

# **Radionuclides, Stable Isotopes, Inorganic Constituents, and Organic Compounds in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering Laboratory to the Hagerman Area, Idaho, 1993**

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## CONVERSION FACTORS AND ABBREVIATED UNITS

Multiply	By	To Obtain
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
mile (mi)	1.609	kilometer
millirem per year (mrem/yr)	0.010	millisievert per year
picocurie per liter (pCi/L)	0.037	becquerel per liter
square mile (mi <sup>2</sup> )	2.590	square kilometer

Temperature can be converted from degrees Celsius (°C) to degrees Fahrenheit (°F) by the equation: °F = (°C × 1.8) + 32

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

# Radionuclides, Stable Isotopes, Inorganic Constituents, and Organic Compounds in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Engineering Laboratory to the Hagerman Area, Idaho, 1993

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## Abstract

The U.S. Geological Survey and the Idaho Department of Water Resources, in response to a request from the U.S. Department of Energy, sampled 19 sites as part of a long-term project to monitor water quality of the Snake River Plain aquifer from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area. Water samples were collected and analyzed for selected radionuclides, stable isotopes, inorganic constituents, and organic compounds. The samples were collected from seven irrigation wells, four domestic wells, two springs, one stock well, three dairy wells, one observation well, and one commercial well. Two quality assurance samples also were collected and analyzed.

None of the radionuclide, inorganic constituent, or organic compound concentrations exceeded the established maximum contaminant levels for drinking water. Most of the radionuclide and inorganic constituent concentrations exceeded their respective reporting levels. All samples analyzed for surfactants and dissolved organic carbon had concentrations that equaled or exceeded their reporting levels. The ethylbenzene concentration in one water sample exceeded the reporting level.

## INTRODUCTION

Recently, the public has expressed concern about waste disposal practices at the Idaho National Engineering Laboratory (INEL) and the impact these practices might have had on the water quality of the Snake River Plain aquifer. The U.S. Department of Energy (DOE) requested that the U.S. Geological Survey (USGS) conduct two studies to respond to the public's concern and to gain a greater understanding of the chemical quality of water in the aquifer. The first study described a one-time sampling effort in the eastern part of the A & B Irrigation District in Minidoka County (Mann and Knobel, 1990). The second study, an ongoing annual sampling effort in the area between the southern boundary of the INEL and Hagerman (fig. 1), is being conducted in cooperation with the Idaho Department of Water Resources (IDWR) and the DOE. The initial round of sampling for the second study involved analyzing water samples collected from 55 sites during August and September 1989 (Wegner and Campbell, 1991). The second round of sampling involved analyzing water samples collected from 19 of the initial 55 sites in 1990 (Bartholomay and others, 1992), another 18 of the initial 55 sites in 1991 (Bartholomay and others, 1993), and the remaining 18 sites in 1992 (Bartholomay and others, 1994). This report summarizes the beginning of the third round of sampling, which

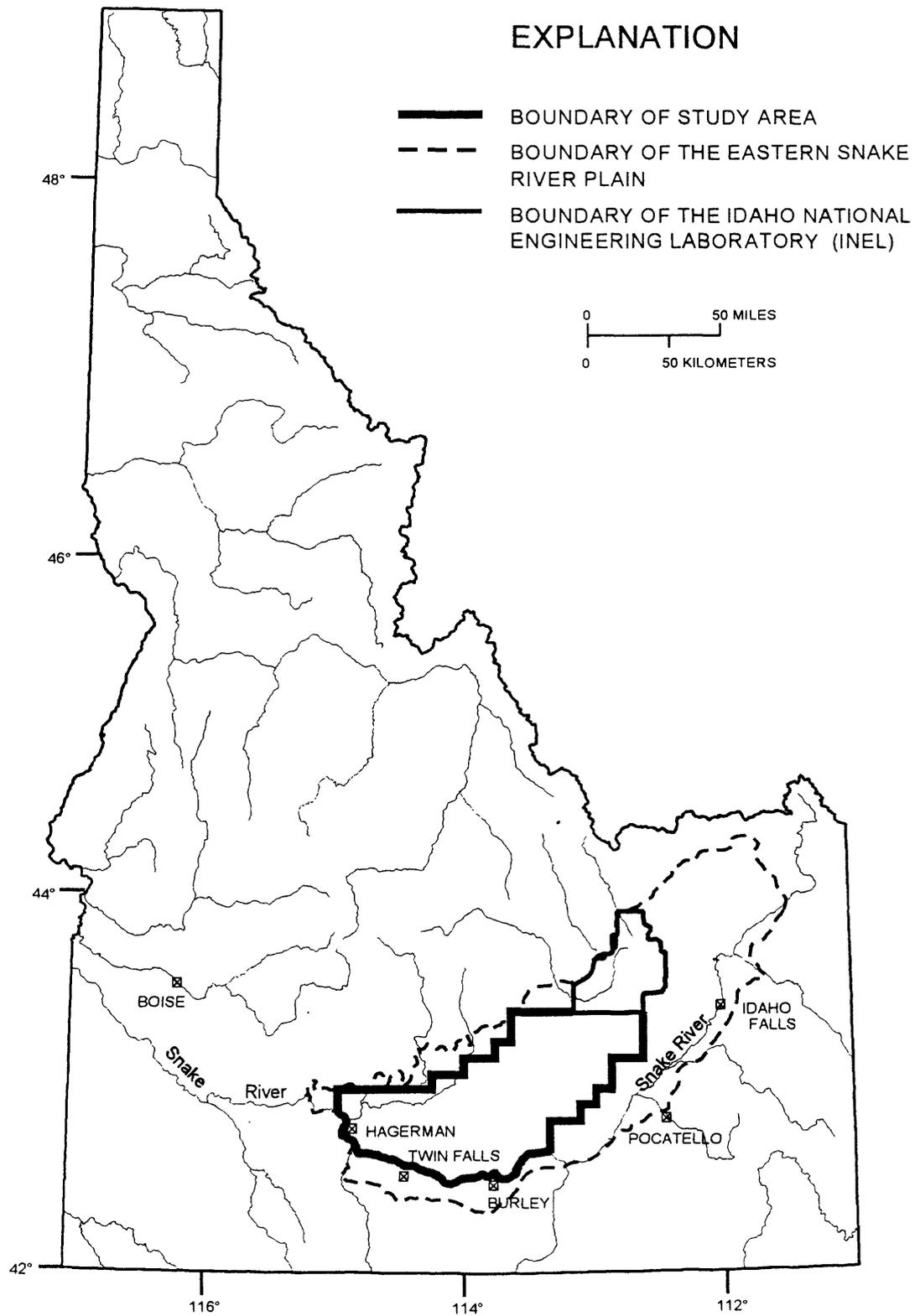


Figure 1. -- Location of the study area, between the Idaho National Engineering Laboratory and Hagerman, Idaho.

involved analyzing water samples collected in August 1993 from 19 of the initial 55 sites.

The INEL includes about 890 mi<sup>2</sup> of the northeastern part of the eastern Snake River Plain and is about 110 mi northeast of the Hagerman area (fig. 1). Wastewater containing chemical and radiochemical wastes generated at the INEL was discharged mostly to ponds and wells in the past. Since 1983, most aqueous wastes have been discharged to infiltration ponds. Many of the constituents in the wastewater enter the aquifer indirectly following percolation through the unsaturated zone (Pittman and others, 1988).

Chemical and radioactive wastes have migrated from less than 1 to about 9 mi southwest of the disposal areas at the INEL (Pittman and others, 1988). Tritium was detected periodically at concentrations of 3,400±200 pCi/L or less in water from three wells along the southern boundary of the INEL between 1983 and 1985. Since April 1986, tritium concentrations in water from wells near the southern boundary of the INEL have been less than the Radiological and Environmental Sciences Laboratory analytical method detection limit of 500 pCi/L (Mann and Cecil, 1990).

Water samples from 19 sites (fig. 2) were analyzed for selected radionuclides, stable isotopes, trace elements, common ions, nutrients, dissolved organic carbon (DOC), surfactants, purgeable organic compounds, carbamate and organophosphorus insecticides, organochlorine insecticides, gross polychlorinated biphenyls (PCB's), gross polychlorinated naphthalenes (PCN's), and triazine and chlorophenoxy-acid herbicides by the USGS's National Water Quality Laboratory (NWQL) at Arvada, Colo. The same sites also were sampled for analyses of selected radionuclides by the Idaho State University (ISU) Environmental Monitoring Laboratory at Pocatello, Idaho. One replicate water sample

and one blank sample also were collected and analyzed as a measure of quality assurance.

## Geohydrologic Setting

The eastern Snake River Plain is a northeast-trending structural basin about 200 mi long and 50 to 70 mi wide. The basin, bounded by faults on the northwest and downwarping and faulting on the southeast, has been filled with basaltic lava flows interbedded with terrestrial sediments (Whitehead, 1986). Individual basalt flows average 20 to 25 ft in thickness with an aggregate thickness of several thousand feet in places. Alluvial fan deposits are composed primarily of sand and gravel, whereas in areas where streams were dammed by basalt flows, the sediments are predominantly silt and clay (Garabedian, 1986). Rhyolitic lava flows and tuffs are exposed locally at the surface and may exist at depth under most of the eastern plain. A 10,365-ft-deep test hole at the INEL penetrated about 2,160 ft of basalt and sediment and 8,205 ft of tuffaceous and rhyolitic volcanic rocks (Mann, 1986).

Movement of water in the aquifer generally is from the northeast to the southwest. Water moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of the interflow zones. Infiltration of surface water, heavy pumpage, geologic conditions, and seasonal fluxes in recharge and discharge locally affect the movement of ground water (Garabedian, 1986).

