WATER POWER AND IRRIGATION IN THE JEFFERSON RIVER BASIN, MONT.

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PREFACE

This report presents data compiled under instructions to make such field and office studies as might be necessary in order to prepare a discussion of present and potential power and irrigation development in the Jefferson River Basin, Mont. The report is the third of a series relating to the Missouri River Basin in Montana; the first one covered the Madison River Basin,[1] and the second the Missouri River bottom land from Fort Benton to the North Dakota line.[2] The field work was done in June and July, 1923, and the office studies at different times before and since.

During the progress of the field work a map showing the location of most of the irrigated land in the basin was compiled from the records of the county tax assessors of Beaverhead and Madison Counties. Similar data for Gallatin, Broadwater, Silver Bow, and Deerlodge Counties were compiled by other members of the Geological Survey. The irrigated land in Jefferson County was mapped approximately in the field by Ward L. Hopper, of the Survey. These data were checked by reconnaissance investigations by the writers in all areas where water is or may be used extensively for irrigation. Special efforts were made to obtain information regarding present and potential development of power and irrigation by interviewing local farmers, engineers, and others interested in water utilization. Plane-table surveys were also made to obtain data for estimating the potential value of power sites and the storage capacity of reservoir sites.

In the course of the field work cordial and helpful aid was obtained from many farmers, business men, water masters, and others—too many to mention individually. Considerable information was also obtained from officials of the Montana Power Co. at Butte, Mont., and from Messrs. George R. Metlin and G. V. Elder, civil engineers at

[1] Deeds, J. F., and White, W. N., Water power and irrigation in the Madison River Basin, Mont.; U. S. Geol. Survey Water-Supply Paper 560, pp. 1–30, 1925.

[2] Deeds, J. F., and Brooks, L. R., Land-classification report, Missouri River bottom land, from Fort Benton to Montana-North Dakota State line (unpublished); copies available for public inspection at the offices of the U. S. Geological Survey in Washington, D. C., and Helena, Mont.

Dillon, Mont. In addition to the data thus obtained, reports and other records of the Weather Bureau, Forest Service, Census Bureau, and Geological Survey have been used extensively.

SUMMARY

Jefferson River is the largest of three large streams that meet at Three Forks, Mont., to form Missouri River. It is the outlet channel for a drainage area of about 10,000 square miles lying in the extreme southwest corner of Montana as shown on the key map (pl. 3). Most of its drainage area is rough, nontillable mountainous land dissected by deeply intrenched drainage channels ranging from narrow valleys to box canyons, but here and there are found broad open valleys and terraced benches that include large areas of smooth tillable lands. The altitude of the tillable lands ranges from 4,400 to nearly 7,000 feet above sea level. In general where the altitude is greater than 5,500 feet the growing season is too short for diversified farm crops. In favorable locations a considerable variety of crops may be grown at as high an altitude as 6,000 feet, but in other places the season may be too short for the same crops at an altitude nearly as low as 5,000 feet. The rainfall on the tillable lands is ordinarily not more than sufficient to mature such drought-resistant crops as wheat and oats, and even these crops can be raised successfully only in a few favorably located places. These physiographic and meteorologic conditions limit the agricultural utility of lands in the area to stock-raising, except where the growing season is of sufficient length to mature general farm crops and where deficient soil moisture due to lack of rainfall is offset by natural flooding or subirrigation or can be offset by artificial irrigation at a reasonable cost.

The water supply of the Jefferson River basin has been measured at numerous gaging stations operated by the Geological Survey. One of these stations is at Sappington, T. 1 N., R. 1. W, near the lower end of the basin, and its record practically represents the outflow from the basin after all diversions have been satisfied. The mean annual discharge for the period of record at this station is 1,620,000 acre-feet, which indicates an immense volume of water in the Jefferson River Basin that is not required by existing projects diverting water in that area.

In the Jefferson River Basin, as in most other sections of the semiarid West the run-off varies at different seasons of the year, attaining a maximum during short flood periods in the spring. Under these conditions projects for utilizing the water require regulation of the stream flow in reservoirs in order to use successfully more than part of the annual run-off. Storage reservoirs having an aggregate capacity of about 113,000 acre-feet are now operated in the basin, and undeveloped storage sites having a potential capacity of about 918,000 acre-feet have been surveyed in connection with water utilization

investigations. A list of these developed and undeveloped reservoir sites is given in Table 1. In the first column of the table will be found an index number by means of which the sites may be identified on Plate 3.

TABLE 1.—*Reservoir sites in the Jefferson River Basin, Mont.*

Developed

Index No.	Name	Source of water supply	Location	Approximate height of dam (feet)	Approximate area (acres)	Capacity (acre-feet)
6AA-2	Lima	Red Rock River	T. 13 S., R. 6 W.; T. 14 S., Rs. 5 and 6 W.	50	2,460	57,000
6AC-3	Esler Lake	Rattlesnake Creek	T. 5 S., R. 11 W.	30		2,000
6AC-4	Phillips	do	T. 6 S., R. 11 W.	25		1,600
6AD-	Unknown (12 reservoirs).	Wisconsin and Mill Creeks.	No details available.			11,000
6AE-1	Mussigbrod	Mussigbrod Creek	T. 1 N., R. 16 W.	14		2,000
6AF-1	Pintlar Lake	Pintlar Creek	T. 1 N., R. 15 W.		165	
6AG-1	Wise River	West Fork of Wise River.	T. 2 S., R. 12 W.	40	538	7,100
6AG-2	Divide	Big Hole River	T. 1 S., R. 10 W.	67	140	1,280
6AG-4	Chain Lake	Birch Creek	T. 5 S., R. 11 W.			60
6AG-5	Tubb Lake	do	T. 5 S., R. 11 W.			180
6AG-6	Anchor Lake	do	T. 4 S., R. 11 W.			500
6AG-7	May Lake	do	T. 5 S., R. 11 W.			70
6AG-8	Fair Lake	do	T. 5 S., R. 11 W.			1,600
6AG-9	Boot Lake	do	T. 4 S., R. 11 W.			2,000
6AH-2	Delmoe Park	Pipestone Creek	T. 3 N., R. 6 W.	80	479	12,000

Undeveloped

Index No.	Name	Source of water supply	Location	Approximate height of dam (feet)	Approximate area (acres)	Capacity (acre-feet)
6AA-1	Red Rock Lakes	Red Rock River	Tps. 13 and 14 S., Rs. 1, 2, and 3 W.	6	22,000	90,000
6AA-2	Lima enlargement	do	T. 14 S., Rs. 3, 4, 5, and 6 W.	60 78	5,700 19,000	[a] 35,000 [a] 100,000
6AA-3	Lower Red Rock Valley.	do	Tps. 13 and 14 S., Rs. 7 and 8 W.	40	1,200	16,000
6AC-2	Grasshopper	Grasshopper Creek	T. 8 S., R. 10 W.	105	554	25,000
6AC-8	Blacktail Deer	Blacktail Deer Creek.	T. 9 S., Rs. 7 and 8 W.	40	600	8,000
6AD-1	Ruby	Ruby River	T. 7 S., Rs. 4 and 5 W.	150	1,880	100,000
6AG-10	Big Hole	Big Hole River	Tps. 4 and 5 S., Rs. 8 and 9 W.	160	7,500	530,000
6AH-3	Whitetail Park	Whitetail Creek	T. 4 N., Rs. 5 and 6 W.	38	2,025	16,600
6AH-7	Willow Creek	Willow Creek	Tps. 1 and 2 S., R. 1 W	122	1,320	32,800

[a] Increase in developed reservoir capacity.

With the exception of the Wise River (6 AG–1) and Divide (6 AG–2) reservoirs, all the constructed reservoirs listed in Table 1 are used to regulate stream flow for irrigation. Furthermore, all the potential sites listed have been investigated in connection with their possible use in extending the irrigated acreage. In most sections of the basin where irrigation is practicable all the low-water flow during the irrigation season is diverted, and in some portions a large amount of land that is irrigated obtains only a flood-water supply. The total area irrigated is about 426,000 acres, distributed through the basin as follows:

	Acres
Main river stem:	
6AA. Red Rock River (head of Missouri River)	49, 000
6AC. Beaverhead River (continuation of Red Rock River)	30, 000
6AH. Jefferson River (continuation of Red Rock River and Beaverhead River) and minor tributaries below Big Hole River	28, 900
Tributaries:	
6AB. Horse Prairie Creek	45, 900
6AC. Grasshopper Creek	10, 500
6AC. Rattlesnake Creek	4, 000
6AC. Blacktail Deer Creek	5, 500
6AD. Ruby River	34, 500
6AE, 6AF, 6AG. Big Hole River	185, 000
6AH. Pipestone and Whitetail Creeks	8, 600
6AJ. Boulder River	7, 300
6AH. South Boulder Creek	4, 000
6AH. Willow Creek	12, 500

Plans have been proposed for irrigating additional areas aggregating nearly 185,000 acres in the Jefferson River Basin and also from 40,000 to 65,000 acres outside the basin but using water from Jefferson River. The surplus water supply as indicated by the record at the Sappington gaging station is more than adequate for irrigating all of this increased area, but the studies of the writers indicate that the undeveloped lands having climatic and soil conditions favorable for irrigation are so located that the cost of the required storage reservoirs and diversion canals would be high, and for a considerable part of the irrigable land it would be prohibitive under present economic conditions. It is believed, however, that eventually nearly all the potential irrigation resources will be developed.

In the course of the field studies in connection with this report five water-power plants were visited, as follows:

6AC–6, 6AC–7. Dillon municipal plants Nos. 1 and 2.
6AH–1. Parrot plant.
6AC–5. Rattlesnake Creek plant.
6AG–2. Divide plant.

Only one other power plant is known to exist in the basin (6AH–6), and it is operated to furnish electric current for municipal lighting in the town of Pony. The Divide plant is the only large one. Its capacity is 3,000 kilowatts, but at present it is being operated to only about one-fourth of this capacity. The Parrot plant had an installed capacity of about 1,000 kilowatts and probably at one time was a source of considerable power, but it has been entirely abandoned and largely dismantled, and the supply canal is used for irrigation. The Rattlesnake Creek plant also has been dismantled and abandoned, and only one of the two Dillon plants is operated, the other having been closed down after the construction of a transmission line from Dillon to Laurin, where a connection is made with a transmission line of the Montana Power Co. that extends into this area from hydroelectric plants in other parts of Montana. The Pony plant and one of the Dillon plants (6AC–7) are the only ones now operated to even approximately their full capacity, and both are small plants having a combined capacity of only about 130 kilowatts. Another small plant was formerly operated on South Boulder Creek to furnish power to a mining camp, but that also has been abandoned, and possibly similar power plants have been constructed at other points and likewise abandoned. The developed water power in Jefferson River Basin is therefore of small economic importance, a situation in large part due to the fact that the general region contains other power sites which are more economical of development and are capable of supplying the available market.

A summary of the undeveloped power resources is given in Table 2. None of these potential power sites are regarded as having commercial importance. The Beaverhead Canyon, Rattlesnake Creek (Argenta), Lower Big Hole Canyon, and Whitetail Canyon sites would require an expenditure in excess of the return obtainable from the sale of power, and the Liberty Mines site is of small local importance and probably will be used only as long as the mining operations are continued.

TABLE 2.—*Summary of undeveloped power sites in the Jefferson River Basin, Mont.*

[Estimates of power based on static head and over-all plant efficiency of 70 per cent]

Index No.	Name	Stream	With existing flow: Static head (H) (feet)	Flow for 90 per cent of the time (Q90) (sec.-ft.)	Flow for 50 per cent of the time (Q50) (sec.-ft.)	Horsepower (0.08HQ90)	Horsepower (0.08HQ50)
6AC-1	Beaverhead Canyon	Beaverhead Creek	200	240	380	3,840	6,080
6AC-5	Rattlesnake Creek	Rattlesnake Creek	200	10	30	160	480
6AG-3	Lower Big Hole Canyon	Big Hole River	80	360	625	2,300	4,000
6AH-4	Whitetail Canyon	Whitetail Creek	2,400	7	15	1,300	1,700
6AH-5	Liberty Mines	South Boulder Creek	231	11	205	205	474

Index No.	Name	Stream	With regulated flow: Static head (H) (feet)	Flow for 90 per cent of the time (sec.-ft.)	Flow for 50 per cent of the time (sec.-ft.)	Horsepower (0.08HQ90)	Horsepower (0.08HQ50)
6AC-1	Beaverhead Canyon	Beaverhead Creek					
6AC-5	Rattlesnake Creek	Rattlesnake Creek					
6AG-3	Lower Big Hole Canyon	Big Hole River	80	408	408	2,600	2,600
6AH-4	Whitetail Canyon	Whitetail Creek	2,400	15		2,300	
6AH-5	Liberty Mines	South Boulder Creek					

INDUSTRIES AND TRANSPORTATION

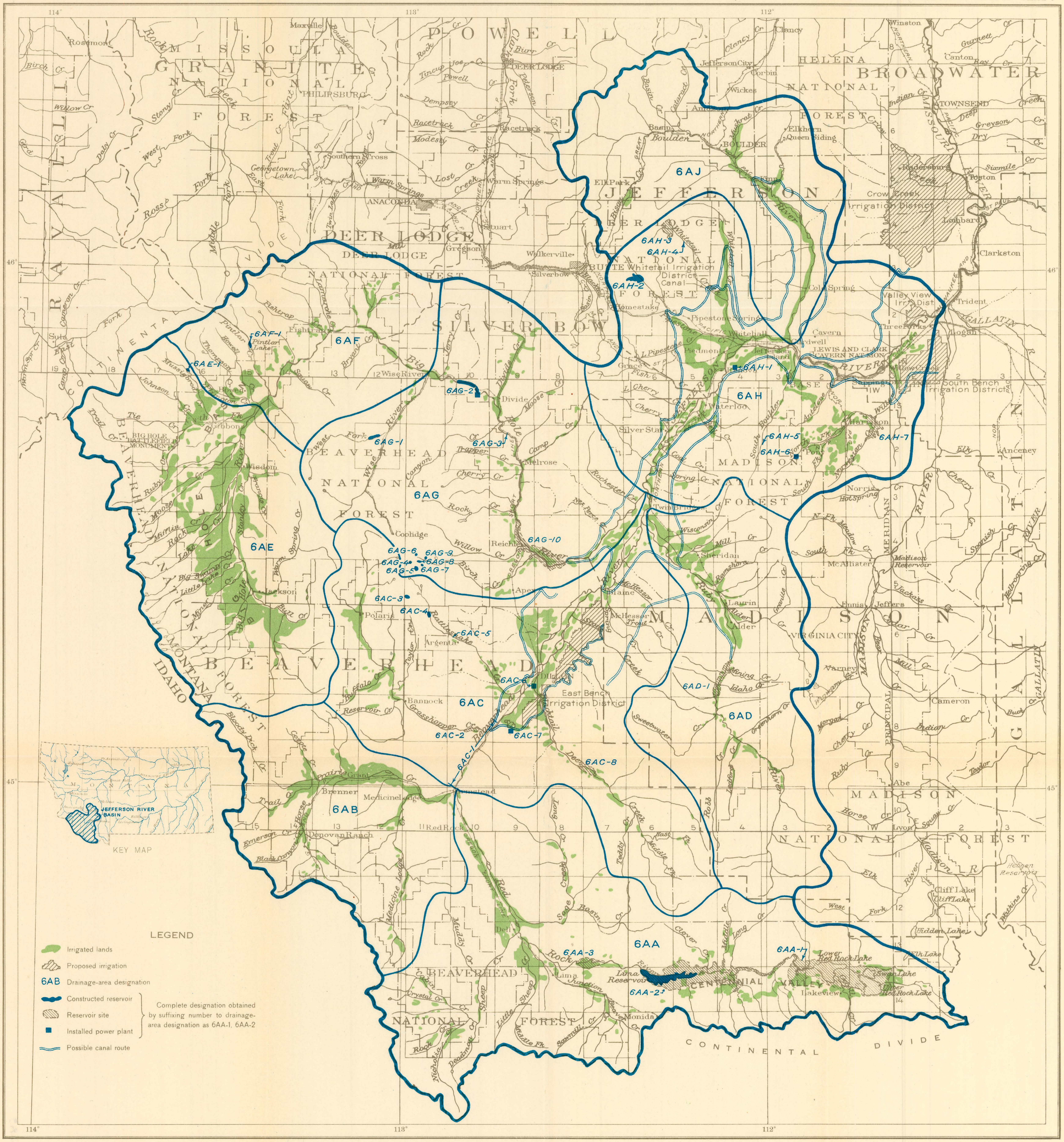
Jefferson River was discovered July 25, 1805, when the Federal Government expedition under the leadership of Lewis and Clark arrived at what is now known as Three Forks (pl. 3), at the mouth of the river. It was nearly 50 years later, however, before white settlers entered in large numbers, and they were largely miners attracted by the discovery of gold there in the early fifties. One of the chief gold discoveries was that of the auriferous gravel in Alder Gulch in T. 6 S., Rs. 3 and 4 W., and it is reported[3] that these placer deposits alone have yielded $40,000,000 in gold. To-day mining has ceased to be a material factor in the economic affairs of the region, and agriculture is the principal industry. The production of farm crops, however, is restricted almost entirely to certain relatively small areas where the physiographic, meteorologic, and stream-flow conditions are favorable to irrigation; the remainder of the area in general is used for grazing.

So far as transportation is concerned the region is reasonably well situated for marketing its products. The main lines of the Northern Pacific Railway and the Chicago, Milwaukee & St. Paul Railway run in a general westward direction across the basin, and a spur line of the Northern Pacific runs from Sappington to Harrison with extensions to Pony and to Norris, and another runs from Whitehall to Alder. The Great Northern Railway also crosses the extreme north end of the basin, at the headwaters of Boulder River. The Oregon Short Line runs approximately through the center of the basin. The Gilmore & Pittsburgh Railroad, along Horse Prairie Creek, and the Montana Southern Railway, a private line along Big Hole and Wise Rivers, complete the list of constructed railroads.

In addition to the railroads the area is traversed by an interconnecting highway system consisting of four well-marked "trails" and many other roads that are in good condition for travel during most of the year. The marked highways and their general routes are as follows:

1. Yellowstone Trail (part of National Parks Highway), from Three Forks to Harrison and Whitehall, thence westward across the Continental Divide to Butte.
2. Vigilante Trail (part of Banff-Grand Canyon Road), from Helena to Boulder, thence to Butte, returning to the Jefferson River Valley by the same route as the Yellowstone Trail but turning south about 7 miles from Whitehall and proceeding south up Jefferson River to Twin Bridges, thence up Ruby River and Alder Gulch to Virginia City, thence across the divide into the Madison River Basin.
3. Geysers to Glacier Trail, from Three Forks to Cold Spring, thence up Boulder River to Boulder, thence to Helena.
4. Great White Way, from Norris to Harrison, thence to the mouth of Boulder River and up that river to Cold Spring, thence along Geysers to Glacier Trail.

[3] Winchell, A. N., The mining districts of the Dillon quadrangle, Montana: U. S. Geol. Survey Bull. 574, p. 57, 1914.



MAP OF JEFFERSON RIVER BASIN, MONTANA

Scale $\frac{1}{500\,000}$

0 10 20 30 Miles

0 10 20 30 40 Kilometers

1926

GEOGRAPHY AND PHYSIOGRAPHY

The Jefferson is one of three rivers that meet at Three Forks, Mont., to form Missouri River; the other two are Madison and Gallatin Rivers. Geographers refer to Jefferson River as the continuation of the main channel above Three Forks. It is approximately 60 miles long from its mouth to the junction of Beaverhead and Big Hole Rivers. Thence the main river stem is Beaverhead River, the head of which lies at a point 56 miles farther upstream, at the junction of Red Rock River and Horse Prairie Creek. Above this point Red Rock River is called the main stem and is the ultimate source of the Mississippi-Missouri River system, which is the longest river channel in the world, having a total length of 4,220 miles. The Jefferson River Basin lies in the extreme southwest corner of Montana and has a total length of about 140 miles in a north-south direction and 115 miles in an east-west direction. (See pl. 3.) The drainage area, which covers about 10,000 square miles, consists for the most part of rugged mountain ranges with a few open valley areas that have been filled to considerable depths by lacustrine and fluviatile deposits. These valleys contain most of the arable land, but the mountains are also important as catchment areas for the precipitation that yields the water necessary for the development of the valleys.

For convenience the discussion of each subject in this paper is arranged in accordance with the standard practice in publishing stream-flow records in the Geological Survey, the main river stem being described first, and then the tributaries in order from the headwaters of the basin downstream

MAIN RIVER STEM

Red Rock River drains an area of 1,580 square miles, about half of which lies on the slopes of the Continental Divide, the river being parallel to this divide throughout its course. Its headwaters are tributary to a mountain park area in T. 14 S., R. 1 E., locally called Alaska Basin. This park is about 5 miles long and 1 mile in maximum width. It is surrounded by high mountains except at its west end, where a short, narrow outlet serves as a passage for Red Rock River into Centennial Valley, an east-west valley that extends 36 miles through Tps. 13 and 14 S., Rs. 1 to 6 W., with an average width of 6 miles. The altitude of Centennial Valley is about 6,600 feet and it is nearly level along the central axis, the gradient being only about 2 feet to the mile. The valley floor has an area of about 100,000 acres. Three large bodies of water, upper and lower Red Rock and Swan Lakes, lie near its upper end. The surface area of these lakes is 3,130, 3,820, and 830 acres respectively, and their combined area, including adjacent and intervening swamp lands, is 22.5 square miles.

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Lower Red Rock Lake is shallow, its maximum depth being only 5 or 6 feet. Upper Red Rock Lake has a maximum depth of about 20 feet. Below lower Red Rock Lake Red Rock River is a sluggish aggrading stream, following a winding course to the lower end of Centennial Valley. Thence through a narrow rock gorge less than 1 mile in length it flows into lower Red Rock Valley, which extends 42 miles westward and northwestward to Horse Prairie Creek, in T. 10 S., R. 10 W. This valley is bounded on the east by relatively low hills and mountains, but on the west a bold rocky range rises about 2,000 feet above it. Its broadest section lies near the upper end, where the flood plain and adjoining benches have a total width of about 4 miles. The lower half of the valley has an average width of 1½ miles. The altitude of the valley floor averages about 6,000 feet, ranging from about 6,400 feet near its upper end to 5,600 feet at the mouth of the river. The bottom lands and the arable portions of the adjoining benches have an estimated combined area of 50,000 acres.

The confluence of Red Rock River and Horse Prairie Creek forms Beaverhead River, which becomes the main stem of the Mississippi-Missouri River system. From this point a canyon section extends downstream 13.8 miles, to a point near the south line of sec. 17, T. 8 S., R. 9 W. The average width of this canyon is nearly a quarter of a mile, and the gradient of the river through it is about 13 feet to the mile. At the end of the canyon Beaverhead River enters a broad open valley that extends downstream 25 miles to the Point of Rocks, in sec. 22, T. 5 S., R. 7 W. This area is locally called Dillon Valley. Its altitude ranges from nearly 4,900 feet above sea level at the lower end to about 6,000 feet on reentrants that extend up Rattlesnake and Blacktail Deer Creeks into the bordering hills and mountains near the head of the valley. On each side of Dillon Valley are large areas of terraced bench lands, and those on the right extend without interruption down past the Point of Rocks nearly to the mouth of Beaverhead River. At the Point of Rocks Beaverhead River passes through a narrow aperture between two rocky points that form a conspicuous landmark in that region; the one on the left is called Beaverhead Rock. The river continues thence a distance of 18 miles through a large open, gently sloping plains area to its confluence with Big Hole River. The total area tributary to Beaverhead River is about 4,880 square miles.

