UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey

REPORT ON WATER-UTILIZATION POSSIBILITIES IN THE UPPER BRUNEAU RIVER BASIN, IDAHO-NEVADA

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by

F. A. Johnson

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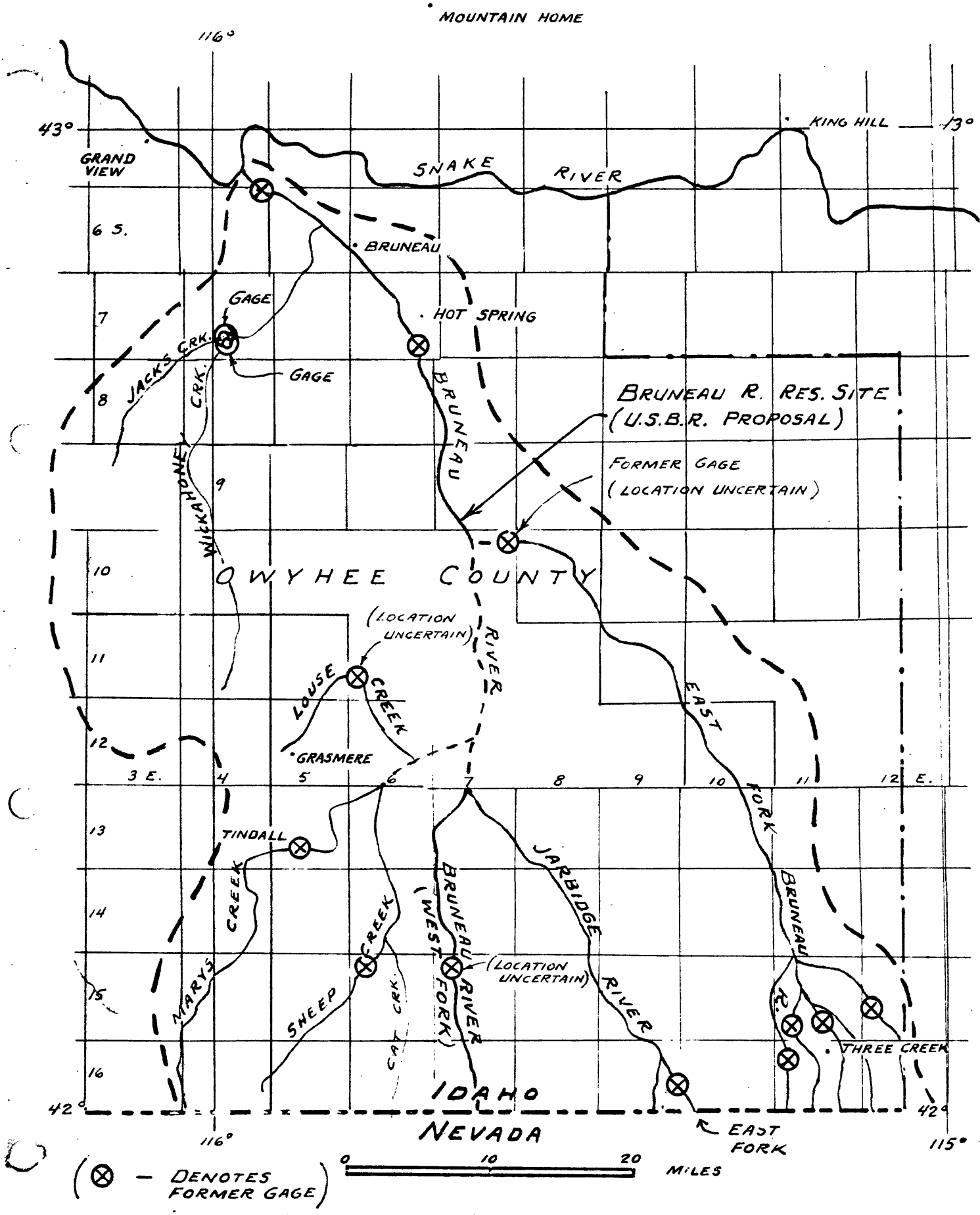
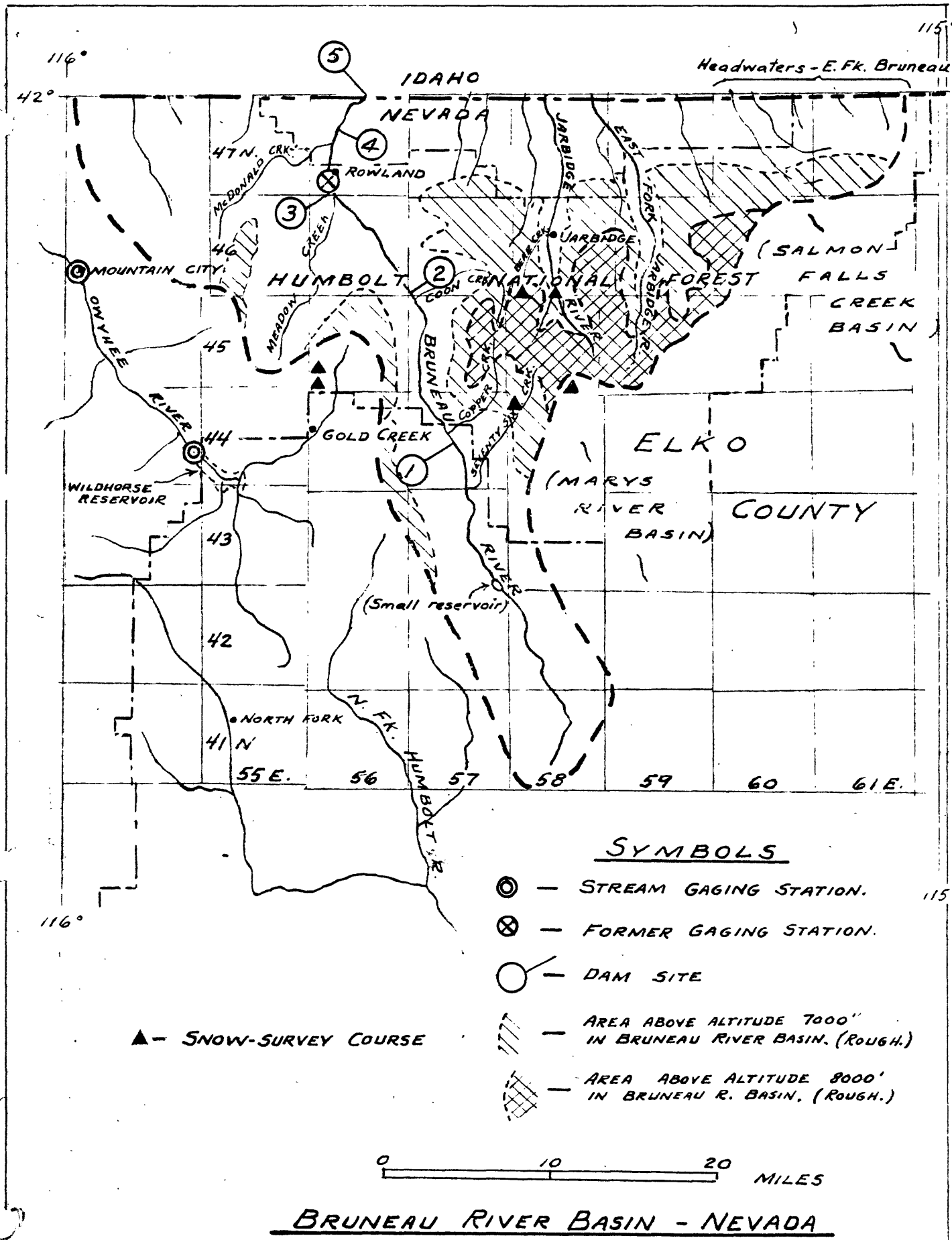
(Prepared for land classification purposes, 1947)

NOTE: PAGE 46 (Summary) IS NOT AVAILABLE



BRUNEAU RIVER BASIN - IDAHO



SYMBOLS

- ◎ — STREAM GAGING STATION.
- ⊗ — FORMER GAGING STATION.
- ○ — DAM SITE
- ▨ — AREA ABOVE ALTITUDE 7000' IN BRUNEAU RIVER BASIN. (ROUGH.)
- ▨ — AREA ABOVE ALTITUDE 8000' IN BRUNEAU R. BASIN. (ROUGH.)
- ▲ — SNOW-SURVEY COURSE

0 10 20 MILES

BRUNEAU RIVER BASIN - NEVADA

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REPORT ON WATER-UTILIZATION POSSIBILITIES IN THE UPPER BRUNEAU RIVER BASIN, IDAHO-NEVADA

INTRODUCTION

Purpose and Scope of Report.

This report is intended primarily to list results of a field examination in the Bruneau River Basin made by the writer September, 1947; to describe general characteristics of the upper part of the basin; and to give some estimates of the water-supply. The storage and power possibilities are roughly indicated on basis of available data. The report may serve as a guide to possible future investigations or surveys; and as a partial basis for classifications of public lands, or review of such classifications.

The scope of this investigation was limited to a study of the upper part of the Bruneau River basin, largely in Nevada. About six days were spent in the field in a search for possible reservoir sites, and to make miscellaneous discharge measurements. The Bruneau River and its tributary Jarbidge River were viewed for a considerable part of their courses in Nevada; and the Bruneau River Canyon was viewed at several points in Idaho as far downstream as the mouth of the Jarbidge River. The Jarbidge River was traversed from Bonanza Gulch downstream to the mouth of the East Fork in Idaho.

These field examinations, some water-supply records published by the Geological Survey, precipitation and snow-survey records, and some quadrangle maps published from 1940 to 1945 provide the basis for

a rough appraisal of water-utilization possibilities. The relative lack of information about the upper Bruneau River had been pointed out by the Nevada State Engineer, Alfred Merritt Smith. The investigation was authorized by the Chief of the Water and Power Division by letter dated July 10, 1947.

Previous Investigations and Reports.

It appears from advise of the State Engineer's office that no systematic investigation has been made of water-utilization possibilities in the Nevada part of the basin. The amount of land under irrigation along the Bruneau River in Nevada was listed in Water-Supply Paper 657, "Water Utilization in the Snake River Basin" by W. G. Hoyt, 1935. In this publication it was also noted that possibilities for diversion of water from the East Fork Jarbidge River to the Salmon Falls Creek basin were investigated by the Salmon River Canal Company. Gaging stations have been operated at various times in the Bruneau River basin, and some of these in Idaho were installed in connection with irrigation proposals. It is possible that other data regarding water-utilization possibilities were obtained in the course of these investigations.

In the Department of the Interior Report on the Columbia Basin, 1946, the Bureau of Reclamation proposes a dam on the Bruneau River below East Fork to provide storage capacity of 350,000 acre-feet for irrigation of lands to the west.

Maps, Surveys and Aerial Photographs.

The following quadrangle maps prepared by the Geological Survey are available for areas within the Bruneau River basin: Jarbidge, Mountain City, Rowland, (all Nevada-Idaho) and Mt. Velma, Nevada; all 15-

minute series, scale 1:62,500, and contour interval 50 feet. Northern boundary of the Nevada-Idaho group is practically at the State Line. A 7½-minute series, scale 1:24,000, and contour interval 25 feet now under preparation will cover all of the lower part of the basin in Idaho north of latitude 42° 30'. A map of the Humbolt National Forest prepared by the Forest Service shows the part of the basin in Nevada.

Aerial photographs are available for the area covered by Jarbidge quadrangle, latitude 41° 45' to 42° 00', longitude 115° 15' to 115° 30'.

GEOGRAPHY

General Description.

