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**Idaho National Engineering
and Environmental Laboratory Offsite
Environmental Surveillance Program Report:
First Quarter 1999**

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Executive Summary

The Environmental Science and Research Foundation conducts an Offsite Environmental Surveillance Program for the Department of Energy's the Idaho National Engineering and Environmental Laboratory (INEEL). The Foundation's environmental surveillance program monitors the effects, if any, of U.S. Department of Energy (DOE) activities on the offsite environment, collects data to confirm compliance with applicable environmental laws and regulations, and observes any trends in environmental levels of radioactivity. This report for the first quarter 1999 is based on 564 samples of air (including airborne radioactivity, fine particulates, and atmospheric moisture), precipitation, milk, and wild game tissues. All concentrations of radioactivity found in these samples were consistent with concentrations which have been found in sampling during recent quarters and which have been attributed in the past to natural background radiation, worldwide fallout from past nuclear weapons testing, and nuclear operations around the world. No measured concentrations could be directly attributed to operations at the INEEL. Concentrations in all samples were below the guidelines set by both the DOE and the U.S. Environmental Protection Agency (EPA) for protection of the public.

Program Description

The Foundation collected filters weekly from low-volume air samplers at 12 offsite locations. Five were at distant locations and seven were near the INEEL boundary. An additional three air samplers were operated on the INEEL. Replicate samplers were operated at two offsite boundary locations for quality assurance purposes. Weekly measurements were made of gross alpha and gross beta activity in airborne particulates. Charcoal cartridges were screened weekly for the presence of iodine-131. At the end of the quarter, weekly filters from each location were combined to form a composite sample for that location. These composites were then analyzed for gamma-emitting radionuclides. Selected composites were also submitted for analyses for strontium-90 and transuranics (plutonium-238, plutonium-239/240, and americium-241).

PM₁₀ samplers were operated at three offsite locations to sample airborne particulates with an aerodynamic diameter smaller than 10 microns. Particles this size can penetrate the body's natural air filtering system and enter the lungs.

Atmospheric moisture and precipitation samples were collected to monitor for tritium. Atmospheric moisture samples were collected by sampling continuously for 13 weeks at each of four locations. The Foundation collected monthly precipitation samples at one onsite location and one offsite location, as well as a weekly precipitation sample at a second onsite location.

The Foundation collected a weekly milk sample from a dairy in Idaho Falls and collected monthly milk samples from eight additional dairies around the INEEL. All milk samples were analyzed for iodine-131.

Three big game animals were killed accidentally on INEEL roads during the quarter, and tissue samples of muscle, thyroid, and liver were collected from each of these animals and subjected to gamma spectroscopic analysis.

For more information concerning the contents of this report, contact the Foundation at (208) 525-7102, or visit the Foundation's web page (<http://esrf.org>).

Summary of First Quarter 1999 Results

During the first quarter of 1999, gross alpha and gross beta activities in low-volume air samples were within the expected range of values for background radioactivity. No statistically significant differences were found between the quarterly means of gross alpha and gross beta activities observed in samples from the INEEL, boundary, and distant stations. No anthropogenic radionuclides were detected in gamma spectroscopic analyses of air filters. Iodine-131 was not found in any air sample.

PM₁₀ sampling for respirable particulates continued in three locations: Atomic City, Rexburg, and Mountain View Middle School in Blackfoot. Twenty-four-hour samples were collected once every six days throughout the first quarter. Observed concentrations at the three stations were all below the short-term EPA standard of 150 µg/m³ averaged over 24 hours.

Tritium was detected at very low concentrations in two atmospheric moisture samples, one from Rexburg and another from Atomic City. Low concentrations of tritium were also found in two precipitation samples collected at Idaho Falls and another collected onsite. The observed tritium concentrations in precipitation and atmospheric moisture samples were well below DOE derived guidelines for the general public and can probably be attributed to natural production of tritium from cosmic ray bombardment of the atmosphere.

No detectable concentrations of iodine-131 were reported in the 36 milk samples collected during the first quarter.

Cesium-137 was found at low concentrations in muscle tissue samples collected from an elk and a pronghorn killed accidentally on INEEL roads during the first quarter of 1999. These cesium-137 concentrations are consistent with past game tissue samples collected on and near the INEEL, and are probably attributable to worldwide fallout from atmospheric weapons testing from 1945 through 1980, though contributions from INEEL operations cannot be ruled out. Tissue samples from a road-killed mule deer also killed onsite during the quarter contained no human-made gamma-emitting radionuclides.

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1. Introduction

This quarterly report summarizes the data collected by the Environmental Science and Research Foundation's Idaho National Engineering and Environmental Laboratory (INEEL) Off-site Environmental Surveillance Program during the period January 1 to March 31, 1999. Consistent with requirements of applicable Department of Energy (DOE) Orders, the Foundation's environmental surveillance program monitors the effects, if any, of DOE activities on the offsite environment, collects data to verify compliance with applicable environmental laws and regulations, and observes trends in environmental levels of radioactivity. Appendix A summarizes the Foundation's surveillance program. Information useful in understanding this report is given in Appendix B.

Most of the reported environmental concentrations are at or near background levels of radioactivity; many results are near the detection limits of the laboratory procedures. Appendix A summarizes the approximate minimum detectable concentrations of radioactivity which can be detected and quantified for a given sample type and analysis. All results are reported with an associated 2s ("two sigma") uncertainty term. The Foundation uses the following method for interpreting analytical results near the minimum detectable concentration: results less than or equal to the 2s uncertainty, which includes some negative values, are considered as "not detected." For results greater than 2s (the 95% confidence level), but not exceeding 3s (the 99% confidence interval), detection of the radioactivity is questionable. Results may exceed the 2s level simply due to the inherent random nature of radioactive decay events. This is expected to occur approximately 2.5% of the time. Results exceeding 3s are interpreted as indicating the detection of radioactivity.

Where appropriate, measured airborne concentrations of radioactivity in this report are compared to the DOE Derived Concentration Guides. The Derived Concentration Guide is the concentration of a radionuclide which, under conditions of continuous exposure for a year, would result in an effective dose equivalent of 100 mrem (the DOE standard for members of the public).