The Snake River Plain aquifer is recharged by seepage from the upper reaches of the Snake River, tributaries and canals, infiltration from irrigation and precipitation, and underflow from tributary valleys on the perimeter of the plain. Discharge from the aquifer primarily is by pumpage for irrigation and spring flow to the Snake River (Mann and Knobel, 1990). Between 1902 and 1980, spring flow to the Snake River increased about 1.2 million

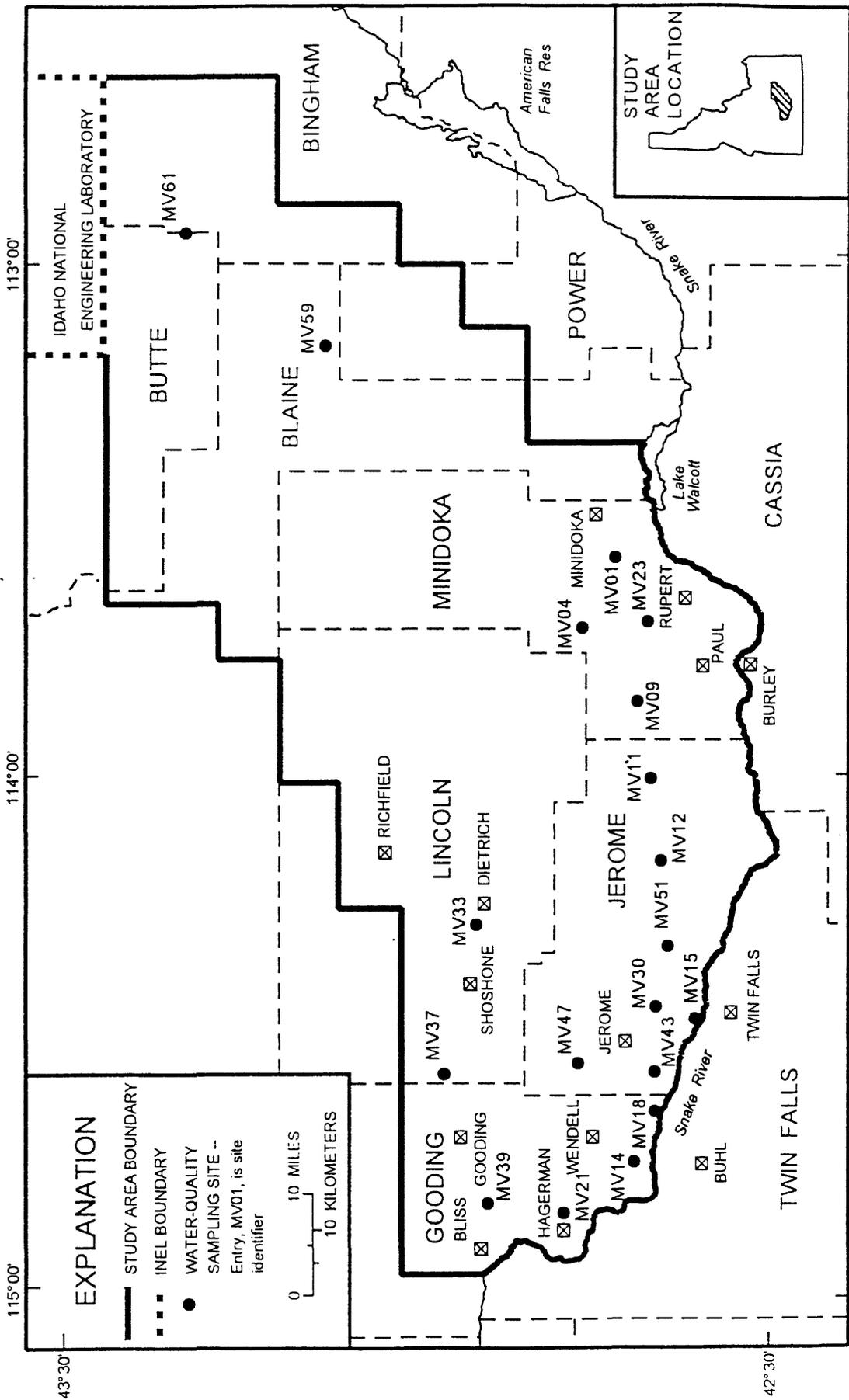


Figure 2. -- Location of selected water-quality sampling sites on the eastern Snake River Plain.

acre-ft/yr, largely as a result of increased recharge from infiltration of irrigation water (Mann, 1989, p. 5).

## **Acknowledgments**

The authors gratefully acknowledge the well owners for granting permission to collect the water samples and extend special thanks to Mike Smith of the Minidoka Grazing Association for his help in locating and pumping one of the wells for sample collection. The authors are grateful for technical review of the manuscript by L. Flint Hall of the Idaho Department of Health and Welfare (IDHW) and Michael F. Reed of the USGS.

## **METHODS AND QUALITY ASSURANCE**

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

### **Site Selection**

Water samples were collected at 19 sites (fig. 2), including seven irrigation wells, four domestic wells, two springs, one stock well, three dairy wells, one observation well, and one commercial well. One replicate water sample and one blank sample also were collected. The irrigation wells were equipped with turbine pumps. The domestic, stock, dairy, observation, and commercial wells were equipped with submersible pumps. Criteria for site selection were geographic location, ease of sample collection, and long-term access.

## **Sample Containers and Preservatives**

Sample containers and preservatives differ depending on the constituent(s) for which analyses are requested. Samples analyzed by the NWQL were collected and preserved in accordance with laboratory requirements specified by C.A. Watterson and A.T. Kashuba (written commun., 1993). Water samples analyzed by ISU were collected in accordance with laboratory requirements specified by the Director of the Environmental Monitoring Program at ISU. Containers and preservatives were supplied by the respective laboratories. Containers and preservatives used for this study are listed on table 1.

## **Sample Collection**

Four of the irrigation wells discharge into stilling ponds and were sampled near the discharge pipe. The rest of the irrigation wells were sampled from spigots in discharge lines near pumps. The domestic, dairy, and commercial wells were sampled from spigots closest to pumps. The stock well was sampled at the water-tank inlet pipe. The observation well was sampled at the well head. All the wells either were pumping on arrival of the sampling team or were started on arrival and, when possible, pumped long enough to ensure that pressure tanks and pumping systems had been thoroughly flushed as evidenced by stable pH, specific conductance, and temperature measurements. The two springs were sampled as near the source as possible by collecting a grab sample from an area of moving water.

Chemical and physical characteristics monitored at the water-sampling sites included pH, specific conductance, water temperature, alkalinity, and concentrations of dissolved oxygen. These characteristics were monitored during pumping using methods described by Wood (1981) and Hardy and others (1989). A water sample was collected when measurements of

Table 1.—*Containers and preservatives used for water-sample collection*

[Abbreviations: L, liter; °C, degrees Celsius; mL, milliliter; µm, micrometer; gal, gallon; HgCl<sub>2</sub>, mercuric chloride; NaCl, sodium chloride; HNO<sub>3</sub>, nitric acid; K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, potassium dichromate; SrCl<sub>2</sub>, strontium chloride. Chilled samples were shipped by overnight delivery mail. Analyzing laboratory: NWQL, U.S. Geological Survey's National Water Quality Laboratory; ISU, Idaho State University's Environmental Monitoring Laboratory]

Type of constituent	Container		Preservative		Other treatment	Analyzing laboratory
	Type	Size	Type	Size		
Tritium	Polyethylene	1 L	None	None	None	NWQL
Strontium-90	Polyethylene	1 L	None	None	None	ISU
	Polyethylene, acid rinsed	1 L	HNO <sub>3</sub>	4 mL	0.45 µm filter	NWQL
Other radionuclides	Polyethylene	1 gal	None	None	None	ISU
	Polyethylene, acid rinsed	1 L	HNO <sub>3</sub>	4 mL	0.45 µm filter	NWQL
	Polyethylene	1 gal	None	None	None	ISU
Stable isotopes	Glass, baked	1 L	Ammoniacal SrCl <sub>2</sub>	50 mL	None	NWQL
	Glass, baked	1 L	HgCl <sub>2</sub>	1 mL	Chill 4°C	NWQL
Trace elements	Polyethylene	1 L	None	None	None	NWQL
	Glass, baked	125 mL	None	None	Chill 4°C	NWQL
	Polyethylene, acid rinsed	250 mL	HNO <sub>3</sub>	1 mL	0.45 µm filter	NWQL
Mercury	Polyethylene	125 mL	None	None	None	NWQL
	Glass, acid rinsed	250 mL	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /HNO <sub>3</sub>	10 mL	0.45 µm filter	NWQL
Common ions	Polyethylene, acid rinsed	500 mL	HNO <sub>3</sub>	2 mL	0.45 µm filter	NWQL
	Polyethylene, acid rinsed	500 mL	HNO <sub>3</sub>	2 mL	None	NWQL
	Polyethylene	250 mL	None	None	0.45 µm filter	NWQL
Nutrients	Polyethylene	250 mL	None	None	None	NWQL
	Polyethylene, brown	125 mL	HgCl <sub>2</sub> /NaCl	0.5 mL	0.45 µm filter, chill 4°C	NWQL
Dissolved organic carbon	Glass, baked	125 mL	None	None	Silver filter, chill 4°C	NWQL
Surfactants	Polyethylene	250 mL	None	None	Chill 4°C	NWQL
Purgeable organic compounds	Glass, baked	40 mL	None	None	Chill 4°C	NWQL
Pesticides	Glass, baked	1 L	None	None	Chill 4°C	NWQL

these properties indicated probable hydraulic and chemical stability. After collection, sample containers were sealed with laboratory film, labeled, and packed into ice chests for shipment by overnight-delivery mail to the NWQL. The samples collected for the ISU were stored in coolers until they were hand-delivered to the laboratory.

