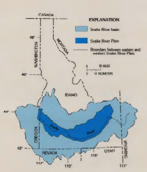
## INTRODUCTION

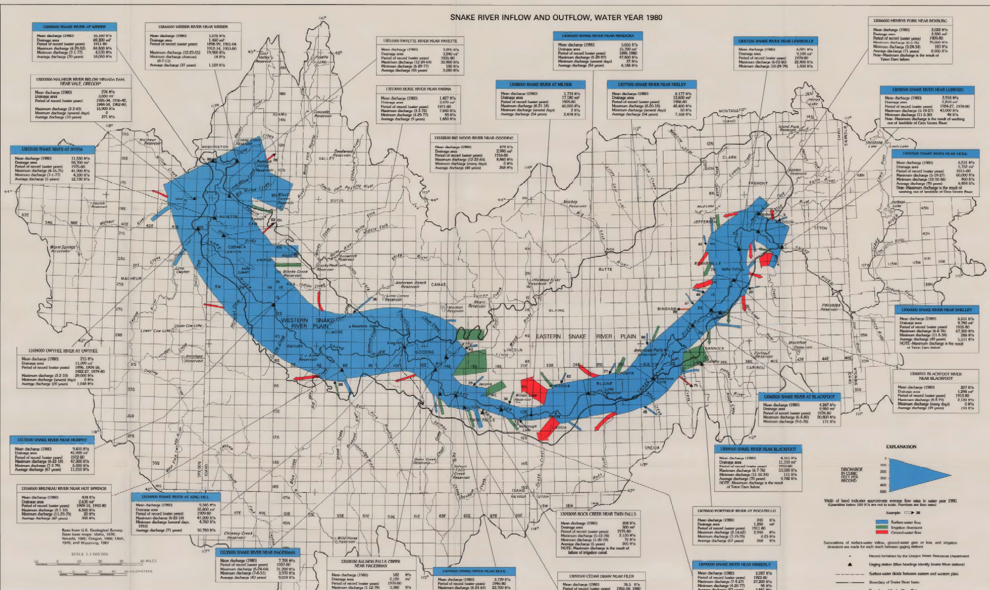
This report is one in a series resulting from the U.S. Geological Survey's Snake River Plain RASA (Regional Aquifer-System Analysis) study that was initiated in October 1979.

Purposes of the RASA study were to (1) refine knowledge of the regional ground-water flow system, (2) determine effects of conjunctive use of ground and surface water, and (3) describe water chemistry. The purpose of this report is to describe flow characteristics of the Snake River and tributaries and to develop a water budget for the Snake River Plain. Data and interpretations in this report will be used in development of ground-water flow models.

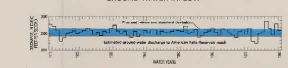



### CONVERSION FACTORS

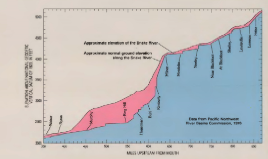
## SNAKE RIVER INFLOW AND OUTFLOW, WATER YEAR 1980

