UNITED STATES DEPARTMENT OF THE INTERIOR
Ray Lyman Wilbur, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Water-Supply Paper 638

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

1931

NATHAN C. GROVER, Chief Hydraulic Engineer

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1932

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - - - 35 cents

CONTENTS

[The letters in parentheses preceding the titles are those used to designate the papers for advance publication]

ILLUSTRATIONS

WATER-POWER RESOURCES OF THE ROGUE RIVER DRAINAGE BASIN, OREGON

By Benjamin E. Jones, Warren Oakey, and Harold T. Stearns

SUMMARY

The volcano whose crater is now occupied by Crater Lake, in southwestern Oregon, during its last active period poured forth volcanic ash that covered the country within a radius of about 25 miles. Rain and melting snow percolate easily into this light material, but after entering the ground the progress of the water is slow, and several months are required before it reaches the streams. Through the long dry season, therefore, run-off from the rains of the previous winter and spring is appearing in the creeks and rivers to maintain the flow, although there is no precipitation.

The Rogue River drains the western half of this area around Crater Lake. It rises at an altitude of about 5,000 feet and flows in a southwesterly direction for 210 miles to the Pacific Ocean. The drainage area is 5,080 square miles. The upper part of the basin is rough and wooded and has little tillable land. Its annual precipitation is 50 to 75 inches. This upper section furnishes practically all of the low-water flow of the river. The middle part of the basin constitutes the agricultural portion. Because of the low rainfall, 20 to 30 inches annually, and its seasonal distribution, very few crops can be raised without irrigation; yet when water is put on the land it is as productive as that in any other part of Oregon. Below the mouth of the Applegate the river enters a more rugged region and flows in a fairly wide canyon containing little marketable timber and practically no tillable land except a few farms below Illahe.

The main tributaries of the Rogue River are the Applegate and Illinois Rivers. The Applegate River drains an agricultural area and during the summer is almost entirely used for irrigation. The Illinois River drains a mountainous area not far from the coast and is used to a slight extent for irrigation above Kerby; below that place it flows in a narrow canyon until it joins the Rogue River. The rainfall in the basin of the Illinois River amounts to about 68 inches, but there is a dry period from June to September, when the flow is very low, for the volcanic ash that acts as a reservoir on the upper Rogue River does not reach to the basin of the Illinois River.

Because of the character of its basin, the large and well-sustained flow, and the steep gradient, the Rogue River is well suited for use as a source of power. Field studies were made by the United States Geological Survey in 1923 and 1926 to determine the amount of power available and its relation to the public lands. Maps and profiles of the river have already been published, and a comprehensive scheme of development is outlined in this report. (See pls. 3 and 4 and Tables 1 and 2.) There are at present (1930) eight constructed power plants in the basin, of which four are on the main stream and four on tributaries. All these sites are capable of further development.

The principal plants are those at Prospect and Raygold, owned by the California-Oregon Power Co. A small plant at Gold Hill is used to pump water for the

town. At Savage Rapids an irrigation company has erected a dam to raise the water level 20 feet for the double purpose of diverting water directly into a low-level canal for irrigation and of supplying power to pump water to a high-level canal. The city of Ashland maintains a small municipal plant on Ashland Creek. The plants on Butte Creek and Mill Creek were erected to supply power to sawmills, and one on Reuben Creek supplies a mine. The information concerning constructed plants in the Rogue River Basin is summarized in Table 1.

Two reservoir sites were found on the Rogue River, one on the Applegate River, and one on the Illinois River. The upper site on the Rogue River is at Hamaker Meadows, in T. 29 S., R. 4 E., where a dam 160 feet high would create 20,000 acre-feet of storage, but the rock of the reservoir site and surrounding country is porous, and a detailed geologic examination is necessary to determine whether or not the reservoir will hold water. The Lost Creek reservoir site on the Rogue River is in T. 33 S., Rs. 1 and 2 E., and has a potential capacity of 110,000 acre-feet with a dam 170 feet high; this reservoir would flood some bottom lands now cultivated and irrigated and would require the moving of a few houses and the relocation of a portion of the Crater Lake Highway. A third possible reservoir site on the Rogue River above Taylor Creek is not considered practicable because of the excessive cost of valuable agricultural land that would be flooded. A reservoir site on the Applegate River in T. 37 S., R. 6 W., has a potential capacity of 195,000 acre-feet with a dam 135 feet high; considerable damage to lands, buildings, and highways would result from its construction. Near Kerby, on the Illinois River, a dam 170 feet high would create a reservoir of more than 400,000 acre-feet capacity; this reservoir site is mostly on private land, but the power plants on the Illinois River below would all be on public land.

The potential power at each proposed power site is summarized in Table 2. The Prospect site, the largest on the upper river, has been considered in connection with the present plant. Most of the sites involve no particular difficulties in construction.

At the Gold Hill site, by building a dam 13 feet high in sec. 11, T. 36 S., R. 3 W., a canal 2.6 miles long, and a penstock half a mile long, a head of 65 feet could be obtained, which would permit the generation of 5,800 horsepower for 90 per cent of the time and 11,400 horsepower for 50 per cent of the time without regulation.

Below Grants Pass there are several good sites where the river flows in narrow rocky canyons. The Taylor Creek site is the first of these. A dam 82 feet high with a crest length of 270 feet at this point would flood only 560 acres of land, most of which lies in the narrow bottom of the canyon. The dam could easily be built to a greater height, but it is doubtful if the increase in head would pay for the agricultural lands overflowed.

At the Swing Bridge site, in T. 34 S., R. 8 W., a dam 107 feet high would have a crest length of 500 feet. The damage to property at this site and the two sites immediately below would be negligible.

At the Horseshoe Bend site, in T. 33 S., R. 9 W., a rock-fill dam 128 feet high is proposed. The spillway would be across the bend.

At the mouth of Stairs Creek, in T. 33 S., R. 10 W., a dam 150 feet high would have a crest length of 320 feet. This is an excellent site for a dam, but it would be difficult to reach with construction materials.

The lowest power site on the Rogue River is at Copper Canyon, where a dam 200 feet high would have a crest length of 550 feet. There would be some property damage due to backwater from this dam, but it would not be excessive The dam site is about 20 miles from Gold Beach, a harbor on the Pacific Ocean, and the construction of a railroad or highway to the site would not be very difficult.

The value of the power sites on the Illinois River is dependent on the construction of the Kerby Reservoir, and the construction of this reservoir is largely dependent on the amount of damages that must be paid for about 8,400 acres of land that would be overflowed. The land is sandy and of little agricultural value, and it should be obtainable at a price that would make the project feasible. There are many excellent dam sites below Kerby. In the scheme proposed, besides the dam to create the Kerby Reservoir, a dam 175 feet high would be built at Fall Creek, a dam 190 feet high with half a mile of tunnel at the site above Clear Creek, and a dam 175 feet high with 2.8 miles of tunnel at Bald Mountain. It is estimated that these three projects, together with the Kerby Reservoir and the power that would be generated at the reservoir, would furnish 145,000 continuous horsepower in a year of normal precipitation. Stream-flow records for the Illinois River, however, cover only short periods, and the estimates may be either too high or too low.

The rated capacity of turbines and water wheels installed at the eight constructed plants in the Rogue River Basin is 59,800 horsepower. The total potential power on the Rogue River and the Illinois River amounts to 558,000 horsepower for 50 per cent of the time and 188,000 horsepower for 90 per cent of the time with the natural flow of the stream, and to 575,000 horsepower for 50 per cent of the time and 455,000 horsepower for 90 per cent of the time with the flow regulated by the four proposed reservoirs.

The power available for 50 and 90 per cent of the time under conditions of natural flow as reduced by prospective irrigation demands and the power available after partial regulation by the use of the Hamaker, Lost Creek, Applegate, and Kerby Reservoirs are shown in Table 2. As the lower sections of these reservoirs contain only a small amount of storage, this portion will be maintained to create a power head. No attempt has been made, however, to estimate the potential power due to the fluctuating head in the reservoirs except at Kerby. The increase from storage in the flow for 90 per cent of the time at Copper Canyon is due largely to the release of stored water from the Kerby Reservoir, which is used to regulate the flow of the Illinois River.

TABLE 1.—*Developed power sites in the Rogue River Basin, Oreg.*

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

Index No.	Name	Stream	With existing flow					With regulated flow				
			Static head (H) (feet)	Flow (second-feet)		Horsepower		Installed horse-power	Flow (second-feet)		Horsepower	
				90 per cent of time (Q90)	50 per cent of time (Q50)	0.08HQ90	0.08HQ50		90 per cent of time	50 per cent of time	0.08HQ90	0.08HQ50
12RD 6	Prospect	Rogue River	620	330	590	16, 400	29, 200	53, 800	[a] 795	[a] 1, 330	39, 400	66, 000
12RD 15	Raygold	do	22	1, 110	2, 150	1, 950	3, 780	2, 750	1, 670	2, 150	2, 940	3, 780
12RD 16a	Gold Hill	do	18	1, 110	2, 190	1, 600	3, 150	20	1, 670	2, 190	2, 380	3, 150
12RD 18	Savage Rapids	do	28	930	2, 340	2, 080	5, 240	1, 800	1, 490	2, 340	3, 340	5, 240
12RD 26	Mill Creek	Mill Creek	25	45	85	90	170	30	45	45	85	170
12RD 29	Butte Falls	Butte Creek	49	133	160	520	626	[b] 750	133	160	520	626
12RD 31	Ashland	Ashland Creek	405					600				
12RD 33	Reuben Creek	Reuben Creek		1. 2	2. 75			20				
								59, 770				

[a] Including proposed diversions.

[b] Not used for several years.

TABLE 2.—*Undeveloped power sites in the Rogue River Basin, Oreg.*

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

Index No.	Name	Stream	With existing flow					With regulated flow				
			Static head (H) (feet)	Flow (second-feet)		Horsepower		Static head (H) (feet)	Flow (second-feet)		Horsepower	
				90 per cent of time (Q90)	50 per cent of time (Q50)	0.08HQ90	0.08HQ50		90 per cent of time	50 per cent of time	0.08HQ90	0.08HQ50
12RD 1	Hamaker	Rogue River	200	80	125	1, 280	2, 000	200	130	130	2, 080	2, 080
12RD 2	Castle Creek	do	200	225	375	3, 600	6, 000	200	270	375	4, 320	6, 000
12RD 3	Union Creek	do	280	290	500	6, 500	11, 200	280	344	500	6, 500	11, 200

12RD 4	Top Creek	do	140	325	575	3,640	6,440	140	385	575	4,310	6,440
12RD 5	Riter Creek	do	200	330	585	5,280	9,360	200	386	585	6,180	9,360
12RD 6	Prospect [a]	do	620	700	1,330	34,700	66,000	700	795	1,330	39,400	66,000
12RD 7	Cascade	do	230	775	1,350	14,200	24,500	230	870	1,330	16,000	24,500
12RD 8	Lost Creek	do	70	845	1,400	10,400	17,100	70	1,140	1,690	14,000	20,700
12RD 9	Butte Creek	do	65	920	1,660	4,780	8,640	65	1,240	1,910	6,450	9,940
12RD 10	Elk Creek	do	30	920	1,660	2,210	3,980	30	1,240	1,910	2,980	4,580
12RD 11	Trail Creek	do	25	1,030	1,860	2,060	3,720	25	1,400	2,030	2,800	4,060
12RD 12	Long Creek	do	60	1,030	1,860	4,950	8,930	60	1,420	2,030	6,820	9,740
12RD 13	Reese Creek	do	43	1,050	1,900	3,610	6,540	43	1,430	2,050	4,920	7,040
12RD 14	Little Butte Creek	do	35	1,110	2,030	3,100	5,680	35	1,650	2,070	4,620	5,800
12RD 16	Gold Hill	do	65	1,110	2,190	5,770	11,400	65	1,670	2,190	8,690	11,400
12RD 17	Rock Point	do	18	1,130	2,210	1,630	3,280	18	1,690	2,210	2,430	3,280
12RD 19	Ament	do	15	930	2,360	1,350	2,630	15	1,490	2,360	2,000	2,630
12RD 20	Hell Gate	do		1,010	2,950				2,390	2,950		
12RD 21	Taylor Creek	do	82	1,020	2,970	6,700	19,500	82	2,400	2,970	6,700	19,500
12RD 22	Swing Bridge	do	107	1,030	3,130	8,800	26,800	107	2,410	3,130	20,600	26,800
12RD 23	Horseshoe Bend	do	128	1,060	3,200	10,800	32,800	128	2,440	3,200	25,000	32,800
12RD 24	Stairs Creek	do	150	1,100	3,250	13,200	39,000	150	2,480	3,250	29,800	39,000
12RD 25	Copper Canyon	do	200	1,220	5,150	19,500	82,400	200	4,850	5,150	77,600	82,400
12RD 27	South Fork	South Fork of Rogue River	660	65	170	3,430	8,980	660	65	170	3,430	8,980
12RD 28	Rancheria	Butte Creek	200	133	160	2,130	2,560	200	133	160	2,130	2,560
12RD 30	McNeil Creek	do	330, 360	133	160	3,830	4,220	330, 360	133	160	3,830	4,220
12RD 34	Kerby	Illinois River	172	38	850	523	11,700	55–172	0	1,070	0	6,500
12RD 35	Fall Creek	do	250	60	1,330	1,200	26,600	250	1,300	1,570	25,000	27,000
12RD 36	Clear Creek	do	220	80	1,800	1,400	31,700	220	1,750	2,010	30,600	33,300
12RD 37	Bald Mountain	do	425	85	1,910	2,900	65,000	425	1,770	2,290	60,300	78,000
	Add for Illinois River, where maximum power at some plants coincides with minimum at others, giving continuous output of 145,000 horsepower.										29,100	200
	Add for developed sites 12RD 15 and 12RD 18.					4,030	9,020				6,280	9,020
	Total potential power of Rogue River Basin.					187,503	557,680				454,870	575,030

[a] Partly developed; compare with No. 6 in Table 1.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

The Rogue River is well suited to use as a source of power because of the character of its basin, its large and well-sustained flow, and its steep gradient. For this reason the United States Geological Survey made an investigation during the summer of 1923 to determine the amount of power available and to examine the public lands that will be affected by the projects when built.

Benjamin E. Jones and Warren Oakey, hydraulic engineers, of the conservation branch, spent a total of eight months in the field studying conditions along the Rogue River and its tributaries. They selected dam and reservoir sites to be surveyed and were constantly in touch with the three parties sent out by the topographic branch. Maps were prepared covering all those portions of the basin which seemed to possess valuable power possibilities. The Rogue River proper was mapped from a point slightly below its source to tidewater at Gold Beach, and the Illinois River, its main tributary, was mapped from a point 7 miles above Kerby to its junction with the Rogue River. These maps and profiles of the streams have been published in 14 sheets.[1] Several dam and reservoir sites were surveyed in greater detail and considerable work showing possible diversion projects was done. In 1926 Harold T. Stearns spent about one month in the field studying the geology at the dam and reservoir sites.

From a study of the maps and of conditions on the ground estimates of potential power available in the different sections of the river have been made and a comprehensive scheme of development has been outlined. (See pls. 3 and 4.) The scheme of development followed in actual construction will be determined by the state of the science at the time the development is made and in the light of further detailed surveys and estimates of cost.

ACKNOWLEDGMENTS

Acknowledgment is due to the California-Oregon Power Co. for furnishing transportation, for the assignment of an engineer to one of the parties, and for general assistance rendered throughout the work. Acknowledgment is also due to the irrigation companies for specific information relative to their projects.

GEOGRAPHY

The Rogue River Basin (see pl. 3) is shut in by the Umpqua Mountains on the north, the Cascade Mountains on the east, the Siskiyou Mountains on the south, and the Coast Range on the west. The

---

1 Plan and profile of Rogue River, Oreg., from mouth to National Creek, South Fork to mile 9, Middle Fork to mile 4, Butte Creek to mile 18, Illinois River to a point 7 miles above Kerby, and minor tributaries. Price, $1.40.

drainage area is 5,080 square miles, practically all of which lies in the southwestern part of Oregon. The river rises on the slope west of Crater Lake at an altitude of about 5,000 feet and flows in a southwesterly direction for 210 miles to the Pacific Ocean. The upper part of the basin is rugged and contains little tillable land. The soil here is porous volcanic ash and pumice, the precipitation is heavy, and there is, in general, a thick forest cover; this part of the basin therefore forms an excellent catchment area. The central part of the basin, from Bear Creek to the Applegate River, constitutes the agricultural portion. Below the mouth of the Applegate River the surface is more rugged and the river flows in a fairly wide canyon almost to Illahe, 7 miles above the mouth of the Illinois River (pls. 5, 6, 7); in this section there is very little timber and practically no tillable land. From Illahe to the mouth of the river the canyon is much wider and there are a few farms.

The main tributaries of the Rogue River are the Applegate and Illinois Rivers. The Applegate River rises in the Siskiyou Range and flows in a northwesterly direction until it reaches the main stream. During the summer it is almost entirely used for irrigation. The Illinois River rises in the same range and flows in the same general direction. Above Kerby it is used to a slight extent for irrigation, but below that place it enters a narrow canyon, in which it flows until it joins the Rogue River at Agness. There is no agricultural land in this canyon, and the timber values are very low.

Mining, both lode and placer, has from time to time been carried on at many points within the basin of the Illinois River, but at the time of this investigation no active operations were noticed.

The chief agricultural areas are along the Rogue River near Grants Pass, the valley of Bear Creek near Medford, and the valley of the Applegate River. Because of the low rainfall in this part of the basin and its seasonal distribution very few crops can be raised without irrigation, yet when water is put on the land it is as productive as that in any other part of Oregon. The principal crops are orchard products, particularly pears.

The timber resources of the country around Butte Falls, on Butte Creek, are now being developed on a large scale, and this will doubtless contribute considerably to the progress of the district by encouraging the settlement of the agricultural land which is being cleared.

GEOLOGY

A description of the geology of the numerous reservoir and dam sites involves mention of so many structural features, formations, and types of rocks that a brief summary of the important events in the geologic history of western Oregon and of the areal distribution of the chief formations is given here.

The known facts in the geologic history of western Oregon before Cretaceous time are few, for the sediments older than Cretaceous have been completely metamorphosed and now occur as schist, slate, and serpentine. These rocks are exposed along the lower part of the Rogue River in Jackson, Josephine, and Curry Counties. Dam sites in these rocks involve no problems of leakage, and all of them are satisfactory for foundations.

Late Jurassic or early Cretaceous time was marked by intrusions of large masses of granodiorite and other igneous rocks and by great movements of the crust. During Cretaceous time the northern and central parts of western Oregon lay below sea level, and in this area were deposited sediments which upon consolidation became conglomerate, shale, and sandstone. These sediments were then subjected to considerable folding, which has altered their original character and tilted the beds at steep angles. Outcrops of these sedimentary rocks are seen along the Illinois and Rogue Rivers in Josephine and Curry Counties. Many of the rugged canyons and consequently the sites of important dams and reservoirs are in the late Jurassic or early Cretaceous intrusive rocks. The granodiorite, diabase, and other intrusive rocks of this period cooled under the weight of overlying sediments, and consequently they do not have the porous structure and leaky contacts and joints that characterize so many of the later extrusive rocks; moreover, in crushing strength most of them are equal to granite, and all are sufficiently strong to support large structures. Generally speaking, these intrusive rocks form excellent sites from the point of view of both the geologist and the engineer, and they are as a whole better than the sites in any of the later formations.

During the Tertiary period numerous changes occurred, chief among which was the building of the Cascade Mountains by uplift and volcanic action. The Eocene, or early part of the Tertiary, was a time of deposition and marine invasion, during which extensive beds of sandstone and conglomerate were deposited. Igneous activity also was intense, for thick dikes and sills of basaltic lava were intruded into the sediments. The sites in the sedimentary rocks of this epoch are generally good, although there may be slight leakage along bedding planes.

During the later half of the Tertiary period marine deposition continued over the northwestern part of the State, interrupted by occasional periods of uplift. None of the dam and reservoir sites are located in the sedimentary rocks of this time. The later Tertiary together with the Pleistocene was a time of greatest volcanic activity. Numerous volcanoes along the Cascade Range poured forth thick flows of lava and emitted showers of pumice; among these was Mount Mazama, whose collapse formed the caldera now occupied by Crater Lake. (See pl. 8, *B*). Many of the lava flows coursed down river valleys and partly filled them. Since that time the rivers have excavated portions of the lava fills and formed narrow canyons with vertical walls of lava, in which are many rapids and waterfalls. (See pls. 9, *B*, and 10).

The Rogue River Valley, as shown by the terraces at the Hamaker and Lost Creek sites, has had a long and complicated geologic history. The ancestral valley at the Lost Creek site had about the same width as the present valley but was not so deep. During the Pliocene epoch numerous eruptions of basalt occurred from vents on the upper slopes of Mount Mazama. This lava was very fluid; it flowed down the Rogue River Valley for many miles and accumulated to a depth of about 200 feet. In reestablishing its course the river naturally sought the lowest places in the lava fill. Many of these places were at the contact of the lava with the old valley wall; consequently the river renewed its work of cutting at one side of its ancient canyon and carved a new canyon with the rocks of the old valley wall on one side and the rocks of the new lava fill on the other. In some places its new course did not coincide with the old one, and long stretches of the old river channel, either to the right or left of the present channel, remain buried under hundreds of feet of lava. The remnants of the lava fill or intracanyon flows now form high flat-topped benches along the river. A very conspicuous one is crossed by the new Crater Lake Highway at the site of the canal of the Prospect power plant. Near this place the Rogue River leaves the top of the intracanyon lava and enters a deep valley at the edge of the lava fill. The bench that lies 220 feet above the south side of the river in the N. ½ sec. 25, T. 33 S., R. 1 E., is a remnant of this intracanyon lava fill. The road from McLeod Bridge up the east side of the Rogue River follows along the top of this bench for several miles. This remnant of the intracanyon lava occupies a critical position in the success of the Lost Creek site and is discussed further on page 76.

Most of the intracanyon lava is fractured and fissured, and at many places it covers ancient gravel beds through which impounded water might escape rapidly.

Pumice deposits cover wide areas, especially in the vicinity of Crater Lake and in the upper part of the Rogue River Valley. (See pl. 8, *A*.) After the Rogue River had carved out a wide valley in the intracanyon lava and had reached approximately its present stage, a gigantic mud flow came down the valley during one of the great explosive eruptions of Mount Mazama, probably not long before the collapse of the volcano. This mud flow consists almost entirely of ash and pumice boulders.

Accompanying explosive volcanic eruptions there are generally torrential downpours resulting from the condensation of volcanic steam and from meteoric storms, but because of the great thickness of light volcanic ash and pumice deposited, the streams become choked and soon either stop flowing or flow as a pasty mud. Thus each valley becomes filled, sometimes to overflowing, with the pasty ash and pumice. During the eruption of Mount Mazama the streams poured their pumiceous mud into the master stream—the Rogue River—where its accumulation formed a mud flow about 200 feet thick, which moved many miles down the valley. As the deposit was only slightly consolidated the river soon carved a new valley in it, leaving terraces along the valley wall at the Hamaker site and elsewhere.

Dam sites in the intracanyon lava and pumice may be excellent so far as purely physical form is considered, but the porous nature of the rock, the misplaced drainage, and concealed river channels (see pl. 9, *A*) make them treacherous for storing water because of possible leakage.

