Chemical Constituents in Water from Wells in the Vicinity of the Naval Reactors Facility, Idaho National Engineering Laboratory, Idaho, 1989-90

By LeRoy L. Knobel, Roy C. Bartholomay, Steven J. Wegner, and Daniel D. Edwards

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED UNITS

Multiply	By	To Obtain
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
acre-foot (acre-ft)	1,233	cubic meter
foot per mile (ft/mi)	0.1646	meter per kilometer
curie (Ci)	3.7×10^{10}	becquerel
picocurie per liter (pCi/L)	0.037	becquerel per liter

For temperature, degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the formula: $°F = (°C \times 1.8) + 32$.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated units used in report: mg/L (milligram per liter); µg/L (microgram per liter); and µS/cm (microsiemens per centimeter at 25 degrees Celsius).

CHEMICAL CONSTITUENTS IN WATER FROM WELLS IN THE VICINITY OF THE NAVAL REACTORS FACILITY, IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO, 1989-90

by

LeRoy L. Knobel, Roy C. Bartholomay, Steven J. Wegner,

and Daniel D. Edwards

ABSTRACT

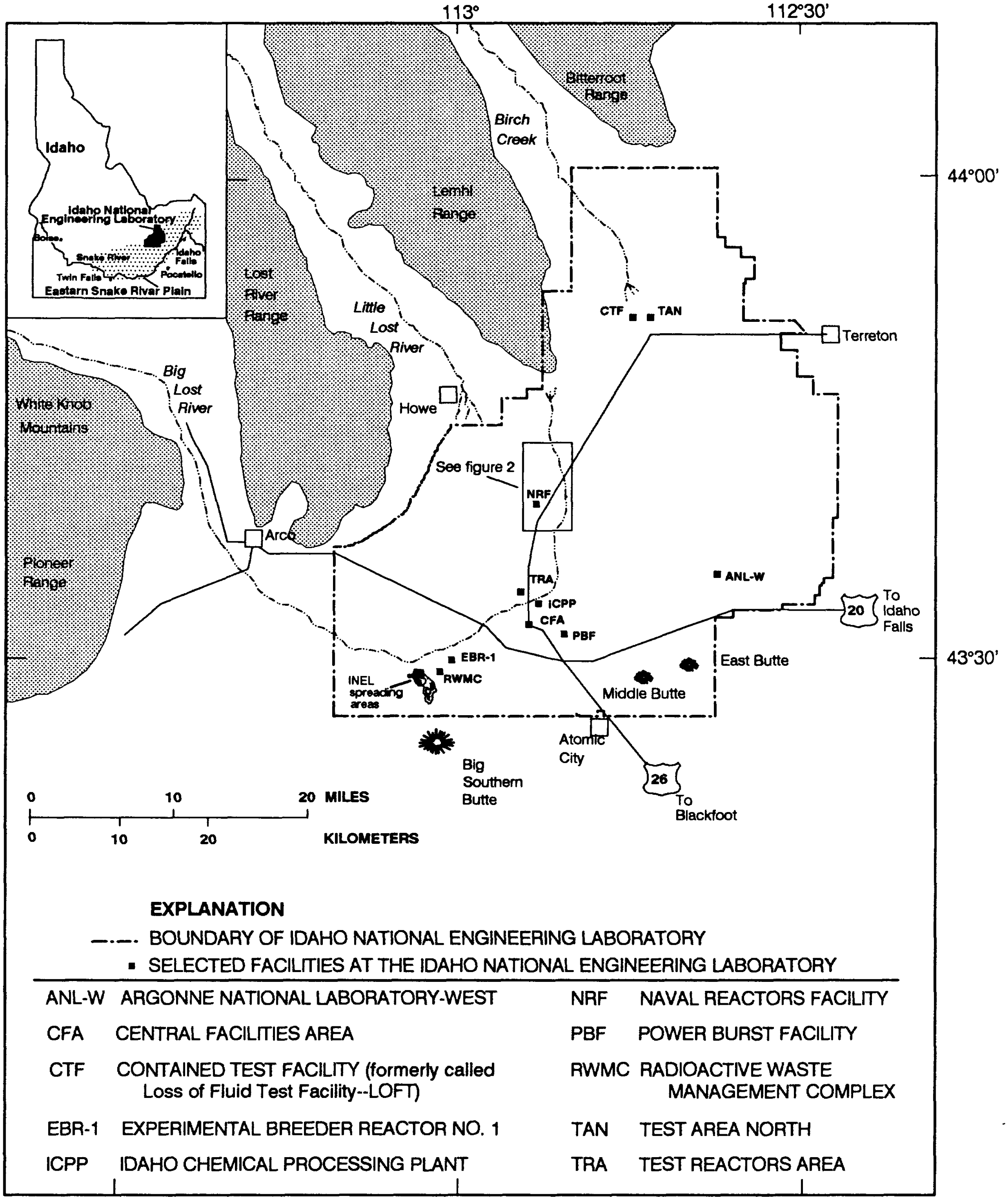
Ground-water-chemistry data collected during 1989-90 from 13 sites on the eastern Snake River Plain is presented as part of the U.S. Geological Survey's continuing water-quality monitoring program in the vicinity of the Naval Reactors Facility, Idaho National Engineering Laboratory, Idaho. Ranges of concentrations for total cations and dissolved anions were calcium--29 to 64 mg/L (milligrams per liter), potassium--1.5 to 2.6 mg/L, magnesium--8.6 to 28 mg/L, sodium--5.6 to 17 mg/L, bromide--0.02 to 0.35 mg/L, chloride--5.7 to 110 mg/L, sulfate--19 to 59 mg/L, and fluoride--less than 0.1 to 0.3 mg/L.

Purgeable organic compounds and extractable acid and base/neutral organic compounds were detected in water from two and nine sites, respectively. Concentrations of total organic carbon ranged from 0.1 to 0.9 mg/L. Total phenols in 9 of 13 samples ranged from 1 to 9 micrograms per liter.

Dissolved concentrations of gross alpha-particle radioactivity as thorium-230 ranged from less than the reporting level to 3.56±0.52 pCi/L (picocuries per liter), and concentrations of dissolved gross beta-particle radioactivity as cesium-137 ranged from 2.89±0.53 to 5.52±0.58 pCi/L. Concentrations of radium-226 ranged from 0.042±0.006 to 0.095±0.009 pCi/L. Tritium concentrations in 13 samples analyzed by the U.S. Geological Survey's National Water Quality Laboratory ranged from less than the reporting level to 179.2±12.8 pCi/L.

INTRODUCTION

The INEL (Idaho National Engineering Laboratory), encompassing about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1), is operated by the U.S. Department of Energy. INEL facilities are used in the development of peacetime atomic-energy applications, nuclear safety research, defense programs, and advanced energy concepts. Liquid radionuclide and chemical wastes generated at these facilities were discharged to onsite infiltration ponds and disposal wells from 1952 to 1983. Since 1983, most of the aqueous wastes have been discharged to unlined infiltration ponds. Liquid-waste disposal has resulted in detectable concentrations of several waste constituents in water in the Snake River Plain aquifer underlying the INEL.



EXPLANATION

—·—· BOUNDARY OF IDAHO NATIONAL ENGINEERING LABORATORY

▪ SELECTED FACILITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

ANL-W	ARGONNE NATIONAL LABORATORY-WEST	NRF	NAVAL REACTORS FACILITY
CFA	CENTRAL FACILITIES AREA	PBF	POWER BURST FACILITY
CTF	CONTAINED TEST FACILITY (formerly called Loss of Fluid Test Facility--LOFT)	RWMC	RADIOACTIVE WASTE MANAGEMENT COMPLEX
EBR-1	EXPERIMENTAL BREEDER REACTOR NO. 1	TAN	TEST AREA NORTH
ICPP	IDAHO CHEMICAL PROCESSING PLANT	TRA	TEST REACTORS AREA

Figure 1.--Location of the Idaho National Engineering Laboratory, Naval Reactors Facility, and other selected facilities.

The U.S. Department of Energy requires information about the mobility of dilute radionuclide- and chemical-waste constituents in the Snake River Plain aquifer. Waste-constituent mobility is, in part, determined by (1) the rate and direction of ground-water flow, (2) the locations, quantities, and methods of waste disposal, (3) waste-constituent chemistry, and (4) the geochemical processes taking place in the aquifer (Orr and Cecil, 1991, p. 2). This study was conducted by the U.S. Geological Survey in cooperation with the U.S. Department of Energy's Pittsburgh Naval Reactors Office, Idaho Branch Office.

Purpose and Scope

In 1989, the Idaho Branch Office of the Pittsburgh Naval Reactors Office, U.S. Department of Energy, requested that the U.S. Geological Survey initiate a water-quality data-collection program in the vicinity of the NRF (Naval Reactors Facility) at the INEL (fig. 1). The purpose of the data-collection program is to provide the Idaho Branch Office with a consistent set of water-chemistry data to evaluate the impact of NRF activities on the general water quality of the Snake River Plain aquifer.