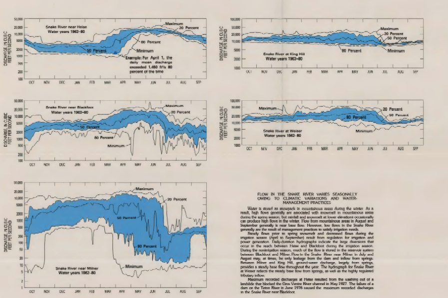


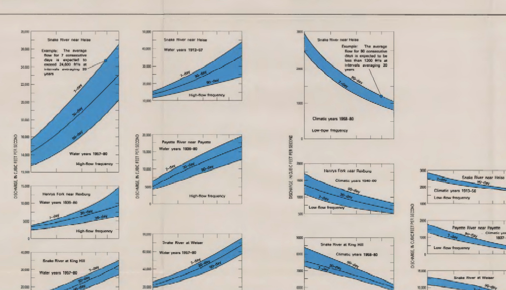

## GROUND-WATER INFLOW



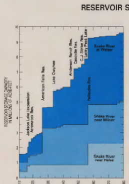

## FLOW IN THE SNAKE RIVER

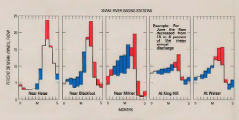


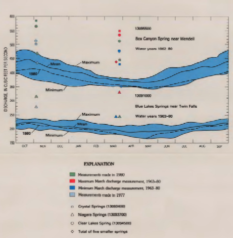



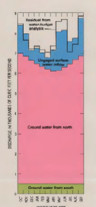



## RESERVOIR STORAGE EFFECTS







# FLOW CHARACTERISTICS OF THE SNAKE RIVER AND WATER BUDGET FOR THE SNAKE RIVER PLAIN, IDAHO AND EASTERN OREGON

By
L. C. Kjelstrom

1986

# WATER BUDGETS

WATER BUDGET FOR EASTERN SNAKE RIVER PLAIN FOR 1934–80

| | Average annual discharge, in millions of acre-feet: Actual conditions | Without development |
|---|---|---|
| Inflow: | | |
| Snake River near Heise | 4.96 | 5.10 |
| Water yield from tributary basins | 5.26 | 5.87 |
| Recharge from precipitation on plain | .60 | .60 |
| Total inflow | 10.82 | 11.57 |
| Outflow: | | |
| Snake River at King Hill | 7.57 | 11.52 |
| Evaporation from Snake River and reservoirs | .20 | .05 |
| Evapotranspiration of irrigation water | 3.00 | 0 |
| Total outflow | 10.77 | 11.57 |
| Change in ground-water storage | + 0.05 | 0 |

WATER BUDGET FOR WESTERN SNAKE RIVER PLAIN FOR 1934–80

| | Average annual discharge, in millions of acre-feet: Actual conditions | Without development |
|---|---|---|
| Inflow: | | |
| Snake River at King Hill | 7.57 | 11.52 |
| Water yield from tributary basins | 7.03 | 7.37 |
| Recharge from precipitation on plain | .05 | .05 |
| Total inflow | 14.65 | 18.94 |
| Outflow: | | |
| Snake River at Weiser | 12.90 | 18.89 |
| Diversions past Weiser | .05 | 0 |
| Evaporation from Snake River and reservoirs | .10 | .05 |
| Evapotranspiration of irrigation water | 1.60 | 0 |
| Total outflow | 14.65 | 18.94 |
| Change in ground-water storage | 0 | 0 |

ANNUAL WATER BUDGETS FOR THE SNAKE RIVER PLAIN WERE DETERMINED FOR 1934-80

Flow from headwaters of the Snake River contributes about 49 percent of the water yield from mountainous areas surrounding the eastern Snake River Plain (above King Hill). Another 23 percent is from Henrys Fork of the Snake River. Tributaries from the north side of the plain, mainly Big Lost and Little Lost Rivers and Birch and Camas Creeks, contribute about 10 percent. Those tributaries lose all their water as they flow onto the plain and never discharge directly to the Snake River. The Wood River basins contribute about 7 percent. About 10 percent of direct precipitation on the eastern plain becomes ground-water recharge or runoff. Direct runoff from the plain is small; therefore, all 10 percent is considered to be recharge.

Discharge of the Snake River at King Hill is assumed to account for nearly all outflow from the eastern Snake River Plain except that which is consumptively used. More than 9 million acre-ft of streamflow is diverted annually for irrigation on the eastern plain. Outflow by evapotranspiration of irrigation water gradually has increased with time as irrigated acreage has increased. Since the 1950's, increases in irrigated acreage have been due largely to increased use of ground water. Ground-water storage increased rapidly in the early 1900's owing to recharge from surface-water supplied flood and furrow irrigation. Since the 1950's, changing irrigation practices, mainly increased withdrawal of ground water and increased use of sprinkler systems, have caused decreases in ground-water storage.

