (ANL-W) and the Naval Reactors Facility (NRF) conduct their own WLAP equivalent and drinking water monitoring. The Environmental Surveillance, Education and Research Program (ESER) contractor monitors drinking water and surface water at offsite locations.

During 2003, 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 state of Idaho groundwater quality primary and secondary constituent standards in specified groundwater monitoring wells. The permits specify annual discharge volume and application rates and effluent quality limits. As required, an annual report was prepared and submitted to the Idaho Department of Environmental Quality (DEQ). Additional parameters are also monitored in the effluent in support of surveillance activities.

Most wastewater and groundwater regulatory and surveillance results were below applicable limits in 2003. The concentration of total dissolved solids (TDS) in the October 2003 sample from perched water well ICPP-MON-V-200 was above the state of Idaho groundwater secondary constituent standard (SCS). The elevated level of total dissolved solids in this well is likely caused by the effluent discharged to the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds. Aluminum, iron, and manganese secondary standards were also exceeded in three wells, including the upgradient well. It is unlikely that these contaminants are related to the discharge of wastewater because (1) similar concentrations were found in the upgradient well, (2) this is the same wastewater that has been discharged for a number of years to the old percolation ponds and never exceeded the standards in those compliance wells, and (3) the concentrations of these constituents in the discharged wastewater have decreased since August 2003. It is more likely that these concentrations are related to incomplete development of the wells, allowing residual well seal

material to exist in the vicinity of the well screen. This notion is supported by the logbook note that the samples were murky during collection and that duplicate samples collected in October that were passed through a 45-micron filter before analysis all were below groundwater standards.

As in the past, perched water samples from the INTEC sewage treatment plant contained measurable concentrations of total coliform bacteria. Nitrate-nitrogen was above the state of Idaho groundwater primary constituent standard (PCS) value in one perched well in April. While above the PCS, this is a sign that significant nitrogen conversion is taking place in that the majority of nitrogen discharged to the sewage treatment plant is in the form of ammonium-nitrogen.

Well Test Area North (TAN)-10A continued to have chemical constituents that were above groundwater quality standards. TAN-10A exceeded the SCS for iron and TDS. As detailed in the 2001 and 2002 annual reports, it is probable that the concentrations of these contaminants are related to the condition of the well casing and the 2001 rehabilitation work. Two compliance wells and the background well also exceeded the groundwater standard for total coliform bacteria in the April 2003 samples. The source of this contamination is under investigation. All other surveillance monitoring of groundwater, drinking water, and surface water were below applicable standards in 2003. Although some storm water samples exceeded benchmark levels for iron, magnesium, total suspended solids, and chemical oxygen demand, they were still within the range of historical values. All other measured parameters were below regulatory limits.

No U.S. Environmental Protection Agency (EPA) health-based drinking water or DOE regulatory limits were exceeded in 2003. In the Radioactive Waste Management Complex (RWMC) public water system and well, 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 2.8 µg/L. The annual average for the production well, of 4.6 µg/L, was also below the MCL. Trichloroethylene concentrations in samples from the Test Area North (TAN) drinking water Well 2 during 2003 also remained below the MCL. The ANL-W and NRF systems were sampled as required by regulations and found to be below all limits during 2003.

Elevated levels of tritium continue to be measured in the groundwater at the INEEL. Neither of these radionuclides has been detected off the INEEL since the mid-1980s. A maximum effective dose equivalent of 0.88 mrem/yr (8.8 µSv/yr), less than the four mrem/yr EPA standard for public drinking water systems, was calculated for workers at the Central Facilities Area on the INEEL in 2003.

No nonradiological constituents exceeded their respective WLAP, PCS/SCS, or MCLs in compliance and surveillance monitoring of liquid effluent samples. Permit required groundwater monitoring samples exceeded SCSs for aluminum, iron, manganese, and total and fecal coliform in wells at the new INTEC percolation ponds, sewage treatment plant, and the TAN/Technical Support Facility sewage treatment plant.

Drinking water samples were collected from 13 locations off the INEEL and around the Snake River Plain in 2003. No samples had measurable gross alpha activity. One had measurable tritium, and 19 samples had measurable gross beta activity. None of the samples exceeded the EPA MCL for these constituents.

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 2003 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. Total suspended solids, iron, magnesium, and chemical oxygen demand all exceeded benchmark levels in samples collected at the RWMC. Concentrations of these parameters have been detected above benchmark levels in the past. No deficiencies in pollution prevention practices have been identified, and no cause has been identified. 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 BBWI Prime Contracts manager to cease compliance activities associated 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 these three sites (Bauer 2003).

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), the Naval Reactors Facility (NRF); and the Environmental Surveillance, Education and Research Program (ESER) contractor are all 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, respectively. 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 ESER contractor monitors drinking water at offsite locations and collected 28 drinking water samples for analyses in 2003.

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.

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

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

Area/Facility[a]	Media				
	Liquid Effluent (Permitted)	Liquid Effluent (Characterization)	Liquid Effluent (Groundwater)	Drinking Water	Storm Water
Argonne National Laboratory-West					
ANL-W		•	•	•	
Management and Operating Contractor					
CFA	•	•		•	•
INTEC	•	•	•	•	•[c]
TRA	•[b]	•	•	•	
TAN	•	•	•	•	•[c]
RWMC				•	•[c]
PBF/CITR				•	•
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/CITR = Power Burst Facility/Critical Infrastructure Test Range, IRC = INEEL Research Center, and NRF = Naval Reactors Facility.

b. The Idaho DEQ has not issued a Wastewater Land Application Permit for TRA. However, TRA follows WLAP regulations for the applicable effluent.

c. Monitoring ceased in December 2003.

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).

During 2003, 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).

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

Facility	Permit Status	Explanation
CFA Sewage Treatment Plant	WLAP expired	Idaho DEQ issued a letter authorizing continued operation under the terms and conditions of original permit until a new permit is issued. Negotiation of a draft permit began in spring 2004.
INTEC New Percolation Ponds	WLAP issued	Idaho DEQ originally issued the WLAP on September 10, 2001. The permit was subsequently modified and a new permit issued on March 28, 2002, and expires on April 1, 2007.
INTEC Sewage Treatment Plant	WLAP expired	Idaho DEQ issued a letter authorizing continued operation under the terms and conditions of original permit until a new permit is issued.
TAN/ TSF Sewage Treatment Plant	WLAP expired	Idaho DEQ issued a letter authorizing continued operation under the terms and conditions of 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].

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 2003. Table 5-3 summarizes the 2003 semiannual monitoring results.

Table 5-3. Semiannual monitoring results for INEEL Research Center (2003).[a]

Parameter	INEEL Research Center		Discharge Limit[b]
	April 2003	October 2003	
Cyanide	0.005 U[c]	0.005 U	1.04
Silver	0.0025 U	0.0025 U	0.43
Arsenic	0.0025 U	0.0025 U	0.04
Cadmium	0.0010 U	0.0010 U	0.26
Chromium	0.0025 U	0.0025 U	2.77
Copper (regular/duplicate)[d]	0.0410	0.0366/0.0366	1.93
Mercury	0.00020 U	0.00020 U	0.002
Nickel	0.0025 U	0.0025 U	2.38
Zinc (regular/duplicate)[d]	0.0422	0.0416/0.0414	0.90
Lead (regular/duplicate)[d]	0.00051	0.00044/0.00028	0.29
Conductivity (µS) (max/avg)[e]	1,176/699	5,232/1,761	N/A
pH (standard units) (max/avg)[e]	8.11/8.0	7.92/6.4	5.5-9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Limit as set in the applicable Industrial Wastewater Acceptance Forms.
c. U flag indicates that the result was below the detection limit.
d. Regular and duplicate samples were collected for the October sampling event only. Unless otherwise noted, for parameters for which results were detected, the regular and duplicates were the same.
e. Values represent the maximum and average for the five samples taken in April and the four samples taken in 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 (2200 ft) downgradient of the nearest drinking water well.

A 1500-L/min (400-gal/min) pump applies wastewater from a 0.2-ha (0.5-acre) lined, polishing pond to approximately 30 ha (74 acres) of desert rangeland through a computerized center pivot irrigation system. The permit limits wastewater application to 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 2003. Effluent samples were collected from the pump pit (prior to the pivot irrigation system) starting in June 2003 and continued through September 2003 (the period of irrigation operation for 2003). 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 (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Biological Oxygen Demand (5-day)	23.0	59.1	45.1	NA[d]
pH (standard units) (grab)	7.62	8.21	7.84	NA
Chemical Oxygen Demand	41.8	196.0	97.1	NA
Nitrogen, Nitrate + Nitrite (mg-N/L)	0.336	1.220	0.655	NA
Nitrogen, Total Kjeldahl	1.48[e]	24.90	12.28	NA
Total Suspended Solids	18.9	324.0	68.0	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were collected in April 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.
e. The minimum shown is from the April duplicate sample.

Table 5-5. CFA STP effluent monitoring results (2003).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Biological Oxygen Demand (5-day)	2.14	7.38	4.26	NA[c]
pH (standard units) (grab)[d]	8.77	9.89	9.44	NA
Chemical Oxygen Demand	34.5	41.6	37.9	NA
Nitrogen, Nitrate + Nitrite (mg-N/L)	0.0115	0.0714	0.0321	NA
Total Phosphorus	0.213	0.408	0.293	NA
Nitrogen, Total Kjeldahl	1.81	6.70	3.92	NA
Total Suspended Solids	2[e]	6.5	3.1	NA
Fecal Coliform (colonies/100 mL)	1	29	8	NA
Total Coliform (colonies/100 mL)	1	80	24	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.
d. pH readings were collected on two separate days in July and are included in the summaries. The minimum pH reading was from one of these samples.
e. Sample result was less than the detection limit; value shown is half the detection limit.

Discharge to the pivot irrigation area averaged less than 598,095 Lpd (158,000 gpd). Application rates ranged from 7.20 to 8.20 m^3/day (0.07 to 0.08 acre-in./day) during the entire 2003 application period of June 16, 2003, through September 25, 2003.

The total volume of applied wastewater for 2003 was approximately 7.38 x 10^{12} L (5.98 million gallons [MG]), which is significantly less than the design hydraulic loading of 4.9 x 10^{13} L (40.5 MG). Hydraulic loading peaked in September. Nitrogen loading rates were significantly lower (3.01 kg/ha/yr [2.7 lb/acre/yr]) than the projected maximum loading rate of 35.87 kg/ha/yr (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 native 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 Sciences, Ltd. (CES), which estimated it would take 20 to 30 years to reach normal nitrogen agricultural levels in the soil (based on a loading rate of 35.87 kg/ha/yr [32 lb/acre/yr]). The extremely low 2003 nitrogen loading rate of 3.01 kg/ha/yr (2.7 lb/acre/yr) had a negligible effect on nitrogen accumulation.

The 2003 annual total chemical oxygen demand (COD) loading rate at CFA STP (29.14 kg/ha/yr [26 lb/acre/yr]) was less than the 2002 rate (53.80 kg/ha/yr [48 lb/acre/yr]) and was substantially less than the state guidelines of 56.04 kg/ha/day (50 lb/acre/day) (equivalent to 20,456 kg/ha/yr [18,250 lb/acre/yr]).

The annual total phosphorus loading rate (0.217 kg/ha/yr [0.194 lb/acre/yr]) was well below the projected maximum loading rate of 5.04 kg/ha/yr (4.5 lb/acre/yr). The small amount of phosphorus applied was probably removed by sorption reactions in the soil and used by vegetation, rather than lost through leaching.

Removal efficiencies (REs) were calculated to estimate treatment in the lagoons. Average REs were lower than the previous year for total nitrogen, biological oxygen demand (BOD), and COD, but equal to the previous year for total dissoved solids (TSS). Only BOD and TSS achieved the projected efficiency (i.e., total nitrogen, BOD, and TSS of 80 percent and COD of 70 percent). During 2003, the average REs indicate that treatment in the lagoons was sufficient to produce a good quality effluent for land application.

A total of 759.46 m^3/ha (2.99 acre-in./acre) of wastewater was applied over approximately 29.7 ha (73.5 acres) during 2003, which was 11.07 cm (4.26 in.) less than that applied in 2002. This total, when adjusted for irrigation efficiency and added to the total adjusted precipitation for the year, yields 1427 m^3/ha (5.62 acre-in./acre), which is well below the permit limit of 6350 m^3/ha/yr (25 acre in./acre/yr). The relatively low volume of wastewater, coupled with below average annual precipitation (lower by 11.18 cm [4.4 in.]) and above average monthly temperatures for all months of the permit year (with the exception of November 2003), resulted in a leaching loss of only 0.25 cm (0.10 in).

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 New INTEC 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/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.

All service waste enters Building CPP-797, the final sampling and monitoring station, before discharge to the Percolation Ponds. In CPP-797, the combined effluent is measured for flow rate and monitored for radioactivity, and samples are collected for analyses. No radioactivity is expected; however, if radioactivity is detected above a specified level, contaminated waters are directed to a diversion tank rather than discharged to the Percolation Ponds. Two sets of two pumps transfer the wastewater from CPP-797 to the Percolation Ponds.

The New INTEC Percolation Ponds are designed to function similarly to the old percolation ponds south of INTEC. 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 L/day (three million gal/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. During 2003 the south pond was in use from January to July. The north pond was used from August through December. Ponds are routinely inspected, and the water depth is recorded via permanently mounted staff gauges.

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 New INTEC Percolation Ponds.

Sample collection for the New Percolation Ponds began in September 2002, after the wastewater was rerouted from the Existing Percolation Ponds to the New Percolation Ponds on August 26, 2002.

Table 5-6. Summary of New INTEC Percolation Pond effluent monitoring results (2003).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
pH (standard units) (grab)[c]	7.5	8.3	8.0	NA[d]
Chloride	15.9	647	175.5	NA
Fluoride	0.005[e]	0.26	0.18	NA
Nitrogen, as Nitrite (mg-N/L)	0.002[e]	0.85[e]	0.07[f]	NA
Nitrogen, as Nitrate (mg-N/L)	0.53	1.00	0.91	NA
Nitrogen, Total Kjeldahl	0.065[e]	0.12[e]	0.08[f]	NA
Nitrogen, Total	0.95	1.50	1.07	NA
Total Dissolved Solids	242.0	1,210.0	494.3	NA
Total Phosphorus	0.0174	0.043	0.026	NA
Silver	0.00075[e]	0.0016[e]	0.0009[f]	NA
Aluminum	0.0027[e]	0.0204	0.0065	NA
Arsenic	0.00175[e]	0.00265[e]	0.00218[f]	NA
Cadmium	0.00015[e]	0.0021	0.0004	NA
Chromium	0.0056	0.0086	0.0062	NA
Copper	0.00045[e]	0.0113	0.0042	NA
Iron	0.00275[e]	0.218	0.029	NA
Mercury	0.00004[e]	0.00004[e]	0.00004[f]	NA
Manganese	0.00015[e]	0.003	0.001	NA
Sodium	39.2	351.0	110.0	NA
Selenium	0.00175[e]	0.00245[e]	0.0020[f]	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. Duplicate pH readings were taken in January and are included in the summaries.
d. NA—Not applicable; no permit limit is set for this parameter. Effluent limits are specified in IDAPA 58.01.17.600.06.B, 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 for each of the monthly values.

The permit for the New Percolation Ponds does not specify concentration limits for the effluent to the ponds. However, effluent concentrations were compared to the groundwater quality standards. During 2003, comparison of the effluent concentrations to the groundwater quality standards, showed only total dissolved solids (TDS) and chloride were above the standards (during four months). However, because no permit limits are set for the effluent, these levels do not reflect permit noncompliances. During these same four months, the sodium concentrations in the effluent were also high, and the TDS, chloride, and sodium concentrations were some of the highest reported to date for the CPP-797 service waste effluent. High concentrations of TDS, chloride, and sodium in the service waste effluent are usually indicative of a problem with the

CPP-606 water treatment system. During the year, several evaluations were conducted in support of a project to upgrade the current INTEC water treatment system. These evaluations included a survey of the treated water demands, water quality requirements, and candidate conservation measures. Several design options to upgrade the water treatment system are currently being evaluated.

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 2003 was approximately 1820 million L (480.9 MG). The total volume was well below the permit limit of 4145 million L (1095 MG/yr).

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 compliance wells are limited by the groundwater PCS and SCS in IDAPA 58.01.11. All permit required samples are collected as unfiltered samples.

Tables 5-7 and 5-8 show water levels (recorded before purging and sampling) and analytical results for all parameters specified by the permit for aquifer and perched water wells, respectively. Perched water well ICPP-MON-V-191 was dry during both the April and October 2003 sampling events. Well ICPP-MON-V-191 is expected to remain dry until the Big Lost River flows sufficiently to recharge the perched water at this well.

The October 2003 TDS sample result for well ICPP-MON-V-200 was above the SCS of 500 mg/L. Both chloride and sodium concentrations have increased since 2002 in this well. The increase in these parameters likely has been caused by the effluent concentrations in the service waste wastewater and the application of this wastewater to the New Percolation Ponds. No parameter concentrations for well ICPP-MON-V-212 were above their respective PCS or SCS

Table 5-7. New INTEC Percolation Ponds groundwater quality data from aquifer wells for April and October 2003.[a]

Depth to Water Table (ft)	ICPP-MON-A-167 (GW-013005)			ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)			
	495.53	495.29	495.29	500.62	500.62	505.13	505.13	506.48	
Sample Date	4/14/2003	10/6/2003	10/6/2003[c]	4/15/2003	10/6/2003	4/14/2003	4/14/2003[c]	10/6/2003	PCS/SCS[b]
pH	8.46	7.88	7.88	8.20	7.55	8.06	8.06	7.52	6.5–8.5
TKN	0.90 U[d]	1.0 U	1.0 U	1.8 U	1.0 U	0.90 U	0.90 U	1.0 U	NA[e]
NO_3-N	0.48	0.46	0.43	0.76	0.62	0.26	0.23	0.14	10
NO_2-N	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	1
Total Phosphorus	0.20	0.31	0.27	0.074	0.10 U	0.03 U	0.062	0.10 U	NA
TDS	205	203	213	224	234	185	175	178	500
Chloride	12.5	7.1	7.2	16.2	17.5	6.8	13.6	6.8	250
Fluoride	0.19	0.11	0.13	0.21	0.12	0.26	0.24	0.14	4
Aluminum	6.61	5.82	6.74	0.025 U	0.025 U	0.199	0.231	1.06	0.2
Aluminum–filtered	NT[f]	0.0362	0.0392	NT	NT	NT	NT	0.025 U	0.2
Arsenic	0.0026	0.0033	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.05
Arsenic–filtered	NT	0.0025 U	0.0033 U	NT	NT	NT	NT	0.0025 U	0.05
Cadmium	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Cadmium–filtered	NT	0.001 U	0.001 U	NT	NT	NT	NT	0.001 U	0.005
Chromium	0.0136	0.0147	0.0186	0.0105	0.0084	0.0078	0.0091	0.0177	0.1
Chromium–filtered	NT	0.0053	0.0063 U	NT	NT	NT	NT	0.0052	0.1
Copper	0.0157	0.0174	0.0182	0.001 U	0.0014	0.001 U	0.001 U	0.004	1.3
Copper–filtered	NT	0.0013	0.0017	NT	NT	NT	NT	0.001 U	1.3
Iron	3.92	3.68	4.13	0.0613	0.0655	0.217	0.238	0.939	0.3
Iron–filtered	NT	0.077	0.0824	NT	NT	NT	NT	0.0612	0.3
Manganese	0.0696	0.0681	0.0758	0.0025 U	0.0025 U	0.0697	0.0692	0.072	0.05
Manganese–filtered	NT	0.009	0.0098	NT	NT	NT	NT	0.0376	0.05
Mercury	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Mercury–filtered	NT	0.0002 U	0.0002 U	NT	NT	NT	NT	0.0002 U	0.002

Table 5-7. New INTEC Percolation Ponds groundwater quality data from aquifer wells for April and October 2003.[a] (continued)

	ICPP-MON-A-167 (GW-013005)			ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)			
Depth to Water Table (ft)	495.53	495.29	495.29	500.62	500.62	505.13	505.13	506.48	
Sample Date	4/14/2003	10/6/2003	10/6/2003[c]	4/15/2003	10/6/2003	4/14/2003	4/14/2003[c]	10/6/2003	PCS/SCS[b]
Selenium	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.05
Selenium –filtered	NT	0.0025 U	0.0025 U	NT	NT	NT	NT	0.0025 U	0.05
Silver	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.1
Silver–filtered	NT	0.0025 U	0.0025 U	NT	NT	NT	NT	0.0025 U	0.1
Sodium	13.4	13.9	14.0	8.08	10.0	9.15	9.22	9.75	NA
Sodium–filtered	NT	12.7	12.9	NT	NT	NT	NT	9.66	NA

a. All concentrations are in milligrams per liter (mg/L), except pH, which is in standard units.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
c. Duplicate sample.
d. U flag indicates that the result was reported as below the detection limit.
e. NA = Not applicable.
f. NT = Not Taken. No filtered metal sample was taken.

Table 5-8. New INTEC Percolation Ponds groundwater quality data from perched water wells for April and October 2003.[a]

Depth to Water Table (ft)	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
	Dry[b]	Dry[b]	117.85	111.04	238.25	234.94	
Sample Date / Parameter	April 2003 Not Sampled	October 2003 Not Sampled	4/17/2003	10/7/2003	4/22/2003	10/7/2003	PCS/SCS[c]
pH	—[d]	—	8.04	7.52	8.13	7.56	6.5-8.5
TKN	—	—	1.8 U[e]	1.0 U	1.8 U	1.0 U	NA[f]
NO_3-N	—	—	0.82	0.93	0.69	0.84	10
NO_2-N	—	—	0.10 U	0.10 U	0.10 U	0.10 U	1
Total Phosphorus	—	—	0.043	0.10 U	0.074	0.10 U	NA
TDS	—	—	407	554	404	412	500
Chloride	—	—	91.4	213	66.8	112	250
Fluoride	—	—	0.28	0.39	0.14	0.21	4
Aluminum	—	—	0.707	0.251	0.0321	0.0591	0.2
Aluminum–filtered	—	—	NT[g]	0.025 U	NT	NT	0.2
Arsenic	—	—	0.0029	0.0025 U	0.0025 U	0.0025 U	0.05
Arsenic–filtered	—	—	NT	0.0029	NT	NT	0.05
Cadmium	—	—	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Cadmium–filtered	—	—	NT	0.001 U	NT	NT	0.005
Chromium	—	—	0.0063	0.0075	0.0061	0.0066	0.1
Chromium–filtered	—	—	NT	0.0063	NT	NT	0.1
Copper	—	—	0.0026	0.0029	0.001	0.001	1.3
Copper–filtered	—	—	NT	0.0024	NT	NT	1.3
Iron	—	—	1.240	0.355	0.0631	0.147	0.3
Iron–filtered	—	—	NT	0.0566	NT	NT	0.3
Manganese	—	—	0.0202	0.0054	0.0025U	0.0025 U	0.05
Manganese–filtered	—	—	NT	0.0025U	NT	NT	0.05
Mercury	—	—	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002

Table 5-8. New INTEC Percolation Ponds groundwater quality data from perched water wells for April and October 2003.[a] (continued)

Depth to Water Table (ft)	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
	Dry[b]	Dry[b]	117.85	111.04	238.25	234.94	
Sample Date / Parameter	April 2003 Not Sampled	October 2003 Not Sampled	4/17/2003	10/7/2003	4/22/2003	10/7/2003	PCS/SCS[c]
Mercury–filtered	—	—	NT	0.0002 U	NT	NT	0.002
Selenium	—	—	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.05
Selenium–filtered	—	—	NT	0.0025 U	NT	NT	0.05
Silver	—	—	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.1
Silver–filtered	—	—	NT	0.0025 U	NT	NT	0.1
Sodium	—	—	47.10	134.0	11.40	21.2	NA
Sodium–filtered	—	—	NT	133.0	NT	NT	NA

a. All concentrations are in milligrams per liter (mg/L), except pH, which is in standard units.

b. ICPP-MON-V-191 is a perched well and was dry in April 2003 and October 2003 when permit-required sampling was performed. Therefore, the well could not be sampled.

c. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.

d. Because the well could not be sampled, no analyte-specific results are available.

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

f. NA = Not applicable.

g. NT = Not Taken. No filtered metal sample was taken.

during 2003. However, TDS, chloride, and sodium concentrations appear to be increasing since 2002.

Aluminum and iron concentrations in well ICPP-MON-V-200 were also above their respective SCSs (Table 5-8). The concentrations for aluminum, iron, and manganese in aquifer wells ICPP-MON-A-167 and ICPP-MON-A-166 were above the SCSs during at least one sample event in 2003 (Table 5-7). Well ICPP-MON-A-167 is the background aquifer monitoring well and is not regulated to these standards by the permit.

It is unlikely that the elevated levels of these parameters in the aquifer wells could be the result of the disposal of wastewater to the new ponds for the following reasons:

- Well ICPP-MON-A-167 was selected as the up gradient (background) monitoring well and should not be affected by discharges to the new ponds;
- The concentrations of aluminum, iron, and manganese in the effluent since August 26, 2002, are considerably lower than the concentrations in the aquifer wells in October 2003;
- The wastewater discharged to the New Percolation Ponds is the same wastewater that had been discharged to the old percolation ponds since 1995, and the concentrations of these parameters in the aquifer wells associated with the existing percolation ponds have not exceeded the SCS levels in the past; and
- Aluminum, iron, and manganese had been detected in the preoperational samples at approximately equal or higher concentrations.

One possible explanation for the elevated levels of aluminum, iron, and manganese may be that both wells were insufficiently developed during construction activities. Another possible explanation is that the annular seals have settled; thus, allowing bentonite slurry to affect the water quality. The sampling logbook entry for October 2003 described the purge water from ICPP-MON-A-167 as murky and the color of bentonite for the entire purge. Before the next sampling event, additional purging will be performed on wells ICPP-MON-A-166 and ICPP-MON-A-167 to try to remove any residual contaminants that may be in the wells as a result of the well construction activities.

During the October 2003 sampling event, an additional filtered (45 micron) sample was collected from wells ICPP-MON-A-166, ICPP-MON-A-167, and ICPP-MON-V-200 and was analyzed for metals. The aluminum, iron, and manganese concentrations in all three wells were significantly less in the filtered samples than in the permit-required unfiltered samples, and all were below the applicable SCSs. Refer to Tables 5-7 and 5-8 for the filtered results. The filters were submitted for additional analysis to try to verify the source of the higher-than-expected aluminum, iron, and manganese concentrations in these three wells. Based on the filter results and further evaluation, corrective actions will be implemented as applicable.

Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant

Description - The INTEC STP treats and disposes of sanitary and other related nonprocess wastes (cafeteria and building water softeners) using natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation). The INTEC STP consists of

- Three aerated lagoons (Cells 1, 2, and 3);
- One quiescent, facultative stabilization lagoon (Cell 4);
- Six control stations; and
- Four rapid infiltration trenches.

The six control stations direct the wastewater flow to the proper sequence of lagoons and infiltration trenches. Automatic flow-proportional composite samplers are located at control stations CPP-769 (influent) and CPP-773 (wastewater from the STP to the rapid infiltration trenches). The composite samplers collect 24-hour flow-proportional samples as required by the permit.

WLAP Wastewater Monitoring Results - The WLAP sets 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 requires 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 samples were analyzed for the parameters required by Schedule B of the permit. The permit-required data are summarized in Tables 5-9 and 5-10. Except for the monthly total coliform grab sample, all samples are collected as 24-hour flow-proportional composites. All permit-required samples were collected as scheduled.

Monthly average effluent TSS concentrations remained below the permit limit of 100 mg/L, with an annual average of 29.2 mg/L. During 2003, the average monthly total nitrogen exceeded the monthly average limit of 20 mg/L during March and November. The annual average total nitrogen concentration was 14.8 mg/L.

Total annual effluent flow to the trenches was 33.4 million L (8.86 million gal) during 2003, which is well below the permit limit of 78 million L/yr (30 million gal/yr). This total includes estimated flow volumes for periods when the flow meter was out of service.

WLAP Groundwater Monitoring Results - To measure potential INTEC STP impacts to groundwater, the WLAP requires 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 STP; and

Table 5-9. INTEC STP influent monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Biological Oxygen Demand (5-day)	121[d]	879	284	NA[e]
Nitrogen, Nitrate + Nitrite (mg-N/L)	0.031	0.365	0.173	NA
Total Phosphorus	5.1	10.4	6.7	NA
Total Kjeldahl Nitrogen	21.3	73.4	45.3	NA
Total Suspended Solids	55.2[f]	388.0	201.3	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were taken in July and are included in the summaries.
c. Annual average is determined from the average of the monthly values.
d. The minimum shown is from the duplicate sample taken in July 2003.
e. NA—Not applicable; no permit limit is set for this parameter.
f. The minimum shown is from the first sample taken in July 2003.

Table 5-10. INTEC STP effluent monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit[d]
Biochemical Oxygen Demand (5-day)	4.4	387.0	50.5	NA[e]
Conductivity (µS) (composite)	356	1,045	776	NA
Chloride	69	181	117	NA
Nitrogen, Nitrate + Nitrite (mg-N/L)	0.099	3.00	1.16	NA
Total Phosphorus	2.95[f]	4.29	3.57	NA
Total Dissolved Solids	296	873	505	NA
Total Kjeldahl Nitrogen	7.7	27.8	13.6	NA
Total Suspended Solids	7.5	69.1	29.2	100
Total Coliform (colonies/100 mL)	50	8,000	2,836	NA
Total Nitrogen[g]	8.8	29.0	14.8	20

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. A duplicate sample were taken in July for all parameters (excluding conductivity and total coliform), and are included in the summaries.
c. Annual average is determined from the average of the monthly values.
d. Effluent limit specified in Section I, Schedule A, Paragraph 1 of the WLAP.
e. NA—Not applicable; no permit limit is set for this parameter.
f. The minimum shown is from the first sample taken in July 2003.
g. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite.

- One aquifer well (USGS-052) downgradient of the STP, which serves as the point of compliance.

Sampling must be conducted semiannually (April and October) and includes a list of specified parameters for analysis. Contaminant concentrations in USGS-052 are 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 2003 permit year, groundwater samples were collected in April and October. Table 5-11 shows the water levels (collected 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 2003. Chloride and nitrate concentrations in USGS-052 were elevated compared to USGS-121, as in previous years.

Monitoring well ICPP-MON-PW-024 was completed 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. As in previous years, TDS and chloride concentrations in ICPP-MON-PW-024 approximated those of the effluent. The October result was above the SCS of 500 mg/L.

Fecal coliform was detected in the October sample from ICPP-MON-PW-024 at 2 col/100 mL. The fecal coliform species identified were *Klebsiella ozanae* and *Escherichia coli*. Total coliform was also identified in the October sample from ICPP-MON-PW-024 at a concentration of 500 colonies/100 mL. The laboratory performing the analysis identified the species of bacteria as *Klebsiella ozanae*.

Fecal coliform consists of various genera and species of coliform bacteria 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 source of coliform bacteria found in well ICPP-MON-PW-024 is probably the INTEC STP effluent.

Total nitrogen concentrations (comprised of NO_2-N, NO_3-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 NH_3-N. This suggests significant nitrification (a process whereby NH_3-N is converted to NO_3-N) by soil microbes, but little denitrification to a gas. This can be seen in the April 2003 sample from well ICPP-MON-PW-024 where the NO_3-N concentration was above the PCS of 10 mg/L.

In March 1997, the trench rotation frequency was increased from biweekly to weekly to increase denitrification in the soil column. The total nitrogen concentrations in the perched water now appear to be reduced compared to that of the effluent, with concentrations generally falling between that of the effluent and that measured at USGS-052. Weekly trench rotation will continue, and concentrations of these parameters will continue to be observed and tracked.

Table 5-11. INTEC STP groundwater monitoring results (2003).[a]

	ICPP-MON-PW-024 (GW-011502)		USGS-052 (GW-011501)				USGS-121 (GW-011503)		
Depth to Water Table m (ft)	61.55	63.8	457.26	457.26	459.32	459.32	460.92	460.94	
Sample Date / **Parameter**	4/15/2003	10/8/2003	4/14/2003	4/14/2003[c]	10/21/2003	10/21/2003[c]	4/15/2003	10/8/2003	**PCS/SCS[b]**
TKN	0.90 U[d]	1.0 U	0.90 U	0.90 U	1.0 U	1.0 U	0.90 U	1.0 U	NA[e]
Chloride	91.0	139	31.3	31.5	25.8	25.8	12.2	12.0	250
TDS	422	569	261	214	254	257	178	219	500
NO_3-N	10.8	5.8	3.7	3.7	2.7	2.6	0.70	0.70	10
NO_2-N	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	1
NH_4-N	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA
BOD	3.8	2.0 U	2.5	2.8	2.0 U	2.0 U	3.0	2.0 U	NA
Total Phosphorus	2.1	2.4	0.068	0.085	0.10 U	0.10 U	0.077	0.10 U	NA
Total Coliform	Absent	500[f]	Absent	Absent	Absent	Absent	Absent	Absent	1 colony/100 mL
Fecal Coliform	Absent	2[g]	Absent	Absent	Absent	Absent	Absent	Absent	NA

a. All concentrations are in milligrams per liter (mg/L), except pH, which is in standard units.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
c. Duplicate sample.
d. U flag indicates that the result was reported as below the detection limit.
e. NA = Not applicable.
f. *Klebsiella ozanae* was speciated in this sample.
g. *Klebsiella ozanae* and *Escherichia coli* were speciated in this sample.

Test Area North/Technical Support Facility Sewage Treatment Plant

Description - The TAN/TSF STP (TAN-623) was constructed in 1956. It was 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 STP 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 Disposal Pond consists of a primary disposal area and an overflow section, both of which are located within an unlined, fenced 14.2-ha (35-acre) area. The overflow pond is used only when wastewater is diverted to it for brief periods of cleanup and maintenance of the primary pond. 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 STP, 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 - The permit flow limit is 129 million L/yr (34 million gal/yr) discharged to the TAN/TSF Disposal Pond. Total effluent to the TAN/TSF Disposal Pond for calendar year 2003 was approximately 39.4 million L (10.42 million gal). This total includes estimated flow volumes for periods when the flow meter was out of service.

The permit for the TAN/TSF STP also sets concentration limits for TSS 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 2003, 24-hr composite samples (except fecal and total coliform, which were grab samples) were collected from the TAN-655 lift station effluent monthly.

Table 5-12 summarizes the effluent monitoring results for calendar year 2003. Monthly concentrations of TSS were well below the permit limit (100 mg/L) throughout the entire year, with an annual average of 9.21 mg/L. All monthly total nitrogen (TKN + nitrogen, nitrite+nitrate) concentrations were well below the permit limit of 20 mg/L, with the maximum monthly concentration of 11.11 mg/L reported in June.

WLAP Groundwater Monitoring Results - To measure potential TAN/TSF Disposal Pond impacts to groundwater, the WLAP for the TAN/TSF STP 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 2003 permit year, groundwater samples were collected in April and October. Table 5-13 shows water levels (recorded 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 TAN-10A in April and October. Iron concentrations in additional filtered samples collected in April and October 2003 from TAN-10A also exceeded the SCS. Elevated iron concentrations historically have been detected in the TAN WLAP monitoring wells.

Video log information gathered on all four WLAP wells showed that the carbon-steel well casing in well TAN-10A appeared to be corroded most of the way to the water table. In August 2001, to address the elevated iron concentration in all four TAN WLAP monitoring wells, the riser pipes attached to the dedicated submersible pumps were replaced with stainless steel riser pipes. Based on samples collected prior to the maintenance and those collected after the maintenance, iron concentrations in three of the WLAP monitoring wells have decreased. However, the iron concentrations in TAN-10A increased after the maintenance and were above the SCS in 2003. The condition of the well casing, coupled with the residual effects relating to the replacement of the galvanized riser pipe, may have resulted in the iron concentrations exceeding the SCS in TAN-10A during 2003.

Total coliform was identified in TANT-MON-A-001 (background well), TANT-MON-A-002 (compliance well), and TAN-13A (compliance well) above the PCS of one colony/100 mL in the October 2003 sample. The total coliform in wells TANT-MON-A-001, TANT-MON-A-002, and TAN-13A were four colonies/100 mL, 17 colonies/100 mL (26 colonies/100 ml, duplicate), and 72 colonies/100 ml, respectively. The coliform species identified by the laboratory was *Hafnia alvei* in wells TANT-MON-A-001 and TANT-MON-A-002. Two coliform species, *Hafnia alvei* and *Serratia marcescens* were identified in well TAN-13A.

Table 5-12. TAN/TSF STP effluent annual monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit[d]
Biological Oxygen Demand (5-day)	7.2	47.5	14.5	NA[e]
Chloride	19.3	245.0	91.1	NA
Fluoride	0.10[f]	0.34	0.24	NA
Nitrogen, as Ammonia	0.05	2.49	0.96	NA
Nitrogen, Nitrate + Nitrite (mg-N/L)	2.65	5.07	3.82	NA
Total Kjeldahl Nitrogen	2.0	8.0	3.4	NA
Total Nitrogen[g]	4.76	11.11	7.23	20
Total Phosphorus	0.207	0.849	0.601	NA
Sulfate	35.6	52.1	39.6	NA
Total Dissolved Solids	260	962	418	NA
Total Suspended Solids	2.0[f]	29.3	9.21	100
Arsenic	0.0013[f]	0.0054	0.0024	NA
Barium	0.091	0.114	0.098	NA
Chromium	0.0013[f]	0.004	0.0028	NA
Iron	0.091	0.370	0.159	NA
Lead	0.0002[f]	0.0036	0.0009	NA
Manganese	0.003	0.012	0.005	NA
Mercury	0.0001[f]	0.0001[f]	0.0001[h]	NA
Selenium	0.0008[i]	0.0026[j]	0.0010	NA
Sodium	8.7	157.0	59.9	NA
Zinc	0.022	0.040	0.030	NA
Fecal Coliform (colonies/100 mL)	5,000	79,000	40,633	NA
Total Coliform (colonies/100 mL)	53,000	160,000	89,333	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were taken in January for all parameters (excluding fecal and total coliform) and 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 the yearly average calculation for those data reported as below the detection limit.
d. Effluent limit specified in Section I, Schedule A, Paragraph 1 of the WLAP.
e. NA—Not applicable; no permit limit is set for this parameter.
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.
h. All data were reported as less than the detection limit. Therefore, the average is based on half the reported detection limit for each of the monthly values.
i. The minimum shown is from the duplicate sample taken in January. It represents the minimum of the detected results and of the reported detection limits (for those results during the year that were reported as less than the detection limit).
j. The maximum shown is from the first sample taken in January.

Table 5-13. TAN/TSF STP groundwater monitoring results (2003).

	TANT-MON-A-001 (GW-015301)		TANT-MON-A-002 (GW-015304)				TAN-10A (GW-015303)		TAN-13A (GW-015302)		
Depth to Water Table m (ft)	206.31	207.96	210.73	210.73	211.41	211.41	206.93	209.79	209.35	209.05	
Sample Date Parameter[b]	4/21/2003	10/14/2003	4/21/2003	4/21/2003[c]	10/14/2003	10/14/2003[c]	4/16/2003	10/1/2003	4/16/2003	10/1/2003	**PCS/SCS[a]**
TKN	0.90 U[d]	2.2	1.8 U	1.8 U	2.0	1.7	1.8 U	1.0 U	0.90 U	1.0 U	NA[e]
BOD	2.9	2.0 U	2.6	2.8	2.0 U	2.0 U	3.1	2.0 U	2.0 U	2.0 U	NA
Chloride	121	10.9	3.6	3.1	3.3	3.2	101	99.6	7.2	3.2	250
TDS	248	225	225	216	196	188	424	479	147	95	500
Total Phosphorus	0.084	0.12	0.030 U	0.084	0.10 U	0.10 U	0.21	0.10 U	0.030 U	0.50 U	NA
Sodium	7.56	7.14	5.49	5.56	5.87	5.83	51.9	48.6	5.63	5.54	NA
NO_3-N	0.83	0.79	0.48	0.51	0.50	0.52	1.1	0.83	0.40	0.40	10
NO_2-N	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	1
NH_4-N	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA
Arsenic	0.0025 U	0.0027	0.0027	0.0025 U	0.0027	0.0038	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.05
Barium	0.0806	0.078	0.0800	0.0796	0.0773	0.0769	0.241	0.242	0.0752	0.0748	2
Chromium	0.0043	0.0042	0.0089	0.0057	0.0079	0.0064	0.0025 U	0.0025 U	0.0044	0.0058	0.1
Mercury	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Selenium	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.05
Fluoride	0.16	0.17	0.18	0.19	0.16	0.12	0.11	0.17	0.18	0.21	4
Iron	0.0356	0.0538	0.172	0.158	0.0935	0.0777	0.433	1.07	0.0387	0.0932	0.3
Iron (filtered)	—	—	—	—	—	—	0.347	0.918	0.025 U	0.0427	0.3
Lead	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.015
Manganese	0.0025 U	0.0025 U	0.0039	0.0034	0.0025 U	0.0025 U	0.0082	0.0111	0.0025 U	0.0025 U	0.05
Sulfate	32.8	30.8	13.3	13.4	14.0	13.6	39.6	39.5	14.2	13.8	250
Zinc	0.0506	0.0398	0.201	0.188	0.107	0.103	0.0291	0.0226	0.171	0.174	5
Total Coliform	Absent	4[f]	Absent	Absent	17[f]	26[f]	Absent	Absent	Absent	72[g]	1 colony/ 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. All concentrations are in milligrams per liter (mg/L), except total and fecal coliform, which are colonies per 100 mL.
c. Duplicate sample.
d. U flag indicates that the result was reported as below the detection limit.
e. NA = Not applicable.
f. *Hafnia alvei* was speciated in this sample.
g. *Hafnia alvei* and *Serratia marcescens* were speciated in this sample.

The TAN/TSF Disposal Pond effluent contains total coliform bacteria; however, it is unlikely the coliform detected in wells TANT-MON-A-001 and TANT-MON-A-002 was the result of the Disposal Pond effluent. TANT-MON-A-001 is the background well and is not influenced by the Disposal Pond. TANT-MON-A-002 is west/southwest of the Disposal Pond, and groundwater flows at TAN are primarily to the south or southeast; therefore, it is unlikely that bacteria could be transported into the well without significant transverse dispersivity in the vadose zone.

For well TAN-13A, the October 2003 detection is the first time coliform bacteria has been detected since 1996. Because well TAN-13A is located southeast of the Disposal Pond, it is possible that the coliform in the effluent discharged to the pond has affected this well. However, fecal coliform is also present in the effluent but was not detected in TAN-13A in 2003.

There are many possible sources for the total coliform detected in the samples from these three wells. Further evaluation will be required to try to identify the specific source of the coliform contamination. If the source can be identified, appropriate corrective actions can be taken.

Test Reactor Area Cold Waste Pond

Description - The TRA Cold Waste Pond was constructed in 1982. The effluent to the Cold Waste Pond receives a combination of process water from various TRA facilities. 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 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 TSS analyses were added in August 2001 to the list of parameters analyzed quarterly at the Cold Waste Pond. These are the only parameters required for compliance. Other parameters are sampled for surveillance purposes, which are discussed in Section 5.3.

Automated samplers are used to collect quarterly 24-hour time-proportional composite samples from TRA-764. TSS and total nitrogen results are summarized in Table 5-14. Additional monitoring for surveillance parameters is discussed in the next section. The 2003 annual average for TSS was 3.3 mg/L with a maximum concentration of 7.3 mg/L. These levels are well below the regulatory limit of 100 mg/L. The maximum total nitrogen concentration during 2003 was 5.05 mg/L, and it was also significantly less then the regulatory limit of 20 mg/L.

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

Table 5-14. TRA Cold Waste Pond effluent monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit[d]
Total Suspended Solids	2.0	7.3	3.3	100
Total Nitrogen[e]	1.10[f]	5.05	3.30	20

a. All values are in milligrams per liter (mg/L).
b. Duplicate samples were taken in October 2003 for both parameters 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 the yearly average calculation for those data reported as below the detection limit.
d. Effluent limit specified in IDAPA 58.01.17.600.06.B, Wastewater Land Application Permit Rules.
e. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite.
f. The minimum shown is from the duplicate sample taken in October 2003.

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 2003, 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, TSS, 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 5-15).

Central Facilities Area

Both the influent and effluent to the CFA STP are monitored according to the WLAP issued for the plant. Table 5-16 summarizes the additional monitoring conducted during 2003 at the CFA STP 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 2003, no applicable limits were exceeded for any of the additional parameters monitored, and all additional parameters were within historical concentration levels.

Table 5-15. ANL-W industrial and Sanitary Waste Pond effluent monitoring results (2003).

Parameter	Industrial Waste Pond			Industrial Waste Ditch			Sanitary Waste Pond		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Iron[a]	0.10	1.14	0.41	0.10	0.44	0.18	0.10	0.35	0.18
Mercury	5.2×10^{-5}	0.007	0.0061	5.2×10^{-5}	0.007	0.0061	—[b]	—	—
Sodium	31.3	65.8	47.31	20	66	29.41	62.60	316.00	226.37
Chloride	28	63	40.14	26	59	35.00	190	430	309.14
Fluoride	1	1	1.04	1	1	1.00	1	1	1.00
Phosphate	1	2	1.14	1	1	1.00	1	28	12.06
Sulfate	21	33	25.29	14	33	21.70	58	111.29	66
Gross alpha[c]	5.2	200	56.83	5.2	200	79.72	5.2	200	68.28
Gross beta	12	200	85.83	13	200	61.67	40	200	87.50
Gross gamma	0	0	0.00	0	0	0.00	0	0	0.00
Tritium	3,200	3,600	3,333.33	3,200	3,600	3,266.67	3,200	3,600	3,300.00
pH[d]	7.59	9.05	8.40	7.19	9.18	7.95	6.56	8.84	7.31

a. Values of iron through sulfate are in milligrams per liter (mg/L).
b. — = constituent not analyzed.
c. Radiological values are in picocuries per liter (pCi/L).
d. pH values are in standard units.

Idaho Nuclear Technology and Engineering Center

Wastewater Land Application Permits exist for the STP and the New Percolation Ponds at the INTEC. Table 5-17 summarizes the additional monitoring conducted during 2003 at INTEC and shows those parameters with at least one detected result during the year.

For the INTEC STP, none of the additional parameters exceeded applicable limits. No additional parameters were analyzed for at the New Percolation Ponds beyond those required by the permit.

Naval Reactors Facility

Liquid effluent monitoring confirmed all discharges to the industrial waste ditch in 2003 were controlled in accordance with applicable federal and State laws. No detections above these limits were seen. Specifics regarding this monitoring are published in the *2003 Environmental Monitoring Report for the Naval Reactors Facility* (Bechtel Bettis 2003).

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

Table 5-16. CFA liquid effluent surveillance monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Influent to CFA Sewage Treatment Plant Pond 1				
Conductivity (µS) (grab)	854	1,201	973	NA
Total Phosphorus	1.26	5.51	2.33	NA
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System				
Conductivity (µS) (grab)	1,418	1,749	1,568	NA
Chloride	373	373	373	NA
Fluoride	0.343	0.343	0.343	NA
Sulfate	57.7	57.7	57.7	NA
Total Dissolved Solids	746	746	746	NA
Aluminum	0.051	0.051	0.051	NA
Antimony	0.00065	0.00065	0.00065	
Arsenic	0.0034	0.0034	0.0034	
Barium	0.099	0.099	0.099	NA
Copper	0.004	0.004	0.004	NA
Iron	0.0754	0.0754	0.0754	
Manganese	0.007	0.007	0.007	NA
Sodium	158	158	158	NA
Zinc	0.005	0.005	0.005	NA
Gross Beta[d]	7.47 ± 2.32	7.47 ± 2.32	7.47 ± 2.32	NA
Tritium[d]	7,670 ± 372	7,670 ± 372	7,670 ± 372	NA
Iodine-129[d]	0.316 ± 0.14	0.316 ± .14	0.316 ± 0.14	NA
Transportation Complex, CFA-696				
pH (standard units) (grab)	7.51	7.93	7.81	NA
Conductivity (µS) (grab)	601	951	729	NA
Total Oil and Grease	5.14	30.70	14.44	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. 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).

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 5-18 summarizes the results of this additional monitoring for those parameters with at least one detected result. During 2003, the concentrations of the additional parameters were below applicable limits and within historical concentration levels.

Table 5-17. INTEC liquid effluent surveillance monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Influent to INTEC Sewage Treatment Plant				
Conductivity (µS)	702	1,125	886	NA
pH (standard units)	8.18	8.71	8.50	NA
Effluent from INTEC Sewage Treatment Plant				
pH (standard units) (grab)	7.85	8.99	8.55	NA
Conductivity (µS) (grab)	604	1,078	819	NA
Sulfate	40.60	40.60	40.60	NA
Aluminum	0.052	0.052	0.052	NA
Barium	0.121	0.121	0.121	NA
Copper	0.004	0.004	0.004	NA
Iron	0.182	0.182	0.182	NA
Manganese	0.020	0.020	0.020	NA
Sodium	72.80	72.80	72.80	NA
Zinc	0.013	0.013	0.013	NA
Gross Alpha[d]	-0.40 ± 1.62[e]	2.35 ± 1.66	0.81 ± 0.65	NA
Gross Beta[d]	4.69 ± 1.26	18.40 ± 2.82	8.23 ± 0.89	NA
Iodine-129[d]	0.10 ± 0.06	0.10 ± 0.06	0.10 ± 0.06	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. 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. Result was a statistical nondetect.

Table 5-18. TAN liquid effluent surveillance monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Effluent to TAN/TSF Disposal Pond				
Conductivity (µS) (grab)	423	1,385	760	NA
pH (standard units) (grab)	7.57	9.31	8.25	NA
Aluminum	0.0125[d]	0.051	0.027	NA
Antimony	0.0003[d]	0.0006	0.0004	
Copper	0.003	0.057	0.013	NA
Gross Alpha[e]	0.80 ± 1.21[f]	3.28 ± 1.64	1.60 ± 0.83	NA
Gross Beta[e]	3.32 ± 1.29	18.80 ± 1.65	10.27 ± 0.75	NA
Strontium-89[e]	1.73 ± 0.13	1.73 ± 0.13	1.73 ± 0.13	
Strontium-90[e]	1.69 ± 0.46	8.30 ± 1.18	2.82 ± 0.41	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. 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), plusor minus the uncertainty (two standard deviations).
f. Result was a statistical nondetect.

Test Reactor Area

Additional monitoring for surveillance purposes is conducted quarterly for metal and radiological parameters. Table 5-19 summarizes the results of this additional monitoring for those parameters with at least one detected result. During 2003, 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 2003, 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 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.

Table 5-19. TRA effluent surveillance monitoring results (2003).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Effluent from TRA Cold Waste Pond				
Conductivity (µS) (grab)	414	1,098	743	NA
pH (standard units) (grab)	7.78	8.00	7.90	NA
Chloride	10.30	30.60	22.60	NA
Fluoride	0.100[d]	0.343	0.219	NA
Nitrogen, Nitrate+Nitrite (mg-N/L)	1.02	2.78	1.89	NA
Sulfate	31.80	425	224.15	NA
Total Dissolved Solids	257	821	498	NA
Total Kjeldahl Nitrogen	0.160	3.97	1.404	NA
Antimony	0.0003[d]	0.001	0.0005	
Arsenic	0.0015[d]	0.004	0.003	NA
Barium	0.050	0.126	0.087	NA
Chromium	0.003	0.008	0.006	NA
Copper	0.002	0.010	0.004	NA
Iron	0.0125[d]	0.103	0.075	NA
Selenium	0.001[d]	0.004	0.002	
Sodium	8.08	27.90	18.05	NA
Zinc	0.0015[d]	0.010	0.005	NA
Gross Alpha[e]	2.10 ± 1.13	4.00 ± 1.95	2.55 ± 0.82	NA
Gross Beta[e]	0.86 ± 1.64[f]	9.07 ± 2.20	4.61 ± 0.54	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. 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 non-detect.

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, each contractor administers their own drinking water program.

The Drinking Water Program was established to monitor drinking water and production wells, which are multiple-use wells for industrial use, fire safety, and drinking water. 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 (40 CFR 141-143 2003). 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 State Department of Environmental Quality 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 maximum contaminant levels must be monitored at least once during every three-year compliance period. Parameters with secondary maximum contaminant levels are monitored every three years based on a recommendation by the EPA. The three year compliance periods for the 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 most probably caused by biofilm on older water lines and stagnant water, because resampling results were normally in compliance with the MCL.

M&O Contractor Drinking Water Monitoring Results

During 2003, 389 routine samples and 53 quality control samples were collected and analyzed from CFA, EBR-I, Gun Range (Live-Fire Test 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. For example, 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. The M&O contractor Drinking Water Program received 48 requests for nonroutine sampling during 2003.

Analytical results of interest for 2003, exceedances, and nitrate (required to be monitored annually) results are presented in Tables 5-20 through 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.

In 2003, total coliform and fecal coliform bacteria were absent in all M&O contractor-operated water systems at the INEEL, except for TRA. Total coliform was detected in September 2003 at TRA because the disinfection system was out of service. After the disinfection system was repaired and the water system was disinfected and returned to service, no coliform bacteria were detected. No other MCL exceedances occurred during 2003 for any parameter.

Table 5-20. Monitored parameters of interest in 2003.

Parameter[a]	Location	Results[b]	MCL[b]
Carbon Tetrachloride	RWMC Distribution	2.80	5
	RWMC Well[c]	4.57	NA[d]
Trichloroethylene	RWMC Distribution	1.60	5
	RWMC Well[c]	2.30	NA
	TAN/TSF Distribution	1.20	5
	TAN/TSF #2 Well[c]	2.50	NA
Tritium	CFA Distribution	9,276 ± 253	20,000
	CFA #1 Well[c]	9,283 ± 304[e]	NA
	CFA #2 Well[c]	8,244 ± 343[e]	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).
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.
e. Result is based on a two quarters of sampling.

Table 5-21. Monitored parameter exceedences in 2003.

Parameter[a]	Location	Results	MCL
Total Coliform	TRA Distribution	Present	Absent

a. Total coliform was detected in the TRA distribution system in September 2003.

Table 5-22. Nitrate results for M&O contractor and ANL-W water systems in 2003.

Water System	PWS Number	Parameter	Concentration[a]	MCL[a]
ANL-W	6060036	Nitrate as nitrogen	1.53	10
CFA	6120008	Nitrate as nitrogen	2.70	10
INTEC	6120012	Nitrate as nitrogen	0.70	10
EBR-I	6120013	Nitrate as nitrogen	0.34	10
Gun Range	6120009	Nitrate as nitrogen	0.81	10
Main Gate	6120035	Nitrate as nitrogen	0.59	10
PBF	6120015	Nitrate as nitrogen	0.84	10
RWMC	6120019	Nitrate as nitrogen	0.75	10
TAN/CTF	6120018	Nitrate as nitrogen	0.87	10
TAN/TSF	6120030	Nitrate as nitrogen	0.80	10
TRA	6120031	Nitrate as nitrogen	0.79	10

a. Concentration and MCL are in milligrams per liter (mg/L).

Central Facilities Area - The CFA water system serves approximately 850 people daily. Since the early 1950s, wastewater containing tritium was disposed to the Snake River Plain Aquifer (SRPA) 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 2003, 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 rates, disposal techniques, recharge conditions, and radioactive decay.

CFA Worker Dose - Because of the potential impacts to down-gradient workers at CFA from radionuclides in the SRPA, the potential effective dose equivalent from radioactivity in water was calculated. CFA was selected because tritium concentrations found in these wells were the

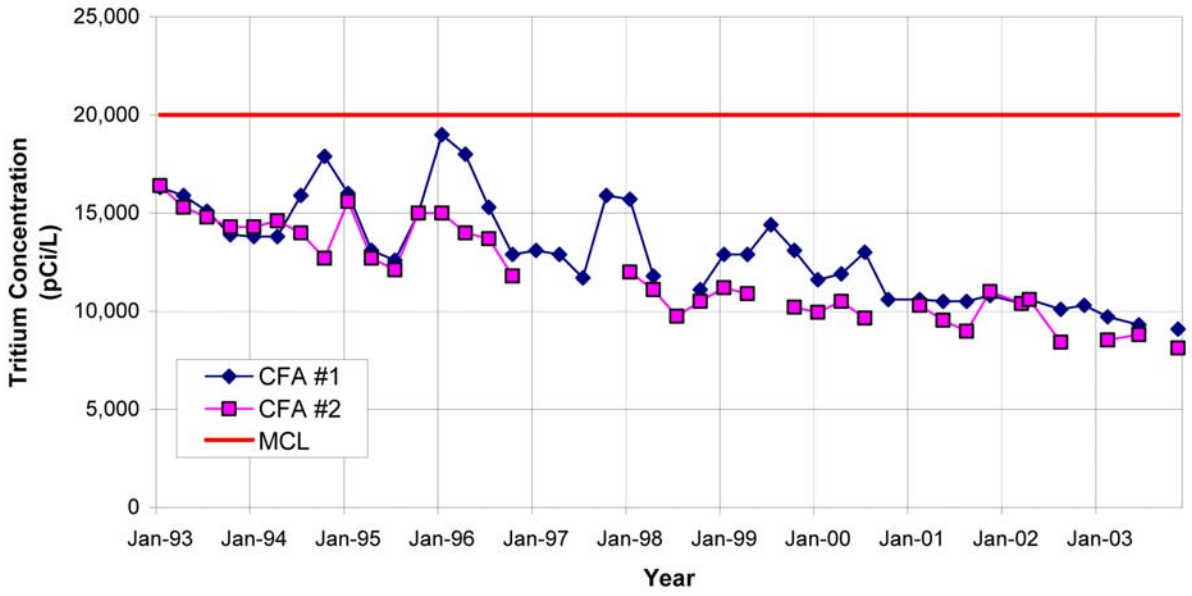


Figure 5-1. Tritium concentrations in two wells and two distribution systems at the INEEL (1993-2003).

highest of any drinking water wells. The 2003 calculation was based on

- Mean tritium concentration for the CFA distribution system in 2003;
- Water usage information for 2003 showing CFA 1 was used for approximately 50 percent of the drinking water and CFA 2 for 50 percent of the drinking water; and
- Data from a 1990-1991 USGS study for ^{129}I using the accelerator mass spectrographic analytical technique that indicated water from both CFA 1 and CFA 2 had measurable concentrations of ^{129}I. The average (four samples) concentration for ^{129}I for the CFA distribution system was 0.28 ± 0.03 pCi/L for 2003. For perspective, the EPA drinking water standard for ^{129}I is 1 pCi/L.

