Chapter 1

Introduction

Oversight Program Mission and Environmental Surveillance Program

The mission of the state of Idaho's Idaho National Engineering and Environmental Laboratory Oversight Program (INEEL OP) is to provide the people of Idaho with independent, factual information about the INEEL, to help ensure the safety of the citizens of Idaho through the protection of public health and the environment, and to provide statewide radiological expertise. In partial fulfillment of this mission, the INEEL OP developed an Environmental Surveillance Program (ESP) with the following objectives:

- Maintain an independent environmental surveillance program designed to verify and supplement U.S. Department of Energy (DOE) surveillance programs.
- Provide the citizens of Idaho with information that has been independently evaluated to enable them to reach informed conclusions regarding the potential impacts of present and future DOE activities in Idaho.

This report documents the 2003 findings, developments, and conclusions of the INEEL OP ESP.

This annual report is intended to address the question: What is the impact of the INEEL on public health and the environment? The information provided herein represents the surveillance data resulting from environmental measurements made by the state of Idaho's INEEL OP on and around the INEEL during 2003.

The purpose of the INEEL OP ESP is to verify and selectively supplement surveillance information gathered by other surveillance programs, including the U.S. Geological Survey (USGS) and DOE-associated programs conducted by Bechtel BWXT Idaho, LLC (BBWI), Argonne National Laboratory-West (ANL-W), Bechtel-Bettis Naval Reactors Facility (NRF), and the Environmental Surveillance Education and Research Program (ESER).

Each of these organizations performs monitoring tasks of defined scope; collectively, these programs gather data on a broad variety of media. To substantiate and augment the results reported by these surveillance programs, the INEEL OP measures external gamma radiation and samples air, precipitation, surface water, groundwater, soil, and milk at a number of strategically selected sites. The INEEL OP maintains monitoring locations separate from the other monitoring organizations to compile independent measurement results, conduct autonomous evaluations of results, and analyze data trends. Also, the INEEL OP collects environmental samples throughout the year at many of the same sites and when possible, at the same time as the other surveillance programs. The independence of both the analytical data is preserved by the INEEL OP's contracting the analytical services of two laboratories not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The INEEL OP's annual findings, developments, and conclusions are presented in the following sections:

Environmental Surveillance Program Scope and Affiliations:

This section includes a descriptive outline of the full scope of the INEEL OP's ESP, including monitoring locations, instrumentation, methodologies and interprogram relationships between the INEEL OP, DOE, and other organizations.

Air, Terrestrial, Water, Verification Water, and External Radiation Monitoring Results:

This section includes individual chapters containing the 2003 data for each media of the INEEL OP’s surveillance network; discussions of identifiable trends; comparisons of 2003 data to previously collected data; and comparisons of INEEL OP results to those reported by DOE and other surveillance programs.

Environmental Surveillance Program’s Quality Assurance (QA) Assessment:

Section includes summary of QA activities for the year including any corrective actions identified and taken.

Appendices:

Addenda on specific topics addressed in the preceding sections:

Appendix A--initial development and design of the INEEL OP ESP.

Appendix B--glossary of technical terms and units used in this report.

Analytical results are available in either electronic or printed format. They can be downloaded from the INEEL Oversight Program's website at: http://www.oversight.state.id.us, or requested by contacting 1-800-232-4635, or:

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INEEL Oversight Program
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Chapter 2

Environmental Surveillance Program Scope and Affiliations

INEEL Oversight Program Environmental Surveillance Program History and Legislative Authority

The INEEL OP was created when there was growing concern about environmental contamination from activities at DOE facilities. In the late 1980s, the U.S. Secretary of Energy proposed an oversight role for states hosting these DOE facilities. According to this proposal, states would receive funding and information that would enable them to independently assess environmental conditions and activities at DOE facilities. In 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL. In May 1990, the state and DOE signed a five-year Environmental Oversight and Monitoring Agreement. This agreement, which has subsequently been renewed for two additional, five-year periods, funded the state's INEEL OP and set forth the following responsibilities:

- Secure independent data and information regarding DOE activities in Idaho;
- Scientifically evaluate information on INEEL impacts to the public and environment; and
- Independently report conclusions to the people of Idaho.

The INEEL Oversight Program (INEEL OP)

The INEEL OP's environmental surveillance network on and around the INEEL generates data that can be used to verify and supplement the results reported by Bechtel Bettis, BBWI, ANL-W, and ESER, as well as results published by the USGS. Analysis results for 2003 are available in INEEL OP's quarterly reports.

The scope of the INEEL OP's network has expanded as goals and objectives for the program have evolved, as described in the history of the network's design and development provided in **Appendix A**.

Currently, the INEEL OP monitors multiple environmental media which have been or potentially could be contaminated by activities at the INEEL, including air, ambient external gamma radiation, soil, milk, surface water, and groundwater.

Independent sampling is performed at selected locations. As summarized in **Table 2-1**, samples collected from these locations are routinely analyzed for a variety of constituents, and the analytical results compiled from this data form an independent base of scientific findings that can be used to verify results reported by DOE and other surveillance programs. To maintain the independent status of INEEL OP results, the INEEL OP contracts analytical services from two laboratories which are not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The ISU EML is the primary provider of radiological analytical services to the INEEL OP. Located in the Physics Department of the university, the laboratory performs analyses that include screening for gross alpha and gross beta radioactivity, gamma spectroscopy, liquid scintillation counting for tritium, and analysis for technetium-99 using Empore Selective Ion filter disks. Environmental samples requiring radiochemical analyses or other specific analyses are contracted out to other laboratories by the ISU EML. The ISU EML is also involved in other aspects of the INEEL OP ESP, including conducting applied research, providing technical guidance, assisting with program design, and providing student interns who participate in field sampling and data analysis.

The IBL is the primary provider for the non-radiological analyses of INEEL OP surface water and groundwater samples. For these samples, the laboratory supplies results on a suite of nonradiological analytes, including common ions, trace metals, nutrients, and volatile organic compounds (VOCs).

Each laboratory maintains an internal quality control program to ensure consistency and accuracy, and to provide a means of assessing the quality of the data reported. Should a laboratory note a concern that could potentially affect the quality of the data or during review by INEEL OP, the INEEL OP may assign a data qualifier to the analytical results for a particular sample, depending on the severity of the problem. During data validation by the INEEL OP, an analytical

result may be rejected or accepted as an estimate, in accordance with protocols developed by the EPA.

Table 2-1. INEEL OP Environmental Surveillance Program (ESP) summary, 2003.

Media Sampled Type of Analysis		Number of Air Locations and Frequency[a]			Minimum Detectable Quantities
		Onsite	Boundary	Offsite	
Air					
Dry Particulate (PM_{10} Samplers)					
	Alpha	-	2 W	1 W	0.001 pCi/m^3
	Beta	-	2 W	1 W	0.001 pCi/m^3
	Gamma	-	2 Q[b]	1 Q[b]	0.003 pCi/m^3 (Cs-137)
	Radiochemical[c]	-	2 A[b]	1 A[b]	Varies
Dry Particulate (TSP Samplers)					
	Alpha	4W	4W	3W	0.001 pCi/m^3
	Beta	4W	4W	3W	0.001 pCi/m^3
	Gamma	4Q[b]	4Q[b]	3Q[b]	0.002 pCi/m^3 (Cs-137)
	Radiochemical[c]	4 A[b]	4 A[b]	3 A[b]	Varies
Gaseous	Iodine-131	4 W	4 W	3 W	0.006 pCi/m^3
Atmospheric Moisture					
	Tritium	4 Q	4 Q	3 Q	1 pCi/m^3
Precipitation					
	Tritium	1 Q	4 Q	1 Q	160 pCi/L
	Gamma	1 Q	4 Q	1 Q	6 pCi/L (Cs-137)
Direct Radiation					
Gamma (High-Pressure Ion Chambers (HPIC))					
	Gamma (µR/hr) (continuous readings)	5	5	2	1.4 µR/hr
Environmental Dosimeters (EIC)		7Q	4Q	3Q	10 mR per quarter

[a] Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T–triennially
[b] Quarterly and annual analyses performed on composited weekly samples for each location.
[c] Radiochemical analyses include Pu-238, Pu-239/240, Am 241, and Sr-90.
[d] Does not include two co-sampling locations with ESER, selected on a random basis.
[e] In-Situ gamma spectroscopy of soil includes examination of the spectra specifically for man-made gamma-emitters (e.g, Cs-137) and naturally occurring gamma-emitters above detection and identified by the analysis software.
[f] Quarterly and semi-annual sampling schedules with varied frequencies. Includes three surface water sites.

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2003.

Media Sampled Type of Analysis	Number of Air Locations and Frequency[a]			Minimum Detectable Quantities
	Onsite	Boundary	Offsite	
Milk				
Gamma Spectroscopy[d]				
Iodine-131			5 M (2M)	4 pCi/L (I-131)
Soil				
In-Situ Gamma Spectroscopy[e]	28 A	11 A	3 A	0.07 pCi/g (Cs-137)
Water: Radiological				
Alpha	33 Q/S[f]	13 Q/S[f]	5 Q, 18 of 55 T	2-5 pCi/L
Beta	33 Q/S[f]	13 Q/S[f]	5 Q, 18 of 55 T	2-3 pCi/L
Gamma	33 Q/S[f]	13 Q/S[f]	5 Q, 18 of 55 T	6-10 pCi/L (Cs-137)
Tritium	23 Q/S[f]	13 Q/S[f]	5 Q, 18 of 55 T	160 pCi/L (15-20 pCi/L for electrolytically enriched)
Sr-90	11 S[f]			3-4 pCi/L
Tc-99	4 S[f]			4-5 pCi/L
Water: Non-radiological				
Common Ions				
Total Alkalinity	15 Q/S[f] 23 A	13 Q/S[f]	5 A	1.0 mg/L
Calcium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.1 mg/L
Chloride	15 Q/S[f] 23 A	13 Q/S[f]	5 A	2.0 mg/L
Fluoride	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.1 mg/L
Magnesium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.05 mg/L
Potassium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.1 mg/L
Sodium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.1 mg/L
Sulfate	15 Q/S[f] 23 A	13 Q/S[f]	5 A	2-4.5 mg/L
Nutrients				
Nitrate + Nitrite as Nitrogen	15 Q/S[e] 23 A	13 Q/S[f]	5 A	0.005 mg/L
Nitrogen (ammonia)	23 A			0.005 mg/L
Nitrogen (Kjeldahl)	23 A			0.05 mg/L
Phosphorus	15 Q/S[f] 23 A	13 Q/S[f]	5 A	0.05 mg/L
Trace Metals				
Aluminum	23 A			50 μg/L

[a] Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T–triennially
[b] Quarterly and annual analyses performed on composited weekly samples for each location.
[c] Radiochemical analyses include Pu-238, Pu-239/240, Am 241, and Sr-90.
[d] Does not include two co-sampling locations with ESER, selected on a random basis.
[e] In-Situ gamma spectroscopy of soil includes examination of the spectra specifically for man-made gamma-emitters (e.g, Cs-137) and naturally occurring gamma-emitters above detection and identified by the analysis software.
[f] Quarterly and semi-annual sampling schedules with varied frequencies. Includes three surface water sites.

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2003.

Media Sampled Type of Analysis	Number of Air Locations and Frequency[a]			Minimum Detectable Quantities
	Onsite	Boundary	Offsite	
Antimony	23 A			5 μg/L
Arsenic	23 A			10 μg/L
Barium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	1 μg/L
Beryllium	23 A			1 μg/L
Cadmium	23 A			100 μg/L
Chromium	15 Q/S[f] 23 A	13 Q/S[f]	5 A	2 μg/L
Cobalt	23 A			5 μg/L
Copper	23 A			10 μg/L
Iron	23 A			10-20 μg/L
Lead	15 Q/S[f] 23 A	13 Q/S[f]	5 A	5 μg/L
Manganese	15 Q/S[f] 23 A	13 Q/S[f]	5 A	10 μg/L
Mercury	23 A			0.5 μg/L
Nickel	23 A			10 μg/L
Selenium	23 A			5 μg/L
Silver	23 A			1 μg/L
Thallium	23 A			1.5 μg/L
Vanadium	23 A			10 μg/L
Zinc	15 Q/S[f] 23 A	13 Q/S[f]	5 A	5 μg/L
Volatile Organic Compounds	5 A			0.5 μg/L

[a] Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T–triennially
[b] Quarterly and annual analyses performed on composited weekly samples for each location.
[c] Radiochemical analyses include Pu-238, Pu-239/240, Am 241, and Sr-90.
[d] Does not include two co-sampling locations with ESER, selected on a random basis.
[e] In-Situ gamma spectroscopy of soil includes examination of the spectra specifically for man-made gamma-emitters (e.g, Cs-137) and naturally occurring gamma-emitters above detection and identified by the analysis software.
[f] Quarterly and semi-annual sampling schedules with varied frequencies. Includes three surface water sites.

Other Surveillance Programs

Bechtel BWXT Idaho, LLC (BBWI)

As the INEEL operating contractor for the DOE, BBWI is responsible for collecting and analyzing radiological and nonradiological samples for the Site Environmental Surveillance Program. BBWI conducts onsite monitoring of air, ground and surface water, soil, and vegetation, with some limited offsite sampling for comparative purposes. BBWI utilized the Radiological Monitoring Lab for 2003.

The S.M. Stoller Corporation (ESER)

S.M. Stoller Corporation operates the offsite monitoring for DOE under the Environmental Surveillance Education and Research (ESER) contract. ESER also performs some limited onsite monitoring. Currently, ESER results applicable to interagency comparisons include those for

samples collected from the air and external radiation measurements, and samples of ground and surface water, soil, and milk. In an effort to maintain independence, ESER employs the services of the ISU Environmental Assessment Laboratory (ISU EAL), which is separate from the ISU EML, for radiological analyses, and contracts with an outside laboratory for radiochemical analyses.

United States Geological Survey (USGS)

As part of the long-term collection of hydrological and geological data related to the presence and movement of radioactive and nonradioactive constituents in groundwater, the USGS conducts ground and surface water monitoring both on and off the INEEL. Samples collected by the USGS on and near the INEEL are analyzed by the DOE Radiological and Environmental Sciences Laboratory (RESL), and by the USGS National Water Quality Laboratory in Arvada, Colorado. Analytical results are presented in USGS reports.

Argonne National Laboratory (ANL-W)

The University of Chicago operates Argonne National Laboratory, with facilities in Illinois (ANL-E) and Idaho (ANL-W), for DOE. As a separate organization from BBWI, ANL-W operates its own environmental sampling program, and contracts with outside laboratories for analyses.

Naval Reactors Facility

Naval Reactors Facility (NRF) is operated for the Naval Nuclear Propulsion Program, United States Department of Energy, Naval Reactors, by Bechtel Bettis, Inc. As a separate organization from BBWI, NRF operates its own environmental sampling program, and contracts with an outside laboratory for analyses.

Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes operate a community air monitoring station at Fort Hall similar in design and complement of instruments to the INEEL OP community monitoring stations. These samples are also analyzed by the ISU EML.

The INEEL OP Sampling Network and Co-Sampling Strategies

Air Monitoring

Air samples collected by the INEEL OP in 2003 were screened for gross alpha and gross beta radioactivity, and gamma radioactivity, and analyzed for tritium in atmospheric moisture. Radiochemical analyses were performed on composited air filters for strontium-90,

plutonium-238 and -239/240, and americium-241. Typically, the INEEL OP reports all results for gross alpha and beta radioactivity, but notes only those gamma spectroscopy results exceeding the minimum detectable concentration (MDC). As part of gamma spectroscopic analyses, specific results are reported by the laboratory for ruthenium/ rhodium-106, antimony-125, cesium-134, and cesium-137.

Air Monitoring Locations

Extensive studies of the complex wind patterns of the Eastern Snake River Plain strongly influenced the placement of the stations in the original INEEL OP air monitoring network. From an initial six monitoring sites in 1992, the INEEL OP Environmental Surveillance Program (ESP) has expanded to include the ten air monitoring stations identified in **Figure 2-1**. Currently, each of these stations is equipped with instruments to collect airborne particulate matter, gaseous radioiodine, and water vapor. Six stations are equipped to collect precipitation. The INEEL OP also reports air monitoring data for samples collected at a station in Fort Hall operated by the Shoshone-Bannock Tribes.

Each monitoring station is categorized by location as onsite, boundary, or distant. **Table 2-2** lists the sample types, frequency, and analyses conducted by the INEEL OP for each location, and also identifies the comparable schedule and analysis activities for other agencies sampling at each location.

Air Monitoring Equipment and Procedures

Air Samplers

During 2003 continuous particulate air sampling was conducted using both intermediate-flow PM_{10} samplers (particulate matter with aerodynamic diameters of 10-µm and less) and high-volume total suspended particulate (TSP) samplers. Starting in the first quarter of 2003, the INEEL OP designated the high-volume TSP air sampler as the primary air sampler, thus replacing the aging PM_{10} samplers. The INEEL OP operated three PM_{10} samplers during 2003 to collect supplementary air data, and radioiodine, at two boundary locations and one distant location. Samples are collected on 10-cm (4-inch) diameter membrane filters. Filters are weighed to the nearest 0.0001-g prior to deployment. Filters are collected weekly, stored for approximately five days in a desiccator to remove excess moisture from the filters, and are then weighed to determine particulate mass concentrations. The five day storage also allows for the radioactive decay of short-lived radon progeny prior to gross alpha and gross beta screening analyses.

At the end of the sampling quarter, after all the gross alpha and beta analyses have been performed, the filters are composited by sampling location. The filters are aligned, one in front of the other, and analyzed for gamma emitting radionuclides using gamma spectroscopy. Typically, gamma spectroscopy results are only reported when exceeding a minimum detectable activity (MDA) or minimum detectable concentration (MDC).

At the end of the year, after all the gamma spectroscopy analyses have been performed, the filters are again composited by sampling location. Each of the annual composites are then sent to a commercial laboratory for radiochemical analyses of strontium-90, plutonium-238, plutonium 239/240, and americium-241. The INEEL OP has had radiochemical analysis performed on the annual composites since 1996. The analysis allows for an additional evaluation of trends in air quality.

During 2003 continuous radioiodine (iodine-131) sampling was conducted using both intermediate-flow PM_{10} samplers and low-volume air samplers. The samplers draw air through an activated charcoal cartridge that preferentially adsorbs gases (e.g., iodine and noble gases). A membrane filter is placed in front of the charcoal cartridge to filter particulate matter, allowing only gases to interact with the charcoal. The cartridges are deployed and collected weekly and analyzed via gamma spectroscopy for iodine-131 within 24-hours of collection.

Atmospheric Moisture Samplers

Atmospheric moisture is collected at 11 monitoring stations by passing air through a column containing a desiccant (molecular sieve) that removes and stores moisture from the air. As indicated in **Table 2-2**, the samples are collected when the column nearly reaches saturation or at the end of each quarter, whichever occurs first. Heating the desiccant releases the moisture, which is collected as condensation and analyzed for tritium.

Precipitation Samplers

Six of the INEEL OP air monitoring stations are equipped to collect precipitation samples for radiological analyses, as shown in **Table 2-2.** The precipitation is collected on a one-meter square, metal tray attached to a polyethylene collection vessel. At the end of each quarter or when the collection vessel is nearly full, whichever occurs first, the precipitation samples are collected and analyzed for tritium and gamma-emitting radionuclides.

Air Monitoring Interprogram Comparison Design

As indicated in **Figure 2-1**, INEEL OP, BBWI, and ESER conducted co-located sampling activities throughout 2003, with each organization separately performing the range of scheduled analyses identified. In this report, the results of INEEL OP measurements are compared directly to those of the two DOE monitoring programs.

Each organization performing air sampling as part of its respective surveillance program collects airborne particulate matter, but collection equipment varies slightly. The INEEL OP uses high-volume TSP samplers and intermediate flow PM_{10}; ESER and BBWI use low-volume particulate air samplers.

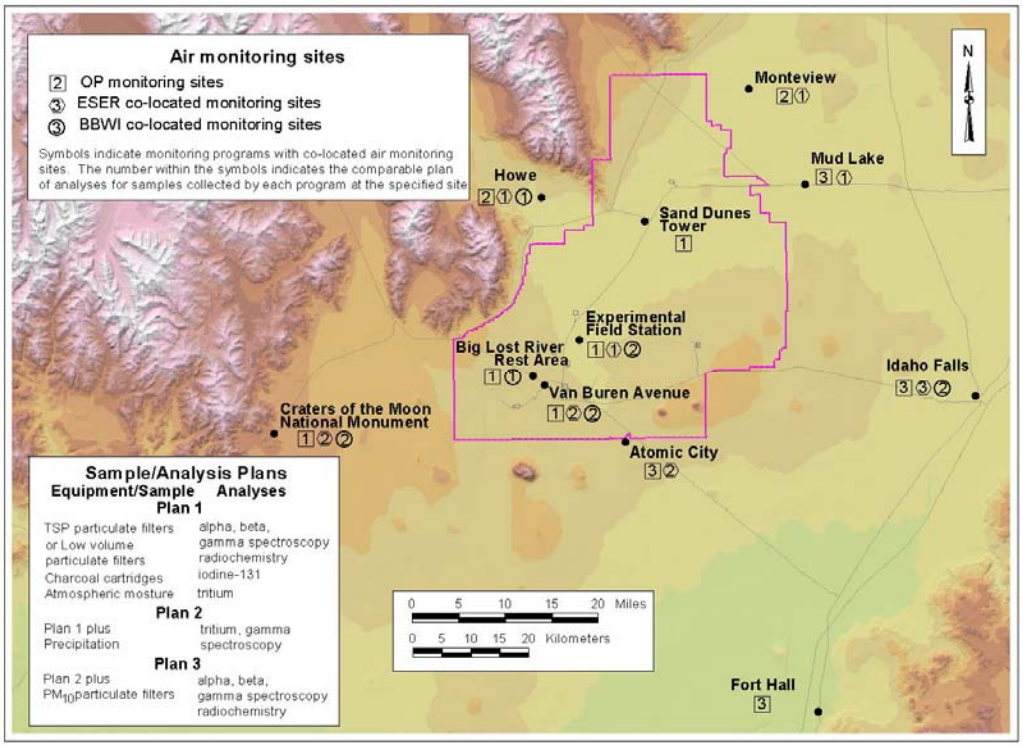

Figure 2-1. Air monitoring locations.

Each agency performing air sampling conducts gross alpha and gross beta radioactivity screening analyses, gamma spectroscopic analyses of composite filter samples, and radiochemical analyses of composite filter samples. Each group also collects iodine-131 samples using activated charcoal cartridges that are analyzed by gamma spectroscopy.

The sampling schedules, analyses, and instruments used by the participating agencies are listed in **Table 2-2**. The INEEL OP and BBWI each collected particulate, radioiodine, and composite atmospheric moisture samples at three identical or nearby locations. Similarly, INEEL OP and ESER collected particulate, radioiodine, and composite atmospheric moisture samples at three identical or nearby locations.

Table 2-2. Interprogram air monitoring sampling/analyses schedules, 2003.

Co-located Sampling Instrumentation, Scheduling, and Analyses				
Equipment/Sample Types	**Particulate Air Sampling**	**Charcoal Cartridges**	**Atmospheric Moisture**	**Precipitation**
Frequency of Sampling	**Weekly**	**Weekly**	**Quarterly[a]**	**Quarterly[b]**
Analyses[c, d]	**Alpha, Beta, Gamma Radiochemistry[e]**	**Iodine-131[f]**	**Tritium**	**Tritium, Gamma**
Onsite Locations/Organization[g]				
Experimental Field Station	OP ESER BB	OP ESER BB	OP BB	ESER
Sand Dunes	OP	OP	OP	
Van Buren Avenue	OP ESER BB	OP ESER BB	OP BB	
Big Lost River Rest Area	OP BB	OP BB	OP	OP
Boundary Locations/Organization[g]				
Atomic City	OP ESER	OP ESER	OP ESER	OP
Howe	OP ESER BB	OP ESER BB	OP	OP
Monteview	OP ESER	OP ESER	OP	OP
Mud Lake	OP ESER BB	OP ESER BB	OP	OP
Distant Locations/Organization[g]				
Idaho Falls	OP ESER BB	OP ESER BB	OP ESER BB	OP ESER
Craters of the Moon	OP ESER BB	OP ESER BB	OP BB	
Fort Hall	SB	SB	OP	

[a] Samples are collected quarterly or when beads reach saturation.
[b] Samples are collected quarterly or when sample container is full, whichever occurs first.
[c] The INEEL OP samples the PM_{10} fraction of airborne particulate matter, as well as the total particulate matter; ESER and BBWI sample total particulate matter.
Identifies all INEEL OP analyses and those co-sampling agency analyses used for comparisons of results.
[e] Samples composited by location and analyzed by radiochemical techniques for plutonium-238, plutonium-239/240, americium-241, and strontium-90 on different schedules.
[f] Samples composited by location and analyzed by gamma spectroscopy on different schedules.
[g] Sampling Organization Abbreviations:
OP = INEEL OP ESER = Stoller BB = BBWI SB = Shoshone-Bannock Tribes

Direct Radiation Monitoring

The INEEL OP uses a combination of instruments that measure the environmental radiation levels from natural cosmic and terrestrial sources as well as from possible contributions from operations at the INEEL. The INEEL OP can therefore report the results of measurements of both time-dependent exposure and time-integrated exposure to environmental gamma radiation.

Direct Radiation Monitoring Locations

Local climatology and atmospheric dispersion models for the INEEL influenced the selection of the locations for the initial radiation monitoring sites in much the same way that such modeling techniques facilitated the placement of the air monitoring stations. Since 1995, the network has included the 15 stations identified in **Figure 2-2**.

Direct Radiation Monitoring Equipment and Procedures

The direct radiation monitoring instrumentation located at each routine station is listed in **Table 2-3**, and additional EIC locations can be found in **Figure 7-2**. The majority of the gamma radiation stations are co-located with air monitoring sites.

Electret Ion Chambers

Electret Ion Chambers (EIC) are deployed at radiation monitoring stations to measure cumulative exposure to penetrating radiation in milliRoentgens (mR). The EICs are deployed at 91 monitoring locations on the INEEL, near the INEEL boundary, and at distant locations. Of these 91 locations, there are 68 monitoring locations on the INEEL along highways, access roads, and at INEEL facilities. Of the 23 remaining monitoring locations, 11 are located at boundary locations and 12 distant locations. Average exposure rates in microRoentgens per hour (µR/hr) are reported using the cumulative exposure divided by the deployment time. The EICs are constructed from carbon-filled polypropylene that offers a nearly air-equivalent response. Before deployment, each EIC's initial voltage is read and recorded. Three EICs are placed in a labeled aluminum canister. At the end of each calendar quarter, the exposed EICs are collected, final voltages are read and recorded, and gamma radiation exposures are calculated.

High-Pressure Ion Chambers (HPICs)

At the 15 monitoring sites identified in **Table 2-3**, high-pressure ion chambers (HPICs) continuously measure the gamma radiation exposure rate in microRoentgens per hour (µR/hr). INEEL OP also uses the data from the HPIC at Fort Hall operated by the Shoshone-Bannock Tribes shown in **Figure 2-2**. Exposure rates are measured every five seconds, and then averaged over five-minute intervals by the data system associated with each HPIC. Each station is equipped with data loggers, as well as a radio telemetry system for transmitting the five-minute values to the INEEL OP Idaho Falls office.

Table 2-3. Direct radiation monitoring locations, 2003.

Instrumentation:	Environmental Dosimeter (EIC)	High-Pressurized Ion Chamber (HPIC)
Onsite Locations		
Base of Howe	♦	♦
Big Lost River Rest Area	♦	♦
Experimental Field Station	♦	
Main Gate	♦	♦
Rover	♦	♦
Sand Dunes Tower	♦	♦
Van Buren Avenue	♦	
Boundary Locations		
Atomic City	♦	♦
Big Southern Butte	♦	♦
Howe	♦	♦
Monteview	♦	♦
Mud Lake	♦	♦
Distant Locations		
Idaho Falls	♦	♦
Craters of the Moon National Monument	♦	
Fort Hall	♦	♦

Direct Radiation Monitoring Interprogram Comparison Design

During 2003, the INEEL OP co-located EICs with a limited number of thermoluminescent dosimeters (TLD) from the other surveillance programs.

Terrestrial Monitoring

Terrestrial environmental surveillance typically includes examination of several mechanisms that tend to collect and/or accumulate radioactive material in the environment. Such mechanisms include the concentration of important nutrients and minerals by cattle. Radioiodine fallout may be detected in milk at concentrations corresponding to relatively low concentrations in the environment.

The INEEL OP conducts *in-situ* soil measurements for selected naturally occurring and man-made, gamma-emitting radionuclides. The locations for soil and milk sampling reflect the consideration of potential source terms, their significance, regional meteorology, and monitoring activities by other programs.

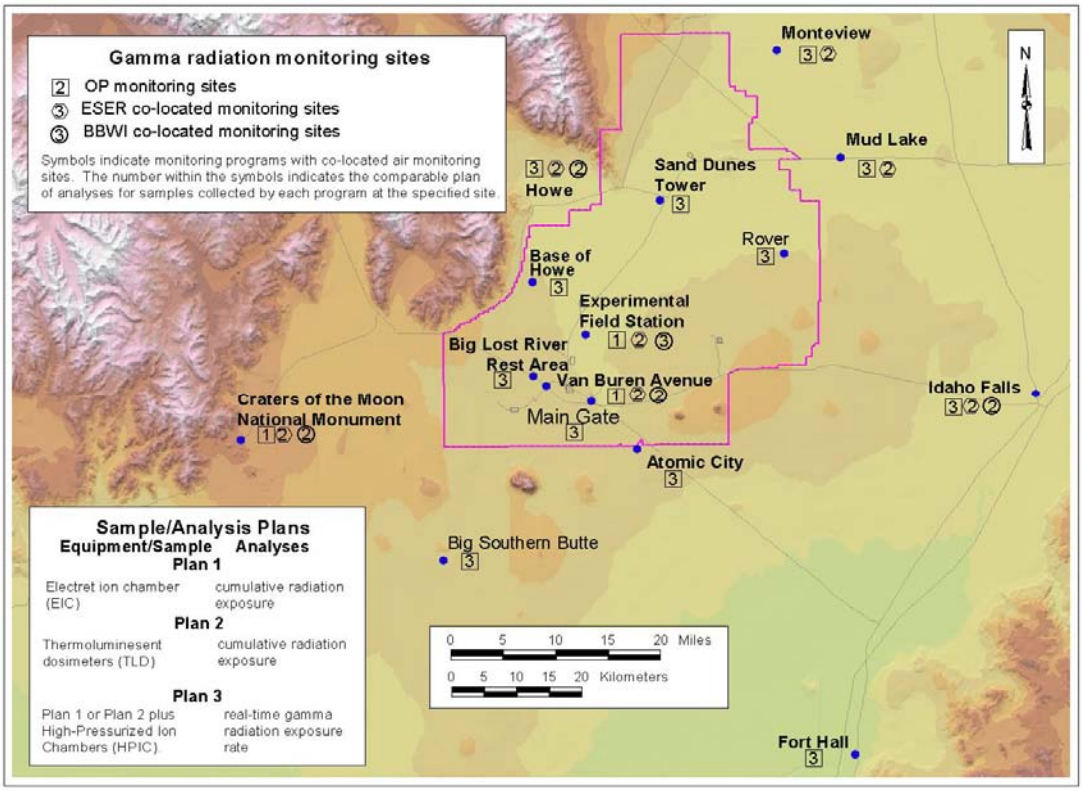

Figure 2-2. Routine gamma radiation monitoring locations.

Terrestrial Monitoring Locations

Milk Sample Collection Sites and Dairy Locations

A total of six milk sample collection locations were used by INEEL OP in 2003 (**Figure 2-3**). Milk samples were collected from four processing plants in Rexburg, Pocatello, Rupert and Gooding. Each plant processes milk produced by dairies in other localities. For example, the Rexburg plant receives milk originally from dairies in the Howe and Mud Lake areas. In addition, the INEEL OP analyzes two samples per quarter that are collected by ESER for verification purposes.