The Payette, Boise, and Weiser Rivers contribute about 79 percent of the tributary water yield to the western Snake River Plain. An additional 18 percent is provided from the Owyhee, Malheur, and Bruneau Rivers. About 2 percent of the direct precipitation on the western plain becomes ground-water recharge. Runoff again is assumed to be negligible. More than 3.5 million acre-ft of streamflow is diverted annually for irrigation on the western plain. Discharge of the Snake River at Weiser is assumed to account for nearly all outflow from the basin, except for that which is consumptively used. Consumptive use as evapotranspiration of irrigation water has increased during the period, owing to increased use of ground water since the 1950's and direct pumping from the Snake River during the 1970's.

If there were no irrigation development in the tributary valleys or on the plain, average annual flow in the Snake River would be 4 and 6 million acre-ft greater at King Hill and Weiser, respectively.

## INFLOW TO EASTERN SNAKE RIVER PLAIN

MEAN ANNUAL DISCHARGE, IN THOUSANDS OF ACRE-FEET, FOR WATER YEARS 1934–80 (columns after "Mean for period of record")

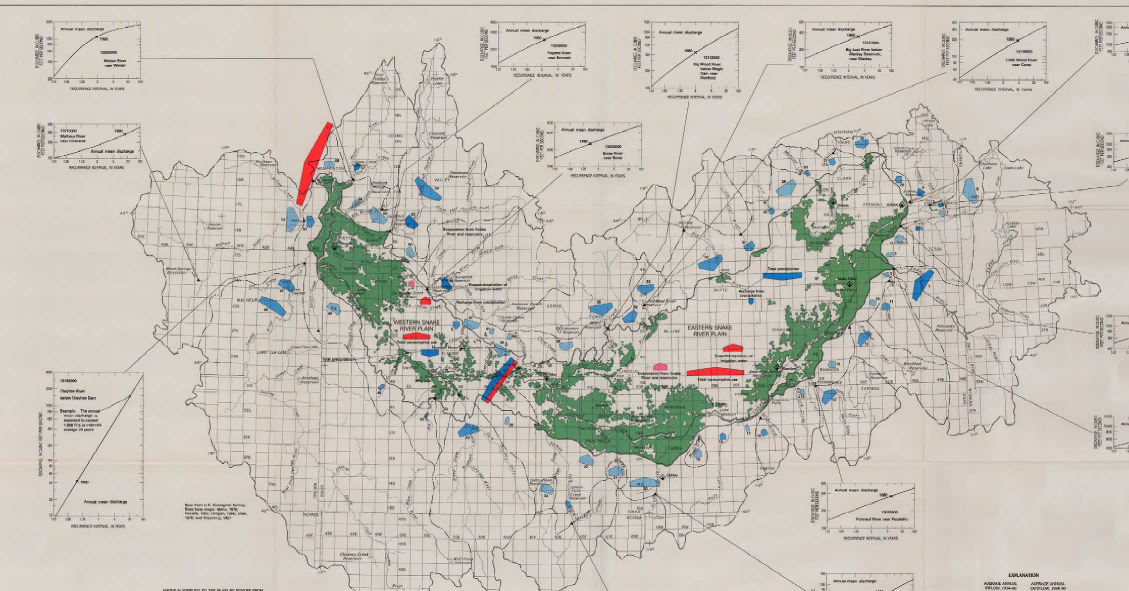
| Map number | Gaging station (number) or contributing area | Period of record (water years) | Mean for period of record | Mean or adjusted mean for 1934–80 period | Estimated underflow | Water yield from ungaged areas | Water used between gage and plain or in ungaged area | Net water yield to plain | Water used upstream of gage | Net water yield to plain with no development |
|---|---|---|---|---|---|---|---|---|---|---|
| 1* | Snake River near Heise (13037500) | 1911-80 | 5,024 | 4,953 | Negligible | | | 4,953 | 142 | 5,100 |
| 2 | Riley ditch | 1928-80 | 5 | 5 | | | | 5 | | |
| 3 | Lyon Creek, Bailey Canyon, and adjacent area | | | | | 6 | | 6 | | 6 |
| 4* | Henrys Fork near Ashton (13046000) | 1903-08 1927-80 | 1,054 | 1,072 | Negligible | | | 1,072 | 37 | 1,109 |
| 5* | Falls River near Squirrel (13047500) | 1905-08 1919-80 | 562 | 570 | Negligible | 5 | 7 | 568 | 1 | 611 |
| 6 | Falls River diversions | 1928-80 | 33 | 35 | | | | 35 | | |
| 7 | Conant Creek basin | | | | | 68 | 4 | 64 | | 68 |
| 8* | Teton River near St. Anthony (13055000) | 1934-80 | 586 | 584 | Negligible | | | 584 | 64 | 648 |
| 9 | Moody Creek near Rexburg (13055319) | 1980 | 11 | 10 | | | | 10 | | 10 |
| 10 | Birch Creek and adjacent area | | | | | 8 | | 8 | | 8 |
| 11 | Willow Creek near Ririe (13058000) | 1904 1917-25 1963-80 | 126 | 126 | Negligible | | | 126 | 9 | 135 |
