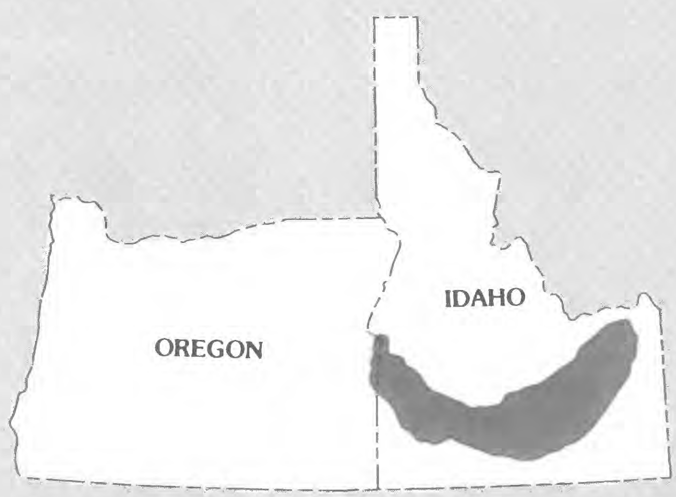
# SOLUTE GEOCHEMISTRY OF THE SNAKE RIVER PLAIN REGIONAL AQUIFER SYSTEM, IDAHO AND EASTERN OREGON

## REGIONAL AQUIFER-SYSTEM ANALYSIS

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# Solute Geochemistry of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon

*By* WARREN W. WOOD *and* WALTON H. LOW

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# FOREWORD

## THE REGIONAL AQUIFER-SYSTEM ANALYSIS PROGRAM

The Regional Aquifer-System Analysis (RASA) Program was started in 1978 following a congressional mandate to develop quantitative appraisals of the major ground-water systems of the United States. The RASA Program represents a systematic effort to study a number of the Nation's most important aquifer systems, which in aggregate underlie much of the country and which represent an important component of the Nation's total water supply. In general, the boundaries of these studies are identified by the hydrologic extent of each system and accordingly transcend the political subdivisions to which investigations have often arbitrarily been limited in the past. The broad objective for each study is to assemble geologic, hydrologic, and geochemical information, to analyze and develop an understanding of the system, and to develop predictive capabilities that will contribute to the effective management of the system. The use of computer simulation is an important element of the RASA studies, both to develop an understanding of the natural, undisturbed hydrologic system and the changes brought about in it by human activities, and to provide a means of predicting the regional effects of future pumping or other stresses.

The final interpretive results of the RASA Program are presented in a series of U.S. Geological Survey Professional Papers that describe the geology, hydrology, and geochemistry of each regional aquifer system. Each study within the RASA Program is assigned a single Professional Paper number, and where the volume of interpretive material warrants, separate topical chapters that consider the principal elements of the investigation may be published. The series of RASA interpretive reports begins with Professional Paper 1400 and thereafter will continue in numerical sequence as the interpretive products of subsequent studies become available.

Dallas L. Peck
Director

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# CONVERSION FACTORS

For readers who prefer to use U.S. Customary units, conversion factors for terms used in this report are listed below. Constituent concentrations are given in mg/L (milligrams per liter) or μg/L (micrograms per liter), which are equal to parts per million or parts per billion.

| Multiply | By | To obtain |
| --- | --- | --- |
| calorie per square centimeter per second ([cal/cm$^2$]/s) | 4.184 × 10 | watt per square meter |
| cubic meter (m$^3$) | 0.0008107 | acre-foot |
| cubic meter per second (m$^3$/s) | 35.31 | cubic foot per second |
| gram | 0.03527 | ounce (avoirdupois) |
| hectare (ha) | 2.471 | acre |
| kilometer (km) | 0.6214 | mile |
| megagram (Mg) | 1.102 | ton (short) |
| meter (m) | 3.281 | foot |
| meter squared per day (m$^2$/d) | 10.76 | foot squared per day |
| microsiemens per centimeter at 25 °Celsius (μS/cm) | 1.000 | micromho per centimeter at 25 °Celsius |
| millimeter (mm) | 0.03937 | inch |
| square kilometer (km$^2$) | 0.3861 | square mile |

Temperature in °C (degrees Celsius) can be converted to °F (degrees Fahrenheit) as follows:

$$°F = (1.8)(°C) + 32$$

Water temperatures are reported to the nearest 0.5 °C.

*National Geodetic Vertical Datum of 1929 (NGVD 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 "Mean Sea Level."

REGIONAL AQUIFER-SYSTEM ANALYSIS

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By WARREN W. WOOD and WALTON H. LOW


## ABSTRACT

Four geochemical approaches were used to determine chemical reactions controlling solute concentrations in the Snake River Plain regional aquifer system: (1) calculation of a solute balance within the aquifer, (2) identification of weathered products in the aquifer framework, (3) comparison of thermodynamic mineral saturation indices with plausible solute reactions, and (4) comparison of stable-isotope ratios of the solutes with those in the aquifer framework. Solutes in the geothermal groundwater system underlying the main aquifer were examined by calculating thermodynamic mineral saturation indices, stable-isotope ratios, geothermometry, and radiocarbon dating.

Water budgets, hydrologic arguments, and isotopic analyses for the eastern Snake River Plain aquifer system demonstrate that most, if not all, water is of local meteoric and not juvenile or formation origin. Thus, the solutes must also originate within the basin. Solute balance, isotopic, mineralogic, and thermodynamic arguments suggest that about 20 percent of the solutes leaving the basin are derived from reactions with rocks forming the aquifer framework. Most of the remaining solutes are introduced from tributary drainage basins.

Mass-balance calculations, thermodynamic arguments, and petrographic observations indicate that calcite and silica are precipitated in the aquifer. Petrographic evidence and thermodynamic arguments suggest that olivine, pyroxene, plagioclase, pyrite, and anhydrite are being weathered from the aquifer framework. Large amounts of sodium, chloride, and sulfate, relative to their concentration in the igneous rock, are being removed from the aquifer. Release of fluids from inclusions in the igneous rocks and initial flushing of grain boundaries and pores of detrital marine sediments in interbeds are believed to be a major source of these solutes. Identification and quantification of reactions controlling solute concentrations in ground water in the eastern plain indicate that the aquifer is not a large mixing vessel that simply stores and transmits water and solutes but is undergoing diagenesis and is both a source and a sink for solutes.

Evaluation of solute concentrations and stable-isotope ratios of hydrogen, oxygen, carbon, and sulfur along groundwater flowpaths that transect irrigated areas suggests that irrigation water may have altered solute concentrations and isotope ratios in the eastern Snake River Plain aquifer system. The changes, however, have been small because of the similarity of solute concentrations and ratios in applied irrigation water and in native ground water, and because of rapid movement and large dispersivity of the aquifer.

Reactions controlling solutes in the western Snake River basin are believed to be similar to those in the eastern basin but, because of different hydrologic conditions, a definitive analysis could not be made.

The regional geothermal system that underlies the Snake River Plain contains total dissolved solids similar to those in the overlying Snake River Plain aquifer system but contains higher concentrations of sodium, bicarbonate, silica, fluoride, sulfate, chloride, arsenic, boron, and lithium, and lower concentrations of calcium, magnesium, and hydrogen. These solutes are believed to be derived from reactions similar to those in the Snake River Plain aquifer system, except that ion exchange and hydrolysis play a role in controlling solute concentrations in the geothermal system.

Geothermometry calculations of selected ground-water samples from known geothermal areas throughout the basin suggest that the geothermal system is large in areal extent but has relatively low temperatures. Approximately half of the silica-quartz calculated water temperatures are greater than 90 °C. Radiocarbon dating of geothermal water in the Salmon Falls and Bruneau–Grand View areas in the south central part of the Snake River basin suggests that residence time of the geothermal water is about 17,700 years.


## INTRODUCTION

Results of the U.S. Geological Survey Snake River Plain RASA (Regional Aquifer-System Analysis) study are presented in U.S. Geological Survey Professional Paper 1408, which contains seven chapters, as follows:

Chapter A is a summary of the aquifer system.

Chapter B describes the geohydrologic framework, hydraulic properties of rocks composing the framework, and geologic controls on ground-water movement.

Chapter C describes relations of ground water and surface water and ground-water budgets.

Chapter D describes solute geochemistry of the cold-water and geothermal-water systems.

Chapter E describes water use.

Chapter F describes results of ground-water flow modeling of the eastern Snake River Plain.

Chapter G describes results of ground-water flow modeling of the western Snake River Plain.

The goal of this report (chapter D) was to determine the geochemical mechanism controlling solute geochemistry in the aquifer system.

### PURPOSE AND SCOPE

The concentrations and types of solutes in water play a major role in its suitability for intended use. In general, three levels of analyses can be used to evaluate solutes in an aquifer system. The first level is descriptive, where solute concentrations are mapped over space and time. The second level is interpretive, where mechanisms controlling solute distribution and concentrations are defined. The third level is predictive, where changes in solute concentrations with space and time are predicted from stresses applied to the aquifer system.

The purpose of this study was to define mechanisms controlling solute distribution and concentrations in the Snake River Plain regional aquifer system. Results of this study, together with results of six other final interpretive RASA studies, will provide a background from which the effect of hydrologic and chemical stresses on the aquifer system can be predicted.

The scope of the present study included collection and analysis of data that enabled determination of aquifer solute balance, stable-isotope content in surface and ground water, mineralogy of the aquifer framework, and thermodynamics of mineral-water reactions. Similar geochemical techniques also were used to gain insight into mechanisms controlling solute concentrations and residence time of water in the regional geothermal system.

### LOCATION

The Snake River Plain (fig. 1) is an arcuate area of about 40,400 km$^2$ of low to moderate topographic relief that extends across southern Idaho into eastern Oregon. The plain ranges from about 50 to 120 km in width and declines gradually in altitude from 1,800 m above the National Geodetic Vertical Datum of 1929 (NGVD of 1929) in the east to 640 m in the west. The plain is within the 180,000-km$^2$ Snake River basin upstream of Weiser, Idaho. Within the plain, the Snake River has 25 tributaries; 6 tributaries do not flow directly into the Snake River but flow onto the plain and recharge the ground-water system.

Areal extent of the plain is defined on the basis of geology and topography and is shown in figure 1. Generally, the plain's boundary was drawn along contacts between Quaternary sedimentary and volcanic rocks and surrounding older rock units. In some places, such as at mouths of stream valleys, the boundary was drawn along a topographic contour.

For purposes of this study, the plain was divided into two parts; the 28,000-km$^2$ eastern plain and the 12,400-km$^2$ western plain. The division is made in the vicinity of King Hill on the basis of distinct geologic and hydrologic differences.

### PREVIOUS INVESTIGATIONS

Surface- and ground-water resources of the Snake River basin have been investigated extensively because of intensive water use—particularly for irrigation and hydroelectric generation. Generally, as part of these investigations, solute chemistry and water quality have been described as measures of the water's suitability for various uses. Areal and percentage distribution of solute concentrations in surface water entering the regional aquifer system underlying the Snake River Plain was described by Low (1985). Laird (1964) and McConnell (1967) described solute chemistry of surface water throughout the Snake River basin. Both investigators described solute chemistry of surface water in the Snake River tributary valleys in relation to geology and water use. McConnell (1967) reported changes in dissolved-solids concentrations along the course of the Snake River. Steele and others (1974), Briggs and Ficke (1977), and Dyer (1973) gave statistical summaries of water-quality data for sampling sites on the Snake River. Low (1980) reported the impact of major waste discharges on water quality of the Snake River between Burley and Murtaugh Lake.

Solute chemistry of ground water in the eastern plain has been reported by several investigators. Robertson and others (1974) inferred that the chemical composition of water beneath the INEL (Idaho National Engineering Laboratory) near Arco, Idaho, reflects the composition of the surrounding tributaries rather than the chemical composition of basalt of the Snake River Group. Several investigators (Morris and others, 1963, 1964, 1965; Barraclough, Teasdale, and Jensen, 1967; Barraclough, Teasdale, Robertson, and Jensen, 1967; Robertson and others, 1974; Barraclough and others, 1976, 1982; Barraclough and Jensen, 1976; Humphrey and Tingey, 1978) described the areal extent of plumes in the aquifer under INEL resulting from disposal of radioactive and chemical wastes. A predictive solute-transport model of the aquifer was developed by Robertson (1974, 1977) and evaluated by Lewis and Goldstein (1982). Distribution and areal extent of organic solutes beneath INEL were reported by Leenheer and Bagby (1982). C.T. Rightmire (TRW Energy Systems Group, written commun., 1983; hereafter, Rightmire, 1983, refers to this communication) described the geochemistry of unsaturated and saturated zones beneath INEL.

Dyer and Young (1971) described areal variations in the quality of ground water withdrawn for irrigation in the eastern Snake River Plain. Norvitch and others (1969) made a general appraisal of the chemical quality of surface and ground water in the eastern plain and concluded that there probably would be no major water-quality impact as a result of large-scale artificial recharge to the aquifer. Mundorff and others (1964) briefly discussed the quality of ground water in the Snake River Plain regional aquifer system and in surrounding valleys.

Parliman (1983b) described ground-water quality and the suitability of ground water for various uses in the easternmost part of the plain and surrounding valleys. Jacobson (1982) reported on the quality of ground water in the eastern plain east of American Falls Reservoir. Castelin (1974) described water quality in the area north of American Falls Reservoir. Seitz and others (1977, p. 32) could not identify any regional water-quality impacts resulting from disposal of irrigation-waste water into drain wells in the eastern plain. Abegglen and others (1970, p. 37), however, concluded that liquid-waste disposal into drain wells in the eastern plain aquifer system poses a local bacterial pollution problem. Graham (1979) reported the localized impact of waste-water discharges into disposal wells in Minidoka County. Carter and others (1971, 1973) and Carter and Robbins (1978) reported water-quality impacts on ground water south of Twin Falls owing to irrigated agriculture.

Stevens (1962) reported the effects of irrigation on ground-water quality in Canyon County in the western Snake River Plain. Ralston and Chapman (1968) characterized ground-water quality from aquifers in the Mountain Home area, Elmore County. Ralston and Chapman (1969, p. 78) noted that the ground water in northern Owyhee County was only fair for irrigation and domestic use because of high salinity hazard and high fluoride content. Ralston and Chapman (1970) reported on suitability of ground water for agricultural and domestic uses in southern Ada and western Elmore Counties. Dion (1972) noted the effects of land use on shallow ground water in

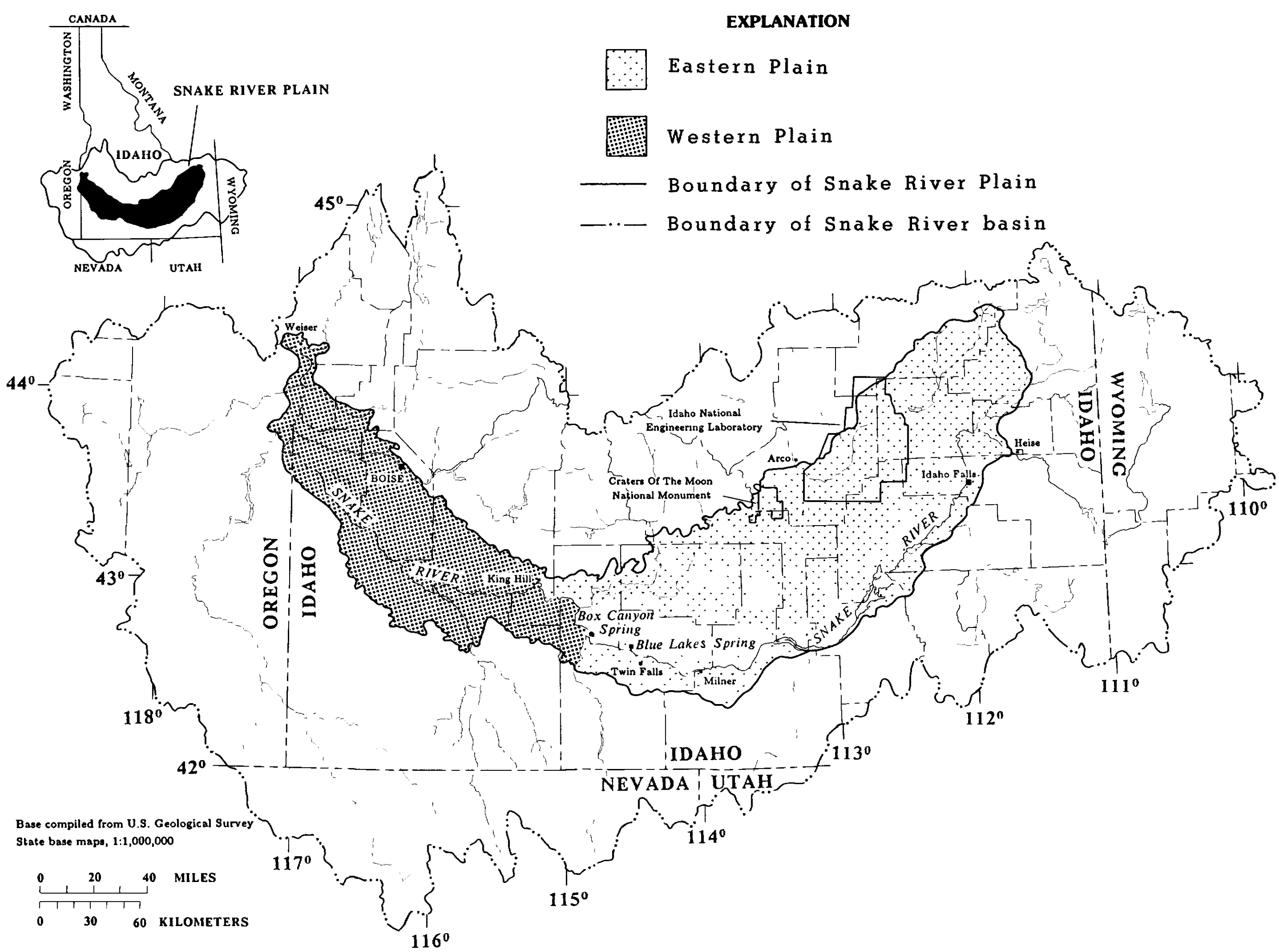


FIGURE 1.—Location and extent of Snake River Plain and basin.

the Boise-Nampa area. Young (1977, p. 38) described ground-water quality in the Mountain Home plateau of the western plain as being characteristic of the quality of recharge water from surrounding mountains. Parliman (1983a) assessed the quality of ground water from Swan Falls upstream to Glenns Ferry.

Low (1981) reported radionuclide concentrations in surface water of the upper Blackfoot River basin in southeastern Idaho. Seitz and Norvitch (1979) and Parliman (1982) described ground-water quality in several basins in southeastern and east-central Idaho. Parliman (1986) described ground-water quality in the Payette River basin.

### SITE-NUMBERING SYSTEM

The Geological Survey in Idaho numbers well and spring locations within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. For example, the first segment (4S) of site number 4S–33E–32ABA1S designates the township north or south, the second (33E), the range east or west, and the third (32), the section in which the site is located. Letters (ABA) following the section number indicate the site's location within the section and are assigned in counterclockwise order beginning with the northeast quarter. The first letter (A) denotes the ¼ section (65-ha tract), the second (B) denotes the ¼ section (16-ha tract), and the third (A) denotes the ¼¼¼ section (4-ha) tract. The last number (1) is a serial number assigned when the site was inventoried. An "S" following the site number indicates the site is a spring.

Surface-water sites are assigned a six-digit downstream order number prefaced by the two-digit part number "13," which indicates the site is in the Snake River basin; for example, 13037500 (Snake River near Heise).

Many sites also are assigned a 15-digit number based on the grid system of latitude and longitude; for example, 430524116110701. The first six digits denote degrees, minutes, and seconds of latitude; the next seven digits denote degrees, minutes, and seconds of longitude; and the last two digits (assigned sequentially) identify sites within a 1-second grid.

### ACKNOWLEDGMENTS

The authors gratefully acknowledge the cooperation of many landowners for allowing access to obtain water samples and other hydrologic information. We thank Karl Gebhardt, U.S. Bureau of Land Management, Boise, Idaho, and Gary Stensland and Michael Peden, Illinois State Water Survey, Champaign, Ill., for providing precipitation data; Ed Harris, Kuna, Idaho, and Stan Landon, Idaho Falls, Idaho, for obtaining precipitation samples; and Craig T. Rightmire, TRW, Inc., Energy Systems Group, McLean, Va., for providing unpublished isotopic data used in this report.

## GEOHYDROLOGY

### GEOLOGY

The geologic features of the Snake River Plain were first described in general by Lindgren (1898) and Russell (1902, 1903). Other geologic investigations were made by Kirkham (1931); Stearns and others (1938, 1939); Savage (1958); Malde (1959); Malde and Powers (1962); Carr and Trimble (1963); Armstrong and Oriel (1965); Armstrong (1971); and Nace and others (1975). Recent work by Whitehead (1986) illustrates the geohydrologic framework of the Snake River Plain relative to the aquifer system. Early geologic history is complex and is discussed in detail in the foregoing references.

At the beginning of Miocene time, central Idaho was predominantly rugged mountains with the Idaho batholith on the north and fault-block mountains of the Basin and Range province on the south. Although its structural development is not fully understood, Kirkham (1931, p. 456) believed the graben-like Snake River Plain to be a giant downwarp. Mabey (1982, p. 139) acknowledged that the western and central parts are fault-bounded. The plain has been characterized by rhyolitic and basaltic volcanism and crustal thinning (Leeman, 1982a, p. 155). Millions of cubic meters of lava was extruded from fractures within the plain. The plain has apparently continued to sink as a result of emptying underlying magma chambers, the weight of accumulated volcanic rocks, and the weight of accumulated sediments derived from adjacent highlands. Basaltic lava flows were extruded intermittently in the eastern plain throughout the Holocene Epoch. The youngest flows were emplaced about 2,000 years ago (Kuntz and others, 1982, p. 423).

In the western Snake River Plain and western parts of the eastern plain, Miocene basalt (Banbury Basalt and Columbia River Basalt Group) and lesser amounts of rhyolitic, silicic-volcanic rocks (Idavada Volcanics) were extruded. Volcanic extrusions alternated with deposition of fluvial and lacustrine sediments. Airfall and water-deposited volcanic ash also accumulated; some of these deposits are more than 300 m thick (Malde and Powers, 1962, p. 1197).

Silicic volcanism (chiefly Idavada Volcanics) in the Snake River Plain progressed eastward with time across the plain (Armstrong, 1971, p. 366). Potassium-argon dating of Idavada Volcanics indicates an age of 9–13 m.y. (million years) before present in the western part of the plain, 8–10 m.y. in the central part, and 4–5 m.y. in the eastern part (Armstrong and others, 1975, p. 225). Basaltic lava flows and deposits of lacustrine and fluvial sediments of the Idaho Group (upper Miocene to middle Pleistocene) followed. Total thickness of the Idaho Group in the western plain is more than 900 m in localized areas (Malde and Powers, 1962, p. 1197). Thick flows of basaltic rocks of the Pleistocene and Holocene Snake River Group in the eastern plain range from about 100 to more than 1,000 m thick (R.L. Whitehead, U.S. Geological Survey, written commun., 1984; Whitehead, 1986).

A generalized stratigraphic sequence of rocks in the Snake River basin is given in figure 2. The Snake River Group consists of numerous thin flows (averaging 8 m thick) of olivine basalt (Mundorff and others, 1964, p. 143) with minor interbedded fluvial and lacustrine sediments, most of which are near the plain's margins.

The Snake River Plain drainage system has changed frequently because of damming of streams by basalt flows. Because of changing drainage patterns and changing areas of sediment deposition, stratigraphic correlations in the eastern plain cannot be made over wide areas.

## PETROGRAPHY AND MINERALOGY OF THE AQUIFER FRAMEWORK

Minerals composing the aquifer framework are a major control on solute concentrations in ground water. Silicic Idavada Volcanics are the oldest rocks that transmit significant quantities of water and constitute an important geothermal reservoir in the western Snake River basin. Idavada Volcanics are largely welded ash flows but include some bedded vitric tuffs and lava flows (Malde and Powers, 1962). The fine-grained matrix of lava flows is rhyolitic. Ash flows consisting of massive beds of transparent glass shards give these flows a sandstone-like texture. The average chemical composition of 64 samples of rhyolite from the Idavada Volcanics is given in table 1. Petrographic studies on rocks in the Snake River Plain were made by Nace and others (1975) and Leeman (1982b, c).

A rhyolite sample from an outcrop in the Shoshone Creek basin south of Twin Falls (lat 42°14′24″, long 114°23′52″) contains a 0.6-mm by 2-mm lath-shaped plagioclase feldspar phenocryst (fig. 3). A 1-mm to 2-mm potassium feldspar phenocryst and pyroxene grains 0.3 mm in diameter in a fine-grained matrix are shown in figure 4. The scanning electron microscope (SEM) photographs (figs. 3 and 4) and semiquantitative chemical analyses by EDXRF (energy dispersive X-ray fluorescence) (analysis 3-1, table 2) show a weathering rind surrounding the phenocrysts. (The analysis number in table 2 refers to the figure sequence number of figures 3–15.) Crystals of intergrowth of both plagioclase and potassium feldspar weathering to kaolinite and iron oxide were also evident (fig. 5 and analysis 5-1, table 2). Several of the plagioclase crystals exhibited a honeycomb structure on their weathering surface, which can be interpreted as either examples of incongruent dissolution of the feldspar or the formation of clay (fig. 6). Crystals of what appeared to be an iron-rich pyroxene altering to kaolinite (fig. 7 and analyses 7-1 and 7-2, table 2) were present in some of the samples.

Secondary alteration of rhyolite from the Weiser River basin (lat 44°50′33″, long 116°37′57″) is shown in figure 8. On fresh outcrop surfaces, the rhyolite appeared to be a black iron-stained basalt. However, analyses 8-1 and 8-2 (table 2 and fig. 8) show that this rock has the composition of a rhyolite. The whitish material filling the fractures and vesicles appears to be an iron-magnesium silicate, perhaps a nontronite with additional iron on the exchange sites (analysis 8-3, table 2).

The petrology and mineralogy of the stratigraphically higher Idaho Group are more difficult to characterize because of the greater variety of rock types. Igneous rocks in the Idaho Group are largely olivine basalt chemically similar to Banbury Basalt (table 1). The basalt contains porphyritic plagioclase and olivine that decompose to greenish-brown, sand-size crystals. The predominant sedimentary formations within the Idaho Group, such as the Chalk Hills, Glenns Ferry, Bruneau, and Poison Creek Formations, are generally basin-fill deposits consisting of coarse igneous and metamorphic pebbles and lacustrine clay and silt (Malde and Powers, 1962). Secondary opal cement and caliche are common.

A sample of Banbury Basalt from a core 251 m below land surface in Gooding County, Idaho (lat 42°49′55″, long 114°39′03″), exhibited vesicles filled with both greenish and whitish clay minerals. X-ray diffraction analyses showed that the green clay exhibited strong 15.1Å (1 angstrom = 0.1 nm) basal spacing that expanded to 17Å on glycol saturation, which is characteristic of smectites. The SEM photograph of this sample (fig. 9) shows the honeycomb structure characteristic of authigenic smectites. X-ray spectra show that this smectite has high iron content and low concentrations of magnesium and aluminum. Inspection of the greenish clay with a transmission electron microscope indicates the presence of two morphologies of smectite, one a lath-shaped crystal and the other a flaky aggregate. The lath-shaped crystal has the greatest iron content, whereas the flaky aggregate has the greatest magnesium content. X-ray spectra and other evidence suggest that both smectites are nontronites. The whitish clay has a basal spacing of 14.7Å and expands to 17Å upon glycol saturation. The white clay has a flaky morphology and exhibits relatively low iron and high magnesium concentrations typical of a montmorillonite. Greenish and whitish clays are not found in the same vesicle.

Calcite is another common secondary vesicular filling in a Banbury Basalt sample collected 270 m below land

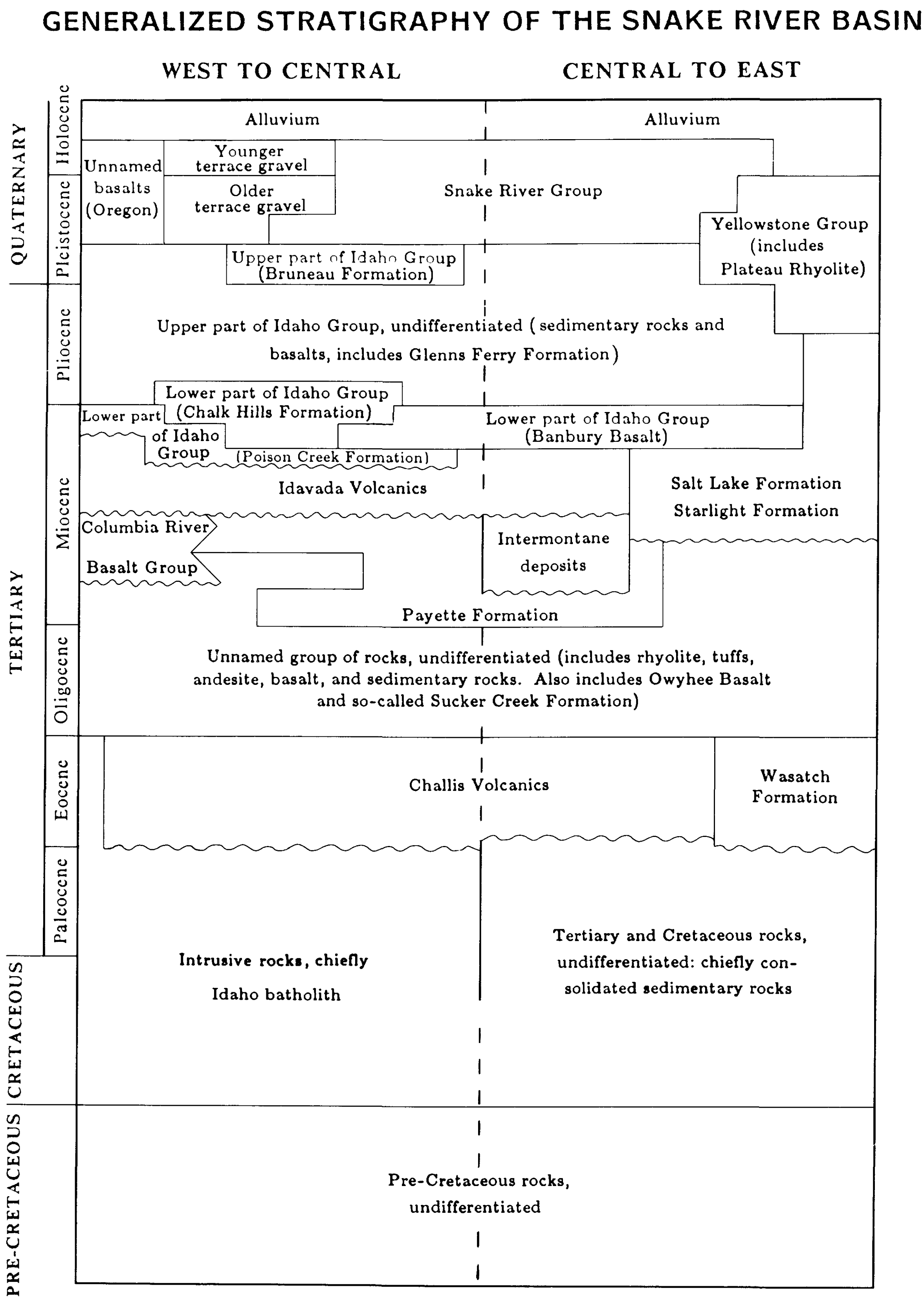


FIGURE 2.—Generalized stratigraphic sequence of rocks in Snake River basin. Modified from Malde and Powers (1962), Bond and others (1978), and Whitehead (1986).

TABLE 1.—*Average chemical composition of selected igneous rocks*
[Chemical composition in percent oxide]

| Oxide | Idavada Volcanics rhyolite[2] | Basalt of the Snake River Group[3] | Idaho Group Banbury Basalt[4] |
|---|---|---|---|
| $SiO_2$ | 71.27 | 46.42 | 47.22 |
| $Al_2O_3$ | 12.42 | 15.25 | 16.15 |
| $Fe_2O_3$ | .48 | 2.04 | 2.28 |
| FeO | 1.38 | 11.49 | 9.52 |
| MgO | .36 | 7.20 | 8.49 |
| CaO | 1.36 | 9.88 | 10.68 |
| $Na_2O$ | 2.83 | 2.76 | 2.25 |
| $K_2O$ | 5.26 | .65 | .35 |
| $H_2O$ | 2.07 | .38 | .48 |
| $TiO_2$ | .47 | 2.76 | 1.98 |
| $P_2O_5$ | .09 | .77 | .35 |
| MnO | .05 | .20 | .18 |

[1] All samples from unpublished files of the U.S. Geological Survey.

[2] Average of 64 samples of rhyolite from the Idavada Volcanics, southern Idaho.

[3] Average of 152 samples of basalt of the Snake River Group, southern Idaho.

[4] Average of 15 samples of Banbury Basalt of the Idaho Group, southern Idaho.

surface in the same Gooding County core hole previously described (fig. 10). Stable-isotope analyses of the secondary calcite showed a carbon-13 value of −6.65 permil relative to the isotope standard PDB (*Belemnitella americana*, Cretaceous Peedee Formation of South Carolina) and an oxygen-18 value of +12.65 permil relative to V–SMOW (Vienna–Standard Mean Ocean Water). For further discussion of stable-isotope analyses, refer to the sections "Solute Sources" and "Carbon and Sulfur Isotopes."

The mineral and chemical composition of basalt in the Snake River Group is uniform, even though the color, rock density, and other properties of the rock vary significantly. Megascopic differences are due largely to the form of emplacement and solidification. Basalt of the Snake River Group is typically 40–60 percent calcic plagioclase (usually labradorite), 20–50 percent pyroxene, and 5–10 percent olivine. Much of the basalt is porphyritic, having phenocrysts of olivine and labradorite 0.5 mm and 2 mm in diameter, respectively. The rock matrix consists of olivine, labradorite, clinopyroxene, ilmenite, magnetite, apatite, and glass. Most samples exhibit ophitic texture. The average of 152 chemical analyses of basalt of the Snake River Group is given in table 1. Nace and others (1975, p. B36) determined that the cation-exchange capacities of basalt from the INEL area ranged from 0.61 to 2.80 meq/100 g (milliequivalents per 100 grams).

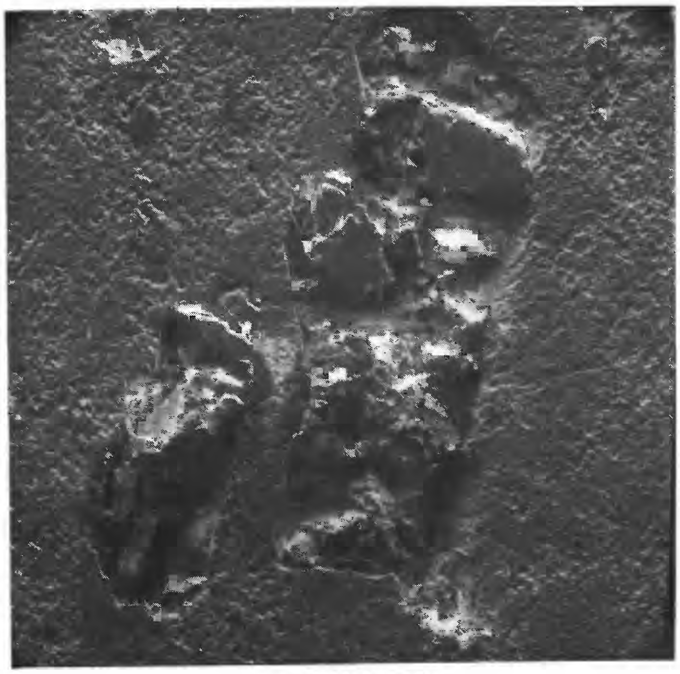

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FIGURE 3.—Scanning electron microscope photograph of plagioclase feldspar phenocrysts weathering from rhyolite outcrop (lat 42°14′24″, long 114°23′52″). Refer to chemical analysis 3-1, table 2.

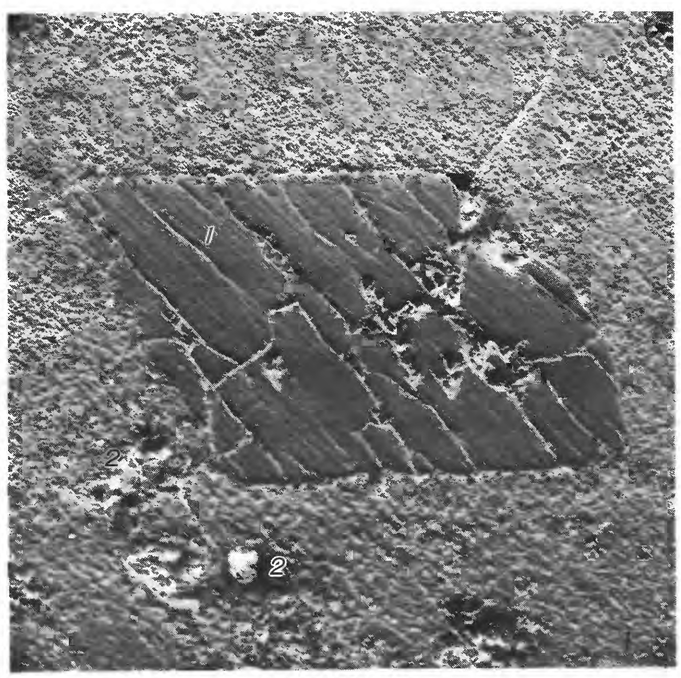


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FIGURE 4.—Scanning electron microscope photograph of (1) potassium feldspar phenocryst and (2) pyroxenes weathering from rhyolite outcrop (lat 42°14′24″, long 114°23′52″). Refer to chemical analysis 4-1, table 2.

TABLE 2.—*Semiquantitative chemical analyses of rocks and minerals from the Snake River basin*

[Analyses by scanning electron microscope equipped with the energy dispersive X-ray fluorescence analyzer; chemical analyses in percent oxide]

| Analysis No. | $SiO_2$ | $Al_2O_3$ | Total Fe | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | Formation | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 3-1 | 64 | 23 | 0.7 | 0.0 | 7.2 | 4.0 | 1.3 | 0.0 | Idavada Volcanics | Plagioclase feldspar in rhyolite |
| 4-1 | 67 | 18 | .7 | .0 | .5 | 2.5 | 10 | 1.0 | Idavada Volcanics | Potassium feldspar in rhyolite |
| 5-1 | 53 | 35 | 9.8 | .0 | .9 | .0 | .8 | .0 | Idavada Volcanics | Kaolinite in rhyolite |
| 7-1 | 53 | 16 | 28 | .0 | 1.3 | .0 | 1.6 | .2 | Idavada Volcanics | Center of crystal |
| 7-2 | 55 | 35 | 8.3 | .0 | .5 | .1 | .6 | .0 | Idavada Volcanics | Weathering of rim above crystal |
| 8-1 | 69 | 14 | 9.2 | .0 | 1.6 | 2.6 | 2.6 | .8 | Idavada Volcanics | Bulk rhyolite sample |
| 8-2 | 76 | 15 | .5 | .0 | .7 | 2.9 | 4.8 | .2 | Idavada Volcanics | Unweathered rhyolite |
| 8-3 | 28 | 12 | 52 | 5.9 | 1.2 | - | .7 | .2 | Idavada Volcanics | Vein filling |
| 11-1 | 51 | 30 | 1.0 | .3 | 13 | 4.2 | .5 | .2 | Snake River Group | Plagioclase, crystal No. 1 |
| 11-2 | 50 | 2.2 | 16 | 13 | 17 | .0 | .0 | 2.1 | Snake River Group | Pyroxene, crystal No. 2 |
| 11-3 | 4.5 | 3.0 | 66 | 1.1 | .6 | 1.5 | .4 | 23 | Snake River Group | Titanomagnetite, crystal No. 3 |
| 11-4 | 34 | .0 | 48 | 17 | .4 | .7 | .1 | .3 | Snake River Group | Olivine, crystal No. 4 |
| 11-5 | 34 | .0 | 43 | 21 | .5 | .9 | .0 | .3 | Snake River Group | Olivine, crystal No. 5 |
| 11-6 | 19 | 3.3 | 36 | .5 | 4.1 | .9 | 1.6 | 35 | Snake River Group | Ilmenite with intergrowth No. 6 |
| 11-7 | 54 | 28 | 1.1 | .0 | 11 | 4.6 | .6 | .3 | Snake River Group | Plagioclase, crystal No. 7 |
| 12-1 | 61 | 17 | 7.3 | 4.0 | 5.6 | .7 | 2.8 | 1.3 | Snake River Group | Vesicle lining |
| 13-1 | 92 | 3.1 | 1.1 | .7 | 1.3 | .6 | .6 | .6 | Snake River Group | Vesicle lining |
| 15-1 | 75 | 8.6 | .0 | 13 | 3.4 | .0 | .0 | .0 | Snake River Group | Vesicle lining |

Basalt of the Snake River Group in the Gooding County core hole is typical for olivine basalt. Energy-dispersive X-ray fractionation and thin-section evaluations on 13 samples of the Gooding County core indicated that olivine averaged 5.6 percent of the rock with a molar composition of 0.43 magnesium and 0.57 iron. Pyroxene averaged 25.4 percent of the rock and had a molar composition of 0.34 calcium, 0.39 magnesium, and 0.27 iron. Labradorite (equal molar sodium and calcium) was the only feldspar identified and averaged 34.6 percent of the rock. Opaque groundmass and glass averaged 17.4 percent of the rock, whereas voids averaged 16.2 percent. Thirteen chemical analyses of basalt from the Gooding County core hole are given in table 3.

Petrographically, the basalt is highly vesicular. Some vesicles are lined with detrital material and cryptocrystalline silica. Vesicle rims show mineral alteration to iron oxides.

A sample from 73 m below land surface at the Gooding County site consists of small, anhedral pyroxenes, opaque minerals, and small, unzoned plagioclase laths. Phenocrysts in the matrix are medium-size (0.01–0.1 mm), unzoned plagioclase laths and subhedral pyroxene and olivine crystals (0.05 mm in diameter). This sample consisted of 38 percent void space, 19 percent plagioclase, 20 percent pyroxene, 5 percent olivine, and 18 percent opaque minerals. Analysis of crystals identified in this sample (fig. 11) are given in table 2. Detrital clay, magnetite or ilmenite, silica, and feldspar fill vesicles in the basalt (figs. 12–14). A detrital clay, shown on the left half of figure 12, partially fills the vesicle.

EDXRF of the vesicle lining is given in analysis 12-1, table 2. Mostly pure silica (analysis 13-1, table 2) lines the vesicles shown in figure 13. In figure 14, the vesicle is filled with detrital potassium feldspar, euhedral quartz grains, and plagioclase feldspar in a clay matrix. The detritus appears to have been derived from a slightly weathered sialic ash. An amorphous to finely crystalline, high-silica-content magnesium aluminum silicate lines the vesicles shown on the right half of figure 15 (analysis 15-1, table 2).

The 73-m sample of basalt of the Snake River Group from the Gooding County core hole is typical of samples taken from the top of flows. Analyses strongly suggest that many flows were exposed to weathering prior to being covered by another flow. Vesicle linings and fillings in the basalt suggest that fill materials were transported rather than weathered in place. Calcite is commonly present in other samples of basalt of the Snake River Group but was not identified in the Gooding County core sample.

Some vesicular basalt of the Snake River Group has been filled by secondary mineralization. A surface outcrop (lat 43°19′30″, long 113°56′10″) contained a soft brown clayey substance consisting of chlorite, illite, and smectite that appears to be dust of eolian origin. A secondary scalenohedral calcite crystal (fig. 16) and quartz in the outcrop probably originated from evaporating soil water. Unfilled vesicles typically exhibit tabular labradorite (fig. 17).

Both fine disseminated pyrite crystals and massive vesicle fillings have been observed in basalt (Doherty, 1979; Whitehead and Lindholm, 1984). A basalt core from Jefferson County (lat 43°52′12″, long 112°39′40″; Crosthwaite, 1973) exhibited a pyrite-filled vesicle and yielded a sulfur-34 isotope value of −8.9 permil relative to the CD (Canyon Diablo meteorite) standard. For further discussion of stable-isotope analyses, refer to the section entitled "Carbon and Sulfur Isotopes."

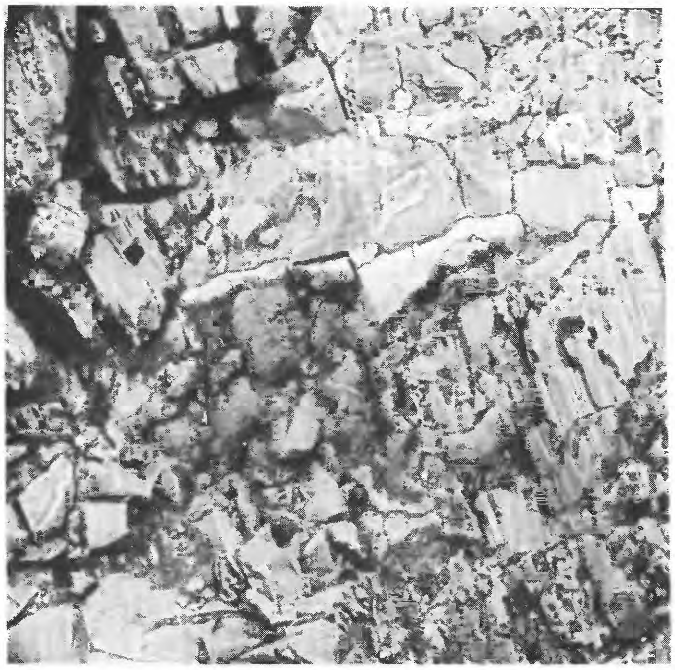

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FIGURE 5.—Scanning electron microscope photograph of intergrowth of plagioclase and potassium feldspar weathering to kaolinite and iron oxide in rhyolite (lat 42°14′24″, long 114°23′52″). Refer to chemical analysis 5-1, table 2.

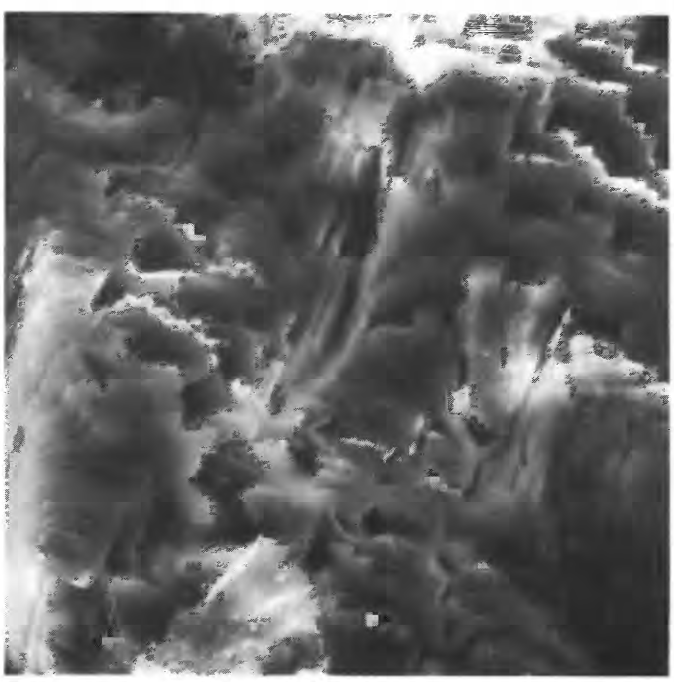

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FIGURE 6.—Scanning electron microscope photograph of rhyolite showing weathering of plagioclase crystals to possible clay with honeycomb structure (lat 42°14′24″, long 114°23′52″).

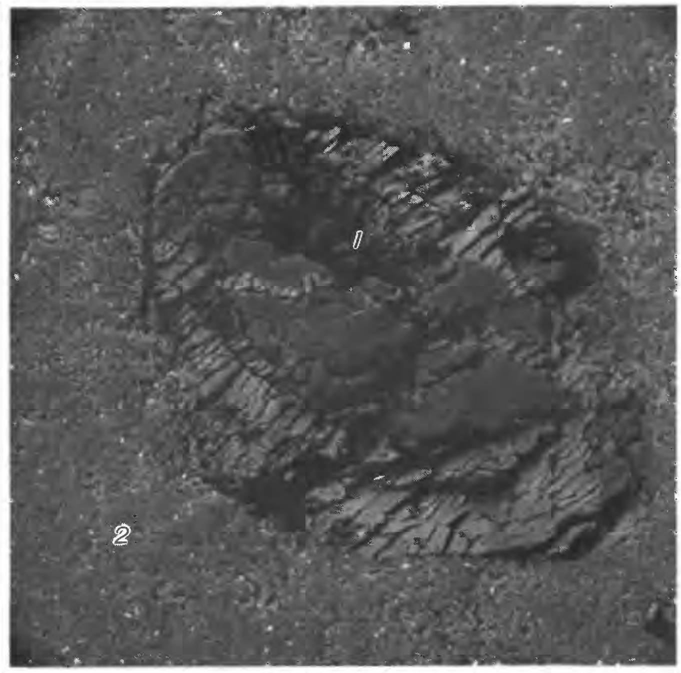


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FIGURE 7.—Scanning electron microscope photograph of (1) iron-rich pyroxene weathering to (2) kaolinite from rhyolite outcrop (lat 42°14′24″, long 114°23′52″). Refer to chemical analyses 7-1 and 7-2, table 2.

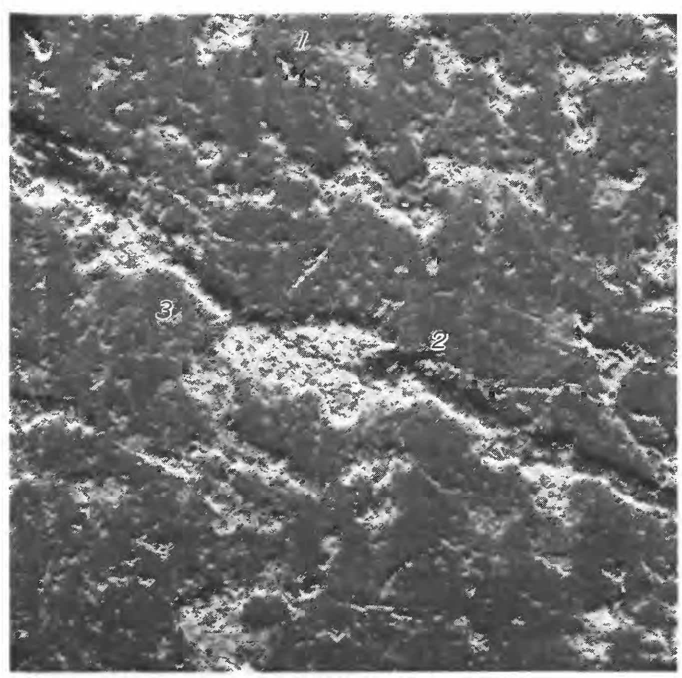


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FIGURE 8.—Scanning electron microscope photograph of secondary alteration of rhyolite (lat 44°50′33″, long 116°37′57″). Numbers refer to chemical analyses 8-1, 8-2, and 8-3, table 2.

Sediment accumulates in vesicles, fractures, and depressions in the basalt by fluvial, lacustrine, and eolian processes. Clay-size particles washed into fractures penetrate many meters into a basalt flow, leaving the surface of the fracture lined with introduced clay. Few data exist on the interbedded sediments; however, Barraclough and others (1976), Burgus and Maestas (1976), and Rightmire (1983) examined sedimentary "interbeds" at 3-, 34-, and 73-m depths at the INEL site. These interbeds vary in thickness from less than 0.09 m to more than 9 m and average about 4 m (Rightmire, 1983). The average grain size of 55 analyses reported by Rightmire (1983) was 0.23 mm. Grains consisted of quartz, potassium feldspar, labradorite, augite, olivine, chlorite, kaolinite, illite, smectite, mixed layer clays, and secondary calcite. Cation-exchange capacities of 56 bulk samples from sediment interbeds ranged from 1.1 to 45 meq/100 g, depending on the amount of expandable clays present (Barraclough and others, 1976). Some of these minerals, such as olivine, labradorite, pyroxene, and smectite, are clearly derived from local basalt flows or weathering of them; however, quartz and potassium feldspar are likely derived from sialic volcanic flows exposed on the flanks of the basin. It is assumed that the samples from INEL are representative of sediment interbeds in the eastern plain.

Surficial sediment in the eastern Snake River basin is probably similar to that composing interbeds. Rightmire (1983) compared surficial and buried sediments at the INEL site and noted that the amount of plagioclase and augite is lower and the amount of clay, particularly smectite, is higher in surficial sediment. Surficial sediment is also finer; the grain size of 12 samples averaged about 0.15 mm in diameter. Nace and others (1975, p. B36) determined that the average ion-exchange capacities of 158 surficial sediment samples from INEL ranged from 4.4 to 21.9 meq/100 g. Caliche is widespread throughout the area in surficial sediment and interbeds and, in places, composes more than 50 percent of the rock. Calcite or caliche appears to have been widespread throughout the Snake River Plain since Pliocene time. Anhydrite is present in the eolian dust and in the interbedded alluvium derived from tributary drainage basins containing marine Paleozoic sedimentary rocks (Robertson and others, 1974, p. 45–74).

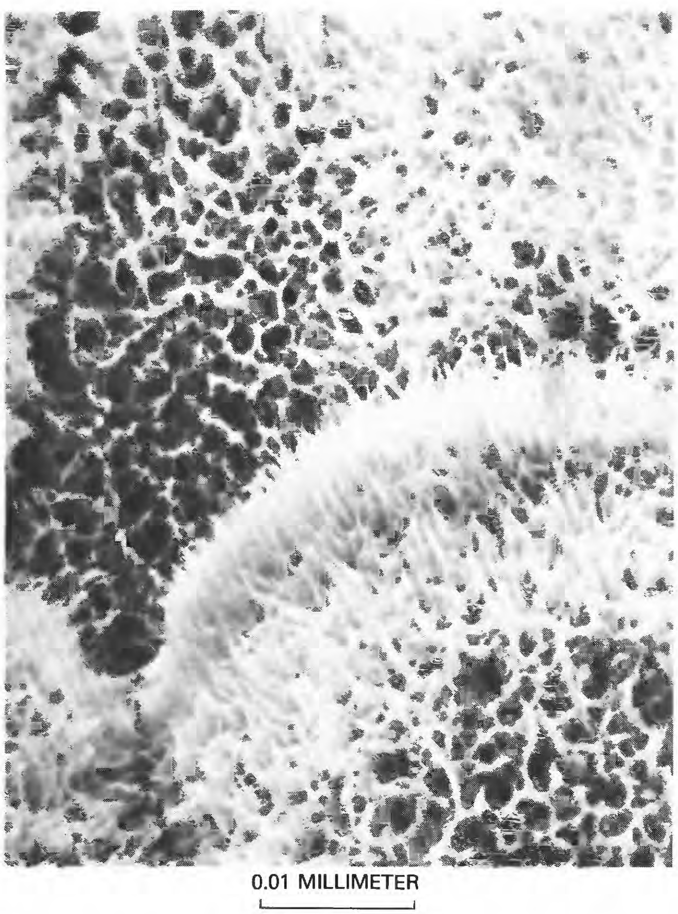




FIGURE 9.—Scanning electron microscope photographs of honeycomb structure of smectites from Banbury Basalt 251 m below land surface (lat 42°49′55″, long 114°39′03″).

### HYDROLOGY

The hydrology of the Snake River Plain has been studied by numerous investigators since 1898. Hydrologic investigations upon which the following discussion is based include those by Stearns and others (1938); Littleton and Crosthwaite (1957); Nace and others (1957); Mundorff and others (1964); Ralston and Chapman (1968, 1969, 1970); Norvitch and others (1969); Robertson and others (1974); Young (1977); G.D. Newton (U.S. Geological Survey, written commun., 1984); Kjelstrom (1986); Garabedian (1986); and Whitehead (1986).

The Snake River Plain regional aquifer system is largely unconfined. Regionally, ground water in the eastern plain moves from northeast to southwest and discharges to the Snake River, mostly as a series of springs between Twin Falls and King Hill (Lindholm and others, 1983). The potentiometric surface drops 610 m along a 320-km-long flowpath with an average gradient of 1.9 m/km. Flowpaths are generally parallel to the Snake River over much of the eastern plain. Flow velocities average approximately 3 m/d (Robertson and others, 1974, p. 13) because of high aquifer transmissivity. In much of the eastern plain, transmissivity exceeds 100,000 $m^2$/d because of the highly fractured, rubbly, and blocky nature of the olivine basalt (Garabedian, 1986). Average residence time in the aquifer is 200–250 years. Depth to water in the eastern plain varies from less than 1 m in alluvium along the Snake River to 300 m in the north-central part of the plain.