Soil Monitoring Locations

Annually, soil is monitored at INEEL OP's routine gamma radiation monitoring locations. Performing these measurements at permanent monitoring sites allows the INEEL OP to evaluate the terrestrial component of gamma radiation measurements. In addition, soil measurements are performed at sites co-located with the DOE contractor to verify their analytical results. For 2003, *in-situ* measurements were made at 42 locations as outlined by **Figure 2-4.**

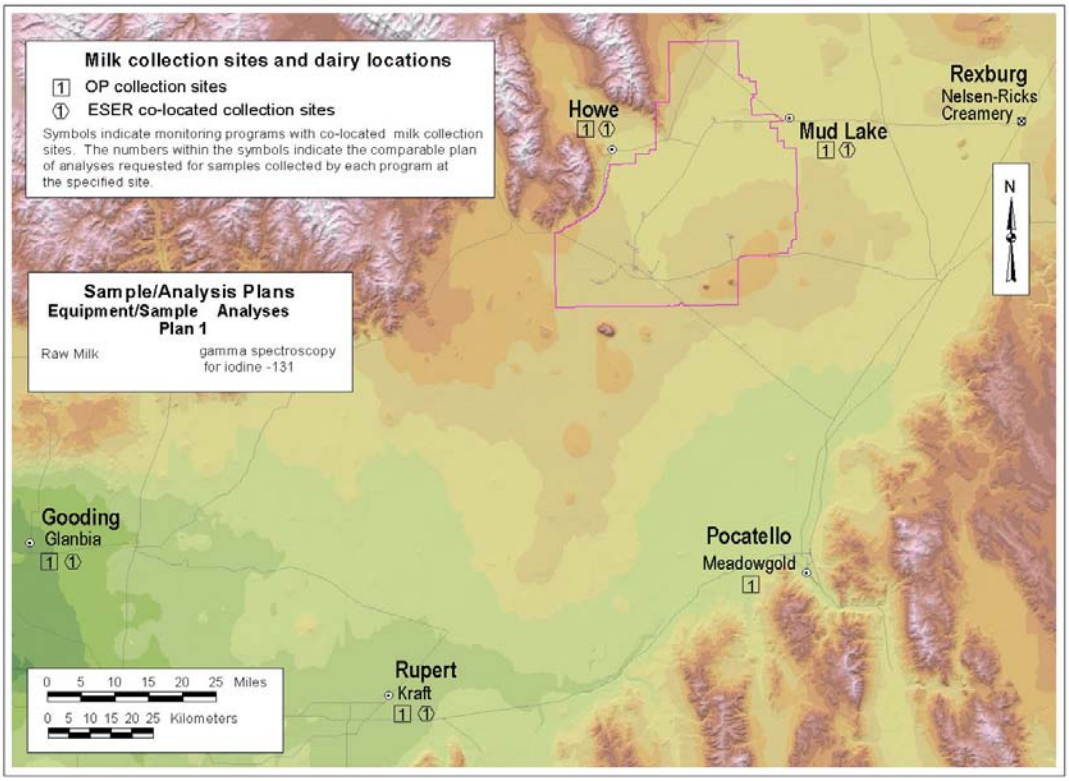

Figure 2-3. Milk monitoring locations.

Terrestrial Monitoring Equipment and Procedures

Milk Monitoring

Monthly milk samples are collected from fresh dairy shipments after receipt at the processing plants. Two-liter composite samples are collected from each of the four offsite distribution locations, as well as two samples collected by ESER. These samples are analyzed by gamma spectroscopy within seven days of collection.

Soil Monitoring

Rather than disturb the soil by physically collecting a sample, radionuclide concentrations in soil were measured *in-situ*. Radionuclide concentrations were determined using an intrinsic, high-purity germanium detector assuming the distribution of radionuclides in the soil are homogenous throughout a depth of 0 to 5 cm.

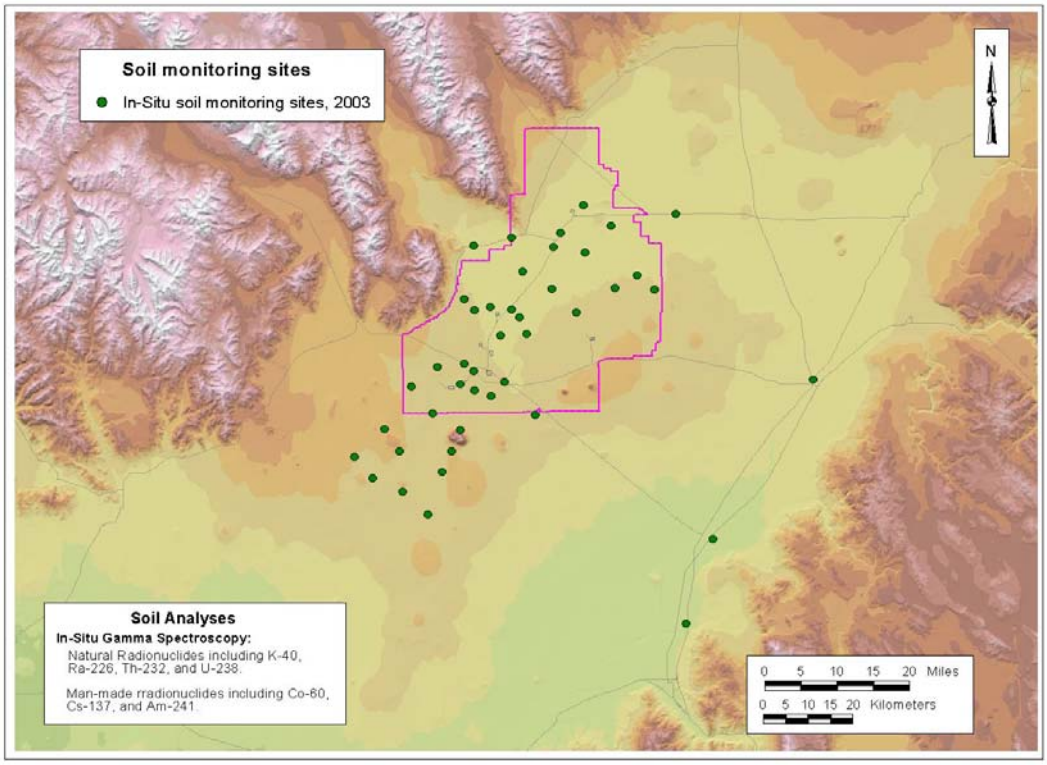

Figure 2-4. Soil monitoring locations.

Interprogram Terrestrial Monitoring Results and Comparisons

The INEEL OP collects milk samples after delivery to the distribution centers; currently, ESER collects milk samples from farms prior to shipment. Two milk samples were collected by ESER each month and submitted to INEEL OP for independent gamma-spectroscopic analysis.

Water Monitoring

Water sites are sampled for surveillance and for verification. Surveillance water sites are sampled for the primary purpose of examining trends of key INEEL contaminants and other general ground water quality indicators. Water verification sites are sampled for the primary purpose of verifying DOE monitoring results for selected CERCLA, WLAP, and surveillance monitoring specific to facilities. Included in surveillance sites are selected surfacewater locations on and near the INEEL, and selected wastewater sites for INEEL facilities. All water sites are co- sampled with others; surveillance sites with the USGS on the INEEL, and ESER, for selected boundary and distant sites, and verification sites with BBWI, NRF, and ANL-W.

Nonradiological analyses are performed for common ions, nutrients, and selected trace metals. Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium isotopes (uranium-234, 235, and 238, plutonium isotopes (plutonium-238, 239-240, and 241) and americium-241.

Although very few of the wells sampled by the INEEL OP supply drinking water systems, all analytical results are compared to the EPA's maximum contaminant levels (MCL) or secondary maximum contaminant levels (SMCL). A contaminant's MCL defines the maximum permissible level of that contaminant allowed in a community water system. Concentrations in excess of the MCL may result in adverse impacts to human health or unacceptable risk levels.

A contaminant's SMCL identifies the maximum level at which the contaminant can be measured before the aesthetic qualities of the water are impacted. Although the SMCL is not a legally enforceable limit, concentrations of contaminants that exceed SMCLs may adversely affect the odor, taste, or appearance of water.

The Eastern Snake River Plain Aquifer has been designated as a “sole source” aquifer by the EPA, supplying the majority of drinking water for many Idahoans. Comparing analytical results of water samples taken from the aquifer with MCLs and SMCLs provides a useful means of determining if the quality of this very important source of water is at risk.

Starting in 1999, INEEL OP initiated a verification portion to the water monitoring program in which wastewater and groundwater locations on the INEEL were co-sampled with BBWI, ANL-W, or NRF for direct comparison purposes. Nonradiological analyses are performed for common ions, nutrients, trace metals, and volatile organic compounds (VOCs). Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, plutonium isotopes, uranium isotopes, neptunium-237, and technetium-99.

Water Monitoring Locations

The INEEL OP monitors water quality at 78 locations for surveillance sampling and 36 locations for verification. Sampling locations are shown in **Figures 2-5,** and **2-6**. Sampling sites are grouped by location and type with the following categories: onsite, boundary, distant, Magic Valley, and surface. **Table 2-4** specifies the routine sampling schedules, analyses, and corresponding co-sampling organizations for each of these locations. Wastewater and groundwater verification samples were collected with BBWI, NRF, and ANL-W at several locations on the INEEL (**Figure 2-7)**. **Table 2-5** presents the verification sampling program’s water monitoring schedules and analyses for each location.

Beginning in October 2001, the USGS reduced sampling frequency for most water monitoring sites on the INEEL, resulting in a reduction in the number of water surveillance samples collected by the INEEL OP. Sites sampled quarterly on the INEEL by the USGS were reduced to semi-annual sampling. A selected number of sites sampled semi-annually prior to October 2001 were reduced to annual sampling. The INEEL OP adjusted its sampling schedule to correspond to USGS sampling frequency, with the exception of Atomic City, where a quarterly sampling schedule was maintained. Sample locations and frequency are summarized in **Table 2-4.** With 2003 sampling, ten locations were dropped from the Magic Valley sampling program. These sites were located very near other Magic Valley sample locations and yielded similar

results. Site accessibility was also a factor in the decision to remove the selected sites from active monitoring. These sites may be used as alternate sample locations in the future.

Water Monitoring Equipment and Procedures

The USGS is relied on to provide equipment and logistics necessary to collect samples at many groundwater sampling locations. Prior to each sample collection, the well is pumped to remove standing water in the borehole and any associated plumbing such as the pressure tank and discharge line. During the purge of the well, measurements of the pH, specific conductance, and water temperature are monitored. After these parameters have stabilized and approximately three well-bore volumes have been pumped, the sample is collected, always from the same designated sampling port.

Surface water samples from the Big Lost River, Birch Creek, and the springs distant from the INEEL in Magic Valley are routinely collected in areas of moving water, in order to collect samples representative of the bulk of the stream.

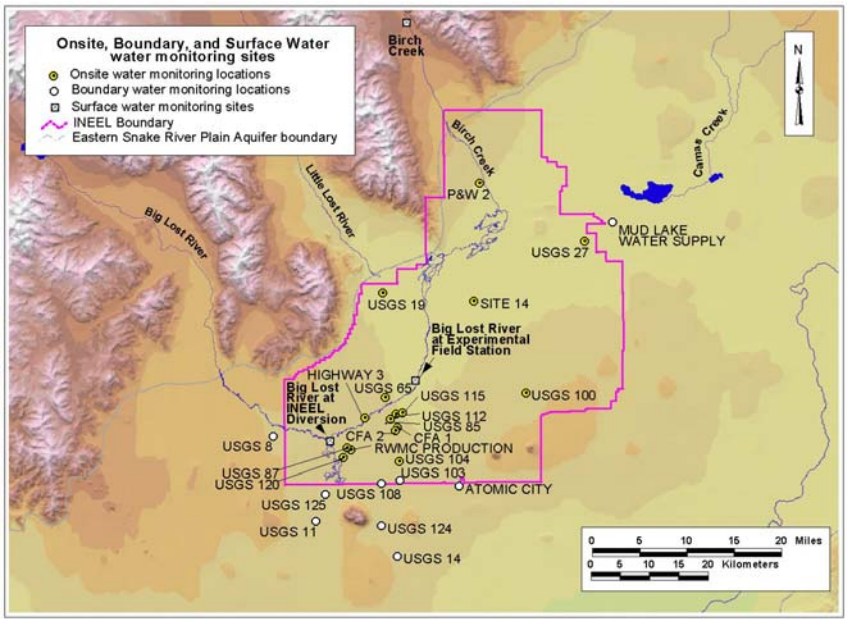

Figure 2-5. Onsite and boundary water monitoring locations.

Water Monitoring Interprogram Comparison Design

Comparisons of INEEL OP, ESER, USGS, BBWI, ANL-W, and NRF results involve the collection of replicate samples—samples collected by two of the agencies at essentially the same time, typically less than a few minutes apart.

Because goals for the water sampling programs conducted by the various agencies may differ, all samples are not analyzed for exactly the same parameters by all agencies. As previously

discussed, separate laboratories perform these analyses, and certain differences in analytical methods can influence the comparisons of interprogram results.

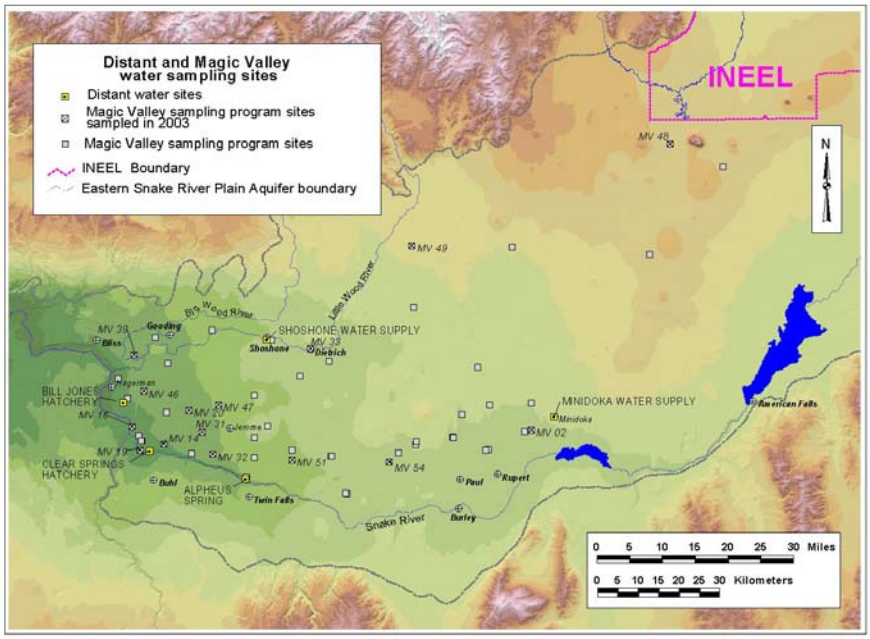

Figure 2-6. Distant and Magic Valley water monitoring locations.

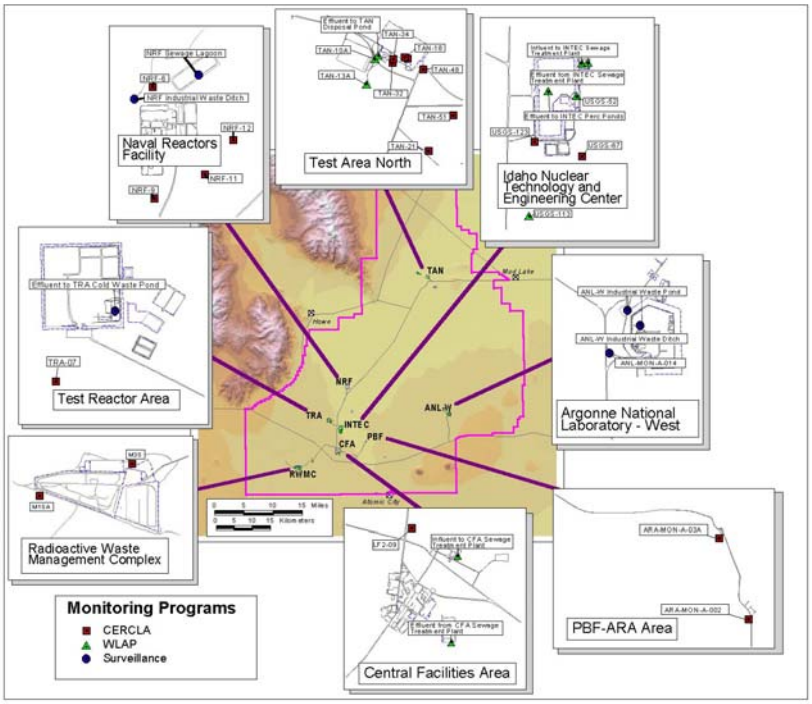

Figure 2-7. Water verification monitoring sites. The purpose of DOE monitoring for each site is indicated in the figure key.

Table 2-4. Interprogram water monitoring sampling schedules and analyses, 2003.

Co-located/Replicate Sample Analyses		Radiological		Nonradiological		
Analysis	**Frequency[a]**	**Gross Alpha, Gross Beta, Gamma Spectroscopy**	**Tritium**	**Metals[b]**	**Common Ions[d]**	**Nutrients[f]**
Onsite Locations				**Organizations**		
CFA 1	S	OP	OP USGS	OP	OP USGS[e]	OP USGS
CFA 2	S	OP	OP USGS	OP	OP USGS[e]	OP USGS
RWMC Production	S	OP	OP	OP	OP USGS[e]	OP USGS
P&W 2	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
Site 14	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 19	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 27	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 65	S	OP USGS	OP USGS	OP USGS[c]	OP USGS[e]	OP USGS
USGS 85	S	OP	OP USGS	OP	OP USGS[e]	OP USGS
USGS 87	S	OP USGS	OP USGS	OP USGS	OP USGS[e]	OP USGS
USGS 100	A	OP	OP USGS	OP USGS	OP USGS[e]	OP
USGS 104	S	OP	OP USGS	OP	OP USGS	OP USGS
USGS 112	S	OP	OP USGS	OP	OP USGS[e]	OP USGS
USGS 115	S	OP	OP USGS	OP	OP USGS[e]	OP USGS
USGS 120	S	OP USGS	OP USGS	OP USGS	OP USGS[e]	OP USGS
Boundary Locations				**Organizations**		
Atomic City	Q/S/A	OP ESER[c]	OP USGS ESER	OP	OP USGS	OP
Highway 3	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
Mud Lake Water Supply	Q/S	OP ESER[c]	OP ESER	OP	OP	OP
USGS 8	A	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 11	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 14	S	OP USGS	OP USGS	OP	OP USGS	OP USGS
USGS 103	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 108	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
USGS 124	S	OP	OP USGS	OP	OP USGS	OP USGS

[a] Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS

[b] The USGS samples only for chromium at these locations.

[c] The USGS samples for a selected list of trace metals at this location

[d] The USGS samples only for chloride and sodium at these locations.

[e] The USGS also samples for sulfate at this location.

[f] The USGS samples for total nitrate plus nitrite at these locations.

[g] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy

[h] INEEL OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.

[i] This site discontinued starting 2003, but available as alternate.

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2003

Co-located/Replicate Sample Analysis		**Radiological**		**Nonradiological**		
Analysis	**Frequency[a]**	**Gross Alpha, Gross Beta, Gamma Spectroscopy[g]**	**Tritium**	**Metals[b]**	**Common Ions**	**Nutrients**
USGS 125	S	OP	OP USGS	OP USGS	OP USGS	OP USGS
Distant Locations				**Organizations**		
Alpheus Spring	Q/S	OP ESER	OP ESER	OP[h]	OP[h]	OP[h]
Bill Jones Hatchery	Q/S	OP ESER	OP ESER	OP[h]	OP[h]	OP[h]
Clear Spring	Q/S	OP ESER	OP ESER	OP[h]	OP[h]	OP[h]
Minidoka Water Supply	Q/S	OP ESER	OP ESER	OP[h]	OP[h]	OP[h]
Shoshone Water Supply	Q/S	OP ESER	OP ESER	OP[h]	OP[h]	OP[h]
Magic Valley Sampling Program				**Organizations**		
MV 01	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 02	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 03	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 04[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 05	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 06[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 07	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 09[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 10[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 11	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 12	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 13	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 14	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 15	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 16	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 17	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 18	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 19	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 20	T	OP USGS	OP USGS	USGS	USGS	USGS

[a] Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS
[b] The USGS samples only for chromium at these locations.
[c] The USGS samples for a selected list of trace metals at this location
[d] The USGS samples only for chloride and sodium at these locations.
[e] The USGS also samples for sulfate at this location.
[f] The USGS samples for total nitrate plus nitrite at these locations.
[g] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy
[h] INEEL OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.
[i] This site discontinued starting 2003, but available as alternate

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2003

Co-located/Replicate Sample Analysis		Radiological		Nonradiological		
Analysis	Frequency[a]	Alpha, Beta, Gamma[g]	Tritium	Metals	Common Ions	Nutrients
MV 21	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 23	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 24	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 25	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 26	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 27	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 29	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 30	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 31	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 32[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 33	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 35	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 36	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 37	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 38	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 39	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 40	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 41	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 42	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 43	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 45[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 46	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 47	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 48 (USGS 11)	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 49	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 50[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 51	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 52[f]	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 53	T	OP USGS	OP USGS	USGS	USGS	USGS

[a] Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS
[b] The USGS samples only for chromium at these locations.
[c] The USGS samples for a selected list of trace metals at this location
[d] The USGS samples only for chloride and sodium at these locations.
[e] The USGS also samples for sulfate at this location.
[f] The USGS samples for total nitrate plus nitrite at these locations.
[g] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy
[h] INEEL OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.
[i] This site discontinued starting 2003, but available as alternate

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2003

Co-located/Replicate Sample Analysis		**Radiological**		**Nonradiological**		
Analysis	**Frequency[a]**	**Alpha, Beta, Gamma[g]**	**Tritium**	**Metals**	**Common Ions**	**Nutrients**
MV 54	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 55	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 56	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 57	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 58	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 59	T	OP USGS	OP USGS	USGS	USGS	USGS
MV 61 (USGS 14)	T	OP USGS	OP USGS	USGS	USGS	USGS
Surface Water Locations		**Organizations**				
Birch Creek at Blue Dome	S	OP	OP USGS	OP	OP USGS	OP
Big Lost River at Experimental Field Station	S	OP USGS	OP USGS	OP USGS[c]	OP USGS[e]	OP USGS
Big Lost River at INEEL Diversion	S	OP USGS	OP USGS	OP USGS[c]	OP USGS[e]	OP USGS

[a] Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS
[b] The USGS samples only for chromium at these locations.
[c] The USGS samples for a selected list of trace metals at this location
[d] The USGS samples only for chloride and sodium at these locations.
[e] The USGS also samples for sulfate at this location.
[f] The USGS samples for total nitrate plus nitrite at these locations.
[g] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy
[h] INEEL OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.
[i] This site discontinued starting 2003, but available as alternate

Table 2-5. Verification sampling program's water monitoring schedules and analyses, 2003

Location/Analytes	Sampling Frequency[a]	Radiological[b]	Nonradiological	
			Inorganics[c]	VOCs[d]
Effluent				
ANL-W Industrial Waste Ditch	A	✓	✓	
ANL-W Industrial Waste Pond	A	✓	✓	
Influent to CFA sewage treatment facility	A		✓	
Effluent from CFA sewage treatment facility	A	✓	✓	
Influent to INTEC sewage treatment facility	A		✓	
Effluent from INTEC sewage treatment facility	A	✓	✓	
NRF Industrial Waste Ditch	T	✓	✓	
NRF Sewage Lagoon	S	✓	✓	
TAN Disposal Pond (TAN-655)	A	✓	✓	
TRA Cold Waste Pond	A	✓	✓	
Groundwater				
ANL-MON-A-014	A	✓	✓	
ANP-8	A			✓
ARA-MON-A-002	A	✓	✓	✓
ICPP-MON-A-166	A	✓	✓	
LF2-08	A	✓	✓	✓
M1S	Q	✓	✓	✓
M3S	Q	✓	✓	✓
NRF-6	A	✓	✓	✓
NRF-9	A	✓	✓	✓
NRF-11	A	✓	✓	✓
NRF-12	A	✓	✓	✓
PBF-MON-A-003	A	✓	✓	✓
TAN-10A	A		✓	
TAN-13A	A		✓	
TAN-16	A	✓	✓	✓
TAN-28	A	✓	✓	✓
TAN-29	A	✓	✓	✓
TAN-37	A	✓	✓	✓
TAN-51	A	✓	✓	✓
TRA-7	A	✓	✓	
TRA-8	A	✓	✓	
USGS-47	A	✓	✓	✓
USGS-52	A	✓	✓	
USGS-55	A	✓	✓	
USGS-67	A	✓	✓	✓
USGS-123	A	✓	✓	✓

[a] Sampling Frequency Abbreviations: A=annually, Q=quarterly, S=semiannually, T=tri-annually
[b] Radiological analyses include one or more of the following: americium-241, gamma spectroscopy, gross alpha radioactivity, gross beta radioactivity, neptunium-237, plutonium isotopes, strontium-90, technetium-99, tritium, and uranium isotopes.
[c] Inorganic analyses include various metals, common ions, and nutrients.
[d] Volatile organic compounds

Chapter 3

Air Monitoring

Major Findings and Developments

Gross alpha and gross beta screening measurements of particulate air filters were consistent with historical background concentrations. Elevated concentrations were observed during periods associated with temperature inversions. Atmospheric tritium and tritium concentrations in precipitation collected at boundary and distant monitoring locations were consistent with the range of historical background concentrations and typically below detection levels. Atmospheric tritium concentrations observed at onsite monitoring locations were well below regulatory limits.

- No offsite environmental impacts from INEEL operations were evident based on the results of particulate air sampling using TSP samplers.
- Strontium-90, americium-241, plutonium-238, and plutonium 239/240 were measured at several monitoring locations. Concentrations were slightly greater than the laboratory's detection capability, yet were significantly below the INEEL OP action levels which are 10 percent of the limits established by the Clean Air Act. Measurable quantities of these radionuclides are expected in the environment due to historic above ground testing of nuclear weapons.
- No radioactive iodine was detected in air samples as has been observed in past years.
- No offsite environmental impacts from INEEL operations were detected in precipitation samples.
- Tritium was measured at several onsite monitoring locations. Concentrations were slightly greater than the laboratory's detection capability, yet were significantly below the INEEL OP action level.
- Interprogram comparisons of different surveillance program results show relatively good agreement. Discrepancies have been traced to differences in sampling methodologies, schedules, and laboratory detection capabilities.

Primary Air Results and Trends

Particulate and Iodine-131 Air Sampling

INEEL OP conducts continuous particulate air sampling at 11 locations. Ten stations are owned and maintained by the INEEL OP and one station is owned and maintained by the Shoshone-Bannock Tribes at the Fort Hall Environmental Monitoring Station (EMS). Data from the Shoshone-Bannock station are used as an additional background site. Air sampling is performed using high-volume, total suspended particulate (TSP) samplers. Air is pulled through a 10.2-mm (4-inch) diameter filter at approximately 170-L/min (6.0 SCFM[1]) and the volume of air sampled is measured using a mass-flow meter.

Three intermediate-flow PM_{10} samplers collect supplementary air data, along with radioiodine, at Fort Hall, Mud Lake, and Atomic City. These samplers selectively sample suspended particulate matter with aerodynamic diameters[2] less than or equal to 10-µm[3] onto a 10.2-mm (4-inch) diameter filter at approximately 112-L/ min (4.0 ACFM[4]) and the volume of air sampled is measured using a volumetric flow meter.

Particulate air filters are collected and analyzed using a gross screening analysis (gross alpha and gross beta). Gross screening analyses of air filters collected during 2003 indicated the presence of radioactive material at concentrations associated with radionuclides found naturally in the environment (**Table 3-1**).

Table 3-1. Descriptive statistics for 2003 particulate air sampling gross screening results from TSP samplers. Screening results given in femtocuries[a] per cubic meter (fCi/m^3).

	Boundary Gross Alpha (fCi/m^3)	Boundary Gross Beta (fCi/m^3)	Distant Gross Alpha (fCi/m^3)	Distant Gross Beta (fCi/m^3)	Onsite Gross Alpha (fCi/m^3)	Onsite Gross Beta (fCi/m^3)
Average:	0.8	19.9	0.9	18.6	0.9	21.8
Median:	0.8	19.0	0.8	18.7	0.8	20.9
Standard Deviation:	0.4	8.1	0.4	7.4	0.4	9.6
Minimum:	0.2	7.4	0.1	6.8	0.2	0.5
Maximum:	2.4	49.4	2.0	40.8	2.3	63.4
# Exceeding Action Level:	4	0	0	0	4	0
Number of Measurements:	200	200	153	153	203	203

[a] Femtocurie corresponds to 10^{-15} Curie or 10^{-3} picocurie

[1] Standard Cubic Feet per Minute (SCFM) is a unit of volumetric flow rate of 1 cubic foot of air per minute at standard conditions (760mm Hg or 29.9inches of Hg and 20°C).
[2] Similar behavior to a unit density sphere (water droplet) with a diameter of 10µm.
[3] A micron or micrometer corresponds to one-millionth of a meter.
[4] Actual Cubic Feet per Minute (ACFM) corresponds to the actual volumetric flow rate at ambient conditions with the units cubic feet per minute.

To streamline the decision-making process, the INEEL OP has established action levels[5] for gross alpha and gross beta screening analyses based solely upon dose considerations. Action levels for weekly screening measurements assume that all of the alpha activity on the filter is from americium-241, and that all of the beta activity on the filter is from strontium-90. Using the dose conversion factors from the Environmental Protection Agency's (EPA) Federal Guidance Report Number 11 (FGR11)[6], assuming a constant air concentration and assuming a breathing rate of 10,000 m^3/y, action levels were set at 50-μSv/y (5 mrem per year) for gross alpha and 10-μSv/y (1 mrem per year) for gross beta. This corresponds to a gross alpha action level of 2.1 femtocuries[7] per cubic meter (fCi m^{-3}). The gross alpha action level, derived from a gross alpha concentration of 1.1 fCi/m^3, corresponds to 50-μSv/y (5 mrem per year) from americium-241 plus the typical gross alpha background of 1.0 fCi/m^3. The gross beta action level is 77 fCi/m^3 corresponding to 10-μSv/y from strontium-90.

Measurements that exceed the action level are compared to those measurements from distant locations. If the difference in concentrations between the distant sites and the boundary or onsite monitoring locations exceeds 1.1 fCi/m^3 for gross alpha or 77 fCi/m^3 for gross beta, an additional analysis of the filter (i.e., gamma spectroscopic analysis) is performed. Of the 556 TSP filters deployed during 2003, 98.6 percent of the gross alpha and 100 percent of the gross beta measurements were less than the action level. Elevated measurements are typically attributed to temperature inversions that hold radon progeny in the lower portion of the atmosphere. **Figure 3-1** and **Figure 3-2** show that gross alpha and gross beta activity fluctuates seasonally with gross beta activity increasing during winter months. Of the individual weekly measurements exceeding the action level, no man-made radionuclides were identified via gamma spectroscopic analysis.

In addition to the individual weekly samples exceeding the action level, quarterly composites of filters are collected using TSP and PM_{10} samplers for the individual monitoring locations are also analyzed via gamma spectroscopy. Typically, gamma spectroscopy results are only reported when exceeding a minimum detectable activity (MDA) or minimum detectable concentration (MDC). Gamma spectroscopy results indicated no man-made, gamma-emitting radionuclides on TSP or PM_{10} quarterly composite filters deployed during 2003.