| 12 | Blackfoot River near Shelley (13066000) | 1910-26 1976-80 | 253 | 253 | Negligible | | | 253 | 27 | 280 |
| 13 | Lincoln Creek, Ross Fork, Pocatello Creek, and adjacent areas | | | | | 24 | 5 | 19 | | 24 |
| 14* | Portneuf River near Pocatello (13075500) | 1913-80 | 194 | 193 | 63 | | | 256 | 78 | 334 |
| 15 | Michaud, Bannock, Sunbeam, and Warm Creek basins | | | | | 61 | 10 | 51 | | 61 |
| 16 | Rock Creek near American Falls (13077650) | 1979-80 | 24 | 17 | 51 | | | 68 | 17 | 85 |
| 17 | Fall Creek and adjacent area | | | | | 4 | | 4 | | 4 |
| 18 | Raft River basin | | | | 82 | | | 82 | 45 | 100 |
| 19 | Marsh Creek near Albion (13082300) | 1967-74 | 16 | 10 | | | | 10 | 5 | 15 |
| 20* | Goose Creek above Trapper Creek near Oakley (13082500) | 1911-16 1919-80 | 34 | 33 | Negligible | 11 | | 44 | 2 | 46 |
| 21 | Rock Creek near Rock Creek (13092000) | 1910-12 1944-74 | 25 | 24 | Negligible | 1 | | 25 | 1 | 26 |
| 22 | Dry, Cottonwood, and Deep Creeks and adjacent areas | | | | | 20 | | 20 | | 20 |
| 23* | Salmon Falls Creek near San Jacinto, Nev. (13105000) | 1910-16 1918-80 | 100 | 104 | 45 | | | 149 | 26 | 175 |
| 24 | Cedar Creek near Roseworth (13107000) | 1958-66 | 17 | 19 | | 2 | 2 | 19 | 1 | 22 |
| 25 | Big Bend Ridge area draining to the west | | | | 111 | | | 111 | | 111 |
| 26 | Camas Creek at Eighteen-Mile Shearing Corral near Kilgore (13108500) | 1946-53 1969-73 | 63 | 63 | 151 | | | 214 | 9 | 223 |
| 27 | Beaver Creek near Spencer (13113000) | 1941-80 | 31 | 31 | 59 | | | 90 | 1 | 91 |
| 28 | Medicine Lodge Creek at Ellis Ranch near Argora (13116000) | 1941-69 | 30 | 30 | 8 | | | 38 | 4 | 42 |
| 29 | Warm Spring, Deep, and Blue Creek basins | | | | | 30 | | 30 | | 30 |
| 30 | Birch Creek near Reno (13119000) | 1951-63 | 56 | 61 | 7 | 6 | | 74 | | 74 |
| 31 | Little Lost River near Howe (13119000) | 1941-80 | 55 | 52 | 152 | 10 | 50 | 164 | 16 | 230 |
| 32* | Big Lost River near Mackay (13127000) | 1905-80 | 219 | 228 | 72 | 145 | 110 | 335 | 35 | 480 |
| 33* | Little Wood River near Carey (13148500) | 1928-42 1945-80 | 109 | 114 | 18 | 15 | | 147 | 3 | 150 |
| 34 | Silver Creek at Sportsman Access near Picabo (13150430) | 1975-80 | 123 | 140 | 50 | 1 | | 191 | 15 | 206 |
| 35* | Big Wood River below Magic Reservoir near Richfield (13142500) | 1913-80 | 332 | 352 | Negligible | 11 | | 363 | 57 | 420 |
| 36 | Clover Creek near Bliss (13154000) | 1939-43 1958-62 | 22 | 22 | Negligible | 5 | | 27 | 1 | 28 |
| | Total water yield to the eastern Snake River Plain from tributary basins | | | | | | | 10,215 | | 10,972 |