Lindholm (1986, p. 89) gave the following description of the geohydrologic framework of the western Snake River Plain.

> Fine-grained Quaternary-Tertiary sediments, which predominate in the western Plain are as much as 5,000 ft (1,520 m) thick near the Idaho-Oregon State line. Alluvial sand and gravel in the Boise River Valley are several hundred feet thick in places. Quaternary basalt in the central and eastern parts of the western Plain are as much as 2,000 ft (610 m) thick. Locally, the basalt yield large quantities of water, although saturated thickness is generally less than 500 ft (150 m). Miocene basalt, stratigraphically equivalent to the Columbia River Basalt Group, underlies most of the western Plain.

The Snake River Plain receives ground and surface water from mountainous areas bordering the plain and from direct precipitation. Kjelstrom (1986) showed that for the period 1934–80, the eastern Snake River Plain received an annual average of about 6.5 billion $m^3$ of water from tributary drainage basins, 6.0 billion $m^3$ from the Snake River above Heise, and 7.2 billion $m^3$ from direct precipitation. About 10 percent of the direct precipitation (0.7 billion $m^3$) became ground-water recharge (Kjelstrom, 1986). For the same period, the western plain received an annual average of about 8.6 billion $m^3$ of water from tributary drainage basins, 9.4 billion $m^3$ from the Snake River above King Hill, and about 3.0 billion $m^3$ from direct precipitation. About 2 percent of the direct precipitation (0.06 billion $m^3$) became ground-water recharge (Kjelstrom, 1986).

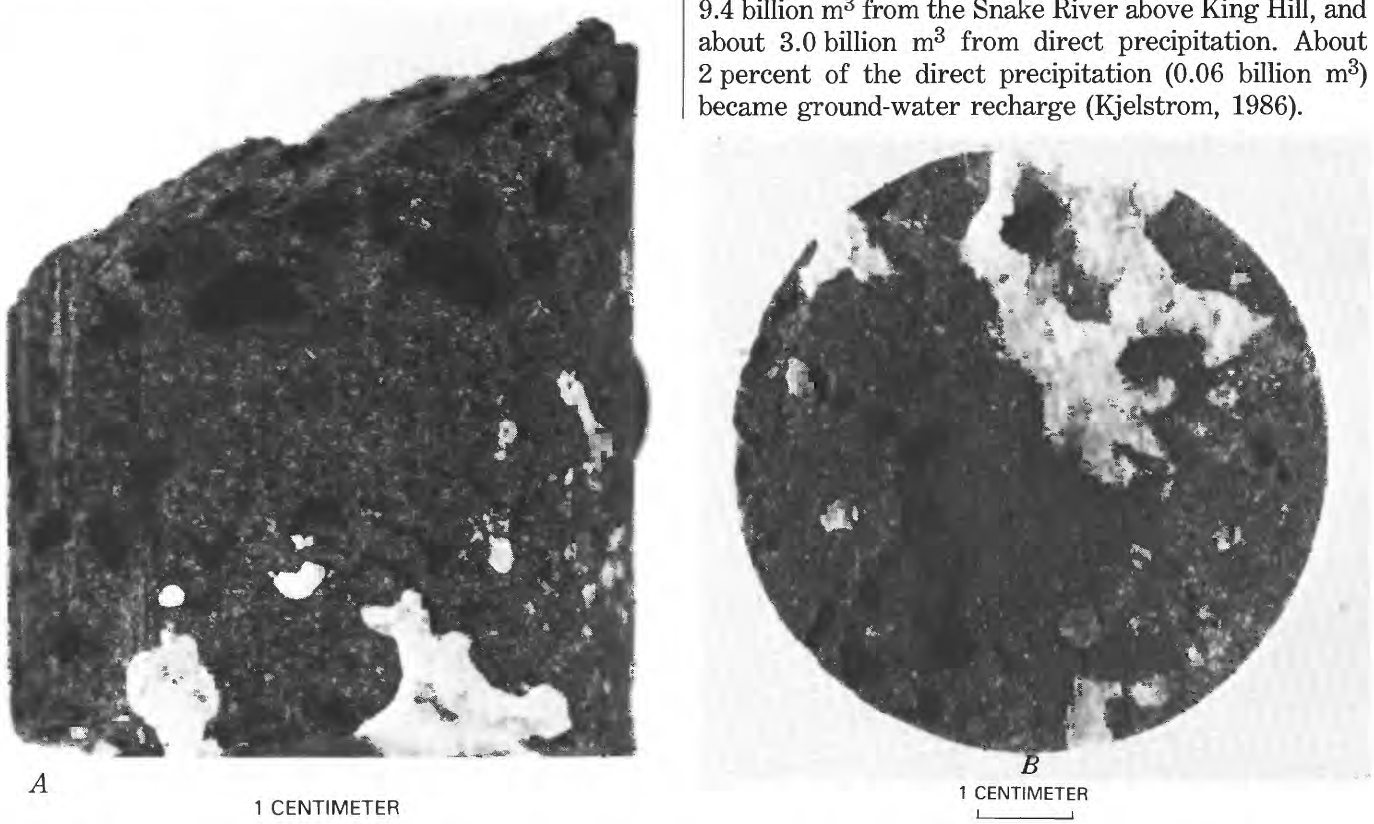



FIGURE 10.—Secondary calcite in Banbury Basalt 270 m below land surface (lat 42°49′55″, long 114°39′03″). *A*, Side view. *B*, Top view.

TABLE 3.—*Chemical analyses of core from Gooding County, Idaho (lat 42°49'55", long 114°39'03")*

[Analyses by X-ray fluorescence in percent oxide; sample depth in meters]

| Sample depth | $SiO_2$ | $Al_2O_3$ | FeO | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | $P_2O_5$ | MnO | Percent total | Formation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | 46.3 | 13.8 | 14.7 | 6.8 | 9.6 | 2.8 | 0.7 | 3.4 | 0.8 | 0.2 | 99.1 | Snake River Group |
| 74 | 46.3 | 12.3 | 15.3 | 5.9 | 9.6 | 2.5 | .8 | 4.1 | 1.1 | .2 | 98.1 | Snake River Group |
| 89 | 46.3 | 14.8 | 12.9 | 8.6 | 10.0 | 2.5 | .6 | 2.5 | .5 | .2 | 98.9 | Snake River Group |
| 91 | 43.0 | 11.9 | 11.2 | 6.3 | 16.7 | 2.1 | .6 | 2.5 | .5 | .2 | 94.9 | Snake River Group |
| 96 | 46.8 | 13.6 | 14.1 | 7.1 | 9.9 | 2.7 | .6 | 3.2 | .6 | .2 | 98.8 | Snake River Group |
| 98 | 47.0 | 13.0 | 14.2 | 6.7 | 10.2 | 2.6 | .7 | 3.5 | .6 | .2 | 98.7 | Snake River Group |
| 99 | 47.0 | 13.8 | 13.9 | 7.1 | 10.0 | 2.5 | .7 | 3.2 | .6 | .2 | 98.8 | Snake River Group |
| 108 | 46.5 | 13.6 | 14.0 | 7.3 | 10.0 | 2.7 | .6 | 3.1 | .6 | .2 | 98.8 | Snake River Group |
| 111 | 46.9 | 14.1 | 13.7 | 7.0 | 10.1 | 2.8 | .6 | 3.1 | .6 | .2 | 99.0 | Snake River Group |
| 123 | 47.2 | 13.8 | 14.0 | 7.1 | 10.1 | 2.7 | .6 | 3.1 | .6 | .2 | 99.5 | Snake River Group |
| 189 | 47.4 | 14.3 | 12.7 | 7.8 | 10.6 | 2.9 | .5 | 2.5 | .4 | .2 | 99.2 | Banbury Basalt |
| 191 | 47.0 | 14.3 | 13.0 | 7.3 | 10.7 | 2.3 | .4 | 2.6 | .4 | .2 | 98.6 | Banbury Basalt |
| 325 | 46.7 | 14.7 | 12.1 | 7.2 | 10.6 | 2.7 | .4 | 2.7 | .5 | .2 | 97.6 | Banbury Basalt |

In 1980, about 5.6 billion $m^3$ of surface water diverted for irrigation became recharge to the aquifer system in the eastern plain; about 2.5 billion $m^3$ of water, of which 85 percent was excess irrigation water, recharged the aquifer system in the western plain (L.C. Kjelstrom, U.S. Geological Survey, written commun., 1984). About 1.7 billion $m^3$ of water enters the eastern plain aquifer system as underflow from tributary drainage basins (Garabedian, 1986). About 28 percent of the total inflow to the eastern plain and 11 percent of total inflow to the western plain is lost by evapotranspiration of irrigation water (Kjelstrom, 1986).

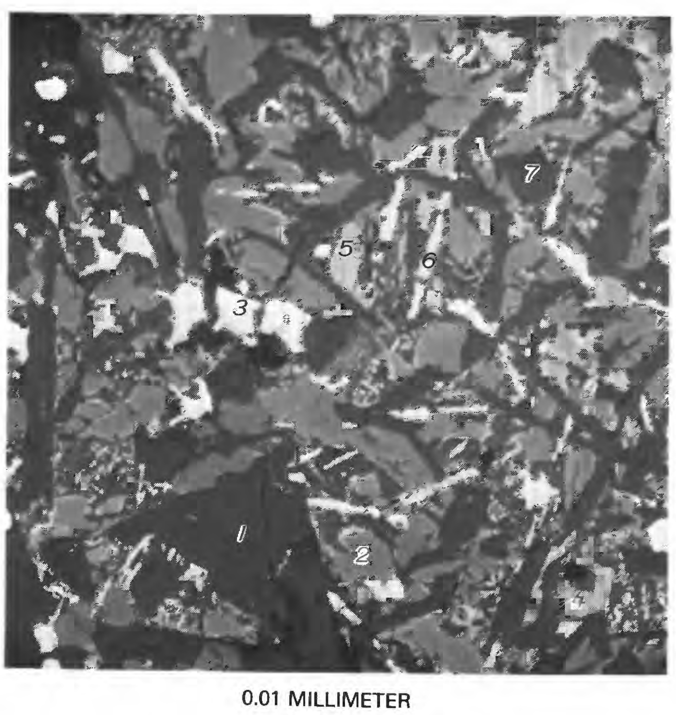



FIGURE 11.—Scanning electron microscope photograph showing olivine in basalt of Snake River Group 73 m below land surface (lat 42°49'55", long 114°39'03"). Numbers refer to chemical analyses 11-1 to 11-7, table 2.

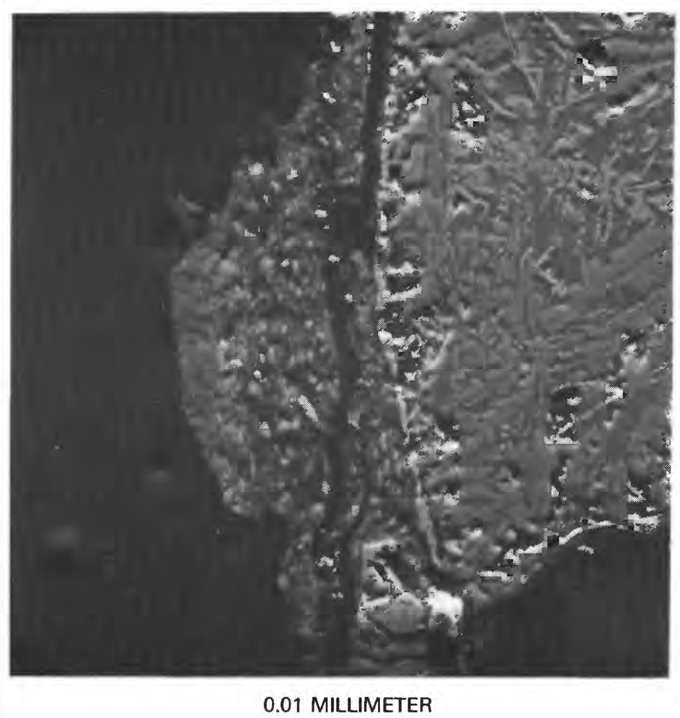



FIGURE 12.—Scanning electron microscope photograph showing detrital mineral material filling basalt vesicle 73 m below land surface (lat 42°49'55", long 114°39'03"). Refer to chemical analysis 12-1, table 2.

Changes in ground-water recharge because of irrigation practices have affected spring flows, which are the major source of ground-water discharge from the eastern plain. Mundorff and others (1964, p. 173) determined that spring discharges between Milner and Bliss increased from 108 to 142 $m^3/s$ from 1902 to 1956. Thomas (1969, p. 26) reported that ground-water discharge from Milner to King Hill increased from 115 $m^3/s$ in 1904 to 193 $m^3/s$ in 1953. The increase is attributed to recharge from surface-water irrigation north and east of the springs. Ground-water discharge to the Milner-to-King Hill reach was about 170 $m^3/s$ in 1980 (Kjelstrom, 1986). This decrease is due in part to increases in ground-water withdrawal for irrigation in the eastern Snake River Plain (Moreland, 1976, p. 9). Ground-water discharge along a 59-km reach of the Snake River between Blackfoot and American Falls is also mostly natural spring flow. Average annual discharge to the reach was 72 $m^3/s$ from 1912 to 1980 and did not change appreciably during that period (Kjelstrom, 1986).

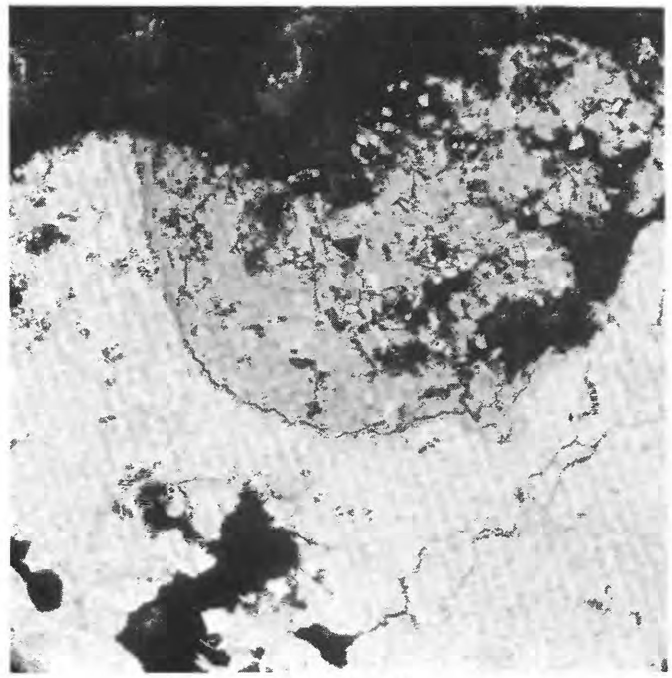



FIGURE 14.—Scanning electron microscope photograph showing detrital mineral material filling basalt vesicle 73 m below land surface (lat 42°49′55″, long 114°39′03″).

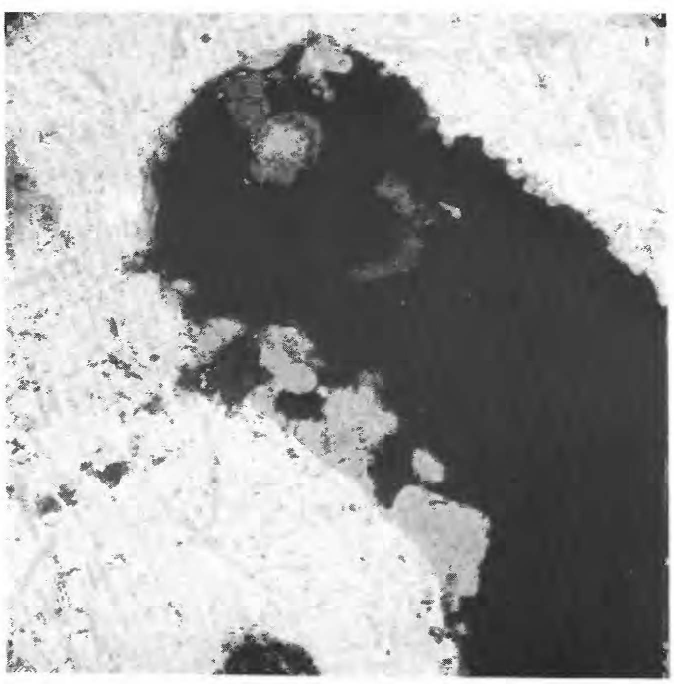



FIGURE 13.—Scanning electron microscope photograph showing pure silica lining in basalt vesicle 73 m below land surface (lat 42°49′55″, long 114°39′03″). Refer to chemical analysis 13-1, table 2.

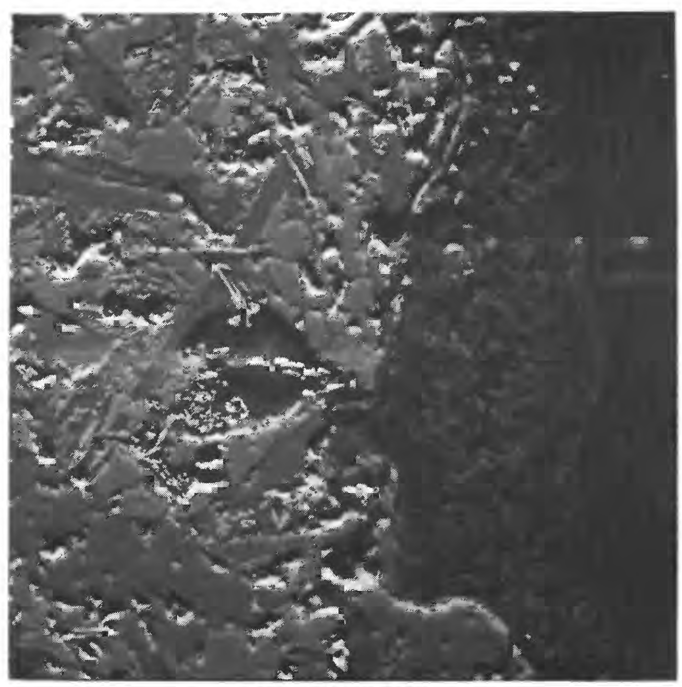



FIGURE 15.—Scanning electron microscope photograph showing magnesium aluminum silicate crystals 73 m below land surface (lat 42°49′55″, long 114°39′03″). Refer to chemical analysis 15-1, table 2.

## GEOCHEMISTRY OF THE SNAKE RIVER PLAIN AQUIFER SYSTEM

Mean, maximum, and minimum concentrations of major solutes and dissolved solids from the Snake River Plain regional aquifer system are shown in table 4. Concentrations of major dissolved solutes in water samples collected from 230 wells and springs representative of the Snake River Plain regional aquifer system are given in tables 20A–C (back of report). Eight solutes—calcium ($Ca^{+2}$), magnesium ($Mg^{+2}$), sodium ($Na^{+}$), potassium ($K^{+}$), silica ($SiO_2$), bicarbonate ($HCO_3^{-}$), chloride ($Cl^{-}$), and sulfate ($SO_4^{-2}$)—constitute more than 95 percent of the total solutes in the analyses listed.

### SOLUTE SOURCES

Potential sources of solutes are atmospheric precipitation, dissolution of the aquifer framework, addition by human activities, fluid inclusions, solutes on mineral grain boundaries, juvenile water, formation water, and regional interbasin flow. Direct quantitative determination of these sources is often difficult or impossible. However, all sources of solutes except from weathering of rocks and human activities are transported into the aquifer by water; thus, solute sources can be determined indirectly by determining the origin of water in the Snake River basin.

Two independent approaches were used to identify the origin of water in the Snake River basin. First, water budgets prepared by Kjelstrom (1986) suggested that within a reasonable error range, all water in the basin is derived from precipitation. Second, stable isotopes of hydrogen ($^{2}H$) and oxygen ($^{18}O$) in water were used to verify that water in the basin was of meteoric origin. Absolute isotopic abundances are difficult to determine with precision; therefore, isotopic variations customarily are measured and expressed as deviations from an arbitrary standard. These deviations are expressed in delta notation ($\delta$):

$$\delta = [(R\text{-sample}/R\text{-standard}) - 1] \times 1{,}000 \qquad (1)$$

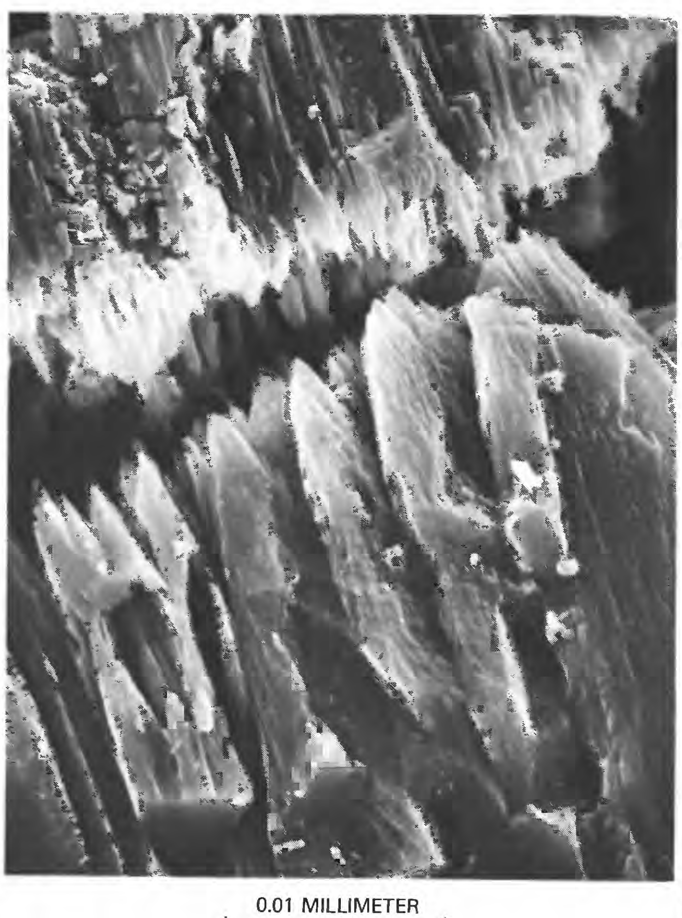


FIGURE 16.—Scanning electron microscope photograph showing scalenohedral calcite in surface basalt sample (lat 43°19′30″, long 113°56′10″).

FIGURE 17.—Scanning electron microscope photograph showing fresh, unfilled basalt vesicles with tabular labradorite from surface basalt sample (lat 43°19′30″, long 113°56′10″).

TABLE 4.—*Mean, maximum, and minimum concentrations of major solutes and dissolved solids in ground water, Snake River Plain*

[Solutes in milligrams per liter; 711 analyses]

| Solute | Mean | Maximum | Minimum |
|---|---|---|---|
| Calcium | 51 | 350 | 1.7 |
| Magnesium | 17 | 170 | .1 |
| Sodium | 43 | 570 | 2.7 |
| Potassium | 5 | 150 | .0 |
| Bicarbonate | 222 | 1,090 | 3.0 |
| Chloride | 32 | 700 | .5 |
| Sulfate | 67 | 1,400 | .8 |
| Silica | 37 | 140 | .2 |
| Dissolved solids | 366 | 2,440 | 60 |

Note--Analyses selected were based on a cation/anion balance within 3 percent and water temperature less than 26 °C.

where $R$ is $^2H/H$ or $^{18}O/^{16}O$ ratio, and $\delta$ is parts per thousand, or permil (‰). The standard to which natural-water isotopic measurements are referred is V–SMOW. Isotope analyses in this report are given an error band of $\pm1$ standard deviation, or $\pm1.5$ permil $^2H$ and $\pm0.1$ permil $^{18}O$.

The best-fit regression line ($\delta^2H = (6.4\ \delta^{18}O) - 21$) in figure 18 is based on samples of surface water (table 21C). The range of deuterium data is typical of values for meteoric water in this area of North America (Sheppard and others, 1969, p. 762). Deuterium and oxygen-18 isotopic ratios of water from the Snake River Plain regional aquifer system (table 20C) are shifted slightly to heavier values of oxygen typical of evaporation prior to recharge in a semiarid area (Gat, 1981, p. 223). Thus, the isotopic data are consistent with the hypothesis that ground water is derived from local precipitation, but this interpretation is not unique.

Because the isotope values of ground water lie near the local meteoric water line for this region, it is reasonable to assume that the water is not of juvenile origin (White and others, 1973). However, because of the relatively large variation of the values shown in figure 18, it is impossible to determine if any formation water or interbasin flow exists in this system. It is difficult to assign a range of errors to either the hydrologic budget or the isotopic method, but it is generally believed that most of the water is from local precipitation (Kjelstrom, 1986). A 4-percent residual for a water budget calculated by Garabedian (1986, p. 10) for the eastern Snake River Plain was considered acceptable. Therefore, if water in the Snake River basin is derived from local precipitation, solutes in the Snake River Plain regional aquifer system also must be derived from within the basin.

If ground water in the Snake River basin is assumed to be of meteoric origin, the only sources of solutes are precipitation and dissolution reactions of the water and dissolved gases with the aquifer framework, and introduction by human activities. Mean solute concentrations in precipitation on the plain (table 5) are much lower than those in ground water (table 4), but precipitation is a source for some solutes in ground water. In agricultural areas, some solutes probably have been added locally to ground water by irrigation, but the basic chemical composition of the ground water does not appear to have been altered significantly by irrigation (Low, 1985).

Kjelstrom (1986) demonstrated that recharge to the Snake River Plain regional aquifer system is largely from surface-water inflow from uplands bordering the plain, rather than from direct precipitation on the plain. Thus, solutes in water from tributary drainage basins are important in evaluating solutes in the Snake River Plain groundwater system. Concentrations of solutes in the Snake River and ground and surface water from tributary drainage basins that recharge the Snake River Plain aquifer system (table 6, tables 21A–C and 22A–C, back of report) are similar to those in the Snake River Plain regional aquifer system (tables 4 and 20A–C). This similarity is consistent with the concept that many of the solutes in the aquifer originate outside the aquifer.

## SOLUTE BALANCE, EASTERN SNAKE RIVER PLAIN

As discussed previously, hydrologic analyses indicate that only about 10 percent of the water in the eastern plain aquifer system is derived from direct precipitation on the plain (Kjelstrom, 1986). Solute concentrations and

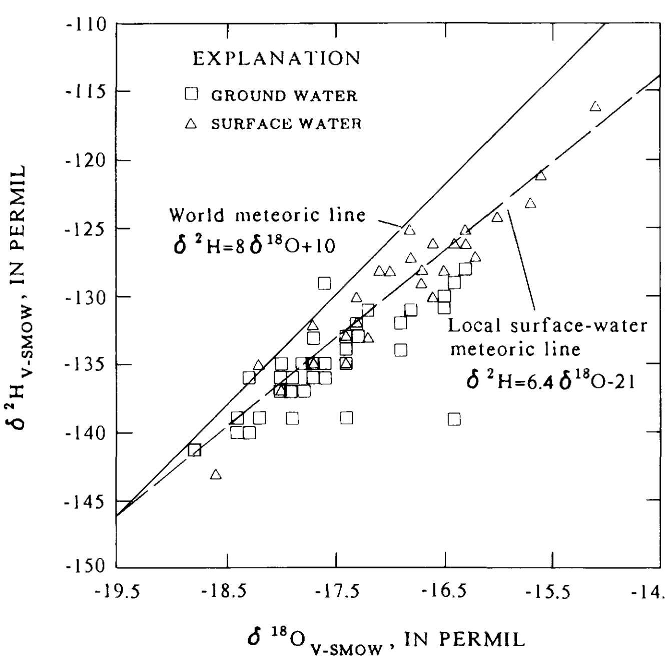



FIGURE 18.—Selected $\delta^2H$ and $\delta^{18}O$ ratios for surface water entering and ground water in Snake River Plain.

TABLE 5.—*Mean solute concentrations in precipitation, southern Idaho*

[Solutes based on 51 samples collected at Craters of the Moon National Monument and 4 samples collected near Boise and Idaho Falls; *, calculated concentrations]

| Solute | Mean concentration (milligrams per liter) |
|---|---|
| Calcium | 0.86 |
| Magnesium | .22 |
| Sodium | .64 |
| Potassium | .39 |
| Bicarbonate | 1.00* |
| Chloride | .84 |
| Sulfate | 1.82 |
| Fluoride | .25 |
| Silica | .08 |

ratios from tributary drainage basins are similar to those observed in the regional aquifer; thus, the primary geochemical question is, are there significant reactions occurring in the eastern plain aquifer system or is it simply a large mixing vessel? A solute balance approach was used to resolve this question.

Because solutes have been shown to originate within the Snake River basin, an average annual balance of solute input and output can be computed to determine whether solutes are generated in or removed from the regional aquifer (table 7). Assuming steady-state conditions, the solute balance is the sum of the solute loads from (1) tributary drainage basins, (2) precipitation on the plain, (3) underflow recharging the eastern Snake River Plain, and (4) weathering of the aquifer framework and human activities.

More than 70 years of Snake River discharge data and 30 years of solute-concentration data have been recorded at U.S. Geological Survey gaging stations at Heise and King Hill (fig. 1). Thus, solute loads can be calculated as described by Miller (1951, p. 5). Methods used to compute solute loads for smaller tributary streams with limited solute record were adapted from Miller (1951), Steele and others (1974), and Porterfield and others (1978). Instantaneous load for each major solute in tributaries to the Snake River was regressed against instantaneous discharge. The regression function that yielded the highest coefficient of determination ($r^2$) was used for the average annual solute load computation. The root-mean-square error of the regression function was used as the cumulative solute load error.

Average discharge and number of days in each of 34 class intervals of flow duration for the period of discharge record were used to compute the average solute load for each class interval of discharge. The summation of each average class interval solute load was divided by the total number of days in the period of water discharge, then multiplied by the number of days in a year to arrive at the average annual solute load for each major solute (table 7). An independent check on this approach is the ionic charge balance. Because each ion was regressed separately with discharge, a deviation in the ionic charge balance would result if any ion were overestimated or underestimated. Because the ionic charge balance of the computed load is within 0.2 percent, it suggests that the computation process outlined above gives a reasonable approximation of the true value.

Annual solute loads from precipitation were computed by multiplying the average composition of rain collected at Craters of the Moon National Atmospheric Deposition Program Site (National Atmospheric Deposition Program, 1981, 1982, 1983a, b, c) by the average annual volume of precipitation of 7.2 billion $m^3$ (Kjelstrom, 1986) on the eastern plain. Solute loads from tributary underflow were calculated by multiplying the volume of recharge from basin underflow (Garabedian, 1986) by the average solute concentration of ground water in each of the tributary drainage basins (table 20A).

Solute loads from weathering of the aquifer framework and human activities were calculated by subtracting individual input solute loads (col. 2 through 5, table 7) from the total output load at King Hill (col. 1, table 7). Percentage values in column 7, table 7, represent the difference between total input and output loads divided by the sum of input and output loads. These calculations suggest that about 20 percent of all solutes leaving the plain are generated within the aquifer.

The effects of human activities on solute loads are difficult to quantify in this system; however, some reasonable estimates can be made. Irrigation would have little effect on major solute loads because the irrigation water is taken from within the basin. The total solute balance would be affected only if irrigation water added or removed solutes. Fertilizers, herbicides, pesticides, and soil conditioners are added to irrigated lands, but other than the possible addition of potassium in fertilizers, these chemical additions probably would not affect the major solutes considered in this study.

The average annual effluent discharges from six of the largest municipalities on the eastern plain are listed in table 8. Although the number of chemical analyses of sewage effluent is small, sewage-load calculation suggests that only about 5 percent of the observed increases in the sodium and chloride loads (rows 3 and 6, col. 7, table 7) is contributed by sewage. Table 8 also shows annual loads contributed by application of sodium chloride for deicing highways. All the applied sodium chloride is assumed to enter the ground water or reach the Snake River as storm run-off. The road salt load is about 1 percent of the observed increases in sodium and chloride loads in the solute balance. This contribution to sodium and chloride loads appears to be approximately 5–6 percent of the total observed load increase.

TABLE 6.—*Discharge-weighted mean solute concentrations in the Snake River and its tributaries, 1960–82*

[Solute concentrations in milligrams per liter]

| Station No. | Name | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | $SiO_2$ | TDS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Eastern Snake River Basin | | | | | | |
| 13037500 | Snake River near Heise | 44 | 11 | 9.0 | 1.8 | 160 | 11 | 41 | 8.7 | 204 |
| 13050500 | Henrys Fork | 11 | 3.1 | 11 | 2.0 | 63 | 3.7 | 3.5 | 28 | 99 |
| 13055000 | Teton River | 32 | 9.0 | 3.5 | 1.5 | 150 | 1.9 | 5.7 | 13 | 142 |
| 13058000 | Willow Creek | 53 | 14 | 12 | 2.2 | 220 | 16 | 16 | 13 | 238 |
| 13068500 | Blackfoot River | 48 | 14 | 11 | 2.9 | 190 | 9.8 | 28 | 14 | 225 |
| 13075500 | Portneuf River | 60 | 25 | 27 | 7.5 | 290 | 31 | 34 | 22 | 348 |
| 13076200 | Bannock Creek | 53 | 17 | 24 | 8.0 | 220 | 39 | 20 | 20 | 292 |
| 13077650 | Rock Creek | 48 | 16 | 14 | 11 | 210 | 23 | 11 | 22 | 257 |
| 13078000 | Raft River | 72 | 17 | 70 | 8.6 | 240 | 115 | 46 | 29 | 416 |
| 13082500 | Goose Creek | 36 | 7.0 | 13 | 5.5 | 140 | 13 | 14 | 35 | 195 |
| 13083000 | Trapper Creek | 28 | 3.4 | 6.1 | 3.5 | 100 | 5.3 | 9.1 | 31 | 136 |
| 13093095 | Rock Creek | 69 | 26 | 48 | 5.2 | 280 | 36 | 107 | 37 | 484 |
| 13108150 | Salmon Falls Creek | 69 | 24 | 56 | 8.6 | 250 | 43 | 122 | 39 | 483 |
| 13112000 | Camas Creek | 19 | 4.4 | 3.6 | 2.1 | 84 | 1.5 | 3.6 | 20 | 98 |
| 13113000 | Beaver Creek | 60 | 15 | 11 | 1.4 | 259 | 7.8 | 6.3 | 15 | 245 |
| 13116000 | Medicine Lodge Creek | 65 | 18 | 8.8 | 3.1 | 240 | 6.8 | 52 | 19 | 281 |
| 13117030 | Birch Creek | 43 | 15 | 5.6 | 1.1 | 180 | 4.7 | 29 | 11 | 200 |
| 13119000 | Little Lost River | 35 | 13 | 7.1 | 1.3 | 160 | 7.2 | 14 | 13 | 169 |
| 13127000 | Big Lost River | 35 | 9.0 | 5.0 | 1.3 | 140 | 3.1 | 14 | 11 | 148 |
| 13141000 | Big Wood River | 33 | 6.6 | 3.3 | 1.0 | 120 | 1.4 | 13 | 13 | 134 |
| 13141500 | Camas Creek | 15 | 3.1 | 6.7 | 1.7 | 67 | 2.1 | 5.6 | 17 | 87 |
| 13148500 | Little Wood River | 25 | 7.1 | 4.2 | 1.3 | 100 | 2.6 | 11 | 13 | 115 |
| 13150450 | Silver Creek | 58 | 14 | 5.3 | 1.7 | 230 | 2.5 | 18 | 14 | 231 |
| 13154500 | Snake River at King Hill | 46 | 19 | 27 | 4.5 | 220 | 24 | 47 | 27 | 302 |
| | | | | Western Snake River Basin | | | | | | |
| 13168500 | Bruneau River | 12 | 2.0 | 8.7 | 3.0 | 58 | 2.9 | 6.3 | 25 | 89 |
| 13181000 | Owyhee River | 8.8 | 1.9 | 9.2 | 2.3 | 46 | 2.4 | 7.6 | 20 | 77 |
| 13202000 | Boise River | 9.4 | 1.2 | 3.7 | .8 | 39 | .5 | 3.0 | 12 | 52 |
| 13240000 | Malheur River[1] | 71 | 28 | 231 | 12 | 450 | 61 | 339 | 42 | 1,030 |
| 13266000 | Weiser River | 8.6 | 3.4 | 4.5 | 1.7 | 49 | 1.6 | 3.1 | 26 | 75 |
| 13269000 | Snake River at Weiser | 36 | 14 | 33 | 4.3 | 170 | 19 | 50 | 24 | 268 |

[1] Laird (1964, p. D39).

Loads given in table 7 should be considered approximate because the cumulative error for each solute load source may be large relative to the net gain or loss from weathering or human activities. Also, the error associated with solute loads from precipitation and underflow cannot be estimated because the solute concentrations are based on numerical averages, not weighted averages. However, if the errors are assumed to be compensating and if the loads reasonably approximate the solute balance of the eastern plain, several geochemical observations can be made. The percentage of calcium contributed by weathering and human activities (row 1, col. 7, table 7) indicates that more calcium in solution is entering the aquifer system than is leaving. Calcite precipitation is widely observed on rock surfaces, in sediment interbeds, and as vesicle fillings in basalt. Also, irrigation water would be expected to precipitate calcite because of evaporation and transpiration. Possible calcite precipitation is also implied by the small increase of bicarbonate (row 5, col. 7, table 7) relative to other solutes. Thus, solute balance and geologic observation suggest that calcite precipitation is a probable reaction.

Use of solute balance to evaluate probable reactions in the eastern plain aquifer system requires that the solute system not vary significantly with time (steady state) or that the variation with time is known. It is difficult to establish whether solute reactions are in steady state because of the lack of long-term records of solute concentrations. In this hydrologic system with large ground-water flux, the assumption of steady-state solute reactions normally could be made with minimal error. However, extensive application of irrigation water may have altered the system with time. Thus, the potential exists for alteration of solute concentrations in the aquifer.

Several factors, however, suggest that the system may either have attained a new steady state reflecting the

TABLE 7.—*Average annual solute balance of the eastern Snake River Plain*

[Solutes in thousands of megagrams per year; (±%), percentage error]

| | Solute | (1) Output solute load Snake River at King Hill | = (2) Input solute load Snake River near Heise | + (3) Input solute load tributary drainage basins | + (4) Input solute load precipitation | + (5) Input solute load underflow | ± (6) Solute load weathering and human activities | (7) Percent difference input to output load |
|---|---|---|---|---|---|---|---|---|
| (1) | Ca | 453 (±4%) | 294 (±9%) | 156 (±13%) | 6 | 56 | -59 | -6 |
| (2) | Mg | 185 (±9%) | 72 (±12%) | 45 (±7%) | 2 | 19 | 47 | 15 |
| (3) | Na | 305 (±12%) | 63 (±18%) | 59 (±35%) | 5 | 24 | 154 | 34 |
| (4) | K | 45 (±9%) | 11 (±50%) | 12 (±20%) | 3 | 4 | 15 | 20 |
| (5) | $HCO_3$ | 2,064 (±8%) | 986 (±9%) | 680 (±12%) | 7 | 253 | 138 | 4 |
| (6) | Cl | 250 (±8%) | 59 (±30%) | 42 (±19%) | 6 | 21 | 122 | 32 |
| (7) | $SO_4$ | 510 (±5%) | 256 (±23%) | 83 (±23%) | 13 | 27 | 131 | 15 |
| (8) | $SiO_2$ | 281 (±14%) | 54 (±23%) | 101 (±12%) | 1 | 35 | 90 | 19 |

input of irrigation water or may not have been significantly affected by recharge of irrigation water. The 100-year history of irrigation would allow attainment of chemical steady state. Rapid ground-water velocity of 2–4 m/d (Garabedian, 1986) and the large values of hydrodynamic dispersion in the aquifer (Robertson, 1974, p. 18) contribute significantly to rapid dilution of any induced solute, making it difficult to identify changes due to irrigation. The 5.6 billion $m^3$ of water recharged annually to the eastern plain by application of surface water for irrigation is a small fraction of the estimated 1,200 billion $m^3$ of water in storage (Barraclough and others, 1982, p. 3) and thus is not likely to have affected the aquifer on a regional scale. Table 9 shows that average solute concentrations in the Snake River at Heise, which is typical of irrigation water in the eastern plain, and in ground water from the eastern plain are similar.

In localized areas, such as at the radioactive and toxic waste disposal sites at the INEL facility (Robertson, 1974) and where irrigation drain wells have significantly altered solute concentrations (Seitz and others, 1977; Graham, 1979), the aquifer may not be in steady state. However, these areas are small and have not been included in the calculations; thus, the eastern plain aquifer is assumed to be essentially in steady state with respect to solute reactions.

The percentage increase of sodium and chloride (rows 3 and 6, col. 7, table 7), even if adjusted for the effects of human activities, is much higher than the other major solutes. Because there is no evidence of sodium chloride minerals in the eastern plain aquifer system, these data suggest that sodium and chloride may be derived from flushing of grain boundaries and pores of the detrital marine sediments in the interbeds. In the geologically young eastern plain aquifer system, fluid inclusions also may contribute sodium and chloride to ground water.

## WEATHERING REACTIONS CONTROLLING SOLUTE GEOCHEMISTRY, EASTERN SNAKE RIVER PLAIN

A series of reactions were developed, using the solute balance derived in table 9, to aid and constrain potential reactions controlling sources and sinks of solutes in the eastern plain aquifer system (table 10). Appropriate reaction equations were selected on the basis of observed mineralogy and literature dealing with similar problems of identifying reactions (Bricker and others, 1968; Cleaves and others, 1970; Kennedy, 1971; Reynolds, 1971; Reynolds and Johnson, 1972; Norton, 1974; Kennedy and Malcolm, 1977; Likens and others, 1977; and Miller and Drever, 1977).

Solutes entering the eastern plain (row 1, table 10) are the sum of all input loads (col. 2 through 5, table 7). Solutes leaving (row 10, table 9) are from column 1, table 7. Proposed reactions in rows 2 through 9, table 10, satisfy the calculated solute loads in column 6, table 7.

TABLE 8.—*Average annual effluent discharges to the Snake River from major municipal sewage-treatment plants upstream from King Hill and average annual road deicing salt application on the eastern Snake River Plain*

[STP, sewage-treatment plant; mean discharge in millions of cubic meters per year; solute concentrations in milligrams per liter; solute load in thousands of megagrams per year]

| Load source or STP | Mean discharge | Solute concentration in sewage effluent | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | $SiO_2$ |
| Rexburg[1] | 1.5 | 65 | 31 | 180 | 18 | 310 | 220 | 113 | 30 |
| Idaho Falls[2] | 10.5 | 67 | 20 | 170 | 10 | 270 | 220 | 64 | 26 |
| Blackfoot[1] | 1.4 | 65 | 31 | 180 | 18 | 310 | 220 | 113 | 30 |
| Pocatello[3] | 8.3 | 64 | 33 | 158 | 18 | 275 | 264 | 123 | 26 |
| Burley[1] | 1.5 | 65 | 31 | 180 | 18 | 310 | 220 | 113 | 30 |
| Twin Falls[2] | 6.5 | 67 | 32 | 210 | 30 | 475 | 250 | 120 | 50 |

| Load source or STP | Solute load | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | $SiO_2$ |
| Rexburg[1] | 0.1 | 0.05 | 0.3 | 0.03 | 0.5 | 0.3 | 0.2 | 0.5 |
| Idaho Falls[2] | .7 | .2 | 1.8 | .1 | 2.8 | 2.3 | .7 | .3 |
| Blackfoot[1] | .09 | .04 | .2 | .02 | .4 | .3 | .2 | .04 |
| Pocatello[3] | .5 | .3 | 1.3 | .01 | 2.3 | 2.2 | 1.0 | .2 |
| Burley[1] | .1 | .05 | .3 | .03 | .5 | .3 | .2 | .05 |
| Twin Falls[2] | .4 | .2 | 1.4 | .2 | 3.1 | 1.6 | .8 | .3 |
| Road salt | - | - | .8 | - | - | 1.2 | - | - |
| Total loads | 1.89 | 0.84 | 6.1 | 0.39 | 9.6 | 8.2 | 3.1 | 1.39 |

[1] Concentrations based on samples from Idaho Falls, Pocatello, and Twin Falls STP.

[2] Concentrations based on one sample.

[3] Concentrations based on four monthly composite samples.

In general, sodium and chloride (row 2, table 10) were added to the amount of total observed solutes entering the eastern plain aquifer system (row 1) to equal the amount observed leaving (row 10). Weathering of olivine added magnesium, silica, and bicarbonate ions (row 3). Weathering of labradorite added calcium, sodium, and bicarbonate ions (row 4). Pyroxene weathering added calcium, magnesium, bicarbonate, and silica (row 5). Anhydrite weathering added sulfate and calcium (row 6). Pyrite oxidation added sulfate and hydrogen (row 7). Finally, calcite and silica were precipitated to achieve calcium and silica balance (rows 8 and 9). The computer program BALANCE (Parkhurst and others, 1982) was used to make computations in table 10.

Several assumptions and operational decisions were made in developing reaction equations shown in table 10:

1. All chloride and an equivalent amount of sodium were assumed to be derived from fluid inclusions, flushing of grain boundaries and pores of detrital marine sediment, and human activities.

TABLE 9.—*Comparison of mean solute concentrations in ground water from the eastern Snake River Plain with those in the Snake River at Heise*

[Solutes in milligrams per liter; ground water from eastern Snake River Plain, 424 analyses; Snake River at Heise, 109 analyses (discharge-weighted mean)]

| Source | Solute | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | $SiO_2$ |
| Ground water | 51 | 18 | 26 | 4.0 | 220 | 28 | 41 | 31 |
| Snake River | 44 | 11 | 9.0 | 1.8 | 160 | 11 | 41 | 8.7 |

2. All aluminum and iron released by mineral breakdown remain fixed in secondary clay minerals and oxyhydroxides.

3. Sulfur-isotope ratios ($\delta^{34}S$) of dissolved sulfate were

TABLE 10.—*Weathering reactions controlling solute chemistry in the eastern Snake River Plain aquifer system*

[Solutes in $10^9$ moles per year; negative values indicate precipitation]

| | Proposed reactions | Ca | Mg | Na | $HCO_3$ | Cl | $SO_4$ | $H_4SiO_4$ |
|---|---|---|---|---|---|---|---|---|
| (1) | Total observed solutes entering the aquifer (col. 2-6, table 7) | 12.78 | 5.67 | 6.57 | 31.57 | 3.60 | 3.94 | 5.09 |
| (2) | Addition of NaCl from fluid inclusions, detrital marine sediments, and man's activities<br>$2.80NaCl = 2.80Na^{+} + 2.80Cl^{-}$ | - | - | 2.80 | - | 2.80 | - | - |
| (3) | Dissolution of olivine<br>$1.72(Mg_{.43}Fe_{.57})_2SiO_4 + 3.44CO_2 + 5.16H_2O =$<br>$1.48Mg^{+2} + 1.96Fe^{+2} + 3.44HCO_3^{-} + 1.72H_4SiO_4$ | - | 1.48 | - | 3.44 | - | - | 1.72 |
| (4) | Weathering of plagioclase to smectite<br>$5.36(Ca_{.5}Na_{.5}Al_{.5}Si_{2.5}O_8) + 4.79CO_2 + 5.83H_2O =$<br>$1.72[Ca_{.33}Al_{4.67}Si_{7.34}O_{20}(OH)_4] + 2.68Na^{+} + 2.11Ca^{+2} +$<br>$4.79HCO_3^{-} + 0.77H_4SiO_4$ | 2.11 | - | 2.68 | 4.79 | - | - | .77 |
| (5) | Dissolution of pyroxene<br>$1.18(Ca_{.34}Mg_{.39}Fe_{.27})Si_2O_6 + 1.18CO_2 + 5.31H_2O = 0.40Ca^{+2} +$<br>$0.46Mg^{+2} + 0.32Fe^{+2} + 1.18HCO_3^{-} + 2.36H_4SiO_4$ | .40 | .46 | - | 1.18 | - | - | 2.36 |
| (6) | Dissolution of detrital anhydrite<br>$0.89CaSO_4 = 0.89Ca^{+2} + 0.89SO_4^{-2}$ | .89 | - | - | - | - | .89 | - |
| (7) | Oxidation of pyrite<br>$0.24FeS_2 + 0.60H_2O + 0.84O_2 = 0.48SO_4^{-2} + 0.96H^{+} + 0.24FeO(OH)$ | - | - | - | - | - | .48 | - |
| (8) | Precipitation of calcite<br>$4.88Ca^{+2} + 9.76HCO_3^{-} = 4.88CaCO_3 + 4.88CO_2 + 4.88H_2O$ | -4.88 | - | - | -9.76 | - | - | - |
| (9) | Precipitation of silica<br>$2.64SiO_2 + 5.28H_2O = 2.64H_4SiO_4$ | - | - | - | - | - | - | -2.64 |
| (10) | Total observed solutes leaving the aquifer (col. 1, table 7) | 11.30 | 7.61 | 12.05 | 33.83 | 6.40 | 5.31 | 7.48 |

used to determine the weathering ratio of pyrite to anhydrite.

4. All errors from rounding reactions are included in the oxygen term of the equations.

5. Carbon dioxide from soil gas reacts in this open system to form bicarbonate in the amount needed for silicate weathering.

6. Chemically well-defined minerals were used in table 10, although it was recognized that volcanic glass may have contributed solutes to the system.

For most multimineral aquifer frameworks, it is difficult to write a unique set of weathering reactions. That is, more than one geologically reasonable set of reactions can satisfy the solute balance. In table 10, this situation occurs in assigning the distribution of magnesium between olivine and pyroxene. Mass balance may be satisfied by weathering only olivine, only pyroxene, or any ratio of the two minerals. In table 10, relative contributions were based on the relative amount of weathering observed in thin sections (40 percent of olivine and 5 percent of pyroxene showed some indication of weathering) after adjusting for mole percent magnesium in the minerals and percentage of each mineral present in the rock (see section entitled "Petrography and Mineralogy of the Aquifer

Framework"). This approach suggested that about 76 percent of magnesium came from olivine and 24 percent from pyroxene. The relative solubility of the two minerals (Plummer and others, 1976) and their kinetic reactions (Luce and others, 1972) are consistent with the above calculations, indicating that olivine weathers faster than pyroxene.

Several thin sections showed numerous fluid inclusions in the feldspars. To gain information on solutes in fluid inclusions and on grain boundaries, several leaching tests were conducted. In these experiments, three 50-g samples of finely ground, oven-dried, fresh flowtop vesicular basalt and three similarly prepared samples of unweathered Paleozoic limestone (assumed to be representative of interbed material) were dissolved with a known volume of reagent-grade nitric acid in separate covered polyethylene bottles. The olivine basalt averaged 0.22 mg/L chloride per gram of rock and less than 0.01 mg/L sulfate per gram of rock. The Paleozoic limestone averaged 0.07 mg/L chloride and 4 mg/L sulfate.

Because the aquifer system is open to the atmospheric and soil carbon dioxide, carbonic acid weathering reactions were chosen rather than mineral acid or hydrolysis. Justification for this choice is provided by analysis of 19 representative ground-water samples (fig. 19), which plot near the line for weathering of alkaline earths by carbonic acid,

$$CO_2 + H_2O + CaCO_3 \rightleftharpoons Ca^{+2} + 2HCO_3^- \quad (2)$$

rather than weathering by mineral acids,

$$CaCO_3 + H^+ \rightleftharpoons Ca^{+2} + HCO_3^- \quad (3)$$

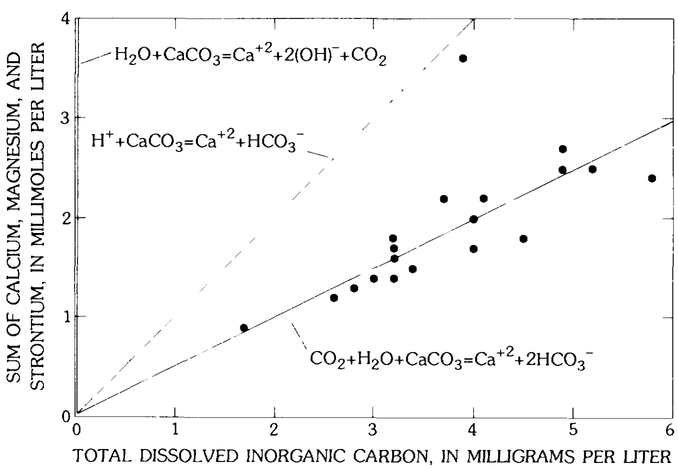



FIGURE 19.—Sum of calcium, magnesium, and strontium versus total dissolved carbon for ground-water samples from eastern Snake River Plain.

or by hydrolysis

$$CaCO_3 + H_2O \rightleftharpoons Ca^{+2} + CO_2 + 2(OH)^- \quad (4)$$

Reactions proposed in table 10 are not unique. Other reactions could yield the same solute content. Isotopes, thermodynamics, and mineralogic arguments provide further constraints on these proposed reactions.

## VERIFICATION OF PROPOSED WEATHERING REACTIONS, EASTERN SNAKE RIVER PLAIN

The suitability of proposed weathering reactions was tested by comparing calculated and observed values of carbon and sulfur isotopes and the thermodynamics of proposed reactions between the aquifer framework and solutes. If the isotope comparisons and mineral-solution equilibrium observations are reasonable and consistent with the calculated solute mass balance, it can be reasonably assumed that the proposed weathering reactions are suitable.

### CARBON AND SULFUR ISOTOPES

Bicarbonate in water recharging the aquifer from tributary drainage basins has an average load-weighted $\delta^{13}C$ value of −9.5 permil (table 11) relative to the isotope standard PDB. The mass and isotopic values of the Snake River and tributaries south of the Snake River (fig. 1) are not included in the calculation given in table 11 because they are believed to have little effect on the regional geochemistry of the eastern plain aquifer system. That is, the Snake River acts as a regional drain and thus contributes few solutes to the aquifer. Because the Snake River acts as a regional drain, streams entering from the south or southeast near the border of the plain do not contribute water or solutes to the main part of the aquifer and thus are not included in the weighted averages.

The average $\delta^{13}C$ of 21 samples of ground water, which is assumed to represent output from the system, is −11.1 permil (table 12). Therefore, the difference in $\delta^{13}C$ between the average bicarbonate recharged to the aquifer from tributary drainage basins (−9.5 permil) and the average bicarbonate in the aquifer (−11.1 permil) is assumed to represent reactions occurring in the aquifer.

The $\delta^{13}C$ of soil gas was measured on the eastern plain at INEL and averaged −14 permil (C.T. Rightmire, TRW, Inc., written commun., 1985). This value is in isotopic equilibrium with caliche forming in this arid area but is not believed to represent areas where significant recharge of carbonates is occurring; for example, much of the inorganic carbon in recharge water at INEL forms caliche and is removed from solution. Bicarbonate derived from weathering of silicates in the upland tributary drainage

TABLE 11.—*Solute load-weighted stable isotopes of carbon-13 in drainage basins tributary to the eastern Snake River Plain*

| Station No. | Name | $HCO_3$ (megagrams/yr) | Percent of total $HCO_3$ load | $\delta^{13}C$ (°/₀₀) | $\delta^{13}C$ weight factor | $SO_4$ (megagrams/yr) | Percent of total $SO_4$ load | $\delta^{34}S$ (°/₀₀) | $\delta^{34}S$ weight factor |
|---|---|---|---|---|---|---|---|---|---|
| 13056500 | Henrys Fork near St. Anthony | 100,860 | 45.6 | -9.4 | -4.29 | 5,867 | 29.0 | -1.2 | -0.35 |
| 13112000 | Camas Creek near Camas [1] | 3,399 | 1.4 | -11.2 | -.16 | 146 | .2 | 6.9 | +.01 |
| 13117030 | Birch Creek near Reno | 13,394 | 5.6 | -6.8 | -.38 | 2,182 | 11.0 | 8.2 | +.90 |
| 13119000 | Little Lost River near Howe [1] | 12,450 | 5.2 | -7.7 | -.40 | 1,104 | 5.0 | [2]1.4 | +.07 |
| 13127000 | Big Lost River near Mackay [1] | 45,681 | 18.9 | -10.9 | -2.06 | 4,876 | 25.0 | 4.4 | +1.10 |
| 13141000 | Big Wood River near Bellevue [1] | 40,007 | 16.6 | -9.4 | -1.56 | 4,041 | 20.0 | .9 | +.18 |
| 13148500 | Little Wood River near Carey | 16,371 | 6.8 | -9.5 | -.65 | 2,037 | 10.0 | -1.1 | -.11 |
| Solute load-weighted average isotope input from tributaries | | | | | -9.5 | | | | +2.0 |

[1] Isotope samples collected at different location on stream than chemical samples used for load computations.