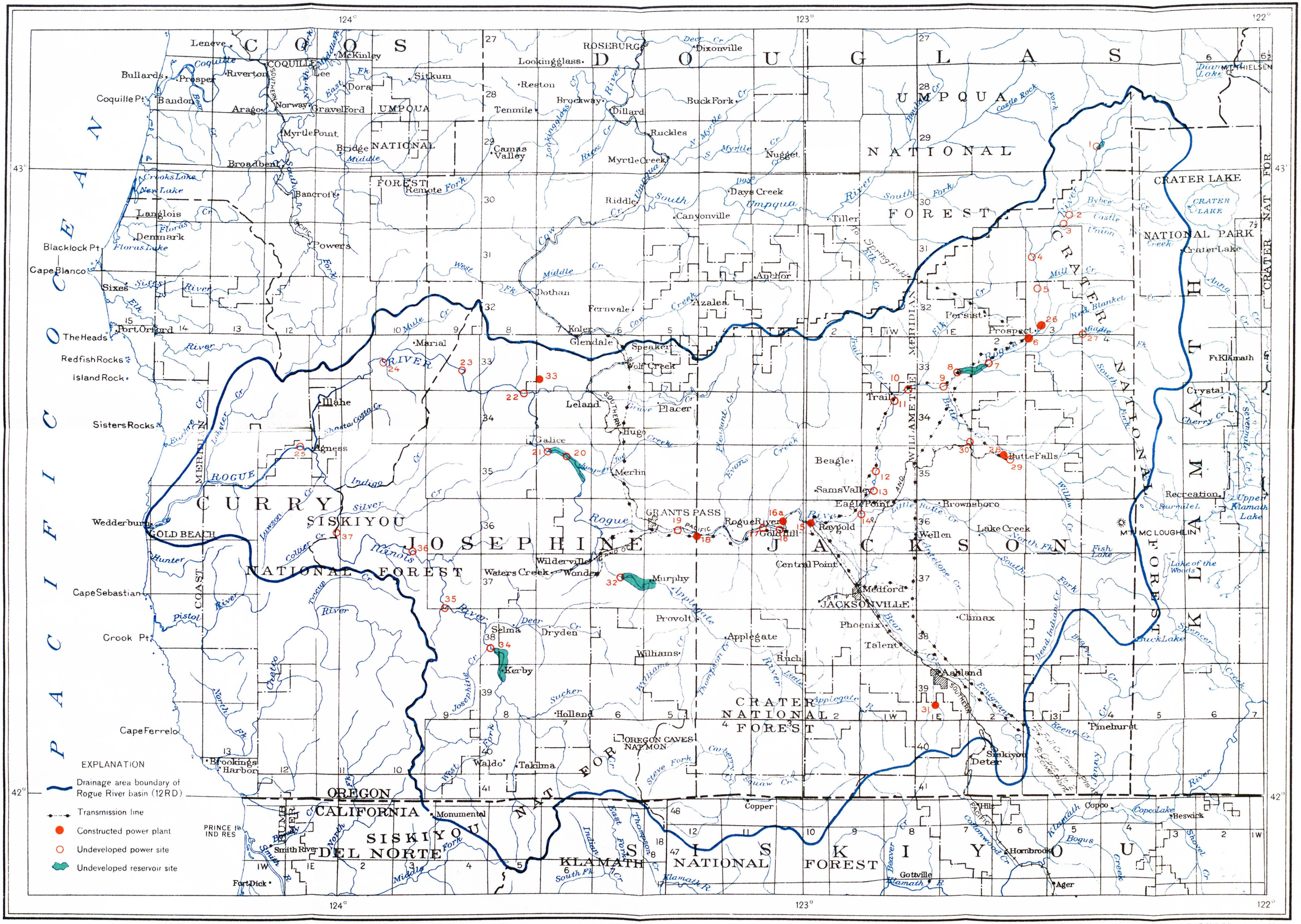
During Pleistocene time the high peaks of the Cascade Range were covered with glaciers, which moved down the valleys of most of the larger streams. While these glaciers existed the master streams were overloaded with débris and aggraded their valleys. Later erosion excavated valleys in the glacial fill, leaving the remnants as gravel terraces. Some of the dam sites are located in this material and are consequently poor because of the amount of excavation necessary to reach bedrock.

CLIMATE

The Rogue River Basin is surrounded by mountains that range in height from about 3,000 feet to over 8,000 feet, increasing gradually as the eastern limit of the basin is approached. The following table giving the mean monthly and mean annual temperature at several points in the basin, listed in order from east to west, shows how the temperature varies with the altitude and with the distance from the sea.

TABLE 3.—*Mean monthly and yearly temperature (°F.) in the Rogue River Basin, Oreg.*

Month	Crater Lake	Prospect	Medford	Grants Pass	Gold Beach
January	24.5	34.8	37.8	39.1	44.6
February	27.7	38.0	41.8	42.5	45.0
March	32.1	42.4	46.1	46.6	46.7
April	36.6	46.9	50.9	51.3	49.6
May	41.6	51.9	56.6	56.8	51.5
June	47.7	58.0	64.8	62.6	55.2
July	55.6	65.9	71.6	69.6	57.6
August	54.7	65.0	70.9	68.9	59.2
September	47.4	57.7	63.3	61.9	57.8
October	39.3	49.6	52.9	53.6	55.2
November	31.0	41.3	43.4	44.5	49.6
December	25.0	35.3	37.1	39.1	46.9
Yearly mean	38.6	48.8	53.1	53.0	51.6
Altitude, feet	6,016	2,800	1,425	940	40



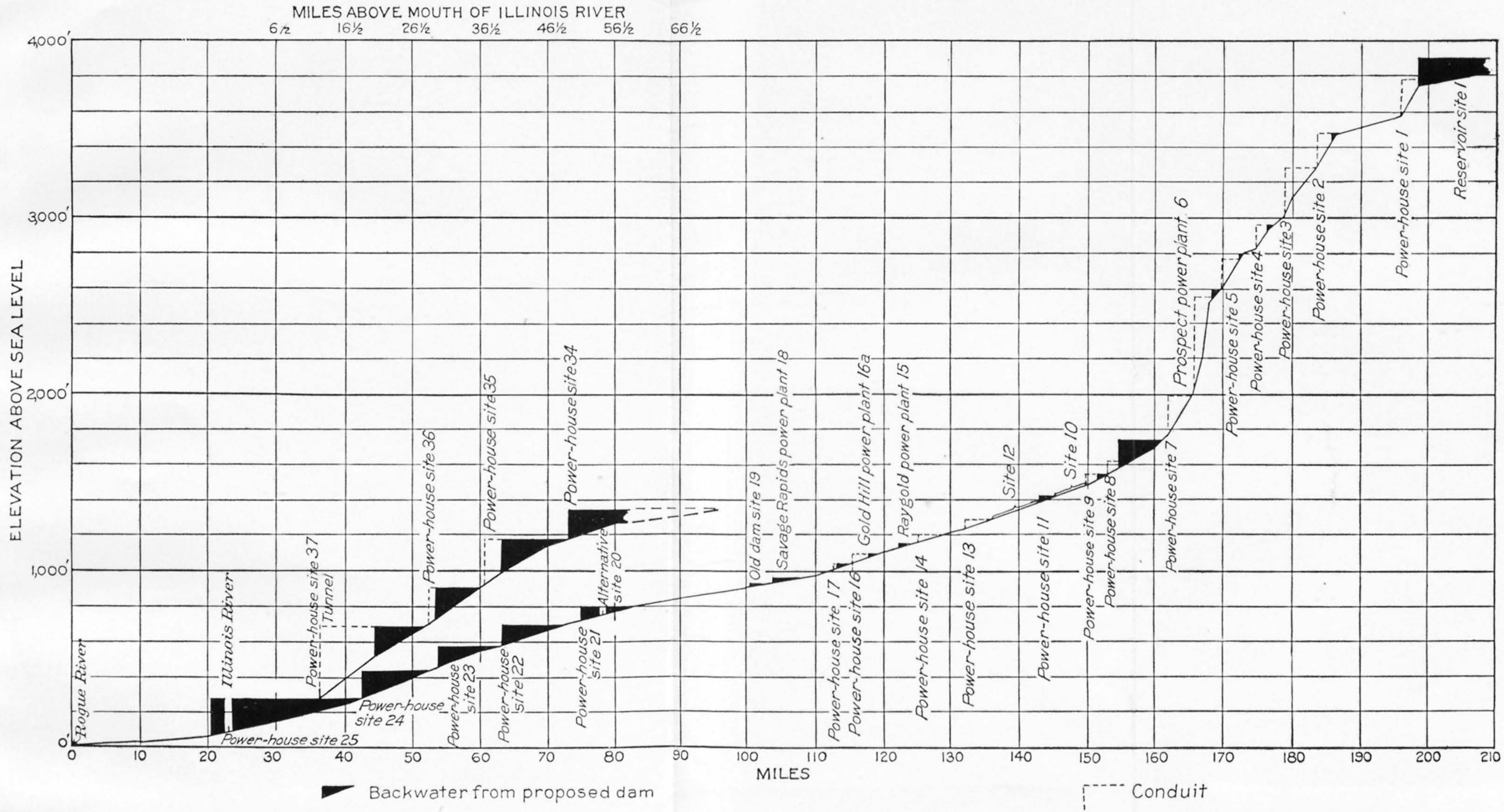
MAP OF SOUTHWESTERN OREGON AND NORTHWESTERN CALIFORNIA SHOWING DEVELOPED AND PROPOSED POWER SITES IN ROGUE RIVER BASIN

Scale $\frac{1}{500000}$

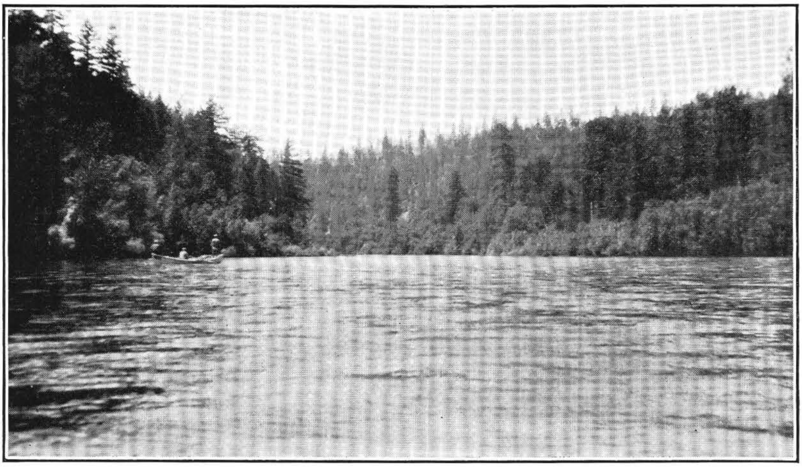
10 0 10 20 30 40 Miles

10 0 10 20 30 40 50 Kilometers

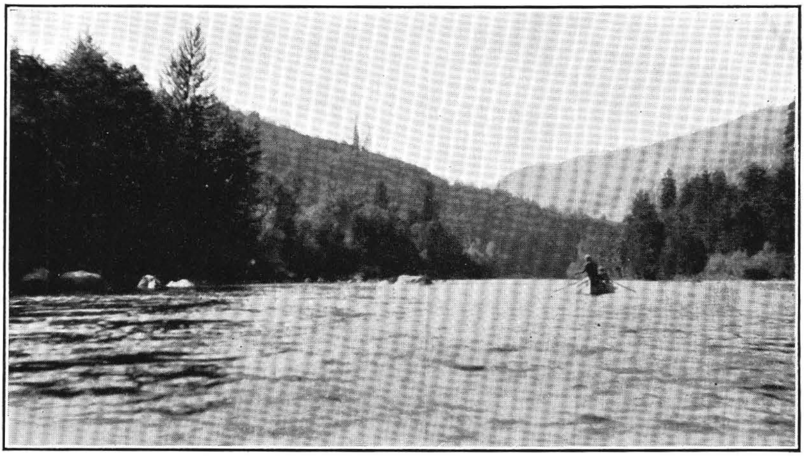
1931



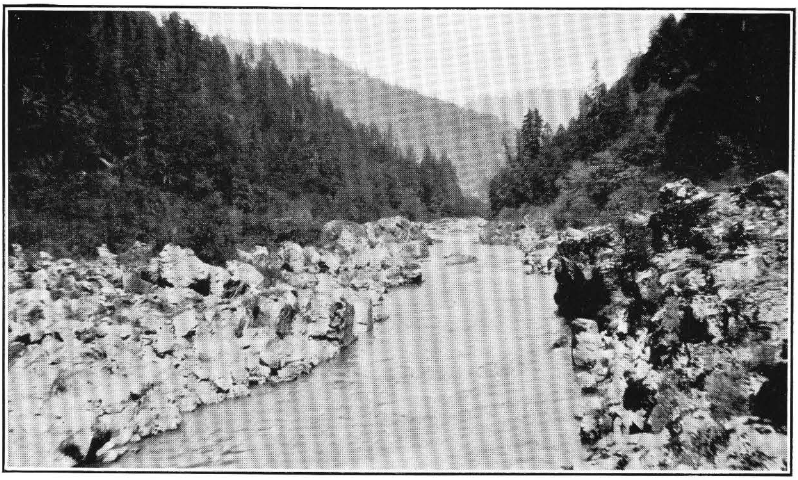
PROFILE OF THE ROGUE AND ILLINOIS RIVERS SHOWING LOCATION OF DAM SITES



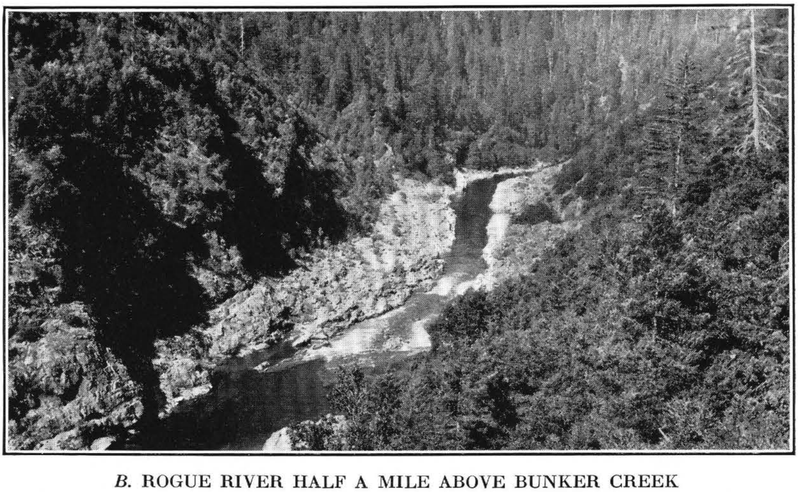
A. ROGUE RIVER ENTERING THE CANYON SECTION 12 MILES BELOW GRANTS PASS



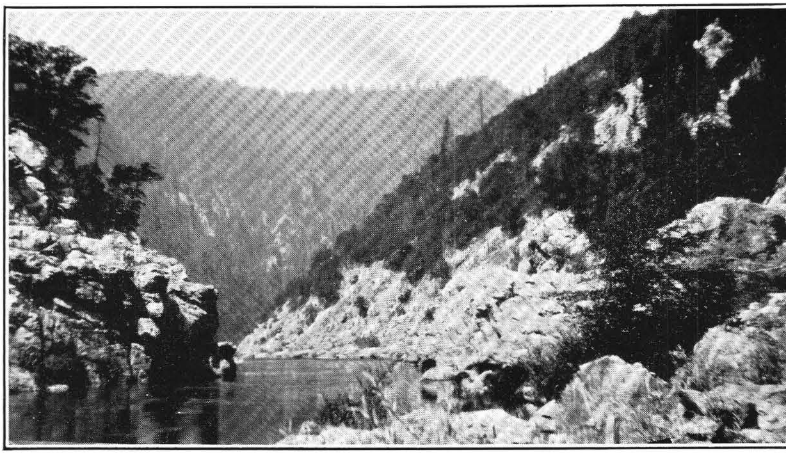
B. ROGUE RIVER 24 MILES BELOW GRANTS PASS



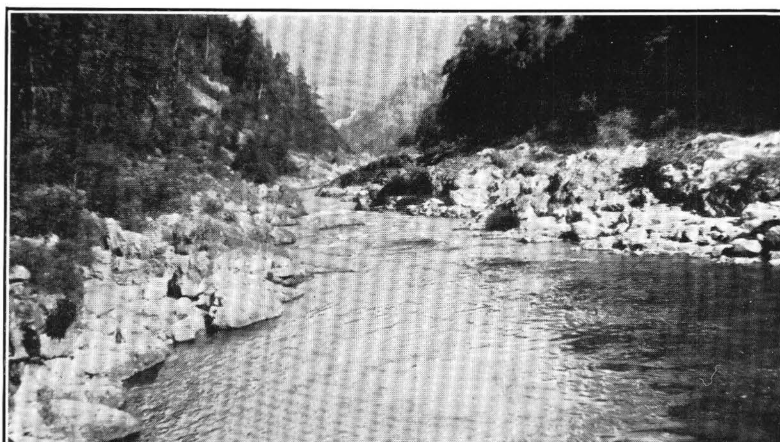
A. ROGUE RIVER LOOKING UPSTREAM FROM HOWARD CREEK



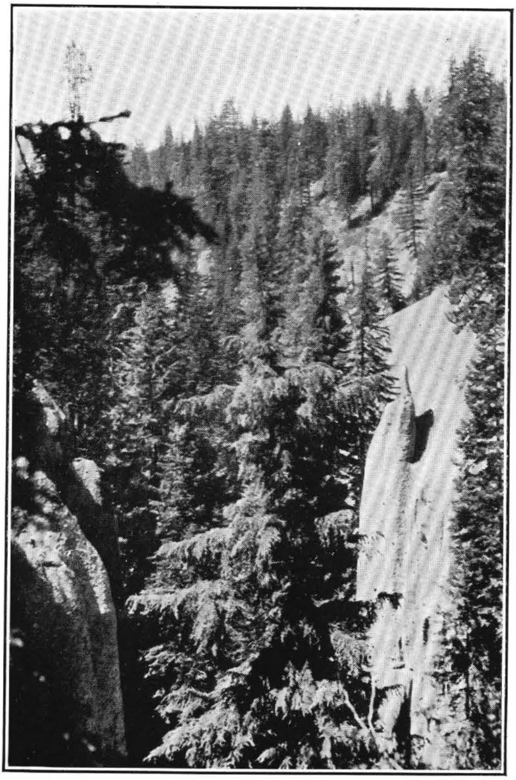
B. ROGUE RIVER HALF A MILE ABOVE BUNKER CREEK



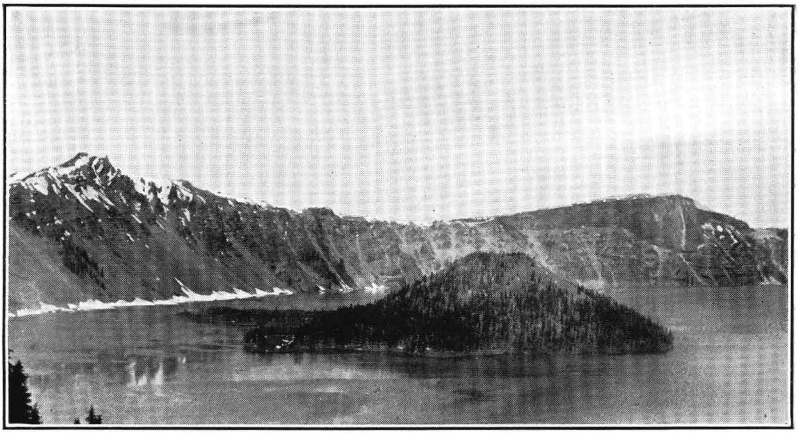
A. ROGUE RIVER IN SEC. 13, T. 34 S., R. 8 W., HALF A MILE BELOW ALMEDA



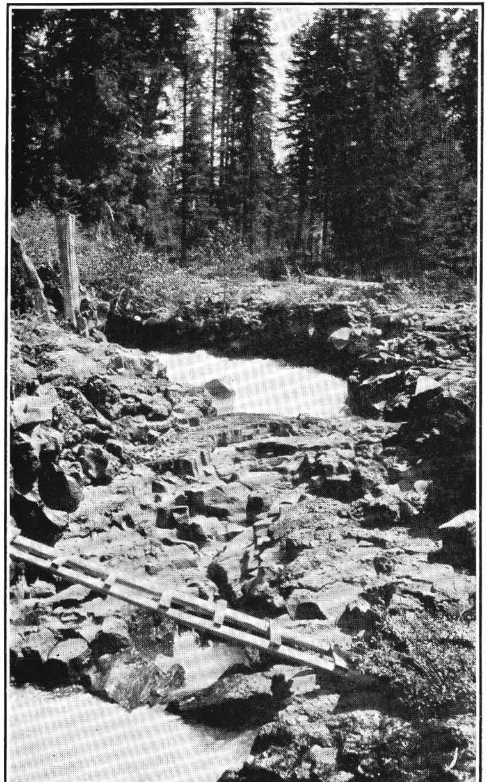
B. ROGUE RIVER HALF A MILE ABOVE CURRY-JOSEPHINE COUNTY LINE



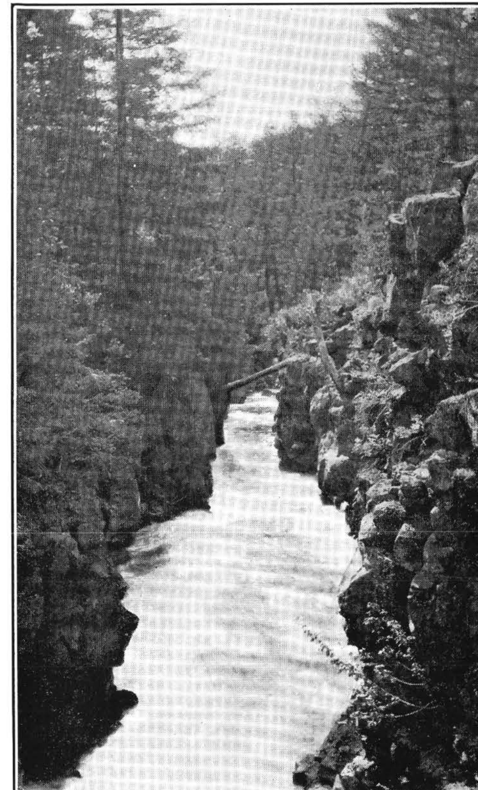
A. CANYON IN VOLCANIC ASH NEAR HEADWATERS OF ROGUE RIVER



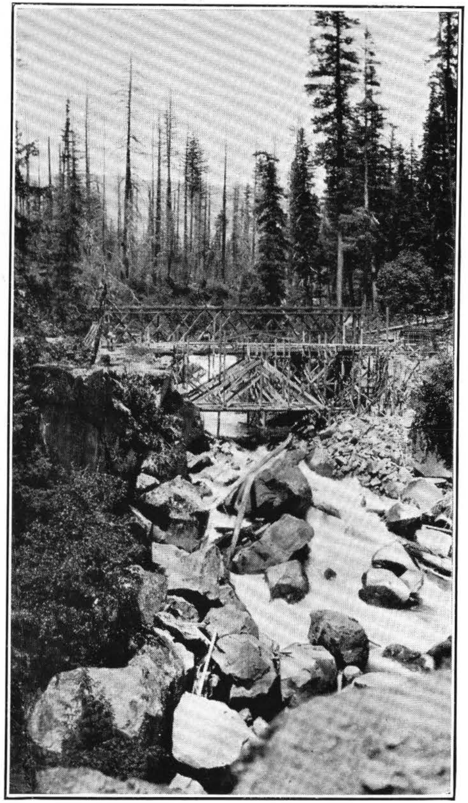
B. CRATER LAKE



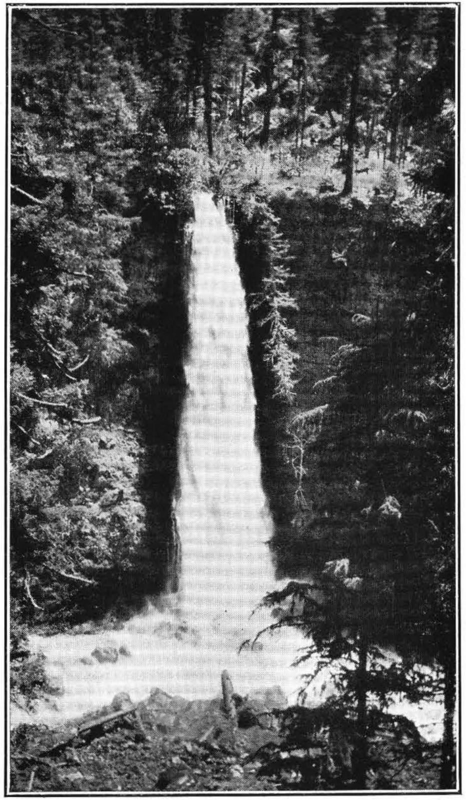
A. NATURAL BRIDGE FORMED BY LAVA TUBE THROUGH WHICH ROGUE RIVER FLOWS



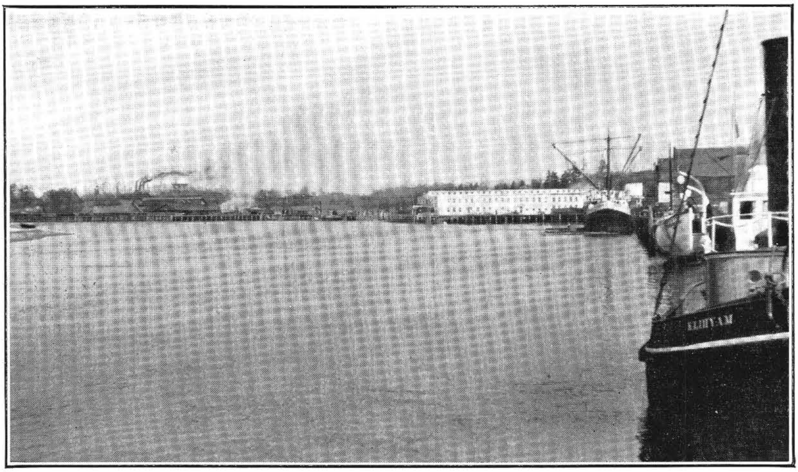
B. CANYON OF ROGUE RIVER ABOVE PROSPECT



A. ROGUE RIVER ABOVE BRIDGE AT PROSPECT



B. MILL CREEK FALLS, ROGUE RIVER



A. MOUTH OF ROGUE RIVER

B. HAMAKER RESERVOIR SITE, ROGUE RIVER

The table also shows that at only the highest points in the basin does the mean monthly temperature fall below the freezing point. In spite of the low winter temperatures at Crater Lake the lake itself never freezes over, but this is probably due to its great depth, as Diamond Lake and Klamath Lake freeze over during the winter, although both are at a much lower altitude.