Beaverhead and Big Hole Rivers unite to form Jefferson River. The plains area in which the junction lies will be called the Upper Jefferson Valley, as it is the upper one of two physically similar basins traversed by the main Jefferson River stem. Besides the lower 18 miles of the Beaverhead River channel the valley contains 32 miles of Jefferson River, which follows a meandering course with a fall of only about 4 feet to the mile. The valley has an average width of about 6 miles, and the flood-plain area is about 2 miles wide. The surficial cover of the flood plain near the junction of Beaverhead and Big Hole Rivers is composed of material ranging from gravel to cobblestones with very little soil. Toward the lower end of the valley the flood plain is dissected in places by numerous sloughs and overflow channels that form islands which are subject to flooding during periods of high water. Adjoining the flood plain are extensive areas of bench lands that generally have a coarse gravel soil, the principal exception being on the right or south side in T. 1 N., Rs. 3 and 4 W., where the soil is a fertile sandy loam. The altitude in the valley ranges from about 4,300 to 5,000 feet above sea level; the bordering mountains on each side rise abruptly to 10,000 feet. From this upper valley Jefferson River flows into a narrow box canyon about 3 miles long, thence through the lower Jefferson Valley for about 25 miles to its mouth at Three Forks. The fall of the river through the lower valley is nearly three times as great as in the upper valley and the flood plain is narrower. The bench lands adjoining the flood plain, however, are more extensive. The altitude of the lower valley ranges from 4,000 to 4,600 feet.

TRIBUTARIES

The principal tributaries of Red Rock River are Elk, Odell, Long, and Clover Creeks in Centennial Valley and Junction, Sheep, and Sage Creeks in lower Red Rock Valley. With the exception of Sheep and Sage Creeks these tributaries are comparatively short and have steep gradients for the most part and relatively small drainage basins. Sheep Creek drains about 300 square miles comprising the extreme westerly portion of Red Rock Basin. That area is almost completely surrounded by mountains, high peaks of the Continental Divide forming a semicircle on the south and west, and lower but equally rugged mountains of the Sheep Creek Range nearly closing it in on the north and east. The upper part of the drainage area includes a mountain park called Sheep Creek Basin, which has an altitude of about 6,800 feet and covers 50 to 75 square miles of slightly rolling valley lands dissected by Sheep Creek and numerous tributaries. Within this basin are extensive areas of wet meadow lands. At its lower end Sheep Creek enters a canyon cut deeply into the Sheep Creek Mountains, in which it continues for 12 to 14 miles to the lower Red Rock Valley. Sage Creek drains an area of about 225 square miles comprising the northerly portion of Red Rock Basin. The area consists of high hills and low mountains inclosing at the headwaters a basin which is similar in characteristics to Centennial Valley and Sheep Creek Basin but much smaller.

Horse Prairie Creek enters lower Red Rock Valley through a break in the hills on the west side and is the first large tributary to the Beaverhead River section of the main river stem. It drains an area of 712 square miles, including a section of the Continental Divide 64 miles in length. Its basin includes one main valley area that contains most of the arable land, which begins less than a mile above the mouth of the creek and extends upstream about 22 miles. The maximum width of this valley is nearly 3 miles. A valley also occurs along Medicine Lodge Creek, a tributary to Horse Prairie Creek, but it is a long, narrow trough that contains only a small area of cultivable land. The remainder of the basin is almost entirely mountainous with practically no cultivable land. All the cultivable land in this basin lies at an altitude higher than 6,000 feet.

The chief tributaries of Beaverhead River below Horse Prairie Creek are Grasshopper, Rattlesnake, and Blacktail Deer Creeks and Ruby River. The drainage area of Grasshopper Creek covers about 335 square miles and is mostly mountainous. The lower 12 miles of the stream lies in a narrow rock-walled canyon, above which an open valley extends nearly to the headwaters. The valley is narrow for the most part but attains a maximum width, including the adjoining benches, of about 4 miles in the vicinity of Polaris, in T. 6 S., Rs. 12 and 13 W. The cultivable lands are practically limited to this open valley section and have an average altitude of about 6,000 feet.

Rattlesnake Creek has a drainage basin covering about 150 square miles, the upper part of which is a mountainous area ranging in altitude from 7,000 to 10,000 feet or more above sea level. In the mountain section the creek channel lies in a deep, narrow V-shaped valley with a gradient of 100 to 200 feet to the mile, which terminates at a point in sec. 30, T. 6 S., R. 10 W., near an old, almost abandoned mining camp called Argenta. The river there enters the open plains area that is part of Dillon Valley. The only noteworthy areas of cultivable land are in the creek flood plain of this plains area.

Blacktail Deer Creek drains an area of 427 square miles. The general topography of its basin is similar to that of the Rattlesnake Creek basin except that the mountainous area has a lower average altitude and is somewhat less rugged. The main channel of the creek now enters Beaverhead River from the right through the town of Dillon, but formerly the mouth of the stream was located at a point 7 miles upstream from Dillon. This change in the course of the creek was made by local interests in connection with water utilization.

The lowest tributary to Beaverhead River is Ruby River, which has a drainage area of 1,540 square miles. The lower 22 miles of its course lies in a broad, open valley which forms a salient to upper Jefferson Valley. The remainder of the area is grazing land and is mountainous for the most part, the principal exception being an area of about 7 square miles in Sweetwater Basin, which lies at an altitude of 6,400 to 7,000 feet and is valuable for grazing only.

Big Hole River is the largest tributary to the main stem of the Missouri system in the area under discussion. It has a drainage area of about 2,960 square miles, including a rugged mountainous tract that forms part of the Continental Divide, which parallels the river on the left side of its basin in a nearly semicircular course for 180 miles. On the right side of the basin is a similarly rugged mountainous area which forms the divide separating the Big Hole and Beaverhead River basins. Most of the nonmountainous land of this drainage area lies in a section called Big Hole Basin, a gently sloping plain that extends nearly 40 miles from north to south, has a maximum width of 12 to 15 miles, and is unbroken except by shallow drainage channels. The average altitude in this area is approximately 6,000 feet.

Big Hole Basin ends in T. 1 N., R. 14 W., where the river flows into a valley averaging nearly 1 mile in width that extends down to a point just below the mouth of Wise River. At this point the river enters a narrow rock-walled box canyon, which continues for about 8 miles. Thence the river flows through a narrow deep valley past Divide Creek and enters another canyon section somewhat less than 5 miles in length. Below the second canyon section the river enters a valley that extends to a narrows in sec. 3, T. 5 S., R. 8 W., which affords an excellent cross section for a dam site. Below this dam site the river flows in a narrow valley for several miles and thence crosses upper Jefferson Valley to its confluence with the Beaverhead to form Jefferson River. Wise River is the principal tributary of Big Hole River and has a drainage area of 266 square miles, composed almost entirely of rugged mountains. The Big Hole receives numerous other tributaries whose drainage areas are smaller than that of Wise River but have for the most part a similarly rugged topography.

The principal tributaries to Jefferson River are Pipestone, Whitetail, and South Boulder Creeks and Boulder River, which enter the river in the upper valley, and Willow Creek, which enters it in the lower valley.

Pipestone Creek has a drainage area of 169 square miles. Its headwaters lie in a rough mountainous country which forms part of the Continental Divide and reaches a maximum altitude of about 8,000 feet; the lower part of its basin consists of terraces forming part of the west side of upper Jefferson Valley.

Whitetail Creek has a drainage area of 162 square miles, which adjoins that of Pipestone Creek on the north, both streams discharging into Jefferson River at points less than 1 mile apart. The physiography of the two basins is similar. A mountain meadow-land area called Upper Whitetail Park lies at the headwaters of Whitetail Creek, and 12 miles above its mouth the creek flows through a second park called Lower Whitetail Park. A third open parklike area known as Whitetail Basin lies at the headwaters of its principal tributary, Little Whitetail Creek. Between Upper and Lower Whitetail Parks the creek flows in a deep, narrow canyon 8 miles long with a fall of about 300 feet to the mile.

Boulder River has a drainage area of about 760 square miles, including a long narrow valley that begins near its mouth and extends upstream about 30 miles, to a point near the town of Boulder, also a mountainous section of the Continental Divide 47 miles in length. South Boulder Creek has a drainage area of 86 square miles that is almost entirely mountainous, the only notable exception being a rather small area of alluvial bottom land near its mouth. The mountainous section of this basin extends to altitudes greater than 10,000 feet.

Willow Creek drains an area of 188 square miles, which is unlike the basins of the other tributaries of Jefferson River in that only a small section of it is mountainous. Most of this area is composed of bench lands on the south side of lower Jefferson Valley, which have a good soil and lie at an altitude ranging from 4,400 to 5,400 feet.

METEOROLOGY

Meteorologic records have been obtained by the United States Weather Bureau at 14 stations in or near the Jefferson River Basin. These records indicate that the rainfall on the arable lands in general is inadequate to provide the moisture required for producing diversified farm crops; that the length of the growing season varies widely and is adequate for producing even a small variety of crops only at certain favorably located places; and that the winters are long and severely cold, necessitating protection from ice interference in the operation of hydroelectric power plants. For the purpose of the present report the records of rainfall and length of growing season are the most important meteorologic data, and the available figures are given at the end of the report, but for convenient reference a summary of them is given in Table 3. Temperature records are not included in the meteorologic data given on pages 87–93, but examination of them in Weather Bureau publications shows that during the winter there are long periods when the temperature is below the freezing point, a condition which may affect the operation of power plants. However, ice cover on the forebay storage reservoir forms an effective blanket below which is water free from ice that can be drawn for operating waterpower plants, and under such conditions there is little ice difficulty except during the spring break-up, when the ice is leaving the reservoir.

TABLE 3.—*Summary of meteorologic data for Jefferson River Basin, Mont.*

Station	Location	Period of record	Altitude (feet)	Mean annual rainfall (inches)	Average length of growing season (days)
Boulder	T. 6 N., R. 4 W.	1891–1919	4,920	12.29	72
Bowen	T. 1 S., R. 15 W.	1906–1921	6,060	12.31	(a)
Brenner	T. 10 S., R. 13 W.	1914–1925	5,900	11.31	67
Dell	T. 13 S., R. 9 W.	1898–1902 1917–1923	6,014	8.14	63
Dillon	T. 7 S., R. 8 W.	1898–1925	5,147	16.95	98
Homepark	T. 8 S., R. 4 W.	1905–1910	[b] 5,800	15.60	(c)
Lima	T. 14 S., R. 8 W.	1914–1916	6,256	11.29	70
Norris	T. 3 S., R. 1 W.	1908–1925	4,845	17.27	136
Pipestone Dam	T. 3 N., R. 6 W.	1923–1925	5,800	12.39	84
Pipestone Pass	T. 2 N., R. 7 W.	1909–1913	5,800	18.84	44
Renova	T. 1 N., R. 4 W.	1898–1925	4,383	12.00	108
Three Forks (near)	T. 2 N., R. 1 E.	1914–1922	4,400	12.19	117
Twin Bridges	T. 3 S., R. 6 W.	1902–1907	[b] 4,580	8.50	(c)
Virginia City	T. 6 S., R. 3 W.	1871–1925	5,880	14.19	104

[a] Frost every month.
[b] Approximate.
[c] No record.

The Lima and Dell stations are located in the trough of lower Red Rock Valley, and these stations are the highest along the main stem of the Mississippi-Missouri River system. These two stations are less than 8 miles apart, and the meteorologic conditions are nearly identical at both. The records show a mean annual rainfall in lower Red Rock Valley ranging from 8.14 to 11.29 inches and a growing season ranging from 63 to 70 days. In Centennial Valley the higher altitude is conducive to a shorter growing season and higher rainfall, but data obtained in the field by the writers indicate that the difference is probably small.

The next station of the Weather Bureau downstream along the main river stem is at Dillon, in the trough of Dillon Valley, where the conditions for crop production are probably the most unfavorable in that area with respect to rainfall and length of growing season. The Renova and Three Forks records show a progressively longer growing season downstream from Dillon Valley to the mouth of Jefferson River.

The record at Norris indicates a more favorable climate for crop production than at any other of the 14 stations listed in Table 3, in that it shows the highest rainfall and longest growing season. The station lies outside the Jefferson River Basin, but its record shows meteorologic conditions similar to those prevailing on the south-side bench lands of lower Jefferson Valley. It is interesting to compare this record with that at Three Forks, where, although the altitude is several hundred feet lower, yet the season is nearly three weeks shorter, owing to the fact that Three Forks lies in the trough of the valley. where air drainage is less efficient and the liability to frost much greater.

The Bowen station is near the north end of Big Hole Basin, and its altitude is about the same as that of the greater part of that basin. The records of this station should therefore indicate nearly average climatic conditions throughout the basin. At points down Big Hole River from Bowen the growing season increases in length, reaching a maximum at the mouth of the stream, at the head of upper Jefferson Valley, where its length is probably a median between that of 97 days at Dillon and that of 108 days at Renova.

WATER SUPPLY

A list of gaging stations that have been maintained in the Jefferson River Basin by the United States Geological Survey and cooperating organizations or persons is given below. The relation of the tributaries to the main stream is shown by indention. A dash after the last date in a line indicates that the station is still being maintained. Detailed descriptions of the stations, with tables showing the monthly maximum, minimum, and mean discharge in second-feet and the run-off in acre-feet, are given on pages 93–113.

Red Rock River (head of Missouri River) above Red Rock Reservoir, near Monida, Mont., 1911; 1914–15.
Red Rock River below Red Rock Reservoir, near Monida, Mont., 1911–1918.
Red Rock River at Lima, Mont., 1907–1911.
Red Rock River at Red Rock, Mont., 1890.
Beaverhead River (continuation of Red Rock River) at Barratts, Mont., 1907–
Jefferson River (continuation of Red Rock and Beaverhead Rivers) near Silver Star, Mont., 1910–1916, 1920–
Jefferson River (continuation of Red Rock and Beaverhead Rivers) near Sappington, Mont., 1894–1905.
Tributaries:
- Grasshopper Creek near Dillon, Mont., 1921–
- Ruby River near Alder, Mont., 1911–1914.
- Big Hole River near Dewey, Mont., 1910–1913.
- Big Hole River near Melrose, Mont., 1924–
- Pipestone Creek near Whitehall, Mont., 1910–11.
- Whitetail Creek near Whitehall, Mont., 1911.
    - Little Whitetail Creek near Whitehall, Mont., 1911.
- Boulder River near Basin, Mont., 1919–20.
- Boulder River at Basin, Mont., 1921–
    - Muskrat Creek near Boulder, Mont., 1912–1914.
- Willow Creek near Willow Creek, Mont., 1919–

Table 4 shows the mean monthly flow computed from the records for all the above-listed stations for which continuous records for a period of 12 months are available. The table also shows the mean monthly flow of Jefferson River as measured at the Silver Star gaging station with estimates for January and February on the assumption that the flow in those months bears approximately the same relation to the total annual run-off as it does at the other stations for which records are available. Another assumption that has been made in preparing the table is that the records of Red Rock River at Lima and near Monida were obtained at the same point, whereas the Lima record shows the run-off from a drainage area nearly 10 per cent larger than that tributary to the Monida station. This additional drainage area, however, does not materially increase the run-off, and the error that may be due to the assumption is largely offset by irrigation diversions between the two stations. The advantage in the combination of these records lies in the fact that they afford a continuous record showing the flow of Red Rock River at a point near the Lima Reservoir (6AA–2) during the years 1908 to 1918. The records subsequent to May 1, 1911, were obtained at a weir installed 150 yards below the Lima Dam (6AA–2). At high-water stages the stilling pool above this weir is filled with rocks and pebbles, and then a strong velocity of approach occurs and introduces errors in the computations of discharge.

TABLE 4.—*Summary of stream-flow data for Jefferson River Basin, Mont.*

Gaging station	Period of record	Drainage area (square miles)	Mean run-off (acre-feet)						
			Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Red Rock River near Monida and at Lima	1908–1918	560	14,000	10,300	3,530	2,210	2,120	2,360	21,400
Beaverhead River at Barratts	1907–1923	2,800	29,100	29,700	23,200	20,000	16,500	25,100	41,000
Jefferson River at Silver Star	1910–1916, 1920–1923	7,940	83,200	87,100	77,200	[a] 64,700	[a] 57,400	71,300	152,000
Jefferson River at Sappington	1896–1905	9,500	68,700	96,500	97,400	96,100	108,000	92,700	148,000
Grasshopper Creek near Dillon	1921–1923	360	1,980	2,250	1,650	2,120	1,390	2,100	5,150
Big Hole River near Dewey	1911–1913	1,990	31,800	25,800	18,800	18,400	13,900	17,700	67,800
Pipestone Creek near Whitehall	1910–1911	115	[b] 114	493	769	615	666	873	1,290
Muskrat Creek near Boulder	1912–1914	7	218	169	62	84	57	56	163
Willow Creek near Willow Creek	1919–1923	167	2,340	2,580	2,760	1,230	1,560	2,310	3,040

Gaging station	Period of record	Drainage area (square miles)	Mean run-off (acre-feet)						Mean annual run-off per square mile (acre-feet)
			May	June	July	Aug.	Sept.	Total	
Red Rock River near Monida and at Lima	1908–1918	560	36,700	26,300	10,600	7,140	9,710	146,000	279
Beaverhead River at Barratts	1907–1923	2,800	61,800	63,900	25,100	21,500	20,100	377,000	135
Jefferson River at Silver Star	1910–1916, 1920–1923	7,940	300,000	409,000	141,999	60,700	65,400	1,570,000	198
Jefferson River at Sappington	1896–1905	9,500	333,000	326,000	149,000	52,000	49,400	1,620,000	171
Grasshopper Creek near Dillon	1921–1923	360	9,790	14,400	3,170	2,230	1,680	47,900	133
Big Hole River near Dewey	1911–1913	1,990	211,000	391,000	123,000	45,500	28,600	993,000	500
Pipestone Creek near Whitehall	1910–1911	115	2,430	3,200	383	138	83	11,000	96
Muskrat Creek near Boulder	1912–1914	7	589	885	324	149	119	2,880	410
Willow Creek near Willow Creek	1919–1923	167	3,940	8,090	5,560	2,200	1,860	37,500	225

[a] Estimated. [b] 19 days only.

The station on Beaverhead River at Barratts is one of the most important in connection with the present discussion. It shows the flow of the main stem of the Mississippi-Missouri River system at the head of Dillon Valley, which is the first area from the headwaters downstream in which meteorologic conditions permit general farm development. During portions of the irrigation season the entire flow of the river is diverted for irrigation in Dillon Valley, and the record at the gaging station is especially useful in studies of water utilization for that area.

The Silver Star and Sappington stations are the only others on the main river stem. The drainage area tributary to the river above Sappington is nearly 20 per cent greater than that above Silver Star, yet the run-off is only 3 per cent greater. This apparent anomaly is probably due in part to the fact that the period of record at the lower station was one of low run-off, so that the records are not strictly comparable, but irrigation diversions between the two stations further tend to offset the natural increase in flow due to the increase in drainage area. Furthermore, most of the high mountain area, in which the precipitation is greatest and which yields the highest rate of run-off, lies above the Silver Star station. The record at the lower station is an approximate indication of the surplus flow in Jefferson River after practically all diversions in the basin have been satisfied.

The Grasshopper Creek record shows the flow through the Grasshopper Reservoir site (6AC–2). The winter record at this station is complete for the year ending September 30, 1923, only. This creek is tributary to Beaverhead River above Barratts, and the record for 1923 at the Barratts station was nearly 11 per cent below normal for the period of record at that station. Hence estimates of water supply available for storage in the Grasshopper Creek Reservoir based on the data in Table 4 should be reasonably safe.

Rattlesnake Creek is one of the streams discussed in this report for which no records have been obtained by the Geological Survey. The only available information relative to its flow was obtained from a water master appointed to enforce the distribution of the water of the creek in accordance with a decree adjudicating the rights to it. This information consists in part of discharge measurements made in the course of the regular duties of the water master during the irrigation season, supplemented by general observations during the nonirrigation season. It appears that 140 second-feet is required to satisfy the decree rights and that the flow of the creek is usually sufficient to meet the demand under these rights during May and June, but that during July and August the flow decreases to about 50 second-feet, part of which is believed to be obtained from storage at the headwaters of the creek. On June 15, 1923, the flow was only about 75 second-feet, and the discharge during the winter is said to average about 10 second-feet. These data are reasonably trustworthy in so far as they relate to the low-water flow during the irrigation season, because for that period actual measurements are necessary. The drainage area tributary to the creek above Argenta, in sec. 30, T. 6 S., R. 10 W., near the point of observation by the water master, is about 50 square miles, and its unit run-off may be approximately comparable to that of Grasshopper Creek. The record from October, 1922, to March, 1923, on Grasshopper Creek shows a mean discharge of less than 0.1 second-foot per square mile. If the rate of discharge from the Rattlesnake Creek Basin was the same the flow at Argenta during the same period was less than 5-second-feet. It is believed that the mean winter discharge of Rattlesnake Creek at Argenta is probably not less than 5 or more than 10 second-feet.

No records of the flow of Blacktail Deer Creek are available, and the only point for which such records would be useful in the present report is in sec. 24, T. 9 S., R. 8 W., at the Blacktail Deer Reservoir site (6AC–8). The drainage area tributary to the creek at this point is 300 square miles, and the unit run-off per square mile from that area may be approximately comparable to that tributary to Beaverhead River at Barratts, or 135 acre-feet per square mile. With such a unit run-off more than 40,000 acre-feet a year would be derived from a drainage area of 300 square miles.

The available records for Ruby River cover portions of the period from May, 1911, to June, 1914, and were obtained at a point near the Ruby Reservoir dam site (6AD–1). These records show a mean run-off of 135,000 acre-feet during the period April to December, inclusive. No data are available for the months of January, February, and March. It is estimated on the basis of the record of Beaverhead River at Barratts and general information relative to the two drainage areas that the flow during these months probably does not exceed 16 per cent of that for the remainder of the year; hence the total annual flow may be approximately 161,000 acre-feet.

The record for Big Hole River at Dewey is complete for 1910–11 only, but during that year the rainfall at Brenner was only 2 per cent above normal, and it is likely that the total annual run-off as measured at Divide is an approximate indication of the normal stream flow. A new station was established in March, 1924, near Melrose, in sec. 27, T. 3 S., R. 9 W., to determine the water supply available for storage at the Big Hole Reservoir site (6AG–10). The record for this station now available, however, covers only a part of one year. In addition to these data the Montana Power Co. has obtained stream flow records at the Divide power plant (6AG–2). The records show the flow through the turbine water wheels of the plant and the discharge over the spillway. They do not include losses by leakage through the dam, which have been estimated at 100 second-feet during low-water periods and probably more at flood stages. These power plant records have therefore been used only in estimating the flow at the power house during 90 per cent and 50 per cent of the time, the assumption being made that the leakage of 100 second-feet is constant. The fact that the flood-season leakage is larger would have no effect on the estimates of flow for 90 per cent and 50 per cent of the time.

The available record for Pipestone Creek is nearly complete for the year ending September 30, 1911. The rainfall records for this year at Renova and Pipestone Pass show a precipitation somewhat below normal, and run-off records for that year should furnish a conservative indication of normal water-supply conditions.

Records of the flow of Willow Creek are being obtained for the purpose of determining the water supply available for storage at the Willow Creek Reservoir site (6AH–7). The available data indicate that the total run-off from October 1 to June 1 amounted to 19,000 acre-feet in one year and 26,800 acre-feet in the other. With the possible exception of part of the May run-off it is believed that all of the flow during the months October to May, inclusive, can be stored in the proposed reservoir, and probably any of the May flow released to satisfy irrigation demands in that month could be offset by surplus flood water in June. The Norris precipitation record is fairly indicative of rainfall in the drainage area tributary to Willow Creek, and from that record it appears that during the winter periods covered by available run-off records the rainfall was below normal, and therefore the run-off also may have been less than normal.