[2] Ground-water sample from Little Lost River basin.

basins with much higher rainfall and consequent different mix of vegetation than exists at INEL suggests a $\delta^{13}C$ gas of approximately −22 permil. However, most of the solutes derived from weathering are believed to occur in areas receiving more recharge than INEL but less than the upland areas; thus, the $\delta^{13}C$ of soil gas is believed to be between −14 permil and −22 permil and was assumed to be approximately −18 permil.

As indicated in table 10, $9.41 \times 10^9$ moles of bicarbonate ($1.9 \times 10^9$ moles of carbon) enters the aquifer from weathering of silicates, and $1.9 \times 10^9$ moles of carbon is precipitated as calcite. Using equations developed by Wigley and others (1978, p. 1120) for one input, one output, and a fractionation factor between bicarbonate and calcite of 2 permil at 20 °C, a $\delta^{13}C$ value of water is calculated to be −10.8 permil. Because this value is within one standard deviation (1.38 permil) of the observed −11.1 permil, it is concluded that the proposed reactions in table 10 are consistent with the carbon isotopes in the system.

Sulfur isotopes were used to separate the relative contributions of sulfate shown in table 10. The only sources of sulfur assumed to be added to this aquifer system are oxidation of pyrite and dissolution of gypsum or anhydrite. Pyrite is observed as isolated grains and in massive vesicular filling in basalt of the Snake River Group. Gypsum or anhydrite exists as detrital grains and eolian dust in fluvial, lacustrine, and eolian interbed deposits. In this dilute and fully oxidized system, no sulfur species are believed to be reduced or to precipitate and, thus, do not affect isotope or solute balance calculations. The small amount of sulfur entering the system through atmospheric precipitation (table 9) is not considered significant.

The average $\delta^{34}S$ for the Snake River near Heise, which drains areas of Permian sulfate deposits, is about +14.9 permil (table 21C, back of report), whereas the $\delta^{34}S$ for the Boise River, which drains pyritized granite in the western Snake River basin, is −6.6 permil (table 21C). Pyrite from a vesicle in a sample of basalt of the Snake River Group in the eastern plain yielded a $\delta^{34}S$ of −8.9 permil. For load calculations, an intermediate $\delta^{34}S$ of −8.0 permil was used to represent the pyrite end member, and +15 permil was used for the anhydrite end member. The weighted average isotopic value of sulfate in the Snake River entering the aquifer system at Heise is +14.9 permil, whereas that leaving the system at King Hill is +13.2 permil. This difference of approximately 1.7 permil is assumed to reflect the contribution of various isotopic sources occurring within the aquifer. Simultaneous solution of linear solute balance and isotope equations using BALANCE (Parkhurst and others, 1982) suggests that approximately 65 percent of the sulfate added by weathering of the aquifer framework is derived from anhydrite; this value then was used to construct table 10.

## THERMODYNAMICS

Thermodynamic consideration is an additional constraint imposed on the reactions proposed between the aquifer system framework and solutes. If a mineral is postulated to be precipitating in a reaction (given in table 10), then the solutes must be at thermodynamic equilibrium or supersaturated with the mineral. Conversely, if a mineral is postulated to be dissolving, the solutes must be thermodynamically undersaturated.

The saturation indices (SI), log IAP/KT (logarithm of ion activity product/equilibrium constant) of water from six wells near the ground-water discharge area between Twin Falls and King Hill are listed in table 13. Solutes (table 20A, back of report) in water from these wells were

TABLE 12.—*Selected analyses of stable isotopes in the eastern Snake River Plain aquifer system*

[Isotopes in permil]

| Station No. | Location | Date | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ |
|---|---|---|---|---|---|---|
| 423758114294401 | 9S-17E-20BDB1 | 6- 4-81 | -129 | -16.4 | -11.7 | -0.8 |
| 423806114311601 | 9S-16E-24AAC1 | 6-23-81 | -128 | -16.3 | -12.2 | +7.3 |
| 424053114421001 | 8S-15E-33DCC1 | 6-23-81 | -135 | -17.4 | -9.8 | +4.5 |
| 424142114285601 | 8S-17E-32AAA1 | 6-25-81 | -132 | -16.9 | -11.9 | +2.3 |
| 424320114485701 | 8S-14E-21ABA2 | 6-23-81 | -136 | -17.9 | -10.7 | +11.2 |
| 424709113592601 | 7S-21E-28DAA1 | 6-24-81 | -139 | -17.9 | -10.1 | +7.2 |
| 424930114260001 | 7S-17E-14BAA1 | 6-25-81 | -136 | -17.6 | -9.0 | +10.3 |
| 424933114515701 | 7S-14E-18BAB1 | 6-25-81 | -135 | -17.8 | -11.0 | +9.6 |
| 424950114385501 | 7S-15E-12CAC1 | 12-22-81 | -136 | -18.3 | - | - |
| 425524114111001 | 6S-19E- 3CDC1 | 6-24-81 | -137 | -17.9 | -9.9 | +6.1 |
| 425619114211701 | 5S-18E-31DDD1 | 6-24-81 | -133 | -17.3 | -12.8 | +4.1 |
| 431857112405501 | 1S-32E-23CDA1 | 7- 8-81 | -136 | -18.0 | -10.6 | +11.6 |
| 431932113571501 | 1S-21E-22BCC1 | 6- 4-81 | -132 | -17.3 | -11.0 | +1.4 |
| 431952114164601 | 1S-18E-14DDC1 | 6- 3-81 | -139 | -18.2 | -11.1 | +1.0 |
| 433428111381601 | 3N-41E-23CAA1 | 6- 9-81 | -141 | -18.8 | -13.4 | +2.8 |
| 433517113190001 | 3N-26E-14DAA1 | 7- 7-81 | -134 | -17.4 | -11.9 | +13.4 |
| 433758113181701 | 4N-26E-36ACB1 | 6- 4-81 | -137 | -17.8 | -11.1 | +1.6 |
| 433852112165201 | 4N-36E-30CBB1 | 7- 8-81 | -133 | -17.7 | -11.8 | +15.3 |
| 434807111463601 | 6N-40E-32CBC1 | 6- 8-81 | -139 | -18.4 | -11.3 | +7.0 |
| 434940113005001 | 6N-29E-20DDD1 | 6- 5-81 | -140 | -18.3 | -10.9 | +1.8 |
| 440142112425501 | 8N-31E-14AAA1 | 6- 6-81 | -140 | -18.4 | -7.4 | +5.1 |
| 442335111532601 | 12N-39E- 5CCB1 | 6- 7-81 | -135 | -18.0 | -12.9 | -3.2 |
| Mean | | | -136 | -17.7 | -11.1 | +5.7 |
| Standard deviation | | | 3.5 | .6 | 1.4 | 4.9 |

TABLE 13.—*Mineral/water thermodynamic saturation indices of ground water from the major discharge area, eastern Snake River Plain*

[Chemical analyses given in table 20A indices in log IAP/KT (ion activity product/equilibrium constant)]

| Station No. | Location | Date | Albite | Anhydrite | Anorthite | Calcite | Diopside | Forsterite | Calcium smectite | Silica glass |
|---|---|---|---|---|---|---|---|---|---|---|
| 423758114294401 | 9S-17E-20BDB1 | 6-22-81 | -0.15 | -1.74 | -2.36 | 0.34 | -2.00 | -7.63 | 3.88 | 0.01 |
| 423806114311601 | 9S-16E-24AAC1 | 6-23-81 | -.03 | -2.19 | -2.61 | .44 | -2.03 | -7.55 | 3.56 | -.05 |
| 424053114421001 | 8S-15E-33DCC1 | 6-23-81 | -.42 | -2.67 | -2.72 | .15 | -2.50 | -7.97 | 3.61 | -.10 |
| 424320114485701 | 8S-14E-21ABA2 | 6-23-81 | -.61 | -2.61 | -2.92 | -.16 | -3.18 | -8.55 | 3.73 | -.10 |
| 424933114515701 | 7S-14E-18BAB1 | 6-25-81 | -.41 | -2.70 | -2.37 | -.20 | -3.15 | -8.47 | 4.33 | -.11 |
| 424950114385501 | 7S-15E-12CAC1 | 12-22-81 | -.69 | -2.91 | -2.91 | .07 | -1.75 | -7.17 | 3.09 | -.11 |

used to compute saturation indices for the reactions proposed in table 10, using the computer program WATEQF (Plummer and others, 1976). Because of uncertainty in the analytical values, particularly aluminum, and in the thermodynamic data base used to compute the saturation indices, the values expressed in table 13 should be viewed with some caution. However, a range of 0.5 saturation indices is believed to encompass the true value.

The saturation indices for calcite and silica glass in table 13 are near zero, which suggests the solutes are essentially in equilibrium with minerals in the aquifer framework. The observed calcite and silica precipitates support the proposal that these reactions control the concentrations of silica, calcium, and bicarbonate in ground water.

Precipitation of calcite is believed to be caused by both an increase in calcium from dissolution of the rock framework and the loss of $CO_2$ because of an increase in water temperature relative to its temperature at the time of recharge. Most recharge occurs in the spring and is associated with snowmelt and near-freezing rain. Where these waters are warmed by regional heat flow, $CO_2$ is lost and calcite is precipitated. The addition of calcium, causing supersaturation, occurs from weathering of silicates and dissolution of detrital anhydrite. Silica is believed to precipitate because of addition of $H_4SiO_4$ from weathering of volcanic glass and silicate minerals.

The secondary clay mineral calcium-smectite is thermodynamically supersaturated and thus is consistent with its proposed precipitation. An iron smectite, nontronite, has been observed, but thermodynamic data are unavailable to calculate its mineral saturation index. Calcium-smectite is assumed to be a surrogate mineral for the purpose of equilibrium calculation (table 13). In contrast, plagioclase feldspars, anhydrite, forsterite, and diopside are thermodynamically undersaturated and can dissolve. Although not listed in table 13, pyrite is undersaturated in this highly oxidizing aqueous environment and also can dissolve.

Aluminosilicate reactions (row 4, table 10) were written with calcium-smectite as the only clay mineral rather than a combination of calcium-smectite and kaolinite. Barshad (1966) suggested that basic igneous rocks with approximately 25 cm of atmospheric precipitation typically would yield 65 percent smectite, 30 percent kaolinite, and 5 percent vermiculite. No clearly authogenic kaolinite or vermiculite was observed in the few weathered samples that were evaluated. Justification for use of calcium-smectite as a weathering product of labradorite also was obtained from the data plotted in figure 20. (Thermodynamic data are from Drever, 1982, p. 185.) The mean of 424 solute samples from the aquifer falls within the calcium-smectite field, as do geographically representative samples from table 20A. The two samples that fall in the kaolinite field are from wells in the recharge zones of the aquifer and reflect solutes entering the aquifer rather than solutes that have established equilibrium with the aquifer framework. All samples from the discharge zone, as identified in table 13, plot in the calcium-smectite field.

Proposed reactions shown in table 10 are consistent with mineralogy, sulfur and carbon isotopes, mineral/water thermodynamics, solute balance, and hydrology of the eastern plain aquifer system. Within geochemical and hydrogeologic constraints, proposed reactions appear to be a reasonable geochemical equilibrium model of the major solute chemistry of the eastern plain aquifer system. Thus, the eastern plain aquifer system is not a simple mixing vessel but is undergoing active diagenesis (Wood and Low, 1986, p. 1460) and is both a source and a sink for solutes.

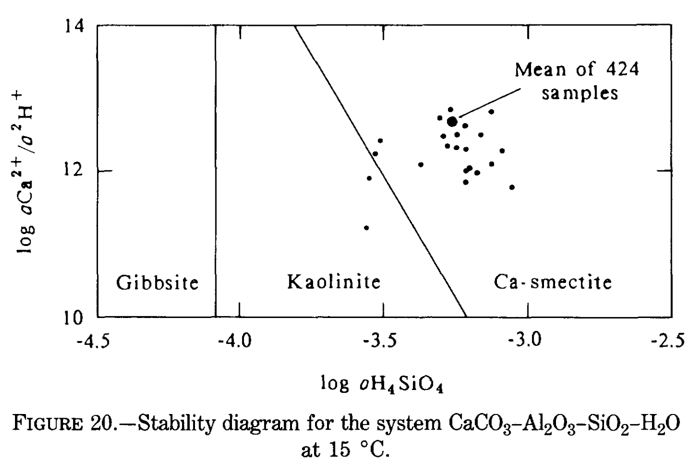



FIGURE 20.—Stability diagram for the system $CaCO_3$–$Al_2O_3$–$SiO_2$–$H_2O$ at 15 °C.

## SOLUTE BALANCE AND WEATHERING REACTIONS, WESTERN SNAKE RIVER PLAIN

The western plain is less well suited for a solute-balance study than the eastern plain because steady-state solute reactions are more difficult to establish and groundwater outlets are not well defined. Irrigation with surface water from two sources also causes difficulty in evaluating the solute balance. The northwestern half of the western plain is irrigated by water from the Boise and Payette Rivers, which are similar to each other in solute composition. The southeastern half of the western plain is irrigated largely by water from the Snake River, which is different in solute composition from the Boise and Payette Rivers (table 14).

Concentrations for several solutes in ground water from the northwestern and southeastern parts of the western plain lie between those of the two surface-water sources. Thus, it is difficult to determine whether solute concentrations in ground water have been affected by the two surface-water sources or whether the differences are natural. Sulfur isotopes from several samples (tables 20C and 21C) are of little aid in defining solute origin, as the $\delta^{34}S$ values of the ground water are generally between those of the two irrigation sources. None of the techniques that were successful in demonstrating solute steady state in the eastern plain are applicable. Thus, it cannot be proven from the data presently available that solute concentrations in the western plain are in steady state. However, if steady state is assumed, a solute balance can be calculated by the same methods used for the eastern plain. Several features of the average annual solute balance for the western plain (table 15) are similar to those observed for the eastern plain. The percent difference of individual solute load contributed by weathering and human activities between the Snake River at King Hill and Weiser (col. 6, table 15) is somewhat proportional to that calculated for the eastern plain (col. 7, table 7). The relatively small increase in calcium and decrease in bicarbonate relative to the other constituents indicate precipitation of caliche, as observed in the eastern plain. The net loss of silica from the solute phase indicates silicate and (or) silica precipitation.

TABLE 14.—*Comparison of mean solute concentrations in the western Snake River Plain aquifer system with those in the Snake and Boise Rivers*

[Solute concentrations in milligrams per liter]

| Source | Solute | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | $SiO_2$ |
| Ground water in the southeastern part of the western Snake River Plain[1] | 36 | 9.8 | 46 | 7.4 | 190 | 17 | 52 | 56 |
| Snake River at King Hill[2] | 46 | 19 | 27 | 4.5 | 220 | 24 | 47 | 27 |
| Ground water in the northwestern part of the western Snake River Plain[3] | 41 | 11 | 53 | 3.8 | 210 | 18 | 59 | 42 |
| Boise River near Boise[4] | 9.4 | 1.2 | 3.7 | .8 | 40 | .5 | 3.0 | 20 |

[1] 67 analyses

[2] 98 analyses (discharge-weighted mean)

[3] 136 analyses

[4] 41 analyses (discharge-weighted mean)

As in the eastern plain, a significant amount of solutes is obtained from weathering of the aquifer framework or from human activities. The relatively small percentage of changes observed in table 15 is a result of large inputs and outputs of this segment of the Snake River basin relative to the solutes contributed by weathering; however, the total load generated by weathering is large. Because no justification exists for assuming a solute steady state, no further geochemical analyses were attempted.

## MINOR AND TRACE SOLUTES

In addition to major solutes, which constitute about 95 percent of the total load, several minor solutes are present in concentrations of only a few milligrams per liter. A large number of solutes also are present in trace concentrations of a few micrograms per liter. Most naturally occurring solutes in the periodic table fall within this group of trace solutes; however, this discussion is limited to solutes in the Snake River Plain regional aquifer system that previously have been identified to be of environmental or economic concern.

Concentrations of minor and trace solutes in water from selected wells are given in table 20B. Table 16 lists the averages of several minor and trace solute concentrations in both ground water and the Snake River. Most minor and trace solutes in the Snake River Plain regional aquifer system are derived from the weathering of minerals from the aquifer framework. However, in some instances, human activities have introduced elements into solution. The concentration of a particular minor or trace solute in solution depends on a variety of factors, many of which are difficult to quantify in natural systems.

In general, in an environment that has similar oxidation potential, pH, alkalinity, sulfate, and temperature, solutes that increase in concentration with increasing dissolved solids usually are controlled by availability of the solute in the aquifer framework. Concentrations of lithium, strontium, and nitrite plus nitrate as nitrogen (figs. 21*A*-*C*) generally increase as dissolved solids increase and are assumed to be controlled largely by their availability in the aquifer framework. In contrast, the concentration of barium greater than 100 μg/L appears to be controlled by the formation of barite (fig. 22*A*), and fluoride concentration greater than about 3 mg/L, by the mineral fluorite (fig. 22*B*). The concentration of lead may be controlled by cerussite, as the plotted data shown in figure 22C appear to asymptotically approach an SI unit of zero. Saturation indices were calculated using WATEQ2 (Ball and others, 1979, 1980). Because of variables in analytical and thermodynamic values, an equilibrium confidence interval of $\pm 0.5$ SI units was assigned. Soluble phosphate is present in low concentrations relative to its concentration in the aquifer framework and probably is sorbed rapidly on iron hydroxide, rather than forming an insoluble inorganic compound or mineral (Hem, 1985, p. 128).

Several solutes given in table 20B, including beryllium, cadmium, chromium, cobalt, copper, molybdenum, and

TABLE 15.—*Average annual solute balance of the western Snake River Plain*

[Solutes in thousands of megagrams per year; (±%), percentage error]

| | Solute | (1) Output solute load Snake River at Weiser | = | (2) Input solute load Snake River at King Hill | + | (3) Input solute load tributary drainage basins | + | (4) Input solute load precipitation | ± | (5) Solute load from weathering and human activities | (6) Percent difference input to output load |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | Ca | 570 (±6%) | | 453 (±5%) | | 86 (±11%) | | 3 | | 28 | 2.5 |
| (2) | Mg | 214 (±10%) | | 185 (±9%) | | 21 (±14%) | | 1 | | 7 | 1.7 |
| (3) | Na | 478 (±10%) | | 305 (±12%) | | 112 (±6%) | | 2 | | 59 | 6.6 |
| (4) | K | 67 (±12%) | | 45 (±9%) | | 13 (±22%) | | 1 | | 8 | 6.4 |
| (5) | $HCO_3$ | 2,402 (±9%) | | 2,064 (±8%) | | 472 (±10%) | | 3 | | -137 | -2.8 |
| (6) | Cl | 310 (±10%) | | 250 (±9%) | | 27 (±18%) | | 3 | | 30 | 5.1 |
| (7) | $SO_4$ | 732 (±6%) | | 510 (±5%) | | 121 (±8%) | | 6 | | 95 | 6.9 |
| (8) | $SiO_2$ | 376 (±14%) | | 281 (±14%) | | 134 (±13%) | | 0 | | -39 | -4.9 |

TABLE 16.—*Minor and trace solute concentrations in ground water and in the Snake River*

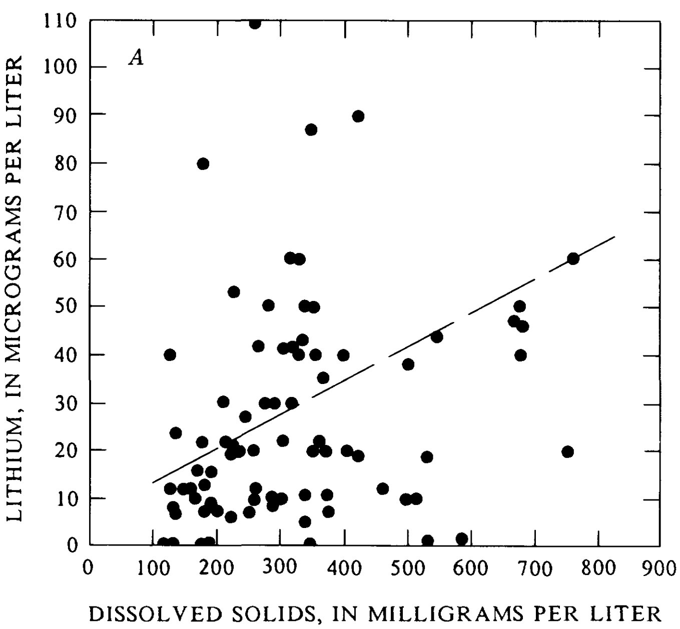
| Source | Minor solutes, in milligrams per liter (No. of samples) | | | Trace solutes, in micrograms per liter (No. of samples) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F | $NO_3$ | P | Al | Ba | Fe | Pb | Li | Mn | Sr | Zn |
| Ground water | | | | | | Mean | | | | | |
| Snake River Plain | 0.7 (627) | 1.5 (372) | 0.10 (364) | 13 (69) | 65 (23) | 41 (361) | 9 (127) | 36 (149) | 22 (200) | 254 (72) | 100 (122) |
| Eastern Snake River Plain | 0.6 (424) | 1.5 (197) | 0.10 (199) | 13 (66) | 69 (20) | 36 (253) | 8 (102) | 37 (53) | 12 (113) | 259 (69) | 108 (45) |
| Western Snake River Plain | 1.0 (203) | 1.5 (175) | 0.09 (165) | 10 (3) | 43 (43) | 55 (108) | 13 (25) | 36 (96) | 35 (87) | 140 (3) | 95 (77) |
| Surface water | | | | | | Range | | | | | |
| Snake River near Heise | 0.2-0.9 (135) | 0- 6.4 (152) | 0-0.36 (151) | 0- 20 (3) | 0-300 (31) | 0- 60 (30) | 0-19 (30) | 19-30 (3) | 0-40 (30) | 230-360 (3) | 0 (31) |
| Snake River at King Hill | 0.5-1.8 (146) | 0- 1.8 (112) | 0-0.95 (164) | 10-100 (4) | 0-400 (21) | 0- 50 (32) | 0-48 (33) | 0-40 (5) | 0-40 (32) | 230-430 (5) | 0 (34) |
| Snake River at Weiser | 0.1-0.7 (63) | 0.08-1.7 (61) | 0-0.54 (129) | 0-600 (10) | 0-400 (28) | 0-360 (39) | 0-26 (38) | 20-30 (2) | 0-50 (27) | 200-300 (7) | 0 (40) |

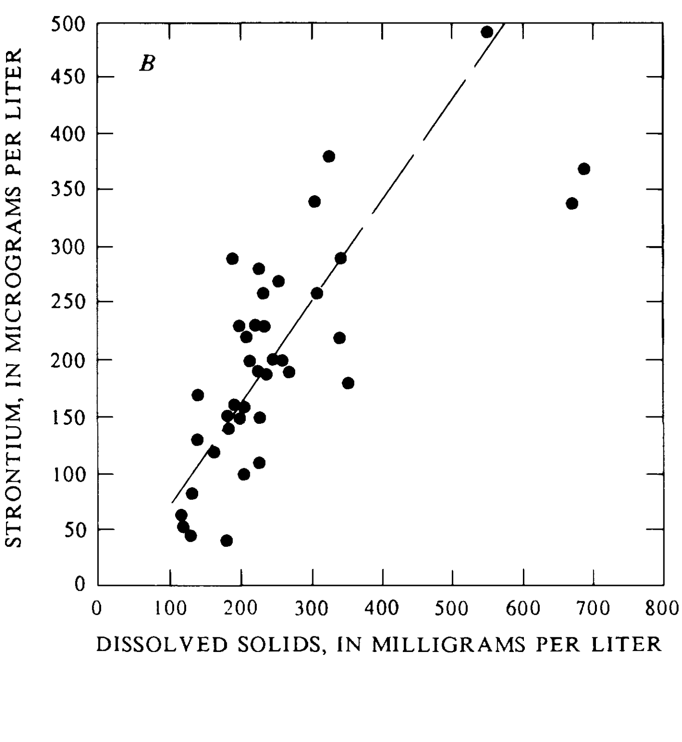
vanadium, are present in low concentrations near the level of detection. The concentration of these elements is significantly less than that of lithium, which has about the same abundances in igneous rocks of the area. The low concentrations of these solutes imply that a chemical mechanism, such as mineral precipitation or exchange, rather than availability in the aquifer framework, is controlling their concentrations. Cobalt probably is removed from solution by coprecipitation with iron and manganese oxide. Cobalt also forms an insoluble carbonate, $CoCO_3$, which may control its concentration in this alkaline ground water. Solutes forming insoluble oxides or hydroxides such as iron, manganese, beryllium, and copper might be expected to be present only in low concentrations in the fully oxidized alkaline water of the Snake River Plain regional aquifer system. Vanadium might be expected in concentrations above detection, but does not appear to increase with increasing dissolved-solids concentrations, which suggests that a chemical reaction is controlling its concentration.

#### EFFECTS OF IRRIGATION ON AQUEOUS CHEMISTRY

About 7.7 billion $m^3$ of surface water diverted for irrigation in excess of plant requirements recharges the Snake River Plain regional aquifer system annually (L.C. Kjelstrom, U.S. Geological Survey, written commun., 1984). After about 100 years of irrigation, it would seem probable that the hydrologic system has changed significantly. However, several studies of heavily irrigated areas have shown that irrigation has had little effect on the concentrations of major solutes (Dyer and Young, 1971; Dion, 1972; Seitz and others, 1977; and Parliman, 1983a, 1983b). The lack of change appears to be the result of two factors: (1) the solute concentrations in surface water used for irrigation, at least for the southeastern half of the western plain and the entire eastern plain, are nearly identical to those present naturally in the aquifer; and (2) the 5.6 billion $m^3$ of irrigation water recharged annually is small relative to the estimated 1,200 billion $m^3$ estimated to be present in the eastern plain aquifer system (Barraclough and others, 1982, p. 3). These factors, combined with rapid flow rate and natural variability of the ground-water chemistry, make increased solute concentrations resulting from irrigation difficult to identify.

Water samples were collected along ground-water flowpaths that intersect irrigated areas (fig. 23, table 20A–C) in an attempt to identify effects of irrigation on solutes. The assumption in this comparison is that solute concentrations and isotopic ratios of solutes in water along a flowpath will change gradually down the flowpath; thus, any significant deviation from this gradual change reflects



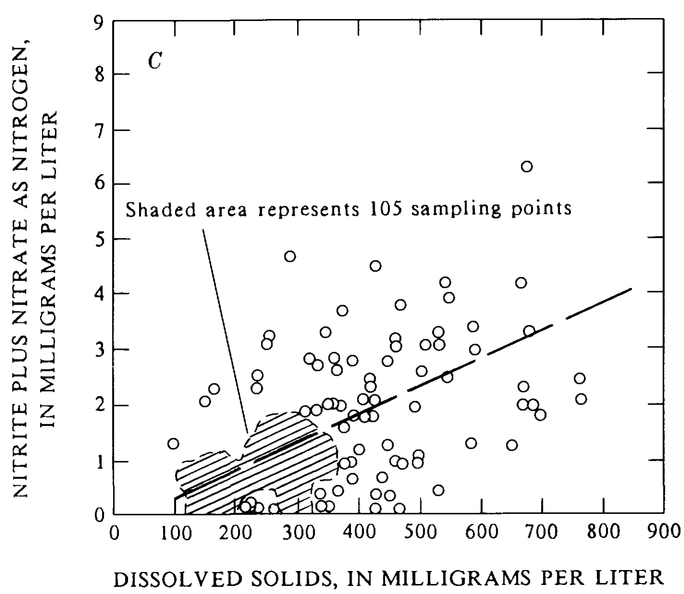
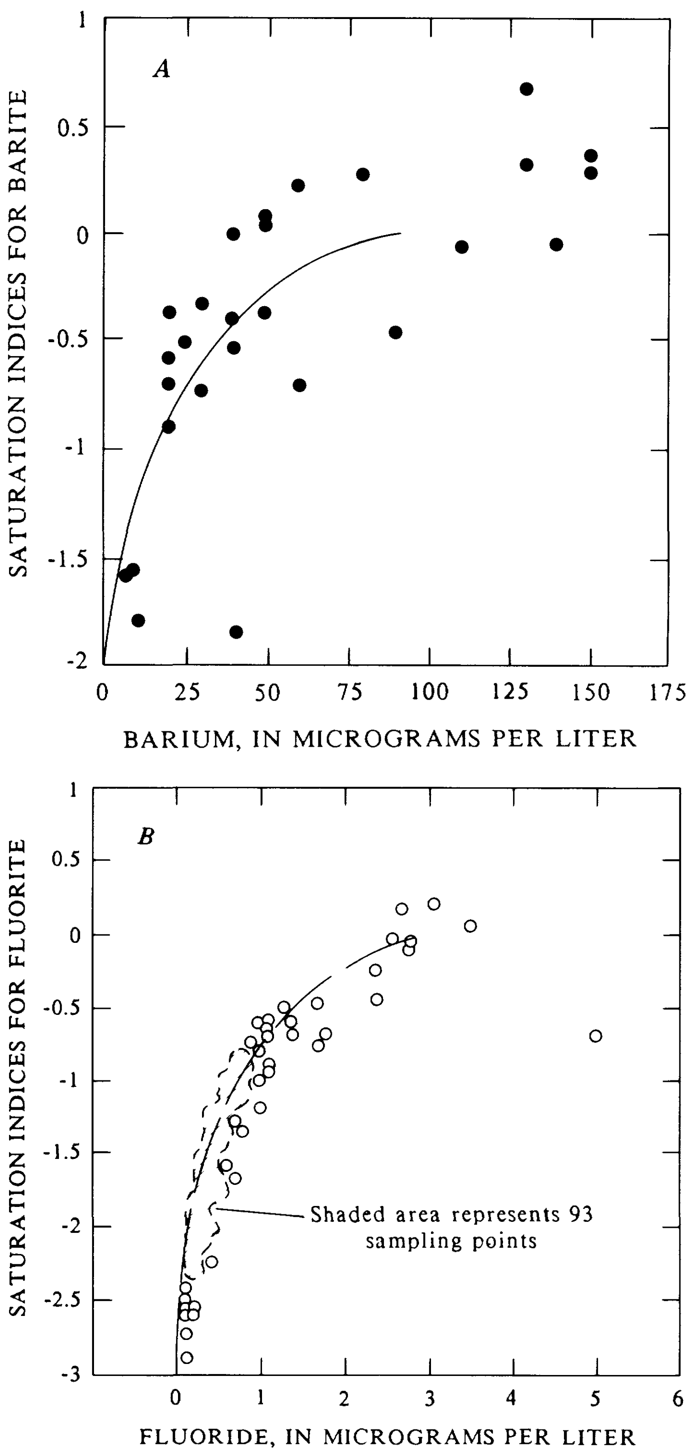




FIGURE 21.—Dissolved-solids concentrations versus (*A*) lithium, (*B*) strontium, and (*C*) nitrite plus nitrate as nitrogen. Dashed lines indicate solute concentrations controlled by air availability in the aquifer framework.

chemical stresses to the system. The three flowpaths (*A–A′*, *B–B′*, and *C–C′*), shown in figure 23, originate near recharge areas and pass through at least one major irrigated area. The longest, *C–C′* (278 km), is considered in detail because it includes several major irrigated areas.

The $\delta^2H$ and $\delta^{18}O$ profiles along flowpath *C–C′* (fig. 24*A*, *B*) suggest that water is isotopically heavier at the 42-, 254-, and 278-km sampling points than at the other points in the aquifer. The isotopically heavier water is assumed to result from irrigation water that has undergone evapotranspiration. The average $\delta^2H$ of 22 ground-water samples (table 12) from the eastern plain is −136 permil, with a standard deviation of 3.5 permil, and the average $\delta^{18}O$ of the same samples is −17.7 permil, with a standard deviation of 0.6 permil. These three sampling points along the flowpaths exhibit isotope values heavier than one standard deviation from the average value of ground water in the eastern plain. Three samples collected during different flow conditions from the Snake River at Heise, which is representative of irrigation water applied on the eastern plain, have an average $\delta^2H$ of about −134 permil and an average $\delta^{18}O$ of −18.1 permil. If these averages are representative of irrigation water applied on the eastern plain, then the observed values at the 42-, 254-, and 278-km sampling points are also isotopically heavier than those in the irrigation water. Thus, it appears that the water at the sampling points has been slightly enriched in heavy isotopes by undergoing evapotranspiration associated with irrigation.

The $\delta^{13}C$ data and bicarbonate and calcium concentrations (fig. 24*C–E*) are consistent with the irrigation recharge argument developed using $\delta^2H$ and $\delta^{18}O$. The abrupt rise of bicarbonate and calcium concentrations and the lighter value of $\delta^{13}C$ at the 42-, 254-, and 278-km sampling points may reflect an increase in carbon dioxide input from soil $CO_2$, which was previously estimated



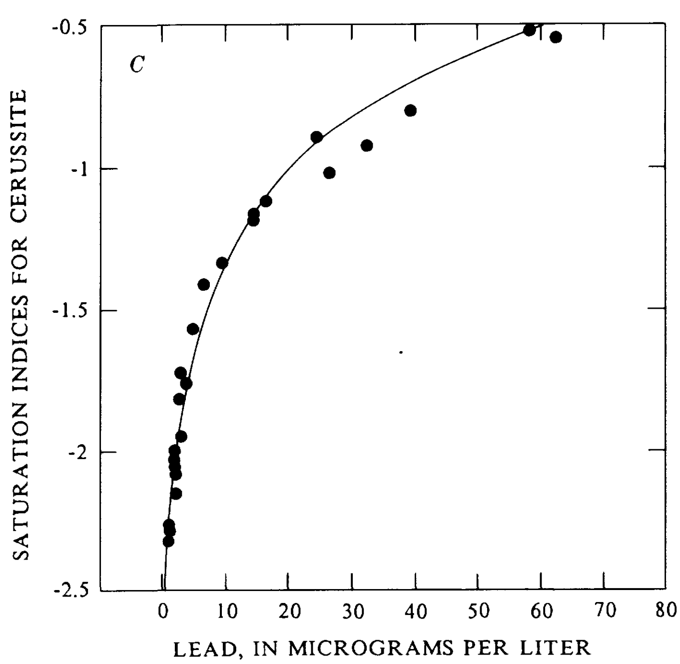




FIGURE 22.—*A*, Saturation indices for barite versus barium concentrations. *B*, Saturation indices for fluorite versus fluoride concentrations. *C*, Saturation indices for cerussite versus lead concentrations. Curved lines represent solute concentrations controlled by mineral/water equilibrium.

to have a $\delta^{13}C$ of about $-18$ permil in recharge areas of the eastern plain. The higher concentrations of bicarbonate and calcium result from soil $CO_2$ input to recharge water and subsequent dissolution of caliche near the surface. The $\delta^{13}C$ ratios and calcium concentrations are consistent with the hypothesis that samples from the 42-, 254-, and 278-km sampling points are affected by carbonate dissolution.

Several investigators, including Stearns and others (1938) and Norvitch and others (1969), determined that discharge from springs along the Snake River between Twin Falls and King Hill is affected by recharge from surface-water irrigation. However, even a conservative solute such as chloride introduced with irrigation recharge water will travel only at the velocity of ground water, whereas the pressure head caused by the recharging water will travel much faster. Movement of solutes and transmission of pressure head through an aquifer are controlled by different physical phenomena represented by different mathematical models. Pressure head is transmitted through an aquifer as a function of the rate of change of the head gradient with distance (the second derivative of head with respect to distance $d^2h/dx^2$), whereas a conservative solute is transported as a function of the head gradient (the first derivative of head with respect to distance $dh/dx$). The storage coefficient controls the speed of head change in the aquifer system but does not affect movement of solutes. Thus, an artesian aquifer with a low storage coefficient would transmit a change in head several orders of magnitude faster than a water-table aquifer, but solutes would move at the same rate in both aquifers if porosity, hydraulic conductivity, and gradient were equal.

A plot of specific conductance versus time at two sites (fig. 25) demonstrates the impact of irrigation recharge on the quality of ground water. Recharge by irrigation water would be expected to change the specific conductance of the ground water, depending on the specific con-

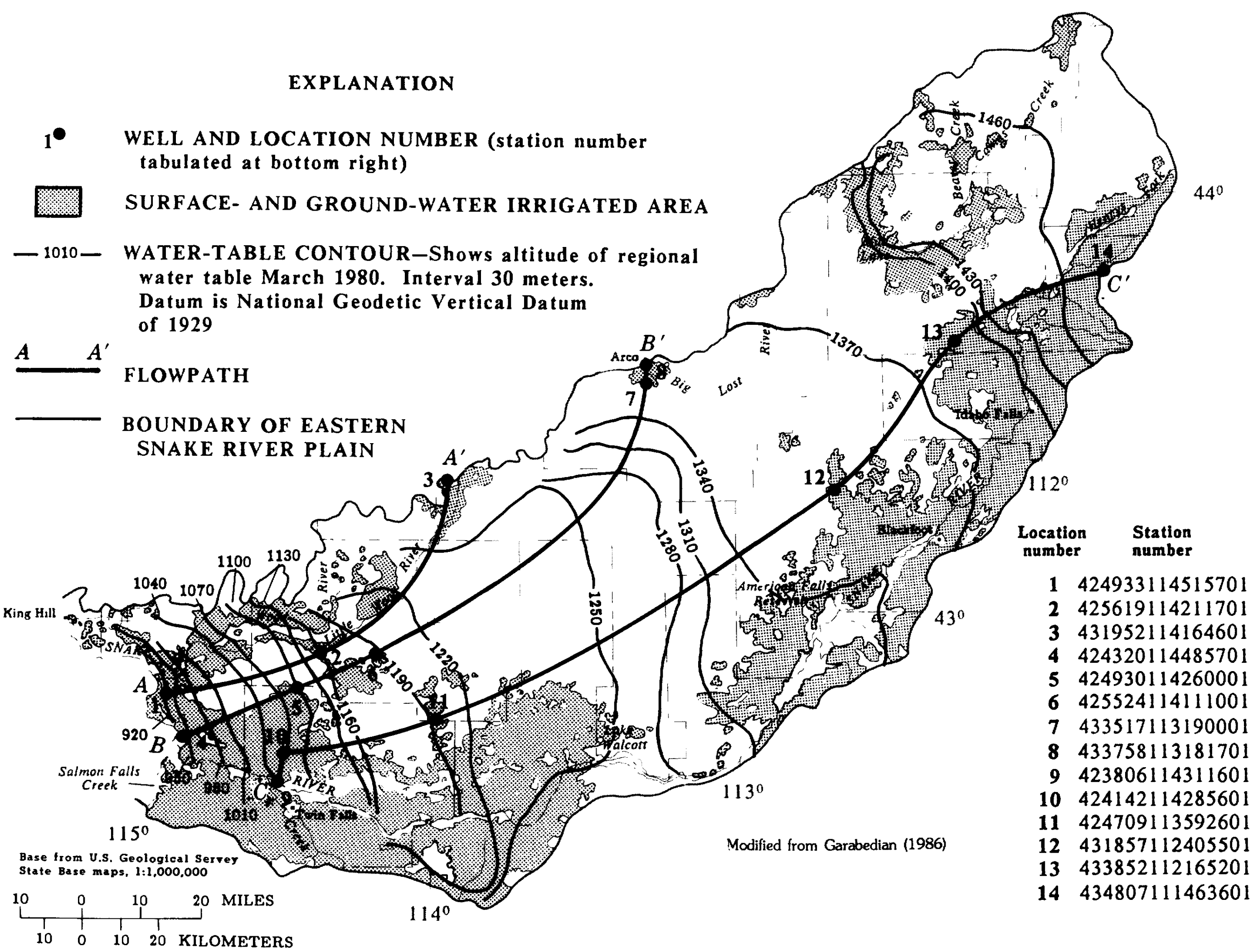
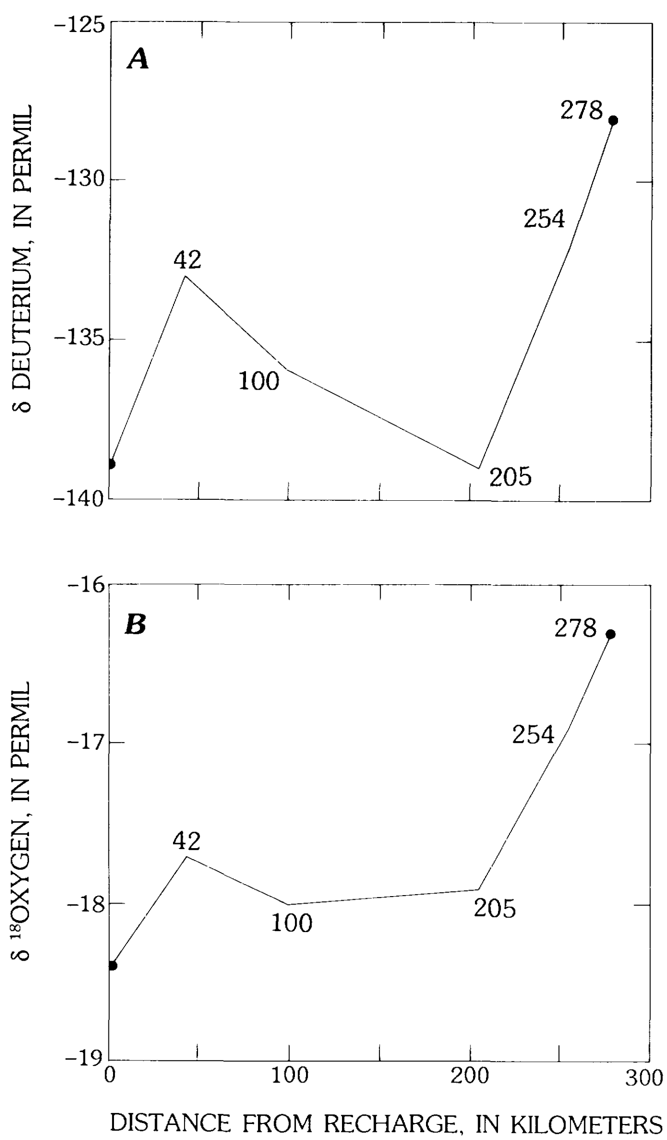



FIGURE 23.—Three ground-water flowpaths in eastern Snake River Plain superimposed upon irrigated areas.

ductance of the recharge water. Thus, as recharge water from irrigation reaches the springs, the conductance changes. Because irrigated areas are at different distances from the springs, multiple variations in conductance occur within a given year. Data from figure 25 indicate that the average specific conductance at Blue Lakes Spring has increased since 1953, probably because of irrigation recharge, whereas the average specific conductance at Box Canyon Spring appears to have remained constant over the period of record. However, analyses from Box Canyon Spring, as well as from Blue Lakes Spring, show greater variability after 1972, which indicates that irrigation recharge may be affecting both springs. A plot of chloride concentrations versus time at these same springs (fig. 26) indicates that solute concentrations have increased in Blue Lakes Spring since 1953



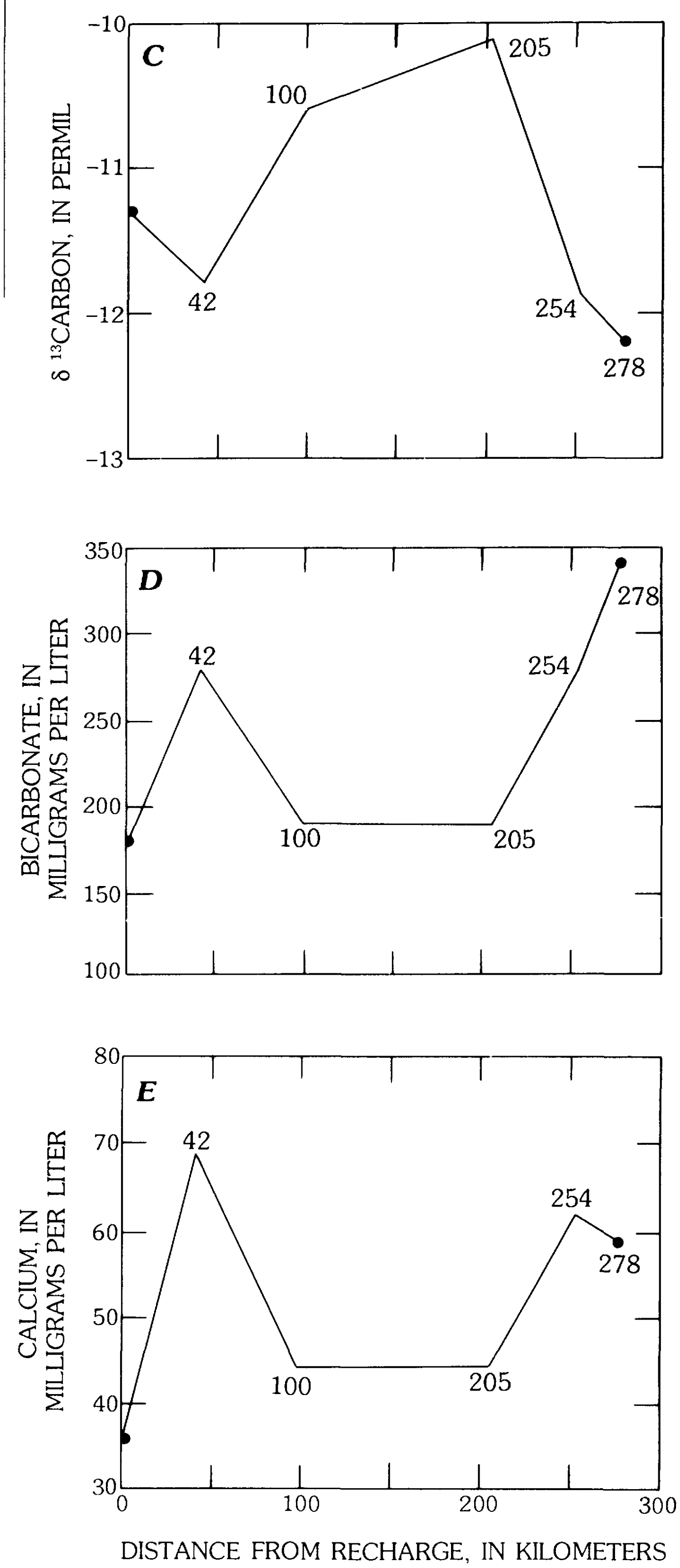




FIGURE 24.—Variations in (*A*) $\delta^2$H, (*B*) $\delta^{18}$O, (*C*) $\delta^{13}$C, (*D*) bicarbonate, and (*E*) calcium along ground-water flowpath *C-C'*. Numbers refer to sampling points at 42, 100, 205, 254, and 278 km along flowpath.

but have not changed at Box Canyon Spring. If this observation is correct, a lag time of about 40 years (1912–53) is indicated between the arrival of the pressure head and the arrival of a conservative solute at Blue Lakes Spring.

Hydrology of these two springs is somewhat different. Mundorff and others (1964) showed that ground-water flow to Blue Lakes Spring is from a small segment of the aquifer. Much of the discharge at Blue Lakes Spring is Snake River water which enters the aquifer a few miles upstream, whereas ground-water flow to Box Canyon Spring traverses much of the eastern plain. Furthermore, the amount of discharge from Box Canyon Spring is large relative to that from Blue Lakes Spring. If the same amount of irrigation water were available to recharge each spring, the effect would be much greater at Blue Lakes Spring than at Box Canyon Spring because of dilution factors. Mundorff and others (1964, p. 173, 174) showed that discharge from Blue Lakes Spring started to increase by 1912, whereas discharge at Box Canyon Spring did not increase until 1935.

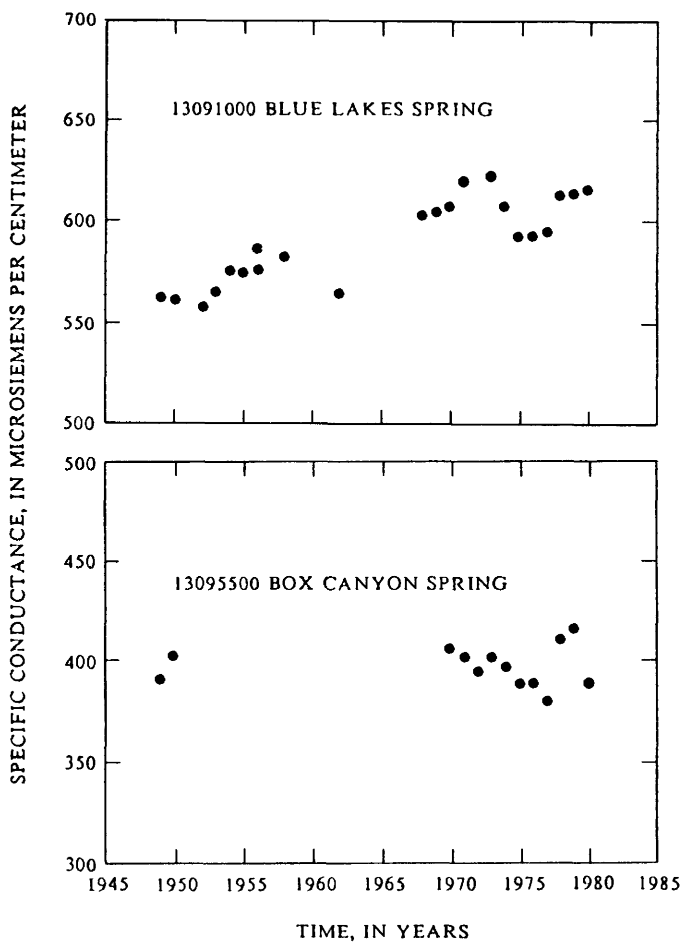



FIGURE 25.—Average annual specific conductance versus time at Blue Lakes and Box Canyon Springs.

Isotopic analyses of hydrogen and oxygen in water collected from the two springs in 1980 support the general thesis just outlined. The deuterium ratio in Blue Lakes Spring is −131 permil, compared with an average of −136.4 permil for ground water from the eastern plain (table 20C). The deuterium ratio in water from Box Canyon Spring is −137 permil, or near the average for ground water from the eastern plain. Ratios of $\delta^{18}O$ show similar correlation; samples from Blue Lakes and Box Canyon Springs are −17.2 permil and −18 permil respectively, compared with an average of −17.7 permil for ground water from the eastern plain. Hydrogen and oxygen isotope ratios at Box Canyon Spring are within one standard deviation of the average for ground water, whereas water from Blue Lakes Spring is isotopically heavier. The isotopically heavier Blue Lakes Spring water is believed to result from the mixing of ground water with irrigation water, some of which has undergone evapotranspiration. On the basis of isotopic analysis, mixing with irrigation water is not apparent in Box Canyon Spring.

## GEOCHEMISTRY OF GEOTHERMAL WATER IN THE SNAKE RIVER BASIN

Geothermal water is used for space heating, swimming pools, greenhouses, and irrigation in the Snake River basin. Geothermal water, generally defined as being naturally heated 10 °C or more above the mean annual air temperature and increasing with depth at least

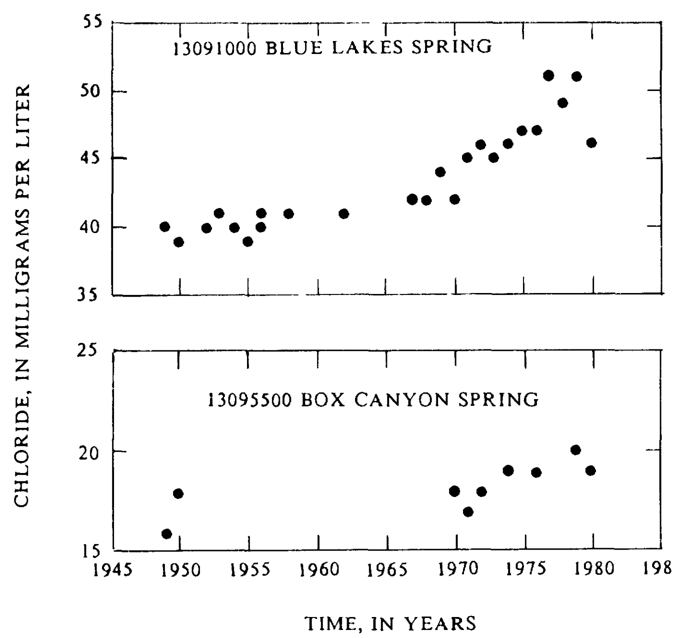



FIGURE 26. Chloride concentrations versus time at Blue Lakes and Box Canyon Springs.

25 °C/km, is defined in this report as water with a temperature greater than 26 °C. The volume of geothermal water presently used is small relative to the amount of cold water; however, a better understanding of the hydrology of the geothermal system may make this resource more attractive.

Radioactive decay of potassium, uranium, and thorium generates most of the heat produced in the outer 48 km of the earth. In accordance with the laws of thermodynamics, heat flows from hot areas toward the cool surface either by convection—transport of heat by mass transport of a fluid, or by conduction—transport of heat through solids by increased atomic vibration. The average heat flow for the earth is $1.5 \times 10^{-6}$ (cal/cm$^2$)/s; representative values for geothermal areas within the Snake River basin range from about 3 to $5 \times 10^{-6}$ (cal/cm$^2$)/s (Brott and others, 1978, p. 1699).

A generalized conceptual hydrologic model of the Snake River basin geothermal system can be made (fig. 27) that satisfies heat flow, hydrogeologic, and geochemical data. In the conceptual model, recharge is from precipitation on the flanks of the basin to two aquifer systems. The upper cold-water system consists of sediments and basalts of the Idaho Group and Snake River Group; the lower geothermal system consists largely of rhyolite flows and tuffs with interbedded sediments of the Idavada Volcanics. The cold-water system exhibits high intrinsic permeabilities and high ground-water flux. The underlying geothermal system exhibits low intrinsic permeabilities and low ground-water flux. Recharge water entering the geothermal system moves slowly through warm rocks, where it is heated and then discharged to the surface or to the cold-water aquifer through fractures.

Heat flow near the margins of the Snake River Plain is about $2.5 \times 10^{-6}$ (cal/cm$^2$)/s or more (Brott and others, 1976, p. 26), whereas heat flow in the interior of the plain is anomalously cool, less than $0.5 \times 10^{-6}$ (cal/cm$^2$)/s (Brott and others, 1981, p. 11,723). They believed the large difference in heat flow is due to the presence of the cold-water system, which carries heat away by convection. The absence of a large, shallow, thermal anomaly in the interior of the plain does not exclude the occurrence of geothermal discharge. On the basis of measured heat flow and other geophysical and geologic data, Brott and others (1976, p. 24; 1981, p. 11,728) suggested the presence of a major crustal heat source beneath much of the Snake River Plain. Total volume of geothermal water discharged to the plain is difficult to estimate because of masking by the large volume of cold water. However, on the basis of a water-budget analysis (Garabedian, 1986), geothermal discharge to the cold-water aquifer system is believed to be negligible.

### AQUEOUS CHEMISTRY OF THE GEOTHERMAL SYSTEM

Selected analyses of major dissolved solutes in geothermal wells and springs in the Snake River basin are given in table 23A–C (back of report). The uniformity of solute concentrations in geothermal water over a large geographic area indicates that the chemical mechanisms and lithologies controlling the concentrations are similar throughout the basin. Solutes are, however, significantly different from those observed in the cold-water system; concentrations of sodium, bicarbonate, silica, fluoride, sulfate, chloride, arsenic, boron, and lithium are higher, and concentrations of calcium, magnesium, and hydrogen are lower.

The following discussion on the origin of solutes and flow in the geothermal system is illustrated in figure 27. Similar to the approach used for the Snake River Plain aquifer system, a series of dissolution reactions are proposed. These reactions are based on probable mineralogy of the aquifer framework and observed solute concentrations. Dissolution reactions are given further support by thermodynamic saturation indices and isotope calculations. This approach is supported by data from the Salmon Falls and Bruneau–Grand View areas (Lewis and Young, 1980; Young and Lewis, 1982) in the central part of the basin and is believed to be generally applicable to the entire geothermal system. Water believed to be representative of recharge to the geothermal system was collected from Antelope (14S-14E-11CAB1S), Summit (8S-1E-20CCA1S), Pole Creek (46N-59E-13ACC1S), and Charity (6S-2W-14CBA1S) Springs (table 22A–C) and is typical of water in drainage basins tributary to the Snake River. Geothermal water typical of discharge was collected from wells owned by Bybee (5S-3E-26BCB1), King (4S-1E-34BAD1), and Sligar (8S-14E-30ACD2) (table 23A–C). The following is a conceptual model of the mechanism adding and removing solutes once the water is in the geothermal system.