The following precipitation table, based on Weather Bureau records, shows the monthly and annual rainfall at various points from west to east and also the way in which the rainfall is distributed. It may be noted that although the amount of precipitation at the various stations for the same month varies greatly, yet the trend at all the stations is the same, as there is a constant decrease from January to August and a constant increase from August to November, and December is usually somewhat lower than November.

TABLE 4.—*Mean monthly precipitation, in inches, in the Rogue River Basin, Oreg.*

	Gold Beach	Agness	Galice	Grants Pass	Medford	Jacksonville	Ashland	Butte Falls	Prospect
January	15.43	10.27	12.10	5.72	2.41	4.64	2.97	4.85	6.74
February	14.50	8.71	4.38	4.59	1.99	3.64	2.34	3.54	4.96
March	9.85	7.79	3.35	3.18	1.27	2.41	1.96	2.41	3.38
April	5.00	4.77	3.22	1.71	1.48	1 48	1 54	2.87	2.97
May	3.88	1.84	1.85	1.53	1.20	1.74	1.66	2.59	2.50
June	1.87	1.09	.67	.85	.75	1.00	1.05	1.60	1.31
July	1.06	.36	.49	.17	.46	.38	.50	.84	.74
August	.33	.31	.08	.24	.20	.36	.32	.34	.34
September	1.38	2.61	2.10	.94	.66	.88	.88	1.75	1.94
October	4.77	2.93	3.17	1.91	1.02	1.60	1.37	2.13	3.15
November	14.24	9.40	8.33	4.51	2.72	3.87	2.60	6.01	7.15
December	9.59	8.21	7.01	4.98	2.21	4.19	3.08	3.69	4.42
Yearly mean	81.90	58.29	46.75	30.33	16.37	26.19	20.27	32.62	39.60

The snowfall ranges from only a trace at Gold Beach to a recorded depth of 354.8 inches at Crater Lake. It seems, however, that the amount recorded for Crater Lake must be largely drift snow, for on Wizard Island, which is somewhat sheltered from the wind, the snow line is clearly marked at about 12 feet, or 144 inches.[2]

The annual precipitation along the course of the Rogue River itself averages 55 inches, ranging from somewhat over 75 inches near the coast to a minimum of 16 inches near Medford and then increasing again to about 75 inches near the headwaters. The two major tributaries of the Rogue River—the Illinois and Applegate Rivers—have an average precipitation of 68 and 38 inches, respectively. The range along the Illinois River is from 100 inches on the west side of the basin to about 50 inches on the east side; that along the Applegate River is from 55 inches on the west to 27 inches on the east.

[2] Diller, J. S. and Patton, H. B., The geology and petrography of Crater Lake National Park; U. S, Geol. Survey Prof. Paper 3, p. 60, 1902.

FACTORS AFFECTING HYDRAULIC STRUCTURES

Ice will not materially interfere with the development of power on the Rogue River except possibly in the part of the basin above Prospect, and even there its effect is questionable. Though the temperature in the upper part of the basin in November, December, January, and February (see Table 3) is favorable for ice formation the discharge record at Prospect shows that the run-off increases steadily during these months. The records of the gaging station at Prospect indicate that there is no trouble due to ice. A possible explanation of the small amount of ice is that during the winter practically all of the discharge from the upper part of the basin comes from ground storage and springs and the temperature of the water from these sources is ordinarily considerably above freezing.

At all proposed developments provision must be made to carry the maximum flood flow without damage to the hydraulic structures. The floods in the upper part of the basin are not severe; and as the suggested plan of power development in this section includes only small diversion dams and canals, the excess flow can readily be carried by the main river channel. In the middle part of the basin low dams must be used in order that the damage due to flooding farm lands may be minimized. The banks here are low and are not very resistant to erosion. In order, therefore, that floods may be passed without allowing too much rise in the pond level, dams composed largely of gates must be used.

In the lower or canyon section of the river and on the Illinois River the floods may be severe, and either spillway tunnels or an overflow dam section must be used to pass the flood waters. Fortunately, most of the dams in these sections form large ponds in which the flow not capable of being passed by the wasteway will be stored, thereby ironing out the maximum flood peak.

The Rogue River is noted for its clear cold water, and no difficulty will be experienced with silt; all other débris is so small in amount that it can readily be disposed of without damage to plant or equipment.

A few of the proposed developments will necessitate the relocation of certain parts of highways, but an effort has been made throughout to provide for the maximum power available with minimum damage to present or proposed improvements. This can readily be accomplished, as the population of the district is very sparse and is, in general, concentrated in the agricultural portion of the basin, where the land is highly developed and where the slope of the river is so low as to preclude development for a long time. In the upper part of the basin the river grade is steep, and small dams with canals and pipe lines are suggested for the generation of power; such development will do little if any damage, considering the character of the country. In the lower part of the basin the river flows in a canyon that is occupied by few people and contains a very small proportion of agricultural land; in this section relatively high dams with adjacent power houses are suggested as a desirable method of development.

Between the town of Galice and the source of the Rogue River the stream is paralleled by a highway that could readily be improved sufficiently to enable construction machinery and materials to be transported. In the lower canyon sections of the Rogue and Illinois Rivers, however, no means of transportation other than pack animals exists, and trails could not be improved sufficiently to withstand heavy trucking except at considerable expense.

By constructing first the dam at Copper Canyon (site 12RD 25), the backwater would enable water transportation to be used on both the Rogue and Illinois Rivers practically to the next higher site; and by continuing this method through the canyon sections transportation difficulties would be largely overcome.

A small motor boat runs from the mouth of the Rogue River (see pl. 11, *A*) to the junction of the Illinois River at Agness, but if a highway were built the boat would be discontinued, so it is considered improbable that there will be any navigation above Copper Canyon except the driving of logs. Provision for passing logs should be made at all dams constructed on the river, and any permits or licenses should contain a provision permitting the United States to construct locks or other works for navigation at any of the dams if this is ever found desirable.

A suitable method of allowing fish to pass up the river must be worked out before any power dams can be built on the lower section of the Rogue River. At present power development on the lower river is prevented entirely by an act of the legislature in the interests of migratory fish. Projects begun prior to the passage of the act, which was approved March 4, 1929, are probably not affected by it.

WATER SUPPLY

SEASONAL VARIATION IN STREAM FLOW

The annual precipitation ranges from 16 to 75 inches at different points in the basin but has the same general seasonal distribution at the different stations. The precipitation in the higher parts of the basin during the winter is largely in the form of snow, which contributes markedly to the stream flow during March, April, May, and June. The upper part of the basin is heavily timbered, and the soil is composed of a very porous volcanic material that absorbs during the rainy season an immense quantity of water, which is gradually released during the remainder of the year. The sustained flow in the headwater streams during the dry season has been attributed by many persons to the presence of Crater Lake. (See pl. 8, *B*.) The following very rough analysis, based largely on data given by Diller and Patton,[3] shows that this belief is hardly warranted, as less than 10 per cent of the flow can be so accounted for. The yearly fluctuation in the stage of Crater Lake is about 4 feet. During the rainy season the water level rises, and during the dry season it falls. Records of the lake level taken during the month of September at varying intervals from 1892 to 1901 disclose the fact that the low stage did not change appreciably during that time. As the level of the lake is practically constant from year to year, the only water that can be contributed to the headwater streams is that due to the excess of precipitation over all other losses. The precipitation is possibly as high as 80 inches a year, and evaporation, which is the source of by far the greatest loss, is about 46 inches a year. The difference, or 34 inches, is available to feed the small streams. The total water and tributary drainage area is about 27.5 square miles, of which all but 7.9 miles is in the lake; the error introduced by treating the whole area as a unit will be small. The total area multiplied by the net amount of water received, with the necessary factors applied to reduce the result to acre-feet, gives about 50,000 acre-feet. This volume of water uniformly distributed throughout the year is the equivalent of a constant addition to the streams heading around Crater Lake of about 70 second-feet, whereas the combined flow of these streams is over 1,000 second-feet. The base data are possibly somewhat in error, but it is hardly conceivable that the error is sufficiently great to account for this difference.

Records of the discharge of the Rogue River at Raygold[4] beginning August 30, 1905, are given in Tables 5 and 6; records for stations above and below Prospect covering shorter periods are given in Tables 7 and 8. A list of all gaging stations that have been maintained in the Rogue River Basin, with the period of record, is given as Table 13. Unless otherwise indicated all stream-flow records cover the 12-month period ending September 30.

July, August, September, and October constitute the period of low run-off; the discharge for January, February, March, April, and May is uniformly high; and that for November, December, and June approximates the average annual flow. During March, April, May, June, July, and August the rainfall constantly decreases, but in spite of this the melting snow keeps the run-off high for the first four months of the period. This effect is particularly evident in the records both above and below Prospect, but at Raygold the deficiency in rainfall and the depletion of the ground-water storage are more than can be

[3] Diller, J. S., and Patton, H. B., op. cit., pp. 53–61.

[4] This station is in sec. 18, T. 36 S., R. 2 W., at Raygold railroad station, half a mile below the mouth of Bear Creek. Records at this station for the years 1906–1921 read "Rogue River near Tolo, Oreg." The post office at Tolo having been discontinued, the designation of the gaging station was changed beginning 1922 to "Rogue River at Raygold, near Central Point, Oreg."

offset by the run-off from melting snow, and the discharge falls rapidly. The great increase of the discharge below Prospect over that above Prospect during this period is worthy of note. It is due in small part to the slightly greater drainage area at the lower station but chiefly to the fact that between the two stations the Rogue River cuts down through about 500 feet of water-bearing strata (see pl. 9, *B*), in which are many springs and seepages. The low-water period extends from July to October at all stations.

ANNUAL YIELD AND MINIMUM FLOW

The records in the Rogue River Basin are not sufficiently long to show the existence of cycles of heavy and light run-off nor any general trend. However, a comparison of the shorter records with those at Raygold gives some idea whether the flow recorded at each station was higher or lower than normal. The index of wetness is found by dividing the total annual precipitation for any one year by the mean annual precipitation for a long period of years. According to the records of discharge above Prospect the index of wetness for 1908 to 1912 at that station is only slightly above normal, and that for 1924 to 1927 is below normal. Below Prospect the index of wetness for the period 1916 to 1926 is about 14 per cent below normal. The record of discharge at Raygold has been compared with the longer records on the Columbia River at The Dalles and the Willamette River at Albany and with the rainfall records. The longest discharge record is that of the Columbia River at The Dalles, which began in 1879. This record shows that the low years were 1889, 1891, 1905, 1915, 1924, and 1926. The lowest year was probably 1926. The precipitation record for western Oregon also shows a continued low period from 1915 to 1926 and an extremely dry period from 1922 to 1926. For 1889 there are few data except the record of the flow of the Columbia River at The Dalles on which to base an estimate of the dryness in the Rogue River Basin; but a note in a Weather Bureau report for 1889 states that the year was very dry in eastern Oregon and in the lower Willamette Valley, so it is inferred that in southwestern Oregon there was more precipitation, and the records of rainfall bear out this inference. In 1891 the precipitation in western Oregon was 71 per cent of the mean, and in 1926 it was 70 per cent of the mean. These rather meager facts seem to indicate that the flow of the Rogue River was lower in 1926 than in either 1889 or 1891. In 1905 the precipitation was 91 per cent of the mean. The run-off of the Willamette River at Albany was nearly 2 inches greater than in 1926. The minimum flow of the Rogue River at Raygold in September, 1905, was 1,240 second-feet, compared with 860 second-feet in 1926. So undoubtedly the discharge of Rogue River was greater in 1905 than in 1926. Beginning with 1906 stream-flow records are available on the Rogue River at Raygold.

From the records on the Columbia River beginning 1879 and the precipitation records for western Oregon beginning 1891 it can be assumed that a year of low flow will occur once for each 8 or 10 years of record and a year of very low flow will occur once in a much longer period. The low years may not occur 10 years apart, however, for records of stream flow seem to indicate cycles of flow, several dry years occurring close together. No method is known for predicting the length, time of occurrence, or cause of such cycles. Plotting the index of wetness for western Oregon for the 36 years ending 1926 against the number of times each figure was equaled or exceeded indicates that a year as dry as 1926 will probably occur only once in scores of years.

The records on the Rogue River include the low period from 1915 to 1926, and the estimates of power available are based on this record. The power estimates are therefore conservative and probably are somewhat low. The Q90 flow (see Table 6) is shown to be remarkably consistent, ranging from 1,030 to 1,543 second-feet, except in 1924, when it fell to 867 second-feet, and in 1926, when it was only 819 second-feet. The Q50 flow ranged from 1,579 to 3,722 second-feet, except in 1924, when it fell to 1,400 second-feet, and in 1926, when it was 1,300 second-feet. The maximum recorded discharge of the Rogue River at Raygold was 60,000 second-feet, but the mean flow for the day on which that stage occurred was 48,300 second-feet. The minimum recorded daily discharge at Raygold was 770 second-feet in 1926. Prior to 1924, when it was 813 second-feet, the minimum recorded mean daily discharge was 937 second-feet.

The run-off at Raygold during a normal year is about 2,200,000 acre-feet. For the years 1906 to 1927 the flow 50 per cent of the time was 2,150 second-feet and the flow 90 per cent of the time was 1,180 second-feet. The maximum annual flow of record on the Rogue River at Raygold occurred during the year 1906–7, when 3,030,000 acre-feet passed the gaging station, and during four other years the flow has been in excess of 2,500,000 acre-feet. The flow in 1925–26, when only 1,100,000 acre-feet passed the station, is the minimum of record, although it was only slightly less than the flow of 1,220,000 acre-feet during the year 1923–24. The results of miscellaneous measurements made in the Rogue River Basin in July and September, 1923, are given in Table 9. Because of an exceptionally dry summer the September measurement given is probably somewhat below the normal low flow.

TABLE 5.—*Summary of monthly mean discharge, in second-feet, of Rogue River at Raygold, Oreg., 1906–1927*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
1905–6	1, 390	1, 370	1, 490	4, 000	4, 040	3, 840	4, 370	4, 220	3, 840	2, 440	1, 390	1, 310	2, 810
1906–7	1, 340	1, 680	2, 820	4, 710	12, 500	7, 650	7, 800	3, 640	3, 310	2, 290	1, 740	1, 490	4, 250
1907–8	1, 320	1, 410	5, 550	5, 350	3, 450	3, 420	4, 530	4, 150	3, 290	2, 260	1, 510	1, 460	3, 140
1908–9	1, 840	2, 440	1, 960	11, 800	6, 730	3, 790	3, 310	3, 200	2, 830	1, 800	1, 450	1, 470	3, 560
1909–10	1, 520	8, 410	5, 620	3, 600	5, 240	6, 750	3, 240	3, 180	2, 290	1, 640	1, 390	1, 180	3, 670
1910–11	1, 260	4, 270	4, 940	4, 110	3, 810	3, 670	3, 930	3, 760	3, 200	1, 890	1, 340	1, 240	3, 120
1911–12	1, 170	2, 160	1, 640	6, 720	7, 720	4, 040	3, 860	5, 910	4, 170	2, 150	1, 530	1, 540	3, 550
1912–13	1, 400	2, 150	2, 350	3, 930	3, 390	3, 450	5, 810	4, 920	3, 750	2, 490	1, 630	1, 410	3, 060
1913–14	1, 650	2, 100	2, 140	6, 300	3, 630	4, 880	4, 090	3, 080	2, 260	1, 500	1, 200	1, 430	2, 860
1914–15	1, 690	1, 460	1, 250	1, 890	2, 900	2, 820	3, 020	2, 710	1, 880	1, 450	1, 050	1, 040	1, 930
1915–16	1, 030	1, 680	2, 400	2, 760	6, 980	4, 420	4, 160	3, 530	2, 940	1, 940	1, 270	1, 250	2, 860
1916–17	1, 230	1, 330	1, 350	1, 900	2, 990	4, 180	6, 450	6, 700	5, 750	2, 700	1, 480	1, 340	3, 120
1917–18	1, 240	1, 430	2, 890	4, 510	4, 420	3, 770	3, 250	2, 510	1, 700	1, 270	1, 130	1, 160	2, 440
1918–19	1, 220	1, 440	1, 460	3, 000	4, 500	4, 860	6, 250	4, 840	2, 600	1, 470	1, 160	1, 200	2, 830
1919–20	1, 140	1, 920	2, 830	2, 060	1, 720	2, 220	3, 780	3, 270	2, 160	1, 280	1, 000	1, 220	2, 050
1920–21	1, 630	3, 350	5, 080	6, 370	8, 030	5, 440	4, 280	5, 410	4, 340	2, 360	1, 690	1, 620	4, 130
1921–22	1, 600	2, 710	3, 320	2, 380	3, 180	3, 810	4, 190	5, 260	3, 750	1, 730	1, 400	1, 300	2, 890
1922–23	1, 350	1, 460	2, 720	4, 160	2, 490	2, 640	3, 250	2, 850	2, 170	1, 480	1, 190	1, 110	2, 240
1923–24	1, 290	1, 290	2, 150	2, 020	3, 540	2, 070	2, 370	1, 680	1, 110	932	879	871	1, 670
1924–25	1, 410	3, 640	3, 950	5, 190	7, 640	2, 830	4, 340	3, 460	2, 410	1, 390	1, 180	1, 250	3, 190
1925–26	1, 190	1, 330	1, 750	1, 820	3, 720	2, 180	1, 650	1, 340	970	831	820	860	1, 520
1926–27	983	3, 040	4, 650	4, 080	8, 740	4, 120	4, 430	4, 300	3, 320	1, 640	1, 210	1, 280	3, 440
Minimum	983	1, 290	1, 250	1, 820	1, 720	2, 070	1, 650	1, 340	970	831	820	860	1, 520
Mean	1, 359	2, 367	2, 923	4, 216	5, 062	3, 948	4, 198	3, 815	2, 911	1, 770	1, 302	1, 274	3, 015
Median	1, 330	1, 680	2, 560	4, 040	3, 925	3, 800	4, 125	3, 585	2, 885	1, 685	1, 305	1, 265	2, 975
Maximum	1, 840	8, 410	5, 620	11, 800	12, 500	7, 650	7, 800	6, 700	5, 750	2, 700	1, 740	1, 620	4, 250

TABLE 6.—*General summary of stream-flow data of Rogue River at Raygold, Oreg., 1906–1927*

Year	Discharge in second-feet					Index of run-off [a]	Index of wetness [b]
	Q90	Q50	Minimum	Maximum	Mean		
1905–6	1, 312	2, 408	1, 230	27, 800	2, 810	0. 97	1. 00
1906–7	1, 349	2, 789	1, 270	48, 300	4, 250	1. 46	1. 21
1907–8	1, 345	2, 896	1, 190	29, 400	3, 140	1. 08	1. 02
1908–9	1, 469	2, 412	1, 320	29, 800	3, 550	1. 22	1. 05
1909–10	1, 346	2, 652	1, 180	48, 300	3, 670	1. 26	1. 06
1910–11	1, 264	2, 655	1, 120	31, 000	3, 110	1. 07	1. 00
1911–12	1, 249	2, 625	1, 120	35, 000	3, 530	1. 21	1. 05
1912–13	1, 417	2, 845	1, 180	11, 300	3, 050	1. 05	1. 00
1913–14	1, 275	2, 167	1, 180	21, 200	2, 850	. 98	1. 05
1914–15	1, 060	1, 579	960	9, 700	1, 920	. 66	. 76
1915–16	1, 157	2, 245	962	15, 800	2, 840	. 98	1. 16
1916–17	1, 265	1, 950	1, 010	9, 100	3, 110	1. 07	. 78
1917–18	1, 147	1, 912	1, 060	16, 700	2, 430	. 84	. 82
1918–19	1, 147	1, 663	948	12, 700	2, 820	. 97	. 93
1919–20	1, 041	1, 716	937	7, 480	2, 050	. 71	. 79
1920–21	1, 543	3, 722	1, 220	19, 300	4, 110	1. 40	1. 05
1921–22	1, 376	2, 329	1, 200	15, 400	2, 880	. 99	. 86
1922–23	1, 186	1, 933	1, 050	15, 600	2, 240	. 77	. 87
1923–24	867	1, 400	813	9, 300	1, 670	. 57	. 61
1924–25	1, 150	2, 540	875	33, 900	3, 190	1. 10	. 94
1925–26	819	1, 300	770	6, 020	1, 520	. 52	. 70
1926–27	1, 030	3, 030	840	48, 900	3, 440	1. 18	1. 19
Minimum	819	1, 300	770	6, 020	1, 520		
Mean	1, 219	2, 308	1, 065	22, 820	2, 910		
Median	1, 257	2, 368	1, 090	18, 000	2, 950		
Maximum	1, 543	3, 722	1, 320	48, 900	4, 250		

[a] Yearly mean divided by the mean for the period.
[b] Yearly precipitation for western Oregon divided by the long-time average.