Measurements of pH, specific conductance, water temperature, alkalinity, and concentrations of dissolved oxygen are shown on table 2. Ranges for these measurements, excluding values for the blank, were: from 7.4 to 8.0 for pH, which is within the U.S. Environmental Protection Agency's (1989) recommended range of 6.5 to 8.5 for community water systems; from 297 to 1,030  $\mu\text{S}/\text{cm}$  for specific conductance; from 12.5 to 16.0°C for water temperature; from 116 to 261 mg/L for alkalinity as calcium carbonate; and from 6.0 to 9.5 mg/L for concentrations of dissolved oxygen. The IDHW (1989) has established a secondary maximum contaminant level of 26.6°C for water temperature.

Conditions at the sampling site during sample collection were recorded in a field logbook; a chain-of-custody record was used to track the samples from the time of collection until delivery to the analyzing laboratory. These records are available for inspection at the USGS's Project Office at the INEL.

### Quality Assurance

Detailed descriptions of internal quality control and overall quality assurance practices used by the NWQL are provided in reports by Friedman and Erdmann (1982) and Jones (1987). Water samples analyzed by the NWQL were collected in accordance with a quality assurance plan for quality-of-water activities conducted by personnel at the INEL Project Office; the plan was finalized in June 1989, revised in March 1992, and is available for

inspection at the USGS's Project Office at the INEL. Water samples analyzed by ISU were collected in accordance with procedures described by B. Graham (ISU, written commun., 1991). About 10 percent of the water samples were quality assurance samples. Sample MV-08 is a replicate of sample MV-21. Sample MV-22 is a blank water sample collected from inorganic- and organic-free water. The blank of organic-free water had a methylene chloride concentration of 0.3  $\mu\text{g}/\text{L}$ . Because the blank water sample is not representative of wells and springs sampled for this report, it will not be included in the discussions of the various constituents measured but will be included in some of the tables.

### RADIONUCLIDES

Water samples were analyzed for strontium-90, tritium, gross alpha- and gross beta-particle radioactivity. In addition, gamma-emitting radionuclides were identified. The samples were analyzed using methods described by Thatcher and others (1977). Maximum contaminant levels for the types of radioactivity and for selected radionuclides are listed on table 3.

An analytical uncertainty,  $s$ , is calculated for each radionuclide concentration. This report presents the analytical uncertainty as  $2s$  for NWQL data and  $1s$  for ISU data. Guidelines for interpreting analytical results are based on an extension of the method described by Currie (1984). In radiochemical analyses, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and 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 greater than the signal for the blank to make the decision that there was detection; and (2) an estimation must be made of the minimum concentration that will yield a sufficiently large signal to make the correct decision for detection or

Table 2.—*Results of field measurements of water for pH, specific conductance, temperature, alkalinity, and concentrations of dissolved oxygen from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Site use: I, irrigation; QA, quality assurance (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water); D, dairy; H, domestic; Sp, spring; C, commercial; S, stock; O, observation. Date sampled: month/day/year. 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; Alkalinity, milligrams per liter (mg/L) as calcium carbonate using digital titration with 0.16 normal sulfuric acid; Dissolved oxygen, mg/L using azide modification of Winkler method (American Public Health Association and Water Pollution Control Federation, 1985). Symbol: --, no analysis was performed]

Site identifier	Site use	Date sampled	pH	Specific conductance	Temperature	Alkalinity	Dissolved oxygen
MV-01	I	8/02/93	7.7	611	14.0	185	6.0
MV-04	I	8/02/93	7.8	661	12.5	172	8.2
MV-08	QA	8/04/93	7.8	346	16.0	138	7.4
MV-09	I	8/03/93	7.6	1,030	14.0	261	7.3
MV-11	I	8/03/93	7.7	829	14.5	229	7.8
MV-12	D	8/03/93	7.8	689	15.0	177	8.5
MV-14	H	8/05/93	7.7	588	15.0	160	8.4
MV-15	Sp	8/04/93	7.8	635	16.0	189	8.4
MV-18	Sp	8/04/93	8.0	690	15.0	199	8.7
MV-21	D	8/04/93	7.8	346	16.0	138	7.4
MV-22	QA	8/11/93	6.4	1	24.0	--	--
MV-23	I	8/03/93	7.5	692	15.5	215	6.0
MV-30	C	8/06/93	7.7	705	15.0	198	9.5
MV-33	H	8/02/93	7.9	297	16.0	120	7.4
MV-37	H	8/05/93	7.5	527	15.0	188	8.5
MV-39	I	8/05/93	7.4	711	15.0	247	7.9
MV-43	I	8/04/93	7.6	726	15.5	230	7.4
MV-47	D	8/06/93	7.8	374	15.0	130	8.2
MV-51	H	8/05/93	7.6	707	15.0	213	7.9
MV-59	S	8/10/93	8.0	306	15.0	116	7.4
MV-61	O	8/11/93	7.7	382	14.0	130	7.8

Table 3.—*Maximum contaminant levels for types of radioactivity and selected radionuclides in drinking water*

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, p. 550) for community water systems and are included for comparison purposes only. Maximum contaminant levels given for strontium-90 and tritium are average annual concentrations assumed to produce a total body or organ dose of 4 mrem/yr (millirem per year) of beta-particle radiation. The maximum contaminant level given for gross alpha-particle radioactivity includes radium-226 but excludes radon and uranium. The maximum contaminant level given for gross beta-particle and gamma radioactivity excludes radioactivity from natural sources and is included for comparison purposes only. Abbreviation: pCi/L, picocurie per liter]

Type of radioactivity or radionuclide	Maximum contaminant level
Strontium-90	8 pCi/L
Tritium	20,000 pCi/L
Gross alpha-particle radioactivity	15 pCi/L
Gross beta-particle and gamma radioactivity	4 mrem/yr

nondetection most of the time. The first aspect of the problem is a qualitative decision based on signals and a definite criterion for detection. The second aspect of the problem is an estimation of the detection capabilities of a complete measurement process that includes hypothesis testing.

In the laboratory, instrument signals must exceed a critical level of  $1.6s$  to make the qualitative decision whether the radionuclide or radioactivity was detected. At  $1.6s$ , there is about a 95-percent probability that the correct decision—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentrations greater than or equal to  $1.6s$ , which were concluded as being detected, might not contain the radioactive constituent. 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 can be established. Concentrations that equal  $3s$  represent a measurement at the minimum detectable concentration. For true concentrations of  $3s$  or greater, there is a 95-percent-or-more probability of correctly concluding that the radioactive constituent was detected in a sample. Given a large number of samples, as many as 5 percent of the samples with measured concentrations greater than or equal to  $3s$ , which were concluded as being not detected, could contain the radioactive constituent at the minimum detectable concentration. 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 greater-than-5-percent probability of false negative results for samples with true concentrations between  $1.6s$  and  $3s$ , and although the radionuclide or radioactivity might have been detected, such detection may

not be considered reliable; at  $1.6s$ , the probability of a false negative is about 50 percent.

These guidelines 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 and with the number of gross counts for individual analyses. The use of the critical level and minimum detectable concentration aids the reader in the interpretation of analytical results and does not represent absolute concentrations of radioactivity that may or may not have been detected. In this report, if the concentration of a selected radionuclide was equal to or greater than  $3s$ , the concentration is considered to be above a "reporting level." The reporting level should not be confused with the analytical method detection limit, which is based on laboratory procedures. At small concentrations, the reporting level approaches the analytical method detection limit; however, at larger concentrations, they may be significantly different.

### **Strontium-90**

Strontium-90 is a fission product that was widely distributed in the environment during atmospheric weapons tests. Strontium-90 generally is present in ground water as a result of these tests and from nuclear industry waste-disposal practices. All water samples analyzed contained concentrations of dissolved strontium-90 less than the reporting level (table 4).

### **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. Samples were submitted to the ISU laboratory and the NWQL. The

Table 4.—*Concentrations of strontium-90 and tritium in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory (NWQL) and Idaho State University's (ISU) Environmental Monitoring Laboratory using the following methods: strontium-90 by chemical separation and precipitation; tritium by enrichment and gas counting at the NWQL and by liquid scintillation at ISU. Analytical results and uncertainties—for example  $49.9 \pm 3.20$ —in picocuries per liter (pCi/L). Analytical uncertainties are reported as 2s for NWQL and 1s for ISU. Symbols: \*, quality assurance sample (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water); --, no analysis was performed]

