BEAR LAKE

Manmade as well as natural factors have played an important role in evolving the present hydrology of Bear Lake, and a description of the history and physical characteristics of the lake are important for understanding the present chemical quality of the lake water. McConnell and others (1957, p. 5-6) state, "Bear Lake is an old lake. The lake basin was formed during the growth of the surrounding mountains; since that time, a lake has been present whenever the climate has been wet enough, but it has probably completely dried up during very dry periods.

"The present lake probably was in existence at least as long ago as the last glaciers when Lakes Bonneville and Lahonton filled much of the Great Basin. At that time Bear Lake filled the entire valley, which is about 50 miles long by 8 to 12 miles wide. The lake was deeper then and traces of the old shorelines still can be seen. The present lake occupies only the southern end of the valley. It is just less than 20 miles long and 4 to 8 miles wide. As the lake became smaller, a large marsh formed at its northern end. Wind and waves gradually built up a natural dike, or beach bar, separating the lake from the marsh. This beach bar now forms the northern shore of the lake.***

"When the lake filled the entire valley, the Bear River flowed into it. As the lake became smaller the lake and river separated and for a long time before man's interference the Bear River flowed into and out of the north end of the valley without entering Bear Lake. During that time, Bear Lake was dependent upon the flow of small streams on the local watershed. In the present climate about four-fifths of this flow is required merely to replace evaporation. During dry periods, evaporation probably exceeded the inflow; the lake became smaller than it is now with no water flowing out.

"Just after 1900 Telluride Power Company began construction of dams and canals to divert the Bear River into Bear Lake. In 1912 the Utah Power and Light Company succeeded the Telluride Company and completed construction of the present canal system. At present water from Bear River is diverted into Bear Lake when not needed downstream, and later is returned to the river by pumping it out of the lake when more water is needed downstream.***"

Figure 1 shows the annual accumulative net tributary inflow to Bear Lake during the period 1936-48. The curve indicates what the accumulative net gain or loss of water in Bear Lake would have been if water from the Bear River had not been diverted to the lake during this period. For example, the lake volume in October 1942 would have been about 100,000 acre-feet less than that in storage in February 1940. Prior to construction of the inlet canal and diversion of water from the Bear River to Bear Lake, several years of below normal precipitation (such as occurred during the period 1939-42) would have resulted in a significant decrease of stored water due to evaporation loss. Accompanying the decreased storage would be an increase of concentration of dissolved solids and possibly precipitation of calcium carbonate. Losses of calcium carbonate from solution would increase the magnesium to calcium ratio. McConnell and others (1957, p. 27) report that at an altitude of about 5,849 feet (above mean sea level), the bottom material of the lake is a fine, gray, silty marl that is 58 percent calcium carbonate. The composition of this marl may be due in part to precipitation of calcium carbonate from the lake water.

The chemical analyses in table 1 indicate that inflow from the Bear River has had a diluting effect on Bear Lake. The first analysis was made during 1912, when diversions from the Bear River to Bear Lake began. Since 1912, the concentrations of magnesium and total dissolved solids have decreased, whereas that of calcium has increased. Because of the large volume of Bear Lake (1,421,000 acre-feet), the chemical composition of the water probably has not reached equilibrium. The changing trend of chemical composition during the period 1912-68 may continue and approach that of the major source of inflow, the Bear River.

The concentration of dissolved solids in the Bear River upstream from Bear Lake during the reconnaissance period was about 50-100 mg/l less than that of the outflow from Bear Lake; consequently, inflow to the Bear River from the lake caused a slight increase in concentration of dissolved solids in the Bear River downstream from the lake.

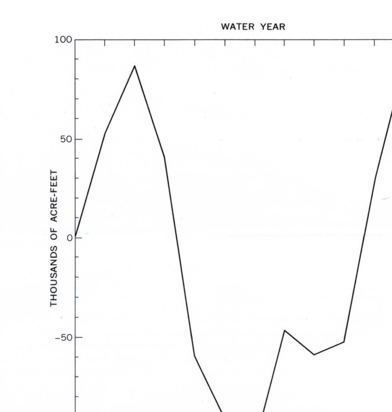


FIGURE 1.—*Annual accumulation of tributary inflow less evaporation loss in Bear Lake, exclusive of diversions to and from the Bear River, October 1, 1936-September 30, 1948. Revised from Iorns, 1959, fig. 3.*

TABLE 1.—*Chemical analyses of water from Bear Lake*
Source of data: U.S., Geological Survey; USU, Utah State University

Site No.	Date of collection	Depth (feet)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids (calculated)	Specific conductance (micromhos at 25°C)	Source of data
			Milligrams per liter										
(1)	8- 8-12	. . . . .	4.1	152	66	10	566	78	97	78	764	. . . .	Kemmerer and others (1923)
41	3- 8-52	Surface	17	87	46	11	370	16	71	53	483	. . . .	USU
42	3- 8-52	Surface	19	78	23	6	341	16	76	56	446	850	USU
43	3- 8-52	200	17	81	28	6	352	18	78	57	458	. . . .	USU
44	3- 8-52	Surface	17	87	47	11	381	13	75	54	491	. . . .	USU
48	7-23-68	Outflow	44	52	39	4.0	336	0	67	44	(2)415	722	GS

[1] Location and depth of sample collection unknown.
[2] Residue on evaporation at 180°C.

BEAR RIVER

At sampling sites above Cutler Reservoir, the concentrations of dissolved solids in Bear River water ranged from less than 100 to about 750 mg/l, and the water was generally of the calcium bicarbonate type or the magnesium bicarbonate type during both low and high flows. At sampling sites below Cutler Reservoir, the concentrations of dissolved solids ranged from about 250 to 4,000 mg/l, and the water was generally of the sodium chloride type during low flows and of the calcium bicarbonate type during high flows.

Bear River above Stewart Dam

Above Stewart Dam, north of Bear Lake, most of the total annual flow of the Bear River is contributed by the East, West, and Smiths Forks of the Bear River. Most of the time the concentrations of dissolved solids in water from these forks ranged from less than 100 to about 250 mg/l, and the water was of the calcium bicarbonate type for both low and high flows.