STORAGE

Owing to the wide seasonal fluctuation in the rate of run-off, development involving the diversion and use of water in the Jefferson River Basin is in a large measure dependent upon the storage available for regulating the stream flow. The census report for 1920, shows that 59 reservoirs had been built in this drainage area, 34 of which are in the Beaverhead River Basin. Data available to the writers obtained independently as well as in the course of the field examination on which this paper is based cover the larger developed and undeveloped reservoir sites. Reservoir sites having a capacity of less than 500 acre-feet in general have been ignored except in so far as data relative to them were obtained together with data relative to larger developments. The present discussion therefore does not embrace all the 59 reservoirs listed by the Census Bureau. The principal developed storage sites for which no detailed data are available are reservoirs on two tributaries of Ruby River (Wisconsin and Mill Creeks) and two reservoirs at the headwaters of Big Hole River (Mussigbrod and Pintlar Lake). General information available to the writers indicates that on Wisconsin and Mill Creeks 12 reservoirs with an aggregate capacity of about 11,000 acre-feet have been built. The Mussigbrod Reservoir (6AE–1) has a capacity of about 2,000 acre-feet; the capacity of the Pintlar Lake Reservoir (6AF–1) is not known.

RESERVOIRS

Lima Reservoir (6AA–2).—At the lower end of Centennial Valley in lot 2, sec. 32, T. 13 S., R. 6 W., an earth-fill dam 50 feet high has been constructed in the narrows leading to lower Red Rock Valley, creating a reservoir which has a surface area of about 2,460 acres. Its capacity, according to the construction engineer, is 86,600 acre-feet when storing water to a depth of 45 feet, which requires 5 feet of flashboards in the spillway. This capacity is said to have been determined by emptying the reservoir when full and measuring both the inflow and the outflow. The effective capacity, according to records filed in the General Land Office by the present owners of the reservoir, is 57,000 acre-feet. A study of available stream-flow records shows that the spring and summer of 1919 was one of the driest periods in the history of Montana. The reservoir caretaker informed the writers that filling of the reservoir was completed and storage discontinued on April 25 in that year and reservoir water was first released on May 27. During the succeeding three months the reservoir was emptied, the measured outflow being 25,100 acre-feet, while the inflow was practically nothing. The effective capacity of the reservoir in 1919, therefore, apparently did not exceed about 25,000 acre-feet. Critical study of available records for other years tends to confirm the conclusion based on the record for 1919 or at least to show that the effective capacity of the reservoir is materially less than is generally estimated by its owners. The winter flow of Red Rock River is more than adequate to fill a reservoir of a larger capacity than the present Lima Reservoir. On page 65 will be found a reference to the potential storage capacity of this site.

The development of the Lima site was first undertaken in 1889, but the dam constructed at that time was washed out in 1890 or 1891. The history of this first undertaking is obscure, and it has not been determined whether the destruction of the dam was due to faulty construction or to action by persons who regarded the structure as unsafe. Surveys for the present structure were commenced December 10, 1901, and construction was completed July 30, 1909. The reservoir was designed to supply an area of raw lands at the upper end of lower Red Rock Valley, but the canal to serve these lands has not been completed. It is reported that a considerable amount of the water stored in 1909 was released in the dry summer of 1910, and that on several other occasions between 1909 and 1919 reservoir water was sold to settlers whose normal supply from stream flow was short. After a dry season that caused an acute water shortage throughout the region, an association composed of water users in lower Red Rock and Beaverhead Valleys purchased the reservoir, and since the summer of 1919 it has been operated to store water for the irrigators of this association.

A question regarding the efficiency of storage on Red Rock River for use in Dillon Valley is understood to have been raised in the minds of some residents of that valley by their observation of the heavy loss in the flow of the river that occurs in lower Red Rock Valley. This loss can be readily detected in a section which begins about 6 miles below Dell, but a measurement made by the writers on July 13, 1923, at Kidd, in sec. 7, T. 12 S., R. 9 W., when compared with the flow measured on the same date at the gaging station of the Geological Survey on Beaverhead River at Barratts showed an increase in flow between the two points amounting to 320 second-feet. Part of this increase comes from Horse Prairie and Grasshopper Creeks, which had a combined flow of 172 second-feet on that date. Some other inflow, which was not measured, was received from the drainage area tributary to Red Rock and Beaverhead Rivers between Kidd and Barratts, but it is believed that the total amount of such inflow did not exceed 20 second-feet, a large part of which was derived from Warm Springs Creek. Of the total increase at Barratts, then, it appears that 128 second-feet was ground-water inflow, which is believed to be derived largely from underflow in lower Red Rock Valley that is returned to the river in Beaverhead Canyon. These data may be summarized as follows:

		Second-feet
Red Rock River at Kidd, July 13, 1923		112
Beaverhead River at Barratts, July 13, 1923		432
Increase from Kidd to Barratts		320
Surface inflow Kidd to Barratts:		
Horse Prairie Creek	102	
Grasshopper Creek	70	
Unmeasured (estimated)	20	
		192
Ground-water inflow		128

The opinion that the ground-water inflow is return water from seepage into lower Red Rock Valley is supported by the fact that Beaverhead Canyon is a rock-walled gorge whose sides are largely impervious to water. Furthermore, the canyon is narrow, and although it may have been considerably deeper at one time than now, yet the rate of movement of water through the detrital material underlying the present stream bed would be slow and almost negligible. Therefore, most of the underflow in lower Red Rock Valley necessarily would be forced to the surface in the canyon above Barratts.

Phillips and Esler Lake Reservoirs (6AC–4, 6AC–3).—Storage is provided at two points in the mountains at the headwaters of Rattlesnake Creek, in Phillips Reservoir, in T. 6 S., R. 11 W., and Esler Lake Reservoir, in T. 5 S., R. 11 W. The records on file in the Washington office of the Geological Survey indicate that the builders originally planned to construct the Phillips Reservoir to store 1,750 acre-feet and the Esler Lake Reservoir to store 2,700 acre-feet, but these quantities apparently are greater than the existing capacity as constructed. According to information obtained in the field the Phillips Reservoir Dam is 25 feet high and the capacity of the reservoir is 1,600 acre-feet, and the Esler Lake Dam is 30 feet high and the capacity of the reservoir 2,000 acre-feet. The stored water is used for irrigation along the lower portion of Grasshopper Creek, beginning at Argenta, in sec. 30, T. 6 S., R. 10 W., and continuing thence downstream.

Mussigbrod Reservoir (6AE–1).—A reservoir having a capacity of about 2,000 acre-feet has been constructed on Mussigbrod Creek in T. 1 N., R. 16 W., by building a dam 14 feet high at the outlet of Mussigbrod Lake. The water stored in this reservoir is used for irrigating land in Big Hole Basin.

Pintlar Lake Reservoir (6AF–1).—A reservoir in T. 1 N., R. 15 W., at Pintlar Lake, is also used to store water for irrigating land in Big Hole Basin, but no information relative to its capacity is available.

Wise River Reservoir (6AG–1).—A reservoir has been constructed on the West Fork of Wise River in T. 2 S., R. 12 W., to provide storage regulation for generating power at the Divide power plant, on Big Hole River in T. 1 S., R. 10 W. (6AG–2). Construction of the reservoir was completed about 1901 by building a dam of earth, rocks, and gravel to a height of 40 feet with a crest length of 410 feet. The estimated surface within the flow line of the reservoir is 538 acres, and its total capacity is 7,100 acre-feet. The abutments of the dam rest on slide-rock material, through which water percolates rapidly until the surface of the reservoir has been lowered to a point 15 feet above the bottom. The outlet is 9 feet above the bottom; hence the effective holding capacity lies between 9 and 15 feet above the bottom of the reservoir. The storage capacity between these levels is estimated at 296 acre-feet.

Practically all of the drainage area of the West Fork of Wise River lies above the reservoir, and provision has also been made to divert water from the main Wise River into the reservoir through a conduit 6,850 feet in length. The conduit is part in open ditch and part in flume. The ditch was constructed with a bottom width of 7 feet, a top width of 13 feet, a depth of 3 feet, and a fall of 13.2 feet to the mile. The flume is 4 feet wide and 2½ feet deep. From these data it is estimated that where maintained in good condition, the conduit will have a capacity of about 50 second-feet.

Under existing conditions the reservoir is of small value for regulating the stream flow. It is possible that these conditions can be remedied by extending a cut-off wall through the talus slope or otherwise preventing leakage and thus providing an effective storage capacity of 7,000 acre-feet. The drainage area of Wise River above the conduit is 136 square miles, and the West Fork has a drainage area of 72 square miles tributary to the reservoir, making a total of 208 square miles. The mean annual run-off at Dewey is 500 acre-feet per square mile (Table 4). The run-off from the drainage area tributary to this reservoir site would not be less and might be even higher. It is manifest, therefore, that the water supply is fully adequate to fill the reservoir to a capacity of 7,000 acre-feet.

Divide Reservoir (6AG–2).—At a point in Big Hole Canyon in sec. 11, T. 1 S., R. 10 W., a rock-filled crib dam 67 feet in effective height was erected in1899, primarily to create a head for generating power. The dam is 81 feet high above its foundation, has a crest length of 512 feet, and contains 39,100 cubic yards of material. The dam is an overflow structure at the left abutment, where a spillway weir has been constructed in the dam with its crest 10 feet below the top of the dam. The area within the flow line at the crest of the spillway is 130 acres, and the storage capacity 400 acre-feet. Provision has been made for placing flashboards in the spillway by means of which the area within the flow line can be increased to 140 acres and the storage capacity to 1,280 acre-feet. The lowest point in the outlet through the dam is 44 feet below the crest of the dam.

Construction of this dam was begun September 1, 1897,[4] and nearly completed in April, 1898, when a flood on Big Hole River caused a partial failure of the structure. Reconstruction of the dam was begun October 26, 1898, and completed April 16, 1899.[5] However, in common with many rock-filled crib dams the structure is not water-tight, and leakage estimated to amount to a minimum of 100 second-feet occurs constantly.

The foundations for the present structure extend to a depth of 14 feet below the original channel surface and rest on a clay material which apparently furnishes a satisfactory foundation for the type of dam now installed. No borings have been made at the dam site, and the depth to bedrock is not known. Such information is an essential prerequisite to the design of an impervious dam to replace the present structure and a determination of the cost of such a dam. Its main economic value would be for generating power.

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[4] Parker, M. S., Partial failure of timber crib dam of the Montana Power Co.: Assoc. Eng. Soc. Jour., vol. 22, p. 175, 1899.

[5] Harper, J. H., The reconstruction of the Big Hole Dam: Idem, vol. 24, p. 239, 1900.

Birch Creek (6AG).—In connection with an irrigation system for an area of 5,000 acres on the Beaverhead ranch, which lies for the most part on the bench between Beaverhead and Big Hole Rivers, six reservoirs have been constructed on Birch Creek, Tps. 4 and 5 S., R. 11 W., a tributary of Big Hole River near the lower end of its course. The following is a list of the reservoirs and their capacity as learned from local sources:

	Acre-feet		Acre-feet
Chain Lake (6AG–4)	60	May Lake (6AG–7)	70
Tubb Lake (6AG–5)	180	Fair Lake (6AG–8)	1, 600
Anchor Lake (6AG–6)	500	Boot Lake (6AG–9)	2, 000

Delmoe Park Reservoir (6AH–2).—The construction of a reservoir near the headwaters of Pipestone Creek, in unsurveyed T. 3 N., R. 6 W., was started in 1913. Data available in the Geological Survey indicate that a dam 80 feet high will create a reservoir with a capacity of 18,400 acre-feet. It further appears that the drainage area naturally tributary to the reservoir has been increased by building diversion canals from two creeks. With these canals in operation the run-off from a total drainage area of 36 square miles can be stored in the reservoir.

The stream-flow record for Pipestone Creek near Whitehall is nearly complete for the year ending September 30, 1911, and shows a run-off of 11,000 acre-feet from a drainage area of 115 square miles. The portion of this area tributary to the Delmoe Park Reservoir site, though only 36 square miles, probably yields at least half of the measured run-off from the area tributary to the river above the gaging station. It further appears that the measured flow may be less than the actual run-off, owing to the irrigation diversions above the station. These factors indicate that during a year such as 1911 probably 6,000 acre-feet could have been stored in this reservoir. Available rainfall data for the general region indicate that the precipitation in 1911 was somewhat below normal; hence any error in estimates based on the run-off record for that year probably occurs on the side of safety.

UNDEVELOPED STORAGE SITES

Red Rock Lakes (6AA–1).—At Metzel's Ford, in the SW. ¼ sec. 26, T. 13 S., R. 3 W., about 3 miles below the outlet of lower Red Rock Lake, an embankment about 6 feet high and 300 feet long would create a reservoir having an area of 22,000 acres and an estimated capacity of 90,000 acre-feet. Of this area about 7,800 acres is now occupied by upper and lower Red Rock Lakes and Swan Lake, and about 6,600 acres by swamp. Under present conditions there is a heavy loss by evaporation and transpiration from the water surface and swamp within the flow line of such a reservoir—probably heavier than would occur from the surface of the reservoir flooding the entire area. This dam site is located on a lava flow that apparently extends completely across Centennial Valley and forms an obstruction that is believed to have produced the Red Rock Lakes. It is estimated from the records at Lima and Monida (Table 4) and simultaneous records above and below the Red Rock Reservoir given on pages 94–95 that about 80,000 acre-feet may be available for storage in the Red Rock Lakes during a normal year.

The 22.5 square miles of lake surface and marsh lands included in the Red Rock and Swan Lakes area presents a somewhat unusual problem in the conservation of water, which is distinct from storage development but may be so solved as to produce similar benefits to the water user. Records of evaporation and transpiration losses, obtained by the Geological Survey in the Mud Lake Basin, Idaho, show an annual loss from an open body of water of 37.8 inches, and from tule beds of 51 to 63 inches. The evaporation from open water surface at Red Rock Lakes may be comparable to that at Mud Lake, but the transpiration loss will occur for the most part from sedges and marsh grasses with only small areas of tule and will be less than at Mud Lake. It is estimated that the combined evaporation and transpiration loss over the entire 22.5 square miles within the Red Rock Lakes and marsh area is about 40 inches in depth annually, or approximately 48,000 acre-feet. In the flood plain of Red Rock River between the lakes and the lower end of Centennial Valley there is an additional area of marsh lands from which the transpiration may increase this loss to 50,000 acre-feet.

By building a dike at the outlet of Upper Red Rock Lake that would raise the water surface a few feet to provide storage regulation of the outflow and also an outlet canal down the valley so constructed as to eliminate the lower lake and the sinuosities of Red Rock River, the area exposed to transpiration and evaporation would be reduced nearly half, and about 25,000 acre-feet could probably be added to the outflow from the valley at the Lima Dam. A canal constructed along the trough of the valley to the upper end of the Lima Reservoir would be about 23 miles long. The maximum flow of the river in this section, according to records at the Lyons Bridge station, is 1,030 second-feet, and the ultimate maximum may be materially greater. With storage in the upper lake, however, the flow could probably be so regulated as not to require a canal capacity in excess of 1,000 second-feet. In the material through which the canal would be excavated the safe velocity would be about 2.5 feet a second and the required cross-sectional area about 400 square feet. A trapezoidal channel with a bottom width of 50 feet, a top width of 75.6 feet, a depth of 6.4 feet, and a slope of about 1.06 feet to the mile would give a canal of adequate velocity and capacity. The fall of the canal would be nearly the same as the natural gradient along the valley trough, and digging with a drag-line excavator at a cost of 15 cents a cubic yard would amount to about $11,200 a mile. The total cost for a 23-mile canal would thus be $258,000. On the basis of the estimate that 25,000 acre-feet of water can be added to the outflow of Centennial Valley by this means, the cost per acre-foot would be $10.30. It is not believed that the construction of a dike at the outlet of upper Red Rock Lake would increase this cost, because, even if it were extended only to a height sufficient to add 6 feet in depth to the storage capacity of the upper lake, it would provide regulation amounting to nearly 40,000 acre-feet, and the value of such storage would probably offset the cost of the dike. The investigations made in connection with the present report were not sufficiently detailed to show the feasibility of the plan above outlined. One of the principal sources of uncertainty is the effectiveness of the dike, and determination of this question would require borings along the axis of the dike to ascertain the type of material available for foundations.

Lima Reservoir enlargement (6AA–2).—By raising the Lima Dam 10 feet the surface area of the reservoir would be increased to 5,700 acres, and 35,000 acre-feet would be added to the storage capacity; by raising it 28 feet an area of 19,000 acres would be flooded, and the additional storage would be 100,000 acre-feet.

The flow of Red Rock River at the Lima Dam during the period October 1 to June 1 in a normal year, as indicated by the Lima and Monida records (Table 4), is 92,600 acre-feet. It can be assumed that a flow equivalent to this amount can be stored in the Lima Reservoir, even though part of the May flow is required to satisfy established rights to divert water for irrigation below that point. These diversions in May will usually be offset by a surplus flood supply in June. There is no apparent prospect of increasing the capacity of this reservoir at present. However, it is a potential site for developing additional storage facilities on Red Rock River which will ultimately be utilized unless storage is developed at some other point in this basin. Most of the lands that would be flooded have no value for any other purpose except summer grazing.

Lower Red Rock Valley (6AA–3).—On August 18, 1894, a reservoir site on Red Rock River in Tps. 13 and 14 S., Rs. 7 and 8 W., was located by the Geological Survey in pursuance of the act of Congress approved October 2, 1888 (25 Stat. 505, 506). A 40-foot dam at a narrows in the NW. ¼ SE. ¼ sec. 36, T. 13 S., R. 8 W., will create a storage reservoir having a surface area of 1,200 acres and a capacity of 16,000 acre-feet. A large part of the area within this reservoir site is irrigated hay land, which would have to be purchased, and as the capacity of the site is small there is no present prospect of the site being utilized for storage. The constructed Lima Reservoir (6AA–2) above it provides storage regulation for practically the same water supply and is a more economical storage site.

Grasshopper Creek Reservoir (6AC–2).—A dam 105 feet high in the Grasshopper Creek Canyon in sec. 27, T. 8 S., R. 10 W., will create a reservoir having a surface area of 554 acres and a capacity of 25,000 acre-feet. The run-off through this reservoir site from October, 1922, to May, 1923, was 22,500 acre-feet. Direct-flow irrigation rights in Dillon Valley may require part of the May flow but not all of the June flow; hence it is estimated that the supply available for storage would have been at least 22,500 acre-feet during 1922–23. A record for a single year, however, is inadequate as a basis for definite conclusions relative to water supply.

Blacktail Deer Creek site (6AC–8).—In the SE. ¼ sec. 24, T. 9 S., Rs. 7 and 8 W., Blacktail Deer Creek has cut a channel through a rock outcrop which apparently affords a good location for a dam. Rock is exposed on both sides of the river channel, and a dam at this point 40 feet high with a crest length of 750 feet would create a reservoir having a surface area of 600 acres [6] and a capacity of about 8,000 acre-feet. The land in this reservoir site was withdrawn in the interest of its development for irrigation, but the withdrawal was canceled September 22, 1894, and no consideration of its possible utilization since that date is on record in the Geological Survey. The estimated run-off of Blacktail Deer Creek indicates an ample water supply to fill a reservoir of 8,000 acre-feet. Most of the land within the flow line of the site is native hay meadow, which would have to be purchased in connection with any development that might be undertaken.

During the irrigation season all the low-water flow of Blacktail Deer Creek is diverted and used for irrigation under water rights adjudicated by court decree for a total of 247.8 second-feet of water. The flow of the creek after the flood season is inadequate to satisfy these water rights, but practically all of the better type of irrigated land covered by these rights lies in Dillon Valley, and any shortage of water from the creek is offset in a large measure by diversions from Beaverhead River for the same lands. Storage development at this site would therefore probably be undertaken only in connection with extensions of irrigated lands in Dillon Valley, and there is no present prospect of its use in that connection.

Ruby Reservoir site (6AD–1).—A suitable site for a storage reservoir exists on Ruby River in T. 7 S., R. 4 W. This site was located by the Geological Survey in the early nineties under the act of Congress approved October 2, 1888 (25 Stat. 526). A dam 150 feet high at this site would flood an area of 1,880 acres, and the storage capacity would be about 100,000 acre-feet. The dam site is in a

[6] U. S. Geol. Survey Twelfth Ann. Rept., pt. 2, p. 147, 1891.

narrow canyon like section of the river about 1½ miles long. It is estimated that the dam would have a crest length of about 900 feet and a width of about 200 feet at the water surface.

It is estimated that if the depth to bedrock is not excessive, a rock-fill dam for this reservoir could be constructed at a cost of about $400,000. This estimate is based on a comparison of the cost of the Big Hole Dam (6AG–10), which although higher will have a shorter crest and better foundations, especially at the abutments. Most of the land within the flow line of the reservoir is grazing land, worth probably not more than $10 an acre. About 400 acres is irrigated hay meadow having an estimated value of $50 an acre. There are also improvements consisting of farm houses, outbuildings, fences, etc., having an assessed value of $8,000 according to records of the county assessor. From these figures it is estimated that the cost of a right of way for the reservoir may be approximately $50,000. Apparently, therefore, the cost of developing the Ruby site will be about $450,000.

The estimated total mean annual flow of Ruby River through the reservoir site during the period 1911 to 1914 was 161,000 acre-feet, most of which occurred during May and June. Practically all the June flow is required to satisfy diversion requirements for existing irrigation canals below the reservoir site, and during July, August, and September probably all the regular flow will be needed for these canals. It is estimated, therefore, that during the period covered by the available records not more than 90,000 acre-feet a year would have been available for storage. Comparison with other available data indicates that this period was one of high run-off, and therefore during an average year the amount may be less than 60,000 acre-feet. If the reservoir were constructed for storing only the normal flow, the cost would be enough less than $450,000 to be reasonable, provided a point of use were so situated as to prevent a high cost of distribution. This site is one of the principal undeveloped storage reservoir sites in the Jefferson River basin and probably will be constructed before utilization of water in that area has reached its maximum development.

Big Hole Reservoir (6AG–10).—A large reservoir site exists along Big Hole River in Tps. 4 and 5 S., Rs. 8 and 9 W. The first reference to this reservoir site in the records of the Geological Survey is contained in the annual report of the director for 1890–91.[7] In that report it is stated that a dam 100 feet high in the NE. ¼ SE. ¼ sec. 3, T. 5 S., R. 8 W., will create a reservoir having a surface area of 11,800 acres. Development of this site forms part of the irrigation scheme of the Crow Creek irrigation district, and that organization

[7] U. S. Geol. Survey Twelfth Ann. Rept., pt. 2, p. 142, 1921.

has been granted an easement for the site under the acts of Congress approved March 3, 1891 (26 Stat. 1095), and May 11, 1898 (30 Stat. 404).

According to a survey executed by engineers of the Crow Creek irrigation district, as shown on maps submitted with its application for the reservoir easement, a dam 160 feet high will be built in the W. ½ sec. 2, T. 4 S., R. 8 W., which will create a reservoir having an area of 6,550 acres. At the left abutment of the dam solid rock is exposed nearly to the water surface, but at the right abutment the rock in place is covered by a talus slope, the depth of which is not known. The depth to bedrock in the river also is undetermined but probably is not excessive.

A reconnaissance plane-table survey of the reservoir site by the writers checked against a map filed in connection with an application for easement for the reservoir site indicates approximate area and capacity at different altitudes as follows:

Altitude (feet)	Area (acres)	Capacity (acre-feet)
4,840	70	700
4,860	550	6,900
4,880	1,460	27,000
4,900	2,470	66,000
4,920	3,300	124,000
4,940	4,100	198,000
4,960	4,970	290,000
4,980	6,000	400,000
5,000	7,500	530,000

Of the 7,500 acres within the flow line at the 5,000-foot contour, approximately 1,820 acres is public land; the remaining 5,680 acres is in private ownership. The privately owned land includes 1,350 acres irrigated and 4,330 acres grazing land, according to classification records prepared by county authorities for purposes of taxation. The assessed valuation of irrigated lands ranges from $25 to $50 an acre, and the grazing land of the poorer type is assessed at $3 an acre. It is deemed safe to assume that a valuation of $50 an acre for all irrigated land and $10 an acre for grazing land in private ownership will cover all right of way costs except that of moving a section of the Oregon Short Line Railroad and purchasing the improvements at the Glenn station, comprising a store and small hotel. To cover all these right of way costs an allowance of $171,000 will be made, which may be somewhat high but at least furnishes a substantial basis for showing the cost of storage as compared with the possible benefits from it.

