DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

INTRODUCTION

This report is one in a series resulting from the U.S. Geological Survey's Snake River Plain RASA (Regional Aquifer-System Analysis) study that began in October 1979. The RASA program is a nationwide effort to describe the geohydrology of major aquifers in the United States.

Sheet 1 of this atlas shows generalized geology of the Snake River basin and relative proportions of each major solute in surface water entering the Snake River Plain from tributary drainage basins. Sheet 2 shows areal distribution of dissolved solids and chloride and percentage ranges of concentrations for other solutes in the Snake River Plain aquifer system. Water-chemistry analyses are based on data in the U.S. Geological Survey computer files (U.S. Geological Survey, 1975) and selected data from Laird (1964) and from Chapman and Ralston (1970).

The Snake River Plain, a section of the Columbia-North Pacific geographical province (Fenneman, 1931), is a 15,600-mi^2 arcuate area that extends across southern Idaho into eastern Oregon. It comprises about 22 percent of the 69,200-mi^2 Snake River basin above Weiser, Idaho. The plain ranges from 30 to 75 mi in width and from 2,100 to 6,000 ft in altitude above sea level. Mountains surrounding the plain range from 7,000 to 12,000 ft in altitude. Surface-water drainage is entirely to the Snake River, which approximates the southern boundary of the Snake River Plain. Within the study area, the river descends from about 5,000 ft near Heise to 2,100 ft at Weiser along a 500-mi course and was described by Malde (1968) as one of the steepest large rivers in North America.

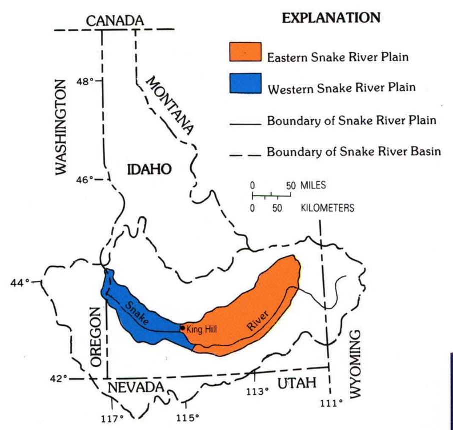
For purposes of this report, the areal extent of the Snake River Plain is defined chiefly on the basis of geology and topography. Owing to distinct geologic and hydrologic differences, the plain can be divided into two parts, as shown on the map at right. The 10,800-mi^2 eastern plain is underlain chiefly by basalt containing large volumes of water. The 4,800-mi^2 western plain is underlain chiefly by sedimentary lacustrine and fluviatile rocks intercalated with thick ash beds. These rocks generally contain much smaller volumes of water.

Estimated average annual inflow to the eastern plain in 1980 from ground and surface water was about 10.2 million acre-ft and, to the western plain, about 14.6 million acre-ft. Sources of recharge to the aquifer system in both parts of the plain are mainly seepage from surface-water bodies, underflow from tributary drainage basins, and percolation from surface-water-irrigated land. The relative contribution and impact of these sources are discussed in reports by Mundorff and others (1964) and Kjelstrom (1984).