The Bruneau River, tributary to the Snake River near Mountain Home, Idaho, drains roughly 2300 square miles of arid plateau in southern Idaho and about 600 square miles of mountainous country in northern Nevada. The basin in Nevada is largely within the Humbolt National Forest, which, however, consists mainly of grassland with only sparse growth of trees. Headwaters of four main branches - the Bruneau, Jarbidge, East Fork Jarbidge and East Fork Bruneau Rivers are in Nevada. This headwaters area is between the Owyhee River basin to the west, and the Salmon Falls Creek basin to the east.

Main Stem of the Bruneau River in Nevada.

The main stem of the Bruneau River, (designated as West Fork Bruneau on Idaho maps) originates about 50 miles south of the State Line, and the course of the stream is somewhat west of north. Range of altitude of the portion of the channel in Nevada shown on the quadrangle maps is from about 6,000 to 4,750 feet, in the reach 30 miles south

of the State Line. Much of the area tributary to the main stem of the Bruneau River in Nevada is above 6,000 feet altitude. The most rugged part of this area is about 15 miles south of the State Line, - the Copper Mountains on the eastern side of the stream which have a maximum altitude of about 10,000 feet. In this general area there are scattered groves of deciduous trees on grass-covered slopes, and a scanty growth of coniferous trees on the highest ridges. Appearance of the country indicates that the precipitation and run-off probably are heavier than in areas upstream, where vegetation is largely sagebrush and grass, and slopes are gentle.

Main tributaries from the east are Willow Creek, Copper Creek and Coon Creek, joining the main stem at altitudes of about 6,025, 5,900 and 5,400 feet respectively. Main tributaries from the west are Dolly and Annie Creeks at about 6,000 foot altitude on the main stem; and Meadow Creek and McDonald Creek with mouths at altitudes roughly 5,000 feet. Of these tributaries, Coon, Copper and Meadow Creeks probably are the most productive in run-off per square mile.

Average drop of the Bruneau River for 30 miles of channel south of the State Line is about 40 feet per mile, and is less for six miles further upstream to the edge of the mapped area; Mt. Velma quadrangle.

Drainage area of the Bruneau River at mouth of McDonald Creek 4 miles upstream from the State Line is estimated as 394 square miles, of which 313 square miles are shown on the standard topographic maps.

<u>The Jarbidge River and East Fork in Nevada.</u>

The Jarbidge River, tributary to the Bruneau River, and the

Bruneau River, Nevada. View from road at point upstream from Deer Creek, looking down river. (See Mt. Velma and Rowland quadrangle maps.)

Bruneau River, Nevada. View from road at point upstream from Cottonwood Creek looking down river. Bend in distance is at Palacio Ranch, shown on Rowland quadrangle map. "Twin Buttes" are in center background below skyline.

East Fork Jarbidge River flow in nearly parallel courses north to the State Line, and are separated only a few miles for most of their courses. Both streams head in rugged mountains at altitudes generally of about 9,000 feet some 15 miles south of the State Line; and drop to altitudes of about 5,250 feet in Nevada. They both have a number of small tributaries also originating at about 9,000 feet altitude, and which form fan-shaped patterns with the main stems. Topography of both basins, as shown on Jarbidge quadrangle, is very similar. The highest ridges extend up to altitudes of more than 10,500 feet; and about a quarter of the drainage area in Nevada is above 8,000 feet altitude. Vegetation is heavier than in the Bruneau River area and slopes are much steeper. General appearance of the Jarbidge River basin indicates that precipitation and run-off probably are relatively large; this is confirmed by available snow survey and run-off records.

Average channel slopes of both the Jarbidge and East Fork in Nevada are uniformly about 110 feet per mile for 10 miles upstream from the State Line, and are steeper further upstream.

Area tributary to the Jarbidge River at mouth of the East Fork Jarbidge River is estimated as about 200 square miles, - this includes 168 square miles shown on the standard topographic maps, Jarbidge and Rowland quadrangles, and 32 square miles estimated for the portion in Idaho. A small portion of the East Fork basin east of the Jarbidge quadrangle was assumed to be negligible.

The East Fork of the Bruneau River in Nevada.

The East Fork of the Bruneau River originates in several small

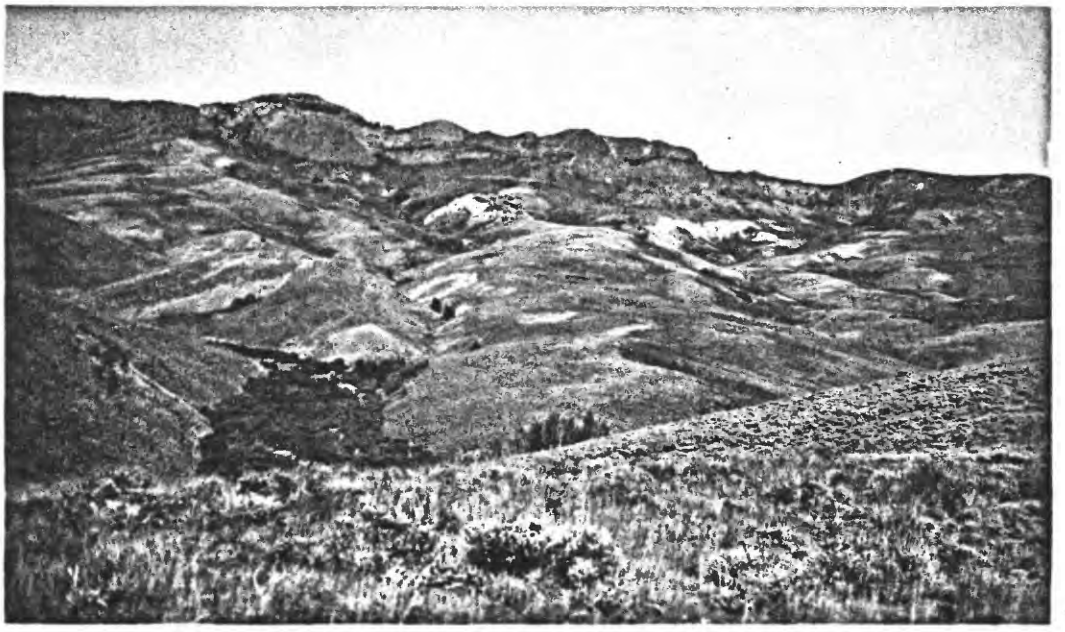
tributaries heading a few miles south of the State Line and east of the Jarbidge River basin in townships 47 N., R. 59, 60, 61 E., Nevada. Aggregate drainage area in Nevada is perhaps about 75 square miles. These streams were not viewed during course of this investigation. Judging from short-time streamflow records of the East Fork Bruneau River and several of its tributaries near Three Creek, Idaho, run-off in this area is relatively small, and much smaller than in the Jarbidge River basin.

AGRICULTURE AND MINING

Stock raising is the principle activity in much of the upper Bruneau River basin. There is extensive grazing under supervision of the Forest Service in the National Forest, and unsupervized grazing on range land outside the Forest area. Hay is raised under irrigation on practically all meadows along the main stem of the Bruneau River, and along several of the tributaries of the Bruneau and Jarbidge Rivers; and where diversion from tributaries is practicable even on some benches on hillsides high above the river in canyon sections.

5,000 acres were irrigated in Nevada along the Bruneau River and tributaries according to classification by the Geological Survey, 1929 (See WSP 657). Most of this was along the main channel of the Bruneau River. It seems possible that this acreage may be larger in 1947 because of the probable increase in stock raising in war and post-war years. All irrigation observed by the writer in 1947 was for hay meadows, most of which are immediately adjacent to the streams.

Brumeau River Basin, Nevada. View is from point on road about sec. 36, T. 47 N., R. 56 E., looking southwest across Rattlesnake Canyon.



Brumeau River Basin, Nevada. View is from point about a mile southwest of the confluence of Copper and Dead Horse Creeks, looking northeast up Copper Creek. (See Jarbidge quadrangle map.) The dense growth of willows along creek is in ponds resulting from beaver dams.

In previous years, there was considerable mining in the upper Bruneau River basin, particularly in the Jarbidge River area near the town of Jarbidge, and along the Bruneau River near Rowland. Evidently there were very few mines being operated in either locality in 1947; and apparently none on a large scale. The town of Rowland and much of the town of Jarbidge appeared to be deserted. These were the only communities in the upper Bruneau basin that could be classified as towns, and the present population of Jarbidge is perhaps not more than 25.

POWER SUPPLY

A power transmission line has been constructed from near Hagerman, Idaho about 75 miles southwest to Jarbidge, Nevada, primarily to serve mines which were developed about 1910. About 1936 this line was extended approximately 25 miles westward primarily to serve the large Rio Tinta copper mine near Mountain City, Nevada but incidentally providing power for the towns of Mountain City and Owyhee, Nevada, and ranches in that locality. In 1947 the Rio Tinta mine was being closed down so that virtually the only power supplied from this line in Nevada is for the stores, residences and ranches near the end of the line. About the only other present market for power in this part of northeastern Nevada is in the Elko region some 80 miles south.

ROADS

Dirt or gravel roads provide access to a considerable portion of the upper Bruneau and Jarbidge River areas. These roads connect to the west with the highway between Elko, Nevada and Mountain Home,

Idaho, and northeastward from Jarbidge with the highways at Twin Falls, Idaho. A road crosses the East Fork Jarbidge River in Idaho near the State Line but nearly all of the Nevada portion of this basin is served only by trail. Secondary roads used by stockmen traverse much of the plateau region of southern Idaho and provide access to the rim of the Brumeau canyon at several points.

CLIMATE

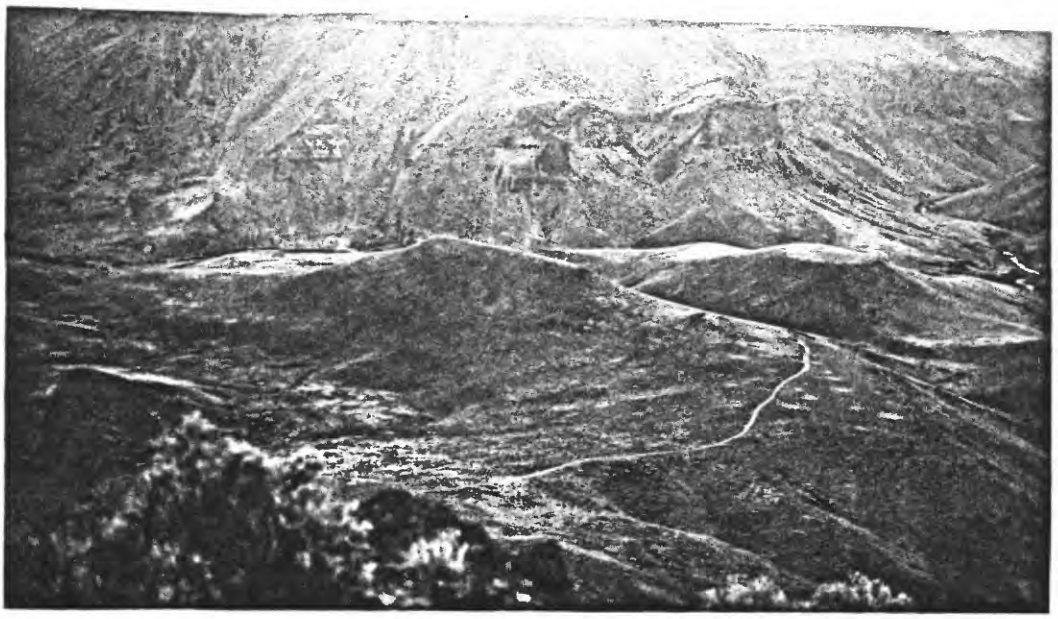
Climatological data are discussed in the following paragraphs in view of their possible use in estimating run-off where stream-flow records are lacking; and as a possible factor in stream-flow forecasts which would be of value for storage regulation.