Two estimates of the cost of a dam made for the Crow Creek irrigation district are on record in the Geological Survey. One estimate is $337,000 and the other $405,000, the figure depending on the type of dam used, which is in turn dependent upon the depth to bedrock at the dam site. For the purpose of the present discussion a cost of

$400,000 for the dam will be assumed, making the total cost of the storage development $571,000. This estimate may prove to be somewhat high after more detailed investigations have been made, including borings to determine foundation conditions at the dam site and a more careful cruise of the land in the flow line of the reservoir. The reservoir might be used to provide regulation for water power at existing hydroelectric plants on Missouri River, but there is no present demand for such storage.

Wise River (6AG).—The location of a reservoir site on Wise River at some point near the present storage development of the Montana Power Co. (6AG–1) would materially increase the potential power resources of the canyon section above Divide. A profile of the Montana Southern Railway on file in the Geological Survey indicates only one possible site where the gradient of the river is sufficiently low to permit reservoir development at a point in T. 3 S., R. 12 W. A letter dated March 16, 1925, from the district forester of the Forest Service confirms this conclusion but adds that no suitable dam site is available for creating a storage reservoir in that section of the river. The letter states that extensive investigations by the Montana Power Co. disclosed a volume of slide rock of such magnitude as to render the construction of a dam impracticable.

Whitetail Park Reservoir site (6AH–3).—A reservoir site in Whitetail Park, at the headwaters of Whitetail Creek, in T. 4 N., Rs. 5 and 6 W., is part of an irrigation scheme proposed by the Whitetail irrigation district. It will require a dam 38 feet high and will have a surface area of 2,025 acres and a capacity of 16,600 acre-feet. The drainage area tributary to the reservoir site is about 20 square miles, but no accurate data are available showing the run-off from that area available for storage. The drainage basin of Pipestone Creek, which adjoins that of Whitetail Creek, had a run-off of 11,000 acre-feet for the year ending September 30, 1911, from a total area of 115 square miles. The unit run-off from that area, therefore, was about 95 acre-feet per square mile, and assuming a similar run-off above this reservoir site gives a total annual flow at the reservoir of less than 2,000 acre-feet. The average altitude of the drainage area tributary to the Whitetail Park Reservoir site is 7,500 feet, whereas that of the Pipestone Creek area is only 6,500 feet; hence the unit run-off of the Whitetail area is probably the higher, but in the writers' opinion there is little prospect of a sufficient supply to warrant building a reservoir as large as the one contemplated. In any event stream-flow measurements should be made prior to development.

Willow Creek Reservoir (6AH–7).—It is proposed to build a dam 122 feet high below the confluence of Willow and Norwegian Creeks, in T. 1 S., R. 1 W., to create a reservoir having a surface area of 1,320 acres and a storage capacity of 32,800 acre-feet. This reservoir will be used to store the nonirrigation season and surplus flood flow from a drainage area of 160 square miles for use by the South Bench irrigation district. The stream-flow records of Willow Creek on pages 112–113 show the run-off from approximately the same drainage area as that tributary to the reservoir, the inflow between the dam and the gaging station being negligible. The stream-flow record now available is complete for two years only and indicates a run-off during the storage period October to May, inclusive, amounting to 19,000 and 26,800 acre-feet.

UTILIZATION OF WATER

The principal industry of the settlers in the Jefferson River Basin is agriculture, the rough noncultivable lands being used for grazing during the summer and most of the cultivable lands being used to produce forage crops for winter feeding. Owing to the light rainfall on the cultivable land irrigation is in general necessary to provide the soil moisture required for producing crops, the only notable exceptions to this rule being bench lands on the south side of lower Jefferson Valley and at places in the Dillon Valley and subirrigated and flooded bottom lands along the larger stream channels. On the bench-land areas mentioned such drought-resistant crops as small grains can be raised during most years by dry-farming methods, but on the river-bottom lands the ground-water plane often lies at so shallow a depth that native hay is the only crop which can be raised. During years of more than normal precipitation crops of small grain can also be raised without irrigation on most of the dry bench lands in the basin, but farming under such conditions is unprofitable. The success of agriculture in this area therefore rests largely on irrigation, and water is used for that purpose more extensively than for any other. Some water power is being developed, and there are undeveloped power sites in the basin, but the power resources under present-day conditions are of minor importance in the economic affairs of the basin. As a natural consequence of settlement in the area communities have been established which require water for municipal use, but the needs for this purpose are nominal. On the map (pl. 3) the present and potential irrigation and water-power projects are indicated.

DUTY OF WATER

The irrigation statistics for Montana compiled by the United States Census Bureau show that the average quantity of water per acre delivered to farms in Montana in 1919 was 2.3 acre-feet. This figure represents water delivered that was measured and includes only about half the irrigated area in the State. Engineers for the

Montana Public Service Commission who are familiar with local irrigation conditions have estimated that in the Jefferson River Basin, where diversified farming is practiced, not more than 1.5 acre-feet per acre at the farm is required to produce crops. In actual practice, as observed by the writers, an excessive amount of water is used on native-hay bottom lands, but in the intensively developed areas, such as the irrigated bench lands in Dillon Valley, where a properly designed irrigation system is installed, water is used with greater economy. The writers believe that estimates of water requirement for most of the potentially irrigable areas in the Jefferson River Basin should be based on a diversion of about 3 acre-feet per acre and that approximately 50 per cent of this diverted water will be returned to the river by seepage from the canals and irrigated lands.

The best available data regarding the distribution of demand for water during the irrigation season consist of records of irrigation practice obtained by the United States Bureau of Reclamation. These records indicate that the water must be delivered during the irrigation season approximately as follows: May 5.4 per cent, June 18.5 per cent, July 36.7 per cent, August 32.5 per cent, September 6.9 per cent.

BUTTE WATER SUPPLY

The largest municipal water-supply system in the Jefferson River Basin is used to provide water for use in Butte and vicinity. The principal features of the system in this river basin consist of a pumping plant on Big Hole River in the SE. ¼ sec. 12, T. 1 S., R. 10 W., where water is pumped against a head of 840 feet, and a pipe line 10 miles in length which carries the pumped water to a reservoir on the south fork of Divide Creek in the NW. ¼ sec. 8, T. 1 N., R. 9 W., whence it is delivered to the city as needed. This reservoir has a capacity of 41.4 acre-feet and can furnish 8,000,000 gallons of water a day to the city water-supply system.

IRRIGATION DEVELOPMENT

Red Rock River (6AA).—A total area of about 49,000 acres is irrigated in the Red Rock River Basin, of which 17,000 acres is in Centennial Valley, 23,500 acres in lower Red Rock Valley, 7,000 acres in the Big Sheep Creek Basin, and 1,500 acres in the Sage Creek Basin. The irrigated areas in Centennial Valley and the Sheep and Sage Creek Basins are almost entirely native-hay meadows, which yield annually about 1 ton to the acre. These meadows are also used to graze stock in the spring until about the middle of May, when the stock can be turned into the hills to forage, and in the fall after August 15, when the hay has been harvested. The meadows can often be grazed in the fall until Christmas and sometimes during an entire winter, but ordinarily feeding is necessary for about six months each winter. In lower Red Rock Valley crops of oats, alfalfa, timothy, and potatoes are reported to have been produced successfully, but the normal growing season of the entire area is too short for diversified farming, and agricultural activity will probably always be centered on livestock, including possibly some dairying.

Beaverhead River (6AC).—Water from Beaverhead River is used to irrigate about 24,600 acres in Dillon Valley and 5,400 acres in the section of upper Jefferson Valley traversed by the river, a total of about 30,000 acres. Irrigation began in Dillon Valley in 1865, as disclosed by court decrees specifying the date on which water was first applied to beneficial use on land in the area. Since that time the courts have declared that water rights for a total of 1,440 second-feet have been established in the area. During the spring flood season the water supply is adequate to satisfy the water requirement for all existing canals. Subsequent to that season the normal flow is ordinarily insufficient to satisfy any rights established later than 1890, and during years of low run-off rights established as early as 1884 have been curtailed. Below the Point of Rocks the flow of the river during the irrigation season consists almost entirely of return seepage from irrigation in Dillon Valley, and it is reported by one resident that a shortage of water for irrigation has occurred there only five times since 1884, although the river is often dry at many places in Dillon Valley. It is said that the benefit from return seepage becomes apparent about July 25 and that in some years the supply may be short from about June 20, when the spring flood season ends, until that date.

Most of the land of the better type irrigated from Beaverhead River consists of low-lying bench lands adjoining the flood plain. The river bottom land, although most readily susceptible of irrigation and probably at one time irrigated extensively, is now for the most part valuable only for grazing, a condition induced, at least in part, by excessive use of water and lack of drainage when irrigation was first practiced. The earlier settlers, especially in Dillon Valley, were chiefly stockmen, who raised native hay by flooding the bottom land in a manner similar to the present-day practice in Big Hole Basin described on page 75. The natural result has been a concentration of alkali at the surface, which is deleterious to the growth of cultivated farm crops. At some points the native-hay meadows still exist. One such area lies at the lower end of the valley, and it was learned by the writers that this meadow was formerly one of the best hay ranches in that section of Montana, but now, because of an increase in the alkali content of the soil, its value is probably below the average for lands of similar type in the region.

The principal crops produced by irrigation on the lands of the better type are alfalfa, grain, potatoes, field peas, and garden truck. An illustration of the yields obtained is given by the record for a tract of irrigated land just below the Point of Rocks, near the head of upper Jefferson Valley. This tract contains 125 acres of meadow in Beaverhead River bottom that is believed to be one of the best areas of its type in the entire Jefferson River Basin. It is planted to timothy and redtop, and the reported yield is in places 2 tons of hay to the acre, and averages from 1 to 1¼ tons. A 40-acre field of alfalfa is reported to yield 4 tons to the acre. A wheat field of 12 acres has yielded 60 bushels to the acre, and a similar yield was obtained from 20 acres of oats. A yield of 40 bushels to the acre was obtained from a 10-acre field of barley. In addition to these crops 35 acres are planted to peas under contract with a large seed concern which has selected tracts of the better farm lands at several points in southwestern Montana and made contracts with the farmers for growing seed peas.

Jefferson River (6AH–6AJ).—A total area of about 61,300 acres is irrigated from Jefferson River and its tributaries entering below the junction of Beaverhead and Big Hole Rivers. Of this area 28,900 acres are irrigated direct from Jefferson River and minor tributaries in the upper and lower valley sections. One of the largest single irrigation developments is the Parrott ditch, which was constructed for developing power but later converted to use for irrigation. This canal is 25 miles long, has a diversion capacity of 150 second-feet, and is used to irrigate 6,000 acres on the east side of Jefferson River in the upper valley section. A portion of this ditch is constructed along a talus slope in Tps. 1 N. and 1 S., R. 4 W., and in this portion flumes are required, the upkeep of which is a considerable problem in the operation and maintenance of the ditch. Much of the remaining 22,900 acres irrigated from Jefferson River and minor tributaries is hay land in the river flood plain, but the crop produced is in general of inferior quality because of alkali soils.

The crops raised on lands under the Parrott ditch as reported by one local resident are as follows:

Alfalfa, 3½ tons to the acre.
Oats, 60 to 65 bushels to the acre.
Wheat, 30 to 40 bushels to the acre.
Potatoes, 5 tons to the acre.
Vegetables, corn (White Flint), and apples (Wealthy, Duchess, and Yellow Transparent) in small quantities.

The lower Jefferson Valley is reported to have a growing season two to three weeks longer than that at Bozeman, in the Gallatin River Valley, in Tps. 1 and 2 S., Rs. 5 and 6 E., where good crops of grain, potatoes, alfalfa, turnips, and sugar beets are raised. Small fruits, such as raspberries, gooseberries, and strawberries, and early-bearing tree fruits are also grown successfully there, as well as practically all vegetables. With irrigation, therefore, the good agricultural land of the lower Jefferson Valley should prove to be highly productive. Much of the better type land in this lower valley lies within three proposed irrigation projects—the Meadow Valley Farms, Valley View, and South Bench irrigation districts, which are described on pages 80–82.

Horse Prairie Creek (6AB).—An area of 45,900 acres is irrigated from Horse Prairie Creek and its tributaries. Most of this area lies in the main valley of the creek. The growing season in this valley is short, being comparable to that in Big Hole Basin, where frost often occurs every month in the year. In consequence the most practicable crop is hay, and a mixture of red clover and native grass is produced. The average yield obtained from these hay meadows each year is 1 ton to the acre, and it is utilized as winter feed for stock. At the time the area was visited (July, 1923), most of the 1922 crop was still stacked in the fields. The failure to utilize the crop was explained locally as due to the fact that very little snow fell during the preceding winter and stock were able to obtain ample feed by grazing the meadow lands.

Grasshopper Creek (6AC).—An area of 10,500 acres is irrigated from Grasshopper Creek and its tributaries. Most of this area lies at an altitude ranging from about 6,000 to 6,500 feet above sea level, where the growing conditions are similar to those in the Horse Prairie Creek Basin. Timothy, red top, and native hay are practically the only field crops raised.

Rattlesnake Creek (6AC).—Diversified farming is practicable in the Rattlesnake Creek Basin only in the alluvial bottoms along the creek below Argenta, where about 4,000 acres is irrigated. There is a large plains area adjoining the creek bottoms which is part of Dillon Valley, but it has a coarse gravelly soil practically all of which has no agricultural value except for grazing; furthermore, no water supply is available for its irrigation at a reasonable cost. The irrigated land along the creek produces two crops of alfalfa in an average season, yielding about 2½ tons to the acre. Oats are also raised with yields reported as high as 80 to 100 bushels to the acre, but the average is probably materially less than this amount. The low-water flow is inadequate to satisfy existing rights, and two reservoirs have been built at the headwaters of the creek to meet the shortage in part.

Blacktail Deer Creek (6AC).—An area of about 5,500 acres is irrigated from Blacktail Deer Creek, most of it in the creek bottoms at the lower end of the stream, where the valley forms a reentrant from Dillon Valley. In addition to this area certain of the irrigated lands in Dillon Valley receive water from the creek. The irrigated land at the lower end of the basin produces crops comparable to those obtained in Dillon Valley, but in the remainder of the basin the irrigated land is used to produce hay.

Ruby River (6AD).—A total area of about 34,500 acres is irrigated from Ruby River and its tributaries, chiefly in the valley between Alder Gulch and the mouth of the stream. Irrigation development in this area has been concurrent with that in Dillon Valley, the first diversions having been made about 1865, according to a list of water rights compiled from a court decree for guidance of a water master in regulating diversions above a point near Laurin. It was learned locally that 1919 and 1921 were the only two years in the 15-year period prior to 1923 in which a water master was needed, and that in 1921, the youngest decreed right, having a priority date of April 12, 1908, was not shut off until July 25. It was also learned that when the river is dry at Alder it has a flow of 25 to 35 second-feet at Laurin, due to return seepage. The normal flow of the creek is therefore adequate for present irrigation development in most years. Any considerable extension to the present irrigated area, however, will be largely dependent upon storage. In the valley section extending from the mouth of the river to a point near the south line of T. 6 S., R. 4 W., the growing conditions are similar to those in Dillon Valley.

Big Hole River (6AE, 6AF, 6AG).—A total area of about 185,000 acres is now irrigated from Big Hole River or its tributaries,116,000 acres of which consists of native-hay meadows in or near Big Hole Basin. The present practice of irrigators in that area is exceedingly wasteful in the use of water, very little effort being made to regulate the supply used and almost no preparation of the land being attempted to promote the economical use of water, the land simply being flooded continuously until early July. These conditions have arisen from several causes. In the first place, the abundance of the available water supply has not rendered rigid economy in its use necessary. Then the irrigation system consists largely of a network of small canals constructed by individuals or small associations to serve relatively small tracts. Although the irrigated area is fairly well graded naturally, it is not entirely smooth and excessive irrigation is required to water the entire area. Plowing and grading and a properly designed system of canals and laterals for the entire valley area would result in a more economic use of water. Plowing, however, would destroy the native growth, and several years would be required to reestablish the existing meadows; moreover, in many places the topsoil cover is too thin to permit grading without uncovering a subsoil composed of coarse gravel. It is believed, therefore, that the most favorable opportunity of improving irrigation practice in the area is by installing a more efficient canal system for the entire valley, but the average value of the irrigated land is only about $25 an acre, and very little expenditure in developing such land is warranted.

The low value of this land is due principally to the climatic conditions, which limit crop production to hay. The most valuable species of native hay is a sedge (*Carex illota*), which produces a grain that is excellent for fattening beef for market. In the wetter parts of the area, where drainage is poor or the land is overirrigated, a sedge of different type (*Carex substricta*) is dominant. This type lacks the nutritive value of the *Carex illota* but is reported to be fair roughage for stock. The yield of native hay ranges from 1,000 to 1,500 pounds to the acre, but 3,000 pounds to the acre could be obtained by planting tame hay such as timothy. The value of the increased yield, however, would be offset by the necessity of providing other feed such as cottonseed cake in order to obtain beef of the type now produced.

The hay crop in the basin is harvested from July 15 to September 1 and fed on the land, the general practice being to bring in cattle during the fall, let them feed during the winter, and take them to market the following spring. From 10,000 to 15,000 head of cattle or "feeders" can be prepared for market during a winter, and the average net increase in weight is 180 pounds a head delivered at the nearest railroad shipping point after a five-day drive. This practice in general has proved more profitable than retaining the cows and raising a calf crop. The postwar drop in beef prices so reduced the margin between the price of "feeders" and that of stock ready for market that an adequate profit to sustain the industry in the basin was not being obtained at the time of the writers' field investigations. Dairying was then receiving more or less attention as a means of diversifying the industrial development, and one resident of the valley estimated that during 1923 500 dairy cows were being maintained and 3,000 pounds of butter was produced each week. At that time about 30 farmers were said to be engaged in dairying. Irrigation development from Big Hole River and its tributaries outside Big Hole Basin is of slight extent, being limited for the most part to scattered tracts along the stream channels devoted largely to the production of winter feed for stock that graze on the interstream and mountain areas during the summer.

Pipestone and Whitetail Creeks (6AH).—Nearly 8,600 acres is irrigated from Pipestone and Whitetail Creeks, consisting of bench lands on the west side of upper Jefferson Valley and bottom lands along Little Whitetail Creek and Whitetail Creek below the mouth of the Little Whitetail. Hay is the principal crop, although grains, potatoes, peas, and dairy produce are also obtained.

Boulder River (6AJ).—The area mapped on Plate 3 as irrigated along Boulder River is considerably in excess of the land actually irrigated, but it is impracticable to show the irrigated land more accurately with the data at hand. Most of such land consists of small hay ranches in the river flood plain. The United States Census report for 1920 shows a total area of about 7,300 acres in this basin under irrigation in 1919 and indicates that this area is a reduction of 22 per cent over the area irrigated in 1902.

South Boulder Creek (6AH).—About 4,000 acres are irrigated from South Boulder Creek, for the most part contiguous to the channel in the 10-mile section above its mouth. Canals have also been constructed that divert water from the creek to Lower Jefferson Valley bench lands in T. 1 S., Rs. 2 and 3 W. The growing conditions on the irrigated lands are favorable to diversified farm products where the water supply is adequate for thorough irrigation.

Willow Creek (6AH).—About 12,500 acres are irrigated from Willow Creek and its tributaries in the bench-land area on the south side of lower Jefferson Valley. The normal flow of the creek is not sufficient to satisfy the water requirement for all the irrigated land, and some small storage reservoirs have been constructed. Hay and grains are the principal crops, but most vegetables can be raised.

UNDEVELOPED IRRIGATION POSSIBILITIES

Beaverhead River flood plains (6AC).—It is believed that there is sufficient fall along Beaverhead River to permit the construction of effective drainage ditches for reclaiming a large part of the moist bottom lands in Dillon Valley, and the subsoil is believed to be sufficiently coarse grained to permit rapid lowering of the ground-water table by means of drainage canals. These facts are demonstrated by one drainage ditch which has been placed in successful operation near Dillon. The feasibility of drainage is therefore an economic question, the answer to which depends on whether the value of the crops that can be produced on the reclaimed land will be adequate to repay the cost of drainage. It will also be important to obtain a more economical use of water on the higher land, to reduce return seepage.

East Bench irrigation district (6AC).—Probably the most actively indorsed project for further irrigation development in Dillon Valley is the scheme for diverting water from Grasshopper Creek in sec. 26, T. 8 S., R. 10 W., and from Beaverhead River in sec. 15, T. 9 S., R. 10 W., whence it will be carried down the right side of Beaverhead Canyon to its lower end and across the head of Dillon Valley to the land to be irrigated, on the east-side bench, as indicated on Plate 3. The irrigators under this scheme have organized the East Bench irrigation district, and the organization was approved by court decree May 8, 1922. According to information obtained from the project engineer the gross area in the district is 23,500 acres, and the net irrigable area 16,000 acres, but these areas can be extended if the water supply obtainable warrants extension. Under the plans originally proposed most of the water supply after the spring flood period would be derived from storage in the Grasshopper Creek Reservoir (6AC–2). At the time of the writers' investigations studies of storage facilities available on Red Rock River were being made for the district. The results of these studies are not known, but the available stream-flow data indicate that an adequate water supply can be conserved from the flow of Red Rock River during the non-irrigation season to satisfy the requirements of the East Bench district land and that undeveloped reservoir facilities are available for regulating the stream flow in Red Rock Lakes (6AA–1) or the Lima Reservoir enlargement (6AA–2).

Bench lands on west side of Dillon Valley (6AC).—The irrigable bench lands on the west side of Dillon Valley comprise a gross area of nearly 90,000 acres, part of which is now irrigated from Birch Creek, a tributary of Big Hole River. No active steps are being taken toward development of an irrigation project for that area, and the water supply available is probably not sufficient for irrigating both sides of Dillon Valley.

Crow Creek irrigation district (6AH).—The largest irrigation scheme affecting the area under discussion contemplates diversion of water from Jefferson River primarily to irrigate an area in the vicinity of Radersburg, in Tps. 3 to 6 N., Rs. 1 W. and 1 and 2 E. The point of diversion will be in sec. 4, T. 3 S., R. 6 W., a few miles below the junction of Beaverhead and Big Hole Rivers. Storage regulation for this scheme will be obtained at the Big Hole Reservoir site, in Tps. 4 and 5 S., Rs. 8 and 9 W. (6AG–10). The surveyed location for the canal line is shown on Plate 3 and extends down the right side of upper Jefferson Valley, across South Boulder Creek, through a tunnel into the Jefferson River Canyon down the canyon 1½ miles, across the canyon in an inverted siphon, eastward and northward 20 miles to a tunnel through the Jefferson and Missouri River divide, and thence northward to the district lands. The total length of this canal will be about 74 miles, and part of it will be located on a talus slope at the base of the Tobacco Root Mountains, where flumes will be required. The cost of construction has been estimated by engineers for the irrigation district at nearly $5,600,000, but the writers of this report are of the opinion that the cost to the water users may be materially higher if a proper allowance is made for interest charges during construction, cost of financing, and other contingencies that are incidental to such an undertaking.

