S.M. Stoller Corporation

Environmental Surveillance, Education, and Research Program
ISSN NUMBER 1089-5469

Idaho National Laboratory Offsite Environmental Surveillance Program Report: Third Quarter 2006

July 2007

Contributors:
Marilyn Case, Russ Mitchell

Program conducted for the U.S. Department of Energy, Idaho Operations Office
Under Contract DE-AC07-00ID13658

By the S.M. Stoller Corporation,
Environmental Surveillance, Education and Research Program
Douglas K. Halford, Program Manager
120 Technology Drive, Idaho Falls, Idaho 83402
www.stoller-eser.com

EXECUTIVE SUMMARY

Most of the radionuclides detected in any of the samples collected during the third quarter of 2006 could not be directly linked with INL activities. An exception was waterfowl taken directly from waste ponds located on the INL. One quarterly composited air sample had an anomalous Americium-241 result of unknown origin. Levels of most detected radionuclides were no different than values measured at other locations across the United States or were consistent with levels measured historically at the INL. All detected radionuclide concentrations were well below guidelines set by the U.S. Department of Energy (DOE) and regulatory standards established by the U.S. Environmental Protection Agency (EPA) for protection of the public. (See Table E-1.)

This report for the third quarter, 2006, contains results from the Environmental Surveillance, Education and Research (ESER) Program's monitoring of the Department of Energy's Idaho National Laboratory's (INL) offsite environment, July 1 through September 30, 2006. All sample types (media) and the sampling schedule followed during 2006 are listed in Appendix A. Specifically, this report contains the results for the following:

- Air sampling, including air filters and charcoal cartridges, atmospheric moisture, and 10-micron particulate matter (PM_{10});
- Precipitation sampling;
- Agricultural product sampling, including milk, lettuce and wheat;
- Game animal sampling, including large game animals;
- Soil sampling.

Gross alpha and gross beta measurements are used as general indicators of the presence of radionuclides. Gross alpha and gross beta results were found to have no discernable statistical distribution during the third quarter of 2006. Because of this, these data were statistically analyzed using nonparametric methods, including the use of the median to represent central tendency. At no time during the third quarter were weekly, monthly, or quarterly gross alpha or gross beta concentrations in air collected at Boundary locations statistically greater than corresponding data for Distant locations, as one would expect if the INL were a significant source of radionuclide contamination. There were no statistical differences between gross alpha or gross beta results when grouped by location on a quarterly basis. Statistical analysis by month also showed no statistical difference between locations for gross alpha or gross beta.

Weekly comparisons of gross alpha concentrations at Distant and Boundary locations showed two statistical differences during the third quarter of 2006, during the weeks of July 12 and August 30, 2006. Weekly gross beta results were not statistically different during the third quarter of 2006.

Iodine-131 (^{131}I) was not detected in any batch of charcoal cartridges during the third quarter.

Selected quarterly composite filter samples were analyzed for gamma emitting radionuclides, strontium-90 (^{90}Sr), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). Cesium-137 was found near the detection limit in three samples: two collected from Craters of the Moon and one from Van Buren Gate. The samples were recounted and ^{137}Cs was confirmed in one sample collected at Craters of the Moon and the other detected at Van Buren Gate. The detected concentration was well below the DOE Derived Concentration Guide for this radionuclide.

Twenty-four atmospheric moisture samples were obtained during the third quarter of 2006 and analyzed for tritium. Three samples from Atomic city, three samples from Blackfoot, two samples from Rexburg, and one sample from Idaho Falls exceeded their respective 3s levels. The maximum value was well below the DOE DCG for tritium in air.

The ESER Program operates three PM_{10} samplers for particulate sampling, one each at Rexburg, Blackfoot, and Atomic City. Sampling of PM_{10} is informational as no analyses are conducted for contaminants. PM_{10} concentrations were well below all health standard levels for all samples.

Sufficient precipitation occurred to allow collection of six samples—one from Idaho Falls, two from the Central Facilities Area (CFA), and one from the Experimental Field Station (EFS). Tritium was not detected above the 3s level in two of the samples collected at CFA and the EFS. The results were within EPA measurements.

Milk samples were collected weekly in Idaho Falls and monthly at eight other locations around the INL. All samples were analyzed for gamma-emitting radionuclides. Iodine-131 was not detected in any milk sample. Cesium-137 was found slightly above the detection limit in one weekly Idaho Falls sample. No ^{137}Cs was found in a recount of the sample.

Six lettuce samples and a duplicate sample were collected from self-contained lettuce planters placed around the area. No sample had measurable concentrations of human-made gamma-emitting radionuclides. Strontium-90 was found exceeding the 3s value in all samples. The level found was consistent with those found in previous years and is attributed to uptake of ^{90}Sr remaining in soil from nuclear weapons testing fallout.

In the third quarter of 2006 twelve wheat samples were collected from area grain elevators. All samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. No gamma-emitting radionuclides were detected above the 3s level in any sample. Strontium-90 was detected in one sample, collected from Idaho Falls.

No game animals were available for sampling during the third quarter.

Thirteen soil samples, including one duplicate, were collected during the third quarter. Cesium-137 was detected in all but one sample. Strontium-90 was detected in all samples. The levels were consistent with historical measurements and were likely deposited during past atmospheric nuclear weapons testing. Plutonium-238 and ^{241}Am were detected at higher than historical levels- ^{238}Pu in one sample collected at Blackfoot and ^{241}Am in a sample collected at Carey. However, both samples were collected at distant locations and ^{241}Am was not detected in a replicate Carey sample. The origin of the radionuclides is therefore not likely to be the INL and most likely due to past fallout associated with atmospheric nuclear weapons testing.

Table E-1 Summary of results for the third quarter of 2006.

Media	Sample Type	Analysis	Results
Air	Filters	Gross alpha, gross beta	There were no statistical differences noted for monthly or quarterly gross alpha or gross beta concentrations measured at INL, Boundary, and Distant locations. Gross alpha concentrations were statistically higher at Distant locations than at Boundary locations during the week of July 12 and higher at Distant locations during the week of August 30. Weekly gross beta results were statistically equivalent. No result exceeded the DCG for gross alpha or gross beta activity in air.
		Gamma-emitting radionuclides, select actinides, ^{90}Sr	Cesium-137 was detected in three samples just above the detection limit, well below the DCG and within historical measurements. No sample had detectable concentration of ^{241}Am, plutonium or ^{90}Sr.
	Charcoal Cartridge	Iodine-131	No detections of ^{131}I were made during the third quarter.
	PM_{10}	Particulate matter	No EPA egulatory limits were exceeded.
Atmospheric Moisture	Liquid	Tritium	Twenty-four atmospheric moisture samples were collected. Nine of the results were greater than the 3s uncertainty. No sample result exceeded the DCG for tritium in air.
Precipitation	Liquid	Tritium	Six samples were collected. Two of these samples had tritium results greater than the 3s uncertainty but well within historical measurements.
Milk	Liquid	Iodine-131, gamma emitting radionuclides	Iodine-131 was not found in any samples. Cesium-137 was detected in one distant sample at a value just above its detection level. A recount of the sample found no ^{137}Cs.
Lettuce	Solid	Gamma emitting radionuclides (including ^{137}Cs), and ^{90}Sr	Seven samples were collected. No manmade gamma-emitting radionuclides were found in any sample. All samples had ^{90}Sr at a detectable level consistent with historical measurements for this isotope.
Wheat	Solid	Gamma emitting radionuclides (including ^{137}Cs), and ^{90}Sr	Twelve samples were collected. No manmade gamma-emitting radionuclides were found in any sample. Strontium-90 was detected in one sample within historical levels.
Game Animals	Tissue	Iodine-131, gamma emitting radionuclides	No game animals available for sampling during the third quarter.
Soil	Solid	Gamma emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium	Cesium-137 was detected in all but one sample collected. Strontium-90 was detected in all samples. The origin of these nuclides is probably deposition of fallout from atmospheric nuclear weapons testing. Plutonium-238 was detected in one distant location sample and Americium-241 was detected in one distant sample. The origin is also likely deposition of fallout radionuclides.

LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
CFA	Central Facilities Area
CMS	community monitoring station
DCG	Derived Concentration Guide
DOE	Department of Energy
DOE – ID	Department of Energy Idaho Operations Office
EAL	Environmental Assessment Laboratory
EFS	Experimental Field Station
EPA	Environmental Protection Agency
ERAMS	Environmental Radiation Ambient Monitoring System
ESER	Environmental Surveillance, Education, and Research
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISU	Idaho State University
MDC	minimum detectable concentration
MFC	Materials and Fuels Complex
M&O	Management and Operating
NRTS	National Reactor Testing Station
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in diameter
RTC	Reactor Technology Complex
SI	Systeme International d'Unites
TLDs	thermoluminescent dosimeters
UI	University of Idaho
WSU	Washington State University

LIST OF UNITS

Bq	becquerel
Ci	curie
g	gram
L	liter
µCi	microcurie
mL	milliliter
mR	milliroentgens
mrem	millirem (rem = unit of dose equivalent [roentgen-equivalent-man])
mSv	millisieverts
pCi	picocurie
R	Roentgen
µSv	microsieverts

1. ESER PROGRAM DESCRIPTION

Operations at the Idaho National Laboratory (INL) are conducted under requirements imposed by the U.S. Department of Energy (DOE) under authority of the Atomic Energy Act, and the U.S. Environmental Protection Agency (EPA) under a number of acts (e.g. the Clean Air Act and Safe Drinking Water Act). The requirements imposed by DOE are specified in DOE Orders. These requirements include those to monitor the effects of DOE activities both inside and outside the boundaries of DOE facilities (DOE 2004). During calendar year 2006, environmental monitoring within the INL boundaries was primarily the responsibility of the INL Management and Operating (M&O) contractor, while monitoring outside the INL boundaries was conducted under the Environmental Surveillance, Education and Research (ESER) Program. The ESER Program is led by the S.M. Stoller Corporation in cooperation with its team members, including the University of Idaho (UI), Idaho State University (ISU), the Wildlife Conservation Society, and Teledyne Brown Engineering. This report contains monitoring results from the ESER Program for samples collected during the third quarter of 2006 (July 1 – September 30, 2006).

The surveillance portion of the ESER Program is designed to satisfy the following program objectives:

- Verify compliance with applicable environmental laws, regulations, and DOE Orders;
- Characterize and define trends in the physical, chemical, and biological condition of environmental media on and around the INL;
- Assess the potential radiation dose to members of the public from INL effluents, and;
- Present program results clearly and concisely through the use of reports, presentations, newsletter articles, and press releases.

The goal of the surveillance program is to monitor different media at a number of potential exposure points within the various exposure pathways, including air, water, agricultural products, wildlife, and soil, that could possibly contribute to the radiation dose received by the public.

Environmental samples collected include:

- air at 16 locations on and around the INL;
- moisture in air at four locations around the INL;
- precipitation from three locations on and around the INL;
- surface water at five locations on the Snake River;
- drinking water at 14 locations around the INL;
- agricultural products, including milk at 10 dairies around the INL, potatoes from at least five local producers, wheat from approximately 10 local producers, lettuce from approximately nine home-owned gardens around the INL and two maintained by ESER at Atomic City and the EFS, and four sheep from two operators which graze their sheep on the INL;
- soil from 12 locations around the INL biennially;
- environmental dosimeters from 15 locations semi-annually; and
- various numbers of wildlife including big game (pronghorn, mule deer, and elk), waterfowl, doves, and marmots sampled on and near the INL.

Table A-1 in Appendix A lists samples, sampling locations and collection frequency for the ESER Program.

The ESER Program used two laboratories to perform analyses on routine environmental samples collected during the quarter reported here. The Idaho State University (ISU) Environmental Assessment Laboratory (EAL) performed routine gross alpha, gross beta, tritium, and gamma spectrometry analyses. Teledyne Brown Engineering, Inc. of Knoxville, Tennessee, performed analyses requiring radiochemistry including ^{90}Sr, plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}Pu$), and americium-241 (^{241}Am).

In the event of non-routine occurrences, such as suspected releases of radioactive material, the ESER Program may increase the frequency of sampling and/or the number of sampling locations based on the nature of the release and wind distribution patterns. Any data found to be outside historical norms in the ESER Program is thoroughly investigated to determine if an INL origin is likely. Investigation may include re-sampling and/or re-analysis of prior samples.

