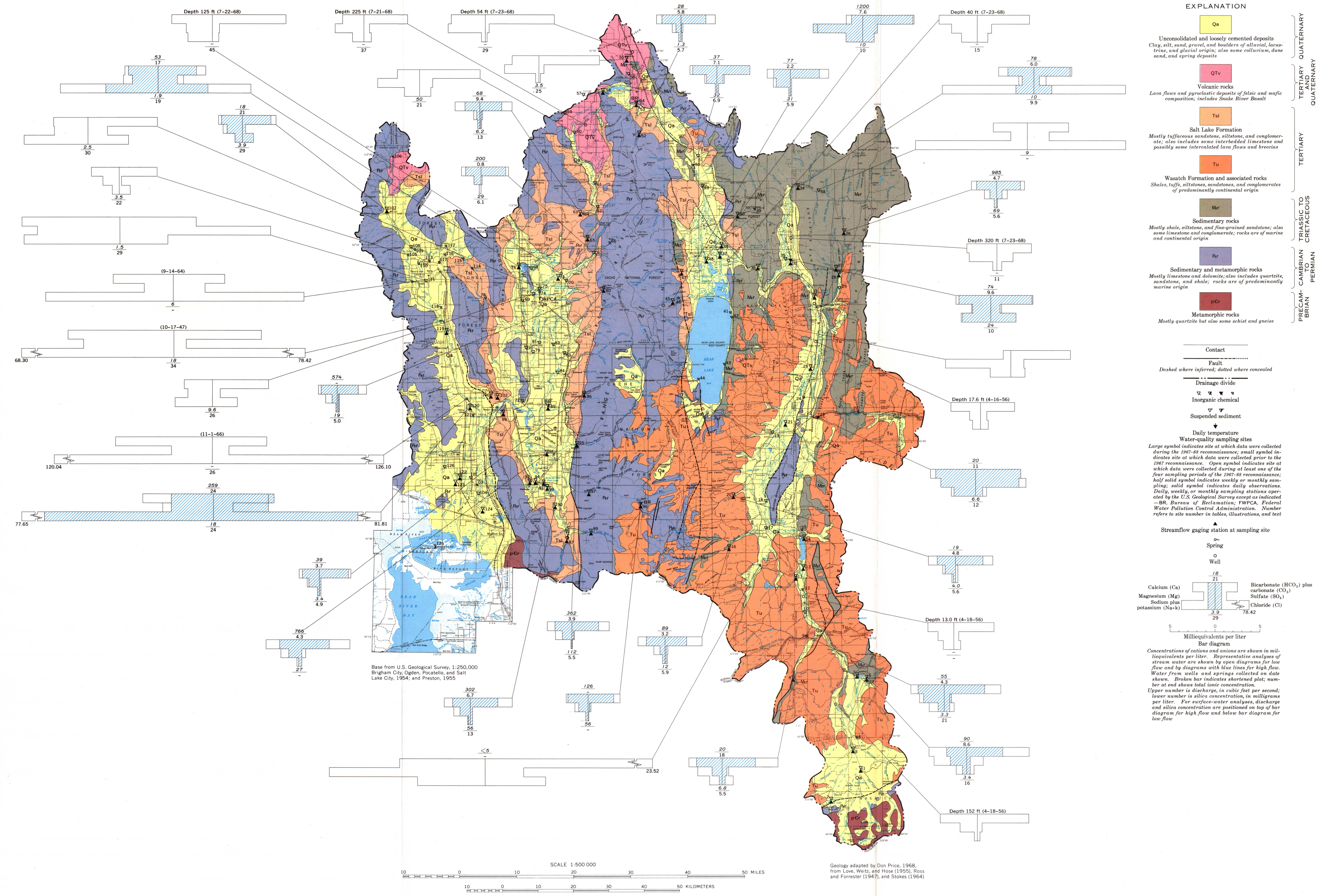
PREPARED IN COOPERATION WITH THE
UTAH DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RIGHTS