According to a copy of a sworn statement by the secretary of the Crow Creek irrigation district dated August 4, 1922, in the files of the Geological Survey, an area of 41,592 acres has been included in the district as provided by the laws of Montana. It further appears from the survey records that the boundaries of the district can be extended to include a net total area of 65,000 acres. The engineers for the district have prepared a map showing that an additional area of 6,000 acres in upper Jefferson Valley and 44,000 acres of bench land on the left or north side of Jefferson River in lower Jefferson Valley can be irrigated by laterals from the main canal. The same map indicates that by extending a canal down the right side of Jefferson River below the proposed inverted siphon to an area between Madison and Jefferson Rivers about 24,000 acres more can be irrigated. Two other canals have been suggested by these engineers starting from the Big Hole Reservoir and extending into upper Jefferson Valley to irrigate all arable bench land of that area. One of these canals would extend down the right side of Big Hole River and following a proper grade would cross Beaverhead River at Point of Rocks and extend thence down the right side of upper Jefferson Valley, irrigating a total area of nearly 29,000 acres. The other canal would extend down the left side of Big Hole and Jefferson Rivers to and across Pipestone and Whitetail Creeks and thence down upper Jefferson Valley to and up the Boulder River Valley, which would be completely encircled by the canal crossing Boulder River at a point about 6 miles below the town of Boulder. Estimated areas of 42,000 acres in upper Jefferson Valley and 26,000 acres in the Boulder River Valley could be irrigated from this canal. The total area irrigable from Jefferson River under these schemes would be 236,000 acres. The approximate location of the several canal lines is shown on Plate 3.

Under a duty of 3 acre-feet per acre at the point of diversion an area of 236,000 acres will utilize 708,000 acre-feet of water annually. The distribution of the demand for this water supply should be approximately as follows:

	Acre-feet
May	38, 200
June	131, 000
July	260, 000
August	230, 000
September	48, 800

The record of the discharge of Jefferson River at Silver Star indicates the water supply available at the head gates of the main canal of the Crow Creek district. This record shows a normal summer flow 288,000 acre-feet short of satisfying the water requirement for 212,000 acres, and the shortage must be made up from storage. On the basis of the Sappington record the shortage would be 289,000 acre-feet. This shortage would occur in July and August. Making an allowance of about 65,000 acre-feet for the needs of an area of 21,300 acres which is now irrigated from Jefferson River would increase the storage requirement indicated by the Sappington record to about 310,000 acre-feet. Some further allowance may be necessary for rights on Missouri River below Three Forks, but data now available are inadequate to serve as a basis for considering these rights, and probably they would be largely satisfied by return seepage. The available reservoir facilities are adequate to meet a storage demand of 310,000 acre-feet.

The foregoing outline of potential irrigation development under the Crow Creek scheme considers the water supply principally and takes little cognizance of the economic features of such an undertaking. The expenditure involved would be large, and a determination of economic feasibility would require extensive studies of soil and climatic conditions to ascertain the agricultural possibilities of the area. The field studies in connection with the present report indicated that most of the good land that can be irrigated lies under the line of the proposed main canal beginning in T. 3 S., R. 6 W., and extending to the Crow Creek district. Large tracts of the land lying under the other suggested canal locations are covered by coarse gravel with very little soil, and it is believed that detailed studies would indicate that the irrigable area is smaller than estimated and that development as proposed would be impracticable for the gravelly tracts. Possibly, however, the canal to the land of the irrigation district may be constructed eventually, and then the major part of the 74,000 acres irrigable from it in upper and lower Jefferson Valley may be irrigated.

Meadow Farm irrigation district (6AH).—An area of 1,040 acres in sec. 3, T. 1 N., R. 1 E., and sec. 35, T. 2 N., R. 1 E., is proposed for irrigation by means of a gravity canal 3½ miles long diverting from Jefferson River in sec. 18, T. 1 N., R. 1 E. No active steps appear to have been taken toward development of this scheme. The land is all in private ownership, title being held by a company that contemplated undertaking the development. The water supply available in Jefferson River is adequate for this area.

Valley View irrigation district (6AH).—Another proposed scheme for irrigating part of lower Jefferson Valley contemplates the installation of a pumping plant on Jefferson River in sec. 33, T. 2 N., R. 1 E., to irrigate land in the Valley View irrigation district. The report of the Montana Irrigation Commission for 1922 indicates that two pumping lifts are contemplated, one of 137 feet for an area of 1,300 acres and the other of 186 feet net for an area of 1,395 acres. The operation of the pumps will require 962 horsepower of electric energy, which could be furnished by the Montana Power Co. The annual maintenance cost for the project will be more than $6.58 an acre, and the first cost $37.40 an acre. The irrigation district organization has been approved since 1920, but development has not been undertaken. This scheme embraces lands that could probably be irrigated from the main canal of the Crow Creek scheme. The water supply available in Jefferson River is adequate for the project.

Ruby River project (6AD).—Plans at one time were under consideration which contemplated the irrigation of 41,000 acres of bench land between Ruby and Beaverhead Rivers. This scheme would require a canal extending down the left side of Ruby River from the Ruby River Reservoir site (6AD–1), following the location shown on Plate 3. The State of Montana filed an application for the segregation of the land to be irrigated under the Carey Act, but the application was not approved, and no active steps looking toward development of the project are known to have been taken since some time prior to 1915.

The writers' studies indicate that abandonment of the Ruby project probably has been due to a combination of unfavorable circumstances. The available stream-flow data, although inconclusive, indicate an almost certain deficiency in the water supply for a 40,000-acre project. To determine the amount actually available, however, would require further records. The canal construction presents another problem. Below its head gates considerable rock excavation would be required, and then hillside construction would be encountered for several miles until the bench lands were reached. These construction difficulties would make the project costly, and the bench lands that could be irrigated have, at least in part, a gravelly soil that would not produce crops of sufficient value to repay a high irrigation charge.

Big Hole Basin (6AE).—An additional area estimated as between 30,000 and 50,000 acres in Big Hole Basin, for the most part on benches along the west side of the basin, is physically irrigable. Efforts heretofore made to irrigate these bench lands have not been successful, in part because the water supply is now largely utilized except during the peak of the flood-water period. One proposed scheme of irrigation involves the building of a canal, from Big Hole River at a point in T. 4 S., R. 15 W., to land along the west side of the valley which is now irrigated from streams tributary to the river on that side. The appropriated water supply from the tributary streams thus released would be used on the higher bench land. It is believed that this scheme presents a logical method of procedure and that eventually some part of the bench land will be irrigated. The soil mantle of the benches, however, is thin in places, and ditch excavations encounter coarse gravel and boulders in which a high rate of seepage loss occurs. The duty of water on such land would therefore be low.

Whitetail irrigation district (6AH).—A district has been organized to irrigate an area of 5,076 acres from Little Whitetail Creek. The location of the canal is shown on Plate 3. It is also proposed to build a reservoir (6AH–3) having a capacity of 16,600 acre-feet. According to the report of the Montana Irrigation Commission for 1922 the estimated cost of the project will be $197,000 and the cost per acre $38.82. The principal crops will be hay, grain, potatoes, peas, and dairy products.

South Bench irrigation district (6AH).—A scheme has been proposed involving a net area of 14,800 acres included in the South Bench irrigation district in lower Jefferson Valley, to be irrigated from Willow Creek and its tributary Norwegian Gulch. The lands are located in Tps. 1 and 2 N. and 1 S., Rs. 1 and 2 E. The flow during the irrigation season is practically all appropriated and used, and the plan of development for this project contemplates the building of a dam 122 feet high at the confluence of Willow and Norwegian Creeks to create a reservoir (6AH–7) of sufficient capacity to satisfy the greater part of the irrigation demand. This scheme has been investigated by the Montana Public Service Commission and the following data relative to it are published in the report on Montana utilities for 1922:

Length of irrigation season, 125 days.
Duty of water delivered to farm, 1.25 acre-feet per acre.
Duty of water in reservoir, 2.14 acre-feet per acre.
Reservoir capacity, 32,800 acre-feet.
Crops, grain, hay, peas, potatoes, and dairy produce.

Records of the flow of Willow Creek indicate that the unappropriated supply available may not be equivalent to 2.14 acre-feet per acre for an area of 14,800 acres but probably is adequate to warrant construction of the proposed scheme.

INSTALLED WATER POWER PLANTS

Dillon municipal plants (6AC–6, 6AC–7).—Two hydroelectric power plants have been constructed in Beaverhead Valley to generate current for municipal lighting at Dillon. One of these plants (6AC–6) is near the center of sec. 25, T. 7 S., R. 9 W., and was constructed to use a flow of 80 second-feet from Beaverhead River and Blacktail Deer Creek. The plant is equipped with a 300-horsepower turbine water wheel operating under a 22-foot head. The generator has a capacity of 150 kilowatts. This power plant was closed November 21, 1923, after the completion of a transmission line connecting Dillon with the Montana Power Co.'s line at Laurin, Mont., and is now held for emergency use. The other plant (6AC–7) is in sec. 28, T. 8 S., R. 9 W., and is operated under a head of 205 feet with a water supply of 8 second-feet from Sturges or Lovell Warm Springs. The equipment consists of two units, each containing a water wheel and generator. At an over-all efficiency of 70 per cent this plant has a capacity of 104 kilowatts. Formerly 4½ second-feet from springs in Beaverhead Canyon was utilized in the plant, but the high cost of maintaining the flumes required in the canyon caused abandonment of that part of the development. This plant was being used together with the transmission system of the Montana Power Co. to supply the power market in Dillon.

Parrot plant (6AH–1).—In 1894 a filing for 500 second-feet of water from Jefferson River was made for a hydroelectric power development in sec. 28, T. 1 N., R. 4 W. The development included an 18-mile diversion canal having a capacity of 250 second-feet and extending from a point on Jefferson River in sec. 24, T. 2 S., R. 6 W., to the power plant. The plant equipment included three horizontal turbines operated under a head of 87 feet with a rated capacity of 500 horsepower each, which were belt connected to three generators.

The plant was owned by the Madison Power Co. and connected with transmission lines extending from other plants of that company. It has not been operated for several years, and most of the machinery has been moved away. The canal is now used by the Parrott Ditch Association for irrigation.

Rattlesnake Creek (6AC–5).—An old flume and power plant that formerly utilized water from Rattlesnake Creek stand on the north side of the stream in T. 6 S., Rs. 10 and 11 W., near the town of Argenta. The flume was between 3 and 4 miles in length and developed a static head of about 120 feet at the power plant. This installation was made during the days of mining activity in the region, apparently to operate a stamp mill. The power plant has been abandoned for a great many years and is practically demolished. With a water supply of 10 second-feet, which is the estimated winter flow, and an over-all plant efficiency of 70 per cent, the power capacity of this plant for 90 per cent of the time was less than 100 horsepower.

Divide plant (6AG–2).—In sec. 11, T. 1 S., R. 10 W., a power plant has been installed which is now part of the Montana Power Co.'s system. The equipment consists of four inward-flow Leffel turbine water wheels with a rated capacity of 1,200 horsepower each, direct connected to four generators with a rated capacity of 750 kilowatts each, also two water wheels with a rated capacity of 150 horsepower each connected to exciter units. The main generators produce 3-phase 60-cycle current at 800 volts and are designed to operate at a speed of 180 revolutions a minute. This current is stepped up to 15,000 volts for transmission by means of 12 transformers. The two exciter units have a rated capacity of 100 kilowatts each with a potential of 125 volts and are designed to operate at a speed of 600 revolutions a minute.

This plant was installed in 1899 and was the first to deliver hydroelectric power to the Butte district. Details concerning the dam will be found in the discussion of the reservoir (6AG–2) on page 62. During recent years until about 1918 the plant was particularly valuable for supplying peak-load power required by the lighting system in Butte and furnished about 1,600 horsepower for operating the pumping plant of the Butte water-supply system, 1 mile below the plant. Since 1918, however, operation of the plant has been almost wholly discontinued, and it is now used principally as a stand-by for the pumping plant. The average annual output during 1919 to 1923 was 2,640,000 kilowatt-hours, which is only about 10 per cent of the installed capacity of the plant. The maximum daily output during this period was 17,000 kilowatt-hours, an amount less than the rated output of one generator running continuously.

The available stream-flow records in the files of the Geological Survey are insufficient to serve as a basis for determining the flow of the river for 90 and 50 per cent of the time for use in estimating the power capacity of this site. Records of the Montana Power Co. show a 90 per cent flow of 360 second-feet and 50 per cent flow of 625 second-feet when corrected for an assumed constant error of 100 second-feet due to unmeasured leakage through the dam. These estimates are believed to be more accurate than any estimate that can otherwise be obtained. The error due to flood-period flow has no effect on the computation.

The lowest point in the outlet from the dam is 44 feet below the crest of the spillway. This head can be readily increased to 65 feet by means of penstocks and draft tubes. With the estimated 90 per cent flow the site has a power capacity of 1,870 horsepower; with the 50 per cent flow, 3,250 horsepower. The present storage facilities, comprising a capacity of 7,100 acre-feet in the Wise River Reservoir and 1,280 acre-feet obtainable by use of flashboards in the spillway of the dam, will furnish an aggregate storage of 8,380 acre-feet. With effective storage regulation of this quantity a continuous flow of approximately 400 second-feet can be maintained. At an over-all plant efficiency of 70 per cent the continuous power output with this stream flow and an average static head of 65 feet would be approximately 2,100 horsepower. In order to obtain this output, however, it will be necessary to make extensive repairs to the two existing dams to eliminate leakage.

Pony plant (6AH–6).—A small plant has been installed on North Willow Creek in T. 2 S., R. 3 W., to furnish power for lighting the town of Pony. The installation consists of a 30-kilowatt generator operated under a head of 58 feet by a water wheel having a rated capacity of 40 horsepower. The plant is owned by the Pony Electric Light Co.

UNDEVELOPED WATER POWER

Beaverhead River (6AC–1).—The potential power resources of Beaverhead River are limited to the canyon section, which terminates at the head of Dillon Valley. If the meanders of the river are disregarded, this canyon is about 12 miles long and has a total fall of about 200 feet as determined from a profile of the railroad paralleling the river. The discharge recorded at Barratts is nearly 260 second-feet for 90 per cent of the time and 425 second-feet for 50 per cent of the time. These records include the flow of Grasshopper Creek, which enters the canyon about 2 miles above its lower end; the flow for 90 per cent of the time through the whole canyon available for power is only about 240 second-feet, and that for 50 per cent of the time about 380 second-feet. The potential power that could be developed in the canyon at an over-all plant efficiency of 70 per cent is 320 horsepower per mile with the 90 per cent flow and 500 horsepower per mile with the 50 per cent flow. Topographic conditions are favorable to the development of practically all these power resources in one or two units by means of high dams, but the Oregon Short Line Railroad, which parallels the river through the canyon, would have to be relocated. Low diversion dams and conduits present a possible alternative method of development, but the railroad grade in places is only a few feet above normal high water, and raising the roadbed would be necessary, especially if the diversion dam were high enough to provide sufficient forebay pondage for protection from ice in winter. The cost of development under either scheme would render utilization of the potential power impracticable, and it is believed that Beaverhead Canyon can be regarded as devoid of potential power having any commercial value.

Argenta site (6AC–5).—In the NE. ¼ sec. 30, T. 6 S., R. 10 W., there is a favorable site for the construction of a dam on Rattlesnake Creek. A dam 100 feet above the water surface at this point would be about 500 feet wide and would back water upstream about 1 mile. By building a conduit 3 or 4 miles long down the left bank of the stream a head of 200 feet could be obtained for generating power. With a flow for 90 per cent of the time amounting to 10 second-feet, the power obtainable would be 160 horsepower. The flow for 50 per cent of the time is probably not less than 30 second-feet and would yield 480 horsepower. The cost of the structures involved in the development of this potential power is far in excess of the value of the power that could be produced. Furthermore, irrigation diversions for land in the vicinity of Argenta occur immediately below the dam site, and either the owners of these water rights must be furnished with water or the water-rights must be purchased in the interest of any prospective power development. It is not believed that the potential power on Rattlesnake Creek in the section under consideration has any commercial value.

Big Hole Canyon (6AG–2, 6AG–3).—The installed Divide power plant (6AG–2) is the most practicable commercial development along Big Hole River. The canyon section above the backwater from this plant contains no practicable high-head dam sites, the fall of the river through that section is only about 20 feet to the mile, which renders low diversion dams and conduits expensive, and no adequate storage regulation is available.

In the 5-mile canyon section (6AG–3) that lies about halfway between Divide and Melrose stations on the Oregon Short Line Railroad the fall of Big Hole River is about 20 feet to the mile. If 80 feet of the total fall can be utilized for power the potential output with the regulated stream flow of 400 second-feet obtainable as described for the Divide plant (p. 83) would be about 2,600 horsepower. With the present flow of 360 second-feet for 90 per cent of the time estimated for the Divide plant, the output would be 2,300 horsepower, and with the flow of 625 second-feet for 50 per cent of the time it would be about 4,000 horsepower. This canyon is traversed by a constructed railroad, and power development here is believed to be impracticable, owing to the cost of building the necessary structures, relocating the railroad, and purchasing bottom lands that would be flooded.

Whitetail Canyon (6AH–4).—From the outlet of the Whitetail Park Reservoir site (6AH–3) Whitetail Creek flows in a deep rugged canyon 8 miles long with a fall of 300 feet to the mile. No stream-flow records are at hand for determining the flow for developing power, but it is estimated that a flow of 7 second-feet is available 90 per cent of the time. With storage regulation in Whitetail Park Reservoir this flow could probably be increased to about 12 second-feet. The power value of the stream at an over-all plant efficiency of 70 per cent is therefore 168 horsepower per mile with the 90 per cent time flow and 288 horsepower per mile with storage regulation.

The most feasible method of development [8] would be by means of low diversion dams and conduits along the canyon walls, delivering the water through high-head penstocks. Considerable difficult hard-rock excavation would be required in building such a project, and its cost would be prohibitive under present economic conditions.

South Boulder Creek (6AH–5).—The Liberty Mines Co. has filed an application with the Federal Power Commission for permission to build a power project on South Boulder Creek in sec. 18, T. 2 S., R. 3 W. The plan of development includes an earth diversion dam

[8] Lamb, W. A. (district engineer), unpublished report on file in the Geological Survey.

and a 20-inch wood-stave pipe line 4,400 feet long, which will create a static head of about 231 feet for developing power. The power will be converted to usable energy by means of two 4-foot Pelton water wheels, one belt connected to a 150-kilowatt generator and the other to a two-stage air compressor.

No stream-flow records for South Boulder Creek are available, hence the power capacity of this site can only be estimated. A report based on field and office studies by engineers of the Forest Service indicates that the power capacity with the estimated flow available 90 per cent of the time is about 205 horsepower. No storage sites exist on the stream, according to that report, which further shows that the channel of South Boulder Creek has a steep gradient and that developments similar to that contemplated by the Liberty Mines Co. might be installed at many points. In fact, another such installation is said to have been operated by a mining company several years ago at a point 3 miles upstream from the site here discussed, but it was abandoned when the mining operations were discontinued and has been dismantled. Commercial utilization of these potential power resources is apparently impracticable.

METEOROLOGIC RECORDS

Length of growing season at stations in Jefferson River Basin, Mont.

Boulder

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1901–1908			[a] 78	1916	June 12	Sept. 14	94
1909	June 12	Aug. 27	[b] 76	1918		Sept. 4	
1910	June 24	Aug. 24	[b] 61	1919		Sept 22	
1911	May 30	July 18	[b] 49	1920	May 31		
1912	June 18	Aug. 17	[b] 60	1921	May 12		
1913	July 14	Aug. 15	[b] 32				
1915	June 16	Sept. 13	89	Average			72.3

Bowen

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1909	June 26	July 12	16	1918	([c])	([c])	
1910	July 13	July 24	11	1919	([c])	([c])	
1911	July 11	July 28	17	1920	([c])	([c])	
1913	([c])	([c])		1921	([c])	([c])	
1914	([c])	([c])					
1916	([c])	([c])		Mean			4
1917	([c])	([c])					

Brenner

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1914	June 22	Sept. 9	79	1921	May 12	Sept. 4	115
1915	July 19	Sept. 13	56	1922	June 1	Sept 8	99
1916	([c])	([c])		1923	June 14	Sept. 17	95
1917	([c])	([c])		1924	([c])	([c])	
1918	June 1	Sept. 25	116				
1919	June 8	Sept. 22	106	Mean			67
1920	June 24	Aug. 29	66				

[a] Average for 8 years.
[b] At Boulder Nursery.
[c] Frost every month.

Length of growing season at stations in Jefferson River Basin, Mont.—Continued

Dell

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1917	June 11	Aug. 7	56	1920	June 24	Aug. 18	55
1918	June 29	Aug. 12	44				
1919	June 7	Sept. 13	98	Average			63

Dillon

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1900–1908			[d] 84	1918	May 27	Sept. 3	99
1909	May 14	Sept. 17	126	1919	June 10	Sept. 22	104
1910	May 26	Aug. 18	84	1920	July 6	Aug. 30	55
1911	May 27	Aug. 24	87	1921	May 12	Sept. 10	121
1912	May 4	Sept. 16	135	1922	June 1	Sept. 28	119
1913	July 13	Sept. 9	58	1923	May 16	Sept. 18	125
1914	May 6	Sept. 3	120	1924	June 5	Sept. 27	114
1915	Apr. 23	Sept. 10	140				
1916	June 12	Sept. 14	94	Average			98
1917	May 31	Sept. 21	113				

Lima

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1914	June 22	Sept. 9	79	1916	June 23	Aug. 19	57
1915	June 27	Sept. 10	75	Average			70

Norris

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1909	June 11	Sept. 23	104	1918	May 29	Sept. 27	121
1910	May 2	Aug. 24	114	1919	May 6	Oct. 8	155
1911	May 11	Sept. 17	129	1920	June 1	Oct. 21	142
1912	May 7	Sept. 21	137	1921	May 14	Sept. 10	119
1913	May 19	Sept. 24	128	1922	May 12	Oct. 14	155
1914	May 12	Oct. 5	146	1923	May 15	Oct. 12	150
1915	Apr. 9	Oct. 6	180	1924	June 7	Sept. 27	112
1916	May 11	Sept. 28	140				
1917	May 31	Oct. 17	139	Average			136

Pipestone Dam

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1923	June 25	Sept. 18	85	Average			84
1924	June 9	Sept. 1	84				

Pipestone Pass

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1909	July 14	Aug. 1	18	1913	[c]	[c]	------
1910	June 8	Aug. 2	56				
1911	May 28	Aug. 8	72	Average			44.2
1912	July 12	Aug. 12	31				

Renova

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1899–1908			[e] 110	1918	May 22	Sept. 4	105
1909	May 19	Sept. 23	127	1919	June 8	Sept. 22	106
1910	June 4	Aug. 25	82	1920	June 1	Aug. 31	91
1911	May 30	Aug. 28	90	1921	May 3	Sept. 17	137
1912	June 4	Aug. 30	87	1922	May 15	Sept. 29	137
1913	July 14	Sept. 10	58	1923	June 15	Sept. 18	95
1914	May 1	Sept. 2	124	1924	June 7	Sept. 27	112
1915	May 6	Sept. 20	137				
1916	June 12	Sept. 14	94	Average			108
1917	June 3	Sept. 29	118				

[d] Average for 9 years.
[e] Average for 10 years.

Length of growing season at stations in Jefferson River Basin, Mont.—Continued

Three Forks

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1910	June 3	Aug. 25	83	1923	June 1	Sept. 18	109
1911	May 31	Sept. 19	111				
1913	May 17	Sept. 20	126	Average			105
1918	May 29	Sept. 4	98				

Near Three Forks

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1914	May 5	Oct. 7	155	1920	July 8	Aug. 19	42
1915	May 6	Sept. 20	137	1921	May 14	Oct. 7	146
1916	June 7	Sept. 14	89	1922	May 31	Sept. 29	121
1917	June 5	Oct. 17	134				
1918	May 22	Sept. 16	117	Average			117
1919	June 2	Sept. 22	112				

Virginia City

Year	Last killing frost in spring	First killing frost in fall	Days	Year	Last killing frost in spring	First killing frost in fall	Days
1903–1908			f 93	1919	June 1	Sept. 22	113
1909	May 19	Sept. 12	116	1920	June 2	Oct. 8	128
1910	June 3	Aug. 25	83	1921	May 12	Sept. 4	115
1911	June 5	Sept. 17	104	1922	May 30	Sept. 8	101
1912	May 31	Aug. 30	91	1923	June 30	Sept. 18	80
1916	May 11	Sept. 13	125	1924	June 9	Sept. 10	93
1917	June 3	Oct. 17	136				
1918	May 29	Oct. 8	132	Average			104

f Average for 6 years.