For the 2003 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 2003 was 0.88 mrem (8.8 µSv), below the EPA standard of 4 mrem/yr for public drinking water systems.

Radioactive Waste Management Complex - Various solid and liquid radioactive and chemical wastes, including transuranic wastes, have been disposed at the RWMC. The RWMC contains pits, trenches, and vaults where radioactive and organic wastes were disposed below grade, as well as placed above grade on a large pad and covered. During an INEEL-wide characterization program conducted by USGS, carbon tetrachloride and other volatile organic

compounds were detected in groundwater samples taken at the RWMC (Lewis and Jensen 1984). Review of waste disposal records indicated an 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) were disposed at the RWMC before 1970. High vapor-phase concentrations (up to 2700 parts per million vapor phase) of volatile organic compounds were measured in the zone above the water table. Groundwater models predict that volatile organic compound concentrations will continue to increase in the groundwater at the RWMC.

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 applies to the distribution

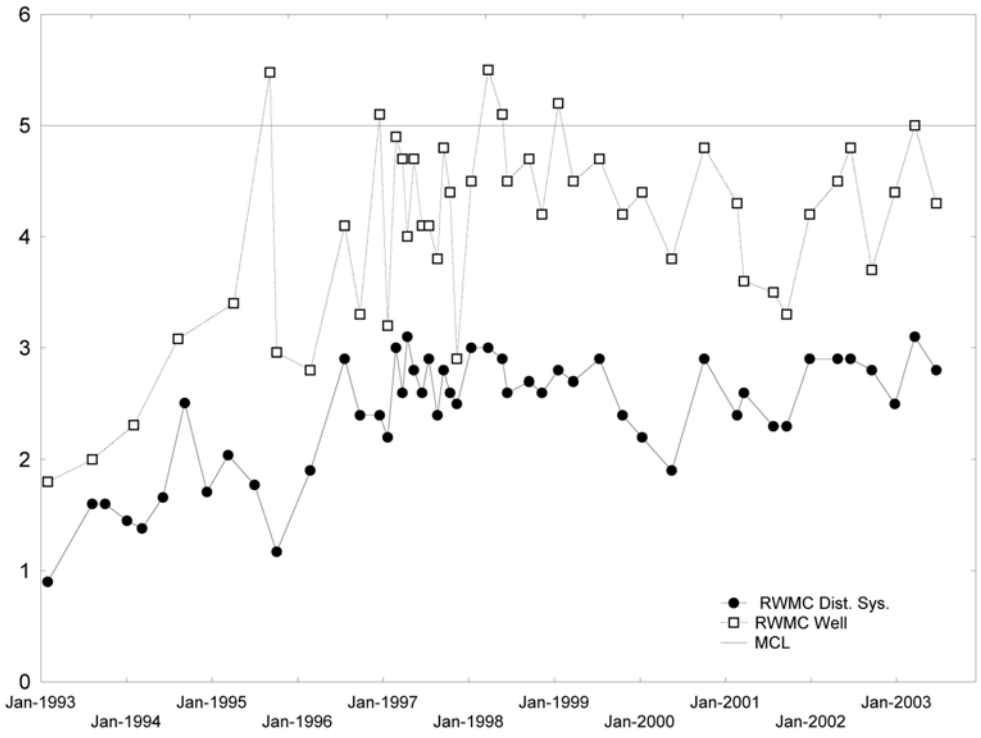


Figure 5-2. Carbon tetrachloride concentrations in the RWMC drinking water well and distribution system.

system. 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 2003. The mean concentration at the well for 2003 was 4.57 µg/L, and the maximum concentration was 5.0 µg/L. The mean concentration at the distribution system was 2.80 µg/L, and the maximum concentration was 3.1µg/L.

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.

Table 5-23. Carbon tetrachloride concentration in the RWMC drinking water well and distribution system (2003).

Location	Number of Samples	Carbon Tetrachloride Concentration[a]			
		Minimum	Maximum	Mean	MCL
RWMC WMF-603 Well	3	4.3	5.0	4.57	NA[b]
RWMC WMF-604 Distribution	3	2.5	3.1	2.80	5.0

a. All concentrations are in micrograms per liter (µg/L).
b. NA = Not applicable. MCL applies to the distribution system only.

Test Area North/Technical Support Facility - In 1987, trichloroethylene was detected at both TSF 1 and 2 Wells, which supply drinking water to approximately 100 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 1993 through 2003. Past distribution system sample exceedances are attributed to preventive maintenance activities interrupting operation of the sparger 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 2003 because it was not required by the regulations. The mean concentration of trichloroethylene at the distribution system for 2003 was 1.20 µg/L, which is below the MCL.

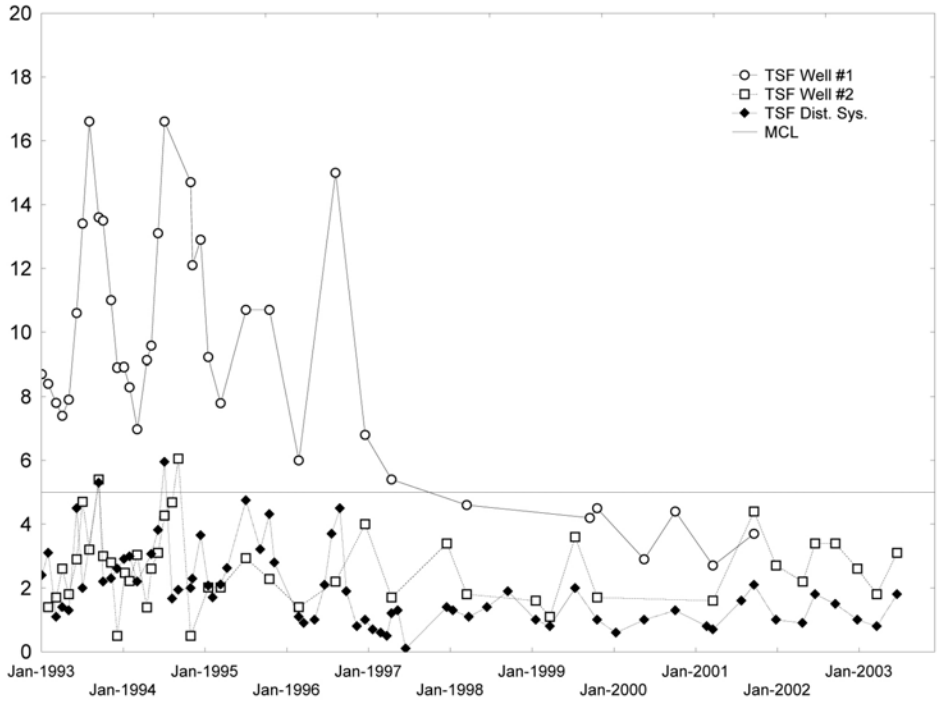


Figure 5-3. Trichloroethylene concentrations in TSF drinking water wells and distribution system.
(Note: During 2003, sampling of Well 1 was not required.)

Table 5-24. Trichloroethylene concentrations at TSF 2 Well and distribution system (2003).

Location	Number of Samples	Trichloroethylene[a]			
		Minimum	Maximum	Mean	MCL
TAN/TSF #2 Well (612)[b]	3	1.8	3.1	2.50	NA[c]
TAN/TSF Distribution (610)	3	0.8	1.5	1.20	5.0

a. All concentrations are in micrograms per liter (μg/L).
b. Regulations do not require sampling at this well.
c. NA = Not applicable. MCL applies to the distribution system only.

Argonne National Laboratory-West

During 2003, 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 volatile organic compounds, inorganic constituents, and water quality parameters. Radionuclides were sampled at each wellhead.

Drinking water monitoring at NRF did not detect any volatile organic compounds above minimum detection levels. No gross alpha, gross beta, programmatic gamma-emitters, or strontium-90 (^{90}Sr) were measured in excess of natural background concentrations in 2003. Tritium values were generally comparable to background concentrations and showed no increase over levels reported in 2002. For more information see the *2003 Environmental Report for the Naval Reactors Facility* (Bechtel Bettis 2003).

Offsite Drinking Water Sampling

As part of the offsite monitoring performed by the ESER contractor, radiological analyses are performed on drinking water samples taken at offsite locations. In 2003, the ESER contractor collected 28 drinking water samples from 13 offsite locations.

No drinking water samples collected during 2003 contained any gross alpha.

As in years past, measurable gross beta activity was present in most offsite drinking water samples (19 of the 28 samples). Detectable concentrations ranged from 2.89 ± 0.85 pCi/L to 9.72 ± 1.16 pCi/L (Table 5-25). 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 a single drinking water sample during 2003. The tritium concentration of 83.6 ± 23.7 pCi/L, was from Taber in November (Table 5-25). 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.

5.5 Storm Water Monitoring

The EPA NPDES regulations for discharges of storm water to waters of the United States require permits for discharges from industrial activities (40 CFR 122.26 2003). Under these regulations, waters of the United States at the INEEL are considered to be the

- Big Lost River;
- Little Lost River;

Table 5-25. 2003 ESER contractor offsite drinking water results.

Location	Sample Results		Limits for Comparison[a]	
	Result ± 2s[a]	MDC[b]	EPA MCL[b]	DOE DCG[b]
Gross Beta				
May 2003				
Aberdeen	5.24 ± 0.94	2.66	50[c]	100
Atomic City	3.25 ± 0.81	2.45	50	100
Fort Hall	9.59 ± 1.03	2.60	50	100
Idaho Falls	3.01 ± 0.82	2.52	50	100
Minidoka	3.57 ± 0.84	2.51	50	100
Monteview	9.72 ± 1.16	3.03	50	100
Moreland	8.36 ± 1.06	2.82	50	100
Mud Lake (Duplicate)	4.87 ± 0.83	2.35	50	100
Roberts	4.38 ± 0.86	2.51	50	100
Shoshone	4.09 ± 0.83	2.45	50	100
November 2003				
Aberdeen	5.08 ± 1.00	—[d]	50	100
Atomic City	2.89 ± 0.85	—	50	100
Fort Hall	8.37 ± 1.06	—	50	100
Minidoka	3.86 ± 0.92	—	50	100
Monteview	4.13 ± 0.89	—	50	100
Moreland	7.79 ± 1.18	—	50	100
Mud Lake	5.38 ± 0.91	—	50	100
Duplicate	4.35 ± 0.93	—	50	100
Taber	5.16 ± 0.99	—	50	100
Tritium				
November 2003				
Taber	83.60 ± 23.70	—	20,000	2×10^6

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

b. MDC = minimum detectable concentration, 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.

d. As a result of improved procedures MDCs are no longer calculated.

- 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 to meet the requirements of the reissued General Permit (DOE-ID 2002). 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 permits' 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. The Storm Water Monitoring Program monitors the following facilities or activities

- Borrow sources (nonmetallic mineral mining, Sector J);
- INTEC (hazardous waste treatment, storage, and disposal, Sector K - ceased monitoring in December 2003);
- Landfills I, II, and III Extension at the CFA (Landfills, Sector L);
- RWMC (Sector K and Sector L - ceased monitoring in December 2003); and
- Specific Manufacturing Capability at TAN (transportation equipment manufacturing, Sector AB - ceased monitoring in December 2003).

In addition to the above discussed NPDES permit-required monitoring, the program monitors storm water to deep injection wells 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

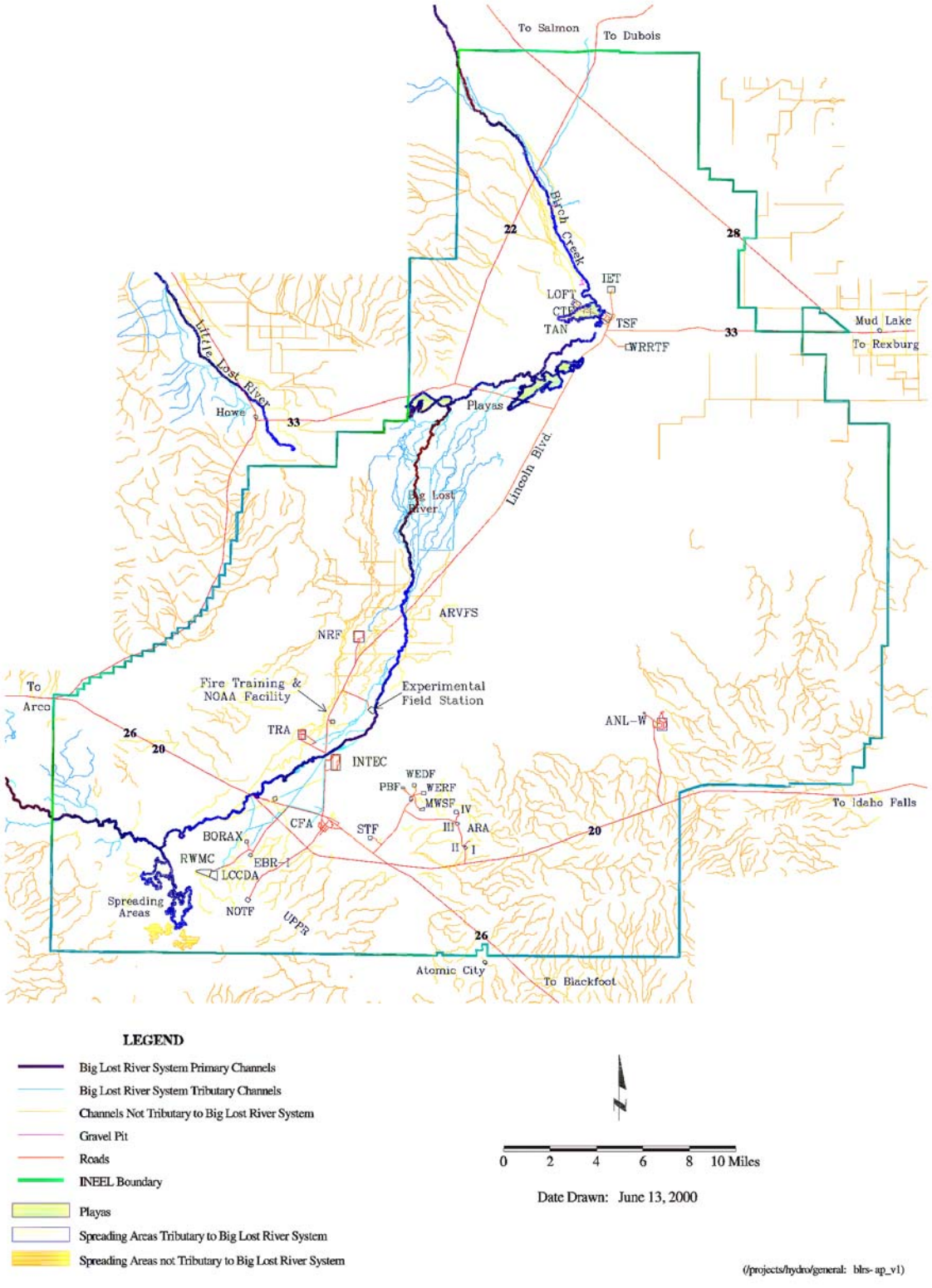


Figure 5-4. Big Lost River System.

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.

A total of thirty-four sites at five INEEL areas are designated as storm water monitoring locations based upon drainage patterns and proximity to potential sources of pollutants. Twenty-seven of these locations met the conditions for quarterly visual monitoring required by the General Permit when discharges occur to the Big Lost River System. 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.

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

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 BBWI 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 BBWI to conduct a technical analysis to determine any other areas under the M&O contractor's evaluation 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 will be evaluated through the technical analysis requested by DOE-ID to determine potential to discharge. Required storm water inspections and reporting will continue for these projects until the technical analysis is complete. At that time, inspections and reports at any additional projects that have no reasonable potential to discharge to waters of the United States, as determined through the technical analysis, will cease.

Storm Water Monitoring Results

During 2003, 68 visual storm water examinations were performed at 22 locations. No rainfall, snowmelt, or discharge down injection wells was observed at 14 monitoring points; therefore, no visual examinations were performed or analytical samples collected at those locations.

The visual examinations performed in 2003 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.

Analytical samples were collected for qualifying rain events that potentially discharged to waters of the United States at applicable monitoring locations. Potential discharges to waters of the United States from a qualifying storm occurred at two locations at the RWMC. Location RWMC-MP-1/2 is in a culvert on the east side of the Operations Area, on the north side of the main channel flow system, and RWMC-MP-4/1 is located in a culvert on the west side of the main channel flow system. Although the potential for discharge to waters of the United States exists, there was no indication that such a discharge occurred for these events. In addition, 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 5-26 through 5-29 summarize the 2003 results and permit benchmark concentrations for these four locations.

Table 5-26. RWMC-MP-1/2 storm water results for 2003.

Parameter[a]	Maximum	# Samples	# Detections[b]	Benchmark
Cyanide	0.0050 U[c]	1	0	0.0636
Chemical Oxygen Demand	112	1	1	120
Nitrogen, as Ammonia	0.155	1	1	NA
Total Suspended Solids	274[d]	1	1	100
Silver	0.0134	1	1	0.0318
Arsenic	0.00638	1	1	0.16854
Cadmium	0.000625	1	1	0.0159
Iron	6.420[d]	1	1	1
Mercury	0.00007 U	1	0	0.0024
Magnesium	20.6[d]	1	1	0.0636
Lead	0.0101	1	1	0.0816
Selenium	0.00630 U	1	0	0.2385
Conductivity (µS)	896.7	1	1	NA
pH (standard units)	7.80	1	1	6.0–9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. # detections indicate the number of samples with results greater than the minimum detectable limit for that constituent.
c. U flag indicates that the result was below the detection limit.
d. Benchmarks exceeded.

Table 5-27. 2003 storm water results for RWMC-MP-4/1.

Parameter[a]	Maximum	# Samples	# Detections[b]	Benchmark
Cyanide	0.0050 U[c]	1	0	0.0636
Chemical Oxygen Demand	147[d]	1	1	120
Nitrogen, as Ammonia	1.62	1	1	NA
Total Suspended Solids	160[d]	1	1	100
Silver	0.00123 U	1	0	0.0318
Arsenic	0.00868	1	1	0.16854
Cadmium	0.00035 U	1	0	0.0159
Iron	3.08[d]	1	1	1
Mercury	0.00007 U	1	0	0.0024
Magnesium	7.71[d]	1	1	0.0636
Lead	0.00783	1	1	0.0816
Selenium	0.0063 U	1	0	0.2385
Conductivity (µS)	1,871	1	1	NA
pH (standard units)	8.11	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.
c. U flag indicates that the result was below the detection limit.
d. Benchmarks exceeded.

Table 5-28. TAN-MP-1/1 (in flow) storm water results (2003).

Parameter[a]	Concentration	# Samples	# Detections[b]	Benchmark
Nitrogen, Nitrate+Nitrite	0.5	1	1	0.68
Total Suspended Solids	5 U[c]	1	0	100
Conductivity (µS)	312.5	1	1	NA
pH (standard units)	8.28	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.
c. U flag indicates that the result was below the detection limit.

Table 5-29. TAN-MP-2/1 (out flow) storm water results (2003).

Parameter[a]	Concentration	# Samples	# Detections[b]	Benchmark
Nitrogen, Nitrate+Nitrite	1.50	1	1	NA
Total Suspended Solids	5 U[c]	1	0	100
Conductivity (µS)	310.3	1	1	NA
pH (standard units)	8.22	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.
c. U flag indicates that the result was below the detection limit.

The measured concentrations for TSS, iron, and magnesium exceeded the benchmark concentration levels at both RWMC locations. In addition, COD exceeded the benchmark concentration for the sample collected at RWMC-MP-4/1. These parameters have been above benchmark concentrations at these locations in the past. No deficiencies in pollution prevention practices have been identified in these areas that would lead to high concentrations for these parameters, and no definite cause has been identified. However, iron and magnesium are common soil-forming minerals and may be attributed to suspended sediment, deposited onsite from high winds and landfill operations, in the storm water discharge. Storm drain filters for petroleum and sediment are in place and maintained regularly to provide additional pollution prevention.

No benchmark concentrations were exceeded at the T-28 north gravel pit.

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 Waste Experimental Reduction Facility (WERF) and the RWMC from the locations shown in Figures 5-5 and 5-6, respectively. Two control locations approximately 2 km (1.24 mi) north of the RWMC are sampled. The control location for the WERF is on the west side of the restrooms at the Big Lost River Rest Area. The control location for the RMWC subsurface discharge area (SDA) is 1.5 km (0.93 mi) west from the Van Buren Boulevard intersection on U.S. Highway 20/26 and 10 m (33 ft) north on the T-12 road.

Surface water is collected to determine if radionuclide concentrations exceed alert levels or if concentrations have increased significantly compared to historical data. Since 1994, quarterly surface water runoff samples have been collected at the WERF seepage basins to determine if contamination has been released from stored waste.

Surface water runoff samples were collected during the second quarter of 2003 at WERF. No gamma-emitting radionuclides were detected.

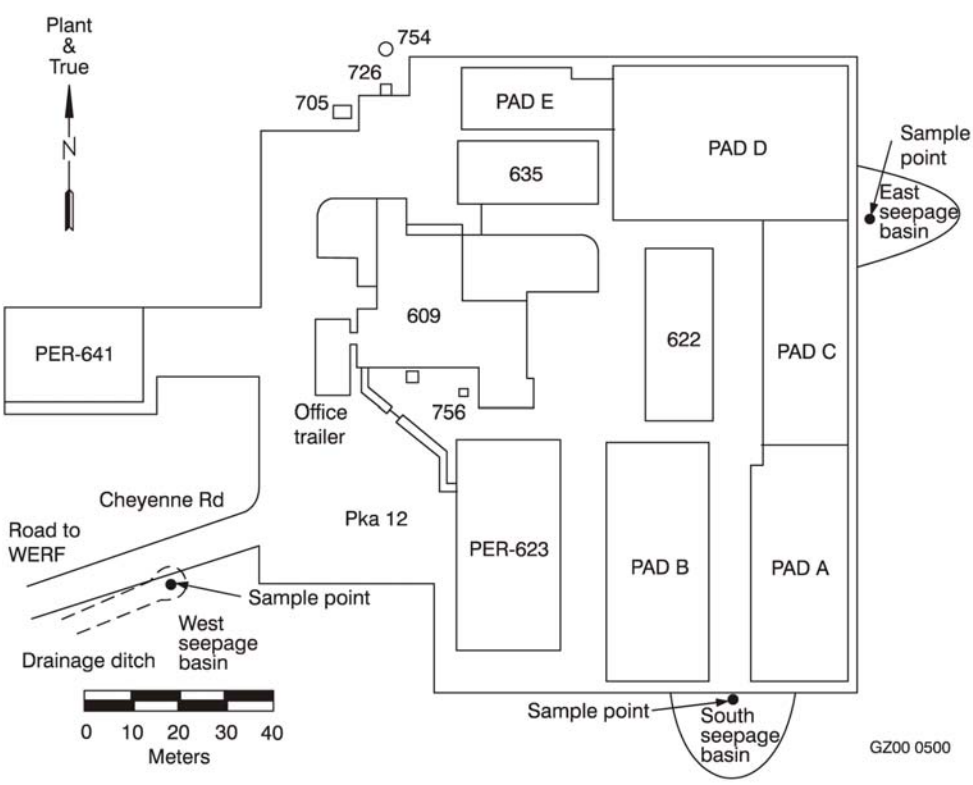


Figure 5-5. WERF surface water sampling locations.

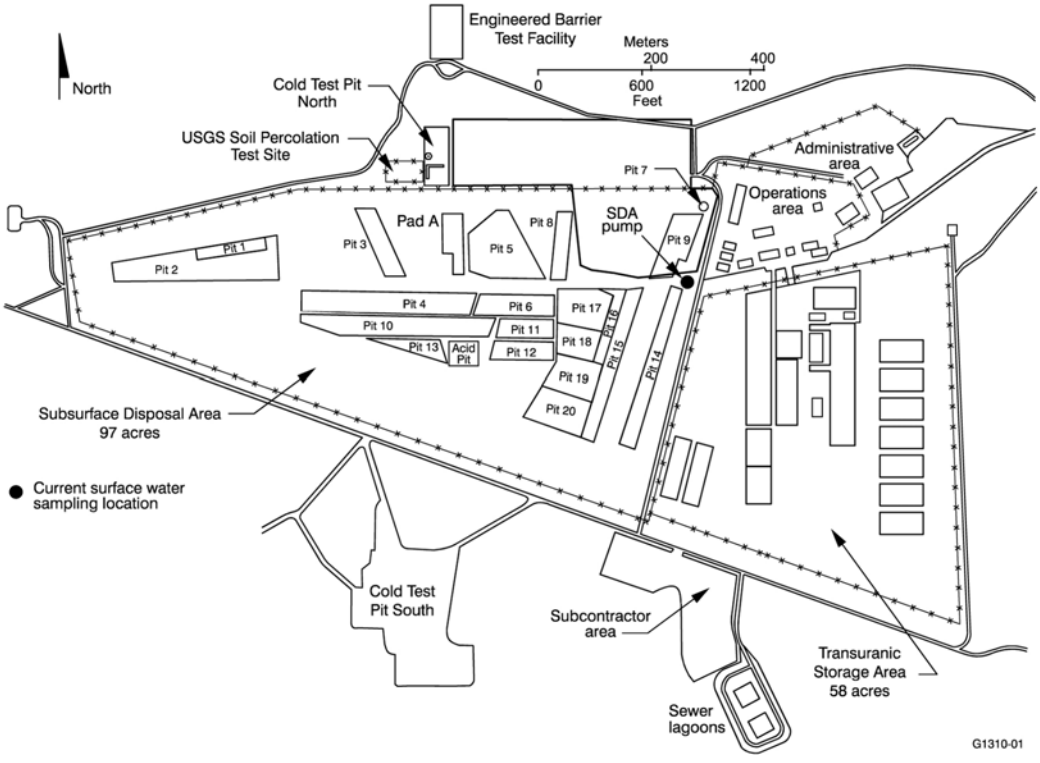
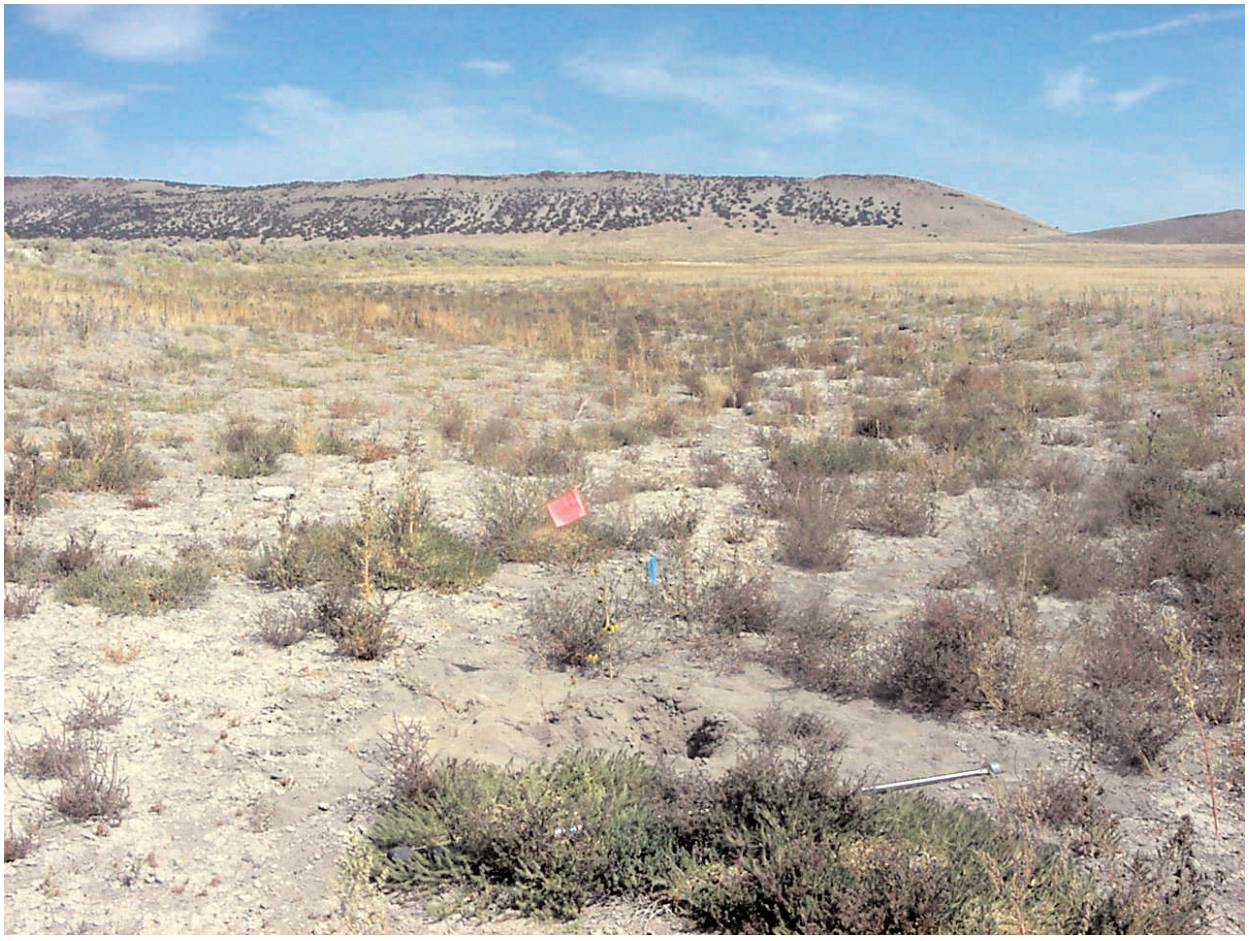


Figure 5-6. RWMC surface water sampling locations.

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 2003.



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

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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, DOE orders, and other requirements (e.g., 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 Snake River Plain Aquifer (SRPA) under and adjacent to the INEEL. The Environmental Surveillance, Education and Research 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 SRPA beneath the INEEL. These contaminated areas are monitored by various organizations.

Results from a number of special studies conducted by the USGS of the properties of the aquifer and the water within it were published during 2003. 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* were performed in 2003. No contaminant concentrations exceeded expected or historical concentrations.

A total of 12 offsite surface water samples were collected from five locations along the Snake River. Nine of the samples had measurable gross beta activity, while only one sample had measurable tritium. Detectable gross alpha activity was found at only one location in the initial sample. None of these constituents were above regulatory limits.

6. ENVIRONMENTAL MONITORING PROGRAMS (GROUNDWATER 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 Snake River Plain Aquifer (SRPA) 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. Section 6.4 describes aquifer studies related to they INEEL and SRPA. Sections 6.2 and 6.3 present discussions of the hydrogeology of the INEEL and hydrogeologic data management, respectively. 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 2003. Section 6.8 describes surface water monitoring.

6.1 Summary of Monitoring Programs

The USGS INEEL Project Office performs groundwater monitoring, analyses, and studies of the SRPA under and adjacent to the INEEL. This is done through an extensive network of strategically placed observation 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 2003, USGS personnel collected 1324 samples for radionuclides and inorganic constituents including trace elements and 28 samples for purgeable organic compounds.

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 2003 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.

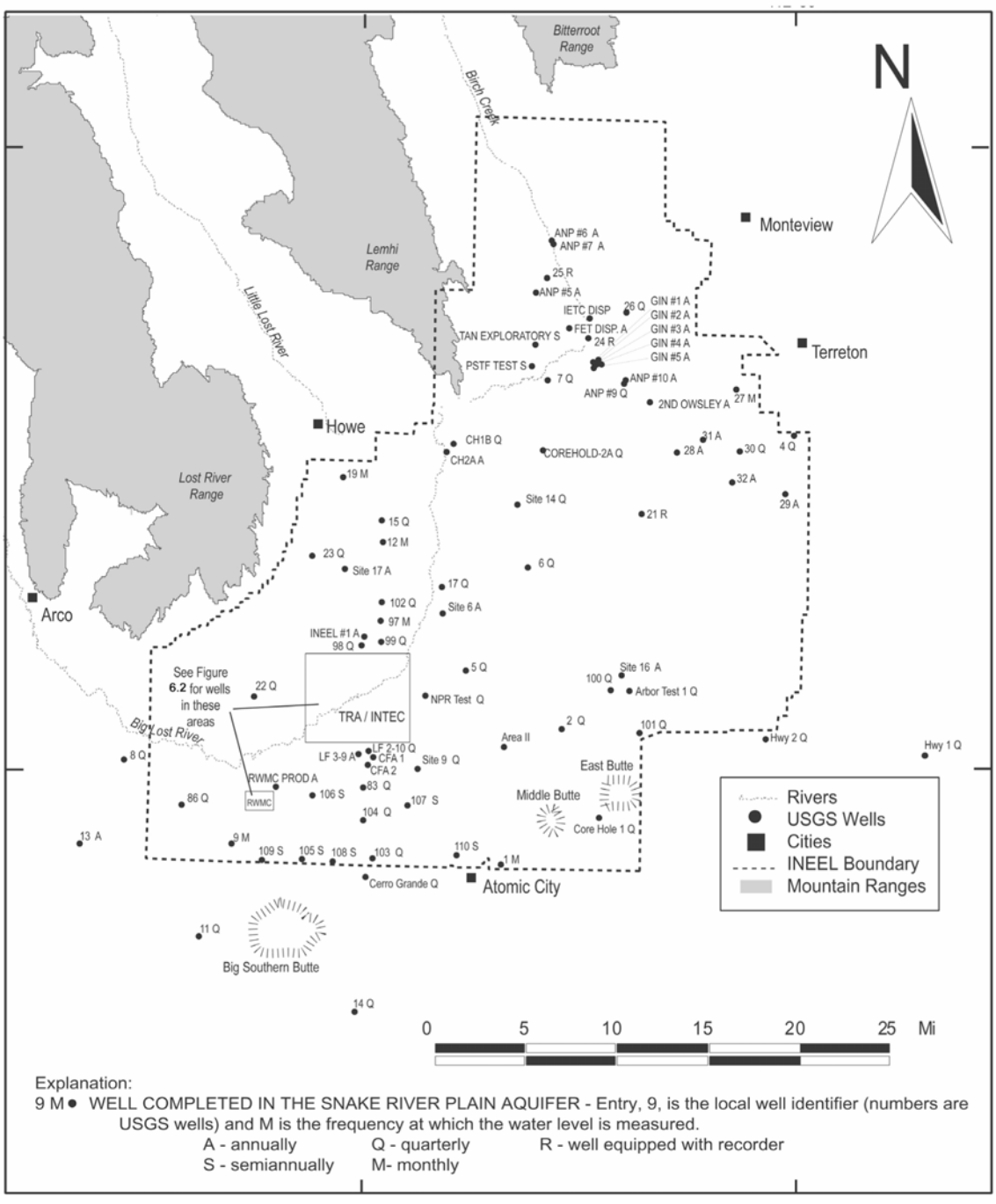

Figure 6-1. USGS well locations (Bartholomay et al. 2000).

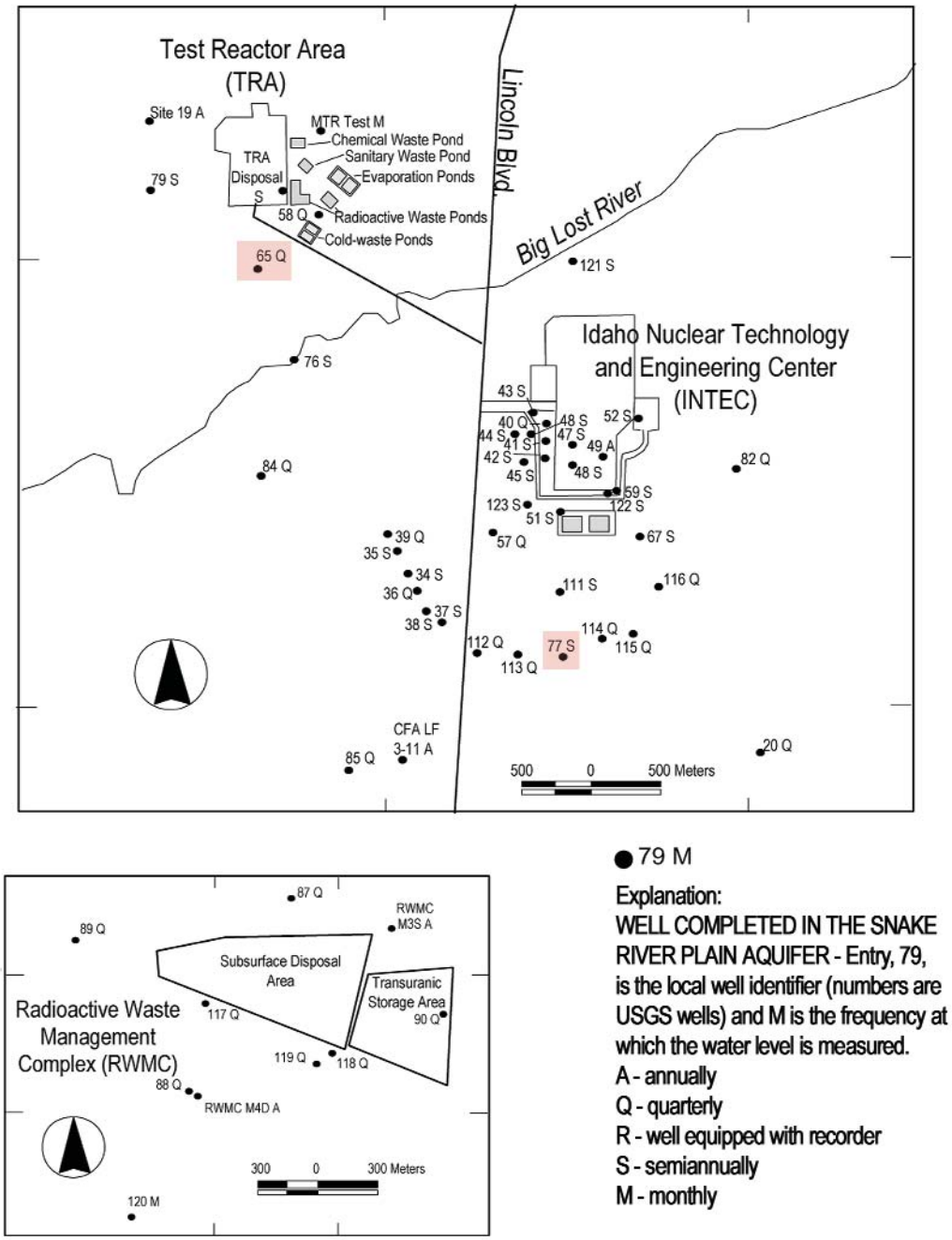

Figure 6-2. USGS well locations at the Idaho Nuclear Technology and Engineering Center, Test Reactor Area, and Radioactive Waste Management Complex (Bartholomay et al. 2000).

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 surface water at offsite locations and collected 12 water samples for analyses in 2003.

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 91 m (299 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 to form interflow zones and interbeds, respectively. Moving through these interflow zones is the water of the SRPA.

The SRPA 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 SRPA. 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 SRPA. In 1990, the SRPA was classified as a "sole-source aquifer" by the EPA. More recently the state of Idaho has implemented protections for the SRPA under its groundwater quality regulations.

The water of the SRPA 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. Other sources of recharge water include the flow of groundwater out of the surrounding mountain valleys (Birch Creek, Medicine Creek, Camas Creek), leakage from irrigation canals and ponds, and infiltration from precipitation and irrigation.

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	•	•	•	•[b]
TRA	•	•	•	
TAN	•	•	•	•[b]
RWMC	•	•	•	•[b]
PBF/CITR				•[b]
IRC				
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.

Once in the SRPA, 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 porosity of the interflow zones.

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

Beyond the regional controls on flow in the SRPA, 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 SRPA.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INEEL has been collected by a number of organizations, including the USGS, the Idaho Cleanup Project, the Environmental Monitoring Unit, 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 SRPA. 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.

In the same vein as the HDR, a single organization was 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 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 SRPA, 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 SRPA 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 2003, the USGS published nine documents covering hydrogeologic conditions at the INEEL or on the Eastern Snake River Plain. 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 SRPA 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 ^{90}Sr. 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 SRPA at TRA; however, at INTEC a portion of the ^{90}Sr was injected directly to the SRPA. 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 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 6-3 (Bartholomay et. al. 2000). The area of contamination

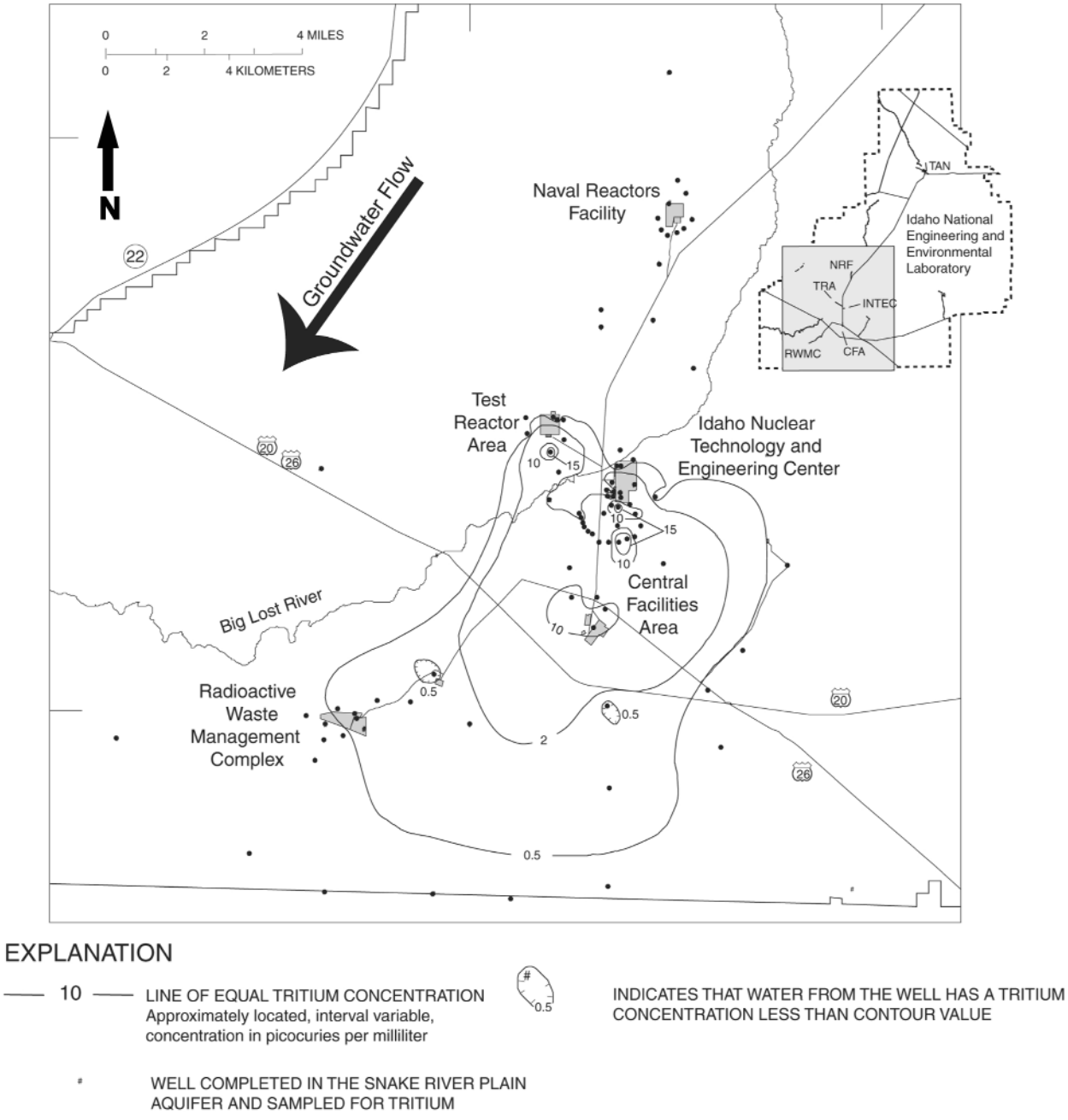

Figure 6-3. Distribution of tritium in the Snake River Plain Aquifer on the INEEL (1998) (Bartholomay et al. 2000).

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.

Two monitoring wells downgradient of TRA (Well 65) and INTEC (Well 77) (see Figure 6-2) have continually shown the highest tritium concentrations in the aquifer over time. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in Well 65 near TRA decreased, from $(13.0 \pm 0.8) \times 10^3$ pCi/L in 2002 to $(9.4 \pm 0.05) \times 10^3$ pCi/L in 2003; the tritium concentration in Well 77 south of INTEC remained the same, $(13.8 \pm 0.04) \times 10^3$ pCi/L in 2002 to $(13.4 \pm 0.03) \times 10^3$ pCi/L in 2003.

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 decrease in tritium disposal rates, and dilution within the SRPA and continue to decrease tritium concentrations (See Figure 6-4).

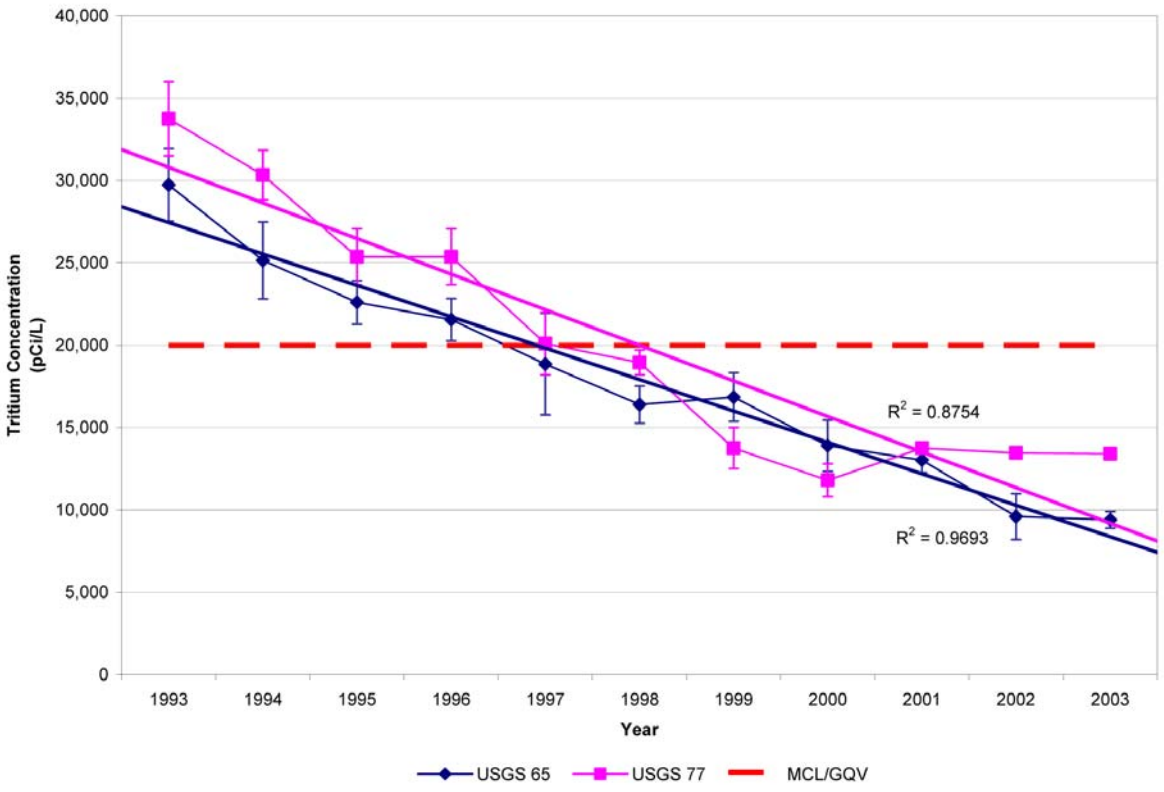

Figure 6-4. Long-term tend of tritium in USGS Well 65 and 77 (1993-2003). (Error bars are plus or minus one standard deviation [1s]).

Strontium-90 - The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-5 (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.

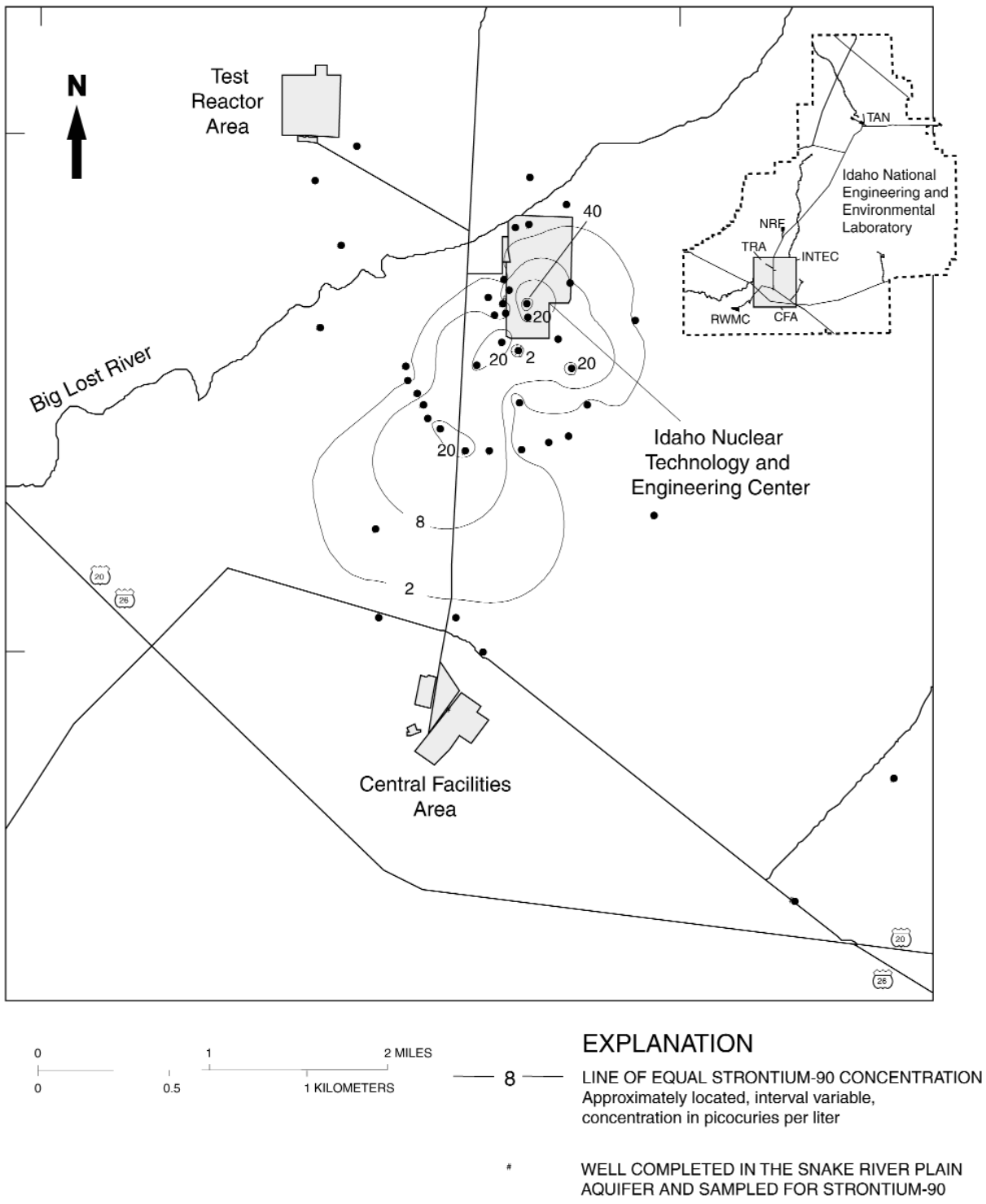

Figure 6-5. Distribution of ^{90}Sr in the Snake River Plain Aquifer on the INEEL (1998) (Bartholomay et al. 2000).

Mean concentrations of ^{90}Sr in wells have remained at about the same concentrations since 1989. The annual average concentration in well 65 increased between 2002 (1.5 ± 0.1 pCi/L) and 2003 (2.55 ± 0.58 pCi/L). Concentrations in Well 77 decreased from 2.0 ± 0.1 pCi/L in 2002 to 1.8 ± 0.7 pCi/L in 2003. The PCS and MCL for ^{90}Sr in drinking water is 8 pCi/L. The increase in ^{90}Sr in 2003 is the result of averaging a small sample set (two samples) and a single large result (3.4 ± 1.4 pCi/L). The other result was essentially the same as 2002 (1.7 ± 1.4 pCi/L).

The trend of ^{90}Sr over the past ten years is shown in Figure 6-6. Although the trend is increasing, the statistical fit is less strong (36 percent for Well 65 and 21 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).

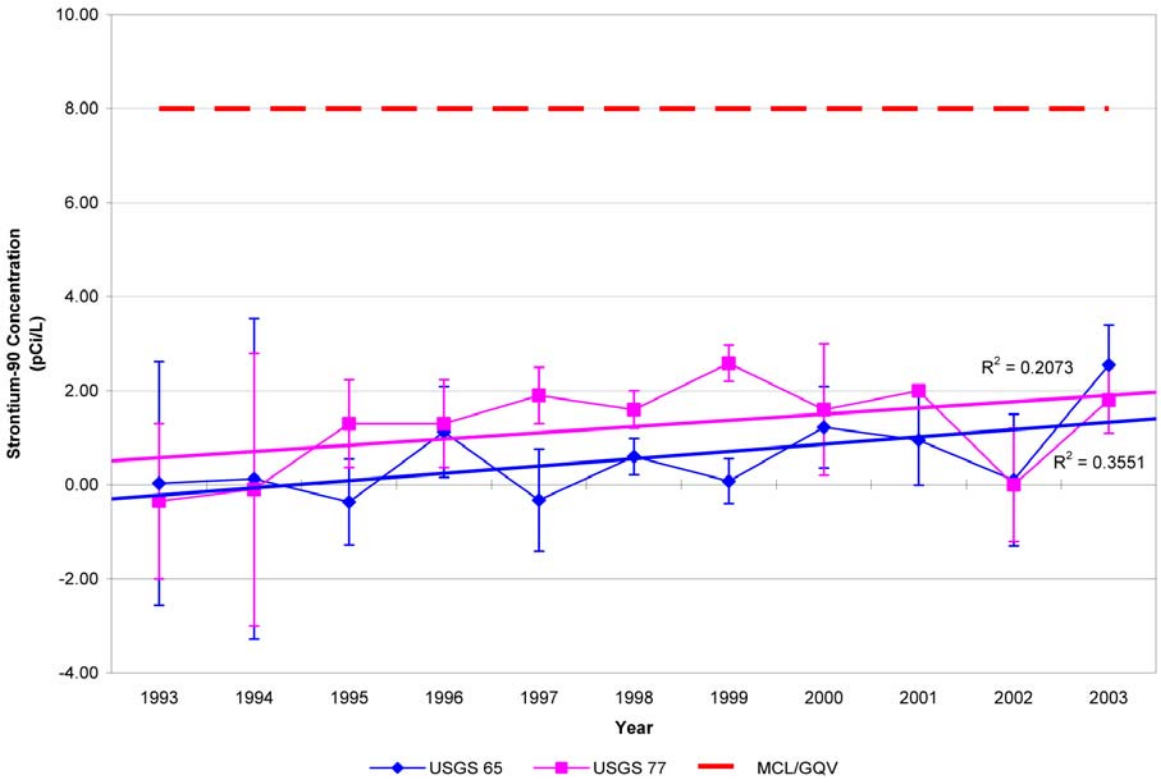

Figure 6-6. Long-term trend of ^{90}Sr in USGS Wells 65 and 77 (1993-2003).

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 MCL values. No ^{90}Sr or programmatic gamma-emitters were detected. For more information, see the *2003 Environmental Monitoring Report for the Naval Reactors Facility* (Bechtel Bettis 2003).

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 2003. 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). Nine 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). Only two of the constituents measured were reported in 2002, while four others are closely related to compounds reported in 2002. Three new methane-containing compounds were measured in 2003, tribromomethane, trichloromethane, and tetrachloromethane. None of the measured constituents were above their respective PCS.

The Radioactive Waste Management Complex (RWMC) production well contained detectable concentrations of six of these purgeable organic compounds. Annual average concentrations of these compounds in this well remained essentially unchanged from those observed in 2002. However, the annual average concentration for trichloroethene (2.48 µg/L) was slightly above the related compound trichloroethylene concentration of 2002 (2.32 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-6. The high average value for chromium in NRF-6 is from a single outlier that appears to be an anomalous result. Groundwater monitoring wells are not used for drinking water supply. For more information, see the 2003 Environmental Monitoring Report for the Naval Reactors Facility (Bechtel Bettis 2003).