GEOHYDROLOGIC MAP

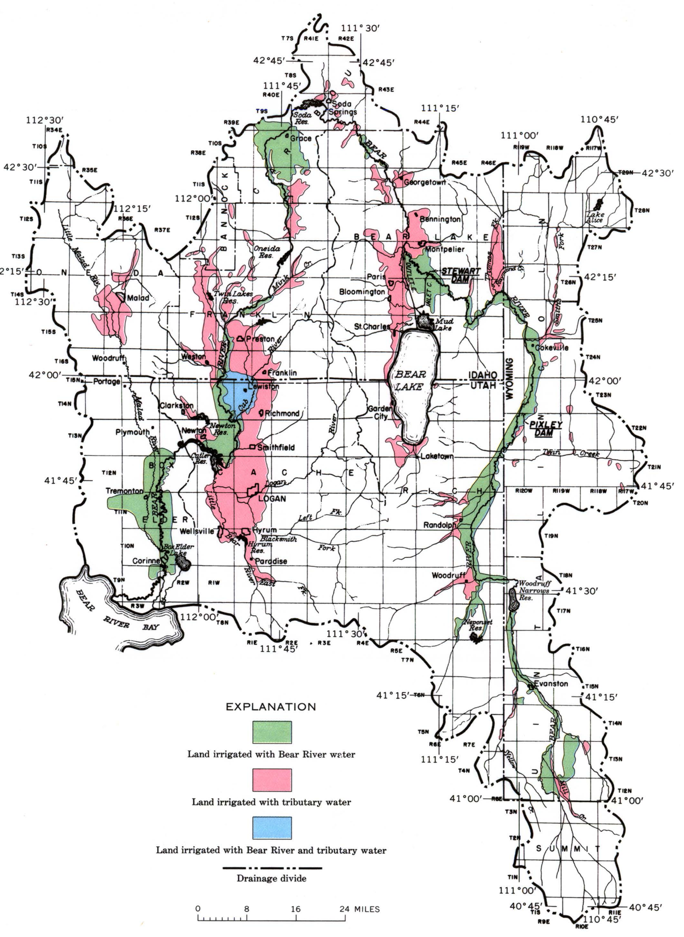


FIGURE 1.—*Irrigated areas.*

INTRODUCTION

The U.S. Geological Survey, in cooperation with the Utah Department of Natural Resources, Division of Water Rights, began a reconnaissance in 1967 to obtain essential water-quality information for the Bear River basin. The reconnaissance was directed toward defining the chemical quality of the basin's surface waters, including suitability for specific uses, geology, and general basin hydrology. Emphasis was given to those areas where water-development projects are proposed or are being considered.

Water samples were obtained at most sites in a selected network four times during an 11-month period (September 1967–July 1968) to define chemical-quality conditions during low flow in the winter, high runoff (snowmelt period) in the spring, midirrigation period in the summer, and postirrigation period in the fall. Each of the four sets of data was obtained within a 5-day period to establish a concurrent, basinwide, seasonal pattern of chemical quality. Sediment data were collected during the snowmelt period in the spring. The reconnaissance data and selected miscellaneous data collected earlier by the U.S. Geological Survey and other agencies were reported by Waddell (1970) and are the basis for this report.

The drainage area of the Bear River basin is about 7,320 square miles—2,630 in Idaho, 3,190 in Utah, and 1,500 in Wyoming. The Bear River is the largest stream in the Western Hemisphere whose water does not eventually empty into an ocean. The river heads in the Uinta Mountains of Utah at an altitude of about 12,500 feet. Its course is about 475 miles long and it crosses the state boundaries of Utah, Wyoming, and Idaho five times before emptying into Great Salt Lake about 90 air-line miles from its source. The principal tributaries of the Bear River are Smiths Fork, Thomas Fork, Mink Creek, Cub River, Little Bear River, Logan River, Blacksmith Fork, and Malad River.

CHEMICAL CHARACTERISTICS

SELECTED TRIBUTARIES

The chemical composition of water from the upper reaches of the tributaries is predominantly affected by the rock types through which the tributaries flow. In the lower reaches of the streams, water use, especially irrigation (see fig. 1) and ground-water inflow are the principal factors that tend to affect the chemical quality.

The water from most of the sites on the tributaries was predominantly of the calcium bicarbonate type, as shown on the geohydrologic map, and the concentration of dissolved solids ranged from 100 to 500 mg/l (milligrams per liter). The chemical composition of water from many of the streams at high altitudes was typical of water draining from areas underlain mainly by limestones and dolomitic rocks; calcium to magnesium ratios in milli-equivalents per liter generally ranged from 3:1 to 1:1, and the concentrations of calcium plus magnesium approximated that of bicarbonate. However, in some reaches of Saleratus Creek, Thomas Fork, Deep Creek, and Big Malad, Little Malad, and Malad Rivers, the water had concentrations of dissolved solids exceeding 1,000 mg/l and was generally of the sodium chloride type.

Yellow Creek

The maximum concentration of dissolved solids observed in the water both upstream (site 8) and near the mouth (site 9) of Yellow Creek was less than 500 mg/l, and the water was of the calcium bicarbonate type during both low and high flows.

The largest increase in concentration of dissolved solids in the reach from site 8 to site 9 was observed during July 1968. The concentration of dissolved solids and water discharge increased from 260 mg/l and 2.5 cfs (cubic feet per second) at site 8 to 372 mg/l and 8.3 cfs at site 9 (fig. 2–*A*). The increased concentration may be due to irrigation return flow from the valley (see fig. 1 for irrigated area). Tributary inflow or ground-water inflow could also have caused or contributed to the increased concentration and discharge downstream, but similar increases of discharge during January and May 1968 were not associated with as great an increase in concentration of dissolved solids.