TABLE 7.—*Summary of combined monthly mean discharge in second-feet, of Rogue River and the California-Oregon Power Co.'s flume below Prospect, Oreg., 1916–1926*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
1915–16	571	763	1,000	705	1,710	1,750	2,020	2,000	1,870	1,280	783	719	1,260
1916–17	670	704	686	669	786	796	1,700	2,600	2,880	1,640	841	715	1,230
1917–18	677	740	1,220	1,670	1,340	1,340	1,760	1,560	1,040	702	608	599	1,100
1918–19	599	615	579	902	941	921	1,900	1,940	1,280	746	637	622	972
1919–20	605	893	936	956	842	806	1,190	1,480	1,020	686	567	606	883
1920–21	774	1,210	1,160	1,510	1,560	1,660	1,720	1,950	1,810	1,100	868	834	1,340
1921–22	834	1,230	1,320	914	882	973	1,400	2,250	1,910	973	825	773	1,190
1922–23	757	763	832	1,140	797	1,020	1,420	1,590	1,190	804	644	615	964
1923–24	614	654	878	750	1,240	811	1,020	844	587	519	485	479	738
1924–25	390	873	921	1,300	1,910	1,070	1,470	1,550	1,030	591	504	498	1,000
1925–26	468	494	628	574	1,170	879	761	571	403	338	320	305	572

TABLE 8.—*Summary of monthly mean discharge, in second-feet, of Rogue River above Prospect, Oreg., 1908–1912 and 1924–1927*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
1907–8	------	------	------	------	590	801	1,180	1,130	1,060	572	417	443	------
1908–9	576	532	468	------	791	715	832	1,020	915	445	440	458	------
1909–10	496	[a]650	[b]1,320	901	982	1,390	1,240	1,160	768	510	464	502	------
1910–11	529	966	1,070	515	601	887	1,090	1,210	1,140	511	443	487	787
1911–12	466	621	516	1,480	------	------	------	------	------	------	------	------	------
1923–24	[c]410	[c]439	666	533	936	572	710	591	389	321	297	295	511
1924–25	376	843	856	1,030	1,490	782	1,200	1,260	801	477	409	408	823
1925–26	379	422	558	503	1,050	767	649	497	356	302	294	283	501
1926–27	325	784	956	806	1,280	846	1,070	1,540	1,330	620	460	462	869

[a] November 1-19. [b] December 10-31. [c] Estimated.

TABLE 9.—*Miscellaneous discharge measurements in the Rogue River drainage basin, Oreg., during the year ending September 30, 1923*

Date	Stream	Tributary to—	Location	Discharge (second-feet)
July 18	Boundary Springs	Rogue River	NE. ¼ sec. 4, T. 29 S., R. 5 E	42.3
Sept. 5	do	do	do	27.5
July 18	Minnehaha Creek	do	SW. ¼ sec. 11, T. 29 S., R. 4 E	14.1
Sept. 5	do	do	do	5.22
July 18	Hamaker Creek	do	NE. ¼ sec. 15, T. 29 S., R. 4 E	1.56
July 18	Hurryon Creek	do	SE. ¼ sec. 15, T. 29 S., R. 4 E	4.23
Sept. 5	do	do	do	1.72
July 18	National Creek	do	NE. ¼ sec. 32, T. 29 S., R. 4 E	45.3
Sept. 10	do	do	do	35.0
July 16	Copeland Creek	do	NE. ¼ sec. 8, T. 30 S., R. 4 E	49.4
Sept. 10	do	do	do	37.1
July 16	Crater Creek	do	NE. ¼ sec. 5, T. 30 S., R. 4 E	65.6
Sept. 10	do	do	do	45.8
July 16	Bybee Creek	do	NE. ¼ sec. 26, T. 30 S., R. 3 E	39.2
Sept. 10	do	do	do	25.8
July 16	Castle Creek	do	SE. ¼ sec. 26, T. 30 S., R. 3 E	30.5
Sept. 10	do	do	do	14.1
July 11	Union Creek	do	NE. ¼ sec. 3, T. 31 S., R. 3 E	62.3
Sept. 10	do	do	do	49.3
July 11	Mill Creek	do	Sec. 33, T. 31 S., R. 3 E	29.9
Sept. 10	do	do	do	23.3
July 17	Bar Creek	do	Sec. 32, T. 32 S., R. 3 E	4.93
July 19	Middle Fork of Rogue River.	do	NE. ¼ sec. 3, T. 33 S., R. 3 E	163
Sept. 6	do	do	do	123.5
July 19	South Fork of Rogue River.	Middle Fork of Rogue River.	SE. ¼ sec. 12, T. 33 S., R. 3 E	184.8
Sept. 6	do	do	do	75.3
July 17	Red Blanket Creek	do	Sec. 33, T. 32 S., R. 3 E	91.0
Sept. 9	do	do	do	62.8
July 21	Willow Creek	Big Butte Creek	NE. ¼ sec. 20, T. 35 S., R. 3 E	71.0
July 21	Rancheria Creek	do	do	58.2
July 14	Elk Creek	Rogue River	Sec. 30, T. 33 S., R. 1 E	17.8
July 13	Illinois River	do	Kerby, Oreg	98.2
July 23	do	do	do	65.2
Sept. 1	do	do	do	29.0

Along the Illinois River the soil of the mountain sides is shallow, and the volcanic ash that acts as a reservoir on the upper Rogue River is lacking; therefore the run-off follows closely on the rainfall, and the period of low precipitation in the summer is a period of very low flow. Precipitation records indicate a mean annual precipitation of 68 inches for the entire basin, and the mean for a 12-year period at Buckhorn Ranch, in the upper Illinois Basin, was 70 inches. The following discharge records were obtained during the investigation of the power possibilities of the Illinois River.

Mean monthly discharge of the Illinois River near Kerby, Oreg., 1923

July	81
August	36
September	27
October	146

Discharge records for the Illinois River at Kerby for the years ending September 30, 1927 and 1928, have been obtained by the State engineer of Oregon and are published in Water-Supply Papers 654 and 674.

Two measurements of the Illinois River made in 1910 by W. E. Herrings, former district engineer, United States Forest Service, were as follows: September 15, below Rancheria Creek, 43 second-feet; October 1, at mouth, 82 second-feet.

The estimates of stream flow and potential power on the Illinois River are based on an assumed normal year. For the 19-year period ending September 30, 1914, the mean annual precipitation in western Oregon was below normal only once, and in the 10 years following 1914 it was above normal only twice. The potential power of the river is determined by the normal flow, whereas the capacity of steam auxiliary required depends on the flow of a dry year. The stream flow as given in Table 10 for the Kerby reservoir site, above Josephine Creek, was estimated from the records of discharge at Kerby for 1927 and 1928 and the records of precipitation. For the other sites on the Illinois River the stream flow was estimated from the flow at Kerby on the basis of comparative drainage areas. The drainage areas used for the computation are given in Table 11. General measurements of the drainage areas of the Rogue River and its principal tributaries are given in Table 12.

TABLE 10.—*Estimated natural flow, in second-feet, of the Illinois River, Oreg.*

Month	Kerby	Fall Creek	Clear Creek	Bald Mountain	Month	Kerby	Fall Creek	Clear Creek	Bald Mountain
November	1,180	1,850	2,500	2,650	May	700	1,100	1,450	1,600
December	1,810	2,850	3,800	4,100	June	200	315	420	450
January	3,000	4,700	6,250	6,800	July	100	160	210	220
February	1,400	2,200	2,900	3,200	August	60	95	125	135
March	1,600	2,500	3,300	3,600	September	50	79	104	112
April	1,500	2,400	3,100	3,400	October	150	237	312	336

TABLE 11.—*Drainage areas and estimated discharge at power sites in the Rogue River Basin, Oreg.*

Rogue River

No.	Name of site	Drainage area (square miles)	Discharge [a] (second-feet) Q50	Q90
1	Hamaker	59	125	80
2	Castle Creek	187	375	225
3	Union Creek	262	500	290
4	Top Creek	312	575	325
5	Riter Creek	319	585	330
6	Prospect	[b] 577	1,330	700
7	Cascade	583	1,350	775
8	Lost Creek	685	1,400	845
9	Butte Creek	926	1,660	990
10	Elk Creek	926	1,660	990
11	Trail Creek	1,137	1,830	1,100
12	Long Creek	1,137	1,830	1,100
13	Reese Creek	1,200	1,860	1,120
14	Little Butte Creek	1,580	2,000	1,180
15	Raygold	2,020	2,150	1,180
16	Gold Hill	2,050	2,190	1,180
17	Rock Point	2,110	2,210	1,200
18	Savage Rapids	2,390	2,340	1,210
19	Ament	2,410	2,360	1,210
20	Hell Gate	3,370	2,950	1,280
21	Taylor Creek	3,390	2,970	1,290
22	Swing Bridge	3,600	3,130	1,300
23	Horseshoe Bend	3,680	3,200	1,330
24	Stairs Creek	3,780	3,250	1,370
25	Copper Canyon	4,870	5,150	1,490

Illinois River

No.	Name of site	Drainage area (square miles)	Q50	Q90
34	Kerby	380	850	38
35	Fall Creek	600	1,330	60
36	Clear Creek	792	1,800	80
37	Bald Mountain	856	1,910	85

[a] With no allowance for diversions by Eagle Point and Grants Pass Irrigation Districts.
[b] Area given is based on the assumption that Mill Creek, Red Blanket Creek, and the Middle and South Forks of the Rogue River will be diverted to the Rogue River above Prospect Dam.

TABLE 12.—*Drainage areas of the Rogue River and its tributaries, Oreg.*

Stream	Point of measurement	Area (square miles)
Rogue River	Above Prospect, sec. 20, T. 32 S., R. 3 E	315
Do	Below Prospect, sec. 6, T. 33 S., R. 3 E	378
Do	Above junction of Middle Fork, NW. ¼ sec. 11, T. 33 S., R. 2 E	386
Do	At Trail gaging station, SW. ¼ sec. 10, T. 34 S., R. 1 W	1,110
Do	At Raygold gaging station, sec. 18, T. 36 S., R. 2 W	2,029
Do	At mouth, SE. ¼ sec. 25, T. 36 S., R. 15 W	5,080
Middle Fork of Rogue River	Above junction of North Fork, NW. ¼ sec. 11, T. 33 S., R. 2 E	240
South Fork of Middle Fork of Rogue River.	At mouth, NW. ¼ sec. 9, T. 33 S., R. 3E	93
Butte Creek	At mouth, SW. ¼ sec. 34, T. 33 S., R. 1 E	245
Do	At forks, NW. ¼ sec. 3, T. 35 S., R. 2 E	166
South Fork of Butte Creek	At gaging station, SE. ¼ sec. 11, T. 35 S., R. 2 E	113
Elk Creek	At mouth, SW. ¼ sec. 20, T. 33 S., R. 1 E	128
Trail Creek	At mouth, NW. ¼ sec. 3, T. 34 S., R. 1 W	61
Little Butte Creek	Above Eagle Point, SW. ¼ sec. 31, T. 35 S., R. 1 E	276
Do	Above Eagle Point, SE. ¼ sec. 35, T. 35 S., R. 1 W	284
Do	At mouth, SW. ¼ sec. 7, T. 36 S., R. 1 W	361
South Fork of Little Butte Creek.	At gaging station, SW. ¼ sec. 11, T. 37 S., R. 2 E	110
North Fork of Little Butte Creek.	At mouth, SW. ¼ sec. 20, T. 36 S., R. 2 E	49
Bear Creek	At mouth, NW. ¼ sec. 20, T. 36 S., R. 2 W	380
Evans Creek	At mouth, SE. ¼ sec. 16, T. 36 S., R. 4 W	222
Applegate River	At mouth, NE. ¼ sec. 19, T. 36 S., R. 6 W	768
Illinois River	At mouth, NW. ¼ sec. 18, T. 35 S., R. 11 W	995

TABLE 13.—*Gaging stations in the Rogue River Basin, Oreg.*

Stream	Location	Period of record
Applegate River	Near Buncom	1911–1914.
Do	At Murphy	1907–1910.
Ashland Creek	At Ashland	1913 (5 months).
Bear Creek	At Medford	1915–
Do	At Talent	1907–1911, 1912, 1913, 1914, 1921, (parts of years)
Butte Creek	Near Butte Falls	1918–1920.
South Fork of Butte Creek	do	1910–11, 1915 1917–
California-Oregon Power Co.'s flume	Near Prospect	1913–
Dead Indian Creek	At Lilyglen, near Ashland	1916–1919 (parts of years).
Emigrant Creek	Near Ashland	1920–
Evans Creek	9 miles above Woodville	1913 (4 months).
Illinois River	At Kerby	1927–
Jumpoff Joe Creek	Near Merlin	1922 (8 months).
Little Butte Creek	Near Eagle Point	1907–1916.
Do	Above Eagle Point	1916–
North Fork of Little Butte Creek	Above Medford intake	1911–1913, 1922–
Do	At Fish Lake	1914–
Do	Above intake of Rogue River Valley Canal	1916–1919, 1921–
South Fork of Little Butte Creek	Near Lake Creek post office	1910–1913, 1921–
Do	Near Deadwood	1917–18.
Little Applegate River	Near Ruch	1913 (6 months).
East Fork of Little Applegate River	Near Buncom	Do.
West Fork of Little Applegate River	do	Do.
Mill Creek	Near Prospect	1910 (2 months).
Neil Creek	Near Ashland	1913 (5 months).
Rogue River	Above California-Oregon Power Co.'s dam above Prospect.	1907–1912, 1923–
Do	At California-Oregon Power Co.'s plant below Prospect.	1913–
Do	Near Trail	1910–1913.
Do	At Raygold near Central Point	1905–
Do	At Galice	1906.
South Fork of Rogue River	Near Prospect	1924–
Thompson Creek	4½ miles above Applegate	1913 (5 months).
Wagner Creek	Near Talent	1913 (3 months).

FLOODS

The following table shows the greatest recorded discharge at gaging stations on the Rogue River:

Maximum recorded discharges in the Rogue River Basin

Locality	Date	Drainage area (square miles)	Greatest recorded discharge (second-feet)
Above Prospect	Nov. 22, 1909	315	9, 300
Below Prospect	Dec. 30, 1925	378	8, 180
At Raygold	Nov. 23, 1909	2, 020	60, 000

The maximum discharge above Prospect and at Raygold during the flood of November, 1909, varied almost exactly in the ratio of the drainage areas. If this held true at the mouth of the Rogue River the maximum flow at that point amounted to 150,000 second-feet. In general the flood flow in second-feet per square mile decreases with the increase in drainage area. But there is a possibility that the flood flow from the lower tributaries is at least as great and possibly greater than the flood flow from the upper river, for the lower basin is rocky, with steep slopes, and probably receives a heavy rainfall during flood periods. Drift on the banks of the river at Copper Canyon indicates that flood flows reach a stage 30 to 40 feet above low water. Undoubtedly large flood flows can be expected at the Copper Canyon dam site and comparatively large flows at sites above the mouth of the Illinois River. The flood flow at Raygold gives an idea of the flows to be expected above the mouth of the Applegate River.

After the construction of the Kerby Reservoir on the Illinois River peak flows on that stream will be largely ironed out, and this will aid materially at the Copper Canyon site. The Kerby Reservoir will probably be built before any plants on the Illinois River are constructed.

PRIOR WATER RIGHTS

A considerable area in the Rogue River Basin is irrigated, but except for the large tract in the vicinity of Grants Pass, the water is almost entirely supplied by the side streams. The greater use of water for irrigation toward the later part of the period from 1906 to 1924 had no marked effect on the discharge at Raygold and at points above, and it is probable that in the future the effect will not differ much from that in the past, except possibly that the diversion of 75 second-feet from Butte Creek at Butte Falls, Oreg., into the Little Butte Creek drainage basin may decrease the low flow below the mouth of Butte Creek by approximately that amount.

The Grants Pass Irrigation District has a dam and pumping plant in the Rogue River at Savage Rapids (see pl. 19, *A*), about 6 miles above Grants Pass, at which two pumping lifts and a gravity canal are in use. One of the pumps delivers 40 second-feet to a canal 150 feet above the pond level; the other delivers 67 second-feet to a canal 90 feet above the pond; and the gravity ditch will carry about 150 second-feet. The total drain on the river is about 260 second-feet during the height of the irrigation season. It seems reasonable to assume that some of this water will return to the river. If 60 second-feet is so returned the decrease in the Q90 flow during the season of low flow will be about 200 second-feet.

As the tributary streams in the agricultural part of the basin are largely used for irrigation at present, their Q90 flow is very low. This fact has been taken into account in estimating their contribution to the flow of the main river.

Considerable water is diverted for irrigation from the East and West Forks of the Illinois River above Kerby and from Deer Creek. These diversions seriously affect the low-water flow during the summer, but with the flow regulated by the Kerby Reservoir the effect on the yearly run-off would be slight and is probably included in the estimated discharge.

RIVER CONTROL

As there is sufficient water in the Rogue River, even during periods of low flow, to satisfy all irrigation needs, regulation of the discharge would be of no material benefit to agriculture. In the interest of power development, however, the increase of the low flow is greatly to be desired, for the amount of firm power that can be produced at all the plants in the basin is dependent on the flow available during the low period, and any increase in this flow will add greatly to the sale value of the produced power. On the Illinois River the period of low precipitation in the summer is a period of very low flow. This long period of low flow would render power development unprofitable without storage.

Four reservoir sites were surveyed—the Hamaker, Lost Creek, and Taylor Creek sites, on the Rogue River, and the Kerby site, on the Illinois River. Another possible reservoir site on the Applegate River was inspected. They are described on pages 58–66. At some of the high dams in the canyon section of the Rogue River ponds of large area will be created, and by their proper manipulation the low flow may be still further increased.

A study of the run-off records of the Rogue River at Raygold shows that a reservoir having a capacity of about 400,000 acre-feet would be necessary to equalize the flow for the normal year. As no site for a reservoir or combination of reservoirs with a capacity so great exists above Raygold, complete regulation can never be attained. Computations made from the hydrograph of the flow at the gaging station above Prospect indicate that a reservoir having a capacity of about 80,000 acre-feet would provide complete regulation during a normal year, whereas to obtain the desired result at the gaging station below Prospect a capacity of 114,000 acre-feet would be required.

To maintain the present Q50 flow through the low season at Raygold would require a reservoir with a capacity of 200,000 acre-feet; above Prospect, 22,000 acre-feet; and below Prospect, 43,000 acre-feet.

The Taylor Creek reservoir site on the Rogue River below Grants Pass, if developed, would provide complete regulation of the flow below the dam, but the land that would be flooded is mostly cultivated and irrigated, and its use for storage can not be economically justified. Below this point there are no sites valuable primarily for storage, but the upper portion of the ponds created by the power dams may be used to regulate the flow in part.

Regulation of the flow of the Illinois River for power in a normal year would require about 475,000 acre-feet of storage in the Kerby reservoir. This could be provided by a dam raising the water to the 1,360-foot contour. In addition to the storage in the Kerby Reservoir, the ponds above proposed power dams on the Illinois River would afford some storage by drawing down the head. At Fall Creek, with a dam 180 feet high, a drawdown of 40 feet would yield 20,000 acre-feet of storage. At Clear Creek a drawdown of 40 feet would yield 16,500 acre-feet of storage, and at Bald Mountain a drawdown of 40 feet would yield 15,000 acre-feet of storage. In computing the potential power at the several sites it has been assumed that in a normal year all of this storage capacity would be used. It has been assumed also that the power plants on the Illinois River would be operated in a single system and the flow regulated to give the maximum continuous output.

STORAGE SITES

There are no developed storage sites in the Rogue River Basin. The undeveloped sites are described below:

HAMAKER RESERVOIR SITE (12RD 1)

At Hamaker Meadows, in secs. 20 and 21, T. 29 S., R. 4 E., about 2 miles above National Creek, there is a possible storage site. (See fig. 8 and pl. 11, *B*.) The bottom lands are relatively flat and marshy and act as a reservoir in their present state. The flow at the site is estimated at 125 second-feet for 50 per cent of the time and 80 second-feet for 90 per cent of the time. The total annual discharge in a normal year is estimated at 102,000 acre-feet, which is equivalent to a continuous flow of 140 second-feet.

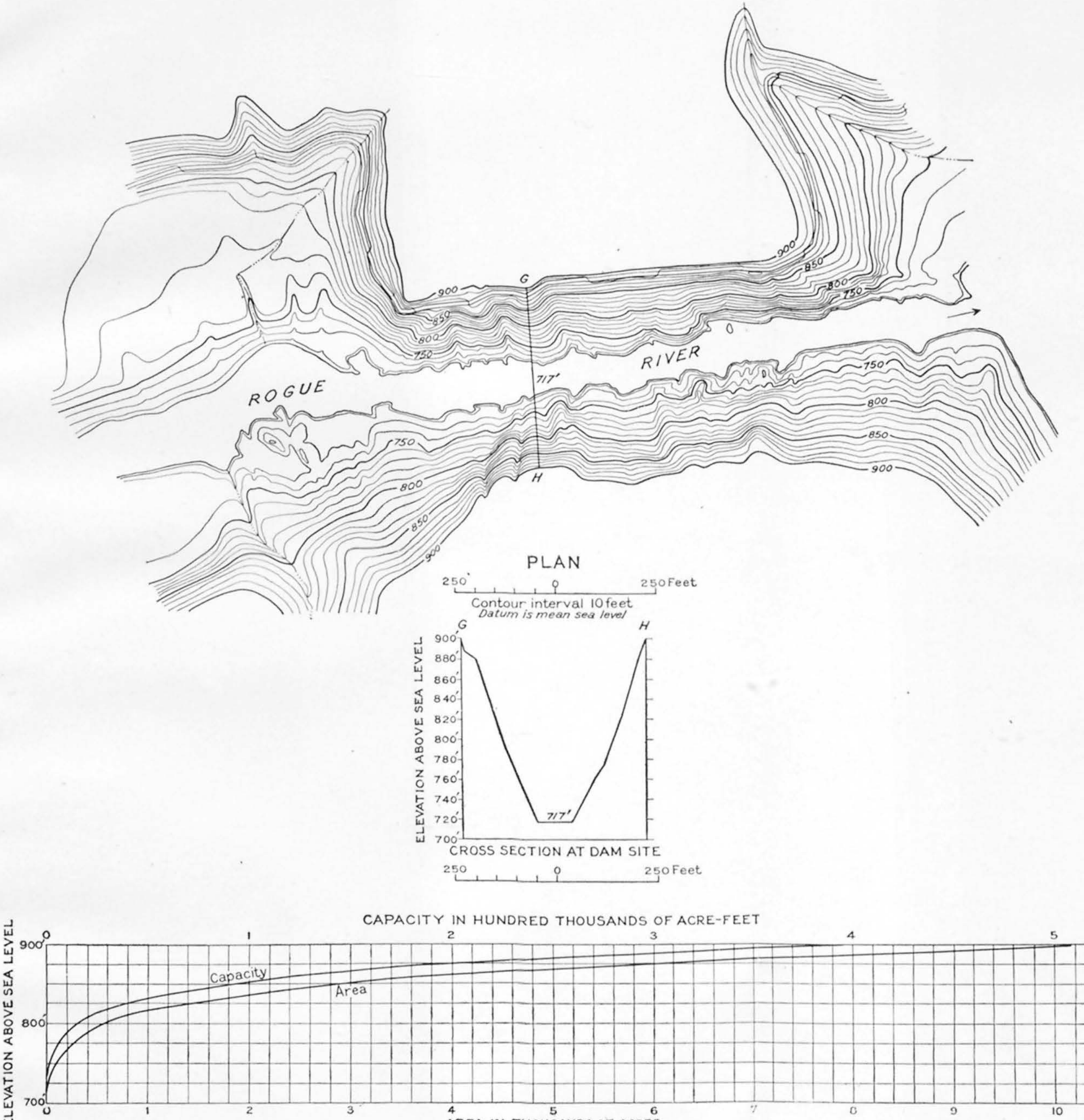
The altitude of the water surface at the dam site is about 3,739 feet, and a dam 160 feet high, or to the 3,900-foot contour, would be necessary to give maximum results for storage at this site. The exact height to which it would be possible to build a dam depends on the conditions disclosed by drilling.

The capacity curve shows that by flooding to the 3,900-foot contour a capacity of 21,000 acre-feet would be made available. While this volume is not quite sufficient to make the Q50 and Q90 flows above Prospect equal, it will increase the Q90 flow by 95 second-feet and will contribute even more to the extreme low flow. This amount of stored water if used through a head of 2,750 feet at proposed power sites lower down at 70 per cent efficiency would generate 42,000,000 kilowatt-hours. This is, therefore, a valuable reservoir site, and the expenditure of considerable money in the construction of a dam would be justified.