Table 6-2. Concentrations of purgeable organic compounds in USGS well samples (2003).[a]

Well ID	Date	Dichloro-difluoro-methane	1,1-Dichloro-ethene	Tetrachloro-ethene	Tetrachloro-methane	Toluene	Tribromo-methane	1,1,1-Trichloro-ethane	Trichloro-ethene	Trichloro-methane
34	04/16	ND[b]	ND	ND	ND	ND	ND[c]	ND	ND	ND
(SW of INTEC)	11/06	ND	ND	ND	ND	ND	ND	0.12	ND	ND
38	04/23	ND	ND	ND	ND	ND	ND	ND	ND	ND
(SW of INTEC)	11/13	0.1807[d]	ND	ND	ND	ND	ND	0.15	ND	ND
65	04/14	0.46[d]	ND	ND	ND	ND	ND	0.17	ND	ND
(S of TRA)	11/04	ND	0.11	ND	ND	1.6	ND	0.21	ND	ND
77	04/16	0.13[d]	0.15	ND	ND	ND	ND	0.20	ND	ND
(S of TRA)	11/03	0.12[d]	0.18	ND	ND	ND	ND	0.25	ND	ND
87	04/10	0.23[d]	ND	0.10	3.18	ND	ND	ND	0.69	0.17
(N of RWMC)	10/09	0.22[d]	ND	0.11	3.29	ND	ND	ND	0.69	0.14
88	04/02	ND	ND	ND	1.58	ND	ND	0.12	0.63	0.45
(S of RWMC)										
120	04/10	ND	ND	ND	3.01	ND	ND	0.24	0.87	0.51
(SW of RWMC)	10/09	ND	ND	0.11	3.03	ND	ND	0.25	0.88	0.45

Table 6-2. Concentrations of purgeable organic compounds in USGS well samples (2003).[a] (continued)

Well ID	Date	Dichloro-difluoro-methane	1,1-Dichloro-ethene	Tetrachloro-ethene	Tetrachloro-methane	Toluene	Tribromo-methane	1,1,1-Trichloro-ethane	Trichloro-ethene	Trichloro-methane
RWMC PROD	01/09	ND	ND	0.22	5.77	ND	ND	0.54	2.42	1.27
	02/13	ND	ND	0.22	4.41	ND	ND	0.43	2.11	0.88
	03/13	ND	ND	0.18	5.14	ND	ND	0.44	2.28	0.91
	04/10	ND	ND	0.24	5.57	ND	ND	0.49	2.60	1.14
	05/15	ND	ND	0.25	5.52	ND	ND	0.50	2.66	1.15
	06/12	ND	ND	ND	5.65	ND	ND	0.46	2.41	1.09
	07/10	ND	ND	0.23	6.65	ND	ND	0.56	2.66	1.19
	08/14	ND	ND	0.26	6.33	ND	ND	0.53	2.85	1.29
	09/10	ND	ND	0.19	4.01	ND	0.22	0.37	1.78	0.81
	10/09	ND	ND	0.23	5.39	ND	ND	0.47	2.29	0.97
	11/13	ND	ND	0.23	6.02	ND	ND	0.52	2.64	1.19
	12/18	ND	ND	0.27	6.79	ND	ND	0.55	3.02	1.33
PCS[e]			**7.0[f]**	**5.0[g]**		**1,000**		**200**	**5[h]**	

a. All values are in micrograms per Liter (µg/L).
b. ND = Not Detected, below the reportable limit of 0.2 µg/L before 10/04 or 0.01 µg/L for 10/04 and later.
c. Not Detect value for tribromomethane is 0.2 µg/L for all samples.
d. Values for dichloro-difluoromethane are laboratory estimates.
e. PCS = Primary constituent standard values from IDAPA 58.01.11.
f. Value is for the related compound 1,1- dichloroethylene.
g. Value is for the related compound tetrachloroethylene.
h. Value is for the related compound trichloroethylene.

6.7 CERCLA Groundwater Monitoring Activities

The 2003 CERCLA activities at the INEEL included the drilling of five new wells at TAN (one corehole was completed as a piezometer), and the abandonment of three coreholes. The 192 aquifer monitoring wells were sampled to satisfy CERCLA requirements (Table 6-3). A detailed accounting of the sampling and results are available in the individual monitoring reports for each WAG. These data have been summarized in their respective sections below.

Table 6-3. Summary of groundwater monitoring wells sampled for CERCLA activities during 2003.

Waste Area Group	Frequency of Sampling	Constituents Analyzed	Number of Wells Sampled in 2003
WAG 1 – Test Area North	Annual	Rad[a], Inorganic[b], Organic[c]	40
WAG 2 – Test Reactor Area	Semi-annual	Rad, Inorganic	14
WAG 3 – Idaho Nuclear Technology and Engineering Center			
- Group 4 Perched Water	Annual	Rad, Inorganic, Organic	40
- Group 5 Snake River Plain Aquifer	Annual	Rad, Inorganic	22
- INEEL CERCLA Disposal Facility	Quarterly	Rad, Inorganic, Organic	8
WAG 4 – Central Facilities Area	Annual	Inorganic, Organic	10
WAG 5 – Power Burst Facility/ Auxiliary Reactor Area	Annual	Organic, Inorganic	9
WAG 7 – Radioactive Waste Management Complex	Quarterly	Rad, Inorganic, Organic	15
WAG 10 – Sitewide	Semiannual	Rad, Inorganic, Organic	34
	Total Number of Wells Monitored in 2003		**192**

a. Rad = radiological constituents, such as tritium, ^{90}Sr, ^{99}Tc, ^{137}Cs, uranium, and plutonium isotopes.
b. Inorganic = inorganic constituents, such as metals (cadmium, chromium) and anions (chloride, nitrate).
c. Organic = organic constituents, such as volatile organic compounds (carbon tetrachloride, trichloroethylene).

Summary of WAG 1 Groundwater Monitoring Results

The objective of the OU 1 07B remedial action is to contain and restore the contaminated groundwater at Test Area North (TAN) for public use. The groundwater at TAN is contaminated with trichloroethene (TCE), tetrachloroethene, and dichloroethene. 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 6-7. The boundaries of each zone of the plume were based on TCE concentrations. The three zones are defined as follows:

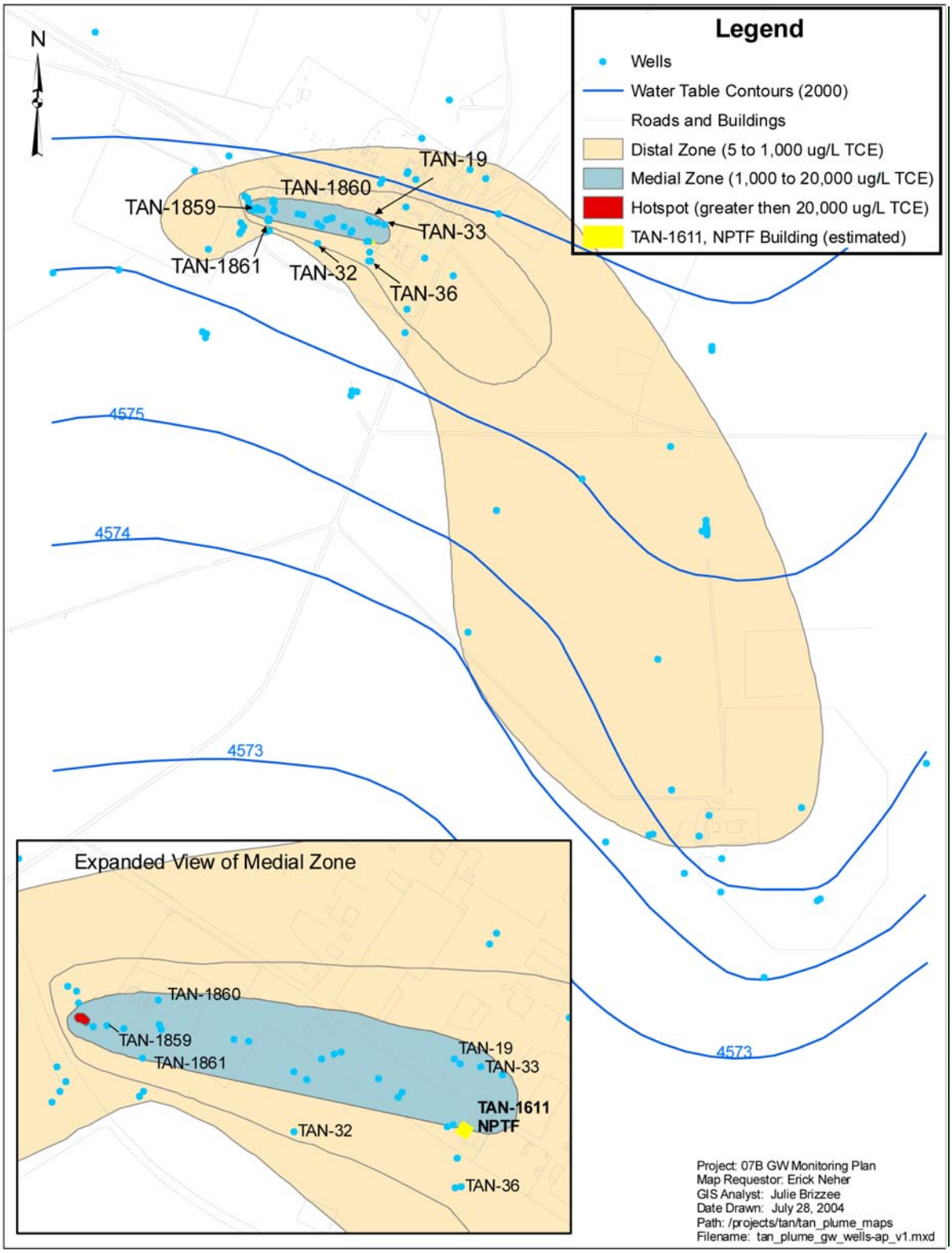

Figure 6-7. WAG 1 Well locations.

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 sodium lactate or whey) is injected into well TSF-05 or other wells in the immediate vicinity. Amendment injections increase the rate at which the microbes break down the organic compounds into harmless compounds by supplying needed nutrients. The amendment supply is distributed, as needed, and the treatment system operates year-round.

In general, activities performed during 2003 included periodic amendment injections (sodium lactate), groundwater sampling and analysis, well-drilling activities, construction activities, and laboratory studies of alternate electron doners. Seven amendment injections were performed during the year, all into well TSF-05. Groundwater samples were collected monthly from 14 to 17 sampling locations in the hot spot zone. Three new wells were drilled during the reporting period, one amendment injection well (TAN-1859) and two cross-gradient monitoring wells (TAN-1860 and -1861). The new ISB injection facility also was completed during the reporting period. The completion of these activities allows the project to conclude Interim Operations and proceed into Initial Operations in accordance with the Remedial Action Work Plan (DOE-ID 2002).

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 2003, 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 2003 were groundwater sampling and data analysis. Groundwater samples were collected for volatile organic compounds 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. In addition, dissolved gas samples and enzyme probe samples were collected to provide evidence for the aerobic TCE biodegradation mechanism that has been hypothesized to be active in the distal zone at TAN.

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. Indirect and direct evidence from 2003 groundwater monitoring confirm that the mechanism for aerobic TCE co-metabolic degradation is active in the aquifer. Radionuclide groundwater monitoring in 2003 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 2003 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 are required under the WAG-2 Record of Decision (ROD) from aquifer wells TRA-06A, TRA-07, TRA-08, USGS-058, USGS-065, and Highway-3. The locations of these wells are shown in Figure 6-8, except the location of the Highway-3 Well, which is shown in Figure 6-1. These wells were sampled in March and October of 2003. In the March 2003 sampling event, aquifer well samples were analyzed for cadmium (filtered and unfiltered), chromium (filtered and unfiltered), and tritium (with the exception of Well Highway-3). Only chromium analysis was performed on samples from the Highway-3 Well. In the October 2003 sampling event, the wells were sampled for chromium (filtered and unfiltered), ^{90}Sr, tritium, gamma spectrometry, technetium-99 (^{99}Tc), and iodine-129 (^{129}I). The data for the March 2003 sampling are in the Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2003 (DOE-ID 2003c) and the data for the October 2003 sampling is found in the 2004 annual report for WAG 2.

The data for the March 2003 sampling event are summarized in Table 6-4. Chromium was the only constituent detected above its PCS. Chromium concentrations in wells TRA-07 and USGS-065 were greater than the 100 µg/L PCS, with a maximum filtered concentration of 158 µg/L in TRA-07 (Figure 6-8). Except for the Highway-3 Well, chromium concentrations were above background at all other aquifer wells sampled in WAG-2. The concentrations of chromium are declining as predicted by the WAG-2 ROD model and are trending to decline below the PCS by 2012. Other than chromium, all other constituents were below PCS/SCS values.

Summary of WAG 3 Groundwater Monitoring Results

The Long Term Monitoring Plan (DOE-ID 2003d) called for sampling 18 aquifer wells in and around as well as to the south of INTEC and collecting three deep discrete samples between wellbore packers. Samples were collected from 16 of the 18 wells from April 13 to May 31, 2003. The deep packer sampling at three wells was conducted in July-August 2003. Groundwater samples were analyzed for tritium, ^{90}Sr, ^{129}I, ^{99}Tc, americium-241 (^{241}Am), neptunium-237 (^{237}Np), uranium isotopes, plutonium isotopes, gross alpha/beta activities, gamma spectrometry, and mercury.

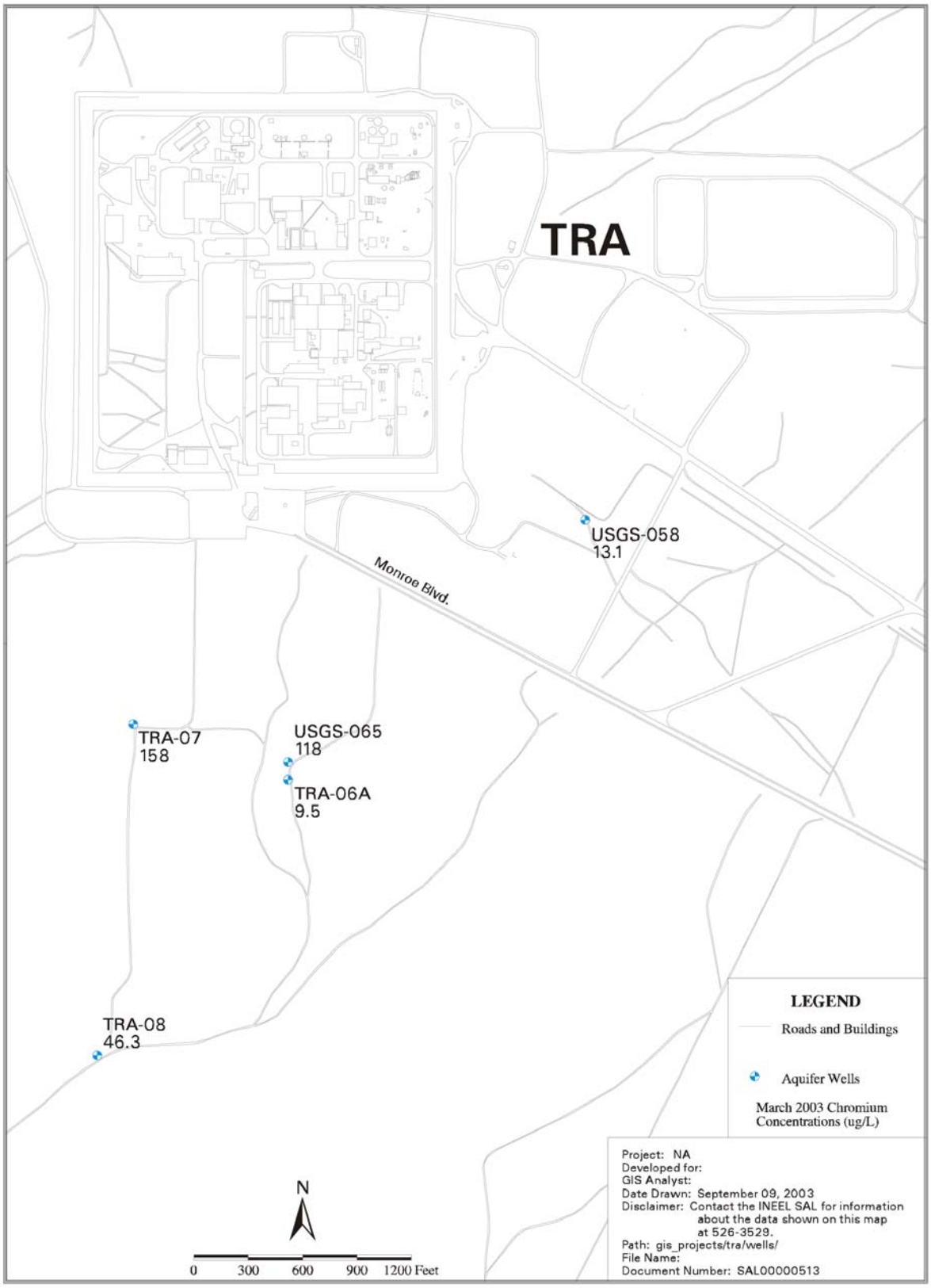

Figure 6-8. Location of TRA monitoring wells and March 2003 chromium concentrations.

Table 6-4. WAG 2 groundwater quality summary for March 2003 sampling event.[a]

Analyte	Background[b]	Maximum Concentration	Number of Wells with Detections above PCS[c]	PCS
Cadmium (Filtered)	<1	0.07	0	5
Cadmium (Unfiltered)		0.06	0	5
Chromium (Filtered)	2 to 3	159	2	100
Chromium (Unfiltered)		167	2	100
Tritium	75 to 150	16,700	0	20,000 pCi/L

a. All values are in micrograms per liter (μg/L) unless noted.
b. Background concentrations are from Knobel, Orr, and Cecil (1992).
c. PCS = primary constituent standard values from IDAPA 58.01.11.

Strontium-90, ^{99}Tc, and gross alpha were detected in some wells above their respective PCS values (DOE-ID 2003e). Tritium, ^{129}I, plutonium, uranium, and ^{137}Cs were also detected, but concentrations were below their PCS values. Uranium concentrations were at background levels in all wells. Cesium-137 was detected in three wells with a maximum concentration of 18.4 pCi/L, which is well below the MCL of 200 pCi/L. Plutonium-241 was detected at one location near the detection limit and was the only plutonium isotope detected.

The sampling results for gross alpha, gross beta, ^{90}Sr, ^{99}Tc, ^{129}I, and tritium are presented in Table 6-5. Strontium-90 was above its PCS and MCL of 8 pCi/L in several wells near INTEC, but was below its PCS in the downgradient direction in wells at the CFA landfills (Figure 6-9). Technetium-99 was detected above its MCL of 900 pCi/L in two wells (one within INTEC and one near CFA) but was below the MCL at all other locations. Gross beta results generally mirrored the results for ^{90}Sr and ^{99}Tc. Gross alpha was above its PCS in one well and at the PCS in another well within INTEC, but was below the PCS downgradient of INTEC.

Sampling and analysis results for 2003 confirm that concentrations of tritium, ^{129}I, and ^{90}Sr continue to decline in the SRPA at and downgradient of INTEC. In contrast, ^{99}Tc concentrations in the SRPA appear to have increased slightly at several locations, although lack of historical ^{99}Tc data makes this conclusion tenuous. The MCL for ^{99}Tc (900 pCi/L) was exceeded at one location, a new aquifer monitoring well ICPP-MON-A-230 located north of the INTEC tank farm.

Summary of WAG 4 Groundwater Monitoring Results

Groundwater monitoring for the CFA landfills consisted of sampling nine wells for volatile organic compounds, metals, and anions. The locations of the wells sampled are shown on Figure 6-10. Analytes detected in groundwater are compared to regulatory levels in Table 6-6. A full description of the groundwater sampling and results is contained in Central Facilities Area Landfills I, II, and III Annual Monitoring Report (2003) (DOE-ID 2004a). The groundwater data

Table 6-5. Summary of gross alpha, gross, beta, ^{129}I, ^{99}Tc, ^{90}Sr, and tritium in the SRPA at INTEC (WAG 3) in 2003.[a]

Location	Sampling Date	Gross Alpha (PCS[b]=15 pCi/L)		FLAG[c]	Gross Beta (PCS= 4mrem/yr)		FLAG	Iodine-129 (PCS=1 pCi/L)		FLAG	Technetium-99 (MCL=900 pCi/L)		FLAG	Strontium-90 (PCS=8 pCi/L)		FLAG	Tritium (PCS=20,000 pCi/L)		
		Result	+/-		Result	+/-		Result	+/-		Result	+/-		Result	+/-		Result	+/-	
ICPP-MON-A-230[d]	5/13/03	**32.7**[e]	2.72	J	931	19.1	J	0.12	0.03		**2,220**	37.7		7.61	1.05		3700	178	
LF2-08	5/28/03	0.06	0.35	UJ	-0.19	0.63	UJ	0.59	0.05		-4.50	2.43	U	-0.13	0.11	U	7740	285	
LF3-08	5/27/03	4.27	1.01	J	14.8	1.26	J	0.77	0.08		1970	34.6	R	7.05	0.89		6940	273	
MW-18	5/13/03	**15.0**	1.84	J	282	7.00	J	0.60	0.06		574	10.7		**23.5**	3.30		13700	324	
USGS-040	4/14/03	1.66	0.75	UJ	39.8	1.57	J	0.24	0.07	J	7.11	1.96	UJ	**16.4**	2.19		3230	143	
USGS-042	4/3/03	1.85	0.90	UJ	57.4	1.92	J	0.74	0.08	J	91.3	3.41		**15.5**	2.00		3360	148	
USGS-047	4/10/03	2.23	0.73	J	91.7	2.31	J	0.46	0.05		42.5	2.52		**30.2**	3.84		2560	137	
USGS-047 Dup	4/10/03	4.81	1.59	J	106	2.68	J	0.52	0.05		42.6	2.57		**33.9**	4.96		2470	133	
USGS-048	4/10/03	3.35	1.03	J	79.6	2.19	J	0.31	0.05		76.4	3.21		**20.6**	2.96		3500	146	
USGS-051	4/2/03	0.35	0.97	UJ	5.89	0.74	J	0.20	0.03		6.36	1.93	UJ	0.08	0.13	U	10300	222	
USGS-052	4/14/03	13.2	1.78	J	196	3.46	J	0.14	0.03	J	313	6.77		7.79	1.18		3230	145	
USGS-057	4/7/03	0.59	0.77	UJ	70.3	1.69	J	0.51	0.04		51.4	2.68		**18.0**	3.08		5450	172	
USGS-067	4/7/03	3.20	1.11	J	34.1	1.48	J	0.31	0.05	J	28.1	2.32		9.53	1.57		6260	180	
USGS-085	4/9/03	1.76	0.80	UJ	10.9	0.91	J	0.17	0.03		8.55	1.93	UJ	3.56	0.62		2390	129	
USGS-112	4/9/03	5.26	1.42	J	56.5	1.90	J	-0.01	0.02	U	50.3	2.70		**14.1**	1.85		4790	156	
USGS-121	4/15/03	3.36	0.94	J	2.4	0.59	J	-0.01	0.02	U	3.29	1.82	U	-0.14	0.13	U	171	99.2	U
USGS-123	4/7/03	10.4	1.95	J	84.5	2.28	J	0.36	0.06		65.1	2.93		**23.8**	3.12		7570	191	
USGS-041 below HI interbed	7/31/03	2.06	0.33	J	18.6	0.79	J	.06	.03	U	1.76	2.21	U	**8.53**	1.38		992	110	
USGS-048 below HI interbed	8/6/03	2.65	0.93	UJ	26.6	1.63	J	.25	.05		9.58	2.81		**9.73**	1.22		2080	141	
USGS-059 below HI interbed	7/29/03	3.06	0.73	J	33.2	1.71	J	.14	.04		36.9	3.23		**9.91**	1.49		1730	127	

a. All values are in picocuries per Liter (pCi/L).

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

c. FLAG = Data validation flag. A "U" indicates that an analyte was not detected. A "J" indicates an estimated value. A "UJ" indicates that the radionuclide may or may not be present, and the result is considered highly questionable. The associated value is an estimate and may be inaccurate or imprecise. The result is considered a non-detect for project data interpretation purposes.

d. The resampled results from August 11, 2003, are 70.4±8, 36.6±4.6, 21.1±2.61, and 24.2±2.61 pCi/L.

e. Bold indicates a value equal or greater than the MCL.

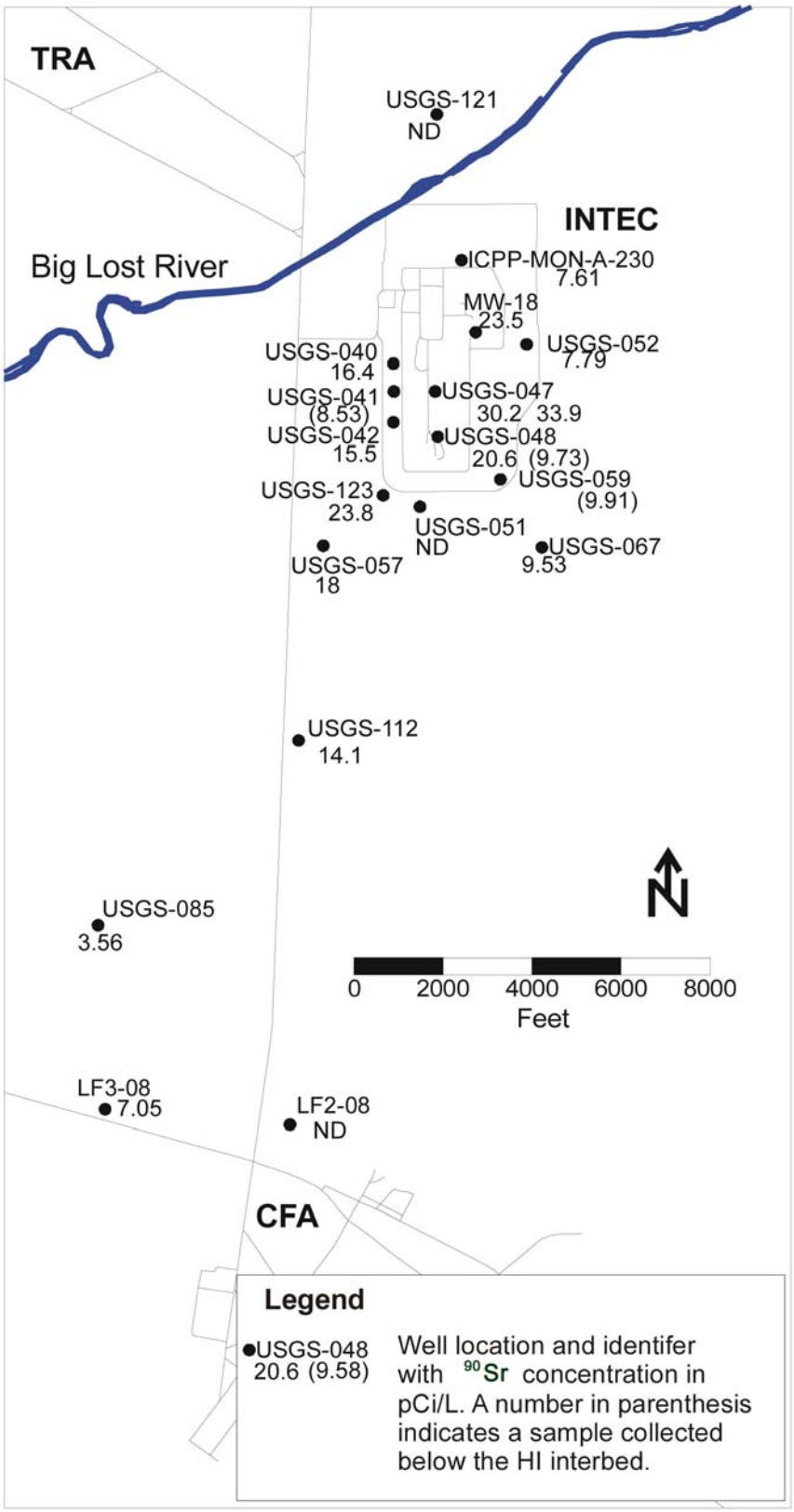

Figure 6-9. Location of INTEC monitoring wells sampled and distribution of ^{90}Sr in the SRPA in May-August 2003.

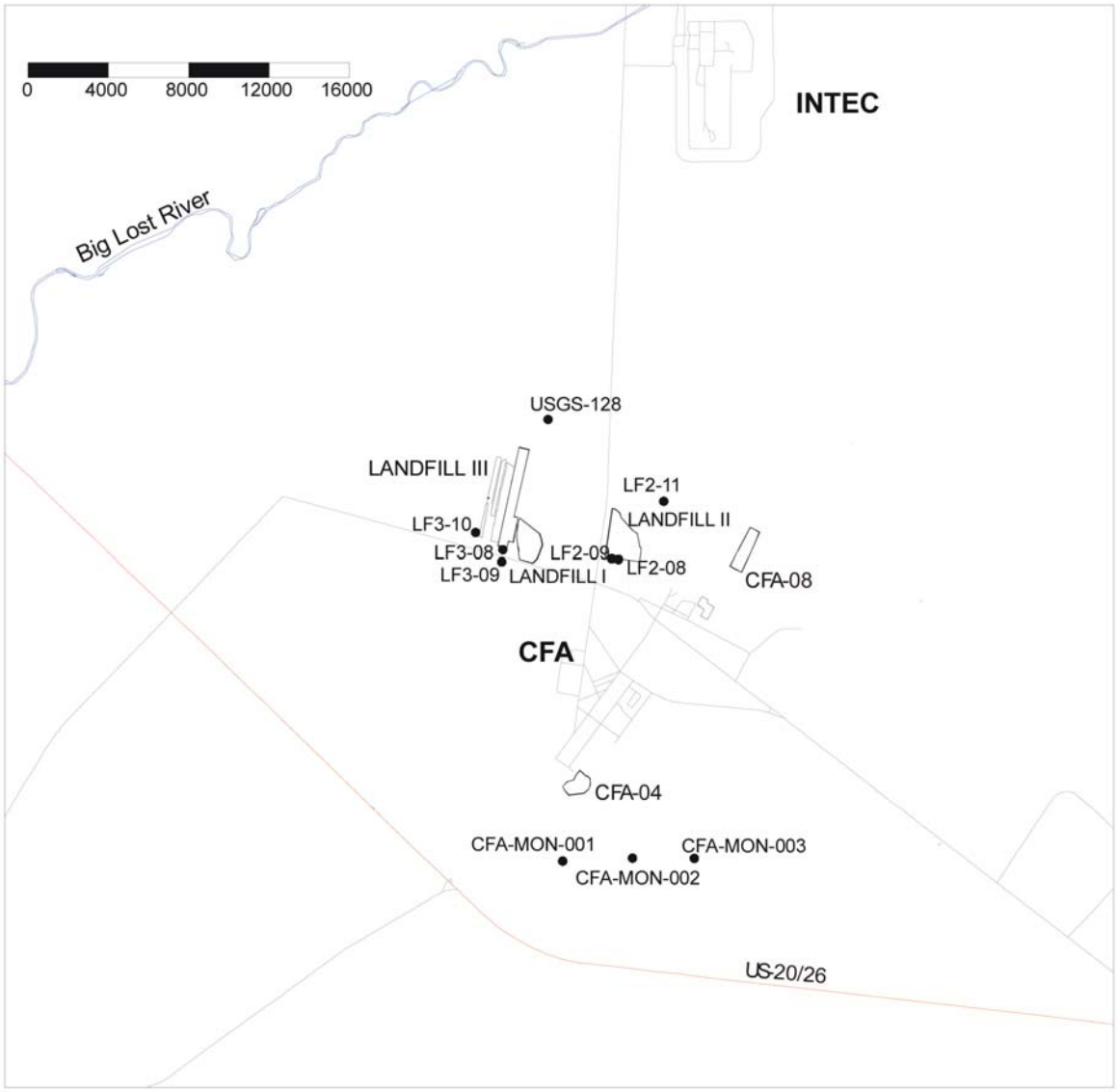

Figure 6-10. Location of WAG 4/CFA monitoring wells.

Table 6-6. WAG 4 groundwater quality summary for 2003.

Compound	Maximum Detected Value	Number of Wells with Detections above PCS[a]	PCS/SCS
Anions[b]			
Alkalinity-bicarbonate	317	NA[c]	NE[d]
Chloride[e]	117	0	250
Fluoride	0.235	0	4
Nitrate	21.3	2	10
Sulfate[e]	36.2	0	250
Organic Analytes[f]			
Toluene	32	0	1,000
Inorganic Analytes[f]			
Aluminum[e]	416	1	200
Arsenic	ND[g]	0	50
Barium	131	0	2,000
Beryllium	ND	0	4
Cadmium	ND	0	5
Chromium	42.4	0	100
Copper	ND	0	1,300
Iron[e]	1,680	2	300
Lead	ND	0	15
Manganese[e]	20.1	0	50
Mercury	ND	0	2
Nickel	112	NA	NE
Selenium	ND	0	50
Vanadium	3.4	NA	NE
Zinc[e]	958	0	5,000

a. PCS/SCS = Primary constituent standard/Secondary constituent standard values from IDAPA 58.01.11.
b. Values are in mg/L, except nitrate/nitrite which is in mg-nitrogen/L.
c. NA = not applicable.
d. NE = not established.
e. Groundwater quality secondary contaminant.
f. Organic and inorganic values are in μg/L.
g. ND = not detected.

indicated that nitrate was the only analyte above a PCS. Nitrate was detected above its PCS of 10 mg/L in wells CFA-MON-A-002 (21.3 mg/L) and CFA-MON-A-003 (11.1 mg/L). Nitrate concentrations in CFA-MON-A-002 and -003 have remained relatively steady since the wells were first sampled in 1996. Groundwater gradients and groundwater flow directions indicate that nitrate concentrations will not migrate to the CFA production wells. Nitrogen and oxygen stable isotope data were collected to evaluate the source of the nitrate. The data for nitrogen and oxygen isotope ratios in nitrate indicate a non-sewage source for the nitrate.

Iron was detected above its SCS of 300 µg/L in two samples, and aluminum was detected above its SCS of 200 µg/L in one sample. Because the pH of the groundwater is between 7 and 8 and the water has a high dissolved oxygen content, both the iron and aluminum are probably the result of suspended particulates.

Summary of WAG 5 Groundwater Monitoring Results

Groundwater monitoring at WAG 5 for 2003 was completed during October 2003 in accordance with the requirements delineated in the WAG 5 ROD (DOE-ID 2000a) and the Groundwater Monitoring Plan (DOE-ID 2000b). Nine wells are listed for sampling and the locations of these wells are shown on Figure 6-11. All the wells except ARA-MON-A-03A were sampled. Well ARA-MON-A-03A was unable to be sampled due to problems with the submersible pump. 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. The complete listing of results can be found in Annual Groundwater Monitoring Status Report for Waste Area Group 5 for Fiscal Year 2004 (DOE-ID 2004b).

All constituents analyzed from the October 2003 sampling event were below PCS/SCS values and/or MCLs. The data are summarized in Table 6-7. There were two detections of toluene and one detection of trichloroethylene. Toluene and trichloroethylene were detected at concentrations less than 1 µg/L and well below their respective PCSs of 1000 and 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 2003. Replacement of galvanized pipe with stainless steel pipe appears to have removed the source of the lead in the wells. Consequently, lead concentrations have declined to background concentrations. Gross alpha and gross beta concentrations were similar to background. Cesium-134 was detected in the sample from well PBF-MON-A-001 at a concentration of 3.88 ± 0.984 pCi/L; however, the result is questionable because it is below the minimum detectable activity (MDA) of 5.26 pCi/L and no ^{137}Cs was detected in this sample. Cesium-134 is a decay product of ^{137}Cs. Iodine-129 was also detected in PBF-MON-A-001 at a concentration of 0.678 ± 0.299. This ^{129}I detection in PBF-MON-A-001 is also questionable because it is near the MDA of 0.56 pCi/L and ^{129}I previously had not been detected at this well.

Summary of WAG 7 Groundwater Monitoring Results

The RWMC at the INEEL has been used for waste disposal operations since the 1950s. The RWMC occupies about 71.6 ha (177 acres) in the southwestern quadrant of the INEEL (see Figure 3-3), and is divided into three areas: (1) the Subsurface Disposal Area (SDA), where

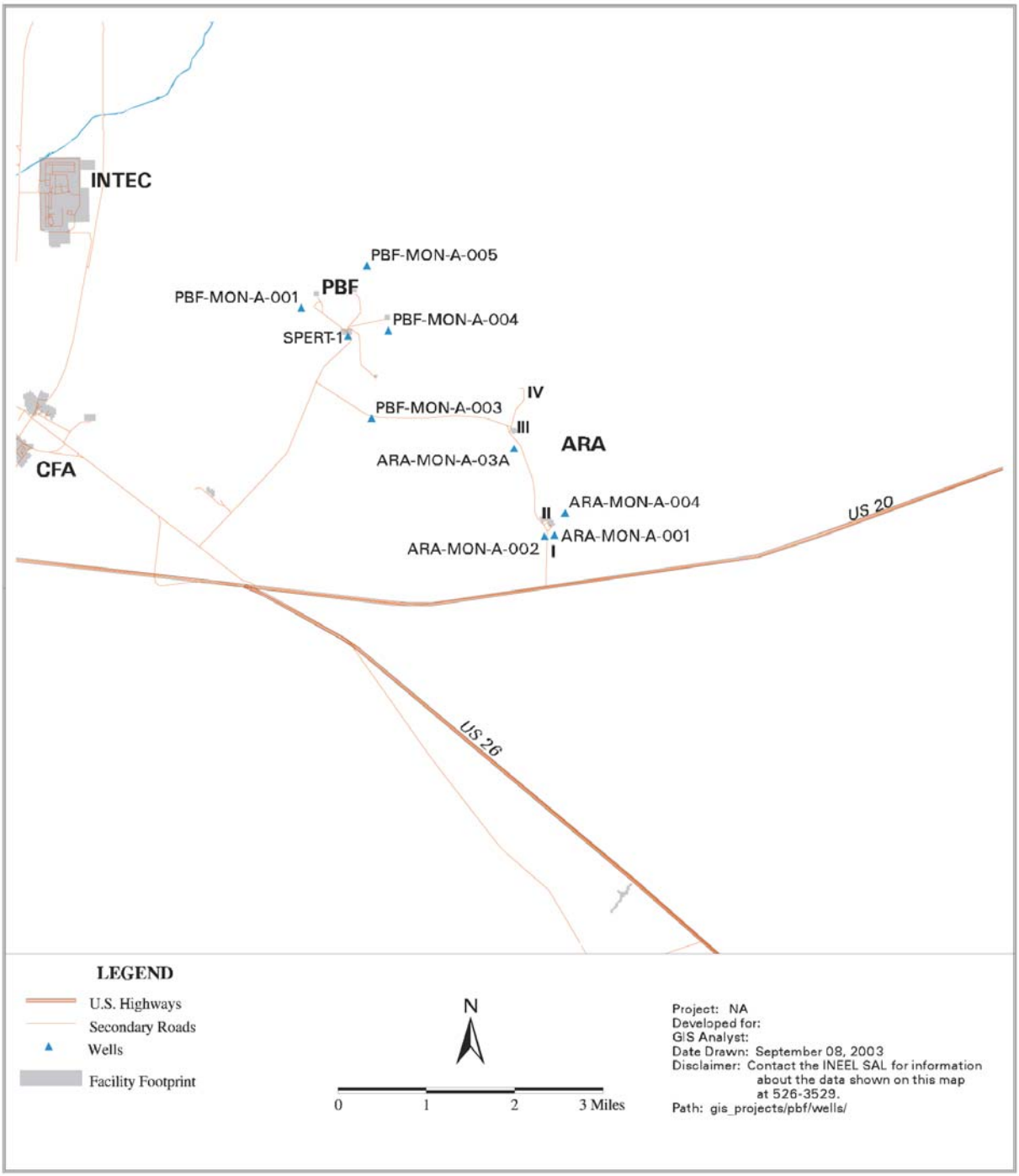

Figure 6-11. Location of WAG 5/PBF/ARA monitoring wells.

Table 6-7. WAG 5 groundwater quality summary for 2003.

Compound		Maximum Detected Value	Number of Wells with Detections above PCS[a]	PCS
Radionuclides[b]				
Gross alpha		4.13	0	15
Gross beta		4.13	0	4 mrem/yr[c]
Iodine-129		0.678	0	1[d]
Cesium-134		3.88	NA[e]	NE[f]
Organics[g]				
Toluene		0.93	0	1,000
Trichloroethene		0.44	0	5
Inorganics[g]				
Arsenic		2.68	0	50
Barium		54.1	0	2,000
Chromium		9.95	0	100
Lead		2.96	0	15
Fluoride	(mg/L)	0.546	0	4
Chloride	(mg/L)	28.4	0	250[h]
Nitrate	(mg/L)	1.1	0	10
Selenium		14.7	0	50
Sulfate	(mg/L)	25.9	0	250[h]

a. PCS = Primary constituent standard values from IDAPA 58.01.11.
b. Values are in picocuries per liter (pCi/L).
c. The primary constituent standard is an exposure as shown, however, a screening value of 50 pCi/L is commonly used.
d. Value is the EPA MCL shown for comparison only; no groundwater quality limit has been established.
e. NA = not applicable.
f. NE = not established.
g. Values are in μg/L, unless otherwise noted.
h. Groundwater quality secondary contaminant.

radioactive and hazardous wastes have been disposed of, (2) the Transuranic Storage Area, and (3) the administration and operations area. Contaminant concentrations are routinely monitored within and around the RWMC in soil gas, soil moisture, and the SRPA to determine whether waste buried in the SDA is impacting the environment. Results from these hydrologic monitoring activities are used to support the CERCLA risk assessment in the Environmental Restoration Program, and the Performance Assessment and Composite Analysis Monitoring Program in the Waste Management Program.

A total of fifteen aquifer-monitoring wells around the RWMC are sampled under Operable Unit (OU) 7-13/14 each quarter and analyzed for a variety of radionuclide, inorganic, and organic contaminants that are potential risk drivers. In addition to the wells monitored by OU 7-13/14, the USGS routinely samples eight wells in the vicinity of the RWMC. Figure 6-12 shows the location of the aquifer monitoring wells sampled in the vicinity of the RWMC.

Groundwater monitoring has been ongoing at the RWMC for more than 30 years. Currently, approximately 1300 analytes are evaluated each quarter. During these analyses, carbon tetrachloride, tritium, chromium and nitrate (as nitrogen) are consistently detected above aquifer background levels in some wells.

A total of sixty-two RWMC aquifer samples were collected by OU 7-13/14 in 2003 and analyzed for carbon tetrachloride. Thirty-three samples had detections above the quantitation limit of 1 µg/L. Of those 33 detections, seven exceeded the PCS and MCL of 5 µg/L. Besides carbon tetrachloride, four other organic compounds (i.e., trichloroethylene, 1,1,1-trichloroethane, chloroform, and toluene) were detected in RWMC groundwater samples in 2003. All sample results were below PCS/SCS values and/or MCLs. Toluene had the highest concentration (47 µg/L) in Well A11A31, followed by trichloroethylene (3 µg/L) in Wells A11A31 and M7S. The maximum chloroform concentration was 1.7 µg/L, and the maximum 1,1,1-trichloroethane concentration was 0.6 µg/L, both in the RWMC production well.

Tritium was found in about one-half of the samples collected in 2003. The maximum tritium concentration was 1690 pCi/L, which is below the aquifer PCS of 20,000 pCi/L. Even though tritium is detected in the aquifer beneath the RWMC, significant concentrations also exist upgradient of the RWMC. It is speculated that tritium at the RWMC is from upgradient facilities, primarily INTEC and TRA; however, it is also possible that the some tritium beneath the RWMC is from sources in the SDA.

Total chromium concentrations in most RWMC monitoring wells are consistent with levels typically observed around the INEEL (i.e., 1 to 22 µg/L). However, chromium concentrations in Wells M1S, M6S, M11S, and M15S are significantly above aquifer background levels and have increasing trends in concentration. Chromium levels in all RWMC aquifer wells, including the trending wells, remain below the PCS. Total chromium concentrations in 2003 ranged from 5 µg/L in Well M4D to 70 µg/L in Well M1S. Potential sources of chromium include natural sources, well construction materials, well pumps, buried waste, and upgradient facilities.

Low levels of nitrates were detected in all aquifer-monitoring wells in the vicinity of the RWMC at background concentrations typically found in the SRPA (i.e., 1 to 2 mg/L), with the exception of Well M6S. Nitrate concentrations in Well M6S are slightly above SRPA background and have a long-term trend that appears to be stabilizing at concentrations just above the SRPA background level.

Summary of WAG 9 Groundwater Monitoring Results

ANL-W samples five wells (four monitoring and one production) (Figure 6-13) 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

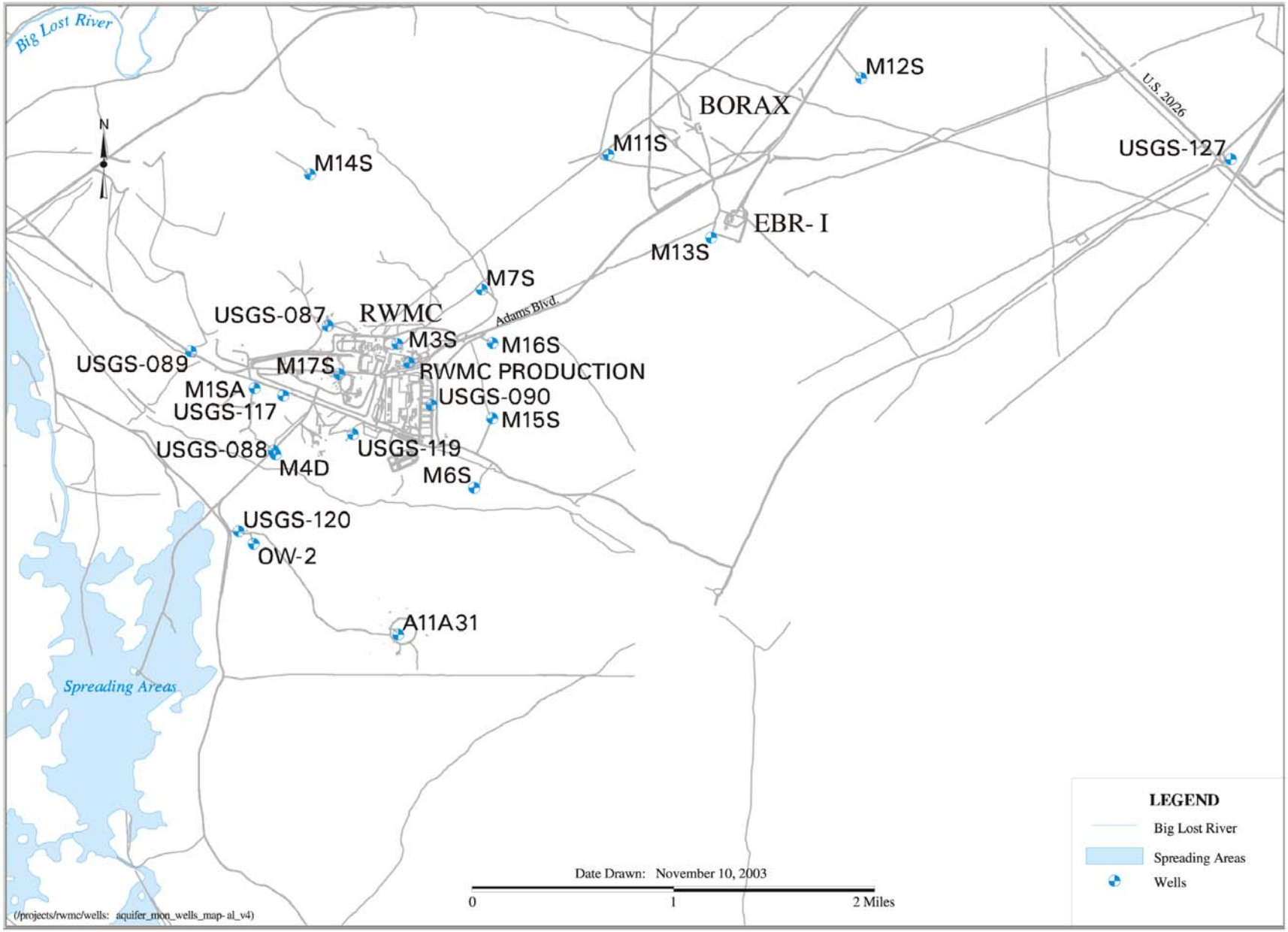

Figure 6-12. Locations of aquifer-monitoring wells at the Radioactive Waste Management Complex (WAG 7).

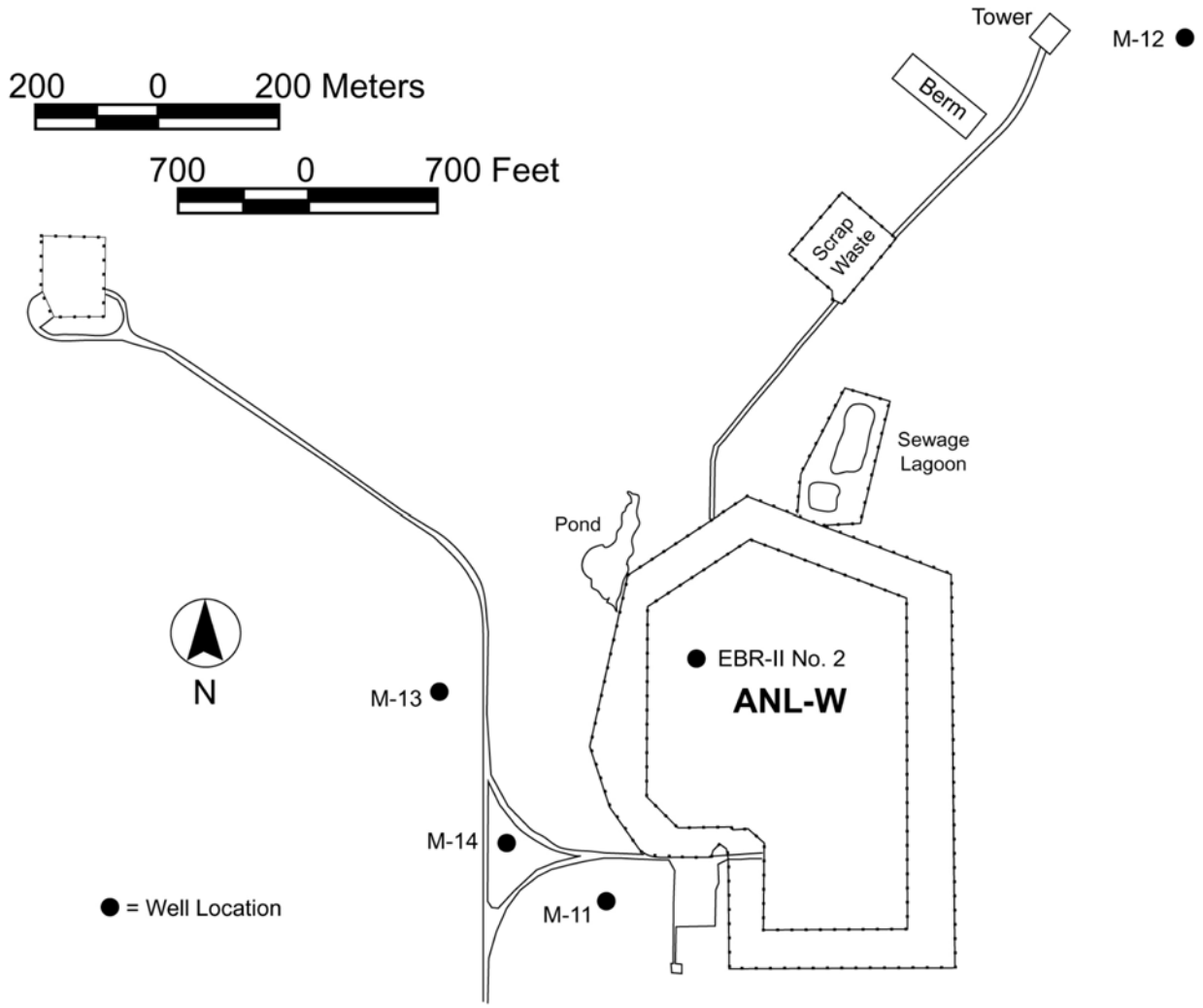

Figure 6-13. ANL-W monitoring well locations.

certain uranium isotopes were detected in groundwater during 2003. Uranium isotopes (i.e., natural uranium, uranium-235, uranium-238) and gross alpha and gross beta activity have been detected 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 6-8 presents the detected radionuclides for 2003.

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 6-8). Anions and water quality parameters were within ranges of past values.

Table 6-8. Summary of metals and water quality parameters in ANL-W monitoring wells (2003).

Well	M-11		M-12		M-13		M-14		EBR-II No. 2		PCS/SCS[a]
Sample Date	4/21/2003	10/7/2003	4/21/2003	10/7/2003	4/21/2003	10/7/2003	6/30/2003	10/7/2003	4/21/2003	10/7/2003	
Parameter											
Radionuclides[b]											
Gross Alpha	1.41	0.669	1.24	1.39	1.64	2.77	1.57	1.75	0.947	1.47	15
Gross Beta	1.88	2.42	2.02	2.21	1.54	2.25	3.37	1.26	2.46	3.06	50[c]
U-233/234	1.35	1.29	1.4	1.34	1.49	1.65	1.34	1.18	1.29	1.11	—[d]
U-235/236	0.0907	0.126	0.0785	0.0655	0.143	0.0734	0.105	0.107	0.0992	0.0733	NE[e]
U-238	0.81	0.644	0.515	0.569	0.687	0.525	0.682	0.577	0.598	0.599	NE
Metals[f]											
Aluminum	5.37	4.82	14.7	26.6	6.75	29.1	2.33	4.65	6.51	28.5	200
Barium	35.2	36.9	42	45.7	34.9	37.6	34	36.3	36	40.3	2,000
Calcium (x 10^4)	3.84	3.82	4.08	4.18	3.89	3.96	3.72	3.76	3.90	3.79	NE
Chromium	6.66	6.34	1.75	4	3.14	9.59	4.29	4.28	2.54	2.46	100
Copper	6.71	5.7	2.63	2.79	2.31	1.1	1.94	2.02	2.01	2.05	1,300
Iron	224	215	146	179	234	3.92	213	173	94	142	300
Lead	3.2	2.14	3.89	2.14	3.64	2.14	1.94	2.14	3.43	2.14	150
Magnesium (x 10^4)	1.36	1.29	1.30	1.22	1.34	1.33	1.17	1.19	1.31	1.23	NE
Manganese	0.653	0.76	1.44	3.01	3.48	6.97	0.529	0.76	0.354	2.37	50
Potassium (x 10^3)	3.21	8.3	4.0	3.85	3.44	3.62	3.38	3.36	3.50	3.28	NE
Sodium (x 10^4)	1.67	1.75	1.79	1.81	1.74	1.85	1.74	1.78	1.90	1.81	NE
Thallium	0.092	0.034	0.289	0.227	0.104	0.091	0.005	0.03	0.044	0.047	2
Vanadium	5.37	5.73	5.55	6.68	5.75	5.72	5.83	6.38	5.96	8.53	NE
Zinc	6.34	1.67	13.8	28.6	5.69	5.16	3.97	1.09	10.6	7.07	5,000
Anions[g]											
Chloride	19.9	19.3	0.86	0.761	18.5	18.5	19.4	18.3	19.6	19.3	250
Nitrate	1.97	2.01	1.92	1.81	1.92	1.9	1.85	1.88	1.7	1.01	10
Sulfate	16.4	16.7	1.86	0.077	17	17.2	16.9	16.5	16.1	16.7	25
Water Quality Parameters[g]											
Bicarbonate Alkalinity	118	129	121	117	143	131	145	128	144	128	NE
Carbonate Alkalinity	1.04	—[h]	1.28	—	1.38	—	1.3	—	1.42	—	NE
Total Alkalinity	119	130	122	118	145	132	146	129	146	130	NE

Table 6-8. Summary of metals and water quality parameters in ANL-W monitoring wells (2003). (continued)

Well	M-11		M-12		M-13		M-14		EBR-II No. 2		
Sample Date	4/21/2003	10/7/2003	4/21/2003	10/7/2003	4/21/2003	10/7/2003	6/30/2003	10/7/2003	4/21/2003	10/7/2003	PCS/SCS[a]
Total Dissolved Solids	235	217	214	226	227	207	279	205	239	227	500
Total Organic Carbon	1.36	2.52	1.58	2.25	1.2	2.94	0.908	1.8	0.804	1.07	NE
Total Organic Halogen	1.48	ND	0	—[i]	0	ND	1.8	ND	0.62	ND	NE
Conductivity (µS)[j]	380	364	357	350	380	361	376	365	382	365	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).
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.
h. — = carbonate alkalinity is no longer analyzed for.
i. Sample lost.
j. µS = micro-siemens.

Summary of WAG 10 Groundwater Monitoring Results

The WAG 10 groundwater sampling consisted of sampling events in March and June to July 2003. In March, eight wells were sampled for explosives, explosive degradation products, metals, anions, and radiological analytes. Explosives and explosive residues are sampled to evaluate any contamination from the time when the INEEL was used as a gunnery range and as a test site for a number of conventional explosives experiments. All results for explosives and explosive degradation products were below detection limits. The wells sampled for this event included USGS-99, USGS-17, USGS-97, USGS-76, USGS-121, Gun Range well, Highway-3, and the fire station well. A complete listing of the results for the explosives sampling in March 2003 is in Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Annual Report (FY 2003) (DOE-ID 2004c).

A second sampling event involving 22 wells occurred in June to July 2003. The wells were sampled for volatile organic compounds (the *Resource Conservation and Recovery Act* [RCRA] Appendix IX Target Analyte List), metals (filtered), anions (including bicarbonate), and radionuclides (gross alpha, gross beta, gamma spec, ^{129}I, tritium, ^{99}Tc, ^{90}Sr, and uranium-isotopes). The locations of the wells sampled in June to July are shown in Figure 6-14. The results are summarized on Table 6-9 and briefly described below. The complete results can be found in the remedial investigation annual report (DOE-ID 2004c).