The concentration of dissolved solids in the water near the mouth of Yellow Creek (site 9) generally was about 150–250 mg/l higher than that of water in the Bear River above its confluence with Yellow Creek. However, inflows from Yellow Creek are generally small in relation to the flow of the Bear River and probably have little effect on the chemical quality of the Bear River.

Twin Creek

Water near the mouth of Twin Creek (site 23) was of the calcium magnesium bicarbonate sulfate type during low flow and the calcium magnesium sulfate bicarbonate type during high flow. The concentrations of dissolved solids ranged from about 400 to 700 mg/l (fig. 2–*B*). Although the curve is not well defined, the relation of the concentration of dissolved solids to water discharge deviates from the typically inverse relation that occurs in most streams; in other words, the concentrations of dissolved solids increased with increasing discharge. The average precipitation for Twin Creek drainage basin is only about 12 inches per year, and about 6 to 8 inches of this falls as snow from October to April. During the period 1943–62, the mean daily discharge at site 23 was only 18.5 cfs or 0.075 cfs per square mile of drainage area. This is a much lower unit yield than observed for all other subbasins of the Bear River basin. Consequently, the basin receives very little flushing except during the period of spring snowmelt. The higher concentrations observed during the periods of high flow were probably due to the flushing of salts from soils and from the banks of Twin Creek. No significant change of chemical quality was observed during the irrigation season.

Twin Creek contributes more dissolved solids to the Bear River during the period of peak runoff than during the period of low flow. Comparison of monthly runoff data for Twin Creek at Sage, Wyo. (site 23) and the Bear River upstream from the confluence with Twin Creek at Randolph, Utah (site 21) for the period 1943–62, indicates that during many years, maximum discharge from Twin Creek occurred about a month earlier than did maximum discharge at site 21 on the Bear River. As a result, Twin Creek contributes a higher percentage of the Bear River flow during the peak runoff period of the creek than during its period of low flow. The concentration of dissolved solids in Twin Creek during flows greater than 10 cfs ranged from about 500 to 700 mg/l as compared to the range of about 250 to 750 mg/l at site 21 on the Bear River. (Compare fig. 2–*B* and fig. 3 on sheet 2 of 2.)

Smiths Fork

The chemical composition of water upstream (site 26) in Smiths Fork was similar during both low and high flows and was of the calcium bicarbonate type. The maximum concentration of dissolved solids observed at site 26 and site 29 (near the mouth) was less than 250 mg/l (fig. 2–*C*). During the reconnaissance only a small increase in concentration of dissolved solids was observed in the reach from site 26 to site 29, and no significant change in chemical quality was observed during the irrigation season.

Inflow from Smiths Fork lowers the concentration of dissolved solids in the Bear River because the concentration of dissolved solids at site 29 near the mouth of Smiths Fork generally is from 150 to 250 mg/l less than that of the Bear River upstream from the confluence at site 25. (Compare fig. 2–*C* and fig. 3 on sheet 2 of 2.)

Thomas Fork

The chemical composition of water at sites 33 and 34 in the upper reach of Thomas Fork was similar during periods of low flow, and the water was of the sodium chloride type. The concentration of dissolved solids generally ranged from about 400 to 1,050 mg/l when flows were less than 15 cfs (fig. 2–*D*). The relatively high concentrations of dissolved solids at these sites during low flows may be due to inflow of water from springs of high mineral content that issue from the Preuss Sandstone of Jurassic age in southeastern Idaho (Mansfield, 1927, p. 99). The Preuss crops out in the upper part of the Thomas Fork drainage basin.

The concentration of dissolved solids at sites 33 and 34 generally decreased with increasing discharges. For discharges greater than 15 cfs, the concentrations of dissolved solids ranged from about 350 to 650 mg/l, and the water changed to a calcium sodium bicarbonate type.

The chemical composition of the water at the mouth of Thomas Fork (site 35) was essentially the same for both low and high flows, and the water was of the calcium sodium bicarbonate type. The concentration of dissolved solids ranged from 450 to 530 mg/l for the observed range of water discharges. Apparently, ground-water inflow in the reach between sites 34 and 35 modifies the chemical composition of the water. An analysis of water from a well in the alluvium between sites 34 and 35 indicated that the concentration of dissolved solids in the ground water was about 400 mg/l, and the water was of the calcium magnesium bicarbonate type. The increase of streamflow between sites 34 and 35 during most of the concurrent sampling periods and the presence of swampy areas above site 35 also indicate that considerable amounts of ground water seep into Thomas Fork along its lower reaches.

Considerable amounts of water are diverted from Thomas Fork for irrigation along the reach between sites 34 and 35 (fig. 1). It is possible, therefore, that part of the increase in the concentration of dissolved solids between sites 34 and 35 during May and July of 1968 can be attributed to return flow from irrigation.