## INFLOW TO WESTERN SNAKE RIVER PLAIN

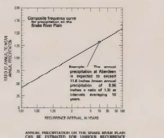
| Map number | Gaging station (number) or contributing area | Period of record (water years) | Mean for period of record | Mean or adjusted mean for 1934–80 period | Estimated underflow | Water yield from ungaged areas | Water used between gage and plain or in ungaged area | Net water yield to plain | Water used upstream of gage | Net water yield to plain with no development |
|---|---|---|---|---|---|---|---|---|---|---|
| 37 | Snake River at King Hill (13154500) | 1911-80 | 7,788 | 7,871 | Negligible | | | 7,871 | | 11,820 |
| 38 | King Hill, Cold Springs, Rattlesnake, and other small adjacent basins | | | | | 25 | | 25 | | 25 |
| 39 | Sailor and Browns Creek basins | | | | | 9 | | 9 | | 9 |
| 40 | Little Canyon Creek at Stout Crossing near Glenns Ferry (13155300) | 1966-71 | 7 | 7 | | 2 | | 9 | | 9 |
| 41 | Bennett Creek near Bennett (13156500) | 1939-45 | 5 | 5 | | 2 | | 7 | | 7 |
| 42 | Mountain Home Feeder Canal near Mountain Home (13160500) | 1946-69 | 23 | 23 | 5 | 5 | | 33 | | 33 |
| 43 | Bruneau River near Hot Springs (13168500) | 1910-14 1944-80 | 286 | 297 | 50 | | | 347 | 20 | 367 |
| 44 | Big Jacks Creek near Bruneau (13169500) | 1940-49 1966-80 | 3 | 3 | 7 | | | 10 | | 10 |
| 45 | Shoofly, Birch, Castle, Sinker, Rabbit, Reynolds, Hardtrigger, Squaw, and Jump Creek basins | | | | | 57 | | 57 | | 57 |
| 46 | Succor Creek near Jordan Valley, Oreg. (13172900) (a) | 1967-80 | 23 | 19 | Negligible | 4 | | 23 | | 23 |
| 47* | Owyhee River below Owyhee Dam, Oreg. (13183000) | 1933-80 | 255 | 255 | Negligible | | | 255 | 44 | 734 |
| 48 | South (13182300) and North (13182400) Owyhee Canals near Adrian (a) | 1962-80 | 435 | 435 | | | | 435 | | |
| 49* | Boise River near Boise (13202000) | 1898-1903 1906 1908-16 1955-80 | 2,156 | 2,097 | Negligible | | | 2,097 | 28 | 2,125 |
| 50 | Indian, Blacks, Dry, and Willow Creek basins | 1968-76 | | | | 15 | | 15 | | 15 |
| 51(b) | Malheur River below Nevada Dam near Vale, Oreg. (13233400) (a) | 1968-76 1978-80 | 197 | 177 | 5 | 18 | | 200 | 65 | 303 |
| 52 | Nevada Canal near Vale, Oreg. (13233200) (a) | 1938-41 1962 1968-80 | 38 | 38 | | | | 398 | | |
| 53* | Payette River near Emmett (13249500) | 1926-80 | 2,169 | 2,200 | Negligible | | | 2,200 | 127 | 2,785 |
| 54 | Payette River diversions from Black Canyon Reservoir (c) | 1975-80 | 458 | 458 | | | | 458 | | |
| 55 | Big Willow Creek near Emmett (13249500) | 1963-80 | 17 | 17 | Negligible | 12 | | 29 | | 29 |
| 56 | Little Willow Creek basin and adjacent areas | | | | | 8 | | 8 | | 8 |
| 57* | Weiser River near Weiser (13266000) | 1896, 1899 1901-04 1912-14 1953-80 | 818 | 764 | Negligible | | | 764 | 47 | 811 |
| 58 | Mann and Monroe Creek basins | | | | | 15 | | 15 | 5 | 20 |
| | Total water yield to the western Snake River Plain from upstream and tributary basins | | | | | | | 14,605 | | 18,890 |