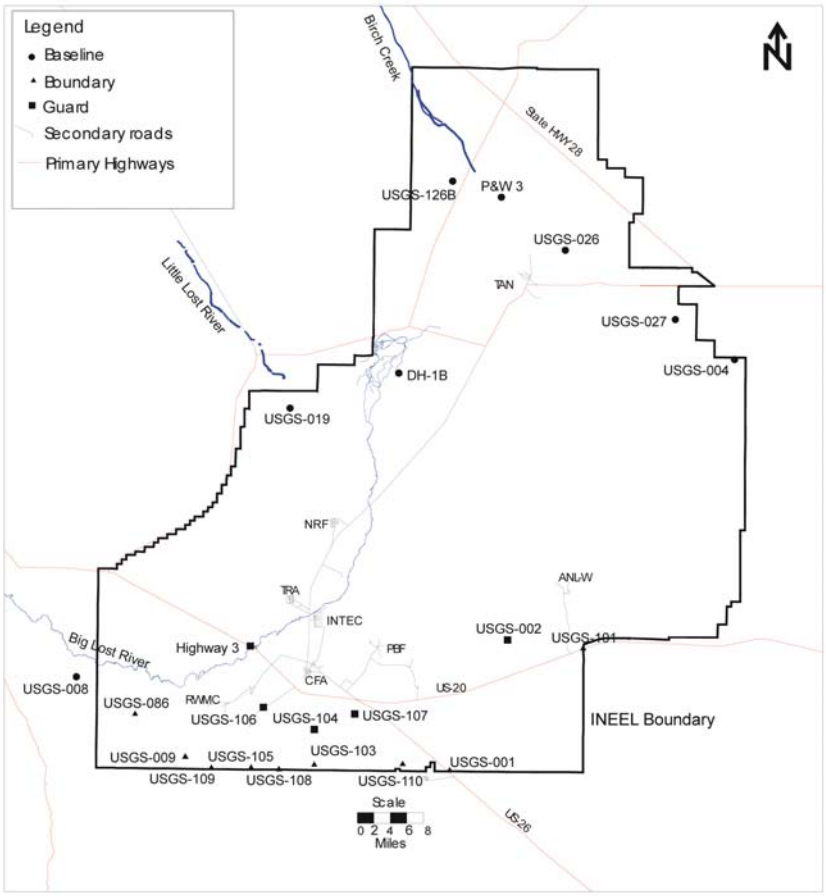

Figure 6-14. Location of monitoring wells sampled by WAG 10 in June to July 2003.

Table 6-9. WAG 10 groundwater quality summary for 2003.

Compound	Maximum Detected Value	Number of Wells with Detections above PCS[a]	PCS/SCS
Radionuclides[b]			
Gross Alpha	4.94	0	5
Gross Beta	5.68	0	4 mrem/yr
Tritium	985	0	20,000
Anions[c]			
Chloride	55.3	0	250[d]
Fluoride	0.87	0	2
Nitrate/Nitrite as N	4.6	0	10
Sulfate	39	0	250[d]
Metals[e]			
Aluminum	ND[f]	0	200[d]
Antimony	ND	0	6
Arsenic	5.2	0	50
Barium	141	0	2,000
Beryllium	ND	0	4
Cadmium	ND	0	5
Chromium	14.7	0	100
Copper	6.1	0	1,300
Iron	150	0	300[d]
Lead	10.1	0	15
Manganese	9.6	0	50[d]
Mercury	ND	0	2
Selenium	5.6	0	50
Silver	ND	NA[g]	NE[h]
Thallium	2.4	1	2
Uranium	7.9	0	30
Zinc	275	0	5,000[d]

a. PCS/SCS = Primary constituent standard/Secondary constituent standard values from IDAPA 58.01.11.
b. Values are in picocuries per liter (pCi/L).
c. Values are in milligrams per liter (mg/L), unless otherwise noted.
d. Groundwater quality secondary contaminant.
e. Values are in µg/L.
f. ND = not detected.
g. NA = not applicable.
h. NE = not established.

Thallium was the only analyte detected at or above its PCS. However, the single thallium occurrence above the PCS is at the detection limit of the analytical method employed, making this detection suspect. Nitrate is elevated in USGS-004 relative to other WAG 10 wells and probably represents off-site agricultural influences upgradient of the INEEL. Offsite influence was also indicated by elevated specific conductivity values for USGS-004 and USGS-27.

Tritium, gross alpha, gross beta, uranium isotopes were the primary radiological analytes detected. Gross alpha, gross beta, and uranium isotopes were at background concentrations. Tritium was detected in two wells at concentrations less than 1,000 pCi/L or well below the PCS of 20,000 pCi/L.

6.8 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 2003, the ESER contractor collected 12 surface water samples from five offsite locations.

Gross alpha activity was detected in one surface water sample from Hagerman during 2003. The maximum concentration of 1.53 ± 0.47 pCi/L is below the PCS of 15 pCi/L and was consistent with historic concentrations. Tritium was detected in one offsite surface water sample during 2003. The November duplicate surface water sample collected in the Twin Falls area had a concentration of 94.7 ± 25.3 pCi/L (Table 6-10). This sample was well below the PCS and EPA MCL of 20,000 pCi/L and the DOE's DCG of 2.0×10^6 pCi/L for tritium in water. The EPA MCL and DOE DCG values are given for comparison purposes only and do not apply to the individual sample locations. These levels can be attributed to natural variability.

Gross beta activity was measured in nine offsite surface water samples. Detectable concentrations ranged from 3.13 ± 0.89 pCi/L to 8.01 ± 1.00 pCi/L at Buhl and Twin Falls, 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 6-10. 2003 ESER contractor offsite surface water results.

Location		Sample Results[a] Result ± 1s	Limits for Comparison[b] PCS[c]	EPA MCL[d]	DOE DCG[e]
Tritium					
		November 2003			
Twin Falls		94.7 ± 25.3	20,000	20,000	2,000,000
Gross Alpha					
Hagerman	(May)	1.53 ± 0.47	15	15	30[f]
Gross Beta					
		May 2003			
Bliss		5.32 ± 0.95	4 mrem/yr	50	100[g]
Buhl		4.47 ± 0.92	4 mrem/yr	50	100
Twin Falls		8.01 ±1.00	4 mrem/yr	50	100
Twin Falls	(duplicate)	5.38 ± 0.97	4 mrem/yr	50	100
		November 2003			
Bliss		4.89 ± 0.97	4 mrem/yr	50	100
Buhl		3.13 ± 0.89	4 mrem/yr	50	100
Hagerman		4.55 ± 0.91	4 mrem/yr	50	100
Twin Falls		7.14 ± 1.05	4 mrem/yr	50	100
Twin Falls	(duplicate)	7.47 ± 1.05	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. **Only detected measurements are reported.**

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 alpha emitter (^{241}Am).

g. Value based on the most conservative beta emitter (Radon-226).

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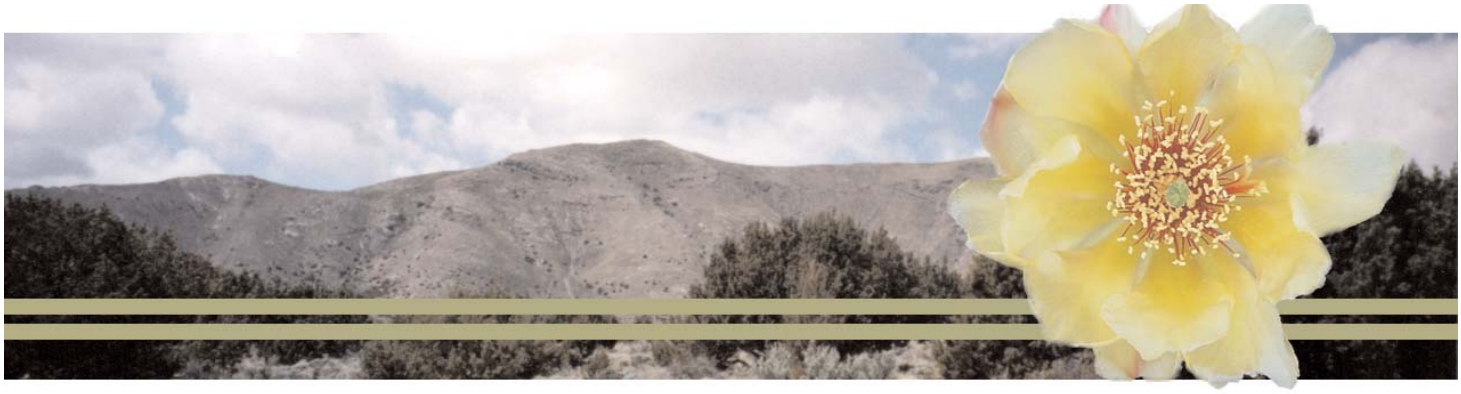

Chapter 7 - Environmental Monitoring Programs (Agricultural, Wildlife, Soil and Direct Radiation)

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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, marmots, large mammals); and soil was sampled and analyzed for radionuclides. In addition, direct radiation was measured on and off the INEEL in 2003.

Some anthropogenic (human-made) radionuclides were detected in agricultural products, wildlife, and soil samples. For the most part, the results could not be directly linked to operations at the INEEL. With the exception of americium-241 in soils collected at the Radioactive Waste Management Complex (RWMC), concentrations of radionuclides detected in 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.

Americium-241 was detected above background levels in soil samples collected around the RWMC. However, the concentrations were consistent with those measured historically and are attributable to past RWMC operations and fallout.

Direct radiation measurements made at offsite, boundary, and onsite (except the RWMC) locations were consistent with background levels. The measured annual dose equivalent from external exposure was 119 mrem. Direct radiation measurements made at the RWMC 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 that relate to agricultural products, wildlife, soil, and direct radiation 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 approximately 500 soil, vegetation, and direct radiation samples for analysis in 2003.

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 (ESER) contractor conducted offsite environmental surveillance and collected samples from an area of approximately 23,308 km^2 (9000 mi^2) of southeastern Idaho at locations on, around, and distant to the INEEL. The ESER contractor collected approximately 250 agricultural products, wildlife, and direct radiation samples for analysis in 2003.

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 collect split samples with the M&O and other INEEL contractors of the various agricultural products and soil, and maintain collocated direct radiation monitors. Results of the Oversight programs 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 deviations (± 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 2003, 146 milk samples were collected under the ESER Program. All of the samples were analyzed for gamma-emitting radionuclides including iodine-131 (^{131}I). During the first and third quarters, selected samples were analyzed for tritium. During the second and fourth quarters, selected samples were analyzed for strontium-90 (^{90}Sr).

Strontium-90 was detected in seven out of nine samples ranging from 0.7 ± 0.2 pCi/L at Howe to 1.4 ± 0.3 pCi/L in a sample from Terreton. 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 for ^{90}Sr in water of 1,000 pCi/L. No other radionuclides were detected above the ± 3s uncertainty level.

Lettuce

The 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 is typically random. To make this sampling more deliberate, 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 were relatively remote and had 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 nine locations where lettuce was collected in 2003.

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. Strontium-90 above the 3s uncertainty was detected in one of the lettuce samples from the EFS on the INEEL at a level of (0.4 ± 0.1) pCi/g ([1.6 ± 0.5] x 10^{-2} Bq/g) (Table 7-2). Cesium-137 (^{137}Cs) was detected in one sample at (1.1 ± 0.3) pCi/g ([(3.9 ± 1.2] x 10^{-2} Bq/g) at Idaho Falls. Strontium-90 and ^{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 in 2003 are similar to those identified in past years. Therefore, these detections were most likely from weapons testing fallout.

Wheat

None of the 13 wheat samples (including one duplicate and one blank) collected during 2003 contained a measurable concentration of ^{90}Sr above the 3s uncertainty level. No other anthropogenic radionuclides were detected (Table 7-3) (DOE-ID 2003).

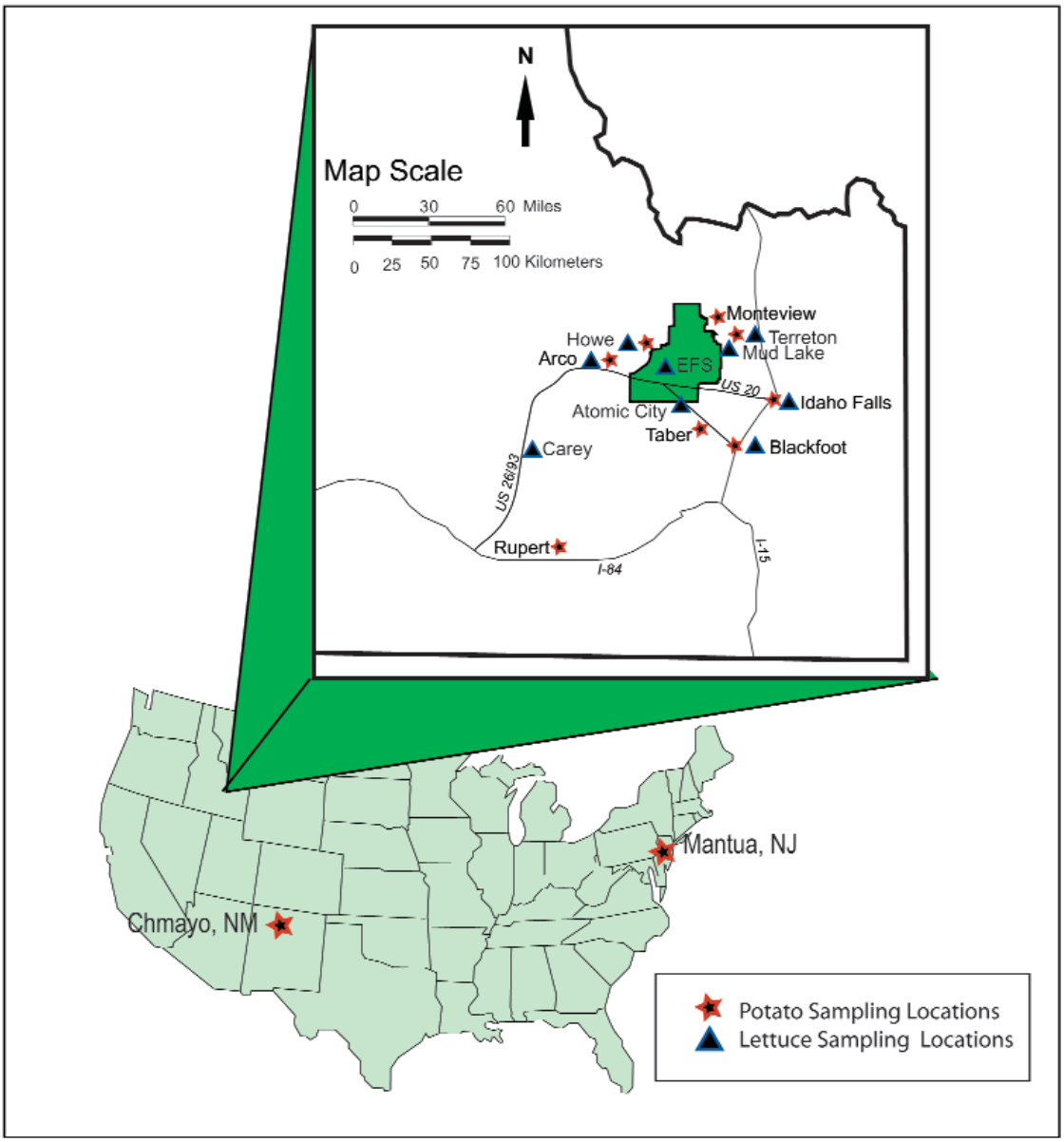


Figure 7-1. Locations of lettuce and potato samples taken during 2003.

Potatoes

Eleven potato samples, including one duplicate, were collected during 2003: four samples and one duplicate from distant locations, four samples from boundary locations, and two samples from out-of-state locations (New Jersey and New Mexico) (Figure 7-1). The eight Idaho samples were collected from Arco, Blackfoot, Howe, Idaho Falls, Monteview, Rupert, Terreton, and Taber. Strontium-90 was detected in four of the Idaho samples at an average level of $(3.4 \pm 0.1) \times 10^{-1}$ pCi/g. The maximum detected concentration was $(4 \pm 1) \times 10^{-1}$ pCi/g from a sample collected at Howe. 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 (1998-2003).[a,b]

Location	1998	1999	2000	2001	2002[c]	2003
Distant Group						
Blackfoot	NS[d]	NS	NS	NS	120 ± 240	228 ± 249
Carey	200 ± 75	120 ± 120	295 ± 210	144 ± 165	280 ± 240	220 ± 540
Idaho Falls	70 ± 60	60 ± 60	61 ± 75	114 ± 165	25 ± 75	254 ± 510
Grand Mean[e]	**135 ± 48**	**90 ± 68**	**330 ± 111**	**201 ± 117**	**150 ± 116**	**234 ± 261**
Boundary Group						
Arco	200 ± 150	120 ± 60	81 ± 62	88 ± 165	93 ± 68	126 ± 480
Duplicate					36 ± 36	324 ± 360
Atomic City[f]	NS	NS	NS	NS	NS	282 ± 390
Howe	100 ± 135	60 ± 105	88 ± 72	21 ± 165	65 ± 84	25 ± 243
Split					78 ± 90	NS
Monteview	100 ± 75	225 ± 300	NS	74 ± 165	85 ± 66	NS
Mud Lake (Terreton)	100 ± 120	160 ± 120	51 ± 77	40 ± 165	110 ± 78	214 ± 420
Grand Mean[e]	**125 ± 62**	**140 ± 87**	**73 ± 41**	**56 ± 83**	**78 ± 30**	**200 ± 173**
INEEL						
Experimental Field Station[f]	NS	NS	NS	NS	NS	442 ± 390

a. Analytical results are times 10^{-3} picocuries per gram (pCi/g).
b. Analytical results are for dry weight plus or minus three standard deviations (± 3s).
c. Approximate minimum detectable concentration (MDC) of ^{90}Sr in lettuce is 2×10^{-4} pCi/g dry weight.
d. NS indicates no sample collected or sample was lost before analysis.
e. Uncertainty calculated as $3\left(\sqrt{\sum_{i=1}^{n} s_i^2}\right)\Big/ n$ where s_i is the standard deviation of sample *i* and *n* is the number of samples within the group.
f. Portable lettuce garden.

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 2003, 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 $(12.1 \pm 1.5) \times 10^{-3}$ pCi/g but was not detected in offsite muscle samples. Cesium-137 was also detected in the liver tissue sample from the same onsite animal at a level of $(4.9 \pm 1.5) \times 10^{-3}$ pCi/g. Cesium-137 was not measured above the 3s uncertainty in any control sheep in 2003. However, all ^{137}Cs concentrations measured in 2003 were similar to those found

Table 7-3. Strontium-90 concentrations in wheat (1998-2003).[a,b]

Location	1998	1999	2000	2001[c]	2002	2003
Distant Group						
Aberdeen	NS[d]	NS	NS	NS	36 ± 390	84 ± 186
Blackfoot	8 ± 6	5 ± 8	6 ± 9	60 ± 149	69 ± 195	NS
Blackfoot[e]	NS	NS	NS	NS	81 ± 405	NS
Carey	NS	8 ± 5	NS	49 ± 270	28 ± 195	-53 ± 141
Idaho Falls	7 ± 5	8 ± 9	5 ± 5	-37 ± 132	50 ± 240	121 ± 192
Idaho Falls	NS	NS	NS	NS	240 ± 405	NS
Menan	NS	NS	NS	NS	NS	54 ± 165
Minidoka	6 ± 5	4 ± 5	6 ± 6	218 ± 435	0.78 ± 285	61 ± 144
Roberts (Menan)	NS	NS	NS	NS	19 ± 195	16 ± 153
Rockford	NS	NS	NS	NS	-220 ± 390	196 ± 204
Rupert	NS	NS	NS	NS	90 ± 405	48 ± 168
Duplicate	NS	NS	NS	NS	NS	-26 ± 156
Tabor	NS	NS	NS	NS	110 ± 450	NS
Grand Mean [g]	6 ± 3	6 ± 3	6 ± 5	73 ± 138	46 ± 102	42 ± 503
Boundary Group						
Arco	6 ± 5	5 ± 5	6 ± 6	95 ± 390	41 ± 570	2 ± 162
Duplicate				59 ± 131	120 ± 540	NS
Howe	NS	NS	NS	NS	18 ± 225	-19 ± 147
Monteview	9 ± 6	6 ± 8	2 ± 3	50 ± 146	220 ± 300	NS
Mud Lake	8 ± 6	3 ± 5	5 ± 6	19 ± 111	54 ± 255	8 ± 168
Terreton	7 ± 5	5 ± 6	3 ± 5	63 ± 195	86 ± 300	5 ± 162
Grand Mean [g]	8 ± 3	5 ± 3	4 ± 3	57 ± 98	90 ± 159	-1 ± 480

a. Concentrations are 10^{-3} picocuries per gram.
b. Analytical Results are for dry weight, plus or minus 3 standard deviations (± 3s).
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 from two Blackfoot locations in 2002.
f. Uncertainty calculated as $3\left(\sqrt{\sum_{i=1}^{n} s_i^2}\right)\Big/ n$, where s is the standard deviation of sample i and n is the number of samples in the group.

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 essentially the same (error bars overlap) since 1998 (DOE-ID 2003) (Figure 7-2). Iodine-131 did not exceed the 3s uncertainty in any sample.

Game Animals

Muscle, liver, and thyroid samples were collected from nine mule deer, nine pronghorn, and two elk, which were accidentally killed on INEEL roads. There was detectable ^{137}Cs radioactivity above 3s in the muscle and thyroid from two different mule deer, and in the liver of two and muscle of three pronghorn taken on or near the INEEL. Additionally, one muscle sample and one liver sample from pronghorn contained detectable ^{131}I above 3s (Table 7-4).

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 $(5.1 \pm 1.5) \times 10^{-3}$ to $(15 \pm 0.2) \times 10^{-3}$ pCi/g.

Muscle results from animals sampled in 2003 were within this range, from $(4.7 \pm 1.2) \times 10^{-3}$ to $(15 \pm 2) \times 10^{-3}$ pCi/g. The 2003 values were also within the range of historical values. The

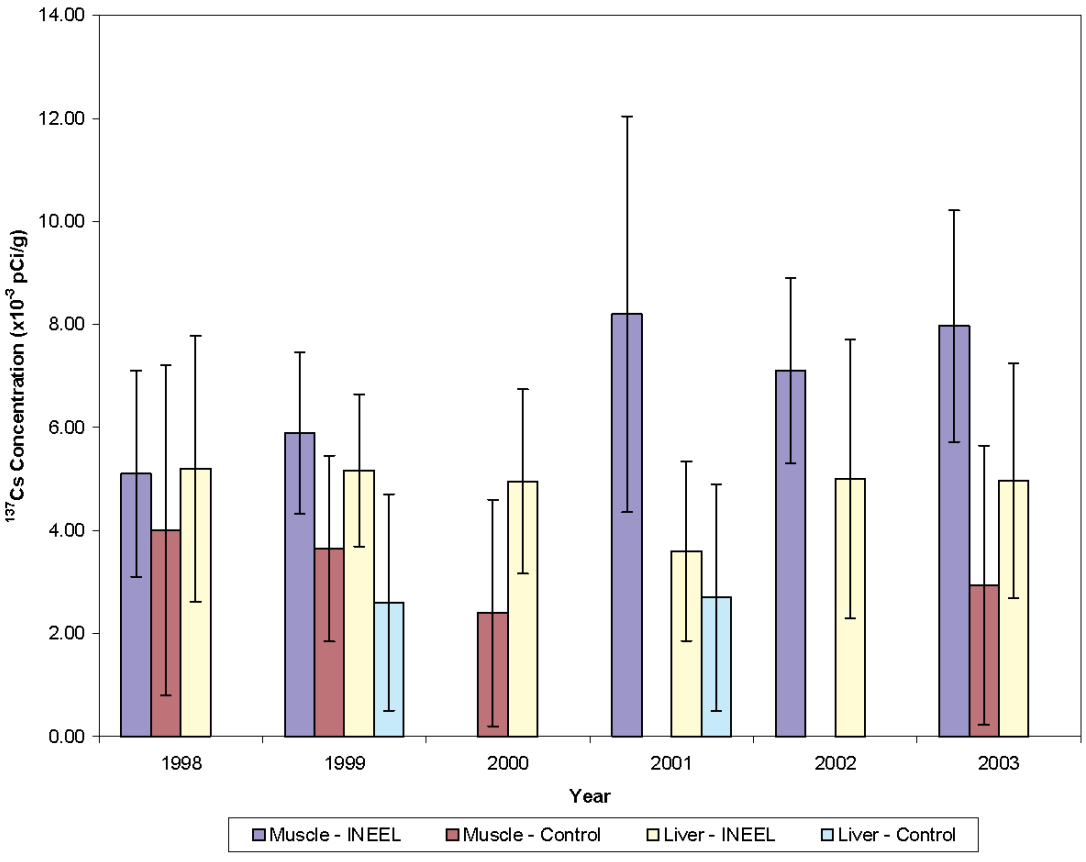


Figure 7-2. Cesium-137 concentrations in muscle and liver of sheep collected from the INEEL and control areas.

Table 7-4. Detectable concentrations of ^{131}I and ^{137}Cs in game tissue on and near the INEEL in 2003.[a]

Tissue	Number of Samples	Minimum	Maximum	Mean
		Mule Deer (^{137}Cs)		
Muscle	1		5.1 ± 4.4 E-3	
Thyroid	1		5.0 ± 4.4 E-3	
		Pronghorn (^{137}Cs)		
Muscle	3	4.7 ± 4.1 E-3	1.5 ± 0.6 E-2	9.1 ± 4.9 E-3
Liver	2	8.1 ± 4.3 E-3	1.1 ± 0.6 E-2	9.0 ± 1.3 E-3
		Pronghorn (^{131}I)		
Muscle	1		1.1 ± 0.6 E-2	
Liver	1		8.4 ± 5.7 E-3	

a Concentrations in picocuries per gram ± 3 standard deviations.

highest value for ^{137}Cs was recorded in the muscle of a pronghorn at $(15 \pm 2) \times 10^{-3}$ pCi/g collected on the INEEL between Central Facilities Area (CFA) and Idaho Nuclear Technology and Engineering Center (INTEC). The same pronghorn also had ^{131}I in the muscle at $(11 \pm 2) \times 10^{-3}$ pCi/g and liver at $(8.4 \pm 1.9) \times 10^{-3}$ 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. During 1998, 2000, 2002, and 2003, a total of 15 marmots were collected from the Radioactive Waste Management Center (RWMC) and 11 from control areas (Table 7-5). 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 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 (Table 7-5). 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 2003). 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 (Table 7-5). However, muscle tissue collected in 2002 and 2003 showed a decrease from the 1998 concentrations. The animals sampled in 2002 and 2003 were

Table 7-5. Maximum radionuclide concentrations in edible, fur/bone or viscera tissues from marmots collected at RWMC and control areas in 1998, 2000, and 2003.[a]

Edible Tissues								
Radionuclide	**1998 RWMC (6)[b]**	**1998 Control (3)**	**2000 RWMC (3)**	**2000 Control (3)**	**2002 RWMC (3)**	**2002 Control (2)**	**2003 RWMC (3)**	**2003 Control (3)**
^{90}Sr	0.122±0.096	0.157±0.011	BD	BD	0.018±0.017	0.004±0.005	0.071±0.019	BD
^{134}Cs	0.015±0.021	BD	BD	BD	BD	BD	BD	BD
^{137}Cs	0.016±0.018	0.018±0.015	BD	BD	0.274±0.051	BD	0.405±0.049	BD
^{238}Pu	0.001±0.002	BD	BD	BD	BD	BD	BD	BD
$^{239/240}Pu$	BD[c]	BD	BD	BD	BD	BD	BD	BD
^{241}Am	BD	BD	BD	BD	BD	BD	0.0013±0.0012	BD
^{60}Co	0.013±0.012	BD	BD	BD	BD	BD	BD	BD
^{141}Ce	16.1±16.1	BD	BD	BD	BD	BD	BD	BD
^{95}Nb	1.395±1.383	BD	BD	BD	BD	BD	BD	BD
External Tissues (Fur/Bone/ Viscera)								
Radionuclide	**1998 RWMC (0)[b]**	**1998 Control (0)**	**2000 RWMC (3)**	**2000 Control (3)**	**2002 RWMC (3)**	**2002 Control (2)**	**2003 RWMC (3)**	**2003 Control (3)**
^{90}Sr	NA[d]	NA	90±84	BD	2.64±0.81	BD	4.74±1.47	0.197±0.068
^{134}Cs	NA	NA	BD	BD	BD	BD	BD	BD
^{137}Cs	NA	NA	0.012±0.011	BD	0.177±0.035	BD	0.002±0.002	BD
^{238}Pu	NA	NA	BD	BD	BD	BD	BD	BD
$^{239/240}Pu$	NA	NA	BD	BD	BD	BD	0.0010±0.001	BD
^{241}Am	NA	NA	BD	BD	0.004±0.005	BD	0.0028±0.002	BD
^{60}Co	NA	NA	BD	BD	BD	0.0006±0.001	BD	BD
^{141}Ce	NA	NA	BD	BD	BD	0.005±0.006	BD	BD
^{95}Nb	NA	NA	BD	BD	BD	0.04±0.045	BD	BD

a Units are in pCi/g ± 3 standard deviations.

b (n) = Total number of samples taken.

c BD = Below Detection limits.

d NA = Not Analyzed

collected from the Pit 9 area. 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).

Eleven waterfowl were collected during 2003: three control samples from Mud Lake, five from the Test Reactor Area (TRA) Northeast Cold Pond, and three from ANL-W waste ponds. Samples of the exterior, edible portions, and the remainder (33 samples total plus three duplicates) of all these waterfowl were analyzed for gamma-emitting radionuclides with a subset analyzed for ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$. All 11 ducks had positive detections for one or more radionuclides in at least one tissue type. Total radionuclide concentrations for those samples are summarized in Table 7-6. The potential dose from consuming these ducks is discussed in Chapter 8.

Mourning doves were not collected in 2003.

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 for the CFA Sewage Treatment Plant. Samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and certain actinides. Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world. 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).

The ESER contractor collects offsite soil samples every two years (in even years); thus no soil sampling was conducted in 2003. Results from 1976 to 2002 are presented in Figure 7-3 for a perspective. Radionuclide levels in soils at 186 site surveillance locations near major INEEL facilities were measured by the M&O contractor in 2003 using in situ gamma spectrometry with additional grab samples from 0 to 5 cm (0 to 2 in.) at selected locations. Table 7-7 summarizes the in situ gamma results.

Wastewater Land Application Permit Soil Sampling at CFA

The Wastewater Land Application Permit (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.

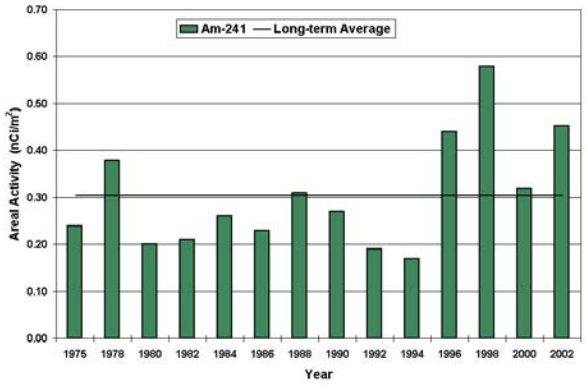
Table 7-6. Radionuclide concentrations in eight waterfowl using INEEL wastewater (sewage) disposal ponds and three waterfowl from background locations (2003).[a]

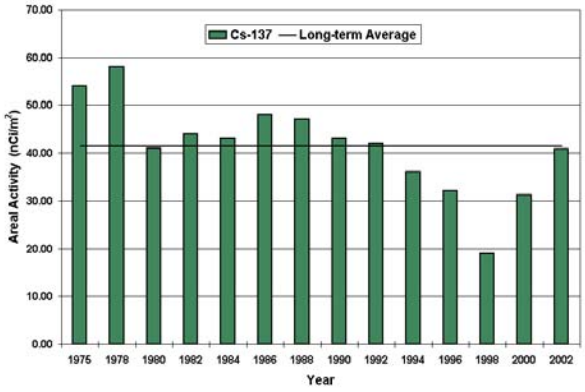
	Waterfowl Species and Location										
Nuclide	Coot TRA	Coot TRA	Coot TRA	Coot TRA	Coot TRA	American Widgeon ANL-W	Northern Shoveler ANL-W	Mallard ANL-W	Gadwall Mud Lake	Green-winged Teal Mud Lake	Green-winged Teal Mud Lake
Edible											
^{141}Ce	--[b]	176±165	--	--	--	79.3±108.0	139±165	--	--	--	--
^{137}Cs	--	--	--	--	--	--	30.0±34.5	--	--	--	--
^{60}Co	--	--	--	--	--	--	35.4±37.5	--	--	34.9±40.5	--
^{95}Nb	--	--	--	--	--	--	--	--	--	187±210	--
^{241}Am	--	--	--	--	--	2.0±3.5	--	--	--	--	--
$^{239/240}Pu$	--	--	--	--	--	--	1.8±3.2	--	--	--	--
^{90}Sr	16.9±22.5	--	18.7±16.5	--	18.0±12.3	--	--	--	10.6±9.0	9.9±13.4	20.4±16.5
Exterior (Feathers and Gut)											
^{241}Am	14.5±18.0	--	--	--	7.9±13.8	--	--	12.9±18.0	--	--	--
^{141}Ce	--	--	--	--	--	--	--	--	52.6±72.0	--	--
^{134}Cs	--	--	--	--	--		--	--	--	66.4±53.0	--
^{137}Cs	--	--	--	--	--	--	6.9±10.2	--	--	--	36.5±46.5
^{60}Co	--	--	8.2±11.7	--	--	--	--	--	--	31.0±42.0	--
^{152}Eu	--	--	--	18.4±21.0	--	--	--	--	--	--	--
^{124}Sb	34.7±42.0	--	--	--	--	--	--	--	--	--	--
$^{239/240}Pu$	--	--	--	--	--	--	6.0±10.4	--	--	--	--
^{90}Sr	252±195	227±131	201±210	269±195	--	282±180	258±315	201±195	144±180	438±357	200±149
Remainder (Bones, Remaining Organs, Residual Muscle)											
^{241}Am	--	2.3±3.2	--	--	3.6±4.5	--	--	--	1.7±2.7	--	--
^{134}Cs	17.2±25.5	--	--	21.7±28.5		25.2±27.0	23.3±33.0	14.8±19.5	--	32.9±36.0	--
^{137}Cs	--	--	--	19.4±25.5	--	--	--	--	--		--
^{58}Co			--	--	--		44.9±57.0		--	--	--
^{51}Cr	--	--	--	--	--	1070±1350	--	--		--	--
^{54}Mn	--		--	--	--	--	--	--	--	--	36.0±48.0
$^{239/240}Pu$	--	--		--	--	--	--	--	0.96±1.65	--	--
^{90}Sr	49.5±22.5	71.5±24.0	78.2±37.5	149±40.5	63.0±22.5	56.6±22.5	213±62	--	116±33	63.3±24.0	79.3±22.5

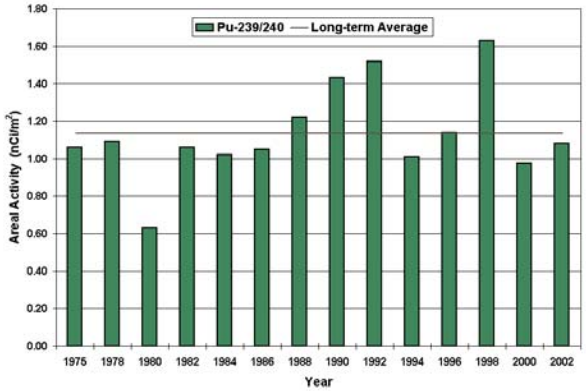
a. All values are $\times 10^{-3}$ picocuries per gram ± 3 standard deviations

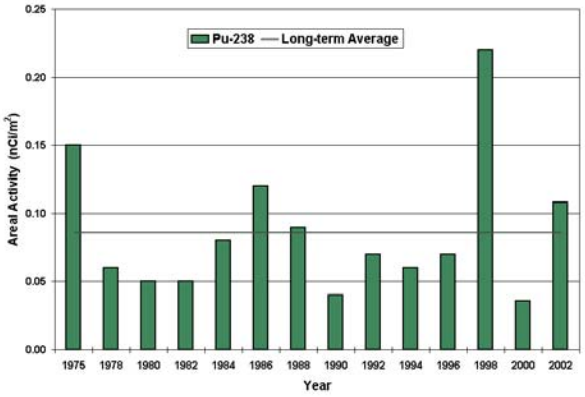
b. A double dash (--) indicates the radionuclide was not detected in the sample.

c. Results in shaded columns are background (control) samples.









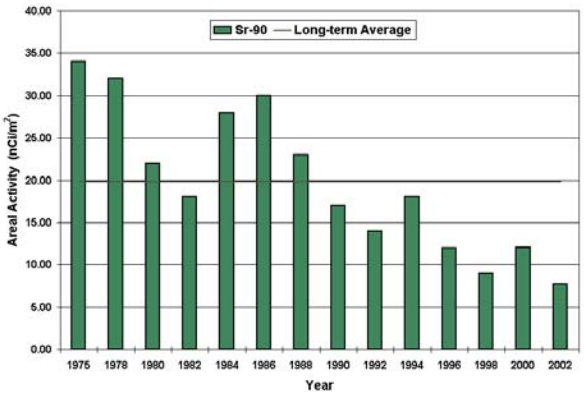


Figure 7-3. Geometric mean areal activity in offsite surface (0 to 5 cm [0 to 2 in.]) soils (1975 to 2002; soils were not collected in 2003).

Table 7-7. In situ gamma results measured by the M&O contractor (2003).

Location	Radionuclide	Concentration[a]			Comment
		Minimum	Maximum	Mean	
ARA	Cesium-137	0.2 ± 0.1	152.8 ± 0.1	10.2	Concentrations above background for the INEEL, but consistent with historical concentrations at ARA.
ANL-W	Cesium-137	0.53 ± 0.10	1.20± 0.05	0.72	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
INTEC	Cesium-137	1.1 ± 0.1	23.0 ± 0.1	5.2	Concentrations above background for the INEEL, but consistent with historical concentrations at INTEC.
Large Grid	Cesium-137	0.34 ± 0.03	0.80 ± 0.14	0.62	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
NRF	Cesium-137	0.27 ± 0.05	1.10 ± 0.06	0.57	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.

a. Concentrations are in picocuries per gram ±2s.

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.

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 2003, 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 increased slightly over historical levels but remained well below the recommended 2 mmhos/cm maximum. Soils with sodium adsorption ratios below 15 are generally classified as not having sodium or salinity problems (Bohn et al. 1985). While 2003 sodium adsorption ratios were elevated at both depths relative to preapplication levels and to historical average levels, they 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.

Table 7-8. CFA Sewage Treatment Plant land application area soil monitoring results (2003).

Parameter[a]	Preapplication Data[b] Depth (in.)	1993	Application Period 1995 through 2002 Depth (in.)	Historical Minimum (1995–2002)	Historical Maximum (1995–2002)	Historical Average (1995–2002)	2003
pH (standard units)	0–6	7.6	0–12	7.6	8.4	8.1	7.97
	6–16	8.0	12–24	7.6[c]	8.6[c]	8.2[c]	8.02
	16–30	8.1	—	—	—	—	—
Electrical Conductivity (mmhos/cm)	0–6	0.6	0–12	0.36	1.20	0.77	1.22
	6–16	0.7	12–24	0.20	1.64	0.70	1.27
	16–30	0.6	—	—	—	—	—
Organic Matter (%)	0–6	2.2	0–12	0.44[c]	3.09[c]	1.65[c]	1.15
	6–16	1.6	12–24	0.56	2.29	1.12	0.62
	16–30	1.4	—	—	—	—	—
Nitrate-Nitrogen	0–6	16	0–12	0.68[d]	6.00	3.10[e]	4.03
	6–16	6	12–24	0.43[d]	5.20	2.10[e]	1.06
	16–30	3	—	—	—	—	—
Ammonium-Nitrogen	0–6	7.9	0–12	0.81[f]	6.10	3.11[e]	2.04[g]
	6–16	7.6	12–24	0.84[f]	6.00	2.76[e]	2.00[g]
	16–30	7.4	—	—	—	—	—
Phosphorus[h]	0–6	29	0–12	3.69	12.0	7.79[e]	8.85
	6–16	18	12–24	2 U	10.2	3.79[e]	2.05[g]
	16–30	12	—	—	—	—	—
Sodium Adsorption Ratio	0–6	1.0	0–12	0.35	6.72	2.72	6.20
	6–16	1.4	12–24	0.31	4.03	1.59	9.12
	16–30	2.6	—	—	—	—	—

a. All values are in milligrams per kilogram unless otherwise noted.
b. 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.
c. The minimum, maximum, and average shown do not reflect a result from 1995. While samples were collected in 1995, the analytical laboratory failed to analyze them.
d. Only includes values that were greater than the detection limit.
e. Where applicable, half the reported detection limit was used to calculate the average.
f. U = the reported result is below the detection limit.
g. Reported as below detection limit. Half detection limit is shown.
h. Available phosphorus was analyzed rather than total phosphorus.

In 2003, available phosphorus concentrations remained below preapplication concentrations and less than that considered adequate for range and pasture crop growth (EPA 1981).

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

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 to 5 cm (0 to 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 2003 sampling effort.

Table 7-9. Soil radiochemistry results reported by ANL-W (2003).

Radionuclide	Concentrations[a]			Location of Maximum Result
	Minimum	Maximum	Average	
Human-Made				
^{137}Cs	0.221	9.79	1.560	IW Pond[b]
^{238}Pu	0	0.014	0.004	Air Monitor #1
$^{239/240}Pu$	0.004	0.025	0.013	Air Monitor #1
Naturally Occurring				
^{228}Ac	0.951	1.32	1.170	Air Monitor #1
^{7}Be	-0.08	0.302	0.072	Air Monitor #4
^{214}Bi	0.843	1.21	1.005	Air Monitor #4
^{214}Pb	1.03	1.23	1.15	Air Monitor #1
^{40}K	17.7	23.3	19.95	Air Monitor #1
^{226}Ra	0.843	1.21	1.005	Air Monitor #4
^{228}Th	1.18	1.37	1.238	Air Monitor #1
^{230}Th	1.15	1.51	1.236	Air Monitor #1
^{232}Th	1.05	1.42	1.216	Air Monitor #1
$^{233/234}U$	0.618	1.81	0.943	IW Pond
$^{235/236}U$	0.079	0.134	0.104	Air Monitor #1
^{238}U	0.613	1.32	0.860	IW Pond

a. All concentrations are in picocuries per gram (pCi/g).
b. IW Pond refers to the ANL-W Industrial Waste Pond.

Naval Reactors Facility

Naval Reactors Facility personnel also sample soil and vegetation annually for programmatic radionuclides. For detailed information see the 2003 Environmental Monitoring Report for the Naval Reactors Facility (Bechtel Bettis 2003).

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 2003 were from November 2002 through April 2003 (spring) and from May 2003 through October 2003 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2002 through October 2003 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 1999-2002 are also included for each location.

The mean annual exposures from distant locations in 2003 were 114 ± 2 milliroentgens (mR) as measured by ESER contractor dosimeters and 117 ± 3 mR, as measured by the M&O contractor dosimeters (Table 7-10). For boundary locations, the mean annual exposures were 113 ± 2 mR as measured by ESER contractor dosimeters and 115 ± 3 mR as measured by M&O contractor dosimeters. Using both ESER and M&O data, the average dose equivalent of the distant group was 119 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 117 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

Table 7-10. Annual environmental radiation exposures (1999-2003).[a]

Distant Group	1999		2000		2001		2002		2003	
	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O
Distant Group										
Aberdeen	130 ± 5	124 ± 4	144 ± 14	133 ± 9	152 ± 11	137 ± 10	141 ± 10	126 ± 9	123 ± 4	122 ± 9
Blackfoot	111 ± 2	111 ± 3	138 ± 14	126 ± 9	145 ± 10	136 ± 9	125 ± 9	119 ± 9	117 ± 4	111 ± 8
Blackfoot (CMS)[b]	113 ±7		114 ± 11		134 ±7		113 ± 8		101 ± 4	
Blue Dome[c]							106 ± 8		103 ± 4	
Craters of the Moon	115 ± 6	120 ± 7	126 ± 13	121 ± 9	137 ± 10	136 ± 9	121 ± 9	124 ± 9	116 ± 4	122 ± 9
Dubois[c]							109 ± 8		98 ± 3	
Idaho Falls	124 ± 7	108 ± 5	129 ± 13	123 ± 9	147 ± 10	127 ± 9	126 ± 9	112 ± 8	126 ± 9	111 ± 8
Jackson[c]							97 ± 7		97 ± 7	
Minidoka	112 ± 4	113 ± 6	118 ± 12	111 ± 8	131 ± 9	122 ± 9	111 ± 8	107 ± 8	111 ± 8	104 ± 7
Rexburg	129 ± 3	110 ± 6	148 ± 15	120 ± 8	155 ± 11	131 ± 9	144 ± 10	115 ± 8	136 ± 5	116 ± 8
Roberts	131 ± 5	129 ± 5	137 ± 14	139 ± 10	157 ± 11	144 ± 11	134 ± 13	132 ± 9	126 ± 4	133 ± 9
Mean	**121 ± 2**	**116 ± 2**	**132 ± 5**	**125 ± 4**	**146 ± 4**	**133 ± 4**	**120 ± 3**	**119 ± 3**	**114 ± 2**	**117 ± 3**
Boundary Group										
Arco	128 ± 6	124 ± 4	128 ± 13	121 ± 9	143 ± 10	134 ± 9	126 ± 9	120 ± 9	113 ± 4	118 ± 8
Atomic City	124 ± 4	133 ± 3	131 ± 13	128 ± 9	147 ± 10	137 ± 9	130 ± 9	124 ± 9	120 ± 4	124 ± 9
Howe	118 ± 1	116 ± 5	118 ± 12	114 ± 9	133 ± 9	130 ± 9	121 ± 9	NS[d]	109 ± 4	110 ± 8
Monteview	114 ± 1	108 ± 7	122 ± 12	116 ± 9	134 ± 10	120 ± 8	118 ± 8	115 ± 8	106 ± 4	112 ± 8
Mud Lake	129 ± 5	128 ± 7	140 ± 14	126 ± 9	151 ± 11	140 ± 10	136 ± 10	129 ± 9	124 ± 4	122 ± 8
Birch Creek Hydro	113 ± 5	113 ± 9	118 ± 12	108 ± 8	114 ± 8	107 ± 8	110 ± 8	104 ± 7	105 ± 4	105 ± 7
Mean	**121 ± 2**	**120 ± 3**	**126 ± 5**	**119 ± 4**	**137 ± 4**	**128 ± 4**	**124 ± 4**	**118 ± 4**	**113 ± 2**	**115 ± 3**

a. All values are in milliroentgens with ± 1 standard deviation.
b. The M&O contractor does not sample at the Blackfoot Community Monitoring Station (CMS).
c. These stations were added by the ESER contractor in 2002.

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 2003 was 348 ± 25 mR at location TRA 2. This location is near a radioactive materials storage area, which is inside the facility fence line. Locations TRA 2, 3, and 4 are also 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 by approximately 50 percent from 2002 (DOE-ID 2003).

The INTEC 20 TLD is located near a radioactive material storage area with an exposure of 249 ± 17 mR. The maximum exposure occurred at the INTEC tree farm at 221 ± 15 mR near Tree Farm 4. Exposures at INTEC 20, INTEC Tree Farm 1, and INTEC Tree Farm 4 for 2003 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.

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

Table 7-11. Calculated effective dose equivalent from background sources (2003).

Source of Radiation Dose Equivalent		Total Average Annual Dose[a]	
		Calculated	Measured
External			
	Terrestrial	75	NA[b]
	Cosmic	48	NA
	Subtotal	123	117
Internal			
	Cosmogenic	1	
	Inhaled Radionuclides	200	
	^{40}K and others	39	
	Subtotal	240	
Total		**363**	

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

products, and ^{40}K based on the above average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr. Because snow cover can reduce the effective dose equivalent Idaho residents receive from the soil, a correction factor must be made each year to the above estimate of 76 mrem/yr. For 2003, this resulted in a corrected dose of 75 mrem/yr because of snow cover, which ranged from 2.54 to 12.7 cm (1 to 5 in.) in depth with an average of 5.95 cm (2.34 in.) over 32 days with recorded snow cover (Table 7-11).

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

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2003 was 123 mrem (Table 7-11). This is above the 119 mrem measured at distant locations by ESER and M&O TLDs after conversion from milliroentgens to millirem in tissue. These values are very close and within normal variability (Table 7-10). 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 363 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 the *2003 Environmental Monitoring Report for the Naval Reactors Facility* (Bechtel Bettis 2003).

7.5 Waste Management Surveillance Sampling

Vegetation, soil, and direct radiation sampling are performed at RWMC and Waste Experimental Reduction Facility (WERF) 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. Crested wheat grass and perennials are collected in odd-numbered years. Samples of crested wheat grass

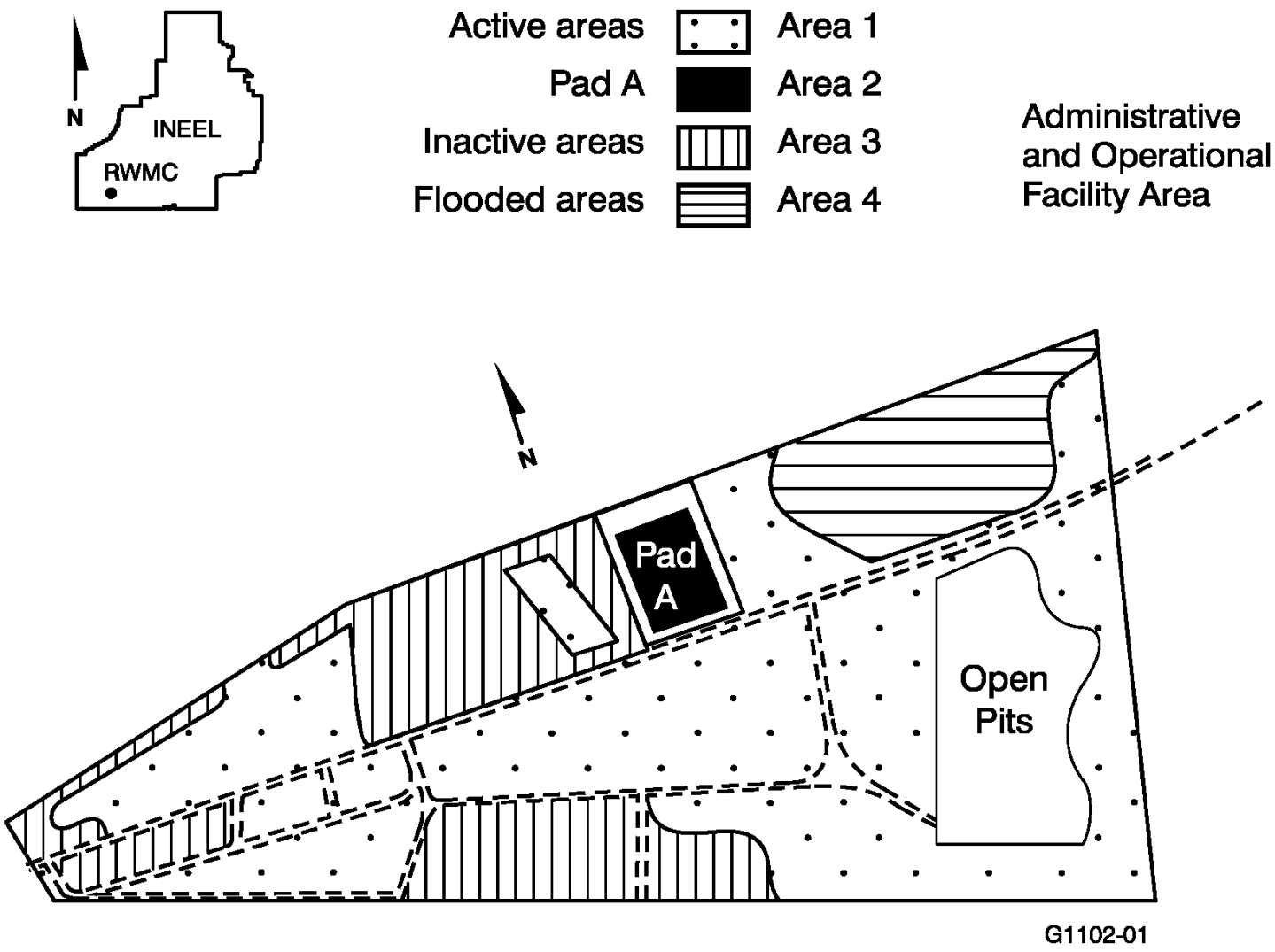


Figure 7-4. Four major areas of the RWMC used for M&O waste management vegetation collection.

were collected from RWMC in 2003. Control samples were collected near Frenchman's cabin (Figure 7-5). Because of recontouring and construction activities at the RWMC, no perennials were available for sampling in 2003. The vegetation samples were analyzed for gamma-emitting radionuclides. No gamma-emitting radionuclides were detected.

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 one kg (2.2 lb) of mixed vegetation is collected and dried. The dried material is then powdered and analyzed for various radionuclides. Table 7-12 presents the 2003 vegetation results for ANL-W.

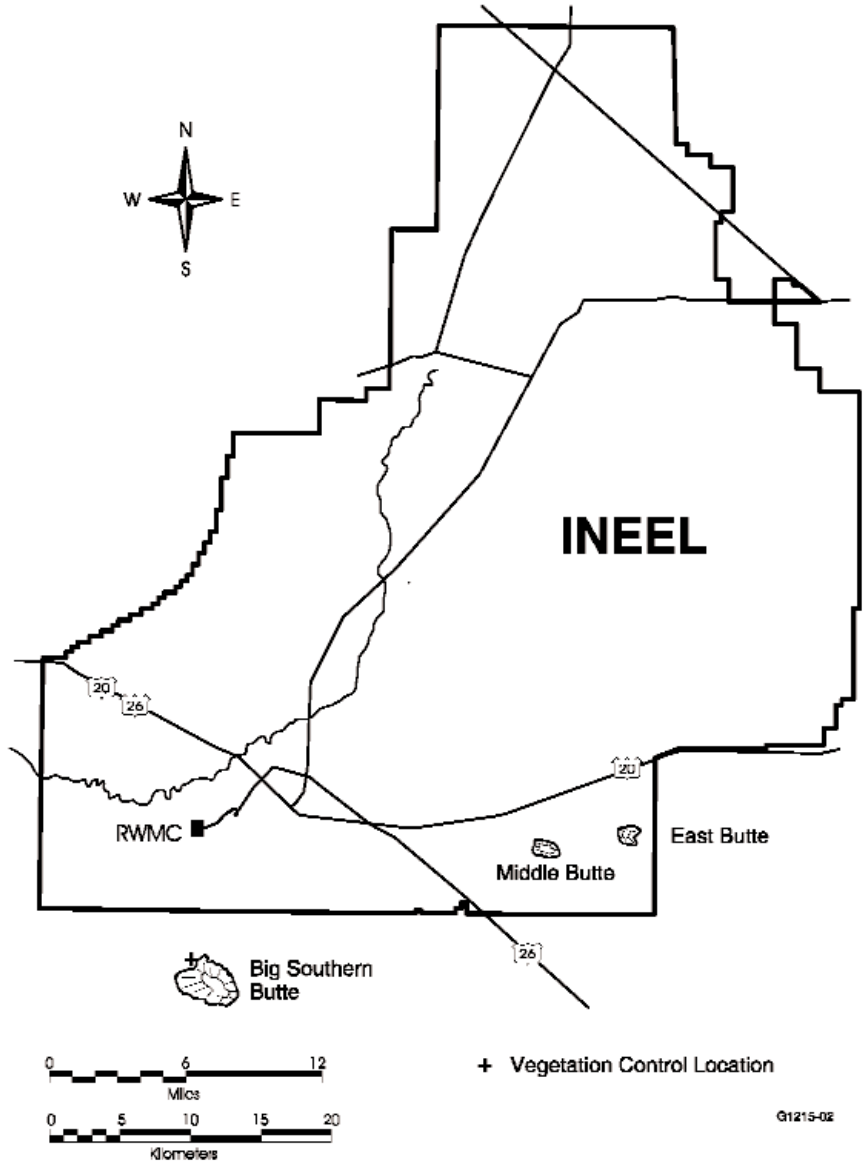


Figure 7-5. Vegetation control sample location (RWMC-Frenchman's Cabin).

Table 7-12. Vegetation radiochemistry results reported by ANL-W (2003).[a]

Radionuclide	Concentrations[a]			Location of Maximum Result
	Minimum	Maximum	Average	
Human-Made				
Cesium-137	-0.107	0.181	0.053	Air Monitor #3
Plutonium-238	-0.001	0.009	0.001	IW Ditch
Plutonium-239/240	-0.0003	0.009	0.003	IW Ditch
Naturally Occurring				
Actinium-228	0.057	1.01	0.321	Air Monitor #1
Beryllium-7	0	9.44	3.864	Air Monitor #4
Bismuth-214	0.028	0.814	0.229	IW Pond
Lead-214	-0.146	0.7	0.194	IW Pond
Potassium-40	10.5	78.8	24.913	IW Pond
Radium-226	0	0.228	0.127	Air Monitor #4
Thorium-228	0.010	0.909	0.146	IW Ditch
Thorium-230	0.0199	0.699	0.121	IW Ditch
Thorium-232	0	0.811	0.139	IW Ditch
Uranium-233/234	0.012	0.767	0.134	IW Ditch
Uranium-235/236	0.001	0.123	0.020	IW Ditch
Uranium-238	0.009	0.642	0.091	IW Ditch

a. Concentrations are in picocuries per gram.

