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THE IDAHO NATIONAL ENGINEERING LABORATORY SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

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PREFACE^a

Every person living in the United States (or the world) is exposed to sources of ionizing radiation—radiant energy that produces ions as it passes through cells. There are three general types of radiation sources: those of natural origin unaffected by human activities, those of natural origin but enhanced by human activities, and those produced by human activities (manmade).

The first group includes terrestrial radiation from natural radiation sources in the ground, cosmic radiation from outer space, and radiation from radionuclides naturally present in the body. Exposures to natural sources may vary depending upon the geographical location and even the altitude at which a person resides. When such exposures are substantially higher than the average, they are considered to be elevated.

The second group includes a variety of natural sources that have been increased by human action. For example, radon exposures in a given home may be elevated because of natural radionuclides in the soil and rock on which the house is built; however, the radon exposures of occupants may be enhanced by characteristics of the home, such as extensive insulation and weatherizing. Another example is the increased exposure to cosmic radiation that airplane passengers receive when traveling at high altitudes.

The third group includes a variety of exposures from manmade materials and devices such as x-rays in medicine, radiopharmaceuticals in the diagnosis and treatment of disease, and consumer products containing minute quantities of radioactive materials. Exposures may also result from radioactive fallout from nuclear weapons testing, accidents at nuclear power plants, and other such episodic events caused by man's activities in the nuclear industry. Except for major nuclear accidents, such as the one that occurred at Chernobyl, exposures to workers and members of the public from activities at nuclear industries are very small compared to exposures from natural sources.

To verify that exposures resulting from operations at the Department of Energy (DOE) nuclear facilities have remained very small, each site at which nuclear activities are underway operates an environmental surveillance program to monitor the air, water and any other pathway where radionuclides from operations might conceivably reach workers or members of the public. The monitoring results are reported annually to the DOE-Headquarters (DOE-HQ) Environmental Compliance Division. This report presents data collected in 1989 for the routine environmental surveillance program conducted by the Radiological and Environmental Sciences Laboratory (RESL) of DOE and the U. S. Geological Survey (USGS) at the Idaho National Engineering Laboratory (INEL) Site. The report is prepared in accordance with the requirements in DOE Order 5400.1 and is not intended to cover the numerous special environmental research programs being conducted at the INEL by RESL and others.

a. Introductory information is paraphrased from the National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, September 1, 1987, p. 1.

COMPLIANCE SUMMARY

The INEL was placed on the National Priorities List during 1989 to facilitate cleanup and monitoring of contaminated areas at INEL, principally the Test Reactor Area Warm Waste Pond, the Radioactive Waste Management Complex, and the Test Area North injection well. DOE-ID, the State of Idaho, and EPA Region 10 have met to formulate a three-party Interagency Agreement (IAG), as required by CERCLA regulations and DOE guidance. Negotiations and planning toward finalizing the IAG in 1990 are continuing.

Approximately 360 Solid Waste Management Units (SWMUs) have been identified on the INEL and may require investigation and corrective action, in accordance with RCRA and CERCLA regulations. On July 10, 1987, DOE-ID entered into a Consent Order and Compliance Agreement (COCA) with the EPA and the U.S. Geological Survey to administer the cleanup of the SWMUs. The COCA required closure plans for 30 of these units designated as Land Disposal Units (LDUs), which were submitted to the EPA and the State of Idaho for approval subsequent to COCA implementation. Comments were received on several of the plans in the form of Notices of Deficiency. Twenty-six of the closure plans are being revised under an agreed upon schedule, two plans have been approved, and two are being developed under a separate schedule. It is anticipated that the COCA will be integrated into the IAG when it is finalized in 1990.

The EPA conducted an inspection of INEL facilities during June of 1989, which resulted in the issuance of a Notice of Noncompliance from the EPA during early February, 1990. The inspection identified 28 violations of the provisions of the hazardous waste or RCRA

regulations. Specifically, violations were identified pertaining to satellite accumulation, container storage, speculative accumulation, waste analysis, and storage requirements. DOE-ID responded to the Notice in writing within 20 days, as required, and has since participated in a settlement conference with the EPA on April 19, 1990. Most of the violations have been corrected, however, in some instances, because of the unique nature of some INEL facilities and operations, final resolutions are being negotiated with the EPA and the State of Idaho.

The EPA issued a Complaint and Notice for Opportunity for Negotiation concerning violations of the Toxic Substances Control Act (TSCA) observed during a September 1988 inspection of the INEL. The Complaint alleged that the INEL violated the record-keeping and use provisions of the PCB regulations in TSCA. The complaint was dated March, 27, 1989, and DOE-ID responded in writing on April 7, 1989 and later attended a settlement conference with the EPA on May 12, 1989. The violations identified in the Complaint have been corrected and a program is now in place to retire all remaining PCB and PCB-contaminated equipment on the INEL and to report to the EPA twice a year on the status of remaining equipment.

Several major processing facilities at the Idaho Chemical Processing Plant did not operate during most of 1989 because of scheduled maintenance and an evaluation of facility compliance with environmental requirements. Preparations are underway to replace or upgrade hazardous waste systems that are not in compliance with the double-containment requirements of RCRA.

ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

The results of the various monitoring programs for 1989 indicate that most radioactivity from the Idaho National Engineering Laboratory (INEL) operations could not be distinguished from worldwide fallout and natural radioactivity in the region surrounding the INEL Site. Although some radioactive materials were discharged during Site operations, concentrations and doses to the surrounding population were of no health consequence and were far less than State of Idaho and Federal health protection guidelines. This report describes the surveillance program, the collection of food-stuffs at the INEL boundary and distant offsite locations, and the collection of air and water samples at onsite locations and offsite boundary and distant locations. The report also compares and evaluates the sample results and discusses implications, if any. Significant environmental activities at the INEL during 1989, nonradioactive and radioactive effluent monitoring at the Site, and the U.S. Geological Survey (USGS) ground-water monitoring program are also summarized.

Investigation of gross beta measurements, which are used as a screening technique for air sampler filters, was done by making statistical comparisons between onsite or boundary location concentrations and the distant community group concentrations. In none of those comparisons in which a statistical difference was seen (9% of the total number) was there any evidence that gross beta concentrations were increased due to INEL operations. Gross beta concentrations also show trends for natural and manmade radionuclides.

Air samples were also analyzed for specific radionuclides. Some radionuclides were detected at offsite locations, but their presence was attributable to natural sources, worldwide fallout, or statistical variations rather than to Site operations. Strontium-90, detected in 7 of 28 onsite and offsite samples during 1989, may possibly be attributable to Site operations during the fourth quarter when it was detected at 4 onsite locations. The concentrations detected at all locations were well below the derived concentration guides for radiation protection. Americium-241 and Pu-239/240, detected onsite at the RWMC, were probably due to resuspended soil as both nuclides were detected on filters during quarters when there was no snow cover. The annual concentrations of both nuclides were well below the derived concentration guide.

Concentrations of tritium in air were seen in nearly 30% of the samples, but examination of the geographical distribution and Site operations information

provided no evidence that these concentrations were related to Site activities.

Less than 25% of all drinking water samples collected during 1989 contained detectable concentrations of gross alpha or gross beta activity, all near the minimum detectable concentration. Both gross alpha and gross beta concentrations were probably due to natural radioactivity or to statistical variation in the analyses. Annual averages for all onsite and offsite drinking water samples were below the Environmental Protection Agency (EPA) maximum contaminant level for community drinking water systems. No offsite water samples contained detectable tritium concentrations. Four onsite production (drinking water) wells contain measurable concentrations of tritium. An effective dose equivalent of 0.75 mrem/yr was estimated for INEL workers at CFA, the location with the highest tritium concentration in drinking water. Concentrations of volatile organic compounds measured in production wells in 1987, which were slightly above the EPA maximum contaminant levels (MCLs), were at levels lower than the MCLs during 1988 and 1989 after appropriate action was taken.

None of the milk samples contained detectable concentrations of I-131. Some milk, wheat, and lettuce samples contained small amounts of Sr-90. The presence of Sr-90 in food samples is probably due to its deposition on soil as a result of worldwide fallout. Low concentrations of Cs-137 were found in muscle and liver tissues of sheep sampled from onsite and boundary areas and are consistent with the deposition of worldwide fallout.

Offsite soil sampling results for 1988, which are reported this year, were within the ranges recorded at each location in the past years.

Ionizing radiation measured simultaneously at the Site boundary and distant locations showed only natural background levels.

For details on monitoring results, see the appropriate sections that summarize results of radioactive, nonradioactive, and ground-water monitoring programs.

A measurable amount of radioactivity, primarily in the form of noble gases and tritium, is released into the atmosphere annually from various plant facilities and is subsequently carried offsite. Upon reaching the Site boundary, this radioactivity is in such a low concentration that its effect on direct radiation levels cannot be

measured; but its potential contribution to offsite dose equivalents is nevertheless calculated.

The hypothetical maximum individual dose equivalent (specifically, the effective dose equivalent) was found to occur near Atomic City and was calculated to be 0.007 mrem (7×10^{-5} mSv) using the MESODIF air dispersion model. The calculation considered continuous submersion in and inhalation of radioactivity in air, ingestion of radioactivity in leafy vegetables, and exposure to radioactive particulates deposited on the ground surface at that location. This calculated dose equivalent is about 0.002% of the natural background radiation effective dose equivalent of approximately 350 mrem per year in this area. The AIRDOS-EPA and RADRISK codes were used for comparison with EPA radiation protection standards. (See the section entitled "Maximum Individual Dose—Airborne Emissions Pathway Only.") The maximum calculated dose to an individual by either of the methods is clearly in compliance with the applicable radiation protection standards.

The maximum potential population dose from submersion, ingestion, inhalation, and deposition to the

approximately 121,000 people residing within an 80-km (50-mi) radius from the center of the TRA-ICPP area of the INEL Site was estimated to be 0.04 person-rem (4×10^{-4} person-Sv) using the MESODIF air dispersion model. This population dose is about 0.00009% of the estimated 42,400 person-rem (424 person-Sv) population dose from natural background radioactivity. These calculations and their implications are discussed in the section "Assessment of Potential Radiation Dose to the Public."

Calculations indicate that the maximum potential 50-year dose commitment to an individual from ingestion of wild game animals is about 2% of the radiation protection standard for individuals at points of maximum probable exposure. A listing of applicable standards is given in the section "Environmental Standards, Regulations, and Permits." Due to the very small probability that an individual in the population would consume an animal containing significant amounts of radioactivity, the potential offsite population dose equivalent from ingestion of game animals would realistically be less than the population dose equivalent from the submersion, inhalation, ingestion, and deposition pathways.

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ACRONYMS

Acronym	Definition
ANL-W	Argonne National Laboratory—West
ARA	Auxiliary Reactor Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CFSGF	Coal-Fired Steam Generating Facility
DOE	U. S. Department of Energy
DOE-HQ	Department of Energy, Headquarters in Washington, D.C.
DOE-ID	Department of Energy, Idaho Operations Office
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor—I
EBR-II	Experimental Breeder Reactor—II
EFS	Experimental Field Station
EG&G	EG&G Idaho, Inc.
EMSL-LV	Environmental Monitoring Systems Laboratory in Las Vegas
EPA	U. S. Environmental Protection Agency
FPR	Fuel Processing Restoration
HEPA	High-Efficiency Particulate Air
IAG	Interagency Agreement
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
ISV	In-situ Vitrification
IWMIS	Industrial Waste Management Information System
LDR	Land Disposal Restrictions
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
NCRP	National Council on Radiation Protection and Measurements
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NRF	Naval Reactors Facility
PBF	Power Burst Facility
PCB	Poly-chlorinated Biphenyl
PREPP	Process Experimental Pilot Plant
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RFI	RCRA Facility Investigation
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System
SIS	Special Isotope Separation
SPERT-IV	Special Power Excursion Test Reactor No. 4
TAN	Test Area North
TCE	Trichloroethylene
TLD	Thermoluminescent dosimeter
TRA	Test Reactor Area
TSCA	Toxic Substances Control Act
USGS	U. S. Geological Survey
VVE	Vapor Vacuum Extraction
WEC	Westinghouse Electric Corporation
WINCO	Westinghouse Idaho Nuclear Company
WRRTF	Water Reactor Research Test Facility

Figure 1. INEL Site vicinity map.

THE IDAHO NATIONAL ENGINEERING LABORATORY SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

INTRODUCTION

The Idaho National Engineering Laboratory (INEL) of the Department of Energy (DOE) was established by the Federal Government in 1949 to conduct research and further the development of nuclear reactors and related equipment. Major DOE programs at the Site include test irradiation services, uranium recovery from highly enriched spent fuels, calcination of liquid radioactive waste solutions, light-water-cooled reactor safety testing and research, operation of research reactors, environmental restoration at the Site, and storage and surveillance of solid transuranic wastes. Major facilities at the INEL are operated by Argonne National Laboratory—West (ANL-W), EG&G Idaho, Inc. (EG&G), Rockwell-INEL, Westinghouse Electric Corporation (WEC), and Westinghouse Idaho Nuclear Company (WINCO).

The 2300-km² (890-mi²) INEL Site is located on the upper Snake River Plain in southeastern Idaho. The nearest INEL Site boundaries are 35 km (22 mi) west of Idaho Falls, 37 km (23 mi) northwest of Blackfoot, 71 km (44 mi) northwest of Pocatello, and 11 km (7 mi) east of Arco, Idaho (see Figure 1). With a population of about 1100, Arco is the largest boundary community in the area surrounding the Site. Approximately 121,000 people reside within a radius of 80 km

(50 mi) of the Site's operational center, but there are no residents within 16 km (10 mi) of that center.

Vegetation and wildlife on the Site are typical of those found in a cool, desert shrub biome. Figure 2 shows a part of the Site and its vegetation. In 1975, the INEL was the second area to be designated as one of the nation's six National Environmental Research Parks, where scientists from universities and from government and private agencies study environmental changes caused by man's activities and obtain data subsequently applied to making land-use decisions.

The surface of the plain is a combination of basalt (lava) outcrops and alluvial sedimentary deposits. There are no surface streams or rivers flowing from onsite to offsite locations, but the Snake River Plain aquifer lies beneath the plain. The Big and Little Lost Rivers and Birch Creek, which originate in mountains to the northwest, flow onto the Site and sink into its porous soils. Water from the aquifer and from surface streams and rivers of the Snake River Plain is used for drinking water and crop irrigation.

A more detailed description of the Site location, environment, and current major activities is given in Appendix A.

Figure 2. Typical vegetation on the INEL Site.

ENVIRONMENTAL PROGRAM INFORMATION

General Summary of the Environmental Surveillance Program

During normal operation of the reactors, the fuel reprocessing plant, and other facilities at the INEL, some materials are released into the environment. The environmental pathways by which radioactive and nonradioactive materials may be transported from the Site to nearby populations include passage directly through atmospheric transport or indirectly through soils, foodstuffs, or animals. Substances originating from Site operations have not, through 1989, been detected in the water of the Snake River Plain aquifer beyond the INEL southern boundary; thus, the aquifer is not presently a pathway to members of the public living near the Site.

The environmental surveillance program for the INEL and vicinity for 1989 included the collection and analysis of samples from potential exposure pathways. Three basic groups of samples were collected. Those collected within the INEL boundaries will be referred to as onsite samples. Samples collected outside, but near, the Site boundaries will be referred to as boundary samples or part of a group of offsite samples. Samples collected from locations considerably beyond the Site boundaries will be referred to as distant samples or part of the offsite group. With the exception of Craters of the Moon National Monument, the distant locations are sufficiently remote from the Site to ensure that detectable radioactivity is primarily due to natural background sources or sources other than INEL operations. The Craters of the Moon location is too distant to be considered a boundary location, but is close enough that radionuclides from Site operations are occasionally detected there at low concentrations.

Table I summarizes the RESL environmental surveillance program that is required by DOE Order 5400.1.¹ The radiological portion of the program is considerably more extensive than the nonradiological portion, which is appropriate for operations at INEL. As shown in Table I, air and ground water were routinely monitored for radioactivity at a number of onsite, boundary, and distant locations. Table II summarizes the USGS portion of the routine ground-water monitoring program for radiological and nonradiological substances. Concentrations of radionuclides were

measured in samples of milk, wheat, and lettuce from boundary and distant locations in 1989. Environmental radiation exposure rates (cumulative from November 1988 through October 1989) were measured at onsite, boundary, and distant locations. Soil samples were collected during 1988, but analytical results were not available at the time of the 1988 report and are, therefore, included this year.

Measurements at boundary and onsite locations are compared to measurements at distant locations to assess the impact of INEL operations on the environment. Concentrations of radioactive pollutants in the environment are compared to applicable standards and guides (see the section "Environmental Standards and Regulations") and to background and natural radioactivity. Most radioactive concentrations in this report are compared to the derived concentration guides given in DOE Order 5400.5.² Calculated doses are compared to DOE and U. S. Environmental Protection Agency (EPA) standards, and nonradioactive pollutants are compared to applicable EPA standards and guides.

In the text, a more detailed description of each routine program is given in a specific section followed by a summary of the results for 1989. Data summary tables are presented in Appendix B.

The section on "Quality Assurance" provides information on RESL's quality control and quality assurance activities while conducting its environmental surveillance program. Appendix C gives a brief discussion of the statistical methods used to analyze the data in this report.

Significant Environmental Activities

This section includes a summary of significant environmental activities at INEL during 1989 and a compliance self-assessment. Information on the current status (January-June 1990) of items mentioned in this section will be included in the "Compliance Self-Assessment January-June 1990" section in the attached cover letter. Results of studies of the fate and effect of pollutants from the Site may be found in the publications of individual INEL organizations (EG&G, WEC, WINCO, ANL-W, DOE-ID, and the USGS).

**TABLE I
RESL ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY**

Medium Sampled	Type of Analysis	Number of Location and Frequency		Minimum Detectable Concentration (MDC)
		Onsite	Offsite	
Air	Low-Volume Samplers:			
	Gross alpha	3 weekly	3 weekly	3×10^{-16} $\mu\text{Ci/mL}$
	Gross beta	12 weekly	11 weekly	8×10^{-15} $\mu\text{Ci/mL}$
	Specific gamma	12 quarterly	11 quarterly	1 to 10×10^{-15} $\mu\text{Ci/mL}$
	Pu	6 quarterly	4 quarterly	6×10^{-18} $\mu\text{Ci/mL}$
	Am	6 quarterly	4 quarterly	8×10^{-18} $\mu\text{Ci/mL}$
	Sr-90	2 quarterly	4 quarterly	1×10^{-16} $\mu\text{Ci/mL}$
	Particulate matter	12 quarterly	11 quarterly	10 $\mu\text{g/m}^3$
	High-Volume Samplers:			
	Gross gamma	2 daily	—	N/A ^a
	Specific gamma	2 monthly	—	1 to 10×10^{-16} $\mu\text{Ci/mL}$
	Kr-85 Sampler	1 biweekly	—	2×10^{-12} $\mu\text{Ci/mL}$
	Tritium Samplers:			
	H-3 as HTO	2 at 1 to 2/quarter	1 to 2/quarter	1×10^{-11} $\mu\text{Ci/mL}$
	TSP Sampler	1 weekly ^b	—	2 $\mu\text{g/m}^3$
Water	Drinking Water:			
	Gross alpha	26 monthly	13 semiannually ^c	3×10^{-9} $\mu\text{Ci/mL}$
	Gross beta	26 monthly	13 semiannually	4×10^{-9} $\mu\text{Ci/mL}$
	H-3 as HTO	26 monthly	13 semiannually	4×10^{-7} $\mu\text{Ci/mL}$
	Sr-90	2 monthly	—	5×10^{-10} $\mu\text{Ci/mL}$
	Surface Water Ponds:^d			
	Specific gamma	2 monthly	—	Varies ^e
	Sr-90	2 monthly	—	5×10^{-8} $\mu\text{Ci/mL}$
	H-3 as HTO	2 monthly	—	4×10^{-7} $\mu\text{Ci/mL}$
	I-129	1 quarterly	—	4×10^{-10} $\mu\text{Ci/mL}$
	U	1 composite ^f	—	1×10^{-4} $\mu\text{g/mL}$
	Am	1 composite ^f	—	5×10^{-11} $\mu\text{Ci/mL}$
	Pu	1 composite ^f	—	4×10^{-11} $\mu\text{Ci/mL}$
	pH	2 monthly	—	N/A
	Na ⁺ , Cl ⁻	2 monthly	—	5 mg/L
	Chromium (total)	1 quarterly	—	5×10^{-2} mg/L
Animal Tissues ^g	Beef—Muscle, Liver			
	Specific gamma	2 biennially	2 biennially	7×10^{-9} $\mu\text{Ci/g}$
	Pu-239/240	2 biennially	2 biennially	5×10^{-11} $\mu\text{Ci/g}$
	Am-241, Pu-238	2 biennially	2 biennially	1×10^{-10} $\mu\text{Ci/g}$
	Sheep—Muscle, Liver			
	Specific gamma	4 annually	2 annually	7×10^{-9} $\mu\text{Ci/g}$
	Game Animals—Muscle			
	Specific gamma	Varies annually ^h	—	7×10^{-9} $\mu\text{Ci/g}$
Foodstuffs	Milk:			
	I-131	None produced	1 weekly	1×10^{-9} $\mu\text{Ci/mL}$
	I-131	None produced	10 monthly	1×10^{-9} $\mu\text{Ci/mL}$
	Sr-90	None produced	10 annually	2×10^{-9} $\mu\text{Ci/mL}$
	H-3 as HTO	None produced	10 annually	4×10^{-7} $\mu\text{Ci/mL}$
	I-129	None produced	3 annually	3×10^{-10} $\mu\text{Ci/mL}$
	Wheat:			
	Specific gamma	None produced	10 annually	4×10^{-9} $\mu\text{Ci/mL}$
	Sr-90	None produced	10 annually	4×10^{-9} $\mu\text{Ci/mL}$
	Lettuce:			
	Specific gamma	None produced	8 annually	2×10^{-7} $\mu\text{Ci/mL}$
	Sr-90	None produced	8 annually	8×10^{-8} $\mu\text{Ci/mL}$
Soil	Specific gamma	Varies annually ⁱ	12 biennially	4×10^{-8} $\mu\text{Ci/mL}$
	Pu	Varies annually	12 biennially	2×10^{-9} $\mu\text{Ci/mL}$
	Am	Varies annually	12 biennially	3×10^{-9} $\mu\text{Ci/mL}$
	Sr-90	Varies annually	12 biennially	9×10^{-8} $\mu\text{Ci/mL}$
Direct Radiation Exposure	Thermoluminescent Dosimeters	135 semiannually	13 semiannually	5 mR
	Gamma Radiation Surveys	Varies annually ^j	—	N/A

a. Not applicable.

b. Sampler operates for 24 h every 6 d.

c. Two additional offsite drinking water samples and three surface water samples from springs in the Magic Valley area are split monthly with Idaho State University Environmental Monitoring Group.

d. TRA and ICPP infiltration ponds. No offsite ponds are monitored.

e. There is considerable variation in approximate MDC, depending on which nuclides are present in the sample.

f. Portions of three monthly samples are composited each quarter for these analyses.

g. "Onsite" animals grazed onsite for at least four weeks before being sampled. "Offsite" animals have never grazed onsite and serve as controls.

h. Only road-killed game animals are sampled onsite. No controls are generally collected except for specific ecological studies.

i. Onsite soil sampling is performed each year at different onsite facilities on a rotating 7-year schedule.

j. Surveys are performed each year at different onsite facilities on a rotating 3-year schedule.