The data-collection program consists of three rounds of sample collection. Round one was a one-time sampling of each site for a comprehensive suite of chemical constituents that approximates those contained in the U.S. Environmental Protection Agency's Ground-Water Monitoring List--Appendix IX (U.S. Environmental Protection Agency, 1989, p. 636-642). Round two consisted of five bimonthly samples from each site that were analyzed for the chemical constituents listed in Appendix III-EPA Interim Primary Drinking Water Standards, the constituents listed as parameters establishing ground-water quality, and selected measurements used as indicators of ground-water contamination (U.S. Environmental Protection Agency, 1989, p. 660-661, 730). Additional constituents determined in round-two samples included copper, nickel, zinc, and extractable acid and base/neutral compounds. Round three is ongoing; samples are collected on a quarterly basis. Constituents include chloride, chromium, iron, lead, mercury, nickel, nitrate as nitrogen, silver, sodium, and sulfate. Other round-three measurements are gross alpha- and gross beta-particle radioactivity, pH, specific conductance, and total organic carbon. All three sample rounds have some additional constituents included as a result of expanded laboratory procedures.

This report presents a compilation of round-one water-chemistry data collected during 1989-90. Round-one water-chemistry data from two additional sites will be presented in a subsequent report.

Hydrologic Conditions

The Snake River Plain aquifer is one of the most productive aquifers in the United States (U.S. Geological Survey, 1985, p. 193). The aquifer underlies the eastern Snake River Plain and consists of a thick sequence of basalts and sedimentary interbeds filling a large, arcuate, structural basin in southeastern Idaho (fig. 1).

Surface Water

The Big Lost River drains more than 1,400 mi^2 of mountainous area that includes parts of the Lost River Range and Pioneer Range west of the INEL (fig. 1). Flow in the Big Lost River infiltrates to the Snake River Plain aquifer along its channel and at sinks and playas at the river's terminus. Since 1958, excess runoff has been diverted to spreading areas in the southwestern part of the INEL where much of the water rapidly infiltrates to the aquifer. Other surface drainages that provide recharge to the Snake River Plain aquifer at the INEL include Birch Creek and the Little Lost River (fig. 1) (Orr and Cecil, 1991, p. 23).

Ground Water

Recharge to the Snake River Plain aquifer is principally from infiltration of applied irrigation water, infiltration of streamflow, and alluvial ground-water inflow from adjoining mountain drainage basins. Some recharge may be from direct infiltration of precipitation, although the small amount of annual precipitation on the plain (8 in. at the INEL), evapotranspiration, and the great depth to water (in places exceeding 900 ft) probably minimize this source of recharge (Orr and Cecil, 1991, p. 22-23).

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in the basalt. A significant proportion of ground water moves through the upper 800 ft of saturated rocks (Mann, 1986, p. 21). Hydraulic conductivity of basalt in the upper 800 ft of the aquifer generally is 1 to 100 ft/day. Hydraulic conductivity of underlying rocks is several orders of magnitude smaller. The effective base of the Snake River Plain aquifer at the INEL probably ranges from about 850 to 1,220 ft below land surface (Orr and Cecil, 1991, p. 25).

Depth to water in wells completed in the Snake River Plain aquifer ranges from about 200 ft in the northern part of the INEL to more than 900 ft in the southeastern part; in the vicinity of NRF, depth to water is about 375 ft. In July 1988, the altitude of the water table was about 4,590 ft above sea level near TAN (Test Area North) and about 4,420 ft above sea level near the RWMC (Radioactive Waste Management Complex); near NRF, the altitude was about 4,500 ft above sea level. Water flowed southward and southwestward beneath the INEL at an average hydraulic gradient of about 4 ft/mi; beneath NRF water generally flowed southward. Locally, however, the hydraulic gradient ranged from about 1 to 15 ft/mi. From July 1985 to July 1988, water-level changes in INEL wells ranged from a 26.8-ft decline near the RWMC to a 4.3-ft rise north of TAN; near NRF the water-level decline was about 1 to 3 ft. Water levels generally declined in the southern two-thirds of the INEL during that time and rose in the northern one-third (Orr and Cecil, 1991, p. 25-27).

Ground water moves southwestward from the INEL and is eventually discharged to springs along the Snake River downstream from Twin Falls, about 100 mi southwest of the INEL. Approximately 4.3 million acre-ft of ground water were discharged to these springs in 1988 (Mann, 1989, p. 2).

Guidelines for Interpreting Results of Radiochemical Analyses

Concentrations of radionuclides are reported with an estimated sample standard deviation, **s**, that is obtained by propagating sources of analytical uncertainty in measurements. The following guidelines for interpreting analytical results are based on an extension of a method proposed by Currie (1984).

In the analysis for a particular radionuclide, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and the blank vary randomly. Therefore, it is essential to distinguish between two key aspects of the problem of detection: (1) the instrument signal for the sample must be larger than the signal observed for the blank before the decision can be made that the radionuclide was detected; and (2) an estimation must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before the correct decision can be made for detection or nondetection of the radionuclide. The first aspect of the problem is a qualitative decision based on an observed signal and a definite criterion for detection. The second aspect of the problem is an estimation of the detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level before the qualitative decision can be made as to whether the radionuclide was detected. Radionuclide concentrations that equal 1.6s meet this criterion; at 1.6s, there is a 95-percent probability that the correct conclusion--not detected--will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentrations larger than or equal to 1.6s, which were concluded as being detected, might not contain the radionuclide. These measurements are referred to as false positives and are errors of the first kind in hypothesis testing.

Once the critical level of 1.6s has been defined, the minimum detectable concentration may be determined. Radionuclide concentrations that equal 3s represent a measurement at the minimum detectable concentration. For true concentrations of 3s or larger, there is a 95-percent or larger probability that the radionuclide was detected in a sample. In a large number of samples, the conclusion--not detected--will be made in 5 percent of the samples that contain true concentrations at the minimum detectable concentration of 3s. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing.

True radionuclide concentrations between 1.6s and 3s have larger errors of the second kind. That is, there is a larger-than-5-percent probability of false negative results for samples with true concentrations between 1.6s and 3s. Although the radionuclide might have been detected, such detection may not be considered reliable; at 1.6s, the probability of a false negative is about 50 percent.

The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values 1.6s and 3s vary slightly with background or blank counts, with the number of gross counts for individual analyses, and for different radionuclides. In this report, radionuclide concentrations less than 3s are considered to be below a "reporting level." The critical level, minimum detectable concentration, and reporting level aid the reader in the interpretation of analytical results and do not represent absolute concentrations of radioactivity which may or may not have been detected.

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METHODS AND QUALITY ASSURANCE

The methodology used in sampling for selected chemicals generally followed the guidelines established by the U.S. Geological Survey (Goerlitz and Brown, 1972; Stevens and others, 1975; Wood, 1981; Claassen, 1982; W.L. Bradford, U.S. Geological Survey, written commun., 1985; Wershaw and others, 1987; Fishman and Friedman, 1989; Hardy and others, 1989). The methods used in the field and quality assurance practices are outlined in following sections.

Sample Containers and Preservatives

Sample containers and preservatives differed depending on the constituent(s) for which analyses were requested. Samples analyzed by the NWQL (U.S. Geological Survey's National Water Quality Laboratory) were placed in containers and preserved in accordance with laboratory requirements specified by Pritt and Jones (1989). Containers and preservatives were supplied by the NWQL and had undergone a rigorous quality control procedure (Pritt, 1989, p. 75) to eliminate sample contamination. The containers and preservatives used for this study are listed on table 1.

Sampling Locations and Sample Collection

Samples were collected from 13 locations (fig. 2): 9 ground-water monitoring wells (NRF-5, USGS 12, 15, 17, 97-99, 102, and Water Supply INEL-1), and 4 production wells (NRF-1, -2, -3, and -4). The production wells were equipped with line-shaft turbine pumps. The ground-water monitoring wells (except NRF-5) were equipped with dedicated submersible pumps. The remaining well (NRF-5) did not have a permanent pump installation. The production wells and NRF-5 are located within the NRF boundary; USGS 102 is located west of the boundary; USGS 12, 15, and 17 are upgradient of the facility; and the remaining monitoring wells are located downgradient (fig. 2).

Samples were collected from a portable sampling apparatus at the wells with dedicated submersible pumps; from sampling ports on the discharge lines of the turbine pumps; and with a Teflon bailer at NRF-5. The only water sample collected at NRF-5 was for analysis of purgeable organic compounds. All portable equipment was decontaminated after each sample. After collection, sample containers were sealed with laboratory film, labeled, and stored under secured conditions. Water samples were placed in ice chests and sealed. The sealed ice chests were shipped daily by overnight-delivery mail to the NWQL.