General Characteristics.

Average annual precipitation shown in Water-Supply Paper 657, Plate 3, is between 15 and 20 inches in the upper part of the basin of the main stem in Nevada, and between 20 and 30 inches in the upper part of the Jarbidge River area. In an intermediate portion in both basins in northern Nevada and southern Idaho the average is listed as 10 to 15 inches, and for the lower part of the basin the average is shown as less than 10 inches.

Climatic records have been obtained at several stations in northeastern Nevada, but none within the Brumeau River basin. There are precipitation records for North Fork, Nevada from 1910 to date; for San Jacinto, Nevada from 1904 to date; for Gold Creek, Nevada, 1914-30, and fragmentary records thereafter; and for Owyhee, Nevada, 1900, 01, 24, 34, 1939 to date, and fragmentary records in other years. Average annual

Bruneau River, Idaho. View is from west rim of canyon approximately in township 15 south, range 7 west, looking downstream. River is at low stage in September, 1947.



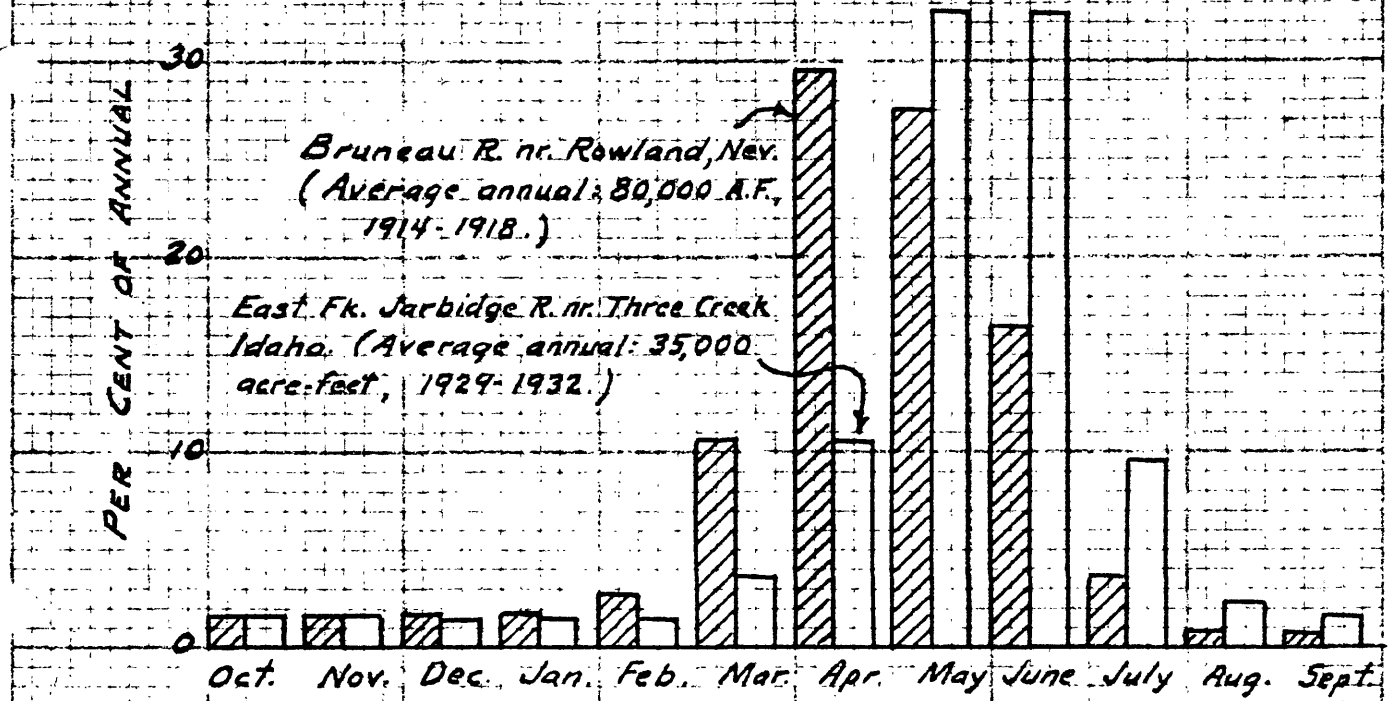
Bruneau River, Idaho. View is from west rim of canyon opposite the mouth of Jarbidge River. Distance to the east rim, (top background), is about a mile and a half, and the canyon is about a thousand feet deep. The mouth of the Jarbidge River is at extreme right. Vapor from a hot spring is visible at left center near the left bank of the Bruneau River. A stock road, (right foreground), crosses the canyon.

precipitation for North Fork, 1910-45, is 9.93 inches; for San Jacinto, 1910-45, 7.82 inches, and for Gold Creek, 1914-30, 13.18 inches. These stations are at altitudes 6,500, 5,200, and 6,600 feet respectively. Gold Creek is near the western boundary of the Bruneau River basin; North Fork is about 20 miles west of headwaters of the main stem, and San Jacinto about 25 miles east of the eastern boundary of the basin near the State Line.

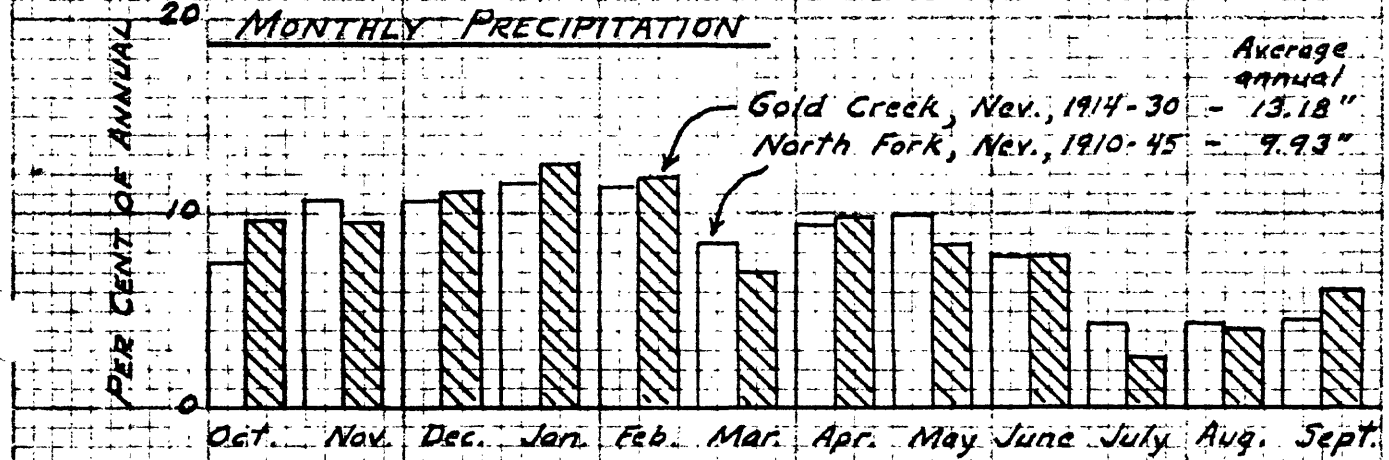
Mean monthly temperatures at Gold Creek for a few years of record, 1914-17, were generally below freezing, November to March, and roughly from 40° to 60° F. in other months. Minimum temperatures of minus 20° or less were recorded during several months, December to February, during the few years when extremes were listed for the Gold Creek, Owyhee, and San Jacinto stations.

It is estimated from the precipitation records described above that about 65% of the annual precipitation in the Bruneau River area occurs October to April, probably largely as snow. Because of low winter temperatures a considerable part of this precipitation in the higher parts of the basin probably is available for run-off starting in March. It is estimated that an average of roughly 20% of the annual precipitation occurs in May and June. It seems probable that this precipitation, falling on a blanket of snow or on moist ground, contributes substantially to the surface run-off, at least in normal or wet years. Thus about 85% of the annual precipitation may contribute to the surface flow during the snow run-off period. In some years, however, the early precipitation, October to December, may be largely lost in evaporation or percolation; and in dry years the spring precipitation also

MONTHLY RUN-OFF

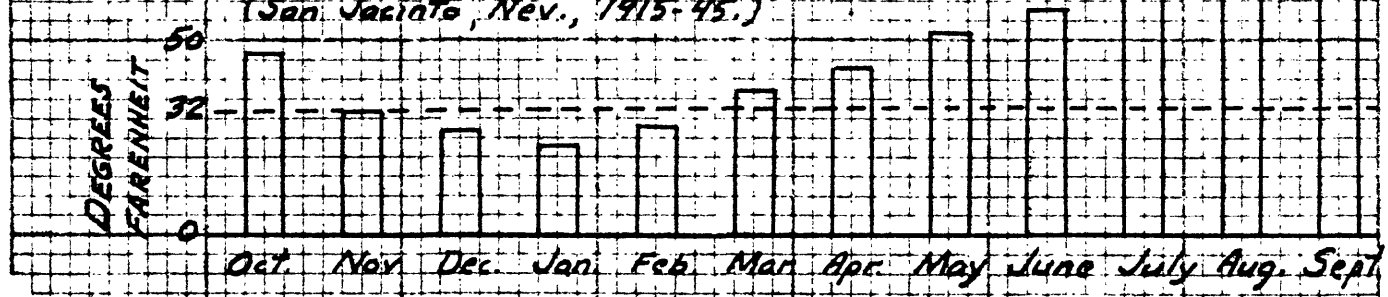


MONTHLY PRECIPITATION



MONTHLY MEAN TEMPERATURE

(San Jacinto, Nev., 1915-45.)



Note: The precipitation and temperature records are for nearby stations and are not necessarily representative of absolute values in the stream basins.

probably is relatively non-productive in run-off.

Comparison of the records for the several stations described above indicates that during many years the relative amounts of annual precipitation differed considerably at the different localities. Thus during the period of 36 years when corresponding records were obtained at North Fork and San Jacinto there were at least 9 years when figures of precipitation were not even roughly comparable. In the calendar year 1944 precipitation at North Fork was 90% of average, and at San Jacinto, 184% of average. In 1912 precipitation at North Fork was 151% of average and at San Jacinto only 56% of average. In the period 1914-30 when records were also obtained at Gold Creek the annual precipitation at this station differed greatly from that at one or both of the other stations in 7 of the 17 years of record. Gold Creek precipitation was 151% of average in 1919 as compared with about 80% for North Fork and San Jacinto; but it was only 48% of average in 1917 when precipitation at the other two stations was almost normal. Because of these large differences it seems probable that the available records do not provide reliable indices of the annual amounts of precipitation even for the basins in which the stations are located, - Salmon Falls Creek, the Owyhee River and the North Fork Humbolt River.

Precipitation and Run-off.

As will be shown in following paragraphs, the Owyhee River, the Bruneau River, and Salmon Falls Creek generally have about the same annual variations in run-off for the several periods of comparable records. This indicates that the amounts of precipitation in the more productive parts of each of the three basins probably have nearly the

same annual variations, - unlike the amounts of precipitation for the several climatological stations within the area. This is another indication that precipitation records for a given station, or even for several stations in this region, may not be representative of conditions throughout the stream basins. Precipitation and run-off figures for several years are compared in the following table:

Water-year	Precipitation - inches				Run-off
	San Jacinto		North Fork		Salmon Falls Creek,
	Oct.-Apr.	Oct.-June	Oct.-Apr.	Oct.-June	percent of average
1914	3.33	6.81	5.08	7.55	146
1915	4.98	6.97	7.67	10.28	60
1918	3.92	6.83	4.60	7.11	65 est.
1926	3.76	5.26	3.80	4.27	63
1930	3.27	5.67	4.87	7.47	58
1931	5.04	6.02	5.04	5.48	45
1934	2.25	3.60	3.29	4.58	36
1937	4.23	5.27	7.33	8.16	65
1940	4.92	5.95	7.24	8.09	62
1941	3.91	7.02	7.32	10.56	64
1942	8.12	12.12	7.85	8.81	171
Average 1911-42	4.01	6.08	6.80	8.50	100

Although run-off figures are for Salmon Falls Creek, these are closely comparable to figures for the Bruneau River 1914,15,18; for the Owyhee River 1918,26; for the Owyhee and Jarbidge Rivers, 1930,31; and for the Owyhee River 1934,40,41 and 42. There is a fairly definite correlation between run-off and precipitation figures only for the extreme low year 1934. The table includes the nine lowest years of record.