In the event of any suspected worldwide nuclear incidents, like the 1986 Chernobyl accident, the EPA may request additional sampling be performed through RadNet [previously known as the Environmental Radiation Ambient Monitoring System (ERAMS) network] (EPA 2006). The EPA established the ERAMS network in 1973 with an emphasis on identifying trends in the accumulation of long-lived radionuclides in the environment. ERAMS was renamed RadNet in 2006 to reflect a new mission. RadNet is comprised of a nationwide network of sampling stations that provide air, precipitation, drinking water, and milk samples. The ESER Program currently operates a high-volume air sampler and collects precipitation and drinking water in Idaho Falls for this national program and routinely sends samples to EPA's Eastern Environmental Radiation Facility for analyses. The RadNet data collected at Idaho Falls are not reported by the ESER Program but are available through the EPA RadNet website (http://www.epa.gov/narel/radnet/).

Once samples have been collected and analyzed, the ESER Program has the responsibility for quality control of the data and for preparing quarterly reports on results from the environmental surveillance program. The quarterly reports are then consolidated into the INL Annual Site Environmental Report for each calendar year. Annual reports also include data collected by other INL contractors.

The results reported in the quarterly and annual reports are assessed in terms of data quality and statistical significance with respect to laboratory analytical uncertainties, sample locations, reported INL releases, meteorological data, and worldwide events that might conceivably have an effect on the INL environment. First, field collection and laboratory information are reviewed to determine identifiable errors that would invalidate or limit use of the data. Examples of such limitations include insufficient sample volume, torn filters, evidence of laboratory cross-contamination or quality control issues. Data that pass initial screening are further evaluated using statistical methods. Statistical tools are necessary for data evaluation particularly since environmental measurements typically involve the determination of minute concentrations, which are difficult to detect and even more difficult to distinguish from other measurements.

Results are presented in this report with an analytical uncertainty term, *s*, where "*s*" is the estimated sample standard deviation (σ), assuming a Guassian or normal distribution. All results are reported in this document, even those that do not necessarily represent detections. The term "detected", as used for the discussion of results in this report, does not imply any degree of risk to the public or environment, but rather indicates that the radionuclide was measured at a concentration sufficient for the analytical instrument to record a value that is

statistically different from background. The ESER has adopted guidelines developed by the United States Geological Survey (Bartholomay, et al. 2003), based on an extension of a method proposed by Currie (1984), to interpret analytical results and make decisions concerning detection. Most of the following discussion is taken from Bartholomay et al (2003).

Laboratory measurements involve the analysis of a target sample and the analysis of a prepared laboratory blank (i.e., a sample which is identical to the sample collected in the environment, except that the radionuclide of interest is absent). Instrument signals for the target and blank vary randomly about the true signals and may overlap making it difficult to distinguish between radionuclide activities in blank and in environmental samples (Figure 1). That is, the variability around the sample result may substantially overlap the variability around a net activity of zero for samples with no radioactivity. In order to conclude that a radionuclide has been detected, it is essential to consider two fundamental aspects of the problem of detection: (1) the instrument signal for the sample must be greater than that observed for the blank before the decision can be made that the radionuclide has been detected; and (2) an estimate must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before the correct decision can be made for detection or non-detection.

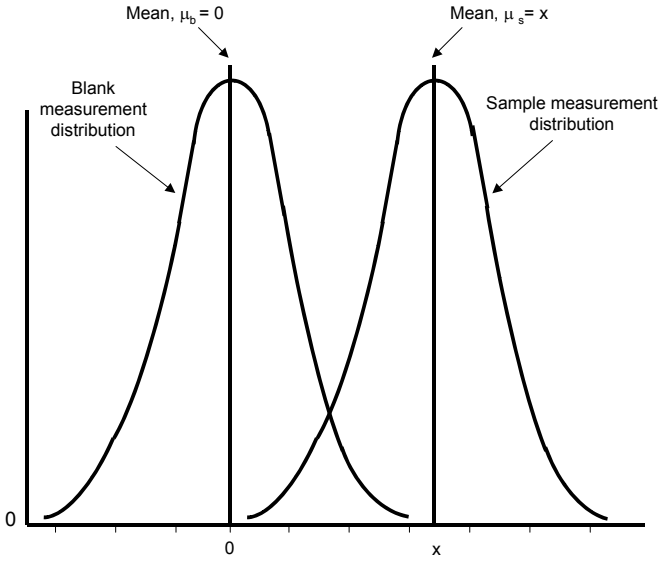


Figure 1. Example of overlap of blank and sample measurement distributions.

In the laboratory, instrument signals must exceed a critical level of 1.6s before the qualitative decision can be made as to whether the radionuclide was detected in a sample. At 1.6s there is about a 95-percent probability that the correct conclusion—not detected—will be made. Given a large number of samples, approximately 5 percent of the samples with measured concentrations greater than or equal to 1.6s, which were concluded as being detected, might not contain the radionuclide. These are referred to as false positives. For purposes of simplicity and consistency with past reporting, the ESER has rounded the 1.6s critical level estimate to 2s.

Once the critical level has been defined, the minimum detectable concentration may be determined. Concentrations that equal 3s represent a measurement at the detection level or minimum detectable concentration. For true concentrations of 3s or greater, there is a 95-percent probability that the radionuclide was detected in the target sample. In a large number of samples, the conclusion—not detected—will be made in 5 percent of the samples with true concentrations at the minimum detectable concentration of 3s. These measurements are known as false

negatives. The ESER reports measured radionuclide concentrations greater than or equal to their respective 3s uncertainties as being "detected with confidence."

Concentrations between 2s and 3s are reported as "questionably detected". That is, the radionuclide may be present in the sample, however, the detection may not be reliable. Measurements made between 2s and 3s are examined further to determine if they are a part of a pattern (temporal or spatial) that might warrant further investigation or recounting. For example, if a particular radionuclide is typically detected at > 3s at a specific location, a sample result between 2s and 3s might be considered detected.

If a result is less than or equal to 2s there is little confidence that the radionuclide is present in the sample. Analytical results in this report are presented as the result value ± one standard deviation (1s) for reporting consistency with the annual report. To obtain the 2s or 3s values simply multiply the uncertainty term by 2 or 3.

For more information concerning the ESER Program, contact the S.M. Stoller Corporation at (208) 525-9358, or visit the Program's web page (http://www.stoller-eser.com).

2. THE INL

The INL is a nuclear energy research and environmental management facility. It is owned and administered by the U.S. Department of Energy, Idaho Operations Office (DOE-ID) and occupies about 890 mi^2 (2,300 km^2) of the upper Snake River Plain in Southeastern Idaho. The history of the INL began during World War II when the U.S. Naval Ordnance Station was located in Pocatello, Idaho. This station, one of two such installations in the U.S., retooled large guns from U.S. Navy warships. The retooled guns were tested on the nearby, uninhabited plain, known as the Naval Proving Ground. In the years following the war, as the nation worked to develop nuclear power, the Atomic Energy Commission (AEC), predecessor to the DOE, became interested in the Naval Proving Ground and made plans for a facility to build, test, and perfect nuclear power reactors.

The Naval Proving Ground became the National Reactor Testing Station (NRTS) in 1949, under the AEC. By the end of 1951, a reactor at the NRTS became the first to produce useful amounts of electricity. Over time the site has operated 52 various types of reactors, associated research centers, and waste handling areas. The NRTS was renamed the Idaho National Engineering Laboratory (INEL) in 1974, and the Idaho National Engineering and Environmental Laboratory (INEEL) in January 1997. With renewed interest in nuclear power the DOE announced in 2003 that Argonne National Laboratory and the INEEL would be the lead laboratories for development of the next generation of power reactors. On February 1, 2006 the INEEL and Argonne National Laboratory-West became the Idaho National Laboratory (INL). The INL is committed to providing international nuclear leadership for the 21st Century, developing and demonstrating compelling national security technologies, and delivering excellence in science and technology as one of the Department of Energy's multiprogram national laboratories.

The cleanup operation, Idaho Cleanup Project (ICP), is now a separately managed effort. The ICP is charged with safely and cost-effectively completing the majority of cleanup work from past laboratory missions by 2012.

3. AIR SAMPLING

The primary pathway by which radionuclides can move off the INL is through the air and for this reason the air pathway is the primary focus of monitoring on and around the INL. Samples for particulates and iodine-131 (^{131}I) gas in air were collected weekly for the duration of the quarter at 16 locations using low-volume air samplers. Moisture in the atmosphere was sampled at four locations around the INL and analyzed for tritium. Concentrations of airborne particulates less than 10 micrometers in diameter (PM_{10}) were measured for comparison with EPA standards at three locations. Air sampling activities and results for the third quarter, 2006 are discussed below. A summary of approximate minimum detectable concentrations (MDCs) for radiological analyses and DOE Derived Concentration Guide (DCG) (DOE 1993) values is provided in Appendix B.

LOW-VOLUME AIR SAMPLING

Radioactivity associated with airborne particulates was monitored continuously by 18 low-volume air samplers (two of which are used as replicate samplers) at 16 locations during the third quarter of 2006 (Figure 2). Four of these samplers are located on the INL, eight are situated off the INL near the boundary, and six have been placed at locations distant to the INL. Samplers are divided into INL, Boundary, and Distant groups to determine if there is a gradient of radionuclide concentrations, increasing towards the INL. Each replicate sampler is relocated every year to a new location. One replicate sampler was placed at Howe (Boundary location) and one at the INL Main Gate (onsite location) during 2006. An average of 14,643 ft^3 (415 m^3) of air was sampled at each location, each week, at an average flow rate of 1.45 ft^3/min (0.04 m^3/min). Particulates in air were collected on membrane particulate filters (1.2-µm pore size). Gases passing through the filter were collected with an activated charcoal cartridge.

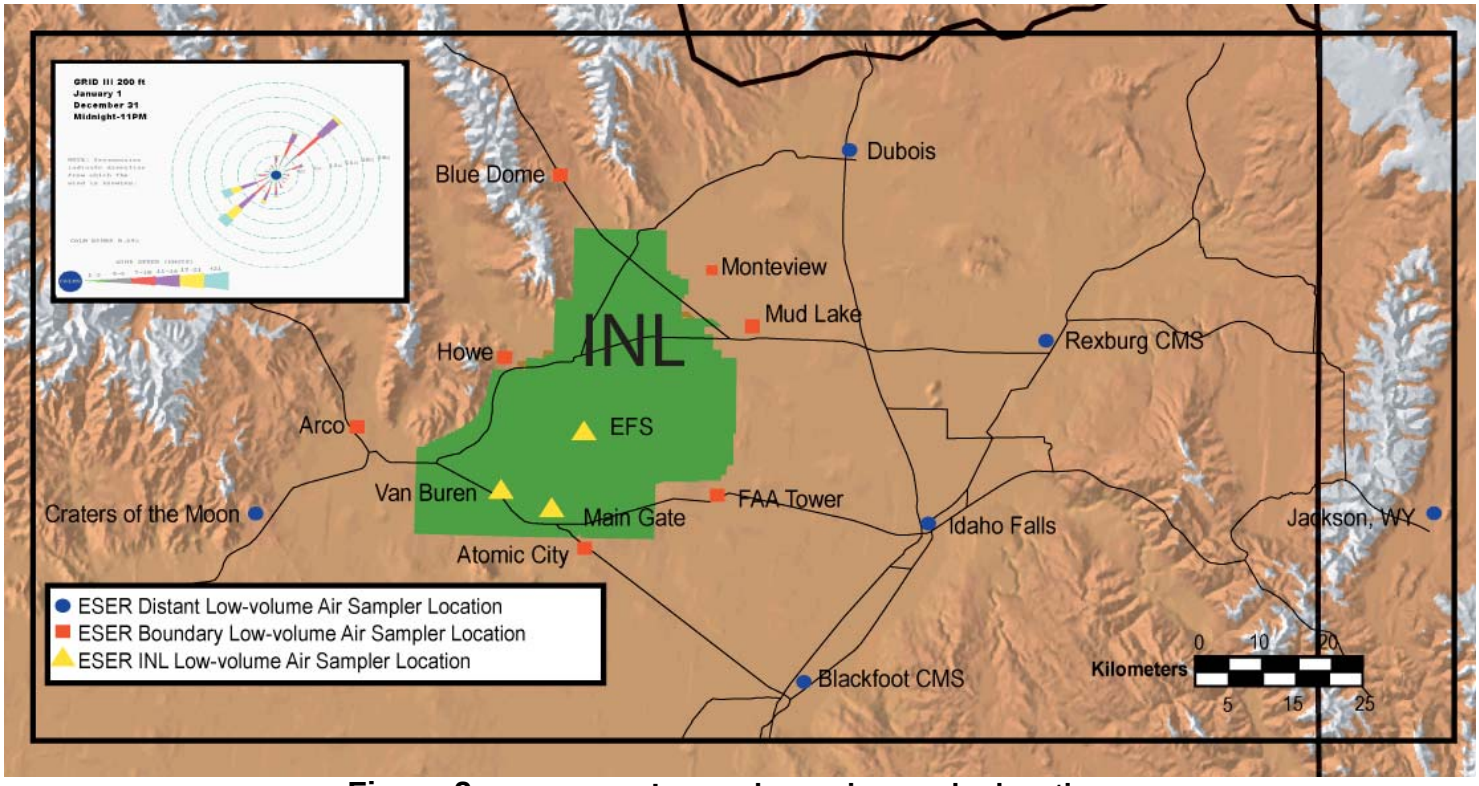


Figure 2. Low-volume air sampler locations.