TABLE II
USGS GROUND-WATER MONITORING PROGRAM SUMMARY

Radiological Monitoring:

Type of Analysis	Frequency of Analysis	Number of Samples	~Minimum Detectable Concentration (MDC) ($\mu\text{Ci/mL}$)
Gross alpha	Semiannually ^a	5	3×10^{-9}
Gross beta	Semiannually ^a	5	4×10^{-9}
Tritium ^b	Quarterly	48	4×10^{-7}
Tritium	Semiannually ^a	82	4×10^{-7}
Specific gamma	Quarterly	9	$1 \text{ to } 10 \times 10^{-8c}$
Specific gamma	Semiannually	17	$1 \text{ to } 10 \times 10^{-8}$
Specific gamma	Annually	26	$1 \text{ to } 10 \times 10^{-8}$
Sr-90	Quarterly	27	5×10^{-9}
Sr-90	Semiannually	26	5×10^{-9}
Am	Quarterly	4	5×10^{-11}
Am	Semiannually	4	5×10^{-11}
Pu	Quarterly	4	4×10^{-11}
Pu	Semiannually	4	4×10^{-11}
I-129	~5 years	20-35	6×10^{-11}

Nonradiological Monitoring:

Type of Analysis	Frequency of Analysis	Number of Samples	~Minimum Detectable Concentration (MDC) ($\mu\text{Ci/mL}$)
Specific conductance	Quarterly	49	N/A ^d
Specific conductance	Semiannually ^a	80	N/A
Sodium ion	Quarterly	5	5
Sodium ion	Semiannually	2	5
Sodium ion	Annually	105	5
Chloride ion	Quarterly	49	5
Chloride ion	Semiannually ^a	80	5
Nitrates (as NO_3)	Annually	63	0.5
Chromium (total)	Quarterly	19	0.05
Chromium (total)	Semiannually	33	0.05
Purgeable organic compounds ^e	Monthly	1	0.0002
	Quarterly	4	0.0002
	Semiannually	3	0.0002
Major inorganic water quality constituents	~5 years	65	Varies

a. In addition, one offsite well is sampled annually.

b. Tritiated water.

c. Varies depending upon radionuclides present in the sample.

d. Not applicable.

e. Each sample analyzed for 36 compounds. Other wells may be sampled for special studies.

Independent Monitoring Programs

- In July 1989, the Idaho State University Environmental Monitoring Group began collecting environmental samples as part of a new, independent environmental monitoring program.
- The U.S. Geological Survey (USGS), an independent federal agency, has monitored ground water at the INEL Site for 40 years, and has provided RESL with independent data to which results of the RESL drinking water surveillance program have been compared. Further information on USGS data for 1989 is included in the "Ground-Water Monitoring Program Information" section of this report.

RCRA/CERCLA Activities

- On November 15, 1989, the INEL was placed on the National Priorities List under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended. This designation requires an Inter-agency Agreement (IAG) between DOE and the EPA. It is DOE policy to include the State of Idaho in a three-party agreement. Planning for negotiations between DOE-ID, the State of Idaho and EPA Region 10 for a CERCLA 120 IAG was completed in October 1989 and resulted in the initiation of negotiations in February, 1990. The tentative schedule provided for completion of a final draft by June 1990. The IAG would integrate Resource Conservation and Recovery Act (RCRA) corrective actions and State hazardous waste authorities with CERCLA remedial activities, so elements of the IAG will include Consent Order and Compliance Agreement (COCA) activities and the Buried Waste Program. The State of Idaho desires to be designated the lead agency to oversee the remediation of the RWMC. Work continues at the INEL to clean up currently identified RCRA regulated units.
- During the week of June 5-9, 1989, DOE-ID and EG&G personnel escorted the EPA Region 10 and State of Idaho inspectors on an annual RCRA inspection of the INEL. At the closeout meeting for the inspection, the EPA team indicated minor concerns in the areas of document upkeep and housekeeping. On February 2, 1990, a Notice of Noncompliance was received from EPA Region 10 concerning hazardous waste management activities at the INEL. DOE-ID developed a formal response and held a settlement conference with the EPA and the State of Idaho on April 18-19, 1990.
- In 1984 Congress amended RCRA by scheduling restrictions on the storage and land disposal of hazardous wastes. These restrictions are referred to, collectively, as Land Disposal Restrictions (LDRs). The INEL believes that LDRs that apply to mixed radioactive and hazardous waste require regulatory agreements to ensure compliance. Full-scale operation of the Waste Isolation Pilot Plant will alleviate many of the LDR issues at INEL, but at present INEL has no way to treat or dispose of mixed waste. Discussions on this issue with the State of Idaho and the EPA were initiated in 1989 and will continue in 1990. DOE-ID will pursue an enforceable agreement with the EPA and the State regarding LDRs at the INEL.
- Representatives from the State of Idaho and EPA Region 10 met November 1, 1989 with DOE-ID to discuss the RCRA status of the Idaho Chemical Processing Plant (ICPP) percolation ponds. Minor amounts of hazardous constituents have been released to the ponds, but adequate measures have been taken to eliminate further releases. It cannot be determined whether or not listed hazardous substances were released. With completion of the Liquid Effluent Treatment and Disposal system, new ponds will be constructed and the old ones placed under closure plans. Continued use of the present ponds will be required until about 1991.
- The Pad A Initial Retrieval, which is part of the RCRA Facility Investigation (RFI) at the Radioactive Waste Management Complex (RWMC), was started in October 1989, but was then delayed because of an LDR issue that arose and has since been resolved. When the first eight drums were uncovered at the above-grade storage pad, designated as Pad A, all eight were corroded, six of which had holes 1-4-in. long. Ultrasonic examination of one uncovered drum showing the least corrosion revealed adequate wall thickness to support lifting, and it was retrieved and found to contain several small holes where it had been in contact with adjacent drums. The

drum was over-packed and placed in storage at the Transuranic Storage Area (TSA). The two underlying drums exposed by that retrieval appeared to be in good condition with less corrosion than the upper layer. Under current Safety Analysis and RWMC Operational Safety Requirements, drums that have been breached may not be moved. The scope of the project was changed and a new safety analysis initiated so that under appropriate procedures, removal of the breached drums will be possible. An unofficial projected date for resumption of drum retrieval is late summer 1990. Retrieval efforts will concentrate on removing a sufficient number of drums so that the condition of drums in underlying layers can be determined.

- The Idaho Air Quality Bureau letter granting the In-situ Vitrification (ISV) Intermediate Field Test an exemption from requirements to obtain a Permit to Construct (PTC) was amended by the State to lengthen the duration of each of two melts from 33 hours to a maximum of five days. The first ISV Intermediate Field Test was started on October 18, 1989, but was shutdown after several hours due to a failure of the fabric air hood that covered the melt zone. Because only simulated waste was used for the test, there was no release of hazardous material. An investigation was initiated by EG&G with the participation of Pacific Northwest Laboratory, who developed the process. The second ISV Intermediate Field Test has been set for mid-June 1990.
- Organic solvents were detected in ground water beneath the RWMC in 1987, and an RFI work plan was approved by the EPA Region 10 and the State. A vapor vacuum extraction (VVE) process is being tested for remediation of the subsurface soils in the RWMC area. The process draws organic vapors from the subsurface into a borehole and passes them through high-efficiency particulate air (HEPA) filters to remove any particles that might be radioactive and then through activated charcoal beds to remove organic compounds. On August 9, 1989, the Idaho Air Quality Bureau approved the first VVE demonstration, which began on October 31, 1989. The demonstration was conducted for two weeks to gather and analyze data to define parameters for optimal effectiveness of the process before a four-month demonstration

test in April 1990. The system functioned well, and the VVE posttest analyses of HEPA filters and the charcoal beds showed that no detectable manmade radionuclides were extracted from the subsurface by the process.

- The RFI at the Test Area North (TAN) to determine the extent of ground water contamination and necessary corrective action was continued in 1989. Removal of a 60-ft column of sediment in the former TAN injection well was completed in January 1990. The well was used between 1955 and 1972 to dispose of liquid effluents generated by operations at the Technical Service Support Facility. This disposal resulted in small accumulations of two volatile organic compounds along with small amounts of low level radioactive contamination in the sediments. Over time, the slow leaching of the contaminants from the sediments allowed them to enter the aquifer. Concentrations of trichloroethylene (TCE), commonly used as a degreasing solvent, at one point exceeded the EPA maximum contaminant level (MCL) in TAN drinking water. An aeration system was installed to remove the TCE from the water before it reached the distribution system, and the drinking water is monitored monthly to ensure that concentrations remain at safe levels. With removal of the source of the contaminants, it is anticipated that concentrations in the water will gradually decrease. Monitoring and treatment of the water will continue as long as necessary for contaminants already in the water. TAN was one of the areas cited by the EPA when it placed INEL on its National Priorities List.
- Testing of active underground storage tanks was completed in September 1989. The five tanks that failed the leak tests were removed and spills were cleaned up. A design process is underway to put in replacement tanks during the summer of 1990.

Environmental Restoration Activities

- On November 20, 1989, the ICPP Injection Well was formally capped. This 500-ft well was used to dispose of ICPP service waste water until 1984, when it was replaced by percolation ponds. On December 20, 1989, DOE-ID submitted its final abandonment letter for the injection well to the State of Idaho.

- A procedure was established to revegetate with native plant species in areas disturbed by construction, archaeological and geological examinations for new facilities, or research activities.
- In February 1989, an underground leak of approximately 1000 gal of unleaded gasoline from a pipeline at the CFA Service Station was reported to the Leaking Underground Storage Tank Office of the State of Idaho. The soft, contaminated soil above the lava bedrock was removed, and the pipe between the dispenser and the tank was replaced with a double-walled pipe. Remedial action was performed on the site in accordance with a plan submitted to the State of Idaho in April 1989.

Environmental Documents

- During 1989, a number of draft Environmental Assessments (EAs) were developed for projects at the INEL, but most remain in the internal review stage. The EA for the Process Experimental Pilot Plant (PREPP) was submitted to DOE-HQ in August 1989, and was modified and resubmitted in March 1990. Work began in 1989 to develop a strategy to meet the need for updated Environmental Impact Statements for operational facilities on the INEL, and the strategy is currently undergoing DOE-HQ review.
- Revision 2 of the *Environmental Compliance Planning Manual at the Idaho National Engineering Laboratory*³ was distributed in August 1989. This manual was designed to be a means of sharing vital information within DOE-ID and contractor organizations involved in environmental compliance activities. Training sessions were held during August and September, 1989.

Additional INEL Activities

- Major processing facilities at ICPP did not operate during most of 1989 because of scheduled maintenance, followed by an evaluation for compliance with current environmental regulations and design standards. There was one potential problem with the transfer lines that pass through the soil at

ICPP. They are not doubly-contained, and transfer solutions may contain mixed-hazardous wastes at times. WINCO personnel identified all of the problem lines and developed plans to replace them with doubly-contained transfer lines. Resolution of regulatory issues is being pursued with the EPA and the State of Idaho.

- In response to EPA concerns regarding regulatory interpretations on lead storage and disposal, DOE-ID developed lead management procedures that are currently under review. Uses of lead are to be minimized. A central storage location for reusable lead was created at the Central Facilities Area (CFA) and three permitted lead waste storage areas were established at RWMC, the Test Reactor Area (TRA), and Special Power Excursion Reactor Test No. 4 (SPERT-IV) for storage of radioactively-contaminated lead. The DOE-ID lead inventory was completed, and about 200,000 pounds of lead were shipped to the DOE Lead Bank for reuse. Bench-scale tests for recycling lead were conducted at INEL, and larger pilot-scale tests are planned when DOE-ID receives the appropriate permits.
- Claims of big game depredation on agricultural lands in southeast Idaho and land adjacent to the INEL Site led to negotiations between the Idaho Department of Fish & Game and representatives of DOE-ID. The INEL Hunting Agreement was signed, allowing elk and pronghorn hunting within 1/2 mi inside the northern INEL boundaries.

Environmental Permits in Effect in 1989

INEL facility permits that were in effect in 1989 are described in Table III. In addition to these permits, four approvals were obtained by the INEL from EPA Region 10 for construction of new sources or modification of existing sources of radionuclide emissions. The approvals are required by Title 40, Part 61 of the Code of Federal Regulations (CFR), National Emission Standards for Hazardous Air Pollutants (NESHAP), and are generally necessary before Prevention of Significant Deterioration (PSD) permits and PTCs can be obtained from the State for facilities that will emit radionuclides. The four NESHAP approvals obtained in 1989 were for the following:

**TABLE III
PERMITS IN EFFECT (1989)**

Type of Document	Issued By	Compliance Status	Expiration Date	Other Pertinent Information
Prevention of Significant Deterioration Permit for Coal-Fired Steam Generation Facility	EPA	In Compliance	None	ICPP
Prevention of Significant Deterioration Permit for Fuel Processing Restoration Facility (FPR)	State of Idaho	In Compliance	None	ICPP
Prevention of Significant Deterioration Permit for Hot Fuel Examination Facility/South (HFEF/S)	State of Idaho	In Compliance	None	ANL-W
Permit to Construct an Air Pollution Source (Small Incinerator)	State of Idaho	In Compliance	None	For burning classified documents at TAN
Permit to Construct an Air Pollution Source (Boilers at TAN)	State of Idaho	In Compliance	None	TAN
Permit to Construct an Air Pollution Source (WERF)	State of Idaho	In Compliance	None	Waste Experimental Reduction Facility (WERF)
Permit to Construct an Air Pollution Source (Boiler at CFA 609)	State of Idaho	In Compliance	None	CFA
Permit to Construct an Air Pollution Source (Boiler Modification at ICPP)	State of Idaho	In Compliance	None	ICPP
Permit to Construct an Air Pollution Source (Drum Venting Facility)	State of Idaho	In Compliance	None	RWMC
Permit to Construct an Air Pollution Source (Hazardous Chemical/Waste Handling Facility)	State of Idaho	In Compliance	None	ICPP
Permit to Construct an Air Pollution Source (A1W Temporary Boiler)	State of Idaho	In Compliance	None	NRF
Permit to Construct an Air Pollution Source (Na/K Processing System)	State of Idaho	In Compliance	None	Sodium/Potassium Processing System at WRRTF

- The Fluorinel Dissolution Process Development and Support Facility
- The Special Isotope Separation (SIS) project
- The SIS Stand-Alone Vault
- CFA Laboratory Complex, No. 3.

Funding for SIS Project activities has been withdrawn and there are currently no ongoing plans to construct SIS facilities at the INEL.

EPA determined that no NESHAP approval was required for the Sodium/Potassium Processing System at the Water Reactor Research Test Facility (WRRTF). The PTC permit for the system was issued by the State of Idaho Air Quality Bureau on October 24, 1989.

The PSD/PTC permit for the Hot Fuel Examination Facility/South at ANL-W was issued by the State of Idaho on December 5, 1989.

The INEL RCRA Part A permit application was amended to include several INEL facilities that were not listed as storage facilities but had accumulated quantities of used HEPA filters containing hazardous constituents. Other INEL facilities added to the Part A

permit application included some additional units at ANL-W, and three areas for lead waste storage: RWMC, TRA, and SPERT-IV.

The experimental exemption from a PSD/PTC permit for the PREPP facility was renewed September 28, 1989 by the State of Idaho Air Quality Bureau. A 2.5-yr facility modification phase is in progress at PREPP, and the facility received the experimental exemption for the purpose of testing the system at various operating parameters. This exemption will be renewed annually pending the receipt of a PSD/PTC permit from the State. A NESHAP application will be submitted in 1990.

The State of Idaho provided exemptions from a PTC for the auxiliary diesel pump used to complete the ICPP injection well abandonment project, and two ANL-W generators were declared Below Regulatory Concern by the State. The State Air Quality Bureau also determined that the In-situ Vitrification (ISV) Field Test and the VVE demonstration tests could be run without requiring a permit.

The issue of State authority in requiring permits for INEL waste water treatment facilities is unresolved. Information concerning these facilities is provided to the State as a matter of comity pending the resolution of this issue.

ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

Summary of Results of Environmental Monitoring Performed

Air Sampling

Low-volume Samplers—Airborne particulate radioactivity is monitored continuously by a network of 12 air samplers within the INEL and 11 air samplers outside the Site boundaries at the locations shown in Figure 3. Locations of onsite samplers were selected to give adequate coverage in the event of facility releases of radioactivity. Seven offsite air samplers are located near the Site boundary in communities when possible, or at noncommunity locations when necessary to encompass the perimeter of the Site. Four samplers are located at the distant communities of Blackfoot, the Craters of the Moon National Monument, Idaho Falls, and Rexburg to provide background measurements for comparison with data from boundary or onsite samplers that might be affected by INEL operations. The whole network provides comprehensive surveillance of particulate atmospheric radioac-

tivity and makes it possible to differentiate INEL releases from worldwide fallout and long-lived natural radioactivity.

Each air sampler maintains an average air flow of about 40 L/min (1.5 ft³/min) through a set of filters consisting of a membrane filter (Gelman Model V-1200)^a followed by an activated charcoal-impregnated cellulose fiber filter (Gelman Model AC-1).^a The filters are 99% efficient for airborne particulate radioactivity and elemental iodine vapor.

Gross Alpha, Gross Beta—The filters from the low-volume air samplers are collected weekly and analyzed after waiting a minimum of four days to allow the naturally occurring, short-lived radon and thoron daughters to decay. "Gross" (nonspecific) analyses of the airborne particulates trapped on the membrane filters are performed weekly, and the

- a. Use of commercial product names is for accuracy in technical reporting and does not constitute endorsement of the product by the United States Government.

Figure 3. INEL Site and vicinity air sampling network.

activity detected is termed "gross alpha" or "gross beta" to differentiate these results from analyses for specific radionuclides. Analyses for gross alpha activity are performed on six selected filters: Blackfoot, Craters of the Moon, Arco, ANL-W, the Experimental Field Station (EFS), and RWMC. Gross alpha concentrations are sometimes greater at the distant location of Blackfoot than at the other locations because of sources outside the INEL Site. None of the boundary or onsite locations showed annual mean concentrations statistically greater than the distant community mean concentration for 1989.

Analysis for gross beta activity is performed on each filter from all 23 locations in a low background beta counter. If the gross beta activity on a membrane filter exceeds an action level of 1×10^{-12} $\mu\text{Ci/mL}$, or if a Site release is suspected, the filter is analyzed by gamma spectrometry. All gross beta activity detected on the charcoal-impregnated filters is initially assumed to be I-131. If the gross beta activity on the charcoal filter exceeds an action level of 7×10^{-14} $\mu\text{Ci/mL}$, the filter is analyzed by gamma spectrometry to determine the I-131 component.