As recharge water moves into the confined geothermal system, water and solutes are isolated, thus restricting reactions involving oxygen and new sources of soil $CO_2$. Pyrite is oxidized, adding both iron and sulfate to the solution. However, pyrite solution is limited by the availability of oxygen. About 2 mg/L of sulfate can form from each milligram per liter of dissolved oxygen consumed in the oxidation of pyrite (row 5, table 10). Thus, if saturated with oxygen, water in confined aquifers should have a maximum concentration of 18–20 mg/L of sulfate from the oxidation of pyrite if none of the oxygen is consumed in other reactions.

When water contacts organic carbon in buried soil horizons and sediment interbeds, some of the sulfate ions may be reduced to hydrogen sulfide by sulfate-reducing bacteria if no oxygen remains. This reaction is written using a simple carbohydrate as the carbon source:

$$2CH_2O + SO_4^{-2} \underset{}{\overset{\text{anaerobic bacteria}}{\rightleftharpoons}} 2HCO_3^{-} + H_2S \qquad (5)$$

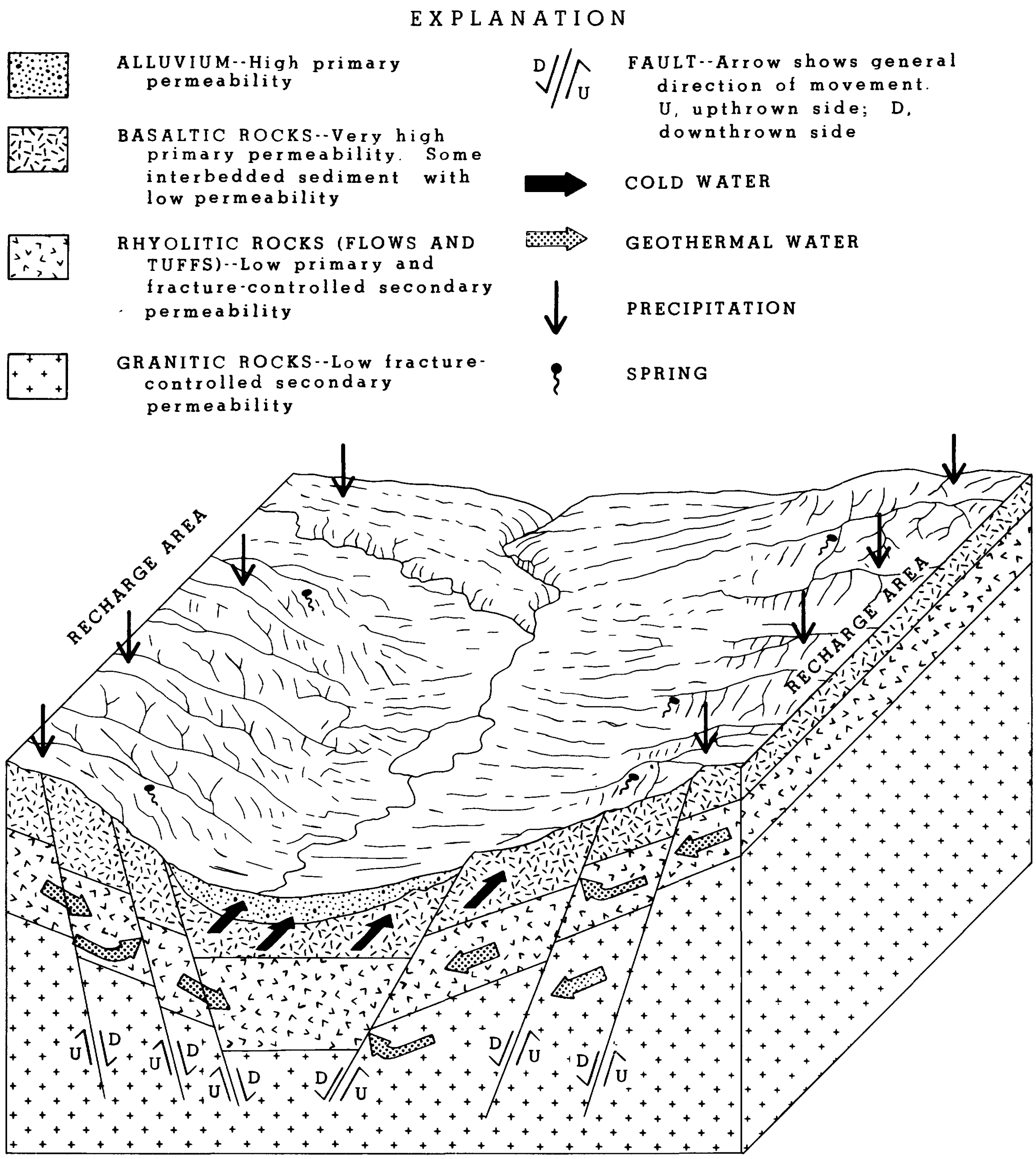



FIGURE 27.—Generalized conceptual hydrologic model of the Snake River basin geothermal system.

At pH 7, about one-half of the $H_2S$ generated would dissociate into $HS^-$ and $H^+$ ions. The more basic the solution, the greater the percentage of $HS^-$ ions present. The bacterial reduction of sulfate is inhibited by high temperatures and high pH. High temperatures destroy the low-molecular weight organic material required by the bacteria for a carbon source; thus, sulfate reduction can occur only in the cooler parts of the aquifer. The amount of sulfate reduction cannot be adequately determined, but it is assumed to be relatively small because of the small amount of $H_2S$ observed in the water. Water from the geothermal wells appears to be in thermodynamic equilibrium with mackinawite (FeS) rather than pyrite ($FeS_2$) (table 17); thus, mackinawite may be significant in controlling the concentrations of $HS^-$ and $Fe^{+2}$ ions in geothermal water.

As water and solutes move into areas of increasing temperatures, new mineral assemblages, including clays and zeolite minerals with significant ion-exchange capacity, are encountered. The zeolite phillipsite ($Na_{0.5}K_{0.5}AlSi_3O_8 \cdot H_2O$) is a common metamorphic product of lava flows, and thermodynamic saturation indices suggest that geothermal water is slightly supersaturated (table 17) with respect to this mineral. Thus, the potential exists for phillipsite being present in the aquifer framework. Sodium montmorillonite is saturated with respect to geothermal water and might also be present. However, no mineralogic analyses of the geothermal aquifer are available, so the presence of ion-exchange minerals cannot be confirmed.

Most of the calcium and magnesium in solution is believed to be exchanged for sodium present on ion-exchange sites. This exchange causes thermodynamic undersaturation of the solutes with respect to calcium and magnesium minerals. In attempting to reestablish chemical equilibrium, any calcite or dolomite encountered by these ground waters will dissolve. The dissolution of calcite adds bicarbonate and removes hydrogen ions from solution, thus increasing the pH, and the mineral equilibrium with the solutes is reestablished. Ion exchange continues to remove the added calcium generated by the dissolution of calcite until either the ion-exchange capacity of the rock is reached or an equilibrium is established because of increased pH. Removal of calcium by ion exchange also causes undersaturation of the solution with respect to the mineral fluorite ($CaF_2$), which dissolves and releases both calcium and fluoride ions to solution. The calcium generated in this reaction also is removed by ion exchange, but as there is no corresponding mechanism for fluoride removal, the concentration increases and exceeds 15–20 mg/L in many analyses (table 23A).

Ion exchange is not the only mechanism capable of removing cations from solution. Mineral precipitation of albite could remove $Na^-$ and some $Ca^{+2}$ and $K^-$, but the saturation indices suggest that albite is thermodynamically undersaturated (table 17). $Ca^{+2}$ and $Na^-$ could be removed by precipitation of laumontite; however, this mineral is also undersaturated (table 17). Precipitation of $CaCO_3$ could remove $Ca^{+2}$; however, this cannot explain the net increase in carbonate from recharge to discharge zones. Thus, the proposed ion-exchange model, rather than a mineral precipitation model, seems to fit the observed data.

Figure 28 illustrates the thermodynamic control of the mineral fluorite on fluoride activity in geothermal water. The activity of fluoride in solution increases as the solution progresses from undersaturation with respect to fluorite toward equilibrium. Although there is some scatter around the 0.0 saturation index caused by analytical errors, activity corrections, and uncertainty in thermodynamic constants, the data in figure 28 indicate that fluorite is important in controlling fluoride activity in geothermal water.

The pH of many geothermal waters is between 9 and 9.5 (table 23A). Increased pH is assumed to be caused by removal of $H^+$ ions in the conversion from carbonate minerals to bicarbonate. In this environment, pH is controlled by the silica dissociation reaction (Krauskopf, 1979, p. 92),

$$H_4SiO_4 + OH^- \rightleftharpoons H_3SiO_4^- + H_2O \qquad (6)$$

which buffers the pH.

Silica concentration increases in solution because increasing temperature and pH result in increased solubility of plagioclase feldspars, quartz, and chalcedony.

Water in the geothermal aquifer is reducing and able to mobilize metal ions that are soluble in a reduced oxidation state. However, presence of hydrogen sulfide, abundance of hydroxyl ions at higher pH, and low solubility of many metal sulfides and hydroxides inhibit the build-up of significant concentrations of most metal ions in solution.

Reactions controlling solute concentrations described above are consistent with the mineral saturation indices given in table 17 for wells typical of the discharge area. For example, albite, fluorite, and anhydrite remain undersaturated and, thus, can release silica, sodium, calcium sulfate, and fluoride to solution.

Reactions controlling solute distribution in geothermal water can be quantified further by using a solute reaction and isotope equilibrium approach similar to that used in the analysis of solutes in the Snake River Plain aquifer system. This approach is used on the assumption that ground water flows from the recharge zone near Antelope Springs (14S-14E-11CAB1S) to the discharge zone near the Sligar well (8S-14E-30ACD2). Solutes in water from the well are assumed to be the result of reactions of that

TABLE 17.—*Thermodynamic saturation indices of some common minerals from the recharge and discharge zones of the geothermal system, Snake River basin*

[Indices calculated using WATEQF (Plummer and others, 1976)]

| Station No. / Location / Name / Date | Recharge 421322114473501 14S-14E-11CAB1S Antelope Springs 8- 4-82 | Recharge 415237115145001 46N-59E-13ACC1S Pole Creek Spring 6-27-78 | Recharge 425402116325001 6S- 2W-14CBA1S Charity Spring 7- 3-73 | Recharge 424240116220601 8S- 1E-20CCA1S Summit Springs 7- 2-73 | Discharge 430236116192601 4S- 1E-34BAD1 King well 7-16-82 | Discharge 425750116043201 5S- 3E-26BCB1 Bybee well 7-16-82 | Discharge 424214114512101 8S-14E-30ACD2 Sligar well 7-21-82 |
|---|---|---|---|---|---|---|---|
| Mineral | | | | Log IAP/KT | | | |
| Albite | -0.42 | -3.53 | - | - | -2.48 | -2.34 | -2.14 |
| Amorphous aluminum hydroxide | .14 | -1.70 | - | - | -3.53 | -3.75 | -3.63 |
| Amorphous iron sulfide | - | - | - | - | -.50 | .14 | -1.16 |
| Analcime | -2.75 | -6.00 | - | - | -3.65 | -3.60 | -3.41 |
| Anhydrite | -3.75 | -4.61 | -3.64 | -3.81 | -3.39 | -3.25 | -3.83 |
| Anorthite | -2.32 | -8.68 | - | - | -4.65 | -5.00 | -5.07 |
| Barite | - | - | - | - | -1.69 | -1.53 | -1.80 |
| Brucite | -7.82 | -11.24 | -7.63 | -7.44 | -1.08 | -1.88 | -1.64 |
| Calcite | -2.19 | -4.12 | -2.25 | -1.64 | .49 | .15 | .09 |
| Chalcedony | .44 | .52 | .39 | .27 | -.28 | -.16 | -.20 |
| Clinoenstatite | -5.40 | -8.72 | -5.26 | -5.18 | .45 | -.24 | -.02 |
| Diopside | -7.50 | -13.47 | -7.37 | -7.20 | 3.35 | 2.58 | 2.62 |
| Dolomite | -5.02 | -9.52 | -4.97 | -3.78 | -.01 | -1.47 | -.88 |
| Fluorite | -2.70 | -3.84 | -3.39 | -2.49 | -.73 | -.96 | -.42 |
| Gibbsite | 1.35 | -.46 | - | - | -2.53 | -2.76 | -2.62 |
| Gypsum | -3.40 | -4.18 | -3.28 | -3.44 | -3.61 | -3.51 | -4.01 |
| Illite | 5.05 | -.05 | - | - | -4.67 | -4.91 | -4.52 |
| Kaolinite | 6.12 | 2.82 | - | - | -4.00 | -4.28 | -3.96 |
| Laumontite | 3.58 | -2.34 | - | - | -2.00 | -2.22 | - |
| Leonhardite | 15.16 | 3.57 | - | - | 2.48 | 1.95 | 2.27 |
| Mackinawite | - | - | - | - | .22 | .85 | -.44 |
| Magnesite | -3.13 | -5.67 | -3.02 | -2.43 | -.46 | -1.51 | -.98 |
| Montmorillonite (sodium) | - | - | - | - | 5.76 | 6.71 | 6.68 |
| Montmorillonite (calcium) | 6.51 | 2.26 | - | - | -4.99 | -5.16 | -4.90 |
| Muscovite | 5.52 | -.43 | - | - | -7.22 | -7.37 | -6.96 |
| Phillipsite | .28 | -3.12 | - | - | 1.00 | 1.49 | 1.14 |
| Phlogopite | -14.12 | -27.56 | - | - | 6.32 | 4.56 | 4.77 |
| Pyrite | - | - | - | - | 5.04 | 13.35 | 17.39 |
| Pyrophyllite | 3.53 | -.91 | - | - | .16 | .64 | -.10 |
| Quartz | .98 | 1.09 | .93 | .82 | .03 | .14 | .13 |
| Sepiolite | -7.24 | -13.61 | -6.98 | -6.91 | 2.53 | 1.20 | 1.76 |
| Siderite | - | - | - | - | -1.26 | -1.51 | -2.50 |
| Silica gel | -.35 | -.25 | -.40 | -.52 | -1.20 | -1.09 | -1.11 |
| Silica glass | -.07 | .00 | -.12 | -.24 | -.77 | -.65 | -.69 |
| Talc | -6.92 | -16.35 | -6.49 | -6.30 | 7.03 | 4.90 | 5.89 |

water with the aquifer framework, not of mixing with other water.

The procedure used in this solute reaction analysis, outlined in table 18, is similar to that used for the Snake River Plain regional aquifer system discussed previously, except that absolute solute changes in the geothermal system and the mineralogical details are not as well known.

Quartz is not shown as a source of silica in the reaction listed in table 18, as it is impossible to determine what percentage, if any, of the silica is from this source. The source of silica in solution appears to be from dissolution of feldspars that are thermodynamically undersaturated (table 17) and, thus, can dissolve. A significant amount of precipitation of silica from solution is not apparent on the basis of the balance obtained from the other ions in table 18. That is, if large quantities of silica had been derived from dissolution of feldspars, the feldspars would have added not only silica but also calcium and sodium to the solution. The balances shown in table 18 suggest that little, if any, additional calcium and sodium could be added from feldspar dissolution without disturbing the calculated balance.

Weathering of feldspar by hydrolysis rather than by carbonic acid (row 7, table 18) is proposed. On the basis of

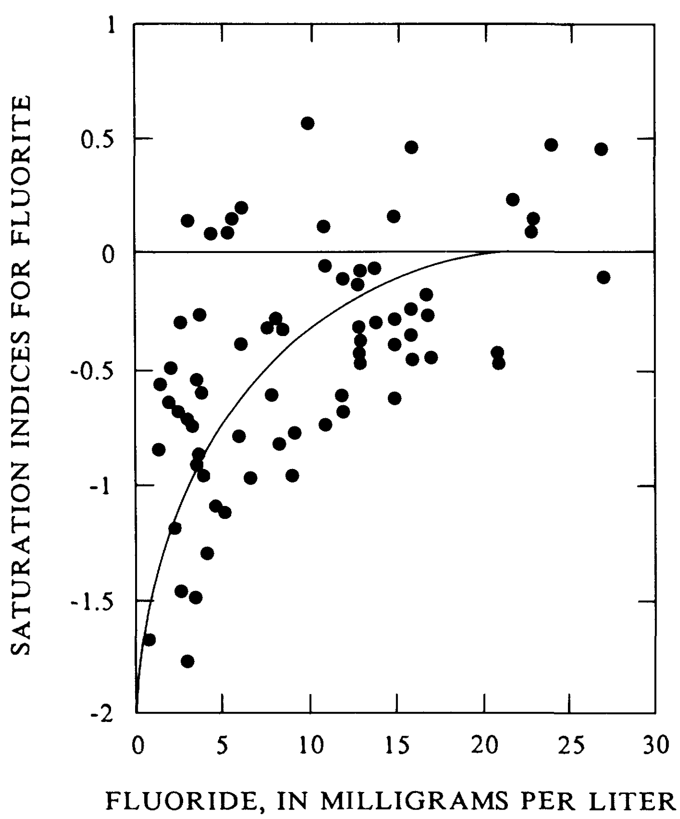



FIGURE 28.—Saturation indices for fluorite versus fluoride concentrations for geothermal water, Snake River basin. Curved line indicates fluoride activity controlled by equilibrium with fluorite.

relative solubilities of feldspar and calcite, hydrogen ions are assumed to be removed by the calcite reaction in preference to the feldspar reaction. If calcite were available, most of the hydrogen ions would react with calcite, and the feldspar would be relatively unweathered by carbonic acid. This assumption is supported by many observations of soil zones where carbonates are leached preferentially from an aquifer framework of feldspar. If carbon in water from the Sligar well is derived from recharge water (atmospheric carbon) and dissolution of the aquifer framework (linear carbon isotopic dilution), then carbon probably is derived from dissolution of calcite, not from carbonic acid reactions with feldspar. The carbon-isotope value at the well then must reflect these two sources. In equation form,

$$(\delta^{13}C)_R(C)_R + (\delta^{13}C)_{AF}(C)_{AF} = (\delta^{13}C)_D(C)_D \qquad (7)$$

where C is total carbon, in millimoles, R is recharge, AF is aquifer framework, and D is discharge. Rightmire (1983) showed that the $\delta^{13}C$ of caliche at INEL averages $-4$ permil. This caliche sequence is assumed to be typical of others in the sedimentary interbeds, which were similarly derived over geologic time. Recharge water, represented by Antelope Springs, has a $\delta^{13}C$ value of $-12.9$ permil (table 22C) and a total calculated carbon content of 0.622 millimoles. Discharge represented by water from the Sligar well has a $\delta^{13}C$ of $-7$ permil and a total calculated carbon of 1.830 millimoles (table 23C). Thus, the amount of carbon contributed by the aquifer framework is calculated by use of equation 7 to be

$$(-12.9)(0.622) + (-4.0)(C)_{AF} = (-7.0)(1.830), \qquad (8)$$

$$(C)_{AF} = 1.20 \text{ millimoles}$$

Equation 8 corresponds closely to the 1.208 millimoles (1.830 − 0.622) observed increase in carbon from the recharge to the discharge zone. The weathering of feldspars by carbonic acid would not give a calculated carbon content close to the observed value when known values of the carbon isotope of soil gas are used.

Relative amounts of sulfate from either oxidation of pyrite or dissolution of sulfate minerals were estimated from sulfur isotopes by the same method that was used to determine the origin of sulfate in the cold-water system. That is, all sulfate is from dissolution of anhydrite or oxidation of pyrite. Pyrite and anhydrite in the geothermal system are assumed to have $\delta^{34}S$ values of $-8$ permil and $+15$ permil, similar to values observed in the cold-water system. It is assumed that the small amount of $H_2S$ generated in this system has not caused significant changes in the sulfur-isotope ratios. Isotope equations solved using a $\delta^{34}S$ value of $+10.5$ permil observed in the

TABLE 18.—*Proposed source minerals and weathering products controlling major solute chemistry in the geothermal system, Snake River basin*

[Solutes in moles × $10^{-4}$]

| Reactions | Ca | Mg | Na | K | $HCO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| (1) Total observed solutes entering from the recharge area (Antelope Springs) | 1.80 | 0.49 | 2.57 | 0.66 | 4.92 | 0.87 | 0.52 | 0.11 | 5.83 |
| (2) Dissolution of NaCl from fluid inclusions, grain boundaries, and pores of detrital marine sediments $13.80NaCl = 13.80Na^+ + 13.80Cl^-$ | - | - | 13.80 | - | - | 13.80 | - | - | - |
| (3) Dissolution of fluorite $6.79CaF_2 = 6.79Ca^{+2} + 13.58F^-$ | 6.79 | - | - | - | - | - | - | 13.58 | - |
| (4) Dissolution of anhydrite (65 percent) $1.90CaSO_4 = 1.90Ca^{+2} + 1.90SO_4^{-2}$ | 1.90 | - | - | - | - | - | 1.90 | - | - |
| (5) Oxidation of pyrite (35 percent) $0.52FeS_2 + 1.80H_2O + 1.92O_2 = 0.52Fe(OH)_3 + 2.04H^+ + 1.02SO_4^{-2}$ | - | - | - | - | - | - | 1.02 | - | - |
| (6) Dissolution of calcite from pyrite reaction $2.04CaCO_3 + 2.04H^+ = 2.04Ca^{+2} + 2.04HCO_3^-$ | 2.04 | - | - | - | 2.04 | - | - | - | - |
| (7) Weathering of feldspar to gibbsite $3.17[K_{.01}Na_{.90}Ca_{.10}Al_{1.39}Si_{2.68}O_8] + 8.43H_2O = 4.33Al(OH)_3 + 8.49SiO_2 + 0.03K^+ + 2.85Na^+ + 0.32Ca^{+2} + 3.52OH^-$ | .32 | - | 2.85 | .03 | - | - | - | - | 8.49 |
| (8) Ion exchange of $Mg^{+2}$ $0.47Mg^{+2} + 0.94NaX = 0.94Na^+ + 0.47MgX$ | - | -.47 | .94 | - | - | - | - | - | - |
| (9) Ion exchange of $K^+$ $0.38K^+ + 0.38NaX = 0.38Na^+ + 0.38KX$ | - | - | .38 | -.38 | - | - | - | - | - |
| (10) Ion exchange of $Ca^{+2}$ $20.19Ca^{+2} + 40.38NaX = 40.38Na^+ + 20.19CaX$ | -20.19 | - | 40.38 | - | - | - | - | - | - |
| (11) Dissolution of calcite $7.38CaCO_3 + 7.38CO_2 + 7.38H_2O = 7.38Ca^{+2} + 14.76HCO_3^-$ | 7.51 | - | - | - | 15.02 | - | - | - | - |
| (12) Total observed solutes at the discharge area (Sligar well) | .23 | .02 | 60.92 | .31 | 20.00 | 14.67 | 3.44 | 13.69 | 14.32 |

Sligar well indicate that approximately 65 percent of the sulfate ions in geothermal water is from the dissolution of anhydrite. This percentage is identical to the 65 percent observed in the oxidizing Snake River Plain aquifer system and justifies the assumption of the negligible effect of $H_2S$ on the calculations. Solutes in the geothermal water are thermodynamically undersaturated with respect to anhydrite (table 17), which would dissolve if present in the flowpath, but are supersaturated with respect to pyrite (table 17). Thermodynamic saturation indices support the conclusion, based on isotope analyses, that sulfate probably is derived from dissolution of anhydrite in the interbedded sediments.

This section has proposed a general outline of the reactions controlling major solute chemistry of the geothermal system by use of a semiquantitative mass- and isotope-balance approach coupled with thermodynamic evaluation of dissolved solutes. Solute concentrations are typical of most geothermal water in the Snake River basin. Concentrations of sodium, bicarbonate, silica, fluoride, sulfate, chloride, arsenic, boron, and lithium are higher and concentrations of calcium, magnesium, and hydrogen are lower than in the cold-water system. The geothermal water has a low oxidation/reduction potential but has few trace metals because of the high concentration of hydroxyl ions (high pH) and the presence of hydrogen sulfide. The foregoing discussion is not intended to explain the solute concentrations of every sample in table 23A–C, but it provides a generalized description of probable reactions in the aqueous phase of the geothermal system.

### TEMPERATURE OF GEOTHERMAL WATER

Characteristics of geothermal water from springs and wells in the Snake River basin have been the subject of numerous investigations. The chemistry of geothermal water has been used to estimate and describe the areal extent, heat content, reservoir temperature, and recharge areas of local geothermal systems. Geothermal studies include those by Young and Mitchell (1973); Young and Whitehead (1975a, 1975b); Mitchell (1976a, 1976b, 1976c, 1981); Rightmire and others (1976); Crosthwaite (1979); Corbett and others (1980); Lewis and Young (1980, 1982a, 1982b); and Young and Lewis (1982).

The measured water temperature of a spring or well is a poor indication of reservoir temperature because of cooling by dilution with cold water, cooling during travel to the land surface, and conduction of heat to cooler rocks. To overcome these limitations, several empirical chemical geothermometers that use solute chemistry to calculate reservoir temperature have been developed.

The silica geothermometer (Fournier and Rowe, 1966, p. 685) is based on observations that the solubility of silica minerals, such as quartz and its cryptocrystalline equivalent, chalcedony, increases with an increase in temperature (fig. 29). These minerals dissolve as the water temperature increases until the solution is thermodynamically saturated. Because silica minerals do not precipitate readily when the solution is cooled, water temperature can be obtained by calculating the temperature at which silica minerals in the reservoir and silica in the water are in equilibrium. Of rocks composing the Snake River basin geothermal system, quartz is present in the system and is probably the mineral controlling silicate concentration. Thermodynamic equilibrium calculations indicate that the silica concentration in geothermal water is in equilibrium with respect to quartz at the calculated reservoir temperature and generally is undersaturated with respect to chalcedony (table 17).

The Na–K–Ca geothermometer depends on the reaction of sodium and potassium with albite and orthoclase. The higher the temperature, the smaller the Na:K ratio because $Na^+$ ions enter the feldspar lattice. Because calcium also will enter the feldspar lattice in competition with $Na^+$, Fournier and Truesdell (1973, p. 1255) suggested that the Na:K ratio be adjusted by considering the concentration of calcium in solution.

The assumptions necessary for using silica and Na–K–Ca chemical geothermometers (Fournier and others, 1974, p. 259) are that (1) the chemical reactions are temperature dependent; (2) an adequate source of solutes is available in the reservoir; (3) chemical equilibrium exists in the reservoir between the solutes and specific minerals; (4) reestablishment of chemical equilibrium after the water and solutes leave the geothermal reservoir is negligible; and (5) concentrations of the solutes do not change after the water leaves the geothermal reservoir by dilution, solution, or precipitation.

The question of which method gives the most accurate estimate depends on which assumptions are least violated at a specific site. Assumptions 2 and 5 are usually the most difficult to define. In the case of the silica geothermometer, it is frequently difficult to determine which of several possible silica minerals are controlling the equilibrium concentration. It is also frequently difficult, at least in shallow wells and springs, to ascertain whether dilution with cold water is occurring.

Quartz, albite, and orthoclase are generally present in tuff and rhyolite flows that make up the geothermal reservoir, so use of both the silica and Na–K–Ca geothermometers is possible. The effects of dilution are important in both methods and, without detailed hydrogeologic information, it is difficult to define which values are closer approximations to the true temperature. The use of the

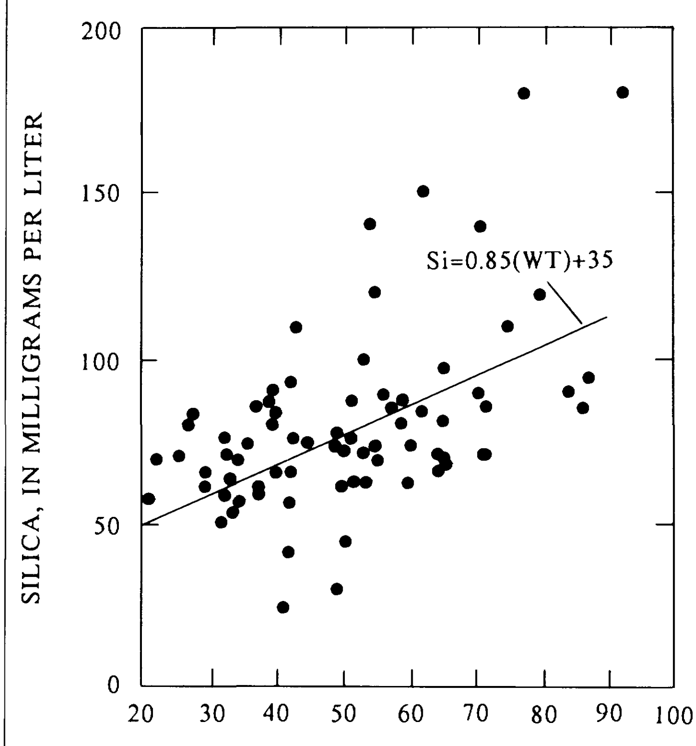



FIGURE 29.—Silica concentration versus water temperature for geothermal water, Snake River basin.

Na–K–Ca geothermometer, which depends on equilibrium with albite and orthoclase, appears to contradict the ion-exchange model proposed previously for control of cations in solution. However, both ion-exchange and feldspar equilibrium (table 18) are proposed; thus, use of the Na–K–Ca geothermometer is reasonable. Geothermometers, like other empirical estimation techniques, are not free of problems; however, they provide a useful indication of potential reservoir temperatures.

The calculated and observed temperatures of the geothermal reservoir in the Snake River basin, given in table 19, use the following conventions: (1) Only calculated temperatures greater than those measured in the field are reported; (2) if the water is thermodynamically saturated or supersaturated with respect to calcite, or if $[Ca]^{1/2}/[Na]$, expressed in molals (moles per kilogram $H_2O$), is greater than 1.0, then no calculated temperature is reported when using the Na–K–Ca geothermometer; (3) the temperature calculated using the Na–K–Ca geothermometer is first calculated using $\beta = 4/3$; if this temperature exceeds 100 °C, the temperature is recalculated using $\beta = 1/3$ and this temperature is reported; and (4) temperatures are not reported if the water is thermodynamically undersaturated with respect to the particular silica mineral when using the silica geothermometer. Fournier and Potter (1979, p. 1547) suggested that a magnesium correction be included for solutions having a ratio of $[Mg/(Mg+Ca+K)\times 100]$ less than 50 or Na–K–Ca calculated temperatures greater than 70 °C with concentrations expressed in equivalents. Only a small number of water samples in the Snake River basin geothermal system required this adjustment (table 19).

Chemical geothermometer calculations of water temperatures from 79 wells and springs throughout the Snake River basin indicate that a regional geothermal system exists. The silica-quartz geothermometer temperatures show that 56 percent of 76 temperatures are greater than 90 °C; the maximum calculated reservoir temperature was 172 °C (Washington County, table 19).

### ORIGIN OF WATER IN THE GEOTHERMAL SYSTEM

The variation of $\delta^2H$ and $\delta^{18}O$ from several geothermal areas in the Snake River basin (fig. 30) indicates that the $\delta^{18}O$ content of some geothermal waters appears to be enriched (heavier) relative to normal meteoric waters with the same deuterium content. The process causing the $\delta^{18}O$ shift is probably an isotopic-exchange reaction between the water and silicate minerals in the system. Such a reaction for a silicate mineral can be written as

$$Si^{16}O^{18}O + H_2{}^{16}O \rightleftharpoons Si^{16}O_2 + H_2{}^{18}O \qquad (9)$$

Because $\delta^{18}O$ in most igneous minerals is enriched relative to V–SMOW, the effect of this reaction is to enrich the $\delta^{18}O$ in exchanging waters. This oxygen-isotope shift also might represent mixing between meteoric water and water emanating from hot juvenile water, which would be isotopically heavier. However, White and others (1973) provided data that indicate juvenile water is heavier in both deuterium and oxygen ($\delta^2H = -25$ permil, $\delta^{18}O = +5$ permil), whereas data in figure 30 indicate that deuterium is similar to or lighter than meteoric water from the area, not heavier. Thus, juvenile waters do not appear to be a likely source of the observed heavier oxygen isotopes.

Deuterium values of some geothermal water are isotopically lighter than deuterium values of cold water in the same area (tables 22C, 23C). In many geothermal systems, deuterium values vary little within a given geographic region and usually reflect local precipitation (Craig, 1963; White, 1970; Bedinger and others, 1979). Young and Lewis (1982, p. J12) determined that the Snake River basin does not have sufficient elevation to account for lighter deuterium values and suggested that geothermal water must have entered the aquifer at a time when the average temperature was cooler. Radiocarbon data of some of this water, given in the following section, confirm an old age for this water.

Tritium ($^3H$), a radioactive isotope of hydrogen with a half-life of about 12.25 years, is formed continuously by cosmic rays in the upper atmosphere. Tritium is expressed as TU (tritium units), which are equal to a $^3H/H$ ratio of $10^{-18}$, and is present naturally in water in the range of

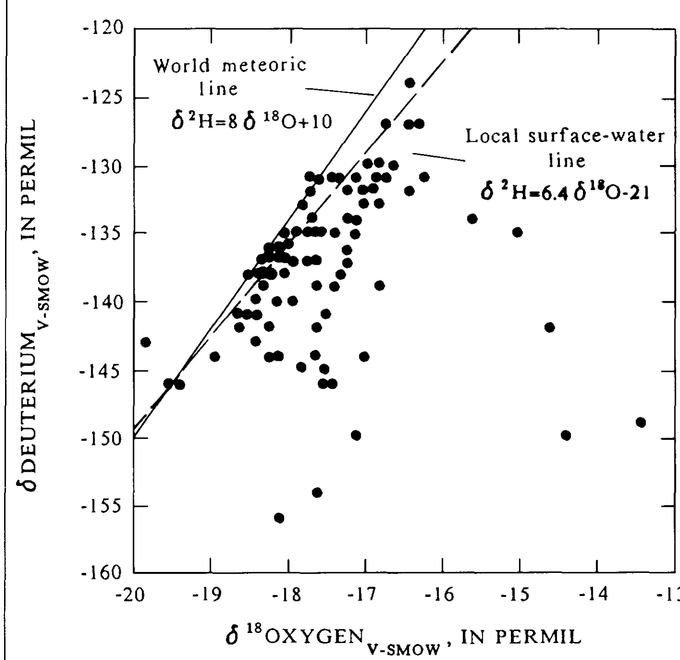



FIGURE 30.—$\delta^2H$ versus $\delta^{18}O$ ratios for geothermal water, Snake River basin.

TABLE 19.—*Calculated and observed temperatures of the geothermal reservoir, Snake River basin*

[Temperatures in degrees Celsius; corr., corrected]

| | | | | Calculated reservoir temperature | | | | |
|---|---|---|---|---|---|---|---|---|
| Station No. | Location | Date | Observed temperature at surface | Silica quartz conductive $H_3SiO_4^-$ corr. | Silica chalcedony $H_3SiO_4^-$ corr. | Sodium-potassium calcium ($\beta$=1/3) | Sodium-potassium calcium ($\beta$=4/3) | Sodium-potassium calcium Mg-corr. |
| | | | Boise County | | | | | |
| 434014115414601 | 4N- 6E-24BCB1S | 5-27-81 | 37 | 90 | 60 | - | - | - |
| 434858115514901 | 6N- 5E-33ADC1S | 5-11-81 | 42 | 70 | - | - | 62 | - |
| 440312115543601 | 8N- 5E- 6DCC1S | 2-26-79 | 51 | 88 | 58 | - | - | - |
| 440241115510001 | 8N- 5E-10BDD1S | 11-27-78 | 55 | 89 | 59 | - | - | - |
| 440340115411401 | 8N- 6E- 1ADB1S | 2-27-79 | 60 | 80 | - | - | - | - |
| 440530116030201 | 9N- 3E-25BAC1S | 11-22-78 | 80 | 143 | 117 | - | - | - |
| 440430115324001 | 9N- 8E-32CBA1S | 2-27-79 | 64 | 86 | - | - | - | - |
| 440910115593801 | 10N- 4E-33CBD1S | 11-27-78 | 75 | 132 | 105 | - | - | - |
| | | | Camas County | | | | | |
| 433609115041501 | 3N-12E- 7DCD1S | 7-15-81 | 50 | 75 | - | - | - | - |
| 433850114485701 | 4N-14E-29DCD1S | 7-15-81 | 65 | 72 | - | - | 70 | - |
| | | | Cassia County | | | | | |
| 422623113255601 | 11S-26E-28BCB1 | 7-25-75 | 35 | 98 | 68 | - | 51 | - |
| 421425113351901 | 14S-25E- 6BBB1S | 8- 5-75 | 28 | 65 | 33 | - | - | - |
| 420627113222801 | 15S-26E-23AAA1 | 10- 6-76 | 62 | 161 | 137 | 182 | - | 182 |
| | | | Elmore County | | | | | |
| 425922116043501 | 5S- 3E-14CBB1 | 7-23-73 | 59 | 67 | - | - | - | - |
| 434518115341501 | 5S- 7E-24BDD1S | 8- 3-81 | 76 | 82 | - | - | 91 | 119 |
| 433307115160101 | 3N-10E-33ACD1S | 7-16-81 | 53 | 73 | - | - | - | - |
| 433814115074701 | 4N-11E-34DBB1S | 7-16-81 | 53 | 67 | - | - | 64 | - |
| 434327115361401 | 5N- 7E-34DBA1S | 5-27-81 | 55 | 64 | - | - | 61 | - |
| 434643115290401 | 5N- 8E-10DCA1S | 9- 2-81 | 51 | 82 | - | - | - | - |
| 434722115260401 | 5N- 9E- 7BAB1S | 5-28-81 | 65 | - | - | - | 78 | 123 |
| 434925115191201 | 6N-10E-30CDA1S | 9- 2-81 | 64 | - | - | - | 65 | - |
| 434842115063501 | 6N-11E-35DAD1S | 9- 1-81 | 60 | - | - | - | 83 | 126 |
| | | | Fremont County | | | | | |
| 435328111355201 | 7N-41E-34ADD1 | 6-16-77 | 33 | 113 | 84 | - | 77 | 67 |
| 435335111351601 | 7N-41E-35CDD1 | 8- 9-72 | 36 | 120 | 92 | - | - | - |
| 435410111343001 | 7N-41E-25CBD1 | 7-20-76 | 32 | 121 | 93 | - | - | - |
| 435653111314301 | 7N-42E- 8CAA1 | 7-19-76 | 29 | 111 | 81 | - | - | - |
| | | | Jerome County | | | | | |
| 423706114282501 | 9S-17E-28BDA1 | 3-18-81 | 27 | 114 | 85 | 136 | - | 140 |
| | | | Jefferson County | | | | | |
| 433834111412401 | 4N-40E-25DCB1S | 7-27-72 | 49 | 81 | - | - | - | - |
| | | | Madison County | | | | | |
| 434729111260801 | 5N-43E- 6BCA1S | 9- 6-77 | 41 | 74 | - | - | - | - |
| 435154111362701 | 6N-41E-10DBB1 | 6-16-77 | 27 | 125 | 97 | - | 80 | 66 |
| | | | Owyhee County | | | | | |
| 420139115214301 | 16S- 9E-24BB1S | 5-23-72 | 55 | 138 | 111 | - | 62 | - |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | 27 | 118 | 89 | - | - | - |
| 424541115454101 | 8S- 6E- 3BDD1S | 7- 5-73 | 39 | 125 | 98 | 182 | - | 143 |
| 424852115513801 | 7S- 5E-16ACD1 | 5-30-73 | 40 | 121 | 93 | - | - | - |
| 425004115442301 | 7S- 6E- 9BAD1 | 6-13-78 | 51 | 87 | 56 | - | - | - |
| 425012115541601 | 7S- 5E- 7ABB1 | 8-27-80 | 39 | 113 | 84 | - | - | - |
| 425255115473501 | 6S- 6E-19CCD1 | 8-28-80 | 36 | 103 | 73 | - | - | - |
| 425425115563801 | 6S- 4E-14ABC1 | 5-30-73 | 54 | 100 | 69 | - | - | - |
| 425526116043201 | 6S- 3E- 2CCC1 | 7- 6-73 | 53 | 103 | 74 | - | - | - |
| 425527115352301 | 6S- 7E- 2CDD1 | 8-26-80 | 34 | 117 | 88 | - | - | - |

TABLE 19.—*Calculated and observed temperatures of the geothermal reservoir, Snake River basin*—Continued

| | | | | Calculated reservoir temperature | | | | |
|---|---|---|---|---|---|---|---|---|
| Station No. | Location | Date | Observed temperature at surface | Silica quartz conductive $H_3SiO_4^-$ corr. | Silica chalcedony $H_3SiO_4^-$ corr. | Sodium-potassium calcium ($\beta$=1/3) | Sodium-potassium calcium ($\beta$=4/3) | Sodium-potassium calcium Mg-corr. |
| | | Owyhee County--Continued | | | | | | |
| 425741116065401 | 5S- 3E-28BCC1 | 5-31-73 | 65 | 85 | - | - | - | - |
| 425750116043201 | 5S- 3E-26BCB1 | 7-16-82 | 81 | 117 | 88 | 169 | - | - |
| 430122116102901 | 5S- 2E- 1BBC1 | 7- 9-73 | 50 | 58 | - | - | - | - |
| 430202116151401 | 4S- 2E-32BCC1 | 7- 9-73 | 43 | 128 | 101 | - | - | - |
| 430236116192601 | 4S- 1E-34BAD1 | 7-16-82 | 76 | 99 | - | - | - | - |
| 431230116322001 | 2S- 2W-35ACB1 | 6-13-78 | 40 | 81 | 49 | - | - | - |
| 432433116415001 | 1N- 3W-21ACD1S | 6-14-78 | 56 | 96 | 66 | - | - | - |
| | | Twin Falls County | | | | | | |
| 423919114385901 | 9S-15E-12CCA1 | 6-23-81 | 44 | 90 | 59 | - | - | - |
| 423542114285701 | 9S-17E-32DDA1 | 4- 8-81 | 40 | 91 | 61 | - | - | - |
| 423400114362101 | 10S-16E- 8CDA1 | 6-23-81 | 32 | 108 | 79 | - | - | - |
| 423452114281101 | 10S-17E- 4CDA1 | 2- 9-81 | 37 | 104 | 74 | - | 81 | 130 |
| 423255114260101 | 10S-17E-14CCD1 | 4- 8-81 | 31 | 101 | 71 | - | 51 | |
| 422646114295201 | 11S-17E-29BBB1 | 4-22-81 | 30 | 109 | 79 | - | - | - |
| 422045114302901 | 12S-17E-31BAB1 | 4-23-81 | 37 | 61 | - | - | - | - |
| 422442114230901 | 12S-18E- 6ADC1 | 2-11-81 | 34 | 117 | 88 | - | 64 | - |
| 424215114512201 | 8S-14E-30ACD1S | 2- 8-78 | 71 | 96 | - | - | - | - |
| 424214114512101 | 8S-14E-30ACD2 | 7-21-82 | 72 | 87 | - | - | - | - |
| 424203114510801 | 8S-14E-30DAD1 | 3-26-79 | 62 | 79 | - | 98 | - | 113 |
| 424131114513201 | 8S-14E-31ACB1S | 4- 5-79 | 57 | 83 | - | - | - | - |
| 424101114500301 | 8S-14E-32DDC1 | 4- 4-79 | 43 | 86 | 55 | 114 | - | 124 |
| 424111114493201 | 8S-14E-33CBD1 | 3-15-79 | 42 | 106 | 77 | - | - | - |
| 424118114493102 | 8S-14E-33CBA2 | 4- 5-79 | 59 | 89 | - | - | - | - |
| 424029114493001 | 9S-14E- 4BDC1 | 3-27-79 | 43 | 96 | 66 | - | - | - |
| 424010114493001 | 9S-14E- 4CDB1 | 3-15-79 | 34 | 100 | 70 | - | - | - |
| 423944114484201 | 9S-14E- 9ADA1 | 3-14-79 | 33 | 101 | 71 | - | - | - |
| 423944114472901 | 9S-14E-10ADA1 | 2- 9-81 | 37 | 108 | 79 | - | - | - |
| 423852114470701 | 9S-14E-14BDB1 | 2-11-81 | 33 | 118 | 89 | - | - | - |
| 423554114452201 | 9S-14E-36DAC1 | 3-14-79 | 29 | 114 | 85 | - | - | - |
| 423240114565201 | 10S-13E-20ADA1 | 4-24-81 | 42 | 86 | 55 | - | 41 | - |
| 421216114400301 | 14S-15E-14CDB1 | 8- 4-82 | 32 | 108 | 78 | - | 67 | - |
| | | Valley County | | | | | | |
| 441732115372001 | 11N- 7E-16AAB1S | 8- 8-79 | 65 | 84 | - | - | 91 | - |
| 442403115491001 | 12N- 5E- 2DAC1S | 7- 8-79 | 50 | 86 | 55 | - | 81 | 119 |
| 442150115512201 | 12N- 5E-22BBC1S | 6- 5-79 | 86 | 101 | - | - | - | - |
| 442500116015501 | 13N- 4E-31CAB1S | 6-26-79 | 71 | 91 | - | - | - | - |
| 442548115454401 | 13N- 6E-29DAB1S | 7- 7-79 | 53 | 77 | - | - | - | - |
| 444032115563401 | 16N- 4E-35CCB1S | 6-27-79 | 50 | 68 | - | - | - | - |
| 451510115532901 | 11N- 5E-29CDB1S | 8- 8-79 | 49 | 107 | 77 | - | - | - |
| | | Washington County | | | | | | |
| 441810116450101 | 11N- 3W- 7CCB1S | 10- 1-73 | 77 | 172 | 150 | 163 | - | 159 |
| 441823116444101 | 11N- 3W- 7BDB1S | 8- 2-72 | 92 | 169 | 146 | - | - | - |
| 441755117025801 | 11N- 6W-10CCA1 | 8- 2-73 | 71 | 104 | 75 | - | - | - |

$1^{-10}$ TU. Large quantities of tritium are produced artificially by nuclear devices, and atmospheric testing of hydrogen bombs during the early 1950's through 1962 raised the tritium level in precipitation to many times its natural level. During the 1950's, levels were in the range of several hundred TU, well above natural levels. Tritium levels peaked in the spring of 1963 in the northern hemisphere at more than 2,500 TU. Since then, they have decreased about 30 percent per year. Detection of tritium in water can give useful information about the length of time the water has been out of contact with the atmosphere and, thus, its age. In the Snake River basin geothermal system, tritium is most useful in identifying mixing of young water with older geothermal water. Tritium concentrations in some geothermal water are given in table 23C.

Results of radioisotope measurements of tritium are expressed with a statistical-error term corresponding to one standard deviation. Of the 16 geothermal wells sampled for tritium, 13 have values so low that they may, within a 95-percent confidence level (that is, 2 standard deviations), contain no tritium. Therefore, geothermal water may be older than 120 years, or 10 half-lives of tritium, the practical limit of detection. Four other samples of geothermal water contain some tritium, but the maximum is 4.1 TU. This low value indicates that the water is young or is mixed with younger water. Nongeothermal water has TU values from 7.8 to 95, which indicates that a large proportion of the water was recharged within the last 30 years (table 22C).

Tritium analyses indicate that most of the geothermal water is older than 120 years, even though some samples include a small proportion of water of recent origin. The tritium may have entered the nongeothermal system locally as geothermal water ascended from depth and mixed with younger water.

## DATING GEOTHERMAL WATER BY THE CARBON-14 METHOD

Management of a geothermal resource generally requires knowledge about the residence time of water in the geothermal reservoir. Long residence times in a fractured rock aquifer of limited areal extent suggest a low water flux and, thus, a small resource. Conversely, a short residence time in a large aquifer system suggests a larger flux and, thus, a larger resource. One method to determine residence time of water in an artesian aquifer is to analyze the water for the amount of dissolved radioactive carbon.

The naturally occurring radioisotope $^{14}C$ (carbon-14) is formed by cosmic-ray reactions in the upper atmosphere and has a half-life of about 5,730 years. Prior to detonation of nuclear devices, $^{14}C$ was virtually at a constant concentration in atmospheric $CO_2$ and, consequently, soil $CO_2$ was in equilibrium with $^{14}C$ in the atmosphere. Thus, $^{14}C$ is dissolved in recharge water. After water and solutes were isolated from the atmospheric source of $^{14}C$, measurement of the remaining $^{14}C$ indicates the length of time the water has been out of contact with the atmosphere and, thus, indicates residence time in the artesian aquifer if no other carbon is added or removed from solution. The equation for dating by radioactive decay is

$$t = (5{,}730/\log 2) \log (N_{sample}/N_{std}) \quad (10)$$

where $t$ is age of sample, in years; $N_{sample}$ is $^{14}C$ in water (percent modern); and $N_{std}$ is $^{14}C$ 100 percent modern.

In natural aquifer systems, the potential exists for the addition of carbon by dissolution of the aquifer framework and removal of carbon from solution by mineral precipitation. Therefore, adjustment of the measured $^{14}C$ values for the addition and removal of carbon is usually necessary. The procedure used in this report for dating residence time of water is (1) definition of a conceptual hydrologic model from recharge to discharge, and (2) development of a conceptual chemical model that considers controls on dissolved carbon and isotopic composition along a flowpath.

The conceptual hydrologic model developed earlier for the geochemistry discussion (fig. 27) is used in this analysis. Water from local precipitation recharges the unconfined aquifer. The water then moves downgradient, becomes confined, and ultimately discharges to the Snake River. The corresponding chemical-reaction model previously developed consists of two parts. (1) Water recharged through the unsaturated zone dissolves $^{14}CO_2$ from the soil atmosphere and forms $H_2{}^{14}CO_3$, $H^{14}CO_3{}^-$, and $^{14}CO_3{}^{-2}$ ions. The carbon species then become isolated from the atmosphere, and the amount of $^{14}C$ declines with time by decay. (2) As the water moves into the artesian aquifer, ion exchange removes calcium from solution, shifting the calcite equilibrium to undersaturation and dissolving isotopically dead calcite. This solution of calcite causes a significant increase of total carbon in solution and dilutes the remaining $^{14}C$. The plausibility of this model is demonstrated by comparing a calculated $\delta^{13}C$ of the aquifer framework with the observed value. If the calculated and observed values agree within one standard deviation, the model is assumed to represent the system, and meaningful radiocarbon dates can be obtained.

Two major assumptions are made in using the conceptual model. (1) The springs represent recharge water and all carbon present is derived from soil $CO_2$. That is, the $\delta^{13}C$ of the water reflects the $\delta^{13}C$ of plant $CO_2$ in the area. The $\delta^{13}C$ of total inorganic carbon in individual springs is assumed to be representative of soil $CO_2$ in these environments. As stated earlier, most of the alkaline earths in solution at this stage of solute evolution are derived from the weathering of silicates, rather than from carbonate minerals. (2) The $\delta^{13}C$ from caliche and other sedimentary carbonate in a vertical soil profile near Arco is assumed to be representative of basinwide values. Rightmire (1983) observed that the $\delta^{13}C$ of caliche near Arco averages $-4$ permil with a standard deviation of 3.1 permil. The model is assumed to adequately represent the system if calculated $\delta^{13}C$ values of caliche fall within $\pm 3.1$ of the observed $\delta^{13}C$ of $-4$ permil.

To illustrate the procedure, water from Antelope Springs (14S-14E-11CAB1S) with a $\delta^{13}C$ of −12.9 permil (table 22C) and a concentration of 0.622 millimoles of carbon is assumed to be typical of recharge water to the Sligar well (8S-14E-30ACD2) about 55 km downgradient. The Sligar well has a $\delta^{13}C$ of −7 permil, 1.830 millimoles of carbon, and a $^{14}C$ activity of 4.0 percent modern (table 23C). To verify the model of this system, the $\delta^{13}C$ of the inorganic carbon added between recharge and discharge was calculated and compared to a measured caliche $\delta^{13}C$ of −4 permil. The difference in total carbon between recharge and discharge zones is 1.207 millimoles. The carbon and its isotopic ratio in the Sligar well, or discharge zone, are a result of carbon in the recharge source (Antelope Springs), plus the carbon derived from the dissolved aquifer framework. Adapting equation 10 and solving for the $\delta^{13}C$ of the aquifer framework,

$$(-7.0)(1.830) = (-12.9)(0.622) + (\delta^{13}C)_{AF}(1.207),$$

$$(\delta^{13}C)_{AF} = -3.96 \qquad (11)$$

Because the calculated value (−3.96 permil) is nearly identical to the observed value (−4 permil), the conceptual model of the system is accepted. In the above calculation, the use of $\delta^{13}C$ of marine limestone, which is known to be present in the interbeds, rather than caliche, changes the precision of the observed fit between observed and calculated values but does not change acceptance of the model.

Ion exchange may remove $Ca^{+2}$ and $Mg^{+2}$ from the geothermal water. Thus, any carbonate minerals encountered between the recharge area (Antelope Springs) and the discharge area (Sligar well) will dissolve, raising the total carbon in solution. Carbon content increased from 0.622 millimoles at Antelope Springs to 1.830 millimoles at the Sligar well. The dilution factor 2.94 is used to adjust the carbon content to a true percent modern $\delta^{14}C$ of 11.8 percent. The residence time of the water is then calculated:

$$t = (5{,}730/\log 2) \log (11.8/100) \qquad (12)$$

yielding a residence time of about 17,700 years.

Similar calculations were made using recharge water from Summit Springs (8S-1E-20CCA1S) and discharge from the King well (4S-1E-34BAD1), a distance of 40 km. Results indicate a residence time of about 18,000 years. Between Pole Creek Spring (46N-59E-13AAC1S) and the Bybee well (5S-3E-26BCB1), a distance of 140 km, a residence time of about 20,300 years is indicated. Residence times vary depending largely on calculation of the dilution factor based on $\delta^{13}C$ and analytical determination of $^{14}C$ in the water sample. Samples analyzed have a maximum analytical error of ±2,000 years. It is difficult to assign an error associated with the dilution factor, but if the average carbon concentration of the four springs were used in the above analysis rather than individual values, the average calculated date would change by about 2,000 years. Thus, it is assumed that reported residence times in this system may vary from the true value by as much as ±4,000 years.

Water from the Snell well (14S-15E-14CDB1) exhibited a cool temperature (32.0 °C) and a large amount of modern carbon (55.6 percent). These features indicate mixing of geothermal water with the overlying cold-water system; consequently, no attempt was made to date the residence time of water from this well.

Several points concerning calculation of water residence time in this system should be addressed in more detail. It is assumed that the $\delta^{13}C$ from plants has not changed significantly during the last 20,000 years. It is also assumed that temperature and precipitation changes during late Pleistocene and Holocene have not affected $\delta^{13}C$ content of the plant community. This assumption is supported by the $\delta^{13}C$ of the caliche evaluated by Rightmire (1983). If caliche were to form in equilibrium with soil $CO_2$ with a $\delta^{13}C$ of −14 permil, the expected value would be about −4 permil (Emrich and others, 1970, p. 367). Because the average caliche is −4 permil, it appears that the average $\delta^{13}C$ of the soil $CO_2$ had not changed significantly when the 5 m of caliche studied by Rightmire (1983) was deposited. Consequently, environmental conditions and plants 20,000 years ago must have been similar to modern ones.

Another factor that should be addressed is the potential for isotopic exchange in geothermal water between the $^{14}C$ in solution and carbonate minerals in the aquifer framework. Isotopic exchange would have a diluting effect by removing $^{14}C$ from the aqueous phase, giving the appearance of old age. A small amount of oxygen-isotopic exchange may have occurred in these geothermal waters (fig. 30), and it might be expected that carbon may also exchange. However, any isotopic exchange of $^{14}C$ also would involve $^{13}C$ and $^{12}C$ and, consequently, would affect the reaction model. The calculated value of $\delta^{13}C$ of carbonate would not be close to the observed value if significant carbon-isotopic exchanges were occurring in the system. Thus, no significant exchange of $^{14}C$ is presumed to have occurred.

The assumption that little or no carbon dioxide from deep within the earth has been added to the system is based on the lack of any unusually high partial pressure of carbon dioxide in the water. Some hydrogen sulfide and an equivalent amount of bicarbonate may have been added by sulfate reducing bacteria. This process is assumed to add only a few milligrams per liter bicarbonate because little hydrogen sulfide is produced and is ignored in the isotopic calculations. Wells sampled from volcanic sources contain little or no methane (Young and Whitehead, 1975b, p. 41); thus, no correction for carbon from this source was considered necessary.