Filters and charcoal cartridges were changed weekly at each station during the quarter. Each particulate filter was analyzed for gross alpha and gross beta radioactivity using thin-window gas flow proportional counting systems after waiting about four days for naturally-occurring daughter products of radon and thorium to decay.

The weekly particulate filters collected during the quarter for each location were composited and analyzed for gamma-emitting radionuclides. Composites were also analyzed by location for ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am as determined by a rotating quarterly schedule.

Charcoal cartridges were analyzed for gamma-emitting radionuclides, specifically for iodine-131 (^{131}I). Iodine-131 is of particular interest because it is produced in relatively large quantities by nuclear fission, is readily accumulated in human and animal thyroids, and has a half-life of eight days. This means that any elevated level of ^{131}I in the environment could be from a recent release of fission products.

Gross alpha results are reported in Table C-1. Median gross alpha concentrations in air for INL, Boundary, and Distant locations for the third quarter of 2006 are shown in Figure 3. The data were tested for normality prior to statistical analyses. The data showed no consistent discernable distribution. Box and whisker plots are commonly used when there is no assumed distribution. Each data group in Figure 3 is presented as a box and whisker plot, with a median (small red square), a box enclosing values between the 25th and 75th percentiles, and whiskers representing the non-outlier range. Note that outliers and extreme values are identified separately from the box and whiskers. Outliers and extreme values are atypical, infrequent, data points that are far from the middle of the data distribution. For this report, outliers are defined as values that are greater than 1.5 times the height of the box, above or below the box. Extreme values are greater than 2 times the height of the box, above or below the box. Outliers and extreme values may reflect inherent variability, may be due to errors associated with transcription or measurement, or may be related to other anomalies. A careful review of the data collected during the third quarter indicates that the outlier values were not due to mistakes in collection, analysis, or reporting procedures, but rather reflect natural variability in the measurements. The outlier and extreme values lie within the range of measurements made within the past five years. Thus, rather than dismissing the outliers, they were included in the subsequent statistical analyses.

Figure 3 graphically shows that the gross alpha measurements made at INL, Boundary, and Distant locations are similar for the third quarter. If the INL were a significant source of offsite contamination, concentrations of contaminants could be statistically greater at Boundary locations than at Distant locations. Because there is no discernable distribution of the data, the nonparametric Kruskal-Wallis test of multiple independent groups was used to test for statistical differences between INL, Boundary, and Distant locations. The use of nonparametric tests, such as Kruskal-Wallis, gives less weight to outlier and extreme values thus allowing a more appropriate comparison of data groups. A statistically significant difference exists between data groups if the (p) value is less than 0.05. Values greater than 0.05 translate into a 95 percent confidence that the medians are statistically the same. The p-value for each comparison is shown in Table D-1. There were no statistical differences in gross alpha concentrations, grouped quarterly, between location groups during the third quarter 2006.

Comparisons of gross alpha concentrations were made for each month of the quarter (Figures 4 – 6). Again the Kruskal-Wallis test of multiple independent groups was used to determine if statistical differences exist between INL, Boundary, and Distant data groups.

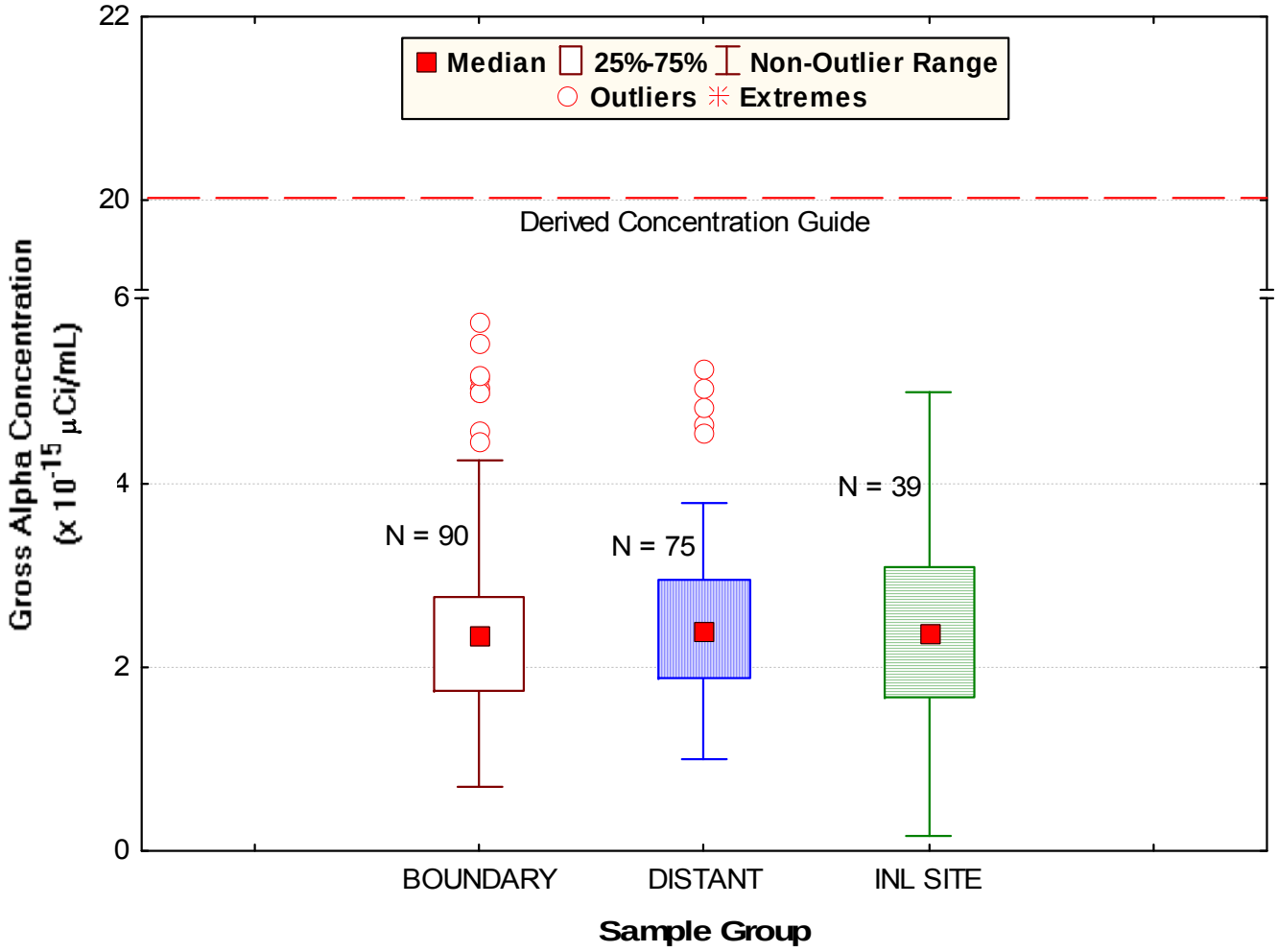


Figure 3. **Gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations for the third quarter of 2006.**

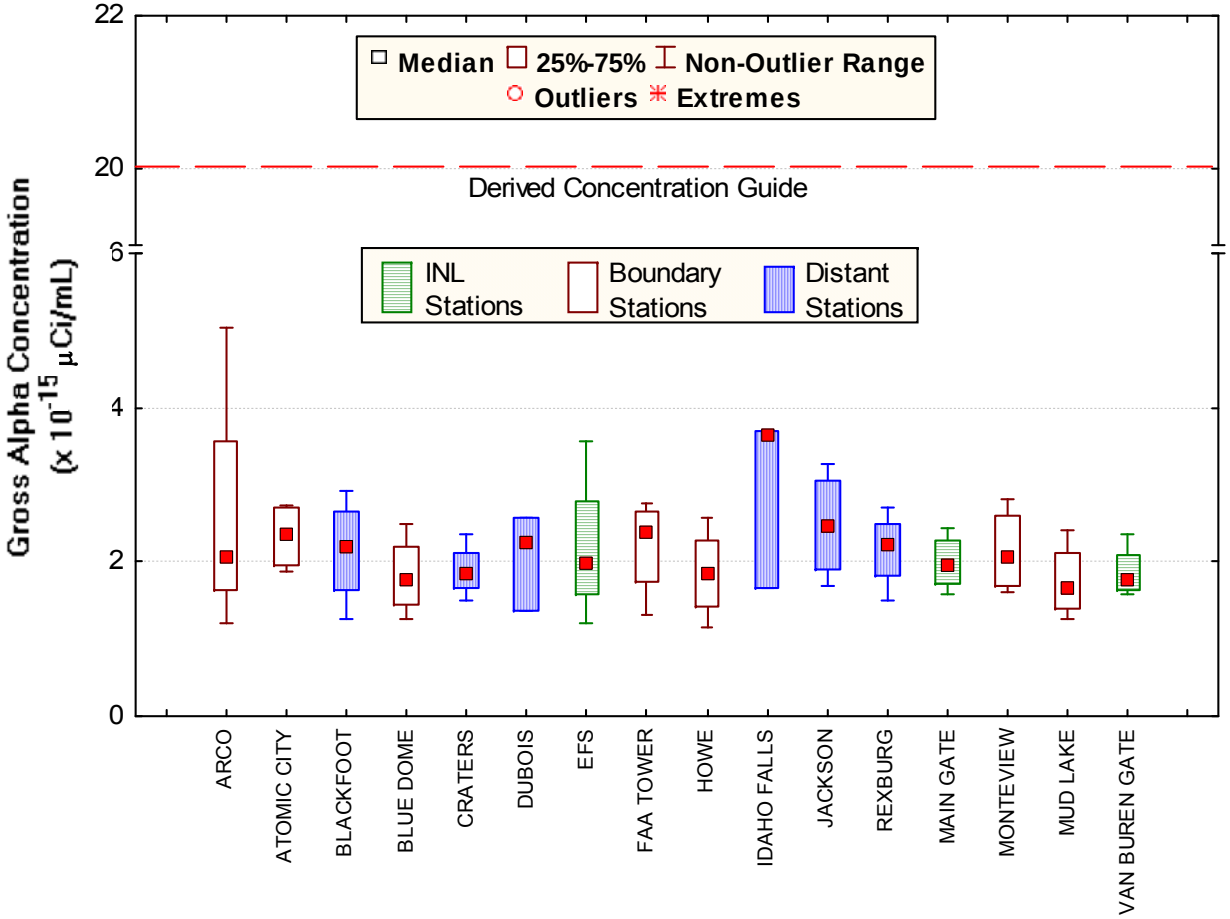


Figure 4. **July 2006 gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations.** Number of samples (N) = 4 at each location except at Dubois and Idaho Falls stations, where N = 3.