2. Air Sampling

2. Air Sampling

2.1. Low-Volume Air Sampling

Airborne particulate radioactivity was continuously monitored by 17 air samplers (Figure 1), located to provide an effective network to detect INEEL releases of radioactivity. Five offsite air samplers are designated as distant, or background, stations and seven are designated as boundary stations. Three air samplers are situated on the INEEL. Two replicate samplers are also operated for quality control purposes. Onsite locations were used to make comparisons of airborne concentrations of radioactivity with boundary and distant locations. Each air sampler averaged a flow of approximately 50 L/min (2 ft³/min) through a filter head consisting of two types of filters—a 1.2-micrometer pore size particulate filter and a charcoal cartridge for the monitoring of radioactive iodine. Filters on each sampler were changed weekly.

Various screening analyses were performed weekly. Charcoal cartridges were screened weekly in batches for ¹³¹I activity. If activity was detected in any batch greater than a preset action level, cartridges were then analyzed individually. Particulate filters were counted each week for gross (nonspecific) beta activity in a low-background beta counter after waiting a minimum of four days for the naturally-occurring daughter products of radon and thoron to decay. The particulate filters were also counted for gross alpha activity. At the end of the quarter, weekly filters from each location were combined to form a composite. All composites were then analyzed by gamma spectrometry for specific radionuclides. Selected composites were also analyzed for ⁹⁰Sr or transuranic radionuclides (²³⁸Pu, ^{239/240}Pu, and ²⁴¹Am).

No ¹³¹I was detected in any of the weekly charcoal cartridges during the first quarter.

Figure 2 shows the weekly gross alpha activities measured throughout the quarter. All measured gross alpha activities were within the expected range of background levels and were generally lower at the INEEL than at the distant stations. Table 1 summarizes the gross alpha measurements for the quarter.

Figure 3 shows gross beta activities over the 13-week quarter. All measured beta activities were also within the range of expected background values. There were no statistically significant differences between the quarterly mean gross beta activity in samples collected on the INEEL and those of distant or boundary stations. Gamma spectroscopic analyses of air filters detected no human-made radionuclides.

2. Air Sampling

Replicate low-volume samplers were operated at Atomic City and at Mountain View Middle School in Blackfoot for quality assurance purposes. T-tests were performed to detect differences between the samplers and their corresponding replicate sampler for both gross alpha and gross beta. At the 95% confidence level, there were no significant differences in replicate measurements of gross alpha activity or gross beta activity at either location. Appendix C contains the observed values of gross alpha and gross beta activities found in weekly air samples.

Selected quarterly composite samples were analyzed for transuranics of interest (^{241}Am , ^{238}Pu , and $^{239/240}\text{Pu}$). None of these radionuclides were detected in any samples.

Several composite samples were also selected for ^{90}Sr analysis; no detections occurred.

2.2 PM_{10} Air Sampling

Air sampling for respirable particulates continued at Madison Middle School (Rexburg), Mountain View Middle School (Blackfoot), and Atomic City. PM_{10} samplers were used to sample airborne particulates with an aerodynamic diameter smaller than 10 microns. Particles this size can penetrate the body's natural air filtering system and enter the lungs. These filters are not analyzed for radionuclides.

Samples were collected every sixth day from Rexburg, Blackfoot, and Atomic City. Concentrations at Rexburg ranged from 1 to $54 \mu\text{g}/\text{m}^3$, with an average of $19 \mu\text{g}/\text{m}^3$. At the Blackfoot location, values ranged from 6 to $43 \mu\text{g}/\text{m}^3$ with an average concentration of $21 \mu\text{g}/\text{m}^3$. In Atomic City the concentrations ranged from 1 to $130 \mu\text{g}/\text{m}^3$ with an average concentration of $21 \mu\text{g}/\text{m}^3$. The EPA standard is $150 \mu\text{g}/\text{m}^3$ averaged over 24 hours, and $50 \mu\text{g}/\text{m}^3$ averaged over the entire year.

Figure 2 Gross Alpha Activity in Air

Figure 3 Gross Beta Activity in Air

2. Air Sampling

Table 1
Gross Alpha Concentrations in Air
First Quarter 1999

<u>Group</u>	<u>Location</u>	<u>Number of Samples</u>	<u>Range of Samples</u>	Gross Alpha Concentration ($\times 10^{-15}$ μ Ci/ml)
				<u>Mean with 95% Confidence Interval</u>
Distant	Blackfoot	13	0.4-2.6	1.2 ± 0.6
	Craters of the Moon	13	0.1-1.7	0.7 ± 0.4
	Idaho Falls	13	0.3-1.9	1.2 ± 0.6
	Rexburg	13	0.6-2.2	1.3 ± 0.5
	Mountain View Middle School (Replicate)	13 (13)	0.6-3.0 (0.5-3.1)	1.6 ± 0.5 (1.6 ± 0.6)
Group Mean				1.3 ± 0.5
Boundary	Arco	13	0.2-2.0	1.0 ± 0.5
	Atomic City (Replicate)	13 (13)	0.3-1.7 (0.2-1.6)	0.8 ± 0.4 (0.9 ± 0.4)
	FAA Tower	13	-0.2-1.9	0.7 ± 0.5
	Howe	13	0.3-1.9	0.9 ± 0.4
	Monteview	13	0.0-1.4	0.7 ± 0.4
	Mud Lake	13	0.4-1.8	1.0 ± 0.5
	Reno Ranch	13	0.3-1.7	0.8 ± 0.5
Group Mean				0.9 ± 0.5
INEEL	EFS	13	0.1-1.3	0.7 ± 0.5
	Main Gate	13	0.1-1.5	0.7 ± 0.4
	Van Buren	13	0.2-2.3	1.0 ± 0.4
Group Mean				0.8 ± 0.4