Conditions at the sampling site during sample collection were recorded in a field logbook and a chain-of-custody record was used to track samples from the time of collection until delivery to the analyzing laboratory. These records are available for inspection at the U.S. Geological Survey's Project Office at the INEL. The results of field measurements for pH, specific conductance, and water temperature are listed in table 2.

Quality Assurance

Detailed descriptions of internal quality control and of the overall quality assurance practices used by the U.S. Geological Survey's NWQL are provided in reports by Friedman and Erdmann (1982) and Jones (1987). The water samples were collected in accordance with a draft quality assurance plan for quality of water activities conducted by personnel assigned to the INEL Project

Table 1.--***Containers and preservatives used for water samples, Naval Reactors Facility and vicinity***

[Analyses by U.S. Geological Survey's National Water Quality Laboratory. Abbreviations: L, liter; mL, milliliter; H_3PO_4, phosphoric acid; $CuSO_4$, copper sulfate; $HgCl_2$, mercuric chloride; NaCl, sodium chloride; HNO_3, nitric acid; $K_2Cr_2O_7$, potassium dichromate; HCl, hydrochloric acid; NaOH, sodium hydroxide; °C, degrees Celsius. Teflon: *The use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.* Samples were shipped by overnight-delivery mail]

Type of constituent	Container		Preservative		Other treatment
	Type	Size	Type	Size	
Anions	Polyethylene	250 mL	None	None	Filter
Cations, total	Polyethylene, acid-rinsed	250 mL	HNO_3	1 mL	None
Metals, total	Polyethylene, acid-rinsed	500 mL	HNO_3	2 mL	None
	Polyethylene, acid-rinsed	250 mL	HNO_3	1 mL	None
Mercury, total	Glass, acid-rinsed	250 mL	$K_2Cr_2O_7$/ HNO_3	10 mL	None
Thallium, dissolved	Teflon, acid-rinsed	250 mL	HNO_3 ultrapure	1 mL	Filter
Nutrients, total	Polyethylene, brown	250 mL	$HgCl_2$/ NaCl	1 mL	Chill 4°C
Cyanide	Polyethylene	250 mL	NaOH	5 mL	Chill 4°C
Total organic carbon	Glass, baked	125 mL	None	None	Chill 4°C
Anionic surfactants	Polyethylene	250 mL	None	None	Chill 4°C
Turbidity	Polyethylene	125 mL	None	None	None
Purgeable organic compounds	Glass, baked	40 mL	None	None	Chill 4°C
Semi-volatile organic compounds	Glass, baked	1 L	None	None	Chill 4°C

Table 1.--***Containers and preservatives used for water samples, Naval Reactors Facility and vicinity***--**Continued**

Type of constituent	Container		Preservative		Other treatment
	Type	Size	Type	Size	
Phenols, total	Glass, baked	1 L	H_3PO_4 / $CuSO_4$	10 mL	Chill 4°C
Pesticides	Glass, baked	1 L	None	None	Chill 4°C
Gross alpha and beta	Polyethylene, acid-rinsed	1 L	None	None	None
Tritium	Polyethylene, acid-rinsed	250 mL	None	None	None
Radium-226	Polyethylene, acid-rinsed	1 L	HCl	5 mL	Filter
Radium-228	Polyethylene, acid-rinsed	1 L	HCl	5 mL	Filter

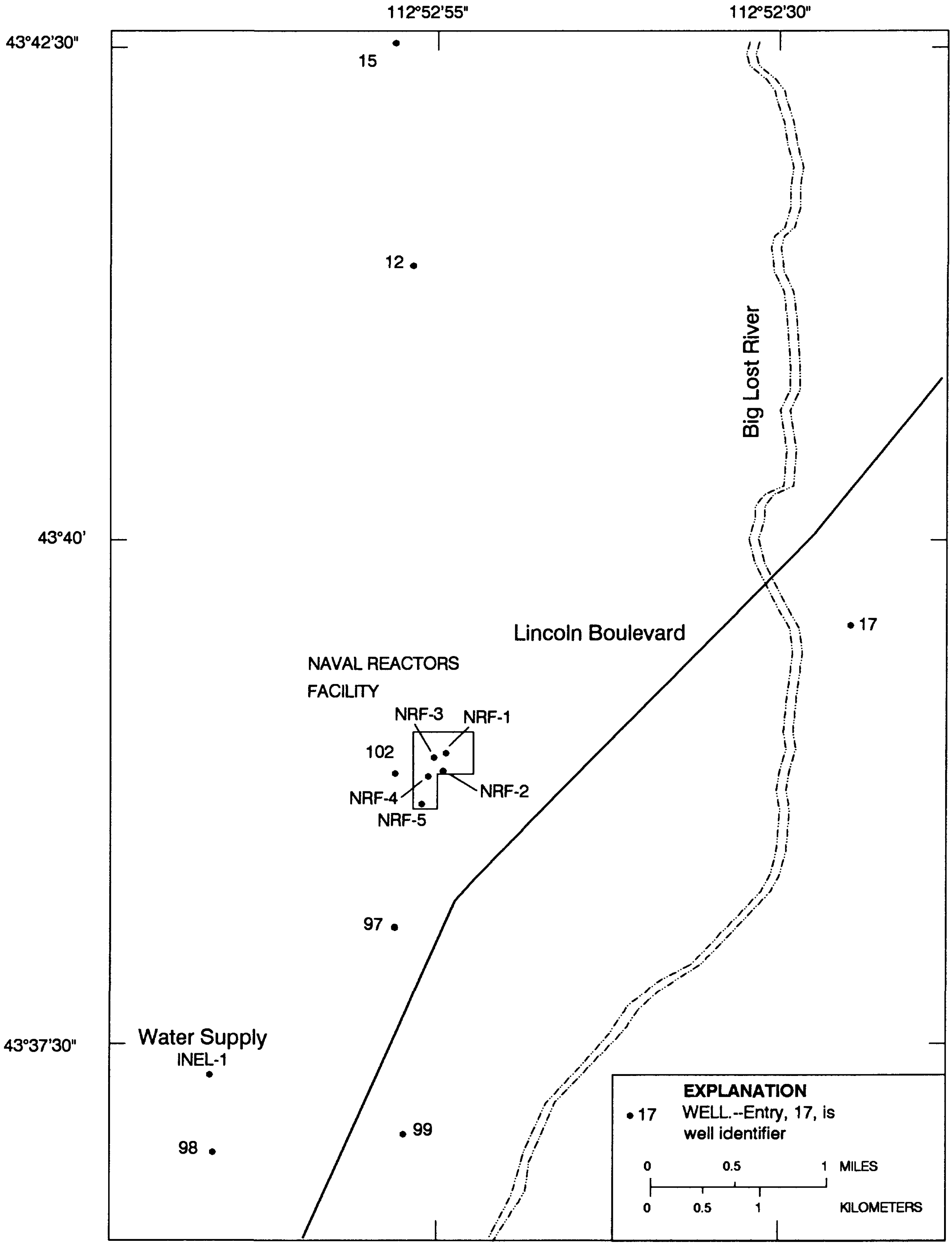

Figure 2.--Location of wells, Naval Reactors Facility and vicinity, Idaho National Engineering Laboratory.

Table 2.--***Results of field measurements for pH, specific conductance, and temperature of water from selected sites, Naval Reactors Facility and vicinity***

[Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Units: pH, negative base-10 logarithm of hydrogen ion activity in moles per liter; specific conductance, microsiemens per centimeter at 25°C (degrees Celsius); temperature, °C. Remarks: QAS indicates quality assurance sample; TP indicates dedicated turbine pump; SP indicates impeller-driven submersible pump]

Site identifier	Date sampled (m/d/y)	Time	pH	Specific conductance	Temperature	Remarks
Blank	12/1/89	1440	7.9	10	18.5	QAS-1
NRF-1	12/19/89	1325	8.0	551	11.5	TP
NRF-2	12/21/89	1100	7.9	620	11.5	TP
NRF-3	12/19/89	1305	8.0	540	12.0	TP
NRF-4	12/19/89	1016	7.6	550	12.0	TP
NRF-5	12/21/89	0955	9.0	190	11.5	Bailed sample
USGS 12	6/15/90	1145	7.8	550	12.5	SP
	6/14/90	1400	7.8	550	12.5	QAS-4, SP, replicate
15	6/6/90	1350	7.8	475	11.5	SP
17	12/14/89	1300	7.3	295	13.0	SP
97	11/30/89	1055	7.8	570	11.5	SP
98	11/29/89	1230	7.9	430	12.0	SP
99	11/30/89	1320	7.8	530	12.0	SP
102	6/8/90	0955	8.0	565	12.0	SP
Water Supply INEL-1	12/14/89	1025	8.2	800	11.0	SP

Office; the draft plan was finalized in June 1989 and is available for inspection at the U.S. Geological Survey's Project Office at the INEL. A comparative study to determine agreement between analytical results for water-sample pairs by laboratories involved in the INEL Project Office's quality assurance program is summarized by Wegner (1989). Additional quality assurance instituted for this sampling program included a replicate of USGS 12 and a blank sample prepared with deionized water from an Idaho Chemical Processing Plant laboratory. Concentrations in the blank sample were not included in the computation of statistical parameters. Analytical results for the quality assurance samples will be discussed along with similar data in subsequent sections of this report.