From site 3, below the confluence of the East and West Forks of the Bear River, to site 25, above the confluence with Smiths Fork, the dissolved-solids content of the Bear River generally increased downstream (fig. 2). Also, the relation of the concentration of dissolved solids to water discharge at sites 3, 21, and 25 indicated a significant increase downstream in the reach from sites 3 to 25 for the observed range of discharges (fig. 3). Inflow from Sulphur, Yellow, and Twin Creeks contributed to the increased concentrations in this reach whereas releases of less concentrated water from Woodruff Narrows Reservoir had a diluting effect.

Woodruff Narrows Reservoir, with a capacity of 28,000 acre-feet, began operation in January 1962, and its principal purpose is to provide a dependable supply of water for irrigation during periods of low flow. The chemical-quality data indicate that the lowest concentrations of dissolved solids in the outflow from the reservoir, at site 14, occurred during September 1967 and July 1968. This is due to the storage of high flows containing low concentrations of dissolved solids during the preceding months. The concentrations of dissolved solids in the outflow from the Woodruff Narrows Reservoir was appreciably lower than the concentration in water upstream from the reservoir during September 1967 and July 1968. Consequently, because of mixing of the inflow water with more dilute reservoir water, the reservoir provided better quality water for downstream use during low-flow periods than would have been available in the absence of the reservoir.

A significant increase in concentration of dissolved solids occurred in the reach between sites 14 and 21 during the September 1967 and July 1968 sampling periods (fig. 2). The increased concentrations are attributed to irrigation return flows from about 51,000 acres of irrigated lands along this reach. Most of the land is irrigated with water from the Bear River.

In the reach from site 25 to site 38, at Stewart Dam, inflow from Smiths Fork generally diluted the concentration of the dissolved solids in the Bear River, whereas inflow from Thomas Fork generally increased the concentration of dissolved solids.

The weighted-average concentration of dissolved solids at site 32 on the Bear River during the 1966 water year was 343 mg/l. The water is generally of the calcium bicarbonate type for both low and high flows. During the period October 1, 1965, to July 31, 1968, estimates based on daily specific conductance measurements indicated that the concentration of dissolved solids ranged from about 200 to 550 mg/l.

The minimum concentrations of dissolved solids in water at site 32 generally were during periods of high flows, and maximum concentrations were during periods of low flows (fig. 4). During the latter part of March and the first part of April 1967, however, higher concentrations were observed on a rising stage. This resulted from the flushing action of snowmelt runoff in the drainage area between sites 14 and 21 on the Bear River. During the period March 13-14, snowfall recorded at Sage and Border, Wyo., and Woodruff, Utah, ranged from 11 to 16 inches. The snowfall was followed by several warm days with maximum air temperatures ranging from 40° to 50°F (5° to 10°C). Streamflow records indicate that a large percentage of the increased discharge at site 32 during the latter part of March was being contributed from the drainage area between sites 14 and 21. The runoff from that reach apparently flushed residual salts that had accumulated on the bordering valley lands into the Bear River, resulting in a significant increase in the concentration of dissolved solids at site 32.

At Stewart Dam (site 38), essentially all the water is diverted from the Bear River to the Rainbow inlet canal. The water may be released from the canal for storage in Mud Lake, or released directly into the Bear Lake outlet canal. The water from Mud Lake reaches Bear Lake by a sluiceway at a pumping plant or by gates in a causeway at the south end of Mud Lake.

Bear River from Stewart Dam to Cutler Reservoir

In the reach from Stewart Dam to Cutler Reservoir, most of the total annual flow of the Bear River is contributed by releases from Bear Lake and from tributary inflows. The principal tributaries in this reach are Mink Creek, Cub, Little Bear, and Logan Rivers, and Blacksmith Fork.

During the 1967-68 reconnaissance, the average increase in concentration of dissolved solids from Stewart Dam (site 38) to near Smithfield (site 85) was about 100 mg/l; and the minimum and maximum increases were 80 and 130 mg/l, respectively. Also, for the 1967 water year, the weighted-average concentration of dissolved solids at site 85 was about 120 mg/l greater than that at Border, Wyo. (site 32), a few miles upstream from site 38 (table 2).

The concentrations of dissolved solids observed in water released from Bear Lake during the reconnaissance ranged from about 400 to 500 mg/l, and the water was of the magnesium bicarbonate type. The concentrations of dissolved solids of the larger tributaries ranged from about 100 to 500 mg/l, and the water was generally of the calcium bicarbonate type. Battle and Deep Creeks had concentrations of dissolved solids ranging from about 500 to 700 mg/l but because of their low discharges they did not have an appreciable effect on the chemical quality of the Bear River except during periods of extremely low flow.

From Stewart Dam (site 38) to the confluence with the Bear Lake outlet canal, most of the flow in the Bear River is maintained by leakage through the dam and ground-water inflow. Below the confluence with the Bear Lake outlet canal, the chemical composition of the Bear River depends to a large extent upon the amounts of water released from Bear Lake to Bear River by way of the outlet canal.

Preceding and during the September 1967 and January and July 1968 sampling periods, considerable quantities of water were released from Bear Lake (fig. 5). The water at most of the sampling sites in the reach from site 38 to site 85 during these sampling periods was predominantly of the magnesium bicarbonate type. Chemical analyses of water samples, collected monthly at site 85, indicate that calcium to magnesium ratios (in milliequivalents per liter) decreased during periods when water was released from Bear Lake. From June 1967 to January 1968, the calcium magnesium ratio decreased from 1.58 prior to when releases began at Bear Lake to ratios less than 1.00 during and immediately following the period of releases (fig. 5). The change of calcium magnesium ratio from values greater than 1.00 to less than 1.00 reflects a transition from a calcium to a magnesium type water, similar to that of outflow from Bear Lake. Ratios in Bear Lake outflow were 0.25 in September 1967 and 0.51 in July 1968.

During the May 1968 sampling period, outflow from Bear Lake was negligible and the effects on the chemical quality of the main stem from diversions, local tributary inflow, ground-water inflow, and releases from reservoirs were more apparent than during other sampling periods (fig. 2). The maximum net increase of concentration of dissolved solids in the reach from sites 38 to 85 was about 130 mg/l.