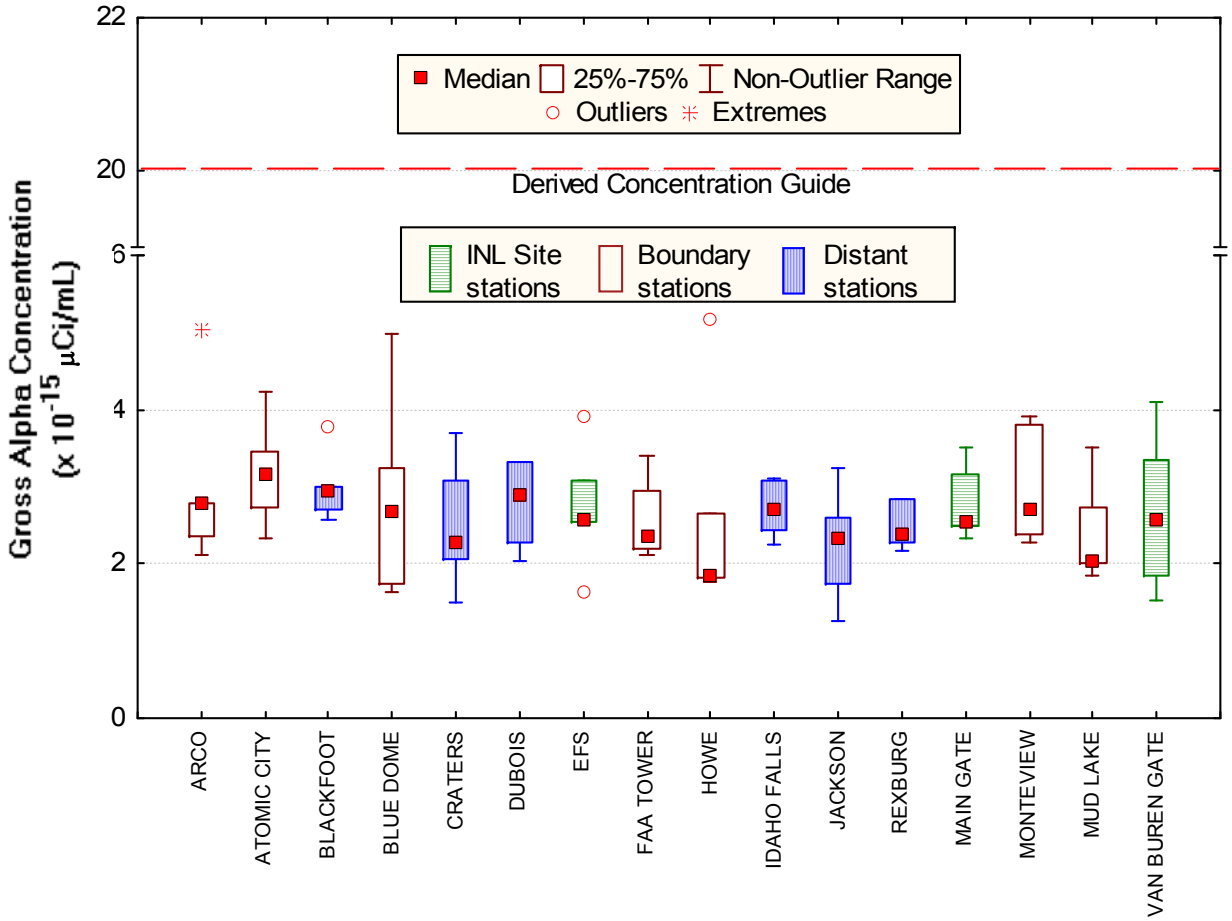


Figure 5. **August 2006 gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations.** Number of samples (N) = 5 at each location except at Dubois and FAA Tower, where N = 4.

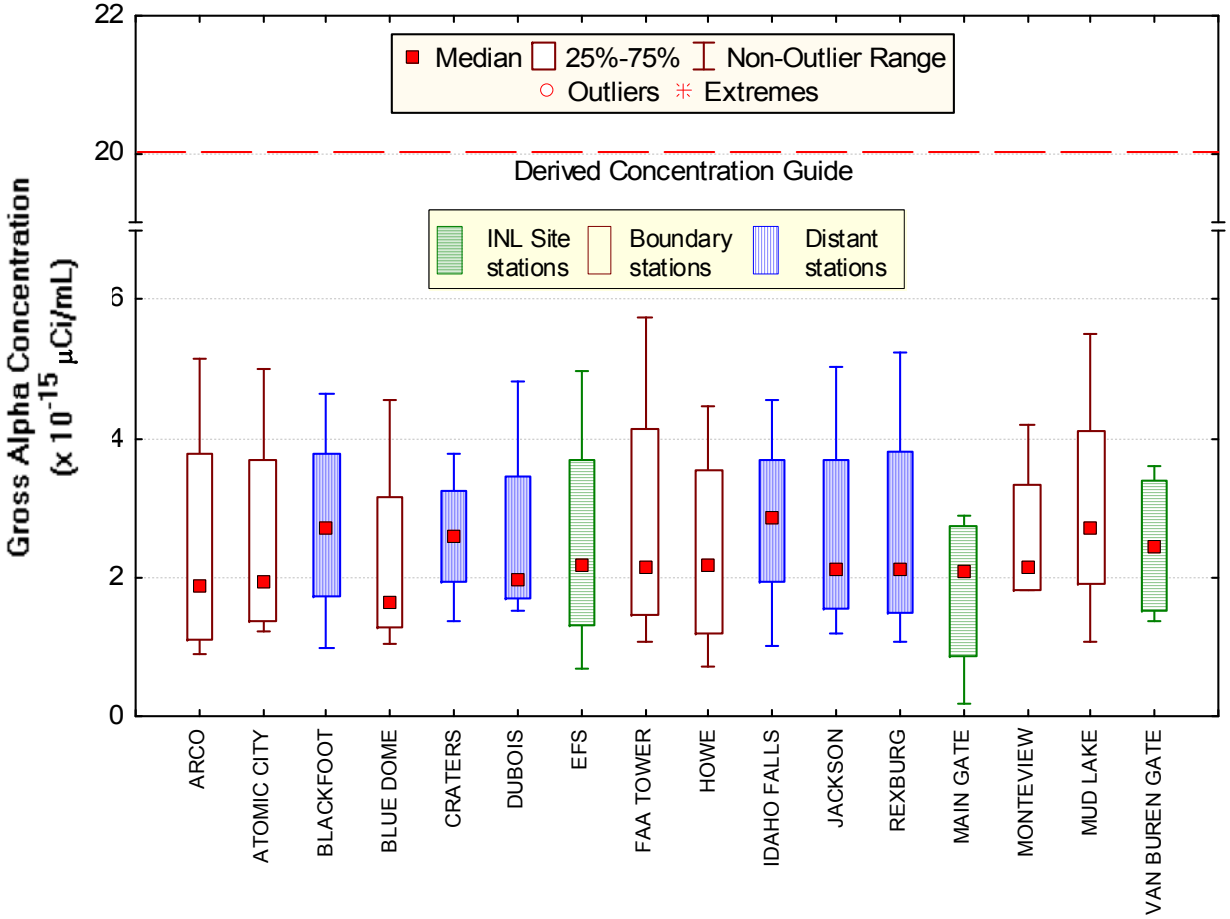


Figure 6. September 2006 gross alpha concentrations in air at ESER Program INL, Boundary, and Distant locations. Number of samples (N) = 4 at each location.

There were no statistical differences in gross alpha results between groups for any month during the third quarter (Table D-1).

As an additional check, comparisons between gross alpha concentrations measured at Boundary and Distant locations were made on a weekly basis. The Mann-Whitney U test was used to compare the Boundary and Distant data because it is the most powerful nonparametric alternative to the t-test for independent samples. INL sample results were not included in this analysis because the onsite data, collected at only three locations, are not representative of the entire INL and would not aid in determining offsite impacts. The gross alpha concentrations measured at Distant locations was statistically greater than those measured at Boundary locations during the week ending July 12 (Table D-2). Because the Distant locations were higher, an INL-related cause for the statistical difference is not implicated. In a second case, the gross alpha concentrations measured at Boundary locations was statistically greater than those measured at Distant locations during the week ending August 30. In this case, no particular distribution was seen in the data to indicate an INL Site-related cause, and it is more likely due to random variability in the data.

Gross beta results are presented in Table C-1. Gross beta concentrations in air for INL, Boundary, and Distant locations for the third quarter of 2006 are shown in Figure 7. The data were tested and found to be neither normally nor log-normally distributed. Box and whiskers plots were used for presentation of the data. Outliers and extreme values were retained in subsequent statistical analyses because they are within the range of measurements made in the past five years, and because these values could not be attributed to mistakes in collection, analysis, or reporting procedures. As in the case of alpha activity, the quarterly data for each group appear to be similar and were determined using the Kruskal-Wallace test to be statistically the same (Table D-1).

Monthly median gross beta concentrations in air for each sampling group are shown in Figures 8 – 10. Statistical data are presented in Table D-1. There were no statistical differences in gross beta between groups for any month during the quarter (Table D-1).

Comparison of weekly Boundary and Distant data sets, using the Mann Whitney U test, only showed no statistical differences between Boundary and Distant measurements during the third quarter of 2006 (Table D-2).

Iodine-131 was not detected in any of the charcoal cartridge batches collected during the third quarter of 2006. Weekly ^{131}I results for each location are listed in Table C-2 of Appendix C. Gamma spectrographic analysis is also done with the ^{131}I analysis.

Weekly filters for the third quarter of 2006 were composited by location. All samples were analyzed for gamma-emitting radionuclides, including ^{137}Cs. Composites were also analyzed for ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. All valid results for composite filter samples are shown in Table C-3, Appendix C. There were some additional results for alpha-emitting radionuclides that were reported by the laboratory; however, they were determined to be invalid due to possible laboratory error. The error has since been corrected.

Cesium-137, a man-made gamma-emitting radionuclide, was detected in samples composited from the distant locations of Craters of the Moon, Idaho Falls, and the onsite location of Van Buren Gate. Recounts of the samples confirmed the detections in two of the three samples, collected at Craters of the Moon and Van Buren Gate. These results were well below the DOE Derived Concentration Guide of 4×10^{-10} μCi/mL and within historical measurements. They are most likely due to the presence of ^{137}Cs in the environment from global fallout derived from past nuclear weapons testing.

None of the composite samples had valid, detectable concentrations of ^{90}Sr, ^{241}Am or isotopes of plutonium.

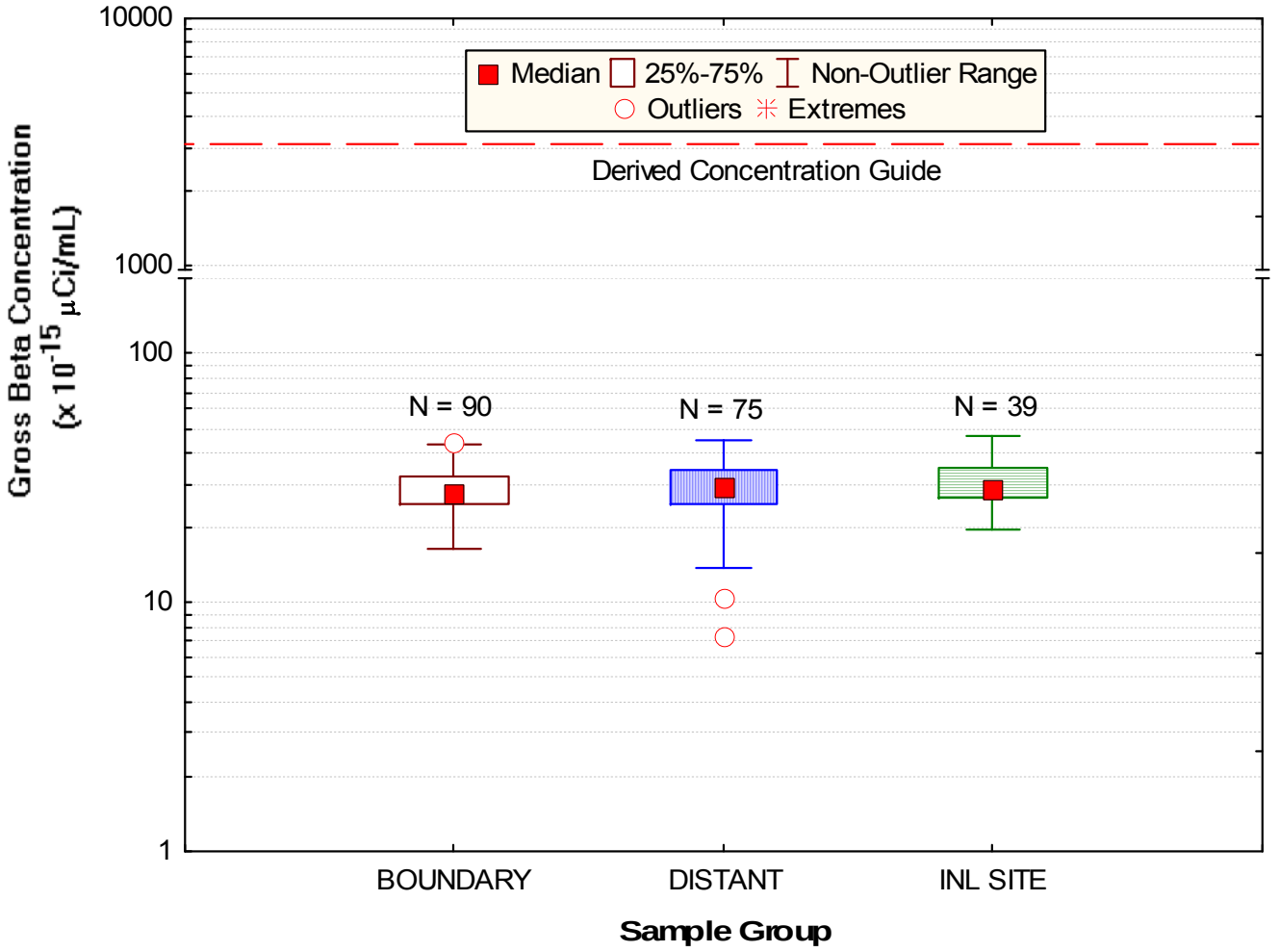


Figure 7. **Gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations for the third quarter of 2006.**