Calculation of Estimated Experimental Standard Errors

The analytical results for radionuclides are presented with calculated analytical uncertainties. There is about a 67-percent probability that the true radionuclide concentration is in a range of the reported concentration plus or minus the uncertainty. The uncertainties are expressed as one sample standard deviation. The associated uncertainties presented with mean concentrations are experimental standard errors and are an estimate of the uncertainty of the mean concentration. The EESE (estimated experimental standard errors) were calculated with the following equation (Iman and Conover, 1983, p. 158):

$$\mathrm{EESE} = \sigma/(n)^{0.5}$$

where σ = population standard deviation, and

n = sample size.

The population standard deviation, σ, is customarily estimated by s (the sample standard deviation) (Iman and Conover, 1983, p. 106). The sample standard deviation is the square root of the sample variance (Iman and Conover, 1983, p. 100-101).

CATIONS AND ANIONS

Water samples were analyzed for total concentrations of calcium, potassium, magnesium, and sodium, and for dissolved concentrations of bromide, chloride, fluoride, and sulfate (tables 3-4). The ranges of concentrations, the median concentration, and the mean concentration for each constituent follow: calcium--29 to 64, 56, and 53 mg/L; potassium--1.5 to 2.6, 1.9, and 1.9 mg/L; magnesium--8.6 to 28, 19, and 19 mg/L; sodium--5.6 to 17, 13, and 12 mg/L; bromide--0.02 to 0.35, 0.06, and 0.08 mg/L; chloride--5.7 to 110, 30, and 34 mg/L; and sulfate--19 to 59, 32, and 33 mg/L. Fluoride ranged from less than 0.1 to 0.3 mg/L and the median was 0.2 mg/L. The mean of 12 fluoride concentrations was 0.2 mg/L.

The concentrations of cations and anions in the replicate sample of USGS 12 were about the same as those in the primary sample. Concentrations in the blank sample were less than or near the laboratory reporting levels.

SELECTED INORGANIC CONSTITUENTS

Water samples were collected and analyzed for total concentrations of aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, sele-

Table 3.--***Concentrations of total cations in water, Naval Reactors Facility and vicinity***
[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using the U.S. Environmental Protection Agency's recommended digestion procedure (Pritt and Jones, 1989). Analytical results in milligrams per liter. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: < indicates less than]

Site identifier	Calcium	Potassium	Magnesium	Sodium	Remarks
Blank	0.2	0.1	<0.1	<0.1	QAS-1
NRF-1	52	1.8	18	12	
NRF-2	57	2.0	19	17	
NRF-3	53	1.8	18	11	
NRF-4	56	1.9	19	14	
USGS 12	64	1.9	20	13	
	63	1.9	20	13	QAS-4, replicate
15	43	1.5	18	15	
17	29	2.0	8.6	5.6	
97	59	1.8	21	11	
98	42	2.2	17	7.9	
99	55	1.7	21	12	
102	62	2.0	21	13	
Water Supply INEL-1	60	2.6	28	16	

Table 4.--***Concentrations of dissolved anions in water, Naval Reactors Facility and vicinity***
[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in milligrams per liter. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: < indicates less than]

Site identifier	Bromide	Chloride	Fluoride	Sulfate	Remarks
Blank	<0.01	<0.1	<0.1	<1.0	QAS-1
NRF-1	.06	32	.2	36	
NRF-2	.07	50	.2	46	
NRF-3	.06	30	.2	35	
NRF-4	.06	40	.2	41	
USGS 12	.06	31	<.1	32	
	.06	30	.1	30	QAS-4, replicate
15	.04	22	.3	25	
17	.02	5.7	.2	19	
97	.07	28	.2	34	
98	.04	13	.2	22	
99	.05	18	.1	27	
102	.05	29	.2	26	
Water Supply INEL-1	.35	110	.1	59	

nium, silver, and zinc. In addition, samples were collected and analyzed for dissolved thallium (table 5). The replicate sample from USGS 12 contained the same concentrations as the primary sample for most constituents; however, aluminum, chromium, and iron differed slightly (table 5). In the blank sample, concentrations of most constituents were less than the laboratory reporting levels; however, concentrations of aluminum, chromium, copper, iron, lead, and zinc were larger (table 5).

Aluminum.--Concentrations in 6 of 13 samples were less than the reporting level of 10 µg/L. Concentrations in the remaining seven samples ranged from 10 to 50 µg/L and were distributed about median and mean concentrations of 30 and 30 µg/L, respectively.

Arsenic.--Concentrations in 13 samples ranged from 1 to 2 µg/L and were distributed about median and mean concentrations of 1 and 1 µg/L, respectively.

Barium.--Concentrations in 9 of 13 samples were less than the reporting level of 100 µg/L. Concentrations in the remaining four samples ranged from 100 to 300 µg/L.

Beryllium.--Concentrations in 12 of 13 samples were less than the reporting level of 10 µg/L. The concentration in the remaining sample was 10 µg/L.

Cadmium.--Concentrations in 13 samples were less than the reporting level of 1 µg/L.

Chromium.--Concentrations in 13 samples ranged from 3 to 19 µg/L and were distributed about median and mean concentrations of 8 and 9 µg/L, respectively.

Cobalt.--Concentrations in 10 of 13 samples were less than the reporting level of 50 µg/L. Concentrations in the remaining three samples ranged from 50 to 60 µg/L.

Copper.--Concentrations in 13 samples ranged from 1 to 7 µ/L and were distributed about median and mean concentrations of 2 and 3 µg/L, respectively.

Iron.--The concentration in 1 of 13 samples was less than the reporting level of 10 µg/L. Concentrations in the remaining 12 samples ranged from 20 to 630 µg/L and were distributed about median and mean concentrations of 50 and 100 µg/L, respectively.

Lead.--Concentrations in 13 samples ranged from 1 to 3 µg/L and were distributed about median and mean concentrations of 1 and 2 µg/L, respectively.

Manganese.--Concentrations in 9 of 13 samples were less than the reporting level of 10 µg/L. Concentrations in the remaining four samples ranged from 10 to 30 µg/L.

Mercury.--Thirteen water samples from the Snake River Plain aquifer were analyzed for mercury and concentrations in all 13 samples were less than the reporting level of 0.1 µg/L.

Nickel.--The concentration in 1 of 12 samples was less than the reporting level of 1 µg/L. Concentrations in the remaining 11 samples ranged from 1 to 2 µg/L and were distributed about median and mean concentrations of 1 and 1 µg/L, respectively.

Selenium.--The concentration in 1 of 13 samples was less than the reporting level of 1 µg/L. Concentrations in the remaining 12 samples ranged from 1 to 3 µg/L and were distributed about median and mean concentrations of 2 and 2 µg/L, respectively.

Table 5.--***Total concentrations of selected minor inorganic constituents and dissolved thallium in water, Naval Reactors Facility and vicinity***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in micrograms per liter. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: NR indicates analysis not requested; < indicates concentration is less than the specified reporting level]

Site identifier	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Remarks
Blank	20	<1	<100	<10	<1	QAS-1
NRF-1	<10	1	<100	10	<1	
NRF-2	<10	2	300	<10	<1	
NRF-3	10	1	<100	<10	<1	
NRF-4	20	1	<100	<10	<1	
USGS 12	50	2	100	<10	<1	
"	10	2	100	<10	<1	QAS-4, replicate
15	<10	1	100	<10	<1	
17	40	2	<100	<10	<1	
97	<10	1	<100	<10	<1	
98	<10	2	<100	<10	<1	
99	<10	1	<100	<10	<1	
102	40	2	<100	<10	<1	
Water Supply INEL-1	30	1	<100	<10	<1	

Table 5.--***Total concentrations of selected minor inorganic constituents and dissolved thallium in water, Naval Reactors Facility and vicinity*****--Continued**

Site identifier	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Remarks
Blank	2	<50	15	80	3	<10	QAS-1
NRF-1	9	<50	2	50	2	<10	
NRF-2	13	<50	1	20	1	10	
NRF-3	7	<50	6	120	1	10	
NRF-4	11	<50	4	20	1	<10	
USGS 12	8	<50	3	30	1	<10	
	7	<50	3	50	1	<10	QAS-4, replicate
15	8	<50	2	60	1	<10	
17	3	<50	1	120	1	20	
97	19	60	2	60	3	<10	
98	7	50	7	20	2	<10	
99	8	50	2	50	3	<10	
102	8	<50	2	<10	2	<10	
Water Supply INEL-1	12	<50	3	630	3	30	