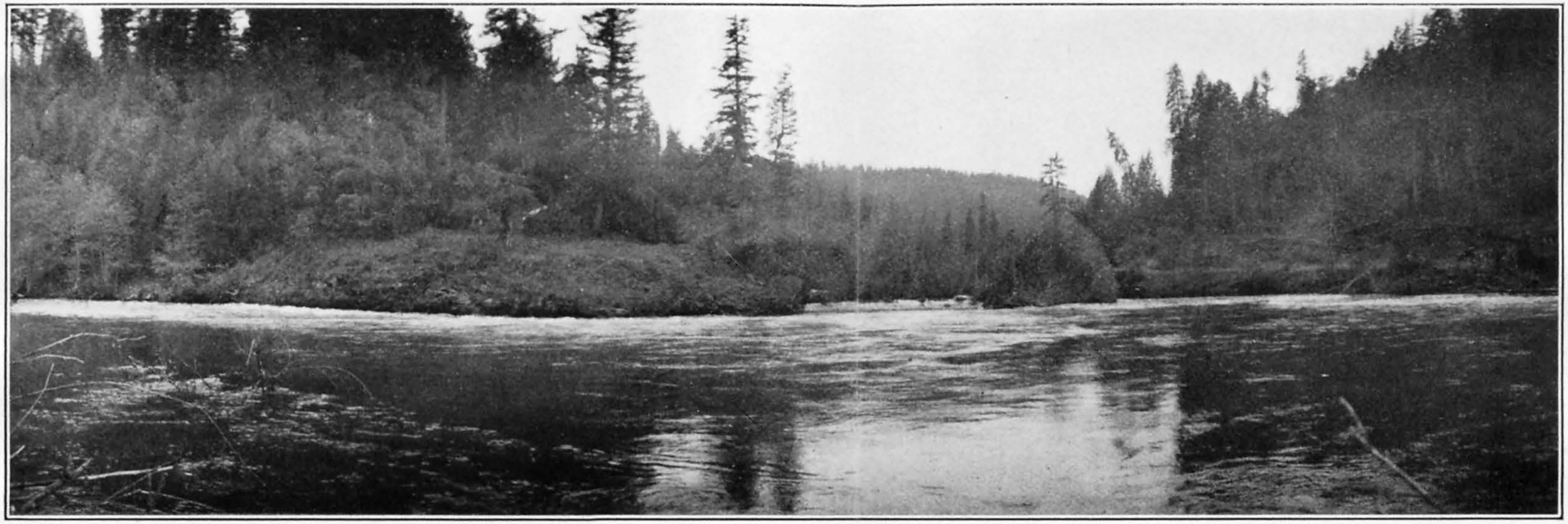
In estimating the potential power of the river, it has been assumed that a dam can be built to the full height of 160 feet, but because of geologic conditions this may not be possible. Most of the reservoir site is clad with timber and dense underbrush. So thickly is the ground covered with the brush and fallen trees that it took 3 hours to walk 3 miles. This condition greatly hampered geologic examination of the site, and time was not available for a detailed study; but sufficient evidence was found in the afternoon spent there to indicate that the site should not be developed without an intensive study of the geology and without thorough drilling and numerous porosity tests.

The reservoir site consists of marshy bottom land bordered on both sides by the pumice-covered banks of the Rogue River. No bedrock was positively identified in the reservoir floor. Numerous subangular boulders indicate that a deposit of glacial débris covers the valley floor; its relation to the pumice was not determined.

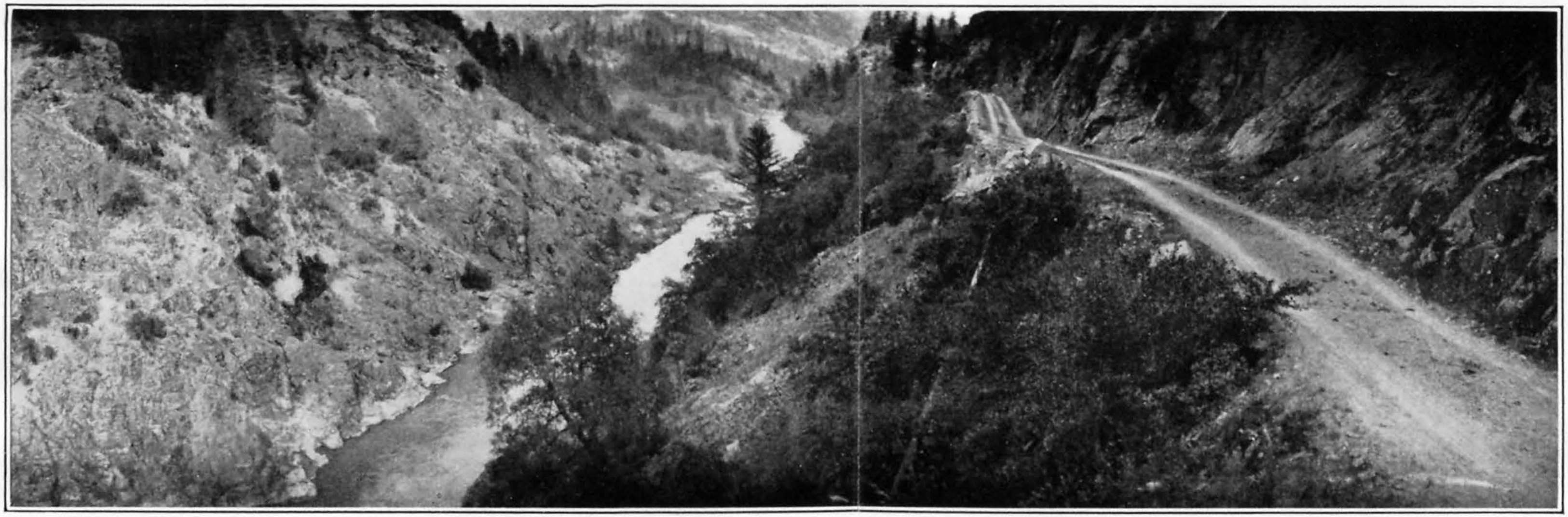
Along one side of the bottom land and in places on both sides there is a bench of ash and pumice which slopes steeply to the river. In a few places these slopes become vertical cliffs nearly 200 feet high which expose unstratified ash and pumice devoid of vegetation. A number of the exposures were examined, and



PLAN, CROSS SECTION, AND AREA AND CAPACITY CURVES, TAYLOR CREEK RESERVOIR SITE, ROGUE RIVER BASIN



A. LOST CREEK DAM SITE, ROGUE RIVER BASIN



B. TAYLOR CREEK DAM SITE, ROGUE RIVER BASIN

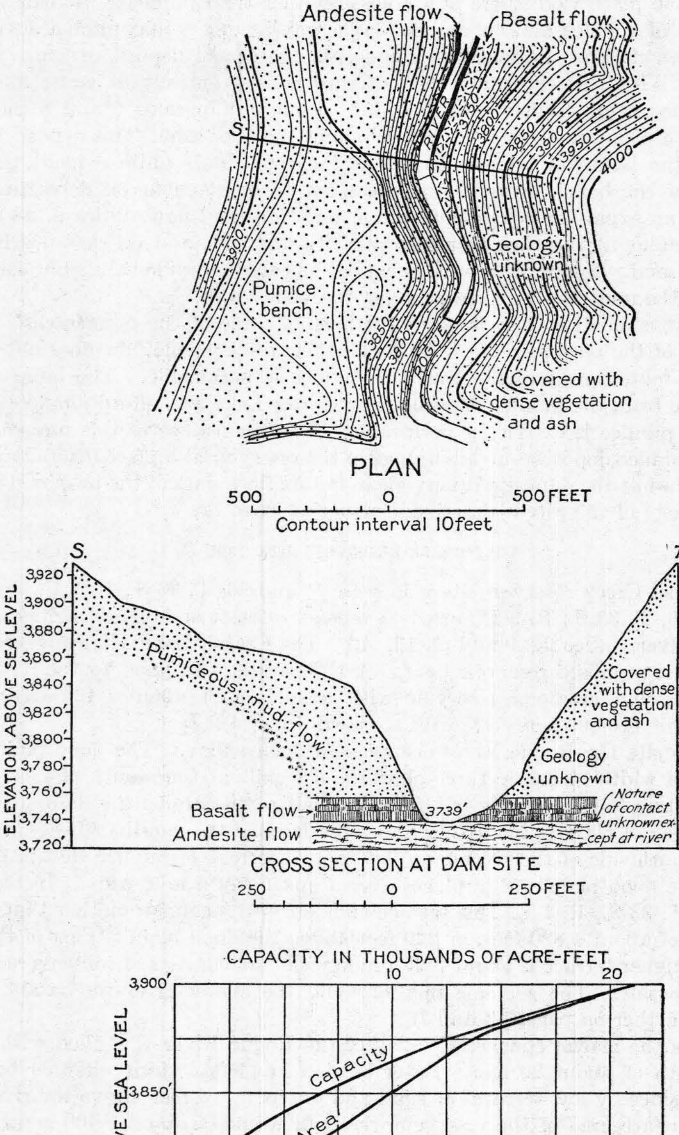


FIGURE 8.—Plan, cross section, and area and capacity curves, Hamaker reservoir site, Rogue River Basin

in only one place were there any boulders other than pumice. At this place a long lens of cobbles and subangular lava rock having a maximum thickness of 3 feet was visible. It doubtless represents the coarse deposit of some ancient stream. With this exception the outcrops consist entirely of white and gray pumice not even crudely stratified, for boulders of pumice 6 and 8 inches in diameter are commonly scattered throughout the finer ash. This deposit is compact at the base but appears looser at the top. It is quite evident that the pumice of the bench owes its thickness not to quiet subaerial deposition as a result of an explosive volcanic eruption, but to a mud flow. (See p. 43.) The ancient valley at the Hamaker reservoir site was wide and was left nearly filled with the mud. Subsequent erosion carved out another wide valley but left remnants of the mud flow as terraces along the valley wall.

Numerous small springs issue at the base of some of the pumice cliffs on the east side of the reservoir site. Although their total visible flow does not exceed 1 second-foot, they indicate that the pumice is permeable. The large springs that issue from the pumice deposits near Crater Lake also afford ample evidence that the pumice is extremely permeable. The occurrence of this immense permeable pumice deposit is an advantage in the reservoir as a place for underground storage, but at the dam site it may mean failure for a dam of the proposed height. The geology of this site is described further on page 72.

LOST CREEK RESERVOIR SITE (12RD 8)

The Lost Creek reservoir site is in secs. 24 and 26, T. 33 S., R. 1 E., and secs. 19 and 20, T. 33 S., R. 2 E., nearly 3 miles northeast of McLeod Bridge, on the Rogue River. (See fig. 9 and pl. 13, *A*.) The Crater Lake Highway crosses a part of the proposed reservoir floor. A 170-foot dam to flood to the 1,745-foot contour would create a reservoir with a surface of about 1,400 acres and a capacity of 110,000 acre-feet, with a drawdown of 125 feet.

At this site the Rogue River occupies an open valley. The flood plain has a maximum width of nearly three-quarters of a mile at the mouth of Lost Creek, which enters the north side of the valley half a mile above the dam site. The flood plain is 1,600 feet in altitude and is bordered at the mouth of Lost Creek and on the south side of the river by a flat-topped terrace of pumice that is 100 feet above the flood plain and in places over a quarter of a mile wide. In the S. ½, sec. 24, T. 33 S., R. 1 E., this terrace ends abruptly against another that has an altitude of about 1,820 feet, or 220 feet above the flood plain. East of the dam site the higher terrace is about half a mile wide and consists of soil-covered intracanyon basalt. The geologic relations and the character of the basalt are described further on pages 43 and 76.

During the glacial epoch the valley of the Rogue River was filled with débris to a depth of about 20 feet. Later erosion has left a stony channel bordered on both sides by low terraces of sand and gravel a few feet above the river.

The surface area of the reservoir when full would be about 1,400 acres, and if a 3-foot evaporation and seepage loss over this entire area is assumed, the total loss from these causes would be 4,200 acre-feet. The reservoir capacity at the 1,620-foot contour is only 4,000 acre-feet, and this lower portion will be maintained to give a power head. By allowing the reservoir to fluctuate between the 1,745-foot and 1,620-foot levels 110,000 acre-feet will be made available for regulation.

The gross head at proposed sites below Lost Creek amounts to 1,141 feet, and 110,000 acre-feet of water used through such a head would produce 75,000,000 kilowatt-hours of energy. By using this capacity to partially equalize the flow at Raygold and by taking advantage of the release of stored water from the

Hamaker Reservoir, the total increase in the Q90 flow at Raygold and all points below would be 560 second-feet.

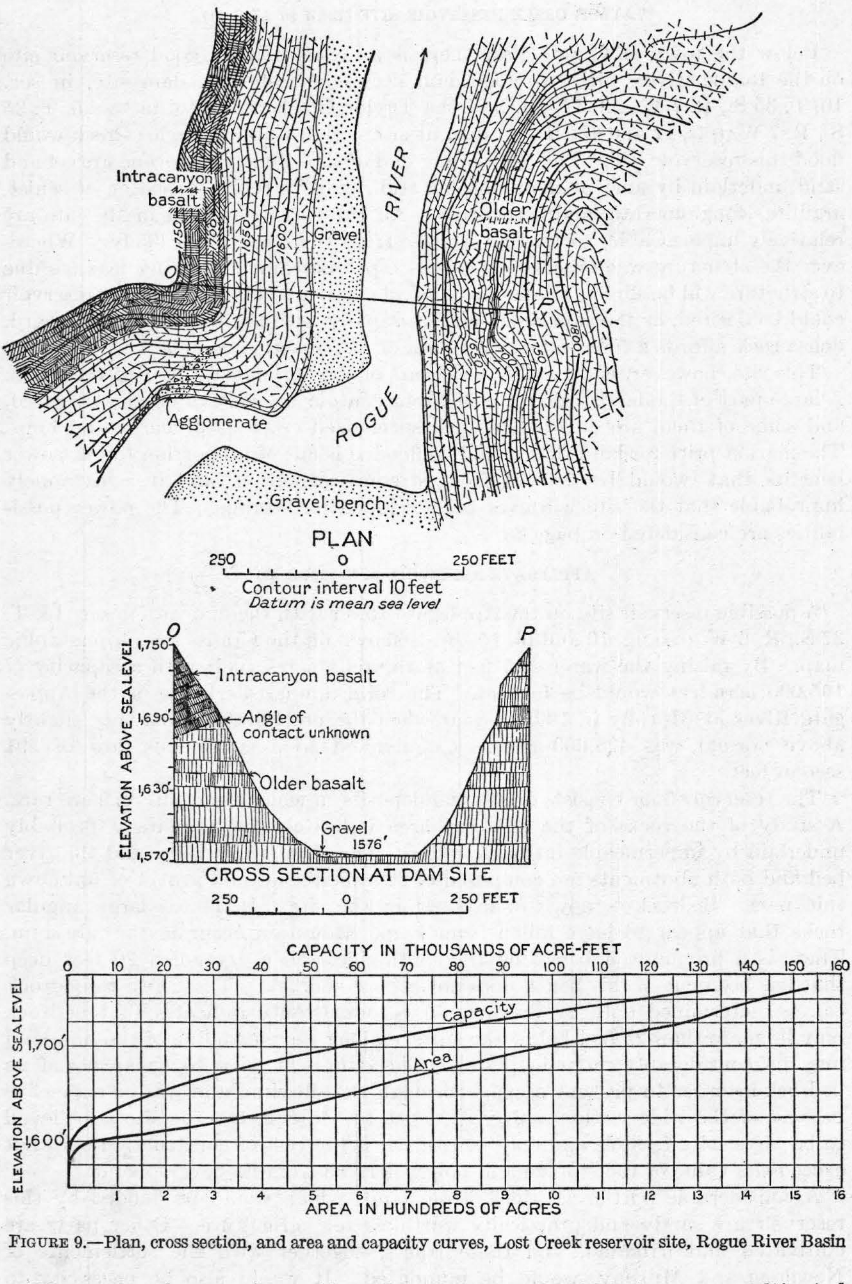


FIGURE 9.—Plan, cross section, and area and capacity curves, Lost Creek reservoir site, Rogue River Basin

The proposed reservoir would flood some bottom lands that are now cultivated and irrigated, and it would also necessitate the moving of a few houses and the relocation of a part of the Crater Lake Highway. The soil is mostly a volcanic ash, and owing to its distance from any large market its agricultural value is low. The hillsides are covered with timber and brush.

TAYLOR CREEK RESERVOIR SITE (12RD 20 AND 21)

Below the town of Grants Pass there is an exceptionally good reservoir site on the Rogue River, with two good dam sites—the Hell Gate dam site, in sec. 10, T. 35 S., R. 7 W. (pl. 14, *B*), and the Taylor Creek dam site, in sec. 5, T. 35 S., R. 7 W. (pls. 12 and 13, *B*). A dam at either Hell Gate or Taylor Creek would flood this reservoir site. The open upper end of the site is Pleistocene gravel and sand underlain by ancient metamorphic and intrusive rocks consisting of schist, argillite, conglomerate, and serpentine. All the rocks observed in the site are relatively impermeable, so that no seepage from the reservoir is likely. Wherever the structure was observed the beds dip upstream, hence any leakage due to structure will be slight. So far as physical characteristics go no better reservoir could be desired, as the capacity increases rapidly with the height, and the hard, dense rock affords a foundation for a dam of any practicable height.

This site, however, is located in the heart of the agricultural part of the basin. A large part of the lands below the 900-foot contour are cultivated and irrigated, and some of them are devoted to such specialized crops as orchards and hops. The market price for land that would be flooded is out of proportion to the power benefits that would be derived from stream regulation, and it is extremely improbable that the site will ever be developed for storage. The power possibilities are considered on page 84.

APPLEGATE RESERVOIR SITE (12RD 32)

A possible reservoir site on the Applegate River with the dam site in sec. 15, T. 37 S., R. 6 W. (see fig. 10 and pl. 15, *B*), is shown on the Grants Pass topographic map. By raising the water 135 feet at the dam a reservoir with a capacity of 195,000 acre-feet would be formed. The total annual discharge of the Applegate River at Murphy in 1908, a year when the precipitation was only slightly above normal, was 428,000 acre-feet, equivalent to a continuous flow of 591 second-feet.

The reservoir floor consists of alluvial deposits in which rock outcrops are rare. A study of the rocks of the adjacent area indicates that the site is probably underlain by impermeable intrusive rocks. The dam site is wide, and the river bed and both abutments are composed of stratified sand and gravel of unknown thickness. Bedrock is nowhere exposed in the site. In places large angular rocks that appear to have fallen from Eagle Mountain occur in the alluvium. There is a pronounced bench on the south side, and a dry gulch 20 feet deep that has been cut in this bench does not expose bedrock. The depth to bedrock can be determined only by drilling. A reconnaissance indicates that bedrock may lie more than 25 feet below the surface along the entire line of the dam and may be considerably more in places. The dam will have to be anchored on bedrock in order to prevent seepage through the alluvium and will be expensive because of the wide section and great depth to bedrock, but the site is believed to be physically feasible and may be utilized if the cost of construction does not exceed the value of the storage and power derived from its development.

A considerable portion of the bottom lands which would be flooded by this reservoir are sandy and practically worthless for agriculture. Other parts are cultivated and irrigated, and these tracts, together with the settlements of Newhope and Murphy, would be inundated. It would also be necessary to relocate a considerable mileage of highway and to move or destroy many isolated buildings.

The gross head at proposed sites below this reservoir, including the head that could be developed at the Applegate Dam, amounts to 765 feet. On the assump-

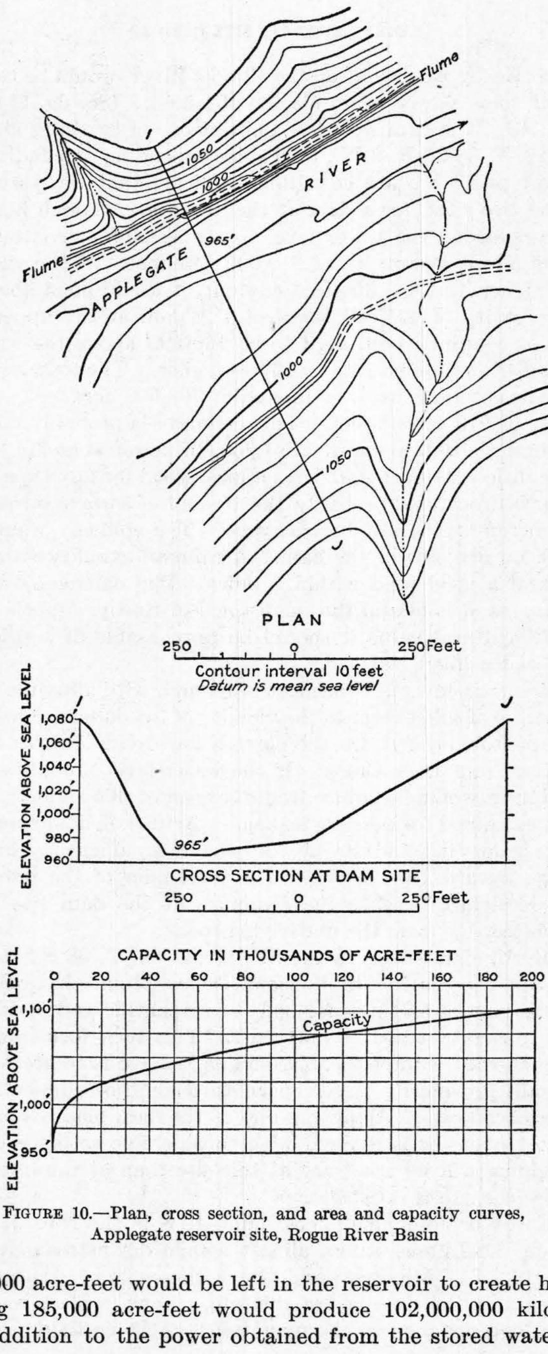


FIGURE 10.—Plan, cross section, and area and capacity curves, Applegate reservoir site, Rogue River Basin

tion that 10,000 acre-feet would be left in the reservoir to create head for power, the remaining 185,000 acre-feet would produce 102,000,000 kilowatt-hours of power. In addition to the power obtained from the stored water considerable power could be developed at the dam from the natural flow. So, although the cost of this reservoir would be high, yet after the Rogue River is developed this storage would be very valuable.

KERBY RESERVOIR SITE (12RD 34)

The proposed Kerby Reservoir, on the Illinois River, would be used principally for storage, but some power could also be obtained. (See fig. 11 and pls. 14, *A*, 15, *A*, and 16, *A*.) The dam would be built at one of two sites above Josephine Creek, in sec. 29, T. 38 S., R. 8 W., the choice depending on conditions shown by borings and test pits. Surface conditions indicate that the yardage would be the same at the two sites, for a dam at the lower site, though higher, would be shorter. A dam raising the water level to the 1,320-foot contour would flood 4,910 acres and afford a capacity of 219,000 acre-feet. If the water level were raised 40 feet higher, to the 1,360-foot contour, it would flood about 8,400 acres and afford a capacity of 475,000 acre-feet. A dam at the upper site to flood to the 1,360-foot contour would need to be 160 feet above the water surface; a dam at the lower site would need to be 12 feet higher. The total annual discharge in a normal year at these sites is estimated at 708,000 acre-feet, equivalent to a continuous flow of 970 second-feet. This estimate is probably conservative, as the actual discharge in 1927 amounted to 1,250,000 acre-feet and in 1928 to 741,000 acre-feet. Conditions at both dam sites appear good for any type of dam. The river flows over bedrock, and probably the amount of surface stripping along the sides of the canyon would not be excessive. The spillway would be an open cut in the rock on one side of the dam. A railroad extends within 15 miles of the dam site and a good road within 3 miles. The damages would consist in flooding 8,400 acres of land and the small town of Kerby. As the land is sandy and of little agricultural value it should be purchasable at a price that would make the project feasible.