## SUMMARY AND CONCLUSIONS

Four independent geochemical techniques were used to quantify the solute chemistry of the eastern Snake River Plain regional aquifer system: (1) calculation of a regional solute balance within the aquifer, (2) identification of mineralogy in the aquifer framework to compare with the postulated mineralogy, (3) comparison of thermodynamic mineral saturation indices with plausible solute reactions, and (4) comparison of stable-isotope ratios of the ground water with those in the aquifer framework. Because each of these techniques gave consistent results, it is assumed that the proposed reactions realistically reflect the solute geochemistry of the system.

Because of the difficulty of defining chemical steady state and lack of well-defined output of ground water, no detailed chemical reactions were defined for the western plain. However, it is reasonable to assume that the equations developed for solute control in the eastern plain are generally applicable for the western plain.

Examination of the mineralogy by petrographic, scanning electron microscope, and energy dispersive X-ray fluorescence techniques identified major primary and alteration minerals in two major lithologies that constitute the aquifer framework. From these examinations and from reported mineralogy, probable equations were written for precipitation of calcite and silica, weathering of olivine, pyroxene, pyrite, anhydrite, and plagioclase. These proposed reactions were compared with saturation indices of the ground water to ensure that the minerals proposed to be dissolving were thermodynamically undersaturated and that water was in equilibrium or was saturated with respect to minerals proposed as precipitating. The proposed reactions were evaluated by the stable isotopes $\delta^{13}C$ and $\delta^{34}S$. Favorable comparison of the calculated $\delta^{13}C$ of $-10.8$ permil of carbon in ground water with the observed $\delta^{13}C$ of $-11.1$ permil suggests that the proposed carbonate reactions are consistent with isotopic constraints. The relative proportion of sulfur from each source was calculated by assuming that sulfate originated from oxidation of pyrite ($\delta^{34}S = -8$ permil) and anhydrite (gypsum) ($\delta^{34}S = +15$ permil).

About 20 percent of the total solute load leaving the eastern plain is derived from weathering of the aquifer framework. The remainder is introduced from tributary drainage basins; thus, the solute load in the Snake River Plain regional aquifer system is sensitive to input from tributary drainage basins. Mass-balance calculations indicate precipitation of calcite and silica, which is consistent with the observed secondary deposits of these products filling vesicles in the basalt. The sources of sodium, chloride, and sulfate are believed to be from fluid inclusions and flushing of grain boundaries and pores of detrital marine sediments in interbeds.

Minor and trace solute concentrations, although composing less than 5 percent of the total dissolved solids, are an important consideration with respect to water use. Concentrations of lithium, strontium, and nitrite plus nitrate as nitrogen probably are controlled by their availability in the aquifer framework. Concentrations of barium, fluoride, lead, iron, and manganese appear to be controlled by mineral precipitation. Beryllium, cadmium, chromium, cobalt, copper, molybdenum, and vanadium also may be controlled by mineral precipitation.

The effects of human activities on solute concentrations and isotope ratios in specific areas were identified by solute concentrations and isotopes along several flowpaths that traversed irrigated areas. Evapotranspiration of irrigation water appears to have enriched the $\delta^{2}H$ and $\delta^{18}O$ of the ground water in irrigated areas and to have slightly increased the concentrations of calcium and bicarbonate. The data indicate that total dissolved solids in Blue Lakes Spring, which has experienced a large increase in discharge, have increased with time. However, the effects of irrigation on solute concentrations are small because of the chemical similarity of irrigation water with that present naturally in the aquifer, rapid ground-water movement, and large dispersivity of the aquifer.

Silica and Na–K–Ca geothermometers were used to evaluate water samples from 79 wells and springs from a large area underlying the cold-water system. The geothermometers suggest that the geothermal system is regionally extensive; approximately one-half of the silica-quartz water temperatures were greater than 90 °C. Dissolved solute concentrations from the geothermal system are similar to those from the overlying Snake River Plain regional aquifer system. The reaction-controlling solutes in the geothermal system are assumed to be similar to reactions in the cold-water system, except that ion-exchange processes combined with increased temperature and hydrolysis reaction increased sodium, bicarbonate, silica, and pH and decreased calcium and magnesium concentrations relative to the Snake River Plain regional aquifer system. The pH of the water probably is controlled by the silica dissociation reaction and is maintained between 9 and 9.5 in the system. The presence of hydrogen sulfide and hydroxide prevents increases in concentrations of many solutes from insoluble sulfide and hydroxide minerals. Fluoride concentration appears to be controlled by thermodynamic saturation with the mineral fluorite, whereas silica concentration appears to be controlled by precipitation of quartz.

Dating of geothermal water in the Salmon Falls River basin by $^{14}C$ methods adjusted for carbonate solution suggests that the residence time is about 17,700 years. Isotopes of oxygen and hydrogen in the geothermal water indicate that the water is of local origin. Lighter values of $\delta^2H$, compared with $\delta^2H$ in the cold water, were observed in several geothermal samples and may indicate that water recharged the geothermal system during a cooler climate in the past.

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# TABLES 20–23

ABBREVIATIONS AND REPORTING UNITS FOR CHEMICAL CONSTITUENTS AND NOTATIONS USED IN TABLES

| | |
|---|---|
| Al | Aluminum, in micrograms per liter |
| As | Arsenic, in micrograms per liter |
| B | Boron, in micrograms per liter |
| Ba | Barium, in micrograms per liter |
| Be | Beryllium, in micrograms per liter |
| $\delta^{13}C$ | Carbon-13/carbon-12 ratio, in permil PDB (*Belemnitella americana*, Cretaceous Peedee Formation of South Carolina) |
| $^{14}C$ | Carbon-14, in uncorrected percent modern |
| Ca | Calcium, in milligrams per liter |
| Cd | Cadmium, in micrograms per liter |
| Cl | Chloride, in milligrams per liter |
| Co | Cobalt, in micrograms per liter |
| $CO_2$ | Carbon dioxide, in milligrams per liter |
| $CO_3$ | Carbonate, in milligrams per liter |
| Cr | Chromium, in micrograms per liter |
| Cu | Copper, in micrograms per liter |
| DO | Dissolved oxygen, in milligrams per liter |
| DS | Dissolved solids, in milligrams per liter |
| Eh | Oxidation-reduction potential, in millivolts |
| F | Fluoride, in milligrams per liter |
| Fe | Iron, in micrograms per liter |
| $\delta^{2}H$ | Deuterium/hydrogen ratio, in permil V-SMOW (Vienna–Standard Mean Ocean Water) |
| $^{3}H$ | Tritium, in tritium units |
| $HCO_3$ | Bicarbonate, in milligrams per liter |
| Hg | Mercury, in micrograms per liter |
| K | Potassium, in milligrams per liter |
| Li | Lithium, in micrograms per liter |
| Log IAP/KT | Logarithm (ion activity product)/(equilibrium constant)(temperature) |
| Mg | Magnesium, in milligrams per liter |
| Mn | Manganese, in micrograms per liter |
| Mo | Molybdenum, in micrograms per liter |
| Na | Sodium, in milligrams per liter |
| $NO_3$ | Nitrate, in milligrams per liter |
| $\delta^{18}O$ | Oxygen-18/oxygen-16 ratio, in permil V–SMOW |
| P | Phosphorus, in milligrams per liter |
| Pb | Lead, in micrograms per liter |
| Q | Water discharge, in cubic meters per second |
| $\delta^{34}S$ | Sulfur-34/sulfur-32 ratio, in permil CD (Canyon Diablo meteorite standard) |
| $SiO_2$ | Silica, in milligrams per liter |
| $SO_4$ | Sulfate, in milligrams per liter |
| Sr | Strontium, in micrograms per liter |
| Ti | Titanium, in micrograms per liter |
| V | Vanadium, in micrograms per liter |
| WT | Water temperature, in degrees Celsius |
| Zn | Zinc, in micrograms per liter |
| – | No data available |

TABLE 20A.—*Concentrations of major dissolved solutes in ground water, Snake River Plain*

[Analyses selected from the 90th percentile of 1,123 analyses (907 analyses) with water temperatures less than 26 °C and ±3 percent cation/anion balance]

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ada County | | | | | | | | | | | | | | | | |
| 430524116110701 | 4S- 2E-11CAA1S | 8-19-76 | 19.0 | 7.8 | - | 22 | 5.7 | 20 | 5.7 | 140 | 0 | 4.9 | 9.9 | 0.4 | 43 | 0.25 |
| 431749116244501 | 1S- 1W-36BBC1 | 8- 4-76 | 23.0 | 8.1 | - | 19 | 5.7 | 54 | 4.6 | 110 | 0 | 20 | 62 | .5 | 32 | 3.20 |
| 431848116295001 | 1S- 1W-30AAB1 | 5-22-81 | 23.5 | 8.3 | 1.4 | 9.5 | 1.9 | 49 | 2.8 | 150 | 0 | 5.9 | 22 | .4 | 28 | .03 |
| 432045115593001 | 1S- 4E- 9CCC1 | 5- 5-65 | 21.0 | 7.7 | - | 23 | 5.4 | 20 | 2.7 | 130 | 0 | 4.5 | 12 | .4 | 37 | - |
| 432304115572601 | 1N- 4E-32AAB1 | 8- 3-76 | 21.0 | 7.5 | - | 22 | 4.9 | 15 | 2.0 | 120 | 0 | 3.6 | 8.2 | .3 | 46 | .31 |
| 432336116164601 | 1N- 1E-25DBA1 | 8- 2-76 | 25.0 | 7.9 | - | 17 | 2.6 | 30 | 2.3 | 120 | 0 | 6.8 | 15 | .4 | 38 | .76 |
| 432732116123401 | 2N- 2E-34CCD1 | 8- 3-76 | 22.5 | 8.2 | - | 17 | 1.0 | 61 | 1.1 | 130 | 0 | 24 | 35 | .8 | 21 | 2.30 |
| 432735116265301 | 2N- 1W-34CCD1 | 5-28-81 | 25.0 | 8.0 | 4.3 | 15 | 1.1 | 39 | 2.0 | 130 | 0 | 6.7 | 15 | .4 | 31 | .00 |
| 433032116092201 | 2N- 2E-13DAB1 | 11- 5-81 | 14.5 | 7.0 | - | 21 | 4.8 | 18 | 1.3 | 110 | 0 | 6.9 | 9.0 | .3 | 38 | 2.30 |
| 433212116195901 | 2N- 1E- 3CBC1 | 10-27-81 | 13.5 | 7.5 | - | 48 | 11 | 100 | 1.1 | 370 | 0 | 9.8 | 70 | .6 | 29 | 3.20 |
| 433218116135301 | 2N- 2E- 4CBB1 | 11- 2-81 | 16.0 | 7.2 | - | 33 | 8.9 | 25 | 1.6 | 140 | 0 | 13 | 46 | .3 | 33 | 1.20 |
| 433313116083901 | 3N- 3E-31BDD1 | 5-29-81 | 21.5 | 8.2 | 2.8 | 15 | .6 | 28 | 1.6 | 100 | 0 | 5.6 | 15 | .8 | 26 | .43 |
| 433328116094201 | 3N- 2E-36ABC1 | 7-29-77 | 21.5 | 7.3 | - | 19 | .8 | 22 | 1.1 | 95 | 0 | 5.9 | 14 | .5 | 23 | .28 |
| 433407116233801 | 3N- 1W-25ADD1 | 8-25-77 | 21.0 | 7.0 | - | 89 | 20 | 58 | 2.7 | 310 | 0 | 26 | 140 | .3 | 32 | 3.10 |
| 433507116092801 | 3N- 2E-24ACA1 | 8- 6-81 | 25.0 | 7.3 | - | 15 | 1.6 | 28 | 2.1 | 95 | 0 | 5.3 | 22 | 1.7 | 42 | .28 |
| 433736116190501 | 3N- 1E- 3ADC1 | 5-28-81 | 20.5 | 7.4 | .5 | 17 | 2.8 | 15 | 2.0 | 100 | 0 | 1.5 | 6.4 | .3 | 51 | .02 |
| 433838116192301 | 4N- 1E-34ACB1 | 8-18-81 | 13.0 | 7.2 | - | 50 | 16 | 65 | 1.9 | 380 | 0 | 5.1 | 16 | .5 | 34 | 1.60 |
| 433856116113001 | 4N- 2E-26CCC1 | 8-10-81 | 20.0 | 7.8 | - | 68 | 3.4 | 21 | 2.1 | 170 | 0 | 3.2 | 81 | .4 | 31 | .00 |
| 433946116161401 | 4N- 2E-19CCC1 | 8- 7-81 | 15.0 | 7.2 | - | 26 | 4.2 | 14 | 1.4 | 130 | 0 | 1.3 | 8.0 | .4 | 31 | .01 |
| 434048116235101 | 4N- 1W-13DDB1 | 8-13-81 | 12.5 | 7.1 | - | 56 | 8.0 | 18 | 1.9 | 190 | 0 | 10 | 45 | .2 | 27 | 1.60 |
| 434406116240801 | 5N- 1W-36ABB1 | 8-10-81 | 14.0 | 7.5 | - | 31 | 7.1 | 35 | 1.1 | 190 | 0 | 5.3 | 15 | .5 | 48 | 1.30 |
| Bannock County | | | | | | | | | | | | | | | | |
| 425456112305501 | 6S-34E- 7ADA1 | 12-11-80 | 13.0 | 7.7 | - | 65 | 25 | 57 | 7.2 | 370 | 0 | 28 | 49 | .2 | 34 | 3.10 |
| 425539112305601 | 6S-34E- 6DAA1 | 12-12-80 | 10.0 | 7.7 | - | 58 | 32 | 43 | 7.5 | 360 | 0 | 20 | 49 | .3 | 31 | 2.10 |
| 425626112302601 | 6S-34E- 5CAC1 | 7-14-76 | 14.0 | 7.5 | - | 50 | 31 | 49 | 7.0 | 370 | 0 | 16 | 44 | .4 | 30 | 2.40 |
| 425740112313501 | 5S-34E-30BAD1 | 7-13-76 | 13.0 | 7.5 | - | 49 | 15 | 17 | 3.3 | 190 | 0 | 20 | 38 | .8 | 26 | .74 |
| 425925112264301 | 5S-34E-14ABC1 | 7-13-76 | 14.0 | 7.5 | - | 81 | 28 | 29 | 5.5 | 370 | 0 | 20 | 53 | .2 | 39 | 2.80 |
| Bingham County | | | | | | | | | | | | | | | | |
| 425254112574201 | 6S-30E-21CAC1 | 9- 3-70 | 11.5 | 7.7 | - | 42 | 15 | 18 | 4 | 170 | 0 | 19 | 35 | .7 | 28 | - |
| 425611112500701 | 5S-31E-33ACC1 | 9-14-66 | 12.0 | 8.0 | - | 56 | 18 | 29 | 4.1 | 170 | 0 | 33 | 86 | .1 | 24 | - |
| 425928112562701 | 5S-30E-15BAC1 | 9- 2-70 | 13.0 | 7.9 | - | 33 | 12 | 17 | 4.0 | 160 | 0 | 13 | 25 | .8 | 30 | - |
| 430205112372001 | 4S-33E-32ABA1S | 12-10-80 | 11.0 | 7.2 | - | 56 | 25 | 55 | 6.9 | 270 | 0 | 63 | 78 | .7 | 30 | 2.10 |
| 430349112342101 | 4S-33E-23BBA1S | 12-10-80 | 11.0 | 7.6 | - | 61 | 23 | 36 | 6.4 | 290 | 0 | 44 | 64 | .7 | 29 | 2.30 |
| 430539112402301 | 4S-32E-11AAC1S | 12-10-80 | 11.0 | 7.9 | - | 60 | 22 | 31 | 5.1 | 240 | 0 | 43 | 64 | .6 | 28 | 1.30 |
| 430545112361501 | 4S-33E- 4CDD1 | 9- 4-70 | 11.5 | 7.6 | - | 65 | 31 | 57 | 7.0 | 330 | 0 | 48 | 66 | .7 | 31 | - |
| 430608112301901 | 4S-34E- 5CAA1S | 12-10-80 | 10.5 | 7.6 | - | 57 | 13 | 13 | 3.1 | 230 | 0 | 10 | 34 | .7 | 29 | .68 |
| 430608112515401 | 4S-31E- 5CBC1 | 9- 8-70 | 11.0 | 7.8 | - | 46 | 16 | 23 | 4.0 | 180 | 0 | 23 | 43 | .7 | 30 | - |
| 430611112322000 | 4S-33E- 1ADC1S | 12-10-80 | 11.0 | 7.6 | - | 63 | 27 | 49 | 6.8 | 280 | 0 | 61 | 75 | .7 | 31 | 2.50 |
| 430754112314401 | 3S-34E-30CAB1 | 9- 4-70 | 11.5 | 7.7 | - | 64 | 18 | 22 | 4.0 | 260 | 0 | 17 | 40 | .6 | 25 | - |
| 431052112211101 | 3S-35E-10BBA1 | 4- 6-78 | 13.0 | 7.1 | - | 77 | 25 | 18 | 4.3 | 300 | 0 | 23 | 46 | .4 | 26 | 3.30 |
| 431421112383501 | 2S-33E-19ABC1 | 9- 9-70 | 9.5 | 7.8 | - | 64 | 20 | 22 | 5 | 240 | 0 | 24 | 55 | .4 | 25 | - |
| 431516112300001 | 2S-34E-17ABA1 | 9- 9-70 | 10.5 | 7.7 | - | 69 | 19 | 29 | 6.0 | 270 | 0 | 33 | 52 | .6 | 24 | - |
| 431857112405501 | 1S-32E-23CDA1 | 7- 8-81 | 13.0 | 7.9 | 8.9 | 44 | 15 | 21 | 3.6 | 190 | 0 | 20 | 43 | .7 | 34 | .92 |
| 431907112560201 | 1S-30E-22DBD1 | 6- 5-78 | 17.0 | 7.6 | - | 36 | 14 | 17 | 2.5 | 160 | 0 | 21 | 20 | 1.0 | 30 | 1.10 |
| 433546112391601 | 3N-32E-13BBD2 | 8-20-68 | 13.0 | 7.6 | - | 31 | 11 | 17 | 2.9 | 150 | 0 | 14 | 13 | .7 | 34 | - |
| Blaine County | | | | | | | | | | | | | | | | |
| 425048113212901 | 7S-26E- 1ABD1 | 9-13-66 | 14.5 | 8.1 | - | 32 | 11 | 16 | 2.8 | 160 | 0 | 10 | 21 | .8 | 28 | - |
| 431932113571501 | 1S-21E-22BCC1 | 6- 4-81 | 11.0 | 7.2 | 8.8 | 48 | 12 | 6.6 | 1.6 | 210 | 0 | 3.2 | 14 | .1 | 17 | .73 |
| 431952114164601 | 1S-18E-14DDC1 | 6- 3-81 | 11.0 | 7.5 | 9.6 | 47 | 9.3 | 4.8 | 1.0 | 180 | 0 | 1.5 | 17 | .2 | 16 | .91 |
| Bonneville County | | | | | | | | | | | | | | | | |
| 432623112031001 | 1N-37E- 1DCC1 | 12- 7-79 | 12.0 | 7.5 | - | 72 | 23 | 17 | 4.4 | 340 | 0 | 10 | 37 | .2 | 28 | 2.80 |
| 432838111582001 | 2N-38E-27ACB1 | 12- 5-79 | 12.0 | 7.6 | - | 69 | 21 | 26 | 4.6 | 290 | 0 | 24 | 42 | .2 | 30 | 2.00 |
| 432856112060801 | 2N-37E-28AAA1 | 8-16-77 | 15.0 | 7.6 | - | 73 | 20 | 18 | 3.6 | 290 | 0 | 11 | 41 | .3 | 20 | 1.90 |
| 433107112011401 | 2N-38E- 8CBB1 | 11-30-79 | 10.0 | 7.8 | - | 69 | 18 | 14 | 3.1 | 280 | 0 | 10 | 43 | .2 | 21 | 1.90 |
| 433114112132401 | 2N-36E- 9ADA1 | 9-19-79 | 13.0 | 7.6 | - | 56 | 19 | 18 | 3.4 | 230 | 0 | 19 | 56 | .4 | 25 | .91 |
| 433233111574301 | 3N-38E-35CCB1 | 12- 5-79 | 14.0 | 7.6 | - | 79 | 21 | 19 | 3.5 | 320 | 0 | 14 | 39 | .2 | 24 | 2.00 |
| 433428111381601 | 3N-41E-23CAA1 | 6- 9-81 | 14.5 | 7.5 | 7.5 | 36 | 10 | 8.7 | 3.3 | 160 | 0 | 12 | 7.2 | .2 | 53 | .80 |
| 433534112111401 | 3N-36E-14ACA1 | 9-10-70 | 10.0 | 7.8 | - | 62 | 17 | 17 | 4.0 | 230 | 0 | 13 | 47 | .4 | 20 | - |
| 433536111550501 | 3N-39E-18BDB1 | 11-28-79 | 9.5 | 7.9 | - | 68 | 18 | 9.9 | 3.1 | 280 | 0 | 9.7 | 39 | .2 | 19 | 1.70 |
| 433733112035301 | 3N-37E- 2AAA1 | 11- 9-79 | 12.0 | 7.5 | - | 64 | 15 | 11 | 2.8 | 230 | 0 | 9.3 | 40 | .4 | 16 | 1.20 |

TABLE 20A.—*Concentrations of major dissolved solutes in ground water, Snake River Plain*—Continued

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Butte County | | | | | | | | | | | |
| 432424113165401 | 1N-27E-22ACB1 | 9-29-77 | - | 7.4 | - | 36 | 13 | 8.4 | 2.1 | 150 | 0 | 9.6 | 18 | 0.2 | 26 | 0.50 |
| 432735113351601 | 2N-24E-27BDB1 | 7- 7-81 | 8.0 | 7.0 | - | 48 | 7.2 | 7.5 | 1.8 | 180 | 0 | 6.0 | 12 | .3 | 18 | .10 |
| 432954113020501 | 2N-29E-17CBC1 | 11-20-72 | 11.5 | 7.7 | - | 37 | 14 | 24 | 3.0 | 170 | 0 | 36 | 23 | .3 | 28 | .61 |
| 433013113043001 | 2N-28E-13BCB1 | 11-20-72 | 12.0 | 7.7 | - | 28 | 12 | 37 | 5.2 | 140 | 0 | 35 | 42 | .3 | 31 | 1.20 |
| 433121113115801 | 2N-27E- 2DDC1 | 6- 8-65 | 11.0 | 7.8 | - | 45 | 14 | 6.4 | 1.7 | 180 | 0 | 9.0 | 22 | .3 | 19 | - |
| 433252112520301 | 3N-30E-34BAD1 | 9- 6-77 | - | 8.0 | - | 39 | 13 | 12 | 2.6 | 170 | 0 | 16 | 20 | .3 | 27 | - |
| 433320112432301 | 3N-32E-29DDC1 | 6- 7-65 | 13.5 | 7.7 | - | 27 | 9.9 | 15 | 3.1 | 140 | 0 | 10 | 11 | .8 | 22 | - |
| 433423113031901 | 3N-29E-19CBB1 | 9- 6-77 | 18.0 | 8.0 | - | 30 | 11 | 24 | 5.7 | 75 | 0 | 71 | 19 | .2 | 12 | - |
| 433433112560201 | 3N-30E-19BCB1 | 9- 5-77 | - | 8.0 | - | 46 | 13 | 8.2 | 2.5 | 190 | 0 | 10 | 22 | .3 | 23 | - |
| 433517113190001 | 3N-26E-14DAA1 | 7- 7-81 | 11.0 | 7.7 | 8.8 | 59 | 12 | 18 | 1.5 | 230 | 0 | 11 | 12 | .2 | 19 | 1.60 |
| 433655113174501 | 3N-26E- 1DAA1 | 9-12-78 | 12.0 | 7.8 | - | 63 | 13 | 5.6 | 1.2 | 240 | 0 | 5.7 | 20 | .2 | 14 | 1.40 |
| 433742113165601 | 4N-27E-31DBD1 | 11- 3-78 | 12.5 | 7.4 | - | 60 | 14 | 20 | 2.4 | 260 | 0 | 10 | 35 | .2 | 20 | 4.70 |
| 433758113181701 | 4N-26E-36ACB1 | 6- 4-81 | 9.5 | 7.9 | 7.3 | 58 | 14 | 5.5 | 1.1 | 230 | 0 | 5.1 | 23 | .1 | 14 | .98 |
| 433858112545501 | 4N-30E-30AAD2 | 8-20-68 | 13.0 | 7.7 | - | 66 | 21 | 16 | 2.0 | 230 | 0 | 42 | 37 | .2 | 25 | - |
| 433908113203101 | 4N-26E-27ABA1 | 8-10-78 | 11.0 | 7.6 | - | 73 | 14 | 7.2 | 1.4 | 260 | 0 | 5.0 | 21 | .2 | 14 | .75 |
| 434334112463101 | 5N-31E-28CCC1 | 9- 7-77 | 16.5 | 8.0 | - | 33 | 13 | 15 | 3.2 | 160 | 0 | 12 | 22 | .5 | 31 | - |
| 434430112575901 | 5N-29E-23CDD1 | 9- 6-77 | 17.0 | 7.8 | - | 47 | 17 | 11 | 1.7 | 210 | 0 | 14 | 25 | .2 | 15 | - |
| 434558112444801 | 5N-31E-15BAD1 | 9- 8-78 | 19.5 | 8.6 | - | 26 | 7.8 | 39 | 4.7 | 180 | 0 | 10 | 24 | .7 | 9.2 | .56 |
| 434833112544901 | 6N-30E-31AAD1 | 7-21-78 | 10.0 | 7.4 | - | 38 | 16 | 6.8 | 1.3 | 200 | 0 | 7.9 | 16 | .1 | 18 | 1.20 |
| 434912112585701 | 6N-29E-27DBB1 | 7-20-78 | 10.5 | 7.3 | - | 70 | 27 | 37 | 1.8 | 310 | 0 | 41 | 43 | .1 | 17 | 2.80 |
| 434912113004601 | 6N-29E-28CBB1 | 8-31-57 | 9.5 | - | - | 56 | 19 | 18 | 1.4 | 250 | 0 | 16 | 25 | .1 | 19 | - |
| 434938112563401 | 6N-29E-25ABB1 | 7-20-78 | 9.5 | 7.2 | - | 64 | 27 | 62 | 1.8 | 330 | 0 | 28 | 61 | .1 | 19 | 4.50 |
| 434940113005001 | 6N-29E-20DDD1 | 6- 5-81 | 10.0 | 7.6 | 8.5 | 64 | 23 | 21 | 1.5 | 300 | 0 | 19 | 31 | .1 | 18 | 1.20 |
| 435120112432101 | 6N-31E-14ABB1 | 9- 7-77 | 11.0 | 8.1 | - | 50 | 15 | 7.5 | 2.7 | 180 | 0 | 16 | 33 | .2 | 22 | - |
| 435522112444201 | 7N-31E-22BDD1 | 9- 7-77 | 10.0 | 7.9 | - | 43 | 16 | 6.1 | 1.4 | 180 | 0 | 7.7 | 26 | .3 | 13 | - |
| | | | | | Canyon County | | | | | | | | | | | |
| 432029116355601 | 1S- 2W-17ACA1 | 9-15-78 | 21.0 | 7.6 | - | 19 | 3.0 | 110 | 11 | 360 | 0 | 14 | 2.8 | 4.7 | 82 | .10 |
| 432241116313001 | 1N- 2W-36CAA1 | 10- 6-77 | 25.0 | 8.2 | - | 9.1 | 2.3 | 88 | 3.8 | 200 | 0 | 17 | 34 | 1.4 | 42 | .40 |
| 432626116360601 | 1N- 2W- 8ACC1 | 10- 6-77 | 21.5 | 7.5 | - | 70 | 8.8 | 46 | 4.7 | 110 | 0 | 55 | 130 | .2 | 35 | 1.20 |
| 432919116403701 | 2N- 3W-22DDC1 | 8-17-81 | 18.0 | 7.8 | - | 40 | 8.8 | 55 | 5.4 | 170 | 0 | 20 | 100 | .5 | 56 | .44 |
| 433208116325001 | 2N- 2W- 2CBD1 | 10-23-81 | 14.5 | 7.5 | - | 54 | 21 | 64 | 5.6 | 280 | 0 | 15 | 110 | .5 | 46 | 3.80 |
| 433217116330501 | 2N- 2W- 2CBB1 | 10-23-81 | 14.0 | 7.4 | - | 52 | 22 | 67 | 4.6 | 290 | 0 | 18 | 110 | .6 | 51 | 3.30 |
| 433230116471801 | 2N- 4W- 2BCA2 | 12- 9-81 | 15.0 | 7.6 | - | 23 | 6.6 | 67 | 19 | 280 | 0 | 8.3 | 23 | 1.4 | 64 | .10 |
| 433409116331601 | 3N- 2W-27ADC1 | 10-28-81 | 23.5 | 7.6 | - | 16 | 4.0 | 30 | 2.5 | 130 | 0 | 6.0 | 9.0 | .9 | 38 | .32 |
| 433600116364001 | 3N- 2W-17BCB1 | 10-28-81 | 23.0 | 7.6 | - | 15 | 3.0 | 34 | 2.5 | 130 | 0 | 5.5 | 7.0 | 1.0 | 37 | .34 |
| 433711116392301 | 3N- 3W- 2DDC1 | 11- 6-81 | 15.0 | 7.7 | - | 60 | 13 | 38 | 4.9 | 230 | 0 | 21 | 69 | .2 | 43 | 2.60 |
| 433843116384301 | 4N- 3W-36BAC1 | 11-10-81 | 19.0 | 7.9 | - | 14 | 1.6 | 23 | 1.2 | 95 | 0 | 4.4 | 12 | .6 | 28 | .42 |
| 434014116353201 | 4N- 2W-21CBB1 | 8-17-81 | 14.0 | 7.3 | - | 58 | 14 | 32 | 2.4 | 180 | 0 | 26 | 85 | .1 | 31 | 1.10 |
| 434232116501001 | 4N- 4W- 5DDB1 | 10- 7-75 | 15.0 | 8.0 | - | 17 | 1.4 | 44 | 5.3 | 180 | 0 | 5.6 | 6.4 | 1.0 | 59 | .04 |
| 434627116461801 | 5N- 4W-13BCB1 | 11- 5-81 | 15.0 | 7.4 | - | 36 | 8.0 | 17 | 3.0 | 110 | 0 | 22 | 41 | .2 | 38 | .10 |
| 434646116425401 | 5N- 3W- 8DDC1 | 11- 9-81 | 14.0 | 6.9 | - | 110 | 24 | 55 | 4.9 | 210 | 0 | 97 | 190 | .1 | 40 | 1.80 |
| 434826116572401 | 5N- 5W- 5ABA1 | 11- 4-81 | 15.0 | 7.5 | - | 93 | 22 | 32 | 7.5 | 200 | 0 | 76 | 120 | .2 | 56 | .97 |
| | | | | | Cassia County | | | | | | | | | | | |
| 422109113592101 | 12S-21E-27BCC1 | 6-10-82 | 23.5 | 8.6 | - | 37 | 7.0 | 9.9 | 3.6 | 130 | 5 | 6.5 | 15 | .2 | 16 | .10 |
| 422319114032801 | 12S-20E-12DCC1 | 6- 9-82 | 25.0 | 7.8 | - | 38 | 4.8 | 13 | 6.4 | 150 | 0 | 9.8 | 14 | .3 | 64 | .24 |
| 422831113592401 | 11S-21E- 9DDD1 | 6-30-82 | 17.5 | 7.9 | - | 42 | 16 | 17 | 4.2 | 140 | 0 | 43 | 36 | .2 | 41 | 1.70 |
| 423550113140501 | 9S-27E-36ADD1 | 8-18-77 | 15.0 | 7.5 | - | 35 | 16 | 38 | 4.0 | 210 | 0 | 45 | 16 | .5 | 34 | .24 |
| | | | | | Clark County | | | | | | | | | | | |
| 440142112425501 | 8N-31E-14AAA1 | 6- 6-81 | 12.0 | 7.6 | 9.2 | 53 | 22 | 14 | 2.8 | 240 | 0 | 23 | 33 | 1.0 | 45 | .77 |
| 440847112303501 | 10N-34E-31CCD1 | 10-24-79 | 11.0 | 7.9 | - | 61 | 15 | 14 | 3.4 | 240 | 0 | 14 | 40 | .4 | 35 | 1.10 |
| 441038112134201 | 10N-36E-21CAC1 | 8-29-79 | 9.0 | 7.8 | - | 45 | 14 | 12 | 2.4 | 210 | 0 | 8.1 | 11 | .2 | 31 | .64 |
| 441258112222201 | 10N-35E- 8BBB1 | 8-31-79 | 10.0 | 7.6 | - | 68 | 19 | 9.7 | 2.7 | 270 | 0 | 6.9 | 43 | .3 | 21 | .87 |
| 441442112114801 | 11N-36E-34AAB1 | 8-30-79 | 12.0 | 7.7 | - | 46 | 12 | 8.9 | 1.9 | 200 | 0 | 6.3 | 10 | .2 | 26 | .59 |
| 441614111593801 | 11N-38E-20ADA1 | 8-29-79 | 16.0 | 8.0 | - | 30 | 11 | 7.7 | 2.5 | 150 | 0 | 4.6 | 4.5 | .2 | 37 | .62 |
| 442322111532401 | 12N-39E- 8BBB1 | 8-30-79 | 17.0 | 7.1 | - | 22 | 6.1 | 4.8 | 2.6 | 110 | 0 | 1.8 | 5.3 | .2 | 41 | .10 |
| 442335111532601 | 12N-39E- 5CCB1 | 6- 7-81 | 10.0 | 7.8 | .9 | 28 | 5.6 | 4.7 | 2.3 | 110 | 0 | 2.4 | 0.5 | .1 | 33 | .09 |
| 442343111474901 | 12N-39E- 1DBA1 | 6-12-75 | 10.0 | 7.4 | - | 11 | 5.9 | 4.3 | 2.0 | 70 | 0 | 2.6 | 4.3 | .1 | 33 | 1.30 |
| | | | | | Elmore County | | | | | | | | | | | |
| 420615115415301 | 4S- 6E- 2DAA1 | 5-27-81 | 19.0 | 8.1 | 7.8 | 14 | 6.6 | 10 | 2.6 | 95 | 0 | 3.0 | 6.9 | .1 | 39 | .57 |
| 425105115191801 | 6S-10E-31CCC1 | 6- 1-82 | 22.0 | 7.8 | - | 36 | 7.5 | 49 | 12 | 230 | 0 | 9.1 | 44 | 2.6 | 70 | .10 |
| 425648115293601 | 5S- 8E-34BDC2 | 9-12-80 | 17.0 | 7.7 | - | 37 | 15 | 75 | 11 | 290 | 0 | 21 | 67 | 2.6 | 56 | .38 |
| 425724115190101 | 5S-10E-30CAC1 | 9-15-80 | 21.5 | 8.2 | - | 9.5 | .7 | 100 | 1.6 | 190 | 0 | 22 | 63 | .4 | 26 | 2.80 |
| 425731115221301 | 5S- 9E-27DBB1 | 9-15-80 | 18.0 | 7.8 | - | 55 | 40 | 35 | 16 | 360 | 0 | 30 | 69 | 1.1 | 70 | 1.30 |

TABLE 20A.—*Concentrations of major dissolved solutes in ground water, Snake River Plain*—Continued

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Elmore County--Continued | | | | | | | | | | |
| 425804115333001 | 5S- 7E-24DDD1 | 9-12-80 | 22.5 | 7.9 | - | 27 | 5.9 | 42 | 15 | 210 | 0 | 7.8 | 27 | 1.0 | 76 | 0.36 |
| 425808115590801 | 5S- 4E-28ABB1 | 8-11-76 | 22.5 | 8.0 | - | 30 | 7.9 | 16 | 6.8 | 140 | 0 | 3.3 | 28 | .3 | 45 | .35 |
| 425911115442801 | 5S- 6E-16DBD1S | 9-23-80 | 15.0 | 7.3 | - | 58 | 17 | 16 | 3.0 | 210 | 0 | 34 | 41 | .2 | 52 | 2.70 |
| 430213116042501 | 4S- 3E-35BCA1 | 8-19-80 | 18.0 | 7.5 | - | 64 | 14 | 35 | 9.7 | 210 | 0 | 22 | 85 | .3 | 45 | .92 |
| 430242116092001 | 4S- 2E-25DAD1 | 9-24-80 | 18.0 | 7.2 | - | 68 | 35 | 34 | 12 | 390 | 0 | 28 | 61 | .9 | 67 | 1.10 |
| 430253115513501 | 4S- 5E-28DAB1 | 11-18-80 | 18.5 | 8.5 | - | 60 | 19 | 24 | 6.3 | 150 | 5 | 49 | 83 | 1.1 | 38 | 10.00 |
| 430310115485701 | 4S- 5E-25BBC1 | 6- 2-81 | 23.0 | 8.6 | 5.5 | 15 | 3.1 | 9.1 | 3.0 | 75 | 5 | 2.0 | 3.3 | .2 | 43 | .67 |
| 430312115375801 | 4S- 7E-28BBA1 | 9-12-80 | 24.0 | 7.6 | - | 17 | 8.5 | 32 | 5.5 | 120 | 0 | 13 | 27 | 1.8 | 60 | 1.70 |
| 430339115502201 | 4S- 5E-22DAC1 | 11-18-80 | 20.0 | 8.6 | - | 33 | 8.4 | 18 | 6.5 | 65 | 5 | 26 | 66 | .1 | 40 | 2.50 |
| 430605115215901 | 4S- 9E- 3DCA1 | 9-10-80 | 17.5 | 8.0 | - | 21 | 4.1 | 14 | 3.9 | 110 | 0 | 2.2 | 3.9 | 1.1 | 63 | .76 |
| 430915115403301 | 3S- 7E-19BBC1 | 11-25-80 | 13.0 | 7.8 | - | 21 | 6.8 | 7.5 | 2.7 | 110 | 0 | 2.5 | 2.7 | .2 | 39 | .81 |
| 430929115423201 | 3S- 6E-14CDA1 | 11-21-80 | 12.5 | 7.3 | - | 33 | 11 | 25 | 5.4 | 180 | 0 | 10 | 30 | .4 | 44 | 3.10 |
| 431037115385601 | 3S- 7E- 8CAA1 | 5-21-81 | 17.0 | 8.4 | 6.6 | 12 | 4.8 | 8.3 | 2.6 | 75 | 0 | 3.6 | 5.0 | .2 | 42 | .65 |
| 431431115501301 | 2S- 5E-23BBC1 | 8-10-76 | 21.5 | 8.0 | - | 17 | 6.9 | 34 | 6.5 | 140 | 0 | 8.3 | 19 | .8 | 48 | 1.30 |
| 431706115571001 | 2S- 4E- 2BBD1 | 8- 6-76 | 22.5 | 8.1 | - | 16 | 4.3 | 18 | 4.2 | 100 | 0 | 4.9 | 9.3 | .4 | 52 | .80 |
| 432239115491101 | 1N- 5E-35DAB1S | 8- 5-76 | - | 8.0 | - | 30 | 5.1 | 18 | 1.8 | 140 | 0 | 4.4 | 13 | .4 | 46 | .10 |
| 432518115554301 | 1N- 4E-12BDB1S | 8- 4-76 | 16.5 | 6.7 | - | 28 | 5.7 | 17 | 2.0 | 150 | 0 | 4.3 | 7.2 | .4 | 54 | .08 |
| | | | | | | Fremont County | | | | | | | | | | |
| 435354111440501 | 7N-40E-27CCC1 | 7-22-76 | 10.5 | 7.6 | - | 44 | 12 | 7.2 | 1.7 | 190 | 0 | 5.7 | 8.1 | .6 | 20 | .75 |
| 435904111373101 | 8N-41E-33ABB1 | 11- 8-79 | 11.5 | 7.0 | - | 21 | 7.0 | 15 | 2.9 | 130 | 0 | 6.1 | 3.4 | 1.8 | 40 | .88 |
| | | | | | | Gem County | | | | | | | | | | |
| 435310116265801 | 6N- 1W- 3CBB1 | 10- 8-75 | 13.5 | 7.5 | - | 25 | 3.6 | 38 | 3.7 | 130 | 0 | 7.0 | 42 | 1.6 | 37 | .02 |
| 435313116312301 | 6N- 2W- 1BDD1 | 11- 3-77 | 14.0 | 7.1 | - | 54 | 16 | 72 | 4.0 | 360 | 0 | 6.7 | 41 | .5 | 29 | 1.80 |
| 435451116301901 | 7N- 1W-30CAB1 | 10- 8-75 | 14.5 | 7.1 | - | 32 | 8.3 | 15 | 3.2 | 160 | 0 | 2.5 | 11 | .4 | 41 | .57 |
| | | | | | | Gooding County | | | | | | | | | | |
| 13095175 | 9S-14E- 3CBA1S | 11- 5-80 | 14.0 | 7.9 | 11.0 | 42 | 20 | 22 | 4.3 | 190 | 0 | 26 | 45 | .7 | 34 | 1.50 |
| 13095500 | 8S-14E-28BBC1S | 11- 7-80 | 14.5 | 8.1 | - | 36 | 16 | 20 | 4.2 | 180 | 0 | 17 | 37 | .6 | 33 | .88 |
| 13132595 | 8S-14E-21ABA1S | 11- 3-80 | 14.5 | 7.8 | 11.0 | 33 | 16 | 20 | 4.0 | 180 | 0 | 12 | 35 | .6 | 33 | 1.60 |
| 424053114421001 | 8S-15E-33DCC1 | 6-23-81 | 14.5 | 7.7 | 8.5 | 52 | 22 | 30 | 4.6 | 220 | 0 | 46 | 56 | .5 | 36 | 1.20 |
| 424320114485701 | 8S-14E-21ABA2 | 6-23-81 | 15.0 | 7.6 | 8.3 | 34 | 17 | 21 | 3.6 | 200 | 0 | 17 | 33 | .5 | 35 | .79 |
| 424933114515701 | 7S-14E-18BAB1 | 6-25-81 | 16.0 | 7.6 | 8.1 | 31 | 16 | 18 | 3.7 | 190 | 0 | 13 | 28 | .4 | 36 | .68 |
| 424950114385501 | 7S-15E-12CAC1 | 12-22-81 | 12.0 | 8.1 | - | 26 | 14 | 14 | 3.4 | 150 | 0 | 8.0 | 21 | .4 | 32 | .63 |
| | | | | | | Jefferson County | | | | | | | | | | |
| 433754111461901 | 4N-40E-32DBD1 | 12- 6-79 | 10.5 | 7.5 | - | 68 | 17 | 19 | 3.3 | 220 | 0 | 26 | 67 | .3 | 14 | .92 |
| 433845111374501 | 4N-41E-28DAC1 | 12-18-79 | 4.5 | 7.9 | - | 39 | 15 | 6.7 | 1.8 | 200 | 0 | 3.6 | 5.4 | .3 | 35 | .34 |
| 433852112165201 | 4N-36E-30CBB1 | 7- 8-81 | 11.0 | 7.5 | 9.4 | 69 | 18 | 15 | 3.3 | 280 | 0 | 16 | 46 | .3 | 25 | 1.40 |
| 434000112053301 | 4N-37E-22BAD1 | 11- 9-79 | 9.5 | 7.3 | - | 54 | 15 | 17 | 3.4 | 200 | 0 | 13 | 48 | .7 | 25 | .54 |
| 434025111545801 | 4N-39E-18CDA1 | 12- 6-79 | 11.0 | 7.7 | - | 66 | 16 | 9.4 | 2.6 | 240 | 0 | 9.8 | 42 | .3 | 14 | 1.10 |
| 434037112193601 | 4N-35E-15DBA1 | 9- 9-70 | 13.0 | 7.9 | - | 30 | 8.0 | 13 | 4.0 | 150 | 0 | 6.4 | 7.0 | 1.0 | 34 | - |
| 434104112015301 | 4N-38E- 7DCC1 | 12-18-79 | 8.0 | 7.5 | - | 69 | 16 | 13 | 3.2 | 240 | 0 | 15 | 49 | .4 | 22 | 1.20 |
| 434323112073801 | 5N-37E-32ACA1 | 10-31-79 | - | 8.0 | - | 51 | 16 | 17 | 4.3 | 190 | 0 | 18 | 61 | .6 | 39 | .00 |
| 434324111564201 | 5N-38E-35ADA2 | 10-31-79 | 10.0 | - | - | 60 | 21 | 17 | 3.1 | 260 | 0 | 9.9 | 45 | .4 | 15 | 1.20 |
| 434820112373001 | 6N-32E-36ADD1 | 9- 7-77 | 12.5 | 8.0 | - | 29 | 17 | 13 | 9.1 | 170 | 0 | 7.9 | 26 | .2 | 25 | - |
| 434854112322101 | 6N-33E-26DDB1 | 9- 7-77 | 15.5 | 7.9 | - | 39 | 14 | 25 | 5.4 | 150 | 0 | 43 | 29 | .8 | 38 | - |
| 434900112110201 | 6N-36E-26DBC1 | 8-29-79 | 14.0 | 8.0 | - | 36 | 10 | 17 | 3.1 | 170 | 0 | 9.9 | 13 | 1.0 | 37 | .54 |
| 434941112454201 | 6N-31E-21DCC1 | 9- 7-77 | 14.0 | 8.0 | - | 33 | 15 | 6.9 | 2.7 | 160 | 0 | 7.0 | 16 | .2 | 25 | - |
| 435031112182101 | 6N-35E-14CCC1 | 10-26-79 | 10.5 | 8.0 | - | 66 | 17 | 41 | 4.3 | 340 | 0 | 22 | 25 | .2 | 25 | 2.00 |
| 435215112394201 | 6N-32E-11ABA1 | 9- 7-77 | 16.0 | 8.0 | - | 39 | 14 | 15 | 3.6 | 180 | 0 | 13 | 29 | .5 | 34 | - |
| 435312112193301 | 7N-35E-34DCC1 | 10-26-79 | 11.5 | 8.0 | - | 24 | 7.5 | 11 | 2.4 | 120 | 0 | 5.8 | 6.5 | .5 | 33 | .54 |
| 435638112264901 | 7N-34E-10CDD1 | 9-10-70 | 11.5 | 7.7 | - | 47 | 16 | 32 | 4.0 | 190 | 0 | 43 | 26 | .4 | 32 | - |
| 435725112351202 | 7N-33E- 9BAA2 | 10-24-79 | 10.0 | 7.5 | - | 86 | 25 | 74 | 5.7 | 410 | 0 | 65 | 71 | .2 | 35 | 3.00 |
| 435753112145101 | 7N-36E- 5CAA1 | 9-20-79 | 13.5 | 7.9 | - | 34 | 9.6 | 9.6 | 2.3 | 140 | 0 | 16 | 6.6 | .5 | 34 | .89 |
| 440022112371801 | 8N-33E- 9DAC1 | 9-10-70 | 13.0 | 7.8 | - | 48 | 16 | 17 | 4.0 | 200 | 0 | 20 | 26 | .3 | 31 | - |
| 440138112350901 | 8N-33E-16ACB1 | 9-10-70 | 14.0 | 7.8 | - | 55 | 15 | 14 | 5.0 | 160 | 0 | 47 | 24 | .4 | 33 | - |
| | | | | | | Jerome County | | | | | | | | | | |
| 13089500 | 10S-18E- 4AAD1S | 11- 7-80 | 14.0 | 8.4 | 11.0 | 54 | 22 | 45 | 7.9 | 270 | 0 | 39 | 65 | .4 | 41 | 2.10 |
| 13090900 | 9S-17E-28ADD1S | 11- 5-80 | 15.0 | 7.8 | 11.0 | 59 | 20 | 37 | 7.7 | 230 | 0 | 47 | 63 | .4 | 38 | 1.80 |
| 423319114045001 | 10S-20E-14BDD1 | 9- 1-70 | 15.0 | 7.8 | - | 41 | 22 | 35 | 7.0 | 210 | 0 | 30 | 56 | .6 | 38 | - |
| 423531113555901 | 9S-21E-36DDD1 | 9-13-66 | 15.5 | 7.8 | - | 42 | 13 | 57 | 6.3 | 180 | 0 | 50 | 64 | .3 | 29 | - |
| 423730114340901 | 9S-16E-16ADA1 | 7-25-78 | 18.0 | 7.6 | - | 65 | 27 | 45 | 6.2 | 270 | 0 | 49 | 73 | .4 | 39 | - |
| 423758114294401 | 9S-17E-20BDB1 | 6-22-81 | 17.5 | 7.6 | 9.7 | 98 | 29 | 34 | 7.1 | 230 | 0 | 110 | 120 | .3 | 49 | 2.50 |
| 423806114311601 | 9S-16E-24AAC1 | 6-23-81 | 16.0 | 7.8 | 8.3 | 59 | 22 | 58 | 6.9 | 340 | 0 | 31 | 63 | .3 | 41 | 2.00 |
| 423930114193201 | 9S-18E-10ADD1 | 11- 2-72 | - | 7.7 | - | 66 | 25 | 44 | 5.5 | 260 | 0 | 52 | 71 | .5 | 35 | 1.80 |
| 424128114183601 | 8S-18E-35AAC1 | 9- 1-70 | 17.0 | 7.9 | - | 57 | 21 | 30 | 5.0 | 200 | 0 | 43 | 62 | .5 | 32 | - |
| 424142114285601 | 8S-17E-32AAA1 | 6-25-81 | 14.5 | 7.5 | 8.7 | 62 | 28 | 37 | 5.6 | 280 | 0 | 55 | 72 | .5 | 39 | 2.00 |
| 424732114241101 | 7S-18E-30BBC1 | 11- 2-72 | 13.5 | 7.8 | - | 30 | 14 | 16 | 3.1 | 150 | 0 | 12 | 28 | .7 | 33 | .42 |
| 424930114260001 | 7S-17E-14BAA1 | 6-25-81 | 14.5 | 7.9 | 8.2 | 32 | 15 | 19 | 3.8 | 180 | 0 | 14 | 31 | .4 | 34 | .83 |

TABLE 20A.—*Concentrations of major dissolved solutes in ground water, Snake River Plain*—Continued

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lincoln County | | | | | | | | | | | | | | | | |
| 424709113592601 | 7S-21E-28DAA1 | 6-24-81 | 12.5 | 7.8 | 8.7 | 44 | 18 | 30 | 4.3 | 190 | 0 | 42 | 50 | 0.6 | 33 | 0.92 |
| 425256114191701 | 6S-18E-21DCA1 | 9- 1-70 | 15.0 | 7.7 | - | 54 | 21 | 22 | 4.0 | 240 | 0 | 16 | 43 | .6 | 32 | - |
| 425524114111001 | 6S-19E- 3CDC1 | 6-24-81 | 15.0 | 8.0 | 7.6 | 24 | 14 | 15 | 3.2 | 160 | 0 | 7.0 | 19 | .4 | 35 | .63 |
| 425619114211701 | 5S-18E-31DDD1 | 6-24-81 | 14.0 | 7.7 | 8.4 | 46 | 16 | 20 | 3.1 | 260 | 0 | 5.5 | 18 | .2 | 32 | 1.40 |
| 425907113444001 | 5S-23E-17CAA1 | 4-11-67 | 13.0 | 7.7 | - | 24 | 14 | 15 | 4.3 | 140 | 0 | 9.0 | 20 | .6 | 26 | - |
| 430250114092001 | 4S-19E-25CBB1 | 11- 2-72 | - | 7.7 | - | 45 | 18 | 24 | 3.2 | 260 | 0 | 7.7 | 17 | .4 | 30 | 1.60 |
| Madison County | | | | | | | | | | | | | | | | |
| 434649111470001 | 5N-40E- 8BCC1 | 6-15-77 | 26.0 | 7.6 | - | 33 | 11 | 20 | 3.9 | 170 | 0 | 12 | 12 | 1.7 | 50 | .81 |
| 434807111463601 | 6N-40E-32CBC1 | 6- 8-81 | 17.5 | 8.0 | 7.8 | 36 | 13 | 20 | 3.2 | 180 | 0 | 13 | 14 | 1.1 | 45 | 1.10 |
| 435000111482201 | 6N-39E-24ACC1 | 11- 7-79 | 10.0 | 7.8 | - | 51 | 14 | 4.5 | 1.6 | 210 | 0 | 3.9 | 10 | .2 | 20 | .12 |
| 435002111380801 | 6N-41E-20BCC1 | 11-29-79 | 8.5 | 7.7 | - | 29 | 8.4 | 17 | 3.1 | 150 | 0 | 10 | 13 | 1.5 | 46 | .40 |
| 435244111332601 | 6N-42E- 6BCB1 | 12-17-79 | 22.0 | 7.5 | - | 27 | 7.8 | 38 | 4.7 | 180 | 0 | 14 | 23 | 2.8 | 59 | .78 |
| 435327111533201 | 7N-39E-32CBA1 | 11-29-79 | 9.0 | 7.3 | - | 19 | 6.5 | 12 | 3.6 | 110 | 0 | 4.4 | 10 | 1.4 | 37 | 2.10 |
| 435341111441101 | 7N-40E-34BBC1 | 11- 7-79 | 11.5 | 8.0 | - | 41 | 11 | 6.2 | 1.6 | 190 | 0 | 3.1 | 8.3 | .8 | 19 | .00 |
| Minidoka County | | | | | | | | | | | | | | | | |
| 423928113530801 | 9S-22E- 9BCD1 | 5-11-72 | 15.0 | 7.9 | - | 53 | 21 | 77 | 12 | 250 | 0 | 110 | 49 | .5 | 41 | 2.00 |
| 424015113413301 | 9S-24E- 6ACD1 | 7-27-72 | - | 7.8 | - | 69 | 22 | 38 | 7.0 | 260 | 0 | 49 | 66 | .3 | 31 | 2.30 |
| 424452113371301 | 8S-24E-11BAC1 | 9-13-66 | 13.0 | 7.8 | - | 52 | 23 | 41 | 5.8 | 200 | 0 | 58 | 63 | .6 | 31 | - |
| 430626113391001 | 4S-24E- 6BBC1 | 4-12-67 | 11.5 | 7.7 | - | 26 | 9.6 | 13 | 2.0 | 130 | 0 | 7.5 | 16 | .5 | 26 | - |
| Owyhee County | | | | | | | | | | | | | | | | |
| 423841115043501 | 9S-12E-17BDC1 | 6- 2-82 | 20.0 | 7.4 | - | 34 | 4.6 | 24 | 8.6 | 130 | 0 | 17 | 30 | 1.5 | 80 | .82 |
| 424737115544801 | 7S- 5E-19CCC1 | 8-27-80 | 25.0 | 8.7 | - | 10 | .2 | 62 | 8.8 | 80 | 10 | 11 | 35 | 13 | 100 | .54 |
| 424918115444701 | 7S- 6E-16ABB1 | 9- 5-80 | 20.5 | 8.3 | - | 10 | .2 | 58 | 11 | 140 | 0 | 9.6 | 32 | .7 | 93 | .24 |
| 425104115564401 | 7S- 4E- 2ABB1 | 8-29-80 | 20.5 | 8.0 | - | 50 | 3.9 | 67 | 10 | 140 | 0 | 20 | 140 | 3.1 | 67 | .00 |
| 425127115515501 | 6S- 5E-33DBB1 | 8-27-80 | 17.0 | 7.9 | - | 26 | 3.0 | 47 | 7.9 | 140 | 0 | 10 | 47 | 7.8 | 58 | .00 |
| 425154116220601 | 6S- 1E-32BBA1S | 7-12-73 | 25.0 | 7.2 | - | 37 | 8.5 | 22 | 1.6 | 130 | 0 | 21 | 35 | .5 | 45 | .56 |
| 425357115564801 | 6S- 4E-14CAD1 | 9- 3-80 | 19.0 | 8.0 | - | 35 | 3.3 | 130 | 10 | 190 | 0 | 18 | 220 | 2.8 | 69 | 3.40 |
| 425408116024601 | 6S- 3E-13ACC1 | 8-18-80 | 16.0 | 7.7 | - | 41 | 5.3 | 35 | 5.7 | 200 | 0 | 5.1 | 37 | 1.3 | 36 | .00 |
| 425528115360701 | 6S- 7E- 3DDC1 | 8-26-80 | 20.5 | 8.6 | - | 46 | 21 | 32 | 4.9 | 200 | 10 | 26 | 51 | .7 | 32 | .96 |
| 430035116101801 | 5S- 2E-12BBD1 | 8-20-80 | 17.0 | 7.5 | - | 44 | 22 | 160 | 10 | 490 | 0 | 32 | 110 | .7 | 54 | 6.30 |
| 430258116231401 | 4S- 1E-30BDB1 | 7-23-73 | 16.5 | 8.9 | - | 33 | 3.2 | 7.9 | 3.1 | 130 | 0 | 2.7 | 10 | .3 | 57 | .00 |
| 430603116160001 | 4S- 2E- 6CDA1 | 8-25-80 | 21.0 | 7.8 | - | 67 | 18 | 42 | 8.1 | 250 | 0 | 11 | 120 | 2.7 | 58 | .34 |
| 430922116263401 | 3S- 1W-15DCC1 | 8-21-80 | 16.0 | 7.5 | - | 84 | 10 | 14 | 2.6 | 220 | 0 | 21 | 77 | .2 | 28 | 3.30 |
| Payette County | | | | | | | | | | | | | | | | |
| 435649116481501 | 7N- 4W-15BDC1 | 10-10-75 | 16.0 | 8.6 | - | 31 | 1.0 | 26 | .9 | 100 | 10 | 13 | 22 | .3 | 20 | .00 |
| 435739116441901 | 7N- 3W- 7ACD1 | 10-10-75 | 14.0 | 8.0 | - | 16 | 4.0 | 33 | 2.2 | 160 | 0 | 1.6 | 1.1 | .5 | 30 | .00 |
| 435828116483501 | 7N- 4W- 3CBB1 | 11- 3-77 | 12.5 | 7.3 | - | 46 | 16 | 120 | 1.6 | 500 | 0 | 1.2 | 8.5 | .6 | 58 | 3.10 |
| 440016116544401 | 8N- 5W-26BCC1 | 8-28-75 | 16.0 | 8.0 | - | 18 | 11 | 18 | 3.6 | 160 | 0 | 2.4 | 8.3 | .5 | 50 | .49 |
| Power County | | | | | | | | | | | | | | | | |
| 13075923 | 5S-33E-35BAD1S | 12-17-80 | 11.0 | 7.9 | - | 49 | 15 | 20 | 3.6 | 200 | 0 | 18 | 42 | .6 | 27 | .98 |
| 424016112553801 | 9S-30E- 3ADB1 | 6-29-79 | 15.5 | 7.5 | - | 57 | 17 | 21 | 6.4 | 210 | 0 | 50 | 23 | .2 | 66 | .49 |
| 424603112525501 | 7S-31E-31CAC1S | 12-12-80 | 12.0 | 7.7 | - | 64 | 21 | 43 | 6.6 | 250 | 0 | 54 | 79 | .5 | 36 | 1.30 |
| 424744112493101 | 7S-31E-22CBD1 | 4- 7-78 | 12.0 | 7.1 | - | 71 | 31 | 21 | 7.0 | 230 | 0 | 87 | 33 | .3 | 51 | - |
| 425031112590501 | 7S-30E- 6DAA1 | 9- 3-70 | 10.5 | 7.9 | - | 53 | 18 | 21 | 4.0 | 190 | 0 | 28 | 52 | .5 | 26 | - |
| 425107112505901 | 6S-30E-34DBD1 | 9- 3-70 | 11.5 | 7.7 | - | 64 | 22 | 35 | 6.0 | 240 | 0 | 43 | 65 | 4.0 | 25 | - |
| 425336112333801 | 6S-33E-14DCD1 | 7-20-82 | 17.5 | 8.1 | - | 43 | 15 | 26 | 8.6 | 210 | 0 | 36 | 20 | .4 | 61 | .93 |
| 425440112312901 | 6S-34E- 7CAD1 | 12- 9-80 | 13.5 | 7.6 | - | 58 | 18 | 45 | 6.8 | 220 | 0 | 33 | 79 | .9 | 36 | .97 |
| 425456112305501 | 6S-34E- 7ADA1 | 12-11-80 | 13.0 | 7.7 | - | 65 | 25 | 57 | 7.2 | 370 | 0 | 28 | 49 | .2 | 34 | 3.1 |
| Twin Falls County | | | | | | | | | | | | | | | | |
| 422629114115901 | 11S-19E-35BDD1 | 9-23-81 | 25.0 | 7.6 | - | 34 | 5.4 | 21 | 9.9 | 120 | 0 | 28 | 22 | .6 | 70 | 1.10 |
| 422749114273701 | 11S-17E-16DDA1 | 4-23-81 | 19.0 | 7.9 | - | 37 | 24 | 38 | 3.6 | 120 | 0 | 55 | 90 | .8 | 56 | 3.70 |
| 423125114391001 | 10S-15E-26DDA1 | 6- 4-82 | 14.5 | 7.3 | - | 78 | 33 | 53 | 4.8 | 380 | 0 | 34 | 91 | .9 | 53 | 4.20 |
| 423133114331201 | 10S-16E-26CBB1 | 6- 4-82 | 14.5 | 7.8 | - | 52 | 35 | 63 | 4.7 | 290 | 0 | 39 | 100 | .9 | 54 | 2.60 |
| 423145114215001 | 10S-18E-28BCB1 | 6- 3-82 | 14.5 | 7.9 | - | 54 | 31 | 86 | 5.5 | 370 | 0 | 36 | 100 | .6 | 48 | 3.90 |
| 423210114123501 | 10S-19E-22DDA1 | 6- 3-82 | 16.0 | 7.6 | - | 44 | 19 | 22 | 3.8 | 200 | 0 | 19 | 43 | .8 | 34 | 1.20 |
| 423435114534801 | 10S-13E-11ABC1 | 6- 4-82 | 15.0 | 7.8 | - | 75 | 53 | 72 | 6.0 | 370 | 0 | 60 | 150 | .8 | 52 | 4.20 |
| 423801114463601 | 9S-14E-23ABD1 | 3-27-79 | 25.0 | 8.1 | - | 17 | 1.1 | 53 | 7.5 | 160 | 0 | 14 | 22 | 2.4 | 87 | .61 |
| Washington County | | | | | | | | | | | | | | | | |
| 441552116575301 | 11N- 5W-29BAC1 | 8- 6-74 | 19.5 | 7.1 | - | 62 | 12 | 38 | 12 | 240 | 0 | 27 | 68 | .4 | 52 | .63 |
| 441813117032601 | 11N- 6W- 9DAB1 | 8-28-73 | 14.5 | 8.3 | - | 1.7 | .1 | 130 | 1.0 | 210 | 0 | 56 | 21 | 5.0 | 20 | .01 |