The gross beta activity is determined weekly for both filters as a screening technique to give timely information in the event of INEL releases or worldwide fallout. This information may be difficult to interpret, however, because of local variations in beta concentrations of airborne particulates at any given time or location. Any of several factors may be responsible for the variations observed. Examples of these factors include dust or soot loading on individual filters, varying concentrations of natural radioactivity at different locations, and uneven distribution of worldwide fallout radioactivity as a result of diverse local meteorological conditions. For example wood smoke in communities sometimes clogs the filters during cold weather. When an individual filter's pores are plugged early in the week, abnormally low gross beta concentrations often result. Because the distant community group is small, a low concentration at only one or two locations can bias the statistical test so that onsite mean gross beta concentrations appear significantly higher than that of the distant community group. This variable alone can make interpretation of the results of gross beta analyses difficult. Therefore, when interpreting air sampling data, RESL relies on the results and comparisons of specific nuclide data rather than gross beta concentrations because the source of the radioactivity on the filters can be determined more easily from the specific nuclide concentrations. Also, specific nuclide analyses are generally more sensitive than gross beta analyses.

The 1989 results of gross beta analyses of particulates on the membrane filters are summarized in Table B-1, Appendix B. The gross beta activity measured at each onsite and boundary location was statistically compared to gross beta activity measured at the group of distant locations for each month and for the entire year. Table B-2, Appendix B, shows 1989 results of the monthly and annual statistical comparisons of boundary and Site locations to the distant community group mean gross beta activity. Site operations information and meteorological data were considered in each case where a location or group was statistically greater than the distant location group. A statistical difference was found in about 9% of the comparisons.

During the first week of December 1989, two weekly filters with gross beta concentrations that were statistically greater than background were submitted for gamma spectrometry. Both filters were from samplers located at the Mud Lake station: one from the routine sampler and one from the quality control sampler that was located at Mud Lake during that quarter. Gamma spectrometry showed no detectable concentrations of any manmade radionuclides. No Site operations information could be found to explain the statistically greater gross beta concentrations on filters from those two samplers during the first week of December.

Four onsite locations had mean gross beta concentrations that were statistically greater than the distant group for at least two months of 1989 and also for the annual mean concentration (see Table B-2, Appendix B). The onsite group mean concentration was statistically greater than that of the distant group for December (perhaps related to soot loading of distant community sampler filters) and for the overall annual mean concentration as well. No evidence could be found to indicate that these increased gross beta concentrations were due to INEL operations.

The boundary location at Mud Lake also had three monthly mean gross beta concentrations that were statistically greater than the distant group mean concentration; the annual mean comparison was also greater (see Table B-2, Appendix B). The station at Montevieu and the boundary group mean gross beta concentrations for 1989 were also statistically greater during December than the distant group and Howe showed a higher annual mean. No evidence could be found to indicate that the higher gross beta concentrations at any of these locations were due to manmade radionuclides or to Site operations. Data from these areas is being observed closely for development of any trends, and some increase in the number and type of

also samples collected has been instituted in an effort to locate the source(s) of the increased beta activity.

The average monthly concentrations of gross beta activity for onsite, boundary, and distant location groups are shown in Figures 4 and 5 for 1981–1989. The diamond-shaped bar represents the time of the Chernobyl accident, after which gross beta activity peaked dramatically. The unusually high concentrations of gross beta activity at the beginning of 1981 were due to a nuclear weapons test by the People's Republic of China in October 1980. In recent years, there also appears to be a small pattern of variation, with slightly higher concentrations occurring near the end and the beginning of most years. Reasons for this variation are unknown but may be related to meteorological conditions.

Specific Radionuclides—Specific radionuclide analyses are more sensitive indicators than gross beta analyses of the impact of INEL operations on the environment. Therefore, the membrane filters of the low-volume samplers are composited according to location at the end of each quarter, and all composites are analyzed for specific radionuclides by gamma spectrometry. Selected composites are then submitted for analyses of alpha-emitting radionuclides and Sr-90. The analyses for alpha-emitting nuclides utilize chemical separation techniques followed by alpha spectrometry; for Sr-90, the chemical separation is followed by beta counting. Because both of the follow up analyses consume the entire sample, only one of the two types can be performed on a given composite. The composites from one distant location and four onsite locations are analyzed each quarter for specific alpha-emitting radionuclides. The composites from another distant location and four other onsite locations are analyzed each quarter for Sr-90. In addition, six offsite and four onsite location composites are analyzed on alternating schedules, producing a total of ten rotating analyses. (Five composites are submitted for alpha-emitting nuclides and five for Sr-90 one quarter; and, during the next quarter, the groups are reversed and submitted for the other type of analysis.)

The quantity and identity of radionuclides released from INEL facilities are reported quarterly in a Radioactive Waste Management Information System (RWMIS) report.^a Whenever any question exists as to the impact of Site operations on the environment, results of the specific radionuclide analyses are

compared to release data from the RWMIS report in an attempt to determine the source of the detected material.

Results of the quarterly specific radionuclide analyses of membrane filter composites are summarized in Table B-3, Appendix B. Beryllium-7, a naturally occurring radionuclide produced by the interaction of cosmic radiation and nitrogen in the atmosphere, is excluded. Although Be-7 is also a manmade radionuclide produced at some national laboratories, it is not a significant product of the processes at INEL. Radionuclides included in Table B-3 are those that could potentially be released from INEL operations.

Six gamma-emitting radionuclides were measured at concentrations near their minimum detectable concentrations: Ce-141, Cs-137, Mn-54, Ru-106, Sb-125 and Zr-95. They are included in the information in Table B-3, but no reason for their presence on filters has been determined. When the reported concentrations are low, it is difficult to draw firm conclusions about the source of the radioactivity (see Appendix C).

Strontium-90, a nuclide deposited on soil worldwide as a result of fallout from nuclear weapons tests, is often detected at concentrations near the minimum detectable concentration on both onsite and offsite samplers. During the fourth quarter 1989, this nuclide was detected on four onsite filter composites. The distribution of the Sr-90 concentrations suggests a possible INEL origin, but no specific source was located. Releases of Sr-90 were reportedly lower than average for all facilities during the fourth quarter. The highest fourth quarter concentration observed on air filters, at TAN, was 0.003% of the annual derived concentration guide for radiation protection of the public.

Plutonium-239/240 and Am-241 are frequently detected on RWMC filters as a result of resuspension of contaminated soil by the wind during quarters when there is no snow cover. During 1989, Am-241 was detected at RWMC during the second and third quarters and Pu-239/240 during the third quarter. The annual concentrations of both nuclides were less than 0.15% of the appropriate annual derived concentration guide.

The second quarter composite at Idaho Falls had a concentration of $6 \pm 4 \times 10^{-18}$ $\mu\text{Ci/mL}$ of Pu-238. Considering Site operations and meteorological information, it is unlikely that this nuclide would reach Idaho Falls from any INEL operations. When the reported value is near the minimum detectable concentration,

a. Preliminary INEL Radioactive Waste Management Information System data.

Figure 4. Site and distant gross beta concentrations in air.

Figure 5. Boundary and distant gross beta concentrations in air.

interpretation as to the actual presence or absence of the nuclide on the composite is difficult (see Appendix C).

Comparisons of onsite group mean concentrations to boundary group means and distant community means revealed statistical differences for Mn-54, Ru-103, and Am-241. Mn-54 was detected at Mud Lake only during the third quarter at a concentration near the minimum detectable concentration and Ru-103 was not detected at any location during 1989. In these instances, the statistical difference has little meaning. The onsite group annual mean was statistically greater than the boundary group mean for Am-241, which was detected a total of three times during the year: once at ANL-W and twice at RWMC. It was not detected at any offsite location. After examination of the geographical pattern and magnitude of detectable concentrations, this difference appears to be related to RWMC operations or to resuspension of slightly contaminated soil at the RWMC area. The reported concentration at ANL-W was near the minimum detectable concentration and cannot be easily interpreted (see Appendix C).

Tritium—Samplers for tritium in water vapor are located in Idaho Falls and at the EFS and Van Buren locations on the INEL. In these samplers, air is passed through a column of silica gel at a rate of 0.3 l./min (0.65 ft³/h). Tritium concentrations are determined by liquid scintillation counting of water extracted from the silica gel columns.

Tritium concentrations at the three locations are summarized in Table B-4, Appendix B. During 1989, three of the five samples collected at Idaho Falls and one of the ten Site samples contained concentrations of tritium near the minimum detectable concentration. No significant difference was found between onsite and offsite locations. Because Idaho Falls lies outside the prevailing wind patterns for the Site and is distant from the INEL, it is unlikely that the tritium detected there originated from Site operations. No tritium was detected in any onsite or offsite 1981-1987 samples, but it was detected during 1988 at all locations. It is possible that the dry summer weather played a role during both 1988 and 1989. If the atmospheric moisture is less than normal, any tritium present in the atmosphere—whether from the Site or other worldwide sources—would be less diluted than normal on the silica gel collecting columns and would therefore appear to be present at a higher-than-normal concentration per mL of atmospheric moisture. Future tritium monitoring results will be closely examined for trends in an attempt to discover a definite explanation for these de-

tectable tritium concentrations. Table B-4, Appendix B, shows that the annual mean tritium concentration at each location is a very small percentage (0.0004% or less) of the annual derived concentration guides for radiation protection of the public.

Krypton-85—Krypton-85 is monitored at one Site location, CFA. Ambient air is collected continuously in a large Tedlar bag and twice a month, the sample (about 0.75 m³ of air) is compressed into a cylinder. Two cylinders are shipped each month to the EPA Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) for analysis. EMSL-LV analyzes for Kr-85 by condensing the samples at liquid nitrogen temperature and using gas chromatography to separate the krypton gas. The separated gas is dissolved in a scintillation cocktail and counted in a liquid scintillation counter.⁴

Compressed air samples from CFA were analyzed for Kr-85 from January 5, 1989, to December 26, 1989 and results are reported in Table B-5, Appendix B. The EMSL-LV results are typical of levels found in the western United States and are consistent with the lower-than-normal releases of Kr-85 by the INEL in 1989. The annual average concentration of 3×10^{-11} $\mu\text{Ci/mL}$ is 0.001% of the derived concentration guide for radiation protection of the public. (See the section entitled "Environmental Standards and Regulations.")

Water Sampling

General Information—There are no streams or rivers flowing from within the INEL to locations outside the boundaries. Therefore, water sampling is limited to onsite and offsite ground-water monitoring plus samples from the Snake River, which flows at a considerable distance outside the Site boundaries. The Snake River Plain aquifer, which lies beneath the INEL Site, serves as a primary source for drinking water and crop irrigation in the Snake River Basin.

Onsite and offsite water samples are collected routinely to monitor the movement of waste substances, both radioactive and nonradioactive, through the aquifer. RESL collects drinking water from boundary and distant communities and Snake River water samples and submits them for radionuclide analyses (see Table I). Approximate locations where RESL offsite water samples are collected are shown in Figure 6, along with locations of four of the observation wells beyond the southern and western Site boundaries that the USGS samples routinely. During the last half of 1989, three surface water locations in the Magic Valley

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Figure 6. Boundary and distant water, milk, and wheat sampling locations and environmental dosimeter locations.

area (Twin Falls and points west were added to the RESL program) and two from communities (Shoshone and Minidoka) were sampled monthly and each sample was split between RESL and the Idaho State University (ISU) Environmental Monitoring Group for their independent environmental surveillance program. Onsite drinking water samples are collected monthly from production (drinking water) wells in use at active Site facilities. ISU also divides some samples with the USGS.

In addition to the production well monitoring performed by RESL, the USGS extensively monitors ground water on the INEL Site. The USGS portion of the water sampling program is described in the section "Ground-Water Monitoring Program Information." Because the USGS maintains more than 250 wells and auger holes, a sample location map is not provided in this report. Locations will be described in terms of proximity to major Site facilities when results from specific wells are mentioned.

Gross Alpha, Gross Beta—Each water sample is submitted for "gross" (nonspecific) analyses for alpha and beta-emitting radionuclides that might be present in the water. For gross alpha analysis, a portion of the sample is evaporated on a stainless steel planchet and counted with a scintillation counter system. For gross beta activity, a portion is evaporated and counted in a low-background beta counter. The minimum detectable concentrations for gross alpha and gross beta are 3×10^{-9} and 4×10^{-9} $\mu\text{Ci/mL}$, respectively, or about 10% and 4% of the DOE derived concentration guides for members of the public. These minimum detectable concentrations are also 20% and 8%, respectively, of maximum contaminant levels for community drinking water listed by the EPA in 1988.

Approximately 23% of all drinking water samples collected in 1989 contained detectable concentrations of gross alpha activity. Two of the 54 boundary and distant water samples collected and analyzed by RESL in 1989 contained detectable gross alpha activity, and 78 of the 289 Site drinking water samples had detectable gross alpha activity. All concentrations were lower than 5×10^{-9} $\mu\text{Ci/mL}$ and represent measurements near and below the minimum detectable concentration (see Appendix C). The average gross alpha concentration for the 1989 samples was 1.9×10^{-9} $\mu\text{Ci/mL}$. This average is within the expected concentration range of 1.5×10^{-9} to 2.5×10^{-9} $\mu\text{Ci/mL}$ for naturally occurring alpha activity in the aquifer underlying the INEL

and surrounding areas.^a According to a recent USGS report,⁵ alpha-emitting wastes from Site operations have not migrated far from their entrance into the aquifer near ICPP. Therefore, the offsite gross alpha activity is unlikely to be due to migration of wastes from Site operations, and all onsite drinking water wells lie outside the migration plumes for alpha-emitting nuclides. Gross alpha concentrations in all samples were less than the EPA community drinking water standard for gross alpha activity of 15×10^{-9} $\mu\text{Ci/mL}$.

Forty-four of the 289 Site samples and 9 of the 54 boundary and distant samples showed gross beta concentrations of $8 \pm 4 \times 10^{-9}$ $\mu\text{Ci/mL}$ or lower, i.e., near the minimum detectable concentration. At these low concentrations, it is difficult to draw firm conclusions about the presence of radioactivity (see Appendix C). Annual averages for gross beta activity at all locations were below the EPA community drinking water standard of 50×10^{-9} $\mu\text{Ci/mL}$.

Natural radioactivity is found in the Snake River Plain aquifer in areas upgradient, parallel to, and far distant from the INEL Site. The natural radioactivity is the most probable source of the presence of low concentrations of gross alpha and gross beta activity.

Specific Radionuclides—Tritium analyses are routinely performed on the water samples collected by RESL, and Sr-90 analyses are performed each month on samples from drinking water wells in the ICPP area because two of these wells lie within the 1985 Sr-90 waste plume as determined by the USGS (see Reference 5). Figures 7 and 8 have been drawn based on USGS data through 1988 to illustrate the approximate extent of the tritium and Sr-90 waste plumes (i.e., the spread of various contaminants in the aquifer and perched water from INEL facilities). The drawing of plumes, such as those shown in Figures 7 and 8, utilizes the judgment of competent professionals based on points of data from the wells shown. Scientists must interpret the data in order to represent it on maps. As seen in Figure 7, the 0.5-pCi/mL concentration, which represents the leading edge of the tritium plume, was inside the Site boundary in 1988.^b

Concentrations of tritium are determined by using a liquid scintillation counter. Strontium-90 is separated from the sample chemically, and after an ingrowth period, its Y-90 daughter is separated chemically and

a. Unpublished data collected by the RESL Analytical Chemistry Branch at INEL, January, 1990.

b. L. J. Mann, personal communication, USGS, INEL, April, 1989.

Figure 7. Distribution of tritium in the Snake River Plain aquifer in the southcentral part of the INEL, 1988. (Based on USGS data.)

Figure 8. Distribution of Sr-90 in the Snake River Plain aquifer in the southcentral part of the INEL, 1988. (Based on USGS data.)

counted in a low-background beta counter to determine the amount of Sr-90 initially present in the sample. The minimum detectable concentrations for tritium and Sr-90 are 4×10^{-7} and 5×10^{-10} $\mu\text{Ci/mL}$, or about 0.02% and 0.05%, respectively, of the DOE derived concentration guides for members of the public. These minimum detectable concentrations are also 2% and 6%, respectively, of maximum contaminant levels for community drinking water listed by the EPA in 1989.

None of the boundary or distant community water samples contained detectable concentrations of tritium. Some samples from onsite wells that lie within the tritium plume consistently contain detectable concentrations of tritium. Data from these wells are presented in Table B-6, Appendix B. Samples from two of the ICPP production wells sometimes have detectable concentrations of Sr-90. These data are also presented in Table B-6. The highest annual average concentration of tritium in Site drinking water (at CFA) is 1.2% of the derived concentration guide for radiation protection. For Sr-90, the highest annual average concentration (at ICPP) was 0.06% of the derived concentration guide.

The USGS detected tritium in some of the observation wells just inside the southern Site boundary for the first time in 1983, but it has not been detected in samples collected from those wells since January 1986. In the nearest offsite well, which is about 0.8 km (0.5 mi) south of the Site boundary, tritium has never been detected above the minimum detectable concentration of 4×10^{-7} $\mu\text{Ci/mL}$.

Strontium-90 analyses were above the minimum detectable concentration (5×10^{-9} $\mu\text{Ci/mL}$) only for those samples collected within 3.2 km (2.0 mi) of the former disposal well at ICPP, or approximately 9.8 km (6.1 mi) inside the nearest Site boundary. As seen in Figure 8, those wells lie within the Sr-90 plume. Isotopes of cesium and plutonium are even less mobile in the aquifer than strontium, and the locations at which detectable concentrations of these isotopes can be detected are still near the point of entrance into the aquifer.

The effective dose equivalent to a worker at CFA was calculated. CFA was selected because the tritium concentrations found in these wells are the highest of any drinking water wells. CFA Well #2 was used for drinking water during 1989. Therefore, the current effective dose equivalent calculation was based on the 1989 average tritium concentration of

16×10^{-6} $\mu\text{Ci/mL}$ in that well. Although CFA #1 contained a detectable concentration of I-129 in the 1986 study, CFA #2 did not; therefore, no I-129 component appeared in the 1989 dose estimate. Another change in the calculation procedure this year is the assumption that each worker's total water intake came from the CFA #2 well. This actually overestimates the dose because workers typically consume only about half their total intake during working hours, and they typically work only 240 days rather than 365 days per year. The estimated effective dose equivalent to a worker from consuming drinking water at CFA during 1989 was 0.75 mrem/year. This is below the EPA standard of 4 mrem for community drinking water systems.

Foodstuff Sampling

General Information—Milk, wheat, leafy garden lettuce, and muscle and liver samples from sheep are sampled annually. Muscle and liver samples from beef cattle are usually sampled biennially, but were not sampled in 1988 or 1989 because no cattle were grazed on the southern portions of the INEL as a result of drought conditions. Because they are part of the typical American diet, all these foodstuffs could be pathways to the public for radionuclides from fallout or from INEL operations. Boundary areas are compared to distant areas to assess possible impacts from INEL operations. Milk and wheat sampling locations are shown in Figure 6. Lettuce was collected at Arco, Atomic City, Blackfoot, Carey, Howe, Idaho Falls, Mud Lake, and Pocatello.

Milk—Milk samples (144 total) were collected from dairies and single-family milk cows in the INEL vicinity. Samples are normally collected monthly except in Idaho Falls, where a sample is collected weekly. All milk samples are passed through an anion exchange resin, which is then analyzed for I-131 by gamma spectrometry. Milk from each location is analyzed for Sr-90 and tritium annually. In 1989, however, an error was made in the requests for analyses and each of the two groups of samples received only one analysis during the year: tritium or Sr-90. In addition to the tritium and Sr-90 analyses, three September samples, one each from Carey, Idaho Falls, and Mud Lake are submitted for I-129 analysis each year. For I-129 analysis, when the gamma spectrometric analysis of the three samples for I-131 is complete, the iodide is chemically stripped from the anion exchange resin, activated in an INEL reactor to convert I-129 to I-130, and analyzed for I-130 by gamma spectrometry.

In 1989, no milk samples contained detectable concentrations of I-131, and none of the nine milk

samples submitted for tritium analyses showed detectable concentrations of that nuclide.

The 1989 Sr-90 mean concentration of $1.1 \pm 0.6 \times 10^{-9}$ $\mu\text{Ci/mL}$ is consistent with Sr-90 levels reported by the EPA for both Regions 8 and 10. Region 8 includes Colorado, Montana, Utah, Wyoming, North Dakota, and South Dakota; and Region 10 includes Idaho, Hawaii, Alaska, Washington, and Oregon. The Region 8 mean concentration from July 1988 through June 1989 was 1.5×10^{-9} $\mu\text{Ci/mL}$, and the Region 10 mean concentration for the same time period was 1.4×10^{-9} $\mu\text{Ci/mL}$.⁶⁻⁹ The Sr-90 in southeast Idaho area samples is most likely due to worldwide fallout deposited on the soil and resuspended on vegetation or taken up in the grass eaten by the cows.

Results for analyses of 1988 milk samples for I-129 were not available in time for inclusion in the 1988 report. None of the three samples contained detectable concentrations of I-129. In 1989, three samples were again submitted for analysis, but none contained detectable concentrations of I-129.