The reservoir site is covered over most of its area with alluvium and elsewhere with a thick mantle of soil, except in the vicinity of the dam sites, where numerous outcrops of serpentine occur. On the north a low divide 4 miles wide separates the Illinois River from Deer Creek. If the water-level should be raised to the 1,360-foot contour it would lie not far from the crest of this divide. Consequently the divide was examined for possible leakage. Artificial cuts expose thin-bedded shales that are contorted and steeply dipping but sufficiently impermeable to prevent seepage toward Deer Creek. The remainder of the reservoir site was not examined in detail, because the structure at the dam site indicates that there will be no seepage from the underlying rocks.

The upper Kerby dam site is in the SE. ¼ sec. 29, T. 38 S., R. 8 W., on the Illinois River, on the south side of Eight Dollar Mountain. (See pl. 16, *A*.) The mountain is part of an immense body of serpentine and peridotite—altered intrusive basic rock—that strikes northeast. This rock forms both abutments of the site. Such rock is impermeable, and as it extends to great depth, it acts as a cut-off wall, preventing any seepage through the sedimentary beds that underlie the reservoir site. Along the line of the dam massive peridotite crops out, but in most places it is covered with considerable rotten rock and soil, so that more stripping will be necessary at this site than at the lower Kerby dam site. Otherwise the site is satisfactory.

The lower Kerby or Josephine Creek dam site is in the NW. ¼ sec. 29, T. 38 S., R. 8 W., on the Illinois River, almost a mile downstream from the upper site. (See pl. 14, *A*.) Massive peridotite with seams of serpentine crops out on both banks and in the river bed at this site. Rock in place is exposed on the west side for a long distance up the mountain; on the east side the outcrop can be traced for a distance of about 25 feet above the river surface, and above this point the surface is strewn with loose blocks of the same rock. About 50 feet upstream from the dam site there is an 8-foot dike of a rock containing black crystals in a gray groundmass; it is apparently allied to a diorite. The lower site has all the advantages of the upper site and would require much less exca-

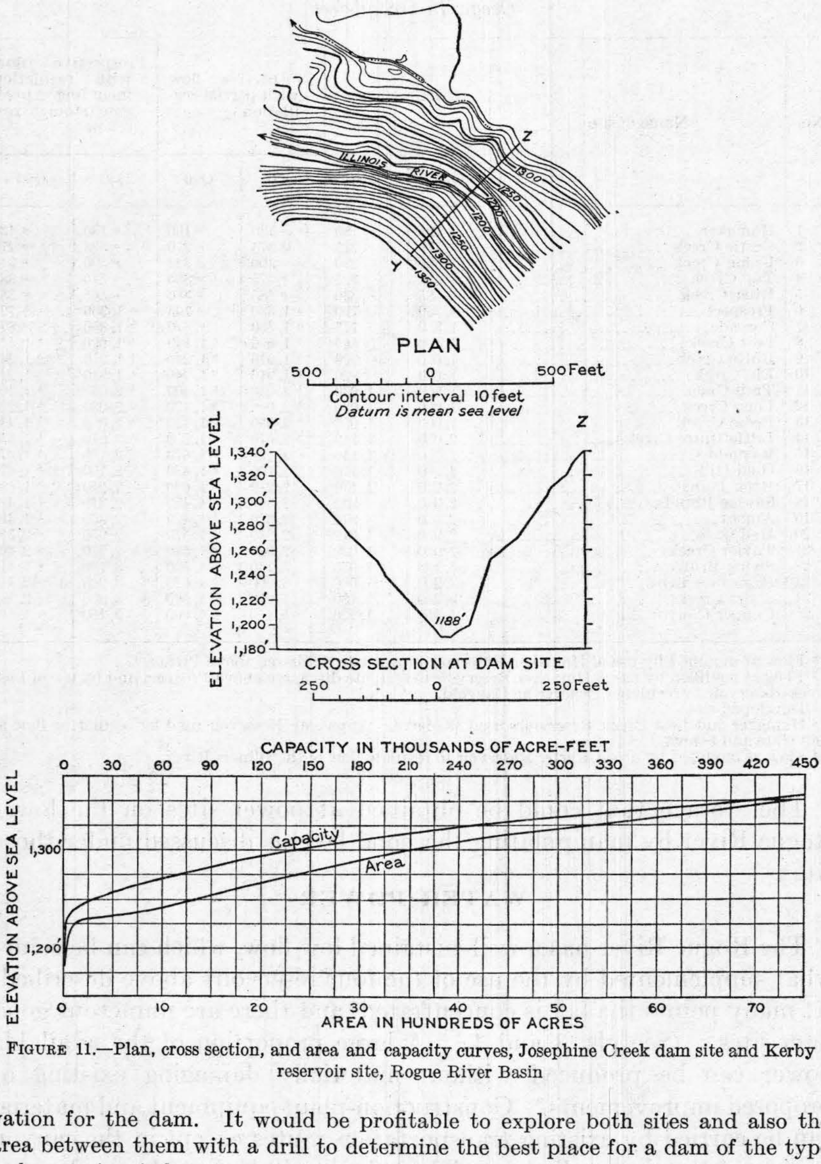


FIGURE 11.—Plan, cross section, and area and capacity curves, Josephine Creek dam site and Kerby reservoir site, Rogue River Basin

vation for the dam. It would be profitable to explore both sites and also the area between them with a drill to determine the best place for a dam of the type to be constructed.

The value of the power sites below on the Illinois River depends upon the construction of the Kerby Reservoir.

SUMMARY OF RESULTS FROM STORAGE ON THE ROGUE RIVER

Table 14 shows for the normal year the Q50 and Q90 flows under various assumptions at the proposed power plants.

TABLE 14.—*Summary of results from storage on the Rogue and Applegate Rivers, Oreg., in second-feet*

No.	Name of site	Existing flow		Prospective flow with partial regulation		Prospective flow with regulation including Applegate storage reservoir	
		Q50	Q90	Q50	Q90	Q50	Q90
1	Hamaker	125	80	[a] 130	[a] 130	[a] 130	[a] 130
2	Castle Creek	375	225	[a] 375	[a] 270	[a] 375	[a] 270
3	Union Creek	500	290	[a] 300	[a] 344	[a] 500	[a] 344
4	Top Creek	575	325	[a] 575	[a] 385	[a] 575	[a] 385
5	Riter Creek	585	330	[a] 585	[a] 386	[a] 585	[a] 386
6	Prospect	1,330	700	[a] 1,330	[a] 795	[a] 1,330	[a] 795
7	Cascade	1,350	775	[a] 1,350	[a] 870	[a] 1,350	[a] 870
8	Lost Creek	1,400	845	[b] 1,690	[b] 1,140	[b] 1,690	[b] 1,140
9	Butte Creek	1,660	920	[b] 1,910	[b] 1,240	[b] 1,910	[b] 1,240
10	Elk Creek	1,660	920	[b] 1,910	[b] 1,240	[b] 1,910	[b] 1,240
11	Trail Creek	1,860	1,030	[b] 2,030	[b] 1,400	[b] 2,030	[b] 1,400
12	Long Creek	1,860	1,030	[b] 2,030	[b] 1,420	[b] 2,030	[b] 1,220
13	Reese Creek	1,900	1,050	[b] 2,050	[b] 1,430	[b] 2,050	[b] 1,430
14	Little Butte Creek	2,030	1,110	[b] 2,070	[b] 1,650	[b] 2,070	[b] 1,650
15	Raygold [c]	2,150	1,110	2,150	[b] 1,670	2,150	[b] 1,670
16	Gold Hill	2,190	1,110	2,190	[b] 1,670	2,190	[b] 1,670
17	Rock Point	2,210	1,130	2,210	[b] 1,690	2,210	[b] 1,690
18	Savage Rapids [c]	2,340	930	2,340	[b] 1,490	2,340	[b] 1,490
19	Ament	2,360	930	2,360	[b] 1,490	2,360	[b] 1,490
20	Hell Gate	2,950	1,010	2,950	[b] 1,570	2,950	[d] 2,390
21	Taylor Creek	2,970	1,020	2,970	[b] 1,580	2,970	[d] 2,400
22	Swing Bridge	3,130	1,030	3,130	[b] 1,590	3,130	[d] 2,410
23	Horseshoe Bend	3,200	1,060	3,200	[b] 1,620	3,200	[d] 2,440
24	Stairs Creek	3,250	1,100	3,259	[b] 1,660	3,250	[d] 2,480
25	Copper Canyon	5,150	1,220	5,150	[e] 4,000	5,150	[e] 4,850

[a] Flow as modified by use of Hamaker Reservoir to regulate discharge above Prospect.
[b] Flow as modified by use of Hamaker Reservoir to regulate discharge above Prospect and by use of Lost Creek Reservoir to regulate discharge at Raygold.
[c] Developed site.
[d] Hamaker and Lost Creek Reservoirs used as above. Applegate Reservoir used for regulating flow at Hell Gate and below.
[e] Flow as modified by use of Kerby Reservoir to regulate flow of the Illinois River.

The storage that could be obtained at power sites on the lower Rogue River by manipulating the pond level is discussed under those sites.

WATER POWER

The Rogue River has a well-sustained low flow, which can be somewhat supplemented by the use of the four reservoirs above described. At many points the fall is concentrated, and there are numerous good dam sites. (See pls. 3 and 4.) A large proportion of the available power can be produced without materially damaging existing or proposed improvements. Construction-plant equipment and material can be carried by existing transportation routes except in the canyon section of the river, where special methods will have to be used.

In spite of the well-sustained flow of some of the creeks tributary to the Rogue River it is not considered probable that any of those above Prospect are worthy of development by themselves except for some special local use, because of the low slope in their lower stretches and because of the more advantageous possibilities on the main river.

Mill Creek, Red Blanket Creek, and the Middle and South Forks of the Rogue River, which flow into it just below Prospect, are all valuable power streams and can be developed separately. It appears preferable, however, that they should be combined into some unified system, and such a system is considered in detail in connection with the Prospect power site. (See pp. 68–69.) Briefly, it consists in collecting the flow of these four tributaries and turning it into the main river above the section of greatest fall. Such a method will utilize the valuable part of Mill and Red Blanket Creeks and the lower part of the Middle and South Forks. On the Middle and South Forks the parts above the diversion dams suggested have further attractive power possibilities.

As Butte Creek drains a heavily timbered region in which there are numerous springs, the low flow is well sustained. At Butte Falls the discharge available for 90 per cent of the time is about 100 second-feet, and the average grade of the creek between this point and the Rogue River is 60 feet to the mile. The construction of a diversion dam and canal would involve no particular difficulty. The power value of this section of the stream is, however, destroyed by the diversion of practically all the low flow for irrigation. The Eagle Point Irrigation District has constructed a small dam and gravity canal taking water from Butte Creek just below the town of Butte Falls and delivering it to lands in the vicinity of Eagle Point. The district has an approved filing of 75 second-feet, and the canal is designed to carry 90 second-feet, the probable ultimate development. This irrigation project has some power possibilities. The McNeil Creek siphon operates under a head of 330 feet, and there are two drops in the canal, one of 60 feet and one of 300 feet, both occurring before any large portion of the canal water is diverted for irrigation. By using the two drops in the canal for power during the irrigation season and the McNeil Creek siphon for power during the rest of the year, a practically constant 2,000 horsepower could be generated with the authorized flow or 2,400 horsepower if the canal is used to its full designed carrying capacity.

The power value of the minor tributaries of the Rogue River below the mouth of Butte Creek is very low. In the agricultural portion of the basin the summer flow is absorbed by irrigation requirements, and in the lower canyon section the creeks are short and steep and carry little water during the season of low rainfall.

Although the Applegate River could furnish some power its chief contribution would be the regulation of flow at sites lower down afforded by the storage of water in the Applegate Reservoir.

The Illinois River flows through an agricultural area and is used to some extent for irrigation. The natural flow is extremely variable, and without some regulation to equalize the flow the power value would be low. Fortunately, however, a practically uniform flow can be insured by developing the Kerby reservoir site. The river for most of its length below Kerby flows in a narrow canyon, good dam sites are abundant, and damage due to flowage would be negligible. The river slope in this section is about 24 feet to the mile, and practically all of the 1,250-foot fall can be utilized. There are no transportation facilities available, and special provisions must be made to handle the material involved in the construction of the power projects. Besides the Kerby site, three other sites were selected for development—the Fall Creek, Clear Creek, and Bald Mountain power sites. If these were operated as one system they would generate in an assumed normal year 145,000 continuous horsepower.

Although it will no doubt be possible to generate some power on many of the minor tributaries of the Rogue River, the plants will necessarily be small, supplying a local market. The municipal plant at Ashland is an example of a development making a maximum use of a small stream. The plants on Mill Creek and Reuben Creek are other examples. However, it seems impracticable to consider these small sites in a preliminary investigation of this sort unless they are already utilized or there is some condition that makes them particularly valuable.

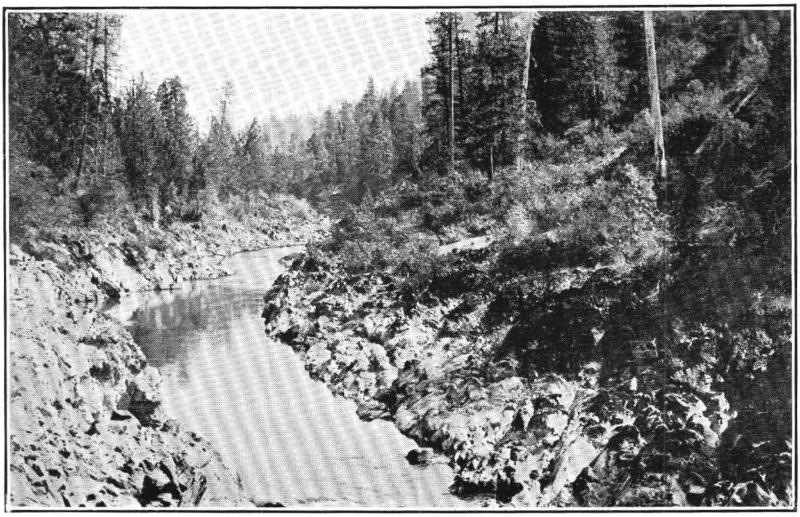
The total potential power on the Rogue River and its tributaries amounts to 558,000 horsepower for 50 per cent of the time and 189,000 horsepower for 90 per cent of the time with the natural flow of the stream, or to 576,000 horsepower for 50 per cent of the time and 456,000 horsepower for 90 per cent of the time with the flow regulated by the four proposed reservoirs.

DEVELOPED SITES

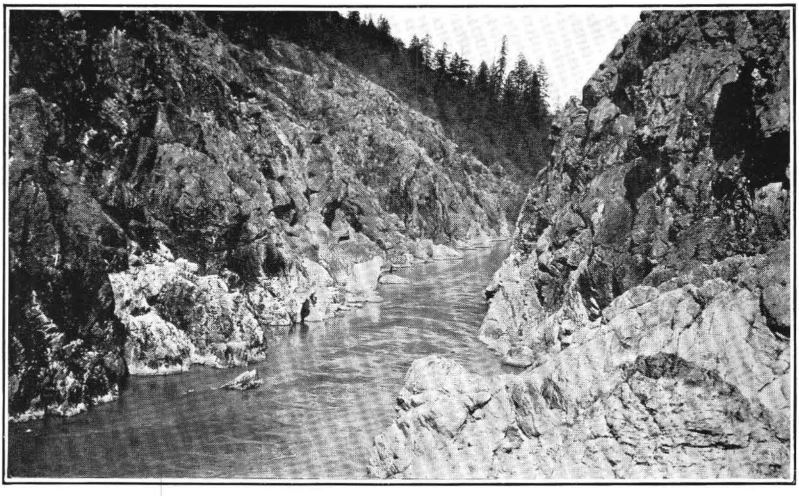
There are eight developed water-power sites in the Rogue River Basin. The rated capacity of the turbines and water wheels installed is 59,800 horsepower. The power generated is used to pump water for irrigation, to drive sawmills, and to produce electricity for general uses.

PROSPECT POWER PLANT (12RD 6)

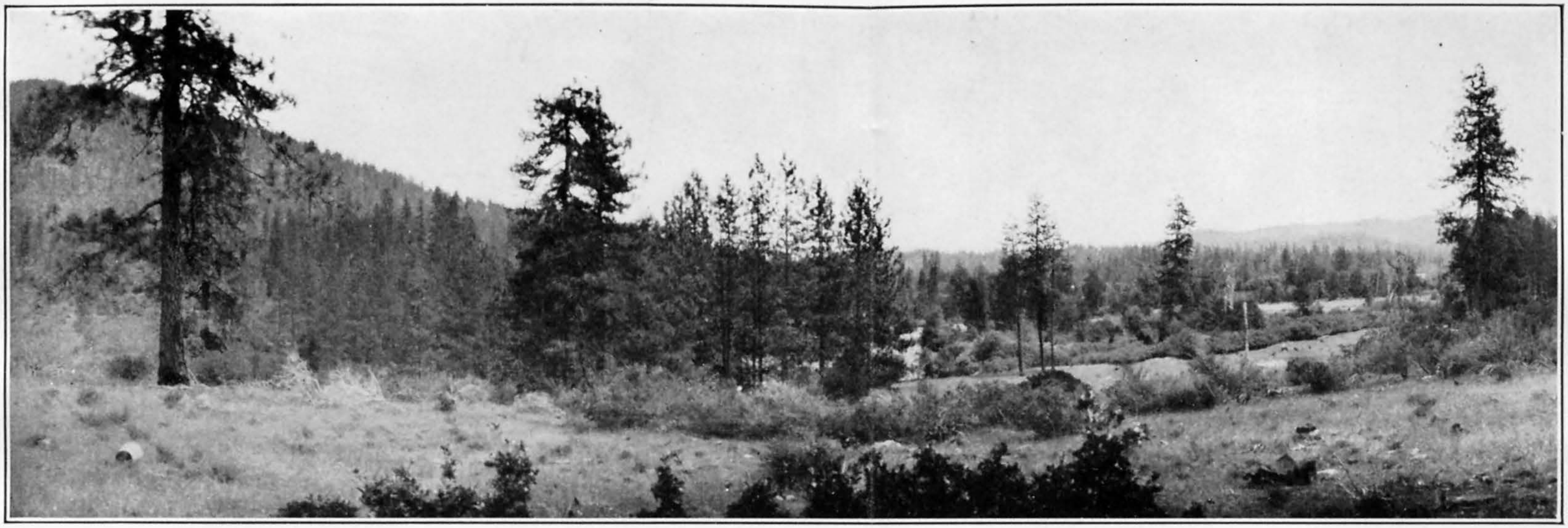
The plant that has its power house below the small town of Prospect is the largest power plant in Oregon. (See pls. 16, *B*, and 17, *B*.) In this vicinity the river falls rapidly (see pl. 10, *A*), and a 50-foot diversion dam has been built in the SE. ¼ sec. 30, T. 32 S., R. 3 E., with a concrete-lined canal 6,840 feet long leading to a small forebay. Two pipe lines 3,100 feet long lead from the forebay to a surge tank 150 feet high at the edge of the canyon. Two steel penstocks 850 feet long conduct the water from the tank to two Pelton water wheels which have a capacity of 23,400 horsepower each and are direct-connected to two