Site 33 is being considered as a potential damsite, but the low flows thus stored would be unsuitable for most uses because of high concentrations of dissolved solids and high sodium-adsorption ratios. The stored water would be more suitable for most uses if the low flows could be diverted past the reservoir and only the high flows stored.

Inflow from Thomas Fork generally increases the concentration of dissolved solids of the Bear River. The concentration of dissolved solids in Thomas Fork was about 100–200 mg/l greater than that normally occurring in the Bear River upstream from the confluence.

Mink Creek

The water at sites 66 and 67 in the upper reach of Mink Creek was of the calcium bicarbonate type for both low and high flows, and the concentration of dissolved solids ranged from about 130 to 175 mg/l.

During the irrigation season, most of the water is diverted from Mink Creek at site 67 to the Oneida Canal and the Preston-Riverdale and Mink Creek Canal. The Oneida Canal conveys the water to the Twin Lakes Reservoir in Deep Creek valley. The reservoir supplies water for irrigation in Deep Creek valley. The Preston-Riverdale and Mink Creek Canal provides water for irrigation of the valley lands bordering the Bear River north of Preston, Idaho.

Chemical analyses of water samples obtained during the 1967–68 reconnaissance at site 68 on the Twin Lakes inlet canal, site 69 on the Twin Lakes outlet canal, and site 70 on the Preston-Riverdale and Mink Creek Canal indicate that the chemical composition was similar to that of Mink Creek and of suitable quality for irrigation. Because of diversions, inflows from Mink Creek are generally small in relation to the flow of the Bear River and probably have little effect on the chemical quality of the Bear River.

Deep Creek

The chemical composition of water in the upper reach of Deep Creek (site 76) varied considerably with discharge. The concentrations of dissolved solids ranged from about 700 mg/l at a discharge of 53 cfs to 3,100 mg/l at a discharge of 2 cfs, and the water was generally of the sodium chloride type. The high concentrations of dissolved solids during low flows at site 76 are attributed to evapotranspiration upstream. Low flows are maintained principally by ground-water inflow between Oxford Station and site 76.

Specific conductance measurements were made at several sites along Deep Creek during July 1968 to determine the source of high concentrations of dissolved solids at site 76 and the sources of dilution downstream from site 76. Near Oxford Station, 6 miles north of Clifton, Idaho, flow was not detectable in Deep Creek; a marshy area with dense cattail growth extended across the poorly developed channel (fig. 3). A specific conductance measurement of the standing water indicated that the concentration of dissolved solids was approximately 700 mg/l. Downstream, at site 76, the discharge was 2.5 cfs and the concentration of dissolved solids was 3,070 mg/l (fig. 4–*A*). Evaporation from the shallow water table between Oxford Station and site 76 has resulted in a concentration of the dissolved solids in the ground water near the surface. Salts have accumulated locally on the land surface (fig. 3), and ground-water inflow to Deep Creek contained high concentrations of dissolved solids. The concentration of dissolved solids at site 76 during January 1968 was only 1,020 mg/l and the discharge was 1.9 cfs. The approximately threefold increase of dissolved solids, which was observed during July at about the same discharge as during January, was probably caused by the higher rate of evaporation during the summer months.

At the mouth of Deep Creek at site 77, the chemical composition of the water changed only slightly with discharge (fig. 2–*E*). The water for the most part was of the sodium bicarbonate chloride type, and the concentrations of dissolved solids ranged from about 500 to 700 mg/l. However, a sample was not obtained at the mouth of Deep Creek during a period of high flow because the snowmelt runoff in the Deep Creek drainage basin occurred prior to the May 1968 sampling period. The concentration of dissolved solids would probably be less than 500 mg/l during a period of high flow.

The decreased concentration of dissolved solids from site 76 to 77 is due to the inflow of considerable amounts of ground water, which contains lower concentrations of dissolved solids than do the flows originating upstream from site 76. During January 1968, when there were no diversions, the discharge increased from about 2 cfs at site 76 to about 10 cfs at site 77.

Specific conductance measurements made during July 1968 indicated that the concentration of dissolved solids in Deep Creek above the inflow of a spring, which is about 0.9 mile downstream from site 76, was about 2,000 mg/l and below the inflow about 1,260 mg/l (fig. 4–*A*). The estimated discharge of the spring, which may be discharging seepage from Twin Lakes Reservoir, was 2 cfs; the concentration of dissolved solids was 350 mg/l.

During the irrigation season much of the water from Deep Creek is diverted in the lower part of Deep Creek valley, and some is diverted into the West Cache Canal, just upstream from site 77. Because of the very low discharge at the mouth of Deep Creek, inflow to the Bear River from the creek probably has very little effect on the chemical quality of the river.

Cub River

The chemical composition of water in the upper reach (site 80) of the Cub River was similar during both low and high flows; the water was generally of the calcium bicarbonate type and the concentrations of dissolved solids generally ranged from about 100 to 200 mg/l (fig. 2–*F*).