Due to the comparatively large quantities of water being released from Bear Lake during the September 1967 and July 1968 sampling periods, the effect of return flow of water diverted for irrigation on the chemical quality of the Bear River in the reach from Stewart Dam to Cutler Reservoir was not significant. However, chemical analyses of water from the Bear River during intermittent, monthly, and bimonthly sampling at sites 65 and 85 during the period 1958-68 indicate that the concentrations of dissolved solids tend to increase somewhat during the post-irrigation season. At site 65, below Oneida Reservoir, the concentration of dissolved solids ranged from about 230 to 540 mg/l; and at site 85, above Cutler Reservoir, the concentrations ranged from about 220 to 730 mg/l. Generally, at both sites the lower concentrations occurred during the spring and the higher concentrations occurred during the late summer and early fall. The seasonal occurrence of the higher concentrations at these sites may be due to residual effects that resulted from increased consumptive use during the irrigation season.

In Gem Valley, Idaho, the entire flow of the Bear River is diverted and delivered (by way of penstocks) to the Grace powerplant near site 60, about 6 miles downstream from the point of diversion. Streamflow in the intervening reach is maintained mostly by local ground-water inflow. During the 1967-68 reconnaissance, the concentrations of dissolved solids in the ground-water inflow ranged from about 400 to 500 mg/l and the gain in streamflow from the ground-water inflow ranged from about 40 to 75 cfs. During the irrigation season, water is diverted from the Bear River just upstream from the penstock diversion for irrigating lands in Gem Valley, and discharges in the 6-mile reach below the point of the penstock diversion reportedly are generally higher during and immediately following the irrigation season.

The chemical composition of water in the Turner Canal at site 59, of the Bear River at site 60, and of water from a well in Black Canyon that taps the basalt underlying the Bear River alluvium, was very similar to that of water released from Bear Lake. Both the surface and ground water were of the magnesium bicarbonate type, and the concentrations of dissolved solids were similar. Water applied for irrigation in Gem Valley apparently readily percolated down to and through the highly permeable basalts, raising the water table and subsequently increasing the discharge of the Bear River in Black Canyon during and immediately after the irrigation season.

Battle Creek Hot Springs and Vincent Hot Springs flow into the Bear River northwest of Preston, Idaho, and contribute considerable amounts of dissolved salts to the Bear River. Milligan and others (1966, table 1) reported a discharge of 2 cfs and dissolved-solids content of 9,010 mg/l for Battle Creek Hot Springs and 0.4 cfs and 13,190 mg/l for Vincent Hot Springs.

A damsite has been proposed on the Bear River about 6 miles below Oneida Reservoir (site 65). The water stored in a reservoir in this area should be of suitable chemical quality for most uses. During the period 1958-61, monthly and bimonthly samples were obtained at site 65. The concentrations of dissolved solids during this period and subsequent periods of miscellaneous sampling ranged from 232 to 537 mg/l. Water stored at the proposed site would probably have concentrations of dissolved solids within these extremes.

Bear River from Cutler Reservoir to Bear River Bay

From Cutler Reservoir to Bear River Bay, the chemical composition of the Bear River was affected mainly by streamflow regulation and inflows from ground water and tributaries. The concentration of dissolved solids and the water type varied, depending upon the quantity of water released from Cutler Reservoir to the Bear River.

During low flows, in the reach from Cutler Reservoir to Bear River Bay between sites 102 and 125, the concentration of dissolved solids ranged from about 750 to 4,000 mg/l; and the water was generally of the sodium chloride type. During high flows, the concentration of dissolved solids ranged from about 250 to 750 mg/l, and the water was generally of the calcium bicarbonate type.

At site 102, below Cutler Reservoir, the average concentration of dissolved solids was about 850 mg/l during low flows and 400 mg/l during high flows (fig. 3). The higher concentrations during low flows are due to inflow from Cutler Springs along the Bear River channel between Cutler Dam and site 102. Milligan and others (1966, table 1) reported a dissolved-solids content of 4,960 mg/l, and Mundorff (1970) reported about 2,000 mg/l for the springs. The total discharge and chemical quality of the springs are difficult to determine because part of the springs are submerged beneath the Bear River.

During the 1967-68 reconnaissance, the most significant increase in concentration of dissolved solids was observed in the reach from Bear River City to near Corinne (between sites 104 and 124) (fig. 2). The increase was due principally to inflow from Salt Creek and the Malad River. Inflows from the Malad River had concentrations of dissolved solids ranging from about 800 to 4,000 mg/l. The chemical composition of inflow from Salt Creek was not determined during the reconnaissance, but the concentrations of dissolved solids of Salt Creek are probably high relative to that of the Bear River because the creek is headed by Crystal (Madsens) Hot Springs. Mundorff (1970, table 1) reported concentrations of dissolved solids ranging from 38,500 to 45,500 mg/l and discharges ranging from about 1 to 4 cfs for the springs.

Although low flows below Cutler Reservoir contained high concentrations of dissolved solids, a large percentage of the total annual water discharge resulted from high discharges that occurred during a relatively small part of the time and contained comparatively low concentrations; thus the annual weighted-average concentrations are in the lower range. During the 1964 water year, the weighted-average concentration of dissolved solids at site 124 was 604 mg/l (table 2), even though concentrations of 600 mg/l were exceeded about 60 percent of the time during the water year (fig. 7). The highest flows and lowest concentrations of dissolved solids were during April, May, and June; whereas the highest concentrations and lowest discharges were during July, August, and September (fig. 6).

The damsite for the proposed Honeyville Reservoir on the Bear River is near site 103. Comparison of the chemical-quality data for sites 102, 103, and 124 indicates that during most years the weighted-average concentration of dissolved solids at site 103 would range from about 400 to 600 mg/l. Water stored in a reservoir upstream from site 103 thus should be of suitable inorganic chemical quality for most purposes. Selective storage of the high flows would result in lower concentrations of dissolved solids.