Soil Sampling

Biennial soil sampling was conducted during 2003. Soil samples were collected at the RWMC locations shown in Figure 7-6, at 0-5 cm (0-2 in.). The soils were analyzed for gamma-emitting radionuclides. The maximum ^{137}C sample concentration was (1.3 ± 0.03) pCi/g (20 percent of Environmental Concentration Guide [EG&G 1986]). Selected samples were analyzed for specific alpha-emitting and beta-emitting radionuclides. Table 7-13 summarizes the results of human-made radionuclides. Cesium-137, $^{239/240}Pu$, and ^{90}Sr concentrations are within background for the INEEL and surrounding areas and are attributable to past fallout. Americium-241 concentrations are above background for the INEEL but are consistent with historical concentrations at RWMC and are attributable to past operational activities and fallout.

Direct Radiation

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

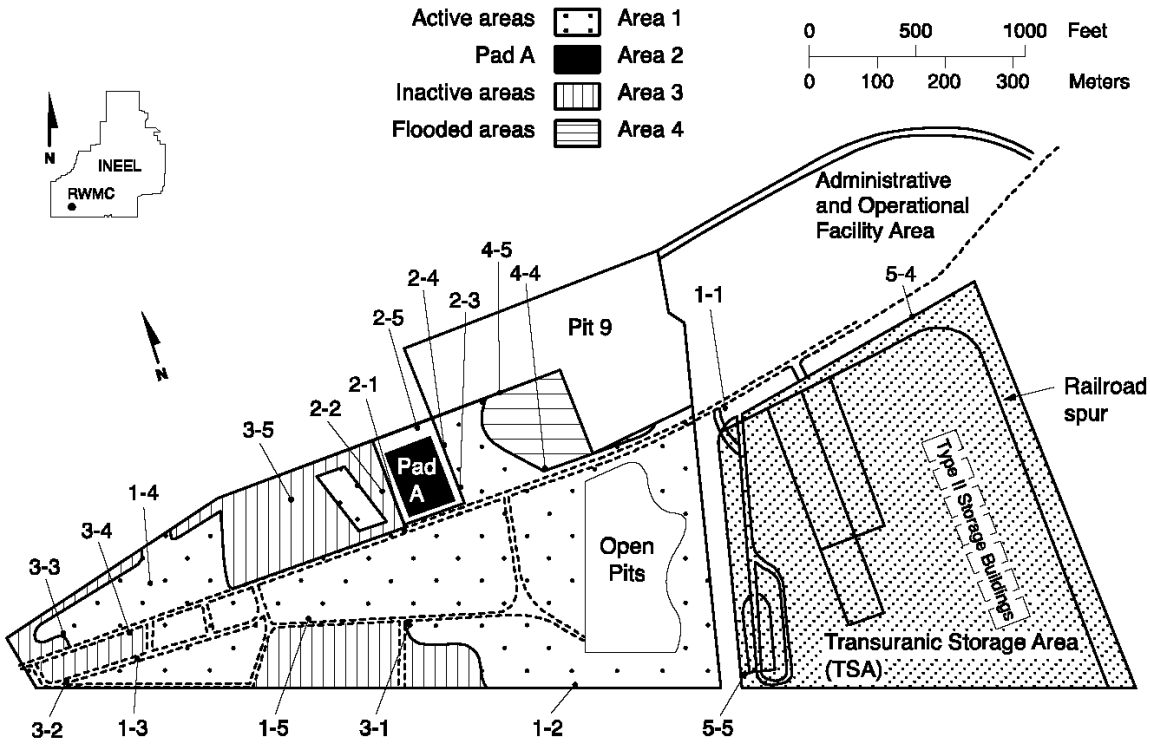
Figure 7-7 shows the radiation readings from the 2003 RWMC annual fall survey. The survey around the active low-level waste pit was comparable to, or lower than, historical measurements for that area. No new elevated readings were identified during the survey. The maximum activity was 359 micro R/hr and identified 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. Therefore, it was traversed with a hand-held detector. No elevated readings were identified on Pad A during the annual fall survey.

Table 7-13. RWMC soil sampling results (2003).

Parameter	Minimum Concentration[a]	Maximum Concentration[a]	%ECG[b]
Cesium-137	0.029 ± 0.008	1.26 ± 0.04	21.0
Americium-241	0.007 ± 0.0002	0.193 ± 0.013	0.48
Plutonium-239/240	0.007 ± 0.002	0.077 ± 0.006	0.10
Strontium-90	0.010 ± 0.005	0.179 ± 0.027	2.98

a. Concentrations are in picocuries per gram ± 1 standard deviation.
b. ECG = Environmental Concentration Guide (EG&G 1986) in picocuries per gram.



Location	General Reference
1-1	Discharge Channel
1-2	6th pole on South side
1-3	Trench 13 West monument
1-4	Middle of Pit 2
1-5	Southwest end of Pit 10, near road
2-1	South end of Pad A culvert
2-2	West side of Pad A
2-3	Southeast, mid-slope
2-4	Northeast, bottom of slope
2-5	North, bottom of slope
3-1	Trench 34 near LMITCO Well 76-4A
3-2	Between West Trench 4 & 6 monuments
3-3	Near LMITCO Well 93

Location	General Reference
3-4	Monitoring Station 25
3-5	Monitoring Station 19
4-4	Pit 8 Southeast Monument
4-5	Pit 8 Northwest Monument
5-4	Channel draining East side of Pad
5-5	West side of ILTSF

Figure 7-6. RWMC soil sampling locations.

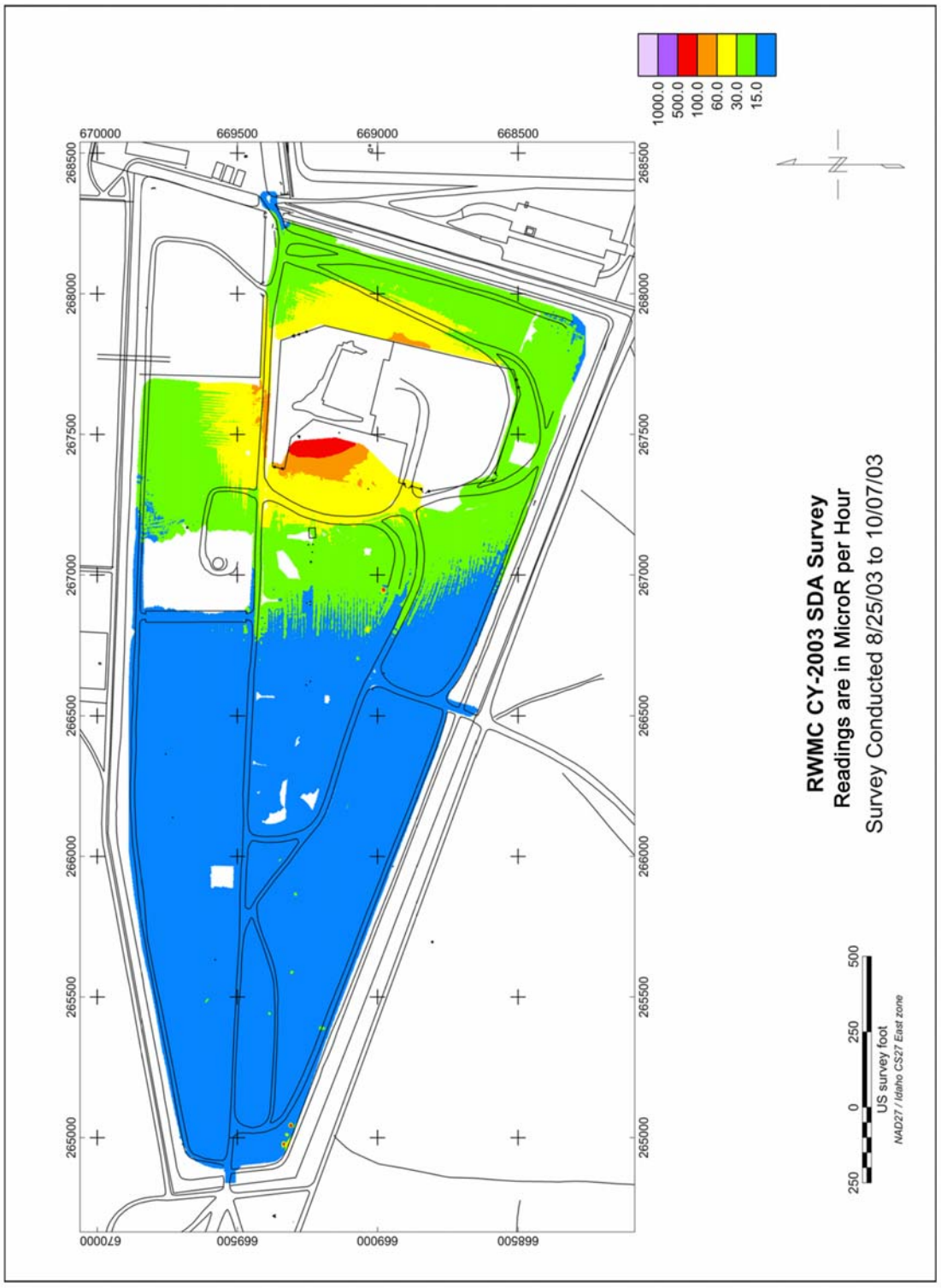


Figure 7-7. RWMC surface radiation survey fall 2003.

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Chapter 8 - Dose to the Public and Biota

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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: 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 0.035 mrem (0.35 µSv). The dose calculated using the MDIFF values was 0.024 mrem (0.24 µSv). The maximum potential population dose to the approximately 276,979 people residing within a 80-km (50-mi) radius of any INEEL facility was 0.022 person-rem (2.2×10^{-4} 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 was calculated. The maximum potential dose for each was estimated to be 0.002 mrem (0.02 µSv) for waterfowl, 0.099 mrem (0.99 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 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 2003). DOE Order 5400.5 further states, "It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable..." (DOE 1993). This chapter describes the dose to members of the public and to the environment based on the 2003 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 2003, 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 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 (EPA 2001). 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 2003 INEEL Report for Radionuclides* (DOE-ID 2004). 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 0.035 mrem (0.35 μSv) was calculated. The facilities making the largest contributions to this dose were the Idaho Nuclear Technology and Engineering Center (INTEC) at 60 percent, the Test Reactor Area (TRA) at 28 percent, the Test Area North (TAN) at 8 percent and the Radioactive Waste Management Complex (RWMC) at 4 percent. The dose of 0.035 mrem (0.35 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 2003 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 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.

In 2000, a revision to the methods and values used for the calculation of the MEI dose from 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 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 2003 would have occurred at Frenchman's Cabin. 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

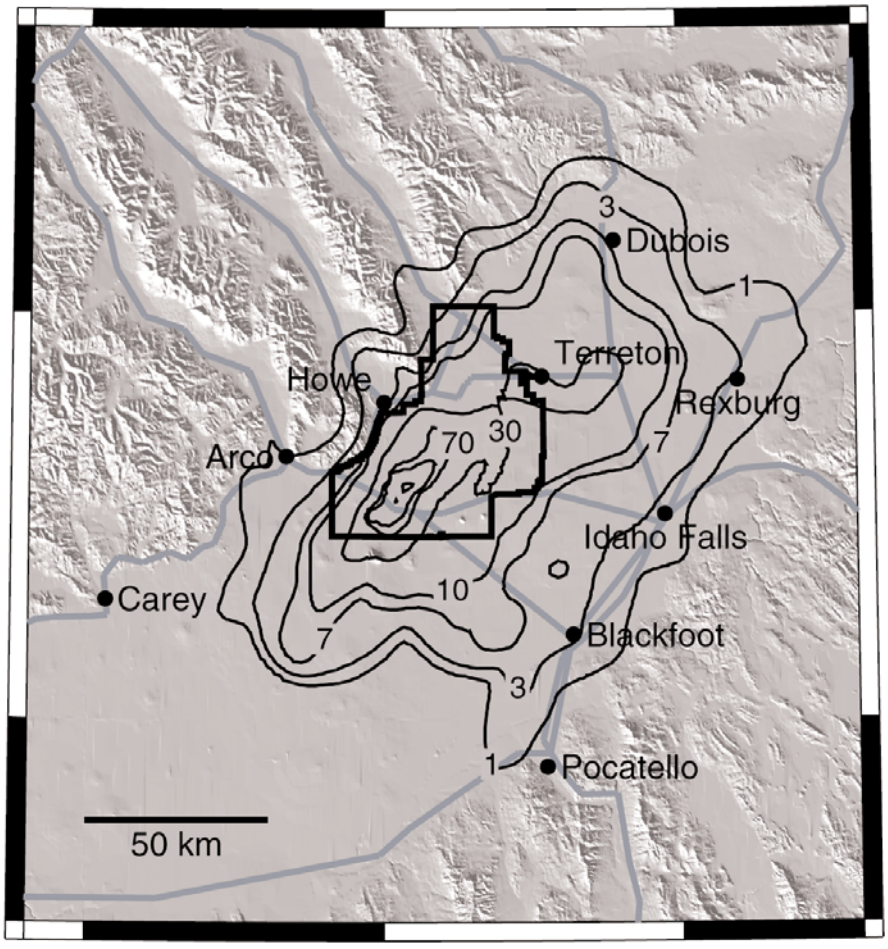

Figure 8-1. Average mesoscale isopleths of total integrated concentrations at ground level normalized to unit release rate from all INEEL facilities.[a]

a. Concentrations are times 10^{-9} hours squared per meter cubed (x 10^{-9} hr^2/m^3).

Table 8-1. Total integrated concentration, 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)
AMWTF	1.44×10^{-7}	0.46	7.9 (4.92)
ANL-W	5.31×10^{-9}	2.34	23.1 (23.12)
CFA	9.30×10^{-8}	0.84	14.5 (9.03)
INTEC	4.66×10^{-8}	1.31	18.8 (11.65)
NRF	4.08×10^{-8}	1.72	27.1 (16.82)
PBF	3.43×10^{-8}	1.49	20.4 (12.68)
RWMC	1.44×10^{-7}	0.46	7.9 (4.92)
TAN	1.84×10^{-8}	3.81	56.4 (35.06)
TRA	3.72×10^{-8}	1.13	19.0 (11.85)

the radionuclides from each facility to the location of the MEI (at Frenchman's Cabin), the potential annual effective dose equivalent from all radionuclides released was calculated to be 0.024 mrem (0.24 µSv) (Table 8-2). This dose is well below the whole body dose limit of 10 mrem set in the 40 CFR 61 for airborne releases of radionuclides.

For 2003, the inhalation pathway was the primary route of exposure and accounted for 73 percent of the total dose, followed by ingestion at 21 percent, and immersion at 6 percent. Deposition accounted for only 0.12 percent of the dose.

Radionuclide releases for 2003 are presented in Figure 8-2. The noble gas krypton-85 (^{85}Kr) accounted for approximately 75 percent of the total release, followed by tritium with 14 percent, and argon-41 (^{41}Ar) at 10 percent of the total. The noble gases xenon-133 (^{133}Xe)

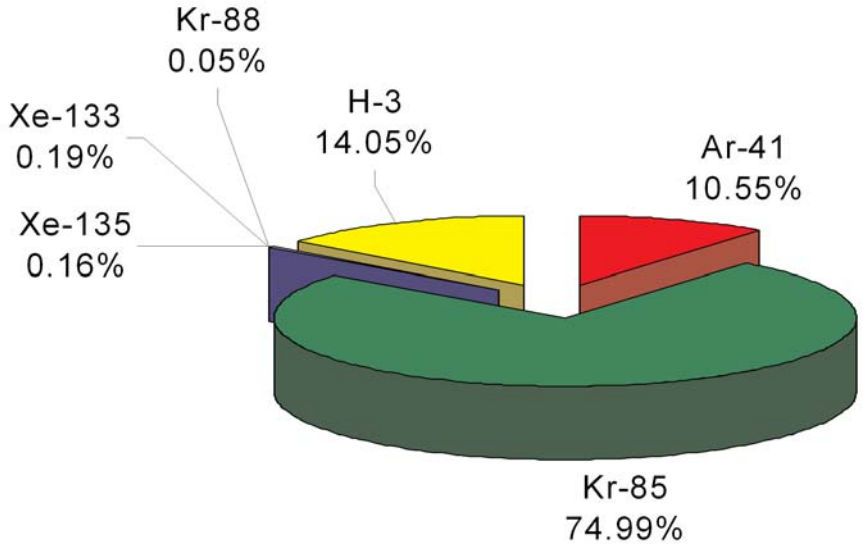

Figure 8-2. Radionuclides released to the environmental (2003).

Table 8-2. Maximum individual effective dose equivalent as calculated from MDIFF model results (2003).

	Radionuclide Concentration in Air at Maximum Offsite Location[b]	Maximum Effective Dose Equivalent	
Radionuclide[a]	**(Ci/m^3)**	**mrem**	**mSv**
^{241}Pu	1.13×10^{-17}	9.64×10^{-4}	9.64×10^{-6}
^{90}Sr + Dd	2.31×10^{-17}	2.51×10^{-3}	2.51×10^{-5}
^{129}I[c]	1.75×10^{-17}	5.77×10^{-3}	5.77×10^{-5}
^{137}Cs + D[c,d]	1.56×10^{-16}	6.74×10^{-3}	6.74×10^{-5}
^{239}Pu	4.09×10^{-19}	1.82×10^{-3}	1.82×10^{-5}
^{41}Ar	1.77×10^{-13}	1.34×10^{-3}	1.34×10^{-5}
^{240}Pu	2.28×10^{-19}	1.01×10^{-3}	1.01×10^{-5}
^{241}Am	1.56×10^{-19}	1.04×10^{-3}	1.04×10^{-5}
^{238}Pu	1.02×10^{-19}	4.13×10^{-4}	4.13×10^{-6}
^{131}I	1.16×10^{-16}	9.46×10^{-4}	9.46×10^{-6}
^{244}Cm	1.38×10^{-19}	5.11×10^{-4}	5.11×10^{-6}
^{60}Co	3.89×10^{-17}	4.61×10^{-4}	4.61×10^{-6}
All Others	NA	3.54×10^{-4}	3.54×10^{-6}
Total		**2.39×10^{-2}**	**2.39×10^{-4}**

a. Table includes only radionuclides that contribute a dose of 1.0 × 10-5 mrem or more.
b. Estimate of radionuclide 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 indicate (+D), the contribution of progeny decay products was also included in the dose calculations.

and xenon-135 (^{135}Xe) each contributed 0.2 percent, followed by krypton-88 (^{88}Kr) at 0.1 percent. However, because these are noble gases they contribute very little to the cumulative dose (affecting immersion only). Other than ^{41}Ar, the radionuclides contributing to the overall dose were 0.004 percent or less of the total radionuclides released.

The largest contributor to the MEI dose was cesium-137 (^{137}Cs), accounting for 28 percent of the total dose (Figure 8-3). This was followed by ^{129}I at 24 percent, strontium-90 (^{90}Sr) at 10.5 percent, plutonium-239 [^{239}Pu] at 8 percent, and argon-41 (^{41}Ar) at 6 percent. Other plutoniums (plutonium-238 [^{238}Pu], plutonium-240 [^{240}Pu] and plutonium-241 [^{241}Pu]) contributed to the dose at 1.7, 4.2 and 4.0 percent, respectively. Americium-41 accounted for 4.3 percent of the dose, with all others combined contributing 9.3 percent .

The respective contribution to the overall dose by facility is as follows: INTEC (64 percent), TRA (23 percent), TAN (12 percent), and CFA (0.4 percent). The PBF and NRF each contributed approximately 0.02 percent of the 2003 total dose, while RWMC contributed about 0.4% and ANL-W contributed 0.005 percent. The percent contribution calculated for NRF is based on the assumption that all gross alpha is ^{239}Pu and all gross beta is ^{90}Sr.

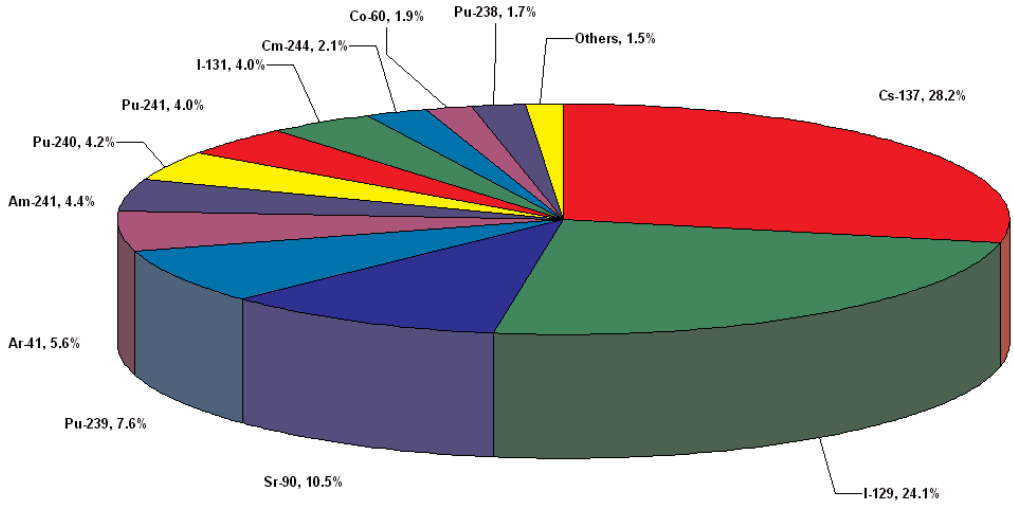

Figure 8-3. Radionuclides contributing to maximum individual dose (as calculated using the MDIFF air dispersion model) (2003).

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 363 mrem (Table 7-11).

Table 8-3 summarizes the calculated annual effective dose equivalents for 2003 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.

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

Table 8-3. Summary of annual effective dose equivalents because of INEEL operations (2003).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF
Dose	0.035 mrem (3.5×10^{-4} mSv)	0.024 mrem (2.4×10^{-4} mSv)	0.022person-rem (2.2×10^{-4} person-Sv)
Location	Frenchman's Cabin	Frenchman's Cabin	Area within 80 km (50 mi) of any INEEL facility
Applicable radiation protection standard[d]	10 mrem (0.1 mSv)	10 mrem (0.1 mSv)	No standard
Percentage of standard	0.35 percent	0.24 percent	No standard
Natural background	363 mrem (3.6 mSv)	363 mrem (3.6 mSv)	100,540 person-rem (1,005 person Sv)
Percentage of background	0.01 percent	0.007 percent	0.00002 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.

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).

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 at Frenchman's Cabin. 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.

Table 8-4. Dose to population within 80 km (50 mi) of the INEEL facilities (2003).

Census Division[a]	Population[b]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,356	4.11×10^{-5}	4.11×10^{-7}
Alridge	633	3.66×10^{-6}	3.66×10^{-8}
American Falls	3,232	2.04×10^{-5}	2.04×10^{-7}
Arbon (part)	29	5.94×10^{-7}	5.94×10^{-9}
Arco	2,381	1.85×10^{-3}	1.85×10^{-5}
Atomic City (division)	3,074	1.13×10^{-5}	1.13×10^{-7}
Blackfoot	13,302	1.04×10^{-3}	1.04×10^{-5}
Carey (part)	1,034	6.85×10^{-5}	6.85×10^{-7}
East Clark	73	8.11×10^{-6}	8.11×10^{-8}
Firth	3,368	1.50×10^{-4}	1.50×10^{-6}
Fort Hall (part)	1,990	7.51×10^{-5}	7.51×10^{-7}
Hailey-Bellevue (part)	5	6.78×10^{-12}	6.78×10^{-14}
Hamer	2,332	3.36×10^{-3}	3.36×10^{-5}
Howe	331	6.23×10^{-4}	6.23×10^{-6}
Idaho Falls	78,324	4.02×10^{-3}	4.02×10^{-5}
Idaho Falls, west	1,824	4.62×10^{-4}	4.62×10^{-6}
Inkom (part)	580	4.35×10^{-6}	4.35×10^{-8}
Island Park (part)	82	9.08×10^{-6}	9.08×10^{-8}
Leadore (part)	5	6.07×10^{-9}	6.07×10^{-11}
Lewisville-Menan	4,002	9.32×10^{-4}	9.32×10^{-6}
Mackay (part)	1,136	2.50×10^{-7}	2.50×10^{-9}
Moody (part)	4,753	1.36×10^{-4}	1.36×10^{-6}
Moreland	9,539	1.76×10^{-3}	1.76×10^{-5}
Pocatello (part)	79,140	2.05×10^{-3}	2.05×10^{-5}
Rigby	11,788	8.54×10^{-4}	9.54×10^{-6}
Ririe	1,486	1.80×10^{-5}	1.80×10^{-7}
Roberts	1,696	8.52×10^{-4}	8.52×10^{-6}
Shelley	7,342	4.55×10^{-4}	4.55×10^{-6}
South Bannock (part)	295	6.29×10^{-6}	6.29×10^{-8}
St. Anthony (part)	2,260	2.33×10^{-4}	2.33×10^{-6}
Sugar City	5,378	8.56×10^{-4}	8.56×10^{-6}
Swan Valley (part)	5,132	1.61×10^{-5}	1.61×10^{-7}
Thornton	20,112	1.52×10^{-3}	1.52×10^{-5}
Ucon	5,773	4.91×10^{-4}	4.91×10^{-6}
West Clark	1,166	1.55×10^{-4}	1.55×10^{-6}
Totals	**276,979**	**0.022**	**2.2×10^{-4}**

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 2004 based on county population growth from 1960 to 2000.

The 2003 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 0.022 person-rem (2.2×10^{-4} person-Sv) to a population of approximately 276,979. When compared with an approximate population dose of 100,540 person-rem (1,005 person-Sv) from natural background radiation, this represents an increase of only about 0.00005 percent. The dose of 0.022 person-rem can also be compared to the following estimated population doses for the same size population: 33,250 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 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 2003, eight ducks were collected from waste ponds on the INEEL and three were collected from offsite locations (Mud Lake, Idaho) as controls. Of the waterfowl collected from the INEEL, five were collected from waste ponds containing radionuclides at the TRA and three from the waste pond at ANL-W. The maximum potential dose from eating 225 g (8 oz) of meat from ducks collected in 2003 is presented in Table 8-5. Radionuclide concentrations driving 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 0.002 mrem (0.02 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).

Table 8-5. Maximum annual potential dose from ingestion of edible waterfowl tissue using INEEL waste disposal ponds in 2003.[a]

Radionuclide	Maximum Dose [b] (mrem/yr)	Background Dose [c] (mrem/yr)
^{141}Ce	1.04×10^{-4}	
^{137}Cs	3.39×10^{-4}	
^{60}Co	1.00×10^{-4}	9.89×10^{-5}
^{95}Nb		9.13×10^{-5}
^{241}Am	3.33×10^{-4}	
$^{239/240}Pu$	3.65×10^{-4}	
^{90}Sr	4.29×10^{-4}	4.68×10^{-4}
Total Dose	**1.67×10^{-3}**	**6.58×10^{-4}**

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

b. Doses are calculated on maximum radionuclide concentrations in eight 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.

Mourning Doves

No mourning doves were collected in 2003.

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 2003, the potential dose was approximately 0.045 mrem (0.45 µSv). This includes maximum doses from both iodine-131 and ^{137}Cs in muscle and liver tissue from a single pronghorn collected between CFA and INTEC on the INEEL (see Table 7-4).

Yellow-bellied Marmots

During the 2003, three marmots were collected from the Subsurface Disposal Area of the RWMC. These samples were biased toward areas of potential highest contamination. Three marmots were also collected from the Pocatello Zoo and one from Tie Canyon in Swan Valley, as

controls. Each marmot was dissected into three samples, the edible portion (muscle tissue), viscera, and the remainder (skin, fur, bones). 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 is 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).

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 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).

Terrestrial Evaluation

For the initial terrestrial evaluation we used maximum concentrations from the management and operating (M&O) contractor 2003 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.

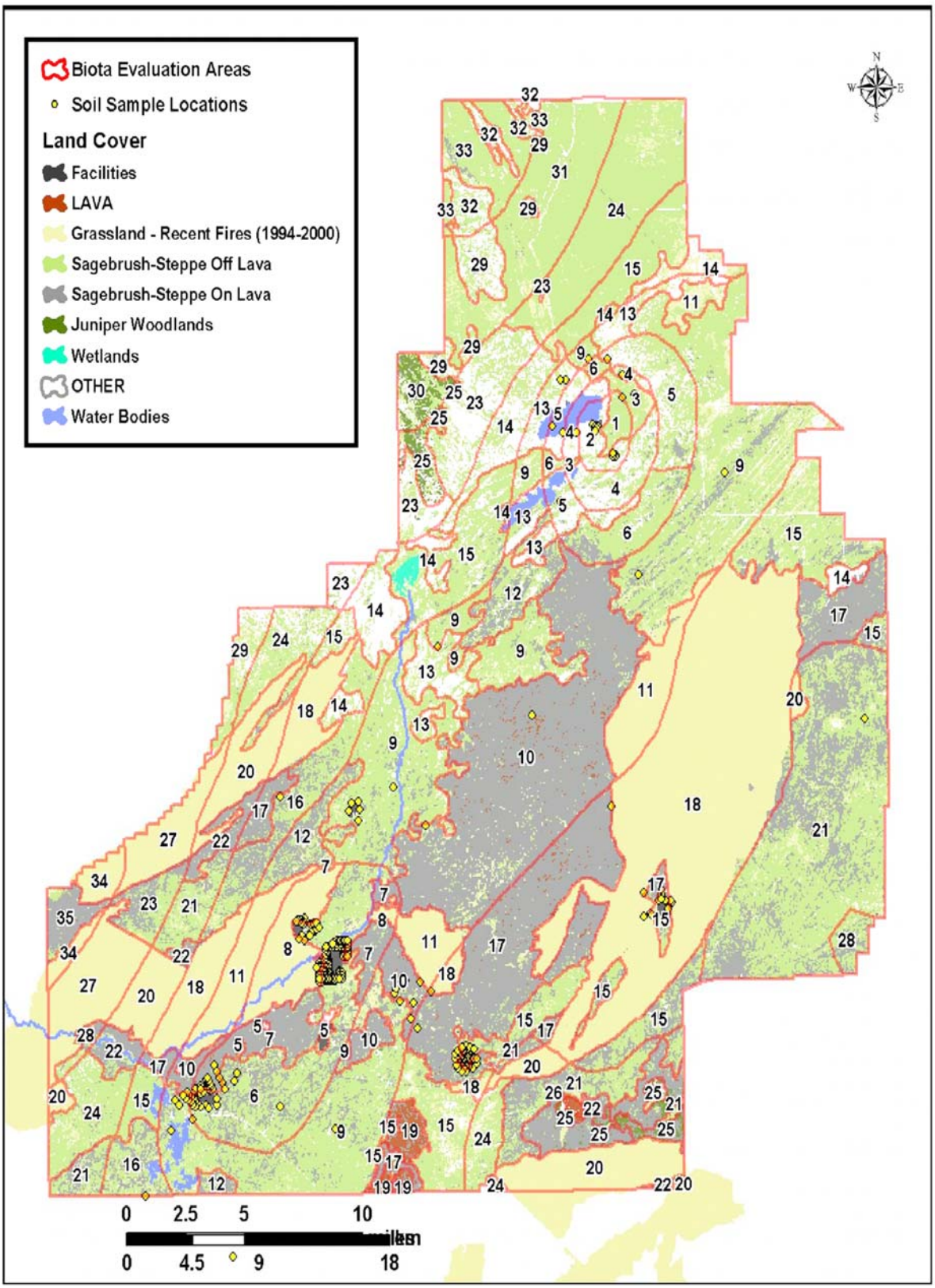

Figure 8-4. Evaluation areas and current soil sampling locations on the INEEL.

Table 8-6. Radionuclides that can currently be evaluated using the Graded Approach (DOE 2002, Morris 2003) compared to those detected in soil or water on the INEEL in 2003. Radionuclides in **bold type** are present in both lists and were included in this assessment.

Graded Approach	Detected
^{241}Am[a]	**^{241}Am**
^{144}Ce	**^{137}Cs**
^{135}Cs	**^{3}H**
^{137}Cs	**^{129}I**
^{60}Co	**$^{239/240}$Pu**[b]
^{154}Eu	**^{226}Ra**
^{155}Eu	**^{90}Sr**
^{3}H	**^{232}Th**
^{129}I	**$^{233/234}$U**[c]
^{131}I	**^{235}U**
^{239}Pu	**^{238}U**
^{226}Ra	
^{228}Ra	
^{125}Sb	
^{90}Sr	
^{99}Tc	
^{232}Th	
^{233}U	
^{234}U	
^{235}U	
^{238}U	
^{65}Zn	
^{95}Zr	

a. Radionuclides in **bold type** are present in both lists and were included in this assessment.
b. Analyzed as ^{239}Pu.
c. Analyzed as ^{233}U.

Table 8-7. Effluent data, biota concentration guides, and sums of fractions, and combined sums of fractions for biota assessment of aquatic ecosystems on the INEEL. (See DOE 2002 for definitions and a detailed description of the procedure.)

Nuclide	Water BCG[a] (pCi/L)	Effluent Concentration (pCi/L)	Partial Fraction[b]	Sediment BCG (pCi/g)	Calculated Sediment Concentration[c] (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
			First Screening				
^{3}H	$3x10^{8}$	$3.60x10^{3}$	$1.36x10^{-5}$	$4x10^{5}$	$3.60x10^{-3}$	$9.63x10^{-9}$	$1.36x10^{-5}$
^{129}I	$4.\times10^{4}$	1.00×10^{-1}	2.60×10^{-6}	$3.\times10^{4}$	1.00×10^{-3}	3.50×10^{-8}	2.64×10^{-6}
^{90}Sr	300	8.30	0.03	60	0.25	$4.28x10^{-4}$	0.03
					Combined Sum of Fractions[f]		**.03**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Calculated by the RadBCG spreadsheet based on the effluent concentration (DOE 2003).
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.

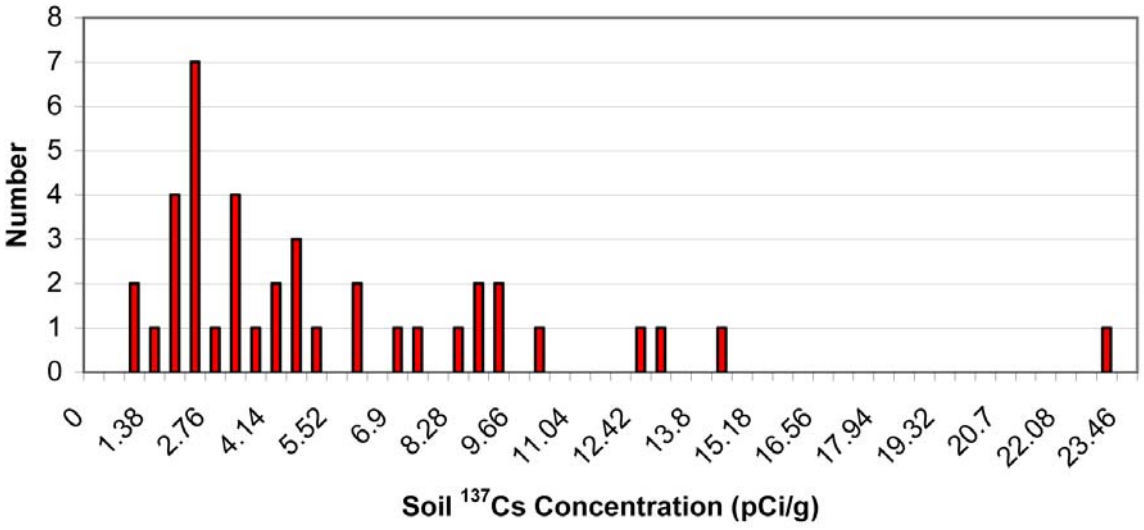

Figure 8-5. Histogram of ^{137}Cs concentration in soils in evaluation area 6 (Figure 8-4).

The histogram bars identify the number of samples with concentrations in specific ranges.

Table 8-8. Soil concentrations data, biota concentrations guides, and sums of fractions, and combined sums of fractions for biota dose assessment of terrestrial ecosystems on the INEEL. (See DOE 2002 for definitions and a detailed description of the procedure.)

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]
First Screening[e]							
^{241}Am				4,000	0.193	4.96×10^{-5}	4.96×10^{-5}
^{137}Cs				20	15.3	7.35	7.35
^{3}H	$2.\times10^{8}$	3.60×10^{3}	1.56×10^{-5}				1.56×10^{-5}
^{129}I	$6.\times10^{6}$	1.00×10^{-1}	1.75×10^{-8}				1.75×10^{-8}
^{239}Pu				6,000	0.0774	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra				50	0.228	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	50,000	8.300	1.52×10^{-4}	20	0.179	7.96×10^{-3}	8.11×10^{-3}
^{232}Th				2,000	0.811	5.37×10^{-4}	5.37×10^{-4}
$^{233/234}U$				5,000	0.767	1.59×10^{-4}	1.59×10^{-4}
^{235}U				3,000	0.123	4.44×10^{-5}	4.44×10^{-5}
^{238}U				2,000	0.642	4.06×10^{-4}	4.06×10^{-4}
						Combined Sum of Fractions[f]	**7.36**
Second Screening (Area 15 removed)[e]							
^{241}Am				4,000	0.193	4.96×10^{-5}	4.96×10^{-5}
^{137}Cs				20	23.0	1.11	1.11
^{3}H	$2.\times10^{8}$	3.60×10^{3}	1.56×10^{-5}				1.56×10^{-5}
^{129}I	$6.\times10^{6}$	1.00×10^{-1}	1.75×10^{-8}				1.75×10^{-8}
^{239}Pu				6,000	0.0774	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra				50	0.228	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	$5.\times10^{4}$	8.30×10^{0}	1.52×10^{-4}	20	0.179	7.96×10^{-3}	8.11×10^{-3}
^{232}Th				2,000	0.811	5.37×10^{-4}	5.37×10^{-4}
$^{233/234}U$				5,000	0.767	1.59×10^{-4}	1.59×10^{-4}
^{235}U				3,000	0.123	4.44×10^{-5}	4.44×10^{-5}
^{238}U				2,000	0.642	4.06×10^{-4}	4.06×10^{-4}
						Combined Sum of Fractions[f]	**1.12**
Third Screening (Area 6 removed)[e]							
^{241}Am				4,000	0.193	4.96×10^{-5}	4.96×10^{-5}
^{137}Cs				20	1.34×10^{1}	0.644	0.644
^{3}H	$2.\times10^{8}$	3.60×10^{3}	1.56×10^{-5}				1.56×10^{-5}
^{129}I	$6.\times10^{6}$	1.00×10^{-1}	1.75×10^{-8}				1.75×10^{-8}
^{239}Pu				6,000	0.0774	1.27×10^{-5}	1.27×10^{-5}
^{226}Ra				50	0.228	4.51×10^{-3}	4.51×10^{-3}
^{90}Sr	$5.\times10^{4}$	8.30×10^{0}	1.52×10^{-4}	20	0.179	7.96×10^{-3}	8.11×10^{-3}
^{232}Th				2,000	0.811	5.37×10^{-4}	5.37×10^{-4}
$^{233/234}U$				5,000	0.767	1.59×10^{-4}	1.59×10^{-4}
^{235}U				3,000	0.123	4.44×10^{-5}	4.44×10^{-5}
^{238}U				2,000	0.642	4.06×10^{-4}	4.06×10^{-4}
						Combined Sum of Fractions[f]	**0.658**

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 < 1, the site passes the screening evaluation.

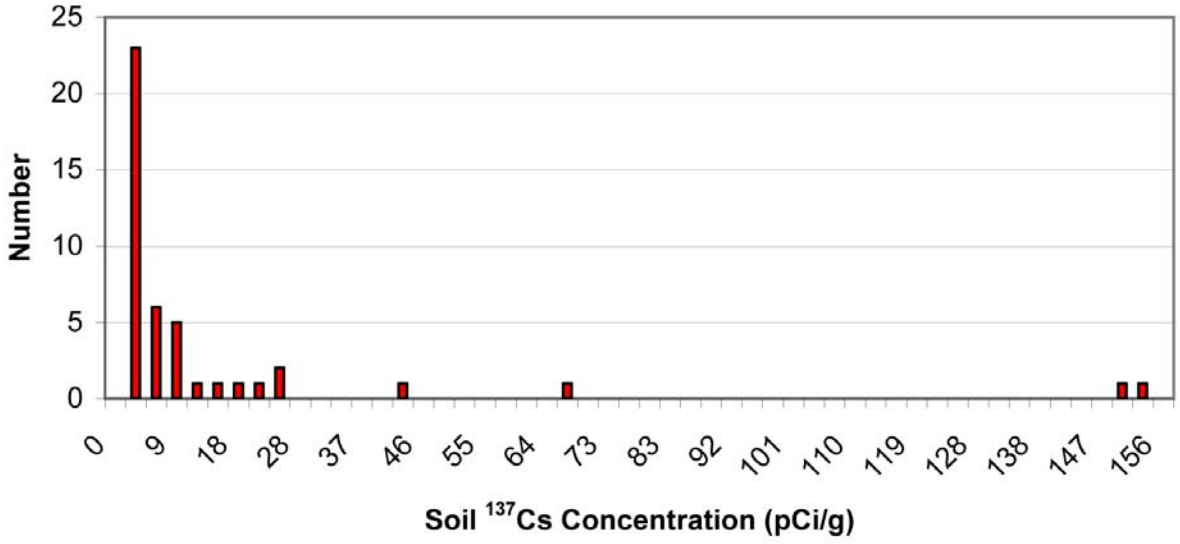

Figure 8-6. Histogram of ^{137}Cs concentration in soils in evaluation area 15 (Figure 8-4).

The histogram bars identify the number of samples with concentrations in specific ranges.

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 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 (Figure 8-3) on the INEEL using spatially averaged soil concentrations.

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				4000	0.10	2.58×10^{-5}	2.58×10^{-5}
^{137}Cs				20	4.96	0.238	0.238
^{3}H	2×10^{8}	3,600	1.56×10^{-5}				1.56×10^{-5}
^{129}I	6×10^{6}	0.10	1.75×10^{-8}				1.75×10^{-8}
^{239}Pu				6000	0.042	6.89×10^{-6}	6.89×10^{-6}
^{226}Ra				50	0.127	0.0025	0.0025
^{90}Sr	50,000	8.08	2×10^{-4}	20	0.095	0.0042	0.0044
^{232}Th				2,000	0.139	9.22×10^{-5}	9.22×10^{-5}
$^{233/234}U$				5000	0.134	2.77×10^{-5}	2.77×10^{-5}
^{235}U				3000	0.020	7.36×10^{-6}	7.36×10^{-6}
^{238}U				2000	0.091	5.75×10^{-5}	5.75×10^{-5}
					Combined Sum of Fractions[e]		**0.246**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Calculated sediment concentration/sediment BCG.
d. Sum of the partial fractions.
e. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

Table 8-10. Biota dose assessment of evaluation area 15 (Figure 8-3) on the INEEL using spatially averaged soil concentrations.

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				4000	0.10	2.58×10^{-5}	2.58×10^{-5}
^{137}Cs				20	13.3	0.637	0.637
^{3}H	2×10^{8}	3,600	1.56×10^{-5}				1.56×10^{-5}
^{129}I	6×10^{6}	0.10	1.75×10^{-8}				1.75×10^{-8}
^{239}Pu				6000	0.0025	4.10×10^{-7}	4.10×10^{-7}
^{226}Ra				50	0.127	0.0025	0.0025
^{90}Sr	50,000	8.08	2×10^{-4}	20	0.095	0.0042	0.0044
^{232}Th				2,000	0.139	9.22×10^{-5}	9.22×10^{-5}
$^{233/234}U$				5000	0.134	2.77×10^{-5}	2.77×10^{-5}
^{235}U				3000	0.020	7.36×10^{-6}	7.36×10^{-6}
^{238}U				2000	0.091	5.75×10^{-5}	5.75×10^{-5}
					Combined Sum of Fractions[e]		**0.644**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Calculated sediment concentration/sediment BCG.
d. Sum of the partial fractions.
e. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

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Chapter 9 - Ecological 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 response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems. The NERPs provide rich environments for training researchers and introducing the public to ecological sciences. NERPs have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

Ecological research at the 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 better land use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increasing contributions to ecological science in general.

The following ecological research activities took place at the Idaho NERP during 2003:

- Monitoring Amphibian and Reptile Populations on the INEEL;
- 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;
- Use of Genetic Markers as a Screening Tool for Ecological Risk Assessment at the INEEL: Microsatellite Mutation Rate of Burrowing Mammals;

- Crested Wheatgrass Rates of Spread into Native Sagebrush Steppe in Eastern Idaho;
- Experimental Remote Sensing of Vegetation on the INEEL;
- Natural and Assisted Recovery of Sagebrush in Idaho's Big Desert;
- Sagebrush Demography on the INEEL;
- Development of an Integrated Watershed Information Management Tool for Long-term Facilities Stewardship at the INEEL;
- Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater;
- The Protective Cap/Biobarrier Experiment;
- Assessing the Effects of Soil-forming Processes on Surface Caps; and
- Coupled Effects of Biointrusion and Precipitation on Soil Caps.

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 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 NERPs. 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, identifying of 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 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* (NEPA) process, natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The following sections describe ecological research activities that took place at the Idaho NERP during 2003.

9.1 Monitoring Amphibian and Reptile Populations on the INEEL: Indicators of Environmental Health and Change

Investigators and Affiliations

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Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

Many amphibian and reptile species have characteristics that make them sensitive environmental indicators. The main research goal is to provide indicators of environmental health and change by monitoring the distribution and population trends of amphibians and reptiles on the INEEL.

Information from this project is important to the DOE for several reasons: (1) as an indicator of environmental health and change; (2) for management of specific populations of sensitive species; (3) for meeting NEPA requirements regarding the siting of future developments; (4) for avoiding potentially dangerous snake-human interactions; and (5) for providing a basis for future research into the ecological importance of these species. Additionally, this project provides venomous snake safety training to INEEL employees and summer assistants. This training provides key information on how to avoid and treat bites from venomous snakes. It also helps workers place the relatively low risk of snakebite in perspective and fosters an appreciation of the ecological role of snakes on the INEEL. Finally, this project assists in the training and support of undergraduate and graduate students in environmental research.

Objectives

The overall goal of this project is to determine amphibian and reptile distribution on the INEEL and monitor populations in select areas. Specific objectives for 2003 included the following:

- Continue monitoring snake and lizard populations;
- Continue entering current herpetological information into a geographic information system (GIS) database;
- Provide herpetological expertise, as needed;

- Provide snake safety workshops; and
- Provide educational opportunities for undergraduate and graduate students.

Accomplishments through 2003

Specific accomplishments for 2003 include the following:

- Continued monitoring efforts at three den sites allowed more accurate estimates of reptile abundances on the INEEL (Figure 9-1). These estimates will allow examination of population trends over time. Currently, the team is working on new ways to monitor the health of rattlesnake populations on the INEEL. It is believed that calculating condition indices may be an additional method for assessing population health in western rattlesnakes. Western rattlesnakes are relatively long lived, active for short periods of the year, and require multiple years of foraging to have one successful reproduction. Because of these factors, environmental characteristics such as habitat degradation or weather patterns could indirectly influence the condition indices by altering prey resources. For example, spatial variation in body condition may indicate spatial patterns of habitat degradation or weather (Figure 9-2). Trends in body condition over time may indicate how patterns in habitat or weather are changing temporally (Figure 9-3). Overall, the team is still evaluating how to incorporate these condition indices into the monitoring program; however, it is agreed that this information will be an effective complementary method for monitoring snake health.

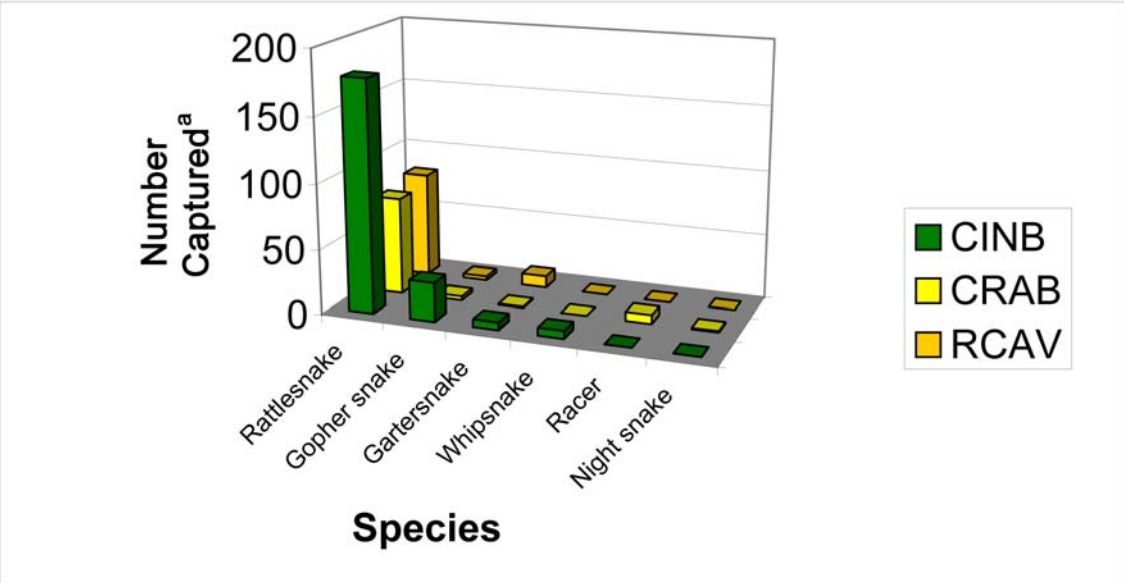

Figure 9-1. Abundance of snakes captured by species at three den complexes (Cinder Butte [CINB], Crater Butte [CRAB], and Rattlesnake Cave [RCAV]) during 2003 on the INEEL.

a. Including western rattlesnakes (Crotalus oreganos), gopher snakes (Pituophis catenifer), western terrestrial garter snakes (Thamnophis elegans), whipsnakes (Masticophis taeniatus), racers (Coluber constrictor), and night snakes (Hypsiglena torquata). In addition, 130 snakes were captured at other den locations on the INEEL.

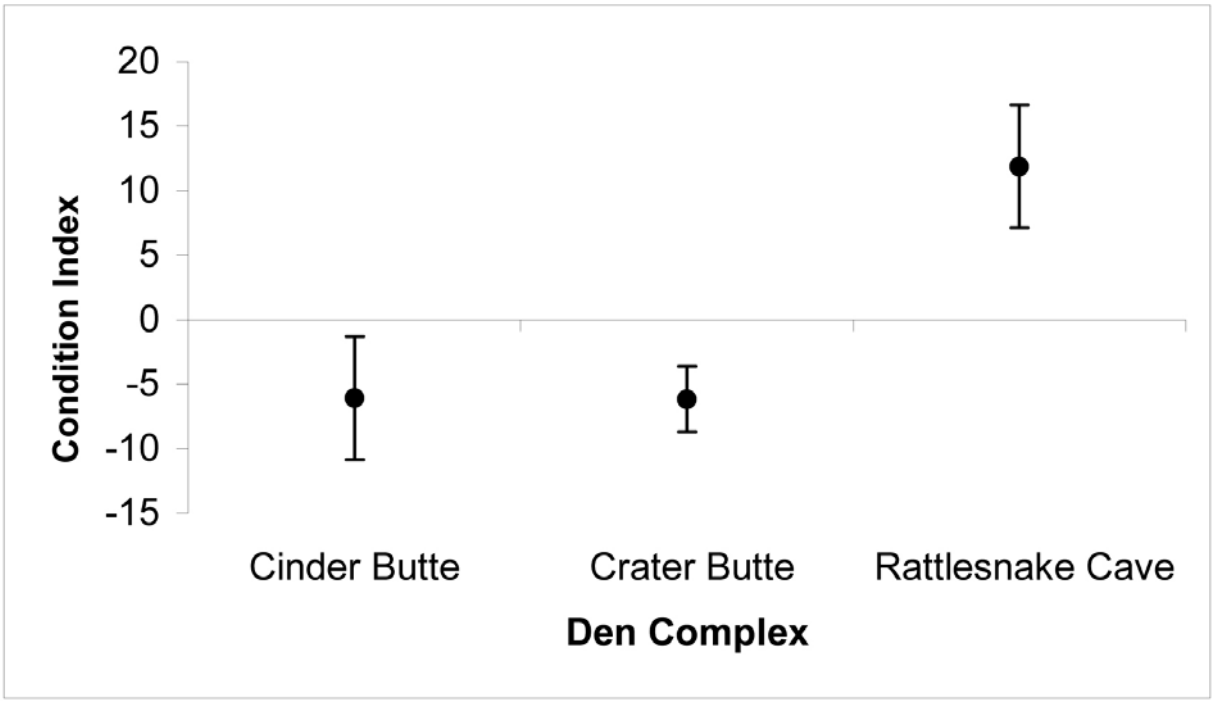

Figure 9-2. Average body condition of female western rattlesnakes by den complex on the INEEL. Error bars represent one standard error.

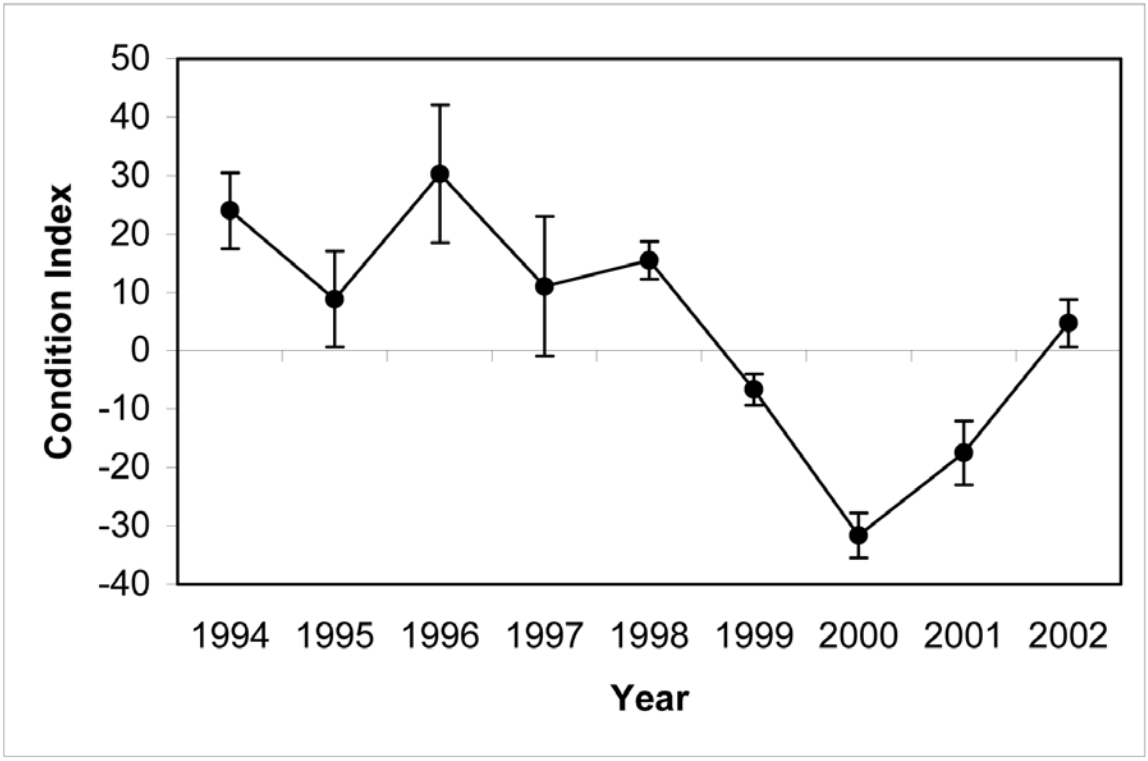

Figure 9-3. Average annual body condition of adult male rattlesnakes captured on the INEEL. Error bars represent one standard error.

- Updated the INEEL Herpetological database using the observations gained from the team's research.

- Provided herpetological expertise to numerous groups on the INEEL in 2003 including snake safety training sessions and field safety consultations.

Results

Important results this year included confirming the continued presence of leopard lizards *(Gambelia wislizenii)* at Circular Butte, continuing radiotelemetry studies, beginning small mammal trapping, and providing specific herpetological expertise to several groups on the INEEL.

- The number of marked snakes on the INEEL increased in 2003 to 3390, including all snakes PIT-tagged since 1994 and marking data collected at Cinder Butte from 1989 to 1994.

- Two observations of a leopard lizard *(Gambelia wislizenii)* were made at Circular Butte in 2003. Many western skinks *(Eumeces skiltonianus)* and sagebrush lizards *(Sceloporus graciosus)* were sited across the entire INEEL, and two short-horned lizards *(Phrynosoma douglassii)* were found close to the Rattlesnake Cave snake den location.

- The team did not observe breeding activity by spadefoot toads (*Scaphiopus intermontanus*) on the INEEL in 2003.

- As part of Chris Jenkins' Ph. D research, radiotelemetry work continued and small mammal trapping began in the southeastern portion of the INEEL to look at the effects of landscape characteristics on rattlesnake populations.

- Provided herpetological expertise in the form of presenting five snake safety training sessions and outreach to the public through programs for children both onsite and at the INEEL Science Expo. In addition, herpetological data for the site was disseminated, and conducted field safety consultations. The snake safety sessions have generated positive feedback from the employees, and many yield invitations for additional presentations, both on the INEEL and in local communities.

9.2 The Effect of Landscape Change on the Life History of Western Rattlesnakes *(Crotalus oreganus)*.

Investigators and Affiliations

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Funding Sources

Idaho Department of Fish and Game

Bureau of Land Management

Idaho State University (ISU) Department of Biological Sciences

ISU Graduate Student Research Committee

INEEL - ISU Education Outreach Program

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 DOE 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 ISU 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 2003 included the following:

- Quantifying spatial variation in rattlesnake life histories.
- Determining if rattlesnakes are selecting habitats with greater small mammal biomass.
- Determining if disturbance to sagebrush steppe systems affects small mammal biomass.