DOE Derived Concentration Guide 20

Table 2
Gross Beta Concentrations in Air
First Quarter 1999

<u>Group</u>	<u>Location</u>	<u>Number of Samples</u>	<u>Range of Samples</u>	Gross Beta Concentration ($\times 10^{-15}$ μ Ci/ml)
				<u>Mean with 95% Confidence Interval</u>
Distant	Blackfoot	13	9-30	19 ± 2
	Craters of the Moon	13	7-28	16 ± 1
	Idaho Falls	13	10-34	20 ± 2
	Rexburg	13	10-33	20 ± 2
	Mountain View Middle School (Replicate)	13 (13)	7-26 (9-26)	16 ± 1 (17 ± 2)
Group Mean				18 ± 1
Boundary	Arco	13	10-36	20 ± 2
	Atomic City (Replicate)	13 (13)	8-38 (6-32)	19 ± 2 (17 ± 1)
	FAA Tower	13	4-25	16 ± 2
	Howe	13	9-42	20 ± 2
	Monteview	13	9-35	19 ± 2
	Mud Lake	13	8-43	22 ± 2
	Reno Ranch	13	10-32	20 ± 2
Group Mean				19 ± 1

2. Air Sampling

Table 2 (continued) Gross Beta Concentrations in Air First Quarter 1999				
<u>Group</u>	<u>Location</u>	<u>Number of Samples</u>	<u>Range of Samples</u>	Gross Beta Concentration ($\times 10^{-15} \mu\text{Ci/ml}$)
				<u>Mean with 95% Confidence Interval</u>
INEEL	EFS	13	8-33	20 ± 2
	Main Gate	13	9-33	20 ± 2
	Van Buren	13	8-39	19 ± 2
			Group Mean	20 ± 1
DOE Derived Guideline				3000

2.3 Atmospheric Moisture Sampling

Five atmospheric moisture samples were obtained from Idaho Falls, Rexburg, Blackfoot and Atomic City during this reporting period. Samples were collected by passing air through a column of silica gel which absorbed water vapor. Tritium concentrations were determined by extracting water from the silica gel and counting the water sample by liquid scintillation. One sample from Rexburg and another from Atomic City contained tritium, both at the barely detectable concentration of $(1.2 \pm 0.9) \times 10^{-7} \mu\text{Ci/ml}$. Tritium in these concentrations is probably attributable to natural production by cosmic ray bombardment in the upper atmosphere.

2.4 Precipitation Sampling

Ten precipitation samples were collected from Idaho Falls and from onsite locations at the Central Facilities Area (CFA) and the Experimental Field Station (EFS), and analyzed for tritium. On three separate occasions, tritium was detected in the samples. These values were consistent with concentrations attributed to natural causes. Table 3 shows the date, location and concentration of the detected tritium.

Table 3 Tritium Concentrations in Precipitation Samples at Idaho Falls and EFS		
Date	Location	Tritium Concentrations $\pm 2s$ Uncertainty ($10^{-7} \mu\text{Ci/ml}$)
01/06/99	Idaho Falls	2.3 ± 0.9
02/09/99	EFS	1.1 ± 1.0
03/03/99	Idaho Falls	1.0 ± 0.9

3. Milk Sampling

3. Milk Sampling

Milk samples were collected weekly in Idaho Falls and monthly at eight other locations around the INEEL (Figure 4). Two types of locations were sampled: single family dairies and large commercial dairies. Each milk sample was analyzed for ^{131}I by gamma spectrometry. Results were decay-corrected to the time of sample collection. A total of 36 milk samples were collected during the first quarter. None of the samples exhibited detectable concentrations of ^{131}I .

Figure 4 Milk Sampling Locations

4. Game Animal Sampling

A mule deer, an elk, and a pronghorn were killed accidentally on INEEL roads during the first quarter of 1999. Tissue samples of muscle, thyroid, and liver were collected from each of these animals and subjected to gamma spectroscopic analysis. Muscle samples from the elk and pronghorn contained low but detectable concentrations of cesium-137 $[(3.4 \pm 2.3) \times 10^{-9} \mu\text{Ci/g}]$ and $(3.5 \pm 2.1) \mu\text{Ci/g}$, respectively]. None of the liver samples exhibited detectable human-made radionuclide concentrations. No iodine-131 was found in any of the thyroid samples. These cesium-137 concentrations are consistent with past game animal tissue samples collected on and near the INEEL and are probably attributable to worldwide fallout from atmospheric weapons testing from 1945 through 1980, though contributions from INEEL operations cannot be ruled out.