Part of the discrepancy between figures of precipitation and run-off may result from the fact that considerable portions of the stream basins are much higher than any of the precipitation stations. As shown by snow surveys, precipitation at the higher altitudes (8,000 feet or higher), is much greater than at points

of measurement. Moreover the amount of this precipitation relative to that of the precipitation stations probably differs in different months and years.

Following are some snow-survey figures for the highest course in the upper Bruneau River basin, and for three courses at roughly the same altitude as the North Fork and Gold Creek precipitation stations:

Course	Elevation, feet	Water content, - inches				Period of Record, years	Average water content, inches
		Date	1945	1946	1947		
Bear Creek	8000	March 1	13.4	17.2	13.4	15	16.1
		April 1	20.9	23.1	16.1	4	20.2
Fox Creek	6800	March 1	6.9	9.4	4.9	15	8.6
		April 1	10.8	8.6	2.8	10	8.6
Gold Creek	6600	March 1	6.3	7.3	3.2	15	6.8
		April 1	9.1	5.5	0	6	7.2
Big Bend	6700	March 1	8.1	10.1	5.3	18	9.1
		April 1	12.1	10.9	3.6	20	9.4

Locations of these courses are listed in a following table.

Water content at the Bear Creek course is generally about double that at the lower courses on March 1, prior to the run-off season, and is more than double on April 1. During the months of March 1945, 1946, 1947 there was a net average gain of 5.4 inches, corresponding to an average increase of 37% in water at the Bear Creek course, as compared with almost negligible gain at the lower courses. Part of this discrepancy is due to the fact that snow run-off starts earlier at the lower altitudes. However, average March precipitation at Gold Creek for 17 years, 1914-30, was only 0.92 inches and the March average at

North Fork, 1911-45, was only 0.83 inches. Ignoring possible losses at Gold Creek and North Fork, this is less than a fifth of the average March increment at Bear Creek, 1945-47. The water supply at Bear Creek probably is further proportionately increased by precipitation in the months of April, May and June. Conditions at the Bear Creek course may not be closely representative for this altitude in the Bruneau River basin, but the snow quantities are roughly comparable to corresponding measurements at several high stations in eastern Nevada.

The foregoing comparison illustrates that precipitation is much greater at high altitudes than at medium altitudes in the Bruneau River basin. It also illustrates that a snow pack of a few inches less than normal at altitudes below 7,000 feet constitutes a very meagre potential supply, disproportionately small in comparison with a subnormal snow pack at high altitudes.

In summary, it is concluded that stream-flow forecasts for the Bruneau River basin cannot be made reliably on basis of available climatological data; first because these data are not representative of conditions in the more productive parts of the basin; and second, because a substantial part of the run-off probably originates from precipitation during the run-off period. It is further concluded that the past records do not provide reliable indices for estimating run-off in periods of missing record because they are not representative and do not provide sufficient information as to evaporation and other losses.

WATER-SUPPLY

General Characteristics.

Run-off of the Bruneau River consists largely of flow during

the period March to June. Available records indicate that the run-off in these four months averages from 75 to 85% of the annual run-off, whereas during the driest six months, August to January, run-off is only 10 to 15% of the annual. These figures apply generally to points both on the main stem, and on main tributaries in Idaho. Snow run-off from the higher parts of the basin, however, is somewhat more concentrated and occurs somewhat later in the year, as shown by records for the East Fork of Jarbidge River near Three Creek, Idaho. Here during the water years 1929-32, 85% of the run-off was concentrated in the four months, April to July, and roughly 65% in the two months, May and June. Flow other than snow run-off, or rain combined with melting snow, evidently consisted almost entirely of seepage to the channel from underground sources.

Above Hot Spring, Idaho there are many small irrigation diversions along the main stem, and along the main tributaries excepting the Jarbidge River. Flows at some points also are affected by regulation from a small reservoir on Mary's Creek in Idaho, and a small reservoir on the upper Bruneau River in Nevada. It is judged that these factors have relatively small effect in determining the magnitude and general distribution of run-off at most points above Hot Spring, Idaho; and that records for early years provide at least a rough measure of run-off under present conditions, even though diversions and storage may have differed somewhat.

Run-off records for the Bruneau River basin are too brief to provide a direct measure of the range of annual run-off. The available records, however, show a rough correlation of figures of annual run-off

with corresponding figures for Salmon Falls Creek near San Jacinto, Nevada. During 29 years of record 1911-16, 19-20, 22-43, the average annual run-off at this station was about 90,000 acre-feet; run-off in the lowest year, 32,900 acre-feet; and in the highest year 169,900 acre-feet. Average annual run-off for 34 years, 1910-43 is estimated as the same, - 90,000 acre-feet. Average annual run-off for the period of 16 consecutive water-years 1926-41 was only 73,000 acre-feet, or about 81 percent of the 34 year average. It is judged that run-off of the main stem and main tributaries of the Bruneau River had similar annual variations.

Discharge Records.

The following records of discharge are available for stations on the Bruneau River and tributaries:

DISCHARGE RECORDS FOR THE BRUNEAU RIVER AND TRIBUTARIES
(Excepting Jacks and Wickahoney Creeks, and Several Canals)

Streams	Stations	Drainage Area* Sq.Miles	Period
Bruneau River	near Rowland, Nevada	350	1913-1918
Bruneau River	near Tindall, Idaho	460	1910-12
Bruneau River	near Hot Spring, Idaho	2400	1909-15
Bruneau River	near Grandview, Idaho	2900	1895-1903, 1909-16
Sheep Creek	near Tindall, Idaho	-	1910-13
Mary's Creek	near Owyhee, Nevada	-	1913-15
Mary's Creek	at Tindall, Idaho	-	1910-13
Louse Creek	near Wickahoney, Idaho	-	1911
E.Fork Jarbidge R.	near Three Creek, Idaho	90	1928-1933
E.Fork Bruneau R.	near Three Creek, Idaho	-	1912-14;16
E.Fork Bruneau R.	near Hot Spring, Idaho	-	1910-15
Three Creek	near Three Creek, Idaho	-	1912-14;16
Cherry Creek	near Three Creek, Idaho	-	1912-14;16
Deadwood Creek	near Three Creek, Idaho	-	1912-14;16

These records are published in Water-Supply Papers of the Geological Survey.

*All figures for drainage areas are approximate; those for Bruneau River near Hot Spring and Grandview were roughly determined from a base map.

In addition to these records several miscellaneous discharge measurements have been made. Ones which give some measure of run-off in the upper portion of the basin, are listed in the following table:

SOME MISCELLANEOUS DISCHARGE MEASUREMENTS IN THE BRUNEAU BASIN

Stream	Date	Point	Discharge Sec. Ft.
Bruneau River	July 13, 1914	near Charleston, Nevada	14.2
Bruneau River	Sept. 15, 1947	near Charleston, Nevada (sec. 21, T. 44 N., R. 57 E.)	0.3 est.
Bruneau River	Sept. 13, 1947	Above mouth Coon Creek, Nevada, near S.E. cor. T. 46 N., R. 56 E.	3.4
Bruneau River	Jan. 24, 1919	near Rowland, Nevada	24.2
Bruneau River	Oct. 24, 1919	near Rowland, Nevada	17.3
Bruneau River	July 11, 1920	near Rowland, Nevada	24.6
Bruneau River	Sept. 12, 1947	near Rowland, Nevada below mouth of Meadow Ck. (sec. 5, T.46 N., R. 56 E.)	5.0
Mason Creek	Sept. 13, 1947	at mouth	no flow
Willow Creek	Sept. 13, 1947	at road crossing near mouth	trickle
Seventy-Six Creek	Sept. 13, 1947	Sec.26, T.44 N., R.57 E.	trickle
Badger Creek	Sept. 13, 1947	at road crossing near mouth	0.2 est.
Copper Creek	Sept. 13, 1947	at road crossing, a mile above mouth	0.4 est.
Copper Creek	Sept. 14, 1947	5 miles above mouth (lat.41° 45', long.115° 30')	1.4
Deer Creek	Sept. 13, 1947	at mouth	0.2 est.
Cottonwood Creek	Sept. 13, 1947	at road crossing (diversion above)	trickle
Little Cottonwood Creek	Sept. 13, 1947	at road crossing	trickle
Miller Creek	Sept. 13, 1947	at road crossing (diversion above)	0.3 est.
Coon Creek	Sept. 13, 1947	100 feet above mouth	1.4
Meadow Creek	Sept. 12, 1947	Sec. 25, T. 46 N., R.55 E.	0.8 est.
Meadow Creek	Sept. 12, 1947	at mouth	0.2 est.
McDonald Creek	Sept. 16, 1947	near mouth	0.4 est.
Jarbidge River	July 11, 1914	Sec. 33, T. 47 N., R. 58 E. (3 miles north of Jarbidge)	62

SOME MISCELLANEOUS DISCHARGE MEASUREMENTS IN THE BRUNEAU BASIN

Stream	Date	Point	Discharge Sec.-ft.
Jarbidge River	Sept.15,1947	Sec.23, T.46 N., R. 58 E. 2 miles south of Jarbidge	8.5
Jarbidge River	Sept.15,1947	150 feet upstream from mouth of East Fork	9.0
East Fork Jarbidge River	July 11,1914	Sec.20, T.47 N., R. 59 E.	93
East Fork Jarbidge River	Sept.15,1947	50 feet above mouth	8.7