INEEL OP monitors for radioactive iodine by drawing air through a RADeCo BG-300 impregnated charcoal cartridge. The activated charcoal cartridge preferentially adsorbs gases (e.g., noble gases and iodine). The cartridges are deployed in the field for a week at a volumetric flow rate between 57 and 112-L/min (2.0-4.0 ACFM) and the volume of air sampled is measured using a volumetric flow meter. Radioiodine samplers are analyzed in a batch process[8] via gamma spectroscopy.

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[5] Action Levels correspond to a dose equivalent of 50 microSieverts (50 μSv or 5 mrem) per year for gross alpha and 10 microSieverts (10 μSv or 1 mrem) per year for gross beta. Action Levels were derived from ICRP 30 dose conversion factors assuming a breathing rate of 10,000 m^3 per year.

[6] US EPA, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11," EPA 520/1-88-020, September 1988.

[7] 1 femtocurie = 10^{-15} curies or 10^{-3} picocuries.

[8] All of the cartridges collected by INEEL OP are analyzed at the same time in a single batch within 24 hours of collection. In event that iodine-131 is observed during the "batch" analysis, individual cartridges will be analyzed to determine iodine-131 concentrations at each monitoring station. Under such circumstances, the individual cartridges will be analyzed within 72 hours of collection.

The action level for airborne radioactive iodine is 21 fCi/m^3 which corresponds to 10 percent of Table 2, 40 CFR 61, Appendix E compliance value. Radioactive iodine has not exceeded the laboratory *a priori* MDC of 0.55 fCi/m^3 since INEEL OP began sampling for radioiodine in 1993.

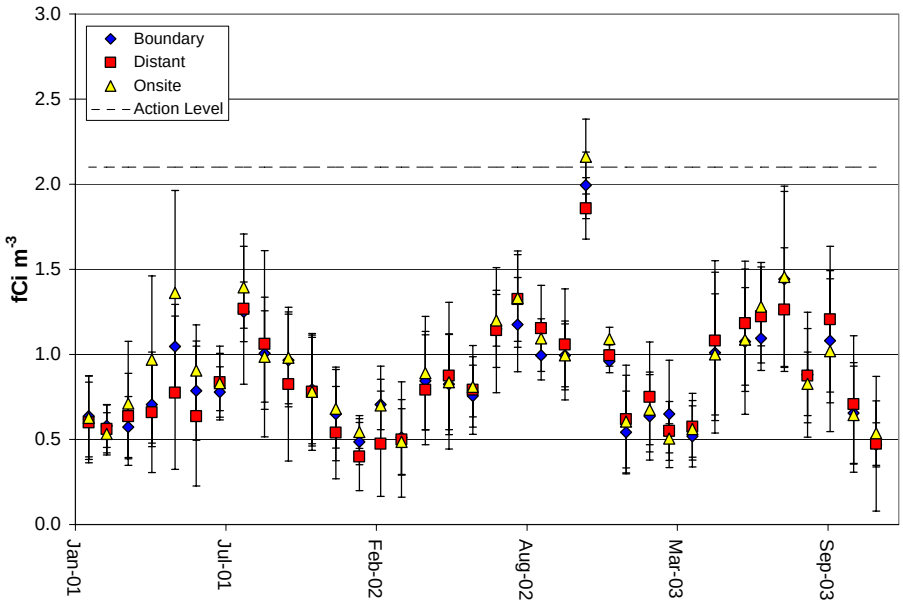

Figure 3-1. Average gross alpha screening results of TSP filters collected 2001-2003. The dotted line corresponds to the gross alpha action level, 2.1 fCi/m^3. This concentration corresponds to approximately 5 μSv (5 mrem) per year assuming all of the activity is due to inhalation of americium-241 and remains constant for an entire year.

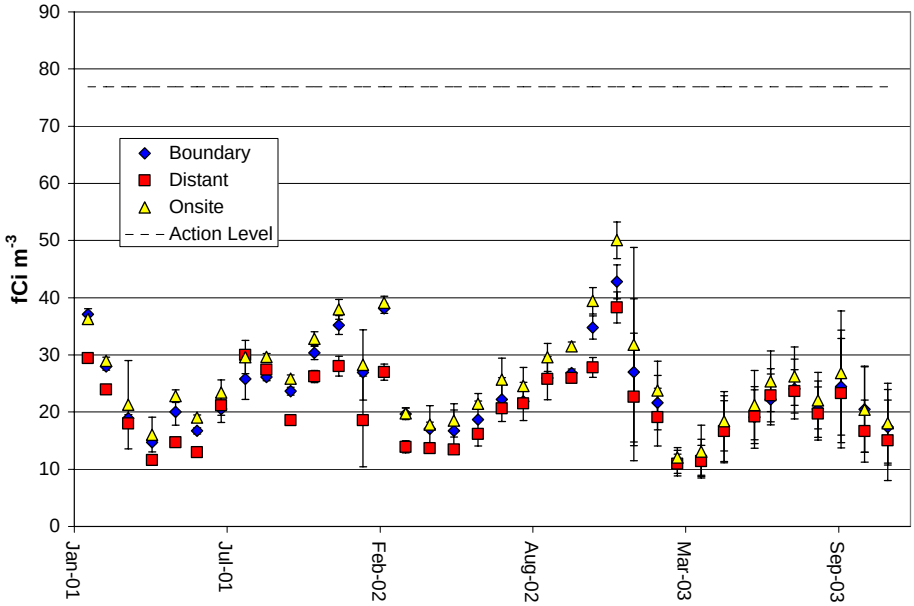

Figure 3-2. Average gross beta screening results of TSP filters collected 2001 - 2003. The dotted line corresponds to the gross beta action level, 77 fCi/m^3. This concentration corresponds to approximately 10 μSv (1 mrem) per year assuming all of the gross beta activity is due to inhalation of strontium-90 and remains constant for an entire year.

Some radionuclides that have the potential to be released to the environment as a result of INEEL operations are not easily identified and quantified using standard gamma spectroscopic analytical techniques. These radionuclides include strontium-90, americium-241, plutonium-238, and plutonium 239/240. A destructive radiochemical separation technique is therefore used in the analysis process. Since radiochemical separation involves destruction of the filter media, the annual composites are submitted for analysis only after all non-destructive analyses (i.e., gross alpha, gross beta, gamma spectroscopy) have been completed. The results of the radiochemical separation analyses can be found in **Table 3-2** and **Table 3-3**. Results indicate activity concentrations exceeding the MDC, but well below the INEEL OP action level for the specific radionuclides. Measurable quantities of these radionuclides are expected in the environment due to historic above-ground testing of nuclear weapons.

Table 3-2. Annual radiochemical separation analysis data for TSP particulate filters collected during 2003. These concentrations are reported in 10^{-6} pCi/m^3 and correspond to filter composites collected during the calendar year.

Station Location	Americium-241			Strontium-90		
	Concentration	± 2 SD	MDC[a]	Concentration	± 2 SD	MDC[a]
On-Site Locations						
Big Lost River Rest Area	0.0	0.0	1.0	4.4	12.4	22.4
Experimental Field Station	0.8	1.1	1.5	20.9[b]	13.0	18.1
Sand Dunes Tower	0.9	1.1	0.9	1.1	10.3	19.2
Van Buren Avenue	1.6[b]	1.6	1.1	23.1[b]	15.0	21.5
Boundary Locations						
Atomic City	0.8	1.1	1.0	18.2	14.2	21.3
Howe	1.0[b]	1.1	0.9	-7.7	9.5	21.2
Monteview	0.7	1.0	0.9	-0.4	10.1	19.4
Mud Lake	1.0	1.4	1.8	10.7	13.3	21.6
Distant Locations						
Craters of the Moon	0.5	1.0	1.6	-7.5	8.9	19.8
Fort Hall[c]	0.2	0.7	1.7	7.6	12.7	21.5
Idaho Falls	0.4	0.8	1.0	10.6	13.9	22.8

[a] MDC corresponds to location specific minimum detectable concentration.
[b] Activity is less than 5% of the Oversight Program's action level. Action level corresponds to 10 % of the compliance values listed for the specific radionuclide in 40CFR61 Appendix E, Table 3. Measurable quantities of these radionuclides are expected in the environment due to historic above ground testing of nuclear weapons.
[c] Operated by Shoshone-Bannock Tribes.

Table 3-2 continued. Annual radiochemical separation analysis data for TSP particulate filters collected during 2003. These concentrations are reported in 10^{-6} pCi/m^3 and correspond to filter composites collected during the calendar year.

Station Location	Plutonium-238			Plutonium-239/240		
	Concentration	± 2 SD	MDC[a]	Concentration	± 2 SD	MDC[a]
On-Site Locations						
Big Lost River Rest Area	0.7	1.0	0.9	2.0[b]	1.6	0.9
Experimental Field Station	0.3	0.6	0.8	3.0[b]	2.0	1.5
Sand Dunes Tower	0.3	0.7	0.9	2.0[b]	1.6	0.9
Van Buren Avenue	0.9	1.2	1.7	0.7	1.0	0.9
Boundary Locations						
Atomic City	1.0	1.4	1.8	4.6[b]	2.7	1.0
Howe	1.6[b]	1.5	0.9	1.9[b]	1.6	0.9
Monteview	1.3[b]	1.3	0.9	1.3[b]	1.3	0.9
Mud Lake	0.4	0.7	1.0	2.8[b]	2.0	1.0
Distant Locations						
Craters of the Moon	2.1[b]	1.6	0.8	2.6[b]	1.8	1.4
Fort Hall[c]	0.2	0.7	1.5	2.0[b]	1.7	1.8
Idaho Falls	1.8[b]	1.7	1.0	1.1[b]	1.3	1.0

[a] MDC corresponds to location specific minimum detectable concentration.
[b] Activity is less than 5% of the Oversight Program's action level. Action level corresponds to 10 % of the compliance values listed for the specific radionuclide in 40CFR61 Appendix E, Table 3. Measurable quantities of these radionuclides are expected in the environment due to historic above ground testing of nuclear weapons.
[c] Operated by Shoshone-Bannock Tribes.

Table 3-3. Annual radiochemical separation analysis data for PM_{10} particulate filters collected during 2003. These concentrations are reported in 10^{-6} pCi/m^3 and correspond to filter composites collected during the calendar year.

Station Location	Americium-241			Strontium-90		
	Concentration	± 2 SD	MDC[a]	Concentration	± 2 SD	MDC[a]
Boundary Locations						
Atomic City	1.2	1.7	1.6	21.5	23.6	37.8
Mud Lake	1.2	1.6	1.5	10.6	23.5	41.0
Distant Locations						
Fort Hall[b]	0.4	1.4	3.0	-9.1	18.0	37.5

[a] MDC corresponds to location specific minimum detectable concentration.
[b] Operated by Shoshone-Bannock Tribes.

Table 3-3 continued. Annual radiochemical separation analysis data for PM_{10} particulate filters collected during 2003. These concentrations are reported in 10^{-6} pCi/m^3 and correspond to filter composites collected during the calendar year.

Station Location	Plutonium-238			Plutonium-239/240		
	Concentration	± 2 SD	MDC[a]	Concentration	± 2 SD	MDC[a]
Boundary Locations						
Atomic City	0.3	1.1	2.4	3.6[b]	2.7	1.4
Mud Lake	2.1[b]	2.2	1.5	6.4[b]	3.8	1.5
Distant Locations						
Fort Hall[c]	0.7	1.8	3.4	0.0	0.0	1.6

[a] MDC corresponds to location specific minimum detectable concentration.
[b] Activity is less than 5 percent of the Oversight Program's action level. Action level corresponds to 10 % of the compliance values listed for the specific radionuclide in 40CFR61 Appendix E, Table 3. Measurable quantities of these radionuclides are expected in the environment due to historic above ground testing of nuclear weapons.
[c] Operated by Shoshone-Bannock Tribes.

Atmospheric Moisture and Precipitation

INEEL OP monitors atmospheric tritium concentrations by collecting atmospheric moisture samples at 11 monitoring locations. Ambient tritium is assumed to be in the form of tritiated water vapor (i.e., HTO). As air passes through a desiccant material, the atmospheric moisture adsorbs to the desiccant. The atmospheric moisture is then driven off from the desiccant in the laboratory by heating the desiccant material and collecting the liquid distillate. The liquid distillate is then analyzed for tritium via liquid scintillation counting. Atmospheric tritium concentrations are then calculated using the tritium concentration in the distillate, the quantity of atmospheric moisture collected, and the volume of air sampled.

Action levels for airborne tritium are set at 10 percent of the compliance limit listed in Table 2 of 40CFR61, Appendix E. During 2003, the MDC for airborne tritium ranged between 0.17 and 0.55 pCi/m^3. Tritium concentrations attributable to INEEL operations have not been observed at offsite monitoring locations. Atmospheric tritium was detected at onsite locations, Big Lost River Rest Area, Van Buren Avenue, and the Experimental Field Station, consistent with historical measurements (see **Figure 3-3**). Atmospheric tritium has been consistently observed at these locations since the Three Mile Island (TMI-2) fuel fragments were placed in dry storage at the Idaho Nuclear Technology and Engineering Complex (INTEC). The observed concentrations of tritium at the onsite locations are significantly below the INEEL OP action level for airborne tritium (150 pCi/m^3).

Average quarterly atmospheric tritium concentrations with detection capabilities (corrected for laboratory MDC, quantity of atmospheric moisture collected, and volume of air sampled) are given in **Table 3-4** for atmospheric tritium monitoring efforts during 2003.

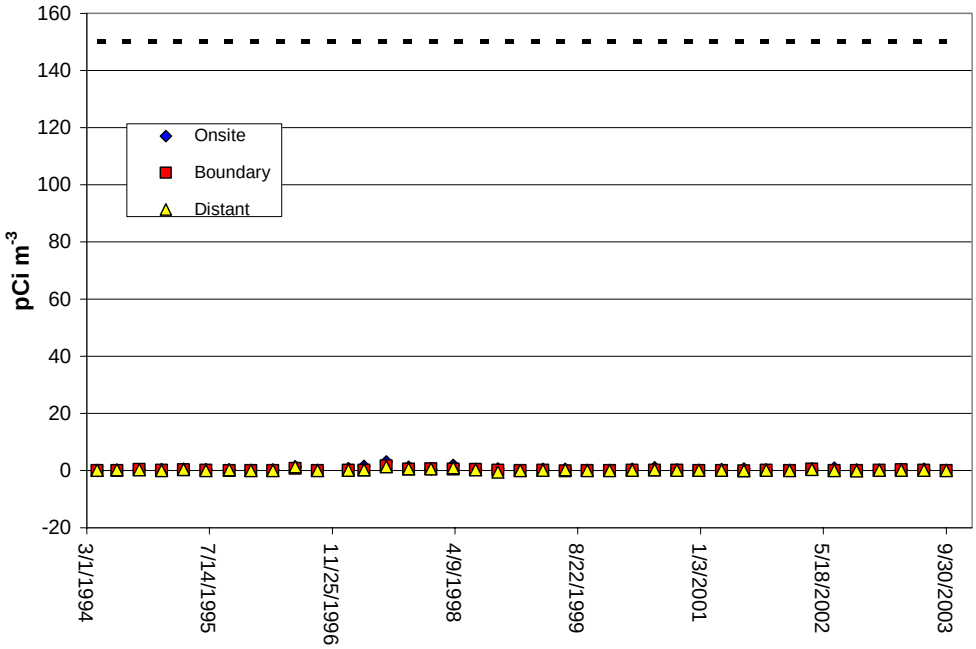

Figure 3-3. Average quarterly tritium concentrations observed at monitoring stations on the INEEL, near the site boundary, and at distant locations since 1994. The dotted line represents the INEEL OP action level or 10 percent of the compliance value listed in Table 2, 40CFR61, Appendix E.

Precipitation is collected at six monitoring stations (Atomic City, Big Lost River Rest Area, Howe, Idaho Falls, Mud Lake/Terreton, and Monteview). Precipitation (including rain and snow) is collected using a 1-square meter collection tray that is heated during winter months to facilitate the melting of snow. Precipitation is accumulated in a 19-L (5-gallon) carboy that is housed in an insulated housing to minimize evaporation. The samples are collected at the end of the calendar quarter or when the carboy is filled, whichever comes first.

Precipitation is analyzed for radionuclides that may have undergone atmospheric wash out. These water samples are analyzed for tritium via liquid scintillation counting and gamma-emitting radionuclides via gamma spectroscopy.

The laboratory reports a MDC of 160 pCi/L for tritium and 6 pCi/L for cesium-137 and other gamma-emitting radionuclides. No man-made radionuclides have been observed in precipitation samples collected by INEEL OP.

Table 3-4. Average quarterly airborne tritium concentrations. All values given in picocuries per cubic meter (pCi/m^3).

Location	1st Quarter 2003	1st Quarter 2003 MDC	2nd Quarter 2003	2nd Quarter 2003 MDC	3rd Quarter 2003	3rd Quarter 2003 MDC	4th Quarter 2003	4th Quarter 2003 MDC
Atomic City	0.06 ± 0.12	0.20	0.23 ± 0.29	0.47	0.09 ± 0.16	0.27	-0.16 ± 0.22	0.38
Howe	0.09 ± 0.21	0.35	0.39 ± 0.31	0.51	0.17 ± 0.24	0.39	-0.02 ± 0.20	0.34
Mud Lake/Terreton	0.15 ± 0.21	0.35	0.12 ± 0.18	0.29	0.05 ± 0.24	0.40	0.02 ± 0.11	0.18
Monteview	-0.03 ± 0.20	0.34	0.10 ± 0.19	0.31	0.01 ± 0.23	0.39	0.03 ± 0.23	0.39
Boundary Average:	**0.07 ± 0.08**	**0.31**	**0.21 ± 0.13**	**0.39**	**0.08 ± 0.07**	**0.36**	**0.05 ± 0.08**	**0.32**
Craters of the Moon	0.11 ± 0.21	0.35	0.13 ± 0.23	0.36	0.02 ± 0.16	0.26	0.11 ± 0.19	0.32
Fort Hall	0.09 ± 0.24	0.40	0.09 ± 0.18	0.30	0.12 ± 0.22	0.37	-0.04 ± 0.26	0.45
Idaho Falls	0.18 ± 0.23	0.39	0.24 ± 0.34	0.55	0.09 ± 0.21	0.36	0.07 ± 0.23	0.40
Distant Average:	**0.13 ± 0.05**	**0.38**	**0.15 ± 0.08**	**0.40**	**0.08 ± 0.05**	**0.33**	**0.05 ± 0.08**	**0.39**
Experimental Field Station	0.22 ± 0.12	0.17	0.73 ± 0.30	0.41	1.13 ± 0.34	0.49	0.24 ± 0.19	0.29
Big Lost River Rest Area	0.23 ± 0.19	0.33	0.22 ± 0.14	0.23	0.36 ± 0.17	0.27	0.13 ± 0.20	0.34
Sand Dunes	0.15 ± 0.19	0.33	0.14 ± 0.15	0.25	0.10 ± 0.16	0.26	0.12 ± 0.23	0.39
Van Buren Avenue	0.08 ± 0.18	0.31	0.32 ± 0.16	0.23	0.41 ± 0.19	0.27	0.14 ± 0.22	0.37
Onsite Average:	**0.17 ± 0.07**	**0.29**	**0.35 ± 0.26**	**0.28**	**0.50 ± 0.44**	**0.32**	**0.16 ± 0.06**	**0.35**

Interprogram Comparisons of Air Sampling Results

The DOE-ID contracts the S. M. Stoller Corporation, through the Environmental Surveillance, Education and Research Program (ESER), and Bechtel BWXT Idaho, LLC (BBWI) to perform air quality measurements on and near the INEEL. The results generated from these monitoring programs are compared to the monitoring results of the INEEL OP. The interprogram comparisons demonstrated relatively good agreement, with the greatest average relative difference being 24 percent. The results differ due to differences in monitoring schedules and sampling methods used by each organization.

Air Monitoring – Suspended Particulate Matter

Gross screening results from particulate air samples collected by INEEL OP, ESER, and BBWI from Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue monitoring stations were compared. Gross alpha and gross beta screening measurements are performed on filters collected each week after the filters have been weighed (to determine mass concentrations of suspended particulate matter) and the filters have been stored long enough to allow for the decay of the short-lived radioactive progeny of radon. Most of the gross screening result are attributable to radioactive progeny of radon-220 and radon-222. Storage for three to five days removes over 99 percent of the contribution to gross alpha and gross beta measurements from short-lived decay products of radon.

The first comparisons made are with respect to the INEEL OP action levels for gross alpha and gross beta measurements. Average weekly gross screening results were plotted to identify potential temporal variations (**Figure 3-4** for gross alpha results and **Figure 3-5** for gross beta results). Temporal variations are expected due to temperature inversions experienced during the winter months that trap radon gas in the lower atmosphere. A number of gross alpha screening analyses performed by DOE-ID contractors exceeded INEEL OP action levels during 2003. The elevated measurements were attributable to natural fluctuations in background since no man-made radionuclides were identified via gamma spectroscopic analysis during the periods in question. No gamma-emitting radionuclides were identified by INEEL OP or by DOE-ID contractors during 2003.

Secondly, measurements made during corresponding weeks are compared. Variations are expected for direct comparisons due to differences in sampling schedules, differences in sampling techniques, and differences in laboratory analysis.

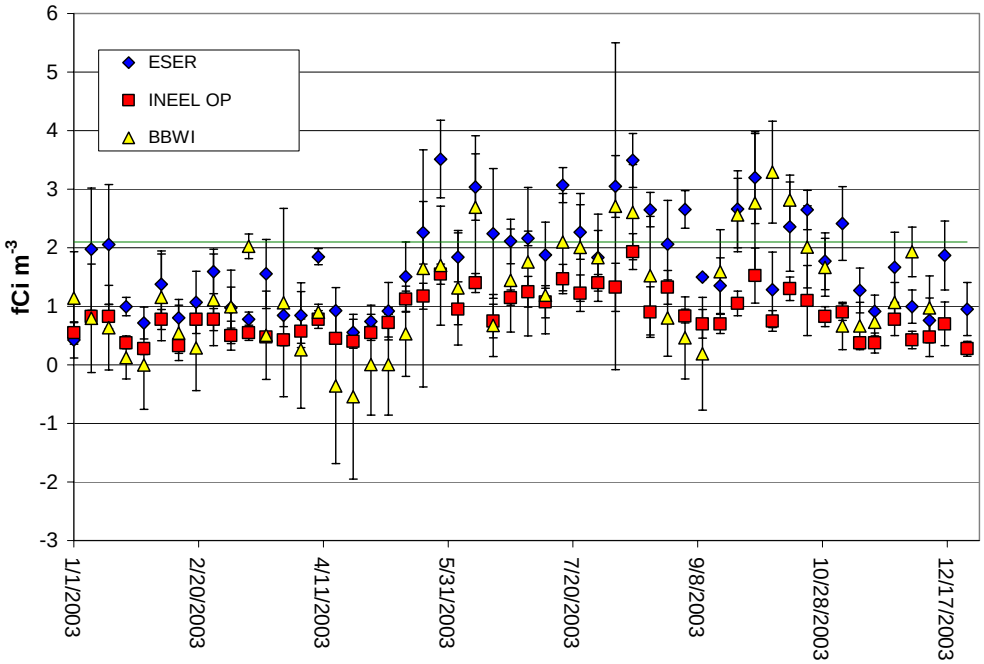

Figure 3-4. Average weekly gross alpha screening results for samples collected at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. The INEEL OP action level corresponds to an airborne concentration corresponding to an inhalation dose of 50 μSv/y (5 mrem per year). This assumes all of the alpha emissions are due to americium-241, an annual breathing rate of 10,000 m^3/y, and an average gross alpha background of 1.0 fCi/m^3, and the air concentration remains constant over the entire year.

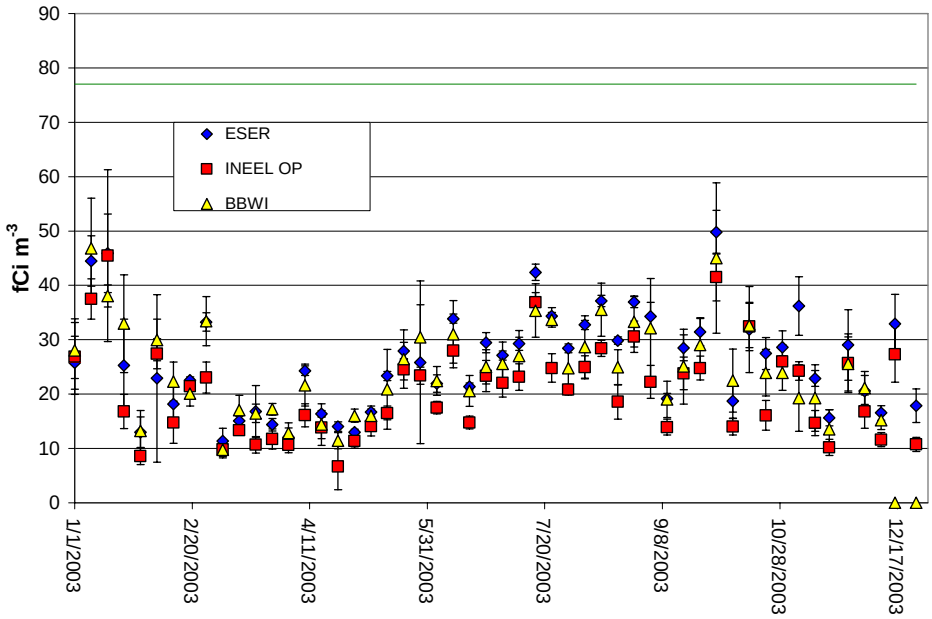

Figure 3-5. Average weekly gross beta screening results for samples collected at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. The INEEL OP action level corresponds to an airborne concentration corresponding to an inhalation dose of 10 μSv/y(1 mrem per year). This assumes all of the beta emissions are due to strontium-90, an annual breathing rate of 10,000 m^3/y, and the air concentration remains constant over the entire year.

Gross alpha screening results are typically very small, have relatively large measurement uncertainty, and a relatively small range of measurement values are observed during natural fluctuations. These factors make linear regression analysis of gross alpha screening results meaningless, therefore each INEEL OP measurement is compared to a DOE-ID measurement during a similar monitoring period and the two measurements are considered "in agreement" if the following expression holds true.

$$\{3 * (\sigma_{C1}^2 + \sigma_{C2}^2)^{1/2}\} \geq |C_1 - C_2|$$

Where,
C_1 = first measurement,
C_2 = second measurement,
σ_{C1} = 1-sigma uncertainty of first measurement, and
σ_{C2} = 1-sigma uncertainty of second measurement.

Gross beta screening results are considered to be "in agreement" if either the above expression holds true or if the absolute value of the relative percent difference of the two measurements (with respect to the mean of the two measurements) is less than 20 percent. The descriptive statistics and results of direct comparisons of gross alpha and gross beta screening analyses are shown in **Table 3-5**. No offsite environmental impacts from INEEL operations were evident based on the results of particulate air sampling.

Air Monitoring – Gaseous Radionuclides

Radioactive Iodine

Each organization uses the RADeCo BN 300 impregnated charcoal cartridge in series with a particulate filter to collect radioiodine. Filters are analyzed within 24-hours of collection via gamma spectroscopy with close examination of the 364-keV region of interest associated with iodine-131. The INEEL OP and the DOE-ID contractors' results did not indicate iodine-131 activity during 2003.

Atmospheric Moisture - Tritium

ESER and INEEL OP showed relatively good agreement for tritium concentrations in atmospheric samples collected at the Idaho Falls monitoring station during 2003 (**Figure 3-6**). Variations in measurements can be attributed to the different types of desiccant material used by the organizations and differences in the collection periods.

Table 3-5. Descriptive statistics of comparing INEEL OP gross alpha and gross beta screening results with DOE-ID results from co-located[a] monitoring locations during 2003. Gross alpha and gross beta screening concentrations given in fCi/m^3 (or 10^{-3} pCi/m^3).

	OP Gross Alpha	ESER Gross Alpha	OP Gross Beta	ESER Gross Beta
Average Value:	0.8	1.7	20.4	25.9
Median Value:	0.8	1.6	19.2	26.2
Standard Deviation:	0.4	0.9	9.2	9.9
Minimum Value:	0.1	0.2	0.0	0.4
Maximum Value:	2.2	4.2	63.4	53.9
Number of Pair Samples:	202		202	
Percent in agreement:	76.2%		82.2%	
Average Relative Difference:	NA [b]		11.9%	
	OP Gross Alpha	**BBWI Gross Alpha**	**OP Gross Beta**	**BBWI Gross Beta**
Average Value:	0.8	1.2	20.5	24.6
Median Value:	0.8	1.0	19.3	23.5
Standard Deviation:	0.4	1.2	9.1	9.2
Minimum Value:	0.1	-2.3	0.5	7.6
Maximum Value:	2.2	6.6	63.4	57.4
Number of Pair Samples:	190		190	
Percent in agreement:	93.2%		86.3%	
Average Relative Difference:	NA [b]		-9.9%	
	BBWI Gross Alpha	**ESER Gross Alpha**	**BBWI Gross Beta**	**ESER Gross Beta**
Average Value:	1.2	1.7	24.6	25.9
Median Value:	1.0	1.6	23.5	26.2
Standard Deviation:	1.2	0.9	9.2	9.9
Minimum Value:	-2.3	0.2	7.6	0.4
Maximum Value:	6.6	4.2	57.4	53.9
Number of Pair Samples:	194		194	
Percent in agreement:	97.4%		93.3%	
Average Relative Difference:	NA [b]		2.1%	

[a] Co-located monitoring was conducted at the distant locations, Craters of the Moon National Monument and Idaho Falls, and the onsite locations, Experimental Field Station and Van Buren Avenue.
[b] Not applicable due to the relatively small value with relatively large measurement uncertainty.

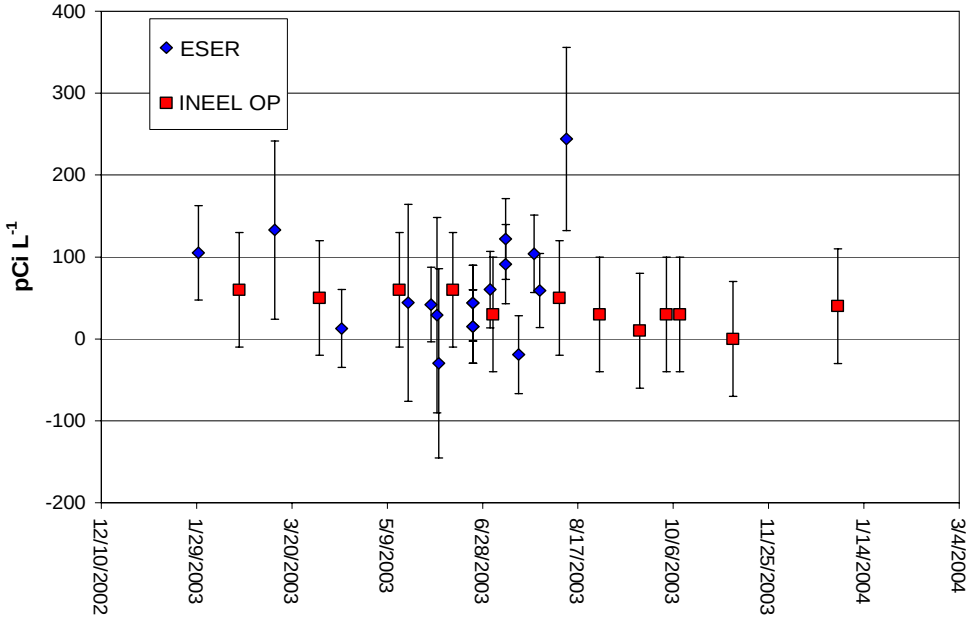

Figure 3-6. Airborne tritium concentrations at the Idaho Falls monitoring stations during 2003.