A. JOSEPHINE CREEK DAM SITE FOR KERBY RESERVOIR, ON ILLINOIS RIVER, ROGUE RIVER BASIN

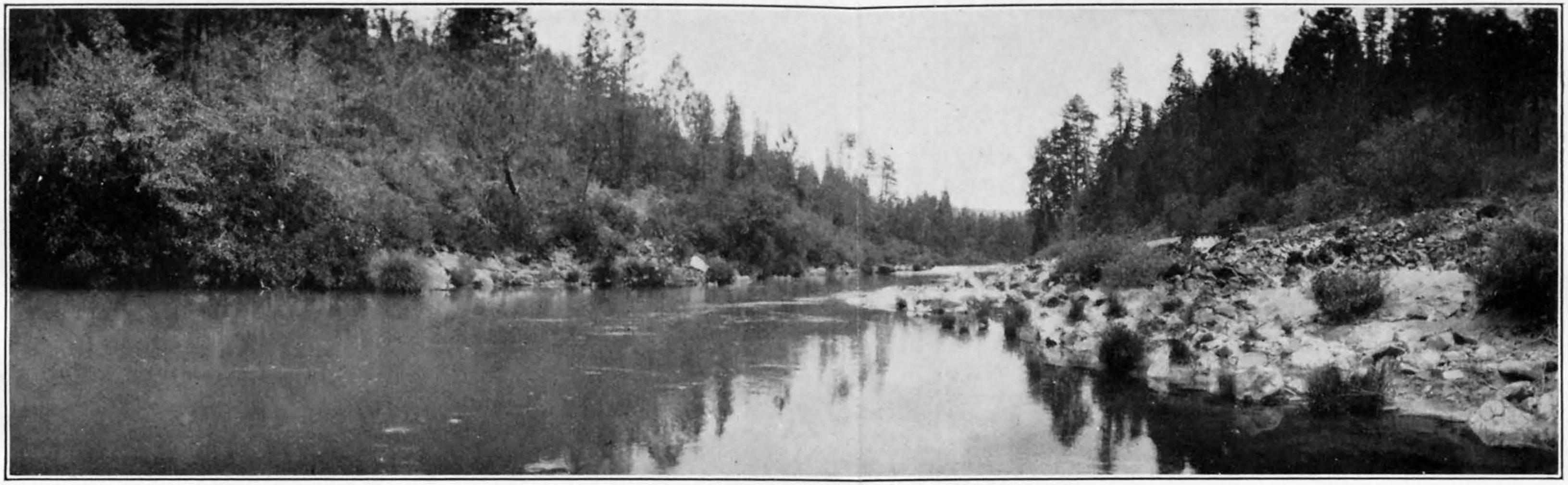


B. HELL GATE DAM SITE, ROGUE RIVER BASIN

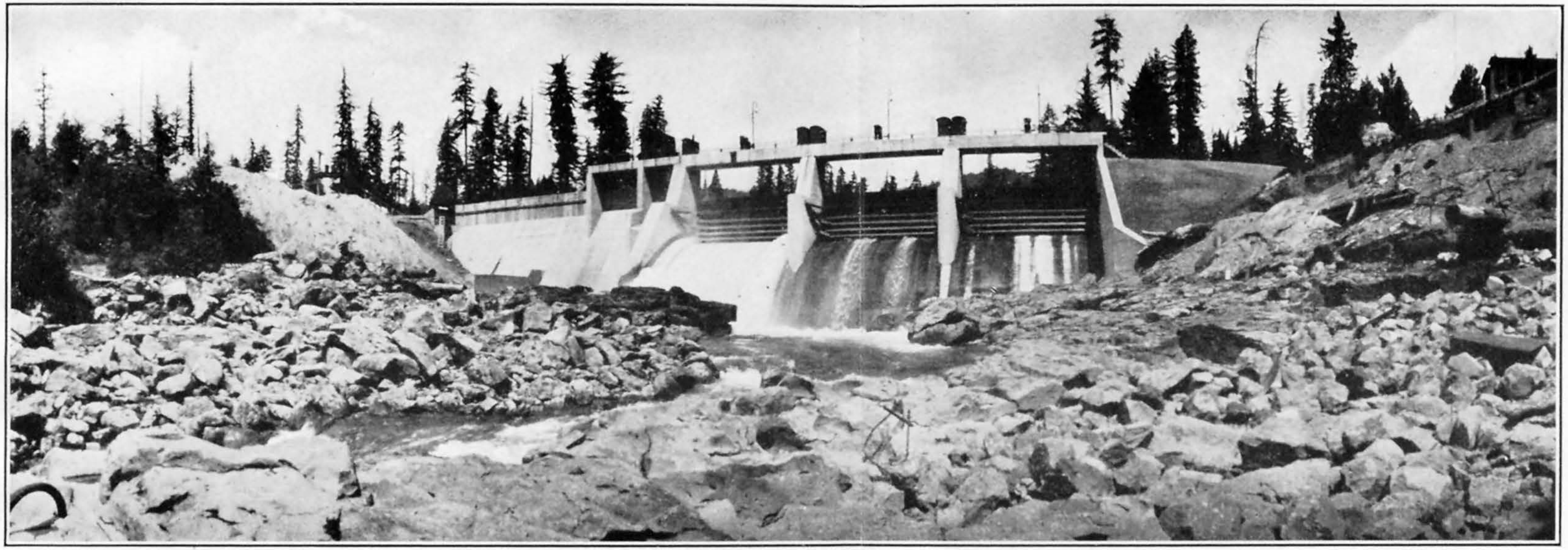


A. LOWER END OF KERBY RESERVOIR SITE ON ILLINOIS RIVER, ROGUE RIVER BASIN

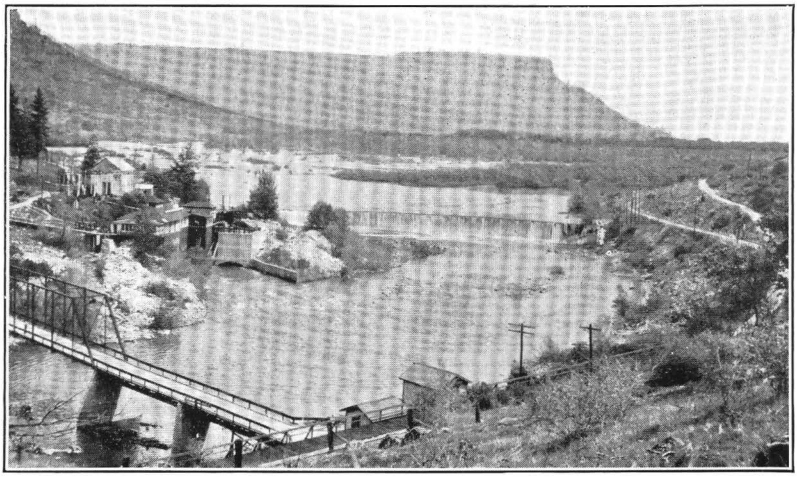
B. DAM SITE FOR RESERVOIR ON APPLEGATE RIVER, ROGUE RIVER BASIN



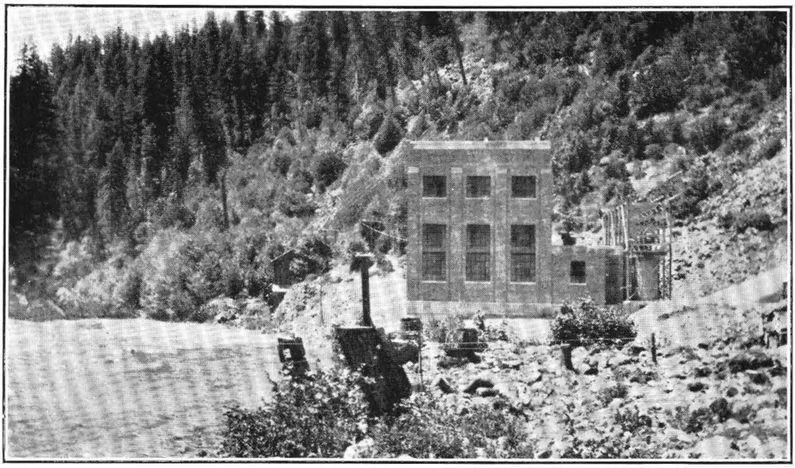
A. KERBY DAM SITE, ILLINOIS RIVER, ROGUE RIVER BASIN



B. DIVERSION DAM OF PROSPECT POWER PLANT, ROGUE RIVER BASIN



A. RAYGOLD POWER PLANT, ROGUE RIVER BASIN



B. PROSPECT POWER HOUSE NO. 2, ROGUE RIVER BASIN

20,000 kilovolt-ampere General Electric generators. The operating head at the plant is 600 feet, and the total head is roughly estimated at 620 feet. The original power house is a short distance upstream and contains an impulse-type Francis turbine rated at 7,000 horsepower direct-connected to a generator rated at 4,590 kilovolt-amperes.

It is planned to divert the Middle and South Forks of the Rogue River, as well as Mill, Bar, and Red Blanket Creeks into the Rogue River above the diversion dam for this project, thus furnishing a large additional supply of water that could be used through the present plant.

Potential power at developed site 12RD 6

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Rogue River only: Natural flow	330	590	16,400	29,200
Rogue River with Middle and South Forks, Mill Creek, Bar Creek, and Red Blanket Creek diverted to this project:				
Natural flow	700	1,330	34,700	66,000
Regulated flow	795	1,330	39,400	66,000

By adopting the unified plan the total power output will be practically doubled. The added expense, which should not be high, will be incurred for the construction of about 7 miles of open flume or canal and 1.5 miles of tunnel.

Practically no water is diverted from the river above the dam. The country that would be crossed by the canals is heavily timbered but is unsettled, and the damage caused by construction would be low. The scenic beauty of Mill Creek Falls would be ruined ecxept during periods of high water, and the sawmill at Prospect would be deprived of its water; but no other material damage would be done to existing or proposed improvements. The flood flow could readily be passed over the small diversion dams.

RAYGOLD POWER PLANT (12RD 15)

The Raygold plant of the California-Oregon Power Co. is on the Rogue River at Raygold, in the SE. ¼ sec. 18, T. 36 S., R. 2 W. The dam is a rock-filled timber-crib structure with a concrete-core wall. (See pl. 17, *A*.) It is about 20 feet high and 420 feet long, is slightly arched upstream, and is built on bedrock, to which it is anchored by iron drift bolts. A granite-masonry retaining wall 4 feet thick at the top and 300 feet long forms one side of the headrace, which is about 60 feet wide and 12 feet deep. Flood waters are taken care of by natural overflow on the entire length of the dam and by gates near the lower end of the forebay. The head available at the power house is slightly over 20 feet. The hydraulic machinery consists of two S. Morgan Smith 42-inch twin turbines, rated at 1,000 horsepower each, and two smaller wheels rated at 375 horsepower each, or a total of 2,750 horsepower. This power drives two 750-kilovolt-ampere generators and one 450-kilovolt-ampere generator, or a total of 1,950 kilovolt-amperes. The electricity produced is fed directly into the transmission system of the California-Oregon Power Co.

Potential power at developed site 12RD 15

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,110	2,150	1,950	3,780
Regulated flow	1,670	2,150	2,940	3,780

The maximum flood that may be expected in a long period of years is about 87,000 second-feet; of this amount about 4,000 second-feet can be used by the wheels and possibly another 4,000 second-feet can be passed through the gates in the headrace. The remainder, or 79,000 second-feet, must be passed over the spillway, which is 420 feet long. Raising the pond level between 14 and 15 feet will permit the passage of this water.

GOLD HILL POWER PLANT (12RD 16a)

The power plant on the Rogue River a short distance above the town of Gold Hill, at the time it was examined in 1923, was being used to pump water for that town. The natural fall of the river is taken advantage of by a small wing dam which diverts the water in the NW. ¼ sec. 15, T. 36 S., R. 3 W., and by a canal about half a mile long which carries the water to a power house in the SW. ¼ sec. 15. The plant was greatly underdeveloped and in a poor state of repair. The head available is about 18 feet, but probably not over 20 horsepower was being produced by the water wheel, which is belt-connected to a small triplex pump. By an enlargement of the present headrace and suitable alterations of the power house and the hydraulic equipment, this development could be made valuable. (See description of the undeveloped power site at Gold Hill (12RD 16), p. 82.)

Potential power at developed site 12RD 16a

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,110	2,190	1,600	3,150
Regulated flow	1,670	2,190	2,380	3,150

SAVAGE RAPIDS POWER PLANT (12RD 18)

The plant of the Grants Pass Irrigation District is at Savage Rapids, on the Rogue River, in the SE. ¼ sec. 24, T. 36 S., R. 5 W., and the SE. ¼ sec. 19, T. 36 S., R. 4 W. A combination multiple-arch and solid-concrete dam is constructed partly on native rock and partly on cemented gravel. (See pl. 19, *A*.) Sixteen hydraulically operated radial-type gates, each capable of passing 3,000 second-feet, are provided to carry the floods. The head developed is 28 feet. Two 48-inch horizontal Allis-Chalmers turbines, each rated at 900 horsepower, are direct-connected to centrifugal pumps that deliver water to ditches 150 feet above the river on the north side and 90 feet above it on the south side. In addition to these lifts the irrigation system includes a gravity canal with a carrying capacity of about 150 second-feet. All the power produced is used for irrigation.

Potential power at developed site 12RD 18

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	930	2, 340	2, 080	5, 240
Regulated flow	1, 490	2, 340	3, 340	5, 240

The maximum flood that may be expected in a long period of years is about 100,000 second-feet. The dam is designed to pass 48,000 second-feet without raising the pond level. With a maximum flood, however, the pond would rise about 5 feet even with all the gates open.

MILL CREEK POWER PLANT (12RD 26)

The Mill Creek power plant, at Prospect, has been used for sawing lumber. A short flume diverts water from Mill Creek and delivers it to the water wheel at the mill under a head of about 25 feet. Less than 30 horsepower was being used. The flume is in poor shape, and the whole outfit is of a temporary nature.

The natural Q90 flow at this site is 45 second-feet and the Q50 flow 85 second-feet; 90 horsepower could be developed for 90 per cent of the time and 170 horsepower for 50 per cent of the time.

BUTTE FALLS POWER PLANT (12RD 29)

The Butte Falls Lumber Co. has a plant on Butte Creek at Butte Falls. By using a small timber-crib dam and a wood flume about 500 feet long a head of 49 feet is made available. The hydraulic equipment consists of a Leffel wheel rated at 500 horsepower and a McCormick wheel rated at 250 horsepower. The power has not been used for several years, and the plant is partly dismantled, but formerly it was used for running a sawmill.

The natural Q90 flow at this site is 133 second-feet and the Q50 flow 160 second-feet; 520 horsepower could be developed for 90 per cent of the time and 626 horsepower for 50 per cent of the time.

ASHLAND POWER PLANT (12RD 31)

The Ashland municipal plant diverts water from the East and West Forks of Ashland Creek and carries it to the power house in the NW. ¼ sec. 21, T. 39 S., R. 1 E. (See pl. 18, *A*.) The effective head is 420 feet. A new dam was constructed in 1928. The equipment consists of a 56-inch impulse turbine making 300 revolutions a minute, rated at 600 horsepower, direct-connected to a 300-kilowatt 4,000-volt 43-ampere 3-phase 60-cycle generator, which in turn is excited by a 12½-kilowatt generator belt connected to the water-wheel shaft. Appropriate governing and switching apparatus is also included.

REUBEN CREEK POWER PLANT (12RD 33)

A mining company has been granted a license by the Federal Power Commission for a project on Reuben Creek, a tributary of Graves Creek. A diversion dam of logs and rock has been built in the SE. ¼ NE. ¼ sec. 24, T. 33 S., T. 8 W. From the dam a conduit 1½ miles long leads to a power house in the NW. ¼ SW. ¼ sec. 30, T. 33 S., R. 7 W. The site has a potential capacity of 62 horsepower for about 50 per cent of the time and 27 horsepower for 90 per cent of the time. Power is used for mining and lighting. In 1913 a 4-inch Pelton wheel was in use at the site. It was operated under a 90-foot head and supplied about 16 horsepower to a sawmill. This was a temporary plant.

UNDEVELOPED SITES

The following study of the undeveloped water power of the Rogue River is based on maps prepared by the topographic branch of the Geological Survey, on a field investigation of each of the proposed sites, and on office studies of such material as is in the files. The sites are described in order, starting with the highest part of the basin and working downstream on the Rogue River, then on its tributaries, in the same order. (See pl. 3.)

HAMAKER POWER SITE (12RD 1)

The Hamaker Reservoir and power site is in secs. 20 and 21, T. 29 S., R. 4 E. (See fig. 8 and pl. 11, *B.*) A dam 160 feet high would flood to the 3,900-foot contour and provide a storage capacity of 21,000 acre-feet, which could be used for partial regulation of the flow above Prospect. The storage possibilities have been considered on pages 58–60. The volume in the lower 40 feet of the reservoir is small. This portion, therefore, may be used to maintain a power head. By tapping the reservoir at the 40-foot level, or at an altitude of 3,780 feet, and carrying the water in a conduit 1½ miles long on the left bank of the river, then turning it into a penstock a quarter of a mile long, the water will be returned to the river at an altitude of 3,580 feet, making available a total head of 200 feet.

The dam site is at a narrows where the river leaves its flood plain and tumbles over rock that crops out in the bed of the stream and to a height of nearly 20 feet on both banks. The geologic structure along the line of the proposed dam is shown in the cross section on Figure 8.

The rock exposed in the banks at the site is a basaltic lava, about 20 feet thick, containing distinct crystals of olivine. This flow has a vesicular crust and a dense middle portion and base. On the east wall it is overlain by a pumice mud flow to the top of the canyon, and hence well above the proposed height of the dam. Lack of time prevented a thorough examination of the brush-covered west wall, but it is believed that this is the ancient rock wall with only a thin cover of ash. Below the olivine basalt lies another lava flow of reddish hue, containing prominent feldspar crystals. This lava was not examined under the microscope, but it resembles an andesite in its habit, for it shows platy structure. It crops out downstream from the site for several hundred feet. The contact of the olivine basalt with this andesite is not exposed. Probably the river has cut through the basalt (see line T–S, fig. 8) and is flowing on the andesite, but it was not feasible to obtain a specimen from the river bed to determine this fact. No trouble should be met in anchoring the proposed dam, as this rock will provide a suitable foundation.

The unfavorable feature of this site is the presence of the mud flow on the east side, which would form an unsatisfactory abutment. Further, there are possibilities of leakage that might be difficult to overcome. Because the mud flow is the critical feature of the dam site a traverse was made of it to the point where National Creek crosses the Diamond Lake road. The pumice-covered bench, or mud flow, was found to extend all the way to National Creek, a distance of nearly 2 miles in a southerly direction. National Creek, at its confluence with the Rogue River, has an altitude of 3,575 feet, or 164 feet lower than the water surface of the Rogue at the Hamaker dam site. Thus water escaping through the east abutment would have a steep hydraulic gradient, and a line of springs would probably result along the east bank of the Rogue between the dam site and National Creek. The amount of water that would escape in this manner is unknown, but it might be sufficient to cause the failure of the reservoir.

The mud flow is estimated to exceed half a mile in width on the east bank of the Rogue at the dam site, hence it appears impracticable to lay a cut-off wall to prevent leakage. The details of the west bank are unknown but should be investigated for a possibility of leakage into Foster Creek, which lies southwest of the dam site. It is recommended that a line of holes be drilled along the line of the dam site to determine the contour of the buried rock floor and the character of the contact of the lava flows underlying the pumice. If the width and thickness of the mud flow at this place are not so great as has been estimated, a cutoff wall to prevent leakage might be feasible. The drill holes should be pressure tested to determine the permeability of the pumiceous flow. Also it would be worth while to determine whether the ancient rock walls of the buried valley are closer together at any place downstream.

This site is believed to be a practicable one in the major program of power development on the river. There is a possibility that a lower dam would regulate the flow of the Rogue as well as one 160 feet high because of the underground storage in the thick pumice beds in the reservoir site; under such conditions the leakage would probably not exceed the amount of water that would have to be released for use downstream. Thus this site would be satisfactory as a power reservoir, though it might be a failure for the storage of irrigation water.

Potential power at undeveloped site 12RD 1

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	80	125	1, 280	2, 000
Regulated flow	130	130	2, 080	2, 080

Between National Creek and Castle Creek the average fall is 14 feet to the mile, and with storage the potential power is 145 horsepower to the mile.

CASTLE CREEK POWER SITE (12RD 2)

By constructing a 40-foot dam just below the mouth of Castle Creek in sec. 26, T. 30 S., R. 3 E., and carrying the water in an open flume on the right bank along the 3,480-foot contour for a distance of 1.6 miles, then turning it into a 700-foot penstock, a head of 200 feet could be used. At the 40-foot height the dam would be 350 feet long, and no difficulty should be experienced in constructing or sealing such a dam. There are no diversions above this project, and practically no damage would be done by flooding above the dam or by the construction of the flume and hydraulic structures.

Potential power at undeveloped site 12RD 2

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	225	375	3, 600	6, 000
Regulated flow	370	375	4, 320	6, 000

The extreme flood that may be expected will amount to about 6,000 second-feet, which can be passed through and around the dam without difficulty.

UNION CREEK POWER SITE (12RD 3)

The site for the diversion dam of the Union Creek project is about a quarter of a mile below the power-house site of the Castle Creek project, near the southwest corner of sec. 35, T. 30 S., R. 3 E. This dam should probably be a very low concrete structure, which under normal conditions will divert most of the flow into the canal but will readily pass the floods over its crest. Union Creek, which enters the Rogue River a short distance below this dam site, has a remarkably well-sustained flow, and it is desirable that this stream be incorporated in the project. This may be accomplished by intercepting the creek by a canal. Waste gates should be placed in the creek channel so that all water in excess of the carrying capacity of the canal may be returned to the river.

Below Union Creek two alternate plans of development are suggested. One contemplates carrying the water across the river from a point in the NW. ¼ sec. 3 to the NE. ¼ sec. 4, T. 31 S., R. 3 E., then in an open canal along the 3,280-foot contour to a point near the south line of section 8, from which a pressure pipe could carry the water to the power house in the NE. ¼ sec. 17.

The second plan involves carrying the water in a canal along the left bank of the river to the SW. ¼ sec. 3 and thence through a pressure pipe to a power house on the same side of the river.

The first plan would require the construction of 4.7 miles of open canal and 0.5 mile of penstock; the second would require 1.8 miles of canal and 2.3 miles of penstock. Owing to the difficulty of constructing and maintaining a canal on the steep hillside, as required in the first plan, it is probable that in spite of its greater length of pressure pipe the second plan would be a more economical development. The bench on which the pipe would be constructed slopes rather gently toward the southwest to a point directly above the power house, where it drops sharply.

Potential power at undeveloped site 12RD 3

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	290	500	6, 500	11, 200
Regulated flow	344	500	7, 700	11, 200

A flood flow of about 8,000 second-feet can be passed over the dam and through the waste gates. No damage to existing improvements would be involved in this development.

TOP CREEK POWER SITE (12RD 4)

By constructing a 20-foot dam in the SE. ¼ sec. 19, T. 31 S., R. 3 E., to flood to the 2,960-foot contour, carrying the water in a canal 1.2 miles long, and turning it into a penstock 0.7 mile long leading to a power house in the NW. ¼ sec. 32, a head of 140 feet would be created at the Top Creek power site.

Potential power at undeveloped site 12RD 4

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	325	575	3, 640	6, 440
Regulated flow	385	575	4, 310	6, 440

The conditions are favorable for the construction of a 20-foot dam of an overflow section. It would have a crest length of about 250 feet and could readily pass the flood flow, which might reach 10,000 second-feet. There are no diversions above this site, and no damage to existing improvements would be caused by the construction of the dam.

RITER CREEK POWER SITE (12RD 5)

The dam site for the Riter Creek project is near the north line of sec. 8, T. 32 S., R. 3 E. The right bank is steep, and it appears that a canal could be carried along it on grade only with difficulty. The left bank is rather flat and slopes toward the south and is therefore much better suited to easy canal construction. A more detailed study might show that a penstock constructed across the sloping bench on the left bank of the river and connecting the lower power house with the gravity ditch would be more economical than a conduit on grade on the right bank. By constructing a 15-foot overflow-section dam the water will be raised to the 2,800-foot level, and by carrying it by combined canal and pipe line a distance of about 3.5 miles to a power house in the SW. ¼ sec. 20, T. 32 S., R. 3 E., a head of 200 feet will be created.

Potential power at undeveloped site 12RD 5

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	330	585	5, 280	9, 360
Regulated flow	386	585	6, 180	9, 360

As the crest length of the dam is over 200 feet the maximum flood which may be expected can easily be passed. No appreciable damage would be caused by this development.

PROSPECT POWER SITE (12RD 6)

The development of additional power at the Prospect site has been considered in connection with the description of the plant now in operation. (See pp. 68–69.)

CASCADE POWER SITE (12RD 7)

Water for the Cascade power project would be diverted in the NW. ¼ sec. 6, T. 33 S., R. 3 E., just below the Prospect power house, and carried by conduit along the right bank to a point in the NW ¼ sec. 15, T. 33 S., R. 2 E., where a head of 230 feet would be obtained. The river in this section flows in a canyon with steep wooded banks, and the conduit would probably be a pipe line. The discharge for this plant would be slightly greater than for the Prospect plant, because of seepage water entering the gorge below the Prospect Dam. This increase is roughly estimated at 70 second-feet for 90 per cent of the time and 100 second-feet for 50 per cent of the time. No damage would be caused by the construction of this plant, as the land affected is valueless for any other purpose. The Crater Lake Highway runs along the edge of the canyon and would facilitate construction.

In estimating the potential power of this site it has been assumed that the flow of Mill and Red Blanket Creeks and the Middle and South Forks of the Rogue River will be diverted to the Rogue River above the intake of the Prospect plant.

Potential power at undeveloped site 12RD 7

[Head, 230 feet]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Rogue River only: Natural flow	625	900	11,500	16,500
Rogue River with Middle and South Forks, Mill Creek, Bar Creek, and Red Blanket Creek diverted to Prospect:				
Natural flow	775	1,430	14,200	26,300
Regulated flow	870	1,430	16,000	26,300

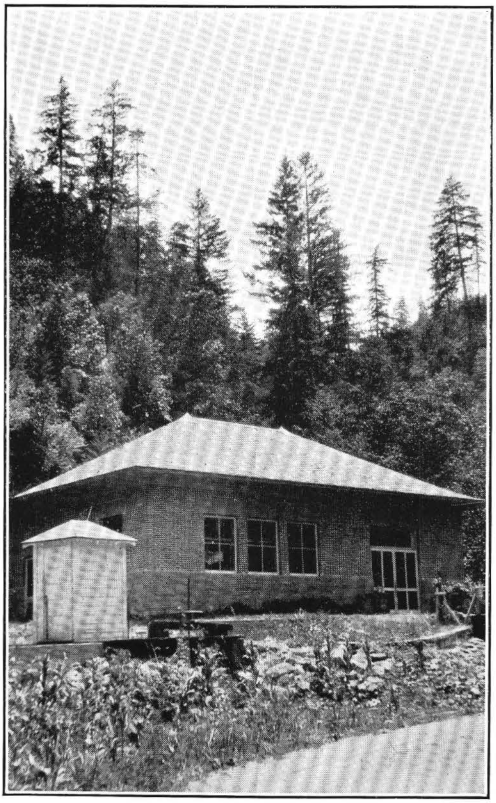
LOST CREEK POWER SITE (12RD 8)

The dam site for the Lost Creek reservoir and power project is in sec. 26, T. 33 S., R. 1 E. The principal features of the reservoir site have been described on pages 60–62. (See fig. 9 and pl. 13, *A*.)