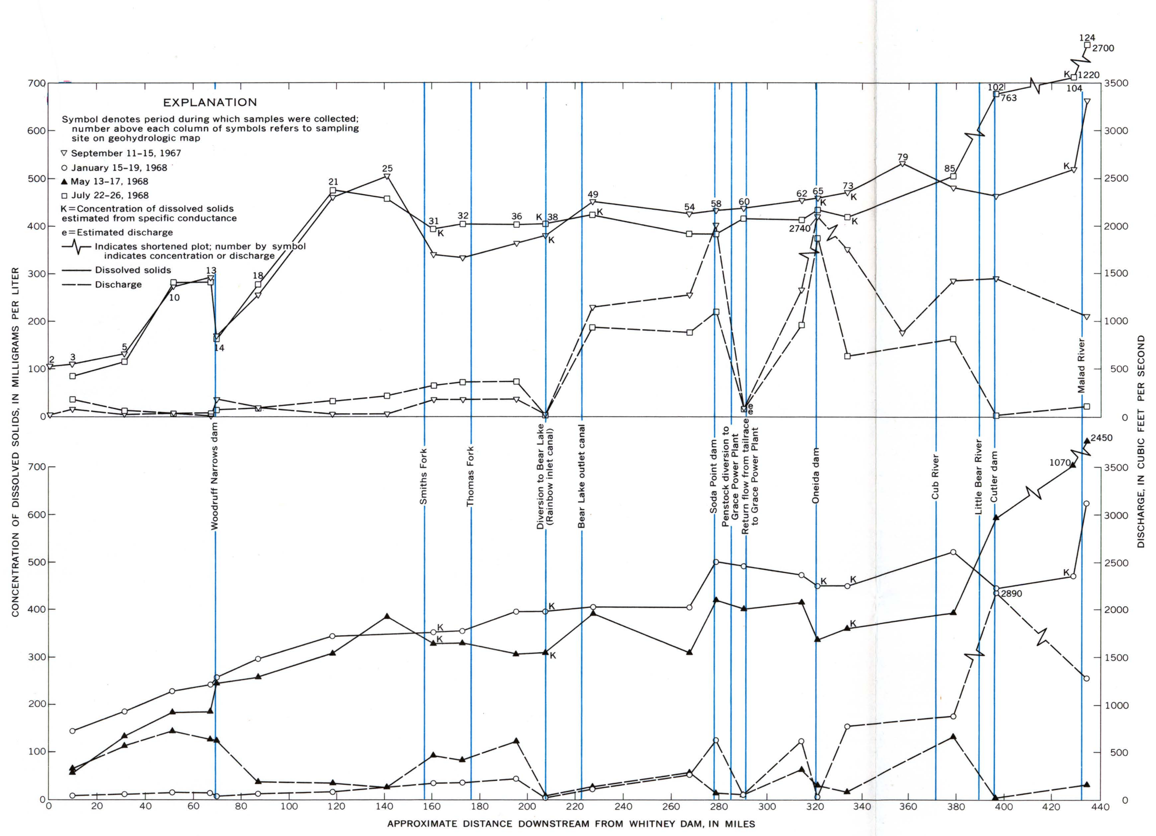


FIGURE 2.—*Concentrations of dissolved solids in water and water discharges at selected sampling sites on the Bear River, during September 1967 and January, May, and July, 1968.*

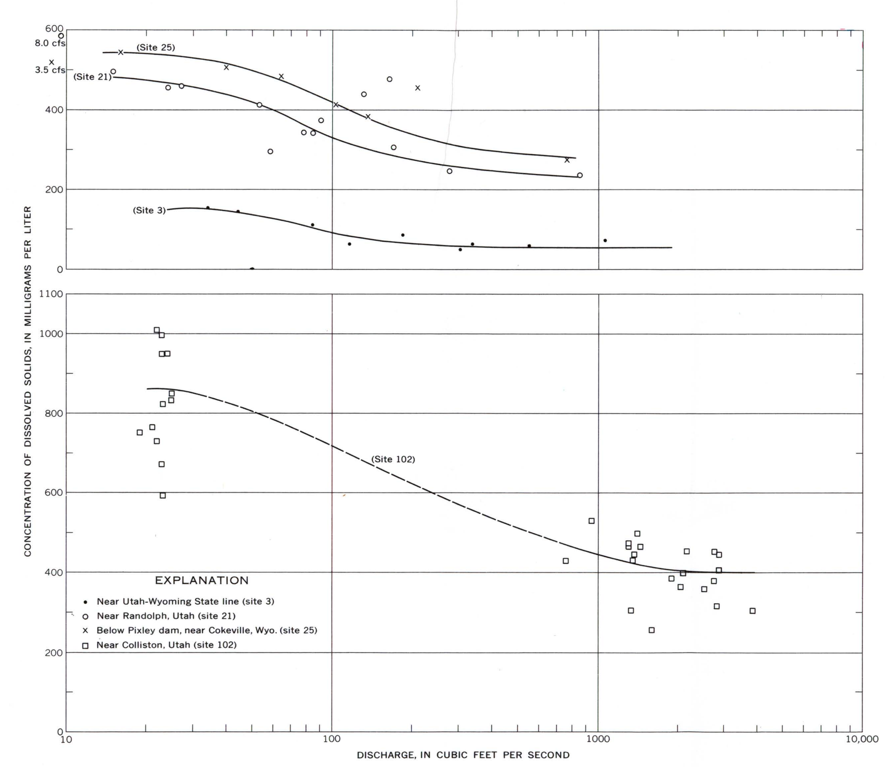


FIGURE 3.—*Relation of the concentration of dissolved solids to water discharge for selected sites on the Bear River.*

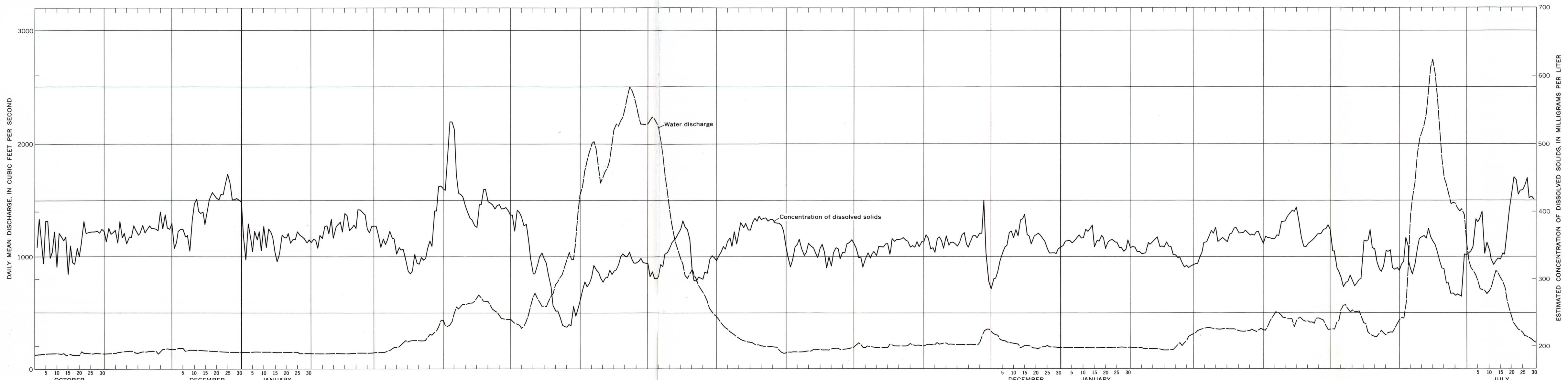


FIGURE 4.—*Daily mean water discharge and estimated concentration of dissolved solids for Bear River at Border, Wyo. (site 32), October 1, 1966 to July 31, 1968.*