TABLE 20B.—*Concentrations of dissolved trace solutes in ground water, Snake River Plain*

| Station No. | Location | Date | Al | As | Ba | Be | B | Cd | Cr | Co | Cu | Fe | Pb | Li | Mn | Mo | Sr | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ada County | | | | | | | | | | | | | | | | | | | |
| 431848116295001 | 1S- 1W-30AAB1 | 5-22-81 | 10 | - | 10 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 22 | 10 | <10 | 41 | <6 | 11 |
| 432735116265301 | 2N- 1W-34CCD1 | 5-28-81 | 10 | - | 30 | <1 | - | <1 | 5 | <3 | <10 | <10 | <10 | 12 | <1 | <10 | 120 | 24 | 12 |
| 433032116092201 | 2N- 2E-13DAB1 | 11- 5-81 | - | 3 | - | - | 10 | - | - | - | - | 22 | - | 12 | 2 | - | - | - | 610 |
| 433212116195901 | 2N- 1E- 3CBC1 | 10-27-81 | - | 2 | - | - | 160 | - | - | - | - | <10 | - | 12 | <1 | - | - | - | 67 |
| 433218116135301 | 2N- 2E- 4CBB1 | 11- 2-81 | - | 1 | - | - | 20 | - | - | - | - | 19 | - | 20 | 11 | - | - | - | 370 |
| 433313116083901 | 3N- 3E-31BDD1 | 5-29-81 | 10 | - | 40 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 7 | 3 | <10 | 170 | <6 | <3 |
| 433328116094201 | 3N- 2E-36ABC1 | 7-29-77 | - | 10 | - | - | 30 | - | <20 | - | - | <10 | 33 | 8 | - | - | - | - | - |
| 433407116233801 | 3N- 1W-25ADD1 | 8-25-77 | - | 1 | - | - | 70 | - | <20 | - | - | 40 | 27 | <10 | - | - | - | - | - |
| 433507116092801 | 3N- 2E-24ACA1 | 8- 6-81 | - | 14 | - | - | 30 | - | - | - | - | 16 | - | 12 | 20 | - | - | - | 67 |
| 433736116190501 | 3N- 1E- 3ADC1 | 5-28-81 | 10 | - | 60 | <1 | - | <1 | 0 | <3 | <10 | 230 | <10 | 24 | 85 | <10 | 130 | <6 | <3 |
| 433838116192301 | 4N- 1E-34ACB1 | 8-18-81 | - | 4 | - | - | 60 | - | - | - | - | <10 | - | 11 | <1 | - | - | - | 33 |
| 433856116113001 | 4N- 2E-26CCC1 | 8-10-81 | - | 31 | - | - | 20 | - | - | - | - | 250 | - | 30 | 330 | - | - | - | <3 |
| 433946116161401 | 4N- 2E-19CCC1 | 8- 7-81 | - | 1 | - | - | 20 | - | - | - | - | 520 | - | 12 | 42 | - | - | - | 15 |
| 434048116235101 | 4N- 1W-13DDB1 | 8-13-81 | - | 0 | - | - | 0 | - | - | - | - | 55 | - | 12 | 53 | - | - | - | 8 |
| 434406116240801 | 5N- 1W-36ABB1 | 8-10-81 | - | 21 | - | - | 50 | - | - | - | - | <10 | - | 20 | <1 | - | - | - | 9 |
| Bannock County | | | | | | | | | | | | | | | | | | | |
| 425456112305501 | 6S-34E- 7ADA1 | 12-11-80 | - | 3 | - | - | 120 | 1 | 0 | - | - | <10 | 0 | - | - | <10 | - | - | <3 |
| 425539112305601 | 6S-34E- 6DAA1 | 12-12-80 | - | 2 | - | - | 90 | <1 | 0 | - | - | <10 | 1 | - | - | <10 | - | - | 130 |
| 425626112302601 | 6S-34E- 5CAC1 | 7-14-76 | - | - | - | - | - | - | - | - | - | 20 | - | - | - | - | - | - | - |
| 425740112313501 | 5S-34E-30BAD1 | 7-13-76 | - | - | - | - | - | - | - | - | - | 20 | - | - | - | - | - | - | - |
| 425925112264301 | 5S-34E-14ABC1 | 7-13-76 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| Bingham County | | | | | | | | | | | | | | | | | | | |
| 425254112574201 | 6S-30E-21CAC1 | 9- 3-70 | - | - | - | - | 60 | - | - | - | - | - | - | - | - | - | - | - | - |
| 425611112500701 | 5S-31E-33ACC1 | 9-14-66 | - | - | - | - | 50 | - | - | - | - | 180 | - | - | - | - | - | - | - |
| 425928112562701 | 5S-30E-15BAC1 | 9- 2-70 | - | - | - | - | 80 | - | - | - | - | - | - | - | - | - | - | - | - |
| 430545112361501 | 4S-33E- 4CDD1 | 9- 4-70 | - | - | - | - | 140 | - | - | - | - | - | - | - | - | - | - | - | - |
| 430608112515401 | 4S-31E- 5CBC1 | 9- 8-70 | - | - | - | - | 30 | - | - | - | - | - | - | - | - | - | - | - | - |
| 430611112322000 | 4S-33E- 1ADC1S | 4- 8-78 | - | 5 | - | - | 100 | 3 | <20 | - | - | <10 | 22 | 60 | - | - | - | - | - |
| 430754112314401 | 3S-34E-30CAB1 | 9- 4-70 | - | - | - | - | 50 | - | - | - | - | - | - | - | - | - | - | - | - |
| 431052112211101 | 3S-35E-10BBA1 | 4- 6-78 | - | 3 | - | - | 70 | <2 | <20 | - | - | <10 | 15 | 40 | - | - | - | - | - |
| 431421112383501 | 2S-33E-19ABC1 | 9- 9-70 | - | - | - | - | 50 | - | - | - | - | - | - | - | - | - | - | - | - |
| 431516112300001 | 2S-34E-17ABA1 | 9- 9-70 | - | - | - | - | 60 | - | - | - | - | - | - | - | - | - | - | - | - |
| 431857112405501 | 1S-32E-23CDA1 | 7- 8-81 | 10 | - | 20 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 42 | 2 | <10 | 190 | <6 | 120 |
| 431907112560201 | 1S-30E-22DBD1 | 6- 5-78 | - | 3 | - | - | 40 | <1 | <20 | - | - | 60 | 4 | 20 | - | - | - | - | - |
| Blaine County | | | | | | | | | | | | | | | | | | | |
| 431932113571501 | 1S-21E-22BCC1 | 6- 4-81 | 10 | - | 110 | 1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 9 | 1 | <10 | 230 | <6 | 13 |
| 431952114164601 | 1S-18E-14DDC1 | 6- 3-81 | 10 | - | 40 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 7 | <1 | <10 | 150 | <6 | 100 |
| Bonneville County | | | | | | | | | | | | | | | | | | | |
| 432623112031001 | 1N-37E- 1DCC1 | 12- 7-79 | - | 2 | - | - | 60 | - | 0 | - | - | <10 | 0 | 50 | - | - | - | - | 70 |
| 432838111582001 | 2N-38E-27ACB1 | 12- 5-79 | - | 1 | - | - | 70 | - | 0 | - | - | 30 | 0 | 40 | - | - | - | - | 7 |
| 432856112060801 | 2N-37E-28AAA1 | 8-16-77 | - | 1 | - | - | 70 | - | <20 | - | - | <10 | 10 | 40 | - | - | - | - | - |
| 433107112011401 | 2N-38E- 8CBB1 | 11-30-79 | - | 2 | - | - | 50 | - | 0 | - | - | <10 | 0 | 40 | - | - | - | - | 20 |
| 433114112132401 | 2N-36E- 9ADA1 | 9-19-79 | - | 1 | - | - | - | - | - | - | - | <10 | <10 | - | - | - | - | - | - |
| 433233111574301 | 3N-38E-35CCB1 | 12- 5-79 | - | 1 | - | - | - | - | - | - | - | 20 | 0 | - | - | - | - | - | - |
| 433428111381601 | 3N-41E-23CAA1 | 6- 9-81 | 10 | - | 90 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 7 | <1 | <10 | 100 | <6 | 25 |
| 433534112111401 | 3N-36E-14ACA1 | 9-10-70 | - | - | - | - | 60 | - | - | - | - | - | - | - | - | - | - | - | - |
| 433536111550501 | 3N-39E-18BDB1 | 11-28-79 | - | 2 | - | - | - | - | - | - | - | <10 | 5 | - | - | - | - | - | - |
| 433733112035301 | 3N-37E- 2AAA1 | 11- 9-79 | - | 1 | - | - | - | - | - | - | - | <10 | 2 | - | - | - | - | - | - |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Butte County | | | | | | | | | | | | | | | | | | | |
| 432424113165401 | 1N-27E-22ACB1 | 6- 5-78 | - | 1 | - | - | <20 | <1 | <20 | - | - | <10 | 2 | <10 | - | - | - | - | - |
| 432735113351601 | 2N-24E-27BDB1 | 7- 7-81 | 10 | - | 100 | - | <10 | - | - | - | - | - | - | <10 | - | - | 290 | - | - |
| 432954113020501 | 2N-29E-17CBC1 | 10-12-72 | 40 | - | - | - | - | - | <20 | - | <20 | <10 | <2 | - | 8 | - | - | - | - |
| 433013113043001 | 2N-28E-13BCB1 | 11-20-72 | 40 | - | - | - | - | - | <20 | - | 14 | 100 | <2 | - | 20 | - | - | - | - |
| 433252112520301 | 3N-30E-34BAD1 | 9- 6-77 | 10 | - | - | - | <20 | - | <20 | - | - | <10 | - | - | <10 | - | 200 | - | - |
| 433343112570101 | 3N-29E-25BAC1 | 9- 5-77 | 60 | - | - | - | <20 | - | <20 | - | - | 60 | - | - | <10 | - | 280 | - | - |
| 433423113031901 | 3N-29E-19CBB1 | 9- 6-77 | 10 | - | - | - | 30 | - | <20 | - | - | <10 | - | - | <10 | - | 220 | - | - |
| 433433112560201 | 3N-30E-19BCB1 | 9- 5-77 | 10 | - | - | - | <20 | - | <20 | - | - | <10 | - | - | <10 | - | 230 | - | - |
| 433517113190001 | 3N-26E-14DAA1 | 7- 7-81 | 10 | - | 140 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 7 | <1 | <10 | 270 | <6 | <3 |
| 433742113165601 | 4N-27E-31DBD1 | 11- 3-78 | - | - | - | - | - | - | - | - | <20 | <10 | - | - | - | - | - | - | - |
| 433758113181701 | 4N-26E-36ACB1 | 6- 4-81 | 10 | - | 150 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 6 | <1 | <10 | 280 | <6 | 47 |
| 434334112463101 | 5N-31E-28CCC1 | 9- 7-77 | 10 | - | - | - | 30 | - | <20 | - | - | <10 | - | - | <10 | - | 160 | - | - |
| 434430112575901 | 5N-29E-23CDD1 | 9- 6-77 | 10 | - | - | - | 30 | - | <20 | - | - | <10 | - | - | 40 | - | 260 | - | - |
| 434558112444801 | 5N-31E-15BAD1 | 9- 8-78 | - | 2 | - | - | 230 | - | - | - | - | - | - | 30 | - | - | - | - | - |
| 434940113005001 | 6N-29E-20DDD1 | 6- 5-81 | 20 | - | 150 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 5 | <1 | <10 | 220 | <6 | 62 |
| 435120112432101 | 6N-31E-14ABB1 | 9- 7-77 | <100 | - | - | - | <20 | - | 20 | - | - | <10 | - | - | <10 | - | 230 | - | - |
| 435522112444201 | 7N-31E-22BDD1 | 9- 7-77 | 10 | - | - | - | <20 | - | <20 | - | - | <10 | - | - | <10 | - | 150 | - | - |
| Canyon County | | | | | | | | | | | | | | | | | | | |
| 432626116360601 | 1N- 2W- 8ACC1 | 10- 6-77 | - | 17 | - | - | 70 | - | - | - | - | - | - | 40 | - | - | - | - | - |
| 432919116403701 | 2N- 3W-22DDC1 | 8-17-81 | - | 12 | - | - | 110 | - | - | - | - | <10 | - | 35 | 5 | - | - | - | 13 |
| 433217116330501 | 2N- 2W- 2CBB1 | 10-23-81 | - | 16 | - | - | 150 | - | - | - | - | <10 | - | 19 | 1 | - | - | - | 5 |
| 433230116471801 | 2N- 4W- 2BCA2 | 12- 9-81 | - | 1 | - | - | 230 | - | - | - | - | 65 | - | 87 | 77 | - | - | - | 320 |
| 433600116364001 | 3N- 2W-17BCB1 | 10-28-81 | - | 6 | - | - | 50 | - | - | - | - | <10 | - | 16 | 3 | - | - | - | 48 |
| 433711116392301 | 3N- 3W- 2DDC1 | 11- 6-81 | - | 3 | - | - | 50 | - | - | - | - | <10 | - | 22 | 17 | - | - | - | 22 |
| 433843116384301 | 4N- 3W-36BAC1 | 11-10-81 | - | 6 | - | - | 40 | - | - | - | - | <10 | - | 12 | <1 | - | - | - | 7 |
| 434014116353201 | 4N- 2W-21CBB1 | 8-17-81 | - | 1 | - | - | 40 | - | - | - | - | 13 | - | 11 | 2 | - | - | - | 17 |
| 434232116501001 | 4N- 4W- 5DDB1 | 8-11-81 | - | 0 | - | - | 80 | - | - | - | - | 240 | - | 53 | 61 | - | - | - | <3 |
| 434627116461801 | 5N- 4W-13BCB1 | 11- 5-81 | - | 11 | - | - | 10 | - | - | - | - | 98 | - | 22 | 78 | - | - | - | 120 |
| 434646116425401 | 5N- 3W- 8DDC1 | 11- 9-81 | - | 2 | - | - | 50 | - | - | - | - | 28 | - | 19 | 11 | - | - | - | 210 |
| 434826116572401 | 5N- 5W- 5ABA1 | 11- 4-81 | - | 20 | - | - | 40 | - | - | - | - | <10 | - | 38 | 100 | - | - | - | 20 |
| Cassia County | | | | | | | | | | | | | | | | | | | |
| 422109113592101 | 12S-21E-27BCC1 | 6-10-82 | - | - | - | - | 20 | - | - | - | - | - | - | - | - | - | - | - | - |
| 422319114032801 | 12S-20E-12DCC1 | 6- 9-82 | - | - | - | - | 30 | - | - | - | - | - | - | - | - | - | - | - | - |
| 422831113592401 | 11S-21E- 9DDD1 | 6-30-82 | - | - | - | - | 40 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423550113140501 | 9S-27E-36ADD1 | 8-18-77 | - | 1 | - | - | 60 | - | 8 | - | - | 90 | 63 | 8 | - | - | - | - | - |
| Clark County | | | | | | | | | | | | | | | | | | | |
| 440142112425501 | 8N-31E-14AAA1 | 6- 6-81 | 20 | - | 130 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 22 | 2 | <10 | 340 | <6 | 120 |
| 440847112303501 | 10N-34E-31CCD1 | 10-24-79 | - | 2 | - | - | - | - | - | - | - | <10 | 0 | - | - | - | - | - | - |
| 441038112134201 | 10N-36E-21CAC1 | 8-29-79 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 441258112222201 | 10N-35E- 8BBB1 | 8-31-79 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 441442112114801 | 11N-36E-34AAB1 | 8-30-79 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 441614111593801 | 11N-38E-20ADA1 | 8-29-79 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 442335111532601 | 12N-39E- 5CCB1 | 8-30-79 | - | - | - | - | - | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 442335111532601 | 12N-39E- 5CCB1 | 6- 7-81 | 10 | - | 40 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | <4 | 5 | <10 | 83 | <6 | 27 |

TABLE 20B.—*Concentrations of dissolved trace solutes in ground water, Snake River Plain*—Continued

| Station No. | Location | Date | Al | As | Ba | Be | B | Cd | Cr | Co | Cu | Fe | Pb | Li | Mn | Mo | Sr | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Elmore County | | | | | | | | | | | | |
| 425648115293601 | 5S- 8E-34BDC2 | 9-12-80 | - | 10 | - | - | 140 | - | - | - | - | 150 | - | 40 | 160 | - | - | - | 4 |
| 425724115190101 | 5S-10E-30CAC1 | 9-15-80 | - | 3 | - | - | 60 | - | - | - | - | 30 | - | 600 | 1 | - | - | - | 130 |
| 425804115333001 | 5S- 7E-24DDD1 | 9-12-80 | - | 7 | - | - | 110 | - | - | - | - | 30 | - | 60 | 140 | - | - | - | 100 |
| 425911115442801 | 5S- 6E-16DBD1S | 9-23-80 | - | 5 | - | - | 60 | - | - | - | - | <10 | - | 10 | <1 | - | - | - | <3 |
| 430213116042501 | 4S- 3E-35BCA1 | 8-19-80 | - | 18 | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 430242116092001 | 4S- 2E-25DAD1 | 9-24-80 | - | 7 | - | - | 120 | - | - | - | - | <10 | - | 60 | <1 | - | - | - | 490 |
| 430310115485701 | 4S- 5E-25BBC1 | 6- 2-81 | 10 | - | 10 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 7 | <1 | <10 | 45 | 23 | <3 |
| 430605115215901 | 4S- 9E- 3DCA1 | 9-10-80 | - | 6 | - | - | 30 | - | - | - | - | 10 | - | 10 | <1 | - | - | - | 40 |
| 430615115415301 | 4S- 6E- 2DAA1 | 5-27-81 | 10 | - | 7 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | <4 | 1 | <10 | 62 | 11 | 41 |
| 430929115423201 | 3S- 6E-14CDA1 | 11-21-80 | - | 5 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| 431037115385601 | 3S- 7E- 8CAA1 | 5-21-81 | 10 | - | 9 | <1 | - | <1 | 1 | <3 | <10 | <10 | <10 | <4 | <1 | <10 | 51 | 13 | 10 |
| | | | | | | | Fremont County | | | | | | | | | | | | |
| 435904111373101 | 8N-41E-33ABB1 | 11- 8-79 | - | 5 | - | - | - | - | - | - | - | 10 | 0 | - | - | - | - | - | - |
| | | | | | | | Gem County | | | | | | | | | | | | |
| 435126116312501 | 6N- 2W-13CAA1 | 10- 6-82 | - | - | - | - | 100 | - | - | - | - | 14 | - | - | 59 | - | - | - | 240 |
| 435310116265801 | 6N- 1W- 3CBB1 | 10- 7-82 | - | - | - | - | 50 | - | - | - | - | 590 | - | - | 270 | - | - | - | 28 |
| 435313116312301 | 6N- 2W- 1BDD1 | 11- 3-77 | - | 1 | - | - | 50 | 2 | <20 | - | - | 60 | 15 | 20 | - | - | - | - | - |
| 435451116301901 | 7N- 1W-30CAB1 | 10- 8-82 | - | - | - | - | 30 | - | - | - | - | 17 | - | - | <1 | - | - | - | 33 |
| | | | | | | | Gooding County | | | | | | | | | | | | |
| 424053114421001 | 8S-15E-33DCC1 | 6-23-81 | 10 | - | 50 | 1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 43 | <1 | <10 | 290 | 6 | 36 |
| 424320114485701 | 8S-14E-21ABA2 | 6-23-81 | 10 | - | 30 | 1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 27 | <1 | <10 | 200 | 8 | <3 |
| 424933114515701 | 7S-14E-18BAB1 | 6-25-81 | 20 | - | 20 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 19 | <1 | <10 | 190 | 9 | 44 |
| 424950114385501 | 7S-15E-12CAC1 | 12-22-81 | - | - | 25 | 1 | - | <1 | - | <3 | <10 | <10 | <10 | 16 | 1 | <10 | 160 | 8 | 13 |
| | | | | | | | Jefferson County | | | | | | | | | | | | |
| 433754111461901 | 4N-40E-32DBD1 | 12- 6-79 | - | 2 | - | - | 60 | - | 0 | - | - | <10 | 0 | 30 | - | - | - | - | 40 |
| 433845111374501 | 4N-41E-28DAC1 | 12-18-79 | - | 1 | - | - | - | - | - | - | - | <10 | 3 | - | - | - | - | - | - |
| 433852112165201 | 4N-36E-30CBB1 | 7- 8-81 | 10 | - | 50 | <1 | - | <1 | 0 | <3 | 11 | <10 | <10 | 41 | <1 | <10 | 380 | <6 | 72 |
| 434000112053301 | 4N-37E-22BAD1 | 11- 9-79 | - | 1 | - | - | - | - | - | - | - | <10 | 1 | - | - | - | - | - | - |
| 434025111545801 | 4N-39E-18CDA1 | 12- 6-79 | - | 2 | - | - | 40 | - | 0 | - | - | 50 | 0 | 30 | - | - | - | - | 20 |
| 434037112193601 | 4N-35E-15DBA1 | 9- 9-70 | - | - | - | - | 20 | - | - | - | - | <10 | - | - | - | - | - | - | - |
| 434104112015301 | 4N-38E- 7DCC1 | 12-18-79 | - | 1 | - | - | - | - | - | - | - | 20 | 7 | - | - | - | - | - | - |
| 434323112073801 | 5N-37E-32ACA1 | 10-31-79 | - | 3 | - | - | - | - | - | - | - | <10 | 0 | - | - | - | - | - | - |
| 434324111564201 | 5N-38E-35ADA2 | 10-31-79 | - | 1 | - | - | - | - | - | - | - | <10 | 0 | - | - | - | - | - | - |
| 434820112373001 | 6N-32E-36ADD1 | 9- 7-77 | <100 | - | - | - | 30 | - | <20 | - | - | 20 | - | - | 290 | - | 160 | - | - |
| 434854112322101 | 6N-33E-26DDB1 | 9- 7-77 | 10 | - | - | - | 50 | - | <20 | - | - | 60 | - | - | <10 | - | 190 | - | - |
| 434941112454201 | 6N-31E-21DCC1 | 9- 7-77 | 10 | - | - | - | <20 | - | 20 | - | - | <10 | - | - | <10 | - | 140 | - | - |
| 435031112182101 | 6N-35E-14CCC1 | 10-26-79 | - | 2 | - | - | - | - | - | - | - | <10 | 27 | - | - | - | - | - | - |
| 435215112394201 | 6N-32E-11ABA1 | 9- 7-77 | 10 | - | - | - | 40 | - | <20 | - | - | <10 | - | - | <10 | - | 190 | - | - |
| 435312112193301 | 7N-35E-34DCC1 | 10-26-79 | - | 4 | - | - | - | - | - | - | - | <10 | 25 | - | - | - | - | - | - |
| 435725112351202 | 7N-33E- 9BAA2 | 10-24-79 | - | 6 | - | - | - | - | - | - | - | <10 | 0 | - | - | - | - | - | - |
| 435753112145101 | 7N-36E- 5CAA1 | 9-20-79 | - | 2 | - | - | <20 | - | <20 | - | - | <10 | <10 | <10 | - | - | - | - | 20 |
| | | | | | | | Jerome County | | | | | | | | | | | | |
| 423531113555901 | 9S-21E-36DDD1 | 9-13-66 | - | - | - | - | 120 | - | - | - | - | 20 | - | - | - | - | - | - | - |
| 423758114294401 | 9S-17E-20BDB1 | 6-22-81 | 0 | - | 130 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 44 | <1 | <10 | 490 | 6 | 22 |
| 423806114311601 | 9S-16E-24AAC1 | 6-23-81 | 10 | - | 80 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 47 | <1 | <10 | 340 | 8 | 190 |
| 424142114285601 | 8S-17E-32AAA1 | 6-25-81 | 10 | - | 60 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 46 | <1 | <10 | 370 | 8 | 120 |
| 424930114260001 | 7S-17E-14BAA1 | 6-25-81 | 10 | - | 30 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 20 | <1 | <10 | 180 | 9 | 73 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Lincoln County | | | | | | | | | | | |
| 424709113592601 | 7S-21E-28DAA1 | 6-24-81 | 10 | - | 40 | <1 | - | <1 | 1 | <3 | <10 | <10 | <10 | 41 | 3 | <10 | 260 | 7 | 48 |
| 425524114111001 | 6S-19E- 3CDC1 | 6-24-81 | 10 | - | 20 | 1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 13 | <1 | <10 | 150 | 8 | 69 |
| 425619114211701 | 5S-18E-31DDD1 | 6-24-81 | 10 | - | 50 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 10 | 1 | <10 | 200 | 7 | 210 |
| | | | | | | | | Madison County | | | | | | | | | | | |
| 434649111470001 | 5N-40E- 8BCC1 | 6-15-77 | - | 4 | <100 | <10 | 30 | - | - | - | - | - | - | 20 | 8 | - | 150 | - | - |
| 434807111463601 | 6N-40E-32CBC1 | 6- 8-81 | 0 | - | 20 | <1 | - | <1 | 0 | <3 | <10 | <10 | <10 | 21 | 2 | <10 | 110 | <6 | <3 |
| 435000111482201 | 6N-39E-24ACC1 | 11- 7-79 | - | 0 | - | - | - | - | - | - | - | 100 | 0 | - | - | - | - | - | - |
| 435002111380801 | 6N-41E-20BCD1 | 11-29-79 | - | 2 | - | - | - | - | - | - | - | <10 | 0 | - | - | - | - | - | - |
| 435244111332601 | 6N-42E- 6BCB1 | 12-17-79 | - | 7 | - | - | - | - | - | - | - | 30 | 3 | - | - | - | - | - | - |
| 435327111533201 | 7N-39E-32CBA1 | 11-29-79 | - | 1 | - | - | - | - | - | - | - | 40 | 2 | - | - | - | - | - | - |
| 435341111441101 | 7N-40E-34BBC1 | 11- 7-79 | - | <1 | - | - | - | - | - | - | - | <10 | 3 | - | - | - | - | - | - |
| | | | | | | | | Minidoka County | | | | | | | | | | | |
| 424452113371301 | 8S-24E-11BAC1 | 9-13-66 | - | - | - | - | 80 | - | - | - | - | 10 | - | - | - | - | - | - | - |
| 430626113391001 | 4S-24E- 6BBC1 | 4-12-67 | - | - | - | - | 60 | - | - | - | - | 440 | - | - | - | - | - | - | - |
| | | | | | | | | Owyhee County | | | | | | | | | | | |
| 424737115544801 | 7S- 5E-19CCC1 | 8-27-80 | - | 19 | - | - | 110 | - | - | - | - | 20 | - | 10 | 10 | - | - | - | 10 |
| 424918115444701 | 7S- 6E-16ABB1 | 9- 5-80 | - | 20 | - | - | - | - | - | - | - | - | 40 | - | - | - | - | - | - |
| 425104115564401 | 7S- 4E- 2ABB1 | 8-29-80 | - | 7 | - | - | 130 | - | - | - | - | 70 | - | 90 | 180 | - | - | - | <3 |
| 425127115515501 | 6S- 5E-33DBB1 | 8-27-80 | - | 28 | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 425154116220601 | 6S- 1E-32BBA1S | 7-12-73 | - | 5 | - | - | 30 | - | - | - | - | - | - | <10 | - | - | - | - | - |
| 425357115564801 | 6S- 4E-14CAD1 | 9- 3-80 | - | 1 | - | - | 180 | - | - | - | - | 110 | - | 110 | 270 | - | - | - | 90 |
| 425408116024601 | 6S- 3E-13ACC1 | 8-18-80 | - | 20 | - | - | 90 | - | - | - | 30 | 160 | - | 50 | 170 | - | - | - | - |
| 430035116101801 | 5S- 2E-12BBD1 | 8-20-80 | - | 18 | - | - | 270 | - | - | - | <3 | <10 | - | 80 | <1 | - | - | - | - |
| 430258116231401 | 4S- 1E-30BDB1 | 7-23-73 | - | 20 | - | - | <20 | - | - | - | - | - | - | <10 | - | - | - | - | - |
| 430603116160001 | 4S- 2E- 6CDA1 | 8-25-80 | - | 15 | - | - | - | - | - | - | - | 30 | 0 | - | 110 | - | - | - | - |
| 430922116263401 | 3S- 1W-15DCC1 | 8-21-80 | - | 1 | - | - | 60 | - | - | - | - | <10 | - | 10 | <1 | - | - | - | <3 |
| | | | | | | | | Payette County | | | | | | | | | | | |
| 435649116481501 | 7N- 4W-15BDC1 | 10-10-75 | - | - | - | - | - | - | - | - | - | 80 | - | - | - | - | - | - | - |
| 435739116441901 | 7N- 3W- 7ACD1 | 10-14-82 | - | - | - | - | 40 | - | - | - | - | 72 | - | - | 97 | - | - | - | <3 |
| 435828116483501 | 7N- 4W- 3CBB1 | 11- 3-77 | - | 17 | - | - | 140 | 2 | 15 | - | - | 60 | 23 | 20 | - | - | - | - | 13 |
| 440016116544401 | 8N- 5W-26BCC1 | 8-28-75 | - | - | - | - | - | - | - | - | - | 40 | - | - | - | - | - | - | - |
| | | | | | | | | Power County | | | | | | | | | | | |
| 13075923 | 5S-33E-35BAD1S | 12-17-80 | - | 2 | - | - | 60 | 1 | 0 | - | - | <10 | 59 | - | - | <10 | - | - | 3 |
| 424744112493101 | 7S-31E-22CBD1 | 4- 7-78 | - | 7 | - | - | 30 | <2 | <20 | - | - | 140 | 17 | 20 | - | - | - | - | - |
| 425336112333801 | 6S-33E-14DCD1 | 12-10-81 | - | 21 | - | - | 60 | <1 | <10 | - | - | <10 | <10 | - | - | <10 | - | - | 100 |
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| | | | | | | | | Twin Falls County | | | | | | | | | | | |
| 422629114115901 | 11S-19E-35BDD1 | 9-23-81 | - | 3 | - | - | 40 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 422749114273701 | 11S-17E-16DDA1 | 4-23-81 | - | 4 | - | - | 60 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 423125114391001 | 10S-15E-26DDA1 | 6- 4-82 | - | - | - | - | 180 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423133114331201 | 10S-16E-26CBB1 | 6- 4-82 | - | - | - | - | 170 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423145114215001 | 10S-18E-28BCB1 | 6- 3-82 | - | - | - | - | 230 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423210114123501 | 10S-19E-22DDA1 | 6- 3-82 | - | - | - | - | 70 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423435114534801 | 10S-13E-11ABC1 | 6- 4-82 | - | - | - | - | 180 | - | - | - | - | - | - | - | - | - | - | - | - |
| 423801114463601 | 9S-14E-23ABD1 | 3-27-79 | - | 8 | - | - | 120 | - | - | - | - | - | - | 50 | - | - | - | - | - |
| | | | | | | | | Washington County | | | | | | | | | | | |
| 441552116575301 | 11N- 5W-29BAC1 | 8- 6-74 | - | 4 | - | - | 60 | - | - | - | - | 30 | - | - | <10 | - | - | - | - |
| 441813117032601 | 11N- 6W- 9DAB1 | 8-28-73 | - | 17 | - | - | 1400 | - | - | - | - | - | - | 50 | - | - | - | - | - |

TABLE 20C.—*Stable-isotope ratios in ground water, Snake River Plain*

| Station No. | Location | Date | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ |
|---|---|---|---|---|---|---|
| | | Ada County | | | | |
| 431848116295001 | 1S- 1W-30AAB1 | 5-22-81 | -139 | -17.4 | -11.1 | - |
| 431848116295001 | 1S- 1W-30AAB1 | 11- 9-81 | - | - | - | +9.8 |
| 432304115572601 | 1N- 4E-32AAB1 | 8- 3-76 | -125 | -16.6 | - | - |
| 432336116164601 | 1N- 1E-25DBA1 | 8- 2-76 | -120 | -14.8 | - | - |
| 432735116265301 | 2N- 1W-34CCD1 | 5-28-81 | -134 | -16.9 | -12.7 | +2.7 |
| 433313116083901 | 3N- 3E-31BDD1 | 5- 8-81 | -129 | -16.4 | -12.6 | +0.5 |
| 433313116083901 | 3N- 3E-31BDD1 | 5-29-81 | -131 | -16.5 | -12.8 | +5.5 |
| 433736116190501 | 3N- 1E- 3ADC1 | 5-28-81 | -135 | -17.6 | -11.0 | +1.6 |
| | | Bingham County | | | | |
| 430205112372001 | 4S-33E-32ABA1S | 12-10-80 | -133 | -17.4 | - | +7.2 |
| 430349112342101 | 4S-33E-23BBA1S | 12-10-80 | -135 | -17.4 | - | +10.3 |
| 430539112402301 | 4S-32E-11AAC1S | 12-10-80 | -135 | -17.7 | - | +11.3 |
| 430608112301901 | 4S-34E- 5CAA1S | 12-10-80 | -135 | -17.6 | - | +10.7 |
| 430611112322000 | 4S-33E- 1ADC1S | 12-10-80 | -134 | -17.4 | - | +8.4 |
| 431857112405501 | 1S-32E-23CDA1 | 7- 8-81 | -136 | -18.0 | -10.6 | +11.6 |
| | | Blaine County | | | | |
| 431932113571501 | 1S-21E-22BCC1 | 6- 4-81 | -132 | -17.3 | -11.0 | +1.4 |
| 431952114164601 | 1S-18E-14DDC1 | 6- 3-81 | -139 | -18.2 | -11.1 | +1.0 |
| | | Bonneville County | | | | |
| 433428111381601 | 3N-41E-23CAA1 | 6- 9-81 | -141 | -18.8 | -13.4 | +2.8 |
| | | Butte County | | | | |
| 433517113190001 | 3N-26E-14DAA1 | 7- 7-81 | -134 | -17.4 | -11.9 | +13.4 |
| 433758113181701 | 4N-26E-36ACB1 | 6- 4-81 | -137 | -17.8 | -11.1 | +1.6 |
| 434940113005001 | 6N-29E-20DDD1 | 6- 5-81 | -140 | -18.3 | -10.9 | +1.8 |
| | | Canyon County | | | | |
| 433230116471801 | 2N- 4W- 2BCA2 | 12- 9-81 | -142 | -18.4 | - | - |
| | | Cassia County | | | | |
| 422109113592101 | 12S-21E-27BCC1 | 6-10-82 | -131 | -17.6 | - | - |
| 422319114032801 | 12S-20E-12DCC1 | 6- 9-82 | -132 | -17.5 | - | - |
| | | Clark County | | | | |
| 440142112425501 | 8N-31E-14AAA1 | 6- 6-81 | -140 | -18.4 | -7.4 | +5.1 |
| 442335111532601 | 12N-39E- 5CCB1 | 6- 7-81 | -135 | -18.0 | -12.9 | -3.2 |
| | | Elmore County | | | | |
| 425105115191801 | 6S-10E-31CCC1 | 6- 1-82 | -148 | -19.1 | - | - |
| 430310115485701 | 4S- 5E-25BBC1 | 8-16-76 | -129 | -17.3 | - | - |
| 430310115485701 | 4S- 5E-25BBC1 | 6- 2-81 | -130 | -16.5 | -12.9 | -2.0 |
| 430615115415301 | 4S- 6E- 2DAA1 | 5-27-81 | -129 | -16.4 | -15.3 | +.6 |
| 431037115385601 | 3S- 7E- 8CAA1 | 5-21-81 | -139 | -16.4 | -12.9 | - |
| 431706115571001 | 2S- 4E- 2BBD1 | 8- 6-76 | -129 | -17.3 | - | - |
| 432239115491101 | 1N- 5E-35DAB1S | 8- 8-76 | -118 | -15.4 | - | - |
| 432518115554301 | 1N- 4E-12BDB1S | 8- 4-76 | -116 | -15.4 | - | - |

TABLE 20C.—*Stable-isotope ratios in ground water, Snake River Plain*—Continued

| Station No. | Location | Date | $\delta^{2}H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ |
|---|---|---|---|---|---|---|
| | | Gooding County | | | | |
| 13095175 | 9S-14E- 3CBA1S | 11- 5-80 | -136 | -17.9 | - | - |
| 13095500 | 8S-14E-28BBC1S | 11- 7-80 | -137 | -18.0 | - | - |
| 13132595 | 8S-14E-21ABA1S | 11- 3-80 | -137 | -18.0 | - | - |
| 424053114421001 | 8S-15E-33DCC1 | 6-23-81 | -135 | -17.4 | -9.8 | +4.5 |
| 424320114485701 | 8S-14E-21ABA2 | 6-23-81 | -136 | -17.9 | -10.7 | +11.2 |
| 424933114515701 | 7S-14E-18BAB1 | 6-25-81 | -135 | -17.8 | -11.0 | +9.6 |
| 424950114385501 | 7S-15E-12CAC1 | 12-22-81 | -136 | -18.3 | - | - |
| | | Jefferson County | | | | |
| 433852112165201 | 4N-36E-30CBB1 | 7- 8-81 | -133 | -17.7 | -11.8 | +15.3 |
| | | Jerome County | | | | |
| 13089500 | 10S-18E- 4AAD1S | 11- 7-80 | -131 | -16.8 | - | - |
| 13090900 | 9S-17E-28ADD1S | 11- 5-80 | -131 | -17.2 | - | - |
| 423758114294401 | 9S-17E-20BDB1 | 6-22-81 | -129 | -16.4 | -11.7 | -.8 |
| 423806114311601 | 9S-16E-24AAC1 | 6-23-81 | -128 | -16.3 | -12.2 | +7.3 |
| 424142114285601 | 8S-17E-32AAA1 | 6-25-81 | -132 | -16.9 | -11.9 | +2.3 |
| 424930114260001 | 7S-17E-14BAA1 | 6-25-81 | -136 | -17.6 | -9.0 | +10.3 |
| | | Lincoln County | | | | |
| 424709113592601 | 7S-21E-28DAA1 | 6-24-81 | -139 | -17.9 | -10.1 | +7.2 |
| 425524114111001 | 6S-19E- 3CDC1 | 6-24-81 | -137 | -17.9 | -9.9 | +6.1 |
| 425619114211701 | 5S-18E-31DDD1 | 6-24-81 | -133 | -17.3 | -12.8 | +4.1 |
| | | Madison County | | | | |
| 434807111463601 | 6N-40E-32CBC1 | 6- 8-81 | -139 | -18.4 | -11.3 | +7.0 |
| | | Power County | | | | |
| 13075923 | 5S-33E-35BAD1S | 12-17-80 | -135 | -17.6 | - | - |
| 424603112525501 | 7S-31E-31CAC1S | 12-12-80 | -136 | -17.7 | - | +7.1 |
| 425336112333801 | 6S-33E-14DCD1 | 12-11-80 | -103 | -18.0 | - | - |
| 425440112312901 | 6S-34E- 7CAD1 | 12- 9-80 | -138 | -18.2 | - | - |
| | | Twin Falls County | | | | |
| 422749114273701 | 11S-17E-16DDA1 | 4-23-81 | -140 | -17.4 | - | - |

TABLE 21A.—*Concentrations of major dissolved solutes in*

[nr, near;

| Station No. | Name | Date | Q | WT |
|---|---|---|---|---|
| | Eastern Snake River Basin | | | |
| 13037500 | Snake River nr Heise | 6- 9-81 | 608 | 8.5 |
| 13037500 | Snake River nr Heise | 4- 7-82 | 261 | 3.0 |
| 13037500 | Snake River nr Heise | 5-26-82 | 526 | 9.0 |
| 13056500 | Henrys Fork nr Rexburg | 6- 8-81 | 227 | 12.5 |
| 13058000 | Willow Creek nr Ririe | 4-28-82 | 22.1 | 6.5 |
| 13068500 | Blackfoot River nr Blackfoot | 5-19-82 | 9.0 | 10.0 |
| 13076200 | Bannock Creek nr Pocatello | 5-19-82 | 1.1 | 10.5 |
| 13077650 | Rock Creek nr American Falls | 5-19-82 | 1.2 | 11.0 |
| 13078205 | Raft River bel One Mile Cr nr Malta | 6-17-82 | .5 | 21.0 |
| 13093095 | Rock Creek nr mouth nr Twin Falls | 6- 8-82 | 5.9 | 14.0 |
| 13105000 | Salmon Falls Creek nr San Jacinto | 6-21-82 | 10.2 | 20.0 |
| 13108150 | Salmon Falls Creek nr Hagerman | 4-22-82 | 3.8 | 13.0 |
| 13108500 | Camas Cr at 18-mi shearing corral nr Kilgore | 6- 7-81 | 9.8 | 13.5 |
| 13117030 | Birch Creek at 8-mi Canyon Rd nr Reno | 6- 6-81 | 1.8 | 13.5 |
| 13119000 | Little Lost River nr Howe | 6- 5-81 | 6.4 | 12.5 |
| 13132500 | Big Lost River nr Arco | 6- 5-81 | 7.4 | 13.0 |
| 13142500 | Big Wood River bel Magic Dam nr Richfield | 6- 3-81 | 30.2 | 11.5 |
| 13148500 | Little Wood River nr Carey | 6- 4-81 | 10.2 | 10.0 |
| 13154500 | Snake River at King Hill | 1- 7-82 | 222 | 6.0 |
| 13154500 | Snake River at King Hill | 3- 4-82 | 325 | 9.0 |
| 13154500 | Snake River at King Hill | 5-12-82 | 750 | 11.0 |
| | Western Snake River Basin | | | |
| 13168500 | Bruneau River nr Hot Spring | 6- 1-82 | 34.4 | 14.0 |
| 13184000 | Owyhee River at Owyhee, OR | 4-28-82 | 33.6 | 4.0 |
| 13203760 | Boise River at Eckert Rd nr Boise | 5-20-81 | 106 | 9.5 |
| 13214000 | Malheur River nr Drewsey, OR | 4-29-82 | 45.6 | 5.0 |
| 13233300 | Malheur River bel Nevada Dam nr Vale, OR | 4-28-82 | 90.7 | 10.5 |
| 13251000 | Payette River nr Payette | 5-20-82 | 288 | 10.0 |
| 13269000 | Snake River at Weiser | 1-25-82 | 414 | 2.5 |
| 13269000 | Snake River at Weiser | 3-26-82 | 781 | 7.5 |

*the Snake River and its tributaries at high water discharges*
bel, below]

| pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Eastern Snake River Basin | | | | | | | |
| 8.2 | 9.7 | 48 | 12 | 10 | 1.7 | 160 | 0 | 7.7 | 47 | 0.3 | 8.0 |
| 7.7 | - | 52 | 13 | 13 | 2.1 | 170 | 0 | 12 | 58 | .5 | 10 |
| 8.3 | 9.3 | 45 | 9.4 | 7.8 | 1.4 | 160 | 0 | 6.2 | 28 | .3 | 8.7 |
| 7.6 | 7.6 | 14 | 3.7 | 5.9 | 1.4 | 70 | 0 | 2.2 | .9 | .8 | 16 |
| 8.1 | 10.1 | 51 | 15 | 19 | 3.4 | 220 | 0 | 19 | 22 | .2 | 9.4 |
| 7.7 | 9.4 | 51 | 16 | 11 | 2.4 | 220 | 0 | 10 | 24 | .3 | 14 |
| 8.1 | 9.0 | 52 | 17 | 22 | 3.8 | 220 | 0 | 40 | 23 | .2 | 21 |
| 8.4 | 10.5 | 78 | 41 | 41 | 12 | 350 | 0 | 89 | 30 | .3 | 36 |
| 8.1 | - | 110 | 26 | 82 | 8.1 | 270 | 0 | 210 | 74 | .8 | 38 |
| 8.3 | - | 67 | 25 | 41 | 5.0 | 270 | 0 | 31 | 94 | .8 | 32 |
| 8.7 | - | 17 | 3.5 | 7.1 | 4.0 | 81 | 0 | 8.1 | 9.0 | .3 | 31 |
| 8.1 | 12.3 | 79 | 29 | 69 | 9.1 | 280 | 0 | 55 | 150 | .9 | 51 |
| 7.7 | 8.0 | 20 | 4.7 | 4.1 | 1.7 | 85 | 0 | 2.0 | 1.6 | .1 | 26 |
| 8.6 | 9.1 | 43 | 15 | 6.0 | 1.1 | 180 | 10 | 5.0 | 28 | .2 | 9.2 |
| 8.3 | 8.8 | 28 | 9.2 | 5.6 | 1.1 | 130 | 0 | 4.4 | 1.0 | .1 | 14 |
| 8.1 | 8.8 | 48 | 12 | 7.1 | 1.6 | 200 | 0 | 4.8 | 27 | .2 | 13 |
| 8.3 | 9.8 | 33 | 6.8 | 5.9 | 1.4 | 140 | 0 | 1.8 | 11 | .2 | 7.5 |
| 8.3 | 10.0 | 24 | 7.2 | 4.1 | 1.1 | 110 | 0 | 2.6 | 2.3 | .1 | 13 |
| 8.5 | 11.0 | 44 | 16 | 40 | 5.5 | 220 | 5 | 20 | 57 | .6 | 31 |
| 8.3 | 10.1 | 48 | 19 | 28 | 4.4 | 280 | 0 | 26 | 49 | .6 | 31 |
| 8.7 | 11.2 | 47 | 16 | 22 | 3.5 | 190 | 0 | 19 | 46 | .7 | 18 |
| | | | | Western Snake River Basin | | | | | | | |
| 8.1 | 9.6 | 11 | 1.7 | 5.5 | 2.3 | 230 | 0 | 1.9 | 6.0 | .4 | 24 |
| 8.0 | 11.8 | 17 | 4.7 | 24 | 3.8 | 96 | 0 | 7.4 | 26 | .8 | 23 |
| 8.1 | 11.1 | 11 | 1.1 | 4.7 | .8 | 45 | 0 | 13 | 2.0 | .3 | 13 |
| 7.8 | 11.1 | 11 | 3.4 | 8.1 | 2.4 | 59 | 0 | 1.4 | 6.0 | .1 | 38 |
| 7.9 | 10.3 | 20 | 6.1 | 22 | 4.0 | 110 | 0 | 4.9 | 33 | .2 | 36 |
| 8.0 | - | 7.1 | 1.1 | 4.6 | .9 | 39 | 0 | .8 | 6.0 | .2 | 15 |
| 8.2 | 12.7 | 49 | 20 | 31 | 5.0 | 220 | 0 | 27 | 47 | .6 | 35 |
| 8.8 | 9.7 | 28 | 9.9 | 22 | 3.1 | 130 | 0 | 12 | 31 | .5 | 23 |

TABLE 21B.—*Concentrations of dissolved trace solutes in the Snake River and its tributaries*

| Station No. | Name | Date | Al | Ba | Li | Sr | Zn | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eastern Snake River Basin | | | | | | | | | | |
| 13037500 | Snake River nr Heise | 6- 9-81 | 0 | 60 | 19 | 280 | <3 | -132 | -17.7 | -8.3 | +13.8 |
| 13037500 | Snake River nr Heise | 4- 7-82 | 10 | 100 | 30 | 360 | 10 | -135 | -17.7 | -9.1 | +17.5 |
| 13037500 | Snake River nr Heise | 5-26-82 | 20 | <100 | 24 | 230 | 12 | -135 | -18.2 | -9.2 | +13.3 |
| 13056500 | Henrys Fork nr Rexburg | 6- 8-81 | 2 | 20 | 21 | 29 | <3 | -130 | -17.3 | -9.4 | -1.2 |
| 13058000 | Willow Creek nr Ririe | 4-28-82 | <10 | 110 | 27 | 220 | <12 | -127 | -16.2 | -9.1 | +10.1 |
| 13068500 | Blackfoot River nr Blackfoot | 5-19-82 | 30 | 69 | 19 | 240 | <12 | -123 | -15.7 | -3.6 | +11.4 |
| 13076200 | Bannock Creek nr Pocatello | 5-19-82 | 80 | 85 | 19 | 190 | <12 | -128 | -17.0 | -9.3 | +8.6 |
| 13077650 | Rock Creek nr American Falls | 5-19-82 | 10 | 140 | 31 | 370 | <12 | -126 | -16.6 | -10.6 | +4.5 |
| 13078205 | Raft River bel One Mile Cr nr Malta | 6-17-82 | <10 | 110 | 64 | 560 | 6 | -124 | -16.0 | -10.8 | +6.8 |
| 13093095 | Rock Creek nr mouth nr Twin Falls | 6- 8-82 | 120 | <100 | 30 | 410 | 40 | -128 | -17.1 | -10.2 | +10.2 |
| 13105000 | Salmon Falls Creek nr San Jacinto | 6-21-82 | 110 | 73 | 21 | 80 | <3 | -125 | -16.8 | -10.7 | - |
| 13108150 | Salmon Falls Creek nr Hagerman | 4-22-82 | 20 | <100 | 50 | 620 | 10 | -128 | -16.5 | -11.0 | +8.7 |
| 13108500 | Camas Cr at 18-mi shearing corral nr Kilgore | 6- 7-81 | 2 | 40 | <4 | 78 | <3 | -127 | -16.8 | -11.2 | +6.9 |
| 13117030 | Birch Creek at 8-mi Canyon Rd nr Reno | 6- 6-81 | 10 | 70 | 8 | 160 | 13 | -143 | -18.6 | -6.8 | +8.2 |
| 13119000 | Little Lost River nr Howe | 6- 5-81 | 10 | 50 | 6 | 94 | <3 | -137 | -18.0 | -7.7 | - |
| 13132500 | Big Lost River nr Arco | 6- 5-81 | 10 | 110 | 7 | 260 | <3 | -135 | -17.4 | -10.9 | +4.4 |
| 13142500 | Big Wood River bel Magic Dam nr Richfield | 6- 3-81 | 10 | 40 | 8 | 120 | 7 | -129 | -16.7 | -9.4 | +.9 |
| 13148500 | Little Wood River nr Carey | 6- 4-81 | 10 | 60 | 5 | 150 | <3 | -128 | -16.7 | -9.5 | -1.1 |
| 13154500 | Snake River at King Hill | 1- 7-82 | 10 | 200 | 30 | 280 | 10 | -133 | -17.2 | -9.3 | +11.4 |
| 13154500 | Snake River at King Hill | 3- 4-82 | 20 | <100 | 30 | 280 | 10 | -133 | -17.4 | -10.3 | +11.2 |
| 13154500 | Snake River at King Hill | 5-12-82 | 30 | <100 | 40 | 260 | 10 | -132 | -17.3 | -7.9 | +14.6 |
| | Western Snake River Basin | | | | | | | | | | |
| 13168500 | Bruneau River nr Hot Spring | 6- 1-82 | 70 | 100 | <10 | 100 | 10 | -126 | -16.6 | -5.7 | - |
| 13184000 | Owyhee River at Owyhee, OR | 4-28-82 | 670 | 29 | 27 | 79 | 120 | -116 | -15.1 | -8.8 | +5.8 |
| 13203760 | Boise River at Eckert Rd nr Boise | 5-20-81 | 10 | 10 | <4 | 100 | <3 | -125 | -16.3 | -4.7 | -6.6 |
| 13214000 | Malheur River nr Drewsey, OR | 4-29-82 | 300 | <100 | <10 | 100 | 10 | -126 | -16.3 | -11.6 | - |
| 13233300 | Malheur River bel Nevada Dam nr Vale, OR | 4-28-82 | 250 | 100 | 10 | 130 | 90 | -121 | -15.6 | -10.0 | +2.4 |
| 13251000 | Payette River nr Payette | 5-20-82 | 130 | 18 | <12 | 66 | <12 | -128 | -17.0 | -10.7 | - |
| 13269000 | Snake River at Weiser | 1-25-82 | 20 | <100 | 30 | 300 | 10 | -130 | -16.6 | -8.2 | +8.2 |
| 13269000 | Snake River at Weiser | 3-26-82 | 90 | <100 | 20 | 200 | 45 | -126 | -16.4 | -10.4 | +8.9 |