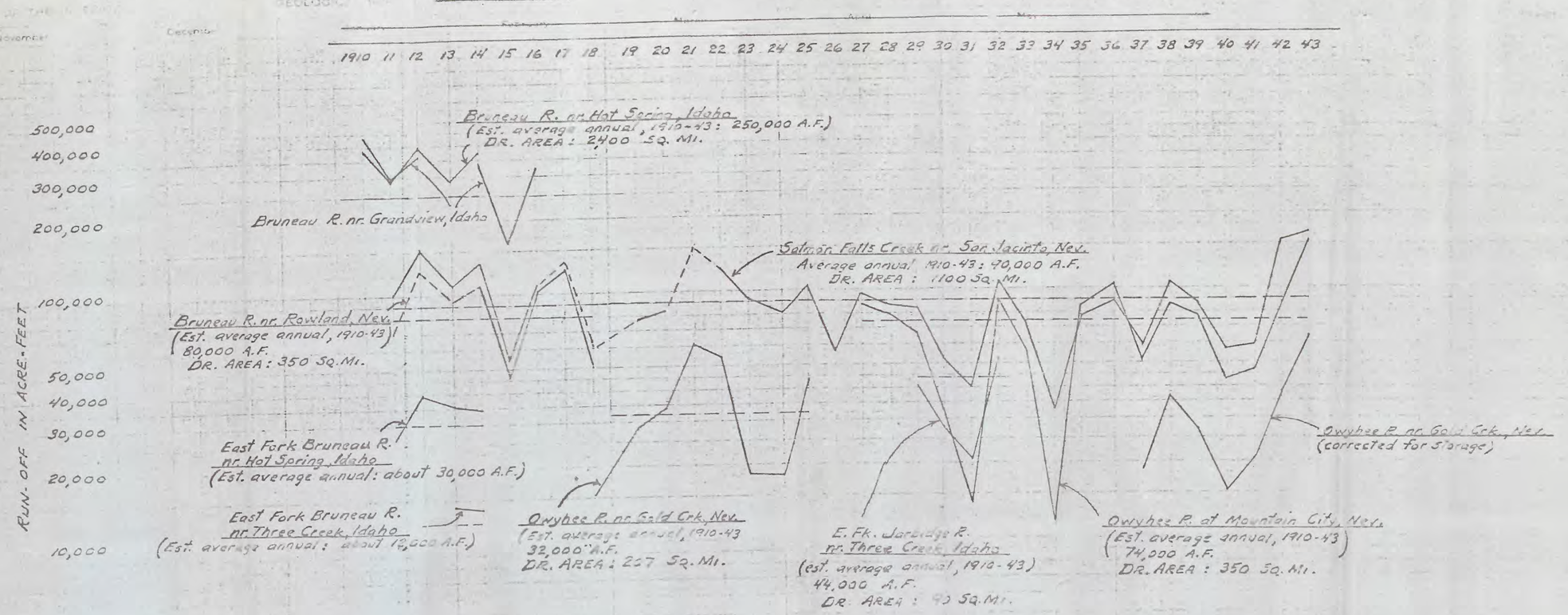
Discharges of the Bruneau River at points measured in 1947 were considerably affected by irrigation diversions. There was an estimated release of several second-feet from a small reservoir on the Bruneau River, 6 miles upstream from the measuring section near Charleston, which was almost entirely used or diverted from the channel flow in the intervening hay meadows. The increase below Charleston to 5 second-feet near Rowland represents only part of the natural increment since there was further irrigation use along this reach. Measurements of Copper Creek at the upper section and of Coon Creek represent natural flows; flow of Meadow Creek was slightly affected by diversion, and also by seepage loss in the channel near the mouth.

Discharge of the Jarbidge River above mouth of the East Fork may have been slightly affected by irrigation diversions, September 1947, but other measurements of the Jarbidge and East Fork probably represent natural flows.

The volume of run-off in the water-years corresponding to these masurements was considerably above average in 1914, probably somewhat below average in 1919 and 1920, and considerably below average in 1947.

The records for several gaging stations in the Bruneau River basin have been summarized on hydrographs that follow. Annual run-off

HYDROGRAPH FOR ANNUAL RUN-OFF: OWYHEE RIVER, BRUNEAU RIVER, SALMON FALLS CREEK



for two stations on the Owyhee River, Nevada, and for the station on Salmon Falls Creek near San Jacinto, Nevada are included for comparative purposes. Estimates of annual run-off during a few missing periods for some stations are shown by dotted lines.

Snow-Survey Records.

Snow surveys are made at several courses in the upper Bruneau and Owyhee River basins in Nevada. These are conducted cooperatively by Nevada State and several Federal Agencies. Results are published at the Nevada Agricultural Experiment Station, Reno, Nevada.

Data for the upper Bruneau River basin and adjacent areas is summarized as follows:

Location					Snow Cover Measurements			
					1946		Past Record	
Snow Course	Sec.	Twp.	Rge.	Elev.	Date	Water content, inches	Years of record	Av. water content inches
Bear Creek	31	46N	58E	7800*	March 1	17.2	15	16.1
" "	"	"	"	"	April 1	23.1	4	20.2
Fox Creek	33	46N	58E	6800	March 1	9.4	15	8.6
" "	"	"	"	"	April 1	8.6	10	8.6
Mary's River	34	45N	58E	8000	March 1	16.9	9	17.7
" "	"	"	"	"	April 1	-	1	13.4
76 Creek	6	44N	58E	7100	March 1	13.3	1	13.3
" "	"	"	"	"	April 1	15.2	1	15.2
Gold Creek	31	45N	56E	6600	March 1	7.3	15	6.8
" "	"	"	"	"	April 1	5.5	6	7.2
Big Bend	30	45N	56E	6700	March 1	10.1	18	9.1
" "	"	"	"	"	April 1	10.9	20	9.4

*Altitude probably is about 8,000 feet as shown on Jarbidge quadrangle map, instead of 7,800 feet.
Mary's River surveys were discontinued March 1947.

Although the past records are for periods of varied lengths and so are not strictly comparable, it is evident that the snow pack in a given locality is much greater at the higher altitudes. The

difference is particularly marked above altitudes of roughly 7,000 feet. Similar differences have been recorded in other localities in eastern Nevada, showing that this is not a local abnormality. The water content at the Bear Creek and Mary's Creek courses, at altitude 8,000 feet, averages about 17 inches on March 1. Assuming that this represents the entire winter precipitation, October-February, and that the monthly distribution is similar to that at lower altitude, the seasonal precipitation at end of April would be about 23 inches and at end of June nearly 30 inches; or about three times the average seasonal precipitation at North Fork and Gold Creek on these dates. Since losses at the higher altitudes probably are comparatively small, the run-off may be proportionately even greater than indicated by this ratio.

Snow-survey data as bases for stream-flow forecasts are subject to the same uncertainties noted for the climatological data. They may not be representative of average conditions in the more productive parts of the basin, and they do not allow for substantial increments to the supply that may be provided by precipitation, April-June, during the run-off season. However, measurements at the comparatively high Bear Creek and Seventy-Six Creek courses should give a much closer measure of probable water supplies in the upper Bruneau River basin than is available from the precipitation data for the lower stations.

Run-off of Bruneau River near Rowland.

Discharge records for this station for the three water-years 1914-16 indicate that the average annual run-off for this period was about 87,000 acre-feet. Annual run-off ranged from 83% to 98% of corresponding figures for Salmon Falls Creek near San Jacinto, Nevada.

The average run-off of Salmon Falls Creek 1914 to 1916 was 109 percent of the average for 29 years of record to 1943. On this basis it is judged that the 1910-43 average for the Bruneau River near Rowland would be between 75,000 and 80,000 acre-feet. Allowing for possible changes in irrigation diversions above both stations from 1916 to 1943, the long-time average for the Rowland station is roughly estimated at the lower figure, - 75,000 acre-feet, or roughly the same as that of Owyhee River at Mountain City, Nevada.

The lowest annual run-off at the San Jacinto station was 32,900 acre-feet in 1934, the driest year of record in many basins of Western States. If the 1934 run-off of the Bruneau River were comparable, the corresponding figure would be about 36 percent of the long-time average or roughly 27,000 acre-feet. However, if Bruneau River run-off was closely comparable to that of the Owyhee River at Mountain City, the run-off at Rowland in 1934 may have been as low as 16 percent of the average, or about 12,000 acre-feet. In 1934 the flow of Salmon Falls Creek near San Jacinto during the snow run-off season was only a little more than during preceding months. It appears that much of the run-off of Salmon Falls Creek in 1934 was from ground-water, presumably related partly to precipitation of the preceding year. Since the flow of the Bruneau River during the snow run-off season is usually a considerable part of the total, and its base flow relatively lower than that of Salmon Falls Creek, it is concluded that its run-off in 1934 was more nearly comparable to that of the Owyhee River at Mountain City. As a very rough estimate it is judged that 1934 run-off at Rowland was about 15,000 acre-feet, but possibly was as low as that of Owyhee

River, - about 12,000 acre-feet. (Irrigation diversions and other losses are judged to have been about the same in both basins; but run-off from a small area at high altitude may have favored Bruneau River flow.)

Run-off of East Fork of Jarbidge River near Three Creek, Idaho.

The average annual run-off for the four water years of record, 1929-32 was about 35,000 acre-feet. During the same period run-off of Salmon Falls Creek near San Jacinto was 79% of a 29-year average and that of Owyhee River at Mountain City 74% of a 17-year average. On this basis it is estimated that the 29-year average for the East Fork Jarbidge River was about 44,000 acre-feet, and about the same for the 34-year period, 1910-43.

Run-off for the minimum year recorded was 20,600 acre-feet in 1931. Annual run-off in 1934 at both the Owyhee River and the Salmon Falls Creek stations was about 80% of that for 1931. If the same relation held for the East Fork Jarbidge River its run-off in 1934 was about 16,000 acre-feet. However, run-off of this stream in dry years is relatively high because there are no diversions, and because natural losses are relatively low due to the high altitude and steep slopes of the basin. (The four years of comparative records verify this trend.) It is therefore estimated that the run-off in 1934 was about 18,000 acre-feet.

Run-off of Jarbidge River at mouth of East Fork.

Excepting miscellaneous discharge measurements, no records have been obtained for this stream. Run-off per square mile, particularly in dry years, is judged to be less than that of the East Fork because the area at the highest altitude is less. For example, area

above altitude of 8,000 feet in the East Fork basin is 31 square miles and the corresponding figure is 22 square miles for the Jarbidge River. The low-flow measurements made September 15, 1947 at confluence of the Jarbidge River and East Fork are about the same for each stream. Measurements of July 11, 1914 near end of the snow run-off season were 62 second-feet for the Jarbidge River and 93 second-feet for the East Fork. These are for points upstream from the confluence where drainage areas are roughly 37 and 51 square miles, respectively. The corresponding discharges per square mile are 1.68 and 1.82 second-feet, or for areas above 8,000 feet, 2.82 and 3.00 second-feet. The measurements probably were made at different stages of the diurnal cycle.

Drainage area of each stream at the confluence is about the same, - roughly 100 square miles. Calling the average annual run-off of the East Fork at mouth 44,000 acre-feet it is judged that the corresponding figure for flow below the confluence is roughly 85,000 acre-feet.

Run-off of the East Fork for the dry year 1934 was estimated as 18,000 acre-feet. That of the Jarbidge River above East Fork is judged to be somewhat less, say 15,000 acre-feet, making the total below the confluence roughly 33,000 acre-feet.

Summary.

On basis of the foregoing estimates it appears that the average annual run-off of the main stem of the Bruneau River at Rowland, Nevada, plus that of the Jarbidge River below mouth of the East Fork was about 160,000 acre-feet for the period 1910-43, and the corresponding run-off in the lowest year, about 48,000 acre-feet. The corres-

ponding average run-off of the Bruneau River near Hot Spring, Idaho, representing the bulk of the entire basin, is judged to be 250,000 acre-feet per year. This is for a drainage area of roughly 2,400 square miles as compared with the 550 square miles in the upper portion which contributes nearly two-thirds of the total run-off.

The estimated average annual run-off of 85,000 acre-feet for the Jarbidge River below mouth of the East Fork is for an area of only about 200 square miles as compared with 350 square miles of the Bruneau River near Rowland. Its relatively high run-off is undoubtedly largely due to its higher altitude (53 square miles above altitude 8,000 feet), and the absence of substantial irrigation diversions. In the mapped area of the main stem basin above Rowland only about 17 square miles are above altitude 8,000 feet, and much of the basin has relatively moderate relief. Natural losses, therefore, probably are larger, and as indicated in Water-Supply Paper 657, precipitation probably is less than in the Jarbidge basin. Irrigation diversions for several thousand acres of hay meadows along the Bruneau River also would materially reduce the run-off.