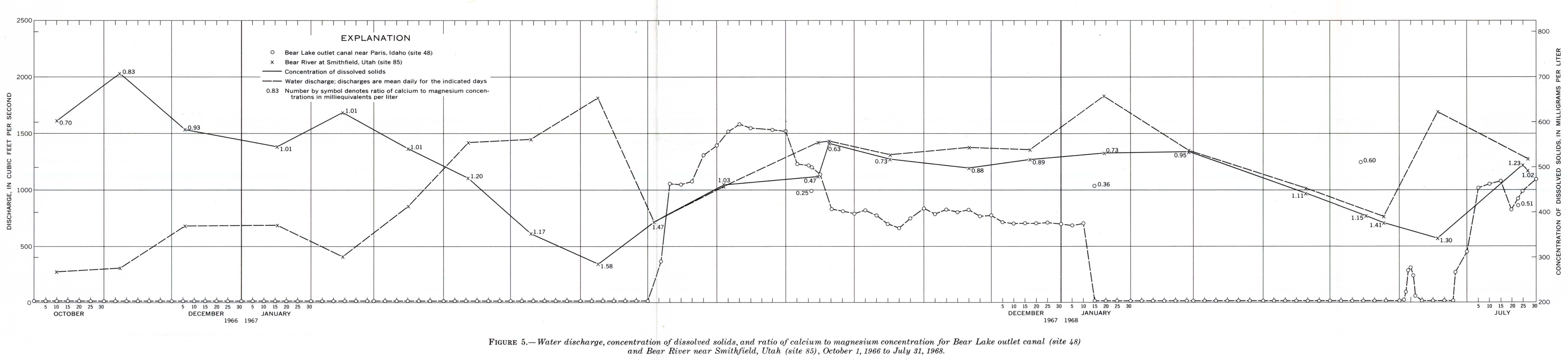


FIGURE 5.—*Water discharge, concentration of dissolved solids, and ratio of calcium to magnesium concentration for Bear Lake outlet canal (site 48) and Bear River near Smithfield, Utah (site 85), October 1, 1966 to July 31, 1968.*

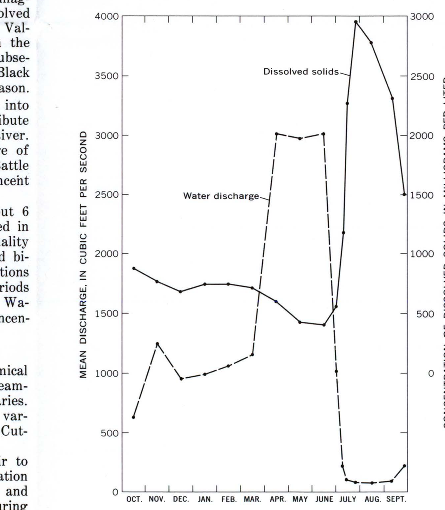


FIGURE 6.—*Monthly mean water discharge and concentration of dissolved solids for the Bear River at Corinne, Utah (site 124), 1964 water year.*