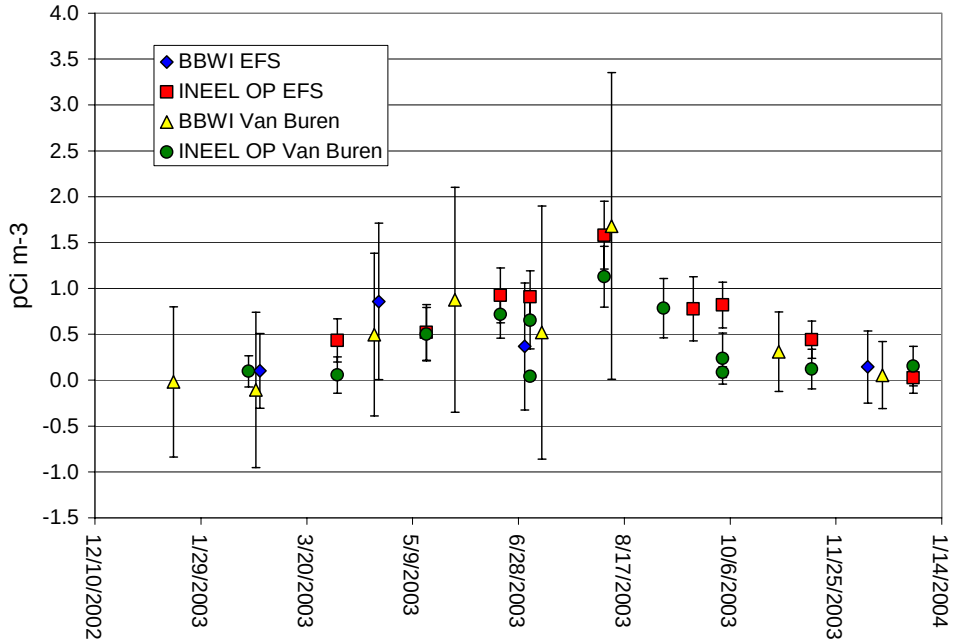

Figure 3-7. Airborne tritium concentrations at the Experimental Field Station and Van Buren Avenue monitoring stations during 2003. Elevated tritium concentrations were well below the INEEL OP action level of 150 pCi/m^3.

Descriptive statistics of airborne tritium concentrations observed by INEEL OP and BBWI at the Craters of the Moon, Experimental Field Station, Idaho Falls, and Van Buren Avenue monitoring

stations are shown in **Table 3-6**. Descriptive statistics of the tritium concentrations in atmospheric moisture (distillate) samples collected by ESER and INEEL OP at the Idaho Falls station may also be found in **Table 3-6.**

Table 3-6. Descriptive statistics of atmospheric tritium monitoring efforts at co-located monitoring stations during 2003

	INEEL OP Moisture Concentration (pCi/L) [a]	ESER Moisture Concentration (pCi/L) [a]	INEEL OP Air Concentration (pCi/m^3) [b]	BBWI Air Concentration (pCi/m^3) [b]
Average:	37.5	62.0	0.32	0.19
Median:	35.0	43.9	0.19	0.12
Standard Deviation:	19.6	64.4	0.36	0.52
Minimum:	0.0	-29.6	-0.18	-0.79
Maximum:	60.0	244.0	1.58	1.68
Number of Samples:	12	18	43	26

[a] Tritium concentration in atmospheric moisture samples collected at the Idaho Falls monitoring station.
[b] Airborne tritium concentrations determined from data collected at the Idaho Falls, Craters of the Moon, Experimental Field Station, and Van Buren Avenue Monitoring Stations.

Precipitation Sampling

Tritium concentrations observed in precipitation samples collected by INEEL OP and ESER at the Idaho Falls station were less than the INEEL OP detection capability (160 pCi/L). Slight discrepancies exist between the reported tritium concentrations in precipitation samples collected by INEEL OP and ESER (**Table 3-7**) due to reporting conventions used by each organization.

Table 3-7. Tritium concentrations observed in precipitation samples collected by INEEL OP and ESER at the Idaho Falls station during 2003. Tritium concentrations in pCi/L

	INEEL OP	ESER
Average Value:	34	42
Median Value:	10	54
Standard Deviation:	33	76
Minimum Value:	10	-114
Maximum Value:	70	110
Number of Samples:	5	7
Number of Samples with Detectable Tritium:	0[a]	0[b]

[a] INEEL OP reports a minimum detectable concentration of 160 pCi/L. All of the precipitation samples collected by INEEL OP during 2003 had tritium concentrations less than MDC.
[b] ESER reports a tritium detection when the concentration exceeds the 2-sigma measurement uncertainty.

References:

National Council on Radiation Protection and Measurements, Exposure of the Population in the United States and Canada from Natural Background Radiation, NCRP Report Number 94, 1987.

National Council on Radiation Protection and Measurements, Measurement of Radon and Radon Daughters in Air, NCRP Report Number 97, 1988.

US EPA, EPA 402-B-92-001, Clean Air Act Assessment Package – 1988 (CAP88PC) computer code, Version 1.0, March 1992.

US EPA, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11", EPA 520/1-88-020, September 1988.

National Emission Standards for Hazardous Air Pollutants (NESHAPs), Appendix E – Compliance Procedures Methods for Determining Compliance with Subpart I – National Emission Standards for Radionuclide Emissions from Federal Facilities other than Nuclear Regulatory Commission Licensees and not covered by Subpart H, Table 2 – Concentration Levels for Environmental Compliance.

Chapter 4
Terrestrial Monitoring

Major Findings and Developments

Gamma spectroscopic analysis of milk samples collected during 2003 and *in-situ* gamma spectroscopic measurements for radionuclide concentrations in soil were consistent with historical concentrations. INEEL OP observed no man-made radionuclides in milk samples collected during 2003, specifically iodine-131 (^{131}I). Cesium-137 (^{137}Cs) concentrations observed in soil were consistent with historical measurements on-site and within expected background concentrations off-site attributable to historical atmospheric nuclear weapons testing**.**

- No offsite environmental impacts resulting from INEEL operations were indicated as a result of the analyses of milk or soil samples.
- No offsite environmental impacts resulting from INEEL operations were indicated as a result of *in-situ* soil analysis.

Primary Terrestrial Results and Trends

Milk samples collected and *in-situ* gamma spectroscopic measurements made during 2003 indicated no concentrations of radionuclides attributable to INEEL operations above levels considered to pose a health risk. Terrestrial monitoring involves collecting milk samples from distribution centers and *in-situ* gamma spectroscopic analysis of soil at various monitoring locations. Milk samples and soil were analyzed specifically to identify gamma emitting man-made radionuclides.

Milk Sampling

Long-term radiological conditions are monitored by INEEL OP through the collection of milk samples in southeastern Idaho. Raw, unprocessed milk samples are collected from dairy product distributors and analyzed for gamma-emitting radionuclides (e.g., cesium-137, iodine-131 and potassium-40, etc.). Monitoring concentrations of gamma emitting radionuclides in foodstuffs provides an opportunity to verify any impact to the environment as a result of INEEL facility operations.

The philosophy behind food pathway assumes that an atmospheric release will eventually reach a member of the public through the food supply. Such a release potentially includes radioactive forms of iodine or radioiodines. Radioiodines are produced in relative abundance during fission reactions. The chemical nature of iodine makes it relatively mobile under ambient conditions and, therefore, is likely to be released to the atmosphere during normal reactor operation and is likely to be released in relatively large quantities during upset or emergency conditions.

The gaseous iodine will be transported through the environment via atmospheric dispersion until the iodine is deposited onto the ground (and other surfaces) and absorbed by plants or animals. Iodine is a nutrient necessary for proper metabolic function and indistinguishable from radioactive forms of iodine and will tend to accumulate in milk via biological mechanisms through absorption or ingestion. When the milk is ingested, the iodine will then accumulate in the thyroid gland. If the iodine is radioactive, this will result in an increased dose to the thyroid gland.

The biological mechanisms that accumulate iodine in milk provide a means to make an extremely sensitive measurement of radioactive material that may enter the food supply as a result of INEEL operations (i.e., reactor facility operation). INEEL OP specifically evaluates milk for isotopes of iodine that are easily observed, in relative abundance, with radioactive half-lives long enough to potentially reach the public considering a 4-day distribution time between milking and consumption. Short-lived isotopes such as iodine-123, iodine-130, iodine-132, iodine-133, iodine-134, and iodine-135 have radioactive half-lives that range from 53 minutes to 21 hours and will likely decay to levels that are difficult to detect in the environment. Longer lived isotopes such as iodine-125 and iodine-129 with low-energy beta radiation and relatively low abundance and low energy gamma photons make gamma spectroscopic analysis inappropriate for quantitative analysis. The remaining isotope of iodine is iodine-131 with a half-life of eight days with a characteristic 364-keV gamma photon with 81.2 percent abundance.

INEEL OP collects milk samples as its sole ingestion pathway-monitoring program. The use of soil sampling and *in-situ* gamma spectrometry has provided insight as to the concentrations of radionuclides in soil. The known quantities of radionuclides in soil near the INEEL boundary in the agricultural regions with respect to plant uptake factors for radionuclides, have not indicated a need for additional food pathway-monitoring.

Milk samples are collected every month from four distribution centers representing five geographical areas in southeastern Idaho (**Figure 4-1**). Raw milk samples are transported in coolers to minimize separation and spoiling to ISU EML as soon as physically possible and the milk samples are counted via gamma spectroscopy for iodine-131.

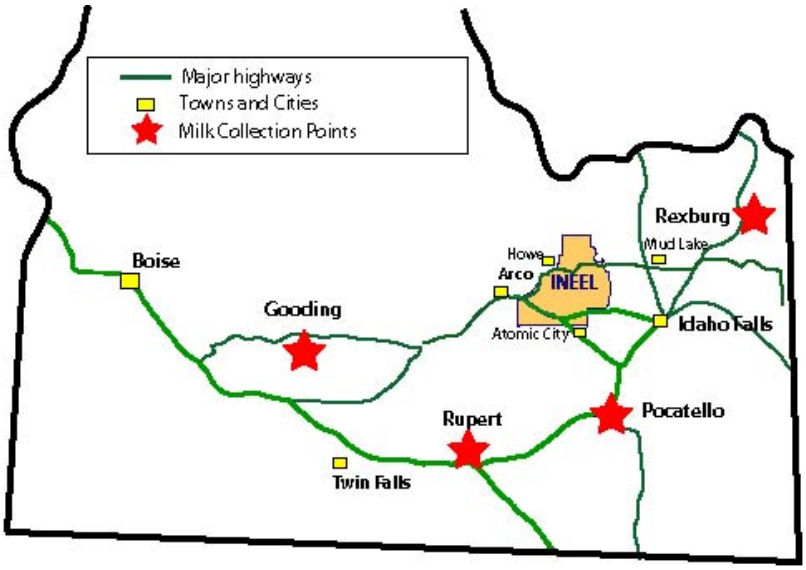

Figure 4-1. Routine milk collection points used by INEEL OP. Raw milk samples are collected at processing facilities at Gooding (Glanbia), Rupert (Kraft Foods), Pocatello (Meadowgold), and Rexburg (Nelson-Ricks). Two samples are collected at Nelson-Ricks from dairies near Howe and Mud Lake

INEEL OP requests that ISU EML report not only iodine-131 concentrations, but also potassium-40 that is found naturally in abundance of 0.012 percent of elemental potassium. The major radioactive constituent in many food products is potassium-40. The potassium-40 measurements performed by ISU EML provide a level of quality control in the measurement and indicate sensitivity. Historically, INEEL OP potassium-40 concentrations in milk have ranged between 1 and 2 nCi/L. Analytical results for iodine-131 and potassium-40 in milk are shown in **Figure 4-2** and summary descriptive statistics are given in **Table 4-1**.

Action Levels for iodine-131 in milk correspond to 50 μSv/y (5 mrem per year) committed effective dose equivalent (CEDE) to the thyroid gland. Action levels were "back calculated" from dose to concentration using consumption rates and dose conversion factors listed in US NRC Regulatory Guide 1.109[1] for infants, children, teens, and adults. Additional assumptions included a four-day distribution time[2], eight-day radioactive half-life for iodine-131, and the concentration remains constant for an entire year. The most restrictive assumptions correspond to a concentration of iodine-131 in milk of 4.4 pCi/L correlating to an infant thyroid CEDE of 50 μSv/y (5 mrem per year).

Concentrations of radioactive iodine in milk (iodine-131) were not detected during 2003 (as shown in **Figure 4-2**). Since INEEL OP began collecting milk samples in 1996, iodine-131 has not been observed in concentrations greater than the ISU EML *a priori* MDC of 4 pCi/L and therefore have not exceeded the INEEL OP Action Level of 4.4 pCi/L.

[1] US Nuclear Regulatory Commission, Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I, Revision 1, October 1977.
[2] Table D-1, US NRC Regulatory Guide 1.109

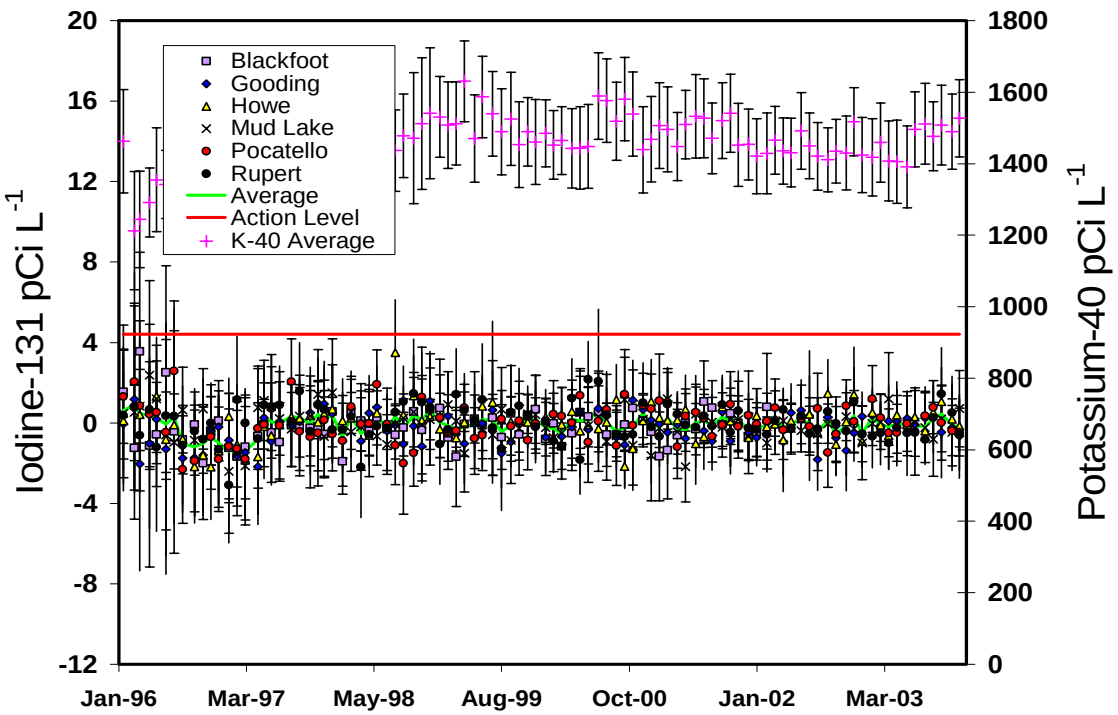

Figure 4-2. Reported concentrations of iodine-131 (primary y-axis) in milk samples collected by INEEL OP since 1996. The action level corresponds to a committed dose equivalent (CEDE) of 50 μSv/y (5 mrem per year) to the thyroid of an infant assuming a constant iodine-131 concentration. The average potassium-40 concentrations (secondary y-axis) are shown to demonstrate the consistency in measurements since 1998. The iodine-131 error bars correspond to 2-sigma counting uncertainty and the potassium-40 error bars represent 1-standard deviation.

Table 4-1. Descriptive statistics for routine monthly milk samples collected by INEEL OP. All measurements in pCi/L.

	Iodine-131 in Milk	Potassium-40 in Milk
Average:	-0.07	1456
Median:	-0.08	1448
Standard Deviation:	0.60	83
Minimum:	-1.64	1288
Maximum:	1.44	1686
Number of Routine Samples:		84

Soil Sampling

Long-term radiological conditions are monitored by identifying and measuring gamma emitting radionuclides in soil at locations on the INEEL, near the INEEL boundary, and at distant locations with respect to INEEL. Monitoring concentrations of gamma emitting radionuclides in surface soil provides insight to the transport, deposition, and accumulation of radioactive material in the environment as a result of INEEL operations and historic atmospheric testing of nuclear weapons.

During 2003, INEEL OP used *in-situ* gamma spectrometry for monitoring gamma radionuclide concentrations in soil. The *in-situ* gamma spectrometry technique is preferred over soil sampling since this is a non-destructive analysis involving no sample collection or preparation. Therefore, no damage or alteration is done to the monitoring location and minimal waste generated.

Measurement of gamma emitting radionuclides *in-situ* has become feasible with the advent of the intrinsically high-purity germanium detector (HPGe) and portable multi-channel analyzers (MCA). Data collected using the HPGe and digital MCA offer an opportunity to quickly set up the detection system in the field and still make accurate and reproducible measurements. Data are stored electronically until it can be downloaded to a personal computer for spectral analysis.

In-situ gamma spectrometry is performed using a HPGe set on a tripod to fixed height of 1-m above the ground surface. Using basic assumptions (e.g., soil density, radionuclide distribution) a soil concentration can be estimated based upon instrument response using energy dependence and angular response.

Descriptive statistics for *in-situ* gamma spectrometry are found in **Table 4-2**. Assumptions used for in-situ gamma spectroscopy include a 1.5-gm/L soil density, a field of view with a ten meter radius, and homogeneous radionuclide distribution in the top five centimeters of soil.

Table 4-2. Descriptive statistics of *in-situ* gamma spectrometry measurements of cesium-137 in soil. All measurements in picocuries per gram (pCi/g).

	Total	Onsite	Boundary	Distant
Number of Locations:	42	28	11	3
Average:	0.45	0.49	0.44	0.10
Median:	0.47	0.52	0.46	0.08
Standard Deviation:	0.15	0.11	0.13	0.05
Minimum:	0.06	0.25	0.08	0.06
Maximum:	0.70	0.70	0.56	0.16

No other man-made radionuclides were identified via *in-situ* gamma spectrometry. *In-situ* gamma spectroscopic monitoring results of soil performed during 2003 were provided in the INEEL OP Environmental Surveillance Program data report for the third calendar quarter of 2003.

Interprogram Comparisons of Terrestrial Monitoring Results

In-Situ Measurements Conducted with BBWI

During the summer of 2002 and during the summer of 2003, INEEL OP performed independent efficiency calibrations of its high-purity Germanium (HPGe) detectors used for *in-situ* gamma spectrometry. INEEL OP used a 30 percent relative efficiency[3] "n-type" HPGe detector (calibrated in 2003) and a 95 percent relative efficiency "n-type" HPGe detector (calibrated in

[3] Relative efficiency with respect to a 3 x 3-inch NaI(Tl) scintillation detector for ^{60}Co.

2002). The signal produced by the detector is collected using a digital MCA that provides high-voltage to the detector as well as electronically storing all spectra collected. Gamma spectra collected at the various monitoring locations are closely examined looking for gamma energies attributable to man-made radionuclides. Once radionuclides are identified, the signal measured by the HPGe is compared to the instrument's efficiency calibration and soil concentrations for the radionuclides are estimated.

Several *in-situ* soil measurements were made on the INEEL "Large Grid" during 2003. The results of the comparison of these results and the descriptive statistics of this comparison are shown in **Table 4-3**.

Table 4-3. Descriptive Statistics of Co-located *in-situ* Gamma Spectroscopic Results for cesium-137 performed by BBWI and INEEL OP during 2003. All values are in picocuries per gram (pCi/g).

	INEEL OP	BBWI
Average:	0.52	0.62
Standard Deviation:	0.08	0.13
Median:	0.54	0.66
Minimum:	0.35	0.34
Maximum:	0.62	0.80
Average Relative Difference:		-7.8%
Percent Agreement (3-sigma):		100.0%
Percent Agreement (Relative Difference):		100.0%
Number of Measurements used for the Comparison:		16

References:

National Council on Radiation Protection and Standards, "Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies", NCRP Report Number 129, January 1999.

Chapter 5

Water Monitoring

Major Findings and Developments:

Tritium, gross beta radioactivity, strontium-90, and chromium exceeded drinking water standards in the Eastern Snake River Plain Aquifer beneath several facilities at the INEEL. Contaminant concentrations generally decreased or remained constant through 2003, based on samples from INEEL OP water surveillance locations.

- Drinking water standards were not exceeded at any sites where water is used by the public or INEEL workers.
- No contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, however, INEEL impacts can be identified at some sites along the southern boundary of the INEEL. Tritium concentrations at these sites were greater than background but less than 1 percent of drinking water standard. Chromium at these wells also exceeded background but was less than 5 percent of the drinking water standard.
- Analytical results from INEEL OP monitoring were generally in close agreement with results reported by the USGS and ESER.

Primary Nonradiological Results and Trends

Water samples collected by the INEEL OP in 2003 from distant or Magic Valley locations did not exhibit concentrations of nonradiological contaminants indicative of impacts from the INEEL. Similarly, the majority of analyses on samples collected from boundary wells detected only concentrations reflecting background or non-INEEL anthropogenic influences. However, common ions, nutrients, or trace metals attributable to INEEL impacts were detected in some boundary wells, as well as in several onsite wells. **Table 5-1** compares the minimum and maximum concentrations of nonradiological constituents to their respective background estimations and any applicable drinking water standards as defined by the U.S. EPA Safe Drinking Water Act.

INEEL OP detected calcium, sodium, potassium, chloride, sulfate, nitrate plus nitrite, total phosphorous, barium, chromium, zinc, gross beta radioactivity, and tritium above background concentrations at some sites on the INEEL. Additionally, strontium-90 and technetium-99, which are beta-emitting radionuclides that were historically disposed of to the aquifer at the INEEL, were detectable in samples from at least two INEEL OP onsite locations. A brief summary of these analytes is presented here. A more complete discussion of surveillance monitoring results for 2003 and historical trends for selected nonradiological and radiological analytes is presented in "Environmental Surveillance Program Water Quality Trends for Surveillance Monitoring Sites, 1994 - 2003 Data" (Hall, 2004).

Table 5-1. Summary of selected nonradiological INEEL OP water surveillance analytical results, 2003.

Analyte	Range of Concentrations						Background[a] Concentrations for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL			Boundary, Distant and Surface Water Sites				
	Min	Max	Median	Min	Max	Median		
Common Ions/Nutrients (mg/L)								
Calcium	32.9	88.0	44.6	28.4	5.24	39.3	5 - 43	None[b]
Magnesium	12.8	26.6	16.0	12.0	20.2	15.9	1 - 15	None
Sodium	7.9	45.0	16.0	5.2	36.0	14.0	5 - 14	None
Potassium	1.3	5.9	3.3	1.0	6.6	2.8	1 - 3	None
Chloride	6.9	123.0	20.7	3.5	44.9	13.6	2 - 16	SMCL[c]=250
Sulfate	19.8	163.0	27.7	16.5	58.8	22.6	2 - 24	SMCL=250
Total Nitrate plus Nitrite (as nitrogen)	0.29	3.83	1.33	0.223	1.90	0.77	1 - 2	MCL[d]=10
Total Phosphorus	0.010	0.026	0.016	0.006	0.029	0.015	<0.02	None
Trace Metals (µg/L								
Barium	29	141	57.5	19	77	36.0	50 - 70	MCL=2000
Chromium	<5	117	9.0	<5	7	<5.0	2 - 3	MCL=100
Zinc	<5	463	<5	<5	205	10.5	<10	SMCL=5000
Manganese	<5	11	<5	<5		<5.0	<1 - 4	None
Lead	<2	8	<2	<2	7	<2.0	<5	AL[e] = 15

[a] Background is defined as ambient conditions for sites with no obviously anthropogenic influence. The range given is from Knobel and others (1992), or defined by the minimum and median from Knobel and others (1999).
[b] Not applicable, no standard set
[c] Secondary maximum contaminant level
[d] Maximum contaminant level
[e] Action level

A synopsis of the water surveillance sampling locations, schedules, analyses, and procedures specific to the INEEL OP water monitoring strategy appears in **Chapter 2.**

Common Ions and Nutrients

Calcium, magnesium, sodium, potassium, chloride, sulfate, total nitrate plus nitrite as nitrogen, and total phosphorus were detected in some groundwater samples collected on the INEEL at concentrations believed to represent contamination from activities on the site. These ions, along with a form of carbonate ion, constitute a majority of the dissolved components of natural

groundwater ("major ions"), and can vary due to differences in geology of aquifer recharge areas (Hall, 2000). Concentrations of these ions can also vary due to anthropogenic influences such as evaporation of infiltrating irrigation water or injection or infiltration of wastewaters. Water quality trends for 2003 monitoring and results are given in Hall (2004).

Calcium

Calcium concentrations at several onsite wells (CFA 1, CFA 2, USGS 65, USGS 85, and USGS 112) exceeded the expected background range for the aquifer estimated from data published by Knobel and others (1992) (see **Table 5.1** for range of concentrations observed for onsite, and boundary and distant locations). Calcium is not identified as a major component of INEEL wastewater. However, the elevated concentration and similarity in historical trends of calcium and some other major ions in groundwater (magnesium, potassium, sodium and chloride) to major waste components which include chloride, sulfate, and sodium suggest that the elevated calcium values observed are disposal-related for the identified onsite wells. Calcium concentrations for samples from onsite locations remained steady or decreased slightly during 2003 for some wells; this is probably due to historical variability in disposal. The Mud Lake water supply well, which typically returns calcium concentrations near 9 mg/L, was out of service during the annual chemistry sampling for boundary sites.

Magnesium

Magnesium concentrations in samples from onsite wells exceeded the expected background range for onsite wells CFA 1, CFA 2, USGS 65, and USGS 112, with CFA 2 having the highest concentrations. Magnesium and calcium results follow similar trends for CFA 1 and CFA 2, and for USGS 65 and USGS 112. Magnesium, as with other major ions, is a natural constituent of groundwater beneath the INEEL. Although not identified as an INEEL waste constituent, the elevated concentrations of magnesium reflect trends observed for other major ions and are likely reflective of INEEL waste disposal. Magnesium concentrations are unchanged from 2001 results.

Sodium

Sodium is identified as a major waste constituent for INEEL facilities, with concentrations for wells CFA 1, CFA 2, USGS 85, and USGS 112 reflecting this waste disposal influence. The highest concentrations are observed in well USGS 112, with historical trends similar to chloride and to most other major ions for CFA 1 and CFA 2. Concentrations for samples from onsite locations remained much the same as concentrations reported for 2002. In general, the boundary, distant, and surface water samples yielded sodium concentrations within background levels.

Potassium

A drinking water standard has not been established for potassium. Concentrations of dissolved potassium in groundwater samples are typically less than 4 mg/L. These concentrations vary as a result of natural variability, waste disposal at the INEEL, or other anthropogenic influences.

Potassium concentrations from onsite wells USGS 112, CFA 1, and CFA 2 are not significantly greater than the expected background levels, but as trends for potassium tend to mirror trends for sodium and other known INEEL wastes, it is likely that at least some portion of the potassium present is due to past disposal activities at INTEC. Potassium concentrations remain relatively unchanged from 2001.

The potassium concentrations were highest for distant site Alpheus Spring, likely due to a combination of natural variability and some anthropogenic influences.

Chloride

The secondary maximum contaminant level (SMCL) for chloride, historically a major constituent of INEEL chemical wastes, is 250 mg/L. Elevated chloride may also indicate influence from surface water, irrigation, or other anthropogenic impacts (Hem, 1985).

Chloride concentrations for onsite wells USGS 112, 115, 85, CFA 1, and CFA 2 exceeded the background range, with the highest values found in samples from CFA 2, at about half the SMCL. Chloride concentrations for USGS 112 have declined about 70 percent from 220 mg/L in 1997 to an average of 78 mg/L for 2003. Concentrations for CFA 2 have varied, but remained near current levels of 123 mg/L. Chloride levels for the onsite locations listed, as well as USGS 85, are likely impacted by INEEL waste disposal. Overall, onsite chloride concentrations for onsite locations are about 10 percent higher than 2002.

Alpheus Springs, Clear Springs, and the Minidoka water supply (locations distant from the INEEL) exceeded the background range for chloride. Other constituents (sodium, nitrate plus nitrite as nitrogen) suggest that Alpheus and Clear Springs have some degree of impact due to nearby anthropogenic sources such as irrigation. This is supported by tritium levels, which reflect levels observed in surface water for other INEEL OP monitoring. Minidoka water supply chloride concentrations are likely due to natural sources, with no indication of impact from INEEL activities or other anthropogenic sources.

Sulfate

No wells sampled exceeded the SMCL of 250 mg/L for sulfate, historically a major INEEL waste constituent. Elevated sulfate can also be an indication of impacts from surface water, irrigation, or other anthropogenic impacts.

Sulfate concentrations were highest in samples collected from USGS 65, where water quality has been impacted by waste disposal at TRA. Concentrations from samples for wells USGS 112, 85, 87, 120, 104, CFA 1, CFA 2, and RWMC Production all exceeded the background range for sulfate, with trends for sulfate similar to calcium and magnesium. Concentrations for these wells are likely due to INEEL waste disposal, and are unchanged for 2003.

Alpheus Springs, and Clear Springs sulfate concentrations were highest for boundary, distant, and surface water samples. These sulfate results along with chloride concentrations are attributable to a combination of local anthropogenic influences.

Nitrogen

The MCL for nitrate plus nitrite (as nitrogen) is 10 mg/L, with concentrations greater than 1-2 mg/L indicating anthropogenic impacts to groundwater of the Eastern Snake River Plain Aquifer (Rupert, 1994, 1997).

Nitrogen concentrations are elevated for seven onsite locations, and greatest for wells CFA 1, CFA 2, and USGS 112. Elevated concentrations at these and other sites (USGS 65, 85, 115, and 100) are the result of past wastewater disposal at INTEC and TRA. The highest concentration detected in groundwater is from well CFA 2. Concentrations for CFA 1 and USGS 112 declined, while concentrations for the remaining onsite locations remained constant. The upgradient site USGS 27 likely shows agricultural impacts.

Concentrations for boundary, distant, and surface water sites were all within the 1-2 mg/L background range. Alpheus Springs and Shoshone water supply, already discussed as having concentrations of other constituents indicative of anthropogenic impacts, were near the upper background range.

Phosphorus

Total phosphorous exceeded the background levels in two wells, USGS 112 and USGS 85. The median result for sample sites on the INEEL was similar to distant, boundary, and surface water sites. Concentrations for onsite locations remain unchanged from 2001 sample results.

Total phosphorus can vary due to local hydrogeologic conditions, as evidenced by historical results for boundary location, Mud Lake water supply (not sampled in 2003). This higher concentration is indicative of local hydrogeologic conditions, as other indicators of anthropogenic influences are absent at this well (such as low nitrate plus nitrite and very low tritium).

Trace Metals

Groundwater samples collected by INEEL OP in 2003 were analyzed for barium, chromium, zinc, lead, and manganese. Elevated chromium and barium can be directly linked to historic INEEL waste disposal activities. Concentrations of zinc, lead, and manganese may be related to well construction materials, natural concentrations, as well as anthropogenic INEEL sources.

Barium

In all 2003 water samples, barium concentrations were considerably lower than the MCL of 5,000 μg/L. Barium was detected in all samples collected from INEEL sites, with the highest concentrations being reported for USGS 112. Barium was above background levels for CFA 1,

CFA 2, and USGS 85. Barium has historically been a waste product from INTEC. Trends observed for CFA 1, CFA 2, and USGS 85 reflect those of most other known INEEL waste constituents (e.g., sodium and chloride), with concentrations unchanged from 2002.

Barium concentrations for boundary, distant, and surface water sites were highest for samples collected from the Big Lost River and lowest for sites on the eastern side of the INEEL. The distribution for sites not influenced by the INEEL may provide information on recharge areas for groundwater.