Lettuce—Lettuce samples were washed with water to remove any soil (as in normal food preparation) then dried and weighed. All lettuce samples were analyzed for Sr-90 and gamma-emitting radionuclides. Cesium-137 was not detected in any of the lettuce samples, and no other gamma-emitting radionuclides were found. Strontium-90 was reported in most samples at approximately the same levels as in past years. Comparison of average concentrations of Sr-90 for boundary and distant communities showed no statistical difference between the two groups. The Sr-90 results are shown in Table B-7, Appendix B.

Wheat—Wheat samples were weighed prior to analysis but not washed. No manmade gamma-emitting radionuclides were detected in any sample. All wheat samples were also analyzed for Sr-90 and results are shown in Table B-7, Appendix B. Average concentrations of Sr-90 in wheat were statistically the same for boundary and distant samples, and there were no significant differences in concentration when compared to recent years.

Because concentrations of radionuclides in milk, lettuce, and wheat samples were normal or statistically the same at distant and boundary locations, it is assumed that the origin of these radionuclides is worldwide fallout.

Sheep—Muscle and liver samples were taken from sheep that had grazed both onsite and offsite near the

Site boundaries (Figure 9). During 1989, two sheep were sampled from the southern area and two were taken from the eastern area of the INEL. In addition, two sheep that had summered near Howe and wintered near Mud Lake were sampled from the U.S. Sheep Experiment Station near Dubois, Idaho. No control sheep from distant locations were sampled in 1989.

Cs-137 was detected in the muscle tissue of one onsite animal at a concentration of $1.3 \pm 1.0 \times 10^{-8}$ $\mu\text{Ci/g}$ wet weight. Cs-137 was found in the liver of one boundary sheep and two onsite animals at concentrations near the minimum detectable concentration ranging from $1.1 \pm 1.0 \times 10^{-8}$ $\mu\text{Ci/g}$ to $1.7 \pm 1.2 \times 10^{-8}$ $\mu\text{Ci/g}$ wet weight. These concentrations are similar to those seen in onsite, boundary, and control sheep from previous years.

Soil Sampling

To establish background levels of natural and fallout radioactivity in surface soil and to assess any potential buildup of radioactivity from Site operations, soil samples were collected annually from distant and boundary locations from 1970-78 (except 1972 and 1977). The biennial soil sampling program was established in 1978, and Figure 10 shows routine offsite sampling locations. A rotating seven-year schedule is used to sample onsite soils around major INEL facilities.

Soil samples collected in 1970, 1971, and 1973 represented a composite of five cores of soil from a 1-m^2 area. Each core was a cylinder 10 cm in diameter and 5 cm in depth. In all other years, the five cores were collected from a 100-m^2 area. A number of samples from the 5- to 10-cm depth were also collected.

All soil samples are analyzed for gamma-emitting radionuclides. Most are also analyzed for Sr-90 and alpha-emitting radionuclides. The soils are dried at least 3 h at 120°C . Only soil particles less than $500\text{ }\mu\text{m}$ in diameter (35 mesh) are analyzed. The data are reported in units of activity per gram of soil (pCi/g dry weight) and also in units of areal activity (nCi/m^2), which is the total activity in each soil sample divided by the surface area (0.039 m^2) of the sample.

Concentrations of natural radioactivity in the surface soil were reported in 1977.¹⁰ The Th-232 and U-238 activities were determined from those of the progeny radionuclides, Ac-228 and Pb-214. Oakley¹¹ indicated that the average concentrations of uranium, thorium, and K-40 in the earth's upper crust, when translated from ppm to pCi/g , are 0.9, 1.1, and

Figure 9. Sheep grazing on the INEL.

17 pCi/g, respectively. The local soils averaged about 1.5, 1.3 and 19 pCi/g, respectively, values that are slightly higher in natural radioactivity than earth crustal averages. Although much of the surface rock on the Snake River Plain is basalt, the local soil is largely derived from silicic volcanics, which have higher uranium and thorium concentrations than basalt.

Estimates of the average external dose equivalent received from U-238 plus daughters, Th-232 plus daughters, and K-40 in average Site area soil were calculated to be 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr. Because heavy snow cover can reduce the effective dose equivalent Idaho residents receive from the soil of the area, a correction for the snow cover reduction of the terrestrial dose will be made in the following section entitled, "Environmental Radiation Measurements."

Surface soil concentrations of Cs-137, Sr-90, Pu-238, Pu-239/240, and Am-241, as measured from 1970-75, are compared to biennial samples since 1978 in Table B-8, Appendix B. The 1976 data are not included because the sampling locations used that year are not considered to be representative of the area.

Three samples from 1984—Mud Lake No. 1, Mud Lake No. 2, and Crystal Ice Caves—were excluded from 1984 data because the concentrations were uncharacteristically low compared to previous years. This may have been caused by disturbance (farming, erosion, vehicular traffic, etc.) of the sampling locations. These sampling locations, plus the location at Montevieu, were re-evaluated and moved to more representative undisturbed locations in 1986.

Distant and boundary location average concentrations for 1988 were not statistically different for any radionuclide. It is concluded, therefore, that all of the radionuclides detected are present as a result of world-wide fallout.

Environmental Radiation Measurements

Thermoluminescent dosimeters (TLDs) are used to measure ionizing radiation exposures (beta greater than 200 keV and gamma greater than 10 keV). The TLDs measure ionizing radiation exposures from natural radioactivity in the air and soil, cosmic radiation from outer space, fallout from nuclear weapons tests,

Figure 10. Soil sampling locations for the INEL vicinity.

radioactivity from fossil fuel burning, and radioactive effluents from Site operations and other industrial processes.

At each location, a dosimeter containing five individual Harshaw TLD-700 chips ($3.18 \times 3.18 \times 0.89$ mm) is placed 1 m above ground level. The dosimeter at each location is changed semiannually. There are seven distant community locations and six boundary locations (see Figure 6). The measured cumulative exposure for the time period from November 1988 to November 1989 for offsite locations is shown in Table B-8, Appendix B. For purposes of comparison, annual exposures from 1986-88 are also included for each location. As reported in the 1987 annual report,¹² dosimeter exposures for that year appeared unusually low as a group due to TLD reader drift. The 1987 results were not used in statistical comparisons.

The mean annual exposures for distant and boundary community locations in 1989 were 117 ± 7 mR and 118 ± 8 mR, respectively, as measured by TLDs. These exposures are approximately equivalent to 112 and 113 mrem, respectively, when an "f" factor of 0.96¹³ is used to convert from mR to mrem in tissue.

Table IV summarizes the calculated dose equivalent rate an individual receives on the Snake River Plain from various background radiation sources. The terrestrial portion of this value varies from year to year, depending on the amount of snow cover.¹⁴ For 1989, the heavier than usual snow cover resulted in about a 10% dose reduction; the terrestrial background dose equivalent rate was calculated to be about 68 mrem.

The cosmic component varies primarily with altitude. The average annual dose equivalent of 26 mrem at sea level essentially doubles with each 2000 m (6560 ft) increase in altitude.¹⁴ The INEL Site altitude is approximately 1500 m (4900 ft). The sum of the estimated terrestrial and cosmic components is 107 mrem, which compares well to the 112 mrem measured by TLDs at distant locations.

The component that varies the most is that of inhaled radionuclides. According to the National Council on Radiation Protection and Measurements (NCRP),¹⁵ the major radionuclides contributing to this component are short-lived decay products of radon, and the amount of radon in buildings and ground water depends upon the natural radionuclide content of the soil and rock of the area. There is also variation within buildings of a given geographic area depending upon the materials it contains, the amount of ventilation and air movement, and other factors. Since no specific esti-

mate for southeastern Idaho has been made, and measurements in homes in this area are few, the U.S. average of 200 mrem has been used in Table IV for this component of the total background dose. Therefore, the effective dose equivalent from natural background radiation for residents in the INEL vicinity varies from one location to another and may actually be higher or lower than the 350 mrem shown.

The background dose equivalent rate shown for the nonradon components of the natural dose rate are consistent with those of previous years, which ranged from 140 to 155 mrem/yr.

TABLE IV.
ESTIMATED NATURAL BACKGROUND
EFFECTIVE DOSE EQUIVALENT

Source of Radiation Dose Equivalent	Total Average Annual Effective Dose Equivalent (mrem)	
	Estimated ^a	Measured (TLD) ^b
External Terrestrial ^c	68	—
Cosmic ^d	39	—
Subtotal	107	112
Internal Cosmogenic ^e	1	—
Inhaled radionuclides ^f	200	—
K-40 and others	39	—
Subtotal	240	—
Rounded Total	350	—

a. Total average annual effective dose equivalents for components as estimated in NCRP Report No. 93.¹⁴

b. For conversion from mR to mrem in tissue, the "f" factor used was 0.96.¹³

c. The terrestrial component for the INEL Site vicinity is based upon soil sampling for natural radionuclides in 1976, and a correction for snow cover during winter months of 1989.

d. The cosmic component is derived from the estimate in NCRP Report No. 93.¹⁴

e. The cosmogenic component is due primarily to C-14 in tissues and is uniform globally.¹⁴

f. The inhaled radionuclides component varies widely with geographic location and is primarily due to contributions from radon daughters. The 200 mrem shown represents the U.S. population average.¹⁴

Game Species

Hunting and fishing are not usually allowed on the INEL Site. In 1989, an exception was made by permitting the hunting of pronghorn and elk within 1/2 mi of the northern INEL boundaries. Just prior to the 1989 pronghorn hunt, RESL collected three antelope from farms adjacent to the INEL and submitted tissue samples for analysis to document radionuclide concentrations, if any. No radionuclides were detected in the edible tissues of any of the animals. The hunt was scheduled in response to claims of significant big game animal depredation and was negotiated between the Idaho Department of Fish and Game and DOE-ID.

By migrating to and from the Site, game animals represent a potential exposure pathway. However, the probability that an individual in the population would consume an animal containing significant amounts of radioactivity is small. While onsite, some game animals may use the waste infiltration ponds at TRA and ICPP for water. Although the ponds are fenced to exclude antelope, the TRA fence may not exclude all deer. Neither, of course, excludes game birds, which have used the ponds in the past for resting and feeding sites. Larger game animals may also ingest vegetation and soil that has been contaminated by Site operations.

Data from game species are generally obtained as part of DOE research programs rather than as part of the routine environmental surveillance program, although analyses of tissues of road-killed animals are reported here. Results from the radioecology and ecology research programs, which use the expertise of university faculty and graduate students, are reported in the scientific literature and supplement the results of the routinely scheduled environmental surveillance included in this report. Results from some of the radioecology studies that investigated potential doses to man from game animals migrating from the Site are discussed in the section entitled "Maximum Individual Dose—Game Animal Pathway."

In addition to the samples collected from offsite animals, muscle and liver samples from two mule deer adults and one fawn, eight adult pronghorn antelope and one fawn, and one elk, all killed by vehicles on Site roads in 1989, were submitted for analysis by gamma spectrometry.

For the road-killed animals, samples collected from all three mule deer contained detectable concentrations of manmade radionuclides. The fawn's muscle tissue contained Cs-137 at $9.3 \pm 1.2 \times 10^{-8}$ $\mu\text{Ci/g}$ and its liver tissue contained Cs-137 at $2.3 \pm 2.0 \times 10^{-8}$ $\mu\text{Ci/g}$

wet weight. One adult had a liver concentration of Cs-137 at $2.5 \pm 1.0 \times 10^{-8}$ $\mu\text{Ci/g}$. The second adult deer had Co-60 at $7.0 \pm 1.2 \times 10^{-8}$ $\mu\text{Ci/g}$ wet weight in the liver and a concentration of Cs-137 in muscle of $4.5 \pm 1.0 \times 10^{-8}$ $\mu\text{Ci/g}$. All three mule deer were killed on roads near CFA.

Among the eight pronghorn onsite road-kills, three had detectable concentrations of Cs-137 in muscle tissue ranging from $1.5 \pm 0.8 \times 10^{-8}$ $\mu\text{Ci/g}$ to $8.6 \pm 1.4 \times 10^{-8}$ $\mu\text{Ci/g}$ wet weight, and two had detectable concentrations of Cs-137 in liver tissue at $1.9 \pm 1.2 \times 10^{-8}$ and $5.3 \pm 1.6 \times 10^{-8}$ $\mu\text{Ci/g}$ wet weight, respectively.

No manmade radionuclides were found in the tissues of the elk.

While it is known that the soil around some facilities is contaminated with Cs-137, this nuclide was also a constituent of worldwide fallout during atmospheric weapons testing and has been found in the soil at locations distant from the Site. As a result, game animals sampled from offsite distant areas (control animals) also frequently contain Cs-137 in their muscle and liver tissues. As reported in our 1980 monitoring report, the average concentrations of Cs-137 found in tissues of control animals sampled in past studies were 3.8×10^{-8} $\mu\text{Ci/g}$ for muscle and 4.7×10^{-8} $\mu\text{Ci/g}$ for liver tissues. Concentrations of Cs-137 above those levels, and the concentration of Co-60 in the liver tissue of the mule deer sampled in 1989, could be the result of the animals ingesting contaminated soil on vegetation around Site facilities.

No fish were collected from the portion of the Big Lost River within the INEL boundaries during 1989 because it was dry the entire year.

Summary of Radioactive Effluent Monitoring

Radionuclides in airborne and liquid effluents released to the environment are carefully monitored at potentially significant release points. Effluent monitoring is summarized in Appendix H of Reference 16. The Industrial Waste Management Information System reports the results of the effluent monitoring by month, facility, and radionuclide.

A summary of the radionuclides released to the atmosphere from Site facilities in 1989 is shown in Table B-10, Appendix B. Because of radioactive decay of the short-lived radionuclides and the overestimation of Kr-85 releases for classification reasons, the activity that would reach offsite areas is less than the

22,000 Ci (8.3×10^{14} Bq) indicated in Table B-10. The ICPP and TRA facilities were the source of about 97% of the total radioactivity released to the atmosphere. Noble gases comprised more than 99% of the total airborne radioactive effluent.

Air emissions from nonpoint sources (RPMC, TRA ponds, and ICPP ponds) were evaluated. None of these sources were significant enough to warrant including the effluents in the dose calculations.

The total annual airborne radioactive effluent varies from year to year, depending on which processes are active at INEL facilities. The 1989 annual total of less than 22,000 Ci was much lower than the 1988 total. The difference is primarily due to a decrease in the amount of Kr-85 released from ICPP. For purposes of comparison, total airborne radioactive effluent releases for the past five years were as follows: 1985—77,000 Ci, 1986—14,500 Ci, 1987—less than 165,000 Ci, 1988—less than 124,000 Ci, 1989 less than 22,000 Ci.

No liquids were released directly into the offsite environment. Onsite releases are summarized in Table B-11, Appendix B. Most liquid radioactive effluents are discharged into seepage ponds. The effluent listed for CFA is discharged through a sewage treatment facility. Site-related radioactive liquids have never been detected outside the INEL boundaries.

Assessment of Potential Radiation Dose to the Public

General Information

Usually, the radiological impact of INEL operations on the resident public surrounding the Site has been too small to be measured by the routine monitoring program. Therefore, the radiological impact of INEL operations by the air pathway has traditionally been estimated using the known amounts of various radionuclides released during the year from Site facilities and the MESODIF meteorological model,¹⁷ described in the next section, to determine the concentrations at selected locations in the vicinity. During 1989, this was done for the radionuclides released from Site facilities to the atmosphere, as summarized in Table B-10, Appendix B.

Because of the different applicable standards for radiation protection of the public (see the "Environmental Standards, Regulations, and Permits" section) and reasons discussed below, two different air dispersion

models and sets of dose conversion factors were used to calculate

- The total-body and organ dose equivalent to the maximally exposed individual residing offsite using the AIRDOS-EPA and RADRISK models
- The effective dose equivalent based on AIRDOS-EPA and RADRISK models
- The effective dose equivalent to the maximally exposed individual residing offsite using the MESODIF dispersion model and DOE dose conversion factors^{18,19}
- The collective effective dose equivalent (population dose) within an 80-km (50-mi) radius of the operations center of the Site (TRA and ICPP) using the MESODIF dispersion model and DOE dose conversion factors.

For simplicity, the term "dose" will be used to mean "effective dose equivalent" in the following dose assessment sections, unless another term is specifically stated. The effective dose equivalent was calculated by summing the committed dose equivalents to organs, each multiplied by a weighting factor that is proportional to the organ's radiosensitivity. The effective dose equivalent includes doses received from both external and internal sources and represents the same risk as if an individual's whole body was irradiated uniformly. For calculations using DOE dose conversion factors, a 50-yr integration period is used both for internally deposited radionuclides and for radionuclides deposited on ground surfaces. A 70-yr integration period is used by the AIRDOS/RADRISK codes. No allowance was made for shielding by housing materials or residence time in the community in any of the dose calculations.

The possible exposure pathways by which radioactive materials from Site operations could be transported to offsite environs are shown diagrammatically in Figure 11. There are no surface streams flowing from within the INEL to offsite locations. The leading edge of the tritium plume (shown earlier in Figure 7), the most mobile low-level radioactive waste in the aquifer, reached the Site boundary in 1983 at low concentrations. However, tritium from the INEL has never been detected in any of the wells south of the boundary. Thus, atmospheric transport is the principal potential exposure pathway from the Site and is described in the section "Maximum Individual Dose—Airborne Emissions Pathway Only."

Figure 11. Possible exposure pathways of the INEL Site radioactive materials to members of the public.

Several indirect exposure pathways are being studied at the INEL to determine their effect, if any, on the highest possible dose that could have been received by a member of the public. The principal indirect exposure pathway involves the eating of game species that have spent time on the Site. The amount of radioactivity present in game species depends upon the length of residence onsite, the Site location at which the animals spent time, the time elapsed since migration from the Site, and the metabolism of the animal. Estimates of the maximum potential dose to a person consuming meat from different game animals is described in the

section "Maximum Individual Dose—Game Ingestion Pathway."

Maximum Individual Dose—Airborne Emissions Pathway Only

During 1989, EPA regulations were in effect that limited the amount of airborne radionuclides released from DOE facilities to a whole-body dose equivalent of 25 mrem/yr (75 mrem/yr to the critical organ) to any member of the public. The EPA has specified that the AIRDOS-EPA computer program shall be used to

demonstrate compliance unless an alternate model has been approved by the Administrator of the EPA.

Using the AIRDOS-EPA and RADRISK codes, a 1989 total-body dose equivalent of 0.0009 mrem was calculated for "members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides or abides" (40 CFR 61, Subpart H.) This dose equivalent is 0.004% of the EPA airborne radionuclide emission standard. The critical organ, the thyroid in this case, was calculated to receive a dose equivalent of 0.005 mrem for 1989, which is 0.007% of the standard. Although not required by this regulation, the effective dose equivalent calculated using the AIRDOS-EPA code was 0.0012 mrem for 1989. The member of the public receiving the maximum dose equivalent in 1989, as calculated by the AIRDOS-EPA code, would have been located near Mud Lake, Idaho, 40 km (25 mi) northeast of the operations center of the INEL

Site. The EPA issued a Final Rule for "National Emission Standards for Hazardous Air Pollutants; Radionuclides" in December 1989²⁰ that changed the airborne radionuclide emission standard to an effective dose equivalent of 10 mrem/yr. The standard is effective for calendar year 1990.

The MESODIF air dispersion model has been used for 17 years to calculate doses to members of the public residing near the INEL. It is included here to allow comparison to previous years. In addition, for reasons discussed in the 1986 report,²¹ the MESODIF model offers significant advantages over the dispersion portion of the AIRDOS-EPA model when assessing doses to the public from INEL Site operations.

The mesoscale meteorological map (Figure 12) shows the calculated 1989 concentrations normalized to a unit release rate for the INEL Site and vicinity. This map has been prepared by the National Oceanic

Figure 12. 1989 average of mesoscale dispersion isopleths of air concentrations at ground level, normalized to unit release rate.

and Atmospheric Administration (NOAA) at the INEL using the MESODIF model and data gathered continuously at meteorological stations on and around the Site. To facilitate the display, the dispersion coefficient values are given in whole numbers and must be multiplied by $10^{-9} \text{ h}^2/\text{m}^3$. To obtain the average air concentration (Ci/m^3) for a radionuclide released from TRA or ICPP along any dispersion coefficient isopleth in Figure 12, the value of the 1989 average dispersion coefficient (e.g., $30 \times 10^{-9} \text{ h}^2/\text{m}^3$) was multiplied by the number of curies of the radionuclide released during 1989 and divided by the number of hours in a year squared (7.67×10^7).

As indicated in Figure 12, the MESODIF model predicts that the highest concentrations of radionuclides in air for an inhabited area would occur at Atomic City, Idaho. The maximum hypothetical dose was calculated for an adult resident of that location from inhalation of air, submersion in air, ingestion of radioactivity on leafy vegetables, and exposure due to deposition of particulates on the ground surface. The calculation was based on data presented in Table B-10 and Figure 12. Using $76 \times 10^{-9} \text{ h}^2/\text{m}^3$ as the dispersion coefficient for that area and allowing for radioactive decay during the 19-km (12-mi) transit of the radionuclides from the TRA-ICPP complex to the Atomic City location, the potential effective dose equivalent from all radionuclides released was calculated to be 0.007 mrem ($7 \times 10^{-5} \text{ mSv}$) (Table V). This dose is 0.007% of the DOE radiation protection standard for a prolonged period of exposure to a member of the public from all pathways and 0.03% of the EPA standard for the airborne emissions pathway only.