Site identifier	Strontium-90, NWQL	Tritium, NWQL	Tritium, ISU
MV-01	$0.203 \pm 0.280$	$49.9 \pm 3.20$	$-100 \pm 100$
MV-04	$.251 \pm 0.246$	$5.38 \pm 0.64$	$-200 \pm 100$
MV-08*	$.026 \pm 0.220$	$13.9 \pm 0.90$	$-100 \pm 100$
MV-09	$.087 \pm 0.206$	$82.6 \pm 5.76$	$100 \pm 100$
MV-11	$.044 \pm 0.243$	$75.2 \pm 5.12$	$-100 \pm 100$
MV-12	$.022 \pm 0.184$	$35.2 \pm 2.56$	$-100 \pm 100$
MV-14	$.093 \pm 0.201$	$27.4 \pm 1.79$	$-100 \pm 100$
MV-15	$-.063 \pm 0.200$	$51.5 \pm 3.20$	$0 \pm 100$
MV-18	$.174 \pm 0.199$	$55.4 \pm 3.84$	$100 \pm 100$
MV-21	$.049 \pm 0.201$	$14.2 \pm 0.96$	$-100 \pm 100$
MV-22*	$.342 \pm 0.152$	$18.3 \pm 1.22$	--
MV-23	$-.017 \pm 0.153$	$65.6 \pm 4.48$	$0 \pm 100$
MV-30	$.073 \pm 0.208$	$61.8 \pm 3.84$	$-100 \pm 100$
MV-33	$.218 \pm 0.256$	$8.26 \pm 0.64$	$-100 \pm 100$
MV-37	$.098 \pm 0.202$	$62.1 \pm 3.84$	$0 \pm 100$
MV-39	$-.011 \pm 0.179$	$60.2 \pm 3.84$	$0 \pm 100$
MV-43	$.019 \pm 0.219$	$63.4 \pm 4.48$	$100 \pm 100$
MV-47	$.091 \pm 0.178$	$8.45 \pm 0.58$	$-200 \pm 100$
MV-51	$.150 \pm 0.202$	$61.4 \pm 3.84$	$-100 \pm 100$
MV-59	$.076 \pm 0.110$	$-.032 \pm 0.640$	$-100 \pm 100$
MV-61	$.053 \pm 0.094$	$22.4 \pm 1.47$	$-100 \pm 100$

ISU laboratory used a liquid scintillation technique and the NWQL used an enrichment and gas counting technique. The analytical method detection limit for the laboratories differed. The analytical method detection limit for the ISU laboratory was 300 pCi/L using a 200-minute counting period, and that for the NWQL was 0.3 pCi/L using a 360- to 1,200-minute counting period.

Concentrations of tritium in 19 of the water samples analyzed by the NWQL exceeded the reporting level and ranged from  $5.38 \pm 0.64$  to  $82.6 \pm 5.76$  pCi/L (table 4). Concentrations of tritium in all water samples analyzed by the ISU laboratory were less than the reporting level. For the purpose of comparison, background concentrations of tritium in ground water in Idaho generally range from 75 to 150 pCi/L (Orr and others, 1991). The maximum contaminant level for tritium in public drinking-water supplies is 20,000 pCi/L (table 3).

### **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; however, laboratories normally report the radioactivity as if it were all given off by one radionuclide. In this report, concentrations are reported both as natural uranium in micrograms per liter and as thorium-230 in picocuries per liter by the NWQL, and as americium-241 in picocuries per liter by the ISU laboratory.

Concentrations of dissolved gross alpha-particle radioactivity reported as uranium and thorium-230 in 14 of the water samples analyzed by the NWQL exceeded the reporting level (table 5) and ranged from  $2.34 \pm 1.47$  to  $7.43 \pm 4.47$   $\mu\text{g/L}$ , and  $1.79 \pm 1.12$  to  $5.73 \pm 3.44$  pCi/L, respectively. Total concentrations of gross alpha-particle radioactivity reported as americium-241 in all but one water

sample analyzed by ISU were less than the reporting level. The sample from MV-43 had a concentration of  $3 \pm 1$  pCi/L which is equal to the reporting level.

### **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. The laboratory instruments for these measurements are calibrated to either a single radionuclide, cesium-137, or a chemically similar pair of radionuclides in equilibrium, strontium-90 in equilibrium with yttrium-90. In this report, concentrations are reported as cesium-137 in picocuries per liter and as strontium-90 in equilibrium with yttrium-90 in picocuries per liter. Reporting of the concentrations of gross beta-particle radioactivity in either one of these ways is for reference purposes only and does not imply that the radioactivity is attributed to these specific isotopes. The average annual concentrations of strontium-90 and cesium-137 in public drinking-water supplies that produce a 4-mrem/yr dose are 8 pCi/L and 120 pCi/L, respectively. Gross beta-particle radioactivity measurements should not be compared directly with these concentrations.

Concentrations of dissolved gross beta-particle radioactivity reported as cesium-137 and as strontium-90 in equilibrium with yttrium-90 in all of the water samples analyzed by the NWQL exceeded the reporting levels (table 6) and ranged from  $3.65 \pm 1.19$  to  $11.8 \pm 2.62$  pCi/L, and  $2.66 \pm 0.750$  to  $8.89 \pm 1.97$  pCi/L, respectively. Total concentrations of gross beta-particle radioactivity reported as cesium-137 in four of the water samples analyzed by ISU equaled or exceeded the reporting level (table 6) and ranged from  $6 \pm 2$  to  $8 \pm 2$  pCi/L.

**Table 5.—Concentrations of gross alpha-particle radioactivity in water from selected wells and springs, eastern Snake River Plain**

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory (NWQL) and the Idaho State University's (ISU) Environmental Monitoring Laboratory using a residue procedure. Analytical results and uncertainties—for example  $4.06 \pm 2.54$ —in indicated units. Analytical uncertainties are reported as 2s for NWQL and 1s for ISU. Abbreviations:  $\mu\text{g/L}$ , microgram per liter;  $\text{pCi/L}$ , picocurie per liter. Symbols: \*, quality assurance sample (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water); --, no analysis was performed]

Site identifier	Dissolved as uranium, NWQL ( $\mu\text{g/L}$ )	Dissolved as thorium-230, NWQL ( $\text{pCi/L}$ )	Total as americium-241, ISU ( $\text{pCi/L}$ )
MV-01	$4.06 \pm 2.54$	$2.89 \pm 1.80$	$1 \pm 1$
MV-04	$6.13 \pm 3.46$	$3.92 \pm 2.22$	$2 \pm 1$
MV-08*	$2.34 \pm 1.47$	$1.79 \pm 1.12$	$1 \pm 1$
MV-09	$7.43 \pm 4.47$	$5.73 \pm 3.44$	$0 \pm 1$
MV-11	$6.70 \pm 3.68$	$4.98 \pm 2.73$	$1 \pm 1$
MV-12	$2.04 \pm 2.28$	$1.44 \pm 1.61$	$2 \pm 1$
MV-14	$3.90 \pm 2.31$	$2.79 \pm 1.65$	$0 \pm 1$
MV-15	$4.98 \pm 2.71$	$3.59 \pm 1.94$	$0 \pm 1$
MV-18	$4.67 \pm 3.18$	$2.96 \pm 2.01$	$2 \pm 1$
MV-21	$2.75 \pm 1.59$	$1.93 \pm 1.11$	$1 \pm 1$
MV-22*	$-.125 \pm 0.210$	$-.070 \pm 0.118$	--
MV-23	$4.21 \pm 2.87$	$3.02 \pm 2.05$	$1 \pm 1$
MV-30	$6.56 \pm 3.44$	$4.64 \pm 2.43$	$0 \pm 1$
MV-33	$1.78 \pm 1.39$	$1.13 \pm 0.886$	$0 \pm 1$
MV-37	$5.86 \pm 2.70$	$4.18 \pm 1.91$	$1 \pm 1$
MV-39	$6.11 \pm 3.33$	$4.49 \pm 2.44$	$2 \pm 1$
MV-43	$4.54 \pm 2.68$	$3.37 \pm 1.98$	$3 \pm 1$
MV-47	$2.38 \pm 1.59$	$1.63 \pm 1.09$	$0 \pm 1$
MV-51	$4.02 \pm 2.59$	$2.99 \pm 1.92$	$0 \pm 1$
MV-59	$1.33 \pm 1.39$	$.851 \pm 0.888$	$0 \pm 1$
MV-61	$4.03 \pm 1.95$	$2.81 \pm 1.36$	$0 \pm 1$

Table 6.—*Concentrations of gross beta-particle radioactivity in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory (NWQL) and Idaho State University's (ISU) Environmental Monitoring Laboratory using a residue procedure. Analytical results and uncertainties—for example  $9.46 \pm 1.89$ —in picocuries per liter. Analytical uncertainties are reported as 2s for NWQL and 1s for ISU. Abbreviation: Sr-90/Y-90, strontium-90 in equilibrium with yttrium-90. Symbols: \*, quality assurance sample (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water); --, no analysis was performed]

Site identifier	Dissolved as cesium-137, NWQL	Dissolved as Sr-90/Y-90, NWQL	Total as cesium-137, ISU
MV-01	$9.46 \pm 1.89$	$7.18 \pm 1.44$	$3 \pm 2$
MV-04	$7.46 \pm 1.65$	$5.56 \pm 1.23$	$3 \pm 2$
MV-08*	$5.63 \pm 1.55$	$4.09 \pm 0.912$	$5 \pm 2$
MV-09	$11.8 \pm 2.62$	$8.89 \pm 1.97$	$7 \pm 3$
MV-11	$10.9 \pm 2.27$	$8.08 \pm 1.68$	$4 \pm 2$
MV-12	$7.44 \pm 1.65$	$5.61 \pm 1.25$	$5 \pm 2$
MV-14	$7.50 \pm 1.56$	$5.59 \pm 1.16$	$5 \pm 2$
MV-15	$9.22 \pm 1.92$	$7.03 \pm 1.46$	$6 \pm 2$
MV-18	$8.97 \pm 1.80$	$6.75 \pm 1.36$	$6 \pm 2$
MV-21	$3.65 \pm 1.19$	$2.66 \pm 0.750$	$1 \pm 2$
MV-22*	$.016 \pm 0.287$	$.017 \pm 0.297$	--
MV-23	$8.57 \pm 1.83$	$6.37 \pm 1.36$	$3 \pm 2$
MV-30	$10.1 \pm 1.97$	$7.60 \pm 1.48$	$8 \pm 2$
MV-33	$3.88 \pm 1.17$	$2.85 \pm 0.753$	$-1 \pm 2$
MV-37	$7.88 \pm 1.60$	$5.97 \pm 1.21$	$4 \pm 2$
MV-39	$9.12 \pm 1.88$	$6.77 \pm 1.40$	$2 \pm 2$
MV-43	$9.17 \pm 2.02$	$7.00 \pm 1.54$	$6 \pm 2$
MV-47	$4.59 \pm 1.30$	$3.31 \pm 0.816$	$-2 \pm 2$
MV-51	$9.38 \pm 1.95$	$6.99 \pm 1.46$	$1 \pm 2$
MV-59	$4.57 \pm 1.09$	$3.54 \pm 0.847$	$0 \pm 2$
MV-61	$4.46 \pm 1.10$	$3.41 \pm 0.843$	$0 \pm 2$

## Cesium-137 and Cobalt-60

Gamma spectrometry involves using a series of detectors to simultaneously determine the concentrations of a variety of radionuclides by the identification of their characteristic gamma emissions. Total concentrations of cesium-137 and cobalt-60 were identified in water samples by ISU.