Precipitation, in inches, at stations in Jefferson River Basin, Mont.

Boulder

[Records for 1909–1913 at Boulder Nursery]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1891									0.56	0.07	0.27	0.13	
1892	0.34	0.02	0.08	1.13	0.62	4.33	1.10	0.22			.69	.19	
1893	1.53	.20	.08	1.31	1.16	1.24	.38	.35	1.76	.57	.54	.45	9.57
1894	.77	.14	.71	.74	1.06	2.59	.90	.70	1.99	.50	.14	.19	10.43
1895	.49	.17	.03	.38	.73	2.90	.74	.06	.81	.46			
1896								2.50		.30		Tr.	
1897					1.12	2.38	1.31						
1898					3.75	1.83	.54	.38			.09	.05	
1899	1.65	.50	.70	1.50	1.60	1.02	.80	1.71	.62	.90	.05	1.05	12.10
1900	.53	.75	.58	1.59	1.88	.19	.97	.54	1.17	1.57	.10	.37	10.24
1901	.58	.70	.21	1.95	2.14	1.81	.38	.35	1.36	.14	.18	1.17	10.97
1902	.05	.51	.39	.61	2.38	.70	1.99	.60	.41	.40	1.25	1.05	10.34
1903	.45	.37	.98	.83	1.70	.85	1.91	.30	.91	.39	.45	.34	9.48
1904	.46	1.09	.61	.13	1.11	.89	.77	.70	.00	.09	.17	.21	6.23
1905	.31	.16	.77	.77	1.11	3.84	2.04	.88	Tr.	Tr.	.20	Tr.	10.08
1906	.25	.40	.83	.08	2.90	1.96	.32	1.95	.30	Tr.	.75	.75	10.49
1907	1.00	.52		.11		2.65							
1908							1.08	.23	2.13				
1909					3.47	2.51	3.20	.99	4.84	.26	.82	.95	
1910		.70	Tr.	1.24	2.49	1.98	.58	1.19	4.27	1.18			
1911					2.47	3.62	.38	1.09	1.15	2.32		.64	
1912	.49	.12	1.01	2.34	2.68	1.48	1.70	1.76	2.87	2.92	.29	.72	18.38
1913	1.01	1.03	1.05	.77	1.90	5.31	2.08	1.31	1.10				
1915				.55	3.51	3.74	2.85	1.64	1.70	Tr.	.27	.27	
1916	.50	.79	.45	.96	2.44	3.27	1.37	.92	1.18	.67	.29		
1918			1.41	.76			2.95	1.88	1.96			.05	
Mean	.65	.48	.58	.97	2.01	2.32	1.32	.97	1.48	.67	.39	.45	12.29

Precipitation, in inches, at stations in Jefferson River Basin, Mont—Continued

Bowen

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1906											0.88	2.52	
1907	2.42	2.18	1.25	0.61	0.57	3.08	1.77	1.81	1.20	0.44	.58	2.56	18.56
1908	.47	1.02	1.77	.57	2.07	3.29	1.03	1.25	.74	1.25	.16	.40	14.02
1909	1.51	.47	.66	.47	1.68	.77	2.31	.63	2.71	.13	2.14	.44	13.92
1910	.69	1.06	.81	.25	1.51	.48	.67	.03	1.08	.73	2.25	.54	10.10
1911	1.00	.29	.08	.82	1.34	3.60	.53	.98	1.35	2.77	1.14	.78	14.68
1912	.68	.43	.55	.36	2.41	.83	1.64	1.16	1.18	.77	.39	.81	11.21
1913		.35	.33	.73	1.41	4.18	1.43	.23	.75	.73	1.23	.39	
1914	.86	.63	.18	1.03	1.86	2.49	.52	.04	1.16	1.27	.51	.18	10.73
1915	.38	.33	.38	.55	2.82	3.25	1.97	.59	1.16	.12	1.07	1.24	13.86
1916	.82	1.21	.89	.58	.76	1.44	1.25	.96	.61	.26	1.12	.43	10.33
1917	1.39	.89	1.17	.84	1.57	.93	.35	.05	1.70	.65	.64	1.95	11.63
1918	1.13	.71	.90	.23	.12	.45	.84	2.20	.79	.94	.25	Tr.	8.56
1919	.21	1.06	.48	.75	.65	.02	.03	.25	.19	1.02	.43	1.41	6.50
1920	.46	.41	1.23	1.54	.49	2.13	.76	.74	.83	.94	.44	.63	10.60
1921	.52	.56	1.09	1.64	1.91	2.00	.48						
Mean	.90	.77	.78	.73	1.41	1.93	1.04	.78	1.10	.86	.88	.95	12.13

Brenner

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1914	0.60	0.22		1.14	2.12	2.95	1.60	0.12	2.16	1.00	0.14	0.38	1.133
1915	.28	.43	0.84	.97	.75	2.99	1.94	.91	1.10	.46	1.02	.97	12.66
1916	.75	1.17	.58	1.17	1.66	1.82	1.66	.75	1.12	1.85	.31		13.64
1917	0	.40	1.03	1.11	1.61	.37	Tr.	.19	.85	.47	.52	1.34	7.89
1918		.37	.36	.77	.75	.71	1.59	2.44	2.70	.87	.63	.49	12.28
1919	.16	.65	.20	1.84	.13	.06	.11	.07	.18	1.65	.88	.86	6.79
1920	1.13	.50	1.03	1.04	1.80	.96	1.89	.29	.68	1.17	.55	.79	11.83
1921		.43	.82	1.90	2.55	1.33	.18	.94	1.38	.07	1.48	.54	12.78
1922	.46	.88	.91	2.24	1.43	1.19	.75	1.77	.10	Tr.	.68	.81	11.22
1923	.37	.34	.96	1.17	2.26	2.89	1.46	1.07	.51	1.22	.44	.64	13.33
1924	.46	.15	1.01	.30	.11	.21	.41	.06	.82	.91	.42	.66	5.52
1925	.72	.35	1.14	1.29	1.54	4.47	1.61	.63					
Mean	.49	.49	.81	1.25	1.39	1.75	1.10	.77	1.06	.88	.64	.68	11.31

Dell

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1898												0.20	
1899	0.20	0.47	0.47	0.20	0.89	1.63	0.03	0.04	0.10	1.23	0.26	.01	5.53
1900	.20	.65	.40	2.58	.05	.15	.01	1.10	.45	1.05	.60	Tr.	7.24
1901	.05	.40	.56	.50	1.32	.96	Tr.	1.12	1.30	.35	.20	1.20	7.96
1902				2.16	.42	.16	.08						
1917					2.25	1.00	.47	.29	1.02	.08	.24	.10	
1918	.22	.32	.09	.44	.69	3.64	2.51	1.70	1.29	.38	.39	.13	11.80
1919	.11	.06	.27	1.02	.21	.04	.33	.14	.91	1.21	.06	.42	4.78
1920	.08	.33	.68	.80	.97	1.48	1.24	1.09	1.26	1.10	.22	.18	9.43
1921	.08					1.90	.26	1.77	.65	.12			
1922	.24	.10		.62	.98								
1923						3.15							
Mean	.15	.33	.41	1.04	.86	1.41	.55	.91	.87	.69	.28	.64	8.14

Dillon

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1898	0.94	0.61	1.58	1.22	4.54	1.37	0.83	0.68	1.38	1.13	1.06	0.94	16.28
1899	1.08	.47	1.51	.65	2.00	2.12	.24	1.24	1.19	1.31	1.03	1.38	14.22
1900	.01	.31	1.23	2.27	1.56	.73	.61	1.32	1.34	2.84	1.15	.17	13.54
1901	.12	.73	.96	3.26	2.48	2.85	.24	1.00	4.77	.43	.46	2.49	19.79
1902	.99	.45	.96	4.95	2.47	1.74	1.18	1.26	.24	.16	1.21	.55	16.17
1903	.82	.07	1.23	5.36	2.12	1.64	2.49	1.16	1.45	.23	1.52	1.01	19.10
1904	.64	2.14	1.38	.98	2.54	1.91	.05	1.18	.07	.31	.02	.29	11.51
1905	.60	.14	2.23	3.00	3.17	3.96	1.36	2.77	.26	.39	.69	.09	18.66
1906	1.01	.25	1.38	.77	4.11	2.62	.42	3.17	.88	.21	1.16	1.27	17.25
1907	1.65	1.43	1.64	1.39	3.03	5.67	2.85	2.00	1.01	.71	.29	.31	21.98
1908	.92	.43	1.59	.34	9.16	3.54	.47	.68	1.00	2.00	.14	.34	20.61
1909	1.74	.29	3.38	1.20	3.56	1.36	3.78	.81	4.14	.57	.92	.93	22.68
1910	1.19	1.69	.31	.48	2.77	1.17	.35	.11	3.21	1.09	1.59	.27	14.23
1911	1.29	1.23	.07	1.33	3.26	2.30	.56	1.44	1.03	1.65	1.76	.80	16.72
1912	.68	.07	2.29	2.42	3.83	2.00	1.83	3.90	.86	1.41	1.02	.87	21.18
1913	.61	.80	2.39	1.43	2.78	6.02	1.61	1.79	1.77	1.77	.68	.27	21.92
1914	.22	.92	.40	3.02	3.98	3.99	1.76	.20	2.24	1.48	.11	.53	18.85
1915	1.03	.70	1.68	1.60	5.18	4.60	4.65	.30	2.51	.44	1.02	1.12	24.83

Precipitation, in inches, at stations in Jefferson River Basin, Mont.—Continued

Dillon—Continued

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1916	3.42	.84	.92	1.84	3.34	3.63	3.96	.96	1.38	1.90	1.01	.49	23.69
1917	1.05	.54	1.53	2.03	2.68	1.45	.01	.26	1.33	.46	.20	.92	12.16
1918	1.36	1.69	1.04	2.21	2.35	2.43	2.61	.96	1.61	.60	1.93	.80	19.59
1919	.85	1.05	.90	1.65	.49	.18	.14	.40	1.14	2.50	1.22	2.37	12.89
1920	.35	1.40	1.71	1.95	3.41	2.44	2.70	.91	1.26	.88	.51	.40	17.92
1921	.32	.77	.90	2.43	4.61	3.71	.82	1.17	1.72	.10	.81	1.12	18.48
1922	.93	1.83	.95	3.74	2.54	1.90	1.82	2.87	.14	.07	1.47	.90	19.16
1923	.56	.80	1.31	1.82	4.64	5.01	1.69	.98	.52	1.39	.30	.50	19.52
1924	.62	.48	3.40	.62	.53	1.28	1.98	.51	1.85	.59	.29	1.36	13.51
1925	1.08	.06	1.83	1.52	2.47	5.38	1.49	2.53					
Mean	.93	.79	1.45	1.98	3.20	2.75	1.52	.14	1.50	.99	.87	.83	16.95

Homepark

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1905				1.09	2.25	1.14	0.70	1.36	0.98	0.80	0.98	0.80	
1906	1.00	1.20	1.70	2.72	3.14	3.14	.68	2.00	1.35	.75	.40	1.40	19.48
1907	.95	.10	2.44	1.00	2.12	4.58	2.09	1.42	.40	.85	.70	3.00	19.65
1908	.60	1.02	.85	.73	5.06	4.33	.70	.49	.75	1.91	.09	.22	16.75
1909	.87	.67	1.01	.63	1.88	.46	2.38	.53	2.52	.41	.73	.36	12.45
1910	.58	.59	.42	1.48	2.70	.78	.55	.35	1.89	1.22	.84		
Mean	.80	.71	1.28	1.27	2.86	2.40	1.18	1.02	1.31	.99	.62	1.16	15.60

Lima

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1914	0.11	0.17	0.05	2.10	1.78	3.34	1.42	0.05	1.29	0.57		0.22	11.10
1915	.38	.04	.16	2.60	2.48		2.56	.35	1.75	.60	0.29	.12	
1916	.78	.17	.13	.51	2.29	1.27	1.01	.41	.84	1.47			
Mean	.42	.12	.11	1.74	2.18	2.30	1.66	.27	1.29	.88	.15	.17	11.29

Norris

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1908	0.22	1.05	1.76	0.55	10.37	4.37	0.65	0.78	1.37	1.05	0.04	0.60	22.81
1909	.05	.02	2.09	1.00	6.04	1.02	2.34	2.83	4.54	.70	1.57	1.85	24.05
1910	2.53	.51	.35	1.50	2.64	1.19	.88	1.96	2.06	1.80	1.98	.35	17.75
1912	.10	.12	1.35	1.71	2.91	1.73	.60	1.50	1.96	2.41	.20	.22	14.81
1913	.19	.45	.91	.75	1.94	5.72	2.17	.27	2.54	3.60	.34	.19	19.07
1914	.29	.32	.18	1.29	2.15	3.77	1.18	.06	2.74	1.04	.09	.05	13.16
1915	.46	.04	.60	1.59	4.03	3.97	2.92	2.07	2.58	.71	1.25	.56	20.78
1916	.73	.57	.87	1.76	3.10	3.40	2.16	.72	1.10	2.52	.29	.34	17.56
1917	.55	.81	.61	2.45	3.20	2.09	.73	.13	3.08	1.34	.25	.23	16.47
1918	.92	.74	.49	2.24	2.30	1.45	1.33	1.25	1.29	1.23	1.06	.36	14.66
1919	.21	1.11	.48	1.47	1.98	.12	.09	.64	.71	3.18	.79	.89	11.67
1920	.37	1.06	1.70	2.29	3.74	2.58	.67	1.10	1.08	.16	.54	.37	15.66
1921	.42	.36	1.31	1.78	4.65	2.11	.93	.58	2.09	.34	1.52	1.84	17.93
1922	.64	.51	.66	3.19	3.45	2.02	1.96	2.51	.59	.39	1.64	.80	18.36
1923	.31	.38	1.15	1.48	2.60	2.85	1.45	1.21	1.44	1.80	.45	.65	15.77
1924	.46	.97	1.97	1.47	1.72	1.07	1.85	.21	3.36	1.69	.96	.32	16.05
1925	.51	.07	1.38	2.34	2.64	3.01	1.06	2.05					
Mean	.53	.53	1.05	1.70	3.50	2.50	1.35	1.17	2.03	1.50	.81	.60	17.27

Pipestone Dam

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1923		0.56	0.51	0.82	2.33	2.47	1.32	1.70	0.13	0.72	0.24	0.44	
1924	0.48	.51	1.30	.38	.36	.35	1.56	.35	.60	.80	.76	.37	7.82
1925	.75	.23	1.41	2.58	2.20	3.64		1.02	2.64				
Mean	.61	.43	1.07	1.26	1.63	2.15	1.44	1.02	1.12	.76	.50	.40	12.39

Precipitation, in inches, at stations in Jefferson River Basin, Mont—Continued.

Pipestone Pass

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1909	------	------	0.94	2.10	2.73	1.47	3.39	1.06	3.62	1.06	1.07	0.83	--------
1910	1.05	0.96	.43	.95	3.36	1.70	1.14	.91	3.52	2.09	1.53	.50	18.14
1911	1.11	.63	.24	1.50	2.80	4.34	.28	1.35	1.94	1.67	.87	.88	17.61
1912	.31	.39	1.34	2.22	3.68	1.90	2.39	2.01	1.83	2.44	.26	.89	19.66
1913	.63	.58	.83	1.27	2.24	3.92	2.11	1.17	------	------	------	------	--------
Mean	.78	.64	.75	1.61	2.96	2.67	1.86	1.30	2.73	1.82	.94	.78	18.84

Renova

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1898	1.00	0.04	0.73	0.25	4.19	4.25	0.73	0.42	1.65	0.62	0.80	0.08	14.76
1899	1.20	.20	.63	1.93	2.12	1.38	.33	1.32	.28	2.24	.29	.36	12.28
1900	Tr.	.20	.57	2.68	.74	.05	.39	.26	.80	1.75	.16	.35	7.95
1901	.31	.10	.28	1.47	2.49	.97	.37	.60	1.84	.23	.13	.79	9.60
1902	.04	.39	.09	1.41	2.69	1.09	1.01	.90	.45	.35	.60	.80	9.82
1903	.37	.10	.62	3.91	.90	2.21	1.34	.08	.84	.06	1.15	.45	12.03
1904	1.50	1.88	1.06	.27	.88	1.40	2.10	.43	0	.22	Tr.	.18	13.79
1905	.04	.11	.23	.86	2.18	2.74	1.11	.67	.76	------	------	------	--------
1906	.40	.51	.40	.80	2.45	1.69	.58	1.88	.60	.50	.31	.45	10.57
1907	.50	.54	1.25	.40	1.85	3.91	3.38	1.27	1.52	.89	.12	.05	15.68
1908	.15	.25	.53	1.12	6.29	4.23	.44	.52	1.08	2.08	.11	.03	16.83
1909	1.21	.12	.82	.96	2.38	.94	3.16	.93	3.35	.45	1.72	.36	16.40
1910	.59	.40	.16	.92	1.83	.94	.51	.04	3.03	1.02	1.18	.09	10.71
1911	.95	.33	0	.76	1.74	3.40	.04	.50	1.75	.84	.27	.11	10.69
1912	.14	Tr.	1.03	1.11	.95	2.64	1.24	2.17	1.43	2.25	Tr.	.08	13.04
1913	.20	.06	.63	1.00	2.14	3.43	2.52	.54	.48	.69	.84	Tr.	12.53
1914	.25	.28	.33	1.31	1.99	3.41	1.17	Tr.	2.28	1.52	Tr.	.20	12.74
1915	.52	.08	.75	1.36	3.28	4.12	2.09	2.33	1.51	.16	.75	.59	17.54
1916	.13	.31	.64	1.52	2.60	2.60	1.12	1.50	1.79	1.54	.20	.09	14.04
1917	.30	.32	.41	2.53	3.39	1.82	.22	.48	1.70	.23	.22	.45	12.07
1918	.38	.50	.47	.45	.98	1.15	2.15	1.03	1.77	1.14	.08	Tr.	10.10
1919	Tr.	.89	.19	.79	.48	.12	.30	.46	.52	1.73	.59	.41	6.48
1920	.03	.34	.59	2.06	2.59	3.37	1.17	1.16	.90	1.08	.26	.03	13.58
1921	.16	.10	.14	.70	1.48	2.13	.82	1.19	2.03	.13	.48	1.26	10.62
1922	.21	.44	1.57	4.07	2.19	1.37	2.13	2.08	.32	0	.59	.32	15.29
1923	Tr.	.24	.21	.76	2.10	2.32	.95	1.51	.45	.74	.12	.26	9.66
1924	.22	.44	.46	.88	.54	.64	.87	.28	1.23	.99	.53	.30	7.38
1925	.27	.10	.98	1.64	1.85	3.35	.98	1.87	------	------	------	------	--------
Mean	.40	.33	.56	1.35	2.11	2.20	1.19	.94	1.27	.90	.44	.31	12.00

Three Forks

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1910	------	0.45	0.34	1.36	1.67	1.24	0.68	0.53	------	------	------	------	--------
1911	------	.23	.02	.48	1.89	2.68	.27	------	1.34	1.08	0.30	------	--------
1913	0.21	.48	.50	1.35	1.93	3.37	2.42	.37	.42	1.98	1.26	0.08	14.37
1914	.25	.31	.17	1.97	1.97	3.34	1.49	0	2.21	2.24	.02	.12	14.09
1915	.28	.02	.97	.57	1.81	4.43	2.53	1.00	2.66	.12	.63	.70	15.72
1916	.41	.51	.38	.88	.79	2.91	1.02	.80	.94	1.21	Tr.	.59	10.44
1917	.65	.42	.31	.97	2.18	1.33	.11	.46	1.90	.17	.19	.45	9.14
1918	.43	.10	.61	.37	1.13	1.39	1.22	.85	1.99	.85	.89	.04	9.87
1919	.11	.65	.16	.20	.44	.34	0	------	.44	1.35	.58	1.13	--------
1920	------	------	.36	------	2.70	2.27	1.41	1.00	.63	------	------	.06	--------
1921	.14	------	.13	.57	1.61	2.76	1.48	.93	1.81	.07	.81	1.30	--------
1922	.60	.85	.48	2.62	1.62	2.06	2.00	1.79	.81	.31	------	.48	--------
1923	.42	.40	Tr.	.54	2.23	3.85	2.27	1.20	.47	.14	0	------	--------
1924	------	.62	.80	1.65	.70	1.24	1.19	.08	1.96	.89	------	.49	--------
1925	.41	------	.80	------	1.20	3.33	.59	.78	------	------	------	------	--------
Mean	.36	.42	.40	1.81	1.59	2.44	1.25	.75	1.35	.87	.46	.49	12.19

Twin Bridges

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1902	0.35	0.80	0.22	1.52	3.70	0.70	0.80	0.65	0.10	0.30	0.70	0.50	10.34
1903	------	Tr.	------	2.30	.40	------	------	------	------	0	.90	.30	--------
1904	------	1.10	------	.10	.30	------	1.10	.10	.10	Tr.	0	------	--------
1905	.01	.10	.20	1.10	2.50	2.50	1.10	------	.20	------	------	------	--------
1906	.20	------	.20	1.00	2.40	------	.60	------	1.10	------	------	.70	--------
1907	------	------	.80	------	------	------	------	------	------	------	------	------	--------
Mean	.19	.50	.36	1.20	1.86	1.60	.90	.38	.38	.10	.53	.50	8.50

Precipitation, in inches, at stations in Jefferson River Basin, Mont.—Continued

Virginia City

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871	------	0.48	1.97	1.47	------	------	------	------	------	------	0.30	1.43	------
1872	1.45	.79	.20	.46	1.78	0.74	2.73	0.60	0.28	0.12	.52	.16	9.83
1873	.13	.19	------	------	------	.71	2.02	2.40	------	.13	.09	.06	------
1874	.11	.06	.14	.10	4.18	3.58	1.10	3.11	1.46	1.12	1.04	.16	16.16
1875	1.29	1.37	1.50	.30	4.61	1.54	.73	2.94	1.25	.81	.91	.22	17.47
1876	.59	.49	1.06	.84	5.58	2.65	1.96	1.56	.88	.91	.20	.91	17.63
1877	.56	.73	1.35	1.38	3.93	2.08	1.79	.23	2.70	1.39	1.19	.14	17.47
1878	.45	.62	.91	1.83	5.13	3.78	.88	2.16	1.36	.98	.31	.65	19.06
1879	.96	1.06	1.51	1.45	2.16	3.71	.28	.23	.51	1.23	.91	3.83	17.84
1880	1.15	1.13	1.94	3.87	4.01	2.69	2.06	.82	.14	2.46	1.29	------	------
1888	.03	------	------	------	1.53	3.30	.55	.88	.57	.23	1.28	.03	------
1889	.06	.11	.92	.63	1.98	.23	.06	1.23	.29	.48	.40	.69	7.08
1890	.87	.91	.51	.26	.89	2.35	.24	1.22	.70	1.06	.06	.70	9.77
1891	.34	.78	.63	1.00	1.37	5.04	3.15	.39	1.37	.29	.12	.65	15.13
1892	.27	.04	.31	1.40	.54	2.83	1.16	.61	.82	1.00	2.09	1.95	13.02
1893	.31	.53	.34	.76	1.12	.93	.74	.70	3.91	1.06	.29	.69	11.38
1894	.45	.28	1.13	1.94	1.01	3.49	2.81	1.31	2.73	.85	Tr.	.58	16.58
1895	.99	.06	1.03	.94	1.42	2.12	1.00	.83	2.04	.19	.76	1.28	12.66
1896	.67	.65	.98	2.15	4.28	1.25	1.19	.86	1.73	.72	1.84	.25	16.57
1897	.21	1.28	2.35	1.29	2.91	3.22	1.43	.52	1.64	1.75	1.77	1.10	19.47
1898	.74	.33	2.08	.74	------	------	------	------	------	------	------	------	------
1905	.20	.15	.69	.78	2.12	1.52	1.55	1.10	.85	1.31	.53	.28	11.08
1906	1.20	.64	.65	1.81	5.31	3.40	.68	2.19	------	------	------	------	------
1909	------	------	3.76	2.84	2.77	.57	1.81	.65	3.17	.58	3.48	.37	------
1910	.18	.10	.30	1.52	3.56	.91	1.65	.62	1.20	1.06	2.12	.30	13.52
1911	.07	.50	.15	.27	2.17	3.46	.83	1.21	1.63	1.05	1.33	1.00	14.57
1912	.14	.44	.84	1.56	3.84	1.06	2.12	2.15	1.57	.83	.52	.50	15.57
1916	------	.10	1.03	.76	1.31	------	------	1.09	.85	1.10	------	.55	------
1917	.47	.56	Tr.	1.05	------	2.06	.50	.16	1.93	.09	.57	.93	------
1918	1.58	.52	.65	1.10	1.25	------	------	.65	.92	1.31	.35	.51	------
1919	.21	1.12	.53	.88	2.05	.07	0	0	------	.82	------	1.77	------
1920	------	------	1.35	1.45	2.66	2.51	.60	.62	1.39	1.43	.46	1.00	------
1921	.77	.30	------	.83	2.71	.93	.98	.82	2.14	.20	1.09	.54	------
1922	.50	.45	.52	1.57	2.30	1.62	1.36	3.10	.71	.65	.35	.35	13.48
1923	.26	.31	.18	1.73	2.02	2.24	1.53	1.82	.57	.74	.38	.60	12.38
1924	.50	.41	1.19	.90	.63	.72	1.56	.45	2.13	1.44	.21	.20	10.34
1925	.60	.14	.54	.48	.50	2.54	.79	1.86	------	------	------	------	------
Mean	.55	.52	.98	1.21	2.53	2.12	1.24	1.17	1.40	.89	.84	.74	14.19

GAGING-STATION RECORDS

RED ROCK RIVER ABOVE RED ROCK RESERVOIR, NEAR MONIDA, MONT.