Accomplishments through 2003

Specific accomplishments for 2003 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 had life history characteristics that would indicate lower fitness.
- Found that small mammal biomass was greater in snake core activity areas than in either migration corridors or random locations (Figure 9-4).
- Found that small mammal biomass was highest in habitats characterized by relatively tall shrub cover, low grass cover, and high biological crust cover (Table 9-2).

Table 9-1. Life history characteristics calculated from western rattlesnakes captured between 1994-2002 at three den locations in southeastern Idaho.

	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[a]	-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**

a. Condition of young and adult females is calculated as the residual mass (i.e., residual values of the regression of mass to length).

b. Values in **bold** type represent the values presumed to be the most advantageous relative to the other den locations.

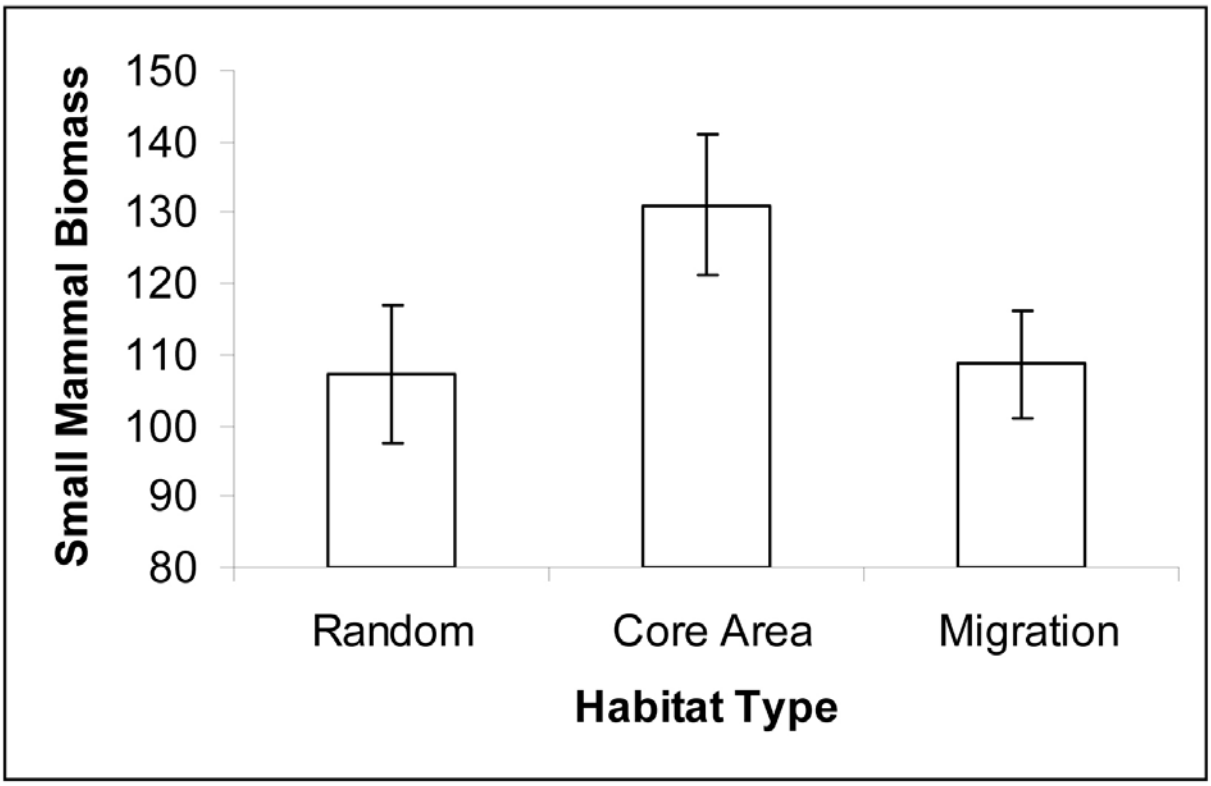

Figure 9-4. Average small mammal biomass found in random areas, core areas of snake activity, and migration corridors used by snakes during summer 2003. Error bars represent one standard error.

Table 9-2. The best model for predicting small mammal biomass in the 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

9.3 Factors Influencing the Road Mortality of Snakes on the Eastern Snake River Plain

Investigators and Affiliations

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Funding Sources

ISU Biological Sciences Department

ISU Graduate Student Research Committee

INEEL - ISU Education Outreach Program

ISU Biology Youth Research Program

Background

As significant features of most landscapes, roads generate a variety of ecological effects. Roads affect wildlife through the loss and fragmentation of habitat, disruption of movement patterns, and mortality from vehicular traffic (Forman and Alexander 1998). Many studies have documented traffic mortality on snakes (Bernardino and Dalrymple 1992; Rosen and Lowe 1994). Such mortality may severely reduce snake populations to a level where reproductive output cannot replace road-killed individuals (Rosen and Lowe 1994; Rudolph et al. 1999).

Unlike many factors (such as global warming and disease), the adverse effects of roads can be minimized, but the correct placement of mitigation efforts is critical. Ultimately, this research seeks to evaluate which landscape factors predict high-risk areas for snakes by developing a spatially-based model that relates observations of snake mortality on roads with attribute data gathered from these observations and landscape variables. This model should prove useful in developing priorities on a regional level concerning the mitigation of snake-highway conflicts.

Objectives

The objectives of this study include:

- Quantifying the road mortality of snakes on the Eastern Snake River Plain.
- Examining the variation of this mortality with respect to species, sex, age class, season, and traffic volume.
- Identifying and modeling the landscape factors that influence the spatial pattern of road mortality.

Accomplishments through 2003

- Successful completion of the 2003 field season including 258 total road observations of snakes along the survey route in more than 9350 km (5810 mi) driven.
- Initiated spatial and statistical analyses of the data.
- Presented general findings of this research at the Intermountain Herpetological Rendezvous in Logan, Utah.
- Generated a poster publication to be used for subsequent presentation.
- This survey method (road-cruising) will be integrated into future monitoring efforts of snake populations on the INEEL if funding is available.

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-km (105.5 mi) 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 U.S. Highways 20, 26, 20/26, and 22/33; Franklin Boulevard; and Lincoln Boulevard. Sampling consisted of 55 total trips along this route, and resulted in 9350 total kilometers (5810 mi) traveled over the 2003 field season.

A total of 258 snakes was 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 0.028 individuals/km surveyed). Spatial visualization and analyses indicate that these observations are clustered along the survey route (Figure 9-5). The road mortality of four species belonging to families Colubridae and Viperidae was documented. However, the majority of observations belonged to two species, *Pituophis catenifer* (Great Basin gopher snake) and *Crotalus oreganus lutosus* (Great Basin rattlesnake). Gopher snakes were the most commonly observed snakes on roads comprising 74 percent of all road records, and rattlesnakes were observed more frequently than the remaining two species comprising 18 percent of all road records (Figure 9-6). Furthermore, more adult males of both species were observed dead on roads than any other sex or age class. Juvenile observations comprised only 28 percent of total gopher snakes, 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 = 2459), with gopher snakes representing most of the remaining percentage of snakes (n = 372) over a 10-year sampling period. This raises an interesting question: are gopher snakes 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 in all months surveyed was documented and seasonal patterns were evident. The mean number of snakes observed per route while road cruising was highest

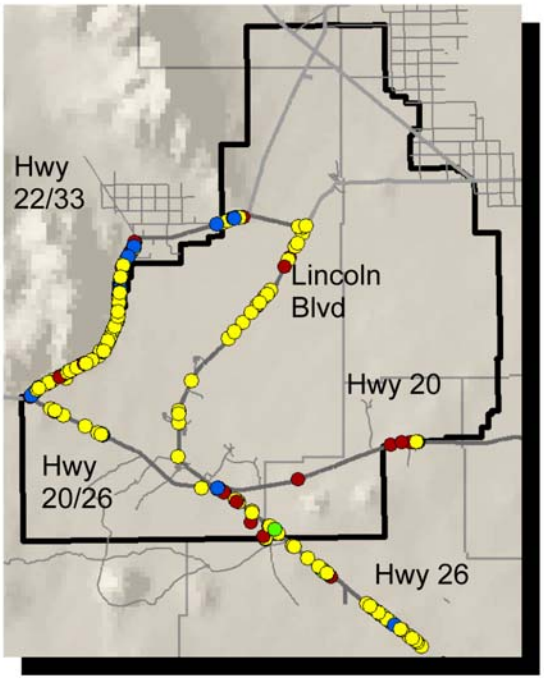

Figure 9-5. Spatial visualization of snake occurrences (n = 258) along the survey route from May to September 2003 generated in Arc GIS.

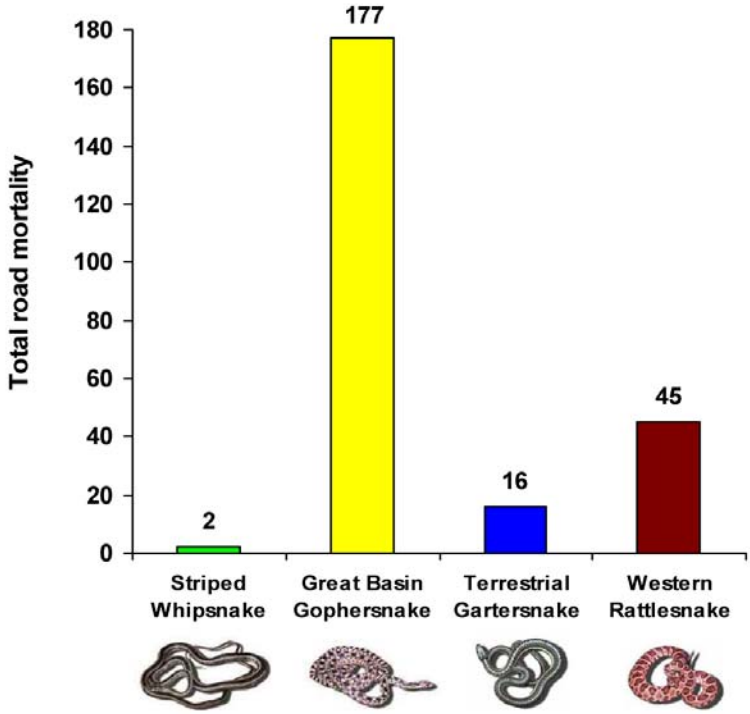

Figure 9-6. Road mortality accounted for 93 percent (n = 240) of all snake observations. (Although racers and night snakes occur within the study region in low densities, none were observed during road surveys. The colors correspond with the spatial map of locations [Figure 9-5]).

during the month of September (7.25), with secondary peaks in May (4.38) and June (4.76). The total number of sampling days without snake observations (10 total) was highest in late July and early August. These seasonal patterns are also evident with respect to sex and age. The road mortality of adult male gopher snakes was observed more often in May and June and of subadults during the month of September. Adult males were not observed on roads in either July or September. Observations of female road mortality did not exhibit a strong trend, but were observed less often during the summer months. These trends are different for rattlesnakes, with male observations exhibiting the highest mortality peaks in June and July, as well as a slightly lower peak in September. Subadult rattlesnakes were observed dead on roads only during the months of May through July, while females exhibited a bimodal peak of mortality with susceptibility to road mortality during June and September. 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. To be effective, methods designed to ameliorate the road mortality of snakes should coincide with these activity periods.

Finally, one road section (Highway 22/33 running N/S) had higher observations of snake roadkill than the others (Figure 9-5). In fact, 48 percent of mortality locations occurred along this 25.6 km (16 mi) stretch of highway. Although the location of many snake hibernacula are known across the INEEL, this particular area has not been extensively surveyed. To create a predictive model of landscape factors that influence road mortality, potential dens surrounding the route need to be located.

Plans for Continuation

- Efforts to search for new den sites along Highway 22/33 commenced in late April 2004 and will continue through early summer.
- Road cruising (as a sampling method) will be added to current monitoring efforts of the snake populations on the site if funding is available.
- Gather data on "available" locations along the route this June.
- Multivariate statistical analysis including landscape and other variables collected onsite.
- Development of a spatial model incorporating significant GIS variables to predict high-risk areas of road mortality.

9.4 Behavior, Dispersal, and Survival of Captive-Raised Idaho Pygmy Rabbits *(Brachylagus idahoensis)* Released onto the INEEL in Idaho

Investigators and Affiliations

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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 (USFWS) 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 2003

A total of 13 rabbits were released in August and seven in September 2002 at the INEEL. In July 2003, an additional seven rabbits were released. These animals were raised in captivity at WSU, fitted with radio collars weighing <2 percent of body weight, and released into temporary, weld-wire containment pens. The temporary pens surrounded the two openings of 3.0 to 4.5 meter (m) (10 to 15 foot [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. Rabbits released in 2003 were monitored almost daily to record behavior, dispersal and habitat use, and survival from July through early September.

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 44 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 (S.E + 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 - In June 2003, it was confirmed that at least one of the two surviving females released in 2002 had given birth on the INEEL release site. One of the females was observed with at least one pygmy rabbit kit associating closely with her around her burrow site. The first observation was made by biologist, Sue Vilord, and this sighting was independently confirmed later by the graduate student working on the release project, Robert Westra.

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 warranted for Idaho pygmy rabbits. Currently, two theses containing five technical papers are being completed at WSU for submission to scientific journals. These detailed technical reports will be available in 2004. Contact the investigators for more information.

9.5 Use of Genetic Markers as a Screening Tool for Ecological Risk Assessment at the Idaho National Engineering and Environmental Laboratory: Microsatellite Mutation Rate of Burrowing Mammals

Investigators and Affiliations

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Joseph Cook, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

Laboratory Directed Research and Development (LDRD)

Background

The purpose of this research was to explore the utility of molecular genetic techniques as screening tools for evaluating the risk to natural populations from contaminant exposure. These tools can be used to help evaluate the need for site remediation. If remediation is implemented,

genetic characterization of populations can provide insight on the effectiveness of the remediation through long-term monitoring.

This was a three-year study to determine if radiological contamination affects the genome of deer mice *(Peromyscus maniculatus)*. Radiological and genetic analysis were performed on deer mice collected outside the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) sites of the stationary low-power reactor number 1 (SL-1) and the Radioactive Waste Management Complex (RWMC), and two control sites (Burn and Atomic City).

Radiological and hazardous wastes have been disposed of at the INEEL since 1952. Escape of radionuclides and hazardous constituents from uncontained wastes, deterioration of waste containers, and waste disposal practices have resulted in contamination of the subsurface soils at the INEEL's Subsurface Disposal Area (SDA) and at other facilities. To assess the risks to human and environmental health, the potential impacts of contaminant exposure on identified receptors must be determined.

Objectives

Burrowing and excavation of the soil by small mammals, including deer mice, has been shown to be responsible for some radionuclide transport through the SDA environment; however, the genomic effects of exposure to contaminants at the INEEL was not known. Research was needed to develop new techniques to determine the effects of that exposure to the genome of individuals, so that environmental and remedial actions can be properly implemented. The objectives of this research were to:

- Perform comparative analysis of mother/offspring genotypes across the study areas using allelic data compiled from two consecutive field seasons (14 genetic markers: 147 females; 529 embryos; and 9464 Polymerase Chain Reactions).
- Identify mutant alleles in all samples and perform statistical analysis.
- Perform microsatellite genetic analysis of the four study area populations to determine population structure using a variety of genetic software packages.
- Analyze radiological data obtained from all the females collected during fiscal years 2001 and 2002 and perform statistical analysis.

Accomplishments through 2003

Laboratory Experimental Procedures - Fourteen genetic markers were used to perform microsatellite genetic analysis. Data were organized by population and families; allelic maternal segregation of the offspring was determined, paternal alleles inferred, and mutations identified. Only mutations of alleles segregated from the mother were used for this analysis. Not all the families provided useful data and some had to be removed for the genetic analysis (36 percent of the families were removed).

Mutation Rate Analysis Results - The ratio of microsatellite mutant alleles versus the non-mutant alleles was used as a direct assessment of mutation using parent/offspring comparison of allele differences. Allele scoring was performed with 14 microsatellite markers for females and offspring from the four study areas. The proportion of mutant alleles from each population was pair-wise compared between populations and tested for significant differences using the Fisher's exact test. The statistical analysis suggests that there is no significant difference when comparing the two contaminated sites (RWMC and SL-1) with the two control sites (Burn and Atomic City).

Population Genetic Structure Analysis - Four different approaches were used to test for population genetic structure:

- The allele frequency differences among populations were tested using the Fisher's exact test, where an unbiased estimate of the p-value of the probability test is obtained. The null hypothesis (H_o) "the allelic distribution is uniform across populations" was tested for each locus on a contingency table.

- The differences in genotype distribution across the populations were based on estimates of Wright's F-statistics. The null hypothesis, $F_{st} = 0$ "the genotypic distribution is uniform across populations" was tested for all loci using a chi-square goodness-of-fit test.

- The estimate of Rho_{st} statistics is a measure analogous to F_{st} but incorporates allele size estimates and assumes a step-wise mutation model.

- Finally, an assignment test was performed using GeneClass. This test uses a Bayesian approach to detect immigrants by using multilocus genotypes.

The null hypothesis was rejected in the first two methods; that is, the differences in allele frequency distribution and the genotype distribution differences between populations are statistically significant. The third method indicates that some level of gene flow occurs between populations but not enough that the distributions of alleles or genotypes between them are homogenized. The assignment test also supports population genetic structure because 98.61 percent of the individuals were correctly assigned to their population of origin.

Radiological Analysis - Samples from 80 females were used for this analysis: 43 from Atomic City; 21 from SL-1; and 16 from RWMC (the Burn site was excluded from the analysis due to small available sample size). Female carcasses were processed and analyzed for presence of radiological contaminants. None of the females showed exposure at levels higher than background. Statistical analysis of the radiological data indicates that the differences between the populations are not significant. That is, female mice collected from RWMC and SL-1 had similar levels of radiological (background) contamination compared to the Atomic City control site.

Results

The populations have different allelic frequency composition, and even though there is evidence that some level of gene flow occurs, and that they are not isolated completely, the migration rate is not strong enough to create a panmictic population (a population with no genetic

structure). This study indicates that the four populations are distinctive when comparing the two control sites with SL-1 and RWMC population.

It is assumed that natural populations share the same level of mutation rate, because this is an evolutionary force that is stochastic. This means that it is not affected by any of the evolutionary selective forces, and it occurs at a very low frequency. If there are no other contributing factors such as anthropogenic activities, it is predicted that in all of the studied populations the mutation rates should be similar. This study shows that there is no difference in the rate of mutation in populations exposed to anthropogenic activities in comparison with populations that have had little or no exposure. This suggests that no external forces (outside from evolutionary forces) are acting on this population.

The population genetic analysis and the mutation rate data support each other. The population genetic analysis suggests that there is a geographical component that plays a role in population differentiation. The radiological analysis indicated that the animals collected at the RWMC site have the same level of background exposure as the ones from the other three sites. Based on this study, we cannot conclude that exposure to radiological contaminants is an issue of concern for mice collected at RWMC or SL-1. One observation that is important to make, however, is that samples were not allowed to be collected from areas of known soil contamination. Therefore, the question of whether microsatellites are a good tool for identifying mutation differences caused by exposure still needs to be tested.

Further research should be pursued using this species as a biological indicator for environmental monitoring of contaminants, as well as long-term stewardship and ecotoxicological studies.

This research is part of a long-term plan for building a capability at INEEL in the use of genetic markers to address environmental issues. Once the technology is established, numerous applications using other species as environmental monitoring indicators can be explored. This information will help researchers focus resources and efforts on environmental monitoring at sites where there is a high probability of adverse biological impact caused by the presence of contaminants.

9.6 Crested Wheatgrass (*Agropyron cristatum)* Rates of Spread into Native Sagebrush Steppe in Eastern Idaho

Investigators and Affiliations

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Funding Sources

INEEL Student Outreach and Education in Remote Sensing from Bechtel BWXT Idaho, LLC

Idaho State University Office of Research and the GIS Center

Background

Loss of sagebrush steppe rangeland has had a large impact on sagebrush obligate wildlife. A number of factors have been associated with the decline in sagebrush steppe including conversion to cropland, urban development, invasive species and conversion to other vegetation community types. Following a 2002 fire on the INEEL, conversion of a rangeland with a sagebrush canopy to a crested wheatgrass dominated grassland was observed. Land cover change of this sort could have important impacts for management of sagebrush-obligate wildlife. This prompted questions about the ecology of crested wheatgrass in the upper Snake Rive Plain and the potential risks to remaining sagebrush steppe caused by the spread of crested wheatgrass. First among those questions were:

- Can crested wheatgrass in range improvement and other plantings invade into nearby, good condition sagebrush steppe?
- If so, how fast does it spread?

Objectives

The objectives of this study were to assess the spread of crested wheatgrass from plantings into sagebrush steppe in the upper Snake River Plain. Specific goals included:

- Developing a GIS layer of historic crested wheatgrass plantings on the INEEL.
- Mapping the present extent of certain crested wheatgrass communities.
- Estimating the rate of spread into adjacent good condition sagebrush steppe.

Accomplishments through 2003

During 2003, two sites were selected for study. One site was along Lincoln Boulevard and one at Tractor Flats. The Lincoln Boulevard crested wheatgrass planting was conducted to revegetate roadside and ditches for this paved roadway. The road was originally built in 1952, but was gravel and not paved. The road was upgraded in the early 1970s (exact date is uncertain) and again in 1991. Aerial photographs from 1976 showed that the road had been paved and that the vegetation immediately adjacent to the roadside (primarily the ditches) was different from that further away from the road. Archival photographs of this section of road in 1981 clearly show

that this different vegetation is crested wheatgrass. This suggests that crested wheatgrass was planted sometime before 1976. The roadsides were again planted with crested wheatgrass after road upgrades in 1991. The native vegetation type in this area is primarily Wyoming big sagebrush steppe. This area has not been grazed by livestock since the 1940s.

Tractor Flats was planted to crested wheatgrass in 1955 to revegetate an area infested with halogeton *(Halogeton glomeratus)*. This crested wheatgrass community was mapped in 1965 from aerial photographs as part of a vegetation community mapping project. Native vegetation of the area is Wyoming big sagebrush steppe. This area is part of the U.S. Bureau of Land Management (BLM) Twin Buttes Allotment and is grazed by sheep in spring.

The boundaries of the crested wheatgrass invasion were mapped with global positioning system (GPS) receivers. Receivers used were Trimble ProXL and GeoIII. The GPS receivers collected data at a rate of one point every three seconds. All the data was differentially (± 1-5 m [± 3.3-16.4 ft]) corrected using Pathfinder Office. The corrected files were then exported to Arc shapefiles, converted into coverages, and edited to fix overlapping boundaries. Different approaches for mapping the extent of spread of crested wheatgrass were used at each of the two study locations, Lincoln Boulevard and Tractor Flats.

At the Lincoln Boulevard site, a GIS coverage of the extent of spread was created by walking with a GPS as described above on a path following the furthest crested wheatgrass plants from Lincoln Boulevard. This was done on both the east and west sides of the road. To calculate how far the crested wheatgrass had spread, a line was digitized over Lincoln Boulevard on an existing GIS coverage for roads. Then, the crested wheatgrass boundary coverage was converted to points using ARCPOINT and the NEAR command was used to measure the distance from each of those points to the Lincoln Boulevard line.

At the Tractor Flats site, a GIS coverage of the extent of spread of crested wheatgrass was created by using GPS to map the extent of spread in areas near existing roads and at some remote areas. In four areas, sections of the boundary were mapped. Using the GPS data and a SPOT 10 m (32.8 ft) image as a guide, ArcEdit was used to create a polygon to estimate the total area now inhabited by crested wheatgrass. NODESNAP was used at 20 m (65.6 ft) to add lines to connect the GPS measurements. GENERALIZE was then used to smooth out the GPS lines as they had small loops and a very irregular texture. The Tractor Flat polygon created for estimating the spread of crested wheatgrass is an estimate based on the actual boundary lines mapped.

Results

At the Lincoln Boulevard site, the mean distance from the road centerline to the farthest crested wheatgrass individual was 447.0 m (1467 ft) with a maximum distance of 818.6 m (2686 ft). On average, more than 50 percent of the crested wheatgrass points have spread 300 to 500 m (984 to 1640 ft) from Lincoln Boulevard. The distribution varies from one side of the road to the other. On the west side, more than 70 percent of the points are in the 300 to 500 m (984 to 1640 ft) range. The majority of points on the east fall between 400 and 600 m (1312 to 1969 ft) from Lincoln Boulevard with approximately 13 percent in the 600 to 700 m (1969 to 2297 ft) range. On the east, more of the points have spread farther from Lincoln Boulevard. If the

roadside was first planted with crested wheatgrass in 1976, based on aerial photos taken that clearly illustrated the presence of a vegetation boundary on either side of the road, the rate of spread was 16.5 m/yr (54 ft/yr).

At Tractor Flats, crested wheatgrass increased its coverage from 692.5 ha (1710.0 acres) in 1965 to 1708.7 ha (4222.3 acres) in 2003. This translates to a spreading rate of 26.7 ha/yr (66.0 acres/yr) or about 18.7 m/yr (61 ft/yr).

On the upper Snake River Plain, crested wheatgrass does invade beyond the area planted into otherwise good condition sagebrush steppe. Rate of spread by crested wheatgrass in an area spring-grazed by sheep was similar to that in an area not grazed by livestock.

9.7 Experimental Remote Sensing of Vegetation on the INEEL

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Funding Sources

ISU-INEEL - Partnership for Integrated Environmental Analysis Education Outreach Program

NASA

Background

This study encompasses several areas within the Birch Creek watershed of the INEEL. The Birch Creek watershed is an ecologically sensitive area and includes a portion of a national sagebrush steppe reserve which is pristine habitat for a number of native species. Precise inventories of ecologic biodiversity in this region assist in the assessment of natural diversity and ecological indicators. This study uses both passive and active remote sensing technologies to assess conservation targets on the INEEL. Specifically, the objectives of this study are to develop the use of hyperspectral remote sensing to monitor spotted knapweed (*Centaurea maculosa*, an invasive species), and airborne laser swath mapping (ALSM) to determine low-height vegetation canopy structure.

Although the application of hyperspectral remote sensing to vegetative mapping is relatively new, recent publications have demonstrated a degree of confidence in the ability of this technology to accurately model a landscape. This study uses HyMap hyperspectral data

(HyVista, Inc.), which records incident solar radiation naturally reflected from the surface target (e.g. passive remote sensing) using an airborne sensor. The high spatial and spectral resolution of this imagery differentiates electromagnetic absorption features that are commonly associated with vegetative targets. Spectral component analysis of these datasets allows for a detailed composition of the ecosystem to be assessed, thereby enabling a large area to be mapped in detail in a relatively short amount of time.

Airborne laser swath mapping (ALSM) is a relatively new and quickly growing field of active remote sensing which makes use of a scanning pulsed laser mounted aboard an airborne or satellite platform. Highly accurate timing instruments measure the pulse travel time, and when used in combination with a GPS and an inertia measurement unit (IMU), are able to determine the elevation of the surface from which the laser pulse is reflected. The ALSM data used in this study (Airborne 1) has a vertical accuracy of less than 10 cm (4 in.) and a horizontal accuracy of less than 1 m (3.2 ft).

Of the numerous studies of canopy structures using ALSM, the vast majority have targeted forests. This is due in part because many ALSM sensors have a vertical accuracy on the order of tens of centimeters and, as such, are well suited to canopies many meters high. In the case of some rangeland areas, however, the canopy heights (i.e. for grasslands) are of the same order as or slightly greater than the sensor accuracy, making it difficult to extract significant information about the vegetation. This study attempts to quantify the sensitivity limits and ultimately the usefulness of ALSM vegetation mapping within a rangeland setting.

Five ALSM areas and four hyperspectral lines were acquired in summer 2002 on the INEEL (Figure 9-7). The ALSM datasets range in size from 2 to 15 km^2 (0.8 to 5.8 mi^2) and have post densities of approximately 1.2 m^{-2} (13 ft^{-2}). Each ALSM data point measurement records time, X and Y coordinates, elevation, and intensity values for the both the first and last return of the laser pulse. The hyperspectral data sets are approximately 2 by 20 km (1.2 to 12.4 mi) each, with a 3.5 m (11.5 ft) spatial resolution and 126 spectral bands in the visible and infrared portions of the electromagnetic spectrum (wavelengths ranging from 450 nm to 2.48 µm).

Objectives

Hyperspectral Data Analysis - Using the hyperspectral data, the primary objective is to produce a remote sensing-based classified map of spotted knapweed in the Birch Creek watershed. The classified map is validated with field ground truth data. Additionally, this study aims to assess the spectral separability of the sagebrush with grasses (e.g. crested wheatgrass, fescue, and/or bunchgrass) in the study area. This project includes:

- Assessing and rectifying the geometric precision of the hyperspectral data;
- Validating and refining classifications for distribution of spotted knapweed in Birch Creek using field data; and
- Exploring the potential to differentiate vegetative species from background (e.g. soil) in a semi-arid climate.

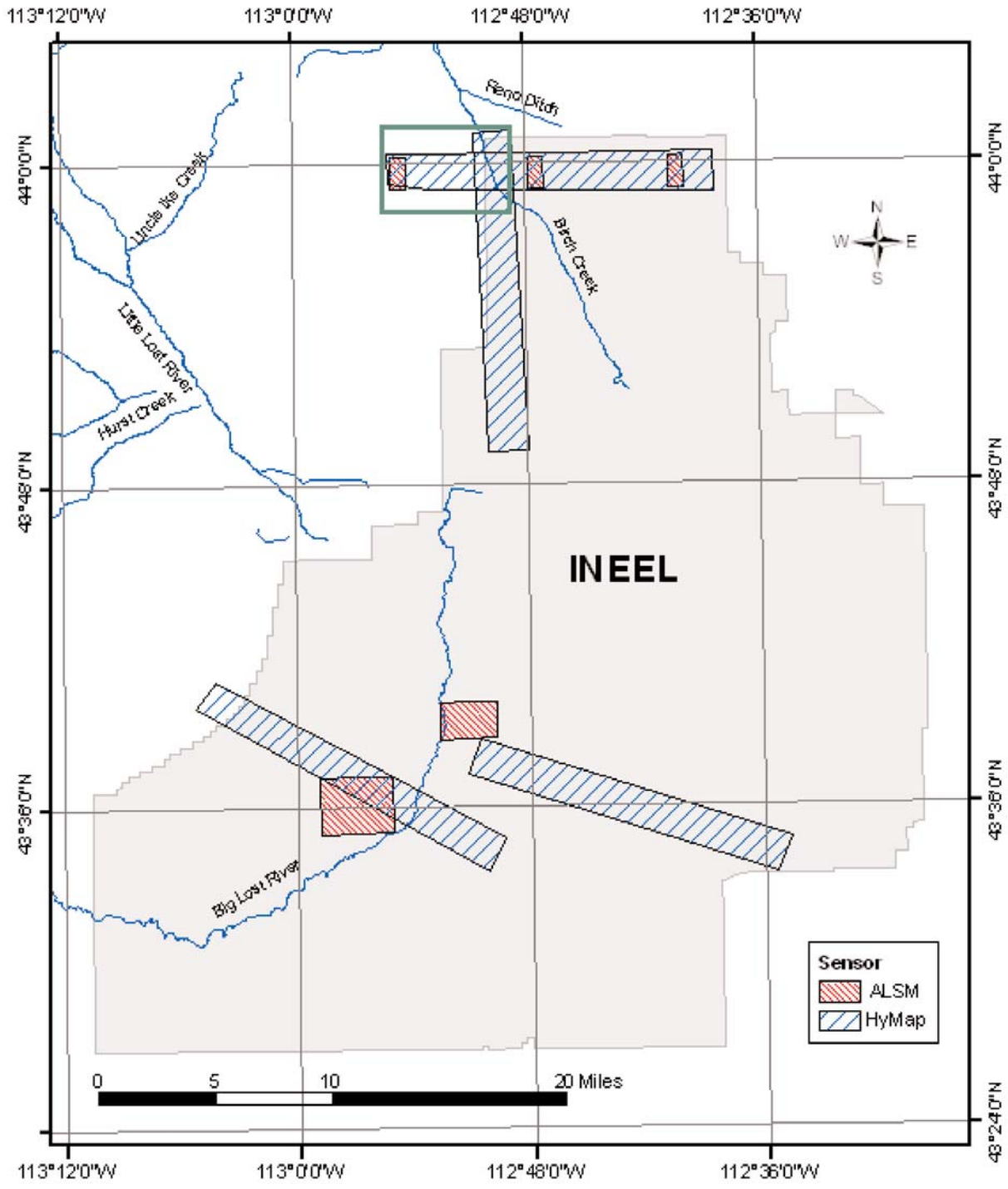

Figure 9-7. Locations of data acquisitions on the INEEL. (The area inside the green outline corresponds to the area illustrated in Figure 9-8.)

ALSM Data Analysis - Using the ALSM data, the primary objective is to determine the heights of various types of rangeland vegetation to an accuracy of a few centimeters. This allows for the discrimination between rangeland grasses (both native and nonnative) from sagebrush, bitterbrush, and other types of low-lying vegetation. Such information is of value in monitoring the recovery of burned sagebrush stands as well as determining where invasive grasses (i.e. cheatgrass) are replacing native stands of sagebrush.

The project scope includes:

- Georeferencing the ALSM data to an accuracy of better than 0.5 m (1.6 ft);
- Validating the calculated ground surface models;
- Determining ALSM reflection/penetration rates into the rangeland canopy and relating such measurements to canopy cross-sections, surface area, and/or biomass;
- Validating discrete vegetation height data points;
- Validating surface roughness characteristics over various length scales; and
- Correlating vegetation height and surface roughness to recovery characteristics in recently burned areas.

An additional objective of this study, to be investigated during summer 2004, is to fuse the ALSM data with hyperspectral data. In areas where the sensors' data overlap, each dataset will be classified independently to map the distribution of both brush and grass groundcover types. Following co-registration, comparative analysis of these datasets in combination with field validation will be performed. For example, the study will address whether the ALSM data is applicable solely to mapping structure (e.g. vegetation heights) or whether it can also provide species discrimination (based on vegetation canopy structure) comparable to the hyperspectral data. The study will also compare the cost and processing feasibility of each dataset.

Accomplishments through 2003

The hyperspectral classification data analysis has been completed for the distribution of spotted knapweed on INEEL (Figure 9-8). Field validation for the classification is ongoing (summer 2004). Several theoretical issues have been explored during data analysis, including hyperspectral processing methods, geometric precision, GPS data integration, field spectra modeling and training, and atmospheric influences. More information on these techniques may be found in Mundt (2003).

Computational algorithms have been developed to analyze the ALSM data for the INEEL. These algorithms use an iterative method to separate the ALSM data into bare ground and vegetation categories. This allows the underlying ground surface to be modeled and subsequently subtracted from the vegetation data, resulting in the vegetation heights. The length scales on which these algorithms operate are determined by a surface fractal analysis.

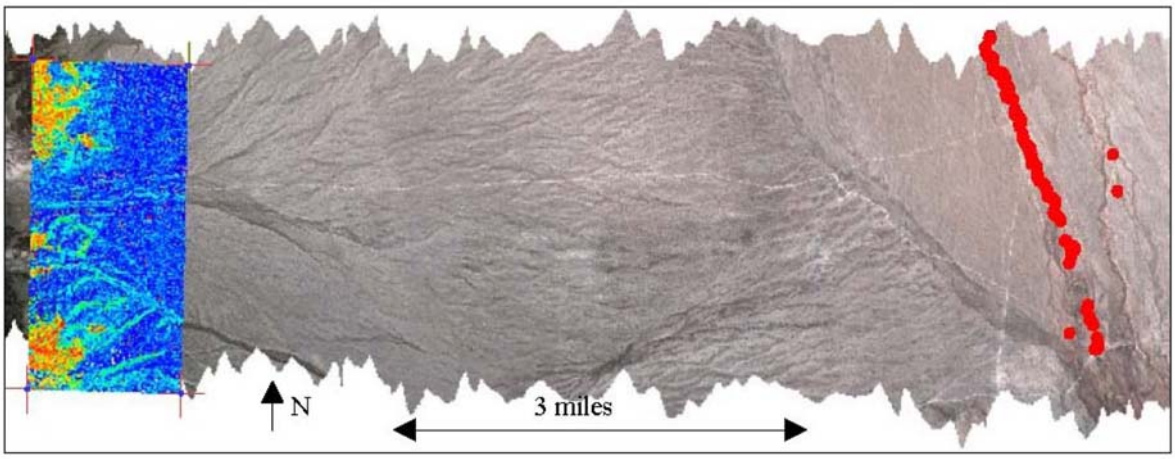

Figure 9-8. Preliminary predicted distribution of spotted knapweed (red points on the right) and modeled surface roughness (superimposed image on the left) generated using the hyperspectral and ALSM data, respectively. (Surface roughness increases from blue to red.)

In the interest of preserving the accuracy of the ALSM data, the raw, irregularly spaced data points are used in the analysis in lieu of interpolating the data into a regularly spaced digital elevation model (DEM). Because the datasets are quite large (several millions of data points), much effort has been invested in developing computationally efficient and numerically precise algorithms. These efforts were presented in a poster titled "Detection and characterization of rangeland vegetation using airborne laser swath mapping" at the Fall 2003 meeting of the American Geophysical Union (Streutker 2003).

Results

Hyperspectral Data Analysis - At this time, field data indicates a high accuracy potential, with approximately 80 percent of classified pixels falling within known spotted knapweed occurrences in the remote sensing-derived map. While these numbers are preliminary and additional field data needs to be collected, the initial results are encouraging for the differentiation of relatively sparse vegetation in a semi-arid ecosystem.

ALSM Data Analysis - Initial maps of vegetation height have been produced for the areas under investigation in the INEEL, as well the other areas in eastern Idaho for which data was collected (e.g. U.S. Sheep Experiment Station, Dubois). The calculated vegetation heights range from a few centimeters for grasslands, several tens of centimeters for sagebrush, and several meters for trees. In areas of recent fires, the fire boundaries are clearly delineated within the vegetation height data. The vegetation height data is also used to calculate surface roughness, which can, in turn, be utilized in discriminating between different vegetation communities (i.e. dense sagebrush stands versus grasslands).

Plans for Continuation

Concurrent with the validation of the spotted knapweed study and validation of the vegetation heights in the ALSM-derived maps, field data will be collected to map the biodiversity where the ALSM and hyperspectral data overlay. This will include detailed GPS measurements of vegetation distribution and structure.

9.8 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

Investigators and Affiliations

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Funding Sources

U.S. 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 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 2003

To address the second objective, surveys for sagebrush seedlings were conducted along transects 1000 m (3281 ft) in length. Surveys were conducted May 7 to 9, 2003. A total of 24 transects were surveyed. There were six transects in each of four planting treatments. In the 2000 Tin Cup burn area, there were six transects in the area aerially seeded with sagebrush in 2001, and six transects in an area of the same burn that was not planted. In 2003, two additional sets of transects in the 1994 Butte City Fire area were added. A portion of this burn was planted in 2001 at the same time the 2000 Tin Cup Fire area was planted. Six transects were established in the planted section of this burned area and six were established in the unplanted area. This was done to determine if the six years of recovery of native vegetation prior to planting sagebrush would have an effect on the establishment of sagebrush.

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 made. 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

In the area burned in 2000, very few sagebrush seedlings were found in 2003. The few that were located during the survey were mostly found in cracks in lava outcrops. In the area burned in 1994, results were opposite of what was expected. The hypothesis was that aerial seeding may be more successful because it was more likely that the seed would not have been as easily blown off of the project areas as appeared to be the case in the 2000 burn. This was expected because the 1994 burn had substantial grass and forb recovery by the time the seed was applied and would have increased boundary layer effect reducing the tendency of the seed to be moved by wind. Wind erosion of soils had stopped before seeding on the 1994 but much erosion was noted on the 2000 burn during the months following seeding. Instead, it was found that in the area burned in 1994 the unplanted area had nearly twice as many seedlings as the planted area.

Species Richness, Density, and Frequency - A total of 70 plant species were encountered in the ten pairs of plots (20 plots). Twelve species found in 2002 were not found in 2003 and four new species were added in 2003. Most of those lost were native annual forbs. Wyoming big sagebrush was encountered in two plots in 2003.

Of the 32 plots planned for study in the older burns, surveys were completed on 18 during 2003. The remainder will be surveyed in 2004. A total of 86 species were encountered on the 18 plots.

Coefficient of community is percentage of total species that the two communities have in common. It was calculated to compare the two plots of each pair for similarity in terms of the species present. Coefficient of community varied from 0.60 to 0.81. On average, the coefficient of community went down slightly from last year, perhaps reflecting the effects of grazing.

Utilization - Utilization of grasses ranged from 3.3 to 11.7 percent with an average utilization of 9.2 percent. Forb utilization was generally lower with a range of 0.9 to 21.7 percent with an average utilization of 5.3 percent.

Plant Cover - Total plant cover on the paired plots was 12.9 percent. Shrub and grass cover were 6.7 and 2.3 percent, respectively. Perennial forb (wildflower) cover was 3.5 percent. Cover by introduced species (weeds) was 0.4 percent.

Plans for Continuation

In 2004, there are plans to continue similar data collection for diversity, richness and cover in the paired plots; the sagebrush seedling survey; and diversity and richness in the older burns.

9.9 Sagebrush Demography on the INEEL

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

As more and more sagebrush steppe habitat in good ecological condition is lost, it becomes increasingly important to understand the ecosystem dynamics of that vegetation type, especially the biology of the dominant species, sagebrush. An understanding of the population dynamics, or demography, of sagebrush should allow land managers to make better decisions about remaining healthy sagebrush steppe vegetation. An understanding of what the historical population dynamics of a sagebrush stand may have been like will also allow land managers to begin to understand how to make improvements in sagebrush steppe communities that are in somewhat degraded conditions.

At the INEEL, the DOE is responsible for the stewardship of 2300 km^2 (890 mi^2) of relatively pristine sagebrush steppe habitat. This land comprises one of the largest reserves of this type of ecosystem that has been largely exempt from anthropogenic disturbance. Some of the primary issues DOE must address as a land manager include fire risk and fuel management, post-fire vegetation recovery, rangeland health, wildlife habitat management (including habitat critical to the survival of threatened, endangered, and sensitive species), and land use planning. Sagebrush is an important component of managing for all of these issues. Unfortunately, the population biology of sagebrush is not well understood. In particular, very little information is available on the typical age structure of sagebrush stands, the frequency of recruitment events, the dynamics of shrub die-off, and the typical lifespan of sagebrush.

The overarching goal of this proposed study is to describe sagebrush stand age structure for a representative sample of sagebrush stands and to identify the population dynamics that influence

that structure at the INEEL. Characterizing sagebrush stand age structure is a critical component to managing sagebrush steppe ecosystems, and understanding some of the basic biology of sagebrush can add tremendously to DOE's ability to make knowledgeable land management and land use decisions. A simple study to establish a working knowledge of the age dynamics of sagebrush stands can yield information useful to those land management issues listed above. Many of the results from this study may also be applied to sagebrush stands with similar climatic conditions and disturbance regimes range-wide, allowing range managers throughout the West to use the data.

The specific goals of this study are designed to allow some basic conclusions to be made about the demography of sagebrush in mature stands. The working knowledge of the dynamics of stand age structure gained from this study will allow managers to better address all of the land management issues mentioned above. The specific goals for this project are:

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

By addressing these goals, the proposed study will facilitate a comprehensive understanding of sagebrush population biology on the INEEL and on climactically similar rangelands including the normal age structure of sagebrush stands, the typical range of variation of sagebrush stand age structure, how age structure of a sagebrush stand relates to stand condition, the dynamics of shrub die-off, the typical lifespan of sagebrush, and the frequency of recruitment events.

Objectives

There are two major objectives for the proposed study. The first is to create a literature database and reprint collection regarding sagebrush demography and related sagebrush topics. The second objective is to conduct a field investigation of sagebrush demography at the INEEL. Products resulting from the completion of these combined objectives will provide researchers with an invaluable resource for information on basic sagebrush biology, which enhances any sagebrush related research. The literature database, reprint collection, technical report, and peer reviewed article resulting from this study will also provide tools that land managers can use to make informed sagebrush management decisions.

Accomplishments through 2003

The literature database was completed as an Endnote library. Endnote is a user-friendly database program specifically designed for literature collections; it is keyword searchable and inserts selected records directly into documents created with word processing software to facilitate compilation of literature cited sections. The reprint collection was completed and is housed with the ESER program.

A comprehensive study proposal was completed and submitted for the field investigation of sagebrush demography at the INEEL. The proposal included a thorough discussion of the literature review, precise goals and objectives for the study, a detailed data sampling and data analysis plan, and deliverables with specific land management benefits for the INEEL.

Plans for Continuation

Commencement of the field study will be dependent on funding in fiscal year 2005.

9.10 Development of an Integrated Watershed Information Management Tool for Long-Term Facilities Stewardship at the INEEL

Investigators and Affiliations

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Funding Sources

Laboratory Directed Research and Development (LDRD)

Background

The objective of this research is to provide DOE with Integrated Watershed Information Management Tools that integrate and leverage water and environmental management information leading to improved long-term stewardship decision making on the INEEL and within the associated watersheds. The tools and methods developed are transferable to other DOE and federal facilities and to address national/global watershed management issues. Key components of the system include data management, access and analysis tools, a Bayesian Decision Network (BDN), System Dynamics Model, and options analysis/decision support capabilities.

Work involved data collection and database development for disparate data sources in the watershed and development of disciplinary data analysis and mathematical modeling tools for the Big Lost River (BLR) and INEEL. These tools were integrated into a Integrated Watershed Information Management Tools (IWIMT). Facility and water resource managers, along with stakeholders can use these tools to help evaluate information, management alternatives, and to communicate decisions to other interested parties.

Objectives

The objective of this project was to develop data access, visualization, and analysis tools to support stakeholder understanding of watershed characteristics that are transferable to other watersheds including:

- Collect and compile data pertinent to watershed management decision making.
- Develop a BDN for the BLR specific to INEEL surface water management issues.
- Develop a Systems Dynamic model for the BLR.
- Make data and software tools available to the general public.

Accomplishments through 2003

- A license agreement for using and distributing the software was completed.
- Software documentation has been completed.
- Other applications for the software were developed and are being pursued.
- The software and examples are available at www.MapWindow.com.

Results

The following data for the BLR and INEEL have been compiled and integrated into the BLR-Data Viewer (DV): Groundwater elevation and quality, SNOTEL (SNOwpack TELemetry), snow course and other meteorological data, wildlife corridors for sensitive and focus species, surface water flow and water quality, soil erosion susceptibility, and a precipitation run-off forecasting model.

A data inventory table for the BLR-DV has been organized and updated. This table provides an example of what data are needed to support the tools and how to document and organize the data. The MapWindow software is used as the primary visualization tool, and GIS engine was re-engineered to be more efficient and stable. Software plug-ins were revised to improve system performance.

A soil erosion risk model was developed for the BLR watershed identifying key areas where soils are most susceptible to erosion causing sediment problems in the streams.

A model identifying key wildlife corridors for sensitive and important vertebrate species has been developed for the BLR watershed. This component of the tool set attempts to address terrestrial ecological sustainability for the identified key species.

The structure of the BLR BDN has been completed. The decision nodes are defined and the conditional probabilities tables have been populated. Some modifications to the INEEL portion

of the BDN are still taking place to capture additional questions and decisions associated with operation of the BLR diversion on the INEEL.

The system dynamics (SD) model for surface water flow in the BLR is completed, but not calibrated. This model is used to predict stream flows based on different dam operation scenarios and its output will populate the conditional probability tables in the BDN.

A precipitation runoff forecasting BDN was completed for the upper BLR basin above Howe Ranch gauge. This model utilizes historic snow pack snow water equivalent data, flow data, and northern sea surface water temperatures to provide probabilities of upcoming run-off conditions in acre-feet based on five types of precipitation years, and can provide information regarding the amount of water expected in the coming year with an uncertainty component.

A snow-cover run-off model was completed for the Copper Basin portion of the BLR. It provides an estimate of total water run-off based on snow cover in early spring. It provides an additional prediction tool for supporting management options for the Mackay dam. It increases the accuracy and reduces the uncertainty associated with using SNOTEL data alone.

9.11 Ecological Impacts of Irrigating Native Vegetation with Treated Sewage Wastewater

Investigators

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

In 1995, the INEEL began disposing of treated sewage 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.) of water per year, which must be applied such that no more than 7.6 cm (3 in.) of water leaches 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 2003

Plant cover sampling techniques were updated in 2003. Plant cover on each plot has been estimated using five contiguous point frames along a single transect through 2002. In 2003, this

sampling effort was increased to four contiguous point frames along five perpendicular transects, for a total of 20 point frames per plot. The increased sampling effort will allow for more accurate vegetation cover estimates with less statistical variability. 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 20 sites in the wastewater application area and 20 control sites throughout the growing season (beginning mid-March and ending at the end of October). Collection of soil moisture measurements was reduced from weekly in 2002 to once every other week in 2003 because changes in water content were very small on a week-to-week basis, and the most important patterns in soil moisture occurred on monthly and seasonal time scales.

A breeding bird survey was conducted according to U.S. Geological Survey (USGS) guidelines on and around the study site to determine any differences between irrigated and non-irrigated areas in bird usage.

Results

Vegetation - Within the crested wheatgrass vegetation type, nearly all plant cover resulted from crested wheatgrass. Total vegetation cover was significantly higher on irrigated plots than on control plots in 2003 ($p < 0.05$). Thus, additional summer moisture from wastewater application did result in an increase in grass cover in this community type. However, with a Morisita's similarity index of 0.99, plant community composition was very similar between irrigated and control plots. Crested wheatgrass communities at the INEEL tend to occur as monocultures; thus, crested wheatgrass communities are very homogenous and unlikely to exhibit much spatial variation, even when disturbed.

The vegetation type that represents a transitional zone between the crested wheatgrass community and the sagebrush steppe community was more greatly affected by the irrigation treatment than the crested wheatgrass community. Although total cover was similar between irrigated and control transitional communities, grass cover was higher on irrigated plots, and shrub cover was much higher on control plots. The Morisita's index value between irrigated and control plots was 0.88, which indicates some differences in species composition between irrigated and control plant communities within the transition zone in 2003.

Species richness was higher in the sagebrush steppe communities than in either of the other two plant communities. As with the crested wheatgrass and transition communities, grass cover was higher on irrigated plots than on control plots within the sagebrush steppe plant community. Forb cover consisted primarily of native forbs and was also higher on irrigated plots than in control plots. The Morisita's similarity index value (0.94) was higher between irrigated and control plots in the sagebrush steppe community in 2003 than in 2002, and was also higher than between irrigated and control plots within the transition zone. Sagebrush steppe community

vegetation is more likely to fluctuate in response to disturbance or changing environmental conditions because sagebrush steppe communities are much more heterogeneous and more likely to vary in space and time.

Animals - On June 13, 2003, breeding bird surveys were conducted on the wastewater application area following USGS, Breeding Bird Survey (BBS) guidelines. A BBS route stop was established on the application area in 1997 and surveys have been conducted yearly since that time. In 2003, Western meadowlark *(Sturnella neglecta)* remained the most abundant species. Other common species included Brewer's sparrow *(Spizella breweri)*, Brewer's blackbird *(Euphagus cyanocelphalus)*, horned lark *(Eremophila alpestris)*, sage sparrow *(Amphispiza belli)*, and sage thrasher *(Oreoscoptes montanus)*. One species, brown-headed cowbird *(Imolothrus ater)*, which has been common in the past, was not observed during the 2003 survey. Two species, lark sparrow *(Chondestes grammacus)* and Say's phoebe *(Sayornis saya)* were observed for the first time on the application area this year, but are not uncommon in surrounding areas. Otherwise, results from the 2003 survey were comparable to previous years and similar to that found on the CFA BBS route.

Soil Moisture - Spring soil moisture wetting fronts in 2003 ranged from 0.2 to 0.6 m (0.7 to 2.0 ft) 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 July in 2003. The soil moisture profiles do not indicate an increase in soil moisture at 20 cm (approximately 8 in.) or deeper due to wastewater application. If irrigation were to affect soil moisture, we would expect to see either small wetting fronts in the profile throughout the summer (in the case of pulses in application), or we would expect 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 dry 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 is evaporated or transpired before it percolates to a depth of 20 cm (approximately 8 in.) 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 2003 growing season.

9.12 The Protective Cap/Biobarrier Experiment

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

Shallow land burial is the most common method for disposing of industrial, municipal, and low-level radioactive waste, but in recent decades it has become apparent that conventional landfill practices are often inadequate to prevent movement of hazardous materials into groundwater or biota (Suter et al. 1993, Daniel and Gross 1995, Bowerman and Redente 1998). Most waste repository problems result from hydrologic processes. When wastes are not adequately isolated, water received as precipitation can move through the landfill cover and into the waste zone (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 groundwater (Fisher 1986, Bengtsson et al. 1994).

In semiarid regions, where potential evapotranspiration (ET) greatly exceeds precipitation, it is theoretically possible to preclude water from reaching interred wastes by (1) providing a sufficient cap of soil to store precipitation that falls while plants are dormant and (2) establishing sufficient plant cover to deplete soil moisture during the growing season, thereby emptying the water storage reservoir of the soil.

The Protective Cap/Biobarrier Experiment (PCBE) was established in 1993 at the Experimental Field Station (EFS) 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 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 soil only caps and that of caps based on U.S. Environmental Protection Agency (EPA) recommendations for *Resource Conservation and Recovery Act* landfill 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 2003 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.

Additionally, replacement of the polypipe irrigation system was scheduled for 2003. All polypipe components of the irrigation system except the dripline were to be replaced with galvanized steel in anticipation of reducing time and supply costs associated with irrigation system maintenance. Finally, an article for submission to a peer-reviewed journal was to be drafted in 2003.

Accomplishments through 2003

Two supplemental irrigation treatments were completed on the PCBE in 2003. Fifty millimeters (2 in.) of water was applied to the summer irrigated plots once every other week from the end of June through the beginning of August for a total of 200 mm (8 in.). Two hundred millimeters (8 in.) of water was applied to the fall/spring irrigated plots during a three week period in October. Soil moisture measurements were collected once every two weeks from mid-March through the end of October. Vegetation cover data were collected throughout the month of July and into August.

Soil moisture and vegetation data collected in 2003 were archived. Soil moisture data were compiled and summarized, and soil moisture profiles were completed for each cap, irrigation, and vegetation treatment. Vegetation data were also complied and summarized to yield a percent cover value for each treatment combination.

Replacement of the irrigation system began in August of 2003. The entire polypipe system was removed and all of the galvanized components were installed by the middle of October. Approximately two-thirds of the dripline was replaced by the end of the year. The irrigation system replacement was completed in the spring of 2004.

An article entitled "Design and Performance of Four Evapotranspiration Caps" by A. D. Forman and J. E. Anderson was completed and submitted for publication in September 2003. It includes much of the 1993 through 2000 data previously published in Environmental Surveillance, Education and Research (ESER) reports. The manuscript is in review and will be published in a special edition of the Practice Periodical of Hazardous, Toxic and Radioactive Waste Management by the American Society of Civil Engineers (due to be published in early 2005). The special edition includes several invited papers from INEEL scientists on landfill capping issues.

Results

Initial data analyses from the 2003 soil moisture data indicated that the spring infiltration event was limited, with the resulting wetting front ranging from 20 to 60 cm (approximately 8 to

24 in.) in depth. The wetting front from the summer irrigation treatment ranged from 40 to 80 cm (approximately 16 to 32 in.) on all cap type and vegetation treatment combinations. Under the fall irrigation treatment, the wetting front reached the bottom of all of the soil only caps and many of the shallow and deep biobarrier caps regardless of vegetation type. All of the RCRA caps drained in response to the fall irrigation treatment. The soil at the bottom of many of the fall irrigated caps was at or above field capacity, indicating that many of those caps likely drained.

Over the 10-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 normal treatment conditions. 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 failure in 2003 was a random and reversible occurrence.

Plans for Continuation

Soil moisture and plant community composition and cover were still experiencing unexpected changes in 2003, 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 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.

9.13 Assessing the Effects of Soil-Forming Processes on Surface Caps

Investigators and Affiliations

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Funding Sources

Environmental Systems Research and Analysis (ESRA), Environmental Management

Background

Vegetative surface caps for the disposal of radioactive or hazardous wastes are often constructed of homogenized subsoil material collected from the local area. In arid regions, these

caps rely on ET to prevent water from percolating into the waste. Over time, these materials are subjected to natural soil-forming processes, eventually resulting in the development of strata within the soil material that may ultimately influence cap performance. Organic carbon and available phosphorus play an important role in the structure and function of the soil ecosystem by influencing the growth of plants at the site which, through transpiration, help to prevent precipitation from moving downward through the cap and ultimately reaching the buried wastes.

The PCBE was established at the INEEL EFS in 1993 to examine four different simulated surface cap designs under two different vegetation types and three different moisture regimes. Because these caps have been in place for ten years, they represent an example of accelerated soil forming processes, providing insight into plant-soil interactions within the surface cap.

Objectives

Specific objectives for this study include:

- Compare the vertical distribution of carbon and phosphorus concentrations in soil cores from the PCBE site with those from an undisturbed site with mature soil development.
- Evaluate cation nutrients (potassium, calcium, and magnesium) for a subset of the soil cores.
- Determine cation exchange capacity, base saturation, and soil texture on a subset of cores.

Accomplishments through 2003

Soil cores were collected from the PCBE site and from an undisturbed site located nearby. In each sampling location, soil cores were collected from beneath a sagebrush and a bunchgrass, as well as from an open area adjacent to each plant. Six depth intervals within the top 12.5 cm (5 in.) were evaluated by cutting each core into segments. Organic carbon concentrations were determined according to the tube digestion/heating block method, a modification of the Walkley-Black method. For plant-available soil phosphorus, samples were extracted with a buffered alkaline solution of sodium bicarbonate, and the solution analyzed using an inductively coupled plasma atomic emission spectroscopy (ICP/AES) analyzer. Concentrations of individual cation nutrients and measurements of cation exchange capacity, base saturation, and soil texture were determined using standard soil analytical techniques.