The ICPP processes were not operating for most of calendar year 1989. Consequently, TRA releases result in the highest doses for 1989, as in 1985 and some other prior years. In 1988, about 68% of the 0.13-mrem computed dose was due to Sb-125; but Sb-125 was not a major contributor to the 1989 dose because the nuclide was not released from ICPP in significant quantities during 1989. Ar-41 was the major contributor to the 1989 dose. Figures 13 and 14 illustrate the proportion of specific nuclides comprising the maximum individual dose for 1988 and 1989, respectively.

One of the parameters necessary to convert air concentrations into dose equivalents is the deposition velocity—the rate at which the particulates are deposited on the surface of the ground. For the calculations based on the MESODIF model, a deposition velocity for particulates of 0.18 cm/s was used, which is consistent with other INEL dose assessments. A deposition

TABLE V.
MAXIMUM INDIVIDUAL EFFECTIVE
DOSE EQUIVALENT (1989)

Radionuclide ^a	Maximum Offsite Concentration ^b ($\mu\text{Ci}/\text{mL}$)	Maximum Effective Dose Equivalent ^c	
		(mrem)	(mSv)
Ar-41	6.0×10^{-13}	0.004	4×10^{-5}
Kr-88 + D	4.6×10^{-14}	0.0008	8×10^{-6}
Xe-138 + D	2.6×10^{-16}	0.0008	8×10^{-6}
Kr-85	2.0×10^{-11}	0.0005	5×10^{-6}
Xe-135	1.4×10^{-13}	0.0002	2×10^{-6}
I-129	4.7×10^{-19}	0.0001	1×10^{-6}
Kr-87	2.3×10^{-14}	0.0001	1×10^{-6}
Xe-133	4.0×10^{-13}	0.0001	1×10^{-6}
Total		0.0066	6.6×10^{-5}

a. Table includes only radionuclides that contribute a dose of 0.0001 mrem ($1 \times 10^{-6} \text{ mSv}$) or more. When indicated (+ D), the contribution of daughter decay products was included in the dose calculations.

b. Estimate of radioactive decay obtained by using the 1989 average windspeed from 315° – 325° of 8.7 km/h and a distance of 19.1 km from TRA-ICPP to the Atomic City area, the location where the maximally exposed individual would have resided. For nuclides where parent-daughter equilibria were used in dose calculations, concentration of the parent is shown.

c. Effective dose equivalent estimated using dose conversion factors for inhalation and ingestion from Reference 18 and dose conversion factors for submersion and deposition from Reference 19.

velocity for elemental iodines of 1.8 cm/s was used. Organic iodides, which make up two-thirds of the ICPP I-129 releases, have a much lower deposition velocity to ground surfaces (0.018 cm/s).

For 1989, the AIRDOS-EPA model predicts that the maximally exposed individual would have resided 40 km (25 mi) northeast of the INEL operations center, near Mud Lake, Idaho, whereas the MESODIF model places that hypothetical individual in Atomic City, Idaho. There is a distance of about 50 km (31 mi) between the two points. The effective dose equivalent, calculated using AIRDOS-EPA, is 0.0012 mrem ($1.2 \times 10^{-5} \text{ mSv}$), and the dose using MESODIF is

Figure 13. Nuclides contributing to maximum individual dose in 1988.

Figure 14. Nuclides contributing to maximum individual dose in 1989.

0.007 mrem (7×10^{-5} mSv). There are major differences in some of the dose conversion factors and in the atmospheric dispersion portions of the two codes. These differences were discussed in the 1986 report (Reference 21). The effective dose equivalent calculated by AIRDOS-EPA is primarily due to Ar-41 and I-129. Again in 1989, the AIRDOS-EPA code appears to underpredict ground-level air concentrations at the INEL Site boundary. The MESODIF diffusion curves, developed from tests at the INEL and Hanford desert environments, appear to be more appropriate for the INEL Site.

The calculated dose (0.007 mrem) resulting from INEL operations is very small compared to the measured 112 mrem average dose individuals in southeastern Idaho received from cosmic and terrestrial radiation during 1989. The calculated dose is even smaller compared to the total estimated effective dose equivalent from natural background radiation of 350 mrem (see Table IV). For perspective, the calculated dose may also be compared to the approximately 30-mrem average dose received from medical diagnostic procedures, the 4-mrem average dose received from highway and road construction materials, and the 0.04 to 0.1 mrem received from luminous watches and clocks.¹⁴ Another source has estimated that the average 5-h jet flight contributes a dose of about 0.7 mrem to passengers, and that the average television viewer receives about 0.05 to 0.1 mrem annually.²²

Maximum Individual Dose—Game Ingestion Pathway

Potential dose to an individual from occasional ingestion of meat from game animals continues to be investigated. One group of studies involves the calculation of potential doses to individuals who might eat ducks that reside briefly upon liquid waste ponds used for the disposal of low-level reactor effluents. In one study, wing-clipped adult mallards were released on the TRA radioactive waste infiltration pond for 56–188 days before collection. The average potential whole body dose equivalent from gamma-emitters due to consumption of the meat of cooked ducks (not including the juices in the pan) was calculated to be 10 mrem.²³

In another study, wing-clipped mallards were released on the TRA pond and after collection, various tissues were analyzed for concentrations of Sr-90, Pu-238, Pu-239/240, Am-241, Cm-242, and Cm-244. The potential effective dose equivalent to a human consuming the entire muscle and liver mass of one experimental duck with average nuclide concentrations was 0.046 mrem from those specific

nuclides.²⁴ These calculated doses are based on the assumption that the duck would be killed and eaten immediately after leaving the pond. However, it is unlikely a duck from the pond would be killed immediately, so a lower dose would be more realistic due to biological elimination of the radioactivity. Because only about one duck in 4000 passing through this part of Idaho is likely to spend time on Site ponds, there is a low probability of a hunter receiving this dose.²⁵

The highest estimated potential whole-body dose equivalent to a person eating the entire muscle mass of a sage grouse that summered near the TRA-ICPP area is 2 mrem.²⁶ The maximum whole-body dose equivalent from consumption of sage grouse from other on-site locations and offsite areas ranges from 0.01 to 0.04 mrem.

The maximum potential whole-body dose equivalent to a person eating the muscle tissue of one mourning dove from the TRA pond area is 0.3 mrem. The average whole-body dose equivalent to people consuming doves migrating from onsite to offsite areas is 0.01 mrem, which is the same as for control birds collected far from the INEL.²⁷

A conservative (or high) estimate of the potential whole-body dose equivalent that could be received by a single individual eating the entire muscle and liver mass of an antelope (collected on the INEL after August 1975) with the highest levels of radionuclides is 0.2 mrem.²⁸

80-Kilometer Population Dose

An estimate was made of the collective effective dose equivalent (population dose) from inhalation, submersion, ingestion, and deposition that could have been received by all members of the public within an 80-km (50-mi) radius of the TRA-ICPP complex. This population dose (person-rem) is calculated by a computer program that multiplies the population number in each square mile²⁹ by the dispersion coefficient at that point (h^2/m^3) and the normalized dose received

at the location of the maximally exposed individual (rem per yr/h^2 per m^3). The calculation overestimates dose, however, because radioactive decay of the isotopes was not calculated during transport over distances greater than the 19 km (12 mi) from the TRA-ICPP midpoint to the Atomic City maximum location. Idaho Falls, for example, is about 66 km (41 mi) from TRA-ICPP. Neither residence time nor shielding by housing was taken into account.

The population dose within each census division (Table VI) was obtained by summing the results from appropriate areas contained within those divisions. The total 80-km (50-mi) population dose was the sum of population doses for the various census divisions. The estimated potential population dose was 0.04 person-rem (4×10^{-4} person-Sv) to a population of about 121,000. When compared with an approximate population dose of 42,400 person-rem (424 person-Sv) from natural background radiation, this represents an increase of only about 0.00009% ($9 \times 10^{-5}\%$). The dose of 0.04 person-rem can also be compared to the following estimated population doses for the same size population: 3600 person-rem for medical diagnostic procedures, about 480 person-rem from exposure to highway and road construction materials¹⁴, or 6-12 person-rem for television viewing.²²

Table VII summarizes the calculated annual effective dose equivalents from 1989 INEL operations for both AIRDOS-EPA and MESODIF calculational methods.

The contribution of game animal consumption to the population dose has not been calculated because of uncertainties regarding the number of people exposed, the small probability of obtaining game animals migrating from the Site during hunting season, and the levels of different radionuclides in various animals. The total population dose contribution from these pathways would, realistically, be less than the sum of population doses from inhalation of air, submersion in air, and deposition on soil.

TABLE VI
80-KILOMETER POPULATION DOSE (1989)

Census Division	Population ^a 1989	Population Dose ^b	
		(person-rem)	(person-Sv)
Aberdeen	2850	0.0013	1.3×10^{-5}
Alridge (part)	160	0.000008	8×10^{-8}
American Falls (part)	110	0.000015	1.5×10^{-7}
Arco	2950	0.00061	6.1×10^{-6}
Atomic City (city)	35	0.00019	1.9×10^{-6}
Atomic City (division)	2300	0.00017	1.7×10^{-6}
Blackfoot	13,380	0.0016	1.6×10^{-5}
Carey (part)	120	0.000002	2×10^{-8}
Challis (part)	10	0.0000001	1×10^{-9}
Firth	3720	0.00041	4.1×10^{-6}
Fort Hall (part)	3930	0.00037	3.7×10^{-6}
Hamer	2590	0.0079	7.9×10^{-5}
Howe	450	0.00079	7.9×10^{-6}
Idaho Falls	62,060	0.012	1.2×10^{-4}
Idaho Falls West	2060	0.00021	2.1×10^{-6}
Leadore	15	0.000003	3×10^{-8}
Lewisville-Menan (part)	2440	0.0021	2.1×10^{-5}
Mackay (part)	1100	0.000091	9.1×10^{-7}
Moreland	8500	0.0034	3.4×10^{-5}
Rigby (part)	640	0.00017	1.7×10^{-6}
Roberts	1430	0.0035	3.5×10^{-5}
Shelley	6550	0.00073	7.3×10^{-6}
Ucon (part)	3690	0.00079	7.9×10^{-6}
West Clark (part)	90	0.00021	2.1×10^{-6}
Totals	121,180	0.037	3.7×10^{-4}

a. Population for each division was based on the 1980 Advance Census Report for Idaho adjusted to estimate 1989 levels.

b. These population doses do not include radioactive decay beyond 19.1 km.

TABLE VII
SUMMARY OF ANNUAL EFFECTIVE DOSE EQUIVALENTS DUE TO 1989 INEL OPERATIONS

	Maximum Dose to an Individual ^a		Collective Dose to Population within 80 km
	MESODIF ^b	AIRDOS-EPA ^c	MESODIF
Dose	0.007 mrem (7×10^{-5} mSv)	0.0009 mrem (9×10^{-6} mSv)	0.04 person-rem (4×10^{-4} person-Sv)
Location	Atomic City	Terreton area	Area within 80-km circle
Applicable Radiation Protection Standard	100 mrem	25 mrem ^d	—
Percentage of Standard	0.007%	0.004%	—
Natural Background	350 mrem (3.5 mSv)	350 mrem (3.5 mSv)	42,400 person-rem (424 person-Sv)
Percentage of Background	0.0019%	0.0003%	0.00009%

- a. Hypothetical dose to a maximally exposed individual residing near the INEL. Calculations do not consider occupancy time or shielding by buildings.
- b. Effective dose equivalent calculated with the MESODIF air dispersion model used for 17 years to calculate doses to members of the public residing in the INEL vicinity.
- c. Total body dose equivalent calculated using the AIRDOS-EPA and RADRISK codes required to demonstrate compliance. For comparison with MESODIF, the AIRDOS-EPA effective dose equivalent for the maximally exposed individual for 1989 was 0.0012 mrem (1.2×10^{-5} mSv).
- d. EPA standard is for total body dose equivalent, airborne pathways only. The standard listed under the MESODIF model is a DOE standard for effective dose equivalent for all pathways.

GROUND-WATER MONITORING PROGRAM INFORMATION

General USGS Program Information

There are no streams or rivers flowing from within the INEL to locations outside the boundaries, so water sampling is limited to onsite and offsite ground-water monitoring plus samples from the Snake River and other surface streams and tributaries in the INEL vicinity, some of which flow onto the Site and sink into its porous soils. A brief description of the hydrogeology of the INEL and the movement of water in the Snake River Plain aquifer is given in Appendix A. Further information may be found in References 5 and 30. The Snake River Plain aquifer, which lies beneath the INEL, serves as a primary source for drinking water and crop irrigation in the Snake River Basin. Therefore, the USGS extensively monitors the aquifer and perched water bodies above it on the INEL Site and at a few locations beyond the southern and western boundaries. The USGS maintains more than 90 aquifer observation wells on or near the INEL, and more than 170 wells and auger holes are available for sampling perched ground-water bodies. Water levels in wells and various radiological and nonradiological substances in the aquifer are monitored. Reference 5 contains maps showing the frequency of water level measurements and water sample collections, as well as information on the shape and extent of waste plumes (i.e., the spread of various contaminants in the aquifer and perched water from INEL facilities) as they were between 1982 and 1985.

In the water sampling portion of the "Environmental Radiological Program Information" section, the RESL portion of the radiological ground-water monitoring was described and 1989 results were summarized. The USGS routine ground-water surveillance program was summarized in Table II in the section "Environmental Program Information." However, the USGS also conducts special studies of the ground water of the Snake River Plain that are not included in the Table II summary. These special studies provide more specific geological and hydrological information on the flow and recharge of the aquifer and the movements of radioactive and nonradioactive substances in the ground water. Most of the information from these studies is published in USGS reports.

During 1989, USGS personnel collected 728 samples (including routine samples summarized in Table II) that were analyzed by the Analytical Chemistry Branch at RESL for radionuclides. One hundred fifty-nine samples were sent to the USGS Laboratory in Arvada, Colorado for nutrient analyses (nitrates, phos-

phates, etc.); 129 samples for purgeable organics, 15 for metals and 236 for radionuclides. Results of analyses collected for special studies will be summarized in this section of future reports when they are published by the USGS.

Contractor personnel also collect monthly drinking water samples for bacteriological tests, but results of these analyses will be summarized in the nonradiological summary of this section only if a contamination problem occurs.

Summary of Radiological Surveillance Results

All radioactivity detected in drinking water samples collected by RESL is evaluated in this report and summarized in the "Environmental Radiological Program Information" section and Appendix B tables. USGS results are briefly discussed here. Results of monitoring or surveillance activities that are published in reports are summarized in the year of publication but may refer to sampling programs of earlier years. If data are not to be published, a summary will be made as soon as results are available. USGS results are also available upon request from the USGS INEL Project Office at CFA.

One sample from each of the three offsite USGS wells beyond the southern and western Site boundaries was submitted for gross alpha, gross beta, and tritium. None indicated detectable radioactivity.

A group of 53 samples from wells and springs in the Thousand Springs area, a major discharge area of the Snake River Plain aquifer downgradient from the INEL Site, was included in the 728 samples collected by the USGS for radionuclide analyses during 1989. No tritium was detected in any of the samples.

Summary of Nonradiological Surveillance Results

Bacteriological Monitoring

During 1989, bacteriological water quality tests were positive for coliform bacteria in the drinking water distribution system only at Fire Station #2 (FIRE), which is approximately four miles north of CFA. There are no longer any personnel working full-time at this facility. It is primarily used by the Fire Department for training exercises and it is occasionally used by subcontractors for construction purposes. The October 1989 sample from FIRE contained two colonies of coliform bacteria. Personnel flushed the system and posted it as nonpot-

able water. However, the water at FIRE is used only for firefighting and construction purposes. November and December samples were negative for coliform colonies.

Chemical Monitoring

The USGS determined the quantity of nonradiological wastes in the aquifer by measuring specific conductance and sodium, chromium, chloride, and nitrate concentrations. (see References 5 and 30). All of these waste products were at background levels at least 4 km (2.5 mi) inside the nearest Site boundary, indicating that INEL ground water nonradiological plumes had not migrated offsite by the end of 1989.^a

WINCO personnel sample the production and potable wells at the ICPP facility monthly for arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, chloride, fluoride, nitrate, and sulfate ions. None of these well samples exceeded the EPA maximum contaminant levels or State of Idaho drinking water limits during 1989.^b

Purgeable Organic Compounds Monitoring

Sampling for purgeable organic compounds in ground water was conducted by the USGS at the INEL Site during January to December 1989. Water samples from 4 production wells and 21 ground water quality monitoring wells that tap the Snake River Plain aquifer were collected and analyzed for 36 purgeable organic compounds. The ground water samples were analyzed at the USGS National Water Quality Laboratory in Arvada, Colorado. In addition, two replicate samples with fictitious numbers were submitted for analysis to the Arvada Laboratory. A 1987 USGS report on the purgeable organic compounds sampling program describes in detail the methods used to collect the water samples and to ensure sampling and analysis quality.³¹

In the USGS sampling at INEL, 14 purgeable organic compounds were detected (above 0.2 µg/L), including carbon tetrachloride; chloroform; 1,1,1-trichloroethane; trichloroethylene; tetrachloroethylene; dichlorodifluoromethane; 1,1-dichloroethane; 1,1-dichloroethylene; 1,2-trans-dichloroethylene; toluene; 1,1,2-trichloroethane; 1,4-dichlorobenzene; benzene; and total xylenes. As with any type of analytical procedure, concentrations near the minimum detectable concentration are difficult to interpret and,

because of analytical and sampling uncertainties, may not actually be present in the sample (see Appendix C). Therefore, to simplify the data table, only concentrations equal to or greater than 1.0 µg/L (parts per billion) for the individual wells are reproduced in Table B-12, Appendix B. The corresponding well locations are shown in Figure B-1, Appendix B. The highest levels of organic contamination were found in water pumped from a disposal well at TAN (TAN Disposal), which has not been used since 1972. Investigations are continuing at TAN to determine the source of the contaminants and a Corrective Action Plan was submitted to the EPA in 1988. As discussed in the "Significant Environmental Activities" section of this report, sediments have been removed from this disposal well, and the concentration of purgeable organic compounds is expected to decrease over time. At the RWMC, the carbon tetrachloride concentration is presumably due to solvents in the containers of radioactive waste buried prior to 1970. DOE accelerated the RWMC Subsurface Investigation Program and performed demonstration tests of the Vapor Vacuum Extraction process and the In-situ Vitrification process, which may ultimately be used in the environmental restoration of the subsurface areas at the RWMC.

The only two drinking water wells sampled by the USGS in 1989 that contained purgeable organic compounds were the ANP-8 well at TAN, which had detectable concentrations of trichloroethylene (TCE) and tetrachloroethylene, and the RWMC production well, which had small quantities of carbon tetrachloride and concentrations not shown of 1,1,1-trichloroethane and TCE at 0.3 µg/L and 0.6 µg/L, respectively. The average concentration of carbon tetrachloride at RWMC is 1.4 µg/L, or 28% of the EPA maximum contaminant level, and the average concentrations of the other two compounds in the RWMC production well are 0.15% and 12% of the appropriate maximum contaminant levels, respectively. At TAN, the water is treated before entering the drinking water system to decrease the concentrations of purgeable organic compounds, and contractor personnel sample drinking water regularly at TAN for TCE according to their Corrective Action Plan.

At any facility, the concentration of purgeable organic compounds measured in a sample collected at the wellhead is typically reduced after the water has passed through a storage tank and into the distribution system simply because the compounds are volatile. Therefore, the concentrations of purgeable organic compounds present in drinking water at the fountains and taps of a facility are even lower with respect to EPA regulations and do not represent a health hazard to Site workers or members of the public.

a. L.J. Mann, private communication, USGS, INEL, April 1989.

b. D. Davis, private communication, Westinghouse Idaho Nuclear Company, INEL, April 18, 1990.

ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

Summary of Air Sampling Results

Atmospheric particulate matter is routinely monitored at the low-volume air sampling stations using the filters previously described. A summary of the results for 1989 is given in Table B-13, Appendix B. The analysis involves determining the net weight of the particulate matter on the quarterly composite of weekly filters at each station. The concentrations of the samples ranged from 2 to 100 $\mu\text{g}/\text{m}^3$. The distant mean was $40 \pm 14 \mu\text{g}/\text{m}^3$, the boundary mean was $30 \pm 7 \mu\text{g}/\text{m}^3$, and the onsite mean was $17 \pm 2 \mu\text{g}/\text{m}^3$. The distant mean is greater than the onsite mean, probably because of the amount of resuspended dust from agricultural operations near the distant sampling locations. Most of the airborne particulates in the Site vicinity are windblown dust from the desert floor. The above concentrations may be compared to the EPA national secondary ambient air quality standard for particulate matter of $60 \mu\text{g}/\text{m}^3$. On July 1, 1987, the EPA revised the standard for particulate matter to $50 \mu\text{g}/\text{m}^3$. The new standard is a primary and secondary standard, but it applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers."³² Measurements of total suspended particulates, such as those reported here, will overestimate particulate concentrations (appear greater than is actually true) in comparison with the new standard. For example, the distant mean of $40 \mu\text{g}/\text{m}^3$ appears to be 80% of the standard, whereas the actual percentage is lower. The standard applies only to particles on the filter with diameters of 10 μm or less, but many of the particles on the RESL filters are actually larger than that size because there is no device on the samplers to screen out the larger particles.