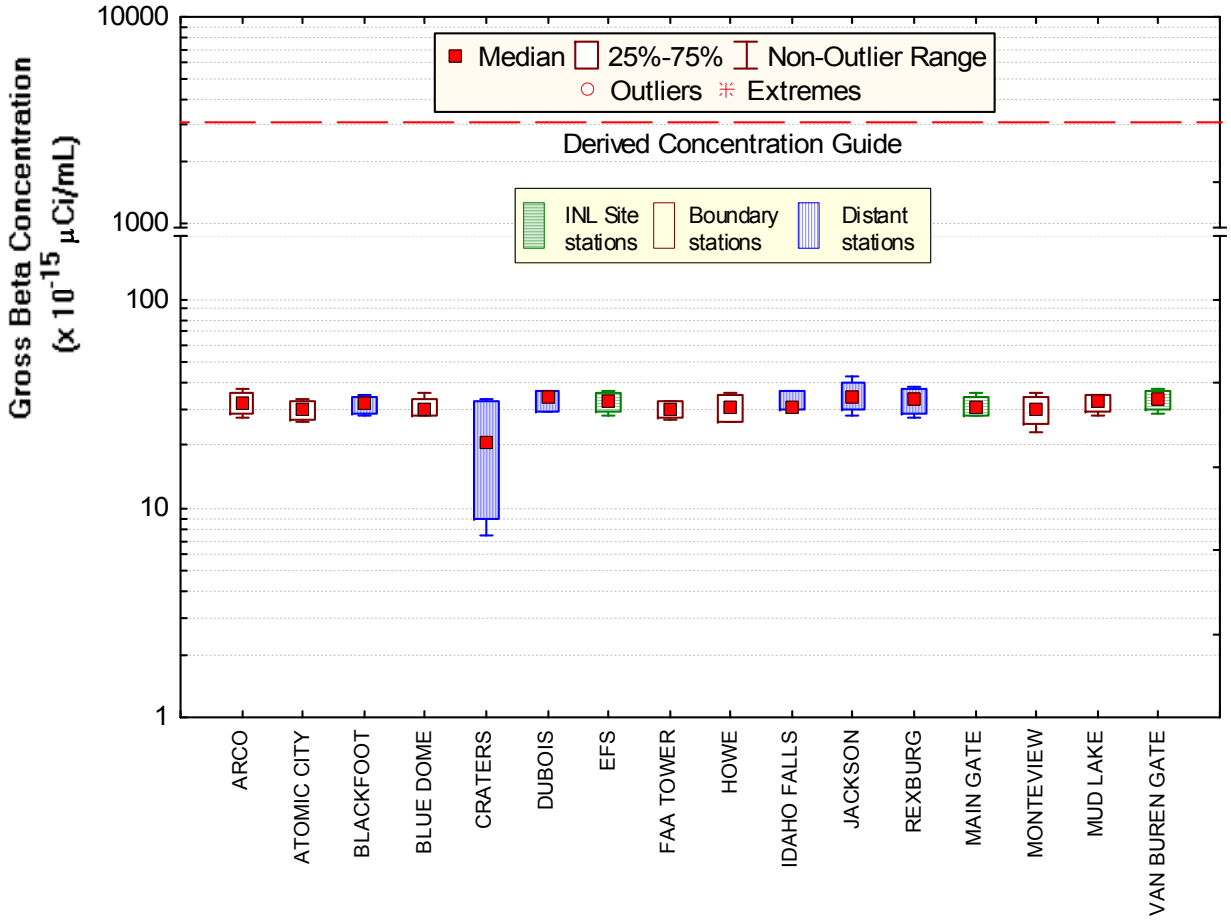


Figure 8. **July 2006 gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations.** Number of samples (N) = 4 at each location except Blue Dome where N = 3.

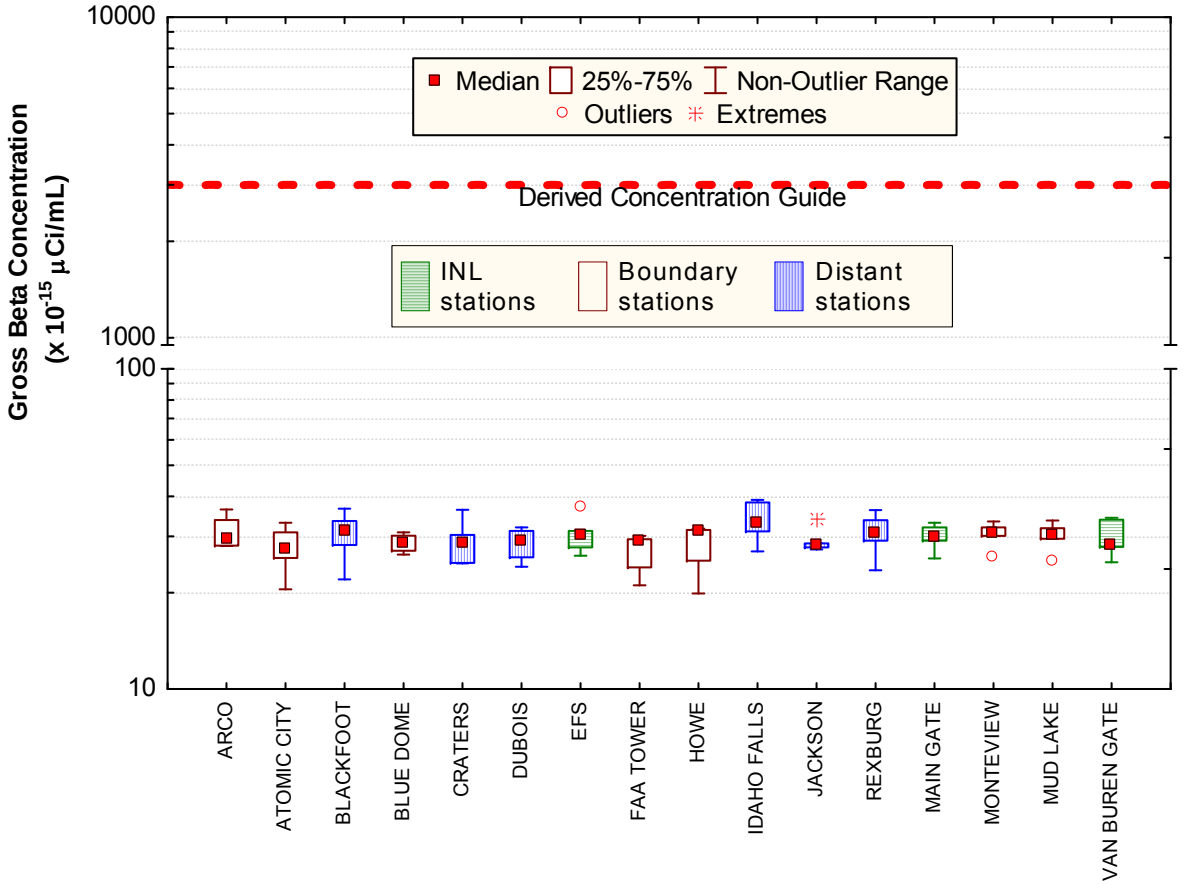


Figure 9. **August 2006 gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations.** Number of samples (N) = 5 at each location except Arco and Blue Dome where N = 4.

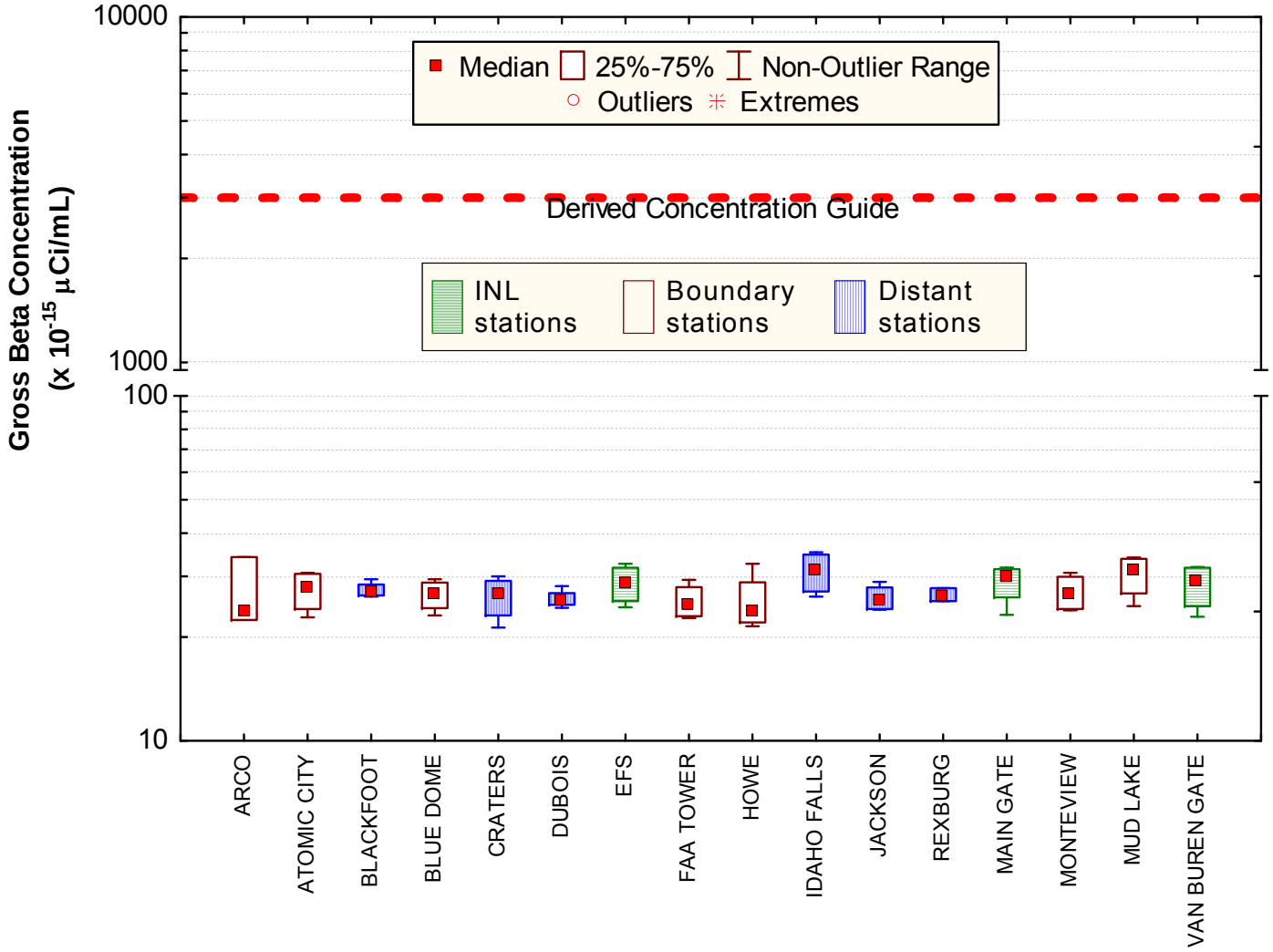


Figure 10. **September 2006 gross beta concentrations in air at ESER Program INL, Boundary, and Distant locations.** Number of samples (N) = 4 at each location, except Arco where N = 3.