Cesium-137 is a fission product of uranium-235, uranium-233, or plutonium-239. None of the samples had concentrations of cesium-137 that exceeded the reporting level (table 7).

Cobalt-60 is a neutron activation product of cobalt-59 or nickel-60 (Eisenbud, 1973). None of the samples had concentrations of cobalt-60 that exceeded the reporting level (table 7).

## STABLE ISOTOPES

Water samples were analyzed for concentrations of stable isotopes of hydrogen (H), oxygen (O), carbon (C), sulfur (S), and nitrogen (N). Because the absolute measurement of isotopic ratios is analytically difficult, relative isotopic ratios are measured instead (Toran, 1982). For example,

$^{18}\text{O}/^{16}\text{O}$  of a sample is compared with  $^{18}\text{O}/^{16}\text{O}$  of a standard:

$$\delta^{18}\text{O} = (R_{\text{sample}}/R_{\text{standard}} - 1) \times 1,000, \text{ where}$$

$$R_{\text{sample}} = ^{18}\text{O}/^{16}\text{O} \text{ in the sample,}$$

$$R_{\text{standard}} = ^{18}\text{O}/^{16}\text{O} \text{ in the standard, and}$$

$\delta^{18}\text{O}$  = relative concentration, in units of parts per thousand (permil).

Delta  $^{18}\text{O}$  ( $\delta^{18}\text{O}$ ) is referred to as delta notation and is the value reported by isotopic laboratories for stable isotope analysis.  $\delta^2\text{H}$ ,  $\delta^{13}\text{C}$ ,  $\delta^{34}\text{S}$ , and  $\delta^{15}\text{N}$  are defined in a similar manner with the respective ratios replacing  $^{18}\text{O}/^{16}\text{O}$  in  $R_{\text{sample}}$  and  $R_{\text{standard}}$ . The

respective precisions of measurement for  $\delta^2\text{H}$ ,  $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ,  $\delta^{34}\text{S}$ , and  $\delta^{15}\text{N}$  at the NWQL are 1.5 permil, 0.15 permil, 0.3 permil, 0.5 permil, and 0.2 permil at the 95-percent confidence level (Ott and others, 1994; C.A. Watterson and A.T. Kashuba, USGS, written commun., 1993).

Relative isotopic ratios reported as  $\delta^2\text{H}$  for water from 19 sites ranged from -116 to -137 permil (table 8). Relative isotopic ratios reported as  $\delta^{18}\text{O}$  for water from 19 sites ranged from -16.48 to -18.08 permil. Relative isotopic ratios reported as  $\delta^{13}\text{C}$  for water from 19 sites ranged from -6.3 to -14.4 permil. Relative isotopic ratios reported as  $\delta^{34}\text{S}$  for water from 20 sites ranged from 9.5 to 15.1 permil. Relative isotopic ratios reported as  $\delta^{15}\text{N}$  for water from 20 sites ranged from 3.8 to 8.4 permil.

## INORGANIC CONSTITUENTS

Water samples were analyzed for selected inorganic constituents. These constituents included trace elements, common ions, and nutrients. In this report, reporting levels established for these constituents are not to be confused with reporting levels and analytical method detection limits for selected radionuclides. The reporting level for inorganic constituents is the lowest measured concentration of a constituent that may be reliably reported using a given analytical method (Pritt and Jones, 1989).

### Trace Elements

Water samples were analyzed for selected dissolved trace elements including aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, and zinc. Water samples also were analyzed for hexavalent and total chromium. The maximum contaminant levels and reporting levels for selected

Table 7.—*Concentrations of cesium-137 and cobalt-60 in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the Idaho State University's Environmental Monitoring Laboratory using gamma spectrometry. Analytical results and uncertainties—for example  $-1.8 \pm 1.2$ —are for total concentrations in picocuries per liter. Analytical uncertainties are reported as 1s. Symbol: \*, quality assurance sample (MV-08 is a replicate of MV-21)]

Site identifier	Cesium-137	Cobalt-60
MV-01	$-1.8 \pm 1.2$	$0.5 \pm 1.2$
MV-04	$.8 \pm 1.3$	$-.2 \pm 1.1$
MV-08*	$1.0 \pm 1.2$	$1.1 \pm 1.2$
MV-09	$.9 \pm 1.3$	$-.9 \pm 1.0$
MV-11	$-1.3 \pm 1.2$	$1.8 \pm 1.1$
MV-12	$.2 \pm 1.2$	$1.8 \pm 1.3$
MV-14	$1.0 \pm 1.3$	$-.6 \pm 1.0$
MV-15	$-.5 \pm 1.3$	$-1.2 \pm 1.2$
MV-18	$-.9 \pm 1.2$	$1.8 \pm 1.2$
MV-21	$-1.1 \pm 1.2$	$2.1 \pm 1.2$
MV-23	$-1.4 \pm 1.2$	$0 \pm 1.2$
MV-30	$-.5 \pm 1.3$	$-.2 \pm 1.1$
MV-33	$-.6 \pm 1.3$	$-.7 \pm 1.0$
MV-37	$1.4 \pm 1.3$	$-.4 \pm 1.0$
MV-39	$.7 \pm 1.3$	$-.9 \pm 1.3$
MV-43	$2.1 \pm 1.4$	$-.8 \pm 1.1$
MV-47	$-1.0 \pm 1.3$	$-.7 \pm 1.0$
MV-51	$-1.4 \pm 1.3$	$1.1 \pm 1.1$
MV-59	$.1 \pm 1.2$	$.2 \pm 1.2$
MV-61	$1.4 \pm 1.3$	$-1.6 \pm 1.1$

Table 8.—*Concentrations of stable isotopes in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Symbols:  $\delta^2\text{H}$ , delta notation for stable hydrogen isotope ratios;  $\delta^{18}\text{O}$ , delta notation for stable oxygen isotope ratios;  $\delta^{13}\text{C}$ , delta notation for stable carbon isotope ratios;  $\delta^{34}\text{S}$ , delta notation for stable sulfur isotope ratios;  $\delta^{15}\text{N}$ , delta notation for stable nitrogen isotope ratios;  $\pm$ , plus or minus; permil, parts per thousand relative to a standard; \*, quality assurance sample (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water); NS, not sampled; BL, bottle broke in laboratory]

Site identifier	$\delta^2\text{H}$ ( $\pm 1.5$ permil)	$\delta^{18}\text{O}$ ( $\pm 0.15$ permil)	$\delta^{13}\text{C}$ ( $\pm 0.3$ permil)	$\delta^{34}\text{S}$ ( $\pm 0.5$ permil)	$\delta^{15}\text{N}$ ( $\pm 0.2$ permil)
MV-01	-131	-17.26	NS	14.5	5.3
MV-04	-137	-18.04	-10.8	12.3	3.8
MV-08*	-135	-17.98	-6.3	11.5	5.2
MV-09	-127	-16.53	-12.3	10.8	4.4
MV-11	-128	-16.83	-11.9	11.8	4.4
MV-12	BL	BL	-11	12.2	5.1
MV-14	-136	-17.66	-11.1	12.8	5.3
MV-15	-129	-16.87	-11.6	11.4	6.3
MV-18	-132	-17.13	-11.7	11.8	5.6
MV-21	-135	-17.9	-11	11.9	5.2
MV-22*	-34	-6.89	NS	NS	NS
MV-23	-128	-16.63	-12.1	12.1	5.1
MV-30	-129	-16.84	-11.8	11.9	3.8
MV-33	-136	-17.99	-10.1	10.3	5.2
MV-37	-129	-16.59	-13	11.3	8.4
MV-39	-126	-16.48	-14.4	12.4	6.7
MV-43	-128	-16.79	-12.9	12.8	6.7
MV-47	-136	-18.08	-10.5	15.1	4.4
MV-51	-116	-16.72	-12.6	12.4	6.2
MV-59	-137	-18.04	-9.7	12.5	4.6
MV-61	-135	-17.67	-10.1	9.5	6.5

trace elements are shown on table 9. The concentrations of dissolved trace elements and hexavalent and total chromium are shown on table 10.

Aluminum.—Concentrations of aluminum in three samples were equal to or greater than the reporting level and ranged from 10 to 20 µg/L. The proposed secondary maximum contaminant level is 50 µg/L.

Arsenic.—Concentrations of arsenic in all samples were equal to or greater than the reporting level and ranged from 1 to 4 µg/L. The maximum contaminant level is 50 µg/L.