One sampler, dedicated to the measurement of total suspended particulates and having an approximate minimum detectable concentration of $2 \mu\text{g}/\text{m}^3$, is located at CFA. The sampler normally operates for 24 h every 6 d, but it was not operating during most of the first quarter of 1989. The annual arithmetic mean particulate matter concentration of samples from the CFA sampler was $40 \pm 7 \mu\text{g}/\text{m}^3$ with a range of 5 to $88 \mu\text{g}/\text{m}^3$. This mean is 80% of the EPA standard mentioned above. This sampler is not equipped with a device designed to screen out large particles (greater than 10 μm in diameter), therefore, the CFA percentage, too, is overestimated.

To fulfill one of the conditions specified in the Permit to Construct Fuel Processing Restoration, two nitrogen oxide monitoring stations were activated by RESL. One sampler is located near the intersection of US Highway 20/26 and Van Buren Boulevard (VANB) and the second is at EFS. The analyzers used are EPA equivalent methods. Both samplers operated satisfactorily 75 to 99% of the time they were on line. At VANB, the annual mean concentration of NO_x for 1989 was about $11 \mu\text{g}/\text{m}^3$ (11% of the applicable EPA standard). At EFS, the annual mean concentration was $7 \mu\text{g}/\text{m}^3$ (7% of the standard). At these locations, the mean concentrations of these gases are calculated to be greater than at the nearest Site boundary in the directions of the prevailing winds. However, even at the on-site locations both annual means are well below the national primary ambient air quality standard of $100 \mu\text{g}/\text{m}^3$. Ambient sulfur dioxide was measured at VANB only during the fourth quarter, and the mean concentration was $0.20 \mu\text{g}/\text{m}^3$ (0.25% of the EPA annual standard).

The average sulfur dioxide and nitrogen dioxide concentrations at the Site boundary are calculated each year using the total 1989 discharges as reported by the Industrial Waste Management Information System.^a Concentrations are calculated from the releases from the Coal-Fired Steam Generating Facility (CFSGF) monitoring data and the MESODIF air dispersion model¹⁷ (Figure 12). The calculation method is the same as described in the Section "Assessment of Potential Radiation Dose to the Public—General," using mass units for releases instead of radioactivity units.

Total sulfur dioxide released in 1989, shown in Table B-14, Appendix B, was about $2.4 \times 10^5 \text{ kg}$. The maximum concentration of sulfur dioxide at the southern INEL boundary, where the MESODIF model predicted the highest concentration, was $0.6 \mu\text{g}/\text{m}^3$, which is well below the national primary ambient air quality standard of $80 \mu\text{g}/\text{m}^3$.

The releases of nitrogen oxides during 1989 are also shown in Table B-14, Appendix B. When the nitrogen oxide was converted to nitrogen dioxide, the total released was about $1.8 \times 10^5 \text{ kg}$. The calculated maximum Site boundary concentration of nitrogen dioxide was $0.5 \mu\text{g}/\text{m}^3$ from all INEL sources. This concentration is well below the national primary ambient air quality standard of $100 \mu\text{g}/\text{m}^3$.

a. Preliminary INEL Industrial Waste Management Information System data.

Summary of Nonradioactive Effluent Monitoring

Nonradioactive airborne effluents originate from five primary sources at the INEL: calcination of high-level radioactive liquid waste at the New Waste Calcining Facility (NWCF), combustion of coal for steam generation at CFSGF, combustion of fuel oil for heating at all INEL facilities, motor vehicle exhausts, and fugitive dusts from waste burial and construction activities.

Nitrogen oxide emissions are routinely monitored at the NWCF. Sulfur dioxide, nitrogen oxides, and carbon oxides are monitored at the CFSGF. Emissions of sulfur dioxide from heating oils are calculated from sulfur content and the amount of fuel used. Emissions of nitrogen oxides from fuel are calculated using emission factors developed by the EPA³³ and the amount and type of fuel burned at each facility as reported by the Industrial Waste Management Information System. Motor vehicle exhausts and fugitive dusts are not monitored at their sources. Major nonradioactive airborne effluents for 1989 are given in Table B-14, Appendix B.

Nonradioactive liquid effluents are disposed of primarily to a waste ditch at the NRF; seepage ponds at the Contained Test Facility (CTF), TAN, TRA, ICPP, and WRRTF; a lined evaporation pond at the Power Burst Facility (PBF); an industrial waste pond at

ANL-W; and through sewage treatment facilities at various locations (Reference 16).

Routine direct disposal of wastes to the Snake River Plain aquifer ceased in 1984. The only other injection wells on the INEL are used for storm runoff water. No waste is discharged to the Big Lost River, the only surface stream on the INEL that might conceivably accept waste water.

The extent of effluent monitoring for liquid waste streams varies depending on the nature of the effluents. The largest effluent stream, that from the ICPP, is monitored by monthly composite samples analyzed for arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, chloride, fluoride, nitrate, sulfate, conductivity, total dissolved solids, and pH. According to WINCO personnel, all analytical results for 1989 were less than concentrations defined as hazardous waste in 40 CFR 261.24.^a Other waste effluents are calculated from the amounts of chemicals used for water treatment, corrosion control, and demineralization; as cleansers, and algicides; and occasionally from waste acids. Sewage processed by treatment facilities is monitored for biochemical oxygen demand, dissolved oxygen, settleable solids, and pH. Results are reported annually by the Industrial Waste Management Information System.

a. D. Davis, private communication, Westinghouse Idaho Nuclear Company, INEL, April 18, 1989.

QUALITY ASSURANCE

A quality control and assurance program is maintained by RESL to ensure consistent and reliable monitoring results. An internal quality control program is maintained by the following:

- Adherence to written procedures for sample collection and analytical methods³⁴
- Documentation of program changes
- Periodic calibration of instruments
- Equipment performance checks for background and counting rates of standards
- Routine yield determinations of radiochemical procedures
- Replicate samples to determine precision
- Analysis of quality control standards in appropriate matrices to test accuracy (except for gross alpha and gross beta)

- Analysis of reagent blanks to verify that there is no radiochemical contamination
- Propagation of random and systematic uncertainties.

The calibration of counting instruments is carefully performed and is traceable to the National Institute of Standards and Technology (NIST). Six times per year, tracer solutions or other standard Intercomparison Test Program sample media with known, but unrevealed, concentrations are sent to the Analytical Chemistry Branch (ACB) at RESL. ACB analyzes the samples per instructions for various gamma ray emitters, beta emitters (including Sr-90 and tritium), and alpha emitters such as Pu-238, Pu-239, and Am-241. The results for ACB analyses compared to NIST known values for 1989 given in Table VIII were reported directly to the NIST. They are generally traceable to within 5% of the standard value. ACB then sends some samples to other INEL laboratories that voluntarily participate in the Intercomparison Test Program (INEL contractor and project office laboratories). Results reported by all laboratories are then compared to known values and to results from the other participating laboratories.

TABLE VIII
NIST QUALITY ASSURANCE COMPARISON TEST RESULTS^a

Reference Date	Radionuclide	RESL Result		NIST Result		Ratio RESL/NIST ^c
		Value (Bq/g)	Uncertainty (%) ^b	Value (Bq/g)	Uncertainty (%) ^b	
2-1-89	Co-57	1402	3.6	1533	1.08	0.91
	Co-60	2005	3.6	2049	0.67	0.98
	Cs-137	2601	3.6	2658	1.11	0.98
4-13-89	H-3	5022	2.6	5082	0.84	0.99
5-3-89	Th-230	93.8	1.6	94.3	1.35	0.99
5-10-89	Am-243	39.62	1.5	40.12	1.26	0.99
7-10-89	Sr-89	1633	1.9	1574	1.0	1.04
	Sr-90	990	3.0	980	1.1	0.99
8-29-89	P-32	625.4	4.3	610.1	2.16	1.03

- a. In 1989, the air filters prepared by NIST for this intercomparison were also used for the INEL Quality Assurance Comparison Test.
- b. The RESL uncertainty is based on the 1s estimated analytical uncertainties.
- c. Ratios of RESL to NIST results are given.

RESL/ACB also participates in the Quality Assurance Program administered by the Environmental Measurements Laboratory of DOE. Results for 1989 are reported in Table IX. As time or opportunity permits, ACB participates in the American Society for Testing Materials' round-robin testing of standard methods.

To verify the quality of the environmental dosimetry program, RESL has participated in eight International Environmental Dosimeter Intercomparison Studies. The RESL results have been within 10% of the test exposure values. The eighth intercomparison was con-

ducted in 1986 and a ninth intercomparison is tentatively scheduled in 1990.

The calibration source for the RESL environmental dosimetry program was calibrated using a reference quality transfer standard that was calibrated by NIST. The RESL calibration source was included in the DOE Intercomparison of Radiological Standards in December of 1983 and found to agree with the reference instrument to within 0.2%. Constancy checks are performed every three months with the reference quality standard.

TABLE IX
RESULTS OF RESL PARTICIPATION IN DOE ENVIRONMENTAL
MEASUREMENTS LABORATORY QUALITY ASSURANCE PROGRAM (April 1989)

Sample Medium	Units	Radionuclide	RESL ID#	RESL		EML ^a		Ratio ^c RESL/EML
				Value	Uncertainty (%) ^b	Value	Uncertainty (%)	
Air	pCi/filter	Be-7	1	1870	4	1950	5	0.96
		Be-7	2	1740	5	1950	5	0.89
		Mn-54	1	2.8	42	3.74	10	0.75
		Mn-54	2	3.2	40	3.74	10	0.86
		Co-60	1	118	4	126	4	0.94
		Co-60	2	118	4	126	4	0.94
		Sr-90	1	2.70	18	2.39	1	1.13
		Sb-125	1	29.0	13	96.8	5	0.30 ^d
		Sb-125	2	47.0	10	96.8	5	0.49 ^d
		Cs-134	1	148	4	158	5	0.94
		Cs-134	2	145	4	158	5	0.92
		Cs-137	1	198	3	189	5	1.05
		Cs-137	2	186	3	189	5	0.98
		Ce-144	1	353	7	327	6	1.08
		Ce-144	2	346	7	327	6	1.06
		Pu-239	1	0.270	11	0.270	9	1.00
	µg/filter	U-234	1	0.080	25	0.090	5	0.89
		U-238	1	0.110	18	0.090	5	1.22
Soil	pCi/g	K-40	1	26.2	4	24.1	1	1.09
		K-40	2	25.8	5	24.1	1	1.07
		Cs-137	1	22.4	3	20.8	3	1.08
		Cs-137	2	22.3	3	20.8	3	1.07
		Pu-239	1	0.46	4	0.42	5	1.10
		Pu-239	2	0.43	4	0.42	5	1.02
		Pu-239	3	0.46	4	0.42	5	1.10
		Am-241	1	0.231	5	0.210	4	1.10
		Am-241	2	0.224	5	0.210	4	1.07
		Am-241	3	0.206	5	0.210	4	0.98
Vegetation	pCi/g	K-40	1	29.5	4	26.1	1	1.13
		K-40	2	27.0	4	26.1	1	1.03
		K-40	3	26.1	4	26.1	1	1.00
		K-40	4	26.4	4	26.1	1	1.01
		Sr-90	1	3.51	3	3.75	0	0.94
		Sr-90	2	3.67	4	3.75	0	0.98

TABLE IX
(continued)

Sample Medium	Units	Radionuclide	RESL ID#	RESL		EML ^a		Ratio ^c RESL/EML
				Value	Uncertainty (%) ^b	Value	Uncertainty (%)	
	$\mu\text{g/g}$	Cs-137	1	1.94	4	1.60	2	1.21
		Cs-137	2	1.01	4	1.60	2	1.01
		Cs-137	2	1.69	4	1.60	4	1.06
		Cs-137	3	1.49	4	1.60	10	0.93
		Pu-239	1	0.021	9	0.022	10	0.95
		Pu-239	2	0.023	8	0.022	10	1.05
		Am-241	1	0.0121	13	0.015	36	0.81
		Am-241	2	0.0160	12	0.015	36	1.07
		U-234	1	0.0190	15	0.010	30	1.90 ^e
		U-234	2	0.0080	25	0.010	30	0.80 ^e
		U-238	1	0.0220	9	0.0120	25	1.83 ^e
		U-238	2	0.0087	18	0.0120	25	0.73 ^e
Water	$\mu\text{Ci/mL}$	H-3	1	5.90	5	6.31	7	0.94
		H-3	2	5.80	5	6.31	7	0.92
		Mn-54	1	0.326	5	0.300	6	1.09
		Mn-54	2	0.353	5	0.300	6	1.18
		Co-57	1	0.820	3	0.880	5	0.93
		Co-57	2	0.830	3	0.880	5	0.94
		Co-60	1	0.890	4	0.940	5	0.95
		Co-60	2	0.910	4	0.940	5	0.97
		Sr-90	1	0.570	3	0.550	3	1.04
		Sr-90	2	0.570	3	0.550	3	1.04
	$\mu\text{g/mL}$	Cs-134	1	2.52	3	2.73	5	0.92
		Cs-134	2	2.49	3	2.73	5	0.91
		Cs-137	1	2.68	3	2.55	5	1.05
		Cs-137	2	2.63	3	2.55	5	1.03
		Ce-144	1	2.69	8	1.89	4	1.42 ^f
		Ce-144	2	2.71	8	1.89	4	1.43 ^f
		Pu-239	1	0.0061	4	0.0059	5	1.03
		Pu-239	2	0.0060	5	0.0059	5	1.02
		U-234	1	0.0040	4	0.0045	6	0.89
		U-234	2	0.0043	6	0.0045	6	0.96
		U-238	1	0.0044	4	0.0044	6	1.00
		U-238	2	0.0044	4	0.0044	6	1.00

a. The EML value is the mean of replicate determinations for each nuclide. The EML uncertainty is the standard error of the mean.

b. The RESL uncertainty is based on the 1s estimated analytical uncertainties.

c. Comparison ratio in which the RESL value is divided by the EML value.

d. Antimony-125 is a volatile component in the standard distributed by EML.

e. RESL results demonstrate the heterogeneity of the standard and are similar to results from other laboratories.

f. Ratio was 0.97 for both samples when the spectrum was re-examined August 23, 1989 using a new gamma spectrometry library.

ENVIRONMENTAL STANDARDS AND REGULATIONS

The following environmental standards and regulations are applicable, in whole or in part, on the INEL Site or at the INEL Site boundary.

U.S. Department of Energy, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A, August 1981.

U.S. Environmental Protection Agency, "National Primary and Secondary Ambient Air Quality Standards," 40 CFR 50, 1989.

U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants," 40 CFR 61, 1988.^a

U.S. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," 40 CFR 141, 1989.

U. S. Environmental Protection Agency, "EPA General Regulations for Hazardous Waste Management," 40 CFR 260, 1989.

U.S. Environmental Protection Agency, "EPA General Regulations for Identifying Hazardous Wastes," 40 CFR 261, 1989.

U. S. Environmental Protection Agency, "EPA Regulations for Hazardous Waste Generators," 40 CFR 262, 1989.

U. S. Environmental Protection Agency, "EPA Regulations for Hazardous Waste Transporters," 40 CFR 263, 1989.

U. S. Environmental Protection Agency, "EPA Regulations for Owners and Operators of Permitted Hazardous Waste Facilities," 40 CFR 264, 1989.

U. S. Environmental Protection Agency, "EPA Interim Standards for Owners and Operators of Permitted Hazardous Waste Facilities," 40 CFR 265, 1989.

U. S. Environmental Protection Agency, "EPA Interim Standards for Owners and Operators of

New Hazardous Waste Land Disposal Facilities," 40 CFR 267, 1989.

Department of Health and Welfare, State of Idaho, Rules and Regulations for the Control of Air Pollution in Idaho, 1972, as amended through 1984.

Department of Health and Welfare, State of Idaho, Idaho Regulations for Public Drinking Water Systems, 1977.

The principal standards and guides for release of radionuclides at the INEL are those of DOE Order 5400.5,² dated February 8, 1990, entitled "Radiation Protection of the Public and the Environment." These standards are shown in Table X. The Derived Concentration Guides (DCG) based on the standard have been calculated using new models and parameters^{18,19} and are shown in Table XI. The most restrictive guide is listed when there is a difference between the soluble and insoluble chemical forms. The DCGs consider only the inhalation of air, the ingestion of water, or submersion in air.

TABLE X
RADIATION STANDARDS FOR PROTECTION
OF THE PUBLIC IN THE VICINITY OF DOE
FACILITIES

All Exposure Modes	Effective Dose Equivalent ^a	
	(mrem/yr)	(mSv/yr)
Routine DOE activities	100	1
Airborne Emissions Only ^b	Dose Equivalent	
	(mrem/yr)	(mSv/yr)
Whole body	25	0.25
Any organ	75	0.75

a. The effective dose equivalent for any member of the public from all routine DOE operations including remedial activities and release of naturally-occurring radionuclides from DOE processes shall not exceed these values. (Routine operations refers to normal, planned operations and does not include accidental or unplanned releases.)

b. Limits of 40 CFR 61, Subpart H, established February 5, 1985, by the EPA.

a. The final rule published in December 1989 (Reference 20) will apply to CY-1990 report, not to CY-1989 as per DOE-HQ guidance.

Ambient air quality standards are shown in Table XII. Water quality standards are dependent on the type of drinking water system sampled. Table XIII is a partial list of maximum contaminant levels set by the EPA for public community drinking water systems

in 40 CFR 141. New regulations were promulgated by the EPA for volatile organic compounds in the Federal Register on July 1, 1987.³⁵ State of Idaho regulations are the same for the first five contaminants listed in Table XIII.

TABLE XI
DERIVED CONCENTRATION GUIDES FOR RADIATION PROTECTION

Radionuclide	Derived Concentration Guide ^a ($\mu\text{Ci/mL}$)		Radionuclide	Derived Concentration Guide ^a ($\mu\text{Ci/mL}$)	
	In Air	In Water		In Air	In Water
Gross Alpha ^b	2×10^{-14}	3×10^{-8}	Sb-125	1×10^{-9}	5×10^{-5}
Gross Beta ^c	3×10^{-12}	1×10^{-7}	I-129	7×10^{-11}	5×10^{-7}
H-3	1×10^{-7}	2×10^{-3}	I-131	4×10^{-10}	3×10^{-6}
Na-24 ^d	4×10^{-9}	1×10^{-4}	I-132	4×10^{-8}	2×10^{-4}
Ar-41	1×10^{-8}	—	I-133	2×10^{-9}	1×10^{-5}
Cr-51	5×10^{-8}	1×10^{-3}	Xe-133	5×10^{-7}	—
Mn-54	2×10^{-9}	5×10^{-5}	Xe-135	8×10^{-8}	—
Co-60	8×10^{-11}	5×10^{-6}	Xe-135m	5×10^{-8}	—
Br-82	9×10^{-9}	8×10^{-5}	Xe-138	2×10^{-8}	—
Kr-85	3×10^{-6}	—	Cs-134	2×10^{-10}	2×10^{-6}
Kr-85m	1×10^{-7}	—	Cs-137	4×10^{-10}	3×10^{-6}
Kr-87	2×10^{-8}	—	Cs-138	1×10^{-7}	9×10^{-4}
Kr-88	9×10^{-9}	—	Ba-139	7×10^{-8}	3×10^{-4}
Rb-88 ^d	3×10^{-8}	8×10^{-4}	Ba-140	3×10^{-9}	2×10^{-5}
Rb-89	3×10^{-7}	2×10^{-3}	Ce-141	1×10^{-9}	5×10^{-5}
Sr-90	9×10^{-12}	1×10^{-6}	Ce-144	3×10^{-11}	7×10^{-6}
Y-91m	4×10^{-7}	4×10^{-3}	Pu-238	3×10^{-14}	4×10^{-8}
Tc-99m	4×10^{-7}	2×10^{-3}	Pu-239	2×10^{-14}	3×10^{-8}
Ru-103	2×10^{-9}	5×10^{-5}	Pu-240	2×10^{-14}	3×10^{-8}
Ru-106	3×10^{-11}	6×10^{-6}	Am-241	2×10^{-14}	3×10^{-8}

a. Derived concentration guides (DCGs) are from DOE Order 5400.5² and are based on an effective dose equivalent of 100 mrem/yr.

b. Based on Am-241, Pu-239, and Pu-240.

c. Based on the most restrictive beta emitter (Ra-228).

d. Submersion in a cloud of gas is more restrictive than the inhalation pathway.

TABLE XII
AMBIENT AIR QUALITY STANDARDS

<u>Pollutant</u>	<u>Type of Standard^a</u>	<u>Sampling Period</u>	<u>EPA^b ($\mu\text{g}/\text{m}^3$)</u>
SO ²	S	3-hour average	1300
	P	24-hour average	365
	P	Annual average	80
NO ²	S&P	Annual average	100
Total Particulates ^c	S	24-hour average	150
	S&P	Annual average	50

a. National primary (P) ambient air quality standards define levels of air quality to protect the public health. Secondary (S) ambient air quality standards define levels of air quality to protect the public welfare from any known or anticipated adverse effects of a pollutant.

b. The State of Idaho has adopted these same ambient air quality standards.

c. The primary and secondary standard for the annual average applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers."