Basis for a rough appraisal of the estimated distribution of run-off is given by records of discharge for the Bruneau River and several tributaries for the year 1911. These are as follows:

WATER-YEAR 1911

Streams	Stations	Run-off, acre-feet
Bruneau River	near Hot Spring, Idaho	288,000
Bruneau River	near Rowland, Nevada	70,000
(estimated as 90% of recorded run-off near Tindall)		

WATER-YEAR 1911

Streams	Stations	Run-off acre-feet
E.Fork Bruneau R.	near Hot Spring, Idaho	26,000
Sheep Creek	near Tindall, Idaho	38,000
Marys Creek	at Tindall, Idaho	19,000
Louse Creek	near Wickahoney, Idaho	2,000
Jarbidge River (Estimated as 110% Bruneau River near Rowland)	below E.Fork Jarbidge River	77,000
	Sub-total	232,000
Remainder from Intermediate Areas		56,000

Run-off other than that of upper Bruneau and Jarbidge Rivers was 141,000 acre-feet from about 1,850 square miles. Area of the intermediate part of the basin corresponding to the remainder, 56,000 acre-feet, was roughly determined from base maps as 900 square miles. The computed run-off per square mile in this area thus is about 80% of that in the portion of the basin above tributary gaging stations in Idaho.

In 1914 records were obtained on a few of the tributaries, affording the following comparison:

WATER-YEAR 1914

Streams	Stations	Run-off acre-feet
Bruneau River	near Hot Spring, Idaho	374,000
Bruneau River	near Rowland, Nevada	109,000
E.Fork Bruneau R.	near Hot Spring, Idaho	34,500
Sheep Creek (Run-off estimated as about double that of Marys Ck)	near Tindall, Idaho	25,000
Marys Creek	at Tindall, Idaho	12,800
Louse Creek	near Wickahoney, Idaho	2,000
Jarbidge River (Estimated as 110% Bruneau River near Rowland)	below East Fork Jarbidge R.	120,000
	Sub-total	303,300
Remainder from Intermediate Areas		71,000

Run-off other than that of upper Brumeau River and Jarbidge Rivers was 145,000 acre-feet from an area of roughly 1,850 square miles. The computed run-off, 71,000 acre-feet from the intermediate area, 900 square miles, thus would correspond roughly to the same volume per unit area as from gaged portions of tributaries in Idaho.

WATER UTILIZATION IN THE BRUNEAU RIVER BASIN

Irrigation.

Present and potential use of Brumeau River water, aside from minor domestic consumption, appears to be limited almost entirely to irrigation. In Water-Supply Paper 657 published in 1935, it was estimated that about 25,000 acres in Nevada and Idaho is irrigated by direct diversion from the Brumeau River and tributaries, - practically all by natural flow. In the Department of Interior Report on Columbia River Basin, June 1946, it was stated that unregulated flows of the Brumeau River and tributaries provide a supply for about 20,950 acres, largely in small tracts along the streams throughout the basin.

It was noted in Water-Supply Paper 657 that some water is diverted from Marys Creek, tributary of the Brumeau River, for irrigation of lands in secs. 16 to 21, T. 14.S., R. 3 E., in the Owyhee River basin. It was also noted that water is diverted from Deadwood Creek, tributary of the East Fork Brumeau River, in sec. 28, T. 15 S., R. 12 E., to Cedar Creek Reservoir in Salmon Falls Creek basin for irrigation in T. 12 S., R. 13 E. In the Columbia River Basin Report, 1946, it is stated that a diversion is made out of the Brumeau River basin to a small project bordering the Snake River downstream from the mouth of

the Bruneau.

So far as known, the only proposal for future development is that given in the Columbia River Basin Report. This is for construction of a dam below mouth of the East Fork Bruneau River for storage of 350,000 acre-feet of water and its diversion to 80,000 acres lying west of the Bruneau River and above lands of the Bruneau Project. The latter is a project previously suggested by the Bureau of Reclamation for irrigation from Snake River. New land to be irrigated from the Bruneau River extends some 40 miles northeast to below mouth of Sinker Creek along the Snake River. The project maps and charts show that the dam would be located approximately in sec. 33, T. 9 S., R. 7 E., roughly at stream bed elevation 2,800 feet, and with crest elevation of 3,150 feet. The reservoir would extend about 12 miles up the Bruneau River and East Fork canyons. Cost of the dam and reservoir on basis of January 1, 1940 costs and preliminary information was listed as $5,800,000; and cost of distribution works as $5,200,000. The estimates of water supply listed herein indicate that a capacity of 350,000 acre-feet may be considerably more than is needed for control in critical periods. This will be discussed further on in this report.

It does not appear feasible to store and divert Bruneau River water to any substantial amount of new land in the upper part of the basin in Nevada and Southern Idaho, because the streams are generally in mountain canyons or deeply entrenched below plateau levels. Furthermore, substantially all suitable lands at bottom of the canyons along the streams are now under irrigation as hay meadows. However, there appear to be several small reservoir sites along the Bruneau

River in Nevada, and there may be others along the Bruneau River and Jarbidge River channels in Idaho. It is possible that some of these might be developed advantageously for irrigation of lands downstream in Idaho if costs of storage capacity were cheaper than at the proposed site below the East Fork Bruneau River. A few possible sites along the Bruneau River are described briefly further on in this report.

Power.

Any substantial development of water power in the main stem or Jarbidge River basins in Nevada seems of doubtful feasibility because of the variable run-off and relatively unfavorable topography. As noted in the foregoing, about 85% of the flow occurs in three or four months of snow run-off. Firm powers from natural flow would be limited to very small amounts, - along some reaches of the main stem virtually to nothing because of irrigation use. Development of any appreciable amount of firm power from the small natural flows would require long conduits for concentration of head. Along both the Bruneau and Jarbidge River channels terrain for conduit sites appeared unfavorable because of cliffs of volcanic rock, and steep slopes of talus.

Even with storage, utilization of a considerable part of the water for power would be very costly because of the very large fluctuations in supply from year to year. Run-off of the Bruneau River near Rowland for the low year 1934 was estimated as about a fifth of the average; and was perhaps only a tenth of the maximum. Characteristics of run-off of the Jarbidge River are judged to be much better in this respect since ratio of the low to the average year probably was double that of the main stem of the Bruneau River in Nevada.

Unfortunately, however, there appear to be no sites favorable for storage in the Jarbidge River basin in Nevada, as judged from field examination and inspection of the Jarbidge quadrangle map.

On basis of available data the writer judges that any development of power in the Bruneau River basin is unlikely under foreseeable conditions. The best possibility would seem to be in the Jarbidge River canyon below mouth of the East Fork of Jarbidge River, if there should be very favorable dam and storage sites in this reach.

Aside from unfavorable natural conditions for development of power, this region is about 80 miles from a probable market, - that near Elko, Nevada. It is about 60 miles nearer to this market than power sources on the Snake River, but as noted in the foregoing, a transmission line has previously been installed from the Snake River into the Jarbidge and Bruneau River areas.

Some descriptions of storage sites along the Bruneau River, and some estimates of theoretical hydro-electric power possibilities are given in the following paragraphs:

DEVELOPED STORAGE

Two reservoirs are described in Water-Supply Paper 657, from which the following summary is taken:

Riddle Reservoir, Idaho (12 H.B.1).

An earth dam 16 feet high with a crest length of 879 feet; reservoir area, 130 acres; capacity, 1,000 acre-feet; located in sec. 32, T. 14 S., R. 4 E., constructed in 1904 and raised in 1911. Water is diverted from Marys Creek in S. E. 1/4 sec. 8, T. 15 S., R. 4 E., and the stored water is used for irrigation in T. 14 S., R. 3 E. in the

Owyhee River basin.

Carey Reservoir, Idaho (12 H B 2).

Three small earth dams constructed in 1919 across Rattlesnake Creek in sec. 19, T. 12 S., R. 5 E., form a reservoir with capacity of 3,000 acre-feet, used for irrigation purposes.

In addition there is another small reservoir in the upper part of the basin in Nevada:

Upper Bruneau River Reservoir, Nevada.

An earth dam across Bruneau River, approximately in sec. 31, T. 43, N., R. 58 E., estimated by the writer to be about 250 feet long and with maximum crest height of about 25 feet above stream-bed. The dam is just below the mouth of Mason Creek. There is a timber by-pass canal at one end controlled by stop-logs, and an outlet works consisting of an 18-inch diameter culvert pipe controlled by valves. Date of construction was not determined. Reservoir capacity was judged very roughly to be less than 1,000 acre-feet, - possibly less than 500 acre-feet; and local residents stated that the reservoir did not fill in very dry years. Drainage area upstream is judged from base maps to be about 60 square miles. Release of several second feet in September 1947 was completely consumed in hay meadows within about 7 miles downstream.

UNDEVELOPED STORAGE

Bruneau River Site No. 1

The dam site is near the center of section 21, T. 44 N., R. 57 E., on the Bruneau River about 3/4 mile upstream from Copper Creek; at stream-bed elevation of about 5,910 feet. It is shown on Mt. Velma

quadrangle map. According to rough determinations from this map a dam 50 feet high would store 10,000 acre-feet of water with a surface area of 400 acres; and one 75 feet high would store 35,000 acre-feet, with a surface area of 1,100 acres. These determinations are of course subject to considerable error since they are based on contour intervals of 50 feet. Crest length as judged on the ground would be roughly 250 feet at 75 feet above stream-bed. Rock was exposed on both sides of the stream, and was judged to be the same as at the Wildhorse Reservoir on the Owyhee River, classified as porphyritic trachyte or rhyolite.

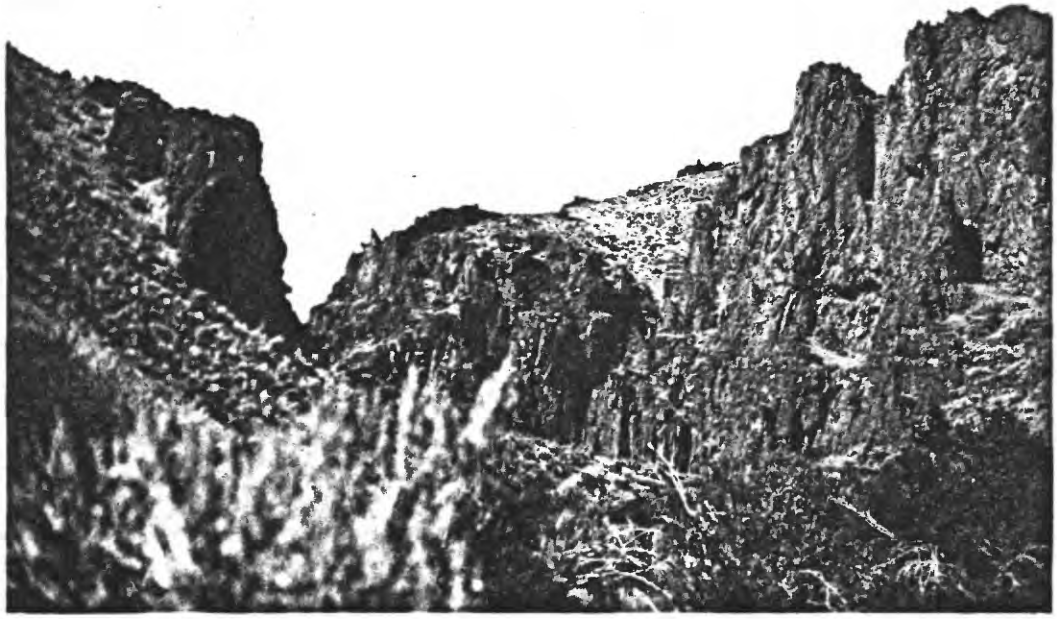
The drainage area above this dam site is estimated to be about 165 square miles, or less than half of the area above the former gaging station near Rowland. The average annual run-off is judged to be considerably less than half that near Rowland, and possibly less than 20,000 acre-feet. Run-off characteristics are judged to be similar to those for Owyhee River near Gold Creek, Nevada, prior to construction of Wildhorse Reservoir, and upstream irrigation diversions from Bruneau River may be even more, considering that there is some storage for irrigation. Run-off in lowest years probably would be less than 5,000 acre-feet.