Appendix A

Summary of Environmental Surveillance Networks

Table A-1
Summary of the Foundation's Environmental Surveillance Program

Sample Type Analysis	Collection Frequency	Locations		
		Distant	Boundary	INEEL
Air				
Gross Alpha	weekly	Blackfoot, Craters of the Moon, Idaho Falls, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteviu, Mud Lake, Reno Ranch	Main Gate, EFS, Van Buren
Gross Beta ¹³⁷ I	weekly	Blackfoot, Craters of the Moon, Idaho Falls, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteviu, Mud Lake, Reno Ranch	Main Gate, EFS, Van Buren
Gamma Spec Particulate Mass	quarterly	Blackfoot, Craters of the Moon, Idaho Falls, Rexburg	Arco, Atomic City, FAA Tower, Howe, Monteviu, Mud Lake, Reno Ranch	Main Gate, EFS, Van Buren
⁹⁰ Sr Transuranics	quarterly	Rotating schedule	Rotating schedule	Rotating schedule
PM-10	every sixth day	Rexburg, Blackfoot	Atomic City	None
Air Moisture				
Tritium	4 to 13 weeks	Blackfoot, Idaho Falls, Rexburg	Atomic City	None
Precipitation				
Tritium	monthly	Idaho Falls	None	CFA
Tritium	weekly	None	None	EFS
Surface H₂O				
Gross Alpha, Gross Beta, ³ H	semiannually	Twin Falls, Buhl, Hagerman Idaho Falls, Bliss	None	None
Drinking H₂O				
Gross Alpha Gross Beta, ³ H	semiannually	Aberdeen, Blackfoot, Carey, Idaho Falls, Fort Hall, Minidoka, Roberts, Shoshone	Arco, Atomic City, Howe, Monteviu, Mud Lake, Reno Ranch	None
Milk				
¹³¹ I	weekly	Idaho Falls	None	None
¹³⁷ I	monthly	Blackfoot, Carey, Dietrich, Minidoka, Roberts	Howe, Terreton, Arco	None
Tritium ⁹⁰ Sr	annually	Blackfoot, Carey, Dietrich, Idaho Falls, Minidoka, Roberts	Howe, Terreton, Arco	None
Potatoes				
Gamma Spec ⁹⁰ Sr	annually	Blackfoot, Idaho Falls, Rupert	Arco, Mud Lake	None
Wheat				
Gamma Spec ⁹⁰ Sr	annually	American Falls, Blackfoot, Dietrich, Idaho Falls, Minidoka, Carey	Arco, Monteviu, Mud Lake, Tabor, Terreton	None
Lettuce				
Gamma Spec ⁹⁰ Sr	annually	Blackfoot, Carey, Idaho Falls, Pocatello	Arco, Atomic City, Howe, Mud Lake	None
Fish				
Gamma Spec	annually	None	None	Big Lost River
Sheep				
Gamma Spec	annually	Blackfoot	None	INEEL grazing areas
Waterfowl				
Gamma Spec ⁹⁰ Sr Transuranics	annually	Fort Hall	None	Waste disposal ponds
Game				
Gamma Spec	varies	None	None	INEEL roads
Soil				
Gamma Spec ⁹⁰ Sr Transuranics	biennially	Carey, Crystal Ice Caves, Blackfoot, St. Anthony	Butte City, Monteviu, Atomic City, FAA Tower, Howe, Mud Lake (2), Reno Ranch	None
TLDs				
Gamma Radiation	semiannual	Aberdeen, Blackfoot, Craters of the Moon, Idaho Falls, Minidoka, Rexburg, Roberts	Arco, Atomic City, Howe, Monteviu, Mud Lake, Reno Ranch	None

Table A-2
Summary of Approximate Minimum Detectable Concentrations for Radiological Analyses

<u>Sample Type</u>	<u>Analysis</u>	<u>Approximate Minimum Detectable Concentration^a</u> <u>(MDC)</u>	<u>Derived Concentration Guide^b</u> <u>(DCG)</u>	<u>Drinking Water Detection Limits^c</u>
Air (particulate filter) ^d	Gross alpha	$1 \times 10^{-15} \mu\text{Ci/ml}$	$2 \times 10^{-14} \mu\text{Ci/ml}$	--
	Gross beta	$3 \times 10^{-15} \mu\text{Ci/ml}$	$3 \times 10^{-12} \mu\text{Ci/ml}$	--
	Specific gamma (¹³⁷ Cs)	$3 \times 10^{-16} \mu\text{Ci/ml}$	$4 \times 10^{-10} \mu\text{Ci/ml}$	
	²³⁸ Pu	$2 \times 10^{-18} \mu\text{Ci/ml}$	$3 \times 10^{-14} \mu\text{Ci/ml}$	
	^{239/240} Pu	$3 \times 10^{-18} \mu\text{Ci/ml}$	$2 \times 10^{-14} \mu\text{Ci/ml}$	
	²⁴¹ Am	$2 \times 10^{-18} \mu\text{Ci/ml}$	$2 \times 10^{-14} \mu\text{Ci/ml}$	--
	⁹⁰ Sr	$3 \times 10^{-17} \mu\text{Ci/ml}$	$9 \times 10^{-12} \mu\text{Ci/ml}$	--
Air (charcoal cartridge) ^d	¹³¹ I	$4 \times 10^{-15} \mu\text{Ci/ml}$	$4 \times 10^{-10} \mu\text{Ci/ml}$	--
Air (atmospheric moisture) ^e	³ H	$4 \times 10^{-12} \mu\text{Ci/ml}$	$1 \times 10^{-7} \mu\text{Ci/ml}$	--
Air (precipitation)	³ H	$1 \times 10^{-7} \mu\text{Ci/ml}$	$2 \times 10^{-3} \mu\text{Ci/ml}$	--
Water (drinking & surface)	Gross alpha	3 pCi/l	30 pCi/l	3 pCi/l
	Gross beta	2 pCi/l	100 pCi/l	4 pCi/l
	³ H	100 pCi/l	2×10^6 pCi/l	1000 pCi/l
Milk	¹³¹ I	$3 \times 10^{-9} \mu\text{Ci/ml}$	--	--
Wheat	Specific gamma (¹³⁷ Cs)	$4 \times 10^{-9} \mu\text{Ci/g}$	--	--
	⁹⁰ Sr	$5 \times 10^{-9} \mu\text{Ci/g}$	--	--
Lettuce	Specific gamma (¹³⁷ Cs)	$1 \times 10^{-7} \mu\text{Ci/g}$	--	--
	⁹⁰ Sr	$2 \times 10^{-7} \mu\text{Ci/g}$	--	--

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

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

c. These limits are required by the National Primary Drinking Water Regulations (40 CFR 141). The "detection limit" is the terminology used by the EPA and means the same as the MDC defined above.

d. The approximate MDC is based on an average filtered air volume (pressure corrected) of 570 m³/week.

e. The approximate MDC is expressed for tritium (as tritiated water) in air, and is based on an average filtered air volume of 25 m³, assuming an average sampling period of eight weeks.