Results

Vertical distribution of carbon and phosphorus at the PCBE site was pronounced; indicating that development of soils on the surface caps is progressing (Figure 9-9). A strong interaction between vegetation, location, and depth was observed for both carbon and phosphorus, which reflects the particularly strong organic enrichment under vegetation. There is also an interaction between irrigation and depth, which indicates surface enrichment following irrigation. Cap design effects are mostly absent. For cation exchange capacity and base saturation data, results differed between the PCBE cores and those collected from the undisturbed site. In particular, the potassium data show increased concentrations in the upper soil layers, decreasing with depth. Significant differences are also apparent between samples collected beneath shrub canopies

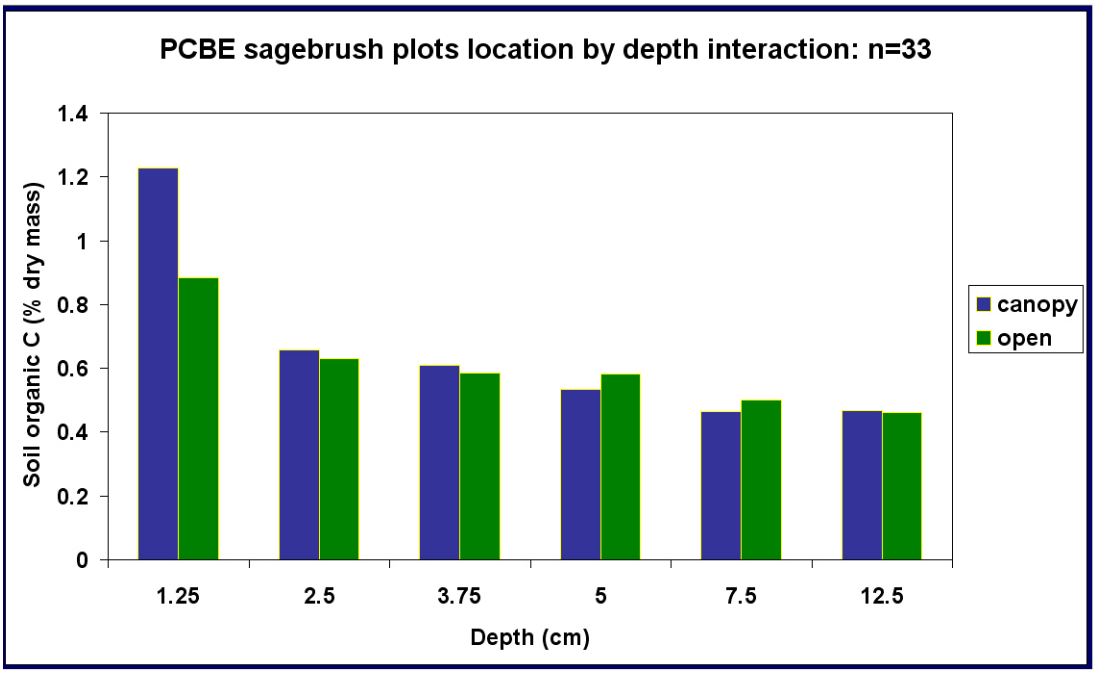

Figure 9-9. Concentration of organic carbon in soil samples at varying depths for samples collected under shrubs (canopy) and between shrubs (open).

versus in the open, again pointing out the influence of vegetation on the chemistry of the cap soil.

Collectively, these data show evidence of discernible development of the upper soil profile in caps after eight years. However, the data also indicate that additional time is needed to approach the accumulation seen in natural soils of sagebrush steppe ecosystems.

The carbon and phosphorus results were presented at the Soil Science Society of America Annual Meeting in Denver in 2003, and a formal journal article has been submitted to the Soil Science Society of America Journal. A second paper on the cation results is in preparation.

9.14 Coupled Effects of Biointrusion and Precipitation on Soil Caps

Investigators and Affiliations

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Funding Sources

Environmental Systems Research and Analysis (ESRA), Environmental Management

Background

The National Research Council's characterization of infrastructure material clearly indicates the need to understand, and to be able to predict over the long term, how integrated processes impact the performance of caps used to isolate hazardous or radioactive wastes. It is recognized that biointrusion and the processes it affects comprises a complex network of interactions; however, two pieces of information seem to be missing from previous studies. First, it is not clear what processes and how much time is needed for long-term exposure to biointrusion to actually affect the performance of the cap. Second, to construct more realistic models of cap performance, it is necessary to be able to understand and evaluate cap performance as a function of coupled processes as opposed to single processes.

Engineered barriers are designed to isolate hazardous waste from moving to the environment and ideally, they are expected to sustain functionality well beyond the breakdown of the materials they contain. Current barrier designs are not invulnerable to environmental and biological assaults and, to date, it is difficult to determine the significance of these intrusions on the long-term performance and effectiveness of the barrier. Therefore, it is important to elucidate the interactions between geophysical and biological processes, and how these processes ultimately act on the long-term performance of caps.

Objectives

This study evaluated the coupled effects of geophysical, environmental, and biological intrusions and how those factors ultimately affect the performance of the cap. This project identified and evaluated time and cost-effective early warning methods for detecting biointrusion. The tests were conducted at the Engineered Barrier Test Facility (EBTF) near the RWMC on the INEEL. The objectives of this study were:

- Test coupled effects for a natural material system, especially increased rainfall and the effects of animal and plant intrusion.
- Induce animals to create worst-case (deepest) animal intrusion.
- Test colored sand tracers (emplaced as layers) to show depth of animal intrusion.
- Evaluate capillary barrier performance.

Accomplishments through 2003

The experimental setting was designed to test a series of interactive conditions: burrowing, plant evapotranspiration, and water percolation through the barrier. Mockups of an evapotranspiration-storage type soil cap were constructed in 12 test cells at the EBTF (Figure 9-10).

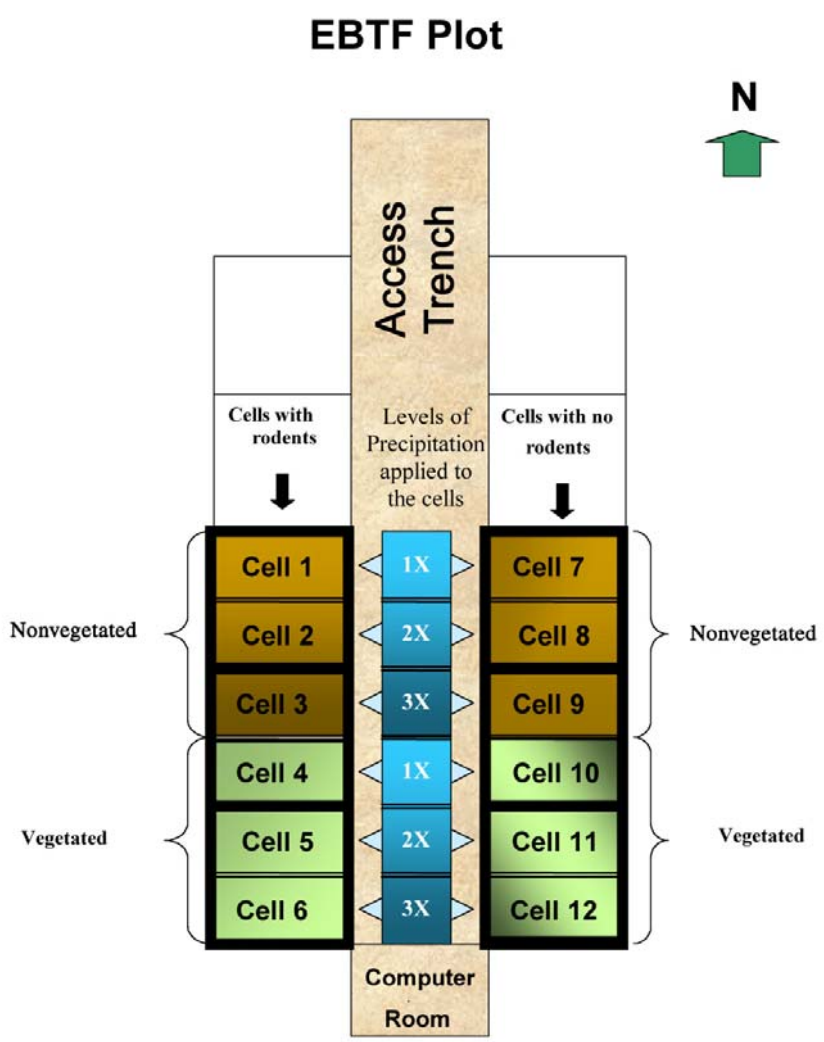

Figure 9-10. Layout of the EBTF plots.

Cells 1 to 3 had rodents (mice) and no vegetation. These cells differ only in the level of precipitation that each cell received (normal, 2X normal, and 3X normal, respectively). Cells 4 to 6 were similar to Cells 1 to 3 with respect to precipitation, the presence of rodents, and the presence of colored sand in the soil. Unlike Cells 1 to 3, however, Cells 4 to 6 were vegetated. The same type and density of vegetation was established on these cells at the start of the experiment. Cells 7 to 9 were similar to Cells 1 to 3 with respect to precipitation and lack of vegetation, but lacked burrowing mammals. Cells 10 to 12 were similar to Cells 4 to 6 with respect to precipitation and vegetation. Again although, Cells 10 to 12 lacked rodents and colored sand in the soil. Cells 1 through 6 had the same number of rodents introduced to each of these cells.

Considered in total, the 12 treatments enabled us to evaluate the coupled effects and interactions between accelerated precipitation, animal burrowing, vegetated/bare surfaces, soil microbiology, and soil cap hydrologic performance.

The caps were comprised of (from top to bottom) 1.6 m (5.2 ft) of silt loam soil, a geotextile fabric, 0.15 m (approximately 5 ft) of gravel, 0.75 m (2.5 ft) of cobbles, and 0.5 m (1.6 ft) of silt loam soil. The surface 0.15 m (approximately 5 ft) of soil was mixed with gravel (25 percent by volume) as a wind erosion preventative.

Each test cap was constructed in lifts to enable precise control of soil density and facilitate the installation of soil moisture monitoring instrumentation and soil tracers for detection of burrowing. Time domain reflectometry (TDR) probes for monitoring soil moisture, heat dissipation sensors (HDS) for monitoring soil moisture tension, and thermocouples (TC) for monitoring soil temperature were installed at various depths. Instrument cables were routed horizontally to a cable tower installed within the test cell. Horizontal installation precluded the creation of vertical preferred pathways for water infiltration at the soil surface. Snowfall accumulating on the test plots was measured using an ultrasonic sensor. Data collection from all soil and snow instruments was automated to provide an uninterrupted time series of data and to reduce manpower requirements. Meteorological parameters were obtained from the National Oceanic and Atmospheric Administration weather station located near the EBTF.

To prevent introduced rodents from escaping and wild fauna from invading the cells (e.g., predators such as snakes or other carnivores, as well as other rodents), 1.5 m (approximately 5 ft) lexan walls were used in the construction of the plots. The walls were buried 20 cm (approximately 8 in.) deep and in direct contact with a concrete lip inside the walls, creating a tight seal and a structural barrier in the event of potential attempts of mice to dig out of the cells. Because the cells were open to the environment (no lids), predation by raptors was prevented using a bird chase ultrasonic model UB43 (Bird-B-Gone, Inc.) that emits a 20 to 25 KHz tone in a variety of mode combinations (i.e.: steady, burst, sweep, and random). This frequency range does not harm the birds and keeps them away from the facility.

Vegetation was incorporated inside plots 4, 5, 6, 10, 11, and 12, following a distribution of vegetation from an area randomly selected in the vicinity of the experimental site. All of the plots were vegetated with the same distribution and type of plants: four sagebrush; four green rabbitbrush; two bluebunch wheatgrass; three prickly phlox, and two forbs. Surveys of test plot vegetation will be conducted at the conclusion of the project to determine the survivorship of plant species and biomass. Test plot soils will be excavated to determine root distributions and biomass. The distribution of animal burrows will be mapped at the conclusion of the project by injecting hardening foam into the burrows and carefully excavating the surrounding soil.

Results

Data collection has just recently been completed and data currently being compiled and interpreted on precipitation, vegetation, and burrowing effects on the cap. Results will be provided in next year's annual report.

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Chapter 10 - Quality Assurance

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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 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 laboratories used by the Environmental Surveillance, Education and Research Program met their quality assurance goals in 2003. Quality issues that arose with laboratories used by the Management and Operating contractor were addressed with the laboratory and resolved.

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 2003, 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 also used Paragon Analytes, Inc. and for radiological analysis and Microwise Laboratories of Idaho Falls for bacteriological inorganic analysis; and Environmental Health Laboratories for organic analyses.

The Environmental Surveillance, Education and Research (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. For 2003, samples from the Naval Reactors Facility were sent to STL of Richland, Washington, for

radiological analyses and the University of Georgia for tritium analyses. All these laboratories participated in a variety of programs to ensure the quality of their analytical data. Some of these programs are described below.

Quality Assessment Program

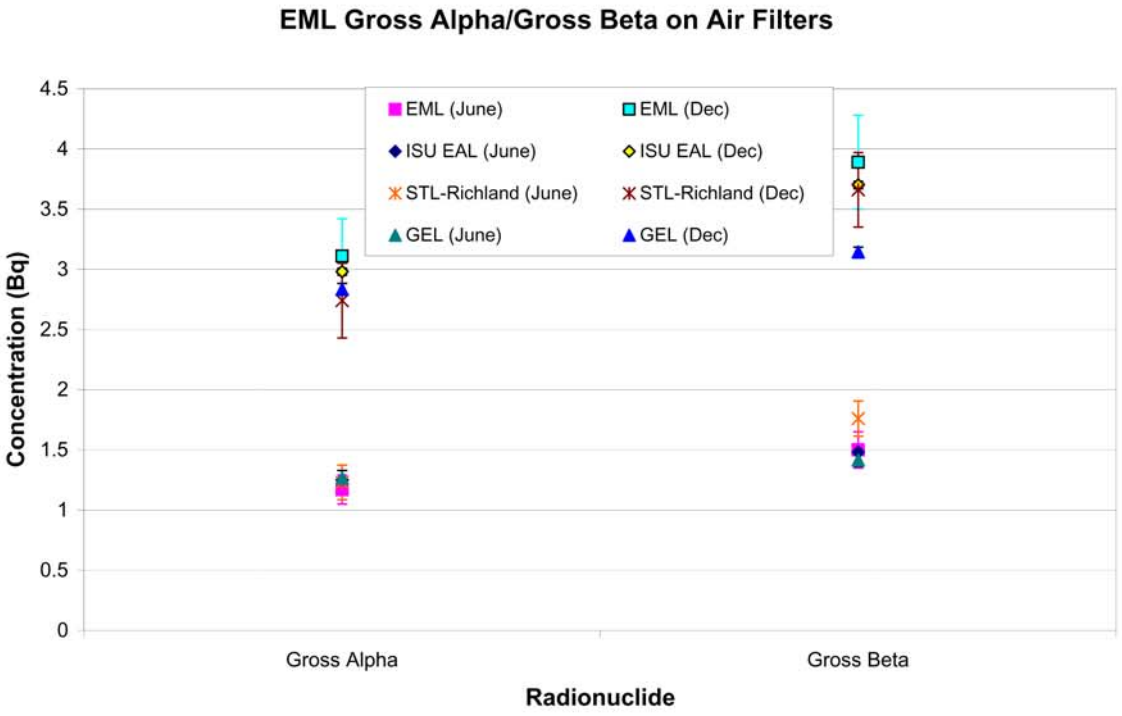
The Quality Assessment Program, administered by the DOE Environmental Measurements Laboratory (EML) in Brookhaven, New York, is a performance evaluation program that tests the quality of DOE contractor and subcontractor laboratories in performing environmental radiological analyses. EML prepares samples containing known amounts of up to 15 radionuclides in four media: simulated air filters, soil, vegetation, and water. These are distributed to participating laboratories in March and September. Participants can use any method for the analysis, and they are required to report their results within 90 days. EML issues quality assessment reports twice per year in which the identities of participating laboratories, their results, and comparison to EML results are presented. These reports are available, along with a searchable database of past results, on the Internet at http://www.eml.doe.gov/qap/reports/ (DOE 2003).

2003 Quality Assessment Program Results

Comparisons of the air and water results for the laboratories used by INEEL environmental monitoring organizations in 2003 are presented in Figures 10-1 and 10-2. For the June air analysis, the DOE EML qualified the ^{241}Am and ^{137}Cs results from RML, Paragons' ^{238}Pu, and STL's uranium-234 (^{234}U) as acceptable with warning. STL also received a "not acceptable" rating on its ^{90}Sr analysis. For December, only General Engineering Laboratories received an "acceptable with warning" on its gross beta analysis. STL received another "not acceptable" rating on its December ^{90}Sr analyses.

Water results were qualified by the DOE EML for at least one constituent for all labs used. General Engineering Laboratories received an "acceptable with warning" for its June ^{134}Cs analysis and its December ^{90}Sr and ^{241}Am analyses. STL received an "acceptable with warning" in June for ^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{90}Sr, and on its December ^{234}U analysis. It also received a "not acceptable" for its ^{90}Sr analysis in December. Paragon received a "not acceptable" rating for its gross alpha in June and improved to "acceptable" in December. The INEEL RML received an "acceptable with warning" for its June gross alpha and plutonium analyses (^{238}Pu and ^{239}Pu), and ^{234}U and uranium-238 analyses in December. The ISU EML received "acceptable with warning" for ^{134}Cs in both June and December and gross alpha in December.

The NWQL performed three duplicate tests for gross alpha and gross beta in June only. One test for gross alpha received a "not acceptable" and a second test received an "acceptable with warning." The third test and all gross beta tests were acceptable.



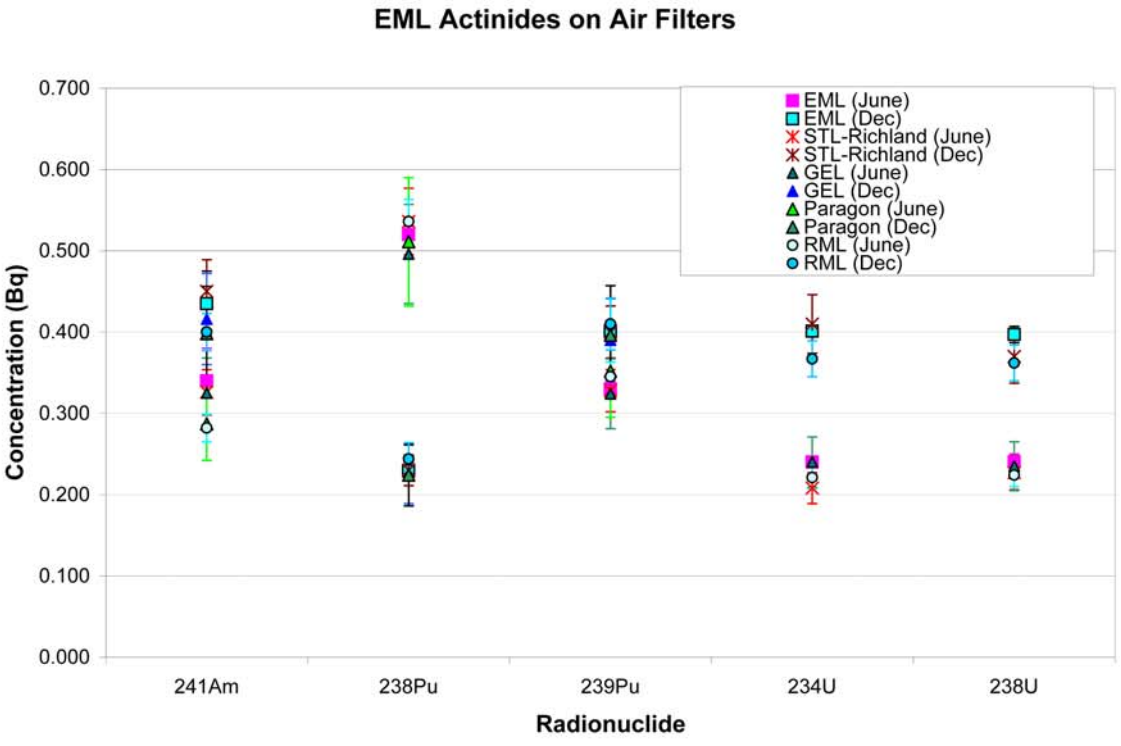
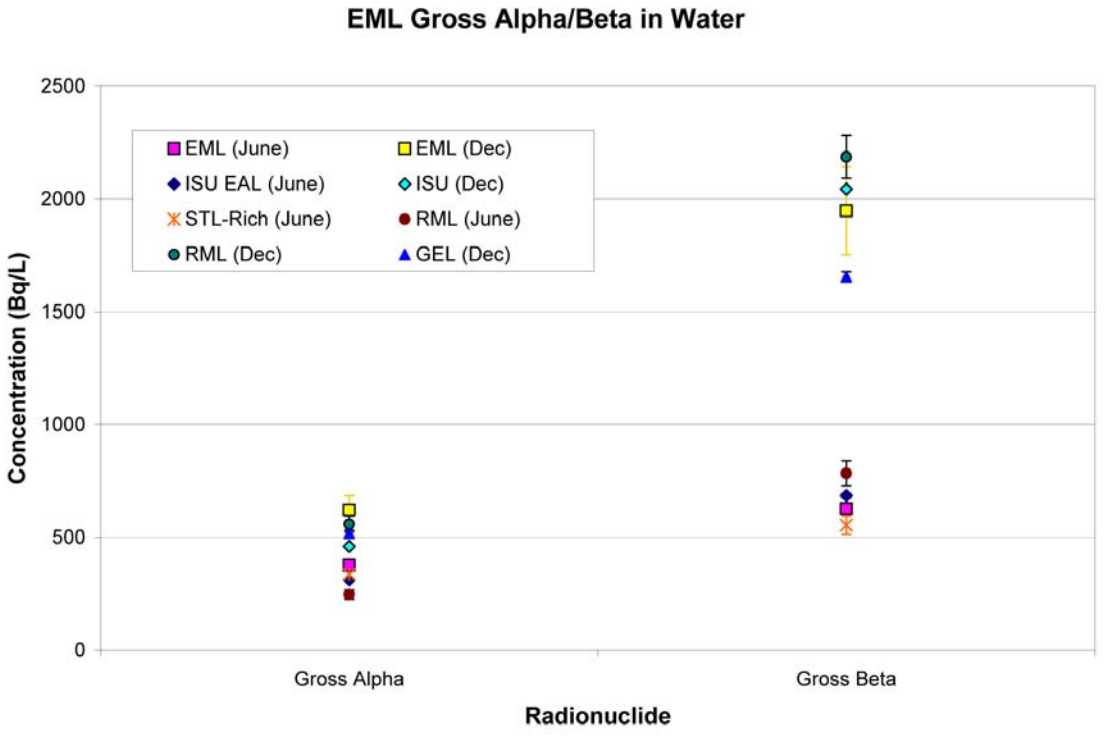


Figure 10-1. Surveillance contractor laboratory air sampling results from the EML intercomparison (2003).



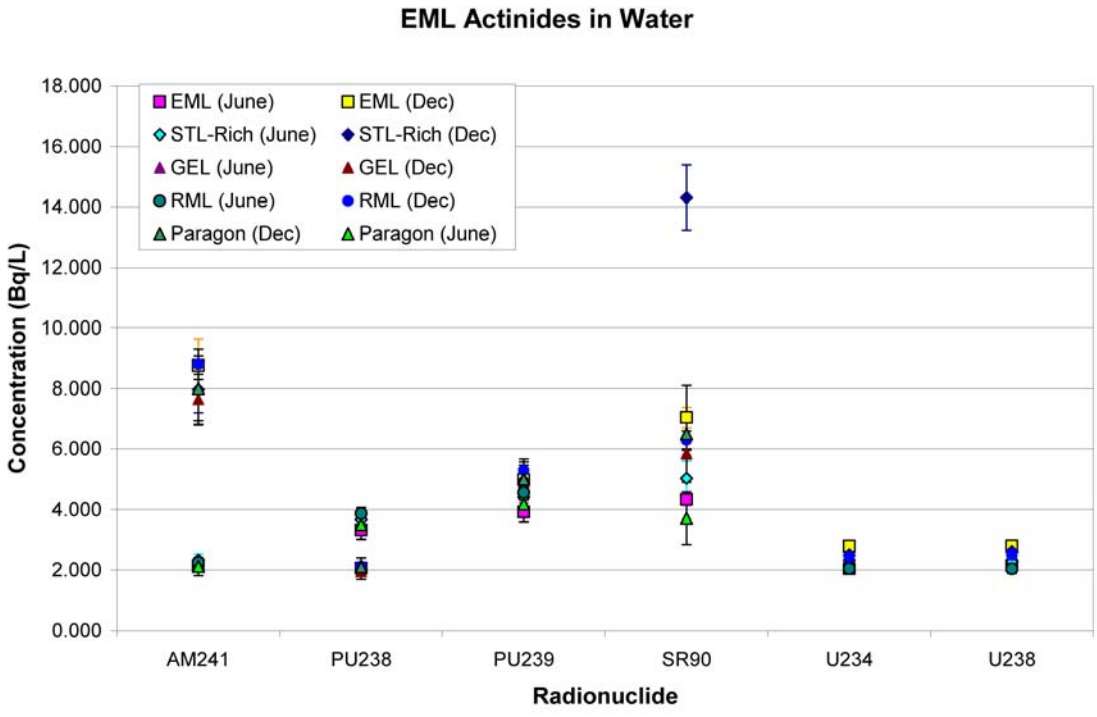


Figure 10-2. Surveillance contractor laboratory water sampling results from the EML intercomparison (2003).

National Institute of Standards and Technology

The DOE RESL participates in a traceability program administered through the National Institute of Standards and Technology (NIST). RESL prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards, generally in liquid media, for analysis by RESL to confirm their analytical capabilities. RESL maintained NIST certifications in both preparation and analysis in 2003.

Dosimetry

To verify the quality of the environmental dosimetry program conducted by the M&O 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 2003, 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 2003. 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.

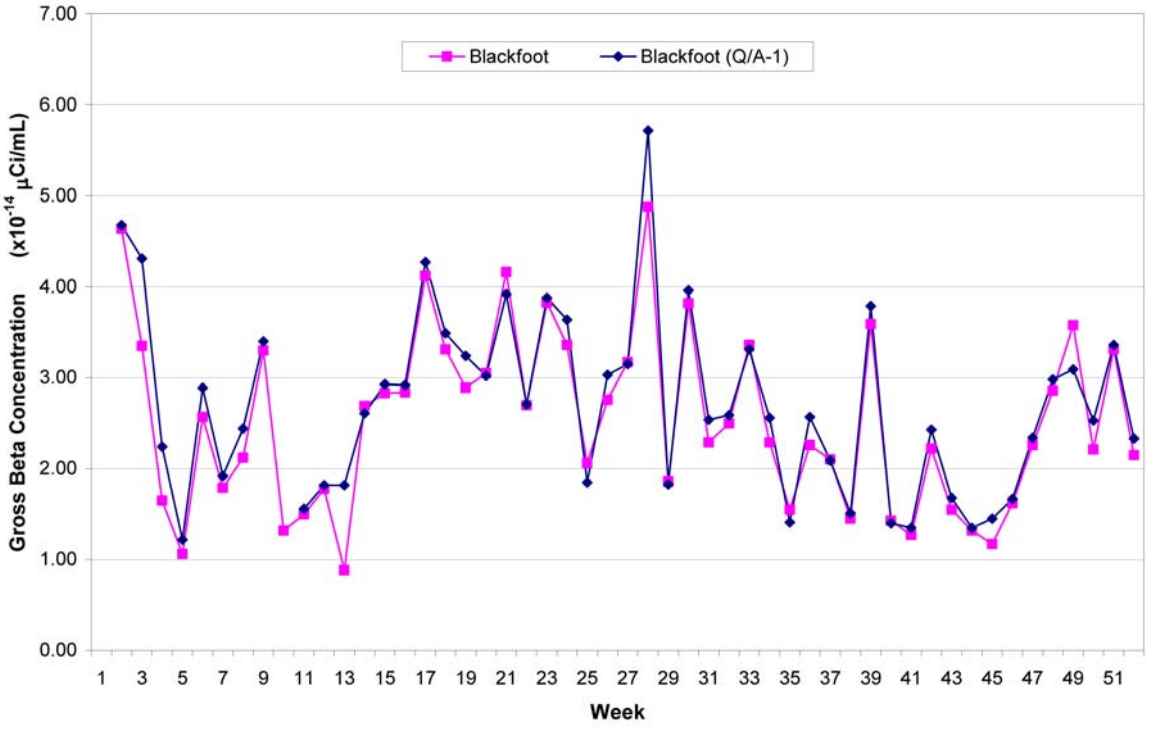
Both the ESER contractor and the M&O contractor maintained duplicate air samplers at two locations during 2003. The ESER contractor operated duplicate samplers at the locations in Blackfoot and Mudlake. The M&O contractor duplicate samplers were located at Argonne National Laboratory-West (ANL-W) and 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.

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 2003 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. Comparisons of data from these sampling locations for gross beta 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 2003 samples taken from these locations.

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.



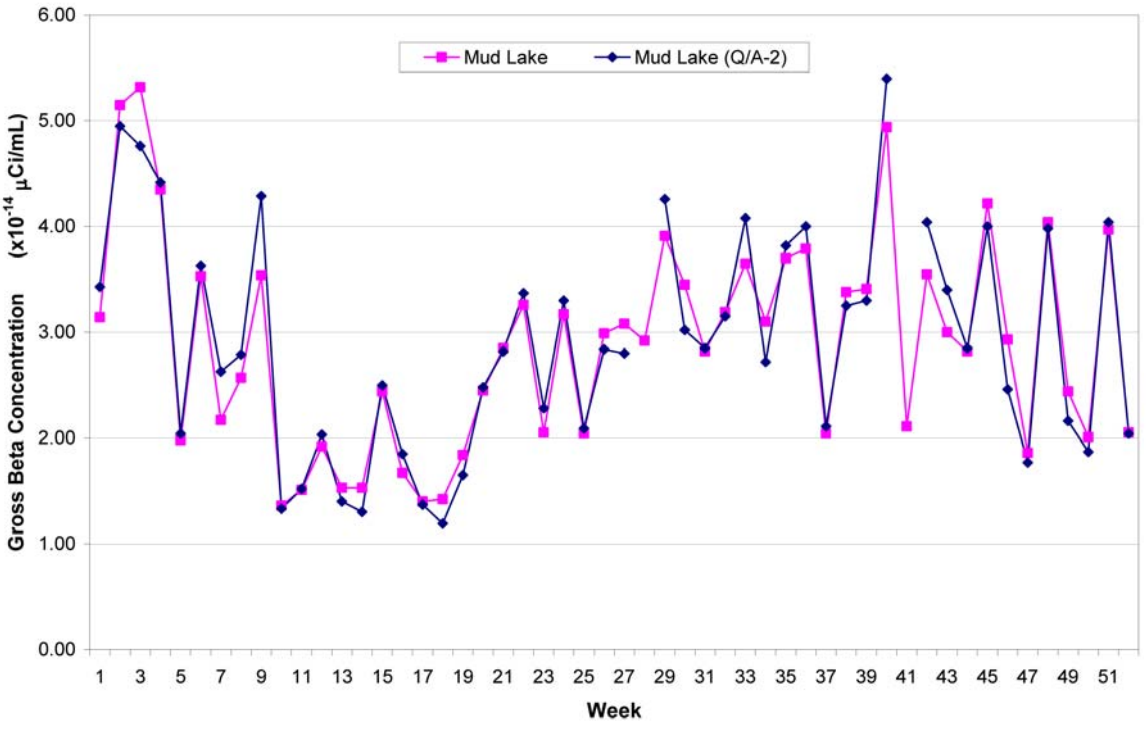
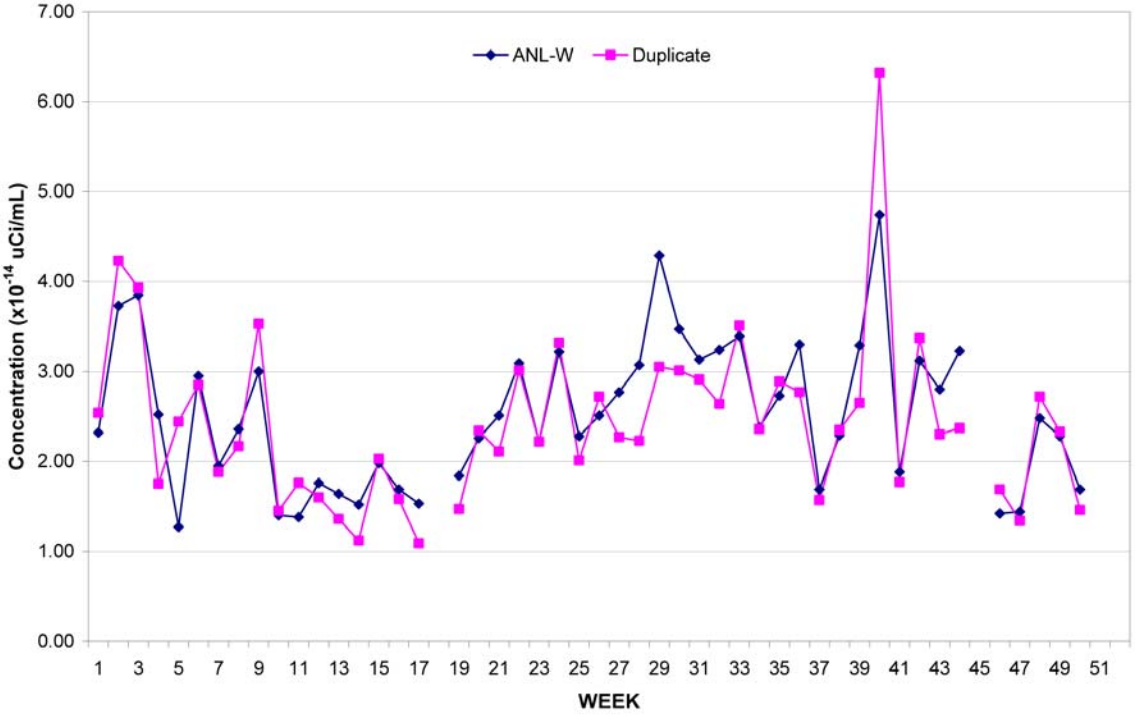


Figure 10-3. ESER contractor duplicate air sampling gross beta results (2003).



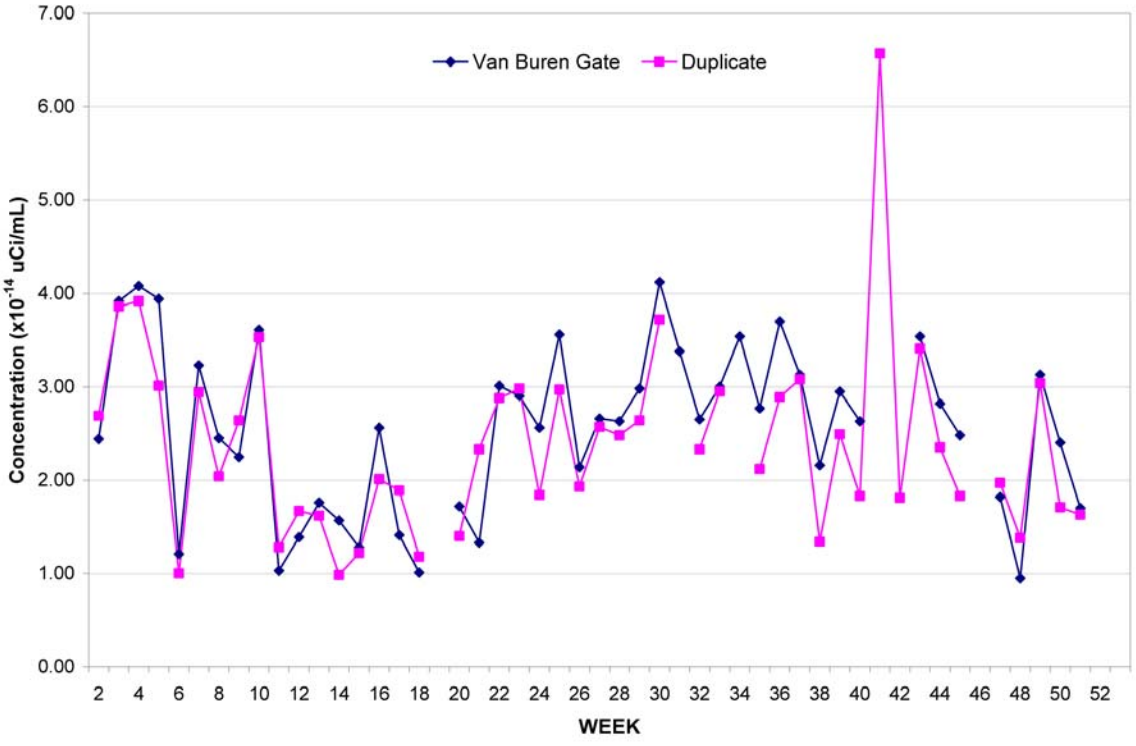


Figure 10-4. M&O contractor duplicate air sampling gross beta results (2003).

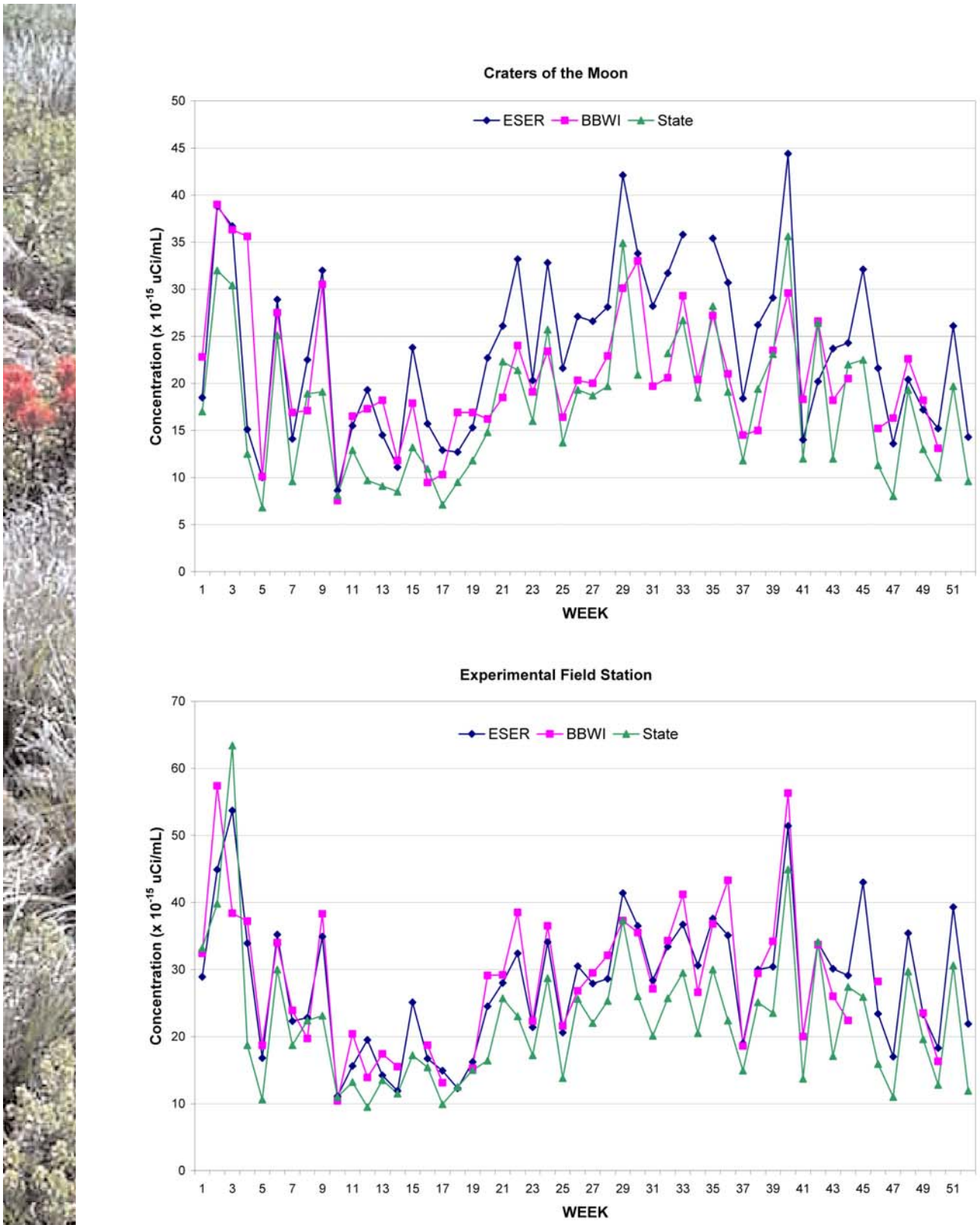


Figure 10-5. Comparison of gross beta concentrations measured by ESER contractor, M&O contractor, and State of Idaho (2003).

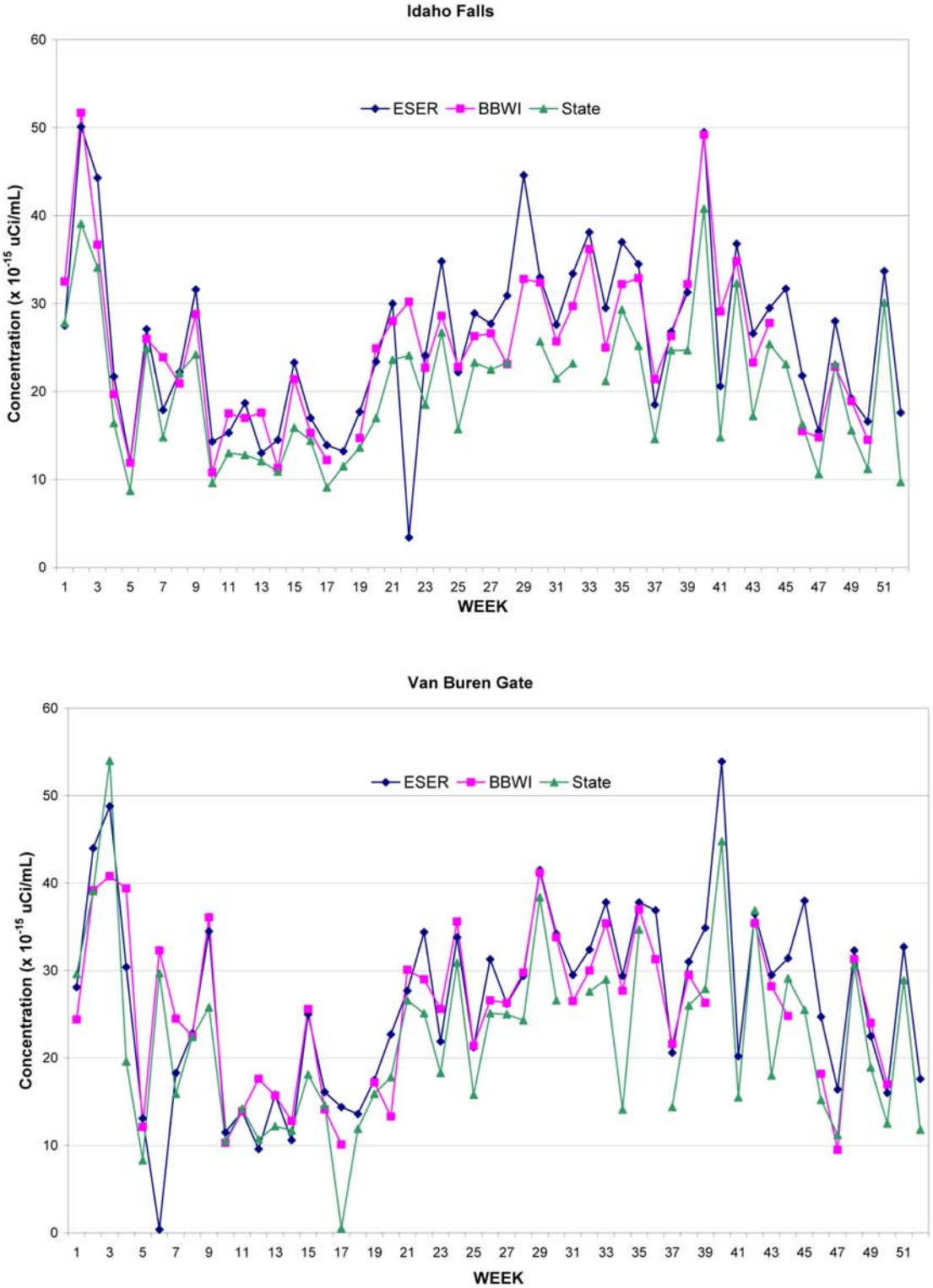


Figure 10-5. Comparison of gross beta concentrations measured by ESER contractor, M&O contractor, and State of Idaho (2003). (continued)

Table 10-1. Comparison of ESER and INEEL Oversight Program water monitoring results (2003).[a]

Location	Date	Gross Alpha (pCi/L)		Gross Beta (pCi/L)		Tritium (pCi/L)	
		ESER	State	ESER	State	ESER	State
Drinking Water							
Atomic City	05/14	0.37 ± 0.8	1.1 ± 1.6	3.3 ± 1.6	1.5 ± 0.9	-66.9 ± 119.0	0 ± 60
	11/13	-0.2 ± 0.6	1.7 ± 2.1	2. 9 ± 1.7	2.9 ± 1.0	54.3 ± 111.0	-30 ± 70
Minidoka	05/14	-0.2 ± 0.7	-0.2 ± 1.2	3.6 ± 1.7	1.5 ± 0.7	-72.0 ± 117.0	10 ± 60
	11/13	0.7 ± 0.9	0.4 ± 2.9	3.9 ± 1.8	1.8 ± 1.2	134.0 ± 112.0	-30 ± 70
Mud Lake	05/14	-0.02 ± 0.5	1.1 ± 1.2	1.0 ± 1.4	2.4 ± 0.8	-30.5 ± 114.0	-90 ± 70
	11/13	-0.01 ± 0.6	-0.6 ± 1.2	5.4 ± 1.8	3.0 ± 0.9	22.5 ± 44.6	-40 ± 70
Shoshone	05/14	0.04 ± 0.7	0.3 ± 1.6	4.1 ± 1.7	2.1 ± 1.0	44.1 ± 45.9	10 ± 60
	11/13	1.3 ± 1.0	2.0 ± 1.7	2.2 ± 1.7	1.6 ± 0.8	33.2 ± 45.2	80 ± 70
Surface Water							
Buhl	05/13	0.0 ± 0.8	0.7 ± 1.4	4.5 ± 1.8	1.8 ± 0.9	-16.6 ± 44.3	65 ± 49
	11/12	-0.2 ± 0.7	2.6 ± 2.7	3.1 ± 1.8	1.9 ± 1.1	0.9 ± 46.3	20 ± 49
Hagerman	05/13	1.5 ± 1.0	2.8 ± 1.5	2.2 ± 1.7	1.7 ± 0.9	-27.8 ± 43.8	60 ± 70
	11/12	1.1 ± 0.9	0.3 ± 1.8	4.6 ± 1.8	1.1 ± 1.0	16.5 ± 44.9	-10 ± 70
Twin Falls	05/13	0.6 ± 1.0	0.9 ± 1.8	5.3 ± 1.9	3.8 ± 1.0	36.5 ± 44.8	70 ± 70
	11/12	-0.1 ± 0.7	1.8 ± 2.8	7.1 ± 2.1	5.1 ± 1.2	94.7 ± 50.6	100 ± 70

a. Values are shown as the result ± 2 standard deviations, where the standard deviation is the total uncertainty.

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.

During 2003, four quarterly sets of performance evaluation samples were submitted to the laboratory along with routine monitoring samples. With the exception of antimony, no blind spike parameters routinely missed the performance acceptance limits. Out of two field blind spikes submitted for antimony, both exceeded the upper performance acceptance limit (the laboratory value was higher than the true value). For blind spike results above the 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 the appearance of a permit limit exceedance when in fact none has occurred. For blind spike results that fall below 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 an unreported exceedance of a permit limit. A review of the reported concentrations for all blind spike parameters that fell below the performance acceptance limit showed that there were no impacts to regulatory limits.

Relative percent difference (RPD) between the duplicate samples is used to assess data precision. Table 10-2 shows the results for 2003.

Table 10-2. RPD results.

Parameter	RPD Result
Inorganic and metals	92% within the program goal of less than or equal to 35%.
Radiological parameters	Only one set of duplicate results had detectable quantities. The RPD for that set of duplicates was < 13.75%, which 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 the 2003 year, this goal was met.

Validation performed on analytical results from the 2003 sampling efforts resulted in one rejected sample:

- The June total dissolved solids result for CFA-689 was rejected for exceeding the hold time.

No other sampling or validation issues were identified during calendar year 2003.

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 2003, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center (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 2003 and October 2003). All of the samples required for permit compliance were collected and none of the analytical results were rejected as unusable during data validation.

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 wastewater and groundwater analyses

during 2003. 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, 5 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 2003, for the 36 duplicate pairs with detectable results, 94 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. The field blanks 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. The equipment rinsates were collected by pouring analyte-free water through the sample port manifold after decontamination and before subsequent use. Again, results from the equipment blanks did not indicate improper decontamination procedures.

Results from the duplicate, field blank, and equipment blank (rinsate) samples indicate that laboratory procedures, field sampling procedures, and decontamination procedures were used effectively to produce high quality data.

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 2003.

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 2003 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 2003, with 90 percent of the relative percent differences calculated from a sample

and its duplicate being less than the required 35 percent (for those with both results detected). Relative percent difference was not calculated if either the sample or its duplicate were reported as nondetects.

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 EML QA Program and the EPA National Center for Environmental Research (NCER) QA Program. The laboratories met the performance objectives specified by the EML and NCER.

The Environmental Surveillance Program met its completeness 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.

On October 1, 2003, the M&O's Environmental Services Project changed laboratories for the analysis of ambient air, soils, and biota samples. As of the time of this report, the laboratory's performance is under review for accuracy of the data. This review is being conducted because of inconsistencies with previous years' data.

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Appendix A - Environmental Statutes and Regulations

C. Martin and M. Case - S. M. Stoller Corporation

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

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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

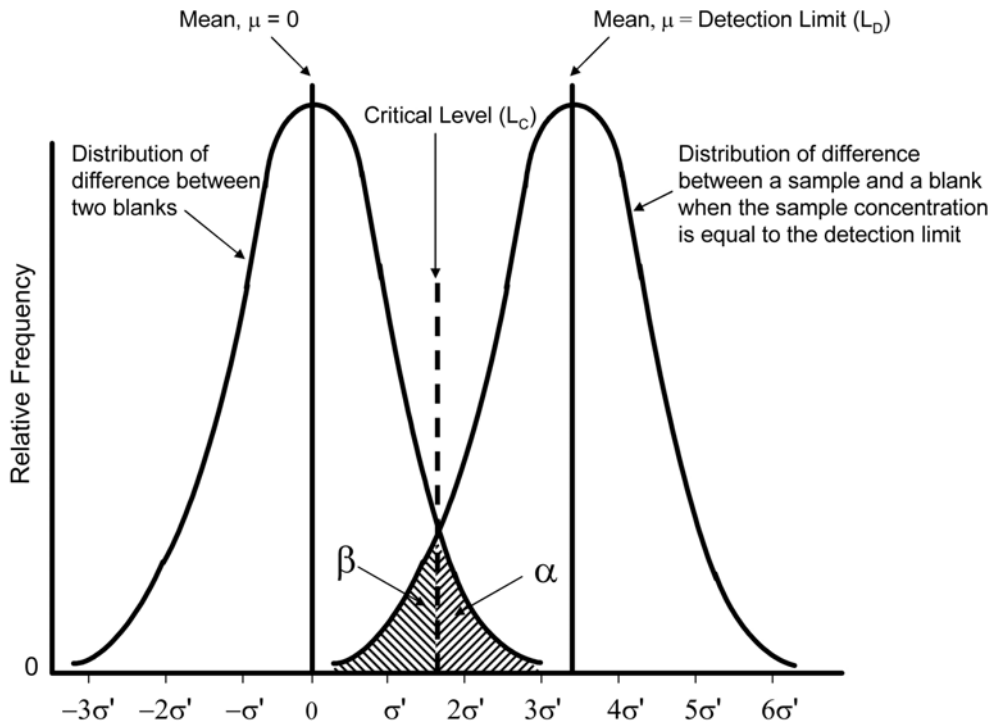

Figure B-1. Illustration of the relation of the criterion of detection (critical level) and the limit of detection (detection limit). Errors of the first kind (false negatives) are represented by the value of α, whereas errors of the second kind (false positives) are represented by the value of β. (from 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.

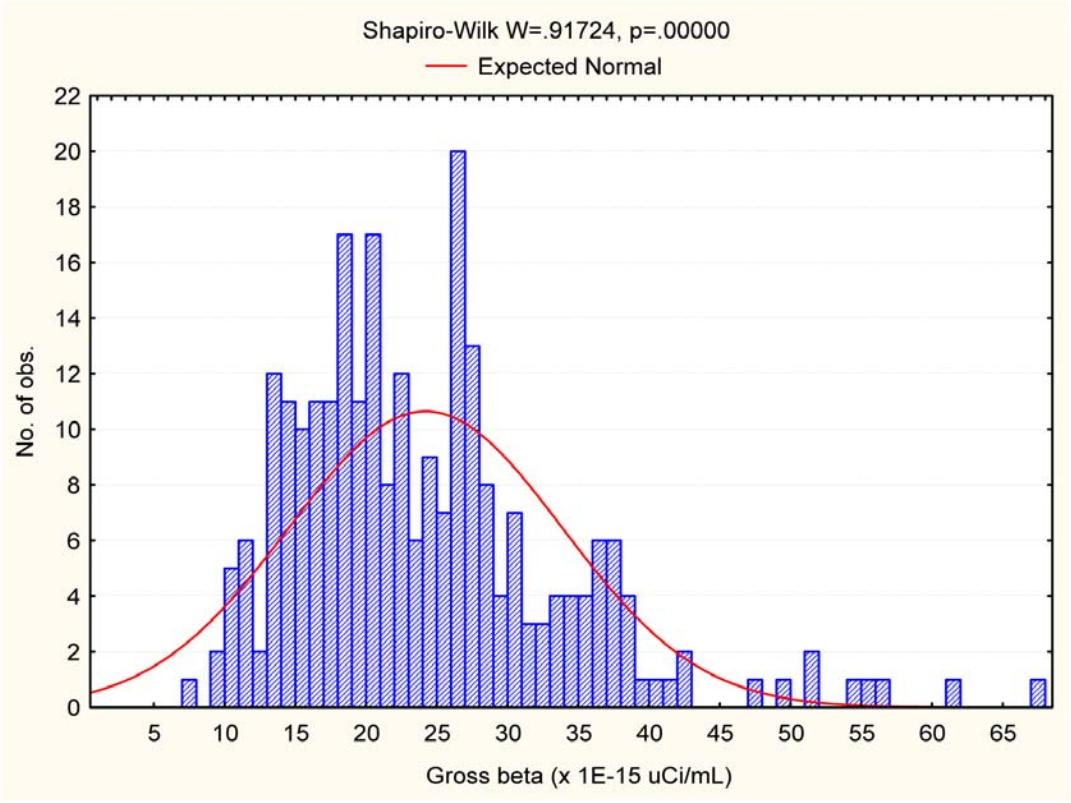

Figure B-2. Test of normality for Arco gross beta data.

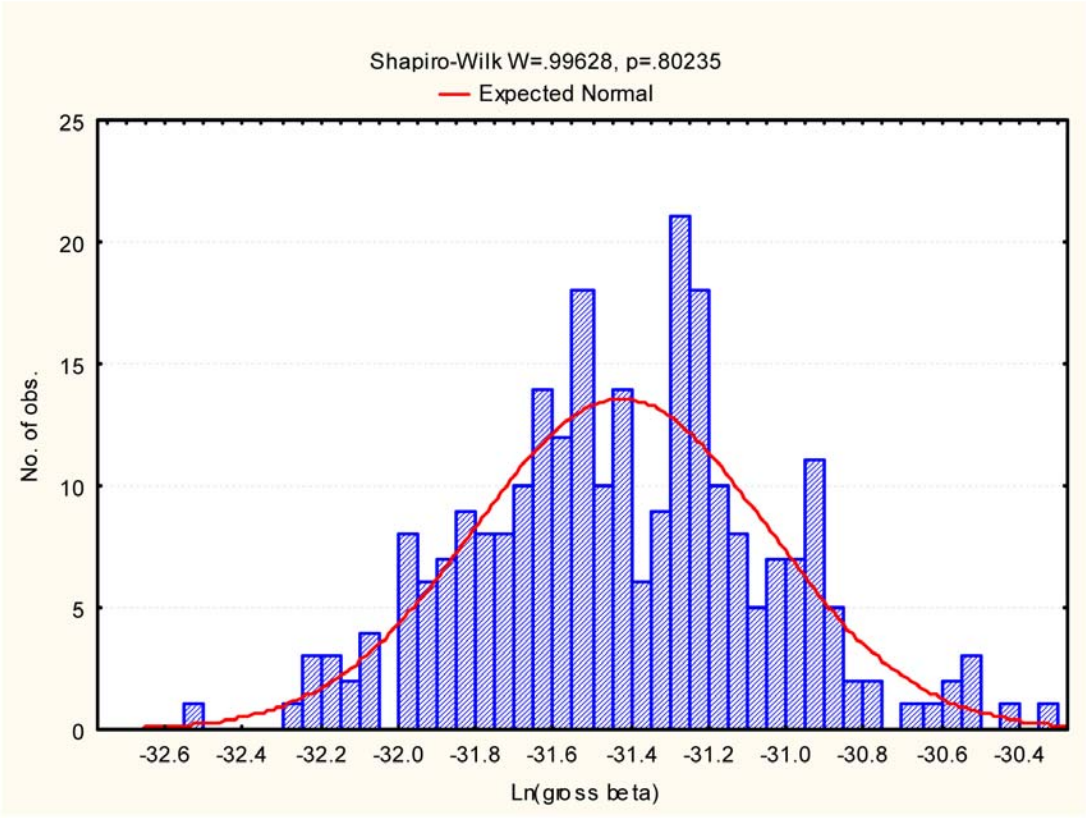

Figure B-3. Test of log normality for Arco gross beta.