The reservoir area is largely in hay meadows excepting about 100 acres at the downstream end where the land is covered with grass, willows, and sage brush. A secondary road is less than a mile from the site and would be partly within the flow line for capacity of 35,000 acre-feet.

Bruneau River Site No. 2

The dam site is on unsurveyed land near the east boundary of

Bruneau River dam site No. 1. View from left bank looking downstream to dam site in left and center foreground.



Bruneau River dam site No. 2. View from left bank looking downstream to dam site. The stream is entrenched at base of cliff on right bank.

sec. 36, T. 46 N., R. 56 E., on the Bruneau River about a quarter of a mile downstream from the mouth of Coon Creek; at stream-bed elevation of about 5,380. It is shown on the Rowland quadrangle map. As roughly determined from this map a dam 120 feet above stream-bed would provide for storage capacity of about 13,500 acre-feet, with surface area of 120 acres; and at 150 feet above stream-bed the capacity would be about 25,000 acre-feet, with surface area of 280 acres. Crest length for a 150 feet dam would be about 400 feet as judged roughly from field examination.

The stream at the dam site is in a narrow channel against a vertical rock face on the right bank; and is entrenched about 20 feet deep at the foot of a rock and earth slope on the left bank. There is solid rock outcrop on the left bank about 300 feet from the rock face at right bank. The rock is similar to that at site No. 1, - presumably porphyritic trachyte. Judging from the map, there may be an alternative site about a mile downstream, below mouth of Wickiup Creek.

Drainage area above site No. 2 is estimated as about 250 square miles, - about 85 square miles more than at site No. 1. The intermediate area includes Copper Creek and Coon Creek which probably drain the most productive area of upper Bruneau River. Average annual run-off at site No. 2 is judged to be about 50,000 acre-feet, and run-off in the lowest years about 10,000 acre-feet.

The reservoir area is almost entirely in hay meadows. There is a secondary road leading from upstream to within about a mile and a half of the dam site, terminating within the reservoir area.

Bruneau River Site No. 3.

The dam site is in the SW 1/4 sec. 32, T. 47 N., R. 56 E., on the Bruneau River about half a mile downstream from the mouth of Meadow Creek at Mink Ranch. It is at stream-bed elevation of about 5,025 feet, as shown on the Rowland quadrangle map. As roughly determined from this map a dam 75 feet above stream-bed would provide for storage capacity of about 7,000 acre-feet with surface area of 200 acres; at 125 feet the capacity would be about 22,000 acre-feet, and area 400 acres; and at 175 feet the capacity would be 46,000 acre-feet and area 550 acres. Crest length at 175 feet above stream-bed would be about 500 feet as judged roughly from field examination.

The main channel is about 40 feet wide at the dam site, and the canyon bottom about 100 feet wide between steep rocky slopes. On the right bank there is a nearly vertical rock outcrop from water surface to about 125 feet above. This resembles a wall about 50 feet thick. Upstream there are masses of the same rock exposed about 50 feet above water surface and higher. On the left bank nearly opposite the vertical face there are outcrops, evidently of the same formation, at points on the steep slope about 75 feet above stream-bed and higher. The rock is of greyish-white color, and has a dense, fine grain. Upstream several hundred feet on both sides of the channel there are distinct outcrops of a darker rock, possibly of volcanic origin.

The drainage area above site No. 3 is about 350 square miles, roughly the same as for the former gaging station near Rowland. As estimated in the foregoing, average annual run-off is about 75,000 acre-feet and run-off in lowest years about 15,000 acre-feet.

Bruneau River dam site No. 3. View is from road a quarter of a mile upstream, looking down river. The rock outcrop at edge of the channel on right bank is also shown at the extreme left of the following photograph.

Bruneau River dam site No. 3. View is from left bank about 125 feet above the channel looking towards the right bank. The width of channel at water surface is about 30 feet, (low-water stage of September 1947.)

The reservoir area is largely in hay meadows. A road from Mountain City to Rowland, Nevada crosses the channel in the reservoir site about half a mile above the dam site. A secondary road, apparently not in use, leads from this road downstream through the dam site. An abandoned ditch along the left bank through the dam site evidently was formerly used for irrigation downstream.

Bruneau River Site No. 4.

Flats along the river downstream from Rowland would constitute a reservoir site if there is a feasible dam site below. This possibility was not examined during course of this reconnaissance.

Assuming, however, that the stream could be dammed near the south boundary of sec. 8, T. 47 N., R. 56 E., it appears from the Rowland quadrangle map that storage capacity of about 36,000 acre-feet would be provided at a height 150 feet above stream-bed. This would cover an area of about 500 acres. Crest length of a dam of this height would be about 700 feet, as scaled from the map. Altitude of the stream-bed at this section is about 4,850 feet.

The reservoir site would include about 300 acres of hay meadows and the town of Rowland, now largely abandoned. A secondary road leads from Rowland to the mouth of McDonald Creek, thence to the plateau area of northern Nevada and southern Idaho.

Bruneau River Site No. 5.

It appears from topography as indicated on the Rowland quadrangle map that there is a very narrow section on the Bruneau River near the Idaho-Nevada State Line, at stream-bed elevation 4,750 feet. However, this is a hundred feet lower than at the section suggested for Site No.4,

and there is comparatively slight intermediate capacity.

As determined roughly from the quadrangle map, a dam 170 feet above stream bed at this section would provide for capacity of 20,000 acre-feet, with surface area of about 375 acres. The crest length of this dam probably would be less than half that at site No. 4, - possibly about 300 feet.

The reservoir site would include about the same amount of meadow land as site No. 4, but would not cover the town of Rowland. The dam site is roughly 3 miles downstream from the road at mouth of McDonald Creek.

WATER SUPPLY WITH REGULATION

Net Safe Yield from Upper Bruneau River.

Probable amounts of water available during the critical period 1925-41 with various amounts of storage capacity were computed on basis of the estimated run-off. Annual run-off at Rowland was figured as 82% of that of Salmon Falls Creek near San Jacinto, Nevada, except in the very dry years 1931 and 1934 when it was judged to be about 50% of Salmon Falls Creek run-off. It was further assumed that monthly distribution of run-off was as follows:

March	April	May	June	All other months
10%	30%	27%	17%	2% each

The monthly distribution was based on the average monthly run-off for the 5 years of record 1914-18. The fact that the run-off is practically limited to snow water and a low base flow minimizes uncertainty as to monthly distribution. Figures of annual run-off computed in this

way are of course subject to considerable error as approximations of the actual; however, they should at least represent a possible distribution for a roughly similar critical period.

On the foregoing basis the safe annual yield from the flow of Bruneau River at Rowland, Nev. is as follows:

ANNUAL YIELD DURING PERIOD 1925-1941 #

Storage capacity	Uniform annual yield		Annual yield with 50% deficiencies, 1931 and 1934	
Acre-feet	Acre-feet	Ratio of yield to storage capacity	Full supply, acre-feet	Ratio of full supply to storage capacity
10,000	19,000	1.90	19,000*	1.90
20,000	26,000	1.30	34,000	1.70
30,000	32,000	1.07	44,000	1.47
40,000	36,000	0.90	48,000	1.20
50,000	38,000	0.76	50,000	1.00
100,000	55,000	0.55	64,000	0.64

Annual evaporation losses were assumed to be about 50 acre-feet per thousand acre-feet of average contents. The average annual run-off during the period was 59,200 acre-feet.

Reservoirs were assumed to be full June 30, 1925.

*Yield was limited to 19,000 acre-feet during several years.

#In this and the following tables, 1925-35 was generally the determining period except for the largest capacities.

The preceding table was computed on the assumption that releases in years of deficiency could be scheduled after March 1 on basis of snow surveys, and precipitation data. Also since the analysis is merely illustrative, annual yields were figured on basis of uniform monthly releases. However, annual yields would not be greatly different if releases were assumed to correspond with probable irrigation demands.

Net Safe Yield from East Fork Jarbidge River.

Flow of the East Fork Jarbidge River was recorded during the water years 1929-32, and during that period the annual run-off ranged

from 48% to 52% of that of Salmon Falls Creek near San Jacinto, Nevada. As a rough approximation, figures of annual run-off during other years of the critical period 1925-41 were computed as 50% of those for Salmon Falls Creek, excepting water year 1934. Run-off for that year was estimated as 18,000 acre-feet, or about 55% of the corresponding figure for Salmon Falls Creek. The monthly distribution of run-off for estimated years in the period 1925-41 was based on the average distribution during 1929-32, which was approximately as follows:

March	April	May	June	July	Aug.	All other months
4%	10%	33%	32%	10%	2%	1.5% each

(On this basis the maximum difference between computed and recorded monthly run-off during the period 1929-32 is about 3,000 acre-feet.)

On basis of the recorded and estimated figures of run-off the safe annual yield of the East Fork Jarbidge River is approximately as follows:

ANNUAL YIELD DURING PERIOD 1925-1941

Storage capacity	Uniform annual yield		Annual yield with 25% deficiencies, except as noted		
Acre-feet	Acre-feet	Ratio of yield to storage capacity	Full supply acre-feet	Ratio of full supply to storage capacity	Years of deficiency
10,000	19,000	1.90	20,000	2.00	—*
15,000	22,000	1.46	24,000	1.60	1931,34
20,000	25,000	1.25	28,000	1.40	1931,34
25,000	28,000	1.13	34,000	1.36	1930,31,34
30,000	30,000	1.00	38,000	1.27	1930,31,34
50,000	35,000	0.70	40,000	0.80	1930,31,34

Annual evaporation losses were assumed to be about 50 acre-feet per thousand acre-feet of average contents. The average annual run-off during the period was 37,000 acre-feet. Reservoirs were assumed to be full June 30,1925.

*Yield limited to about 20,000 acre-feet in most years, with deficiency of 5% in 1934.

Net Safe Yield from Jarbidge River.

Run-off of the Jarbidge River above mouth of the East Fork is judged to have similar characteristics to that of the East Fork. The combined annual run-off of the East Fork and the main stem at the confluence was estimated as 85,000 acre-feet or about 1.93 times that of East Fork. Combined run-off in the low year 1934 was estimated as 1.83 times that of East Fork.

A rough measure of the yield from flow of the Jarbidge River below mouth of the East Fork therefore may be obtained by multiplying figures of storage capacity and yield in the preceding table by a factor of about 1.85.

Net Safe Yield from Upper Bruneau and Jarbidge Rivers.

As previously estimated, the combined average annual run-off of the Jarbidge River below mouth of the East Fork and Bruneau River near Rowland, Nevada is about 160,000 acre-feet, (nearly two-thirds that of the entire basin above Hot Spring, Idaho). Combined monthly run-off from this upper portion of the basin can be determined roughly by adding the estimated and recorded figures for the Bruneau and Jarbidge Rivers. On this basis the safe annual yield during a period like 1925-41 is as follows, assuming storage regulation at any point below mouth of Jarbidge River, or coordinated storage regulation upstream:

ANNUAL YIELD DURING PERIOD 1925-41

Storage capacity	Uniform annual yield		Annual yield with 25% deficiencies as noted		
Acre-feet	Acre-feet	Ratio of yield to storage capacity	Full supply acre-feet	Ratio of full supply to storage capacity	Years of deficiency
25,000	59,000	2.36	59,000	2.36	*
50,000	72,000	1.38	86,000	1.60	1931-34

ANNUAL YIELD DURING PERIOD 1925-41

Storage capacity	Uniform annual yield		Annual yield with 25% deficiencies as noted		
Acre-feet	Acre-feet	Ratio of yield to storage capacity	Full supply acre-feet	Ratio of full supply to storage capacity	Years deficiency
75,000	84,000	1.12	100,000	1.33	1931-34
100,000	95,000	0.95	112,000	1.20	1931-34
125,000	105,000	0.84	122,000	1.00	1931-34
150,000	111,000	0.74	129,000	0.86	1931-34-40
175,000	115,000	0.66	132,000	0.76	1930-31-34-40
200,000	120,000	0.60	135,000	0.67	1930-31-34-40
250,000	124,000	0.51	137,000	0.55	1930-31-34-40

Annual evaporation losses were assumed to be roughly 50 acre-feet per thousand acre-feet of average contents. The average annual run-off during the period was 128,500 acre-feet.