Appendix B

Helpful Information for Readers

Radionuclide Nomenclature

Radionuclides are sometimes expressed with the one- or two-letter chemical symbol for the element. A radionuclide is an unstable, or radioactive, form of an element. A given element may have many different radionuclides. Each is designated by a superscript number to the left of the chemical symbol. This number is the atomic weight of the radionuclide, equal to the number of protons and neutrons in its nucleus. Radionuclides which may be used in this report are shown in the following table:

<u>Symbol</u>	<u>Radionuclide</u>	<u>Symbol</u>	<u>Radionuclide</u>
³ H	Tritium	¹³¹ I	Iodine-131
⁷ Be	Beryllium-7	¹³⁴ Cs	Cesium-134
⁵¹ Cr	Chromium-51	¹³⁷ Cs	Cesium-137
⁵⁴ Mn	Manganese-54	¹⁴⁴ Ce	Cerium-144
⁵⁸ Co	Cobalt-58	¹⁸¹ Hf	Hafnium-181
⁶⁰ Co	Cobalt-60	²³⁸ Pu	Plutonium-238
⁶⁵ Zn	Zinc-65	^{239/240} Pu	Plutonium-239/240
⁹⁰ Sr	Strontium-90	²⁴¹ Am	Americium-241
⁹⁵ Nb	Niobium-95		

Scientific Notation

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

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

Unit Prefixes

Units for very small and very large numbers are commonly expressed with a prefix. One example is the prefix *kilo*, abbreviated k, which means 1,000 of a given unit. A kilometer is therefore equal to 1,000 meters. Prefixes that may be used in this report are:

<u>Prefix</u>	<u>Abbreviation</u>	<u>Meaning</u>
milli	m	1/1,000 ($=1 \times 10^{-3}$)
micro	μ	1/1,000,000 ($=1 \times 10^{-6}$)
pico	p	1/1,000,000,000,000 ($=1 \times 10^{-12}$)

Units of Radioactivity and Radiation Exposure and Dose

The basic unit of radioactivity used in this report is the curie, abbreviated Ci. The curie is defined as the amount of radioactivity equivalent to 37 billion nuclear transformations per second. Historically, this was based upon the radioactivity from one gram of the radionuclide Radium-226. For any other radionuclide, one curie is the amount of that radionuclide that decays at this same rate.

Radiation exposure is expressed in terms of the Roentgen (R), the amount of ionization produced by gamma radiation in air. Dose is given in units of "Roentgen equivalent man," or "rem," which takes into account the effect of radiation on tissues. For the types of environmental radiation generally encountered, the unit of Roentgen is approximately numerically equal to the unit of rem.

Units of Environmental Concentrations

Concentration of radioactivity in air and milk samples are expressed in units of microcuries per milliliter ($\mu\text{Ci/ml}$). Concentrations in water samples are expressed as picocuries per liter (pCi/l); federal standards are expressed in these units. Radioactivity in foodstuffs are given in microcuries per gram ($\mu\text{Ci/g}$), dry weight. Radioactivity in soil samples is expressed as picocuries per gram (pCi/g), dry weight. Annual human radiation exposure, measured by environmental dosimeters, is expressed in units of milliRoentgens (mR). This is sometimes expressed in terms of dose as millirem (mrem).

Uncertainty of Measurements

Due to many variables, there is always an uncertainty associated with the measurement of environmental contaminants. For radioactivity, the predominant source of uncertainty is due to the inherent statistical nature of radioactive decay events, particularly at the low activity levels encountered in environmental samples. The uncertainty of a measurement is denoted by following the result with a " $\pm$ " (uncertainty) term. This report follows convention in reporting the uncertainty as a 95% confidence limit (or interval), designated in the tables as " $\pm 2s$." That means there is approximately a 95% level of confidence that the real concentration in the sample lies somewhere between the measured (reported) concentration minus the uncertainty term and the measured (reported) concentration plus the uncertainty term.

Negative Numbers as Results

Environmental measurements are frequently conducted at levels where the contaminant, such as radioactivity, cannot be distinguished from natural background levels. In this case, the result will still be reported by the analytical laboratory, even though it is below the measurement system's approximate minimum detectable concentration, or is less than zero. Negative values occur when the measured result is less than a pre-established average background level for the particular system and procedure used. These values, rather than "not detectable" or "zero," are reported to better enable statistical analyses and to observe trends in the data.

Gross versus Specific Analyses

Many of the radiological analyses of environmental samples yield information only about the overall, or gross, amount of a particular type of radiation (e.g., gross beta), rather than identifying and quantifying specific radionuclides. For example, rather than performing an analysis for particular gamma-emitting radionuclides, called gamma spectroscopy, one can do a gross gamma or, more commonly, a gross beta analysis, since gamma-emitting radionuclides also emit beta particles. This type of analysis is an effective screening tool and is much quicker and less costly than specific radionuclide analyses.

Appendix C **Weekly Gross Alpha and Gross Beta Concentrations in Air** **1st Quarter 1999**

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci}/\text{ml} \times 10^{-15}$)	Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci}/\text{ml} \times 10^{-15}$)
Blackfoot NOAA	01/06/99	1.0 $\pm$ 0.5	21.3 $\pm$ 2
	01/13/99	0.9 $\pm$ 0.5	30.2 $\pm$ 2
	01/20/99	1.1 $\pm$ 0.6	11.1 $\pm$ 2
	01/27/99	0.5 $\pm$ 0.5	13.7 $\pm$ 2
	02/03/99	1.1 $\pm$ 0.7	25.9 $\pm$ 3
	02/10/99	0.4 $\pm$ 0.6	12.6 $\pm$ 2
	02/17/99	0.7 $\pm$ 0.4	16.7 $\pm$ 2
	02/24/99	0.8 $\pm$ 0.4	9.3 $\pm$ 1
	03/03/99	1.7 $\pm$ 0.6	14.7 $\pm$ 1
	03/10/99	0.9 $\pm$ 0.5	12.9 $\pm$ 1
	03/17/99	2.0 $\pm$ 0.7	26.9 $\pm$ 2
	03/24/99	2.6 $\pm$ 0.8	25.5 $\pm$ 2
	03/31/99	2.2 $\pm$ 0.7	23.3 $\pm$ 2
Craters of the Moon	01/06/99	0.8 $\pm$ 0.4	22.1 $\pm$ 2
	01/13/99	1.2 $\pm$ 0.5	25.4 $\pm$ 2
	01/20/99	0.4 $\pm$ 0.3	7.7 $\pm$ 1
	01/27/99	0.6 $\pm$ 0.3	9.2 $\pm$ 1
	02/03/99	0.4 $\pm$ 0.3	18.6 $\pm$ 1
	02/10/99	0.3 $\pm$ 0.3	8.1 $\pm$ 1
	02/17/99	0.1 $\pm$ 0.2	13.4 $\pm$ 1
	02/24/99	0.2 $\pm$ 0.2	7.1 $\pm$ 1
	03/03/99	1.2 $\pm$ 0.5	14.5 $\pm$ 1
	03/10/99	0.5 $\pm$ 0.3	13.0 $\pm$ 1
	03/17/99	1.3 $\pm$ 0.5	28.1 $\pm$ 2
	03/24/99	1.7 $\pm$ 0.6	21.0 $\pm$ 2
	03/31/99	1.0 $\pm$ 0.4	19.6 $\pm$ 1
Idaho Falls	01/06/99	1.2 $\pm$ 0.6	26.9 $\pm$ 2
	01/13/99	1.6 $\pm$ 0.7	34.0 $\pm$ 3
	01/20/99	1.0 $\pm$ 0.5	9.9 $\pm$ 1
	01/27/99	0.3 $\pm$ 0.3	13.6 $\pm$ 2
	02/03/99	1.0 $\pm$ 0.6	28.8 $\pm$ 2
	02/10/99	0.7 $\pm$ 0.5	12.7 $\pm$ 2
	02/17/99	1.1 $\pm$ 0.6	15.7 $\pm$ 2
	02/24/99	0.7 $\pm$ 0.5	9.6 $\pm$ 2