Chromium

The primary source of chromium contamination at the INEEL is TRA, where it was used as a corrosion inhibitor until 1972. Lesser amounts of chromium, used for the same purpose, were disposed of at INTEC and other INEEL facilities (Frederick and others, 1998). Chromium concentrations for samples from USGS 65 located south of TRA exceeded the MCL of 100 µg/L.

Samples for other INEEL sites, RWMC Production, USGS 85, 87, CFA 1, CFA 2, and USGS 115, exceeded background. Other sites, USGS 104, 103, 108, 112, and 14, also show results greater than background. Monitoring results suggest the chromium background in the vicinity of the INEEL may be greater than the published range of 2-3 µg/L (Knobel and others, 1992). Chromium in excess of about 6-7 µg/L for samples from onsite locations downgradient from TRA-INTEC is likely due to historical waste disposal. Chromium concentrations for USGS 65 have decreased consistently, declining about 30 percent since 1994 and about 20 percent from 2002 to 2003.

Chromium concentrations for boundary, distant, and surface water sites were less than 7 µg/L. All surface water and distant sites were at or less than the detection level. Concentrations for boundary sites USGS 14, 103, 104, 108, 124, and 125 may indicate INEEL impacts, contamination from well materials, or natural variations in background.

Zinc, Lead and Manganese

A clear relationship between a disposal point, distribution within the aquifer, and historical contaminant trends does not appear to exist for zinc, lead, and manganese.

Zinc concentrations were less than the secondary MCL (5,000 µg/L) with the highest zinc concentrations observed in samples from USGS 115. Most other INEEL wells returned detectable levels of zinc. Wells with detectable zinc tend to have dedicated submersible pumps installed in them. Thus, some degree of zinc contamination may be related to the well construction and the type of pump installed in the well.

Historically, lead and manganese have been measured in some INEEL waste streams (Frederick and others, 1998) and detected in a limited number of INEEL monitoring wells. Lead was detected in samples from five wells on the INEEL, CFA 2, USGS 19, 27, 85, and 87 (3 – 8 µg/L). Manganese was detected at one site, USGS 100 (11 µg/L). While both of these

contaminants are or have been present in INEEL wastewater, concentrations are within the ranges that reported by others for the Eastern Snake River Plain Aquifer (<8 µg/L for lead and < 12 µg/L manganese, reported in Wood and Low, 1988) and are likely due to natural variability or anthropogenic influences at the well, such as well construction materials or foreign materials known to be present in the well (Hall, 2003a).

Primary Radiological Results and Trends

Water samples were collected by the INEEL OP and analyzed for gross alpha and gross beta radioactivity, gamma-emitting radionuclides, and tritium. Samples from selected sites were also collected and analyzed for strontium-90 and technetium-99. **Table 5-2** summarizes INEEL OP's radiological results for water sampling.

Gross Radioactivity

Water samples collected from all sample sites are analyzed for gross alpha and gross beta activity. Gross measurements are primarily a screening tool used to identify whether or not more specific analyses are needed. As samples for these gross measurements are collected at all monitoring sites, they provide a means of determining overall variability. Where these gross measures exceed expected ranges, or historical sampling has indicated the presence of alpha- or beta-emitting radionuclides, radiochemical analyses are completed.

Table 5-2. Summary of selected radiological INEEL OP water surveillance analytical results, 2003.

Analyte	Range of Concentrations (pCi/L ± 2s)						Background Concentration for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL			Boundary, Distant and Surface water sites				
	Min	Max	Median	Min	Max	Median		
Gross Alpha (as Thorium–230)[a,b]	<MDC	8.5 ± 1.2	<MDC	<MDC	5.7 ± 2.9	<MDC	0 – 3	15
Gross Beta (as Cesium-137)[a,b]	<MDC	43.8 ± 2.1	2.6 ± 1.0	<MDC	7.8 ± 1.3	1.9 ± 0.9	0 – 7	50[c]
Cesium-137[b]	<MDC	<MDC	<MDC	<MDC	<MDC	<MDC	0	200[c]
Tritium[b]	<MDC	10350 ± 270	1205 ± 95	<MDC	190 ± 70	<MDC	0 – 40	20,000
Tritium[b,d]	<MDC	131 ± 7	15 ± 6	<MDC	170 ± 10	13 ± 6	0 – 40	20,000
Strontium-90[b]	<MDC	12.9 ± 3.1	<MDC		N/A		0	8[c]
Technetium-99[b]	<MDC	42.5 ± 0.4	2.3 ± 0.2		N/A		0	900[c]

[a] The terms "as thorium-230" and "as cesium-137" refer to the radionuclide used to calibrate the instrument and do not imply that the activities present are due to the presence of these specific radionucides.

[b] MDC for gross alpha and gross beta radioactivity is approx. 2.5 and 1.4 pCi/L cesium is typically >6 pCi/L, tritium by standard analysis methods is 160 pCi/L and tritium by enhancement method is 10-15 pCi/L. The MDC for strontium-90 is approx. 1.5 pCi/L. The MDC for technetium-99 analyzed by the contract lab is 4-9 pCi/L (total or unfiltered), and 0.5 pCi/L for dissolved technetium-99 analyzed by ISU-EML.

[c] Expressed as a cumulative annual dose of 4 millirem/year. For unspeciated gross beta, 50 pCi/L is used as an action level; a activity-concentration is calculated for specific nuclides; e.g., for cesium-137, 4 millirem is equivalent to 200 pCi/L, if cesium-137 were the only detectable radionuclide.

[d] Tritium analyzed using an Electrolytic Enhancement Method. For onsite locations, this includes just those samples that did not exceed MDC for tritium by the standard method.

Gross Alpha Radioactivity

Results for samples from 13 locations during 2003 exceeded the MDC (approximately 2.5 pCi/L) for gross alpha radioactivity. All results were well below the MCL of 15 pCi/L.

Samples from six onsite locations yielded detectable gross alpha radioactivity, with the highest activity measured at RWMC Production (8.5 ± 1.2 pCi/L). Additional analyses were done for this sample to rule out the presence of americium and plutonium isotopes, but none were detected. The remaining five gross alpha radioactivity detections ranged from 2.5 ± 1.6 to 4.7 ± 1.8 pCi/L. No gross alpha radioactivity trends are apparent for any monitored sites, including sites with gross alpha detections in 2003. Onsite gross alpha detections are attributable to naturally occurring radionuclides (uranium and thorium isotopes). Ten boundary, distant, and surface water sites and five Magic Valley sites also yielded detections.

Gross alpha radioactivity levels for all sites were within the range expected for naturally occurring radioactivity due to uranium and thorium decay products in the aquifer and illustrate the range of activity typical for the Eastern Snake River Plain.

Gross Beta Radioactivity

Samples from about two thirds of all onsite, boundary, distant, and Magic Valley locations during 2003 contained gross beta radioactivity exceeding the MDC at approximately 1.4 pCi/L. Drinking water MCLs are based on an exposure limit equivalent to 4 millirem per year to the whole body, with a screening level of 50 pCi/L for gross beta radioactivity. Strontium-90, an INEEL contaminant present in groundwater downgradient from INTEC, decays primarily with beta particles and has an MCL of 8 pCi/L.

Gross beta radioactivity concentrations for samples collected from onsite wells ranged from less than the MDC to 43.8 ± 2.1 pCi/L. The highest observed gross beta activities were from samples collected at observation wells USGS 112 and 85, where groundwater is known to have been impacted by historical waste disposal practices at INTEC. Gross beta concentrations for these sites have in general been declining since INEEL OP monitoring began in 1994; however, results for individual sampling periods tend to fluctuate. Gross beta radioactivity trends, along with trends for strontium-90, for sites USGS 85 and 112 are presented in **Figure 5-4**.

Gross beta radioactivity concentrations in samples collected from the boundary, distant, surface water, and Magic Valley sites ranged from less than the MDC to 7.8 ± 1.3 pCi/L due to naturally occurring gross beta radioactivity. Concentrations for gross beta radioactivity across the Eastern Snake River Plain Aquifer can vary, with typical values ranging from less than the MDC to about 7 pCi/L (Knobel and others, 1992).

Gamma Spectroscopy

Gamma spectroscopy results are reported for cesium-137, potassium-40, and for any gamma-emitting isotope that might be detected. No cesium-137 results exceeded the MDC. In 2003, naturally occurring potassium-40 was detected in samples from two sites. The levels of potassium-40 detected are greater than that expected and appear to be an artifact of the analysis process. Approximately 0.01 percent of all potassium naturally consists of radioactive potassium-40, resulting in background concentrations for the aquifer of approximately 0 – 7 pCi/L, significantly less than the detection level for this isotope (100 – 130 pCi/L). Potassium-40 is the predominant radioactive component in most foods and human tissues (Eisenbud and Gesell, 1997). No other gamma-emitting radionuclides were identified.

Tritium

Tritium concentrations for onsite monitoring locations did not exceed the MCL of 20,000 pCi/L for any sample collected in 2003. Concentrations in onsite samples ranged from less than the MDC to 10,350 ± 270 pCi/L. Nine onsite wells yielded tritium concentrations above the approximately 160 pCi/L MDC. The highest tritium concentrations are from CFA 1. Historically, sample results from USGS 65 have been the highest for all sites monitored. The source of tritium contamination for well USGS 65 was TRA's warm waste pond. This infiltration pond, used to dispose of low-level radioactive waste, was taken out of service in 1993, removing the source of tritium. Tritium concentrations for samples from USGS 65 have continued to decline about 10-20 percent each year since that time. Other onsite locations with detectable tritium are USGS 112, 85, 115, CFA 2, RWMC Production, USGS 87, and 104.

The median tritium concentration for onsite wells is relatively unchanged from 2003, after an approximate 28 percent decline from 2001 to 2002.

Samples from one boundary site, USGS 124, exceeded the MDC for tritium. This site has historically been at or above the standard tritium MDC, and reflects INEEL tritium disposal. No other boundary, distant, or surface water sites exceeded the standard tritium MDC. Background levels of tritium in the Snake River Plain Aquifer range from 0 to 40 pCi/L (Knobel and others, 1992).

The onsite wells with detectable tritium are downgradient from TRA-INTEC and have been impacted by historical waste disposal. The median tritium concentrations for onsite wells decreased 28 percent from 2002 levels, while concentrations for individual sites either remained steady, or decreased up to 35 percent. Historical trends for locations USGS 65, 112, and 115 are presented in **Figure 5-1.** Concentrations for USGS 65 and 112 have each declined about 20 percent, while USGS 115 declined about 5 percent from 2002.

As seen in **Figure 5-2**, tritium concentrations in USGS 85 have a similar downward trend while concentrations at CFA 1 and CFA 2 have fluctuated. Concentrations for samples from RWMC production well, USGS 87, and USGS 104 have declined about 10 percent, as shown in **Figure 5-3.**

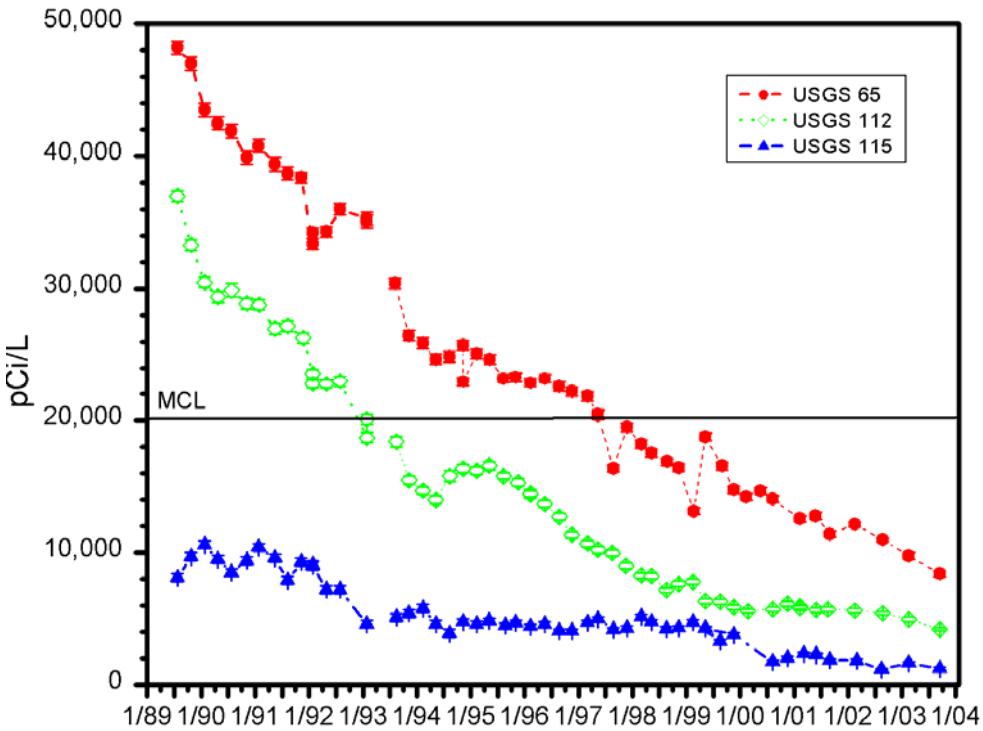

Figure 5-1. Tritium concentration over time, wells USGS 65, 112, and 115. Error bars represent 2-sigma uncertainty.

An electrolytic enhancement technique was used to reanalyze samples that did not yield detectable tritium using the standard liquid scintillation analysis method. The MDC for this enriched or enhanced tritium analysis is about 10-15 pCi/L.

Onsite locations reanalyzed using the enhanced tritium method ranged from less than detectable levels to 141 ± 8 pCi/L, with a median concentration of 15 ± 6 pCi/L. Samples from six onsite locations were reanalyzed. Results from one location, USGS 120, were clearly above expected ambient concentrations with an average of 136 ± 8 pCi/L for samples from this site. The remaining sites, P&W 2, Site 14, USGS 19, USGS 27, and USGS 100, showed tritium concentrations within background levels.

Enhanced tritium analysis of boundary sites USGS 103, 108, 124, 125, 11, and 14 all showed some degree of INEEL tritium contamination, while other boundary sites, USGS 8 and Atomic City, did not. Concentrations ranged from less than detection to 183 ± 9 pCi/L, with a median value of 19 ± 6 pCi/L. Tritium samples from USGS 108 and 124 showed results clearly greater than that expected for background conditions, with concentrations for these sites ranging from 183 ± 9 at USGS 124 to 105 ± 7 at USGS 108. Sites USGS 8, 11, 14, and 125 showed detectable tritium concentrations ranging from 10 ± 5 to 54 ± 8 pCi/L.

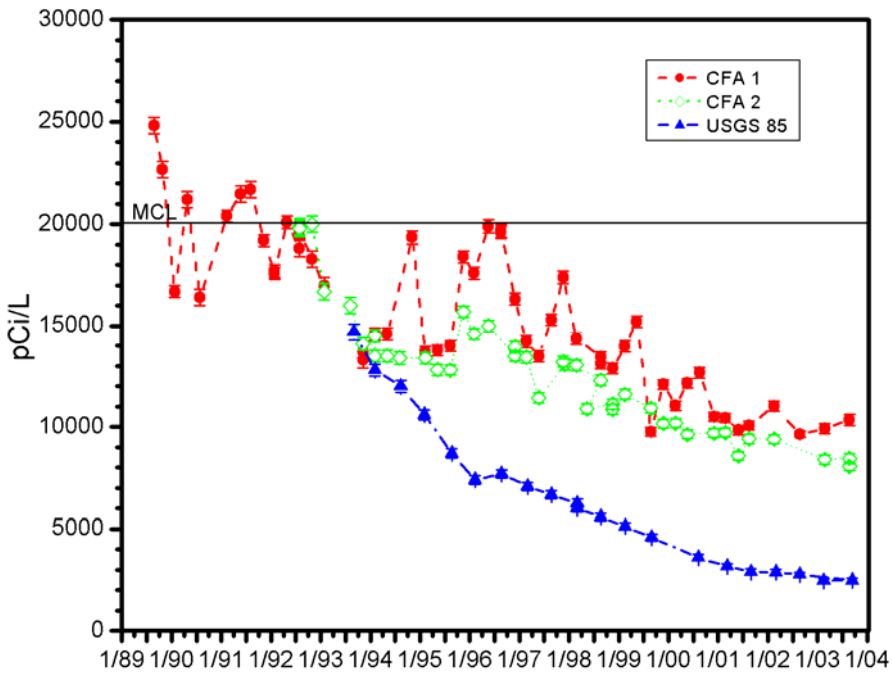

Figure 5-2. Tritium concentration over time, wells CFA 1, CFA 2, and USGS 85. Error bars represent 2-sigma uncertainty.

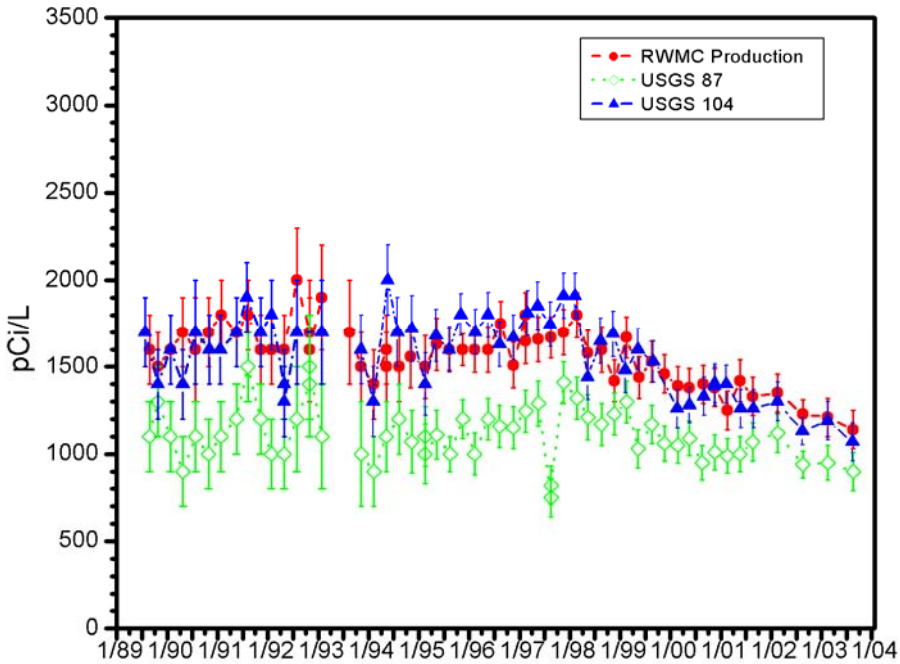

Figure 5-3. Tritium concentration over time, wells RWMC Production, USGS 87 and 104. Error bars represent 2-sigma uncertainty.

Historical sampling at USGS 11 and 14 has revealed the presence of INEEL contaminants, chlorine-36 and iodine-129, suggesting that tritium detected there is also a result of INEEL

contamination. Tritium concentrations for USGS 8 have historically averaged about 40-50 pCi/L, consistent with concentrations observed for Big Lost River sites for previous years and other sites that are influenced by surface water or irrigation. Another boundary site, USGS 103, returned tritium concentrations just above sample-specific detection levels, at 9 ± 6 and 10 ± 4 pCi/L. An exhaustive study by Busenburg and others (2001) suggests that water from this well is influenced in a small degree from INEEL waste disposal.

Low-level tritium results for distant sites, Alpheus Springs and Shoshone water supply, average 28 pCi/L and also show nitrate values 1.2 to 1.99 mg/L, indicative of some degree of influence by surface water and irrigation. The tritium values observed for distant sites overall ranged from less than the MDC to 36 ± 9 with a median result of 13 ± 6 pCi/L.

Rupert (1997) suggests that when tritium concentrations exceed about 4.5 pCi/L for a specific site, some portion of that groundwater had been recharged since the advent of nuclear testing in the early 1950s. Differing degrees of mixing older and recent (post-1950's) water result in the range of natural tritium concentrations observed. The tritium concentrations should be less than the ISU-EML MDC for enhanced tritium analysis of groundwater in the central portion of the Eastern Snake River Plain Aquifer where sources of recent recharge are absent or minimal.

Strontium-90 and Technetium-99

Strontium-90 and technetium-99 are contaminants that were released from spent nuclear fuel when it was reprocessed at the INTEC and introduced to the aquifer through the INTEC injection well and possibly through the TRA Warm Waste Ponds.

Samples from five onsite wells were analyzed for strontium-90. At CFA 1, CFA 2 and USGS 115, strontium-90 was below the MDC of about 1 pCi/L. Results for wells USGS 85 and 112 for 2003 showed strontium-90 at 2.83 ± 0.70 to 16.4 ± 3.1 pCi/L. Trends for strontium-90 concentrations, wells CFA 1, CFA 2, USGS 85, and 112 are shown in **Figure 5-4**.

Samples were collected from six locations for dissolved (filtered) technetium-99 and analyzed by ISU-EML using ion-selective filter disks. Concentrations ranged from less than the MDC (about 1-2 pCi/L) to 42.5 ± 0.4 pCi/L. The highest concentrations were measured in samples from well USGS 112 (37.6 ± 0.7 to 42.5 ± 0.4 pCi/L). Historical trends for dissolved technetium-99 trends for selected wells are shown in **Figure 5.4a.** A trend of generally decreasing concentrations for strontium-90 for USGS 85 and 112 is apparent from **Figure 5.4** and is consistent with the observed trend for tritium at these locations. Trends for technetium-99 for these same locations (USGS 85 and 112) do not reflect strontium-90 trends for prior to 2000, but do for concentration trends after 2000. Results for dissolved technetium-99 discussed in the following paragraph confirm this post-2000 trend. The difference between pre- and post 2000 trends may be indicative of a difference in contaminant transport characteristics of the two INEEL contaminants, and of a change in major sources for post-2000 technetium-99 and strontium-90 concentrations for USGS 85 and 112.

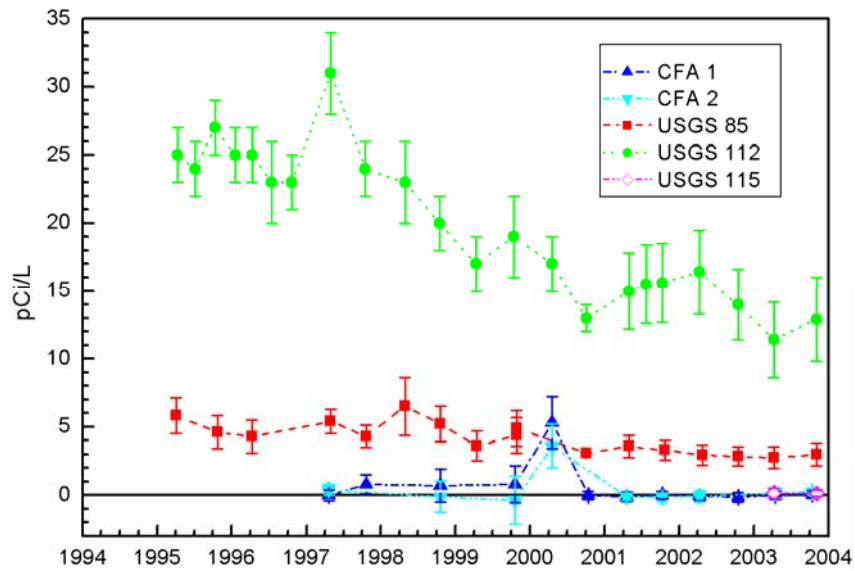

Figure 5-4. Strontium-90 concentrations for wells CFA 1, CFA 2, USGS 85, 112, and 115.

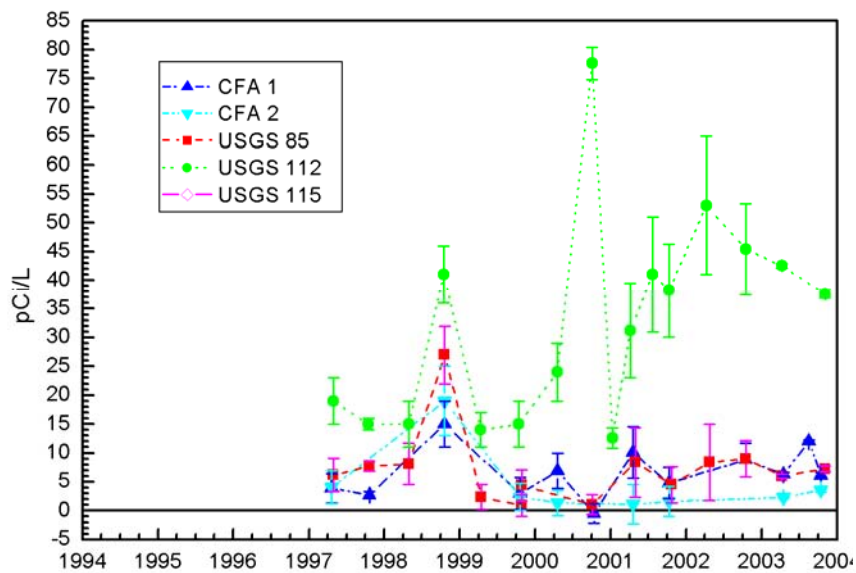

Figure 5-4a. Dissolved technetium-99 concentrations for wells CFA 1, CFA 2, USGS 85, 112, and 115.

Technetium-99 was also detected in samples from USGS 85, 115, CFA 1, and CFA 2, with concentrations ranging from 2.0 ± 0.3 to 6.2 ± 0.3 pCi/L for these wells. Analysis of 2003 samples from USGS 104 did not yield detectable concentrations of technetium-99, at 0.1 ± 0.2 and 0.5 ± 0.4 pCi/L.

Interprogram Comparisons of Water Results

The INEEL OP collects samples concurrently with the USGS and ESER. Goals for the water sampling conducted by these three organizations differ, but the use of similar analytical techniques serves to support meaningful interprogram data comparison.

Comparisons of available 2003 monitoring results were made for various radiological parameters for all co-sampled locations. Nonradiological results were compared for locations co-sampled with the USGS on and near the INEEL. A summary of the sampling locations, frequency, analyses, and methods specific to interprogram comparisons appears in **Chapter 2**.

During 2003, replicate co-samples were collected with the USGS at 24 groundwater and surface water locations on and near the INEEL. Two sites on the Big Lost River were not sampled due to lack of flow in the river. In addition, the INEEL OP and the USGS collected replicate groundwater and surface water samples at 15 locations (including one duplicate location) in the Magic Valley. Seven sites were also co-sampled with ESER, including two public drinking water wells along the INEEL boundary, and three springs and two drinking water supply wells south of the INEEL and in the Magic Valley.

Statistical comparisons were made for nonradiological analyses where the analyte of interest was present in both results of a data pair. Other criteria were used where a “less than” was reported for one or both samples. For radiological data, all analyses were used for statistical comparisons.

Linear regression analyses were applied to data where a sufficient number of replicate sample pairs were available. When such regressions were not meaningful, differences between replicate results were compared using histograms of the differences and evaluated with paired t-tests to compare population means. Relative percent differences are used for comparison when data are too limited (not enough data pairs) for comparison by other means. The linear regression is used because it can provide both an estimate of the mean difference between the INEEL OP result and co-sampling agency result, quantified by the y-intercept, and an estimate of the mean of y for a given x (shown by the slope of the regression). Hypothesis testing is used to determine if the y-intercept and slope terms are significant, as evidenced by associated t-statistics and probability values. Also displayed on the regression graphs are the 95 percent confidence interval about the regression line, and a 95 percent confidence interval for the predicted y value for a given x. If the more powerful regression is not statistically significant and meaningful, then a paired t-test is computed to determine if there is a significant difference between the paired data. Where censored data are presented (results reported simply as “<”) relative percent differences and comparisons relative to the reporting level are made.

Linear regressions were determined meaningful where a combination of factors applied: y-intercept and slope coefficients appeared reasonable (a positive slope approaching 1), the correlation coefficient (R) is sufficiently large (generally >0.80), and associated probability values (P for intercept, P for slope) for the slope and intercept indicate that the values are statistically significant (based on t-test statistics for $\alpha = 0.05$, or 95 percent confidence). Also reviewed were regression assumptions that residuals (the difference between the data value and the value predicted by the regression) versus predicted values were randomly distributed and that the residuals themselves were normally distributed, and that the standard deviation of the residuals was small compared to the magnitude of the data. These plots were assessed

qualitatively and are not presented here. The regression parameters are presented for all data sets where there are a sufficient number of data pairs (more than 2). If the regression was not significant then t-test results, a summary of the mean differences (the mean of the difference between result pairs), and a histogram of these differences are presented.

Nonradiological Results Comparisons

Linear Regression Comparisons

Samples collected by INEEL OP for nonradiological analyses are analyzed by the Idaho Bureau of Labs (IBL) in Boise and replicate samples from the USGS for nonradiological parameters are analyzed at the National Water Quality Laboratory (NWQL).

Regression results were meaningful for replicate data for chloride, chromium, nitrate plus nitrite, sodium, and sulfate. As summarized in **Table 5-3**, and depicted in **Figures 5-5** through **5-9**, linear regression comparisons of INEEL OP and USGS results showed good agreement for replicate data. Such agreement was not found for total phosphorus.

Table 5-3. Regression parameters with 95 percent confidence intervals for the replicate samples collected by the USGS and the INEEL OP, 2003.

Analyte	y-intercept	P for intercept	Slope	P for slope	R	SD of the residual	Number of replicate sample sets
Chloride	-0.54 ± 0.46	0.239	1.02 ± 0.01	$<10^{-4}$	0.997	2.14	41
Chromium	0.75 ± 2.67	0.785	1.05 ± 0.05	$<10^{-4}$	0.988	7.33	11
Nitrate + nitrite (as nitrogen)	0.00 ± 0.02	0.950	0.998 ± 0.01	$<10^{-4}$	0.998	0.06	25
Total Phosphorus	0.035 ± 0.04	0.432	-0.86 ± 2.66	0.750	-0.074	0.042	21
Sodium	-0.13 ± 0.80	0.009	0.95 ± 0.04	$<10^{-4}$	0.974	1.92	28
Sulfate	-0.022 ± 0.77	0.978	1.01 ± 0.01	$<10^{-4}$	0.999	1.88	13

Chloride

Forty-one replicate sample sets were collected for chloride in 2003. Regression analyses showed good agreement (**Figure 5-5).** The p-value for the y-intercept and slope indicate that the intercept term is not significant. The slope of the regression is very near 1.0 and the associated p-value is significant. The correlation coefficient (R) and the standard deviation indicated that the regression model reasonably predicts the relationship between USGS and INEEL OP chloride results. Because the USGS collects a filtered sample (dissolved chloride), while the INEEL OP collects an unfiltered sample (total chloride), this data agreement suggests that since there is no difference between the two, chloride present is largely in dissolved form.

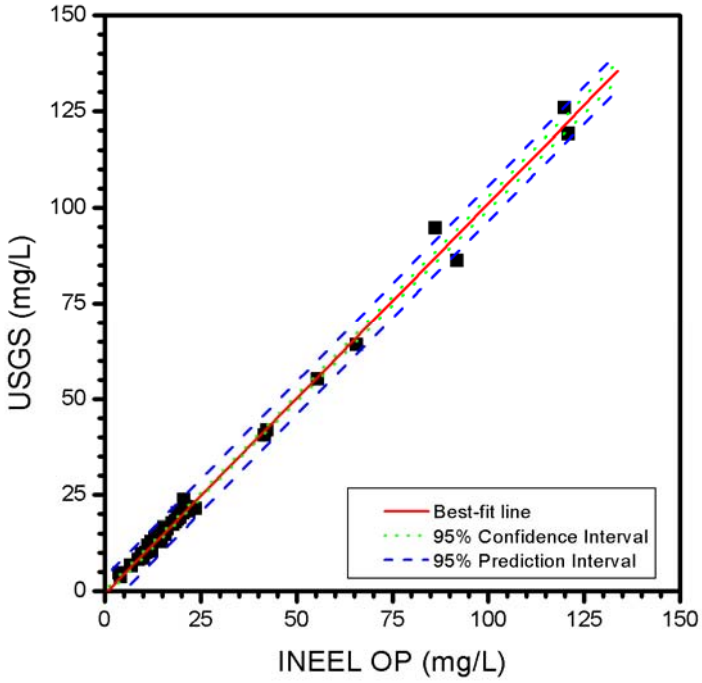

Figure 5-5. Concentrations of chloride reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2003.