ATMOSPHERIC MOISTURE SAMPLING

Twenty-four atmospheric moisture samples were obtained during the third quarter of 2006 from Atomic City, Blackfoot CMS, Idaho Falls, and Rexburg CMS. Atmospheric moisture is collected by pulling air through a column of absorbent material (molecular sieve material) to absorb water vapor. The water is then extracted from the absorbent material by heat distillation. The resulting water samples are then analyzed for tritium using liquid scintillation.

Nine samples exceeded the 3s uncertainty level for tritium—three from Atomic City, three from Blackfoot, one from Idaho Falls, and two from Rexburg. All samples with detectable tritium were well below the DOE DCG for tritium in air of 1×10^{-7} μCi/mL (3.7×10^{-3} Bq/mL), ranging from $(6.6 \pm 1.7) \times 10^{-13}$ $\mu Ci/mL_{air}$ ($[24.4 \pm 6.4] \times 10^{-9}$ Bq/mL) at Atomic City in September to $(10.5 \pm 2.4) \times 10^{-13}$ $\mu Ci/mL_{air}$ ($[38.7 \pm 8.8] \times 10^{-9}$ Bq/mL), at Blackfoot in August. All results are shown in Table C-4, Appendix C.

PM_{10} AIR SAMPLING

The EPA began using a standard for concentrations of airborne particulate matter (PM) less than 10 micrometers in diameter (PM_{10}) in 1987 (40 CFR 50.6 [CFR 2006]). Particles of this size can be inhaled deep into the lungs and are considered to be responsible for most of the adverse health effects associated with airborne particulate pollution. The air quality standards for these particulates are an annual average of 50 $\mu g/m^3$, with a maximum 24-hour concentration of 150 $\mu g/m^3$.

The ESER Program operates three PM_{10} particulate samplers, one each at the Rexburg CMS and Blackfoot CMS, and one in Atomic City. Sampling of PM_{10} is informational only as no chemical analyses are conducted for contaminants. A twenty-four hour sampling period is scheduled to run once every six days. The maximum 24-hour particulate concentration was 66.1 $\mu g/m^3$ on September 7, 2006, at Rexburg. The average, maximum, and minimum results of the 24-hour samples are shown are shown in Table 1. Results for all PM_{10} samples are listed in Table C-5, Appendix C.

Table 1. Summary of 24-hour PM_{10} values.

	Concentration[a]		
Location	**Minimum**	**Maximum**	**Average**
Atomic City	4.4	65.8	24.1
Blackfoot, CMS	7.8	50.1	22.3
Rexburg, CMS	12.6	66.1	29.5

a. All concentrations are in ($\mu g/m^3$).

4. WATER SAMPLING

The ESER program samples precipitation, surface water, and drinking water. Monthly composite precipitation samples are collected from Idaho Falls and the Central Facilities Area (CFA) on the INL. Weekly precipitation samples are collected from the Experimental Field Station (EFS) on the INL. Surface and/or drinking water are sampled twice each year at 19 locations around the INL. This occurs during the second and fourth quarters.

PRECIPITATION SAMPLING

Precipitation samples are gathered when sufficient precipitation occurs to allow for the collection of the minimum sample volume of approximately 20 mL. Samples are taken of monthly composites from Idaho Falls and CFA, and weekly from the EFS. Precipitation samples are analyzed for tritium. Storm events in the third quarter of 2006 produced sufficient precipitation to yield six samples – one from Idaho Falls, three from CFA, and two weekly samples from the EFS.

Tritium was measured above the 3s value in two of the samples collected during the third quarter 2006 at CFA and EFS. Low levels of tritium exist in the environment at all times as a result of cosmic ray reactions with water molecules in the upper atmosphere. The EPA's RadNet program collects precipitation samples from across the United States. From 1978 to 2001 tritium measured in those samples ranged from -2.00 to 7.38×10^6 pCi/L (-7.4 to 2.7×10^4 Bq/L) (EPA 2006). Tritium detected in third quarter ESER samples were within this range, with a maximum of 219 ± 31.4 pCi/L (8.1 ± 1.2 Bq/L) at Idaho Falls. Data for all third quarter 2006 precipitation samples collected by the ESER Program are listed in Table C-6 (Appendix C).

5. AGRICULTURAL PRODUCT AND WILDLIFE SAMPLING

Another potential pathway for contaminants to reach humans is through the food chain. The ESER Program samples multiple agricultural products and game animals from around the INL and Southeast Idaho. Specifically, milk, wheat, potatoes, garden lettuce, sheep, big game, waterfowl, and marmots are sampled. Milk is sampled throughout the year and large game animals are sampled whenever available. Sheep are sampled during the second quarter. Lettuce and wheat are sampled during the third quarter, while potatoes are collected during the fourth quarter. See Table A-1, Appendix A, for more details on agricultural product and wildlife sampling. This section discusses results from milk, lettuce, wheat, large game, and soil sampled during the third quarter of 2006.

MILK SAMPLING

Milk samples were collected weekly in Idaho Falls at Reed's Dairy and monthly at eight other locations around the INL (Figure 11) during the third quarter of 2006. All samples were analyzed for gamma emitting radionuclides. Samples are analyzed for ^{90}Sr and tritium during the second and fourth quarters.

Iodine-131 (^{131}I) was not detected in any milk sample during the third quarter. Cesium-137 was reported in one of the weekly Idaho Falls samples near the detection limit. No ^{137}Cs was detected when the sample was recounted. Data for ^{131}I and ^{137}Cs in milk samples are listed in Appendix C, Table C-7.

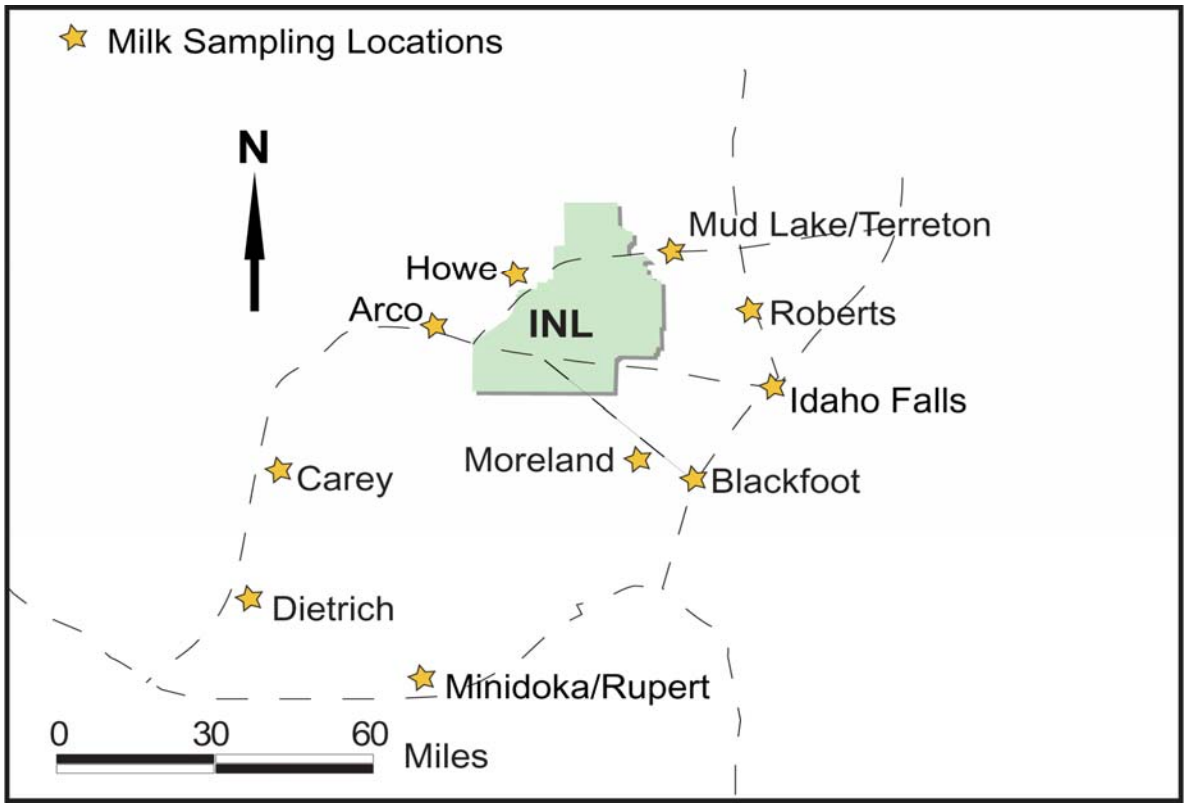


Figure 11. ESER Program milk sampling locations.

LETTUCE SAMPLING

In 2004 the ESER Program tested two prototype self-contained lettuce planters at the sampling locations in Atomic City and at the EFS on the INL. These locations were relatively remote and had no access to water, requiring that a self-watering system be developed. This prototype method allows for the placement and collection of lettuce at areas previously unavailable to the public (i.e., on the INL). The planters are set out in the spring with the lettuce grown from seed. This new method also allows for the accumulation of deposited radionuclides on the plant surface throughout the growth cycle.

Six lettuce samples and one duplicate sample were collected from prototype planters. The lettuce crop failed in the planter located at the EFS in 2006. Each sample was analyzed for gamma-emitting radionuclides and ^{90}Sr. No gamma results were measured above the 3s uncertainty value. Strontium-90 was reported in all samples except the Federal Aviation Administration (FAA) Tower. The quantities detected are consistent with those found in previous years, which are attributed to uptake of soil with residual ^{137}Cs and ^{90}Sr from nuclear weapons testing that took place between 1945 and 1980.

Data for ^{137}Cs and ^{90}Sr in all lettuce samples taken during the third quarter are listed in Table C-8 (Appendix C).

WHEAT SAMPLING

A total of 12 wheat samples (including one duplicate) were collected from local grain growers. All samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. Strontium-90 was positively detected in one wheat sample, collected from Idaho Falls, at a concentration well within historical measurements. Data for ^{137}Cs and ^{90}Sr in all wheat samples taken during the third quarter are listed in Appendix C, Table C-9.

LARGE GAME ANIMAL SAMPLING

No large game animals were available for sampling during the third quarter of 2006.

SOIL SAMPLING

Thirteen soil samples (including one duplicate at Carey) were collected at boundary and offsite locations. All samples were analyzed for gamma-emitting radionuclides, ^{241}Am. ^{238}Pu, $^{239/240}$Pu, and ^{90}Sr (Tables C-10 and C-11). Cesium-137 was detected in all samples except one (FAA Tower) at concentrations consistent with historical measurements and is most likely present from past atmospheric nuclear weapons testing fallout. Similarly ^{90}Sr, another fallout radionuclide, was detected in all soil samples at levels within historical measurements.

Plutonium-238 was detected in one sample collected at Blackfoot at a concentration about three times higher than the maximum historic measurement. Americium-241 was also detected one sample (Carey) at a level about three times higher than the maximum historic measurement. The fact that the soil samples were collected offsite and, in the case of ^{241}Am was not detected in a duplicate sample, indicate that the source(s) of these radionuclides is most likely not the INL and is probably environmental in origin.

6. QUALITY ASSURANCE

The ESER Quality Assurance Program consists of five ongoing tasks which measure:

1. method uncertainty;
2. data completeness;
3. data accuracy, using spike and laboratory control samples;
4. data precision, using split samples, duplicate samples, and recounts; and
5. presence of contamination in samples, using blanks.

The following discussion briefly summarizes the results of the quality assurance program for the period from July 1 to September 30, 2006.