Ranking of discharge accuracy: good (blue), fair (green), poor (pink)

*Gaging station was used in inflow analysis.
(a) Records furnished by Oregon Water Resources Department.
(b) Records of Malheur River below Warm Springs Reservoir near Riverside, Oreg. (13215000), were used for inflow analysis.
(c) Records furnished by U.S. Bureau of Reclamation.




WATER IS SUPPLIED TO THE PLAIN BY RUNOFF FROM ADJACENT MOUNTAINS AND BY DIRECT PRECIPITATION; WATER NOT CONSUMPTIVELY USED OR STORED FLOWS FROM THE PLAIN IN THE SNAKE RIVER




ANNUAL PRECIPITATION ON THE SNAKE RIVER PLAIN CAN BE ESTIMATED FOR VARIOUS RECURRENCE INTERVALS FROM THE COMPOSITE FREQUENCY CURVE

Precipitation records for the eight stations listed in the table at right were used to develop the composite frequency curve. An estimate of annual precipitation at a particular recurrence interval may be obtained by multiplying average annual precipitation at any of these stations by the ratio of annual to average annual precipitation for that recurrence interval (taken from the curve). Most long-term records of precipitation on the basin are from stations located near populated areas on the plain, and few precipitation data are available for large parts of the plain. Within certain limits, precipitation increases with an increase in elevation. Some mountainous areas in the basin receive an average of 40-50 in./yr; a few small areas receive more than 60 in.

WATER YIELD FROM MOUNTAINS ADJACENT TO THE PLAIN WAS DETERMINED FROM STREAMFLOW RECORDS AND TRIBUTARY BASIN STUDIES

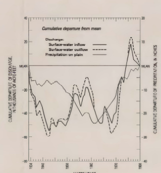
Gaged streams contribute about 89 and 97 percent of water supplied by tributary basins to the eastern and western parts of the Snake River Plain, respectively.

Underflow from many tributary basins is too small to be estimated accurately from basin-budget analyses. For these basins, underflow is shown as negligible in the table; however, it is recognized that underflow from some basins may be significant.

Water yield from ungaged tributary basins was estimated on the basis of runoff from nearby gaged streams or by use of a regression equation developed from records of mean annual discharge at 55 gaging stations. Drainage area, mean annual precipitation, and percentage of forest cover are the independent variables in the equation. Those stations selected for regression analysis are on streams draining areas with little irrigation and from which underflow is assumed to be relatively small.

Net water yield to the plain includes gaged discharge from tributary basins, estimated underflow, and ungaged water yield minus water consumptively used between gage and plain.

An estimate of water yield to the plain assuming no irrigation or reservoir storage in tributary basins was made by adding the amount of irrigation water evapotranspired and water evaporated from reservoirs upstream from the plain's boundary to the net water yield. Irrigation diversions that bypass gaging stations are added to the water yield from tributary basins.