In the lower reach (sites 83 and 84) the water was of about the same chemical type as upstream, but the concentrations of dissolved solids were appreciably higher; the dissolved-solids content ranged from about 200 to 500 mg/l. The maximum concentrations, which were observed at site 83, probably result from the inflow of Worm Creek or ground-water inflow upstream. During the irrigation season much of the water in Worm Creek is derived from irrigation return flows. Also, subsurface seepage directly to the Cub River due to irrigation may contribute to the increased mineralization. Sediments of low permeability lie at shallow depths throughout much of the flatlands in the Idaho part of Cache Valley. These sediments restrict the deep percolation of water, and much of the water applied for irrigation moves laterally to Worm Creek, Cub River, and other streams.

During July and August 1959 and July 1968, considerable dilution occurred between sites 83 and 84 (figs. 2–*F* and 4–*B*). Concentrations of dissolved solids in the water decreased as much as 200 mg/l, probably because of ground-water inflow and some tributary inflow.

A potential damsite is being studied on the Cub River about 2 miles below Mapleton, Idaho. The water at this site should be of suitable chemical composition for all purposes; the weighted-average concentration of dissolved solids for average water years would be about 150–200 mg/l.

The concentrations of dissolved solids near the mouth of the Cub River are about 50–250 mg/l less than those of the Bear River above the confluence, and the inflow of the Cub River should improve the water in the Bear River during most periods of the year.

Little Bear River

The water at all sites (sites 88, 90, 93, and 94) on the Little Bear River, for both low and high flows, was generally of the calcium or calcium magnesium bicarbonate type. The concentrations of dissolved solids ranged from about 100 to 400 mg/l and generally increased downstream (fig. 4–*C*). The maximum concentration of dissolved solids was observed at the site nearest the mouth (site 94) during July 1968 when little or no water was being released from Hyrum Reservoir to the river (figs. 2–*G* and 4–*C*). At that time, the following changes were observed between sites 93 and 94:

	Site 93	Site 94
Discharge (cfs)	2.6	26
Nitrate (mg/l)	2.6	9.6
Phosphate (mg/l)	.09	.33
Chloride (mg/l)	8.6	32

Increased concentrations of nitrate, phosphate, and chloride are sometimes indicative of pollution from sewage effluent or irrigation return flows. Just upstream from site 94 a canal, which heads at Wellsville Reservoir and extends through the eastern part of Wellsville, enters the river. Daily sewage and seasonal irrigation effluents are reported to drain to the canal.

Because of lack of a sampling site near the mouth of the Little Bear River, the effect of its inflow on the chemical quality of the Bear River is undetermined.

Logan River

At sites 95 and 98 on the lower reach of the Logan River the water was of the calcium magnesium bicarbonate type during both low and high flows, and the concentration of dissolved solids ranged from about 150 to 350 mg/l (fig. 2–*H*). The average concentration of dissolved solids at site 98 was about 100 mg/l higher than at the upstream site (site 95) for the observed range of discharges. The maximum increase of concentration of dissolved solids in the reach between sites 95 and 98 occurred during July 1968 when most of the water was being diverted upstream for irrigation.

Blacksmith Fork

The water at sites 96 and 97 on the Blacksmith Fork was generally of the calcium magnesium bicarbonate type during both low and high flows, and the concentrations of dissolved solids ranged from about 150 to 250 mg/l (fig. 2–*I*). No significant change of dissolved-solids content or chemical composition was observed in the stream between sites 96 and 97.

A potential damsite is being studied about 2 miles below site 96. The weighted-average concentration of dissolved solids at site 96 for the 1967 water year was about 200 mg/l. The water stored in a reservoir at this site would be of suitable chemical quality for most uses.

Big Malad River

At the headwaters of the Big Malad River, at site 105, the water was of the calcium magnesium bicarbonate type, and the concentration of dissolved solids was less than 400 mg/l. Big Malad Spring comprises the headwaters of the Big Malad River, and discharges ranging from about 3.5 to 8 cfs have been reported for the spring.

Pleasantview Springs flow into the Big Malad River 6 miles downstream from site 105. Mower and Nace (1957, p. 23) reported discharges of 6.7 and 8.7 cfs from the springs and concentrations of dissolved solids of 1,260 and 1,390 mg/l. Inflow of the springs causes a significant increase in the concentration of dissolved solids in the Big Malad River.

Little Malad River

The chemical composition of water at sites 107 and 108 on the upper reaches of the Little Malad River was similar during both low and high flows. The water was of either the calcium bicarbonate or the calcium magnesium bicarbonate type, and the concentration of dissolved solids ranged from about 260 to 325 mg/l. Downstream at site 110, the water was of different types at different times of the year; the calcium sodium bicarbonate type was the most prevalent, and the concentration of dissolved solids ranged from 270 to 630 mg/l. Still farther downstream, at site 111, the water was generally of the sodium or the calcium sulfate type, and the concentration of dissolved solids ranged from about 1,900 to 2,600 mg/l.