METHOD UNCERTAINTY

The Quality Assurance Project Plan (QAPP) establishes data quality and method quality objectives for the ESER surveillance program (Stoller 2002). Since the primary concern is with detection, the lower bound for the method uncertainty is set at zero. The upper bound is defined by the ESER program as the maximum concentration for the range of data over the past ten years, excepting those values determined to be extremes using box plots generated by a statistical data program. Each individual result is checked for acceptance on the basis of the result, whether it is below the lower limit (i.e., a negative value), greater than the upper limit, or between the lower and upper limit (the most common occurrence). The calculated method uncertainty is then compared to the 1s measured uncertainty. A sample is deemed acceptable when the measured 1s uncertainty is less than the calculated uncertainty. The upper bound values were recently re-evaluated and revised. Preliminary results indicate that more calculated method uncertainties for detected results were acceptable.

DATA COMPLETENESS

The Quality Assurance Project Plan (QAPP) specifies a 98 percent completeness goal for all regularly scheduled sample types (Stoller 2004). Data completeness for sample collection and delivery was 100 percent during the third quarter for all sample types with these exceptions: a number of precipitation samples were not collected due to lack of precipitation and one of the lettuce samples failed to grow in the portable lettuce gardens.

Three air samples were determined to invalid due to insufficient volume collected because of equipment failure or electrical work (two from Arco and one from Blue Dome). In addition, one air sample was invalidated because the gooseneck assembly holding the sampler head was broken and found on the ground at sample collection time. Another filter was lost when the pump malfunctioned and blew the paper filter out of the head. The completeness of air filter data is thus considered to be 98.1 percent.

No samples were lost in analysis during the third quarter.

DATA ACCURACY

Accuracy is a measure of the degree to which a measured value agrees with the "true" value for a given parameter; accuracy includes elements of both bias and precision.

Spike Samples Submitted with Field Samples

During the third quarter of 2006, spikes (samples prepared with known amounts of radionuclides) of the following types were obtained and submitted:

- Milk spike analyzed for tritium by ISU.
- Air filter spike analyzed for actinides by Teledyne Brown.

Tritium in milk and plutonium-238 in air were within specifications. Although the Americium-241 result for the air filter spike was within about 6 percent of the known value, the result was considered out of specification because of a low yield and a high uncertainty value.

Internal Laboratory Spikes

The Idaho State University Environmental Assessment Laboratory uses NIST standards to prepare spiked water samples and uses commercially prepared calibration standards as NIST-traceable spiked samples. ISU considers a performance to be acceptable if results pass either the ±20 percent test specified by the ESER program or the three-sigma test described in the data precision section. A variety of checks are made each quarter on different geometries.

During the third quarter of 2006, seven analyses were conducted on NIST-traceable standards for gamma-emitting radionuclides. Geometries tested included low-volume air filter composites, single charcoal cartridge screening, 10-charcoal cartridge screening and 500 ml 0.8 g/cc samples. A total of 28 analytical results were generated. All of the results were within the ±20 percent range, with the exception of one result for Cobalt-57. This radionuclide had decayed for approximately 10 half-lives, which may have contributed to the result outside the ±20 percent range. The sample was within the three-sigma test criterion.

Water samples spiked with tritium received six analyses during the quarterly reporting period. All were well within the ±20 percent criterion, generally -4 percent to -5 percent. Gross beta spikes analyzed in the third quarter were within 20 percent of the expected values; three of four gross alpha spikes were within 20 percent; the one sample outside this range was within the 3σ criterion.

Severn-Trent analyzed a laboratory control sample (LCS) with each batch of samples submitted by the ESER. During the third quarter this consisted of strontium-90 in wheat.

Media	Analyte	QAPP Accuracy	LCS Result	Within Criterion?
Air	Strontium-90	±10 percent	+4.1 percent	Yes
Air	Americium-241	±10 percent	-42.4 percent	No
Air	Plutonium-239/240	±10 percent	-12.9 percent	No
Wheat	Strontium-90	±20 percent	+14.3 percent	Yes

DATA PRECISION

Data precision is a measure of the variability associated with a measurement system. Precision is measured using duplicate samples, split samples, and recounts. Data precision is

measured using duplicate samples, split samples, and recounts. The Quality Assurance Project Plan specifies that sample results should agree within ±20 percent or 3σ, whichever is greater. For environmental samples at levels that are within the normal range found by the ESER, the 3 standard deviation criterion is the one that applies in nearly all cases. The standard deviation criterion is considered to be met if the values of the duplicate samples differ by less than the root mean square of three standard deviations of each sample result. Mathematically, this is expressed as:

$|X-Y| < 3\ (\mathrm{sqrt}(\sigma_x^2 + \sigma_y^2))$, where:

X is the result of the regular sample

Y is the result of the duplicate sample

σ_x is the uncertainty of the regular sample

σ_y is the uncertainty of the duplicate sample

Another measure of duplicate sample results is the relative percent difference. This value is the difference in the two results divided by the mean of the two results. The following sections of this report first check the sample results using the 3 standard deviation criterion. If this criterion is not met, the results are then listed for the relative percent difference.

Field Duplicate Samples

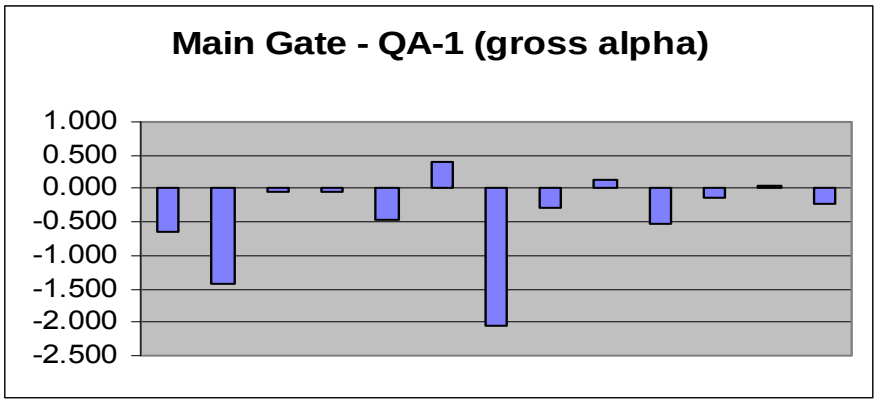
Duplicate milk samples were collected from Blackfoot and Carey on September 6 and analyzed for gamma-emitting radionuclides. All results were within the 3σ criteria.

Duplicate lettuce samples were obtained from Howe and duplicate wheat samples were collected from Menan. These were analyzed for gamma-emitting radionuclides and ^{90}Sr. All results were within the 3σ criteria, with the exception of naturally-occurring Potassium-40 in lettuce.

Duplicate air samplers are operated at two locations adjacent to regular air samplers. In the third quarter of 2006 these samplers, designated as QA-1 and QA-2, were in operation at the INL Main Gate and Howe, respectively. Particulate filters receive the standard analysis for gross alpha and gross beta; charcoal cartridges are analyzed specifically for iodine-131. All gross alpha and gross beta results for the co-located samplers met the acceptability criteria, with the exception of two weeks when the pump on one sampler did not run the entire week. Charcoal cartridge results are difficult to present because cartridges are counted in batches of ten.

Composite air samples from the two QA samplers were submitted for analysis at the end of the third quarter for gamma spectrometry at the EAL and for ^{90}Sr and transuranics at Teledyne Brown. The ^{90}Sr result for the duplicate air samplers was found to be outside the 3σ criterion.

A comparison of duplicate results can also show bias in the sampling system. For example, if one set of results is consistently lower or higher than the other one might suspect that this bias was due to a leak in the system or variations in the calibration of the flow meter. Figures 12 and 13 show the difference in results (Main sampler - QA duplicate sampler) over time. The figures show that the bias is small and not consistent in one direction, indicating that there is no obvious bias in the duplicate sampling systems in these cases.



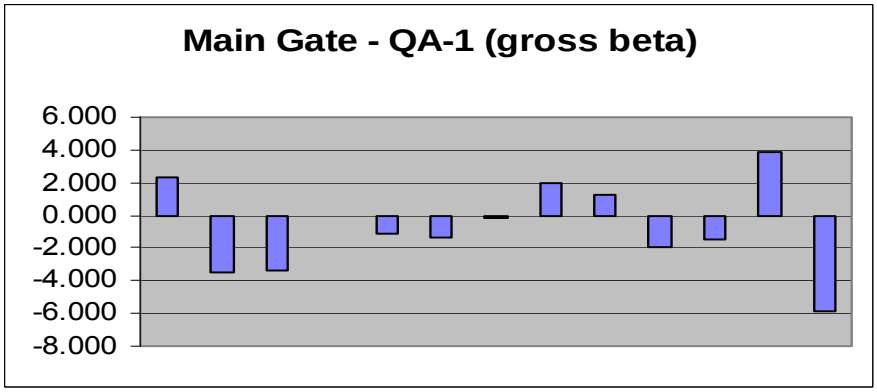
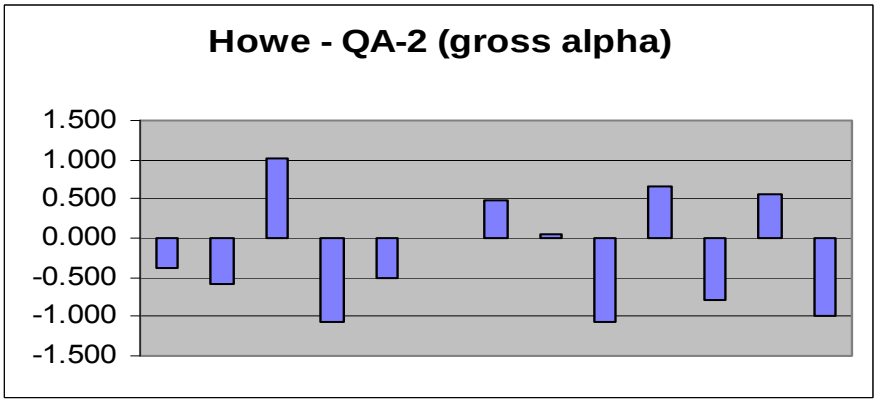


Figure 12. Difference in QA-1/Main Gate gross alpha and gross beta activities.



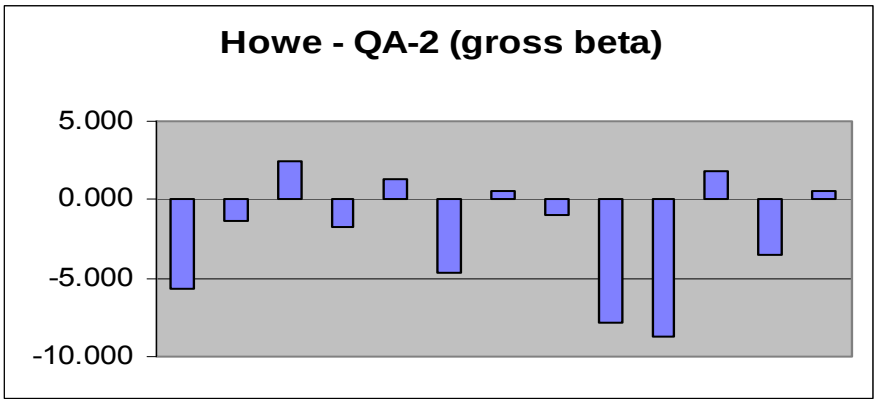


Figure 13. Difference in QA-2/Howe gross alpha and gross beta activities.

Lab Split Samples

The EAL splits and analyzes a number of milk, precipitation, and atmospheric moisture samples each quarter. The laboratory tests each result using both the ±20 percent criterion and the 3s criterion, although it considers the former test meaningless for analyses producing fewer than 15 total counts and questionable even where counts are on the order of 100. The latter criterion is applied in nearly all cases at the levels seen in environmental samples analyzed for the ESER program. Results of the EAL split sample analyses met the criteria for acceptance during the third quarter 2006.

Sample Recounts

The ISU EAL recounts a number of samples of each media type. The lab tests each recount using both the 20 percent criterion and the 3σ criterion, subject to the limitations described in the previous section. For the third quarter reporting period, all 143 recounts met the criteria for acceptance.

BLANKS

Field blanks

The ESER program submits field blanks along with the regular samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. The current program includes the use of two field blanks, designated as Blank A and Blank B, that each accompanies one of the air filter routes. Quarterly composites of the blanks are also submitted. After gamma spectrometry analysis, one of the blanks is analyzed for Sr-90 and the other for transuranics. Blanks are also submitted for milk and some other sample types.