TABLE 21C.—*Stable-isotope ratios in the Snake River and its tributaries*

| Station No. | Name | Date | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ |
|---|---|---|---|---|---|---|
| | Eastern Snake River Basin | | | | | |
| 13037500 | Snake River nr Heise | 6- 9-81 | -132 | -17.7 | -8.3 | +13.8 |
| 13037500 | Snake River nr Heise | 4- 7-82 | -135 | -17.7 | -9.1 | +17.5 |
| 13037500 | Snake River nr Heise | 5-26-82 | -135 | -18.2 | -9.2 | +13.3 |
| 13056500 | Henrys Fork nr Rexburg | 6- 8-81 | -130 | -17.3 | -9.4 | -1.2 |
| 13058000 | Willow Creek nr Ririe | 4-28-82 | -127 | -16.2 | -9.1 | +10.1 |
| 13068500 | Blackfoot River nr Blackfoot | 5-19-82 | -123 | -15.7 | -3.6 | +11.4 |
| 13076200 | Bannock Creek nr Pocatello | 5-19-82 | -128 | -17.0 | -9.3 | +8.6 |
| 13077650 | Rock Creek nr American Falls | 5-19-82 | -126 | -16.6 | -10.6 | +4.5 |
| 13078205 | Raft River bel One Mile Cr nr Malta | 6-17-82 | -124 | -16.0 | -10.8 | +6.8 |
| 13093095 | Rock Creek nr mouth nr Twin Falls | 6- 8-82 | -128 | -17.1 | -10.2 | +10.2 |
| 13105000 | Salmon Falls Creek nr San Jacinto | 6-21-82 | -125 | -16.8 | -10.7 | - |
| 13108150 | Salmon Falls Creek nr Hagerman | 4-22-82 | -128 | -16.5 | -11.0 | +8.7 |
| 13108500 | Camas Cr at 18-mi shearing corral nr Kilgore | 6- 7-81 | -127 | -16.8 | -11.2 | +6.9 |
| 13117030 | Birch Creek at 8-mi Canyon Rd nr Reno | 6- 6-81 | -143 | -18.6 | -6.8 | +8.2 |
| 13119000 | Little Lost River nr Howe | 6- 5-81 | -137 | -18.0 | -7.7 | - |
| 13132500 | Big Lost River nr Arco | 6- 5-81 | -135 | -17.4 | -10.9 | +4.4 |
| 13142500 | Big Wood River bel Magic Dam nr Richfield | 6- 3-81 | -129 | -16.7 | -9.4 | +.9 |
| 13148500 | Little Wood River nr Carey | 6- 4-81 | -128 | -16.7 | -9.5 | -1.1 |
| 13154500 | Snake River at King Hill | 1- 7-82 | -133 | -17.2 | -9.3 | +11.4 |
| 13154500 | Snake River at King Hill | 3- 4-82 | -133 | -17.4 | -10.3 | +11.2 |
| 13154500 | Snake River at King Hill | 5-12-82 | -132 | -17.3 | -7.9 | +14.6 |
| | Western Snake River Basin | | | | | |
| 13168500 | Bruneau River nr Hot Spring | 6- 1-82 | -126 | -16.6 | -5.7 | - |
| 13184000 | Owyhee River at Owyhee, OR | 4-28-82 | -116 | -15.1 | -8.8 | +5.8 |
| 13203760 | Boise River at Eckert Rd nr Boise | 5-20-81 | -125 | -16.3 | -4.7 | -6.6 |
| 13214000 | Malheur River nr Drewsey, OR | 4-29-82 | -126 | -16.3 | -11.6 | - |
| 13233300 | Malheur River bel Nevada Dam nr Vale, OR | 4-28-82 | -121 | -15.6 | -10.0 | +2.4 |
| 13251000 | Payette River nr Payette | 5-20-82 | -128 | -17.0 | -10.7 | - |
| 13269000 | Snake River at Weiser | 1-25-82 | -130 | -16.6 | -8.2 | +8.2 |
| 13269000 | Snake River at Weiser | 3-26-82 | -126 | -16.4 | -10.4 | +8.9 |

TABLE 22A.—*Concentrations of major dissolved solids in ground water in Snake River tributary drainage basins*

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ada County | | | | | | | | | | | | | | | |
| 431752116283001 | 1S- 1W-32AAD1S | 8-12-76 | 16.5 | 8.1 | - | 36 | 25 | 70 | 4.9 | 330 | 0 | 13 | 38 | 0.4 | 32 |
| 431946116004501 | 1S- 4E-17CCC1 | 8- 6-76 | 17.5 | 7.7 | - | 23 | 6.3 | 13 | 3.7 | 120 | 0 | 5.9 | 10 | .3 | 56 |
| 432304115572601 | 1N- 4E-32AAB1 | 8- 3-76 | 21.0 | 7.5 | - | 22 | 4.9 | 15 | 2.0 | 120 | 0 | 3.6 | 8.2 | .3 | 46 |
| 432834116213801 | 2N- 1E-29DCA1 | 8- 2-76 | 14.5 | 7.3 | - | 77 | 31 | 69 | 6.1 | 400 | 0 | 13 | 84 | .5 | 56 |
| 432918116013801 | 2N- 4E-19CDC1 | 8- 3-76 | 17.0 | 8.0 | - | 22 | 5.7 | 12 | 1.1 | 75 | 0 | 8.9 | 12 | .7 | 46 |
| 433134116053301 | 2N- 3E-10BCB1 | 8- 3-76 | 20.0 | 7.9 | - | 17 | 4.2 | 14 | 1.2 | 77 | 0 | 7.3 | 16 | .3 | 32 |
| 433218116134201 | 2N- 2E- 4CBA1 | 8- 3-76 | 19.0 | 7.1 | - | 46 | 10 | 27 | 1.7 | 160 | 0 | 12 | 62 | .4 | 34 |
| Adams County | | | | | | | | | | | | | | | |
| 445033116375701 | 17N- 2W- 6BCB1S | 6-17-82 | 15.0 | 8.1 | 5.6 | 24 | 4.5 | 14 | 9.3 | 110 | 0 | 8.6 | 23 | .2 | 11 |
| 445033116375701 | 17N- 2W- 6BCB1S | 8-26-82 | 16.0 | 8.0 | 1.0 | 24 | 4.4 | 15 | 1.9 | 120 | 0 | .7 | 23 | .1 | 31 |
| Boise County | | | | | | | | | | | | | | | |
| 433704115494701 | 3N- 5E-11BAB1S | 5-26-82 | 13.0 | 7.6 | 5.5 | 23 | 1.2 | 8.2 | .6 | 92 | 0 | .9 | 9.0 | .2 | 20 |
| 433704115494701 | 3N- 5E-11BAB1S | 8-27-82 | 14.0 | 7.6 | 3.9 | 24 | 1.3 | 9.3 | .6 | 92 | 0 | .9 | 11 | .1 | 21 |
| 435350115390001 | 7N- 7E-32DAC1S | 9-15-81 | 6.0 | 6.6 | - | 2.3 | .4 | 2.1 | .0 | 15 | 0 | .1 | 5.0 | .0 | 14 |
| 440449115250801 | 9N- 9E-32BAD1S | 8-13-79 | 4.5 | 6.6 | - | 3.8 | 1.9 | 3.1 | .6 | 29 | 0 | .4 | 1.9 | .1 | 14 |
| Bonneville County | | | | | | | | | | | | | | | |
| 431940111071501 | 1S-45E-13DAC1S | 7-13-77 | 13.5 | 7.5 | - | 57 | 20 | .9 | .4 | 280 | 0 | 1.2 | 2.2 | .1 | 5.4 |
| 433405111180001 | 3N-44E-20CCC1S | 7-13-77 | 9.0 | 7.3 | - | 61 | 19 | 2.6 | .5 | 270 | 0 | 1.2 | 18 | .1 | 10 |
| Camas County | | | | | | | | | | | | | | | |
| 433720114521301 | 3N-13E- 2DBA1S | 7-14-81 | 6.0 | 6.9 | - | 36 | 3.0 | 4.6 | 1.0 | 120 | 0 | 1.0 | 2.0 | .2 | 12 |
| Cassia County | | | | | | | | | | | | | | | |
| 420043113252601 | 16S-26E-21CDB1S | 7-29-75 | 15.5 | 7.1 | - | 80 | 34 | 150 | 4.7 | 350 | 0 | 200 | 75 | .3 | 19 |
| 420456113043101 | 15S-29E-33BBA1S | 8- 7-75 | 8.0 | 7.7 | - | 100 | 36 | 58 | 2.0 | 190 | 0 | 96 | 110 | .4 | 16 |
| 422116114035801 | 12S-20E-25BCA1 | 6- 8-82 | 20.5 | 7.8 | - | 38 | 8.4 | 10 | 2.6 | 140 | 0 | 7.5 | 11 | .2 | 20 |
| 422319113583601 | 12S-21E-10DCC1 | 6-30-82 | 21.0 | 8.1 | - | 23 | 2.3 | 8.4 | 5.3 | 88 | 0 | 8.5 | 6.0 | .2 | 59 |
| 422644113532501 | 11S-22E-28BBB1 | 6-30-82 | 16.0 | 7.6 | - | 110 | 19 | 35 | 8.4 | 250 | 0 | 110 | 86 | .2 | 45 |
| Elmore County | | | | | | | | | | | | | | | |
| 425924115435401 | 5S- 6E-15BCD1 | 8-11-76 | 22.0 | 8.2 | - | 58 | 18 | 19 | 5.2 | 170 | 0 | 45 | 68 | .3 | 51 |
| 430001115564601 | 5S- 4E-11DCB1S | 8-19-76 | 19.0 | 8.2 | - | 14 | 3.8 | 11 | 3.0 | 79 | 0 | 3.1 | 6.9 | .3 | 36 |
| 430112116001001 | 5S- 4E- 5CAA1 | 8-11-76 | 21.0 | 8.4 | - | 11 | 3.5 | 12 | 4.1 | 81 | 1 | 2.1 | 6.0 | .3 | 37 |
| 430156116035401 | 4S- 3E-35CAD1S | 8-16-76 | 19.5 | 8.2 | - | 13 | 3.8 | 12 | 3.5 | 82 | 0 | 2.1 | 6.0 | .3 | 39 |
| 4310141'5442901 | 3S- 6E- 9DDC1 | 8- 9-76 | 16.5 | 6.9 | - | 34 | 11 | 35 | 5.4 | 180 | 0 | 17 | 34 | .1 | 30 |
| 431204115533201 | 2S- 4E-36DCC1 | 8- 6-76 | 16.5 | 8.0 | - | 10 | 5.0 | 11 | 3.0 | 77 | 0 | 2.9 | 6.9 | .3 | 40 |
| 431620115493801 | 2S- 5E-11BAA1 | 8-10-76 | 18.0 | 8.0 | - | 25 | 7.3 | 33 | 7.3 | 170 | 0 | 11 | 20 | .9 | 48 |
| 431712115321101 | 1S- 8E-32CCD1S | 8-13-76 | 12.0 | 6.9 | - | 3.5 | .7 | 2.9 | 1.2 | 14 | 0 | .8 | 2.8 | .1 | 25 |
| 432238115424101 | 1N- 6E-35CBA1S | 8- 5-76 | 13.0 | 6.1 | - | 4.7 | 1.1 | 4.5 | 1.5 | 29 | 0 | 1.0 | 3.5 | .1 | 43 |
| 432443115391701 | 1N- 7E-20BBB1S | 8- 5-76 | 14.0 | 5.9 | - | 2.5 | .3 | 3.8 | 3.0 | 20 | 0 | 1.2 | 1.9 | .1 | 57 |
| 433220115170601 | 2N-10E- 5ADB1S | 8- 4-81 | 9.5 | 6.7 | - | 18 | 2.3 | 6.8 | .8 | 78 | 0 | .5 | 1.0 | .5 | 24 |
| 433732115094601 | 3N-11E- 5ADA1S | 7-15-81 | 10.0 | 8.0 | - | 33 | 2.8 | 10 | .6 | 120 | 0 | .9 | 5.0 | .1 | 19 |
| 434726115063501 | 5S-11E- 2DCC1S | 9- 1-81 | 7.5 | 6.7 | - | 14 | 1.1 | 3.4 | .5 | 51 | 0 | .3 | 5.0 | .5 | 15 |
| 434953115112801 | 6N-11E-30ADB1S | 9- 2-81 | 20.5 | 9.6 | - | 3.2 | .1 | 48 | .8 | 5 | 34 | 3.0 | 29 | 7.8 | 58 |
| Lemhi County | | | | | | | | | | | | | | | |
| 441405112582501 | 11N-29E-35CCC1S | 6- 8-82 | 9.0 | 7.9 | 8.8 | 37 | 12 | 3.4 | .8 | 170 | 0 | 4.4 | 17 | .2 | 8.2 |
| 441405112582501 | 11N-29E-35CCC1S | 8-24-82 | 10.0 | 7.9 | 8.3 | 36 | 12 | 3.4 | .8 | 160 | 0 | 4.6 | 15 | .2 | 8.3 |
| Madison County | | | | | | | | | | | | | | | |
| 433815111351501 | 4N-41E-35ADB1S | 6-18-77 | 11.5 | - | - | 11 | 2.7 | 4.2 | 2.6 | 51 | - | 2.5 | 5.7 | .3 | 44 |
| 434817111423501 | 6N-40E-35BDD1 | 6-16-77 | 13.0 | 7.7 | - | 47 | 19 | 13 | 2.6 | 210 | 0 | 21 | 13 | .4 | 33 |
| 435100111404401 | 6N-40E-13ADA1 | 7-15-77 | 9.5 | 7.1 | - | 50 | 13 | 11 | 2.5 | 220 | 0 | 12 | 6.7 | .2 | 28 |
| Owyhee County | | | | | | | | | | | | | | | |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | 26.5 | 7.9 | - | 31 | 10 | 30 | 5.4 | 140 | 0 | 19 | 32 | 1.0 | 71 |
| 421815115560501 | 13S- 4E-12CDD1 | 6-15-78 | 8.0 | 7.0 | - | 10 | 2.1 | 10 | 4.4 | 40 | 0 | 18 | 7.8 | .2 | 35 |
| 422940116531201 | 11S- 5W- 2DAB1S | 6-13-78 | 7.5 | 7.3 | - | 4.3 | 1.0 | 6.0 | 1.9 | 21 | 0 | 2.1 | 3.4 | .2 | 32 |
| 424240116220601 | 8S- 1E-20CCA1S | 7- 2-73 | 9.5 | 7.1 | - | 11 | 2.8 | 6.0 | .7 | 62 | 0 | 2.0 | 3.2 | .2 | 22 |
| 425402116325001 | 6S- 2W-14CBA1S | 7- 3-73 | 11.0 | 7.1 | - | 5.6 | 1.4 | 8.2 | 2.0 | 28 | 0 | 6.3 | 8.5 | .1 | 30 |

TABLE 22A.—*Concentrations of major dissolved solids in ground water in Snake River tributary drainage basins*—Continued

| Station No. | Location | Date | WT | pH | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Power County | | | | | | | | | |
| 13075810 | 6S-34E- 7ACA1S | 12-11-80 | 13.5 | 7.6 | - | 66 | 25 | 50 | 5.7 | 330 | 0 | 24 | 42 | 0.3 | 35 |
| 13075890 | 6S-33E- 1BAA1S | 12-18-80 | 11.0 | 7.8 | - | 51 | 15 | 18 | 3.4 | 210 | 0 | 19 | 36 | .7 | 25 |
| 13075915 | 5S-33E-36CAC1S | 12-17-80 | 10.5 | 7.6 | - | 84 | 35 | 86 | 4.9 | 260 | 0 | 130 | 160 | .8 | 30 |
| 13075973 | 5S-33E-27AAD1S | 12-17-80 | 11.0 | 8.0 | - | 49 | 16 | 19 | 3.5 | 200 | 0 | 20 | 42 | .7 | 20 |
| 425339112345301 | 6S-33E-15DCD1 | 12-11-80 | 6.5 | 7.4 | - | 130 | 39 | 40 | 3.2 | 390 | 0 | 100 | 58 | 1.6 | 31 |
| 425422112331401 | 6S-33E-13BBB1 | 12- 9-80 | 14.0 | 7.5 | - | 53 | 16 | 34 | 6.3 | 200 | 0 | 38 | 50 | .8 | 38 |
| 425426112332001 | 6S-33E-14AAA1 | 12-11-80 | 12.5 | 7.8 | - | 44 | 14 | 21 | .0 | 160 | 0 | 20 | 41 | .6 | 38 |
| 425429112324101 | 6S-33E-12CDD1 | 12- 9-80 | 14.5 | 7.0 | - | 90 | 31 | 62 | 11 | 240 | 0 | 120 | 120 | - | 43 |
| 425429112330301 | 6S-33E-12CCD1 | 12-10-80 | 8.5 | 7.3 | - | 140 | 51 | 140 | 1.4 | 290 | 0 | 320 | 150 | .8 | 46 |
| 425436112313001 | 6S-34E- 7CDA1 | 12- 8-80 | 12.0 | 7.2 | - | 110 | 31 | 69 | 8.3 | 340 | 0 | 47 | 200 | .7 | 38 |
| 425443112321201 | 6S-33E-12DAD1 | 12- 9-80 | 18.0 | 7.3 | - | 64 | 39 | 130 | 140 | 470 | 0 | 180 | 150 | - | 70 |
| 425444112321002 | 6S-33E-12DAD2 | 12- 9-80 | 12.5 | 7.7 | - | 47 | 15 | 29 | 5.4 | 180 | 0 | 29 | 48 | 1.1 | 32 |
| 425444112343602 | 6S-33E-10DAD2 | 12-11-80 | 11.0 | 7.9 | - | 46 | 15 | 20 | 3.6 | 180 | 0 | 20 | 47 | .6 | 27 |
| 425503112320101 | 6S-34E- 7BBC1 | 12-11-80 | 10.5 | 7.9 | - | 54 | 17 | 20 | 3.7 | 220 | 0 | 17 | 38 | 1.2 | 27 |
| | | | | | | Teton County | | | | | | | | | |
| 433420111122501 | 3S-44E-24ACD1S | 7-12-77 | 10.0 | 7.1 | - | 49 | 10 | 22 | 1.3 | 180 | 0 | 45 | 5.2 | .1 | 8.1 |
| 434304111181701 | 5N-44E-31ACA1S | 6-19-77 | 7.0 | 7.3 | - | 53 | 9.1 | 76 | 1.3 | 390 | 0 | 1.9 | 5.5 | .4 | 8.6 |
| 434428111233901 | 5N-43E-21CCA1S | 7-14-77 | 4.0 | 7.2 | - | 5.4 | .9 | 3.5 | .8 | 21 | 0 | 1.0 | 2.4 | .1 | 23 |
| 434553111182601 | 5N-44E-18ABD1S | 6-19-77 | 12.0 | 7.5 | - | 45 | .1 | 5.4 | 3.3 | 170 | 0 | 3.7 | 4.1 | .2 | 44 |
| 434944111351501 | 6N-43E-24DCA1S | 6-19-77 | 9.5 | 7.1 | - | 17 | 3.9 | 4.9 | .9 | 71 | 0 | 1.9 | 6.0 | .1 | 25 |
| | | | | | | Twin Falls County | | | | | | | | | |
| 421157114351001 | 14S-16E-21BAB1S | 2-10-81 | 7.5 | 7.6 | - | 34 | 5.4 | 19 | 3.6 | 120 | 0 | 16 | 17 | .3 | 52 |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | 26.0 | 7.5 | - | 22 | 2.6 | 19 | 5.8 | 110 | 0 | 6.4 | 12 | .6 | 60 |
| 421245114182401 | 14S-18E-14ABD1S | 5-13-81 | 4.5 | 6.0 | - | 2.6 | .7 | 3.4 | 2.6 | 20 | 0 | 1.3 | 3.4 | .1 | 38 |
| 421322114473501 | 14S-14E-11CAB1S | 6-27-78 | 12.0 | 7.0 | - | 7.2 | 1.2 | 5.9 | 2.6 | 30 | 0 | 3.1 | 5.0 | .2 | 35 |
| 421352114223801 | 14S-18E- 5CCC1S | 5-18-82 | 6.5 | 6.2 | 2.9 | 3.2 | .9 | 4.0 | 3.3 | 29 | 0 | 1.8 | 7.0 | .1 | 47 |
| 421424114235201 | 14S-18E- 6BCC1S | 8-25-82 | 9.0 | 6.8 | 8.5 | 5.1 | 1.2 | 6.1 | 5.8 | 38 | 0 | 2.3 | 5.0 | .1 | 58 |
| 421528114231801 | 13S-18E-31BAA1S | 5-14-81 | 7.0 | 6.6 | - | 6.1 | 1.3 | 8.9 | 7.0 | 44 | 0 | 3.5 | 1.5 | .2 | 65 |
| 421617114213501 | 13S-18E-29AAD1S | 5-13-81 | 9.0 | 6.7 | - | 5.4 | 1.3 | 6.0 | 5.0 | 34 | 0 | 1.6 | 2.0 | .2 | 56 |
| 422347114412601 | 12S-15E-10CBB1 | 3-18-81 | 18.5 | 7.8 | - | 23 | 8.4 | 13 | 2.9 | 120 | 0 | 9.0 | 11 | .2 | 48 |
| 422517114342301 | 11S-16E-34CCB1 | 4-22-81 | 21.0 | 7.7 | - | 94 | 26 | 22 | 6.8 | 150 | 0 | 110 | 100 | .4 | 58 |
| 422743114305501 | 11S-16E-24AAA1 | 3-19-81 | 20.5 | 7.8 | - | 56 | 88 | 110 | 6.8 | 360 | 0 | 120 | 260 | .4 | 39 |
| 422954114370701 | 11S-16E- 6DBA1 | 6-24-81 | 20.0 | 7.9 | - | 78 | 66 | 94 | 11 | 230 | 0 | 150 | 290 | .4 | 55 |
| 423443114441501 | 10S-15E- 7ABD1 | 2-10-81 | 25.0 | 8.0 | - | 35 | 4.5 | 63 | 12 | 160 | 0 | 35 | 69 | 1.6 | 71 |
| 423455114592401 | 10S-12E- 1DDC1 | 6- 2-82 | 26.0 | 7.6 | - | 45 | 9.1 | 39 | 7.0 | 130 | 0 | 31 | 64 | 1.3 | 65 |
| 424239115001801 | 8S-12E-24CCC1 | 6-10-82 | 24.0 | 8.6 | - | 11 | 1.6 | 54 | 4.5 | 130 | 0 | 9.3 | 18 | 6.3 | 70 |
| | | | | | | Valley County | | | | | | | | | |
| 442644115520001 | 13N- 5E-21CAA1S | 6-26-79 | 6.5 | 6.2 | - | 1.1 | .1 | 1.9 | .2 | 7 | 0 | .4 | 1.4 | .1 | 13 |
| 443712115483601 | 15N- 5E-23DAC1S | 6-27-79 | 4.0 | 6.2 | - | 1.7 | .2 | 2.4 | .3 | 12 | 0 | .3 | .7 | .2 | 17 |
| 444900116121401 | 17N- 2E-15BAB1S | 6-28-79 | 7.0 | 7.3 | - | 7.8 | 2.9 | 3.9 | 1.8 | 51 | 0 | .4 | 2.6 | .1 | 45 |
| | | | | | | Washington County | | | | | | | | | |
| 442024116480401 | 12N- 4W-34ABB1S | 8- 7-73 | 13.5 | 7.4 | - | 30 | 11 | 13 | 3.9 | 170 | 0 | 3.5 | 13 | .7 | 54 |
| 442115117065201 | 12N- 7W-24ADD1S | 8- 6-73 | 15.0 | 7.9 | - | 20 | 3.6 | 24 | 7.5 | 130 | 0 | 3.3 | 22 | .4 | 47 |
| | | | | | | Elko County, NV | | | | | | | | | |
| 415237115145001 | 46N-59E-13ACC1S | 6-27-78 | 4.0 | 6.1 | - | 1.9 | <.1 | 1.7 | 2.8 | 13 | 0 | .4 | 2.7 | .1 | 33 |

TABLE 22B.—*Concentrations of dissolved trace solids in ground water in Snake River tributary drainage basins*

| Station No. | Location | Date | Al | As | Ba | Be | B | Cd | Cr | Co | Cu | Fe | Pb | Li | Mn | Mo | Sr | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Adams County | | | | | | | | | | | | |
| 445033116375701 | 17N- 2W- 6BCB1S | 6-17-82 | <10 | - | <100 | - | - | - | - | - | - | - | - | <10 | - | - | 200 | - | 10 |
| 445033116375701 | 17N- 2W- 6BCB1S | 8-26-82 | 10 | - | 44 | - | - | - | - | - | - | - | - | 13 | - | - | 150 | - | <3 |
| | | | | | | | Boise County | | | | | | | | | | | | |
| 433704115494701 | 3N- 5E-11BAB1S | 5-26-82 | <10 | - | 8 | - | - | - | - | - | - | - | - | 20 | - | - | 140 | - | 5 |
| 433704115494701 | 3N- 5E-11BAB1S | 8-27-82 | <10 | - | 10 | - | - | - | - | - | - | - | - | 22 | - | - | 150 | - | 8 |
| 435350115390001 | 7N- 7E-32DAC1S | 9-15-81 | - | 0 | - | - | 0 | - | - | - | - | - | - | 4 | - | - | - | - | - |
| 440449115250801 | 9N- 9E-32BAD1S | 8-13-79 | - | <1 | - | - | <20 | - | - | - | - | - | - | <10 | - | - | - | - | - |
| | | | | | | | Bonneville County | | | | | | | | | | | | |
| 431940111071501 | 1S-45E-13DAC1S | 7-13-77 | - | <1 | <100 | <10 | 4 | - | - | - | - | <10 | - | 2 | 4 | - | 100 | - | - |
| 433405111180001 | 3N-44E-20CCC1S | 7-13-77 | - | <1 | <100 | <10 | 9 | - | - | - | - | 20 | - | 2 | <10 | - | 180 | - | - |
| | | | | | | | Camas County | | | | | | | | | | | | |
| 433720114521301 | 3N-13E- 2DBA1S | 7-14-81 | - | 0 | - | - | 0 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| | | | | | | | Cassia County | | | | | | | | | | | | |
| 422116114035801 | 12S-20E-25BCA1 | 6- 8-82 | - | - | - | - | 20 | - | - | - | - | - | - | - | - | - | - | - | - |
| 422319113583601 | 12S-21E-10DCC1 | 6-30-82 | - | - | - | - | 20 | - | - | - | - | - | - | - | - | - | - | - | - |
| 422644113532501 | 11S-22E-28BBB1 | 6-30-82 | - | - | - | - | 60 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | Elmore County | | | | | | | | | | | | |
| 433220115170601 | 2N-10E- 5ADB1S | 8- 4-81 | - | 2 | - | - | 10 | - | - | - | - | - | - | 8 | - | - | - | - | - |
| 433732115094601 | 3N-11E- 5ADA1S | 7-15-81 | - | 1 | - | - | 0 | - | - | - | - | - | - | 30 | - | - | - | - | - |
| 434726115063501 | 5S-11E- 2DCC1S | 9- 1-81 | - | 0 | - | - | 0 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| 434953115112801 | 6N-11E-30ADB1S | 9- 2-81 | - | 5 | - | - | 30 | - | - | - | - | - | - | 79 | - | - | - | - | - |
| | | | | | | | Lemhi County | | | | | | | | | | | | |
| 441405112582501 | 11N-29E-35CCC1S | 6- 8-82 | 10 | - | <100 | - | - | - | - | - | - | - | - | 10 | - | - | 170 | - | <10 |
| 441405112582501 | 11N-29E-35CCC1S | 8-24-82 | 10 | - | 66 | - | - | - | - | - | - | - | - | 16 | - | - | 130 | - | 4 |
| | | | | | | | Madison County | | | | | | | | | | | | |
| 433815111351501 | 4N-41E-35ADB1S | 6-18-77 | - | 2 | <100 | <10 | <20 | - | - | - | - | - | - | <10 | <10 | - | 60 | - | - |
| 434817111423501 | 6N-40E-35BDD1 | 6-16-77 | - | 2 | <100 | <10 | <20 | - | - | - | - | - | - | <10 | 8 | - | 160 | - | - |
| 435100111404401 | 6N-40E-13ADA1 | 7-15-77 | - | - | - | - | 40 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | Owyhee County | | | | | | | | | | | | |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | - | 9 | - | - | 70 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 421815115560501 | 13S- 4E-12CDD1 | 6-15-78 | - | 1 | - | - | 50 | - | - | - | - | - | - | 9 | - | - | - | - | - |
| 422940116531201 | 11S- 5W- 2DAB1S | 6-13-78 | - | 1 | - | - | 30 | - | - | - | - | - | - | 5 | - | - | - | - | - |
| 424240116220601 | 8S- 1E-20CCA1S | 7- 2-73 | - | 2 | - | - | <20 | - | - | - | - | - | - | <10 | - | - | - | - | - |
| 425402116325001 | 6S- 2W-14CBA1S | 7- 3-73 | - | 1 | - | - | 30 | - | - | - | - | - | - | <10 | - | - | - | - | - |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Power County | | | | | | | | | | | | |
| 13075810 | 6S-34E- 7ACA1S | 12-11-80 | - | 3 | - | - | 90 | <1 | 10 | - | - | <10 | 1 | - | - | <10 | - | - | <3 |
| 13075890 | 6S-33E- 1BAA1S | 12-18-80 | - | 2 | - | - | 60 | <1 | 0 | - | - | <10 | 48 | - | - | <10 | - | - | <3 |
| 13075915 | 5S-33E-36CAC1S | 12-17-80 | - | 2 | - | - | 120 | 1 | 0 | - | - | 10 | 45 | - | - | 12 | - | - | <3 |
| 13075973 | 5S-33E-27AAD1S | 12-17-80 | - | 2 | - | - | 60 | <1 | 0 | - | - | <10 | 40 | - | - | <10 | - | - | <3 |
| 425339112345301 | 6S-33E-15DCD1 | 12-11-80 | - | 1 | 180 | - | 50 | <1 | 0 | <3 | - | <10 | <10 | - | <1 | <10 | - | <6 | 90 |
| 425422112331401 | 6S-33E-13BBB1 | 12- 9-80 | - | 7 | - | - | 110 | <1 | 10 | - | - | 10 | <10 | - | - | <10 | - | - | <3 |
| 425426112332001 | 6S-33E-14AAA1 | 12-11-80 | - | 3 | 80 | - | 40 | <1 | 0 | <3 | - | 10 | <10 | - | 5 | <10 | 250 | - | 270 |
| 425429112324101 | 6S-33E-12CDD1 | 12- 9-80 | - | 16 | - | - | 280 | <1 | 0 | - | - | 60 | <10 | - | - | 15 | - | - | <3 |
| 425429112330301 | 6S-33E-12CCD1 | 12-10-80 | - | 7 | 130 | - | 160 | <1 | 0 | <3 | <10 | 20 | <10 | - | <1 | <10 | - | - | 310 |
| 425436112313001 | 6S-34E- 7CDA1 | 12- 8-80 | - | 5 | - | - | 120 | <1 | 10 | - | - | <10 | <10 | - | - | <10 | - | - | <3 |
| 425443112321201 | 6S-33E-12DAD1 | 12- 9-80 | - | 40 | 250 | - | 960 | <1 | 0 | 14 | - | 40 | <10 | - | 1,100 | 51 | 440 | - | <3 |
| 425444112321002 | 6S-33E-12DAD2 | 12- 9-80 | - | 3 | 80 | - | 40 | <1 | 0 | <3 | <10 | 30 | <10 | - | 4 | 10 | - | - | <3 |
| 425444112343602 | 6S-33E-10DAD2 | 12-11-80 | - | 2 | 70 | - | 50 | <1 | 0 | <3 | <10 | <10 | <10 | - | <1 | <10 | - | - | <3 |
| 425503112320101 | 6S-34E- 7BBC1 | 12-11-80 | - | 2 | 80 | - | 30 | <1 | 10 | <3 | <10 | 10 | <10 | - | <1 | <10 | - | - | 80 |
| | | | | | | | Teton County | | | | | | | | | | | | |
| 433420111122501 | 3S-44E-24ACD1S | 7-12-77 | - | <1 | 300 | <10 | <20 | - | - | - | - | 20 | - | 2 | <10 | - | 170 | - | - |
| 434304111181701 | 5N-44E-31ACA1S | 6-19-77 | - | <1 | 500 | <10 | 50 | - | - | - | - | - | - | 20 | 140 | - | 640 | - | - |
| 434428111233901 | 5N-43E-21CCA1S | 7-14-77 | - | <1 | <100 | <10 | 9 | - | - | - | - | 60 | - | 2 | <10 | - | 50 | - | - |
| 434553111182601 | 5N-44E-18ABD1S | 6-19-77 | - | 1 | <100 | <10 | <20 | - | - | - | - | - | - | 2 | 4 | - | 110 | - | - |
| 434944111351501 | 6N-43E-24DCA1S | 6-19-77 | - | 1 | <100 | <10 | 9 | - | - | - | - | - | - | <10 | <10 | - | 70 | - | - |
| | | | | | | | Twin Falls County | | | | | | | | | | | | |
| 421157114351001 | 14S-16E-21BAB1S | 2-10-81 | - | 6 | - | - | 60 | - | - | - | - | - | - | 0 | - | - | - | - | - |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | - | 3 | - | - | 10 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 421245114182401 | 14S-18E-14ABD1S | 5-13-81 | - | 0 | - | - | 5 | - | - | - | - | - | - | 4 | - | - | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 6-27-78 | - | 1 | - | - | <20 | - | - | - | - | - | - | 4 | - | - | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 7-14-82 | 80 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 421352114223801 | 14S-18E- 5CCC1S | 5-18-82 | 340 | - | <100 | - | - | - | - | - | - | - | - | <10 | - | - | 50 | - | 10 |
| 421424114235201 | 14S-18E- 6BCC1S | 8-25-82 | 70 | - | 73 | - | - | - | - | - | - | - | - | 14 | - | - | 34 | - | 3 |
| 421528114231801 | 13S-18E-31BAA1S | 5-14-81 | - | 1 | - | - | 20 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| 421617114213501 | 13S-18E-29AAD1S | 5-13-81 | - | 0 | - | - | 20 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| 422347114412601 | 12S-15E-10CBB1 | 3-18-81 | - | 4 | - | - | 20 | - | - | - | - | - | - | 6 | - | - | - | - | - |
| 422517114342301 | 11S-16E-34CCB1 | 4-22-81 | - | 3 | - | - | 50 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 422743114305501 | 11S-16E-24AAA1 | 3-19-81 | - | 5 | - | - | 270 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 422954114370701 | 11S-16E- 6DBA1 | 6-24-81 | - | 6 | - | - | 170 | - | - | - | - | - | - | 40 | - | - | - | - | - |
| 423443114441501 | 10S-15E- 7ABD1 | 2-10-81 | - | 9 | - | - | 80 | - | - | - | - | - | - | 70 | - | - | - | - | - |
| 423455114592401 | 10S-12E- 1DDC1 | 6- 2-82 | - | - | - | - | 70 | - | - | - | - | - | - | - | - | - | - | - | - |
| 424239115001801 | 8S-12E-24CCC1 | 6-10-82 | - | - | - | - | 90 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | Valley County | | | | | | | | | | | | |
| 442644115520001 | 13N- 5E-21CAA1S | 6-26-79 | - | <1 | - | - | <20 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| 443712115483601 | 15N- 5E-23DAC1S | 6-27-79 | - | 1 | - | - | <20 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| 444900116121401 | 17N- 2E-15BAB1S | 6-28-79 | - | <1 | - | - | 2 | - | - | - | - | - | - | <4 | - | - | - | - | - |
| | | | | | | | Washington County | | | | | | | | | | | | |
| 442024116480401 | 12N- 4W-34ABB1S | 8- 7-73 | - | 41 | - | - | <20 | - | - | - | - | - | - | 20 | - | - | - | - | - |
| 442115117065201 | 12N- 7W-24ADD1S | 8- 6-73 | - | 18 | - | - | <20 | - | - | - | - | - | - | 40 | - | - | - | - | - |
| | | | | | | | Elko County, NV | | | | | | | | | | | | |
| 415237115145001 | 46N-59E-13ACC1S | 6-27-78 | - | 1 | - | - | 2 | - | - | - | - | - | - | 2 | - | - | - | - | - |

TABLE 22C.—*Stable-isotope ratios and tritium in ground water in Snake River tributary drainage basins*

[Tritium data from Rightmire and others (1976), Young (1977), Crosthwaite (1979), Lewis and Young (1980, 1982a, b), Jacobson (1982), Young and Lewis (1982), and unpublished data files of the U.S. Geological Survey]

| Station No. | Location | Date | $\delta^{2}H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ | $^{3}H$[1] |
|---|---|---|---|---|---|---|---|
| | | Ada County | | | | | |
| 431752116283001 | 1S- 1W-32AAD1S | 8-12-76 | -130 | -17.6 | - | - | - |
| 431946116004501 | 1S- 4E-17CCC1 | 8- 6-76 | -128 | -17.4 | - | - | - |
| 432304115572601 | 1N- 4E-32AAB1 | 8- 3-76 | -125 | -16.6 | - | - | - |
| 432520116260401 | 1N- 1W-15DAA1 | 8-12-76 | -133 | -16.9 | - | - | - |
| 432834116213801 | 2N- 1E-29DCA1 | 8- 2-76 | -127 | -17.6 | - | - | - |
| 432918116013801 | 2N- 4E-19CDC1 | 8- 3-76 | -120 | -14.8 | - | - | - |
| 433134116053301 | 2N- 3E-10BCB1 | 8- 3-76 | -126 | -17.5 | - | - | - |
| 433218116134201 | 2N- 2E- 4CBA1 | 8- 3-76 | -124 | -15.2 | - | - | - |
| | | Adams County | | | | | |
| 445033116375701 | 17N- 2W- 6BCB1S | 6-17-82 | -132 | -17.6 | -15.4 | +8.3 | - |
| 445033116375701 | 17N- 2W- 6BCB1S | 8-26-82 | -132 | -17.6 | -15.7 | +5.5 | - |
| | | Boise County | | | | | |
| 433704115494701 | 3N- 5E-11BAB1S | 5-26-82 | -125 | -16.4 | -16.1 | - | - |
| 433704115494701 | 3N- 5E-11BAB1S | 8-27-82 | -124 | -16.2 | -16.5 | -1.4 | - |
| 435350115390001 | 7N- 7E-32DAC1S | 9-15-81 | -123 | -16.5 | - | - | - |
| 440449115250801 | 9N- 9E-32BAD1S | 8-13-79 | -131 | -17.7 | - | - | - |
| | | Bonneville County | | | | | |
| 431940111071501 | 1S-45E-13DAC1S | 7-13-77 | -138 | -17.7 | - | - | - |
| 433405111180001 | 3N-44E-20CCC1S | 7-13-77 | -134 | -17.9 | - | - | - |
| | | Camas County | | | | | |
| 433720114521301 | 3N-13E- 2DBA1S | 7-14-81 | -131 | -17.5 | - | - | 45.0±2.5 |
| | | Cassia County | | | | | |
| 420043113252601 | 16S-26E-21CDB1S | 7-29-75 | -126 | -16.8 | - | - | - |
| 420456113043101 | 15S-29E-33BBA1S | 8- 7-75 | -130 | -17.1 | - | - | - |
| 420518113440101 | 15S-23E-26DBB1S | 7-31-75 | -133 | -17.6 | - | - | - |
| 420657113434201 | 15S-23E-14DDC1S | 7-31-75 | -136 | -18.2 | - | - | - |
| 420720113303001 | 15S-25E-14BBC1S | 8- 5-75 | -133 | -17.7 | - | - | - |
| 421406113415801 | 14S-24E- 6BDC1S | 8- 6-75 | -127 | -17.7 | - | - | - |
| 421501113411701 | 13S-24E-32BDA1S | 8- 6-75 | -126 | -16.7 | - | - | - |
| 421814114080001 | Bowers Spring | 6- 8-82 | -123 | -16.7 | - | - | - |
| 421914113272501 | 13S-26E- 6DBA1S | 8- 8-75 | -131 | -17.1 | - | - | - |
| 421943114075901 | Unnamed Spring | 6-10-82 | -124 | -16.7 | - | - | - |
| 422116114035801 | 12S-20E-25BCA1 | 6- 8-82 | -131 | -17.5 | - | - | - |
| 422319113583601 | 12S-21E-10DCC1 | 6-30-82 | -128 | -17.2 | - | - | - |
| 422644113532501 | 11S-22E-28BBB1 | 6-30-82 | -126 | -16.5 | - | - | - |
| | | Elmore County | | | | | |
| 425924115435401 | 5S- 6E-15BCD1 | 8-11-76 | -125 | -16.7 | - | - | - |
| 430001115564601 | 5S- 4E-11DCB1S | 8-19-76 | -130 | -17.8 | - | - | - |
| 430112116001001 | 5S- 4E- 5CAA1 | 8-11-76 | -128 | -16.6 | - | - | - |
| 430156116035401 | 4S- 3E-35CAD1S | 8-16-76 | -129 | -17.3 | - | - | - |
| 431014115442901 | 3S- 6E- 9DDC1 | 8- 9-76 | -118 | -16.2 | - | - | - |
| 431204115533201 | 2S- 4E-36DCC1 | 8- 6-76 | -127 | -16.4 | - | - | - |
| 431620115493801 | 2S- 5E-11BAA1 | 8-10-76 | -129 | -16.4 | - | - | - |
| 431712115321101 | 1S- 8E-32CCD1S | 8-13-76 | -125 | -16.6 | - | - | - |
| 432238115424101 | 1N- 6E-35CBA1S | 8- 5-76 | -120 | -15.7 | - | - | - |
| 432443115391701 | 1N- 7E-20BBB1S | 8- 5-76 | -126 | -17.6 | - | - | - |
| 433220115170601 | 2N-10E- 5ADB1S | 8- 4-81 | -128 | -16.8 | - | - | 24.4±3.4 |
| 433732115094601 | 3N-11E- 5ADA1S | 7-15-81 | -140 | -18.3 | - | - | - |
| 434726115063501 | 5S-11E- 2DCC1S | 9- 1-81 | -133 | -17.5 | - | - | 53.6±3.4 |
| | | Fremont County | | | | | |
| 441219111145901 | 10N-44E-10CBA1S | 7-22-77 | -135 | -17.8 | - | - | - |
| 443003111151501 | 14N-44E-34BBB1S | 7-22-77 | -140 | -18.2 | - | - | - |
| | | Lemhi County | | | | | |
| 441405112582501 | 11N-29E-35CCC1S | 6- 8-82 | -144 | -19.5 | -6.5 | -.5 | - |
| 441405112582501 | 11N-29E-35CCC1S | 8-24-82 | -142 | -18.8 | -6.5 | -.8 | - |

TABLE 22C.—*Stable-isotope ratios and tritium in ground water in Snake River tributary drainage basins*—Continued

| Station No. | Location | Date | $\delta^{2}H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ | $^{3}H$[1] |
|---|---|---|---|---|---|---|---|
| | | Madison County | | | | | |
| 433815111351501 | 4N-41E-35ADB1S | 6-18-77 | -134 | -17.5 | - | - | - |
| 433835111394501 | 6N-41E-31AAC1 | 7-23-77 | -140 | -18.0 | - | - | - |
| 434638111414101 | 5N-40E-12CAA1 | 7-23-77 | -139 | -18.0 | - | - | - |
| 434811111463901 | 6N-40E-31DAA1 | 7-23-77 | -139 | -17.8 | - | - | - |
| 434817111423501 | 6N-40E-35BDD1 | 6-16-77 | -140 | -18.0 | - | - | - |
| 435043111351801 | 6N-41E-14CAD1 | 7-23-77 | -143 | -18.4 | - | - | - |
| 435100111404401 | 6N-40E-13ADA1 | 7-15-77 | -132 | - | - | - | - |
| 435129111353401 | 6N-41E-11CDB1 | 6-17-77 | -143 | -18.8 | - | - | - |
| | | Owyhee County | | | | | |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | -124 | -16.4 | - | - | - |
| 421815115560501 | 13S- 4E-12CDD1 | 6-15-78 | -116 | -13.8 | - | - | 67 |
| 422940116531201 | 11S- 5W- 2DAB1S | 6-13-78 | -118 | -15.4 | - | - | 84 |
| 423720116325701 | 9S- 2W-26CCC1S | 5-18-77 | -122 | -16.5 | - | - | - |
| 424240116220601 | 8S- 1E-20CCA1S | 7- 2-73 | -128 | -17.1 | - | - | - |
| 424240116220601 | 8S- 1E-20CCA1S | 4-30-82 | - | - | -17.3 | - | - |
| 425402116325001 | 6S- 2W-14CBA1S | 7- 3-73 | -133 | -16.4 | - | - | - |
| 425402116325001 | 6S- 2W-14CBA1S | 4-30-82 | - | - | -16.6 | - | - |
| | | Power County | | | | | |
| 13075810 | 6S-34E- 7ACA1S | 12-11-80 | -127 | -16.4 | - | - | 84 |
| 13075890 | 6S-33E- 1BAA1S | 12-18-80 | -131 | -17.2 | - | - | 40 |
| 13075915 | 5S-33E-36CAC1S | 12-17-80 | -131 | -17.1 | - | - | 34 |
| 13075973 | 5S-33E-27AAD1S | 12-17-80 | -136 | - | - | - | 14 |
| 425339112345301 | 6S-33E-15DCD1 | 12-11-80 | -130 | -17.1 | - | - | 34 |
| 425422112331401 | 6S-33E-13BBB1 | 12- 9-80 | -138 | -18.2 | - | - | - |
| 425426112332001 | 6S-33E-14AAA1 | 12-11-80 | -138 | -18.1 | - | - | - |
| 425429112324101 | 6S-33E-12CDD1 | 12- 9-80 | -134 | -17.6 | - | - | 7.8 |
| 425429112330301 | 6S-33E-12CCD1 | 12-10-80 | -132 | -17.4 | - | - | 11 |
| 425436112313001 | 6S-34E- 7CDA1 | 12- 8-80 | -137 | -18.0 | - | - | - |
| 425443112321201 | 6S-33E-12DAD1 | 12- 9-80 | -134 | -17.6 | - | - | 12 |
| 425444112321002 | 6S-33E-12DAD2 | 12- 9-80 | -137 | -18.3 | - | - | - |
| 425444112343602 | 6S-33E-10DAD2 | 12-11-80 | -139 | -18.2 | - | - | - |
| 425503112320101 | 6S-34E- 7BBC1 | 12-11-80 | -131 | -17.5 | - | - | 24 |
| | | Teton County | | | | | |
| 433420111122501 | 3S-44E-24ACD1S | 7-12-77 | -134 | -17.2 | - | - | - |
| 434304111181701 | 5N-44E-31ACA1S | 6-19-77 | -136 | -17.8 | - | - | - |
| 434325111212001 | 5N-43E-26CCD1S | 7-23-77 | -136 | -18.0 | - | - | - |
| 434428111233901 | 5N-43E-21CCA1S | 7-14-77 | -134 | -17.6 | - | - | - |
| 434553111182601 | 5N-44E-18ABD1S | 6-19-77 | -145 | -18.8 | - | - | - |
| 434944111351501 | 6N-43E-24DCA1S | 6-19-77 | -137 | -17.9 | - | - | - |
| | | Twin Falls County | | | | | |
| 421157114351001 | 14S-16E-21BAB1S | 2-10-81 | -120 | -14.6 | - | - | - |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | -131 | -16.7 | - | - | - |
| 421245114182401 | 14S-18E-14ABD1S | 5-13-81 | -123 | -16.2 | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 6-27-78 | -126 | -17.1 | - | - | 95 |
| 421322114473501 | 14S-14E-11CAB1S | 2- 2-82 | - | - | -12.9 | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 3-10-82 | -125 | -16.9 | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 5-17-82 | -124 | -16.5 | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 7-14-82 | -125 | -16.5 | - | - | - |
| 421322114473501 | 14S-14E-11CAB1S | 10-22-82 | - | - | - | +12.6 | - |
| 421352114223801 | 14S-18E- 5CCC1S | 5-18-82 | -123 | -16.2 | -19.9 | - | - |
| 421424114235201 | 14S-18E- 6BCC1S | 8-25-82 | -121 | -16.0 | -17.9 | - | - |
| 421528114231801 | 13S-18E-31BAA1S | 5-14-81 | -127 | -16.4 | - | - | - |
| 421617114213501 | 13S-18E-29AAD1S | 5-13-81 | -127 | -16.4 | - | - | - |
| 422347114412601 | 12S-15E-10CBB1 | 3-18-81 | -123 | -15.4 | - | - | - |
| 422517114342301 | 11S-16E-34CCB1 | 4-22-81 | -139 | -17.4 | - | - | - |
| 422743114305501 | 11S-16E-24AAA1 | 3-19-81 | -120 | -15.0 | - | - | - |
| 422954114370701 | 11S-16E- 6DBA1 | 6-24-81 | -131 | -16.4 | - | - | - |
| 423443114441501 | 10S-15E- 7ABD1 | 2-10-81 | -129 | -16.4 | - | - | - |
| 423455114592401 | 10S-12E- 1DDC1 | 6- 2-82 | -131 | -17.3 | - | - | - |
| 424239115001801 | 8S-12E-24CCC1 | 6-10-82 | -150 | -19.5 | - | - | - |

TABLE 22C.—*Stable-isotope ratios and tritium in ground water in Snake River tributary drainage basins*—Continued

| Station No. | Location | Date | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ | $^3H$ [1] |
|---|---|---|---|---|---|---|---|
| | | | Valley County | | | | |
| 442644115520001 | 13N- 5E-21CAA1S | 6-26-79 | -128 | -17.3 | - | - | 60.2±2.7 |
| 443712115463801 | 15N- 5E-23DAC1S | 6-27-79 | -124 | -17.7 | - | - | 46.8±2.1 |
| 444900116121401 | 17N- 2E-15BAB1S | 6-28-79 | -127 | -17.1 | - | - | - |
| | | | Washington County | | | | |
| 442024116480401 | 12N- 4W-34ABB1 | 8- 7-73 | -120 | -15.1 | - | - | - |
| 442115117065201 | 12N- 7W-24ADD1 | 8- 6-73 | -128 | -16.1 | - | - | - |
| | | | Elko County, NV | | | | |
| 415237115145001 | 46N-59E-13ACC1S | 6-27-78 | -127 | -16.7 | -21.9 | - | 59 |

[1] Data from Rightmire and others (1976); Young (1977); Crosthwaite (1979); Lewis and Young (1980, 1982a, 1982b); Jacobson (1982); Young and Lewis (1982); and unpublished data files of the U.S. Geological Survey.