Return flows from St. John Canal may cause the significant change of chemical composition observed between sites 110 and 111. St. John Canal diverts water from the Little Malad River, a short distance downstream from site 108, and returns to the river just above site 111.

Malad River

Water at all sites on the Malad River was of the sodium chloride type during both low and high flows, and the concentrations of dissolved solids ranged from about 800 to 5,700 mg/l. The maximum concentration observed during concurrent sampling periods was at site 120 (fig. 4–*D*) near Plymouth, Utah.

The high concentrations of dissolved solids observed on the Malad River are attributed principally to the inflow of spring water that contains high concentrations of dissolved solids. Mower and Nace (1957, p. 23) reported a discharge of about 18 cfs and a dissolved solids content of 5,130 mg/l for Woodruff Springs, and Mundorff (1970, p. 32) reported discharges ranging from about 2 to 8 cfs and a dissolved-solids content of 7,850 mg/l for Uddy Hot Springs. The water from both Woodruff Springs and Uddy Hot Springs was of the sodium chloride type.

The combined inflow from Woodruff Springs and Uddy Hot Springs accounts for a large percentage of the discharge of the Malad River during low flow periods; low flows at sites 119 and 120 commonly ranged from 20 to 40 cfs. Other highly mineralized springs may also discharge beneath the water surface directly into the Malad River channel.

At site 123, near Bear River City, the water was of the sodium chloride type; the concentrations of dissolved solids ranged from about 1,700 to 2,600 mg/l. The decrease in concentration of dissolved solids, which occurred in the reach from site 120 near Plymouth, Utah, to site 123 during concurrent sampling periods (fig. 4–*D*), was probably due to less concentrated irrigation return flows and inflow of ground water. The lands bordering the Malad River below Plymouth are irrigated extensively with water diverted from Cutler Reservoir on the Bear River (fig. 1). The greatest decreases in concentration of dissolved solids in the reach between sites 120 and 123 occurred during September 1967 and July 1968, when considerable quantities of water were being diverted from Cutler Reservoir.

A potential damsite is being studied on the Malad River near site 120. The planned purpose is to provide supplemental water supplies to downstream bird refuges. The water stored in this reservoir would not be of suitable chemical quality for most other uses unless provisions were made to use water from other sources to dilute the water from the Malad River or possibly to divert the low flows past the reservoir. Figure 5 shows the percentage of time the concentrations of dissolved solids was equal to or less than the value indicated for years of below-average runoff (1960), above-average runoff (1962), and for the period of record (December 1938–July 1968). The graphs were based on discharges estimated from site 119 and the chemical quality data shown in figure 2–*J*. The graph for the period of record (December 1938–July 1968), indicates that the concentration of dissolved solids was less than 1,250 mg/l about 5 percent of the time. Although this is a small percentage of time, flows occurring during this time that exceeded 130 cfs accounted for approximately 30 percent of the mean annual runoff. Selective storage of the flows greater than 130 cfs would have resulted in an approximate weighted-average concentration of about 1,150 mg/l as compared to the concentration of 2,100 mg/l if equal percentages of all flows for the period December 1938–July 1968 had been stored.

The concentration of dissolved solids in water near the mouth of the Malad River was about 1,000 to 2,000 mg/l higher than that usually occurring in the Bear River upstream from the confluence of the two streams. Thus, inflow from the Malad River causes a considerable increase of concentration of dissolved solids in the Bear River.