TABLE XIII
MAXIMUM CONTAMINANT LEVELS FOR PUBLIC COMMUNITY DRINKING WATER SYSTEMS

Gross alpha	$1.5 \times 10^{-8} \mu\text{Ci}/\text{mL}$
Gross beta	$5.0 \times 10^{-8} \mu\text{Ci}/\text{mL}$
Manmade radionuclides	Concentrations resulting in 4 mrem total body or organ dose equivalent
Nitrate (as N) ^a	10 mg/L
Chromium	0.05 mg/L
Trihalomethanes	0.1 mg/L
Carbon tetrachloride ^b	0.005 mg/L
1,1,1-trichloroethane ^b	0.20 mg/L
Trichloroethylene ^b	0.005 mg/L

a. Applies to noncommunity water systems also.

b. Applies to nontransient noncommunity water systems also.

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APPENDIX A
MAJOR PROGRAMS, LOCATION, GEOLOGY, AND CLIMATOLOGY

IDAHO NATIONAL ENGINEERING LABORATORY

Figure A-1. INEL Site facility locations.

APPENDIX A

MAJOR PROGRAMS, LOCATION, GEOLOGY AND CLIMATOLOGY

The INEL Site was established in 1949 as the National Reactor Testing Station to provide an isolated station where various kinds of nuclear reactors and support facilities could be built and tested, and to demonstrate that nuclear energy could be safely harnessed for generating electricity and other peaceful uses. More nuclear reactors have been built at the INEL Site than at any other location in the world. Fifty-two reactors have been built at this Site, 12 of which are operating or operable. The broad mission of the INEL is to develop economic energy sources by applying its engineering and scientific expertise to DOE research and development programs. Major DOE programs currently underway at the INEL Site fall into eight categories:

- Providing test irradiation services from the high-flux Advanced Test Reactor (ATR)
- Recovering uranium from highly enriched spent fuels and calcining liquid radioactive waste solutions into a solid form for storage at the Idaho Chemical Processing Plant (ICPP).
- Conducting light-water-cooled reactor safety testing and research
- Operating the Experimental Breeder Reactor No. 2 (EBR-II)
- Operating the Naval Reactors Facility (NRF)
- Storing, processing, and monitoring radioactive wastes
- Special manufacturing of defense components
- Conducting environmental restoration at the INEL Site.

See Figure A-1 and Table A-1 for the location of INEL Site facilities and an explanation of their acronyms.

The Site is situated on the upper Snake River Plain in southeastern Idaho at an average elevation of 1500 m (4900 ft). The Site encompasses 2300 km² (890 mi²); it extends 63 km (39 mi) from north to south and is about 58-km (36-mi) wide at its broader southern part. Land immediately beyond the boundaries of the Site is either desert or agricultural. Most of the nearby farming is concentrated northeast of the Site. Large areas of agricultural land are farmed in the Snake River Valley, but these regions are more distant from the Site.

The desert plain on which the INEL Site is located is part of a cool desert shrub biome. Average annual temperature at the Site is 5.6°C (42°F), with extremes

of 39°C (103°F) and -44°C (-47°F).^{A-1} Vegetation is typical of the Great Basin, with sagebrush conspicuous over 80% of the Site. Frequenting the Site are the pronghorn antelope, a few deer and elk, coyotes, bobcats, rabbits, large populations of small mammals, and various kinds of birds and reptiles. The INEL is one of six National Environmental Research Parks, where scientists from DOE, other federal and state agencies, universities, and private research foundations can study changes caused by human activities and obtain data for use in making decisions on land use. At present, about 20 different environmental studies are being conducted at the INEL.

The surface of the plain is a combination of basaltic lava outcrops and alluvial sedimentary deposits. The sediments range from gravel and sands deposited by streams (as alluvial fans, channel fillings, and deltas) to silts and clays deposited in playas. The subsurface of the plain is principally composed of basalt flows interbedded with lacustrine and alluvial sedimentary deposits to a depth of about 760 m (2500 ft). The most recent volcanism, occurring about 2000 years ago,^{A-2} is evident in the scenic basalt flows at Craters of the Moon National Monument, about 30 km (19 mi) to the southwest of the Site.

Annual precipitation in the Site area has averaged 22 cm (8.7 in.) over the past 15 years. Underlying the desert plain is a natural aquifer in the basaltic rock. Ground water underflow from the Henry's Fork of the Snake River supplies a significant amount of water to the Snake River Plain aquifer below the INEL. Additional recharge to the aquifer comes from the Big and Little Lost Rivers and Birch Creek, which originate in the mountains to the northwest of the INEL, flow onto the Site during at least a few months of the year, and sink into its porous soils. The underground water moves laterally at an average rate of 1.5 to 6 m/d (5 to 20 ft/d) to the south and west, emerging in springs along the Snake River between Milner and Bliss, Idaho. Discharge volumes from springs in this region are approximately 4.3×10^9 m³ (3.5×10^6 acre-ft) per year. Both the aquifer and surface waters of the Snake River Plain are used for crop irrigation.

Winds are predominantly along the SW-NE axis of the plain, with the most frequent and strongest winds from the SW. The NE winds are mostly nocturnal. Spring is the windiest time of the year, while winter has more calm periods and more nighttime temperature inversions.

TABLE A-1
TABULATION OF FACILITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

Name	Abbreviation	Operating Contractor ^a	Name	Abbreviation	Operating Contractor ^a
Reactors Operating or Operable as of December 1989			Other Facilities in Use		
Advanced Reactivity Measurement Facility No. 1 ^b	ARMF-I	EG&G	Expend Core Facility	ECF	WEC
Advanced Test Reactor	ATR	EG&G	Experimental Field Station	EFS	DOE-ID
Advanced Test Reactor Critical	ATRC	EG&G	Fluorinel and Fuel Storage Facility	FAST	WINCO
Argonne Fast Source Reactor	AFSR	ANL	Fuel Manufacturing Facility	FMF	ANL
Coupled Fast Reactivity Measurement Facility ^b	CFRMF	EG&G	Hot Cell Facility (TRA)	—	EG&G
Experimental Breeder Reactor No. 2	EBR-II	ANL	Hot Fuel Examination Facilities	—	ANL
Large Ship Reactor "A"	AIW-(A)	WEC	Hot Shop Facilities (TAN)	—	EG&G
Natural Circulation Reactor	SSG	WEC	Idaho Chemical Processing Plant	ICPP	WINCO
Power Burst Facility	PBF	EG&G	Idaho Research Center (Idaho Falls)	IRC	EG&G
Transient Reactor Test Facility	TREAT	ANL	Naval Reactors Facility	NRF	WEC
Neutron Radiography Facility	NRAD	ANL	New Waste Calcining Facility	NWCF	WINCO
Zero Power Physics Reactor ^b	ZPPR	ANL	Process Experimental Pilot Plant	PREPP	EG&G
Reactors Dismantled, Transferred, or in Standby Status			Radiation Measurements Laboratory	RML	EG&G
Boiling Water Reactor No. 1	BORAX-I	ANL	Radioactive Waste Management Complex	RWMC	EG&G
Boiling Water Reactor No. 2	BORAX-II	ANL	Radiological & Environmental Sciences Laboratory	RESL/ID	DOE-ID
Boiling Water Reactor No. 3	BORAX-III	ANL	Reactor Training Facility	RTF	EG&G
Boiling Water Reactor No. 4	BORAX-IV	ANL	Remote Analytical Laboratory	RAL	WINCO
Boiling Water Reactor No. 5	BORAX-V	ANL	Security Training Facility	STF	PTI
Engineering Test Reactor	ETR	EG&G	Semiscale Test Support Laboratory	STSL	EG&G
Engineering Test Reactor Critical	ETRC	EG&G	Standards Calibration Laboratory (CF-698)	—	EG&G
Experimental Breeder Reactor No. 1	EBR-I	ANL	Stored Waste Examination Pilot Plant	SWEPP	EG&G
Experimental Organic Cooled Reactor (Modballbed before startup)	EOCR	PPCo	Technical Services Center (CT-688, -689)	TSC	EG&G
Large Ship Reactor "B"	AIW-(B)	WEC	Technical Service Facility	TSF	EG&G
Loss-of-Fluid Test Facility	LOFT	EG&G	Technical Support Buildings A&B (Idaho Falls)	TSA-TSB	EG&G
Materials Test Reactor	MTR	PPCo & INC	Test Area North	TAN	EG&G
Organic Moderated Reactor Experiment	OMRE	AI	Test Reactor Area	TRA	EG&G
Special Power Excursion Reactor Test No. 1	SPERT-I	PPCo	Waste Experimental Reduction Facility	WERF	EG&G
Special Power Excursion Reactor Test No. 2	SPERT-II	PPCo & INC	Water Reactor Research Test Facility	WRRIF	EG&G
Special Power Excursion Reactor Test No. 3	SPERT-III	PPCo & INC	Willow Creek Building (Idaho Falls)	WCB	EG&G
Special Power Excursion Reactor Test No. 4	SPERT-IV	PPCo & INC	Facilities Not Presently in Use		
Spherical Cavity Reactor Critical Experiment	SCRCE	ANC	Initial Engineering Test Facility	IET	EG&G
Submarine Thermal Reactor	SIW (STR)	WEC	Field Engineering Test Facility	FET	EG&G
Zero Power Reactor No. 3 ^b	ZPR-III	ANL	Waste Calcining Facility	WCF	WINCO
Other Facilities in Use			Major Programs at INEL		
Argonne National Laboratory-West	ANL-W	ANL	Chemical Processing Program	—	WINCO
Auxiliary Reactor Area	ARA	EG&G	Environmental Restoration Program	—	ANL INEL
Badging Facility	None	EG&G/M-K	Liquid Metal Fast Breeder Reactor Program	—	ANL
Central Facilities Area	CFA	EG&G	Naval Propulsion Reactors Program	—	WEC
Chemical Engineering Laboratory	CEL	EG&G	Radioactive Waste Management Program	—	EG&G
Coal-Fired Steam Generating Facility	CFSGF	WINCO	Reactor Materials Testing Program	—	EG&G
INEL Supercomputing Center	ISC	EG&G	Specific Manufacturing Capability	—	R-INEL
Contained Test Facility	CTF	EG&G	Water Reactor Safety Program	—	EG&G

a. Operating contractor acronyms: Atomic International (AI), Aerojet Nuclear Company (ANC), Argonne National Laboratory (ANL), EG&G Idaho, Inc. (EG&G), Idaho Nuclear Corporation (INC), M-K Ferguson of Idaho (M-K), Protection Technology Idaho, Inc. (PTI), Phillips Petroleum Company (PPCo), Rockwell-INEL (R-INEL), Westinghouse Electric Corporation (WEC), Westinghouse Idaho Nuclear Company (WINCO).

b. Zero or low power reactor.

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- A-2. M.A. Kuntz, et al., "Holocene Basaltic Volcanism Along the Great Rift, Central and Eastern Snake River Plain, Idaho," *Utah Geological and Mineral Survey Special Studies 61, 1983, Guidebook, Part-3*, GSA Rocky Mountain and Cordilleran Sections Meeting: Salt Lake City, Utah, May 1983.

APPENDIX B
ENVIRONMENTAL MONITORING PROGRAM DATA SUMMARIES

APPENDIX B

ENVIRONMENTAL MONITORING PROGRAM DATA SUMMARIES

This appendix contains data summary Tables (B-1 through B-14) and one map (Figure B-1) for the environmental monitoring program at the INEL Site for 1989.

TABLE B-1
GROSS BETA ACTIVITY IN AIR (1989)

<u>Group</u>	<u>Location</u>	<u>Number of Samples</u>	<u>Range</u>	<u>Annual Average^a</u>
Distant	Blackfoot	51	12-97	31 ± 4
	Craters of the Moon	50	8-53	25 ± 3
	Idaho Falls	50	11-77	28 ± 4
	Rexburg	52	7-51	27 ± 3
	Grand Mean ^a	—	—	28 ± 2
Boundary	Arco	52	7-53	27 ± 3
	Atomic City	52	11-61	28 ± 3
	FAA Tower	51	7-55	27 ± 3
	Howe	52	8-77	31 ± 4
	Monteview	52	11-66	30 ± 4
	Mud Lake	52	12-117	35 ± 5
	Reno Ranch	52	11-61	28 ± 3
	Grand Mean ^a	—	—	30 ± 1
Site	ANL-W	51	8-91	29 ± 4
	AKA	51	10-66	29 ± 3
	CFA	52	11-65	28 ± 4
	EBR-I	52	11-66	32 ± 4
	EFS	51	11-76	31 ± 4
	ICPP	52	9-74	30 ± 4
	NRF	52	11-88	33 ± 5
	PBF	52	11-87	31 ± 4
	RWMC	50	10-74	31 ± 4
	TAN	51	5-76	33 ± 4
	TRA	50	11-109	35 ± 5
	VANB	52	9-74	30 ± 4
	Grand Mean ^a	—	—	31 ± 1

a. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-2
GROSS BETA STATISTICAL COMPARISONS^a BY LOCATION (1989)

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
ARCO	—	—	—	—	—	—	—	—	—	—	—	—	—
ATOM	—	—	—	—	—	—	—	—	—	—	—	—	—
FAAT	—	—	—	—	—	—	—	—	—	—	—	—	—
HOWE	—	—	—	—	—	—	—	—	—	—	—	—	+
MON	—	—	—	—	—	—	—	—	—	—	—	+	—
MUDL	—	—	—	—	—	—	—	+	—	—	+	+	+
RENO	—	—	—	—	—	—	—	—	—	—	—	—	—
Boundary Group ^b	—	—	—	—	—	—	—	—	—	—	—	+	—
ANL-W	—	—	—	—	—	—	—	—	—	—	—	—	—
ARA	—	—	—	—	—	—	—	—	—	—	—	—	—
CFA	—	—	—	—	—	—	—	—	—	—	—	—	—
EBR-I	—	—	—	—	—	—	+	+	+	—	—	—	+
EFS	—	—	—	—	—	—	—	—	—	—	—	—	+
ICPP	—	—	—	—	—	—	—	—	—	—	—	—	—
NRF	—	—	—	—	—	—	—	—	—	—	—	—	+
PBF	—	—	—	—	—	—	—	+	—	—	—	+	+
RWMC	—	—	—	—	—	—	—	—	—	—	—	—	—
TAN	—	—	—	—	—	—	+	—	—	—	—	+	+
TRA	—	—	—	—	—	—	+	—	—	—	—	+	+
VANB	—	—	—	—	—	—	—	—	—	—	—	—	—
Site Group ^b	—	—	—	—	—	—	—	—	—	—	—	+	+

a. Comparison used was unpaired t-test ($\alpha + 0.05$) between means of individual locations and the distant communities (background) group mean. Means that were statistically greater than the background mean are indicated by "+" in the array (see Appendix C).

b. Group mean was compared to the background group mean for a comparable time period.

TABLE B-3
SPECIFIC RADIONUCLIDE ACTIVITY IN AIR (1989)

Radionuclide	Composite Group ^a	Concentration (10 ⁻¹⁵ μ C/mL)			Derived Concentration Guide ^d	~MDC ^e
		Minimum ^b	Maximum ^b	Mean ^c		
Ce-141	Distant Boundary Site	<MDC ^f <MDC <MDC	5 $\pm$ 4 <MDC <MDC	NSS ^g NSS NSS	1,000,000	2
Cs-137	Distant Boundary Site	<MDC <MDC <MDC	<MDC 1.1 $\pm$ 1.0 <MDC	NSS NSS 0.15 $\pm$ 0.11	400,000	1
Mn-54	Distant Boundary Site	<MDC <MDC <MDC	<MDC 0.9 $\pm$ 0.8 <MDC	NSS NSS NSS	2,000,000	1
Ru-106	Distant Boundary Site	<MDC <MDC <MDC	<MDC <MDC 11 $\pm$ 8	NSS NSS NSS	30,000	10
Sb-125	Distant Boundary Site	<MDC <MDC <MDC	<MDC <MDC 2.0 $\pm$ 1.8	NSS NSS NSS	1,000,000	6
Sr-90	Distant Boundary Site	<MDC <MDC <MDC	0.32 $\pm$ 0.16 0.18 $\pm$ 0.16 0.25 $\pm$ 0.18	0.09 $\pm$ 0.08 0.08 $\pm$ 0.06 0.12 $\pm$ 0.06	9,000	0.1
Zr-95	Distant Boundary Site	<MDC <MDC <MDC	<MDC 2.5 $\pm$ 2.2 <MDC	NSS NSS NSS	600,000	1
Concentration (10 ⁻¹⁸ μ C/mL)						
Am-241	Distant Boundary Site	<MDC <MDC <MDC	<MDC <MDC 30 $\pm$ 12	NSS NSS 3.1 $\pm$ 2.0	20,000	8
Pu-238	Distant Boundary Site	<MDC ¹ <MDC <MDC	6 $\pm$ 4 <MDC 9 $\pm$ 8	NSS NSS NSS	30,000	6
Pu-239/240	Distant Boundary Site	<MDC <MDC <MDC	<MDC <MDC 7 $\pm$ 4	NSS NSS 1.1 $\pm$ 0.9	20,000	6

a. Sampling stations are shown in Figure 3 of this report.

b. Single quarterly composite sample analytical results $\pm$ 2s, decay corrected assuming a constant concentration and buildup during the sampling period (see Appendix C).

c. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

d. Annual derived concentration guides given in Reference 2.

e. The minimum detectable concentrations (MDC) are approximate and are calculated for typical values for airflow volume, counting time, radionuclide composition of the sample, and time elapsed between collection and analysis. These values may vary slightly for actual samples.

f. Below minimum detectable concentration.

g. Mean is not statistically significant (NSS), or zero is included within the 95% confidence interval for the mean (see Appendix C).

TABLE B-4
TRITIUM (HTO) CONCENTRATIONS IN AIR (1988)

<u>Samples Dates</u>	<u>Concentrations^a (10^{-7} pCi/mL)</u>		
	<u>Idaho Falls</u>	<u>EFS</u>	<u>Van Buren</u>
12/30/88-04/08/89	<MDC ^b	<MDC	<MDC
04/08/89-07/03/89	<MDC	<MDC	<MDC
07/03/89-10/05/89	2.3 ± 1.6	<MDC	<MDC
10/05/89-11/16/89	9 ± 3	<MDC	<MDC
11/16/89-12/30/89	<u>2.1 ± 1.8</u>	<u><MDC</u>	<u>4 ± 3</u>
Annual Mean ^c	4 ± 4	3 ± 2	2 ± 1
% DCG ^d	0.0004	0.0003	0.0002

a. Analytical results ± 2s (see Appendix C).

b. Below minimum detectable concentration.

c. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C). The Idaho Falls mean is not statistically significant because zero is included in the 95% confidence interval.

d. Mean is compared to the derived concentration guide, 1×10^{-7} μ Ci/mL, which corresponds to 0.1 pCi/mL.

TABLE B-5
KRYPTON-85 CONCENTRATIONS IN AIR AT CFA (1989)

<u>Sample Dates</u>	<u>Concentration^a</u> <u>(10⁻¹² μCl/mL)</u>
Jan 5 to Jan 19	28 $\pm$ 3
Jan 19 to Feb 2	26 $\pm$ 3
Feb 2 to Feb 16	32 $\pm$ 3
Feb 16 to Mar 2	27 $\pm$ 3
Mar 2 to Mar 16	28 $\pm$ 3
Mar 16 to Mar 30	25 $\pm$ 3
Mar 30 to Apr 13	27 $\pm$ 3
Apr 13 to Apr 27	25 $\pm$ 3
Apr 27 to May 11	Lost in analysis
May 11 to May 25	32 $\pm$ 3
May 25 to Jun 8	28 $\pm$ 3
Jun 8 to Jun 22	28 $\pm$ 3
Jun 22 to Jul 7	29 $\pm$ 3
Jul 7 to Jul 21	29 $\pm$ 3
Jul 21 to Aug 4	29 $\pm$ 3
Aug 4 to Aug 18	22 $\pm$ 3
Aug 18 to Sep 1	28 $\pm$ 3
Sep 1 to Sep 18	28 $\pm$ 3
Sep 18 to Oct 2	31 $\pm$ 3
Oct 2 to Oct 16	29 $\pm$ 3
Oct 16 to Oct 30	28 $\pm$ 3
Oct 30 to Nov 13	32 $\pm$ 3
Nov 13 to Nov 27	29 $\pm$ 3
Nov 27 to Dec 11	31 $\pm$ 3
Dec 11 to Dec 26	30 $\pm$ 3
Annual Mean ^b	28.4 $\pm$ 1.0

a. Results $\pm$ 2s analytical uncertainty reported by HPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

b. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-6
RADIONUCLIDE CONCENTRATIONS IN SITE DRINKING WATER WELLS (1989)

Well Code	H-3 Concentration (10 ⁻⁶ µCi/mL) ^a				Sr-90 Concentration (10 ⁻⁹ µCi/mL) ^a			
	No. Samples ^b	Range	Annual Mean ^c	% DCG	No. Samples ^b	Range	Annual Mean ^c	% DCG
CFA #1	12	17-27	24.0 ± 1.8	1.2	0	—	—	—
CFA #2	12	15-18	16.4 ± 0.5	0.8	0	—	—	—
ICPP #1	8	<MDC ^d -<MDC	0.25 ± 0.08	0.013	8	0.3-1.4	0.6 ± 0.3	0.06
ICPP #2	4	<MDC-<MDC	NSS ^e	—	4	<MDC-0.3	NSS	—
ICPP #4	12	<MDC-<MDC	NSS	—	12	<MDC-<MDC	NSS	—
OMRE	12	2.2-2.9	2.5 ± 0.2	0.13	0	—	—	—
RWMC	12	1.4-1.8	1.57 ± 0.08	0.08	0	—	—	—

a. Concentrations expressed as 10⁻⁶ µCi/mL are equivalent to pCi/mL; 10⁻⁹ µCi/mL are equivalent to pCi/L.

b. RESL collects samples only from wells actually in use at collection time. Tritium and Sr-90 results from samples collected by USGS from these wells appear periodically in USGS reports.⁵

c. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

d. <MDC refers to concentrations less than the minimum detectable concentration.

e. Mean is not statistically significant, or zero is included within the 95% confidence interval.