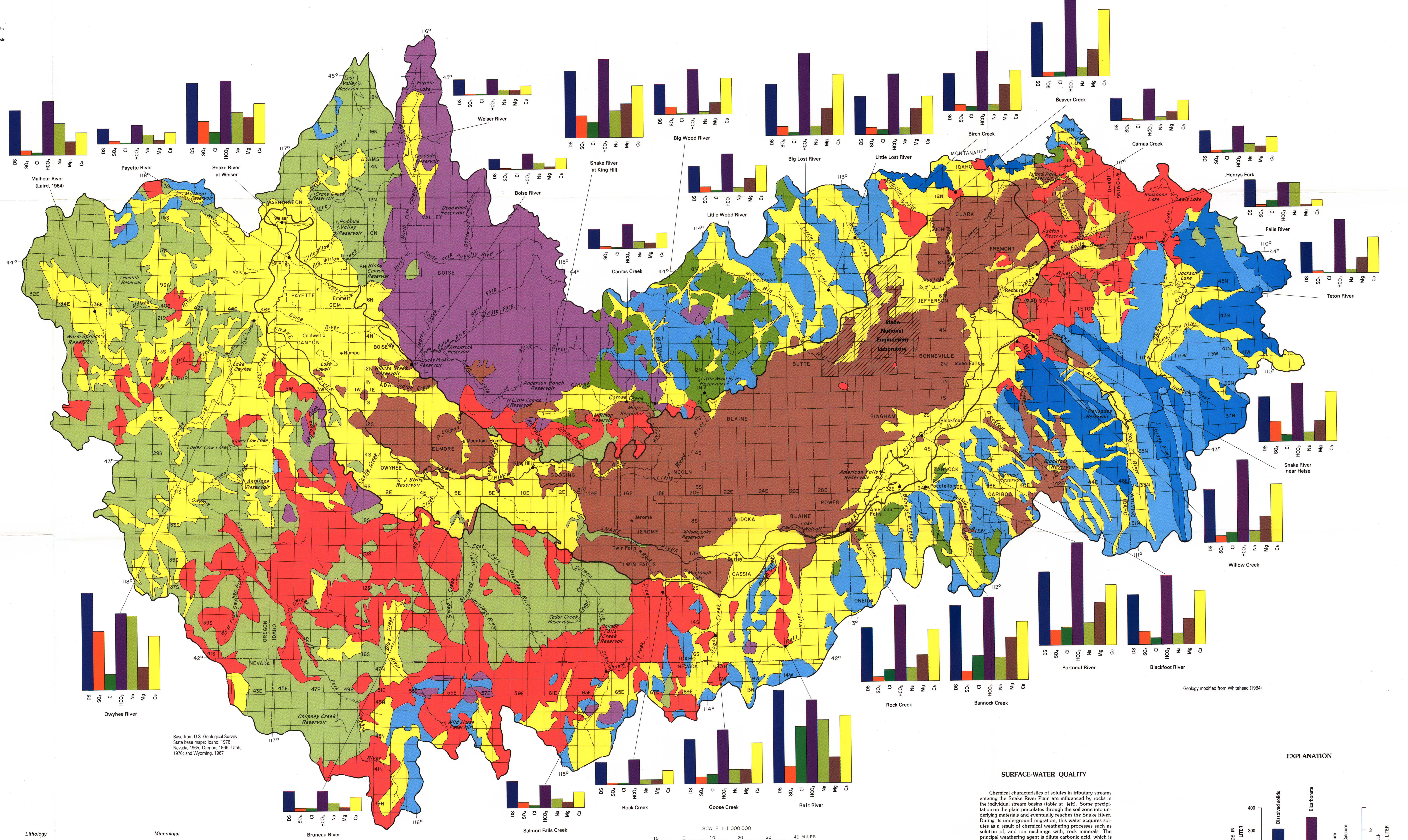
Irrigated agriculture is the largest use of ground and surface water on the Snake River Plain. In 1980, about 12.7 million acre-ft of surface water were diverted to irrigate about 2 million acres, 2.3 million acre-ft of ground water were used to irrigate 986,000 acres, and a combination of ground and surface water was used to irrigate about 117,000 acres (Lindholm and Goodell, 1984).

Ground water in the eastern plain flows generally from the northeast to the southwest, where most of the water discharges as a series of springs along the Snake River canyon wall between Twin Falls and King Hill. Ground water in the western plain flows to the Snake River from recharge areas to the northeast and southwest (Lindholm and others, 1983).