Table 5.--*Total concentrations of selected minor inorganic constituents and dissolved thallium in water, Naval Reactors Facility and vicinity*--**Continued**

Site identifier	Mercury	Nickel	Selenium	Silver	Thallium, dissolved	Zinc	Remarks
Blank	<0.1	NR	<1	<1	<1	10	QAS-1
NRF-1	<.1	1	2	<1	<1	40	
NRF-2	<.1	1	2	<1	<1	<10	
NRF-3	<.1	1	2	<1	<1	30	
NRF-4	<.1	1	2	<1	<1	<10	
USGS 12	<.1	1	2	<1	<1	10	
	<.1	1	2	<1	<1	10	QAS-4, replicate
15	<.1	2	1	<1	<1	<10	
17	<.1	1	<1	<1	<1	<10	
97	<.1	<1	2	<1	<1	100	
98	<.1	1	1	<1	<1	100	
99	<.1	1	1	<1	<1	90	
102	<.1	2	2	<1	<1	<10	
Water Supply INEL-1	<.1	NR	3	<1	<1	130	

Silver.--Concentrations in all 13 water samples from the Snake River Plain aquifer were less than the reporting level of 1 µg/L.

Thallium, dissolved.--Concentrations in all 13 water samples from the Snake River Plain aquifer were less than the reporting level of 1 µg/L.

Zinc.--Concentrations in 5 of 13 samples were less than the reporting level of 10 µg/L. Concentrations in the remaining eight samples ranged from 10 to 130 µg/L and were distributed about median and mean concentrations of 65 and 60 µg/L, respectively.

NITROGEN COMPOUNDS

Total concentrations of ammonia as nitrogen, ammonia plus organic nitrogen as nitrogen, nitrite as nitrogen, and nitrite plus nitrate as nitrogen were determined in 13 water samples from the Snake River Plain aquifer. In addition, the water samples were analyzed for concentrations of dissolved cyanide (table 6). The concentrations in the replicate of USGS 12 were the same as those in the primary sample except for ammonia plus organic nitrogen as nitrogen. The concentrations were 0.6 mg/L and less than the reporting level of 0.2 mg/L (table 6). The blank sample had concentrations less than the reporting levels except for ammonia as nitrogen, which was 0.03 mg/L.

Ammonia as nitrogen.--Concentrations in 8 of 13 samples were less than the reporting level of 0.01 mg/L; concentrations in the remaining five samples ranged from 0.01 to 0.03 mg/L.

Ammonia plus organic nitrogen as nitrogen.--Concentrations in 8 of 13 samples were less than the reporting level of 0.2 mg/L; concentrations in the remaining five samples ranged from 0.2 to 0.6 mg/L.

Nitrite as nitrogen.--Concentrations in all 13 water samples from the Snake River Plain aquifer were less than the reporting level of 0.01 mg/L.

Nitrite plus nitrate as nitrogen.--Concentrations in 13 samples ranged from 0.30 to 5.9 mg/L and were distributed about median and mean concentrations of 1.6 and 1.9 mg/L, respectively.

Cyanide, dissolved.--Concentrations in 13 samples were less than the reporting level of 0.01 mg/L.

MISCELLANEOUS CHEMICAL CONSTITUENTS AND TURBIDITY

Water samples were collected and analyzed for total concentrations of anionic surfactants reported as MBAS (methylene blue active substances), organic carbon, phenols, and phosphorus. In addition, 12 of 13 water samples from the Snake River Plain aquifer were measured for turbidity (table 7). The turbidity sample from USGS 98 was lost by the laboratory. Concentrations of all constituents in the replicate sample of USGS 12 were similar to those in the primary sample; however, the turbidity measurements differed slightly; 0.6 NTU (nephelometric turbidity units) as compared to 1.1 NTU. Concentrations of all constituents in the blank sample were less than the reporting levels except for the concentration of total phenols, which was 4 µg/L. The turbidity measurement in the blank sample was 0.1 NTU.

Table 6.--***Total concentrations of selected nitrogen compounds and dissolved cyanide in water, Naval Reactors Facility and vicinity***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in milligrams per liter. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: < indicates concentration is less than the specified reporting level]

Site identifier	Ammonia as nitrogen	Ammonia plus organic nitrogen as nitrogen	Nitrite as nitrogen	Nitrite plus nitrate as nitrogen	Cyanide, dissolved	Remarks
Blank	0.03	<0.2	<0.01	<0.10	<0.01	QAS-1
NRF-1	.02	<.2	<.01	1.7	<.01	
NRF-2	.02	<.2	<.01	1.9	<.01	
NRF-3	.01	<.2	<.01	1.5	<.01	
NRF-4	.02	<.2	<.01	2.1	<.01	
USGS 12	<.01	<.2	<.01	1.6	<.01	
	<.01	.6	<.01	1.6	<.01	QAS-4, replicate
15	<.01	.5	<.01	1.3	<.01	
17	<.01	<.2	<.01	.30	<.01	
97	<.01	<.2	<.01	1.9	<.01	
98	<.01	<.2	<.01	1.1	<.01	
99	<.01	.3	<.01	1.6	<.01	
102	<.01	.3	<.01	1.7	<.01	
Water Supply INEL-1	.03	.2	<.01	5.9	<.01	

Table 7.--*Total concentrations of anionic surfactants, organic carbon, phenols, and phosphorus in water, and turbidity, Naval Reactors Facility and vicinity*

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: < indicates less than; LS indicates sample lost by laboratory; MBAS indicates methylene blue active substances; P indicates phosphorus; NTU indicates nephelometric turbidity units; mg/L indicates milligram per liter; µg/L indicates microgram per liter]

Site identifier	Anionic surfactants as MBAS (mg/L)	Organic carbon (mg/L)	Phenols (µg/L)	Phosphorus as P (mg/L)	Turbidity (NTU)	Remarks
Blank	<0.01	<0.1	4	<0.01	0.1	QAS-1
NRF-1	.05	.3	9	.03	.1	
NRF-2	.04	.5	4	.02	.2	
NRF-3	.03	.7	2	.02	.1	
NRF-4	.03	.5	4	.02	.3	
USGS 12	.03	.3	1	.02	.6	
	.04	.3	2	.02	1.1	QAS-4, replicate
15	.01	.2	4	.02	.5	
17	<.01	.1	2	.01	.1	
97	.04	.3	<1	.02	.1	
98	.01	.1	<1	.02	LS	
99	.03	.2	<1	.02	.1	
102	.02	.3	3	.02	.2	
Water Supply INEL-1	.08	.9	<1	.01	.2	

Anionic surfactants.--The concentration in 1 of 13 samples was less than the reporting level of 0.01 mg/L. Concentrations in the remaining 12 samples ranged from 0.01 to 0.08 mg/L and were distributed about median and mean concentrations of 0.03 and 0.03 mg/L, respectively.

Organic carbon.--Concentrations in 13 samples ranged from 0.1 to 0.9 mg/L and were distributed about median and mean concentrations of 0.3 and 0.4 mg/L, respectively.

Phenols.--Concentrations in 4 of 13 samples were less than the reporting level of 1 µg/L. Concentrations in the remaining nine samples ranged from 1 to 9 µg/L and were distributed about median and mean concentrations of 3 and 3 µg/L, respectively.

Phosphorus.--Concentrations in 13 samples ranged from 0.01 to 0.03 mg/L and were distributed about median and mean concentrations of 0.02 and 0.02 mg/L, respectively.

Turbidity.--Measurements of 12 samples ranged from 0.1 to 1.1 NTU and were distributed about median and mean measurements of 0.2 and 0.3 NTU, respectively.

EXTRACTABLE ACID AND BASE/NEUTRAL ORGANIC COMPOUNDS

Extractable acid and base/neutral organic compound samples for 12 wells, a quality assurance replicate, and a blank sample were analyzed by the NWQL for 54 compounds (table 8). Concentrations of compounds that are larger than the reporting level (table 8) are listed in table 9. Compounds in table 9 that are not listed in table 8 are TIOC's (tentatively identified organic compounds[1]).

PURGEABLE ORGANIC COMPOUNDS

Concentrations of 36 purgeable organic compounds (table 10) in 15 samples from 13 sites (table 2) were determined by the NWQL using a method that conforms to U.S. Environmental Protection Agency method 524.2 (Pritt and Jones, 1989; M.P. Schroeder, U.S. Geological Survey, written commun., 1991). USGS 12 and the replicate sample both contained 0.2 µg/L of toluene. The sample from NRF-5 contained 0.2 µg/L of 1,1-Dichloroethane. No other purgeable organic compounds were present in any sample at concentrations larger than the reporting level of 0.2 µg/L. TIOC's were not identified in any of the samples.