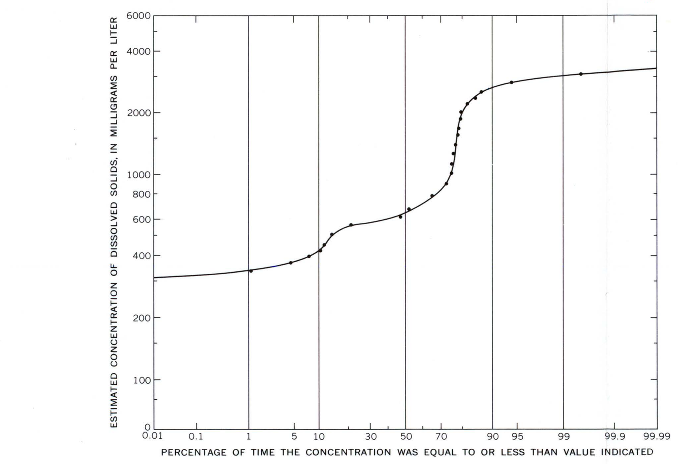
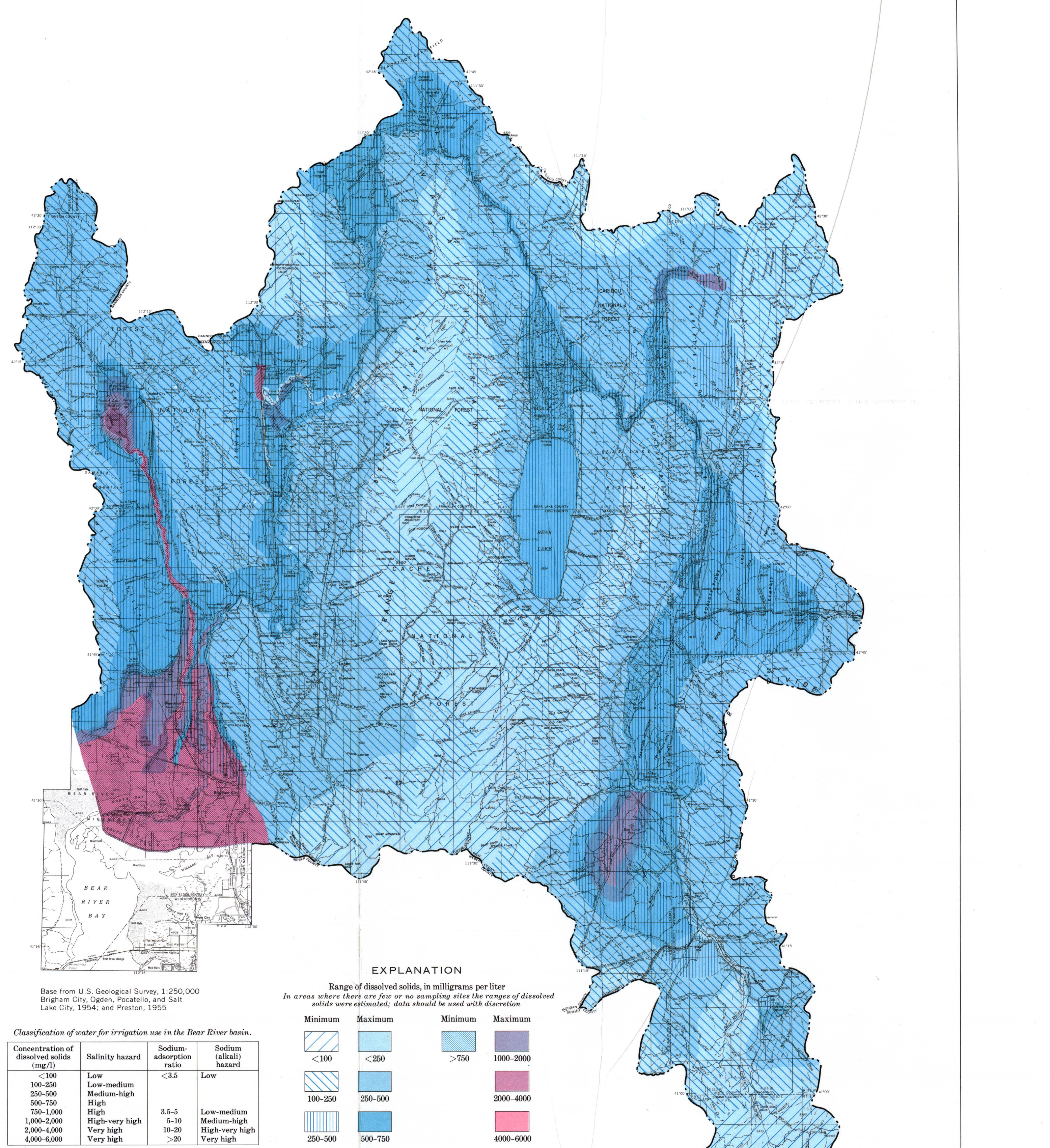


FIGURE 7.—*Duration curve of concentration of dissolved solids for the Bear River at Corinne, Utah (site 124), 1964 water year.*

TABLE 2.—*Weighted-average concentrations of chemical constituents and properties of water at sites in the Bear River basin*

Site No.	Name	Frequency of sampling	Water year	Discharge (acre-feet): Mean annual (through 1967 WY)	Discharge (acre-feet): Water year	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (Fl)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids: Milligrams per liter	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Sodium-adsorption ratio
						Milligrams per liter														(residue at 180°C)			
32	Bear River at Border, Wyo.	Daily	1966	. . . . . .	311,200	9.4	53	25	26	2.4	236	. . .	55	25	0.3	0.5	0.09	232	37	343	0.46	399	0.7
85	Bear River near Smithfield, Utah	Monthly	1967	. . . . . .	740,000	. . .	64	36	56	9.3	329	1	64	71	. . .	. . .	. . .	308	37	459	.62	1,260	1.4
96	Blacksmith Fork below Mill Creek, near Hyrum, Utah	do	1967	. . . . . .	46,700	. . .	48	18	4.5	.8	215	1	17	5.6	. . .	. . .	. . .	194	16	196	.27	35	.1
120	Malad River near Plymouth, Utah[1]	. . . . . .	1960	. . . . . .	29,560	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,940	4.00	323	. . . .
			1962	. . . . . .	59,480	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1,780	2.42	394	. . . .
			1937-68	47,600	. . . . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,100	2.86	. . .	. . . .
124	Bear River near Corinne, Utah	Daily	1964	1,174,000	936,100	. . .	. . .	. . .	122	. . .	324	. . .	53	168	. . .	. . .	. . .	289	23	604	.82	2,100	3.0
125	Bear River at Bear River Bay Bird	do	1960	. . . . . .	448,100	16	65	39	180	. . .	346	. . .	62	257	. . .	2.8	. . .	322	39	792	1.08	1,870	4.4
	Refuge, near Brigham City, Utah	do	1961	. . . . . .	635,210	15	68	42	217	17	366	. . .	67	327	. . .	3.1	. . .	342	42	933	1.27	1,560	5.1

[1] Dissolved solids estimated from monthly and miscellaneous samples collected 4-14-64 to 7-27-68; discharge estimated from Malad River at Woodruff.



Classification of water for irrigation use in the Bear River basin.

Concentration of dissolved solids (mg/l)	Salinity hazard	Sodium-adsorption ratio	Sodium (alkali) hazard
<100	Low	<3.5	Low
100-250	Low-medium		
250-500	Medium-high		
500-750	High		
750-1,000	High	3.5-5	Low-medium
1,000-2,000	High-very high	5-10	Medium-high
2,000-4,000	Very high	10-20	High-very high
4,000-6,000	Very high	>20	Very high

The column for sodium-adsorption ratio was derived from a plot of the concentration of dissolved solids versus sodium-adsorption ratio for all available sites in the basin.