The Quality Assurance Project Plan does not specify requirements for blank performance, but ideally the result should be within ±2σ of zero and preferably within ±1σ of zero on most analyses. It would be expected, based on counting statistics for a sample that was truly a blank (i.e., the true value of the analyte was zero), that 68.3 percent of analyses would fall within one standard deviation, 95.5 percent would fall within two standard deviations, and 99.7 percent would fall within three standard deviations. In the third quarter, all results were within the 3σ significance level except for two gross alpha blanks and one gross beta blank.

Reagent Blanks

The Environmental Assessment Laboratory prepares and analyzes reagent blanks to help determine if the analysis will yield a zero result when no activity is present. ISU considers the result within specification if the concentration is less than the minimum detectable concentration (MDC) for the analysis. One such blank was analyzed for tritium in the third quarter for milk. The blank was below the MDC for the analysis and between two and three standard deviations.

Severn-Trent analyzes a blank with each set of results. The third quarter blank was less than three standard deviations of zero for strontium-90 in wheat.

Teledyne Brown also analyzes a blank with each set of results. All blanks for third quarter samples met Teledyne Brown's acceptance limits.

7. REFERENCES

Bartholomay, R.C., Knobel, L.L., and Rousseau, J.P., 2003, *Field Methods and Quality Plan for Quality-of-Water Activities, U.S. Geological Survey, Idaho National Engineering and Environmental Laboratory, Idaho*, DOE/ID-22182, January 2003.

Code of Federal Regulations (CFR), 2006, 40 CFR 50.6, "National Primary and Secondary Ambient Air Quality Standards for Particulate Matter," Code of Federal Regulations, Office of the Federal Register, 2006.

Calder, W.A. III and E.J. Braun, 1983, "Scaling of Osmotic Regulation in Mammals and Birds," *American Journal of Physiology 244:R601-R606.*

Currie, L.A., 1984, *Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements*, NUREG/CR-4007, U.S. Nuclear Regulatory Commission, Washington, D.C., September 1984.

DOE, 2003, "Environmental Management System," U.S. Department of Energy Order 450.1, January 2003.

DOE, 1998, "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 5400.1, January 1993.

EPA, 2006, RadNet—Tracking Environmental Radiation Nationwide, Web-page: http://www.epa.gov/narel/radnet/

Halford, D.K., O.D. Markham, and G.C. White, 1983, "Biological Elimination Rates of Radioisotopes by Mallards Contaminated at a Liquid Radioactive Waste Disposal Area," *Health Physics 45(3), September 1983.*

Stoller, 2002, *Quality Assurance Project Plan for the INEEL Offsite Environmental Surveillance Program*, Environmental Surveillance, Education and Research Program, October, 2002.

Twinning, B.V, and Rattray, G., 2003, *Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman Area, Idaho, 2001*, DOE/ID-22185, April 2003.

United Nations, 2000, *Sources and Effects of Ionizing Radiation*, United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes, United Nations, New York, 2000, Vol. 1.

Warren, R.W., S.J. Majors, and R.C. Morris, 2001, *Waterfowl Uptake of Radionuclides from the TRA Evaporation Ponds and Potential Dose to Humans Consuming Them*, Stoller-ESER-01-40, October 2001.

APPENDIX A

SUMMARY OF SAMPLING SCHEDULE

PAGE INTENTIONALLY LEFT BLANK

Table A-1. Summary of the ESER Program's Sampling Schedule

Sample Type Analysis	Collection Frequency	LOCATIONS		
		Distant	Boundary	INL
AIR SAMPLING				
LOW-VOLUME AIR				
Gross Alpha, Gross Beta, ^{131}I	weekly	Blackfoot, Craters of the Moon, Dubois, Idaho Falls, Jackson WY, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Blue Dome	Main Gate, EFS, Van Buren
Gamma Spec	quarterly	Blackfoot, Craters of the Moon, Dubois, Idaho Falls, Jackson WY, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, Blue Dome	Main Gate, EFS, Van Buren
^{90}Sr, Transuranics	quarterly	Rotating schedule	Rotating schedule	Rotating schedule
ATMOSPHERIC MOISTURE				
Tritium	4 to 13 weeks	Blackfoot, Idaho Falls, Rexburg	Atomic City	None
PRECIPITATION				
Tritium	monthly	Idaho Falls	None	CFA
Tritium	weekly	None	None	EFS
PM-10				
Particulate Mass	every 6th day	Rexburg, Blackfoot	Atomic City	None
WATER SAMPLING				
SURFACE WATER				
Gross Alpha, Gross Beta, ^{3}H	semi-annually	Twin Falls, Buhl, Hagerman, Idaho Falls, Bliss	None	None
DRINKING WATER				
Gross Alpha, Gross Beta, ^{3}H	semi-annually	Aberdeen, Carey, Idaho Falls, Fort Hall, Minidoka, Moreland, Roberts, Shoshone, Tabor	Arco, Atomic City, Howe, Monteview, Mud Lake	None
ENVIRONMENTAL RADIATION SAMPLING				
TLDs				
Gamma Radiation	semiannual	Aberdeen, Blackfoot, Craters of the Moon, Idaho Falls, Minidoka, Jackson WY, Rexburg, Roberts	Arco, Atomic City, Howe, Monteview, Mud Lake, Birch Creek	None
SOIL SAMPLING				
SOIL				
Gamma Spec, ^{90}Sr, Transuranics	biennially	Carey, Crystal Ice Caves (Aberdeen), Blackfoot, St. Anthony	Butte City, Monteview, Atomic City, FAA Tower, Howe, Mud Lake (2), Birch Creek	None

Table A-1. Summary of the ESER Program's Sampling Schedule (continued)

Sample Type Analysis	Collection Frequency	LOCATIONS		
		Distant	Boundary	INL
FOODSTUFF SAMPLING				
MILK				
Gamma Spec (^{131}I)	weekly	Idaho Falls	None	None
Gamma Spec (^{131}I)	monthly	Blackfoot, Carey, Dietrich, Minidoka, Roberts, Moreland	Howe, Terreton, Arco	None
Tritium, ^{90}Sr	Semi-annually	Blackfoot, Carey, Dietrich, Idaho Falls, Minidoka, Roberts, Moreland	Howe, Terreton, Arco	None
POTATOES				
Gamma Spec, ^{90}Sr	annually	Blackfoot, Idaho Falls, Rupert, occasional samples across the U.S.	Arco, Mud Lake	None
WHEAT				
Gamma Spec, ^{90}Sr	annually	Am. Falls, Blackfoot, Dietrich, Idaho Falls, Minidoka, Carey	Arco, Monteview, Mud Lake, Tabor, Terreton	None
LETTUCE				
Gamma Spec, ^{90}Sr	annually	Blackfoot, Carey, Idaho Falls, Pocatello	Arco, Atomic City, Howe, Mud Lake	None
BIG GAME				
Gamma Spec	varies	Occasional samples across the U.S.	Public Highways	INL roads
SHEEP				
Gamma Spec	annually	Blackfoot or Dubois,	None	N. INL (Circular Butte), S. INL (Tractor Flats)
WATERFOWL				
Gamma Spec, ^{90}Sr, Transuranics	annually	Varies among: Heise, Fort Hall, Mud Lake and Market Lake	None	Waste disposal ponds
Marmots				
Gamma Spec	varies	Pocatello Zoo, Tie Canyon	None	RWMC

APPENDIX B

SUMMARY OF MDC'S AND DCG'S

PAGE INTENTIONALLY LEFT BLANK

Table B-1. Summary of Approximate Minimum Detectable Concentrations for Radiological Analyses Performed During Third Quarter 2006

Sample Type	Analysis	Approximate Minimum Detectable Concentration[a] (MDC)	Derived Concentration Guide[b] (DCG)
Air (particulate filter)[e]	Gross alpha[c]	4.9×10^{-16} µCi/mL	2×10^{-14} µCi/mL
	Gross beta[d]	1.6×10^{-15} µCi/mL	3×10^{-12} µCi/mL
	Specific gamma (^{137}Cs)	9.6×10^{-17} µCi/mL	4×10^{-10} µCi/mL
	^{238}Pu	2.3×10^{-18} µCi/mL	3×10^{-14} µCi/mL
	$^{239/240}$Pu	2.2×10^{-18} µCi/mL	2×10^{-14} µCi/mL
	^{241}Am	1.4×10^{-17} µCi/mL	2×10^{-14} µCi/mL
	^{90}Sr	4.4×10^{-17} µCi/mL	9×10^{-12} µCi/mL
Air (charcoal cartridge)[e]	^{131}I	7.3×10^{-16} µCi/mL	4×10^{-10} µCi/mL
Air (atmospheric moisture)[f]	^{3}H	1.1×10^{-13} µCi/mL$_{air}$	1×10^{-7} µCi/mL$_{air}$
Air (precipitation)	^{3}H	1.1×10^{-7} µCi/mL	2×10^{-3} µCi/mL
Milk	^{131}I	1.3 pCi/L	--
	^{137}Cs	1.9 pCi/L	--
Lettuce	^{137}Cs	270 pCi/kg	--
	^{90}Sr	0.02 pCi/g	--
Wheat	^{137}Cs	2.7 pCi/kg	--
	^{90}Sr	0.01 pCi/g	--
Game Animal Tissue[g]	^{137}Cs	0.87 pCi/kg	--
	^{131}I	18.9 pCi/kg	--
Soil	^{137}Cs	1.6 pCi/kg	--
	^{241}Am	21.7 pCi/kg	--
	^{238}Pu	42.5 pCi/kg	--
	$^{239/240}$Pu	21.3 pCi/kg	--
	^{90}Sr	39.7 pCi/kg	--

Sample Type	Analysis	Approximate Minimum Detectable Concentration[a] (MDC)	Derived Concentration Guide[b] (DCG)

a The MDC is an estimate of the concentration of radioactivity in a given sample type that can be identified with a 95 percent level of confidence and precision of plus or minus 100 percent under a specified set of typical laboratory measurement conditions.

b DCGs, set by the DOE, represent reference values for radiation exposure. They are based on a radiation dose of 100 mrem/yr for exposure through a particular exposure mode such as direct exposure, inhalation, or ingestion of water.

c The DCG for gross alpha is equivalent to the DCGs for ^{239,240}Pu and ^{241}Am.

d The DCG for gross beta is equivalent to the DCGs for ^{228}Ra.

e The approximate MDC is based on an average filtered air volume (pressure corrected) of 570 m^3/week.

f The approximate MDC is expressed for tritium (as tritiated water) in air, and is based on an average filtered air volume of 39 m^3, assuming an average sampling period of eight weeks.

g The approximate MDC assumes a sample size of 500 g.

APPENDIX C

SAMPLE ANALYSIS RESULTS

PAGE INTENTIONALLY LEFT BLANK

APPENDIX D

STATISTICAL ANALYSIS RESULTS

PAGE INTENTIONALLY LEFT BLANK

Table D-1. Results of the Kruskal-Wallace statistical test between INL, Boundary, and Distant sample groups by month.

Parameter	P[a]
Gross Alpha	
Quarter	0.61
July	0.44
August	0.92
September	0.76
Gross Beta	
Quarter	0.53
July	0.26
August	0.51
September	0.86

a. A 'p' value greater than 0.05 signifies no statistical difference between data groups.

Table D-2. Statistical difference in weekly gross alpha and gross beta concentrations measured at Boundary and Distant locations.

		Mann-Whitney U test
Parameter	**Week**	**P[a]**
Gross Alpha		
	July 5th	1.00
	July 12th	0.04
	July 19th	0.29
	July 26th	0.29
	August 2nd	0.20
	August 9th	0.48
	August 16th	0.67
	August 23rd	0.78
	August 30th	0.01
	September 6th	0.39
	September 13th	0.57
	September 20th	0.07
	September 27th	0.67
Gross Beta		
	July 5th	0.56
	July 12th	0.20
	July 19th	0.10
	July 26th	0.22
	August 2nd	0.52
	August 9th	0.48
	August 16th	0.25
	August 23rd	0.58
	August 30th	0.20
	September 6th	0.06
	September 13th	0.09
	September 20th	0.09
	September 27th	0.15

a. A 'p' value greater than 0.05 signifies no statistical difference between data groups.