LOCATION.—In NE. ¼ sec. 8, T. 14 S., R. 4 W., at county road bridge at Lyon's ranch, about 12 miles above the dam of the Red Rock Reservoir & Irrigation Co., and about 11 miles northeast of Monida.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May to October, 1911; April 15, 1914, to September 30, 1915.

GAGE.—Vertical staff on downstream side of pier, about 10 feet from left shore. Records for 1911 were obtained from staff gage at about the same site, but the gage was on a bridge that has been replaced by the one now in use. The bench mark has been destroyed, so no determined relation exists between the datum of the former gage and that of the present gage.

DISCHARGE MEASUREMENTS.—Made from downstream side of bridge at gage section.

CHANNEL AND CONTROL.—The stream is extremely sluggish, sediment is apt to accumulate, and aquatic growth on the bed causes backwater. Water begins to overflow the right bank 200 above the gage at a gage height of about 5.5 feet, and the overflow passes under several small bridges along the road.

WINTER FLOW.—Discharge relation affected by ice.

DIVERSIONS.—None from the river itself above the station, but numerous small tributaries are used for irrigating meadows and hayfields.

Monthly discharge of Red Rock River above Red Rock Reservoir, near Monida, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1911				
May	650	320	465	28,600
June	470	185	360	21,400
July	295	85	124	7,620
August	110	65	82.6	5,080
September	110	70	96.6	5,750
October	155	125	139	8,550
1914				
April 15-30	1,030	471	[a] 848	26,900
May	805	427	576	35,400
June	566	275	433	25,800
July	328	130	204	12,500
August	130	100	114	7,010
September	186	122	142	8,450
1914-15				
October	218	178	194	11,900
April	805	310	578	34,400
May	566	292	430	26,400
June	427	146	297	17,700
July	210	70	126	7,750
August	100	70	75.6	4,650
September	122	85	107	6,370

[a] Partly estimated.

RED ROCK RIVER BELOW RED ROCK RESERVOIR, NEAR MONIDA, MONT.

LOCATION.—In sec. 32, T. 13 S., R. 6 W., at weir 150 yards below reservoir of Red Rock Reservoir & Irrigation Co., 8 miles northeast of Monida and 15 miles east of Lima, in Beaverhead County.

DRAINAGE AREA.—About 560 square miles.

RECORDS AVAILABLE.—July 22, 1911, to September 30, 1918; also miscellaneous measurements made in summer of 1910.

GAGE.—Stage determined by measuring with graduated rod, the depth on a peg in concrete well set with its top at elevation of crest of weir. Float gage in concrete well used in 1912 and 1913. During 1911 a temporary vertical staff on the left bank about 300 yards below the dam was read. Gage heights, beginning with those for 1912, indicate head on crest of 40-foot weir about 150 yards below dam.

DISCHARGE MEASUREMENTS.—Made from footbridge 40 feet above the weir or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse gravel, pebbles, and boulders. Banks high; right bank is subject to overflow only during extremely high water. Current so swift at high stages that channel above weir, if cleaned out, soon becomes partly filled with rocks and pebbles, which cause considerable velocity of approach. Stage-discharge relation seldom changes after natural deposit has been allowed to rest undisturbed.

ICE.—Stage-discharge relation not affected by ice.

DIVERSIONS.—None.

REGULATION.—Dam is used to store flood waters to be released as required during irrigating season.

COOPERATION.—Record of daily gage heights furnished by Red Rock Reservoir & Irrigation Co.

Monthly discharge of Red Rock River below Red Rock Reservoir, near Monida, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1911				
July 23-31	95	88	90.8	1,620
August	105	63	78.4	4,820
September	105	69	95.8	5,700
1911-12				
October	450	100	207	12,700
November	280	123	179	10,700
December (estimated)			22.5	1,380
January	21	21	21	1,290
February	21	19	19.2	1,100
March	21	20	20.4	1,250
April	209	20	57.6	3,430
May	988	94	651	40,000
June	715	186	545	32,400
July	200	98	160	9,840
August	172	113	130	7,990
September	183	109	117	6,960
The year				129,000
1912-13				
October	390	120	316	19,400
November	382	278	353	21,000
December	145	6	76.7	4,720
January	5	5	5	307
February	5	5	5	278
March	5	5	5	307
April	1,120	5	571	34,000
May	1,040	360	658	40,500
June	640	262	491	29,200
July	360	162	237	14,600
August	320	228	254	15,600
September	280	245	265	15,800
The year				196,000
1913-14				
October	340	252	282	17,300
November	280	146	189	11,200
December	149	29	41.0	2,520
January	30	15	18.8	1,160
February	17	15	15.2	844
March	18	15	16.7	1,030
April	1,220	15	502	29,900
May	1,100	540	718	44,100
June	590	468	560	33,300
July	360	141	228	14,000
August	133	77	96.3	5,920
September	119	104	109	6,490
The year				168,000
1914-15				
October	565	165	329	20,200
November	590	29	270	16,100
December	32	30	31.8	1,960
January	32	30	31.8	1,960
February	33	32	32.1	1,780
March	33	32	32.6	2,000
April	1,040	33	487	29,000
May	915	340	506	31,100
June	515	160	407	24,200
July	154	60	136	8,360
August	320	96	146	8,980
September	340	280	324	19,300
The year	1,040	29	228	165,000

Monthly discharge of Red Rock River below Red Rock Reservoir, near Monida, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1915-16				
October	280	68	77.7	4,780
November	70	25	48.2	2,870
December	25	25	25	1,540
January	25	23	24.8	1,520
February	25	25	25	1,440
March	26	25	25	1,540
April	1,170	25	406	24,200
May	1,170	495	733	45,100
June	576	422	460	27,400
July	445	155	270	16,600
August	155	123	137	8,420
September	506	128	241	14,300
The year	1,170	25	206	150,000
1916-17				
October	659	234	430	26,400
November 1-10	207	141	185	3,670
April 15-30	775	106	340	10,800
May	1,050	775	948	58,300
June	955	422	754	44,900
July	234	115	155	9,530
August	111	75	85.6	5,260
September	82	75	77.5	4,610
1917-18				
October	124	78	96.9	5,960
November	124	124	124	7,380
December	124	51	67.7	4,160
January	51	51	51	3,140
February	51	51	51	2,830
March	48	48	48	2,950
April	328	48	176	10,500
May	391	272	349	21,500
June	266	222	241	14,300
July	450	45	202	12,400
August	138	24	110	6,760
September	167	129	140	8,330
The year	450	24	138	100,000

RED ROCK RIVER AT LIMA, MONT.

LOCATION.—Near the Gleed ranch, 1 mile east of Lima, Mont. Principal tributaries below the station, Sheep and Sage Creeks.

DRAINAGE AREA.—About 615 square miles.

RECORDS AVAILABLE.—August 14, 1907, to September 30, 1911.

GAGE.—Chain; installed October 27, 1908, at a point just above the cable and 300 feet farther downstream than the old staff gage which it replaced; datum of chain gage not the same as that of the staff gage.

DISCHARGE MEASUREMENTS.—At ordinary and high-water stages made from a cable below the gage; at extremely low stages measurements made by wading just below the cable section.

CHANNEL.—Probably permanent.

WINTER FLOW.—River generally remains open the entire year, as a large spring discharges into the stream just above the gage.

DIVERSIONS.—Three ditches, each carrying approximately 900 miner's inches, take water from Red Rock above the station. The flow of water above the station is all appropriated, but the rights are unadjudicated.

STORAGE.—The dam of the reservoir storing the water of the Red Rock has been completed, but no canals have been built. The dam is of earth with concrete core, is 50 feet high, and will impound 90,000 acre-feet; its top elevation is 6,700 feet; the dam is 16 miles above Lima, Mont., and 27 miles below lower Red Rock Lake.

Monthly discharge of Red Rock River at Lima, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1908				
August 14-31	216	81	169	6,030
September	167	122	157	9,340
1908-9				
October	229	167	202	12,400
November	246	107	168	10,000
December	122	80	101	6,210
January	90	40	60.3	3,710
February	62	44	51.6	2,870
March	107	58	75.7	4,650
April	583	107	261	15,500
May	775	190	471	29,000
June	406	28	174	10,400
July	200	79	123	7,560
August	93	56	73.8	4,540
September	160	79	122	7,260
The year				114,000
1909-10				
October	180	141	161	9,900
November	170	79	128	7,620
December	108	66	93.2	5,730
January	105	91	94.2	5,790
February	91	79	86.3	4,790
March	190	91	106	6,520
April	936	190	736	43,800
May	765	209	502	30,900
June	748	38	393	23,400
July	146	38	59.9	3,680
August	129	59	99.9	6,140
September	590	29	234	13,900
The year				162,000
1910-11				
October	765	48	183	11,300
November	121	71	105	6,250
December	71	48	57.6	3,540
January	18	14	16	984
February	21	16	18.2	1,010
March	18	14	16.6	1,020
April	191	16	40.6	2,420
May	525	250	432	26,600
June	510	213	397	23,600
July	237	54	149	9,160
August	92	54	66	4,060
September	160	78	110	6,550
The year				96,500

RED ROCK RIVER AT RED ROCK, MONT.

Location.—Sec. 33, T. 10 S., R. 10 W., a short distance above mouth of Horse Prairie Creek.

Drainage area.—1, 330 square miles.

Records available.—April 9 to October 31, 1890.

Monthly discharge of Red Rock River at Red Rock, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1890				
January			[a] 40	2,460
February			[a] 40	2,220
March			[a] 40	2,460
April 9-30	605	40	184	10,948
May	675	465	577	35,485
June	500	250	384	22,848
July	220	50	93	5,720
August	50	40	48	2,952
September	60	40	47	2,800
October	220	60	150	9,230

[a] Estimate.

BEAVERHEAD RIVER AT BARRATTS, MONT.

LOCATION.—In SW. ¼ SW. ¼ sec. 20, T. 8 S., R. 9 W., on highway bridge at point where highway crosses railroad and where both highway and railroad bridges cross river, 1 mile above Barratts, in Beaverhead County, 2 miles below mouth of Grasshopper Creek, and 10 miles southwest of Dillon.

DRAINAGE AREA.—About 2,800 square miles.

RECORDS AVAILABLE.—August 12, 1907, to September 30, 1923.

GAGE.—Chain gage on downstream side of bridge. Before June 22, 1908, a staff gage was used. Datum of chain gage same as that of staff gage.

DISCHARGE MEASUREMENTS.—Made from downstream side of bridge.

CHANNEL AND CONTROL.—Banks high, covered with brush, and not subject to overflow. Stream bed clean and rocky. Two channels at low and medium stages, caused by an old pier; sudden changes unlikely.

DIVERSIONS.—Numerous diversions are made above the station. Water rights aggregating 85,866 inches of water are decreed from Lima on Red Rock Creek to a point 10 miles above Twin Bridges. The three largest canals diverting below the station are Canyon Creek Canal, appropriating 6,000 inches; Union Canal, appropriating 4,000 inches; and Beaverhead Canal, diverting just north of Dillon, appropriating 5,000 inches. The Union Electric Co. of Dillon has a canal with a carrying capacity of 6,000 inches.

REGULATION.—Operation of the dam used to store flood waters of Red Rock Creek near Monida has some effect on the flow at this station.

Monthly discharge of Beaverhead River at Barratts, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1907				
August 12-31	640	389	468	18,600
September	430	322	350	20,800
1907-8				
October	444	342	393	24,200
November	494	404	440	26,200
December	424	296	358	22,000
January	350	288	309	19,000
February	300	259	277	15,900
March	524	278	345	21,200
April	909	322	637	37,900
May	2,920	398	805	49,500
June	3,640	1,710	2,610	155,000
July	1,480	550	865	53,200
August	627	487	530	32,600
September	596	432	505	30,000
The year				487,000
1908-9				
October	809	568	714	43,900
November	765	468	629	37,400
December	831	412	539	33,100
January	550	350	416	25,600
February	418	335	383	21,300
March	550	382	445	27,400
April	970	530	705	42,000
May	1,480	595	906	55,700
June	1,510	400	921	54,800
July	618	280	402	24,700
August	470	260	358	22,000
September	572	260	438	26,100
The year				414,000

Monthly discharge of Beaverhead River at Barratts, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1909–10				
October	618	470	549	33,800
November	685	510	581	34,600
December	685	418	477	29,300
January	580	351	442	27,200
February	435	360	393	21,800
March	2,010	415	934	57,400
April	1,360	688	1,150	68,400
May	1,500	580	1,070	65,800
June	550	114	304	18,100
July	235	155	202	12,400
August	267	160	220	13,500
September	505	145	268	15,900
The year				398,000
1910–11				
October	530	338	378	23,200
November	555	405	452	26,900
December	455	311	361	22,200
January			[a] 250	15,400
February			[a] 200	11,100
March	512	200	300	18,400
April	595	241	373	22,200
May	740	295	440	27,100
June	1,310	435	799	47,500
July	770	210	304	18,700
August	340	171	224	13,800
September	255	174	223	13,300
The year				260,000
1911–12				
October	770	234	447	27,500
November	650	350	509	30,300
December			[a] 350	21,500
March 15–31	440	255	283	9,540
April	900	390	550	32,700
May	2,100	490	1,170	71,900
June	2,900	595	1,640	97,600
July	650	198	329	20,200
August	1,300	340	603	37,100
September	595	340	439	26,100
1912–13				
October	900	390	664	40,800
November 1–11	900	835	870	19,000
March 15–31	1,510	225	399	13,500
April	1,860	880	1,350	80,300
May	2,070	1,000	1,450	89,200
June	2,280	880	1,540	91,600
July	1,000	350	560	34,400
August	880	350	546	33,600
September	575	350	442	26,300
1913–14				
October	700	600	660	40,600
November	700	500	638	38,000
December	500	265	324	19,900
March 22–31	318	280	288	5,710
April	1,220	299	769	45,800
May	1,410	869	1,110	68,300
June	1,410	494	874	52,000
July	447	318	392	24,100
August	299	151	205	12,600
September	380	166	283	16,800

[a] Estimated.

Monthly discharge of Beaverhead River at Barratts, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1914–15				
October	756	402	606	37,300
November	898	338	648	38,600
December		228	286	17,600
January	280	181	229	14,100
February	262	212	230	12,800
March 1–13	299	245	266	6,860
April 23–30	1,220	1,140	1,200	19,000
May	1,220	359	919	56,500
June	1,660	447	839	49,900
July	986	338	476	29,300
August	543	402	417	25,600
September	674	402	591	35,200
The year				343,000
1915–16				
October	567	398	447	27,500
November	467	332	414	24,600
December	398	312	343	21,100
January (estimated)			310	19,200
February	354	256	296	17,000
March	900	256	510	31,400
April	1,280	398	686	40,800
May	1,540	840	1,160	71,300
June	2,010	840	1,160	69,000
July	1,340	332	623	38,300
August	354	238	311	19,100
September	467	222	330	19,600
The year				399,000
1916–17				
October	961	467	717	44,100
November	840	354	511	30,400
December	375	332	362	22,300
January	375	292	329	20,200
February	332	256	286	15,900
March	354	256	278	17,100
April	1,340	292	757	45,000
May	3,130	1,210	1,910	117,000
June	2,570	1,080	1,840	109,000
July	1,080	256	442	27,200
August	332	256	301	18,500
September	292	256	286	17,000
The year	3,130	256	670	484,000
1917–18				
October	615	294	417	25,600
November	669	563	630	37,500
December	558	461	489	30,100
January	553	368	430	26,400
February	368	368	368	20,400
March	599	363	433	26,600
April	702	402	510	30,300
May	818	359	618	38,000
June	594	202	387	23,000
July	788	202	392	24,100
August	359	278	307	18,900
September	359	239	290	17,300
The year	818	202	440	318,000
1918–19				
October	647	359	525	32,300
November	543	402	472	28,100
December	402	359	364	22,400
January	338	239	268	16,500
February	318	239	280	15,600
March	568	239	308	18,900
April	938	359	490	29,200
May	674	167	360	22,100
June	359	167	268	15,900
July	167	106	136	8,360
August	135	106	122	7,500
September	135	106	126	7,500
The year	938	106	310	224,000

Monthly discharge of Beaverhead River at Barratts, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1919–20				
October	220	135	161	9,900
November	318	239	278	16,500
December	359	202	304	18,700
January	318	239	250	15,400
February	278	202	235	13,500
March	318	202	252	15,500
April	647	239	471	28,000
May	1,130	402	776	47,700
June	836	416	587	34,900
July	445	151	248	15,200
August	396	195	283	17,400
September	222	195	204	12,100
The year	1,130	135	337	245,000
1920–21				
October	388	219	294	18,100
November	471	313	385	22,900
December	313	279	284	17,500
January	279	219	265	16,300
February	416	219	270	15,000
March	786	367	484	29,800
April	1,230	467	852	50,700
May	1,400	696	1,010	62,100
June	2,070	535	1,400	83,300
July	493	270	350	21,500
August	432	286	374	23,000
September	392	286	351	20,900
The year	2,070	219	527	381,000
1921–22				
October	378	309	328	20,200
November	590	378	520	30,900
December	516	375	432	26,600
January	452	339	396	24,300
February	339	274	307	17,000
March	511	271	320	19,700
April	1,160	302	579	34,500
May	2,320	847	1,460	89,800
June	1,820	336	1,080	64,300
July	444	268	339	20,800
August	529	299	358	22,000
September	386	268	328	19,500
The year	2,320	268	538	390,000
1922–23				
October	299	268	281	17,300
November	444	299	383	22,800
December	405	315	375	23,100
January	329	312	328	20,200
February	329	265	310	17,200
March	401	265	282	17,300
April	595	382	445	26,500
May	1,090	566	916	56,300
June	1,200	776	953	56,700
July	631	357	471	29,000
August	498	364	425	26,100
September	336	265	292	17,400
The year	1,200	265	456	330,000

JEFFERSON RIVER NEAR SILVER STAR, MONT.

LOCATION.—In sec. 23, T. 2 S., R. 6 W., at highway bridge at Cornforth's ranch, on road from Silver Star, Madison County, to Iron Rod, a station on Ruby Valley branch of Northern Pacific Railway, 5 miles below junction of Beaverhead and Bighole Rivers.

DRAINAGE AREA.—7,940 square miles.

RECORDS AVAILABLE.—August 11, 1910, to September 30, 1916; July 22, 1920, to September 30, 1924.

GAGE.—1910–1916 staff gage nailed to downstream side of bridge; 1920 on chain on downstream side of bridge.

DISCHARGE MEASUREMENTS.—Made from bridge.

CHANNEL AND CONTROL.—Bed composed of gravel; practically permanent. Left bank high and clean. Right bank covered with brush and subject to overflow during extreme floods. No well-defined control.

ICE.—Stage-discharge relation seriously affected by ice.

DIVERSIONS.—Numerous irrigating ditches divert water above and below station.

Monthly discharge of Jefferson River near Silver Star, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1910				
August 11-31	385	320	359	15,000
September	925	368	572	34,000
1910–11				
October	1,140	805	974	59,900
November	1,910	1,210	1,440	85,700
December	1,720	1,210	1,370	84,200
May	3,300	2,240	2,700	166,000
June	9,280	2,790	6,850	408,000
July	3,400	620	1,510	92,800
August	800	440	639	39,300
September	1,120	710	846	50,300
1911–12				
October	1,580	900	1,270	78,100
March 25-31	1,180	900	1,070	14,900
April	3,090	1,180	2,010	120,000
May	9,820	2,500	5,990	368,000
June	13,100	5,600	9,600	571,000
July	5,350	1,660	2,640	162,000
August	2,890	1,510	2,030	125,000
September	1,900	1,510	1,740	104,000
1912–13				
October	2,240	1,820	1,970	121,000
April	6,730	1,920	3,730	222,000
May	14,700	2,870	7,060	434,000
June	16,500	4,940	10,500	625,000
July	7,800	950	2,910	179,000
August	2,270	630	1,390	85,500
September	1,680	1,000	1,240	73,800
1913–14				
October	1,920	1,240	1,590	97,800
November	2,000	1,310	1,640	97,600
March 16-31	1,380	1,060	1,210	38,400
April	3,530	1,060	2,520	150,000
May	7,530	2,870	5,030	309,000
June	8,610	4,220	5,420	323,000
July	3,990	715	2,030	125,000
August	670	460	554	34,100
September	1,450	520	965	57,400
1914–15				
October	2,000	1,350	1,850	114,000
November	2,000	1,500	1,890	112,000
March 21-31	1,660	1,080	1,330	29,000
April	4,090	1,830	2,990	178,000
May	4,780	2,370	3,550	218,000
June	7,260	1,660	4,210	251,000
July	5,720	1,500	2,780	171,000
August	2,780	965	1,410	86,700
September	2,000	1,080	1,630	97,000

Monthly discharge of Jefferson River near Silver Star, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1915–16				
October	2,180	1,660	1,900	117,000
November 1–10	1,660	1,350	1,470	29,200
March 19–31	2,780	2,000	2,420	62,400
April	5,480	2,180	3,180	189,000
May	6,990	4,090	5,040	310,000
June	13,500	4,090	8,340	496,000
July	10,600	1,080	5,130	315,000
August	1,660	465	1,070	65,800
September	2,180	1,500	1,890	112,000
1920				
July 22–31	1,500	642	960	19,000
August	1,000	433	618	38,000
September	928	486	725	43,100
1920–21				
October	1,340	928	1,120	68,900
November	1,370	1,230	1,310	78,000
December	1,230	1,100	1,160	71,300
March 5–31	1,420	1,120	1,240	66,400
April	3,420	1,340	2,490	148,000
May	8,750	2,180	5,000	307,000
June	13,400	3,200	8,580	511,000
July	2,990	599	1,480	91,000
August	881	571	696	42,800
September	1,320	748	1,120	66,600
1921–22				
October	1,080	881	964	59,300
November	1,560	1,080	1,310	78,000
December 1–20	1,600	1,440	1,510	59,900
March 23–31	1,660	1,290	1,400	25,000
April	3,310	1,240	1,930	115,000
May	11,400	2,990	6,750	415,000
June	13,200	2,500	8,540	508,000
July	2,410	1,130	1,680	103,000
August	1,470	992	1,220	75,000
September	1,390	948	1,170	69,600
1922–23				
October	970	780	827	50,800
November	1,470	970	1,290	76,800
December 1–6	1,300	1,200	1,260	15,000
January 28–31	1,230	1,200	1,210	9,600
February 1–17	1,280	1,100	1,180	39,800
March 13–31	1,360	1,080	1,200	45,200
April	3,530	1,420	2,060	123,000
May	7,260	2,160	3,970	244,000
June	7,260	3,530	5,080	302,000
July	4,660	1,040	2,160	133,000
August	1,280	926	1,040	64,000
September	1,020	800	859	51,100
1923–24				
October	1,230	860	1,070	65,800
November	1,470	1,230	1,370	81,500
December	1,390	1,100	1,240	76,200
February 13–29	1,390	1,150	1,230	41,500
March	1,200	1,130	1,160	71,300
April	2,700	1,180	2,060	123,000
May	5,240	2,320	3,810	234,000
June	2,830	598	1,520	90,400
July	970	305	660	40,600
August	329	129	193	11,900
September	670	137	443	26,400

JEFFERSON RIVER AT SAPPINGTON, MONT.