Chromium

Nineteen replicate dissolved chromium results were available for 2003. For these nineteen data pairs, eight INEEL OP results were less than the 5 µg/L MDC and three USGS results were reported as less than the 5 µg/L MDC. Estimated values were reported for six samples with concentrations less than 5 µg/L. For three result pairs, both the USGS and INEEL OP results were reported as less than their respective MDCs. For another five pairs, one of the results was less than the reporting level. EPA guidance suggests that for replicate samples in which the concentrations are less than five times the MDC, results are comparable if they differ by less than the sample MDC (EPA, 1994). All of these replicates differed by less than the sample MDC.

Regression analyses, presented in **Figure 5-6**, showed very good agreement, with an intercept that does not differ from zero and a slope close to one. Chromium was detected in both results for eleven replicate pairs. Although the number of data pairs is small, the regression is reasonably strong, as evidenced by the small uncertainty for the slope, the high correlation coefficient (R), and the relatively small standard deviation for the regression.

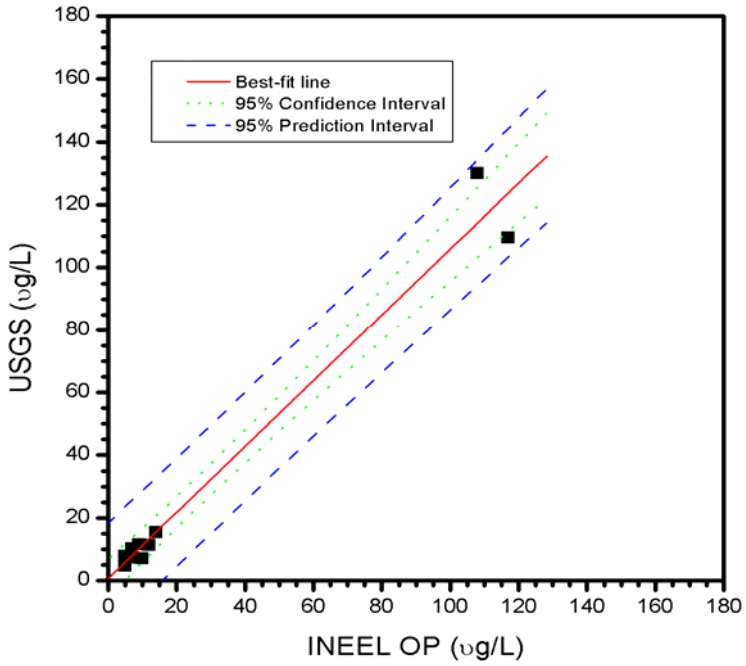

Figure 5-6. Concentrations of chromium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2003.

Nitrogen and Phosphorus

Regression analysis for the 25 replicate values for nitrate plus nitrite for INEEL OP and USGS results (**Figure 5-7**) also shows good agreement. The slope suggests a small difference between USGS and INEEL OP results (slope of 1.00 and uncertainty of 0.01). The p-value for the y-intercept indicates an intercept indistinguishable from zero.

Replicate analyses for total phosphorus were available for 26 sample pairs, with total phosphorus detected for both samples for 22 of these sample pairs. All results exceeded the 0.005 mg/L MDC detection level for the INEEL OP. Three results for USGS samples were less than the reporting level (0.01 – 0.02 mg/L) for their analyzing laboratory. Regression analysis of the 22 sample pairs where both had detections did not yield a meaningful result. Because the regression was not considered significant, a paired t-test and histogram of differences was completed. The conclusion drawn from the t-test is that the mean of INEEL OP results did not differ from the mean of the USGS results (t= -0.5798 and p 0.5685). The mean of the differences between INEEL OP and USGS results was <0.005 mg/L.

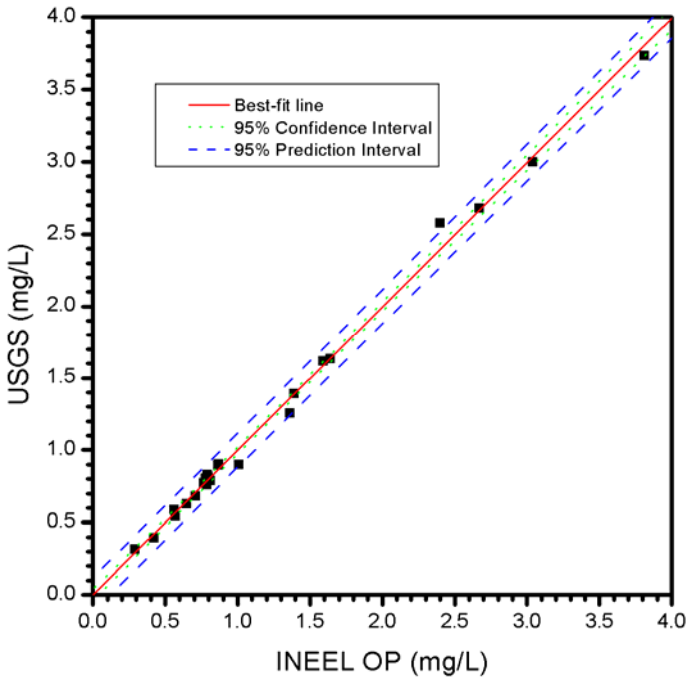

Figure 5-7. Concentrations of dissolved nitrite plus nitrate as nitrogen reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2003.

Sodium and Sulfate

There were 13 replicate results for sulfate and 29 replicate results for sodium. Sulfate results shown in **Figure 5-8** demonstrate good agreement, with a slope of 1.01 ± 0.01 and a y-intercept not differing from zero. The regression analyses presented in **Figure 5-9** indicate that the sodium results are well correlated with a slope of 0.95 ± 0.04 and a y-intercept not differing from 0.

Relative Percent Differences Comparisons

Relative percent differences show excellent agreement for all of the analytes that could not be compared with linear regressions. **Table 5-4** demonstrates the comparison of the concentrations of these constituents reported in replicate samples during 2003.

Two replicate sample sets were collected for barium, lead, manganese, and zinc from USGS 65.

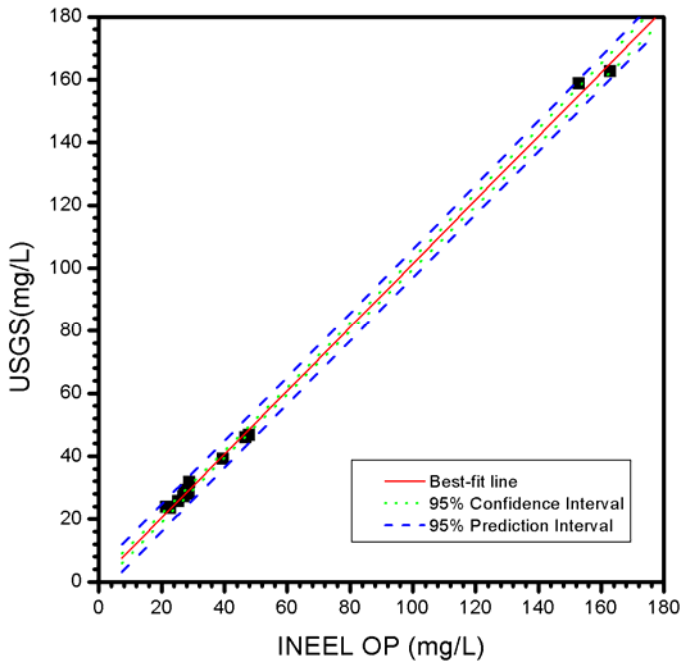

Figure 5-8. Concentrations of sulfate reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2003.

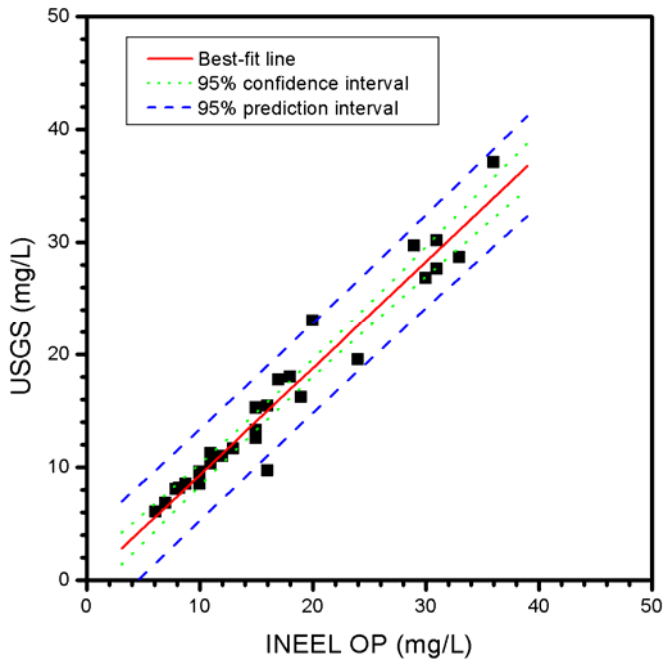

Figure 5-9. Concentrations of sodium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2003.

Table 5-4. Comparison of common ion, nutrient, and trace metal concentrations reported for replicate samples, 2003.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference <20%, or where results are within +/- detection limit	Percent of replicate samples with comparable results
Barium	2	2	2	100
Chromium	19	11	19[a]	100
Chloride	41	41	(compared by linear regression)	
Lead	2	0	2	100
Manganese	2	0	2	100
Sodium	28	28	(compared by linear regression)	
Sulfate	13	13	(compared by linear regression)	
Nitrite plus nitrate as nitrogen	25	25	(compared by linear regression)	
Phosphorus as P	26	23	26[b]	100
Zinc	2	2	1	50

[a] Eleven replicate pairs compared by linear regression.
[b] Linear regression was not meaningful.

In summary, comparisons of INEEL OP and USGS results for nonradiological analytes demonstrate very good agreement for replicate data, with exception of zinc. Only two comparable results were available for zinc, both from USGS 65. One data pair was within the detection level, while the other data pair returned a relative percent difference of 21 percent. Overall, such close agreement in results indicates that data between respective programs are comparable, and that there are no significant biases introduced by differences in sample collection or analysis methods for replicate samples collected during 2003.

Radiological Results Comparisons

Results for gross alpha, gross beta, tritium, and strontium-90 were available for samples collected by the INEEL OP and the USGS on and near the INEEL, and for the USGS Magic Valley sampling program, an area including sites from the southern boundary of the INEEL to the Snake River between Twin Falls and Hagerman. Results are also available for the seven INEEL boundary and distant locations co-sampled by INEEL OP and ESER.

Differences in the sample collection and analysis methodology used by an individual agency can influence interprogram comparisons. **Table 5-5** provides a summary of collection and analysis methods used by the INEEL OP, ESER, and the USGS and their possible impacts on comparability of gross alpha and gross beta results.

For each analyte, regression analysis was attempted first. If the regression result was meaningful based on the criteria presented in the introduction to the previous section, Interprogram Comparisons, a plot of the data and regression was presented without discussion of further

analysis. **Table 5-6** summarizes results of simple liner regression analyses for all datasets. The regressions that met the given criteria for being "meaningful" are identified.

When regression results were not meaningful, data were compared using a paired t-test to evaluate whether the means of the data were statistically different. **Table 5-7** summarizes these results. To characterize the differences between replicates, the result obtained by the INEEL OP was subtracted from ESER or USGS result. **Table 5-8** outlines these differences for each of the respective analytes.

Histograms of these differences were generated to identify outliers and illustrate how the differences are distributed with a normal curve fitted to the histogram. Where the INEEL OP collected field replicates, the mean of these replicates and the pooled analytical errors were compared to the replicate results from ESER and USGS.

Gross Alpha Radioactivity

A total of 48 replicate results for gross alpha radioactivity were available: 14 co-sampled with ESER, 18 with the USGS on and near the INEEL, and 16 with the USGS in the Magic Valley.

With regression results not meaningful, paired t-test analysis indicated that, at a 95 percent confidence level, the means of gross alpha radioactivity measurements made by the INEEL OP differed from those of ESER, and from the USGS, both in the Magic Valley and on or near the INEEL. Comparison results are presented in **Tables 5-6, 5-7,** and **5-8**. Histograms of these differences are presented in **Figures 5-10, 5-11**, and **5-12**.

INEEL OP gross alpha radioactivity results tended to be greater than that of ESER and USGS results. Differences were small, less than the typical 2-sigma uncertainty for those measurements. Histograms of differences (**Figures 5-10, 11,** and **12**) show that differences between the co-sample results appear to be normally distributed, thus indicating a random bias in the compared results. The differences between INEEL OP and ESER may be explained by the difference between instruments used. See **Table 5-5** for further discussion.

Gross Beta Radioactivity

A total of 48 replicate results for gross beta radioactivity were available: 14 co-sampled with ESER, 18 with the USGS on and near the INEEL, and 16 with the USGS in the Magic Valley. Regression results were not meaningful for gross beta radioactivity compared with ESER and with USGS, both on and near the INEEL, and in the Magic Valley.

Table 5-5. Sampling and analysis techniques for gross alpha and gross beta samples collected by the INEEL OP, USGS and ESER, 2003.

Sampling or analytical technique	INEEL OP	ESER	USGS-INEEL Monitoring Program	USGS-Magic Valley Monitoring Program	Effect on measured concentration
Manufacturer, model, and operational mode for gas-proportional counting system, and typical count time.	Protean 5", automatic feed, thin-window, 300 minutes.	Canberra model 2404 1.85" (47 mm), automatic feed, thin-window, 125 minutes.	For alpha, scintillation counter and 60 minutes. For beta, Tennelec 2", automatic feed, thin-window (85μg/cm^2) 20 minutes.	Tennelec model 5100 automatic feed, thin-window, 125 minutes.	Differences in radiation detector models' operation and maintenance, and standard count-times can have significant impacts on counting efficiency and resulting MDC. In general terms, thicker windows, smaller detectors and shorter count times decrease sensitivity of the measurement.
Calibration isotope[a] gross alpha analyses	Thorium-230	Thorium-230	Plutonium-239	Thorium-230	In general, a lower energy standard would result in a slightly higher reported concentration.
Calibration isotope[a] gross beta analyses	Cesium-137	Cesium-137	Cesium-137	Cesium-137	In general, a lower energy standard would result in a slightly higher reported concentration. In the past, strontium-90 has been used as a calibration isotope for gross beta by some laboratories.
Filtration	Not Filtered	Not Filtered	Not Filtered	Filtered	Samples that are not filtered include dissolved and suspended constituents, which may result in a higher concentration than filtered samples containing only the dissolved fraction.
Preservation	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Not preserving the sample in the field may result in radionuclides present in the sample adhering to the sample container, which could result in a lower measured concentration in the unpreserved sample.

[a] The lower the energy of the decay particle, the less efficient the detector. Because the concentration is determined by dividing the number of counts by the efficiency, calibration with a lower energy particle yields a higher concentration. Peak energies are listed below (from Shleien, 1992). (1) americium-241: 5.49 MeV alpha particle (85%) (2). Strontium-90/yttrium-90: 2.28 MeV beta particle (yttrium-90, 100%) (3) plutonium-239: 5.16 MeV alpha particle (73%) (4). 0 .55 MeV beta particle (strontium-90, 100%) (5). thorium-230: 4.69 MeV alpha particle (76%) (6). cesium-137: 1.17 MeV beta particle (5%) and 0.51 MeV beta particle (95%).

Table 5-6. Summary of linear regression parameters with 95 percent confidence intervals for the replicate samples collected by INEEL OP, USGS, and ESER, 2003. Shaded rows indicate a meaningful regression.

Analyte	Co-sampling Agency	y-intercept	P for intercept	Slope	P for slope	R	SD of the residual	Number of replicate sample sets
Gross Alpha	ESER	0.33 ± 0.24	0.197	0.07 ± 0.14	0.675	0.122	0.61	14
	USGS (INEEL)[a]	0.69 ± 0.12	$<10^{-4}$	-0.01 ± 0.06	0.919	-0.026	0.35	18
	USGS (MV)[b]	0.11 ± 0.62	0.862	0.27 ± 0.26	0.319	0.266	1.49	16
Gross Beta	ESER	1.50 ± 0.92	0.131	1.04 ± 0.36	0.014	0.642	1.48	14
	USGS (INEEL)[a]	2.89 ± 0.63	0.0003	0.12 ± 0.27	0.669	0.108	1.149	18
	USGS (MV)[b]	2.28 ± 1.34	0.170	0.85 ± 0.41	0.056	0.487	2.82	16
Cesium-137	USGS (INEEL)[a]	8.81 ± 6.13	0.167	-0.33 ± 14.6	0.982	-0.005	26.8	20
Tritium	ESER	4.7± 14.4	0.750	0.23 ± 0.27	0.407	0.241	51.7	14
	USGS (INEEL)[a]	1.21 ± 30.9	0.969	1.04 ± 0.01	$<10^{-4}$	0.999	172	42
	USGS (MV)[b]	16.0 ± 3.19	0.0002	0.22 ± 0.12	0.082	0.448	10.6	16
	USGS (MV)[bc]	3.03 ± 2.82	0.301	0.88 ± 0.13	$<10^{-4}$	0.874	5.75	16
Strontium-90	USGS (INEEL)[a]	0.65 ± 0.40	0.15	1.22 ± 0.07	$<10^{-4}$	0.986	1.06	10

[a] USGS on and near the INEEL
[b] USGS in the Magic Valley
[c] Tritium results using electrolytic enhancement and liquid scintillation

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Table 5-7. Summary of paired t-tests for replicate samples analyses, 2003. Shaded cells indicate means that differ at the 95 percent confidence level.

Analyte	Co-sampling Agency	Mean of Data (pCi/L)	Standard Deviation of Data	Number of Replicate Samples	t-statistic	Probability (P-Value)	Conclusion (at 95% probability)
Gross Alpha							
OP with	ESER	1.06 0.40	1.01 0.58	14	2.24	0.043	Means are significantly different
OP with	USGS (INEEL)[a]	1.66 0.68	1.51 0.34	18	2.68	0.0158	Means are significantly different
OP with	USGS (MV)[b]	1.91 0.62	1.49 1.49	16	2.86	0.0120	Means are significantly different
Gross Beta							
OP with	ESER	2.32 3.92	1.14 1.85	14	-4.20	0.001	Means are significantly different
OP with	USGS (INEEL)[a]	2.13 3.14	1.04 1.12	18	-2.96	0.0089	Means are significantly different
OP with	USGS (MV)[b]	2.78 4.65	1.78 3.13	16	-2.73	0.0155	Means are significantly different
Cesium-137							
OP with	USGS (INEEL)[a]	0.09 8.79	0.42 26.0	20	-1.33	-1.49	Means are not significantly different
Tritium							
OP with	ESER	15.4 8.2	54.1 51.2	14	0.41	0.687	Means are not significantly different
OP with	USGS (INEEL)[a]	Compared by linear regression					
OP with	USGS (MV)[b]	15.3 19.4	23.6 11.4	16	-0.765	0.456	Means are not significantly different
Tritium[c]							
OP with	USGS (MV)[c]	Compared by linear regression					
Strontium-90							
OP with	USGS (INEEL)[a]	Compared by linear regression					

[a] Locations on and near the INEEL
[b] Distant, Magic Valley locations
[c] Tritium analyzed using an electrolytic enhancement

Table 5-8. Summary of mean differences between results of replicate pairs, 2003.

Analyte	Co-sampling Agency	Mean difference (INEEL OP) (pCi/L)	Standard Deviation	Number of replicate pairs
Gross alpha				
	ESER	-0.66	1.10	14
	USGS (INEEL)[a]	-0.98	1.56	18
	USGS (MV)[b]	-1.29	1.80	16
Gross beta				
	ESER	1.60	1.43	14
	USGS (INEEL)[a]	1.01	1.44	18
	USGS (MV)[b]	1.87	2.74	16
Cesium-137				
	USGS (INEEL)[a]	8.70	26.1	20
Tritium				
	ESER	-7.16	65	14
	USGS (INEEL)[a]	Compared by linear regression		
	USGS (MV)[b]	4.04	21.1	16
Tritium[c]				
	USGS (MV)[b]	Compared by linear regression		
Strontium-90				
	USGS (INEEL)[a]	Compared by linear regression		

[a] Locations on and near the INEEL
[b] Magic Valley sampling locations
[c] Tritium measured using an Electrolytic Enhancement Method

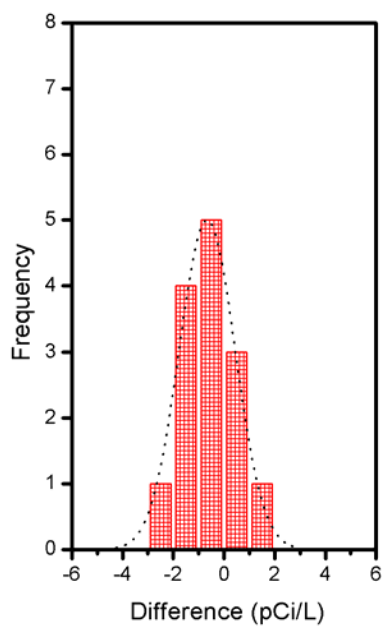

Figure 5-10. Histogram of differences between INEEL OP and ESER for gross alpha radioactivity, 2003.

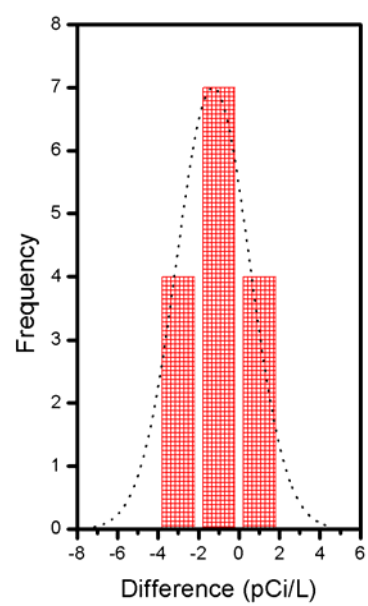

Figure 5-11. Histogram of differences between INEEL OP and USGS in the Magic Valley for gross alpha, 2003.

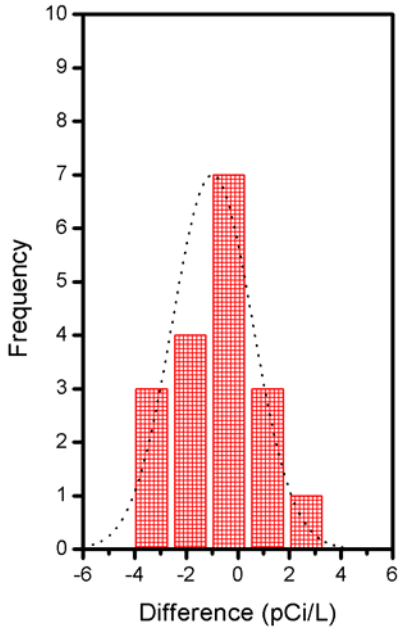

Figure 5-12. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross alpha radioactivity, 2003.

Paired t-test analyses were completed for INEEL OP and ESER, and INEEL OP and USGS (**Table 5-7)**. The means of INEEL OP gross beta radioactivity measurements differed (at the 95-percent confidence level) from those of both USGS, both on and near the INEEL, and in the Magic Valley, and with ESER. Differences between replicate samples for gross beta radioactivity, presented in **Table 5-8**, showed that INEEL OP results for 2003 were less than those of ESER and the USGS. Mean differences for the datasets were nearly the same as the typical 2-sigma sample counting uncertainty. This difference is consistent with comparisons from previous years. Histograms of these differences, presented in **Figures 5-13, 5-14,** and **5-15** suggest that differences appear to be distributed normally. Contributing factors for observed differences between USGS results and those of INEEL OP include detector size and count times.

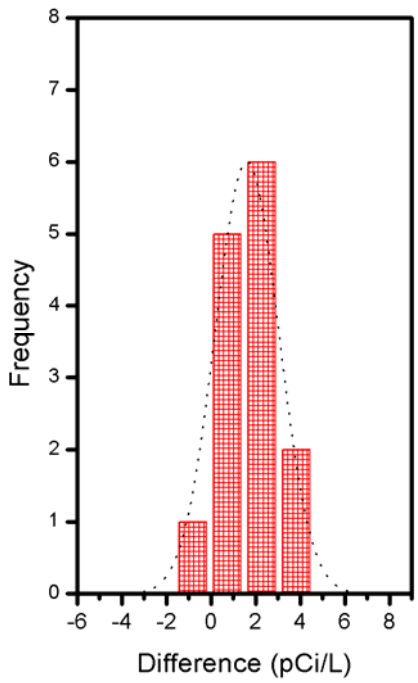

Figure 5-13. Histogram of differences between INEEL OP and ESER for gross beta radioactivity, 2003.

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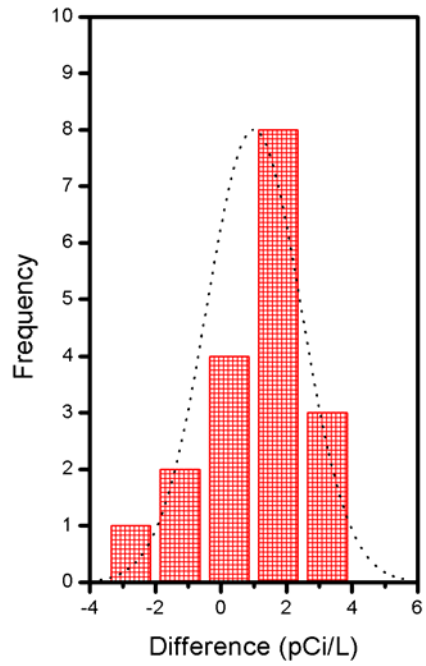

Figure 5-14. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross beta radioactivity, 2003.

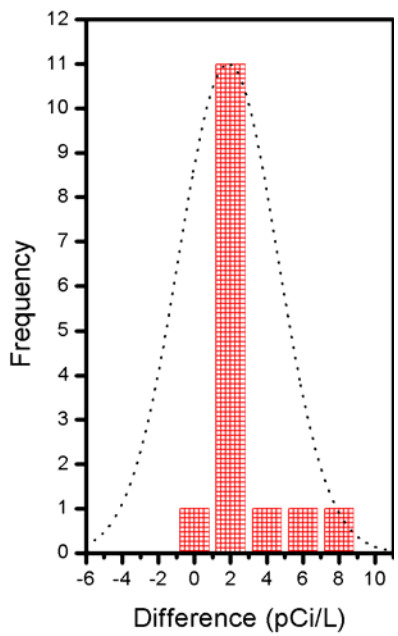

Figure 5-15. Histogram of differences between INEEL OP and USGS in the Magic Valley gross beta radioactivity, 2003.

Cesium-137

All of the 20 replicate results available for cesium-137 were for samples co-located with the USGS on the INEEL. Regression analysis was not meaningful, as noted on **Table 5-6**. Paired t-test analysis indicated that the means were not significantly different for cesium-137 analyses at a 95 percent confidence level. Mean differences, presented in **Table 5-8**, show that the USGS results on the INEEL were typically greater than the INEEL OP results, a difference likely due to the level of resolution (comparatively high MDC) of the USGS results (about 100 pCi/L) compared to about 2.5 pCi/L for INEEL OP results. The large differences in MDC are factors of the smaller volumes analyzed (400 ml of sample analyzed for USGS and 1,000 ml for INEEL OP) and the shorter counting times for those volumes (1 hour for USGS and 8 hours for INEEL OP). **Figure 5-16** presents the histogram of these results that shows differences that appear normally distributed.

Tritium

A total of 72 replicate results for tritium were available: 14 co-sampled with ESER, 42 with the USGS on and near the INEEL, and 16 with the USGS in the Magic Valley. As indicated in **Table 5-6**, regression results were not meaningful for locations co-sampled with the ESER and with the USGS in the Magic Valley, but were meaningful for locations co-sampled with the USGS on and near the INEEL.

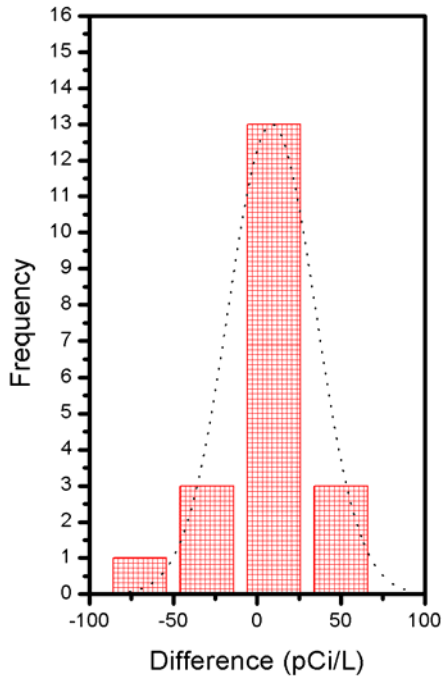

Figure 5-16. Histogram of differences between INEEL OP and USGS cesium-137 concentrations on and near the INEEL, 2003.

The regression results for sites co-sampled with the USGS on and near the INEEL (**Figure 5-17)** demonstrate good agreement. The regression slope for 2003 comparisons (1.04 ± 0.01), combined with all supporting information, indicates good agreement between INEEL OP and USGS tritium on and near the INEEL.

Replicate tritium results for ESER and INEEL OP and USGS in the Magic Valley compared by paired t-test, did not differ at the 95 percent confidence level. Histograms of these differences are presented in **Figures 5-18** and **5-19,** show differences normally distributed**.**

Enhanced Tritium

The USGS National Water Quality Laboratory uses an enrichment and liquid scintillation method with increased counting times to measure tritium at very low levels. This method provides an MDC of approximately 3 pCi/L, about 100 times lower than liquid scintillation alone reported by the USGS on and near the INEEL, suitable for measuring tritium at background levels. ISU EML uses a similar electrolytic enrichment method for tritium analyses, lowering sample MDCs to less than 25 pCi/L (practice has shown MDC values from 10-15 pCi/L), within the range typically observed for background levels of tritium for the Eastern Snake River Plain Aquifer (0 to 40 pCi/L).

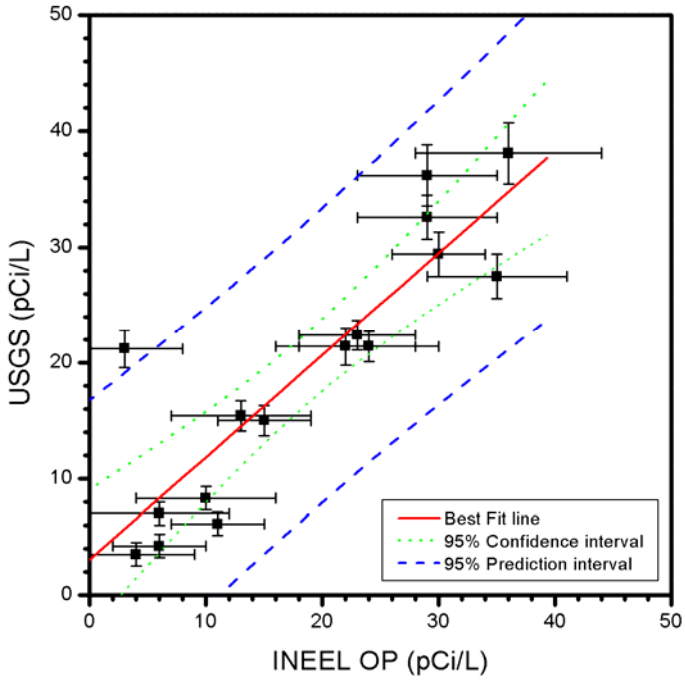

Figure 5-17. Comparison of replicate tritium results (with 2-s error bars) for INEEL OP and USGS for sites on and near the INEEL, 2003.