Appendix C **Weekly Gross Alpha and Gross Beta Concentrations in Air** **1st Quarter 1999**

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)		Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)	
	03/03/99	1.5 $\pm$ 0.6		14.6 $\pm$ 2	
	03/10/99	1.1 $\pm$ 0.6		16.1 $\pm$ 2	
	03/17/99	1.6 $\pm$ 0.7		24.8 $\pm$ 2	
	03/24/99	1.9 $\pm$ 0.7		26.4 $\pm$ 2	
	03/31/99	1.7 $\pm$ 0.7		24.0 $\pm$ 2	
Rexburg	01/06/99	1.6 $\pm$ 0.6		26.1 $\pm$ 2	
	01/13/99	1.7 $\pm$ 0.6		32.9 $\pm$ 2	
	01/20/99	0.8 $\pm$ 0.4		12.0 $\pm$ 1	
	01/27/99	0.9 $\pm$ 0.4		12.0 $\pm$ 1	
	02/03/99	1.3 $\pm$ 0.6		28.1 $\pm$ 2	
	02/10/99	0.8 $\pm$ 0.4		14.6 $\pm$ 2	
	02/17/99	0.7 $\pm$ 0.4		18.4 $\pm$ 2	
	02/24/99	0.6 $\pm$ 0.4		10.1 $\pm$ 1	
	03/03/99	1.1 $\pm$ 0.5		12.6 $\pm$ 1	
	03/10/99	1.3 $\pm$ 0.5		14.5 $\pm$ 1	
	03/17/99	2.0 $\pm$ 0.6		29.9 $\pm$ 2	
	03/24/99	2.2 $\pm$ 0.7		24.2 $\pm$ 2	
	03/31/99	1.9 $\pm$ 0.6		20.3 $\pm$ 2	
Mountain View Middle School			Replicate Sampler		Replicate Sampler
	01/06/99	3.0 $\pm$ 0.8	1.2 $\pm$ 0.6	23.0 $\pm$ 2	21.6 $\pm$ 2
	01/13/99	1.0 $\pm$ 0.4	1.0 $\pm$ 0.5	25.7 $\pm$ 2	18.1 $\pm$ 2
	01/20/99	0.8 $\pm$ 0.4	1.2 $\pm$ 0.5	8.0 $\pm$ 1	9.6 $\pm$
	01/27/99	0.6 $\pm$ 0.3	0.5 $\pm$ 0.3	7.5 $\pm$ 1	12.2 $\pm$ 1
	02/03/99	1.6 $\pm$ 0.5	1.4 $\pm$ 0.6	24.7 $\pm$ 2	26.4 $\pm$ 2
	02/10/99	0.8 $\pm$ 0.4	0.7 $\pm$ 0.4	10.3 $\pm$ 1	11.3 $\pm$ 1
	02/17/99	1.5 $\pm$ 0.5	2.0 $\pm$ 0.6	15.5 $\pm$ 1	16.5 $\pm$ 2
	02/24/99	1.0 $\pm$ 0.4	1.0 $\pm$ 0.5	7.3 $\pm$ 1	8.8 $\pm$ 1
	03/03/99	1.7 $\pm$ 0.5	1.7 $\pm$ 0.6	13.7 $\pm$ 1	15.7 $\pm$ 2
	03/10/99	1.2 $\pm$ 0.5	1.7 $\pm$ 0.6	13.7 $\pm$ 1	13.4 $\pm$ 1
	03/17/99	2.8 $\pm$ 0.7	3.1 $\pm$ 0.8	20.5 $\pm$ 2	25.4 $\pm$ 2
	03/24/99	2.6 $\pm$ 0.7	2.8 $\pm$ 0.8	22.7 $\pm$ 2	23.2 $\pm$ 2
	03/31/99	3.0 $\pm$ 0.7	2.4 $\pm$ 0.7	20.9 $\pm$ 2	24.6 $\pm$ 2
Arco	01/06/99	1.6 $\pm$ 0.6		26.4 $\pm$ 2	
	01/13/99	1.7 $\pm$ 0.7		36.3 $\pm$ 3	

Appendix C **Weekly Gross Alpha and Gross Beta Concentrations in Air** **1st Quarter 1999**