HERBICIDES

Concentrations of 16 herbicides (table 11) were determined by the NWQL. Herbicides were not detected in any wells at concentrations larger than the reporting levels.

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[1] Data for TIOC's in this report are based on comparison of sample spectra with library spectra followed by visual examination by gas chromatograph/mass spectrometer analysts. TIOC data have not been confirmed by direct comparison with reference standards. Therefore, TIOC identification is tentative, and reported concentrations are semiquantitative.

Table 8.--***Extractable acid and base/neutral organic compounds for which water samples were analyzed***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using gas chromatography to separate the compounds and mass spectrometry and flame ionization for identification and quantification. Initial extraction was with methylene chloride. Reporting levels are in micrograms per liter (Pritt and Jones, 1989)]

Compound	Reporting level	Compound	Reporting level
Acenaphthene	5.0	2,4-Dinitrophenol	20.0
Acenaphthylene	5.0	2,4-Dinitrotoluene	5.0
Anthracene	5.0	2,6-Dinitrotoluene	5.0
Benzo (a) anthracene	10.0	Di-n-octylphthalate	10.0
Benzo (b) fluoranthene	10.0	bis (2-Ethylhexyl) phthalate	5.0
Benzo (k) fluoranthene	10.0	Fluoranthene	5.0
Benzo (g,h,i) perylene	10.0	Fluorene	5.0
Benzo (a) pyrene	10.0	Hexachlorobenzene	5.0
4-Bromophenyl phenyl ether	5.0	Hexachlorobutadiene	5.0
Butyl benzyl phthalate	5.0	Hexachlorocyclopentadiene	5.0
bis (2-Chloroethoxy) methane	5.0	Hexachloroethane	5.0
bis (2-Chloroethyl) ether	5.0	Indeno (1,2,3-cd) pyrene	10.0
bis (2-Chloroisopropyl) ether	5.0	Isophorone	5.0
4-Chloro-3-methylphenol	30.0	2-Methyl-4,6-dinitrophenol	30.0
2-Chloronaphthalene	5.0	Naphthalene	5.0
2-Chlorophenol	5.0	Nitrobenzene	5.0
4-Chlorophenyl phenyl ether	5.0	2-Nitrophenol	5.0
Chrysene	10.0	4-Nitrophenol	30.0
Dibenzo (a,h) anthracene	10.0	n-Nitrosodimethylamine	5.0
1,2-Dichlorobenzene	5.0	n-Nitrosodi-n-propylamine	5.0
1,3-Dichlorobenzene	5.0	n-Nitrosodiphenylamine	5.0
1,4-Dichlorobenzene	5.0	Pentachlorophenol	30.0
2,4-Dichlorophenol	5.0	Phenanthrene	5.0
Diethyl phthalate	5.0	Phenol	5.0
Dimethyl phthalate	5.0	Pyrene	5.0
2,4-Dimethylphenol	5.0	1,2,4-Trichlorobenzene	5.0
Di-n-butyl phthalate	5.0	2,4,6-Trichlorophenol	20.0

Table 9.--*Concentrations of selected extractable acid and base/neutral organic compounds in water, Naval Reactors Facility and vicinity*

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in micrograms per liter; no entry indicates the concentration was less than the reporting level. Compounds not listed in table 8 are TIOC's (tentatively identified organic compounds): the reported concentration generally is accurate to one order of magnitude. Data for TIOC's in this report are based on a comparison of sample spectra with library spectra followed by visual examination by gas chromatograph/mass spectrometer analysts. TIOC data have not been confirmed by direct comparison with reference standards. Therefore, TIOC identification is tentative, and reported concentrations are semiquantitative. Site identifier: see figure 2 for location of sites. Retention time: time required for a compound to pass through the column of a gas chromatograph. Remarks: QAS indicates quality assurance sample. CAS No. indicates Chemical Abstract Services number; no entry indicates CAS No. not listed in Pritt and Jones (1989) or on laboratory analytical result sheet. Symbols: # indicates that retention time was not reported by the laboratory]

Site identifier	Compound	Concentration	Retention time (minutes)	Remarks
Blank	bis (2-Ethylhexyl) phthalate	28	#	QAS-1, CAS No. 117-81-7
	1,2-Benzenedicarboxylic acid, diethyl e	.4	27.38	CAS No. 84662
	Dibrominated hydrocarbon	.2	29.45	
	Unknown compound	.4	32.59	
	Aromatic hydrocarbon	.4	32.87	
	1,2-Benzenedicarboxylic acid, dibutyl e	.3	34.12	CAS No. 84742
	Aromatic hydrocarbon	.2	36.52	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	4.0	37.68	CAS No. 38949198
NRF-1	Unknown compound	.3	30.66	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.4	37.80	CAS No. 38949198

Table 9.--*Concentrations of selected extractable acid and base/neutral organic compounds in water, Naval Reactors Facility and vicinity*--**Continued**

Site identifier	Compound	Concen-tration	Retention time (minutes)	Remarks
NRF-2	Unknown compound	.3	19.71	
	Unknown compound	.1	29.86	
	Unknown compound	.3	30.77	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.2	37.95	CAS No. 38949198
	Unknown compound	4.0	48.68-48.76	
NRF-3	1H-Indene, octohydro-2,2,4,4,7,7, hexame	.5	23.83	CAS No. 54832836
	Phenol, 2,6-bis (1,1-dimethylethyl)-	.6	24.08	CAS No. 128392
	Hydrocarbon background, summed	2,000	24-42	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.1	37.76	CAS No. 38949198
NRF-4	Organic acid ester	.3	30.66	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.3	37.83	CAS No. 38949198
USGS 17	Cyclohexanol, 4-chloro-,trans-	.9	12.98	CAS No. 29538770
	Dibromo benzene	1.0	18.04	
	Unknown compound	.2	25.44	
	Unknown compound	.3	30.66	

Table 9.--*Concentrations of selected extractable acid and base/neutral organic compounds in water, Naval Reactors Facility and vicinity*--**Continued**

Site identifier	Compound	Concentration	Retention time (minutes)	Remarks
USGS 17 cont.	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.4	37.77	CAS No. 38949198
97	Unknown compound	.3	32.58	
	Unknown compound	.4	32.85	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	5.0	37.66	CAS No. 38949198
	6 Methyl-2 phenylindole	.1	44.66	
98	Unknown compound	.3	30.64	
	Unknown compound	.3	32.57	
	Unknown compound	.3	32.85	
	Unknown compound	.2	36.49	
	Fatty acid ester	.1	37.55	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	4.0	37.66	CAS No. 38949198
99	Alkane	.3	7.48	
	Dibrominated hydrocarbon	.1	29.42	
	Aromatic hydrocarbon	.3	32.85	
	Unknown hydrocarbon	.2	36.50	
	Hexadecanoic acid, butyl ester	.4	37.55	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	3.0	37.66	CAS No. 38949198

Table 9.--*Concentrations of selected extractable acid and base/neutral organic compounds in water, Naval Reactors Facility and vicinity*--**Continued**

Site identifier	Compound	Concentration	Retention time (minutes)	Remarks
USGS 99 cont.	Fatty acid, butyl ester	.2	40.47	
Water Supply INEL-1	Unknown compound	.2	24.74	
	Unknown compound	.5	24.94	
	Aromatic hydrocarbon	.3	30.66	
	1,3-Benzenediamine, 2,4-dinitro-6-(trif)	.5	37.76	CAS No. 38949198

Table 10.--***Purgeable organic compounds for which water samples were analyzed***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using an analytical method that conforms to U.S. Environmental Protection Agency method 524.2. Reporting level for all compounds is 0.2 microgram per liter (Pritt and Jones, 1989)]

Compound
Benzene
Bromoform
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethyl vinyl ether
Chloroform
Chloromethane
Dibromochloromethane
Dichlorobromomethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Dichlorodifluoromethane
1,2-Dibromoethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-trans-Dichloroethylene
1,2-Dichloropropane
Cis-1,3-Dichloropropene
Trans-1,3-Dichloropropene
1,3-Dichloropropene
Ethylbenzene
Methyl bromide
Styrene
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
Trichlorofluoromethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl chloride
Xylenes, mixed

Table 11.--***Herbicides for which water samples were analyzed***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using the following methods: Triazine herbicides by optional adsorption chromatography on alumina to eliminate interferences followed by identification with selective gas chromatographic separation and a nitrogen specific detector; Chlorophenoxy acid herbicides by converting the compounds to methyl esters followed by identification with gas chromatography and an electron-capture detector (Wershaw and others, 1987, p. 40, 47). Reporting levels are from Pritt and Jones (1989). Abbreviations--µg/L indicates microgram per liter]

Triazines and other nitrogen-containing herbicides: reporting level is 0.1 µg/L

Herbicide	Herbicide
Alachlor	Prometon
Ametryn	Prometryn
Atrazine	Propazine
Cyanazine	Simazine
Metolachlor	Simetryn
Metribuzin	Trifluralin

Chlorophenoxy acid herbicides: reporting level is 0.01 µg/L

Herbicide	Herbicide
2,4-D	Silvex
2,4-DP	2,4,5-T

INSECTICIDES, BENZENE HEXACHLORIDES, POLYCHLORINATED COMPOUNDS, AND AROCLORS

Concentrations of 10 carbamate insecticides, 13 organophosphorus insecticides, 15 organochlorine insecticides, 3 benzene hexachlorides (BHC), gross polychlorinated biphenyls (PCB), gross polychlorinated naphthalenes (PCN), and 7 aroclors (table 12) were determined by the NWQL. Water from USGS 97 contained 0.1 µg/L of cyanazine--a carbamate insecticide. Other carbamate, organophosphorus, and organochlorine insecticides were not identified in any of the water samples. Two water samples for analysis of azinphos-methyl (Guthion)--from USGS 12 and its replicate (QAS-4)--were lost by the laboratory and no results are available. Concentrations of polychlorinated compounds--PCB, PCN, and aroclors--were less than the reporting levels in all water samples collected.