Barium.—Concentrations of barium in all samples were greater than the reporting level and ranged from 10 to 140 µg/L. The maximum contaminant level is 2,000 µg/L.

Beryllium.—Concentrations of beryllium in all samples were less than the reporting level of 0.5 µg/L. The proposed maximum contaminant level is 1 µg/L.

Cadmium.—Concentrations of cadmium in all samples were less than the reporting level of 1 µg/L. The maximum contaminant level is 5 µg/L.

Chromium.—Chromium analyses included dissolved, hexavalent, and total chromium. All the samples had concentrations of dissolved chromium less than the reporting level of 5 µg/L. Concentrations of hexavalent chromium in six samples equaled or exceeded the reporting level and ranged from 1 to 4 µg/L. Concentrations of total chromium in seven samples equaled or exceeded the reporting level and ranged from 1 to 8 µg/L; the maximum contaminant level is 100 µg/L.

Cobalt.—Concentrations of cobalt in all samples were less than the reporting level of 3 µg/L.

Copper.—Concentrations of copper in all samples were less than the reporting level of

10 µg/L. The proposed maximum contaminant level is 1,300 µg/L.

Iron.—Concentrations of iron in three samples exceeded the reporting level and ranged from 9 to 17 µg/L. The secondary maximum contaminant level is 300 µg/L.

Lead.—Concentrations of lead in three samples were equal to the reporting level of 1 µg/L. The maximum contaminant level is 50 µg/L.

Lithium.—Concentrations of lithium in all the samples exceeded the reporting level and ranged from 10 to 50 µg/L.

Manganese.—Concentrations of manganese in three samples were equal to or greater than the reporting level and ranged from 1 to 3 µg/L. The secondary maximum contaminant level is 50 µg/L.

Mercury.—All but one sample had concentrations of mercury less than the reporting level of 0.1 µg/L. MV-04 had a concentration of 0.9 µg/L. The maximum contaminant level for mercury is 2 µg/L.

Molybdenum.—Concentrations of molybdenum in all samples were less than the reporting level of 10 µg/L.

Nickel.—All the samples had concentrations of nickel less than the reporting level of 10 µg/L. The maximum contaminant level is 100 µg/L.

Selenium.—Concentrations of selenium in six samples were equal to the reporting level of 1 µg/L. The maximum contaminant level is 50 µg/L.

Silver.—All but one sample had concentrations of silver less than the reporting level of 1 µg/L. MV-51 had a concentration of 3 µg/L. The maximum contaminant level is 50 µg/L.

Strontium.—Concentrations of strontium in all samples exceeded the reporting level and ranged from 120 to 440 µg/L.

Table 9.—*Maximum contaminant levels and reporting levels of selected trace elements in drinking water*

[The maximum contaminant levels are for total measurements and were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, 1992) for community water systems and are for comparison purposes only. Proposed maximum contaminant levels—in parentheses—are from U.S. Environmental Protection Agency (1990, 1991). Proposed secondary and secondary maximum contaminant levels—in brackets—are from U.S. Environmental Protection Agency (1989, 1990). Reporting levels for the U.S. Geological Survey's National Water Quality Laboratory are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are in micrograms per liter. Symbol: ••, maximum contaminant level has not been established]

Constituent	Maximum contaminant level	Reporting level
Aluminum	[50]	10
Arsenic	50 (30)	1
Barium	2,000	2
Beryllium	(1)	.5
Cadmium	5	1
Chromium, dissolved	••	5
Chromium, hexavalent	••	1
Chromium, total	100	1
Cobalt	••	3
Copper	(1,300)	10
Iron	[300] ••	3
Lead	50 (5)	1
Lithium	••	4
Manganese	[50] ••	1
Mercury	2	.1
Molybdenum	••	10
Nickel	100	10
Selenium	50	1
Silver	50 [90]	1
Strontium	••	.5
Vanadium	••	6
Zinc	••	3

Table 10.—*Concentrations of dissolved trace elements and hexavalent and total chromium in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in micrograms per liter. Symbols: <, concentration was less than the respective reporting level; \*, quality assurance sample (MV-08 is a replicate of MV-21; MV-22 is a blank of inorganic-free water)]

Site identifier	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium		
						dissolved	hexavalent	total
MV-01	<10	3	66	<0.5	<1	<5	<1	<1
MV-04	<10	3	100	<.5	<1	<5	<1	<1
MV-08*	20	2	19	<.5	<1	<5	2	<1
MV-09	<10	4	140	<.5	<1	<5	<1	1
MV-11	<10	2	100	<.5	<1	<5	<1	<1
MV-12	<10	3	44	<.5	<1	<5	<1	<1
MV-14	<10	2	44	<.5	<1	<5	2	<1
MV-15	<10	2	80	<.5	<1	<5	<1	<1
MV-18	<10	2	56	<.5	<1	<5	<1	<1
MV-21	<10	2	19	<.5	<1	<5	<1	3
MV-22*	<10	<1	<2	<.5	<1	<5	<1	<1
MV-23	<10	2	53	<.5	<1	<5	<1	1
MV-30	<10	2	74	<.5	<1	<5	<1	<1
MV-33	10	2	13	<.5	<1	<5	<1	4
MV-37	<10	1	66	<.5	<1	<5	<1	<1
MV-39	<10	3	62	<.5	<1	<5	3	<1
MV-43	<10	2	86	<.5	<1	<5	<1	<1
MV-47	<10	2	19	<.5	<1	<5	2	2
MV-51	10	2	62	<.5	<1	<5	<1	<1
MV-59	<10	2	10	<.5	<1	<5	1	8
MV-61	<10	2	20	<.5	<1	<5	4	3

Table 10.—*Concentrations of dissolved trace elements and hexavalent and total chromium in water from selected wells and springs, eastern Snake River Plain—Continued*

Site identifier	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum
MV-01	<3	<10	<3	<1	39	<1	<0.1	<10
MV-04	<3	<10	<3	<1	37	<1	.9	<10
MV-08*	<3	<10	<3	<1	17	<1	<.1	<10
MV-09	<3	<10	<3	<1	50	<1	<.1	<10
MV-11	<3	<10	<3	<1	48	<1	<.1	<10
MV-12	<3	<10	<3	<1	38	<1	<.1	<10
MV-14	<3	<10	<3	<1	35	<1	<.1	<10
MV-15	<3	<10	<3	<1	32	<1	<.1	<10
MV-18	<3	<10	<3	<1	41	<1	<.1	<10
MV-21	<3	<10	<3	<1	14	<1	<.1	<10
MV-22*	<3	<10	<3	<1	<4	<1	<.1	<10
MV-23	<3	<10	<3	<1	39	<1	<.1	<10
MV-30	<3	<10	17	<1	34	<1	<.1	<10
MV-33	<3	<10	<3	<1	10	<1	<.1	<10
MV-37	<3	<10	<3	<1	10	1	<.1	<10
MV-39	<3	<10	<3	<1	11	<1	<.1	<10
MV-43	<3	<10	<3	1	37	<1	<.1	<10
MV-47	<3	<10	<3	<1	18	<1	<.1	<10
MV-51	<3	<10	<3	<1	39	<1	<.1	<10
MV-59	<3	<10	9	1	12	3	<.1	<10
MV-61	<3	<10	12	1	24	1	<.1	<10

Table 10.—*Concentrations of dissolved trace elements and hexavalent and total chromium in water from selected wells and springs, eastern Snake River Plain—Continued*

Site identifier	Nickel	Selenium	Silver	Strontium	Vanadium	Zinc
MV-01	<10	<1	<1	310	<6	<3
MV-04	<10	1	<1	360	<6	39
MV-08*	<10	<1	<1	170	8	10
MV-09	<10	1	<1	440	<6	5
MV-11	<10	1	<1	430	<6	5
MV-12	<10	1	<1	300	9	8
MV-14	<10	<1	<1	300	7	<3
MV-15	<10	<1	<1	320	7	<3
MV-18	<10	<1	<1	350	8	5
MV-21	<10	<1	<1	170	8	7
MV-22*	<10	<1	<1	.7	<6	5
MV-23	<10	1	<1	340	6	19
MV-30	<10	<1	<1	370	8	10
MV-33	<10	<1	<1	150	8	180
MV-37	<10	<1	<1	240	<6	75
MV-39	<10	<1	<1	340	10	4
MV-43	<10	<1	<1	370	<6	11
MV-47	<10	<1	<1	190	8	11
MV-51	<10	<1	3	350	10	28
MV-59	<10	<1	<1	120	10	250
MV-61	<10	1	<1	170	<6	54

**Vanadium.**—Concentrations of vanadium in 13 samples equaled or exceeded the reporting level and ranged from 6 to 10 µg/L.

**Zinc.**—Concentrations of zinc in 17 samples exceeded the reporting level and ranged from 4 to 250 µg/L.

## Common Ions

Water samples were analyzed by the NWQL for dissolved common ions including bromide, calcium, chloride, fluoride, magnesium, potassium, silica, sodium, and sulfate. The maximum contaminant levels or secondary maximum contaminant levels and the reporting levels for these ions are shown on table 11. The concentrations of dissolved common ions are shown on table 12.

**Bromide.**—Concentrations of bromide in all samples exceeded the reporting level and ranged from 0.02 to 0.22 mg/L.

**Calcium.**—Concentrations of calcium in all samples exceeded the reporting level and ranged from 25 to 77 mg/L.

**Chloride.**—Concentrations of chloride in all samples exceeded the reporting level and ranged from 6.5 to 94 mg/L. The secondary maximum contaminant level is 250 mg/L.