Location.—In T. 1 N., R. 1 W., 1 mile north of railroad station at Sappington, Mont., and 7 miles above Willow Creek.

Drainage area.—About 9,500 square miles.

Records available.—November 13, 1894, to December 31, 1905. Prior to September 1, 1896, miscellaneous measurements only.

GAGE.—Original gage vertical staff fastened to metal pier of Northern Pacific Railway bridge. Later chain gage.

DISCHARGE MEASUREMENTS.—Made from cable except from June 15 to November 1, 1904, when measurements were made from old Northern Pacific Railway bridge.

CHANNEL AND CONTROL.—Channel straight 500 feet above and below station. Both banks composed of clay and covered with willows and underbrush. The right bank may be overflowed at extremely high water. The bed is smooth and regular and is covered with gravel. Current swift and free from eddies.

Monthly discharge of Jefferson River at Sappington, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1896				
September	1,480	1,227	1,342	79,900
1896-97				
October	1,375	1,299	1,327	81,600
November	1,675	1,254	1,499	89,200
December			1,650	101,000
January			[a] 1,500	92,200
February			[a] 1,500	83,300
March			[a] 1,500	92,200
April			[a] 3,300	196,000
May	11,040	5,375	8,587	528,000
June	7,900	2,900	4,274	254,000
July	4,100	1,100	2,356	145,000
August	1,100	550	794	48,800
September	860	550	758	45,100
1897				
October	1,225	780	1,013	62,300
November			[a] 1,300	77,400
December			[a] 1,400	92,200
1899				
April	2,645	1,870	1,992	119,000
May	7,645	2,020	4,915	302,000
June	15,470	7,445	10,933	651,000
July	11,165	2,485	6,159	379,000
August	2,485	1,455	2,003	123,000
September	1,325	1,090	1,297	77,200
1899-1900				
October	2,170	1,090	1,614	99,200
November	2,170	1,725	1,936	115,000
December 1-14			1,925	53,500
March 10-31	2,485	1,725	2,098	129,000
April	3,870	2,020	3,067	182,000
May	9,075	3,870	6,511	400,000
June	5,890	2,020	4,070	242,000
July	1,870	600	1,024	63,000
August	600	475	519	31,900
September	980	515	743	44,200
1900-1901				
October	1,590	1,090	1,363	83,800
November	1,590	1,455	1,486	88,400
December	1,725	1,325	1,541	94,800
March			1,443	69,500
April	5,510	1,260	2,281	136,000
May	9,325	5,730	6,949	427,000
June	7,580	2,375	3,754	223,000
July	2,375	610	1,187	73,000
August	610	550	535	32,900
September	820	430	665	39,600

[a] Approximate.

Monthly discharge of Jefferson River at Sappington, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1901–2				
October	935	820	847	52,100
November	1,155	975	1,057	62,900
December			1,164	43,900
April	3,550	875	1,875	112,000
May	9,255	2,390	5,028	309,000
June	9,060	2,710	5,081	302,000
July	4,640	1,210	2,502	154,000
August	1,150	485	801	49,000
September	875	645	739	44,000
1902–3				
October	1,210	875	1,059	65,100
November	1,755	1,210	1,460	86,900
December	1,755	1,470	1,630	100,000
January	2,470	1,330	1,797	110,000
February	4,020	1,890	2,848	158,000
March	2,320	1,750	1,974	121,000
April	4,020	1,890	2,561	152,000
May	5,630	3,070	3,654	225,000
June	9,770	4,020	7,117	423,000
July	4,020	1,470	2,412	148,000
August	1,470	570	859	52,800
September	1,060	570	828	49,300
1903–4				
October	1,330	940	1,202	73,900
November	6,435	1,190	3,204	191,000
December	5,515	1,260	2,712	167,000
January			[b] 1,400	86,100
February			[b] 1,400	81,000
March [c]	1,860	1,210	1,433	88,100
April	7,150	1,450	3,218	191,000
May	9,240	5,060	6,516	401,000
June	7,720	2,780	5,440	324,000
July	3,445	1,045	2,055	126,000
August	1,045	465	606	37,300
September	630	545	566	33,700
The year				1,799,100
1904–5				
October	1,155	545	824	50,700
November	1,580	990	1,308	77,800
December [d]	1,720	1,100	1,353	83,200
March 7–31	1,700	1,180	1,413	70,100
April	2,005	1,125	1,578	93,900
May	1,555	978	1,214	74,600
June	5,485	1,180	3,206	191,000
July	3,605	798	1,665	102,000
August	978	498	658	40,500
September	600	465	536	31,900
October	1,180	600	814	50,000
November	1,625	978	1,346	80,100

[b] Estimated by C. C. Babb.
[c] Mar. 10–31, inclusive. Mean for 22 days taken as mean for month
[d] Discharge Dec. 27–31, estimated 1,720 second-feet.

GRASSHOPPER CREEK NEAR DILLON, MONT.

Location.—In NW. ¼ sec. 26, T. 8 S., R. 10 W., 5 miles above Barratts and 14 miles above Dillon, Beaverhead County.

Drainage area.—360 square miles (measured on Forest Service map of Beaverhead National Forest).

Records available.—March 10, 1921, to September 30, 1923.

Gage.—Vertical staff.

Discharge measurements.—Made by wading at gage or from bridge one-eighth mile above.

Channel and control.—Banks high and covered with brush. Stream bed composed of boulders and coarse gravel; subject to shift.

ICE.—Stage-discharge relation seriously affected by ice.
DIVERSIONS.—Considerable water diverted for irrigation above gage.
REGULATION.—None.

Monthly discharge of Grasshopper Creek near Dillon, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1921				
March 10-31	131	21	51	2,230
April	33	122	65.6	3,900
May	307	47	136	8,360
June	480	81	277	16,500
July	99	15	38.7	2,380
August	39	10	21.6	1,330
September	46	10	32.1	1,910
1921-22				
October	47	23	33.2	2,040
November 1-16	47	40	44.1	1,400
March	70	15	31.5	1,940
April	292	17	114	6,780
May	543	95	243	14,900
June	520	63	289	17,200
July	104	26	47.4	2,910
August	73	20	40.9	2,510
September	36	13	21.7	1,290
1922-23				
October	39	19	31.4	1,930
November	46	32	37.8	2,250
December	38	20	26.9	1,650
January	35	30	34.4	2,120
February			25.0	1,390
March	98	25	36.6	2,250
April	114	68	80.1	4,770
May	175	65	99.4	6,110
June	277	107	161	9,580
July	114	38	68.8	4,230
August	77	37	46.4	2,850
September	44	28	31.1	1,850
The year				41,000

RUBY RIVER NEAR ALDER, MONT.

LOCATION.—At private bridge on Lauterbach's ranch, about 8 miles south of Alder.

DRAINAGE AREA.—About 540 square miles.

RECORDS AVAILABLE.—April 27, 1911, to June 30, 1914, when station was discontinued.

GAGE.—Vertical staff spiked to bridge pile 4 feet from right bank.

DISCHARGE MEASUREMENTS.—At low and ordinary stages made by wading on riffle at control 200 feet below gage; high-stage measurements made from downstream side of bridge.

CHANNEL AND CONTROL.—Slightly shifting. Bed of stream below the gage composed of gravel and pebbles. At the gage the water is deeper and the material of the bed is finer than below.

WINTER FLOW.—Discharge relation affected by ice.

DIVERSIONS.—A number of small diversions are made for irrigation.

Monthly discharge of Ruby River near Alder, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1911				
May	652	141	373	22,900
June	920	340	630	37,500
July	340	141	189	11,600
August	219	95	147	9,040
September	141	76	114	6,780
1911-12				
October	166	117	139	8,550
November	141	117	134	7,970
December			[a] 100	6,150
April	219	117	145	8,630
May	1,060	141	422	25,900
June	1,060	407	748	44,500
July	372	140	287	17,600
August	372	165	243	14,900
September	204	115	153	9,100
1912-13				
October	204	152	174	10,700
November	165	115	140	8,330
December	140	128	130	1,860
June 22-30	570	317	447	7,980
July	490	180	285	17,500
August	230	65	160	9,840
September	127	85	97.1	5,780
1913-14				
October			179	11,000
November	219	166	186	11,100
December 1-6	166	141	159	1,890
April 20-30	337	245	289	6,300
May	935	275	630	38,700
June	935		661	39,300

[a] Estimated.

BIG HOLE RIVER NEAR DEWEY, MONT.

LOCATION.—In sec. 36, T. 1 N., R. 11 W., at Young's bridge, 4 miles above Dewey and 11 miles above Divide, Mont.; a few miles below the mouth of Wise River.

DRAINAGE AREA.—About 1,990 square miles.

RECORDS AVAILABLE.—September 15, 1911, to July 31, 1913, when station was discontinued.

GAGE.—Staff fastened to southeast piling of bridge on downstream side. This gage was washed out on April 16, 1913, and on May 2, 1913, a temporary staff gage was installed on the left abutment of the old bridge. The temporary gage was read May 2, 1913, to July 31, 1913.

DISCHARGE MEASUREMENTS.—Made from bridge.

CONTROL.—Rocky and clean; nonshifting.

WINTER FLOW.—Stage-discharge relation affected by ice.

DIVERSIONS.—Water is diverted from this stream for irrigation.

Monthly discharge of Big Hole River near Dewey, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1910				
September 15-31	387	187	271	9,140
1910-11				
October	542	304	393	24,200
November	524	430	500	29,800
December	478		367	22,600
January			a 300	18,400
February			a 250	13,900
March	655		343	21,100
April	2,000	680	1,160	69,000
May	2,600	1,360	1,870	115,000
June	10,400	1,900	6,590	392,000
July	4,560	755	1,640	101,000
August	870	265	551	33,900
September	350	250	276	16,400
The year				857,300
1911-12				
October	605	280	488	30,000
November	430	280	365	21,700
December	315		245	15,100
March	265	190	233	14,300
April	2,100	250	1,120	66,600
May	6,930	1,530	4,280	263,000
June	9,270	4,950	6,680	397,000
July	4,590	935	1,910	117,000
August	1,810	470	928	57,100
September	1,130	560	685	40,800
1912-13				
October	755	515	672	41,300
November 1-9	630	492	538	9,600
March 14-31	332	250	278	9,930
April 1-15	2,460	350	754	22,400
May	9,990	1,280	4,150	255,000
June	11,100	3,300	6,440	383,000
July	4,950	1,280	2,440	150,000

a Estimated.

BIG HOLE RIVER NEAR MELROSE, MONT.

Location.—In SE. ¼ sec. 27, T. 3 S., R. 9 W., at highway bridge at Browns siding on Oregon Short Line Railroad, 8 miles south of Melrose.

Records available.—March 16 to September 27, 1924.

Gage.—Stevens continuous recorder in wooden shelter on left bank on downstream side of bridge.

Discharge measurements.—Made from the highway bridge. Downstream handrail graduated with white paint at 10-foot intervals. Wading section for extreme low water located at riffle about 400 feet below.

Channel.—Composed of heavy boulders and sand. Probably shifts with the movement of gravel and sand. Two channels at high stage. Channel is straight for 200 feet above and about 500 feet below gage. Current swift at high stage, with some eddies on left bank. Right banks high, wooded, and not subject to overflow. Left bank low, wooded, and subject to overflow above gage.

Regulation.—Power-plant operations above station cause some fluctuation.

Monthly discharge of Big Hole River near Melrose, Mont.

Month	Discharge (second-feet)			Run-off (inches)
	Maximum	Minimum	Mean	
1924				
March 16-31	356	338	347	11,000
April 11	2,400	346	1,150	68,400
May	4,520	1,640	3,210	197,000
June	2,530	685	1,480	88,100
July	746	374	563	34,600
August	360	231	294	18,100
September 1-27	271	231	249	13,300

PIPESTONE CREEK NEAR WHITEHALL, MONT.

LOCATION.—6 miles west of Whitehall, Mont., at Peyton Allred's ranch, a short distance above junction of Pipestone and Little Pipestone Creeks.

DRAINAGE AREA.—About 115 square miles.

RECORDS AVAILABLE.—October 13, 1910, to September 30, 1911.

GAGE.—Staff fastened securely to a large post on the left bank of the stream directly north of the observer's house.

CHANNEL.—Sandy and shifting.

COOPERATION.—Gage heights and discharge measurements supplied by G. E. Baker.

Monthly discharge of Pipestone Creek near Whitehall, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1910-11				
October 13-31	3.5	2.5	3.03	114
November	15	2.5	8.28	493
December	16	10	12.5	769
January			[a] 10	615
February			[a] 12	666
March	23	10	14.2	873
April	49	15	21.6	1,290
May	49	29	39.5	2,430
June	87	27	53.8	3,200
July	33	1.5	6.23	383
August	8	.5	2.24	138
September	1.5	.5	1.40	83
The year				11,000

[a] Estimated.

WHITETAIL CREEK AT WHITEHALL, MONT.

LOCATION.—At highway bridge in northeastern part of town.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—March 19 to June 30, 1911.

GAGE.—Staff gage nailed to pile on upstream side of bridge.

DISCHARGE MEASUREMENTS.—Made by wading at ordinary stages.

CHANNEL.—Sandy; liable to shift.

WINTER FLOW.—Stage-discharge relation affected by ice.

ARTIFICIAL CONTROL.—Water is diverted above the station for irrigation.

COOPERATION.—Gage heights and discharge measurements supplied by G. E. Baker.

Monthly discharge of Whitetail Creek at Whitehall, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1911				
March 19-31	20	14	17.1	440
April	124	16	41.6	2,480
May	72	14	34.6	2,130
June	96	10	32.2	1,920

LITTLE WHITETAIL CREEK NEAR WHITEHALL, MONT.

LOCATION.—At Collin's ranch, 7 miles above Whitehall.

RECORDS AVAILABLE.—March 17 to September 22, 1911.

DRAINAGE AREA.—Not measured.

GAGE.—Staff gage on right bank just above ford near the stables.

CHANNEL.—Sandy and shifting.

DISCHARGE MEASUREMENTS.—Made by wading at different sections.

WINTER FLOW.—Stage-discharge relation affected by ice.

ARTIFICIAL CONTROL.—Water is diverted for irrigating.

ACCURACY.—Fair. The shifting affects the results to some extent.

COOPERATION.—Gage heights and discharge measurements supplied by G. E. Baker.

Monthly discharge of Little Whitetail Creek near Whitehall, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1911				
March	9.7	3.3	5.54	341
April	12	4.7	6.65	396
May	6.8	.6	3.15	194
June	12	.6	4.96	295
July	1.5	.6	1.24	76.2
August	4.7	1.5	2.67	164
September	2.9	.6	1.89	112
The period				1,580

MUSKRAT CREEK NEAR BOULDER, MONT.

LOCATION.—In sec. 6, T. 6 N., R. 3 W., 1,000 feet above Boulder Nursery, near Boulder.

DRAINAGE AREA.—About 7 square miles.

RECORDS AVAILABLE.—April 27, 1912, to September 30, 1914.

GAGE.—Staff gage fastened to a flume 2.5 feet upstream from crest of weir. Gage heights give the head on the weir.

DISCHARGE MEASUREMENTS.—Flow measured by a sharp-crested weir 4.85 feet long with end contractions. Discharge computed by Francis formula, correcting for end contractions and velocity of approach.

CHANNEL AND CONTROL.—Flume; principal control is sharp-crested weir.

WATER FLOW.—Stage-discharge relation affected by ice.

REGULATION.—No regulation or diversion above the station.

Monthly discharge of Muskrat Creek near Boulder, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1912				
May	13.5	1.7	6.53	402
June	25.5	7.1	13.5	803
July	9.4	3.2	5.34	328
August	4.6	2.0	2.86	176
September	5.3	2.1	2.95	176
1912–13				
October	4.9	2.6	3.54	218
November	3.6	2.4	2.84	169
December	2.4	2.2	2.24	62
January	1.6	1.2	1.36	83.6
February	1.2	1.0	1.03	57.2
March	1.0	.8	.91	56.0
April	4.8	.8	2.74	163
May	27.4	2.6	8.83	543
June	29.2	8.2	14.4	857
July	10.0	3.8	5.66	348
August	3.5	1.6	2.55	157
September	2.2	1.2	1.53	91
The year				2,800

Monthly discharge of Muskrat Creek near Boulder, Mont.—Continued

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1913–14				
October 1–14	4.1	1.4	2.71	75.2
April 10–30	3.2	.8	1.85	77.1
May	27	2.6	13.2	812
June	33	8.6	16.7	994
July	7.6	2.5	4.80	295
August	2.4	1.4	1.86	114
September 1–24	3.2	1.4	1.88	89.5

BOULDER RIVER AT BASIN, MONT.

Location.—In NE. ¼ sec. 18, T. 6 N., R. 5 W., half a mile above mouth of Basin Creek and 1½ miles above mouth of Cataract Creek, at Basin, Jefferson County.

Drainage area.—226 square miles.

Records available.—February 26, 1921, to September 30, 1923; June 6, 1919, to July 22, 1920, at station 1½ miles downstream; discharge not comparable.

Gage.—An overhanging cable and weight.

Discharge measurements.—Made by wading at gage or from railway bridge 600 feet below.

Channel and control.—One channel at all stages; bed composed of gravel and large boulders. Banks high and clean.

Ice.—Stage-discharge relation affected by ice.

Diversions.—None.

Regulation.—None.

Monthly discharge of Boulder River at Basin, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1921				
February 26–28	122	69	96.7	575
March	164	35	61.6	3,790
April	253	41	142	8,450
May	931	114	591	36,300
June	613	91	323	19,200
July	155	28	63	3,870
August	30	12	21.6	1,330
September	37	9.2	26.1	1,550
The period				75,100
1921–22				
October	30	21	24.4	1,500
November 1–15	30	21	26.1	777
March 13–31	24	13	18.5	697
April	174	19	60.4	3,590
May	1,390	148	683	42,000
June	1,130	162	610	36,300
July	179	50	94.7	5,990
August	84	29	51.1	3,140
September	54	23	30.8	1,830
1922–23				
October	34	24	28.1	1,730
November	37	17	27.8	1,650
December 1–13	27	20	21.6	557
March 18–31	62	17	29	805
April	284	44	115	6,840
May	540	118	297	18,300
June	481	133	252	15,000
July	197	38	94.6	5,820
August	60	23	34.7	2,130
September	26	13	17.5	1,040

BOULDER RIVER NEAR BASIN, MONT.

LOCATION.—Near center of east line of sec. 17, T. 6 N., R. 5 W., just below mouth of Cataract Creek and 1½ miles below railway station at Basin, Jefferson County.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—June 6, 1919, to September 30, 1920; fragmentary.

GAGE.—Vertical staff.

DISCHARGE MEASUREMENTS.—Made by wading at gage or from cable bridge half a mile upstream and above mouth of Cataract Creek.

CHANNEL AND CONTROL.—Control affected by beaver dams.

ICE.—Records discontinued during winter.

DIVERSIONS.—None.

REGULATION.—None.

Monthly discharge of Boulder River near Basin, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1919				
June 6-30	130	6.4	56.6	2,810
July	44	.6	8.10	498
August	44	2.7	20.3	1,250
September	34	1.5	11.0	654
The period				5,210
1919-20				
October	28	6.4	14.2	873
November	62	17	44.6	2,650
December 1-6	44	36	40.3	480
April 4-29	184	67	136	7,010
June 19-30	568	317	431	10,300
July 1-22	317	66	160	6,980

WILLOW CREEK NEAR WILLOW CREEK, MONT.

LOCATION.—In sec. 18, T. 1 S., R. 1 E., at highway bridge at Harwood's ranch, 7 miles south of Willow Creek, Gallatin County.

DRAINAGE AREA.—167 square miles.

RECORDS AVAILABLE.—September 5, 1919, to September 30, 1923.

GAGE.—Chain gage on upper handrail of bridge; September 5, 1919, to March 31, 1920, gage at different datum, located at Capps' ranch, half a mile downstream.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading on riffle below gage.

CHANNEL AND CONTROL.—Stream bed composed of sand and gravel. Banks low and covered with brush.

ICE.—Stage-discharge relation seriously affected by ice.

DIVERSIONS.—Numerous diversions for irrigation both above and below gage.

REGULATION.—None.

COOPERATION.—The South Bench irrigation district pays the observer.

Monthly discharge of Willow Creek near Willow Creek, Mont.

Month	Discharge (second-feet)			Run-off (acre-feet)
	Maximum	Minimum	Mean	
1919				
September 5-30	8.9	5.5	7.01	362
1919-20				
October 1-23	15	7.5	10.7	488
November	67	12	43.2	2,570
February	60	20	39.8	2,290
March 11-31	119	27	60.6	2,520
June 14-30	286	197	228	7,690
July	253	65	140	8,610
August	91	15	42.9	2,640
September	48	23	29.5	1,760
1920-21				
October	57	25	38.0	2,340
November	77	20	43.4	2,580
December	70		44.9	2,760
January			[a] 20	1,230
February			[a] 15	833
March	64	20	37.5	2,310
April	59	34	51.1	3,040
May	104	33	64.1	3,940
June	280	65	136	8,090
July	98	22	40.8	2,510
August	59	19	28.8	1,770
September	49	17	32.7	1,950
The year	280		46.1	33,400
1921-22				
October	40	31	36	2,210
November 1-19	42	26	39.3	1,480
March 22-31	59	42	46.7	926
April	114	45	58.3	3,470
May	287	71	146	8,980
June	399	146	241	14,300
July	133	44	71.6	4,400
August	45	24	32.2	1,980
September	45	28	33.7	2,000
1922-23				
October	47	26	34.9	2,150
November	84	34	54	3,210
December		34	50.9	3,130
January			[a] 40	2,460
February			25	1,390
March	142		39.2	2,410
April	126	59	74	4,400
May	260	64	125	7,690
June	317	74	145	8,630
July	144	25	73.2	4,500
August	34	18	25.1	1,540
September	42	23	26.2	1,560
The year	317		59.5	43,100

[a] Estimated.

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