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

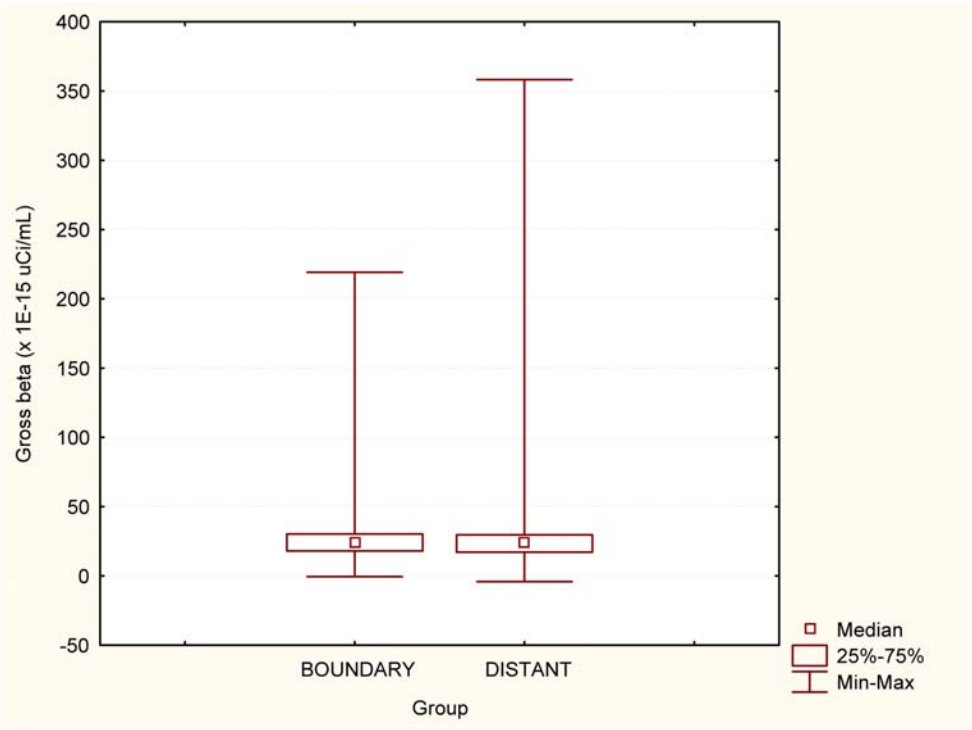

Figure B-4. Box plot of gross beta data from boundary and distant locations.

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.

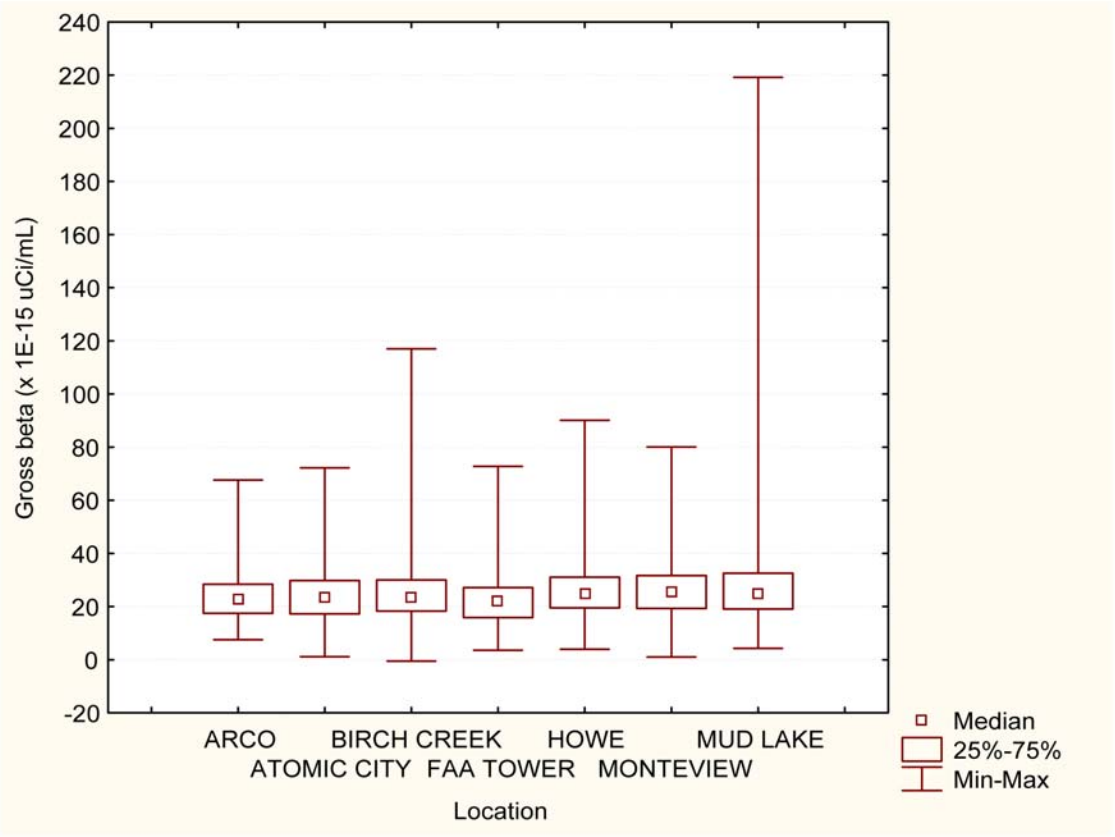

Figure B-5. Box plot of gross beta data for each boundary location.

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.

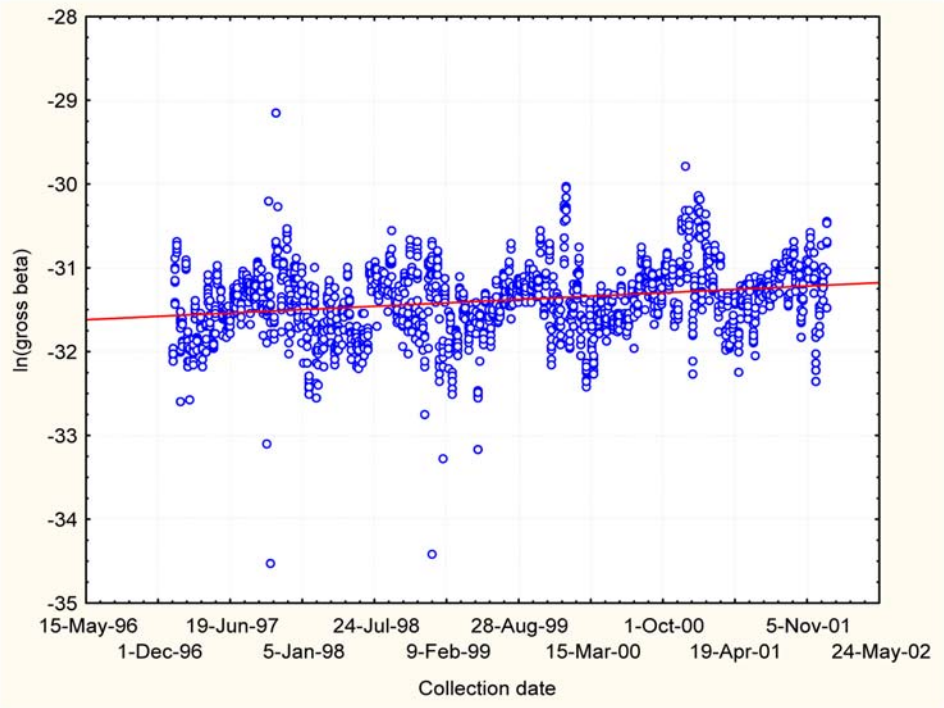

Figure B-6. Scatter plot and regression line for ln(gross beta) from boundary locations.

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.

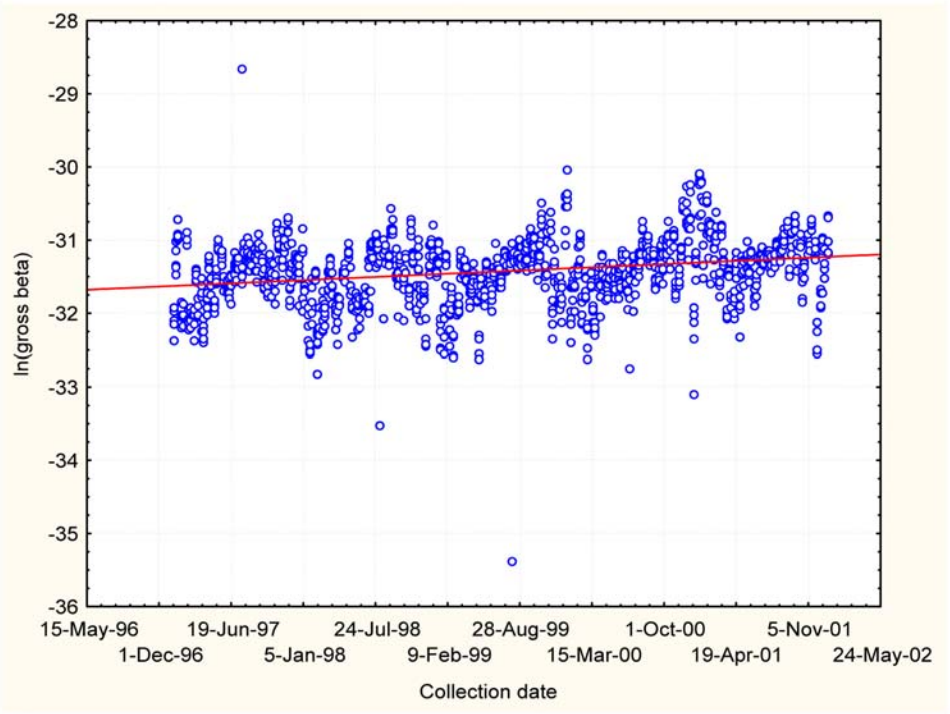

Figure B-7. Scatter plot and regression line for ln(gross beta) from distant locations.

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.

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Appendix C - U.S. Geological Survey 2003 INEEL Publication Abstracts

C. Martin - S. M. Stoller Corporation
L. Knobel - United States Geological Survey

Field Methods and Quality-Assurance Plan for Quality-Of-Water Activities, U.S. Geological Survey, Idaho National Engineering and Environmental Laboratory, Idaho *(Bartholomay et. al. 2003)*

Water-quality activities at the Idaho National Engineering and Environmental Laboratory (INEEL) Project Office are part of the U.S. Geological Survey's (USGS) Water Resources Division mission of appraising the quantity and quality of the Nation's water resources. The activities are conducted in cooperation with the U.S. Department of Energy's (DOE) Idaho Operations Office and the U.S. Environment Protection Agency, Region 10. Results of the water-quality investigations are presented in various USGS publications or in referenced scientific journals. The results of the studies are highly regarded and are used with confidence by researchers, regulatory and managerial agencies, and interested civic groups.

In its broadest sense, quality assurance refers to doing the job right, the first time. It includes the functions of planning for products, review and acceptance of the products, and an audit designed to evaluate the system that produces the product. Quality assurance and quality control differ in that quality control ensures that things are done correctly given the "state-of-the-art" technology, and quality assurance ensures that quality control is maintained within specified limits.

Stage-Discharge Relations for Selected Culverts and Bridges in the Big Lost River Flood Plain at the Idaho National Engineering and Environmental Laboratory, Idaho *(Berenbrock and Doyle 2003)*

Information is needed by the DOE at the INEEL to determine the extent and severity of potential flooding at facilities along the Big Lost River. Two computer programs (the Culvert Analysis Program [CAP] and the HEC-RAS model) were used to define stage-discharge relations for 31 culverts and two bridge sites in a ten-mile reach of the river. These relations can be used to improve surface-water flow models to evaluate potential flooding.

Relations between headwater, tailwater, and discharge through each structure were unique. Discharge through the culverts, as computed by the CAP, ranged from about nine cubic feet per second to as much discharge as could be conveyed. Tailwater elevations ranged from about 0 to 30 feet above the outlet elevation. Discharge through the bridges, as computed by the HEC-RAS model, ranged from nearly 0 to 7000 cubic feet per second, and tailwater elevations ranged from nearly 0 to 30 feet above the stream bed on the downstream cross section of each bridge.

Stage-discharge relations provided in lookup tables in this report can be incorporated into numerical surface-water flow models to simulate the effects of hydraulic structures on flood flows. One limitation of the CAP and HEC-RAS models is that changes in flow conditions, such as obstruction by sediment and debris, are not simulated. If flow through a hydraulic structure is

obstructed by sediment or debris, then model-simulated discharges through the structure might be greater than would be experienced under actual conditions.

Reevaluation of Background Iodine-129 Concentrations in Water From the Eastern Snake River Plain Aquifer, Idaho, 2003 *(Cecil, et. al. 2003)*

Background concentrations of iodine-129 (^{129}I, half-life = 15.7 million years) resulting from natural production in the earth's atmosphere, in situ production in the earth by spontaneous fission of uranium-238 (^{238}U), and fallout from nuclear-weapons tests conducted in the 1950s and 1960s were reevaluated on the basis of 52 analyses of ground- and surface-water samples collected from the Eastern Snake River Plain (ESRP) in southeastern Idaho. The background concentration estimated using the results of a subset of 30 groundwater samples analyzed in this reevaluation is 5.4 attocuries per liter (aCi/L; 1 aCi = 10^{-18} curies) and the 95-percent nonparametric confidence interval is 5.2 to 10.0 aCi/L. In a previous study, a background ^{129}I concentration was estimated on the basis of analyses of water samples from 16 sites on, or tributary to, the ESRP. At the 99-percent confidence level, background concentrations of ^{129}I in that study were less than or equal to 8.2 aCi/L.

During 1993 and 1994, 34 water samples from 32 additional sites were analyzed for ^{129}I to better establish the background concentrations in surface and ground water from the ESRP that is presumed to be unaffected by waste-disposal practices at the INEEL. Surface water contained larger ^{129}I concentrations than water from springs and wells contained. Because surface water is more likely to be affected by anthropogenic fallout and evapotranspiration, background ^{129}I concentrations were estimated in the current research using the laboratory results of groundwater samples that were assumed to be unaffected by INEEL disposal practices.

Estimating the Magnitude of the 100-Year Peak Flow in the Big Lost River at the Idaho National Engineering And Environmental Laboratory, Idaho *(Hortness and Rousseau 2003)*

Accurate estimates of peak flows in the Big Lost River at the INEEL are needed to assist planners and managers with evaluating possible effects of flooding on facilities at the INEEL. A large difference of 4350 cubic feet per second (ft^3/s) between two previous estimates of the magnitude of the 100-year peak flow in the Big Lost River near the western boundary of the INEEL prompted the present study.

Regression models that compared annual peak flows and attenuation of annual peak flows between successive gaging stations for the same flow event were used to estimate the magnitude of the 100-year peak flow in the Big Lost River. The 100-year peak flow of 4790 ft^3/s at the Howell Ranch gaging station was used as the starting point for this analysis. This estimate was determined by using a three-parameter log-Pearson Type III distribution as outlined in "Guidelines for Determining Flood Flow Frequency" (Bulletin 17B by the Interagency Advisory Committee on Water Data).

The regression models indicated that, in the reach of the Big Lost River between Howell Ranch and Mackay Reservoir, downstream peak flows are lower than upstream peak flows. Peak-flow attenuation values for this reach of the river decreased nonlinearly as the magnitude of the peak flow increased. Extrapolation of the trend resulted in an attenuation estimate of 13 percent for this reach relative to the 100-year peak flow at the Howell Ranch gaging station.

In the lower reach of the Big Lost River between Mackay Reservoir and Arco, downstream peak flows are also lower than upstream peak flows. However, in contrast to the upper reach, peak-flow attenuation values decreased linearly as the magnitude of the peak flow increased. Extrapolation of the data indicated that peak-flow attenuations in this reach of the river approach zero for flows approaching the 100-year peak flow estimate immediately upstream and downstream from Mackay Reservoir.

A regression model of annual maximum daily mean flows between Arco and the INEEL diversion dam indicated that the attenuation values in this reach of the river are nearly the same for all flows of record. Extrapolation of the linear regression of these values resulted in an attenuation estimate of 10 percent. Seepage measurements made during 1951-1953 also resulted in a loss estimate of approximately 10 percent. This attenuation value, combined with the values from analyses of the upstream reaches, resulted in an estimate of the 100-year peak flow for the Big Lost River immediately upstream from the INEEL diversion dam of 3750 ft^3/s; therefore, the upper and lower 95-percent confidence limits were 6250 and 1300 ft^3/s, respectively.

Localized rainfall, even of high intensity, is not likely to produce large peak flows at the INEEL because of high loss rates (infiltration, bank storage, and channel storage) along much of the stream channel. The relatively short flow durations resulting from rainstorms historically have not provided sufficient volumes of water to satisfy local storage demands (bank and channel storage). Only after these storage demands are met do the loss rates decrease enough for significant peak flows to reach the INEEL site.

An uncertain component of the present analysis is the effect of seismic activity on the 100-year peak-flow estimate. Analysis of the effect of the magnitude 7.3 Borah Peak earthquake in 1983 on normal flow conditions in the Big Lost River suggests that the joint occurrence of a large earthquake and a 100-year peak flow could significantly increase the magnitude of the peak flow at the INEEL.

Measurement of Sedimentary Interbed Hydraulic Properties and Their Hydrologic Influence Near the Idaho Nuclear Technology and Engineering Center at the Idaho National Engineering and Environmental Laboratory *(Perkins 2003)*

Disposal of wastewater to unlined infiltration ponds near the Idaho Nuclear Technology and Engineering Center (INTEC), formerly known as the Idaho Chemical Processing Plant, at the INEEL has resulted in the formation of perched water bodies in the unsaturated zone (Cecil et al., 1991). The unsaturated zone at the INEEL comprises numerous basalt flows interbedded with thinner layers of coarse- to fine-grained sediments and perched groundwater zones exist at various depths associated with massive basalts, basalt-flow contacts, sedimentary interbeds, and sediment-basalt contacts. Perched groundwater is believed to result from large infiltration events such as seasonal flow in the Big Lost River and wastewater discharge to infiltration ponds. Evidence from a large-scale tracer experiment conducted in 1999 near the Radioactive Waste Management Complex, approximately 13 km from the INTEC, indicates that rapid lateral flow of perched water in the unsaturated zone may be an important factor in contaminant transport at the INEEL (Nimmo et al., 2002). Because sedimentary interbeds, and possibly baked-zone alterations at sediment-basalt contacts (Cecil et al., 1991) play an important role in the generation of perched water, it is important to assess the hydraulic properties of these units.

In September 2001, the Vadose Zone Research Park (VZRP) was established near the INTEC for study of the movement of water and solutes through the unsaturated zone. Two new percolation ponds at the VZRP receive about a million gallons of equipment-cooling water each day. The subsurface at this location is much more complex than that near the RWMC and little is known about the hydraulic properties of the sedimentary interbeds. As part of an ongoing sedimentary interbed characterization project, hydraulic properties, including saturated and unsaturated hydraulic conductivity and water retention, were measured on 12 cores recovered from two interbeds from borehole ICPP-SCI-V-215 in the vicinity of the INTEC, which was drilled by the U.S. Geological Survey (USGS) as a part of the development of the VZRP.

In general, the upper interbed examined in this study exhibits hydraulic properties consistent with higher clay contents than those of the lower interbed and also contains low-permeability layers that could enhance perching. These interbeds, which are separated by a relatively thin basalt flow, also exhibit distinctly different baked-zone features that are apparent from visual and scanning electron microscope examination. Heat exposure from overlying lava flows produces baked zones at the tops of interbeds due to the dehydration and oxidation of iron-rich minerals. The baked zone of the upper interbed is macroporous, containing highly cemented aggregates, while the baked zone of the lower interbed contains highly-oxidized, mainly unconsolidated sand. Baked-zone sediments from both interbeds, although texturally and structurally different, have comparable, relatively high saturated hydraulic conductivities.

In order to quantify the effect of the macro-porous structure of the baked material in the upper interbed, water retention was measured on two undisturbed cores in addition to the 12 cores used for hydraulic property measurements. Water retention measurements were performed on the two undisturbed cores, the cores were air dried, disaggregated, and repacked for additional measurements in order to identify any structural effects.

A Conceptual Model of Flow in the Snake River Plain Aquifer at and near the Idaho National Engineering and Environmental Laboratory, with Implications for Contaminant Transport *(Rousseau et al. 2003)*

A 50-year history of waste disposal associated with nuclear-reactor research and nuclear-fuel processing at the INEEL in southeast Idaho has resulted in measurable concentrations of radioactive and chemical contaminants in the Snake River Plain Aquifer. A thorough understanding of the movement and fate of these contaminants in the subsurface is needed by the DOE and the State of Idaho to minimize health and safety risks, and to plan effectively for remediation activities. To achieve this understanding, a conceptual model has been developed as the foundation for numerical models that simulate flow and contaminant transport in the aquifer.

Volcanology, Geochemistry, and Stratigraphy of the F Basalt Flow Group, Eastern Snake River Plain, Idaho *(Scarberry 2003)*

The ESRP volcanic basin in southeast Idaho is underlain by approximately 1 km of dominantly Pliocene-Quaternary olivine tholeiite basalt and interbedded sediment. The F basalt flow group is a stratigraphic marker bed near the top of the regional aquifer and underlies a portion of the INEEL, where radiochemical and chemical wastewater has been discharged to the aquifer. This flow group erupted during an unusual, short-lived period of reversed magnetic

polarity approximately 565 ka, probably in less than or equal to 200 years. This study uses new petrographic, geochemical, and isotopic analyses of the flow group to refine the subsurface stratigraphy. This sequence of lava flows is uneroded, apparently comagmatic, and is observed in drill core over an area of approximately 75 km^2 between approximately 120 to 220 m depth. Lithologic logs for six sections of F flows in drill-core reveal textural discordance within the sequence and that the thickest (approximately 55 m) lie in the southwest part of the study region and contain the upper portion (approximately 15 to 23 m) that is texturally coarser and significantly enriched in incompatible elements relative to the remainder of the sequence. In addition, lava flows in the lower sequence have lower initial strontium-87/strontium-86 isotopic ratios than the upper flows (0.7068 versus 0.7071) while all exhibit similar neodymium-143/neodymium-144 isotope ratios (approximately 0.5124; $epsilon_{Nd}$ approximately -4.3). Petrographic, isotopic, and geochemical features support correlations between sampled sections and define two flow groups within the F sequence. Variations in the texture and stratigraphy of the two flow groups indicate that they were derived from multiple coeval eruptive centers aligned along a common rift or fissure system, and not from a central vent complex. The stratigraphy of the entire F sequence is consistent with formation by constructional volcanic processes and is unaffected by post depositional structural offsets.

Geochemical Modeling of the Little Lost River and Birch Creek Drainage Basins *(Swanson 2003)*

The USGS and Idaho State University, in cooperation with the DOE, are conducting studies to describe the chemical character of groundwater that moves as underflow from drainage basins into the SRPA system at, and near, the INEEL and the effects of these recharge waters on the geochemistry of the SRPA system. Each of these recharge waters has a hydrochemical character related to geochemical processes, especially water-rock interactions that occur during migration to the SRPA. Results of these studies will benefit ongoing and planned geochemical modeling of the SRPA at the INEEL by providing model input on the hydrochemical character of water from each drainage basin.

For this study, water samples were collected from six wells and two surface sites from the Little Lost River drainage basin during 2000. The samples were analyzed for selected inorganic constituents, dissolved organic carbon, stable isotopes, tritium, and selected gross measurements of radioactivity. Four duplicate samples were collected for quality assurance. Results show that most water from the Little Lost River drainage basin has a calcium-magnesium bicarbonate character. Two wells had elevated chloride concentrations. The computer code NETPATH was used to evaluate geochemical mass-balance reactions in the Little Lost River basin. Attempts to model water to the most downgradient wells, Mays and Ruby Farms, were unsuccessful. On closer inspection of these two wells, it was determined that they were much deeper than the other sample locations and that they may have chemical interaction with the SRPA. It was also apparent that another of the sample locations had contamination due to local agricultural practices. One well had concentrations that mirrored Little Lost River water. Of all the sites sampled, only two upgradient wells had water representative of the system. Mass-balance modeling of the system identified that the dissolution of dolomite was the major reaction taking place in the system. Nitrification of ammonium ion to nitrate and dissolution of inorganic fertilizers also are chemical processes that occur in the system. To obtain a better geochemical

model for the Little Lost River drainage basin more sites need to be sampled, paying close attention to the type of well that is being sampled and the agricultural practices in the surrounding area.

Water samples were collected from five wells and one surface site from the Birch Creek drainage basin during 2000. The samples were analyzed for selected inorganic constituents, dissolved organic carbon, stable isotopes, tritium, and selected gross measurements of radioactivity. Four duplicate samples were collected for quality assurance. Results show that most water from the Birch Creek drainage basin has a calcium-magnesium bicarbonate character.

The Birch Creek Valley can be roughly divided into three hydrologic areas. The northern part of the valley, where groundwater is forced to the surface by a basalt barrier and the sampling sites are either surface water or shallow wells. This area has a water chemistry that can be characterized by simple evaporation models, simple calcite-carbon dioxide models, or by complex models involving carbonate and silicate minerals. The central part of the valley is filled by sedimentary material and the sampling sites are wells that are deeper than the northern part. This area has a water chemistry that can be characterized by simple calcite-dolomite-carbon dioxide models. The southern part is where the groundwater enters the SRPA. In this area, the sampling sites are wells with depths and water levels much deeper than the northern and central parts of the Birch Creek Valley. The calcium and carbon water chemistry in this area can be characterized by a simple calcite-carbon dioxide model, but more complex calcite-silicate models do a better job of accounting for mass transfer in these areas.

Throughout the system, calcite precipitates if it is an active phase. Carbon dioxide can either precipitate (outgas) or dissolve depending on the partial pressure of carbon dioxide in water from the modeled sites. Dolomite was only an active phase in models from the central part of the system. Generally, the entire system can be modeled with either evaporative models, carbonate models, or carbonate-silicate models. Both of the latter types of models generally have a significant amount of calcite precipitation relative to the mass transfer to and from the other active phases. The precipitation of calcite in the more complex models is consistent with the amount of calcite precipitated in the simpler models. This suggests that although the simpler models easily predict calcium and carbon concentration in Birch Creek Valley ground and surface water, silicate mineral based models are required to account for other constituents. The amount of mass transfer to and from the silicate mineral phases is generally small compared to the carbonate phases. It appears that the water chemistry of USGS 126B is representative of water recharging the SRPA by means of underflow from the Birch Creek Valley.

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, 2001 *(Twining et al. 2003)*

The USGS and the Idaho Department of Water Resources, in cooperation with the DOE, sampled water from 16 of 18 sites as part of the fifth round of a long-term project to monitor water quality of the SRPA from the southern boundary of the INEEL to the Hagerman area. The samples were collected from eight irrigation wells, four domestic wells, two stock wells, one spring, and one public supply well and analyzed for selected radiochemical and chemical constituents. Two

sites were not sampled because one was decommissioned and the other was discontinued due to complications with a new well owner. Two quality assurance replicate samples were also collected and analyzed. Tritium analyses from 19 spring samples collected along the Snake River in the Twin Falls-Hagerman area also are presented within this report along with two replicate quality assurance samples.

None of the reported radiochemical or chemical constituent concentrations exceeded the established maximum contaminant levels for drinking water. Many of the radionuclide and inorganic constituent concentrations were greater than the respective minimum reporting levels. Most of the organic constituent concentrations were less than the minimum reporting levels.

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Appendix D - Onsite Dosimeter Measurements and Locations

D. Halford - S. M. Stoller Corporation

Table D-1. Environmental dosimeter measurements at Argonne National Laboratory West (2003).

Location	Exposure[a]
ANL 7	154 ± 11
ANL 8	128 ± 9
ANL 9	148 ± 10
ANL 10	127 ± 9
ANL 11	128 ± 9
ANL 12	124 ± 9
ANL 13	126 ± 9
ANL 14	122 ± 9
ANL 15	154 ± 11
ANL 16	151 ± 11
ANL 17	121 ± 8
ANL 18	149 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

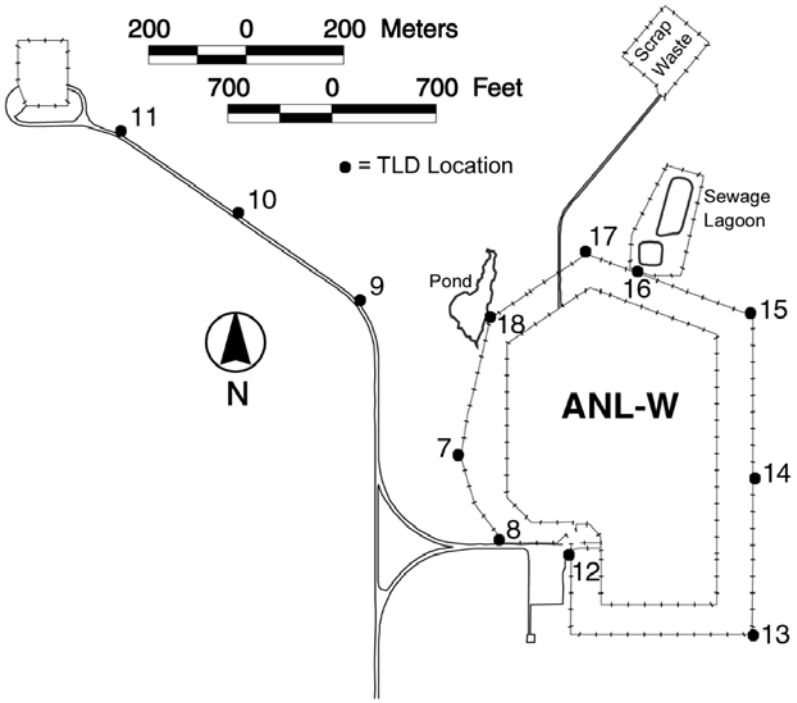

Figure D-1. Environmental dosimeter locations at Argonne National Laboratory West (2003).

Table D-2. Environmental dosimeter measurements at the Auxiliary Reactor Area (2003).

Location	Exposure[a]
ARA 1	148 ± 10
ARA 2	172 ± 12
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.

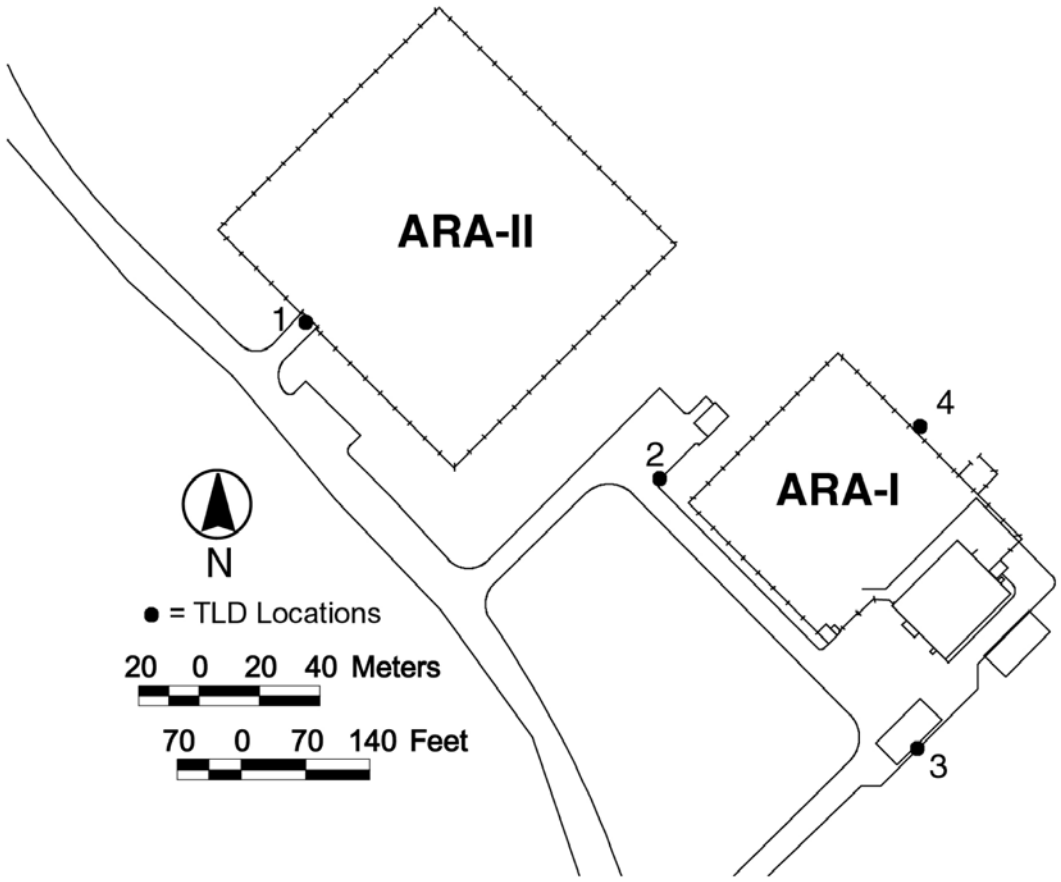

Figure D-2. Environmental dosimeter locations at Auxiliary Reactor Area (2003).

Table D-3. Environmental dosimeter measurements at the Central Facilities Area (2003).

Location	Exposure[a]
CFA 1	132 ± 9
CFA 2	118 ± 8
CFA 3	139 ± 10
CFA 4	124 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

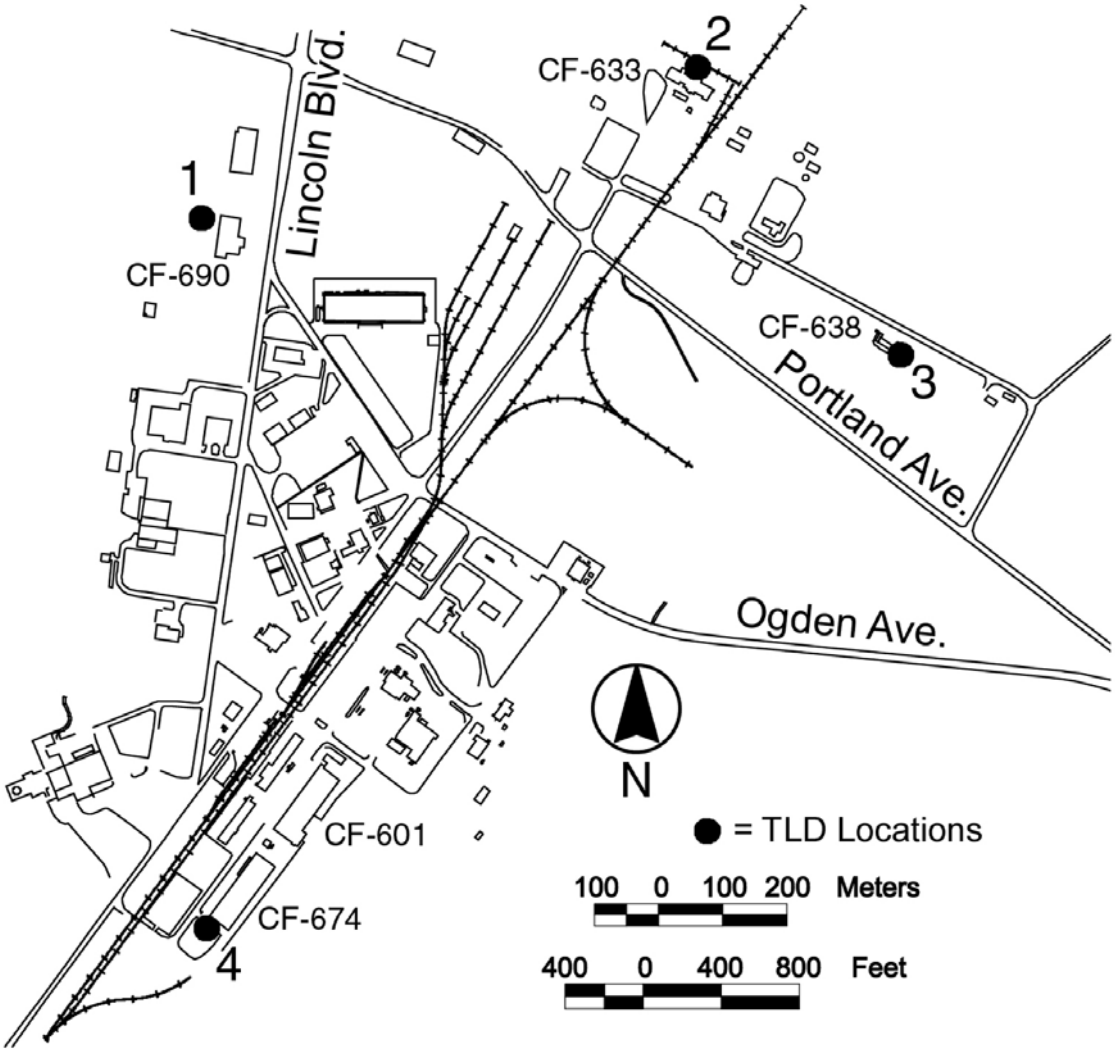

Figure D-3. Environmental dosimeter locations at Central Facilities Area (2003).

Table D-4. Environmental dosimeter measurements at the Idaho Nuclear Technology and Engineering Center (2003).

Location	Exposure[a]
INTEC 1	154 ± 11
INTEC 9	183 ± 13
INTEC 14	139 ± 10
INTEC 15	144 ± 10
INTEC 16	129 ± 9
INTEC 17	132 ± 9
INTEC 18	125[b]
INTEC 19	139 ± 10
INTEC 20	249 ± 17
INTEC 21	157 ± 11
INTEC 22	186 ± 13
INTEC 23	146 ± 10
INTEC 24	140 ± 10
INTEC 25	124 ± 9
INTEC 26	131 ± 9
TREE FARM 1	191 ± 13
TREE FARM 2	169[b]
TREE FARM 3	166 ± 12
TREE FARM 4	221 ± 15

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

b. Only spring data were collected. This number was doubled to reflect an annual exposure. No error associated with this exposure was determined.

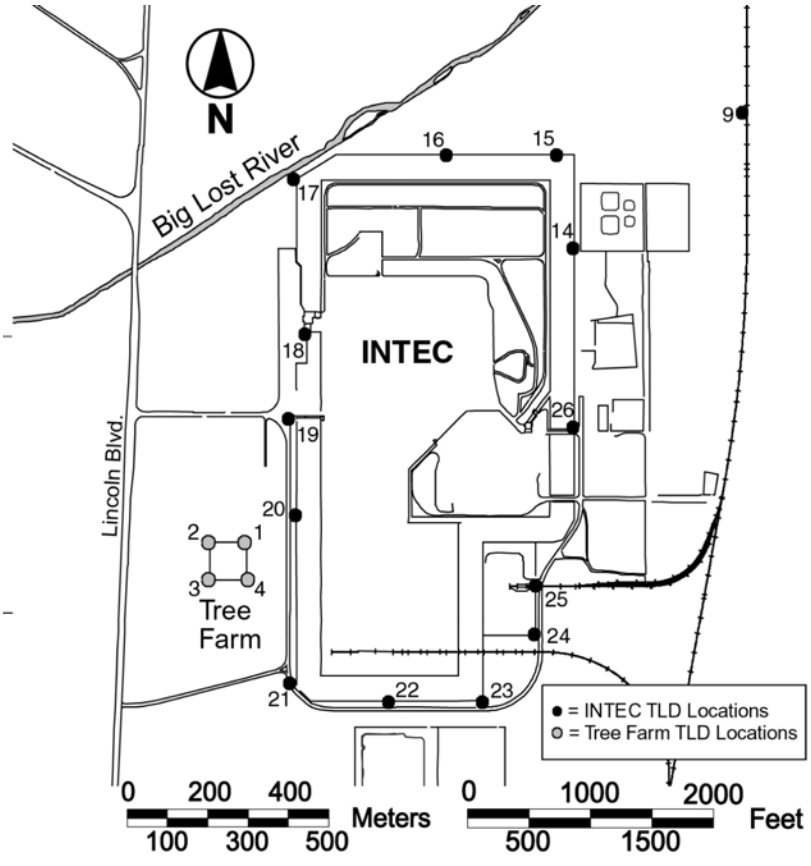

Figure D-4. Environmental dosimeter locations at Idaho Nuclear Technology and Engineering Center (2003).

Table D-5. Environmental dosimeter measurements at the Naval Reactors Facility (2003).

Location	Exposure[a]
NRF 4	131 ± 9
NRF 5	138 ± 10
NRF 11	132 ± 9
NRF 12	135 ± 9
NRF 13	133 ± 9
NRF 16	130 ± 9
NRF 17	136[b]
NRF 18	133 ± 9
NRF 19	135 ± 9
NRF 20	140 ± 10
NRF 21	147[b]

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Only spring data were collected. This number was doubled to reflect an annual exposure. No error associated with this exposure was determined.

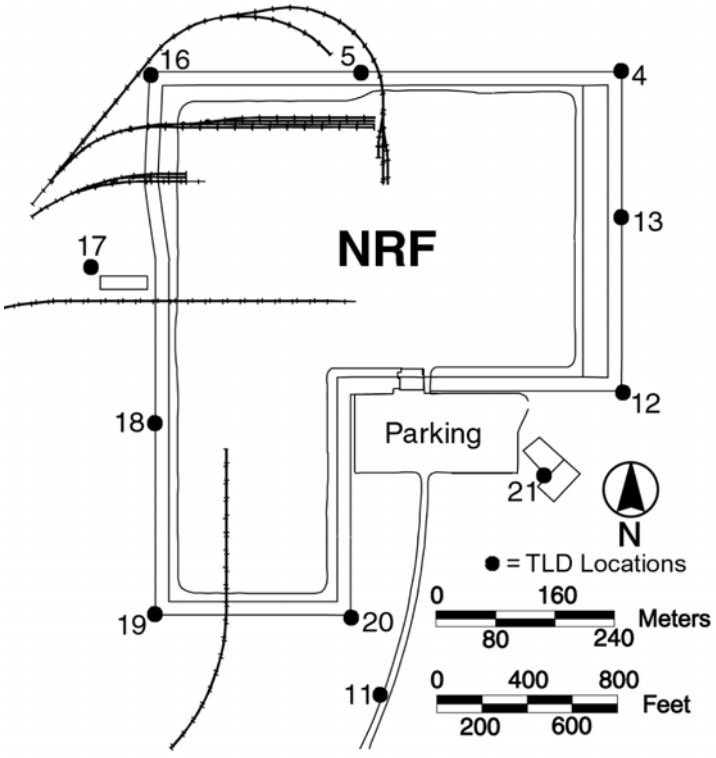

Figure D-5. Environmental dosimeters locations at Naval Reactors Facility (2003).

Table D-6. Environmental dosimeter measurements at the Power Burst Facility (2003).

Location	Exposure[a]
PBF/SPERT 1	133 ± 9
PBF/SPERT 2	128 ± 9
PBF/SPERT 3	134 ± 9
PBF/SPERT 4	149 ± 10
PBF/SPERT 5	138 ± 10
PBF/SPERT 6	141 ± 10
PBF/WERF1	125 ± 8
PBF/WERF2	110 ± 8
PBF/WERF3	123 ± 9
PBF/WERF4	129 ± 9
PBF/WERF5	125 ± 9
PBF/WERF6	133[b]
PBF/WERF7	131 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

b. Only spring data were collected. This number was doubled to reflect an annual exposure. No error associated with this exposure was determined.

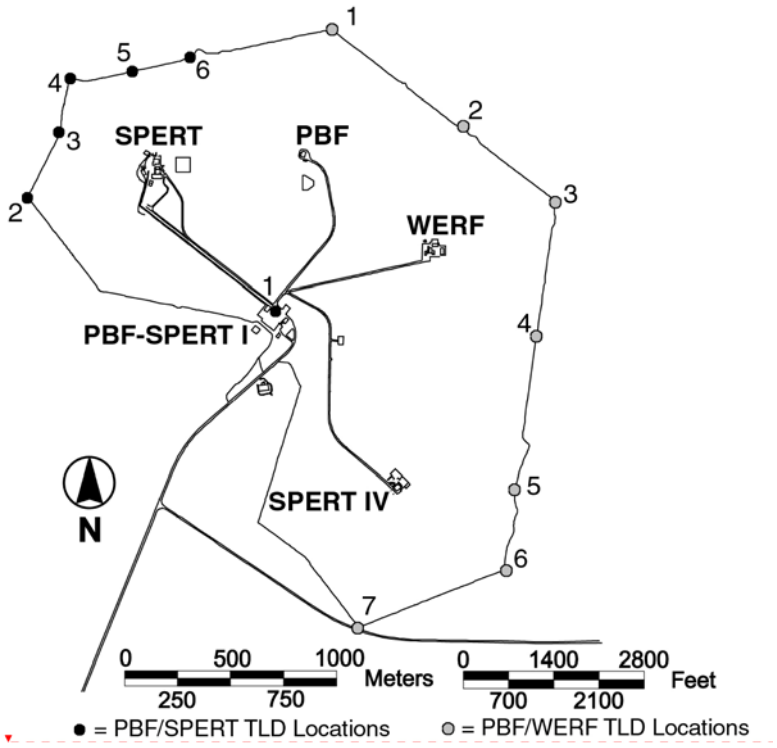

Figure D-6. Environmental dosimeter locations at Power Burst Facility (2003).

Table D-7. Environmental dosimeter measurements at the Radioactive Waste Management Complex (2003).

Location	Exposure[a]
RWMC 3a	138 ± 10
RWMC 5a	138 ± 10
RWMC 7a	147 ± 10
RWMC 9a	154 ± 11
RWMC 11a	148 ± 10
RWMC 13a	131 ± 9
RWMC15a	129 ± 9
RWMC 17a	128 ± 9
RWMC 19a	128 ± 9
RWMC 21a	140 ± 10
RWMC 23a	135 ± 9
RWMC 25a	147 ± 10
RWMC 27a	180 ± 12
RWMC 29a	193 ± 13
RWMC 31a	134 ± 10
RWMC 37a	127 ± 9
RWMC 39	136 ± 9
RWMC 40	143 ± 10
RWMC 41	318 ± 22
RWMC 42	140 ± 10
RWMC 43	125 ± 9
RWMC 45	131 ± 9
RWMC 46	139 ± 10
RWMC 47	122 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

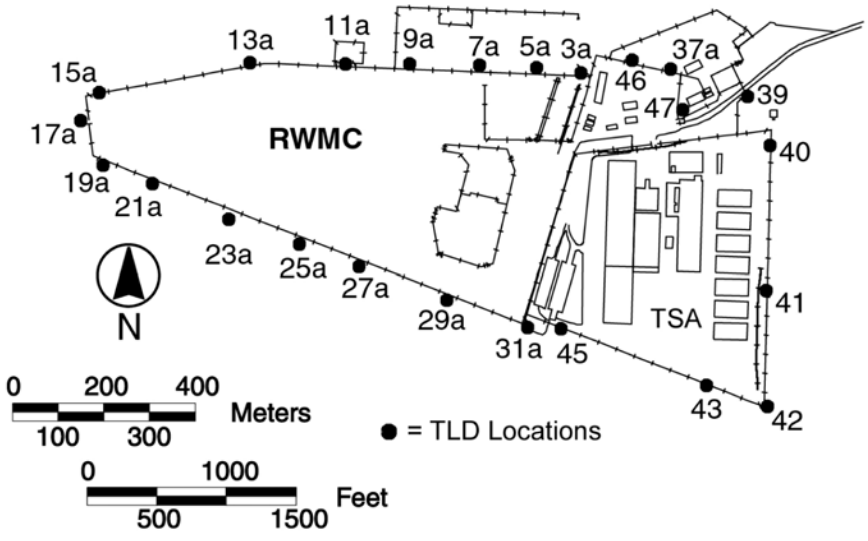

Figure D-7. Environmental dosimeter locations at Radioactive Waste Management Complex (2003).

Table D-8. Environmental dosimeter measurements at the Test Area North (2003).

Location	Exposure[a]
TAN/TSF 1	106 ± 7
TAN/TSF 2	126 ± 9
TAN/TSF 3	105 ± 7
TAN/TSF 4	119 ± 8
TAN/LOFT 1	125 ± 9
TAN/LOFT 2	137 ± 10
TAN/LOFT 3	107 ± 7
TAN/LOFT 4	113 ± 8
TAN/LOFT 5	118 ± 8
TAN/LOFT 6	136 ± 9
TAN/LOFT 7	137 ± 10
TAN/WRRTF1	118 ± 8
TAN/WRRTF2	112 ± 8
TAN/WRRTF3	No data
TAN/WRRTF4	108 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

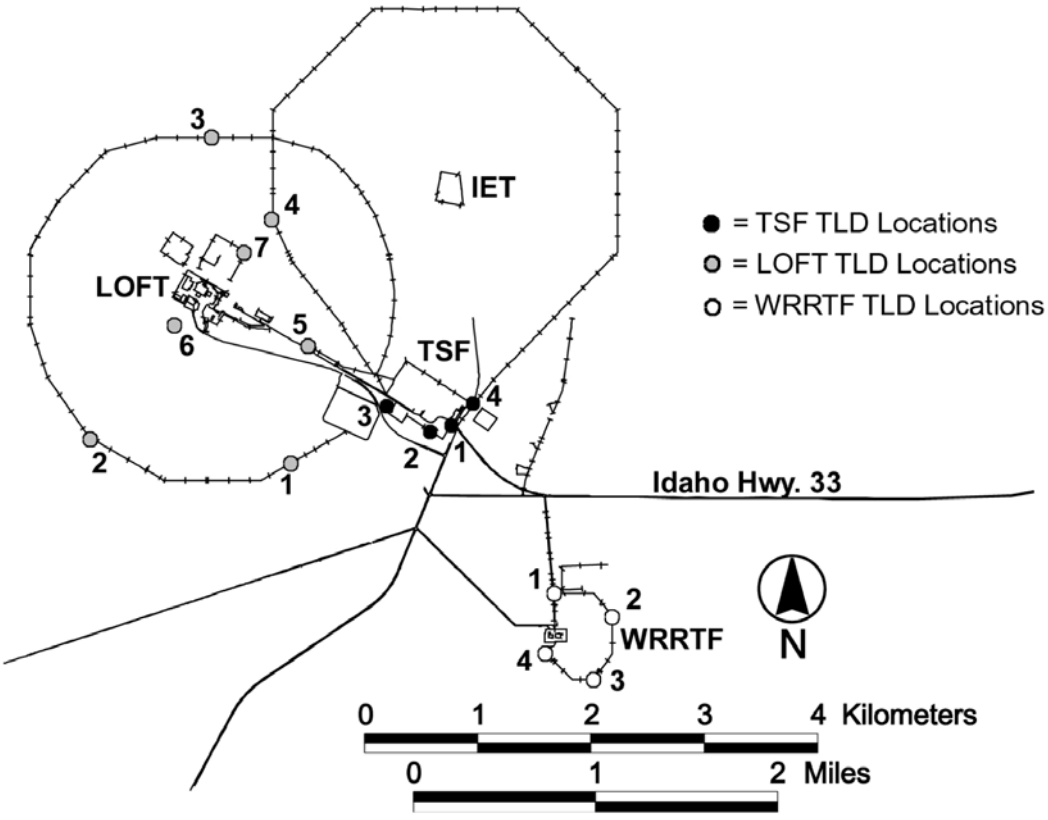

Figure D-8. Environmental dosimeter locations at Test Area North (2003).

Table D-9. Environmental dosimeter measurements at the Test Reactor Area (2003).

Location	Exposure[a]
TRA 1	159 ± 11
TRA 2	348 ± 25
TRA 3	323 ± 23
TRA 4	190 ± 13
TRA 5	156 ± 11
TRA 6	132 ± 9
TRA 7	132 ± 9
TRA 8	152 ± 11
TRA 9	139 ± 10
TRA10	141 ± 10
TRA11	151 ± 10
TRA12	153 ± 11
TRA13	148 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

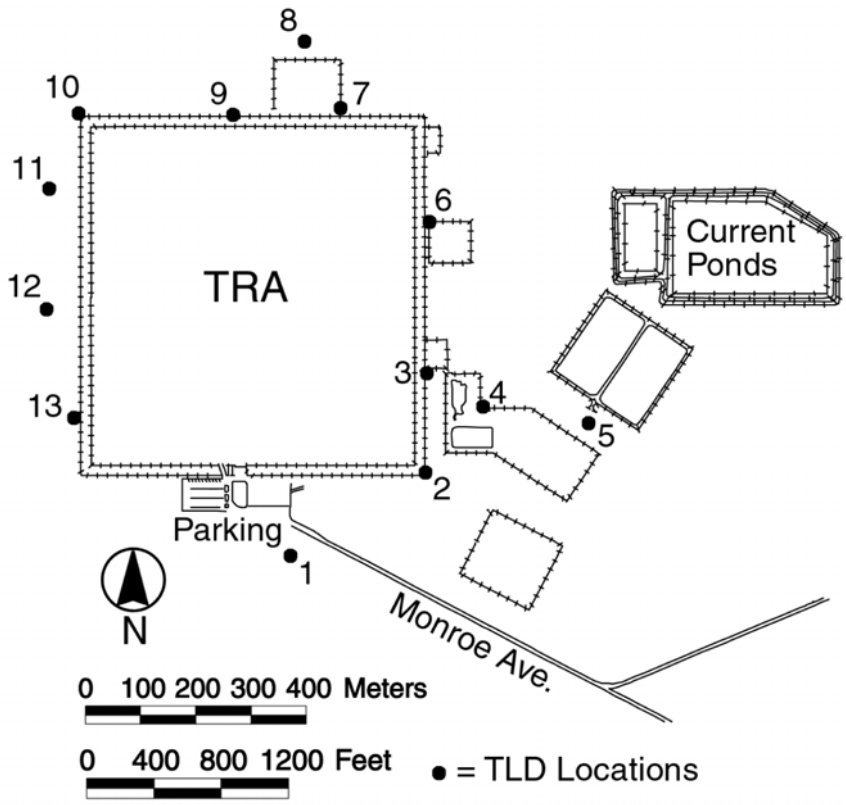

Figure D-9. Environmental dosimeter locations at Test Reactor Area (2003).

Table D-10. Environmental dosimeter measurements along Lincoln Blvd. and US Highway 20 (2003).

Location	Exposure[a]
LINCOLN BLVD 1	127 ± 9
LINCOLN BLVD 3	137 ± 10
LINCOLN BLVD 5	137 ± 10
LINCOLN BLVD 7	132 ± 9
LINCOLN BLVD 9	132 ± 9
LINCOLN BLVD 11	126 ± 9
LINCOLN BLVD 13	133 ± 9
LINCOLN BLVD 15	134 ± 9
LINCOLN BLVD 17	135 ± 9
LINCOLN BLVD 19	124 ± 8
LINCOLN BLVD 21	119 ± 8
LINCOLN BLVD 23	119 ± 8
LINCOLN BLVD 25	121 ± 8
HWY 26-266	127 ± 9
HWY 26-268	125 ± 9
HWY 26-270	124 ± 9
HWY 20-264	120 ± 8
HWY 20-266	112 ± 8
HWY 20-268	121 ± 8
HWY 20-270	123 ± 9
HWY 20-272	112 ± 8
HWY 20-274	103 ± 7
HWY 20-276	119 ± 8
EBR 1	119 [b]

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Only spring data were collected. This number was doubled to reflect an annual exposure. No error associated with this exposure was determined.

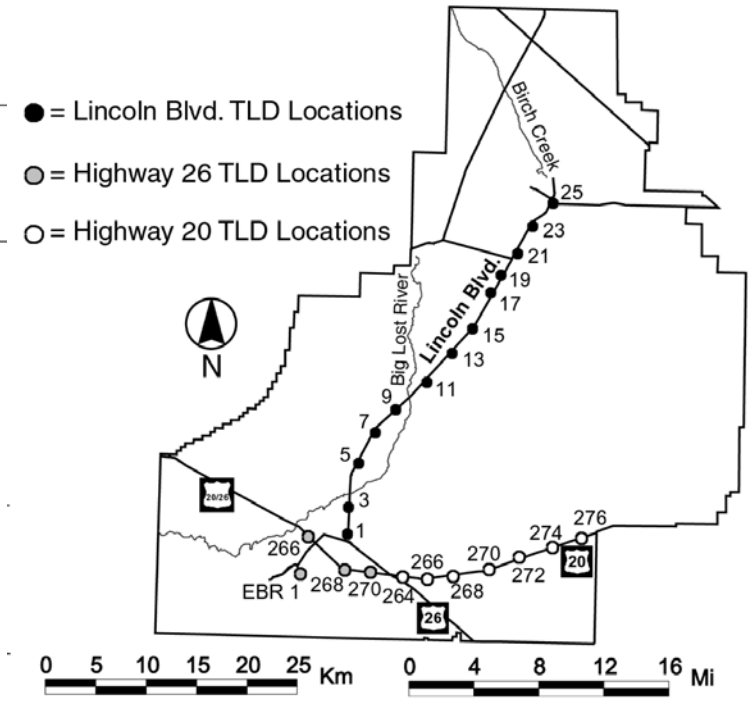

Figure D-10. Environmental dosimeter locations along Lincoln Blvd. and US Highway 20 (2003).

Appendix E - Glossary

M. Case, D. Halford, C. Martin - S. M. Stoller Corporation

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.