**Fluoride.**—Concentrations of fluoride in all samples exceeded the reporting level and ranged from 0.3 to 1 mg/L. The maximum contaminant level is 4 mg/L.

**Magnesium.**—Concentrations of magnesium in all samples exceeded the reporting level and ranged from 13 to 34 mg/L.

**Potassium.**—Concentrations of potassium in all samples exceeded the reporting level and ranged from 2.9 to 8.4 mg/L.

**Silica.**—Concentrations of silica in all samples were greater than the reporting level and ranged from 29 to 39 mg/L.

**Sodium.**—Concentrations of sodium in all samples were greater than the reporting level and ranged from 13 to 85 mg/L. IDHW (1989) recommends an optimum concentration of 20 mg/L of sodium for public drinking-water supplies.

**Sulfate.**—Concentrations of sulfate in all samples exceeded the reporting level and ranged from 18 to 100 mg/L. The secondary maximum contaminant level is 250 mg/L.

## Nutrients

Water samples were analyzed by the NWQL for dissolved ammonia (as nitrogen), nitrite (as nitrogen), nitrite plus nitrate (as nitrogen), and orthophosphate (as phosphorus). The maximum and secondary maximum contaminant levels established by the U.S. Environmental Protection Agency (1989 and 1992) and the reporting levels are shown on table 13. A maximum contaminant level has not been established or proposed for ammonia or orthophosphate.

Concentrations of nutrients are shown on table 14. Concentrations of ammonia (as nitrogen) in all the samples equaled or exceeded the reporting level and ranged from 0.01 and 0.03 mg/L. Concentrations of nitrite (as nitrogen) in one sample, MV-43, equaled the reporting level of 0.01 mg/L; the maximum contaminant level is 1 mg/L. Concentrations of nitrite plus nitrate (as nitrogen) in all samples exceeded the reporting level and ranged from 0.58 to 5.9 mg/L; the maximum contaminant level is 10 mg/L. Concentrations of orthophosphate (as phosphorus) in 17 samples equaled or exceeded the reporting level and ranged from 0.01 to 0.06 mg/L.

## ORGANIC COMPOUNDS

Water samples were analyzed by the NWQL for selected organic compounds. These compounds included DOC, surfactants, purgeable

Table 11.—*Maximum contaminant levels and reporting levels of selected common ions in drinking water*

[The maximum contaminant levels are for total measurements and were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, p. 547) for community water systems and are for comparison purposes only. Secondary maximum contaminant levels—in brackets—are from U.S. Environmental Protection Agency (1989, 1990). Reporting levels for the U.S. Geological Survey's National Water Quality Laboratory are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are in milligrams per liter (mg/L). Symbol: ••, maximum contaminant level has not been established]

Constituent	Maximum contaminant level	Reporting level
Bromide	••	0.01
Calcium	••	.02
Chloride	[250]	.1
	••	
Fluoride	4	.1
	[2]	
Magnesium	••	.01
Potassium	••	.1
Silica	••	.01
Sodium <sup>1</sup>	••	.2
Sulfate	[250]	.1
	••	

<sup>1</sup>Idaho Department of Health and Welfare (1989) recommends an optimum concentration of 20 mg/L.

Table 12.—*Concentrations of dissolved common ions in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in milligrams per liter. Symbols: \*, quality assurance sample (MV-08 is a replicate of MV-21, MV-22 is a blank of inorganic-free water); <, the concentration was less than the respective reporting level]

Site identifier	Bromide	Calcium	Chloride	Fluoride	Magnesium	Potassium	Silica	Sodium	Sulfate
MV-01	0.09	52	50	0.5	21	7.3	38	39	53
MV-04	.11	77	45	.3	22	5.7	30	30	60
MV-08*	.02	33	10	.5	15	5.1	33	16	26
MV-09	.22	74	94	.4	34	8.4	36	85	100
MV-11	.18	70	69	.4	28	7.5	36	57	83
MV-12	.12	52	56	.5	23	4.5	32	47	66
MV-14	.12	56	45	.6	22	4.4	34	29	60
MV-15	.13	61	47	.4	21	7.4	39	38	61
MV-18	.15	65	52	.5	25	5.3	36	35	70
MV-21	.04	31	10	.4	16	3.9	33	17	24
MV-22*	<.01	.17	<.1	<.1	.02	<.1	<.01	<.2	<.1
MV-23	.16	65	63	.4	22	4.9	34	41	72
MV-30	.15	65	53	.4	25	6	37	42	71
MV-33	.02	26	6.5	.4	14	3.2	33	13	19
MV-37	.05	59	18	.4	17	5	29	21	43
MV-39	.09	71	28	.4	27	4.3	38	42	71
MV-43	.12	70	47	.4	27	6.5	38	41	64
MV-47	.04	33	15	.6	16	3.4	33	19	32
MV-51	.13	68	53	.5	25	5.7	33	40	72
MV-59	.03	25	11	.5	13	3.2	34	15	18
MV-61	.06	37	20	1	15	2.9	32	17	23

Table 13.—*Maximum contaminant levels and reporting levels of selected nutrients, dissolved organic carbon, and surfactants in drinking water*

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, 1992) for community water systems and are included for comparison purposes only. The secondary maximum contaminant level—in brackets—is from U.S. Environmental Protection Agency (1989). Reporting levels are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are milligrams per liter. Symbol: \*\*, maximum contaminant level has not been established or proposed]

Constituent	Maximum contaminant level	Reporting level
Ammonia (as nitrogen)	**	0.01
Nitrite (as nitrogen)	1	.01
Nitrite plus nitrate (as nitrogen)	10	.05
Orthophosphate (as phosphorus)	**	.01
Dissolved organic carbon	**	.1
Surfactants	[0.5]	.01

Table 14.—*Concentrations of nutrients, dissolved organic carbon, and surfactants in water from selected wells and springs, eastern Snake River Plain*

[See figure 2 for location of sites. Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. Analytical results in milligrams per liter. Symbols: <, concentration was less than the respective reporting level; \*, quality assurance sample (MV-08 is a replicate of MV-21, MV-22 is a blank of inorganic-free water)]

Site identifier	Ammonia (as nitrogen)	Nitrite (as nitrogen)	Nitrite plus nitrate (as nitrogen)	Orthophosphate (as phosphorus)	Dissolved organic carbon	Surfactants
MV-01	0.02	<0.01	1.3	0.02	0.5	0.02
MV-04	.02	<.01	2	.01	1.2	.05
MV-08*	.01	<.01	1	.01	.2	.01
MV-09	.02	<.01	5.9	.02	1.9	.08
MV-11	.03	<.01	4.6	.02	1.1	.07
MV-12	.02	<.01	1.8	.02	.8	.04
MV-14	.01	<.01	2	.01	.6	.03
MV-15	.01	<.01	2	.01	.6	.03
MV-18	.01	<.01	2.3	.02	.8	.03
MV-21	.01	<.01	1	.01	.3	.01
MV-22*	.02	<.01	<.05	<.01	<.1	<.01
MV-23	.02	<.01	3.9	.05	.5	.06
MV-30	.02	<.01	2.6	.03	.9	.04
MV-33	.01	<.01	.58	<.01	.2	.02
MV-37	.02	<.01	3.8	.05	1.2	.04
MV-39	.01	<.01	2.6	.06	1	.03
MV-43	.02	.01	3.6	.02	.9	.03
MV-47	.01	<.01	.76	.01	.2	.01
MV-51	.02	<.01	2.4	.04	1.1	.03
MV-59	.02	<.01	.74	<.01	.1	.01
MV-61	.02	<.01	1.1	<.01	.3	.02

organic compounds, insecticides, polychlorinated compounds, and herbicides. Reporting levels established for these constituents (C.A. Watterson and A.T. Kashuba, USGS, written commun., 1993) are not to be confused with reporting levels and analytical method detection limits for selected radionuclides.

### **Dissolved Organic Carbon**

Water samples were analyzed for DOC (table 14). Concentrations of DOC in all the samples were equal to or greater than the reporting level of 0.1 mg/L, and ranged from 0.1 to 1.9 mg/L; no maximum contaminant level has been established.

### **Surfactants**

Water samples were analyzed for surfactants (table 14). Concentrations of surfactants in all the samples equaled or exceeded the reporting level and ranged from 0.01 to 0.08 mg/L; the secondary maximum contaminant level is 0.5 mg/L (U.S. Environmental Protection Agency, 1989).

### **Purgeable Organic Compounds**

Water samples were analyzed for 63 purgeable organic compounds. The maximum contaminant levels and reporting levels for these compounds are shown on table 15. Only one of the compounds, ethylbenzene, was detected in one water sample. The ethylbenzene concentration from MV-09 was 1 µg/L; the maximum contaminant level is 700 µg/L.

### **Insecticides and Polychlorinated Compounds**

Water samples were analyzed for concentrations of 12 carbamate insecticides, 12 organophosphorus insecticides, 15 organochlorine insecticides, gross PCB's and gross PCN's. The

maximum contaminant levels and reporting levels for these compounds are shown on table 16. None of the concentrations of these compounds exceeded their respective reporting levels.

### **Herbicides**

Water samples were analyzed for concentrations of 23 triazine herbicides and 4 chlorophenoxy-acid herbicides. Maximum contaminant levels and reporting levels for these compounds are shown on table 17. None of the concentrations of these herbicides exceeded their respective reporting levels.

## **SUMMARY**

The USGS and the IDWR, in response to a request from the DOE, sampled 19 sites as part of a long-term project to monitor water quality of the Snake River Plain aquifer from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area. Water samples were collected and analyzed for selected radionuclides, stable isotopes, inorganic constituents, and organic compounds. The samples were collected from seven irrigation wells, four domestic wells, two springs, one stock well, three dairy wells, one observation well, and one commercial well. Two quality assurance samples also were collected and analyzed.