TABLE 2.7
STRONTIUM-90 CONCENTRATIONS IN WHEAT AND LETTUCE (1989)

	Group	Sample Location	Concentrations ^a (10 ⁻⁹ µCi/g dry wt)	
			Wheat	Garden Lettuce
			Sr-90	Sr-90
~Minimum detectable concentration	—	—	4	80
	Distant	American Falls	3 ± 2	NA ^b
		Blackfoot	9 ± 3	170 ± 60
		Chey	NA	140 ± 60
		Dietrich	7 ± 3	NA
		Idaho Falls	11 ± 3	<MDC ^c
		Minidoka	8 ± 3	NA
		Pocatello	NA	130 ± 40
		Mean ^d	8 ± 4	125 ± 75
	Boundary	Arco	5 ± 3	110 ± 60
		Atomic City	NA	210 ± 80
		Howe	NA	60 ± 40
		Monteview	6 ± 2	NA
		Mud Lake	12 ± 3	160 ± 60
		Taber	8 ± 3	NA
		Terreton	5 ± 2	NA
		Mean ^d	7 ± 4	135 ± 105

a. Analytical results ± 2s (see Appendix C).

b. No analysis.

c. Below minimum detectable concentration.

d. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-8
RADIONUCLIDES IN OFFSITE SURFACE SOILS^a (1988)

Radionuclide	Year ^d	Geometric Mean with 95% Confidence Interval ^b		Number of Samples	-MDC ^c	
		pCi/g	nCi/m ²		pCi/g	nCi/m ²
Cs-137	1970-75	0.94	(0.78-1.1)	54	(49-59)	1
	1978	0.94	(0.72-1.2)	58	(44-75)	1
	1980	0.64	(0.46-0.90)	41	(29-57)	1
	1982	0.90	(0.64-1.2)	44	(31-62)	1
	1984	0.69	(0.49-0.97)	43	(31-60)	1
	1986	0.81	(0.54-1.2)	48	(34-67)	1
	1988	0.66	(0.34-1.3)	47	(46-48)	1
Sr-90	1970-75	0.54	(0.43-0.59)	34	(31-37)	10
	1978	0.52	(0.40-0.68)	32	(23-45)	10
	1980	0.35	(0.25-0.49)	22	(15-33)	10
	1982	0.37	(0.26-0.52)	18	(11-29)	10
	1984	0.45	(0.32-0.63)	28	(20-39)	10
	1986	0.52	(0.43-0.62)	30	(25-37)	10
	1988	0.38	(0.28-0.53)	23	(17-31)	10
Pu-238	1970-75	0.0028	(0.0023-0.0034)	0.15	(0.13-0.18)	0.1
	1978	0.0010	(0.0005-0.0020)	0.06	(0.03-0.11)	0.1
	1980	0.0007	(0.0005-0.0009)	0.05	(0.04-0.07)	0.1
	1982	0.0011	(0.0007-0.0017)	0.05	(0.03-0.08)	0.1
	1984	0.0015	(0.0008-0.0027)	0.08	(0.04-0.15)	0.1
	1986	0.0021	(0.0010-0.0046)	0.12	(0.06-0.27)	0.1
	1988	0.0014	(0.0009-0.0024)	0.09	(0.05-0.14)	0.1
Pu-239/240	1970-75	0.020	(0.017-0.024)	1.06	(0.96-1.17)	0.1
	1978	0.018	(0.013-0.025)	1.09	(0.78-1.53)	0.1
	1980	0.010	(0.006-0.017)	0.63	(0.37-1.07)	0.1
	1982	0.022	(0.016-0.031)	1.06	(0.76-1.48)	0.1
	1984	0.016	(0.011-0.022)	1.02	(0.73-1.43)	0.1
	1986	0.018	(0.012-0.027)	1.05	(0.70-1.58)	0.1
	1988	0.021	(0.015-0.029)	1.22	(0.91-1.65)	0.1
Am-241	1970-75	0.004	(0.003-0.005)	0.24	(0.20-0.29)	0.2
	1978	0.006	(0.004-0.009)	0.38	(0.29-0.49)	0.2
	1980	0.063	(0.002-0.004)	0.20	(0.14-0.28)	0.2
	1982	0.004	(0.003-0.006)	0.21	(0.13-0.34)	0.2
	1984	0.004	(0.002-0.007)	0.26	(0.15-0.44)	0.2
	1986	0.004	(0.002-0.007)	0.23	(0.13-0.41)	0.2
	1988	0.005	(0.004-0.008)	0.31	(0.22-0.45)	0.2

a. Soil samples collected to a depth of 5 cm.

b. Geometric mean with the 95% confidence interval for the mean (see Appendix C).

c. Approximate minimum detectable concentration.

d. Excluding 1972 in which no samples were taken.

TABLE B-9
ENVIRONMENTAL RADIATION EXPOSURES (1986-1989)

Location	Annual Exposures (mR) ^a			
	1986	1987 ^b	1988	1989
Distant Group:				
Aberdeen	111 ± 6	104 ± 4	108 ± 4	114 ± 6
Blackfoot	113 ± 6	100 ± 2	112 ± 5	117 ± 8
Craters of the Moon	111 ± 6	98 ± 4	118 ± 4	123 ± 7
Idaho Falls	120 ± 8	113 ± 4	113 ± 4	— ^c
Minidoka	97 ± 6	95 ± 4	92 ± 3	108 ± 6
Rexburg	111 ± 6	94 ± 3	114 ± 4	114 ± 5
Roberts	124 ± 8	— ^d	122 ± 6	127 ± 6
Mean ^e	112 ± 8	101 ± 7	111 ± 9	117 ± 7
Boundary Group:				
Arco	109 ± 9	100 ± 4	106 ± 6	117 ± 5
Atomic City	121 ± 7	95 ± 4	118 ± 7	125 ± 6
Howe	110 ± 8	98 ± 4	105 ± 6	117 ± 6
Montevieu	114 ± 6	98 ± 4	101 ± 5	120 ± 6
Mud Lake	113 ± 7	104 ± 4	111 ± 5	125 ± 6
Reno Ranch	107 ± 7	93 ± 3	110 ± 4	105 ± 6
Mean ^e	112 ± 5	98 ± 4	109 ± 4	118 ± 8

- a. Annual exposure ± 2s (see Appendix C).
- b. Some or all annual exposures listed for 1987 may be 11% low. See text.
- c. Dosimeter missing at November 1989 collection time.
- d. Dosimeter missing at May 1987 collection time.
- e. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-10
RADIONUCLIDE COMPOSITION OF AIRBORNE EFFLUENTS (1989)

		Airborne Effluent (Ci) ^a				
	Radionuclide	Half-Life	ANL-W	ICPP	NRF	TRA
Noble Gases	Kr-85	10.7 yr	0.78	<20,000 ^c	6.4 × 10 ⁻⁴	Total ^b
	Ar-41	1.83 h	1.9	—	—	<20,000
	Xe-133	5.25 d	400	—	—	1400
	Xe-135	9.10 h	120	—	—	4.8
	Xe-138	14.2 min	43	—	—	46
	Kr-88	2.84 h	45	—	—	120
	Kr-87	1.27	35	—	—	34
	Xe-135m	15.3 min	20	—	—	79
	Kr-85m	4.48 h	23	—	—	41
						26
Particulates	Cs-138	32.2 min	—	—	—	13
	Rb-89	15.4 min	—	—	—	0.42
	Rb-88	17.7 min	—	—	—	0.26
	Be-139	1.39 h	—	—	—	0.17
	Br-82	1.49 d	—	—	—	3.0 × 10 ⁻²
	Na-24	15.0 h	4.8 × 10 ⁻³	—	—	—
	Cs-51	27.8 d	—	—	—	2.7 × 10 ⁻³
	Ru-106	372 d	—	2.0 × 10 ⁻³	—	2.3 × 10 ⁻³
	Y-91 m	49.7 min	—	—	—	2.0 × 10 ⁻³
	Sb-125	2.73 yr	—	3.9 × 10 ⁻⁴	—	1.5 × 10 ⁻³
H-3, C-14 and Iodine Isotopes	Cs-137	30.2 yr	—	1.5 × 10 ⁻⁴	—	3.9 × 10 ⁻⁴
	Si-90 + D ^d	28.6 yr	—	4.5 × 10 ⁻⁵	—	2.1 × 10 ⁻⁴
	Pu (total)	—	—	8.1 × 10 ⁻⁸	—	9.1 × 10 ⁻⁵
	H-3	12.3 yr	1.0	1.7	3.9 × 10 ⁻²	8.1 × 10 ⁻⁸
	C-14	5.7 × 10 ³ yr	—	3.4 × 10 ⁻²	0.15	2.7
	I-129	1.6 × 10 ⁷ yr	—	1.4 × 10 ⁻³	—	0.19
	I-132	83.0 min	—	—	—	1.4 × 10 ⁻³
	I-133	20.8 h	—	—	—	3.8 × 10 ⁻⁴
	I-131	8.04 d	—	—	3.5 × 10 ⁻⁷	3.5 × 10 ⁻⁴
						1.2 × 10 ⁻⁴
All Other						
Total			3.9 × 10 ⁻⁵	4.1 × 10 ⁻⁷	1.2 × 10 ⁻⁵	2.4 × 10 ⁻³
Grand Totals			690	<20,000	0.19	1,700
						2.5 × 10 ⁻³
						<22,000

a. Radioactivity listed in 1989 Radioactive Waste Management Information System Report.⁴ Values are not corrected for decay after release. Data are preliminary.

b. Totals include small amounts from facilities not listed.

c. The actual number of curies is classified information.

d. Parent-daughter equilibrium assumed.

TABLE B-11
RADIONUCLIDE COMPOSITION OF LIQUID EFFLUENTS RELEASED ONSITE (1989)

Radionuclide	Half-Life	Liquid Effluent (Ci) ^a				
		ANL-W	CFA	ICPP	TRA	Total ^b
H-3	12.3 yr	0.14	2.2 ^c	—	130	130
Cr-51	27.8 d	—	—	—	5.7	5.7
Co-60	5.26 yr	—	—	4.0×10^{-3}	0.31	0.32
Ru-106	372 d	—	—	0.12	—	0.12
Cs-137	30.2 yr	—	—	7.9×10^{-2}	1.3×10^{-2}	9.3×10^{-2}
Na-24	15.0 h	—	—	—	7.0×10^{-2}	7.0×10^{-2}
Sr-90	28.6 yr	—	2.0×10^{-4}	3.2×10^{-2}	—	3.3×10^{-2}
Ce-144	2.84 d	—	—	8.6×10^{-4}	2.5×10^{-3}	3.4×10^{-3}
Pu-(total)	—	—	—	2.3×10^{-3}	—	2.3×10^{-3}
All Others	—	—	1.0×10^{-2}	2.8×10^{-2}	1.4	1.5
Grand Totals		0.14	2.2	0.27	130	140

a. Radioactivity provided by Radioactive Waste Management Information System. Values are not corrected for decay after release. Data are preliminary.

b. Totals include small amounts from facilities not listed.

c. Tritium in the effluent is due to tritium in the water supply at CFA.

Figure B-1. Locations of wells listed in Table B-12.

TABLE B-12
PURGEABLE ORGANIC COMPOUNDS IN GROUND WATER (1989)

Well Number	Date Sampled	Concentration ^a (µg/L)							Others
		Carbon Tetra-chloride	Chloro-form	1,1,1-Tri-chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	1,2-trans-dichloro-ethylene	Toluene	
RWMC Area									
88	01-04-89	2.3	—	—	1.0	—	—	—	—
	04-04-89	2.2	—	—	1.0	—	—	—	—
	07-12-89	1.0	—	—	—	—	—	—	Dichlorodifluoromethane, 1.0
	07-12-89 ^b	1.1	—	—	—	—	—	—	Dichlorodifluoromethane, 1.1
	09-29-88	1.9	—	—	—	—	—	—	—
90	07-11-89	1.0	—	—	—	—	—	—	—
120	07-12-89	1.0	—	—	—	—	—	—	—
RWMC	01-18-89	1.5	—	—	—	—	—	—	—
	02-16-89	1.5	—	—	—	—	—	—	—
	03-23-89	1.4	—	—	—	—	—	—	—
	04-25-89	1.3	—	—	—	—	—	—	—
	05-24-89	1.3	—	—	—	—	—	—	—
	06-20-89	1.3	—	—	—	—	—	—	—
	07-11-89	1.5	—	—	—	—	—	—	—
	08-29-89	1.3	—	—	—	—	—	—	—
	09-28-89	1.4	—	—	—	—	—	—	—
	10-26-89	1.6	—	—	—	—	—	—	—
TAN Area									
24	02-28-89	—	1.0	12	1400	64	11	—	1,1-Dichloroethane, 1.5 1,1-Dichloroethylene, 9 (MCL=7)
TAN-Disp. ^c	03-07-89	—	—	—	24,000	—	13,000	—	—
TDD-1 ^d	03-02-89	—	—	—	44	9	—	—	—
TDD-2 ^d	03-06-89	—	—	—	180	11	1.2	—	—
ANP-8	12-13-89	—	—	—	6.4	3.7	—	—	—
Other Areas									
11	09-13-89	—	—	—	—	—	—	1.7	—
14	09-14-89	—	—	—	—	—	—	0.9	—
	09-14-89 ^b	—	—	—	—	—	—	1.0	—
MCL ^e		5	100	200	5	None	None	None	—

- a. Concentrations shown are those measured that were equal to or above 1.0 µg/L. For all analyses, the reporting level was 0.2 µg/L.
- b. Blind replicates—duplicate samples assigned a fictitious sample identification number submitted to the same laboratory for analysis.
- c. TAN disposal well used for waste-water disposal prior to 1973.
- d. Well that samples the discontinuous perched-water zone above the aquifer.
- e. Maximum contaminant level for drinking water established by the EPA on July 8, 1987, except for chloroform, which is a trihalomethane regulated under 40 CFR 141. The only wells to which the MCL is applicable are ANP-8 and RWMC, which are drinking water or production wells.

TABLE B-13
PARTICULATE MATTER
CONCENTRATIONS IN AIR (1989)

Group	Locations	Concentration ^a ($\mu\text{g}/\text{m}^3$)	
		Range	Mean ^b
Distant	Blackfoot	30-50	40 $\pm$ 20
	Craters of the Moon	6-15	10 $\pm$ 8
	Idaho Falls	30-100	60 $\pm$ 50
	Rexburg	20-50	40 $\pm$ 20
	Grand Mean ^b		40 $\pm$ 14
Boundary	Arco	15-80	40 $\pm$ 40
	Atomic City	7-30	20 $\pm$ 20
	FAA Tower	8-16	12 $\pm$ 6
	Howe	13-40	30 $\pm$ 20
	Monteview	11-40	30 $\pm$ 20
	Mud Lake	19-50	40 $\pm$ 20
	Reno Ranch	10-30	17 $\pm$ 13
	Grand Mean ^b		30 $\pm$ 7
Site	ANL-W	14-30	25 $\pm$ 12
	ARA	10-19	15 $\pm$ 7
	CFA	8-20	14 $\pm$ 10
	EBR-I	6-19	13 $\pm$ 9
	EFS	9-40	20 $\pm$ 20
	ICPP	9-20	16 $\pm$ 9
	NRF	12-20	18 $\pm$ 10
	PBF	10-19	14 $\pm$ 7
	RWMC	2-40	20 $\pm$ 30
	TAN	20-20	22 $\pm$ 3
	TRA	11-20	15 $\pm$ 8
	VANB	7-19	13 $\pm$ 8
	Grand Mean ^b		17 $\pm$ 2

a. The approximate minimum detectable concentration (~MDC) is $10 \mu\text{g}/\text{m}^3$. The EPA's national primary and secondary ambient air quality standard is $50 \mu\text{g}/\text{m}^3$, annual average, for particulates with diameter less than or equal to $10 \mu\text{m}$.

b. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-14
NONRADIOACTIVE AIRBORNE
EFFLUENTS (1989)

Facility	Emissions (metric tonnes)		
	NO	NO ₂ ^a	SO ₂
ANL-W	—	5	11
CFA	—	1	4
CFSGF ^b	73	—	23
ICPP (oil)	—	5	34
ICPP (main stack) ^c	1	9	—
NRF	—	22	84
PBF	—	—	1
TRA	—	3	8
TSF	—	14	64
WERF	—	4	10
Totals	74	63	239

a. Calculated from fuel oil usage reported by IWMIS and emission factors given in Reference 33.

b. Calculated from CFSGF plant operating data supplied by T. W. Chesnovar, WINCO, following a telephone request.

c. Reported in IWMIS on ICPP Airborne Summary page, as amended.

APPENDIX C
STATISTICAL METHODS

APPENDIX C

STATISTICAL METHODS

Individual analytical results are given in the report with plus or minus ($\pm$) two analytical standard deviations (2s), where all analytical uncertainties have been calculated and "s" is an estimate of the population standard deviation " σ ". Many of the results were less than or equal to 2s (and, in fact, some were negative), which means that they were below the minimum detectable concentration. Gamma spectrometric analyses differ from other types because the radionuclide is not considered detectable unless the net count in the peak is equal to or greater than three times its estimated analytical uncertainty (3s). A deliberate search for specific nuclides can be made and results reported, but such results might include negative values.

If the result lies in the range of two to three times its estimated analytical uncertainty (2s to 3s), and assuming that the result belongs to a Gaussian distribution, detection of the material by the analysis may be questionable because of statistical variations within the group of samples. Analyses with results in the questionable range are published in this report with the understanding that there may be some doubt as to whether the material was actually present.

There are many factors that can influence the result to some degree, and these factors are considered and included in the methods used to determine the estimated uncertainty of the measurement. Uncertainties in measurements near the minimum detectable concentration are primarily caused by counting statistics. For low concentrations near the minimum detectable concentration, the uncertainty in the measurement is nearly equal to the measurement itself, and the lower limit of the range of the measurement approaches "zero." Such a result might not be very reliable because the uncertainty is only an estimate and the actual probability distribution of the results is not usually known. In reality, the material being measured may not actually be present in the sample. Therefore, when analytical results show a measurement very near the minimum detectable concentration, statistical tools, meteorological data, and Site release information are all considered when interpreting and evaluating the results.

If the result exceeds 3s, there is confidence that the material was detected by the analysis.

Arithmetic means were calculated using actual assay results, regardless of their being above or below the minimum detectable concentration. The uncertainty of the mean, or the 95% confidence interval, was determined by multiplying the standard deviation of the mean (also called the standard error of the mean) or $s/(n)^{1/2}$ by the $t_{(0.05)}$ statistic. Means for which the 95% confidence interval does not include zero were assumed to indicate detectable amounts of activity. In situations where the analytical results of a group of samples are near the minimum detectable concentration, the 95% confidence interval for the mean may not include zero and thus appears to be statistically significant even though, on the basis of the 2s-to-3s criterion, it is doubtful that any individual sample contained detectable radioactivity.

Geometric means were calculated by summing the natural logarithms ($\ln$) of the positive analytical results, dividing by the number of samples (n), and then transforming the quotient. If the result was either a negative number or a zero, the $\ln$ of the smallest positive, nonzero measurement in the group was used. The 95% confidence interval was determined by multiplying the standard deviation of the geometric mean by the $t_{(0.05)}$ statistic and then transforming the result. The actual interval is determined by dividing the transformed mean by the transformed 95% confidence interval term for the lower limit, then multiplying the mean by the confidence interval term for the upper limit.

Unpaired t -tests were used to determine whether the annual means for the Site or boundary stations were greater than the annual means for the distant stations. All statistical tests used a level of significance of 5% ($\alpha = 0.05$).^{C-1}

REFERENCE

- C-1. Lyman Ott, *An Introduction to Statistical Methods and Data Analysis*, Boston, Massachusetts: Duxbury Press, 1977.

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