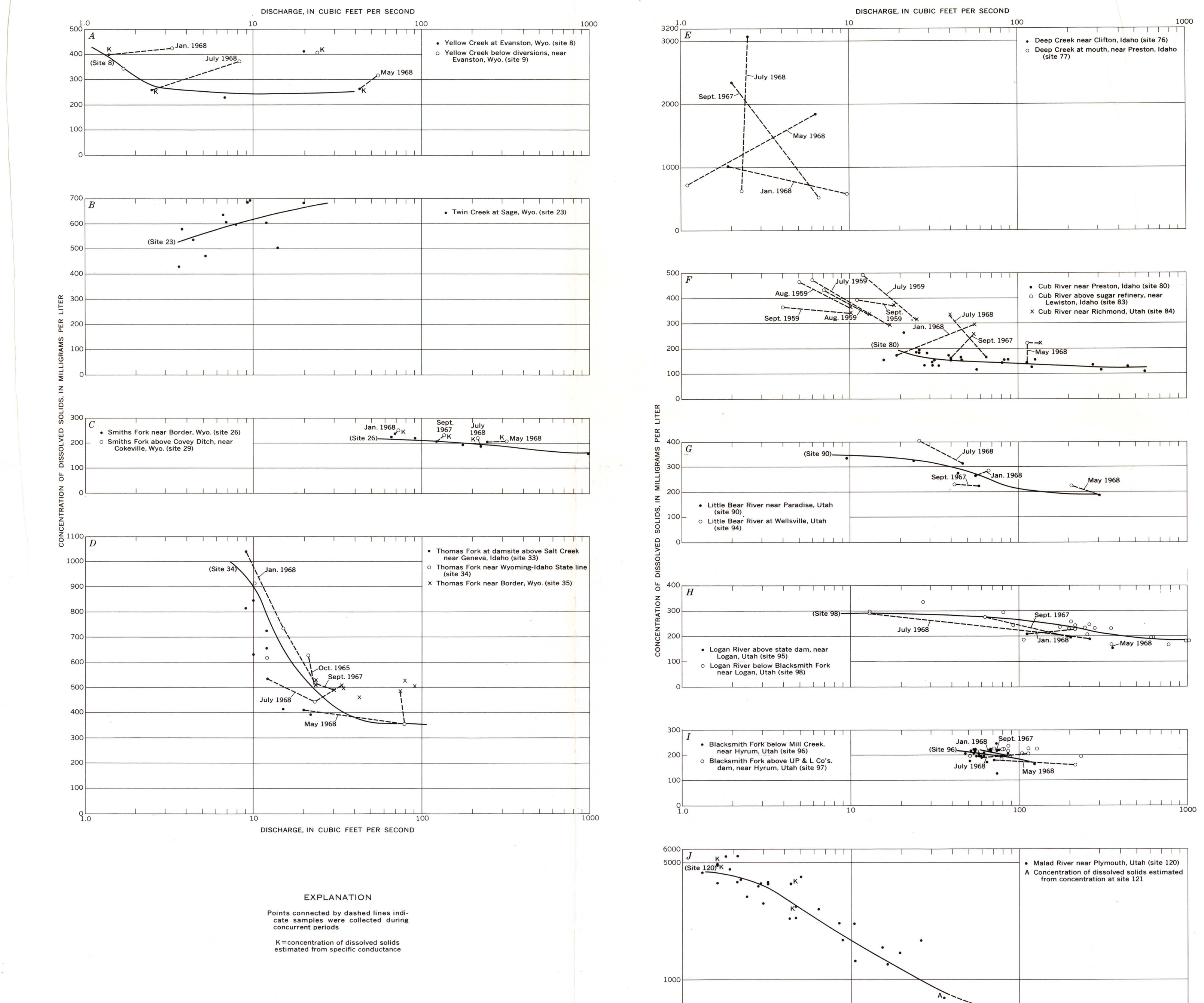
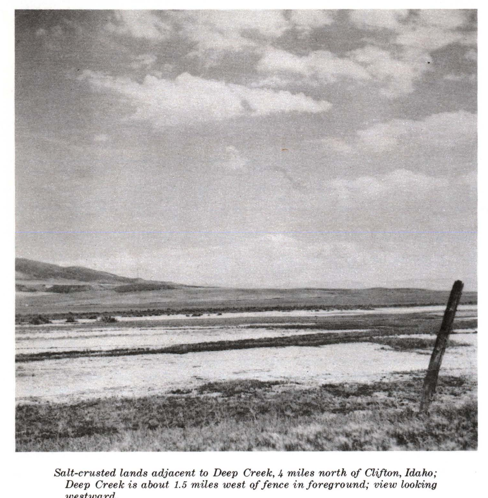


FIGURE 2.—*Relation of the concentration of dissolved solids to water discharge for selected tributaries in the Bear River basin.*

Marsh area with dense cattail growth across Deep Creek, 6 miles north of Clifton, Idaho, near Oxford Station; view looking eastward.



Salt-crusted lands adjacent to Deep Creek, 4 miles north of Clifton, Idaho; Deep Creek is about 1.5 miles west of fence in foreground; view looking westward.

FIGURE 3.—*Marsh area and salt-crusted lands along Deep Creek, north of Clifton, Idaho.*