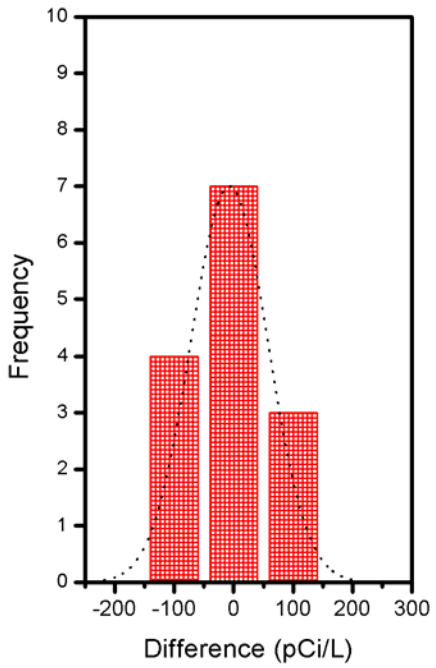

Figure 5-18. Histogram of differences between INEEL OP and ESER for Tritium, 2003.

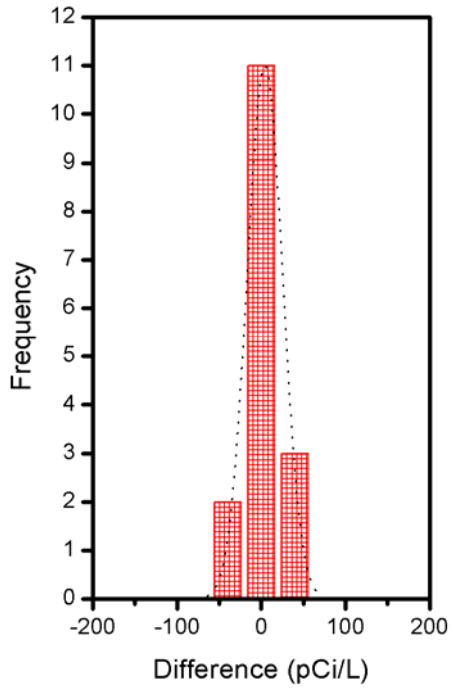

Figure 5-19. Histogram of differences between INEEL OP and USGS Magic Valley for Tritium by the standard method, 2003.

Sixteen replicate samples were collected with the USGS in the Magic Valley for environmental-level tritium analysis. Results were compared with tritium analyses from the USGS National Water Quality Laboratory (**Figure 5-20**). The regression for low-level tritium results from ISU-EML and the USGS were comparable, with a slope of 0.88 ± 0.13, and a y-intercept indistinguishable from zero. One of the 16 replicate data pairs for enhanced tritium differed by more than 3-times the pooled sample uncertainty, with the INEEL OP enhanced tritium result less than that for USGS. As seen from the y-intercept of the regression analysis, the mean of INEEL OP enhanced tritium results did not differ from the mean of the USGS Magic Valley tritium measurements.

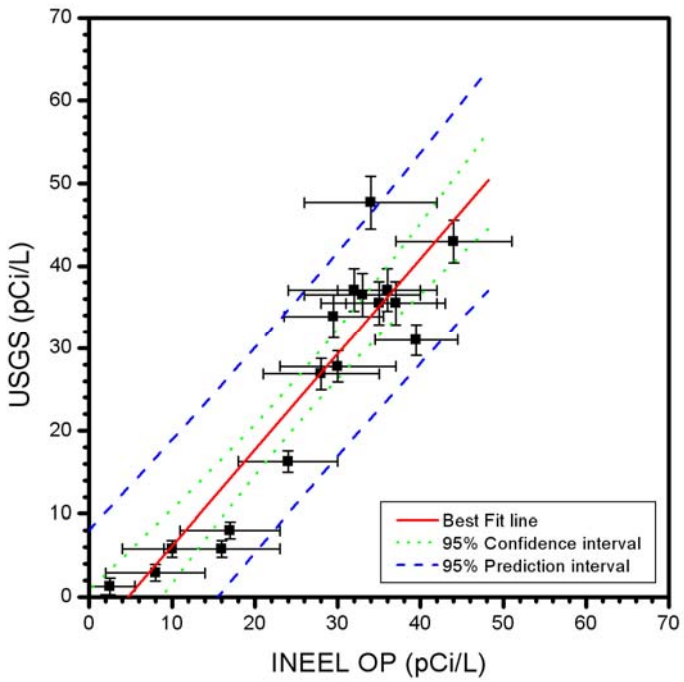

Figure 5-20. Comparison of replicate results for tritium by electrolytic enrichment and liquid scintillation (with 2-sigma error bars) for the USGS MV and INEEL OP, in the Magic Valley, 2003.

Strontium-90

Ten replicate results for strontium-90 for four locations co-sampled with the USGS on the INEEL were compared. Regression analysis of these data, shown on **Figure 5-21**, correlates reasonably well for such a small number of compared samples. The regression slope was 1.22 ± 0.07, suggesting reasonable agreement between USGS results completed by the Department of Energy Radiological and Environmental Sciences Laboratory (DOE-RESL), and INEEL OP results for strontium-90, completed by Paragon Analytics, Inc, with a y-intercept indistinguishable from zero (**Figure 5-21**).

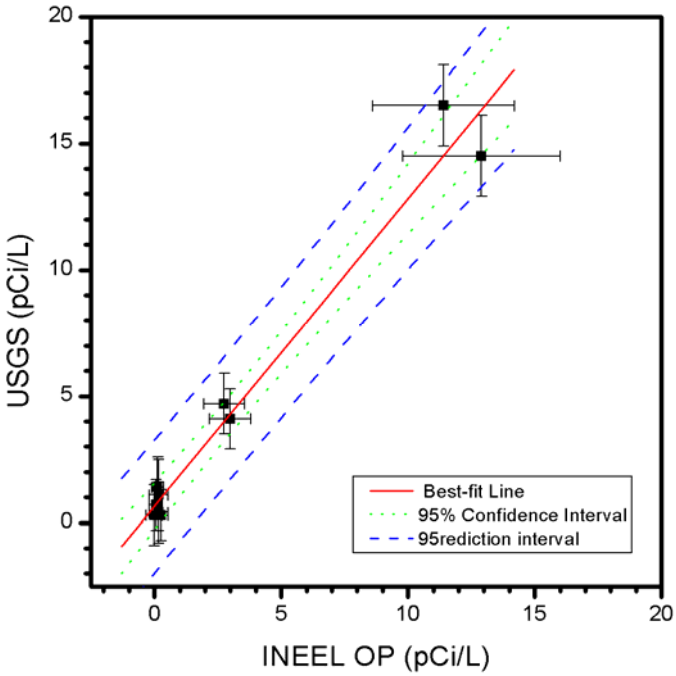

Figure 5-21. Comparison of replicate results for strontium-90 (with 2-sigma error bars), INEEL OP and USGS on and near the INEEL, 2003.

Summary of Differences

While statistically significant differences (at the 95 percent confidence level) were observed for gross alpha and gross beta, and for one group of tritium replicate results, these differences were relatively small compared to the concentrations observed. **Figure 5-22** summarizes the relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

The x-axis (**Figure 5-22)** shows the mean and standard deviation of differences for individual replicate results divided by the absolute value of the INEEL OP result for that data pair. Dividing by the INEEL OP result serves to normalize the differences, with the unit-less computation result being a "relative mean difference."

The mean relative differences for all data sets are within one standard deviation of the zero difference line. The range of relative differences is much less than 10 with the exception of cesium-137 with the USGS on and near the INEEL. The difference between INEEL OP and USGS MDC analysis methods (volumes analyzed and sample counting times, as previously discussed) can explain the wide range of relative difference (-170 to 116 with a mean of -27). While their respective analysis methods may be sufficient for the goals of the USGS and the INEEL OP, such a difference makes meaningful comparison difficult. However, replicate results for both the USGS on the INEEL and INEEL OP conclude that cesium-137 is not detectable in

replicate samples collected. Such results do provide an informative example of the impact that differences in analytical methods can have on a given set of data.

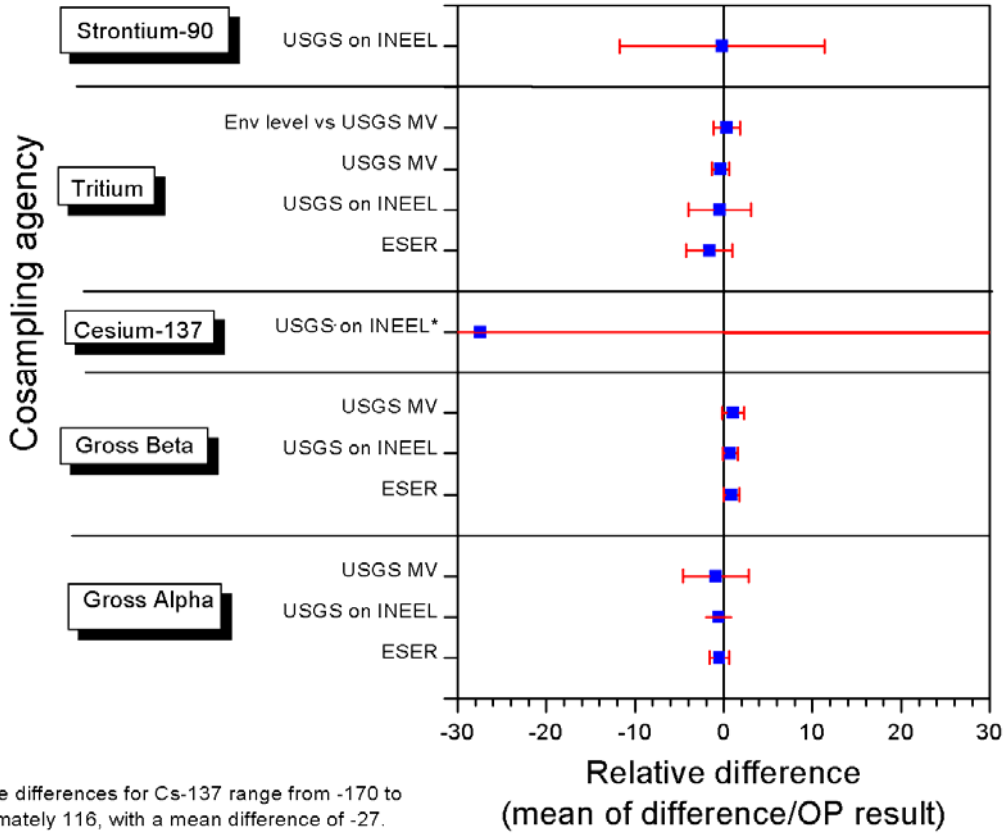

Figure 5-22. Summary of relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

Comparison of replicate radiological results with ESER and with the USGS on and near the INEEL and in the Magic Valley did show some differences, the biases appeared relatively small (much less than any drinking water standard) and could be explained by differences in laboratory and sample collection methods. In general, comparison of results from these co-sampling organizations verified that, while the differences between replicate results obtained by these agencies and INEEL OP may have statistical significance (i.e., failing the statistical criteria), the magnitude of any differences is small compared to the magnitude of the data and the reporting levels.

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Chapter 6

Verification Water Monitoring Program

Major Findings and Development

In 2003, the INEEL OP collected replicate groundwater and wastewater samples at 36 sites with the DOE's primary contractor (BBWI), ANL-W, and NRF.

Results reported by INEEL OP were comparable to those reported by BBWI, ANL-W, and NRF for most analytes. The observed differences were attributable to issues including laboratory analysis failure (fluoride), sample heterogeneity (primarily for wastewater samples), or the use of different analytical methods (gross radioactivity).

Introduction

The objective of INEEL OP's verification program is to verify and supplement the analytical data reported for wastewater and groundwater samples collected by BBWI, ANL-W and NRF. Sampling is limited to long-term monitoring programs such as those developed for CERCLA Records of Decision (RODs), Wastewater Land Application Permits (WLAP), and environmental surveillance. The sampling program was not designed to duplicate DOE's extensive sampling network, but rather to collect a sufficient number of samples, typically about 10 percent to provide an additional level of confidence in the analytical data reported by DOE. During 2003, the INEEL OP collected replicate samples at 26 groundwater and 10 wastewater locations shown in **Figure 2-7** in **Chapter 2**. The analytical results are summarized in **Table 6-1.**

Because the samples are collected for various purposes (WLAP, CERCLA, surveillance), the analytes and analytical methods vary between programs. Therefore, the interprogram comparison is performed on a per sample basis; that is, each analytical result is compared directly to the result reported by the INEEL OP. As sites and analytical results available for comparison are likely to change from year to year as monitoring to meet regulatory and compliance needs change, trending of results may not be appropriate, but may be considered in the future.

Table 6-1. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2003.

Analyte	Range of Concentrations				Drinking Water Standard
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Common Ions (mg/L)					
Alkalinity (as CaCO3)	103.0	525.0	94.0	233.0	None
Calcium	4.4	1500.0	25.9	137.0	None
Chloride	7.5	14924.0	2.59	334.0	SMCL=250
Fluoride	<0.1	0.87	0.19	0.98	SMCL=2, MCL = 4
Magnesium	1.3	450.0	10.1	48.6	None
Potassium	3.4	56.0	2.2	5300.0	None
Silica	5.07	52.3	15.8	40.5	None
Sodium	5.8	126.0	2.2	5300.0	None
Sulfate	15.7	403.0	14.4	143.0	SMCL=250
Total Dissolved Solids	190.0	18000.0	170.0	1100.0	SMCL=500
Total Suspended Solids	1.0	280.0	1.0	26.0	None
Alkalinity (as CaCO3)	103.0	525.0	94.0	233.0	None
Nutrients (mg/L)					
Ammonia (as N)	NR	NR	0.005	1.81	None
Nitrite (as N)	0.01	0.31	0.005	<5.0	1
Nitrite + Nitrate (as N)	0.01	2.6	0.391	4.86	10
Phosphate (as P)	0.04	5.73	0.01	0.7	None
Total Kjeldahl N (TKN)	0.05	23.5	0.05	2.15	None
Trace Metals (μg/L)					
Aluminum	<0.10	900.0	<100.0	710.0	SMCL=50-200
Antimony	<5.0	10.0	<5.0	<5.0	6
Arsenic	<5.0	<25.0	<5.0	9.0	10
Barium	21.0	3100.0	20.0	210.0	2000
Beryllium	<1.0	<1.0	<1.0	<1.0	4
Cadmium	<1.0	<1.0	<1.0	<1.0	5
Chromium	<5.0	<100.0	<5.0	9.0	100
Cobalt	<101.0	<100.0	<10.0	<10.0	None
Copper	<10.0	<100.0	<10.0	<10.0	SMCL=1000, AL = 1300
Iron	<10.0	2600.0	<10.0	930.0	SMCL=300
Lead	<5.0	6.0	<0.5	36.0	AL=15
Manganese	<2.0	26.0	<1.0	15.0	SMCL=50

[a.] Maximum contaminant level (MCL) unless otherwise noted. AL=Action Level from Lead and Copper Rule; SMCL=Secondary maximum contaminant level.
[b.] List limited to analytes detected in at least one sample. See Table 6-4 for complete list of analytes.
[c.] NR=Not requested
[d.] Counting uncertainty reported at 2 sigma.
[e.] For beta-emitters, the maximum contaminant level is expressed as a cumulative annual dose of 4 millirem/year; for cesium-137. This is equivalent to 200 pCi/L, if cesium-137 were the only radionuclide detected.

Table 6-1 continued. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2003.

Analyte	Range of Concentrations				Drinking Water Standard
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Mercury	<0.5	<0.5	<0.5	<5.0	2
Nickel	<10.0	<50.0	<10.0	<10.0	None
Selenium	<10.0	<50.0	<10.0	<10.0	50
Silver	<1.0	3.0	<1.0	<1.0	SMCL = 100
Thallium	<1.5	<1.7	<1.5	<25.0	2
Vanadium	<100.0	<100.0	<100.0	<100.0	None
Zinc	<5.0	170.0	<5.0	340.0	SMCL=5000
Volatile Organic Compounds (μg/L)[b]					
Carbon Tetrachloride	NR	NR	<0.5	2.3	5
Chloroform	NR	NR	<0.5	0.6	None
cis 1,2 Dichloroethene	NR	NR	<0.5	141.0	0.07
1,1 Dichloroethene	NR	NR	<0.5	1.1	0.007
Toluene	NR	NR	<0.5	12.7	1
Trans 1,2 Dichloroethene	NR	NR	<0.5	77.0	0.1
Trichloroethylene	NR	NR	<0.5	804.0	0.005
Vinyl Chloride	NR	NR	<0.5	5.3	0.002
Radionuclides (pCi/L)[d]					
Americium-241			0	0.045	15
Cesium-137	-0.8	1.3	-1.1	4.0	200
Cobalt-60					100
Gross Alpha	-6.9	14.1	-0.4	5.5	15
Gross Beta	3.2	16.9	0.8	1041.0	200[e]
Neptunium-237	NR	NR	-0.013	0.006	15
Strontium-90	-0.05	0.07	-0.06	520.0	8
Plutonium-238	NR	NR	-0.01	0.023	15
Plutonium-239/240	NR	NR	-0.006	0.038	15
Plutonium-241	NR	NR	-6.5	5.9	15
Technetium-99			0.15	59.8	900[e]
Tritium	-20.0	120.0	-70.0	18790.0	20000
Uranium-234	NR	NR	1.15	1.84	20 mg/L
Uranium-235	NR	NR	0.06	0.086	20 mg/L
Uranium-238	NR	NR	0.06	0.77	20 mg/L

[a.] Maximum contaminant level (MCL) unless otherwise noted. AL=Action Level from Lead and Copper Rule; SMCL=Secondary maximum contaminant level.
[b.] List limited to analytes detected in at least one sample. See Table 6-4 for complete list of analytes.
[c.] NR=Not requested
[d.] Counting uncertainty reported at 2 sigma.
[e.] For beta-emitters, the maximum contaminant level is expressed as a cumulative annual dose of 4 millirem/year; for cesium-137. This is equivalent to 200 pCi/L, if cesium-137 were the only radionuclide detected.

Comparison of Nonradiological Results

For non-radionuclide analyses, if the reported concentration of the analyte exceeded the detection limit by a factor of five or more in both samples, the relative percent difference (RPD) between the two analytical results was calculated using the following equation:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:
C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor

An RPD of 30 percent is considered acceptable for inorganic compounds and an RPD of 40 percent is acceptable for organic compounds. For replicate samples in which one, or both, of the results reported for a particular analyte are less than five times the detection limit, the results are considered comparable if the two results differ by an amount equal to or less than twice the detection limit. These comparison criteria are based primarily on the degree of accuracy the IBL and the EPA requires for internal matrix spikes (EPA, 1994; 1994a). The INEEL OP has adopted these standards as guidelines. If less than 90 percent of the replicates for a particular analyte meet the desired level of accuracy, the results are investigated further. For 2003, twelve waste water and seven groundwater inorganic analytes failed to meet these criteria (**Table 6-3 and 6-4).**

Wastewater sample pairs for sulfate, TDS, TSS, nitrite, TKN, aluminum, arsenic, copper, lead, iron, manganese and zinc all failed the comparison criteria. Heterogeneity of wastewater may explain the varying results between the INEEL OP and the cosampler, which can be compounded for unfiltered samples (Hall, 2002). Other factors which affect the results include the difference in labs that the INEEL OP and cosamplers utilize, as well as each instrument's detection level.

There have been problems in the past with fluoride analysis at the IBL and may still be persisting since two samples had been rejected earlier this year. In all sample pairs the INEEL OP results were twice the concentration of the cosampler result.

Groundwater sample pairs for iron and manganese that failed the comparison criteria were unfiltered samples. Differences in the amount of suspended particulate iron (e.g., rust and basalt fragments) in the replicate samples can result in significant differences in the reported iron concentration (Hall 2002). Such differences may also account for variation in manganese concentrations. Manganese only failed the comparison criteria by 1 percent.

Comparisons for trichloroethylene and cis-1,2-dichloroethene failed to meet the criteria of ≥90 percent comparable results for volatile organic compounds (VOCs). Trichloroethene was detected in 10 of the 18 sample pairs, with 16 meeting the comparison criteria (**Table 6-4**). Cis-1,2-dichloroethene was detected in 5 of the 9 sample pairs, with 7 meeting the comparison

criteria. Small sample sizes may contribute to the failed comparisons. In each of the failed sample pairs, the INEEL OP results reported lower concentrations than the cosampler result.

Table 6-2. Comparison of waste water concentrations of common ions, nutrients, and trace metals reported for replicate samples collected with ANL-W, BBWI, and NRF, 2003.

Wastewater Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference 30 percent, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Common Ions				
Calcium	4	4	4	100
Chloride	8	8	8	100
Fluoride	4	4	3	75
Sodium	7	7	7	100
Sulfate	8	8	7	88
Total Dissolved Solids	6	6	5	83
Total Suspended Solids	7	2	5	29
Nutrients				
Ammonia (as N)	NR	NR	NR	NR
Nitrite (as N)	4	1	3	75
Nitrite+Nitrate (as N)	8	6	8	100
Total Phosphorus (as P)	7	7	7	100
Total Kjeldahl N (TKN)	8	7	2	25
Trace Metals				
Aluminum	6	5	4	67
Antimony	6	0	6	100
Arsenic	7	1	6	75
Barium	7	7	7	100
Beryllium	7	0	7	100
Cadmium	7	0	7	100
Chromium	8	2	8	100
Copper	7	1	6	86
Iron	7	5	6	86
Lead	7	1	6	86
Manganese	7	3	6	86
Mercury	5	0	5	100
Nickel	7	0	7	100
Selenium	6	0	6	100
Silver	7	1	7	100
Zinc	6	1	5	83

Table 6-3. Comparison of groundwater concentrations of common ions, nutrients, and trace metals reported for replicate samples collected with ANL-W, BBWI, and NRF, 2003.

Groundwater Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference < 30 percent, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Common Ions				
Alkalinity (as $CaCO_3$)	6	6	6	100
Calcium	11	11	11	100
Chloride	19	19	18	95
Fluoride	14	14	7	50
Magnesium	11	11	11	100
Potassium	16	16	15	94
Sodium	21	21	20	95
Sulfate	15	15	15	100
Total Dissolved Solids	6	6	5	83
Total Suspended Solids	1	1	10	0
Nutrients				
Ammonia (as N)	5	2	5	100
Nitrite (as N)	11	0	12	100
Nitrite+Nitrate (as N)	21	20	21	100
Total Phosphorus (as P)	12	4	7	58
Total Kjeldahl N (TKN)	9	4	6	67
Trace Metals				
Aluminum	17	0	16	94
Antimony	16	0	16	100
Arsenic	21	0	21	100
Barium	19	19	19	100
Beryllium	21	0	21	100
Cadmium	25	0	25	100
Chromium	25	21	25	100
Cobalt	13	0	13	100
Copper	20	0	20	100
Iron	20	19	14	70
Lead	19	0	18	95
Manganese	19	5	17	89
Mercury	18	0	19	100
Nickel	19	0	21	100
Thallium	14	0	14	100
Selenium	21	0	21	100
Silver	20	0	20	100
Vanadium	8	0	8	100
Zinc	20	11	20	100

Table 6-4. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2003.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference < 30 percent, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	4	0	4	100
1,1,1-Trichloroethane	15	0	15	100
1,1,2,2-Tetrachloroethane	16	0	16	100
1,1,2-Trichloroethane	13	0	13	100
1,1-Dichloroethane	16	0	16	100
1,1-Dichloroethene	16	0	16	100
1,2,4-Trichlorobenzene	4	0	4	100
1,2-Dibromo-3-chloropropane (DBCP)	4	0	4	100
1,2-Dibromoethane (EDB)	4	0	4	100
1,2-Dichlorobenzene	4	0	4	100
1,2-Dichloroethane	14	0	14	100
1,2-Dichloropropane	11	0	11	100
1,3,5-Trimethylbenzene	2	0	2	100
1,3-Dichlorobenzene	4	0	4	100
1,4-Dichlorobenzene	4	0	4	100
2-Hexanone	4	0	4	100
4-Methyl-2-Pentanone (MIBK)	3	0	3	100
Acetone	3	0	3	100
Benzene	15	0	15	100
Bromochloromethane	1	0	1	100
Bromodichloromethane	12	0	12	100
Bromoform	12	0	12	100
Bromomethane	12	0	12	100
Carbon tetrachloride	15	4	15	100
Chlorobenzene	12	0	12	100
Chloroethane	8	0	8	100
Chloroform	8	0	8	100
Chloromethane	12	0	12	100
cis-1,2-Dichloroethene	9	5	7	77
cis-1,3-Dichloropropene	5	0	5	100

Table 6-4 continued. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2003.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference < 30 percent, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Dibromochloromethane	10	0	10	100
Dibromomethane	3	0	3	100
Dichlorodifluoromethane	2	0	2	100
Ethylbenzene	9	0	9	100
Isopropylbenzene	3	0	3	100
Methyl Tert Butyl Ether (MTBE)	3	0	3	100
Methylene Chloride	9	0	9	100
Naphthalene	3	0	3	100
Styrene	4	0	4	100
Tetrachloroethylene (PERC)	18	7	17	94
Toluene	15	1	15	100
trans-1,2-Dichloroethene	8	2	8	100
trans-1,3-Dichloropropene	4	0	4	100
Trichloroethylene	18	10	16	88
Trichlorofluoromethane	7	0	7	100
Vinyl chloride	15	3	15	100
Xylenes (total)	7	0	7	100

Comparison of Radiological Analyses

Unlike the nonradioactive constituents for which analytical error is not reported, the analytical (counting) error must be considered when evaluating radioactivity analyses. Therefore, the results reported for the replicate radionuclide analyses are considered to be comparable if either:

1) $|C_1-C_2| \leq 3(s_1^2+s_2^2)^{1/2}$

where:

C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor
s_1 = sample standard deviation of the INEEL OP sample
s_2 = sample standard deviation of the contractor sample

or

2) The relative percent difference (RPD) was less than or equal to 20 percent.

The approach outlined above is used by the ISU EML to determine whether the results of its duplicate analyses are within control limits.

As shown in **Table 6-6**, radiological analyses for plutonium-238 and technetium-99 failed the comparison criteria.

While plutonium-238 failed the comparison criteria, none of the sites had detectable levels in both sample pairs. Technetium-99 failed the comparison criteria and had three sample pairs which contained detectable levels in both samples.

Table 6-5. Comparison of radionuclide concentrations reported for replicate samples collected with ANL-W, BBWI, and NRF, 2003.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference <20 percent, or where results are within three times the weighted counting error	Percent of replicate samples with comparable results
Groundwater				
Amercium-241	11	0	11	100
Cesium-137	8	1	8	100
Gross Alpha	12	0	11	92
Gross Beta	12	7	10	92
Plutonium-238	11	0	6	83
Plutonium-239/240	11	0	11	100
Plutonium-241	2	0	2	100
Strontium-90	5	1	5	100
Technetium-99	11	3	9	82
Tritium	16	11	16	100
Uranium-234	3	3	3	100
Uranium-235	3	3	3	100
Uranium-238	3	3	3	100
Neptunium-237	3	0	3	100
Wastewater				
Cesium-137	5	0	5	100
Gross Alpha	5	0	5	100
Gross Beta	5	5	5	100

References

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Chapter 7
External Radiation Monitoring

Major Findings and Developments

Ambient penetrating exposure measurements performed during 2003 were consistent with historical background measurements. Redundancy in data collection and use of passive radiation detectors provided adequate cumulative average exposure rates at each gamma monitoring location.

- No offsite environmental impacts from INEEL operations were detected with environmental ambient gamma radiation exposure-rate measurements.
- Interprogram comparisons of different surveillance programs' results show good agreement. Discrepancies are attributable to differences in monitoring schedules and different penetrating radiation measurement techniques.

Ambient Penetrating Radiation Monitoring and Trends

Radiological conditions are monitored by INEEL OP through the use of measurement devices capable of measuring ambient, penetrating radiation exposures at locations on the INEEL, near the INEEL boundary, and at distant locations with respect to INEEL. INEEL OP uses a network of 12 high-pressure ion chambers (HPICs) to monitor exposure rates "real time". Eleven of the HPIC stations are owned and operated by INEEL OP and one station is owned and operated by the Shoshone-Bannock Tribes at Fort Hall. Data collected at Fort Hall are transmitted to the INEEL OP office via the same radio telemetry network used to collect data from the stations owned and operated by INEEL OP.

INEEL OP uses Electret Ion Chambers (EICs) to supplement data collected using the HPIC network and to provide additional information regarding environmental conditions on the INEEL during emergency or upset conditions. EICs are deployed as environmental dosimeters to measure cumulative exposure at 91 monitoring locations on the INEEL, near the INEEL boundary, and at distant locations. Of these 91 locations, there are 68 monitoring locations on the INEEL along highways, access roads (along northwest and eastern INEEL boundaries), and at INEEL facilities (**Figure 7-1**). Of the 23 remaining locations, 11 are located at boundary locations and 12 at distant locations (**Figure 7-2**).

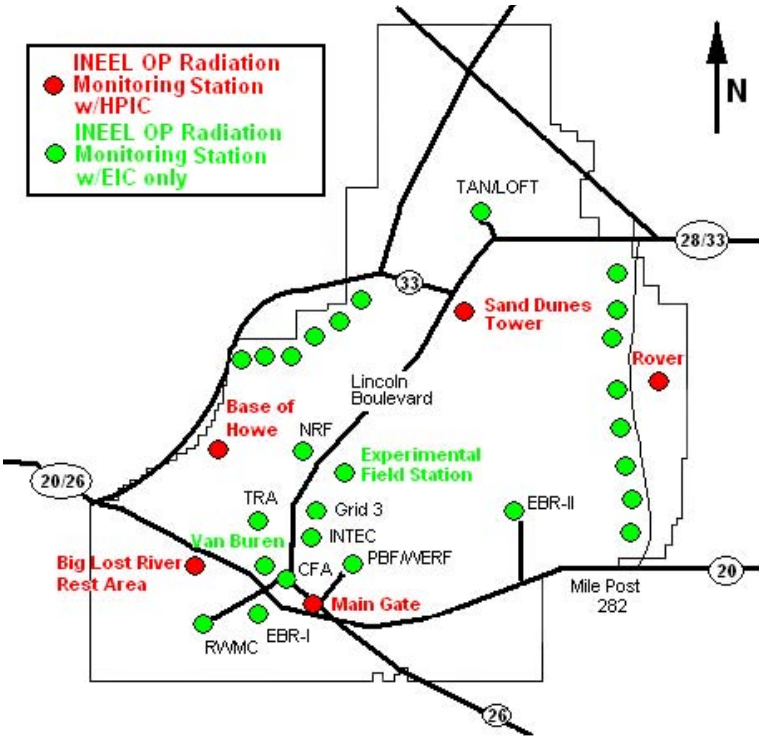

Figure 7-1. Penetrating radiation monitoring stations located on the INEEL maintained and operated by INEEL OP. Not included are the electret ion chamber located at mile markers along Highway 33, Highway 20/26, Highway 28/33, Highway 20, and Lincoln Boulevard.

Data collected using either the HPIC network or the EIC network are closely examined to identify potential trends or indicate potential upset conditions during INEEL operations. Ambient penetrating radiation is ubiquitous in the environment due to cosmic sources, naturally occurring radionuclides found in rock and soil, and man-made sources including historic above-ground testing of nuclear weapons and nuclear reactor operation.