GROSS ALPHA- AND GROSS BETA-PARTICLE RADIOACTIVITY

Concentrations of both dissolved and suspended gross alpha- and gross beta-particle radioactivity were determined for 14 samples using a residue procedure. Concentrations of gross alpha-particle radioactivity are listed in table 13 and concentrations of gross beta-particle radioactivity are listed in table 14.

Concentrations of dissolved gross alpha-particle radioactivity in the quality assurance replicate and the primary sample from USGS 12 were not in agreement (table 13). The reason for the disagreement between sample results is unknown. Concentrations of dissolved and suspended gross beta-particle radioactivity and suspended gross alpha-particle radioactivity were in general agreement (tables 13 and 14).

The dissolved concentrations of gross alpha- and gross beta-particle radioactivity in the blank samples were small but greater than the reporting level of 3 times the 1*s* value. Suspended concentrations were less than the reporting level.

Gross alpha-particle radioactivity.--Gross alpha-particle radioactivity is a measure of the total radioactivity given off as alpha particles during the radioactive decay process. For convenience, laboratories report the radioactivity as if it were all given off by one radionuclide. In this report, concentrations are reported two ways: as thorium-230 in picocuries per liter, and as natural uranium in micrograms per liter. Gross alpha-particle radioactivity was measured in both the dissolved and suspended fractions of 13 water samples from the Snake River Plain aquifer (table 13). Six of 13 samples contained concentrations of gross alpha-particle radioactivity in the dissolved fraction larger than the reporting level. The concentrations reported as thorium-230 ranged from less than the reporting level to 3.56±0.52 pCi/L. The concentrations of 13 samples were distributed about median and mean concentrations of 1.31±0.49 and 1.29±0.32 pCi/L, respectively. The concentrations reported as uranium ranged from less than the reporting level to 5.11±0.73 µg/L. The concentrations of 13 samples were distributed about median and mean concentrations of 1.18±0.44 and 1.58±0.45 µg/L, respectively. Concentrations of gross alpha-particle radioactivity in the suspended fractions of 13 water samples were less than the reporting level. The concentrations of 13 samples--reported as thorium-230--were distributed about median and mean concentrations of 0.043±0.089 and 0.043±0.017 pCi/L, respectively. The concentrations of 13 samples--reported as uranium--were distributed about median and mean concentrations of 0.048±0.123 and 0.049±0.017 µg/L, respectively.

Table 12.--***Insecticides, benzene hexachlorides, gross polychlorinated compounds, and aroclors for which water samples were analyzed***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using the following methods: carbamate insecticides are extracted with methylene chloride, concentrated, and analyzed by high-performance liquid chromatography using a dual-channel variable-wavelength ultraviolet detector; organophosphorus compounds are extracted with hexane and determined on a gas chromatograph with flame-photometric detectors; and organochlorine compounds are extracted with hexane and determined by gas chromatography using electron-capture detectors (Wershaw and others, 1987, p. 27-28 and 49). Reporting levels are from Pritt and Jones (1989). Abbreviations--µg/L indicates microgram per liter]

Carbamate insecticides: reporting level is 0.5 µg/L

- Aldicarb
- Aldicarb sulfone
- Aldicarb sulfoxide
- Carbaryl (Sevin)
- Carbofuran
- 3-Hydroxycarbofuran
- Methomyl
- 1-Naphthol
- Oxamyl
- Propham

Organophosphorus insecticides:
reporting level is 0.01 µg/L except for guthion (0.1 µg/L)

- Azinphos-methyl (Guthion)
- Chlorpyrifos; Dursban
- Diazinon
- Disulfoton
- Ethion
- Fonofos
- Malathion
- Methyl parathion
- Methyl trithion
- Parathion
- Phorate
- Phosphorotrithioate, S,S,S-tributyl- (DEF)
- Trithion

Organochlorine insecticides: reporting level is 0.01 µg/L
except for chlordane and perthane (0.1 µg/L), and toxaphene (1.0 µg/L)

- Aldrin
- Chlordane
- DDD
- DDE
- DDT
- Dieldrin
- Endosulfan
- Endrin
- Heptachlor
- Heptachlor epoxide
- Lindane
- Methoxychlor
- Mirex
- Perthane
- Toxaphene

Table 12.--***Insecticides, benzene hexachlorides, gross polychlorinated compounds, and aroclors for which water samples were analyzed***--**Continued**

Benzene hexachlorides: reporting level is 0.01 µg/L

alpha-Benzene hexachloride (alpha-BHC)
beta-Benzene hexachloride (beta-BHC)
delta-Benzene hexachloride (delta-BHC)

Gross polychlorinated compounds: reporting level is 0.1 µg/L

Gross polychlorinated biphenyls (PCB)
Gross polychlorinated naphthalenes (PCN)

Aroclors: reporting level is 0.1 µg/L

Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260

Table 13.--***Concentrations of gross alpha-particle radioactivity in water, Naval Reactors Facility and vicinity***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using a residue procedure. Analytical results and uncertainties--for example, 1.31±0.49--in indicated units. Analytical uncertainties are reported as 1s. Concentrations that exceed the reporting level of 3 times the 1s value are shown in bold-face type. Site identifier: See figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Abbreviations: µg/L--microgram per liter; pCi/L--picocurie per liter]

Site identifier	Dissolved		Suspended		Remarks
	as uranium (µg/L)	as thorium-230 (pCi/L)	as uranium (µg/L)	as thorium-230 (pCi/L)	
Blank	**0.643±0.143**	**0.639±0.142**	-0.334±0.093	-0.327±0.092	QAS-1
NRF-1	1.18±0.44	1.31±0.49	.149±0.118	.150±0.120	
NRF-2	**1.83±0.48**	**2.02±0.54**	.048±0.123	.049±0.124	
NRF-3	1.33±0.45	1.46±0.50	.112±0.120	.113±0.122	
NRF-4	.891±0.419	.984±0.463	.043±0.110	.043±0.110	
USGS 12	**2.08±0.458**	**1.47±0.324**	.009±0.186	.005±0.102	
	5.11±0.73	**3.56±0.52**	.058±0.203	.031±0.110	QAS-4, replicate
15	**3.08±0.54**	**1.90±0.353**	.074±0.152	.043±0.089	
17	.114±0.328	.125±0.362	.090±0.115	.089±0.112	
97	**1.16±0.38**	**1.29±0.42**	.053±0.456	.061±0.52	
98	.669±0.338	.736±0.371	-.110±0.098	-.108±0.096	
99	.389±0.68	.429±0.76	.046±0.100	.045±0.098	
102	**3.72±0.60**	**2.55±0.414**	.046±0.212	.027±0.124	
Water Supply INEL-1	-.964±0.85	-1.06±0.94	.013±0.112	.013±0.110	

Table 14.--***Concentrations of gross beta-particle radioactivity in water, Naval Reactors Facility and vicinity***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using a residue procedure. Analytical uncertainties are reported as 1s. Concentrations that exceed the reporting level of 3 times the 1s value are shown in bold-face type. Analytical results and uncertainties--for example, 0.721±0.158--in picocuries per liter. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample]