Previous investigations of the Snake River basin emphasized local ground- and surface-water quality conditions. Dyer and Young (1971) determined that the quality of water in the eastern plain is suitable for most uses. Dion (1972) noted some effects of land-use changes on the quality of shallow ground water in the Boise-Nampa area. Graham (1979) examined effects of irrigation-return water on quality of domestic ground-water supplies in southeastern Minidoka County. Seitz and Norvitch (1979) concluded that most ground water in the southeastern part of the Snake River basin is suitable for most uses. Robertson and others (1974), Barraclough and Jensen (1976), and Barraclough and others (1982) described local ground-water quality in the vicinity of waste-water disposal sites at INEL. Parliman (1983a, 1983b, and written commun., 1982) noted relations between water quality and geology in the Snake River basin. Laird (1964), McConnell (1967), Dyer (1973), and Low (1980) described surface-water quality in the Snake River basin.



SOLUTES IN SURFACE WATER



SUMMARY

Dissolved-solids concentrations in 26 tributaries to and 3 sites along the Snake River range from 50 mg/L in the Boise River basin to more than 400 mg/L in the Owyhee and Raft River basins. Weathering processes produce solutes characteristic of rock units in tributary drainage basins. Surface water from most basins surrounding the Snake River Plain is predominantly a calcium bicarbonate or calcium-magnesium bicarbonate type. Surface water from the Falls, Owyhee, and Malheur River basins is a sodium bicarbonate or sodium-calcium bicarbonate type. All surface water in the Snake River basin is suitable for most uses, including irrigated agriculture.

Solutes in the Snake River Plain aquifer system originate from tributary drainage basins, precipitation, weathering of aquifer minerals, and various land-use activities. The greatest areal variations in solute concentrations coincide with intensively irrigated areas. Temporal changes in solute concentrations are not obvious.

Minimum, median, and maximum concentrations of dissolved solids are 60, 293, and 5,740 mg/L. Minimum, median, and maximum concentrations of chloride are less than 0.1, 16, and 2,380 mg/L. Ground water in the Snake River Plain is generally suitable for most uses.

CONVERSION FACTORS

Multiply	*By*	*To obtain*
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

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

$$°F = (°C)(1.8) + 32$$

All water temperatures are reported to the nearest 0.5°C.

Map unit	*Period*	*Geologic age*	*Lithology*	*Mineralogy*
(yellow)	Quaternary and late Tertiary	Young and old alluvium and eolian deposits	Flood-plain, glacial, colluvium, windblown, and lake deposits; compacted to poorly consolidated; beds lenticular and intertongued with minor intercalated basalt layers.	Composition highly variable depending on the parent rock composition.
(brown)	Quaternary and Tertiary	Basalt	Chiefly irregular to columnar olivine basalt; beds of basaltic cinders with some interflow sedimentary rocks.	Chiefly calcic plagioclase (calcic labradorite to sodic bytownite), pyroxene (augite to titanaugite), and minor magnetite and ilmenite (Nace and others, 1975).
(red)	Quaternary and Tertiary	Young and old silicic volcanic rocks	Rhyolitic, latitic, and andesitic rocks; occurs as thick flows and blankets of welded tuff with fine- to coarse-grained ash and pumice beds.	Younger rocks in the northeast chiefly quartz, sanidine, and oligoclase (Witkind, 1972); older rocks in the southwest chiefly plagioclase and clinopyroxene (pigeonite) (Ekren and others, 1981).
(light green)	Tertiary	Older basalt	Flood-type basalt, dense, columnar jointing; folded and faulted; minor interbedded sediments.	Basalts are chiefly labradorite, augite, and magnetite in the west (Newcombe, 1972) and calcic plagioclase, pyroxene, and olivine in the central part (Nace and others, 1975; Ekren and others, 1981).
(dark green)	Tertiary	Volcanic rocks, undifferentiated	Rhyolitic to basaltic rocks; includes welded tuff, pyroclastic, tuffaceous sedimentary rocks.	Members are highly variable in composition; the most extensive member, a latite-andesite, is composed chiefly of oligoclase with some biotite (Ross, 1937).
(blue)	Tertiary and Cretaceous	Sedimentary rocks, undifferentiated	Shale, siltstone, sandstone, and fresh-water limestone, undifferentiated; well indurated and structurally deformed.	Calcite, dolomite, quartz, and highly variable clay minerals in shales and siltstone (Cressman, 1964).
(purple)	Tertiary and Cretaceous	Intrusive rocks	Chiefly granitic rocks of the Idaho batholith.	Quartz, potassium feldspar, plagioclase biotite, muscovite, and pyroxene (Ross, 1963).
(light blue)	Pre-Cretaceous	Sedimentary and metamorphic rocks	Limestone, shale, siltstone, and sandstone; well indurated, folded and faulted.	Carbonate fluorapatite, calcite, dolomite, quartz, feldspar, muscovite, clay minerals, and pyrite (U.S. Department of the Interior and U.S. Department of Agriculture, 1977).