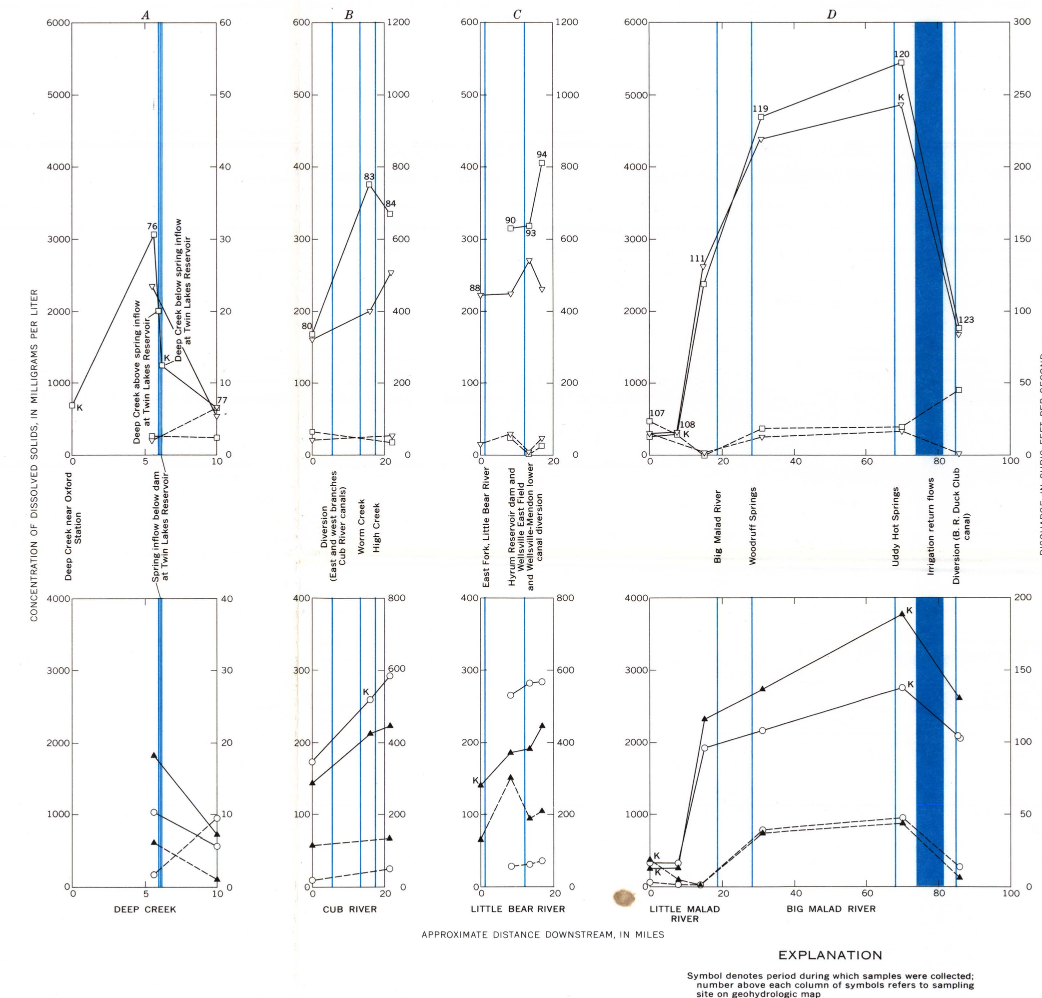


FIGURE 4.—*Concentration of dissolved solids in water and water discharges at sites on selected tributaries of the Bear River.*

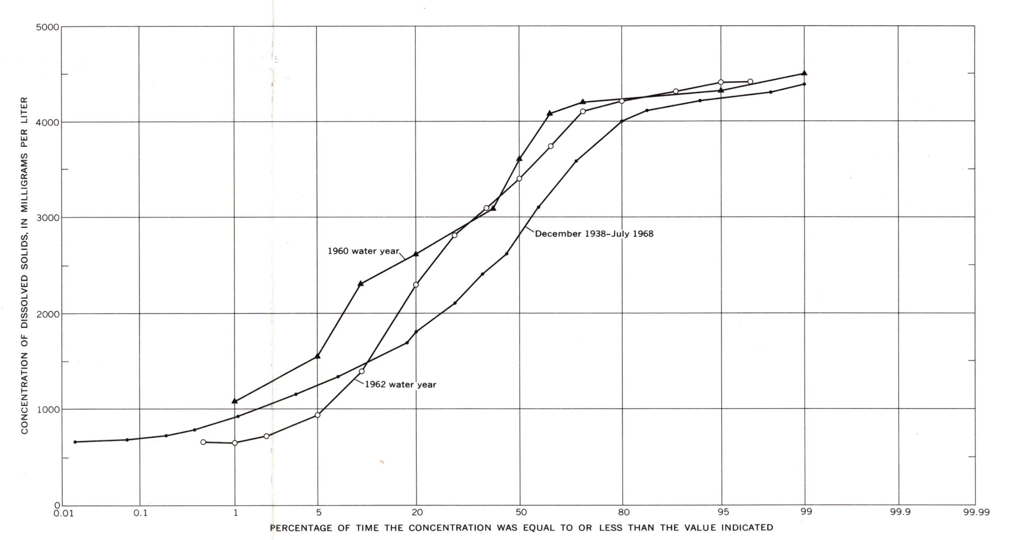


FIGURE 5.—*Duration curves of concentration of dissolved solids for the Malad River near Plymouth, Utah.*

QUALITY OF SURFACE WATER IN THE BEAR RIVER BASIN, UTAH, WYOMING, AND IDAHO

By
K. M. Waddell and Don Price
1972

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