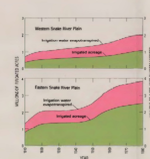



CUMULATIVE DEPARTURE CURVES OF SURFACE-WATER INFLOW AND OUTFLOW ARE SIMILAR BUT DEPART CONSIDERABLY FROM THE CURVE FOR PRECIPITATION

The cumulative departure curve for surface-water inflow is computed from the differences between the 1934–80 mean and the annual summations of discharge from 15 streams tributary to the plain; the cumulative departure curve for surface-water outflow is computed from the differences between the mean and the annual discharges for the Snake River at Weiser. The cumulative departure curve for precipitation is computed from the differences between the mean and the annual summations of precipitation at the following stations, whose locations are shown on the map above.

| Station | Average annual precipitation 1934–80 (inches) | Average percentage of precipitation from April to September | Average annual temperature (°F) |
|---|---|---|---|
| Aberdeen | 8.93 | 50 | 46 |
| Ashton | 18.47 | 44 | 41 |
| Bliss | 9.23 | 33 | 50 |
| Dubois | 11.61 | 57 | 43 |
| Idaho Falls | 9.55 | 52 | 44 |
| Mountain Home | 9.60 | 36 | 50 |
| Oakley | 11.05 | 57 | 49 |
| Parma | 10.81 | 37 | 51 |

The precipitation curve and the surface-water inflow curve are not similar because precipitation on the plain is a poor indicator of the amount of water available; most of the water originates as precipitation on mountainous areas surrounding the plain. Precipitation on the plain was less than average before 1962 and greater than average after 1962. An extremely wet period occurred from 1969 to 1976 in surrounding mountainous areas.




## SUMMARY

The Snake River is the regional drain for the hydrologic system in southern Idaho. Net ground-water discharge to the Snake River equaled 58 percent of the flow in the Snake River at Weiser in water year 1980. Because surface and ground water are so closely related, water budgets were used to calculate recharge to and discharge from the Snake River Plain.

Flow in the Snake River is highly regulated; usable storage capacity upstream from Weiser is more than 9.5 million acre-ft. Water is regulated for generation of power, flood control, recreation, and irrigation. This regulation, particularly that for irrigation, has greatly affected the natural flow regime of the Snake River. Maximum discharges in rivers during the spring snowmelt season have been reduced by reservoir storage. Releases for water-management purposes have augmented the flow at other times. Highest recorded discharges in the Snake River above American Falls Reservoir were the result of catastrophic events: the washing out of a landslide that had blocked the Gros Ventre River channel in 1927 and the failure of a dam on the Teton River in 1976.

Increased ground-water recharge in surface-water irrigated areas has raised ground-water levels and consequently increased ground-water discharge to the Snake River. Ground-water discharge in the Milner-King Hill reach increased from 1911 to 1961, then stabilized for the next 4 years, which indicates that ground-water recharge and discharge had reached a new equilibrium. Since 1966, increased ground-water withdrawals for irrigation have decreased ground-water discharge to that reach of the Snake River. Annual ground-water discharge to the Snake River in the American Falls Reservoir area had the largest increase before 1912. Increased ground-water withdrawals since the 1950's have had only a small effect on ground-water discharge in this area.

Water-budget analyses indicate that more than 90 percent of the water yield from tributary basins to the plain is measured at gaging stations. Thus, possible errors in the estimates of underflow and flow from ungaged areas have small impact on the water-budget analyses. Outflows from the eastern and western parts of the Snake River Plain are measured at gaging stations on the Snake River at King Hill and at Weiser, respectively. Because domestic and industrial water uses are relatively small, annual differences between inflow and outflow are due largely to evapotranspiration of irrigation water and changes in ground-water storage. Water-budget analyses further indicate that recharge from precipitation on the plain is very small on the western plain and near 10 percent on the eastern plain.

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By
L. C. Kjelstrom

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