	Dissolved		Suspended		
Site identifier	as strontium-90 in equilibrium with yttrium-90	as cesium-137	as strontium-90 in equilibrium with yttrium-90	as cesium-137	Remarks
Blank	**0.721±0.158**	**0.779±0.172**	-1.91±0.23	-1.89±0.23	QAS-1
NRF-1	**4.07±0.40**	**4.59±0.46**	-.308±0.151	-.354±0.174	
NRF-2	**2.82±0.34**	**3.15±0.38**	-.697±0.164	-.802±0.189	
NRF-3	**3.06±0.36**	**3.34±0.38**	-.314±0.154	-.362±0.178	
NRF-4	**3.73±0.40**	**4.15±0.45**	-.206±0.152	-.237±0.175	
USGS 12	**3.61±0.55**	**4.79±0.73**	.256±0.232	.318±0.288	
	2.62±0.404	**3.62±0.62**	-.062±0.240	-.079±0.304	QAS-4, replicate
15	**2.16±0.395**	**2.89±0.53**	.346±0.228	.409±0.270	
17	**4.06±0.33**	**4.72±0.38**	-1.43±0.23	-1.41±0.22	
97	**3.31±0.43**	**3.80±0.49**	-1.04±0.24	-1.31±0.30	
98	**3.11±0.34**	**3.55±0.39**	-.929±0.218	-.918±0.216	
99	**2.55±0.41**	**3.04±0.49**	-.932±0.223	-.894±0.214	
102	**3.66±0.55**	**4.87±0.74**	.156±0.224	.196±0.281	
Water Supply					
INEL-1	**4.99±0.52**	**5.52±0.58**	-1.14±0.24	-1.13±0.23	

Gross beta-particle radioactivity.--Gross beta-particle radioactivity is a measure of the total radioactivity given off as beta particles during the radioactive decay process. For convenience, laboratories report the radioactivity as if it were all given off by one radionuclide or a chemically similar pair of radionuclides in equilibrium. In this report, concentrations are reported two ways: as strontium-90 in equilibrium with yttrium-90 in picocuries per liter, and as cesium-137 in picocuries per liter. Gross beta-particle radioactivity was measured in both the dissolved and suspended fractions of 13 water samples from the Snake River Plain aquifer (table 14). All the water samples contained concentrations of gross beta-particle radioactivity in the dissolved fraction larger than the reporting level. The concentrations reported as strontium-90 in equilibrium with yttrium-90 ranged from 2.16±0.395 to 4.99±0.52 pCi/L. Concentrations of 13 samples were distributed about median and mean concentrations of 3.31±0.43 and 3.37±0.21 pCi/L, respectively. The concentrations reported as cesium-137 ranged from 2.89±0.53 to 5.52±0.58 pCi/L. Concentrations of 13 samples were distributed about median and mean concentrations of 3.80±0.49 and 4.00±0.23 pCi/L, respectively. Concentrations of gross beta-particle radioactivity in the suspended fractions of 13 water samples were all less than the reporting level. The concentrations of 13 samples--reported as strontium-90 in equilibrium with yttrium-90--were distributed about median and mean concentrations of -0.314±0.154 and -0.485±0.161 pCi/L, respectively. The concentrations of 13 samples--reported as cesium-137--were distributed about median and mean concentrations of -0.362±0.178 and -0.506±0.171 pCi/L, respectively.

SELECTED RADIUM ISOTOPES

Radium-226 and radium-228 are naturally occurring decay products of uranium-238 and thorium-232, respectively. The concentrations of radium-226 and radium-228 in the primary and replicate samples from USGS 12 are in general agreement (table 15). The reason for the anomalously large concentrations of radium-226 and radium-228 in the blank sample is unknown. Samples for USGS 17 and Water Supply INEL-1 were lost by the laboratory and results for the radium isotopes are not available.

Concentrations of radium-226 in all 11 water samples from the Snake River Plain aquifer were larger than the reporting level. The concentrations ranged from 0.042±0.006 to 0.095±0.009 pCi/L and were distributed about median and mean concentrations of 0.071±0.008 and 0.071±0.005 pCi/L, respectively. Concentrations of radium-228 were all less than the reporting level. The concentrations ranged from -1.73±1.38 to 0.734±0.494 pCi/L and were distributed about median and mean concentrations of 0.136±0.270 and 0.01±0.19 pCi/L, respectively.

TRITIUM

Tritium, a radioactive isotope of hydrogen, is formed in nature by interactions of cosmic rays with gases in the upper atmosphere. Tritium also is produced in thermonuclear detonations and is a waste product of the nuclear-power industry (Orr and others, 1991, p. 17). Fourteen water samples were analyzed for tritium concentrations by the NWQL (table 15). The concentrations in the primary and replicate samples from USGS 12 were in general agreement. The tritium concentration in the blank sample (185.6±12.8 pCi/L) is attributed to the water supply at the Idaho Chemical Processing Plant, which feeds the deionization system. The concentrations of 13 water samples from the

Table 15.--***Concentrations of selected radium isotopes and tritium in water, Naval Reactors Facility and vicinity***

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using the following methods: radium-226 by radon emanation; radium-228 by separation and beta counting; and tritium by liquid scintillation. Analytical results and uncertainties--for example, 185.6±12.8--in picocuries per liter. Analytical uncertainties are reported as 1**s**. Concentrations that exceed the reporting level of 3 times the 1**s** value are shown in bold-face type. Site identifier: see figure 2 for location of sites; Blank--indicates that sample was deionized water from an Idaho Chemical Processing Plant laboratory. Remarks: QAS indicates quality assurance sample. Symbols: LS indicates that laboratory lost sample]

Site identifier	Radium-226, dissolved	Radium-228, dissolved	Tritium, total	Remarks
Blank	**0.490±0.075**	**2.52±0.28**	**185.6±12.8**	QAS-1
NRF-1	**.071±0.008**	.174±0.218	**92.8±12.8**	
NRF-2	**.082±0.009**	-1.73±1.38	**115.2±12.8**	
NRF-3	**.079±0.009**	.136±0.270	**108.8±12.8**	
NRF-4	**.083±0.010**	.023±0.224	**179.2±12.8**	
USGS 12	**.064±0.007**	.409±0.342	**99.2±12.8**	
	.050±0.006	.153±0.301	**108.8±12.8**	QAS-4, replicate
15	**.066±0.008**	-.043±0.166	22.4±12.8	
17	LS	LS	**92.8±12.8**	
97	**.042±0.006**	-.190±0.318	**89.6±12.8**	
98	**.087±0.009**	.36±0.40	12.8±12.8	
99	**.060±0.006**	.734±0.494	**48.0±12.8**	
102	**.095±0.009**	.098±0.195	**99.2±12.8**	
Water Supply INEL-1	LS	LS	**83.2±12.8**	

Snake River Plain aquifer ranged from less than the reporting level to 179.2±12.8 pCi/L and were distributed about median and mean concentrations of 92.8±12.8 and 88.6±11.8 pCi/L, respectively.

SUMMARY

This report presents ground-water-chemistry data collected during 1989-90 from 13 sites on the eastern Snake River Plain. It is part of the U.S. Geological Survey's continuing water-quality monitoring program in the vicinity of the NRF at the INEL. The ranges of concentrations for total cations and dissolved anions follow: calcium, 29 to 64 mg/L; potassium, 1.5 to 2.6 mg/L; magnesium, 8.6 to 28 mg/L; sodium, 5.6 to 17 mg/L; bromide, 0.02 to 0.35 mg/L; chloride, 5.7 to 110 mg/L; sulfate, 19 to 59 mg/L; and fluoride, less than 0.1 to 0.3 mg/L.

Samples were analyzed for as many as 17 trace elements. Concentrations of arsenic, beryllium, cadmium, cobalt, lead, manganese, mercury, nickel, selenium, silver, and thallium were either less than or near the laboratory reporting levels. Concentrations of aluminum, barium, iron, and zinc ranged from less than the laboratory reporting levels to 50, 300, 630, and 130 µg/L, respectively. The respective ranges of concentrations for chromium and copper were 3 to 19 and 1 to 7 µg/L. The predominant nitrogen-bearing compound in these samples was nitrite plus nitrate, which ranged in concentration from 0.3 to 5.9 mg/L expressed as nitrogen.

One purgeable organic compound was present in water from 2 of 13 sampling sites and one or more extractable acid and base/neutral organic compounds were present in water from 9 of 12 sampling sites. Total phenols in 9 of 13 samples ranged from 1 to 9 µg/L. Concentrations of total organic carbon ranged from 0.1 to 0.9 mg/L. Water from USGS 97 contained 0.1 µg/L of cyanazine--a carbamate insecticide.

Concentrations of dissolved gross alpha-particle radioactivity reported as thorium-230 ranged from less than the reporting level to 3.56±0.52 pCi/L, and concentrations of dissolved gross beta-particle radioactivity reported as cesium-137 ranged from 2.89±0.53 to 5.52±0.58 pCi/L. Concentrations of suspended gross alpha-particle radioactivity reported as thorium-230 and concentrations of suspended gross beta-particle radioactivity reported as cesium-137 were all less than the reporting level of 3 times the 1s value. Radium-226 concentrations ranged from 0.042±0.006 to 0.095±0.009 pCi/L, and radium-228 concentrations were all less than the reporting level. Tritium concentrations in 13 samples analyzed by the NWQL ranged from less than the reporting level to 179.2±12.8 pCi/L.

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