Concentrations of strontium-90 in all samples were less than the reporting level. Tritium concentrations in 19 of the samples analyzed by the NWQL exceeded the reporting level, but none exceeded the maximum contaminant level for drinking water. All samples analyzed by ISU had concentrations of tritium less than the reporting level. Concentrations of dissolved gross alpha-particle radioactivity in 14 of the samples analyzed by the NWQL exceeded the reporting level; none exceeded the U.S. Environmental Protection Agency maximum contaminant level. Concentrations of dissolved gross beta-particle radioactivity in all samples

Table 15.—*Maximum contaminant levels and reporting levels of selected purgeable organic compounds in drinking water*

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using an analytical method equivalent to U.S. Environmental Protection Agency method 524.2. Maximum contaminant levels were established pursuant to the recommendation of the U.S. Environmental Protection Agency (1989, 1992) for community water systems and are included for comparison purposes only. Reporting levels are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are in micrograms per liter ( $\mu\text{g/L}$ ). Symbols: ••, maximum contaminant level has not been established or proposed; \*, total trihalomethanes—which include bromoform, chlorodibromomethane, chloroform, and dichlorobromomethane—in community water systems serving 10,000 or more persons cannot exceed 100  $\mu\text{g/L}$  (U.S. Environmental Protection Agency, 1989, p. 548)]

Compound	Maximum contaminant level	Reporting level	Compound	Maximum contaminant level	Reporting level
Acrolein	••	20	2,2-Dichloropropane	••	0.2
Acrylonitrile	••	20	Cis-1,3-Dichloropropene	••	.2
Benzene	5.0	0.2	Trans-1,3-Dichloropropene	••	.2
Bromobenzene	••	.2	1,1-Dichloropropene	••	.2
Bromochloromethane	••	.2	Ethylbenzene	700	.2
Bromoform	*	.2	Hexachlorobutadiene	••	.2
N-Butylbenzene	••	.2	Isopropylbenzene	••	.2
Sec-butylbenzene	••	.2	P-Isopropyltoluene	••	.2
Tert-butylbenzene	••	.2	Methylbromide	••	.2
Carbon tetrachloride	5.0	.2	Methylene chloride	••	.2
Chlorobenzene	100	.2	Methylchloride	••	.2
Chlorodibromomethane	*	.2	Methyltertbutylether	••	1.0
Chloroethane	••	.2	Naphthalene	••	.2
2-Chloroethylvinylether	••	1.0	N-propylbenzene	••	.2
Chloroform	*	.2	Styrene	100	.2
1,2-Chlorotoluene	••	.2	1,1,1,2-Tetrachloroethane	••	.2
1,4-Chlorotoluene	••	.2	1,1,2,2-Tetrachloroethane	••	.2
Dibromochloropropane	0.2	1.0	Tetrachloroethylene	5.0	.2
1,2-Dibromoethane	••	.2	Toluene	1,000	.2
Dibromomethane	••	.2	1,2,3-Trichlorobenzene	••	.2
1,2-Dichlorobenzene	600	.2	1,2,4-Trichlorobenzene	70	.2
1,3-Dichlorobenzene	••	.2	1,1,1-Trichloroethane	200	.2
1,4-Dichlorobenzene	75	.2	1,1,2-Trichloroethane	5	.2
Dichlorobromomethane	*	.2	Trichloroethylene	5.0	.2
Dichlorodifluoromethane	••	.2	Trichlorofluoromethane	••	.2
1,1-Dichloroethane	••	.2	1,2,3-Trichloropropane	••	.2
1,2-Dichloroethane	5.0	.2	Trichlorotrifluoroethane	••	.5
Cis-1,2-Dichloroethene	••	.2	1,2,4-Trimethylbenzene	••	.2
1,1-Dichloroethylene	7.0	.2	1,3,5-Trimethylbenzene	••	.2
1,2-Transdichloroethene	100	.2	Vinyl chloride	2.0	.2
1,2-Dichloropropane	5.0	.2	Xylenes, total ortho, meta, and para	10,000	.2
1,3-Dichloropropane	••	.2			

Table 16.—*Maximum contaminant levels and reporting levels of selected insecticides and gross polychlorinated compounds in drinking water*

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. The maximum contaminant level was established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, 1992) for community water systems and are included for comparison purposes only. Proposed maximum contaminant levels—in parentheses—are from U.S. Environmental Protection Agency (1992). Reporting levels are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are in micrograms per liter ( $\mu\text{g/L}$ ). Symbol: \*\*, maximum contaminant level has not been established or proposed]

Carbamate insecticides: reporting level is 0.5  $\mu\text{g/L}$

Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Aldicarb	3	Methiocarb	**
Aldicarb sulfone	2	Methomyl	**
Aldicarb sulfoxide	4	1-Naphthol	**
Carbaryl (Sevin)	**	Oxamyl	(200)
Carbofuran	40	Propham	**
3-Hydroxycarbofuran	**	Propoxur	**

Organophosphorus insecticides: reporting level is 0.01  $\mu\text{g/L}$

Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Chlorpyrifos; Dursban	**	Malathion	**
DEF	**	Methyl parathion	**
Diazinon	**	Methyl trithion	**
Disulfoton	**	Parathion	**
Ethion	**	Phorate	**
Fonofos	**	Trithion	**

Table 16.—*Maximum contaminant levels and reporting levels of selected insecticides and gross polychlorinated compounds in drinking water—Continued*

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

Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Aldrin	••	Heptachlor	0.4
Chlordane	2	Heptachlor epoxide	.2
DDD	••	Lindane	.2
DDE	••	Methoxychlor	40
DDT	••	Mirex	••
Dieldrin	••	Perthane	••
Endosulfan	••	Toxaphene	3
Endrin	.2, (2)		

Gross polychlorinated compounds: reporting level is 0.1 µg/L

Compound	Maximum contaminant level
Gross polychlorinated biphenyls (PCB's)	0.5
Gross polychlorinated naphthalenes (PCN's)	••

Table 17.—*Maximum contaminant levels and reporting levels of triazines and chlorophenoxy-acid herbicides in drinking water*

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory. The maximum contaminant level was established pursuant to the recommendations of the U.S. Environmental Protection Agency (1989, 1992) for community water systems and are included for comparison purposes only. Proposed maximum contaminant levels—in parentheses—are from U.S. Environmental Protection Agency (1991, 1992). Reporting levels are from C.A. Watterson and A.T. Kashuba (USGS, written commun., 1993). Units are in micrograms per liter ( $\mu\text{g/L}$ ). Symbol: \*\*, maximum contaminant level has not been established or proposed]

<u>Triazines and other nitrogen-containing herbicides</u>					
Herbicide	Maximum contaminant level	Reporting level	Herbicide	Maximum contaminant level	Reporting level
Alachlor	2	0.1	Metolachlor	**	0.2
Ametryn	**	.1	Metribuzin	**	.1
Atrazine	3	.1	Prometon	**	.2
Bromacil	**	.2	Prometryn	**	.1
Butachlor	**	.1	Propachlor	**	.1
Carboxin	**	.2	Propazine	**	.1
Cyanazine	**	.2	Simazine	**	.1
Cycloate	**	.1	Simetryn	(4)	.1
De-ethylatrazine	**	.2	Terbacil	**	.2
De-isopropylatrazine	**	.2	Trifluralin	**	.1
Diphenamid	**	.1	Vernolate	**	.1
Hexazinone	**	.2			

Chlorophenoxy-acid herbicides: reporting level is 0.01  $\mu\text{g/L}$

Herbicide	Maximum contaminant level	Herbicide	Maximum contaminant level
2, 4-D	70	Silvex	10, (50)
2,4-DP	**	2,4,5-T	**

analyzed by the NWQL exceeded the reporting level. Concentrations of total gross beta-particle radioactivity in four of the samples analyzed by ISU equaled or exceeded the reporting level. Two radionuclides were identified using gamma spectroscopy. Concentrations of cesium-137 and cobalt-60 in all samples were less than the reporting level.

Water samples were analyzed for concentrations of stable isotopes of H, O, C, S, and N. Relative isotopic ratios ranged from -116 to -137 permil for  $\delta^2\text{H}$ , -16.48 to -18.08 permil for  $\delta^{18}\text{O}$ , -6.3 to -14.4 permil for  $\delta^{13}\text{C}$ , 9.5 to 15.1 permil for  $\delta^{34}\text{S}$ , and 3.8 to 8.4 permil for  $\delta^{15}\text{N}$ .

All the samples contained one or more dissolved trace elements and common ions in concentrations greater than the reporting levels. No concentration exceeded an established maximum contaminant level.

Concentrations of ammonia (as nitrogen) in all the water samples equaled or exceeded the reporting level. Concentrations of nitrite (as nitrogen) in one sample equaled the reporting level. Concentrations of nitrite plus nitrate (as nitrogen) in all the water samples exceeded the reporting level. Concentrations of orthophosphate (as phosphorus) in 17 of the water samples equaled or exceeded the reporting level. No nutrient concentration exceeded an established maximum contaminant level.

Concentrations of dissolved organic carbon in all the samples equaled or exceeded the reporting level. Surfactants in all the water samples equaled or exceeded the reporting level but did not exceed the secondary maximum contaminant level. The concentration of ethylbenzene in one sample exceeded the reporting level. No carbamate insecticides, organophosphorus insecticides, organochlorine insecticides, gross PCB's, gross PCN's, or herbicides were detected at concentrations exceeding their respective reporting levels.

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