Since the environment has measurable amounts of ambient penetrating radiation, an action level was established to set a threshold where additional scrutiny may be needed to identify significant changes in radiation levels. In the event that a measurement exceeds twice its expected "background" measurement, a series of events will take place to identify the cause of the increase. Such increases may be due to improper instrument operation situations (which are remedied through quality control procedures as soon as they are identified), natural fluctuations in background (cosmic events, solar events, changes in meteorological conditions [e.g., sudden thundershowers or temperature inversions], or upset conditions at INEEL.) If the action level is exceeded for more than three sequential measurements, the direct cause will be investigated.

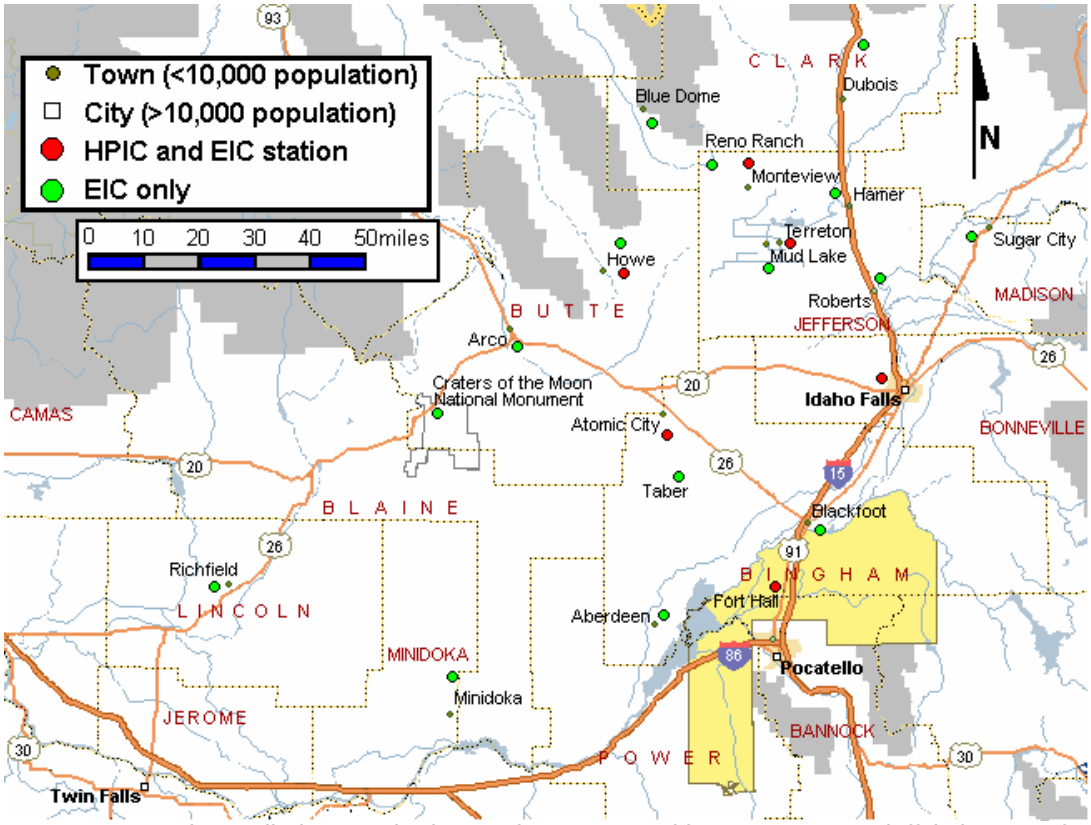

Figure 7-2. Penetrating radiation monitoring stations operated by INEEL OP at (offsite) INEEL boundary locations and distant locations.

The action levels for radiation monitoring have been arbitrarily established at twice the expected background exposure rate as expected from cosmic ray exposures estimated based upon the elevation of HPIC stations[1] and estimated gamma exposure rates[2] determined using *in-situ* gamma spectroscopic measurements of gamma emitting radionuclides in local soils.

The peak analysis software estimates an exposure rate based upon the distribution of radionuclides identified. Radiation measurements that are corrected for elevation response (cosmic radiation effect) compare moderately well (**Table 7-1**) with estimated response with respect to the *in-situ* measurement results.

[1] Cosmic ray instrument response was estimated from elevation correction factors listed in the operator's manual for the GE Reuter-Stokes, RSS-1013 Environmental Radiation Monitoring Station, version 1.4, May 1993.
[2] Estimated from dose conversion factors listed in Table 5.1 of the National Council on Radiation Protection and Measurements (NCRP), "Exposure of the Population of the United States and Canada from Natural Background Radiation", NCRP Report Number 94, 1987.

Table 7-1. Estimated HPIC response from NCRP 94 and cosmic ray response, corresponding action level, response observed during 2003, and 2003 *in-situ* gamma spectroscopy estimated exposure rate (corrected response). All measurements in micro-Roentgen per hour ($\mu R\ h^{-1}$).

HPIC Location	Estimated Response	Corresponding Action Level	2003 Average Response	*In-situ* Gamma Spectroscopy Estimated Response
Atomic City	18.0 ± 1.0 [a]	36.0	13.3	17.6
Base of Howe Peak	18.3 ± 1.6	36.6	12.6	15.2
Big Lost River Rest Area	15.7 ± 1.2	31.4	13.7	19.1
Big Southern Butte	12.9 ± 0.6	25.8	13.7	15.3
Howe	13.3 ± 0.6	26.6	12.8	14.5
Idaho Falls	14.3 ± 1.3	28.6	11.5	10.8
Main Gate	15.0 ± 0.6	30.0	14.3	17.3
Mud Lake/Terreton	13.3 ± 0.6	26.6	12.6	17.6
Monteview	12.3 ± 0.6	24.6	11.8	12.1[b]
Rover	15.8 ± 1.2	31.6	14.1	17.5
Sand Dunes Tower	18.1 ± 1.4	36.2	13.2	18.2

[a] Estimated response ± 1-sigma uncertainty
[b] The *in-situ* measurement at Monteview was performed during 2002 due to excessive moisture at the monitoring location in 2003.

During the past two years, the HPIC and EIC measurements have correlated quite well. Differences are due to the energy sensitivity of the two instrument types. The HPIC is made of stainless steel which attenuates low energy x-rays more drastically that the plastic EIC. This accounts for an over response of the EIC by 20 to 40 percent depending upon the distribution of radionuclides in the soil. Average quarterly responses from onsite, boundary, and distant locations are shown in **Figure 7-3**. Average quarterly responses from HPICs and EICs during 2003 from onsite, boundary, and distant locations are found in **Table 7-2** and **Table 7-3**, respectively. Exposure rate measurements in excess of the location specific action levels for HPIC measurements were not exceeded by either the HPICs or the EICs. Descriptive statistics for HPIC and EIC measurements made during 2003 are shown in **Table 7-4**.

Table 7-2. Average exposure rate measurements at routine monitoring stations using high-pressure ion chambers (HPICs). All measurements in micro-Roentgen per hour ($\mu R\ h^{-1}$).

Location	First Quarter 2003	Second Quarter 2003	Third Quarter 2003	Fourth Quarter 2003
Boundary				
Atomic City	13.0 ± 0.6 [a]	13.2 ± 0.4	13.4 ± 0.4	13.6 ± 0.5
Big Southern Butte	12.8 ± 1.0	13.9 ± 0.5	14.3 ± 0.4	13.9 ± 0.9
Howe	12.8 ± 0.5	12.6 ± 0.5	12.7 ± 0.5	13.2 ± 0.5
Monteview	11.6 ± 0.4	11.7 ± 0.4	12.0 ± 0.4	11.9 ± 0.5
Mud Lake/Terreton	12.5 ± 0.4	12.4 ± 0.5	12.6 ± 0.6	13.1 ± 0.4
Boundary Average:	**12.5 ± 0.6**	**12.8 ± 0.8**	**13.0 ± 0.9**	**13.1 ± 0.8**
Distant				
Fort Hall	12.3 ± 0.5	12.4 ± 0.6	12.7 ± 1.0	12.1 ± 1.3
Idaho Falls	11.2 ± 0.8	11.3 ± 0.7	11.5 ± 0.8	11.9 ± 1.0
Distant Average:	**11.7 ± 0.4**	**11.9 ± 0.5**	**12.1 ± 0.6**	**12.0 ± 0.8**
Onsite				
Base of Howe Peak	12.4 ± 0.5	12.6 ± 0.6	12.5 ± 0.4	12.8 ± 0.5
Main Gate	14.3 ± 3.8	14.0 ± 0.4	14.2 ± 0.4	14.5 ± 0.5
Big Lost River Rest Area	13.7 ± 0.5	13.6 ± 0.4	13.7 ± 0.4	14.0 ± 0.5
Rover	14.0 ± 0.4	13.9 ± 0.4	13.9 ± 0.5	14.4 ± 0.4
Sand Dunes	13.3 ± 0.4	13.0 ± 0.5	13.1 ± 0.5	13.6 ± 0.6
Onsite Average:	**13.5 ± 0.7**	**13.4 ± 0.6**	**13.5 ± 0.7**	**13.9 ± 0.7**

[a] 1-sigma sample standard deviation of HPIC measurements made every 5 minutes.

The INEEL OP procedure for deploying EICs was modified during the 2003 calendar year. Primarily, the Tyvek envelopes have been replaced with aluminum cans with EICs deployed at each monitoring station to provide replicate analyses for each monitoring location.

During 2003, the responses observed using EICs at boundary and distant locations were similar to those observed at onsite locations. Descriptive statistics from the 91 EIC monitoring locations are shown in **Table 7-4** during 2003.

Comparison of External Radiation Monitoring Results Reported by DOE Contractor

Ambient penetrating radiation measurements that were made by the INEEL OP during 2003 agreed moderately well with measurements made by DOE-ID contractors during that time. Differences were expected due to differences in monitoring schedules and significant differences in methods used by each organization for environmental dosimetry.

Table 7-3. Average exposure rate measurements at routine monitoring stations using electret ion chambers (EICs). All measurements in micro-Roentgen per hour ($\mu R\ h^{-1}$).

Location	First Quarter 2003[a]	Second Quarter 2003[a]	Third Quarter 2003[a]	Fourth Quarter 2003[a]
Boundary				
Atomic City	16.3 ± 2.0	17.2 ± 2.0	18.3 ± 1.8	19.7 ± 2.0
Big Southern Butte	16.6 ± 2.0	18.3 ± 3.5	19.9 ± 1.8	[b]
Howe	16.9 ± 2.0	14.3 ± 1.7	14.9 ± 1.7	15.1 ± 1.8
Monteview	15.5 ± 1.9	17.1 ± 2.0	15.3 ± 1.7	19.2 ± 2.0
Mud Lake/Terreton	15.8 ± 2.0	16.6 ± 2.0	18.2 ± 1.8	19.1 ± 2.0
Boundary Average:	**16.2 ± 2.0**	**16.7 ± 2.2**	**17.3 ± 1.8**	**18.3 ± 2.0**
Distant				
Craters of the Moon	20.8 ± 2.1	15.5 ± 1.7	18.1 ± 1.8	20.5 ± 2.0
Ft Hall	16.4 ± 2.0	16.5 ± 2.0	17.9 ± 1.8	16.8 ± 1.9
Idaho Falls	14.5 ± 1.9	14.5 ± 2.0	14.8 ± 2.1	16.1 ± 1.9
Distant Average:	**17.2 ± 2.0**	**15.5 ± 1.9**	**16.9 ± 1.9**	**16.3 ± 1.9**
Onsite				
Base of Howe Peak	15.5 ± 1.9	14.8 ± 1.9	19.5± 1.9	15.2 ± 1.7
Big Lost River Rest Area	18.1 ± 2.0	18.3 ± 1.9	16.3 ± 1.8	18.2 ± 1.9
Experimental Field Station	20.2 ± 2.1	21.3 ± 2.1	19.4 ± 1.9	20.2 ± 2.0
Main Gate	18.6 ± 2.0	18.5 ± 2.0	19.3 ± 1.9	18.8 ± 1.9
Rover	16.1 ± 2.0	20.3 ± 2.1	19.5 ± 2.3	[b]
Sand Dunes	16.1 ± 2.0	18.5 ± 2.0	19.6 ± 2.3	20.1 ± 2.0
Van Buren Avenue	18.4 ± 2.0	19.7 ± 2.1	23.2 ± 2.0	22.3 ± 2.1
Onsite Average:	**17.6 ± 2.0**	**18.8 ± 2.0**	**19.5 ± 2.0**	**19.1 ± 1.9**

[a] 2-sigma measurement uncertainty
[b] Not Available. The EIC was either stolen, tampered with, or damaged therefore no measurement was available

Table 7-4. Descriptive statistics of HPIC and EIC measurements made during 2003 at boundary, distant, and onsite locations. All measurements in micro-Roentgen per hour ($\mu R\ h^{-1}$).

	HPIC Boundary Locations	EIC Boundary Locations	HPIC Distant Locations	EIC Distant Locations	HPIC Onsite Locations	EIC Onsite Locations
Average:	12.9	17.1	11.9	16.9	13.6	18.7
Median:	12.8	16.9	12.0	16.5	13.7	18.8
Standard Deviation:	0.6	1.7	0.8	2.1	0.9	2.1
Minimum:	6.8 [a]	14.3	6.0 [a]	14.5	8.2 [a]	14.8
Maximum:	21.9 [a]	19.9	19.0 [a]	20.8	132.4 [a]	23.2
Number of Locations:	5	5	2	3	5	7

[a] Average measurement during a five-minute time interval.

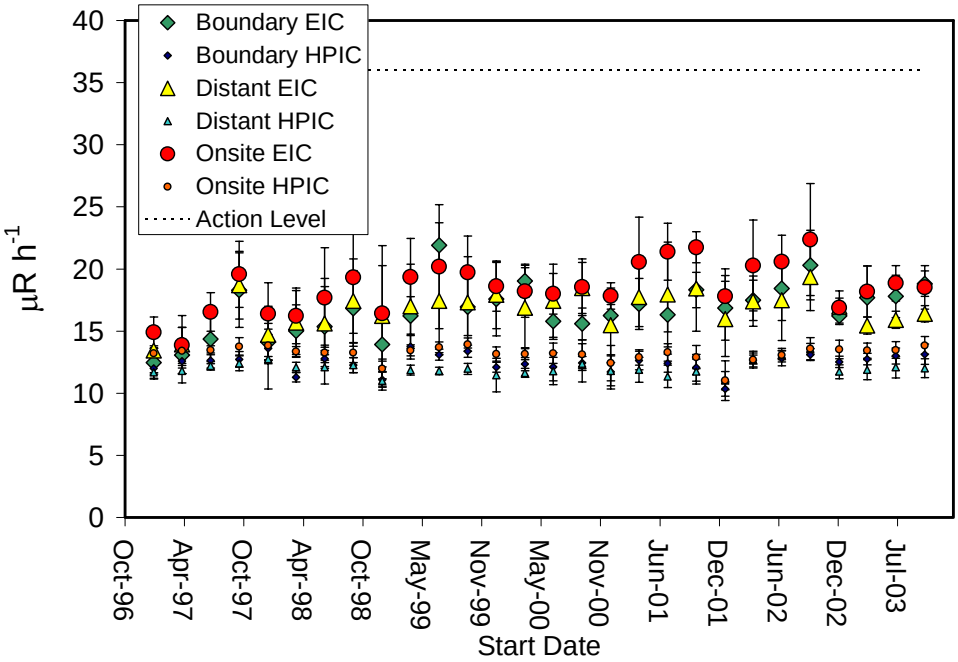

Figure 7-3. Average quarterly exposure rates observed at monitoring stations on the INEEL, near the INEEL boundary, and at distant locations using high-pressure ion chambers (HPICs) and electret ion chambers (EICs). The HPIC action level corresponds to twice the expected background measurement based upon *in-situ* gamma spectroscopy measurements and cosmic ray contributions estimated from elevation.

The INEEL OP does not co-locate HPICs near DOE-ID contractor's HPICs. Since HPICs are not co-located, a direct comparison between INEEL OP's HPIC measurements and DOE-ID's measurements was not considered appropriate.

Several electret ion chambers (EICs) operated by INEEL OP are co-located with DOE-ID's TLDs used to monitor penetrating radiation. The TLDs deployed by DOE are deployed for a period of six months (May to November) whereas the EICs deployed by INEEL OP are deployed for a period of three months (calendar quarter). Differences are expected to variations in monitoring schedules and differences between the types of environmental dosimeters used. Historically, the EICs used by INEEL OP have been expected to be more sensitive to low-energy x-ray and gamma photons and have shown between 10 and 20 percent greater response than the TLDs used by DOE-ID. **Table 7-5** shows a summary of comparisons between INEEL OP and DOE contractors during 2001 and 2003.

Table 7-5. Descriptive statistics of environmental dosimetry comparison results for 2001 and 2002 between INEEL and DOE-ID contractors for monitoring environmental penetrating radiation. All measurements reported in (mR).

	INEEL OP Exposure	BBWI Exposure	INEEL OP Exposure	ESER Exposure
Average:	89.3	67.3	74.6	62.4
Median:	89.4	67.1	73.3	61.5
Standard Deviation:	13.2	5.9	9.0	6.1
Minimum:	64.5	51.1	60.1	51.7
Maximum:	144.1	84.0	96.1	75.1
Number of Paired Samples:	89		48	
Percent agreement (Relative Difference):	88.8%		93.8%	
Percent agreement (3-sigma):	75.3%		85.4%	
Average Relative Difference:	13.7%		9.7%	

References:

National Council on Radiation Protection and Measurements, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report Number 94, 1987.

Reuter-Stokes. *RSS-1013 PIC Environmental Radiation Monitoring Station Operational Manual*. Version 1.4, May 1993.

Chapter 8

Quality Assurance

INEEL Oversight Program Quality Assurance for Environmental Surveillance Measurements

This section summarizes the results of the quality assurance (QA) assessment of the data collected for calendar year 2003 for the INEEL OP's ESP. In addition, this section includes any corrective actions that were identified or implemented for the ESP.

All analyses and quality control (QC) measures in the analytical laboratories were performed in accordance with approved written procedures maintained by each respective analytical laboratory. Sample collection was performed in accordance with written procedures maintained by the INEEL OP.

- No issues involving sample chain of custody, sample holding times, the analysis of blank, duplicate, and spiked samples were observed during the calendar year 2003. Methodologies and data reports issued by the contracting laboratories conformed to the requirements of the INEEL OP.

- External spiked samples for radiological analytes were not submitted during 2003 pending the development of an external, round-robin, spiked sampling program involving DOE-ID sampling programs conducting environmental surveillance.

- One significant quality assurance issue was identified during the fourth quarter of 2003. ISU-EML identified twelve groundwater samples that were affected by problems exhibited by a liquid scintillation counter for the technetium-99 analysis. The resultant concentrations for these samples exceeded the MDC in all 12 samples, which include samples from wells that had no prior history of technetium-99 contamination. The laboratory hypothesized that the problem was caused by an interaction between minerals in the sample water and the liquid scintillation fluid used. Once a new fluid was employed by the laboratory, the technetium-99 analyses have been performed within quality control parameters.

- All data have been verified and deemed complete, meeting the requirements and data quality objectives established by the INEEL OP.

Quality Assurance Program

The measurement of any physical quantity is subject to uncertainty from errors that may be introduced during sample collection, measurement, calibration, and the reading and reporting of results. While the sum of these inaccuracies cannot be quantified for each analytical result, a quality assurance program can evaluate the overall quality of a data set and possibly identify and address errors or inaccuracies.

This section summarizes the results of the quality assurance (QA) assessment of the data collected for calendar year 2003 for the INEEL OP's ESP. All analyses and quality control (QC) measures for INELL OP and their analytical laboratories are performed in accordance with approved written procedures maintained by each respective program. Sample collection is performed in accordance with written procedures maintained by the INEEL OP.

Air Monitoring Quality Assurance

Quality control for the air monitoring program is maintained through adherence to INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all field air sampling measurements and laboratory analyses. Air flow rates and volume measurements for particulate samplers and atmospheric moisture samplers receive annual performance evaluations. Air sample results are reviewed for adequate sample volume before final results are calculated.

Quality control checks also involve the preparation of external field blanks and internal laboratory protocols. Field blanks are prepared weekly for the air particulate filters and quarterly for atmospheric moisture samples. The laboratory's internal protocols include instrument performance checks, sample recounts, and cross-check programs.

Terrestrial Monitoring Quality Assurance

Quality control for the terrestrial monitoring program is maintained through adherence to the INEEL OP standard operating procedures. Laboratory quality assurance and quality control methods include the use of calibration standards, laboratory-prepared spikes, and other technical practices and protocols.

Water Monitoring Quality Assurance

Quality control for the water monitoring program is maintained through adherence to INEEL OP standard operating procedures. To verify the accuracy and precision of the laboratory analyses, INEEL OP obtains analytical results of field blanks and duplicates of radiological water samples and both field blanks, duplicates, and spiked samples of non-radiological water samples.

Gamma Radiation Monitoring Quality Assurance

Quality control for the gamma radiation monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for the two primary gamma radiation instrumentation and analyses (EICs and HPICs) performed by the organization. Each quarter, INEEL OP has EICs irradiated with known gamma exposures for QC purposes. Irradiations of EICs are conducted by ISU-EML using known exposure rates. In addition, each quarter a second EIC is placed at some monitoring sites as a dulicate measurement to evaluate the reproducibility of the exposure measurement.

The responses of HPICs are verified annually in the field with a radiation source and a calibrated reference instrument. At every location, side-by-side measurements are made of the source with the reference instrument and with the HPIC. Whenever these measurements do not agree to within 10 percent, the HPIC is removed and returned to the manufacturer for service and calibration.

Quality Control Assessment

Analytical results for blanks, spikes, and duplicates are used to assess the precision, accuracy, and representative nature of results from analyzing laboratories. During 2003, the INEEL OP submitted 288 QC samples for various radiological and nonradiological analyses as summarized in **Table 8-1**. Detailed data tables for all quality controls measurements collected by INEEL OP can be found in each of the quarterly reports for the sampling year 2003.

Blank Sample Results

Blank samples consist of matrices that have negligible, acceptably low, or unmeasurable amounts of the analyte(s) of interest in them. They are designed to determine if analyses will provide a “zero” result when no contaminant is expected to be present or an acceptable measure of “background,” and therefore monitor any bias that may have been introduced during sample collection, storage, shipment, and analysis. During 2003, INEEL OP submitted 186 blank samples for analysis to assess the validity of the data generated for the ESP. No significant anomalies were observed from the assessment of blank samples submitted to the analytical laboratories during 2003.

Table 8-1. Summary of quality control samples collected in calendar year 2003.

Sample Type	Analyte	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Analyte Total
Blanks of all types	Gross Alpha	14	14	15	15	58
	Gross Beta	14	14	15	15	58
	Gamma Emitters	2	2	3	3	10
	Tritium	3	3	2	6	14
	Enriched Tritium	3	3	3	3	12
	EICs	4	4	0	4	12
	Metals	0	2	2	2	6
	Common Ion and Nutrient	0	6	2	2	10
	Radiochemical	1	1	4	0	6
Duplicates of all types	Gross Alpha	1	2	4	2	9
	Gross Beta	1	2	4	2	9
	Gamma Emitters	1	2	4	2	9
	Tritium	1	2	4	2	9
	Enriched Tritium	0	0	0	3	3
	Metals	0	2	2	1	5
	Common Ion and Nutrient	0	6	2	1	9
	VOCs	0	0	1	0	1
Spikes of all types	Rad (EIC irradiations only)	8	8	8	8	32
	Nonrad	0	8	4	4	16
	Gamma Emitters	0	0	0	0	0
Quarterly QC Sample Total		53	81	79	75	
2003 QC Sample Total						288

Spike Sample Results

Spiked samples are samples to which known concentrations of specific analytes have been added. One indicator of agreement is the difference between the known concentration in the sample and the measured concentration, expressed as percent recovery (%R). This quantity is calculated to assess the bias a laboratory may have in accurately measuring analytes in a particular sample.

No field matrices were spiked to assess the influence of the sample media on laboratory performance, however, during 2003, the INEEL OP submitted lab-generated deionized water spikes for various nonradiological constituents. A total of 16 samples spiked analyses were submitted to assess laboratory performance.

No significant anomalies were observed from the assessment of spiked sample data received from analytical laboratories during 2003.

External spiked samples for radiological analytes were not submitted during 2003 pending the development of an external, round-robin, spiked sampling program involving DOE-ID sampling programs conducting surveillance.

Electret Ion Chambers

Four times per year, INEEL OP irradiates a number of electret ionization chambers (EIC) to verify EIC response. Irradiations of EICs are conducted in a repeatable geometry to a known exposure of 30 mR and a "blind" exposure ranging from 20 to 50 mR. INEEL OP measures the EIC responses and compares them directly with the actual exposure they received from a NIST traceable cesium-137 source provided by ISU. The response data are considered acceptable if the "measured" response of each irradiated EIC agrees within 25 percent of the "actual" received exposure. A summary of the irradiation test results for 2003 are shown in **Table 8-2.**

No anomalies were observed from the assessment of measuring known irradiated quantities to EICs for the second quarter of 2004.

Table 8–2. Quality assurance irradiation summary of EICs conducted in 2003.

	"Measured" Exposure (mR) [a]	"Actual" exposure (mR) [a]	Relative Difference
1st Quarter 2003 ("known")	27.52 ± 1.43	29.50 ± 1.50	-6.7%
1st Quarter 2003 ("blind")	39.77 ± 1.06	41.00 ± 2.10	-3.0%
2nd Quarter 2003 ("known")	31.14 ± 2.48	30.00 ± 1.50	3.8%
2nd Quarter 2003 ("blind")	48.54 ± 0.56	49.50 ± 2.50	-1.9%
3rd Quarter 2003 ("known")	30.61 ± 2.48	30.00 ± 1.50	2.1%
3rd Quarter 2003 ("blind")	48.01 ± 0.56	49.50 ± 2.50	-2.9%
4th Quarter 2003 ("known")	27.50 ± 1.36	30.00 ± 1.50	-8.4%
4th Quarter 2003 ("blind")	20.25 ± 1.94	22.20 ± 1.11	-8.8%
	Overall Relative Difference:		**-3.23%**

[a] Propagated 1-sigma measurement uncertainty

High-Pressure Ion Chambers

Annual source checks were conducted at each HPIC deployed as part of the penetrating radiation monitoring network. The source check involves the direct comparison of instrument response to a gamma source between the HPIC deployed in the field and a "mobile" HPIC calibrated by the manufacturer. The results of this source check are shown in **Table 8-3**. Variation in HPIC response between different HPICs deployed by INEEL OP is being investigated. The relative positioning of the 10 μCi cesium-137 check source with respect to the chamber inside the protective housing may be responsible for the observed differences in instrument response.

Table 8–3. 2003 summary of HPIC source field checks

Location	Date Performed	Relative Difference with Respect to the Calibrated HPIC
Atomic City	10/21/03	-1.0%
Base of Howe Peak	10/9/03	-2.0%
Big Lost River Rest Area	10/21/03	-5.0%
Big Southern Butte	10/7/03	3.0%
Fort Hall	11/7/03	-2.0%
Howe	10/9/03	-1.0%
Idaho Falls	10/20/03	-3.0%
INEEL Main Gate	10/7/03	-3.0%
Monteview	10/22/03	-3.0%
Mud Lake	10/22/03	-3.0%
Rover	10/9/03	-3.0%
Sand Dunes Tower	10/22/03	-7.0%
	Average Relative Difference:	**-2.5%**

Duplicate Sample Results

Duplicate samples are collected in a manner such that the samples are thought to be essentially identical in composition and are used to assess analytical precision. The difference between the original sample and the duplicate sample is expressed as a relative percent difference (RPD) and is used to measure a laboratory's ability to reproduce consistent results. For radiological analyses, the standard deviation of the differences can be used as an indicator of the overall precision of the data set. The following provides a general overview of the "RPD" process used by INEEL OP.

Radiological Analyses

During 2003, the INEEL OP submitted 39 duplicate samples for radiological analyses. Unlike the nonradioactive constituents for which no analytical uncertainty is reported, the counting uncertainty must be considered when evaluating the reproducibility of radioactivity analyses.

The results reported for the duplicate sample sets were considered to be within control limits for precision if:

$/R_1 - R_2/ \leq 3\ (s_1^2 + s_2^2)^{1/2}$

where,

R_1 = concentration of analyte in the first sample
R_2 = concentration of analyte in the duplicate sample
S_1 = sample standard deviation of the first sample
S_2 = sample standard deviation of the duplicate sample
or,

The Relative Percent Difference (RPD) was less than or equal to 20 percent.

If less than 90 percent of the duplicate analyses meet these criteria, further evaluation is conducted to determine whether a corrective action is necessary.

Nonradiological Analyses

During 2003, the INEEL OP submitted 15 duplicate samples for various nonradiological analyses. If the reported concentration of the analyte exceeded the detection limit by a factor of five or more in a sample and corresponding duplicate, the laboratory precision was determined by calculating the RPD between the two analytical results using the following equation:

$$RPD = \frac{/R_1 - R_2/}{\frac{(R_1 + R_2)}{2}} \times 100$$

where

R_1 = concentration of analyte in the first or primary sample
R_2 = concentration of analyte in the duplicate sample.

For duplicate sample sets in which one or both of the results reported for a particular analyte were less than five times the detection limit, the level of precision was considered acceptable if the two results differed by an amount equal to or less than the detection limit. If less than 90 percent of the duplicate sample sets for a particular analyte meet the desired level of precision, the results are discussed with the laboratory to determine whether a corrective action is required.

No anomalies were observed by the INEEL OP from the assessment of duplicate samples submitted to the analytical laboratories in 2003.

Analytical QA/QC Assessment

No issues involving sample chain of custody, sample holding times, the analysis of blank, duplicate, and spiked samples were observed during the calendar year 2003. Methodologies and data reports issued by the contracting laboratories conformed to the requirements of INEEL OP. No transcription errors were noted for data collected in 2003.

External QA/QC

During 2003, the INEEL OP did not participate in external QA/QC programs. An external round-robin spike sample program involving DOE-ID sampling programs conducting surveillance sampling is under development but has not yet been implemented. The ISU-EML, however, participated in the "Interlab RadChem™ Proficiancy Testing Program." Analyses were conducted for blind water samples received as part of this program for gross alpha, gross beta, and gamma. ISU-EML performed satisfactorily in this program in 2003.

Resolution of Analytical Issues

One significant quality assurance issue was identified during the fourth quarter of 2003. Twelve groundwater samples were affected by problems exhibited by a liquid scintillation counter at ISU-EML for the technetium-99 analysis. The resultant concentrations for these samples exceeded the MDC in all 12 samples, which included wells that had no prior history of technetium-99 contamination. The laboratory blanks for this quarter were acceptable on this equipment. The liquid scintillation spectra suggested an interference believed to be from natural minerals dissolved in the water samples. This resulted in a spurious signal equivalent to about 2 pCi/L which may have resulted from "spill-down" of the alpha-particle signal into the technetium-99 region of interest. A Pocatello tap water blank was analyzed, and was found to have a concentration of about 2 pCi/L, and was used in a reanalysis of the data. Since this was a deviation from the established procedure, which called for a de-ionized (DI) water blank, the results with less than 10 pCi/L were considered to be "estimates" and J qualifiers were applied. Higher concentrations were not qualified because the approximately 2 pCi/L difference between the DI and tap water blanks did not contribute much relative uncertainty to these higher concentrations.

The laboratory hypothesized that the problem was caused by an interaction between minerals in the sample water and the liquid scintillation fluid currently used (ScintiVerse™). Experiments indicated that a new liquid scintillation fluid (Packard Ultima Gold XR) did not exhibit the interference and has been used for subsequent analyses. No problems have been seen with the Ultima Gold XR thus far and technetium-99 analyses have been performed within quality control parameters.

Conclusion

All data collected for the 2003 calendar year has been assigned the applicable qualifiers to designate the appropriate use of the data. In addition, all data has been verified and deemed complete, meeting the requirements and data quality objectives established by the INEEL OP.