MAP SHOWING APPROXIMATE RANGES OF CONCENTRATIONS OF DISSOLVED SOLIDS IN SURFACE WATER

TABLE 3.—*Ranges of concentrations of dissolved solids, hardness, and alkalinity and of pH for selected sites in the Bear River basin.*

Site No.	Name	Dissolved solids Min.	Dissolved solids Max.	Hardness as $CaCO_3$ Min.	Hardness as $CaCO_3$ Max.	Alkalinity as $CaCO_3$ Min.	Alkalinity as $CaCO_3$ Max.	pH Min.	pH Max.
		Milligrams per liter							
32	Bear River: at Border, Wyo.	262	538	188	330	156	280	7.5	8.5
85	near Smithfield, Utah	224	727	145	383	136	356	7.5	8.7
124	near Corinne, Utah	356	2,960	215	420	202	341	7.4	8.3
8	Yellow Creek: near Evanston, Wyo.	230	414	194	318	183	372	7.8	8.3
9	below diversions, near Evanston	317	426	240	335	223	317	7.8	8.1
23	Twin Creek at Sage, Wyo.	430	694	272	440	143	253	7.6	8.5
26	Smiths Fork near Border, Wyo.	160	237	154	208	133	157	7.4	8.2
33	Thomas Fork: at damsite above Salt Creek, near Geneva, Idaho	394	1,040	195	286	136	264	8.1	8.3
35	near Border, Wyo.	460	526	258	298	205	246	7.5	8.0
76	Deep Creek: near Clifton, Idaho	705	3,070	304	785	215	354	7.7	8.0
77	at mouth, near Preston, Idaho	526	733	262	330	243	315	7.7	8.3
80	Cub River: near Preston, Idaho	111	263	116	227	112	216	7.4	8.6
84	near Richmond, Utah	222	370	179	265	179	265	7.5	7.9
90	Little Bear River: near Paradise, Utah	187	332	157	288	151	276	7.5	8.1
94	at Wellsville, Utah	221	406	158	336	151	305	7.6	8.1
95	Logan River: above State dam, near Logan, Utah	155	210	148	224	149	207	7.4	8.1
98	below Blacksmith Fork, near Logan, Utah	164	336	151	294	137	274	7.5	8.5
96	Blacksmith Fork: below Mill Creek, near Hyrum, Utah	127	243	133	229	121	212	7.6	8.6
97	above Utah Power and Light Co's dam, near Hyrum, Utah	160	236	147	222	144	211	7.4	8.3
119	Malad River: at Woodruff, Utah	2,160	4,690	396	635	170	428	7.7	8.5
123	below Bear River Duck Club Canal, near Bear River city, Utah	1,690	2,630	264	550	287	415	7.6	9.0

SUITABILITY FOR USE

IRRIGATION

Water from streams in the Bear River basin is used extensively for irrigation (fig. 1 on sheet 1 of 2). In most of the basin, precipitation must be supplemented to provide sufficient water for efficient crop production. The suitability for irrigation use, as considered in this report, is based on a method developed by the U.S. Salinity Laboratory Staff (1954, p. 75-82). The method utilizes the sodium-adsorption ration as an index of the sodium (alkali) hazard and the specific conductance as an index of the salinity hazard. The concentration of dissolved solids is generally proportional to the specific conductance. Therefore, the concentration of dissolved solids was used in this report as an index of the salinity hazard.

The suitability of surface water for irrigation in the Bear River basin can be evaluated from the map showing dissolved solids in surface water. For example, the concentrations of dissolved solids along the reach of the Malad River between Cherry Creek and Bear River City ranged from 750 to 6,000 mg/l. The tabulation on the map indicates that the sodium-adsorption ratios ranged from 3.5 to greater than 20 for the associated range of concentration of dissolved solids. Thus, the salinity hazard ranged from high to very high, and the sodium (alkali) hazard ranged from low to very high. The minimum concentrations of dissolved solids and sodium-adsorption ratios are generally applicable during periods of high flow for each stream in the basin, and the maximum concentrations and ratios are applicable during periods of low flow.

Most of the streams in the Bear River basin had low- to medium-salinity hazards and low-sodium hazards during periods of both low and high flows. However, in reaches of Saleratus Creek, Thomas Fork, Deep Creek, Big Malad River, Little Malad River, Malad River, and Bear River below Cutler Reservoir, the water generally had high to very high sodium hazards during periods of low flow.

Chemical analyses of samples obtained at sites on some of the major canals generally indicated only a slight change of chemical composition of water between the points of diversion and downstream sampling sites on the canals.

DOMESTIC AND PUBLIC SUPPLY

The concentrations of individual dissolved constituents generally were less than the maximum levels for drinking water recommended by the U.S. Public Health Service (1962) in reaches of the streams in the Bear River basin which have maximum concentrations of dissolved solids less than 500 mg/l. However, the concentrations of dissolved solids and one or more other constituents exceeded the recommended limits for drinking water much of the time in water from reaches of Saleratus Creek, Twin Creek, Thomas Fork, Battle Creek, Deep Creek, Big Malad, Little Malad, and Malad Rivers, and the Bear River below Cutler Reservoir.

Water from most of the streams in the basin contained more than 180 mg/l of hardness as calcium carbonate ($CaCO_3$) and is classed as very hard by the U.S. Geological Survey.

INDUSTRIAL USE

Most of the surface-water supplies in the Bear River basin would be suitable for most industrial purposes if the water were treated for excessive hardness and alkalinity. The ranges of concentrations of dissolved solids, hardness, and alkalinity and of pH for selected sites in the Bear River basin are listed in table 3, and some of the suggested water-quality tolerances for industrial use are listed in table 4 (New England Water Works Assoc., 1940).

TABLE 4.—*Suggested water-quality tolerances for industrial uses.*

Industry or use	Dissolved solids	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	pH
	Concentration, in milligrams per liter			
Boiler feed				
Pressure 0-150 psi	3,000-500	80	. . . . . .	8.0 (minimum)
Pressure 150-250 psi	2,500-500	40	. . . . . .	8.4 (minimum)
Pressure 250-400 psi	1,500-100	10	. . . . . .	9.0 (minimum)
Pressure > 400 psi	50	2	. . . . . .	9.6 (minimum)
Brewing and distilling				
Light beer, gin	500	. . . . . .	75	6.5-7.0
Dark beer, whiskey	1,000	. . . . . .	150	7.0 (minimum)
Canning				
Legumes	. . . .	25-75	. . . . . .	. . . .
Carbonated beverages	850	250	50-100	. . . .

SUSPENDED SEDIMENT

Suspended-sediment data were collected concurrently at several sites in the Bear River basin during a period of high discharge in June 1965 and again during the reconnaissance in May 1968. In addition, during the period 1959-65, more extensive data were collected intermittently at a few sites by the U.S. Bureau of Reclamation. The sediment data collected in 1965 and 1968 are probably representative of high-water discharges resulting from snowmelt, and they are inadequate to make generalized predictions regarding concentrations or discharges of sediment in the basin or parts thereof.