TABLE 23A.—*Selected analyses of major dissolved solutes in geothermal wells and springs, Snake River basin*

| Station No. | Location | Date | WT | pH | Eh | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Boise County | | | | | | | | | |
| 434014115414601 | 4N- 6E-24BCB1S | 5-27-81 | 37.0 | 9.5 | - | - | 1.7 | 0.1 | 49 | 1.3 | 9 | 43 | 1.6 | 21 | 4.1 | 86 |
| 434858115514901 | 6N- 5E-33ADC1S | 5-11-81 | 42.0 | 9.5 | - | - | 2.0 | .1 | 65 | .8 | 41 | 36 | 2.7 | 22 | 13 | 57 |
| 440241115510001 | 8N- 5E-10BDD1S | 8-18-72 | 55.0 | 8.6 | - | - | 1.9 | .0 | 68 | 1.1 | 40 | 30 | 5.6 | 38 | 14 | 59 |
| 440241115510001 | 8N- 5E-10BDD1S | 11-27-78 | 54.5 | 9.2 | - | - | 2.0 | .1 | 75 | 1.0 | 50 | 23 | 5.7 | 38 | 14 | 74 |
| 440312115543601 | 8N- 5E- 6DCC1S | 2-26-79 | 51.0 | 9.1 | - | - | 5.0 | .1 | 72 | 1.3 | 61 | 22 | 7.8 | 36 | 15 | 63 |
| 440340115411401 | 8N- 6E- 1ADB1S | 2-27-79 | 59.5 | 9.2 | - | - | 2.0 | .1 | 75 | 1.1 | 39 | 29 | 6.7 | 38 | 17 | 63 |
| 440430115324001 | 9N- 8E-32CBA1S | 2-27-79 | 64.0 | 9.1 | - | - | 1.9 | .1 | 70 | 1.3 | 29 | 29 | 3.9 | 39 | 16 | 67 |
| 440530116030201 | 9N- 3E-25BAC1S | 8- 4-72 | 80.0 | 8.1 | - | - | 4.5 | .0 | 130 | 4.8 | 160 | 0 | 34 | 79 | 13 | 120 |
| 440530116030201 | 9N- 3E-25BAC1S | 11-22-78 | 79.5 | 8.0 | - | - | 6.1 | .1 | 120 | 5.3 | 160 | 0 | 39 | 88 | 12 | 120 |
| 440910115593801 | 10N- 4E-33CBD1S | 11-27-78 | 75.0 | 8.4 | - | - | 1.9 | .1 | 90 | 3.2 | 130 | 2 | 19 | 27 | 13 | 110 |
| 440915115184001 | 10N-10E-31BCC1S | 8-18-72 | 85.0 | 8.1 | - | - | 2.2 | .1 | 75 | 2.9 | 58 | 21 | 7.2 | 52 | 17 | 100 |
| 440915115184001 | 10N-10E-31BCC1S | 3-13-79 | 84.0 | 9.3 | - | - | 1.5 | .1 | 77 | 3.2 | 18 | 38 | 8.0 | 50 | 17 | 91 |
| | | | | | | | Camas County | | | | | | | | | |
| 433349114475501 | 3N-14E-28CAD1S | 7-14-81 | 87.0 | 9.4 | - | - | 1.5 | .0 | 69 | 1.9 | 33 | 40 | 5.3 | 35 | 13 | 95 |
| 433609115041501 | 3N-12E- 7DCD1S | 7-15-81 | 50.0 | 9.1 | - | - | 3.5 | .1 | 53 | .9 | 71 | 12 | 8.4 | 24 | 5.8 | 45 |
| 433850114485701 | 4N-14E-29DCD1S | 7-15-81 | 64.5 | 9.4 | - | - | 3.4 | .0 | 60 | 1.5 | 38 | 25 | 4.9 | 31 | 14 | 71 |
| | | | | | | | Cassia County | | | | | | | | | |
| 420627113222801 | 15S-26E-23AAA1 | 10-23-75 | 85.0 | 8.1 | - | - | 43 | 1.0 | 400 | 37 | 63 | 0 | 680 | 40 | 9.1 | 140 |
| 420627113222801 | 15S-26E-23AAA1 | 10- 6-76 | 62.0 | 5.9 | - | - | 35 | .1 | 370 | 32 | 59 | 0 | 57 | 46 | 10 | 150 |
| 421425113351901 | 14S-25E- 6BBB1S | 8- 5-75 | 28.0 | 8.2 | - | - | 29 | 7.5 | 15 | 3.3 | 120 | 0 | 19 | 10 | .4 | 22 |
| 422136114021901 | 12S-21E-19DCC1 | 6-10-82 | 39.5 | 7.6 | - | - | 37 | 6.9 | 11 | 4.4 | 150 | 0 | 5.3 | 15 | .3 | 19 |
| 422623113255601 | 11S-26E-28BCB1 | 7-25-75 | 35.0 | 7.6 | - | - | 31 | .4 | 34 | 4.1 | 140 | 0 | 20 | 13 | 1.4 | 47 |
| | | | | | | | Elmore County | | | | | | | | | |
| 425922116043501 | 5S- 3E-14CBB1 | 5-31-73 | 58.5 | 9.6 | - | - | 1.5 | .1 | 85 | .7 | 0 | 77 | 17 | 6.9 | 24 | 82 |
| 425922116043501 | 5S- 3E-14CBB1 | 7-23-73 | 58.5 | 9.6 | - | - | 2.4 | .0 | 91 | .8 | 66 | 42 | 18 | 10 | 23 | 81 |
| 433307115160101 | 3N-10E-33ACD1S | 7-16-81 | 53.0 | 9.5 | - | - | 1.5 | .1 | 46 | 1.1 | 27 | 38 | 2.9 | 16 | 2.9 | 72 |
| 433814115074701 | 4N-11E-34DBB1S | 7-16-81 | 53.0 | 9.5 | - | - | 2.1 | .1 | 46 | 1.0 | 24 | 32 | 3.2 | 23 | 5.1 | 63 |
| 434327115361401 | 5N- 7E-34DBA1S | 5-27-81 | 55.0 | 9.6 | - | - | 2.4 | .1 | 42 | 1.0 | 4 | 36 | 11 | 21 | 4.7 | 70 |
| 434518115341501 | 5S- 7E-24BDD1S | 8- 3-81 | 76.0 | 9.4 | - | - | 1.6 | .0 | 64 | 1.7 | 16 | 46 | 2.4 | 28 | 9.2 | 100 |
| 434643115290401 | 5N- 8E-10DCA1S | 9- 2-81 | 51.0 | 9.4 | - | - | 1.8 | .1 | 52 | 1.3 | 37 | 31 | 1.3 | 25 | 6.6 | 77 |
| 434722115260401 | 5N- 9E- 7BAB1S | 5-28-81 | 65.0 | 9.6 | - | - | 1.6 | .1 | 57 | 1.2 | 15 | 38 | 1.8 | 27 | 8.3 | 70 |
| 434842115063501 | 6N-11E-35DAD1S | 9- 1-81 | 60.0 | 9.7 | - | - | 1.9 | .1 | 67 | 1.5 | 2 | 46 | 4.6 | 41 | 13 | 74 |
| 434925115191201 | 6N-10E-30CDA1S | 9- 2-81 | 64.0 | 9.5 | - | - | 3.0 | .3 | 58 | 1.2 | 7 | 38 | 2.5 | 41 | 7.9 | 67 |
| | | | | | | | Fremont County | | | | | | | | | |
| 435328111355201 | 7N-41E-34ADD1 | 6-16-77 | 33.0 | 7.6 | - | - | 25 | 5.9 | 69 | 6.9 | 200 | 0 | 22 | 26 | 5.7 | 64 |
| 435335111351601 | 7N-41E-35CDD1 | 8- 9-72 | 36.0 | 7.9 | - | - | 28 | 6.3 | 78 | 8.6 | 240 | 0 | 24 | 33 | 5.4 | 75 |
| 435410111343001 | 7N-41E-25CBD1 | 7-20-76 | 32.0 | 7.8 | - | - | 23 | 3.3 | 88 | 12 | 180 | 0 | 25 | 26 | 6.2 | 76 |
| 435653111314301 | 7N-42E- 8CAA1 | 6-22-76 | 31.5 | 7.6 | - | - | 38 | 14 | 22 | 4.8 | 200 | 0 | 14 | 8.8 | 2.0 | 65 |
| 435653111314301 | 7N-42E- 8CAA1 | 7-19-76 | 29.0 | 7.7 | - | - | 40 | 13 | 22 | 5.7 | 170 | 0 | 18 | 10 | 2.1 | 61 |
| | | | | | | | Gem County | | | | | | | | | |
| 435714116211501 | 7N- 1E- 8DAA1S | 11-24-72 | 55.0 | 7.7 | - | - | 8.7 | .6 | 60 | 7.7 | 190 | 0 | 62 | 110 | 16 | 120 |
| 435714116211501 | 7N- 1E- 8DAA1S | 9- 5-79 | 64.0 | 8.0 | - | - | 8.4 | .2 | 160 | 8.0 | 180 | 0 | 61 | 120 | 16 | 110 |
| | | | | | | | Jefferson County | | | | | | | | | |
| 433834111412401 | 4N-40E-25DCB1S | 2-17-70 | 48.0 | 6.7 | - | - | 430 | 85 | 1,530 | 190 | 1,080 | 1 | 2,360 | 760 | 3.1 | 33 |
| 433834111412401 | 4N-40E-25DCB1S | 7-27-72 | 49.0 | 6.7 | - | - | 450 | 82 | 1,500 | 190 | 1,100 | 0 | 2,400 | 740 | 3.1 | 30 |

TABLE 23A.—*Selected analyses of major dissolved solutes in geothermal wells and springs, Snake River basin*—Continued

| Station No. | Location | Date | WT | pH | Eh | DO | Ca | Mg | Na | K | $HCO_3$ | $CO_3$ | Cl | $SO_4$ | F | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Jerome County | | | | | | | | | | |
| 423655114291801 | 9S-17E-29ACD1 | 12- 7-77 | 42.0 | - | - | - | 2.5 | .1 | 110 | 1.9 | 140 | 22 | 16 | 15 | 16 | 74 |
| 423706114282501 | 9S-17E-28BDA1 | 3-18-81 | 27.0 | 9.0 | - | - | 1.9 | .1 | 110 | 3.5 | 140 | 25 | 10 | 18 | 22 | 82 |
| | | | | | | Madison County | | | | | | | | | | |
| 434729111260801 | 5N-43E- 6BCA1S | 2-17-70 | 42.0 | 7.5 | - | - | 130 | 31 | 3.9 | 4.4 | 160 | 1 | 1.0 | 310 | 1.6 | 24 |
| 434729111260801 | 5N-43E- 6BCA1S | 8- 9-72 | 44.0 | 6.9 | - | - | 140 | 32 | 3.8 | 3.8 | 170 | 0 | 1.7 | 330 | 1.6 | 25 |
| 434729111260801 | 5N-43E- 6BCA1S | 9- 6-77 | 41.0 | 6.7 | - | - | 130 | 30 | 3.6 | 3.9 | 160 | 0 | 1.4 | 320 | 1.5 | 26 |
| | | | | | | Owyhee County | | | | | | | | | | |
| 420139115214301 | 16S- 9E-24BB1S | 5-23-72 | 51.0 | 8.6 | - | - | .6 | .0 | 30 | 2.0 | 67 | 1 | 2.3 | 4.7 | 3.6 | 83 |
| 420139115214301 | 16S- 9E-24BB1S | 6-28-78 | 54.5 | 8.5 | - | - | 5.9 | .1 | 30 | 2.1 | 56 | 5 | 2.0 | 4.7 | 3.6 | 120 |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | 26.5 | 7.9 | - | - | 31 | 10 | 30 | 5.4 | 140 | 0 | 19 | 32 | 1.0 | 71 |
| 422000115390001 | 12S- 7E-33C1S | 6- 2-72 | 69.0 | 8.9 | - | - | 1.5 | .0 | 75 | .6 | 67 | 30 | 8.4 | 24 | 14 | 75 |
| 422000115390001 | 12S- 7E-33C1S | 6-15-78 | 71.5 | 9.4 | - | - | 1.3 | .1 | 80 | .8 | 56 | 36 | 9.1 | 23 | 16 | 71 |
| 424541115454101 | 8S- 6E- 3BDD1S | 7- 3-72 | 39.0 | 8.6 | - | - | 5.9 | 0.4 | 54 | 7.3 | 120 | 2 | 8.0 | 15 | 8.8 | 76 |
| 424541115454101 | 8S- 6E- 3BDD1S | 7- 5-73 | 39.0 | 8.3 | - | - | 6.5 | .6 | 53 | 6.7 | 110 | 5 | 9.1 | 15 | 6.0 | 87 |
| 424852115513801 | 7S- 5E-16ACD1 | 5-30-73 | 39.5 | 8.7 | - | - | 6.7 | .1 | 56 | 6.5 | 100 | 0 | 9.8 | 20 | 16 | 90 |
| 425004115442301 | 7S- 6E- 9BAD1 | 6-15-72 | 50.0 | 9.2 | - | - | 1.6 | .1 | 99 | 2.8 | 72 | 40 | 9.7 | 27 | 22 | 93 |
| 425004115442301 | 7S- 6E- 9BAD1 | 7- 5-73 | 50.5 | 9.4 | - | - | 1.6 | .3 | 100 | 2.8 | 59 | 43 | 10 | 27 | 24 | 100 |
| 425004115442301 | 7S- 6E- 9BAD1 | 6-13-78 | 51.0 | 9.4 | - | - | 2.1 | .1 | 100 | 2.8 | 56 | 46 | 9.7 | 28 | 23 | 87 |
| 425012115541601 | 7S- 5E- 7ABB1 | 6-14-72 | 39.0 | 8.5 | - | - | 6.3 | .1 | 50 | 7.2 | 96 | 1 | 8.3 | 18 | 9.7 | 81 |
| 425012115541601 | 7S- 5E- 7ABB1 | 7- 6-73 | 39.0 | 8.5 | - | - | 8.5 | .2 | 51 | 7.4 | 96 | 0 | 9.8 | 17 | 9.7 | 91 |
| 425012115541601 | 7S- 5E- 7ABB1 | 6-13-78 | 39.5 | 8.7 | - | - | 6.7 | .1 | 52 | 7.2 | 83 | 7 | 8.9 | 18 | 9.4 | 77 |
| 425012115541601 | 7S- 5E- 7ABB1 | 8-27-80 | 39.0 | 8.8 | - | - | 6.3 | .2 | 52 | 7.6 | 85 | 7 | 9.1 | 19 | 11 | 80 |
| 425255115473501 | 6S- 6E-19CCD1 | 5-22-73 | 38.0 | 9.0 | - | - | 3.0 | .1 | 93 | 3.1 | 94 | 19 | 10 | 38 | 26 | 88 |
| 425255115473501 | 6S- 6E-19CCD1 | 8-28-80 | 36.0 | 9.1 | - | - | 2.6 | .1 | 95 | 3.8 | 81 | 26 | 9.8 | 36 | 27 | 75 |
| 425425115563801 | 6S- 4E-14ABC1 | 5-30-73 | 54.0 | 9.5 | - | - | 5.0 | .1 | 110 | 4.7 | 20 | 74 | 19 | 65 | 24 | 140 |
| 425438115413301 | 6S- 6E-12CCD1 | 7- 6-73 | 37.0 | - | - | - | 10 | .6 | 180 | 15 | 490 | 0 | 19 | 3.6 | 5.9 | 120 |
| 425526116043201 | 6S- 3E- 2CCC1 | 6-12-72 | 55.0 | 8.1 | - | - | 1.2 | .1 | 110 | 3.9 | 150 | 29 | 17 | 25 | 17 | 92 |
| 425526116043201 | 6S- 3E- 2CCC1 | 7- 6-73 | 53.0 | 9.2 | - | - | 1.2 | .1 | 110 | 4.0 | 120 | 37 | 18 | 27 | 17 | 100 |
| 425527115352301 | 6S- 7E- 2CDD1 | 6-25-73 | 34.5 | 8.0 | - | - | 5.8 | .5 | 210 | 7.6 | 520 | 0 | 56 | 2.8 | 7.6 | 75 |
| 425527115352301 | 6S- 7E- 2CDD1 | 8-26-80 | 34.0 | 8.0 | - | - | 5.9 | .2 | 240 | 8.2 | 540 | 0 | 57 | .5 | 8.1 | 70 |
| 425741116065401 | 5S- 3E-28BCC1 | 5-31-73 | 65.0 | 9.4 | - | - | .8 | .0 | 97 | 1.3 | 27 | 67 | 15 | 9.8 | 21 | 98 |
| 425750116043201 | 5S- 3E-26BCB1 | 6-12-72 | 84.5 | 7.6 | - | - | 1.6 | .1 | 110 | 1.5 | 74 | 38 | 14 | 74 | 30 | 110 |
| 425750116043201 | 5S- 3E-26BCB1 | 6- 7-73 | 83.0 | 9.3 | - | - | 2.1 | .1 | 110 | 1.7 | 22 | 64 | 15 | 62 | 15 | 110 |
| 425750116043201 | 5S- 3E-26BCB1 | 6-13-78 | 81.0 | 9.3 | - | - | 2.4 | .1 | 120 | 1.7 | 48 | 48 | 15 | 74 | 15 | 110 |
| 425750116043201 | 5S- 3E-26BCB1 | 7-16-82 | 81.0 | 9.1 | -173.0 | 0.0 | 1.3 | .0 | 110 | 1.6 | 110 | 56 | 12 | 76 | 13 | 110 |
| 430122116102901 | 5S- 2E- 1BBC1 | 6- 7-72 | 49.5 | 8.2 | - | - | 1.5 | .1 | 87 | .6 | 60 | 54 | 11 | 20 | 5.8 | 68 |
| 430122116102901 | 5S- 2E- 1BBC1 | 7- 9-73 | 49.5 | 9.8 | - | - | 1.7 | .0 | 86 | .6 | 46 | 59 | 16 | 7.1 | 15 | 77 |
| 430202116151401 | 4S- 2E-32BCC1 | 6- 6-72 | 42.0 | 8.2 | - | - | 4.1 | .7 | 150 | 8.8 | 390 | 0 | 15 | 7.1 | 7.7 | 94 |
| 430202116151401 | 4S- 2E-32BCC1 | 7- 9-73 | 43.0 | 8.8 | - | - | 5.8 | .7 | 150 | 8.5 | 380 | 0 | 17 | 5.2 | 8.7 | 110 |
| 430236116192601 | 4S- 1E-34BAD1 | 6- 6-72 | 75.0 | 7.9 | - | - | 1.1 | .2 | 98 | .7 | 110 | 33 | 12 | 40 | 12 | 83 |
| 430236116192601 | 4S- 1E-34BAD1 | 6-13-78 | 76.5 | 9.2 | - | - | 1.1 | .1 | 110 | .8 | 78 | 38 | 16 | 40 | 13 | 77 |
| 430236116192601 | 4S- 1E-34BAD1 | 7-16-82 | 76.0 | 9.2 | -240.0 | .0 | 2.2 | .1 | 98 | .8 | 130 | 52 | 10 | 38 | 13 | 77 |
| 431230116322001 | 2S- 2W-35ACB1 | 6-13-78 | 40.0 | 9.6 | - | - | 3.9 | .1 | 98 | 2.0 | 71 | 48 | 8.7 | 59 | 2.7 | 84 |
| 432433116415001 | 1N- 3W-21ACD1S | 6-14-78 | 56.0 | 9.2 | - | - | 3.0 | .1 | 130 | 2.0 | 140 | 38 | 24 | 41 | 13 | 89 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Twin Falls County | | | | | | | | | | | | | | | | |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | 26.0 | 7.5 | - | - | 22 | 2.6 | 19 | 5.8 | 110 | 0 | 6.4 | 12 | .6 | 60 |
| 421216114400301 | 14S-15E-14CDB1 | 8- 4-82 | 32.0 | 7.8 | - | 5.4 | 21 | 2.0 | 18 | 6.9 | 120 | 0 | 6.8 | 10 | .7 | 58 |
| 422045114302901 | 12S-17E-31BAB1 | 7-25-72 | 36.0 | 7.6 | - | - | 34 | 14 | 43 | 11 | 270 | 0 | 8.0 | 18 | 1.9 | 19 |
| 422045114302901 | 12S-17E-31BAB1 | 4-23-81 | 37.0 | 7.7 | - | - | 31 | 13 | 43 | 11 | 270 | 0 | 6.3 | 21 | 1.9 | 19 |
| 422442114230901 | 12S-18E- 6ADC1 | 2-11-81 | 33.5 | 7.4 | - | - | 17 | 1.6 | 18 | 5.5 | 93 | 0 | 6.8 | 8.2 | .8 | 69 |
| 422646114295201 | 11S-17E-29BBB1 | 4-22-81 | 30.0 | 7.9 | - | - | 44 | 17 | 49 | 12 | 160 | 0 | 56 | 79 | 1.3 | 59 |
| 423240114565201 | 10S-13E-20ADA1 | 4-24-81 | 41.5 | 8.6 | - | - | 12 | .2 | 170 | .9 | 77 | 2 | 71 | 230 | 2.2 | 41 |
| 423255114260101 | 10S-17E-14CCD1 | 4- 8-81 | 30.5 | 7.8 | - | - | 37 | 6.8 | 31 | 4.9 | 100 | 0 | 31 | 51 | 1.0 | 50 |
| 423400114362101 | 10S-16E- 8CDA1 | 6-23-81 | 31.5 | 8.0 | - | - | 20 | 3.9 | 37 | 7.0 | 130 | 0 | 11 | 17 | 3.7 | 59 |
| 423452114281101 | 10S-17E- 4CDA1 | 2-20-79 | 37.0 | 8.6 | - | - | 4.8 | .5 | 75 | 2.7 | 120 | 5 | 12 | 20 | 12 | 56 |
| 423452114281101 | 10S-17E- 4CDA1 | 2- 9-81 | 37.0 | 8.5 | - | - | 4.3 | .2 | 78 | 2.3 | 120 | 5 | 14 | 22 | 11 | 59 |
| 423542114285701 | 9S-17E-32DDA1 | 4- 8-81 | 39.5 | 9.2 | - | - | 1.9 | .1 | 99 | 1.9 | 110 | 23 | 15 | 25 | 14 | 66 |
| 423550114564001 | 9S-13E-33CBD1 | 6-26-78 | 30.0 | 8.0 | - | - | 26 | 3.9 | 35 | 7.9 | 120 | 0 | 16 | 35 | 1.8 | 86 |
| 423554114452201 | 9S-14E-36DAC1 | 3-14-79 | 29.0 | 7.9 | - | - | 36 | 5.4 | 61 | 10 | 170 | 0 | 31 | 61 | 1.9 | 66 |
| 423852114470701 | 9S-14E-14BDB1 | 2-11-81 | 32.5 | 7.8 | - | - | 18 | 2.2 | 54 | 6.0 | 150 | 0 | 13 | 27 | 2.5 | 71 |
| 423919114385901 | 9S-15E-12CCA1 | 6-23-81 | 44.0 | 9.3 | - | - | 1.5 | .1 | 96 | 1.5 | 78 | 38 | 14 | 24 | 16 | 75 |
| 423944114472901 | 9S-14E-10ADA1 | 2- 9-81 | 37.0 | 8.1 | - | - | 13 | 1.2 | 58 | 4.1 | 140 | 0 | 12 | 25 | 3.6 | 60 |
| 423944114484201 | 9S-14E- 9ADA1 | 3-14-79 | 33.0 | 8.4 | - | - | 11 | .5 | 61 | 3.9 | 150 | 4 | 11 | 24 | 3.1 | 53 |
| 424010114493001 | 9S-14E- 4CDB1 | 3-15-79 | 34.0 | 8.7 | - | - | 5.4 | .2 | 66 | 2.9 | 110 | 7 | 13 | 30 | 3.7 | 56 |
| 424029114493001 | 9S-14E- 4BDC1 | 3-27-79 | 42.5 | 9.2 | - | - | 1.3 | .1 | 93 | 1.7 | 89 | 34 | 24 | 27 | 12 | 76 |
| 424101114500301 | 8S-14E-32DDC1 | 4- 4-79 | 42.5 | 9.3 | - | - | 1.3 | .1 | 90 | 1.7 | 85 | 31 | 14 | 28 | 9.4 | 67 |
| 424111114493201 | 8S-14E-33CBD1 | 3-15-79 | 42.0 | 9.2 | - | - | 3.7 | .2 | 100 | 2.1 | 88 | 38 | 23 | 27 | 13 | 94 |
| 424118114493102 | 8S-14E-33CBA2 | 4- 5-79 | 59.0 | 9.3 | - | - | 1.1 | .1 | 110 | 1.6 | 78 | 46 | 23 | 30 | 15 | 88 |
| 424131114513201 | 8S-14E-31ACB1S | 5-24-72 | 54.0 | 9.0 | - | - | 2.2 | .0 | 120 | 1.5 | 63 | 54 | 35 | 29 | 20 | 93 |
| 424131114513201 | 8S-14E-31ACB1S | 4- 5-79 | 57.0 | 9.4 | - | - | .9 | .1 | 130 | 1.5 | 59 | 58 | 34 | 34 | 21 | 86 |
| 424203114510801 | 8S-14E-30DAD1 | 3-26-79 | 62.0 | 9.4 | - | - | .7 | .1 | 150 | 1.4 | 56 | 55 | 48 | 35 | 15 | 84 |
| 424214114512101 | 8S-14E-30ACD2 | 8-15-79 | 72.0 | 9.3 | - | - | .9 | .1 | 140 | 1.2 | 59 | 52 | 51 | 35 | 27 | 86 |
| 424214114512101 | 8S-14E-30ACD2 | 7-21-82 | 71.5 | 9.2 | 13.0 | .0 | .9 | .1 | 140 | 1.2 | 120 | 52 | 52 | 33 | 26 | 86 |
| 424215114512201 | 8S-14E-30ACD1S | 2- 8-78 | 70.5 | 9.1 | - | - | 1.2 | .1 | 140 | 1.1 | 70 | 46 | 50 | 32 | 27 | 89 |
| Valley County | | | | | | | | | | | | | | | | |
| 441732115372001 | 11N- 7E-16AAB1S | 7-24-79 | 65.0 | 9.3 | - | - | 1.8 | 0.1 | 65 | 1.8 | 13 | 35 | 3.9 | 36 | 15 | 82 |
| 442150115512201 | 12N- 5E-22BBC1S | 8- 3-72 | 85.0 | 8.8 | - | - | 1.9 | .1 | 71 | 1.7 | 81 | 24 | 12 | 12 | 13 | 94 |
| 442150115512201 | 12N- 5E-22BBC1S | 6- 5-79 | 86.0 | 8.9 | - | - | 1.4 | .1 | 74 | 1.9 | 95 | 18 | 11 | 12 | 12 | 86 |
| 442403115491001 | 12N- 5E- 2DAC1S | 7- 8-79 | 50.0 | 9.3 | - | - | 1.3 | .1 | 65 | 1.1 | 34 | 34 | 6.5 | 16 | 16 | 73 |
| 442500116015501 | 13N- 4E-31CAB1S | 8- 3-72 | 70.5 | 7.7 | - | - | 1.7 | .0 | 100 | 1.9 | 70 | 26 | 49 | 46 | 11 | 78 |
| 442500116015501 | 13N- 4E-31CAB1S | 6-26-79 | 71.0 | 9.0 | - | - | 1.5 | .1 | 110 | 2.1 | 68 | 25 | 40 | 43 | 11 | 71 |
| 442548115454401 | 13N- 6E-29DAB1S | 7- 7-79 | 53.0 | 9.5 | - | - | 1.6 | .1 | 64 | 1.3 | 32 | 36 | 7.8 | 31 | 15 | 80 |
| 444032115563401 | 16N- 4E-35CCB1S | 6-27-79 | 50.0 | 9.5 | - | - | 1.1 | .1 | 70 | .7 | 49 | 36 | 11 | 12 | 9.0 | 62 |
| 451510115532901 | 11N- 5E-29CDB1S | 10-20-77 | 48.0 | 8.9 | - | - | 7.0 | .1 | 63 | .8 | 77 | 21 | 6.2 | 22 | 12 | 51 |
| 451510115532901 | 11N- 5E-29CDB1S | 8- 8-79 | 49.0 | 8.8 | - | - | 3.1 | .1 | 97 | .9 | 99 | 4 | 9.6 | 24 | 13 | 74 |
| Washington County | | | | | | | | | | | | | | | | |
| 441755117025801 | 11N- 6W-10CCA1 | 6-28-72 | 70.0 | 8.2 | - | - | 2.7 | .0 | 160 | 5.1 | 92 | 19 | 55 | 150 | 4.6 | 170 |
| 441755117025801 | 11N- 6W-10CCA1 | 8- 2-73 | 70.5 | 9.3 | - | - | 2.9 | .1 | 140 | 5.0 | 35 | 38 | 56 | 150 | 3.3 | 140 |
| 441810116450101 | 11N- 3W- 7CCB1S | 10- 1-73 | 77.0 | 7.1 | - | - | 26 | .3 | 290 | 18 | 200 | 0 | 200 | 240 | 3.8 | 180 |
| 441823116444101 | 11N- 3W- 7BDB1S | 6-30-72 | 87.0 | 6.8 | - | - | 27 | .7 | 300 | 19 | 200 | 0 | 190 | 270 | 2.9 | 170 |
| 441823116444101 | 11N- 3W- 7BDB1S | 8- 2-73 | 92.0 | 7.8 | - | - | 29 | .5 | 280 | 18 | 200 | 0 | 200 | 250 | 3.2 | 180 |

TABLE 23B.—*Selected analyses of dissolved trace solutes*

| Station No. | Location | Date | Al | As | Ba | Be | B | Cd |
|---|---|---|---|---|---|---|---|---|
| | | Boise County | | | | | | |
| 434014115414601 | 4N- 6E-24BCB1S | 5-27-81 | - | 16 | - | - | 30 | - |
| 434858115514901 | 6N- 5E-33ADC1S | 5-11-81 | - | 35 | - | - | 50 | - |
| 440241115510001 | 8N- 5E-10BDD1S | 11-27-78 | - | 4 | - | - | 70 | - |
| 440312115543601 | 8N- 5E- 6DCC1S | 2-26-79 | - | 6 | - | - | 110 | - |
| 440340115411401 | 8N- 6E- 1ADB1S | 2-27-79 | - | 6 | - | - | 80 | - |
| 440430115324001 | 9N- 8E-32CBA1S | 2-27-79 | - | 2 | - | - | 50 | - |
| 440530116030201 | 9N- 3E-25BAC1S | 11-22-78 | - | 5 | - | - | 240 | - |
| 440910115593801 | 10N- 4E-33CBD1S | 11-27-78 | - | 9 | - | - | 120 | - |
| 440915115184001 | 10N-10E-31BCC1S | 3-13-79 | - | 1 | - | - | 70 | - |
| | | Camas County | | | | | | |
| 433349114475501 | 3N-14E-28CAD1S | 7-14-81 | - | 3 | - | - | 50 | - |
| 433609115041501 | 3N-12E- 7DCD1S | 7-15-81 | - | 1 | - | - | 70 | - |
| 433850114485701 | 4N-14E-29DCD1S | 7-15-81 | - | 1 | - | - | 50 | - |
| | | Cassia County | | | | | | |
| 420627113222801 | 15S-26E-23AAA1 | 10-23-75 | - | 2 | - | - | - | - |
| 420627113222801 | 15S-26E-23AAA1 | 10- 6-76 | - | 2 | - | - | 160 | - |
| 422136114021901 | 12S-21E-19DCC1 | 6-10-82 | - | - | - | - | 30 | - |
| | | Elmore County | | | | | | |
| 425922116043501 | 5S- 3E-14CBB1 | 5-31-73 | - | <1 | - | - | 1,100 | - |
| 425922116043501 | 5S- 3E-14CBB1 | 7-23-73 | - | 2 | - | - | 1,100 | - |
| 433307115160101 | 3N-10E-33ACD1S | 7-16-81 | - | 1 | - | - | 10 | - |
| 433814115074701 | 4N-11E-34DBB1S | 7-16-81 | - | 4 | - | - | 20 | - |
| 434327115361401 | 5N- 7E-34DBA1S | 5-27-81 | - | 1 | - | - | 0 | - |
| 434518115341501 | 5S- 7E-24BDD1S | 8- 3-81 | - | 1 | - | - | 40 | - |
| 434643115290401 | 5N- 8E-10DCA1S | 9- 2-81 | - | 6 | - | - | 20 | - |
| 434722115260401 | 5N- 9E- 7BAB1S | 5-28-81 | - | 11 | - | - | 10 | - |
| 434842115063501 | 6N-11E-35DAD1S | 9- 1-81 | - | 3 | - | - | 50 | - |
| 434925115191201 | 6N-10E-30CDA1S | 9- 2-81 | - | 10 | - | - | 20 | - |
| | | Fremont County | | | | | | |
| 435328111355201 | 7N-41E-34ADD1 | 6-16-77 | - | 12 | <100 | <10 | 150 | - |
| | | Gem County | | | | | | |
| 435714116211501 | 7N- 1E- 8DAA1S | 9- 5-79 | - | 10 | - | - | 710 | - |
| | | Jefferson County | | | | | | |
| 433834111412401 | 4N-40E-25DCB1S | 2-17-70 | - | - | - | - | 5 | - |
| | | Jerome County | | | | | | |
| 423706114282501 | 9S-17E-28BDA1 | 3-18-81 | - | 46 | - | - | 330 | - |
| | | Madison County | | | | | | |
| 434729111260801 | 5N-43E- 6BCA1S | 2-17-70 | - | - | - | - | 0 | - |
| 434729111260801 | 5N-43E- 6BCA1S | 9- 6-77 | - | 1 | - | - | <20 | - |
| 435154111362701 | 6N-41E-10DBB1 | 6-16-77 | - | 11 | <100 | <10 | 130 | - |
| | | Owyhee County | | | | | | |
| 420139115214301 | 16S- 9E-24BB1S | 6-28-78 | - | 9 | - | - | 30 | - |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | - | 9 | - | - | 70 | - |
| 422000115390001 | 12S- 7E-33C1S | 6-15-78 | - | 16 | - | - | 110 | - |
| 424541115454101 | 8S- 6E- 3BDD1 | 7- 5-73 | - | 18 | - | - | 80 | - |
| 424852115513801 | 7S- 5E-16ACD1 | 5-30-73 | - | 17 | - | - | 90 | - |
| 425004115442301 | 7S- 6E- 9BAD1 | 7- 5-73 | - | 78 | - | - | 210 | - |
| 425004115442301 | 7S- 6E- 9BAD1 | 6-13-78 | - | 80 | - | - | 220 | - |
| 425012115541601 | 7S- 5E- 7ABB1 | 7- 6-73 | - | 21 | - | - | 90 | - |
| 425012115541601 | 7S- 5E- 7ABB1 | 6-13-78 | - | 14 | - | - | 100 | - |
| 425012115541601 | 7S- 5E- 7ABB1 | 8-27-80 | - | 17 | - | - | 120 | - |

*in geothermal wells and springs, Snake River basin*

| Cr | Co | Cu | Fe | Pb | Li | Mn | Hg | Mo | Sr | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Boise County | | | | | | |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 70 | - | 0 | - | - | - | - |
| - | - | - | - | - | 130 | - | 0 | - | - | - | - |
| - | - | - | - | - | 100 | - | 0 | - | - | - | - |
| - | - | - | - | - | 110 | - | 0 | - | - | - | - |
| - | - | - | - | - | 150 | - | 0 | - | - | - | - |
| - | - | - | - | - | 100 | - | 0 | - | - | - | - |
| - | - | - | - | - | 110 | - | 0 | - | - | - | - |
| | | | | | Camas County | | | | | | |
| - | - | - | - | - | 190 | - | 0 | - | - | - | - |
| - | - | - | - | - | 110 | - | 0 | - | - | - | - |
| - | - | - | - | - | 180 | - | 0 | - | - | - | - |
| | | | | | Cassia County | | | | | | |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | | Elmore County | | | | | | |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 90 | - | 0 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 92 | - | 0 | - | - | - | - |
| - | - | - | - | - | 96 | - | 0 | - | - | - | - |
| - | - | - | - | - | 80 | - | 0 | - | - | - | - |
| - | - | - | - | - | 240 | - | 0 | - | - | - | - |
| - | - | - | - | - | 84 | - | 0 | - | - | - | - |
| | | | | | Fremont County | | | | | | |
| - | - | - | - | - | 140 | <10 | 1 | - | 100 | - | - |
| | | | | | Gem County | | | | | | |
| - | - | - | - | - | 220 | - | 0 | - | - | - | - |
| | | | | | Jefferson County | | | | | | |
| - | - | - | 0 | - | 2 | 0 | - | - | - | - | - |
| | | | | | Jerome County | | | | | | |
| - | - | - | - | - | 20 | - | 0 | - | - | - | - |
| | | | | | Madison County | | | | | | |
| - | - | - | 0 | - | 0 | - | - | - | - | - | - |
| - | - | - | - | - | 20 | <10 | - | - | - | - | 20 |
| - | - | - | - | - | 130 | <10 | 1 | - | 100 | - | - |
| | | | | | Owyhee County | | | | | | |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 20 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | 20 | - | 0 | - | - | - | - |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | <10 | - | 0 | - | - | - | - |
| - | - | - | <10 | - | 8 | <1 | - | - | - | - | <3 |

TABLE 23B.—*Selected analyses of dissolved trace solutes in*

| Station No. | Location | Date | Al | As | Ba | Be | B | Cd |
|---|---|---|---|---|---|---|---|---|
| | | Owyhee County--Continued | | | | | | |
| 425255115473501 | 6S- 6E-19CCD1 | 5-22-73 | - | 15 | - | - | 340 | - |
| 425255115473501 | 6S- 6E-19CCD1 | 8-28-80 | - | 31 | - | - | 350 | - |
| 425425115563801 | 6S- 4E-14ABC1 | 5-30-73 | - | 30 | - | - | 540 | - |
| 425526116043201 | 6S- 3E- 2CCC1 | 7- 6-73 | - | 3 | - | - | 760 | - |
| 425527115352301 | 6S- 7E- 2CDD1 | 6-25-73 | - | 1 | - | - | 1,700 | - |
| 425527115352301 | 6S- 7E- 2CDD1 | 8-26-80 | - | 1 | - | - | 2,100 | - |
| 425741116065401 | 5S- 3E-28BCC1 | 5-31-73 | - | 5 | - | - | 620 | - |
| 425750116043201 | 5S- 3E-26BCB1 | 6- 7-73 | - | 4 | - | - | 570 | - |
| 425750116043201 | 5S- 3E-26BCB1 | 6-13-78 | - | 4 | - | - | 550 | - |
| 425750116043201 | 5S- 3E-26BCB1 | 7-16-82 | 90 | 6 | 6 | <1 | 550 | <1 |
| 430122116102901 | 5S- 2E- 1BBC1 | 7- 9-73 | - | 1 | - | - | 1,100 | - |
| 430202116151401 | 4S- 2E-32BCC1 | 7- 9-73 | - | 5 | - | - | 1,000 | - |
| 430236116192601 | 4S- 1E-34BAD1 | 6-13-78 | - | 30 | - | - | 150 | - |
| 430236116192601 | 4S- 1E-34BAD1 | 7-16-82 | 130 | 31 | 7 | <1 | 140 | <1 |
| 431230116322001 | 2S- 2W-35ACB1 | 6-13-78 | - | 7 | - | - | 110 | - |
| 432433116415001 | 1N- 3W-21ACD1S | 6-14-78 | - | 1 | - | - | 280 | - |
| | | Twin Falls County | | | | | | |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | - | 3 | - | - | 10 | - |
| 421216114400301 | 14S-15E-14CDB1 | 8- 4-82 | 20 | 2 | 80 | 1 | 50 | <1 |
| 422045114302901 | 12S-17E-31BAB1 | 4-23-81 | - | 0 | - | - | 120 | - |
| 422442114230901 | 12S-18E- 6ADC1 | 2-11-81 | - | 1 | - | - | 10 | - |
| 422646114295201 | 11S-17E-29BBB1 | 4-22-81 | - | 4 | - | - | 110 | - |
| 423240114565201 | 10S-13E-20ADA1 | 4-24-81 | - | 28 | - | - | 100 | - |
| 423255114260101 | 10S-17E-14CCD1 | 4- 8-81 | - | 4 | - | - | 0 | - |
| 423400114362101 | 10S-16E- 8CDA1 | 6-23-81 | - | 8 | - | - | 80 | - |
| 423452114281101 | 10S-17E- 4CDA1 | 2-20-79 | - | 17 | - | - | 180 | - |
| 423452114281101 | 10S-17E- 4CDA1 | 2- 9-81 | - | 16 | - | - | 180 | - |
| 423455114592401 | 10S-12E- 1DDC1 | 6- 2-82 | - | - | - | - | 70 | - |
| 423542114285701 | 9S-17E-32DDA1 | 4- 8-81 | - | 32 | - | - | 160 | - |
| 423550114564001 | 9S-13E-33CBD1 | 6-26-78 | - | 9 | - | - | 60 | - |
| 423554114452201 | 9S-14E-36DAC1 | 3-14-79 | - | 9 | - | - | 120 | - |
| 423852114470701 | 9S-14E-14BDB1 | 2-11-81 | - | 17 | - | - | 90 | - |
| 423919114385901 | 9S-15E-12CCA1 | 6-23-81 | - | 56 | - | - | 200 | - |
| 423944114472901 | 9S-14E-10ADA1 | 2- 9-81 | - | 13 | - | - | 90 | - |
| 423944114484201 | 9S-14E- 9ADA1 | 3-14-79 | - | 16 | - | - | 110 | - |
| 424010114493001 | 9S-14E- 4CDB1 | 3-15-79 | - | 22 | - | - | 120 | - |
| 424029114493001 | 9S-14E- 4BDC1 | 3-27-79 | - | 31 | - | - | 210 | - |
| 424101114500301 | 8S-14E-32DDC1 | 4- 4-79 | - | 28 | - | - | 170 | - |
| 424111114493201 | 8S-14E-33CBD1 | 3-15-79 | - | 32 | - | - | 230 | - |
| 424118114493102 | 8S-14E-33CBA2 | 4- 5-79 | - | 36 | - | - | 260 | - |
| 424131114513201 | 8S-14E-31ACB1S | 4- 5-79 | - | 48 | - | - | 340 | - |
| 424203114510801 | 8S-14E-30DAD1 | 3-26-79 | - | 43 | - | - | 490 | - |
| 424214114512101 | 8S-14E-30ACD2 | 8-15-79 | - | 52 | - | - | 470 | - |
| 424214114512101 | 8S-14E-30ACD2 | 7-21-82 | 90 | 54 | 6 | <1 | 460 | <1 |
| 424215114512201 | 8S-14E-30ACD1S | 2- 8-78 | - | 60 | - | - | 440 | - |
| | | Valley County | | | | | | |
| 441732115372001 | 11N- 7E-16AAB1S | 7-24-79 | - | 14 | - | - | 50 | - |
| 442150115512201 | 12N- 5E-22BBC1S | 6- 5-79 | - | 10 | - | - | 90 | - |
| 442403115491001 | 12N- 5E- 2DAC1S | 7- 8-79 | - | 6 | - | - | 60 | - |
| 442500116015501 | 13N- 4E-31CAB1S | 6-26-79 | - | 39 | - | - | 400 | - |
| 442548115454401 | 13N- 6E-29DABIS | 7- 7-79 | - | 6 | - | - | 50 | - |
| 444032115563401 | 16N- 4E-35CCB1S | 6-27-79 | - | 11 | - | - | 50 | - |
| 451510115532901 | 11N- 5E-29CDB1S | 10-20-77 | - | 6 | - | - | 60 | - |
| 451510115532901 | 11N- 5E-29CDB1S | 8- 8-79 | - | 6 | - | - | 70 | - |
| | | Washington County | | | | | | |
| 441755117025801 | 11N- 6W-10CCA1 | 8- 2-73 | - | <1 | - | - | 2200 | - |
| 441810116450101 | 11N- 3W- 7CCB1S | 10- 1-73 | - | 42 | - | - | 11,000 | - |
| 441823116444101 | 11N- 3W- 7BDB1S | 8- 2-73 | - | 41 | - | - | 10,000 | - |

*geothermal wells and springs, Snake River basin*—Continued

| Cr | Co | Cu | Fe | Pb | Li | Mn | Hg | Mo | Sr | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Owyhee County--Continued | | | | | | |
| - | - | - | - | - | <100 | - | 1 | - | - | - | - |
| - | - | - | <10 | - | 7 | 2 | - | - | - | - | <3 |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | 40 | - | 1 | - | - | - | - |
| - | - | - | - | - | 20 | - | 1 | - | - | - | - |
| - | - | - | 50 | - | 210 | 30 | - | - | - | - | <3 |
| - | - | - | - | - | 20 | - | 1 | - | - | - | - |
| - | - | - | - | - | 40 | - | 1 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | <3 | 10 | <3 | <10 | 41 | <1 | - | 50 | 3 | <6 | 14 |
| - | - | - | - | - | <10 | - | 1 | - | - | - | - |
| - | - | - | - | - | 260 | - | 1 | - | - | - | - |
| - | - | - | - | - | <10 | - | 0 | - | - | - | - |
| - | <3 | <10 | <3 | <10 | 11 | <1 | - | 20 | 4 | <6 | 5 |
| - | - | - | - | - | <10 | - | 0 | - | - | - | - |
| - | - | - | - | - | 9 | - | 0 | - | - | - | - |
| | | | | | Twin Falls County | | | | | | |
| - | - | - | - | - | 20 | - | 0 | - | - | - | - |
| - | <3 | <10 | 25 | <10 | 34 | 2 | - | <10 | 180 | <6 | 20 |
| - | - | - | - | - | 50 | - | 0 | - | - | - | - |
| - | - | - | - | - | 20 | - | 0 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 190 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 2 | - | 0 | - | - | - | - |
| - | - | - | - | - | 10 | - | 0 | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | 6 | - | 0 | - | - | - | - |
| - | - | - | - | - | 50 | - | 0 | - | - | - | - |
| - | - | - | - | - | 70 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 50 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 40 | - | 0 | - | - | - | - |
| - | - | - | - | - | 50 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | <3 | <10 | <3 | <10 | 57 | <1 | - | 120 | 1 | <6 | 32 |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| | | | | | Valley County | | | | | | |
| - | - | - | - | - | 80 | - | 0 | - | - | - | - |
| - | - | - | - | - | 80 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 30 | - | 0 | - | - | - | - |
| - | - | - | - | - | 60 | - | 0 | - | - | - | - |
| - | - | - | - | - | 90 | - | 0 | - | - | - | - |
| | | | | | Washington County | | | | | | |
| - | - | - | - | - | 40 | - | 1 | - | - | - | - |
| - | - | - | - | - | 660 | - | 1 | - | - | - | - |
| - | - | - | - | - | 620 | - | 1 | - | - | - | - |

TABLE 23C.—*Selected analyses of stable-isotope ratios, tritium, and carbon-14 in geothermal wells and springs, Snake River basin*

[Data from Rightmire and others (1976), Crosthwaite (1979), Lewis and Young (1980, 1982a, b), Young and Lewis (1982), and unpublished data files of the U.S. Geological Survey]

| Station No. | Location | Date | $\delta^2H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ | $^3H$ | $^{14}C$ |
|---|---|---|---|---|---|---|---|---|
| | | | Boise County | | | | | |
| 434014115414601 | 4N- 6E-24BCB1S | 5-27-81 | -131 | -17.6 | - | - | 0.6±.4 | - |
| 434858115514901 | 6N- 5E-33ADC1S | 5-11-81 | -141 | -17.5 | - | - | 1.0±.4 | - |
| 440312115543601 | 8N- 5E- 6DCC1S | 2-26-79 | -136 | -18.0 | - | - | 2.0±.1 | - |
| 440241115510001 | 8N- 5E-10BDD1S | 11-27-78 | -137 | -18.3 | - | - | - | - |
| 440340115411401 | 8N- 6E- 1ADB1S | 2-27-79 | -138 | -18.5 | - | - | - | - |
| 440530116030201 | 9N- 3E-25BAC1S | 11-22-78 | -136 | -17.2 | - | - | - | - |
| 440430115324001 | 9N- 8E-32CBA1S | 2-27-79 | -135 | -17.9 | - | - | .0±.1 | - |
| 440910115593801 | 10N- 4E-33CBD1S | 11-27-78 | -136 | -18.2 | - | - | - | - |
| 440915115184001 | 10N-10E-31BCC1S | 3-13-79 | -140 | -18.1 | - | - | - | - |
| | | | Camas County | | | | | |
| 433609115041501 | 3N-12E- 7DCD1S | 7-15-81 | -139 | -18.3 | - | - | - | - |
| 433349114475501 | 3N-14E-28CAD1S | 7-14-81 | -146 | -19.5 | - | - | - | - |
| 433850114485701 | 4N-14E-29DCD1S | 7-15-81 | -146 | -19.4 | - | - | - | - |
| | | | Cassia County | | | | | |
| 422623113255601 | 11S-26E-28BCB1 | 7-25-75 | -130 | -16.9 | - | - | - | - |
| 422136114021901 | 12S-21E-19DCC1 | 6-10-82 | -133 | -17.8 | - | - | - | - |
| 420559113075101 | 15S-24E-22DDB1S | 8- 5-75 | -135 | -17.4 | - | - | - | - |
| 420627113222801 | 15S-26E-23AAA1 | 7-22-75 | -135 | -17.5 | - | - | - | - |
| | | | Elmore County | | | | | |
| 433307115160101 | 3N-10E-33ACD1S | 7-16-81 | -140 | -18.4 | - | - | - | - |
| 433814115074701 | 4N-11E-34DBB1S | 7-16-81 | -141 | -18.6 | - | - | - | - |
| 434327115361401 | 5N- 7E-34DBA1S | 5-27-81 | -131 | -17.7 | - | - | - | - |
| 434643115290401 | 5N- 8E-10DCA1S | 9- 2-81 | -138 | -18.0 | - | - | - | - |
| 434722115260401 | 5N- 9E- 7BAB1S | 5-28-81 | -138 | -18.2 | - | - | - | - |
| 425922116043501 | 5S- 3E-14CBB1 | 5-31-73 | -142 | -17.6 | - | - | - | - |
| 434518115341501 | 5S- 7E-24BDD1S | 8- 3-81 | -138 | -18.0 | - | - | - | - |
| 434925115191201 | 6N-10E-30CDA1S | 9- 2-81 | -140 | -18.4 | - | - | - | - |
| 434953115112801 | 6N-11E-30ADB1S | 9- 2-81 | -138 | -18.3 | - | - | .3±.4 | - |
| 434842115063501 | 6N-11E-35DAD1S | 9- 1-81 | -141 | -18.5 | - | - | - | - |
| | | | Fremont County | | | | | |
| 435410111343001 | 7N-41E-25CBD1 | 7-20-76 | -143 | -19.8 | - | - | - | - |
| 435328111355201 | 7N-41E-34ADD1 | 6-16-77 | -144 | -18.9 | - | - | - | - |
| 435335111351601 | 7N-41E-35CDD1 | 6-16-77 | -142 | -18.6 | - | - | - | - |
| 435653111314301 | 7N-42E- 8CAA1 | 7-22-77 | -140 | -17.9 | - | - | - | - |
| 435535111332601 | 7N-42E-19BBB1 | 7-23-77 | -143 | -18.4 | - | - | - | - |
| | | | Gem County | | | | | |
| 435714116211501 | 7N- 1E- 8DAA1S | 9- 5-79 | -134 | -15.6 | - | - | - | - |
| | | | Jefferson County | | | | | |
| 433834111412401 | 4N-40E-25DCB1S | 6-18-77 | -139 | -17.4 | - | - | - | - |
| | | | Jerome County | | | | | |
| 423706114282501 | 9S-17E-28BDA1 | 3-18-81 | -137 | -17.7 | - | - | - | - |
| 423655114291801 | 9S-17E-29ACD1 | 12- 7-77 | -132 | -16.9 | - | - | - | - |
| 423655114291801 | 9S-17E-29ACD1 | 6-26-78 | -132 | -16.9 | - | - | - | - |
| 423655114291801 | 9S-17E-29ACD1 | 3-12-82 | - | - | - | +9.7 | - | - |
| | | | Madison County | | | | | |
| 434729111260801 | 5N-43E- 6BCA1S | 7-24-77 | -137 | -18.1 | - | - | - | - |
| 435154111362701 | 6N-41E-10DBB1 | 6-16-77 | -141 | -18.4 | - | - | - | - |
| | | | Owyhee County | | | | | |
| 430202116151401 | 4S- 2E-32BCC1 | 7- 9-73 | -146 | -17.4 | - | - | - | - |
| 430122116102901 | 5S- 2E- 1BBC1 | 7- 9-73 | -144 | -17.0 | - | - | - | - |
| 425741116065401 | 5S- 3E-28BCC1 | 5-31-73 | -142 | -17.6 | - | - | - | - |
| 432433116415001 | 1N- 3W-21ACD1S | 6-14-78 | -139 | -16.8 | - | - | .0±.2 | - |
| 431230116322001 | 2S- 2W-35ACB1 | 6-13-78 | -145 | -17.8 | - | - | - | - |
| 430300116184401 | 4S- 1E-26BCB1 | 6- 8-73 | -144 | -18.2 | - | - | - | - |
| 430236116192601 | 4S- 1E-34BAD1 | 6-13-78 | -145 | -17.5 | - | - | 1.4±.6 | - |
| 430236116192601 | 4S- 1E-34BAD1 | 1-27-82 | - | - | -11.5 | - | - | 6.9 |
| 430236116192601 | 4S- 1E-34BAD1 | 4-30-82 | - | - | - | +10.7 | - | - |
| 425750116043201 | 5S- 3E-26BCB1 | 6- 7-73 | -146 | -17.5 | - | - | - | - |

TABLE 23C.—*Selected analyses of stable-isotope ratios, tritium, and carbon-14 in geothermal wells and springs, Snake River basin*—Continued

| Station No. | Location | Date | $\delta^{2}H$ | $\delta^{18}O$ | $\delta^{13}C$ | $\delta^{34}S$ | $^{3}H$ | $^{14}C$ |
|---|---|---|---|---|---|---|---|---|
| | | | Owyhee County--Continued | | | | | |
| 425750116043201 | 5S- 3E-26BCB1 | 6-13-78 | -135 | -17.6 | - | - | 0.0±.2 | - |
| 425750116043201 | 5S- 3E-26BCB1 | 1-26-82 | - | - | -14.0 | - | - | 4.7 |
| 425750116043201 | 5S- 3E-26BCB1 | 4-30-82 | - | - | - | +5.0 | - | - |
| 425526116043201 | 6S- 3E- 2CCC1 | 7- 6-73 | -154 | -17.6 | - | - | - | - |
| 425425115563801 | 6S- 4E-14ABC1 | 5-30-73 | -144 | -17.6 | - | - | - | - |
| 425438115413301 | 6S- 6E-12CCD1 | 7- 6-73 | -144 | -18.1 | - | - | - | - |
| 425255115473501 | 6S- 6E-19CCD1 | 5-22-73 | -156 | -18.1 | - | - | - | - |
| 425527115352301 | 6S- 7E- 2CDD1 | 6-25-73 | -135 | -15.0 | - | - | - | - |
| 425012115541601 | 7S- 5E- 7ABB1 | 7- 6-73 | -135 | -17.6 | - | - | .9±.6 | - |
| 424852115513801 | 7S- 5E-16ACD1 | 5-30-73 | -135 | -17.1 | - | - | - | - |
| 425004115442301 | 7S- 6E- 9BAD1 | 7- 5-73 | -142 | -18.2 | - | - | .0±.2 | - |
| 424541115454101 | 8S- 6E- 3BDD1S | 7- 5-73 | -150 | -17.1 | - | - | - | - |
| 422000115390001 | 12S- 7E-33C1S | 6-15-78 | -130 | -16.6 | - | - | - | - |
| 421450115223001 | 14S- 9E- 2BAA1 | 6-27-78 | -124 | -16.4 | - | - | - | - |
| 420139115214301 | 16S- 9E-24BB1S | 6-28-78 | -131 | -17.3 | - | - | .5±.6 | - |
| | | | Twin Falls County | | | | | |
| 424215114512201 | 8S-14E-30ACD1S | 2- 8-78 | -137 | -17.2 | - | - | - | - |
| 424214114512101 | 8S-14E-30ACD2 | 1-18-82 | - | - | -7.0 | - | - | 4.0 |
| 424214114512101 | 8S-14E-30ACD2 | 3- 9-82 | - | - | - | +10.5 | - | - |
| 424214114512101 | 8S-14E-30ACD2 | 7-21-82 | -137 | -17.9 | - | - | - | - |
| 424203114510801 | 8S-14E-30DAD1 | 3-26-79 | -137 | -18.0 | - | - | .1±.1 | - |
| 424131114513201 | 8S-14E-31ACB1S | 4- 5-79 | -139 | -17.6 | - | - | - | - |
| 424101114500301 | 8S-14E-32DDC1 | 4- 4-79 | -134 | -17.1 | - | - | .2±.1 | - |
| 424118114493102 | 8S-14E-33CBA2 | 4- 5-79 | -137 | -17.6 | - | - | - | - |
| 424111114493201 | 8S-14E-33CBD1 | 3-15-79 | -135 | -17.7 | - | - | - | - |
| 423550114564001 | 9S-13E-33CBD1 | 6-26-78 | -131 | -16.2 | - | - | - | - |
| 424029114493001 | 9S-14E- 4BDC1 | 3-27-79 | -135 | -17.7 | - | - | - | - |
| 424010114493001 | 9S-14E- 4CDB1 | 3-15-79 | -131 | -16.8 | - | - | - | - |
| 423944114484201 | 9S-14E- 9ADA1 | 3-14-79 | -132 | -16.9 | - | - | 4.1±.2 | - |
| 423944114472901 | 9S-14E-10ADA1 | 2- 9-81 | -132 | -17.2 | - | - | - | - |
| 423852114470701 | 9S-14E-14BDB1 | 2-11-81 | -131 | -17.1 | - | - | - | - |
| 423554114452201 | 9S-14E-36DAC1 | 3-14-79 | -130 | -16.8 | - | - | .0±.1 | - |
| 423919114385901 | 9S-15E-12CCA1 | 6-23-81 | -134 | -17.2 | - | - | - | - |
| 423542114285701 | 9S-17E-32DDA1 | 4- 8-81 | -132 | -17.0 | - | - | - | - |
| 423455114592401 | 10S-12E- 1DDC1 | 6- 2-82 | -131 | -17.3 | - | - | - | - |
| 423240114565201 | 10S-13E-20ADA1 | 4-24-81 | -133 | -16.8 | - | - | - | - |
| 423400114362101 | 10S-16E- 8CDA1 | 6-23-81 | -127 | -16.7 | - | - | - | - |
| 423452114281101 | 10S-17E- 4CDA1 | 2- 9-81 | -131 | -17.4 | - | - | - | - |
| 423255114260101 | 10S-17E-14CCD1 | 4- 8-81 | -127 | -16.4 | - | - | - | - |
| 422646114295201 | 11S-17E-29BBB1 | 4-22-81 | -132 | -16.4 | - | - | - | - |
| 422045114302901 | 12S-17E-31BAB1 | 4-23-81 | -133 | -17.0 | - | - | - | - |
| 422442114230901 | 12S-18E- 6ADC1 | 2-11-81 | -127 | -16.3 | - | - | - | - |
| 421216114400301 | 14S-15E-14CDB1 | 8- 4-82 | -130 | -16.9 | -11.2 | +5.8 | - | 55.6 |
| 421207114414901 | 14S-15E-16DDC1 | 3-18-81 | -131 | -16.7 | - | - | - | - |
| | | | Valley County | | | | | |
| 451510115532901 | 11N- 5E-29CDB1S | 8- 8-79 | -132 | -17.7 | - | - | - | - |
| 441732115372001 | 11N- 7E-16AAB1S | 7-24-79 | -138 | -18.4 | - | - | - | - |
| 442403115491001 | 12N- 5E- 2DAC1S | 7- 8-79 | -136 | -18.1 | - | - | - | - |
| 442150115512201 | 12N- 5E-22BBC1S | 6- 5-79 | -134 | -17.7 | - | - | - | - |
| 442500116015501 | 13N- 4E-31CAB1S | 6-26-79 | -138 | -17.3 | - | - | - | - |
| 442548115454401 | 13N- 6E-29DAB1S | 7- 7-79 | -137 | -18.2 | - | - | .1±.1 | - |
| 444032115563401 | 16N- 4E-35CCB1S | 6-27-79 | -135 | -18.0 | - | - | - | - |
| | | | Washington County | | | | | |
| 441823116444101 | 11N- 3W- 7BDB1 | 8- 2-73 | -150 | -14.4 | - | - | - | - |
| 441810116450101 | 11N- 3W- 7CCB1 | 10- 1-73 | -142 | -14.6 | - | - | - | - |
| 441755117025801 | 11N- 6W-10CCA1 | 8- 2-73 | -149 | -13.4 | - | - | - | - |

[1] Data from Rightmire and others (1976); Crosthwaite (1979); Lewis and Young (1980, 1982a, 1982b); Young and Lewis (1982); and unpublished data files of the U.S. Geological Survey.

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