Reservoirs were assumed to be full June 30, 1925.

*Yield not substantially improved by systematic operation with deficiencies.

Summary.

All of the foregoing yield tables are presented merely as illustrative examples of storage potentialities in the Bruneau River Basin, not necessarily representing optimum possibilities.

The tables indicate that there is a fairly definite limit beyond which incremental yield from added capacity becomes relatively small. This is partly due to the approach to full utilization of the run-off and partly to increased evaporation losses with greater storage and longer hold-over periods. With the assumed deficiencies the storage capacity that can be used advantageously for control of the combined flow of the Bruneau and Jarbidge Rivers appears to be about the same in volume as the average annual run-off during the period 1925-1935, which is roughly 75% of the long-time average.

On this basis flow of the Bruneau River in the lower part of the basin below East Fork Bruneau River during a period like 1925-1941 could be substantially controlled for irrigation with a total storage capacity of about 185,000 acre-feet. (Requirements for possible flood control are not considered here.)

In practice, releases probably would differ considerably from those assumed, since the monthly demand would be variable, and in dry years the annual release probably would be varied in accordance with the reservoir contents and the probable water supply at start of the season.

UNDEVELOPED POWER SITES

Estimates of potential power given in the following paragraphs are intended to serve only as a rough appraisal of theoretical possibilities in the upper Bruneau River Basin. Data are lacking as to the feasibility of storage sites, the topography of the canyons in Idaho, and the run-off at many points on the streams.

The estimates are made arbitrarily on basis of gross heads and 70 percent over-all efficiencies. In practice, plans for development of power in this basin, if any should be contemplated, presumably would feature the use of conduits for concentration of head. The channel gradients of the main stem and lower Jarbidge River, however, are generally only about 40 feet per mile or less, so that relatively large conduits would be required to hold friction losses within the required limits for 70 percent overall efficiency. In view of this circumstance and the fact that conduit terrain is generally unfavorable in this basin it is probable that optimum design efficiencies would be less than 70%.

Brumeau River Site No. 1.

Between reservoir sites No. 1 and 2 there is a drop of about 380 feet in a channel distance of 9 miles. The average annual run-off at site No. 1 is estimated as 20,000 acre-feet; the minimum annual run-off, 5,000 acre-feet; and the safe yield available 90 percent of the time as zero, (owing to irrigation diversion upstream). On this basis the theoretical possibilities without regulation are summarized as follows:

Potential Power at Brumeau River Site No. 1.
(Channel Length of 9 miles)

	Gross head, 380 fet. Natural flow in second-ft.			70 percent efficiency Horsepower		
	90% of time	50% of time	Mean	90% of time	50% of time	From mean flow
Average Yr.	0	10	27	0	300	820
Low Year	0	4	8	0	120	240

These quantities might be increased considerably by addition of flow from Copper Creek, which enters from the right bank below reservoir site No. 1. However, the possibilities with unregulated flow are so unfavorable that an estimate of this increment does not appear justified.

If the stream were completely controlled during critical periods such as 1925-41, the flow available 100 percent of the time would be roughly 20 second-feet, corresponding to about 600 h.p., or 67 h.p. per mile of channel. This would require storage capacity of 30,000 acre-feet or more, and would entail carry-over through extended periods with consequent large evaporation losses.

A more practicable scheme of regulation might contemplate the use of standby service in dry years. As an illustrative example,

it is estimated that storage capacity of about 10,000 acre-feet at site No. 1 would provide for a safe yield of 15 second-feet 95 percent of the time. (The deficiency is assumed to be 50 percent in extreme dry years, - roughly 1 year in 10.) This is equivalent to about 50 h.p. per mile of channel. On the same basis, capacity of 30,000 acre-feet would permit generation of about 80 h.p. per mile of channel, 95 percent of the time.

Omitting storage site No. 2, there is a drop of about 710 feet in 16 miles of channel between sites No. 1 and 3. Theoretical power available in this reach from the flow at site No. 1 would be approximately 1.85 times the total amounts estimated for the reach between sites Nos. 1 and 2. The potential power per mile of channel in this over-all reach would average slightly more than between sites Nos. 1 and 2.

Brumeau River Site No. 2.

Below reservoir site No. 2 there is a drop of about 600 feet in 17 miles of channel to the State Line. The average annual run-off at site No. 2 is estimated as 50,000 acre-feet; the minimum as 10,000 acre-feet; and the safe yield available 90 percent of the time as about 5 second-feet. On this basis the theoretical possibilities with unregulated flow are summarized as follows:

Potential Power at Brumeau River Site No. 2.
(Channel Length of 17 miles)

	Gross head, 600 ft. Natural flow in second-ft.			70 percent efficiency Horsepower		
	90% of time	50% of time	Mean	90% of time	50% of time	From mean flow
Average Yr.	5	24	68	240	1152	3264
Low Year	4	8	14	192	384	672

Capturable flow from Meadow and McDonald Creeks, entering from the left bank in this reach would consist largely of snow run-off. Potential firm power would hardly be affected by addition of these streams, and evidently is too small for economical development.

If the stream were completely controlled for critical periods such as 1925-41 the safe yield at reservoir site No. 2 would be roughly 50 second-feet 100 percent of the time. This corresponds to about 2400 h.p. in the reach of 17 miles downstream, or 140 h.p. per mile. Such regulation would require the large storage capacity of 70,000 acre-feet or more. It is estimated that storage capacity of 20,000 acre-feet would provide for a safe yield of 29 second-feet, or 82 h.p. per mile, 100 percent of the time.

The possibilities for generation of firm power would be improved by provision for standby service in dry years. Assuming 50 percent deficiencies in the full supply 1 year in 10, power available 95 percent of the time would be 114 h.p. per mile, with storage capacity of 20,000 acre-feet. The hydro energy production would thus be about a third more than with uniform annual generation. (This is cited merely as an illustrative example and not as the optimum condition.)

Bruneau Site No. 3.

Below reservoir site No. 3 there is a drop of 275 feet in the channel distance of 8 miles to the State Line. The average annual run-off is estimated as 75,000 acre-feet; the minimum 15,000 acre-feet; and the safe yield available 90 percent of the time as 6 second-feet. On this basis the theoretical possibilities with unregulated flow are summarized as follows:

Potential Power at Brumeau River Site No. 3.

(Channel length of 8 miles)

	Gross head, 275 ft. Natural flow in second-ft.			70 percent efficiency horsepower		
	90% of time	50% of time	Mean	90% of time	50% of time	From mean flow
Average Yr.	6	30	100	176	660	2200
Low Year	4	10	20	110	220	440

McDonald Creek enters from the left bank in this reach but its low flow, if capturable, would improve the firm power possibilities only slightly.

If the stream were completely controlled during critical periods such as 1925-41 the safe yield would be roughly 75 second-feet at site No. 3. This corresponds to about 1,650 h.p., 100 percent of the time or 205 h.p. per mile of channel. Such regulation, however, would require the large storage capacity of 100,000 acre-feet or more. Capacity of 30,000 acre-feet would provide for a yield of about 44 second-feet, or 120 h.p. per mile of channel, 100 percent of the time.

Illustrative examples of yields available 95% of the time are listed as follows:

Assumed storage capacity	Potential power	Yield
Acre-feet	H.P. per mile of channel	H.P. per 1,000 A.F. of capacity
10,000	72	7.2
20,000	128	6.4
30,000	165	5.5
40,000	182	4.6

Deficiencies of 50 percent in the full supply were scheduled for the extreme dry years 1931 and 1934, assumed to occur an average of 1 year in 10.

Bruneau River Site No. 4.

Downstream from the State Line there is a drop of roughly 1,000 feet to the mouth of the Jarbidge River, in a channel length of about 30 miles. This gradient is roughly the same as for the 8 miles from reservoir site No. 3 to the State Line. (Topographic maps are not available for the Idaho reach, and the estimates are based on aneroid and speedometer readings.)

Possibilities for storage in the reach downstream from the State Line have not been investigated. Inflow between site No. 3 and mouth of Jarbidge River would consist largely of the flow of McDonald Creek joining the Bruneau River upstream from the State Line.

Since the channel gradients are comparable, the potential power per mile of channel in site No. 4 is roughly the same as in site No. 3, except for the problematical increase that might be obtained by control and use of water from McDonald Creek. Regulation of the bulk of the flow could be provided by storage at site No. 3 and upstream on the main stem.

East Fork of Jarbidge River Power Site.

This stream has a drop of 1,100 feet in the 10 miles upstream from the State Line, and about 400 feet in the reach of about 5 miles downstream to its confluence with the Jarbidge River. The average annual run-off near the lower end of this reach was estimated as 44,000 acre-feet, and the minimum annual as 18,000 acre-feet on basis of records obtained near Three Creek, Idaho. It is estimated that at least three-quarters of this run-off enters the channel 5 miles or more upstream from the State Line, from the upper half of the drainage basin.

This would represent an average annual run-off of 33,000 acre-feet; and a minimum of 14,000 acre-feet. The safe yield available 90 percent of the time is estimated as 6 second-feet. On this basis the theoretical power is as follows:

Potential Power in Reach 10 Miles above Mouth

	Gross head, 950 ft. Natural flow in second-feet			70 percent efficiency Horsepower		
	90% of time	50% of time	Mean	90% of time	50% of time	From mean flow
Average Yr.	6	9	45	455	680	3400
Low Year	4	7	19	305	530	1440

On basis of the topography indicated on the Jarbidge quadrangle map there does not appear to be any possibility for substantial storage on the East Fork Jarbidge River in Nevada.

Jarbidge River above the East Fork.

The Jarbidge River has a fall of about 950 feet in the 10 miles upstream from mouth of the East Fork, or about the same fall as the East Fork. Its run-off is estimated to be somewhat less than that of the East Fork. Theoretical power available from natural flow would therefore be less than for the corresponding reach on the East Fork. There appears to be no possibility for substantial storage upstream from the East Fork.

Jarbidge River below the East Fork.

The average annual run-off of the Jarbidge River below the East Fork is estimated as 85,000 acre-feet; the minimum annual as 33,000 acre-feet, and the flow available 90 percent of the time as 14 second-feet. The drop from the mouth of the East Fork to the con-

ably precludes economical development in the Nevada portion of the basin. Consideration of the feasibility of development of the Jarbidge River in Idaho would require a reconnaissance or survey to disclose possible storage sites, possible sites for power dams, and possible location for conduits.

Estimates of the costs of power generation are not within the scope of this investigation, and these scarcely could be made on basis of the available information. In general, however, it appears to the writer that few if any of the power sites considered herein would be economically feasible.

Because of the character of the run-off it would seem essential to have storage regulation for any practicable development. Since the power possibilities are small and their development probably relatively costly if not entirely impracticable, it is judged that any feasible storage sites have a greater potential value for irrigation than for power. Storage sites in the upper part of the basin have more power value than others, however, and have primary value for this purpose if there is adequate storage capacity for irrigation purposes at comparable cost downstream.

The use of storage capacity in the upper Bruneau River basin for joint power and irrigation release seems unlikely. It is probable that there will be an ample supply of seasonal hydro-electric energy from present or proposed plants on the Snake River adjacent to projects where such energy presumably might be used for irrigation pumping.