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci}/\text{ml} \times 10^{-15}$)		Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci}/\text{ml} \times 10^{-15}$)	
	01/20/99	0.6 $\pm$ 0.4		11.1 $\pm$ 1	
	01/27/99	0.7 $\pm$ 0.4		11.9 $\pm$ 2	
	02/03/99	0.8 $\pm$ 0.5		27.1 $\pm$ 2	
	02/10/99	0.6 $\pm$ 0.4		13.3 $\pm$ 2	
	02/17/99	0.2 $\pm$ 0.3		19.6 $\pm$ 2	
	02/24/99	0.3 $\pm$ 0.4		10.1 $\pm$ 1	
	03/03/99	1.5 $\pm$ 0.6		16.6 $\pm$ 2	
	03/10/99	0.7 $\pm$ 0.5		14.7 $\pm$ 2	
	03/17/99	1.4 $\pm$ 0.6		27.4 $\pm$ 2	
	03/24/99	2.0 $\pm$ 0.6		20.8 $\pm$ 2	
	03/31/99	1.3 $\pm$ 0.5		18.8 $\pm$ 2	
Atomic City			Replicate Sampler		Replicate Sampler
	01/06/99	1.2 $\pm$ 0.5	1.0 $\pm$ 0.5	26.0 $\pm$ 2	24.7 $\pm$ 2
	01/13/99	1.7 $\pm$ 0.6	1.6 $\pm$ 0.5	38.1 $\pm$ 2	32.0 $\pm$ 2
	01/20/99	0.9 $\pm$ 0.4	0.5 $\pm$ 0.3	10.6 $\pm$ 1	9.7 $\pm$ 1
	01/27/99	0.3 $\pm$ 0.3	0.3 $\pm$ 0.2	10.8 $\pm$ 1	7.0 $\pm$ 1
	02/03/99	0.4 $\pm$ 0.4	0.8 $\pm$ 0.4	25.3 $\pm$ 2	26.0 $\pm$ 2
	02/10/99	0.3 $\pm$ 0.3	0.4 $\pm$ 0.3	12.5 $\pm$ 1	10.6 $\pm$ 1
	02/17/99	0.3 $\pm$ 0.3	0.5 $\pm$ 0.3	16.8 $\pm$ 2	16.6 $\pm$ 1
	02/24/99	0.4 $\pm$ 0.3	0.2 $\pm$ 0.2	8.2 $\pm$ 1	5.8 $\pm$ 1
	03/03/99	1.1 $\pm$ 0.5	1.0 $\pm$ 0.5	14.3 $\pm$ 1	13.4 $\pm$ 1
	03/10/99	0.8 $\pm$ 0.4	0.6 $\pm$ 0.4	12.9 $\pm$ 1	11.2 $\pm$ 1
	03/17/99	1.2 $\pm$ 0.6	1.4 $\pm$ 0.5	27.5 $\pm$ 2	27.1 $\pm$ 2
	03/24/99	1.2 $\pm$ 0.5	1.5 $\pm$ 0.5	25.2 $\pm$ 2	21.0 $\pm$ 2
	03/31/99	1.1 $\pm$ 0.5	1.2 $\pm$ 0.5	22.1 $\pm$ 2	20.6 $\pm$ 2
Howe	01/06/99	1.2 $\pm$ 0.5		22.8 $\pm$ 2	
	01/13/99	1.6 $\pm$ 0.5		41.9 $\pm$ 2	
	01/20/99	0.5 $\pm$ 0.3		9.8 $\pm$ 1	
	01/27/99	0.5 $\pm$ 0.3		10.7 $\pm$ 1	
	02/03/99	0.8 $\pm$ 0.4		27.4 $\pm$ 2	
	02/10/99	0.3 $\pm$ 0.3		14.3 $\pm$ 1	
	02/17/99	0.6 $\pm$ 0.4		19.0 $\pm$ 1	
	02/24/99	0.4 $\pm$ 0.3		9.0 $\pm$ 1	
	03/03/99	1.0 $\pm$ 0.4		16.1 $\pm$ 1	
	03/10/99	0.4 $\pm$ 0.3		15.7 $\pm$ 1	

Appendix C **Weekly Gross Alpha and Gross Beta Concentrations in Air** **1st Quarter 1999**

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)	Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)
	03/17/99	0.5 $\pm$ 0.4	26.9 $\pm$ 2
	03/24/99	2.0 $\pm$ 0.6	24.8 $\pm$ 2
	03/31/99	1.4 $\pm$ 0.5	20.9 $\pm$ 2
FAA	01/06/99	0.8 $\pm$ 0.4	24.9 $\pm$ 2
Tower	01/13/99	0.9 $\pm$ 0.4	24.1 $\pm$ 2
	01/20/99	0.3 $\pm$ 0.3	9.0 $\pm$ 1
	01/27/99	-0.2 $\pm$ 0.9	3.6 $\pm$ 5
	02/03/99	0.5 $\pm$ 0.4	23.9 $\pm$ 2
	02/10/99	0.5 $\pm$ 0.3	10.4 $\pm$ 1
	02/17/99	0.8 $\pm$ 0.5	18.2 $\pm$ 2
	02/24/99	0.4 $\pm$ 0.4	7.7 $\pm$ 1
	03/03/99	0.8 $\pm$ 0.5	14.3 $\pm$ 2
	03/10/99	0.3 $\pm$ 0.4	12.1 $\pm$ 2
	03/17/99	1.9 $\pm$ 0.7	24.5 $\pm$ 2
	03/24/99	0.9 $\pm$ 0.6	19.5 $\pm$ 2
	03/31/99	1.1 $\pm$ 0.6	21.2 $\pm$ 2
Montevieu	01/06/99	1.4 $\pm$ 0.6	27.8 $\pm$ 2
	01/13/99	0.9 $\pm$ 0.5	35.2 $\pm$ 2
	01/20/99	0.4 $\pm$ 0.3	10.8 $\pm$ 1
	01/27/99	0.7 $\pm$ 0.4	12.8 $\pm$ 1
	02/03/99	0.7 $\pm$ 0.4	22.9 $\pm$ 2
	02/10/99	0.5 $\pm$ 0.4	13.3 $\pm$ 1
	02/17/99	0.5 $\pm$ 0.4	16.6 $\pm$ 2
	02/24/99	0.0 $\pm$ 0.2	9.0 $\pm$ 1
	03/03/99	0.7 $\pm$ 0.5	14.4 $\pm$ 1
	03/10/99	0.3 $\pm$ 0.3	14.2 $\pm$ 1
	03/17/99	0.9 $\pm$ 0.5	25.1 $\pm$ 2
	03/24/99	1.2 $\pm$ 0.5	21.1 $\pm$ 2
	03/31/99	1.2 $\pm$ 0.6	22.3 $\pm$ 2
Mud	01/06/99	0.8 $\pm$ 0.5	32.3 $\pm$ 2
Lake	01/13/99	1.3 $\pm$ 0.5	42.6 $\pm$ 2
	01/20/99	0.6 $\pm$ 0.4	13.5 $\pm$ 1
	01/27/99	0.8 $\pm$ 0.4	14.5 $\pm$ 1
	02/03/99	1.2 $\pm$ 0.6	30.6 $\pm$ 2