SURFACE-WATER QUALITY

Chemical characteristics of solutes in tributary streams entering the Snake River Plain are influenced by rocks in the individual stream basins (table at left). Some precipitation on the plain percolates through the soil zone into underlying materials and eventually reaches the Snake River. During its underground migration, this water acquires solutes as a result of chemical weathering processes such as solution of, and ion exchange with, rock minerals. The principal weathering agent is dilute carbonic acid, which is derived from atmospheric carbon dioxide and decomposition of organic matter in the soil zone.

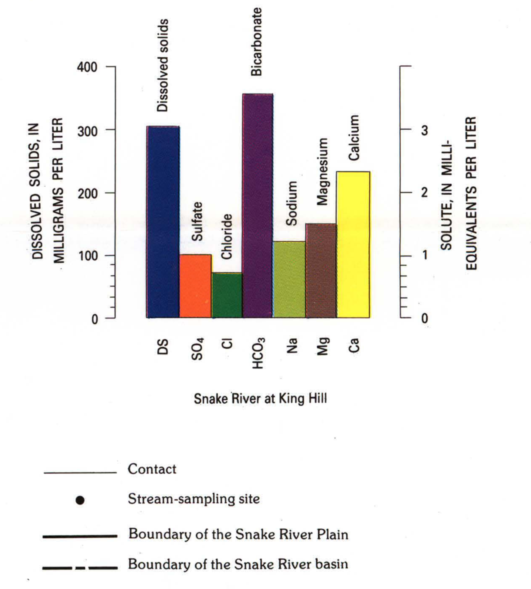
Weathering processes produce solutes characteristic of rock units in tributary drainage basins. A mineral's susceptibility to weathering controls the amounts of ions in solution. Every major rock unit listed in the table will provide, to some degree, all the ions shown on the bar graphs surrounding the map at center.

The bar graphs show discharge-weighted averages of dissolved-solids concentrations and major ions in 26 tributaries to and 3 sites along the Snake River. The graphs represent the quality of surface water where minimal impact of upstream uses, such as irrigation-return flows, might affect the stream's natural chemical composition. Bar graphs for the Snake River at King Hill and at Weiser represent outflow from the eastern and western parts of the plain.

Water from most of the drainage basins surrounding the plain is dilute calcium bicarbonate or calcium-magnesium bicarbonate type, in which dissolved calcium, magnesium, and bicarbonate ions predominate. Distinctly different types of water (sodium bicarbonate and sodium-calcium bicarbonate) characterize the Falls, Owyhee, and Malheur Rivers, which drain silicic volcanic rocks containing these major ions (see table at left). Weathering of minerals in silicic volcanic rocks yields predominantly sodium, calcium, and bicarbonate ions (Wood and Low, U.S. Geological Survey, written commun., 1984).

Dissolved-solids concentrations in surface water range from about 50 mg/L (milligrams per liter) in the Boise River basin to more than 400 mg/L in Owyhee and Raft River basins. In general, water draining rocks that are more resistant to weathering—for example, granitic rocks of the Idaho batholith—contains the lowest dissolved-solids concentration. All surface water in the Snake River basin is suitable for most uses, including irrigated agriculture.

EXPLANATION



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SOLUTE DISTRIBUTION IN GROUND AND SURFACE WATER IN THE SNAKE RIVER BASIN, IDAHO AND EASTERN OREGON

By
Walton H. Low

1987

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