During June 1965, the concentrations of suspended sediment generally increased downstream (fig. 8). Although the maximum water discharge was at site 32, the sediment concentration of about 35 mg/l at that site was comparatively low. The low concentration was probably due to deposition of sediments upstream in Woodruff Narrows Reservoir.

During May 1968, the concentration of sediment increased from about 15 mg/l in the headwaters (site 3) to about 135 mg/l just above Woodruff Narrows Reservoir (site 13). Below the reservoir (site 14), the concentration decreased to about 40 mg/l due to retention of upstream flow and deposition of sediment. The diversion and retention of upstream flow at Bear Lake resulted in a decreased concentration downstream at Soda Springs, Idaho (site 54). Downstream from Soda Springs the concentrations of sediment generally increased, reaching a maximum of about 105 mg/l near Smithfield (site 85) in the lower reach of the basin.

During June 1965 and May 1968, assuming that sediment concentrations in water released from Oneida Reservoir were about the same as the observed concentrations immediately below the reservoirs and diversion structures upstream, comparatively large quantities of sediment were being contributed to the Bear River in the reach from Oneida Dam to near Smithfield, Utah. Battle Creek, which enters in this reach, had a sediment concentration of 4,010 mg/l at a water discharge of 0.74 cfs. The comparatively high concentrations may be indicative of sediment yields in the drainage area of Battle Creek and the source of increased concentrations of sediment in the reach of the Bear River below Oneida Reservoir.

Figure 9 shows the relation of concentration of suspended sediment to water discharge for sites 85, 102, and 103 on the Bear River. At site 85, near Smithfield, Utah, the concentrations of sediment increased with water discharge. The concentration of sediment at site 102 near Collinston and site 103 near Honeyville below Cutler Reservoir did not change significantly with changing discharge and was generally at least 100 mg/l less than that at site 85. If the observed relation of concentration of sediment to water discharge at site 102 was representative of average water years, the suspended-sediment discharge during the 1967 water year would have been about 218,000 tons.

The suspended sediment in the Bear River at site 102 has lower percentages of coarse-grained particles than that in the Bear River at site 85. The lower percentages are due to deposition of the coarse-grained sediments in Cutler Reservoir.

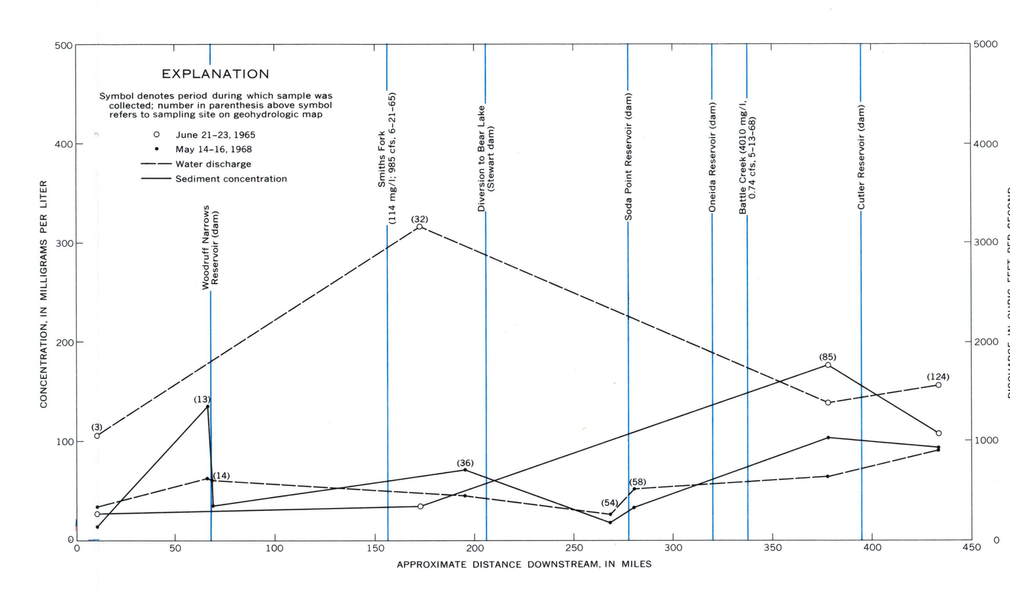


FIGURE 8.—*Concentrations of suspended sediment and water discharge at sites on the Bear River, June 21-23, 1965, and May 14-16, 1968.*

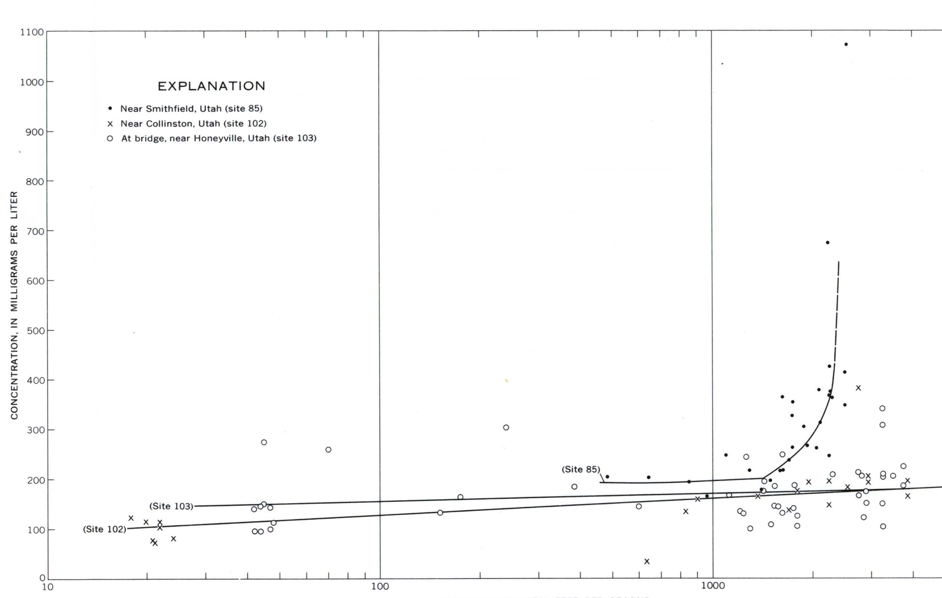


FIGURE 9.—*Relation of the concentration of suspended sediment to water discharge for sites on the Bear River.*

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