Appendix C **Weekly Gross Alpha and Gross Beta Concentrations in Air** **1st Quarter 1999**

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)	Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)
	02/10/99	0.8 $\pm$ 0.5	20.7 $\pm$ 2
	02/17/99	0.7 $\pm$ 0.4	19.4 $\pm$ 2
	02/24/99	0.4 $\pm$ 0.3	7.8 $\pm$ 1
	03/03/99	1.0 $\pm$ 0.5	15.8 $\pm$ 2
	03/10/99	0.9 $\pm$ 0.4	13.6 $\pm$ 1
	03/17/99	1.3 $\pm$ 0.6	25.3 $\pm$ 2
	03/24/99	1.6 $\pm$ 0.5	25.8 $\pm$ 2
	03/31/99	1.8 $\pm$ 0.6	21.6 $\pm$ 2
Reno	01/06/99	0.9 $\pm$ 0.5	26.1 $\pm$ 2
Ranch	01/13/99	0.9 $\pm$ 0.5	31.8 $\pm$ 2
	01/20/99	1.0 $\pm$ 0.5	11.8 $\pm$ 1
	01/27/99	0.3 $\pm$ 0.3	13.7 $\pm$ 2
	02/03/99	0.4 $\pm$ 0.4	26.1 $\pm$ 2
	02/10/99	0.6 $\pm$ 0.4	12.5 $\pm$ 1
	02/17/99	0.4 $\pm$ 0.4	18.5 $\pm$ 2
	02/24/99	0.6 $\pm$ 0.6	9.7 $\pm$ 2
	03/03/99	0.7 $\pm$ 0.5	13.2 $\pm$ 2
	03/10/99	0.4 $\pm$ 0.4	15.4 $\pm$ 2
	03/17/99	1.6 $\pm$ 0.7	31.4 $\pm$ 2
	03/24/99	1.7 $\pm$ 0.6	25.3 $\pm$ 2
	03/31/99	1.0 $\pm$ 0.6	22.5 $\pm$ 2
INEEL	01/06/99	0.7 $\pm$ 0.4	27.6 $\pm$ 2
Main	01/13/99	1.1 $\pm$ 0.5	32.7 $\pm$ 2
Gate	01/20/99	0.3 $\pm$ 0.3	10.4 $\pm$ 1
	01/27/99	0.4 $\pm$ 0.3	11.9 $\pm$ 1
	02/03/99	0.2 $\pm$ 0.4	29.4 $\pm$ 2
	02/10/99	0.4 $\pm$ 0.3	12.9 $\pm$ 1
	02/17/99	0.8 $\pm$ 0.4	19.1 $\pm$ 2
	02/24/99	0.1 $\pm$ 0.2	8.7 $\pm$ 1
	03/03/99	1.0 $\pm$ 0.4	13.7 $\pm$ 1
	03/10/99	0.8 $\pm$ 0.4	14.3 $\pm$ 1
	03/17/99	1.5 $\pm$ 0.5	29.2 $\pm$ 2
	03/24/99	1.3 $\pm$ 0.5	24.8 $\pm$ 2
	03/31/99	1.2 $\pm$ 0.5	20.5 $\pm$ 2

Appendix C
Weekly Gross Alpha and Gross Beta Concentrations in Air
1st Quarter 1999

Location	Collection Date	Gross Alpha Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)	Gross Beta Concentration $\pm 2s$ ($\mu\text{Ci/ml} \times 10^{-15}$)
EFS	01/06/99	0.6 $\pm$ 0.4	26.9 $\pm$ 2
	01/13/99	0.9 $\pm$ 0.4	22.9 $\pm$ 2
	01/20/99	0.9 $\pm$ 0.6	11.5 $\pm$ 2
	01/27/99	0.5 $\pm$ 0.5	15.8 $\pm$ 2
	02/03/99	0.4 $\pm$ 0.7	33.5 $\pm$ 3
	02/10/99	0.9 $\pm$ 0.6	15.3 $\pm$ 2
	02/17/99	0.2 $\pm$ 0.3	19.3 $\pm$ 2
	02/24/99	0.1 $\pm$ 0.3	8.2 $\pm$ 1
	03/03/99	0.8 $\pm$ 0.5	14.6 $\pm$ 1
	03/10/99	0.3 $\pm$ 0.3	14.3 $\pm$ 1
	03/17/99	1.3 $\pm$ 0.6	28.0 $\pm$ 2
	03/24/99	0.8 $\pm$ 0.5	26.1 $\pm$ 2
	03/31/99	1.2 $\pm$ 0.5	23.4 $\pm$ 2
VanBuren Avenue	01/06/99	1.5 $\pm$ 0.5	22.0 $\pm$ 2
	01/13/99	2.3 $\pm$ 0.6	39.1 $\pm$ 2
	01/20/99	0.4 $\pm$ 0.3	9.4 $\pm$ 1
	01/27/99	0.3 $\pm$ 0.3	10.5 $\pm$ 1
	02/03/99	1.0 $\pm$ 0.5	28.1 $\pm$ 2
	02/10/99	0.8 $\pm$ 0.4	9.6 $\pm$ 1
	02/17/99	0.8 $\pm$ 0.4	18.1 $\pm$ 2
	02/24/99	0.2 $\pm$ 0.3	7.8 $\pm$ 1
	03/03/99	1.0 $\pm$ 0.5	13.5 $\pm$ 1
	03/10/99	0.6 $\pm$ 0.4	14.2 $\pm$ 1
	03/17/99	1.0 $\pm$ 0.5	27.7 $\pm$ 2
	03/24/99	1.6 $\pm$ 0.5	25.0 $\pm$ 2
	03/31/99	1.3 $\pm$ 0.5	21.2 $\pm$ 2