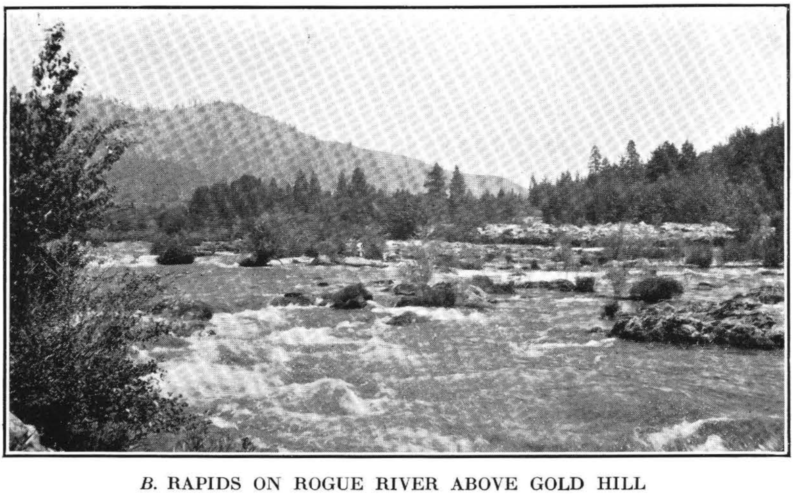
The west abutment of the dam site is massive basalt similar in appearance to Columbia River basalt. It is irregularly jointed and nearly impermeable. The same massive dark fine-grained basalt is exposed also in the river bed and for about 100 feet up the west wall of the canyon. Above this point there crops out an olivine basalt which is fresher and more recent than the basalt below it. The contact of the two rocks is not visible because of vegetation. No difficulty will be experienced in obtaining an excellent foundation for the proposed dam. About 200 feet upstream from the left abutment there are outcrops of a soft thin-bedded volcanic agglomerate dipping upstream. This rock was not found in the west abutment, but the absence of outcrops might possibly be due to the cover of vegetation. If it does occur there it is probably thin and of little consequence in the construction of a dam at this site, but it should be looked for in the test holes.

The olivine basalt in the east abutment would not affect the construction of a dam at this site, but it would affect the success of the reservoir. This olivine basalt represents the outcrop of the intracanyon lava. It was traced eastward for about half a mile where it forms the broad bench described on page 43. The width of the bench and its thickening eastward indicate that the river has cut down on the west side of the intracanyon flow, leaving its ancient buried channel from an eighth to a quarter of a mile to the east of its present channel. This condition is shown in the cross section of the valley on Figure 9. As the ancient channel apparently was not cut as deep as the present one, the ancient channel does not now cause any seepage losses from the river. Considerable time would be necessary to map the exact location of this buried channel, because the area is thickly wooded. The facts now available indicate that the upstream end of it is in the SE. ¼ sec. 24, T. 33 S., R. 1 E., and the downstream end is on the east bank about 1½ miles downstream from the dam site. The upstream or intake end is buried by the pumiceous mud flow, which is known to be permeable and which would not prevent seepage into and through the buried channel.

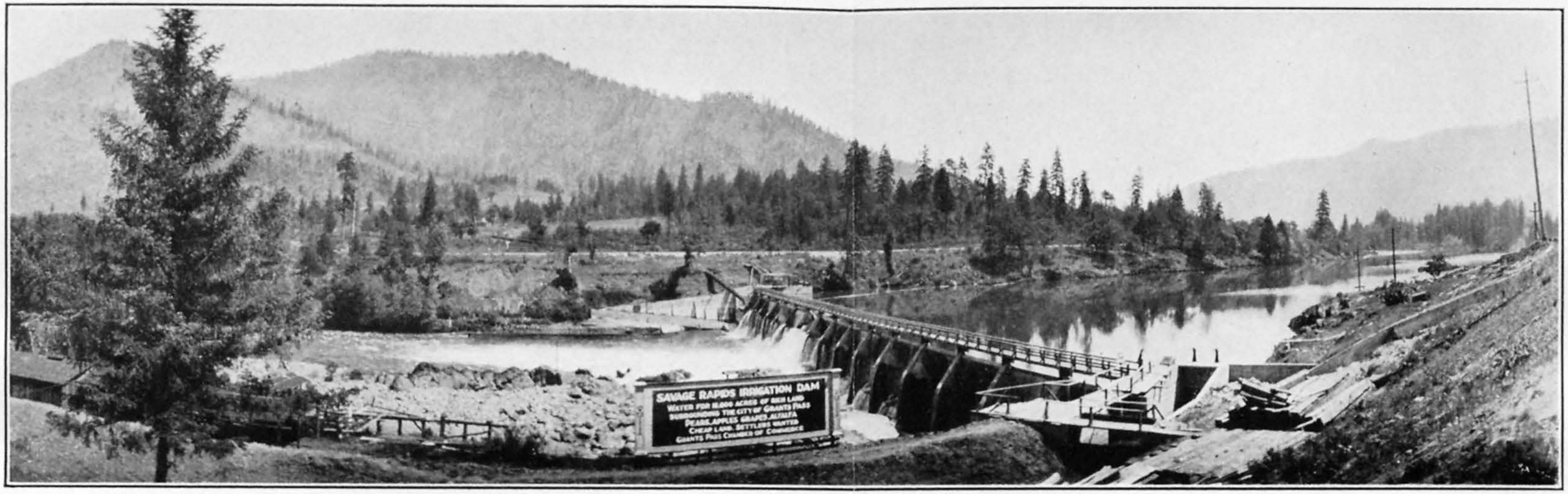
The amount of seepage is difficult to estimate under the known conditions. Experience elsewhere has shown that both the basalt and the gravel occupying such buried channels will carry large amounts of water. Lava tubes and slaggy, open contacts between the intracanyon flows and between these flows and the ancient canyon walls are common under such conditions and are not easily located on the surface or by means of the drill. In Plate 9, *A*, is shown a lava tube in this intracanyon basalt of Rogue Valley at the natural bridge, about 20 miles



A. ASHLAND POWER HOUSE, ROGUE RIVER BASIN



B. RAPIDS ON ROGUE RIVER ABOVE GOLD HILL



A. DAM AND PUMPING PLANT OF GRANTS PASS IRRIGATION DISTRICT AT SAVAGE RAPIDS, ROGUE RIVER

B. BUTTE CREEK DAM SITE, ROGUE RIVER BASIN upstream. The lava tube, or cavern, at this place carries the entire summer flow of the Rogue River underground, about 500 cubic feet a second. If such a tube occurred in the intracanyon basalt at a low level east of the Lost Creek dam site it would probably mean total failure of the Lost Creek reservoir, because its great depth below the surface and the probability of other smaller tubes associated with it would prevent its being filled with concrete at a cost commensurate with the value of the dam site. The width and thickness of the intracanyon basalt east of the site are too great to allow interception of the leakage by means of a cut-off wall or by grouting; consequently, any dam designed for this site must allow for possible leakage.

Although this site is unfavorable geologically, it is worth a detailed investigation, which should include drilling. It certainly should be included as a feasible site in the major program of power development along the Rogue, because as a power reservoir it can stand considerable leakage before being considered a failure. The time required for the passage of the water underground would help to regulate the flow of the river, and the amount of leakage would probably form only a small portion of the total flow of the river and might not exceed the amount of water that would of necessity have to be released. The basalt through which the water would pass is not soluble, hence there is little danger of the crevices enlarging by solution. Most of the seepage would doubtless return to the river above McLeod Bridge. It appears that the flow of the Rogue River is sufficient to fill the reservoir, although very little water might pass over the dam except in flood time. For this reason any large leakage would probably mean that little or no power could be developed either at the dam or by carrying the overflow by conduit to the power-house site a mile below the dam.

The capacity at an altitude of 1,620 feet is only 4,000 acre-feet. (See fig. 9.) By maintaining this small storage in the reservoir a mean head of 128 feet will be available at the dam. This head combined with that obtained by a pressure pipe a little over a mile long will enable a mean head of 153 feet to be used at a power house in the SE. ¼ sec. 27, T. 33 S., R. 1 E.

Potential power at undeveloped site 12RD 8

[Total head, 195 feet; assumed drawdown, 125 feet]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	845	1, 400	10, 400	17, 100
Regulated flow	1, 140	1, 690	14, 000	20, 700

The damages incident to the reservoir construction have been considered in connection with the Lost Creek reservoir site. No additional damage will be caused by the power development as here outlined.

The maximum flood that may be expected at this point will not be very great and can be passed over the spillway or around or through the dam, as seems best when a detailed design is made.

BUTTE CREEK POWER SITE (12RD 9)

The Butte Creek power site is about half a mile below the mouth of Butte Creek. in the NE. ¼ sec. 33, T. 33 S., R. 1 E. (See fig. 12 and pl. 19, *B*.) Conditions here are favorable for the construction of a 30-foot dam to raise the water to the

1,545-foot contour. The dam will be about 380 feet long on the crest and may be of an overflow section.

The site is excellent geologically, for the dam will be founded on dense black diabase that appears to be a thick water-tight intrusive dikelike mass. This diabase crops out continuously along the line of the dam, even in the river bed. On the upstream side of the dike there is about 10 feet of soft, weathered rock, and on the downstream side about 2 feet of similar material. These soft rocks may be the result of local metamorphism due to the intrusion of the diabase. In any event it is advisable to drill at the site to determine whether any of the soft material occurs in the line of the dam. No difficulty will be experienced in preventing seepage under or around the dam. The site is readily accessible, as the Crater Lake Highway runs past one end of the dam.

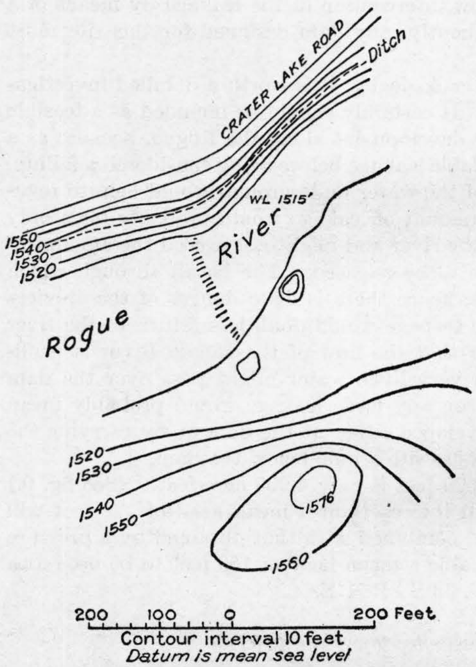


FIGURE 12.—Plan, Butte Creek dam site, Rogue River Basin

The pond will flood a small area of agricultural and meadow land. It will also necessitate the relocation of about 1 mile of highway and half a mile of secondary road and the raising of the McLeod Bridge about 15 feet. It may be more desirable to abandon the old bridge and carry the traffic which is headed up Butte Creek across the top of the dam.

A canal 1.2 miles long constructed on the right bank along the 1,545-foot contour and a penstock 0.2 mile long will connect the dam with the power house in the center of sec. 32, T. 33 S., R. 1 E., and make a total head of 65 feet available.

Potential power at undeveloped site 12RD 9

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	920	1,660	4,780	8,640
Regulated flow	1,240	1,910	6,450	9,940

If the entire crest length of the dam is used as a spillway, the probable maximum flow may be passed with a rise in pond level between 5 and 6 feet.

The Eagle Point Irrigation District diverts about 70 second-feet from Butte Creek at Butte Falls. The discharge for 90 per cent of the time at the dam sites below has been reduced by this amount. A flume carrying about 2 second-feet is used to irrigate a small tract of land a short distance downstream from this site. No other diversions from the main stream exist above this point.

ELK CREEK POWER SITE (12RD 10)

Between the Butte Creek and Trail Creek sites the fall of the Rogue River amounts to 60 feet in 3½ miles. The flow available at the Elk Creek site is the same as at the Butte Creek site. Construction of low dams or canals to develop the power would be expensive, and this site would be one of the last to be used. But the potential power exists, and probably some of it could be developed if a market were available. It is assumed that half of the head, or 30 feet, can some day be economically used, and the potential power of the site has been calculated on that basis.

Potential power at undeveloped site 12RD 10

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	920	1,660	2,210	3,980
Regulated flow	1,240	1,910	2,980	4,580

TRAIL CREEK POWER SITE (12RD 11)

The Trail Creek dam site is about 1.2 miles below the mouth of Trail Creek and a short distance above the middle of sec. 10, T. 34 S., R. 1 W. (See fig. 13 and pl. 20, *C*.) The proposed 25-foot dam will have an excellent foundation, for massive, dense basalt crops out on both banks and in the river bed. Although the basalt is considerably jointed, the joints appear to be tight, and no appreciable leakage for a dam of this height should occur. The site is readily accessible, as the Crater Lake Highway is adjacent to the west end of the dam.

By flooding to an altitude of 1,420 feet a head of 25 feet would be created without appreciable damage either to agricultural land in section 3 or to the highway. As the bottom lands are relatively flat, and as the highway is not very much above the pond level in places, it will be necessary to pass the maximum flood without any great increase in the water level above the dam. The crest length of the dam is 370 feet, and if this entire length were used as a spillway, the rise in pond level for the probable maximum flood would be about 8 feet. As it is desirable to limit the pond rise to about 5 feet, gates with an aggregate width of 80 feet and a depth below the spillway crest of 10 feet must be used to supplement the discharge of the overflow section of the spillway. The power house may be constructed at either end of the dam.

Potential power at undeveloped site 12RD 11

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,030	1,860	2,060	3,720
Regulated flow	1,400	2,030	2,800	4,060

LONG CREEK POWER SITE (12RD 12)

Between the Trail Creek power site and the Reese Creek site there is a fall of 115 feet in 8½ miles, or 13½ feet to the mile. The valley through this section is wide and flat, and compared with other sites on the river appears to offer very unfavorable conditions for the use of this potential power. But if this site were

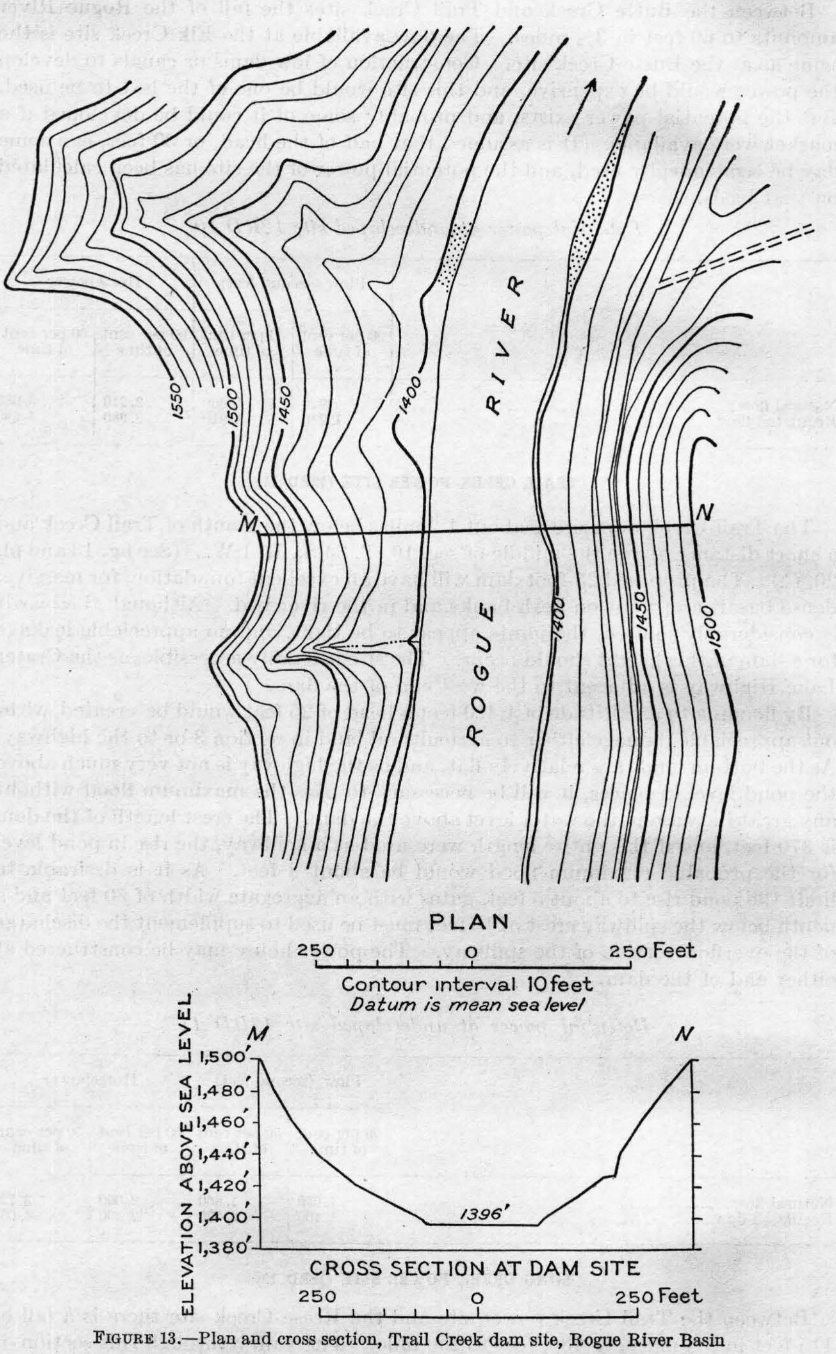


FIGURE 13.—Plan and cross section, Trail Creek dam site, Rogue River Basin

located in an industrial section of the East or Middle West, it would soon be used, so it is possible that in 50 years sites in Oregon similar to this will be put to use. The power will be developed by means of low dams, or low dams and conduits. On account of unfavorable conditions it is assumed that only half of the head in this section can be developed, or 60 feet.

Potential power at undeveloped site 12RD 12

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,030	1,860	4,950	8,930
Regulated flow	1,420	2,030	6,820	9,740

REESE CREEK POWER SITE (12RD 13)

A very low diversion dam or a wing dam could be built below the mouth of Reese Creek near the east line of sec. 17, T. 35 S., R. 1 W., to turn the water into an open canal 2.5 miles long, constructed along the left bank on the 1,280-foot contour. A penstock 0.10 mile long would connect the end of this canal with a power house in the SW. ¼ sec. 29 of the same township. The total head created would be 43 feet. The stream flow at this site has been corrected by deducting 70 second-feet because of the irrigation diversion from Butte Creek.

Potential power at undeveloped site 12RD 13

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,050	1,900	3,610	6,540
Regulated flow	1,430	2,050	4,920	7,040

Practically no damage will be caused by this development. The site is readily accessible, and no difficulty should be experienced in constructing a canal and power house at the location indicated.

LITTLE BUTTE CREEK POWER SITE (12RD 14)

At the Little Butte Creek power site a low diversion dam could be built in the SW. ¼ sec. 7, T. 36 S., R. 1 W., to divert water into a ditch at an altitude of 1,200 feet. Four miles of canal along the left bank would carry the water to the SW. ¼ sec. 15, T. 36 S., R. 2 W., where a head of 35 feet would be obtained. The canal would probably require lining in places because it approaches so near to the river; otherwise this project should be comparatively inexpensive. The discharge would be about the same as at Raygold, which is the site next below.

Potential power at undeveloped site 12RD 14

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,110	2,030	3,100	5,680
Regulated flow	1,650	2,070	4,620	5,800

GOLD HILL POWER SITE (12RD 16)

The Gold Hill power site can be developed by building a dam 13 feet high in the NW. ¼ sec. 11, T. 36 S., R. 3 W., to flood to the 1,100-foot contour and by constructing an open canal along the 1,100-foot contour on the left bank of the river a distance of 2.6 miles, with a penstock half a mile long connecting the end of the canal with a power house in the NW. ¼ sec. 22. A total head of 65 feet would be created.

At the dam site bedrock extends across the river (see pl. 18, *B*) and a very shallow excavation would permit the structure to be securely anchored to the rock. No difficulty will be experienced in preventing seepage under or around the dam. As the main line of the Southern Pacific Railroad passes one end of the dam the delivery of material will be very simple.

Potential power at undeveloped site 12RD 16

	Flow (second feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,110	2,190	5,770	11,400
Regulated flow	1,670	2,190	8,690	11,400

Practically no damage will be done to existing or proposed improvements by flooding to the 1,100-foot contour. In order, however, that possible damage to the railroad right of way, the wagon road, and the agricultural land in sec. 12 may be avoided, it seems desirable that the fluctuation in pond level due to high water shall be limited to about 10 feet. The crest length of the dam will be 500 feet, and the maximum flood to be passed will be much the same as that at Raygold. By using gates cut 10 feet below the crest of the dam and having an aggregate length of 150 feet and by constructing the remainder of the dam as an overflow section, the maximum flood can be passed without raising the pond level more than 10 feet.

ROCK POINT POWER SITE (12RD 17)

The Rock Point power site is 2 miles west of the town of Gold Hill and about 300 feet upstream from Rock Point Bridge. (See pl. 20, *B*.)

Bedrock is well exposed on both banks and lies at a shallow depth below the river bed. A microscopic examination of a specimen from this site made by C. S. Ross, of the United States Geological Survey, showed the rock to be profoundly metamorphosed, possibly of the diorite type. This rock will form an excellent foundation for the proposed dam, as the joints are fairly tight, and any seepage through them will be slight.

By constructing a 16-foot dam in the NW. ¼ sec. 20, T. 36 S., R. 3 W., to flood to an altitude of 1,030 feet, and a canal about 800 feet long on the left bank, a total head of 18 feet would be made available. The 2-foot additional head obtained by the canal might not ordinarily justify its construction, but directly under the bridge the river channel is only about 60 feet wide, and in time of high water the constricted opening would probably cause considerable backwater. The canal will carry the water past this place and return it to the river where the channel is much wider.

The site is readily accessible, as the main line of the Southern Pacific Railroad and the highway between Grants Pass and Medford both pass one end of the dam.

The crest length of the proposed dam is 300 feet, and by limiting the rise in pond level to 10 feet no damage will be done to existing improvements. The banks are of solid rock, and water may be passed over them without danger. The river side of the canal between the dam and the bridge should be designed as an overflow section in order that it may assist the rest of the dam in passing floods. If the main dam is also designed as an overflow section the total spillway length will be about 850 feet, and the probable flood flow can be passed with an increase in pond level of 9 or 10 feet.

Potential power at undeveloped site 12RD 17

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,130	2,210	1,630	3,280
Regulated flow	1,690	2,210	2,430	3,280

AMENT POWER SITE (12RD 19)

The Ament power site is in the NW. ¼ sec. 23, T. 36 S., R. 5 W. (See pl. 20, *A*.) At this point there are the ruins of an old rock-fill timber-crib dam and also a concrete power house and wing wall. At some time in the past a section of the dam adjacent to the power house was washed out. The concrete is still in good shape, and it appears that the timber portion of the dam could be made serviceable with minor repairs. The washed out portion appears to have been founded on bedrock, and there is no good reason why it should not have remained in place had it been properly anchored. The south end of the dam is founded on cemented gravel. This material is fairly stable, but in case of reconstruction it should be protected from backwash, as the south bank directly below the dam is composed of the same material and is cutting rather badly. By repairing the dam a head of 15 feet would be made available.

Potential power at undeveloped site 12RD 19

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,130	2,190	1,350	2,630
Regulated flow	1,670	2,190	2,000	2,630

In order that backwater from this site may not cause damage, the pond here should not be raised more than 5 feet. If a 200-foot section of the dam adjacent to the power house were replaced by a gate section with the gate sills about on a level with the rock bottom floods could probably be passed without exceeding the 5-foot limit. The opening of the gates would practically wipe out the head on the wheels, but the excessive flow would then be confined to the part of the stream bed best suited to withstand it, and as the floods are usually of short duration the power loss would be small.

Between the tail water of the Ament Dam and backwater from the proposed dam at Taylor Creek there is a fall of 100 feet in 18 miles, or about 5½ feet to the mile. This head could be developed by increasing the height of the Taylor Creek Dam, but the damages to agricultural land would be too great. Conduits also would be too expensive with so slight a fall to the mile. It is possible that low dams could be constructed to use part of this head, but such development will not take place for many years; therefore the potential power value of this section has been disregarded in this report and in the tabulation showing the power value of the Rogue River.

HELL GATE POWER SITE (12RD 20) AND TAYLOR CREEK POWER SITE (12RD 21)

As the Hell Gate and Taylor Creek projects overlap to a considerable extent and as only one of the sites can be economically developed they will be considered together.

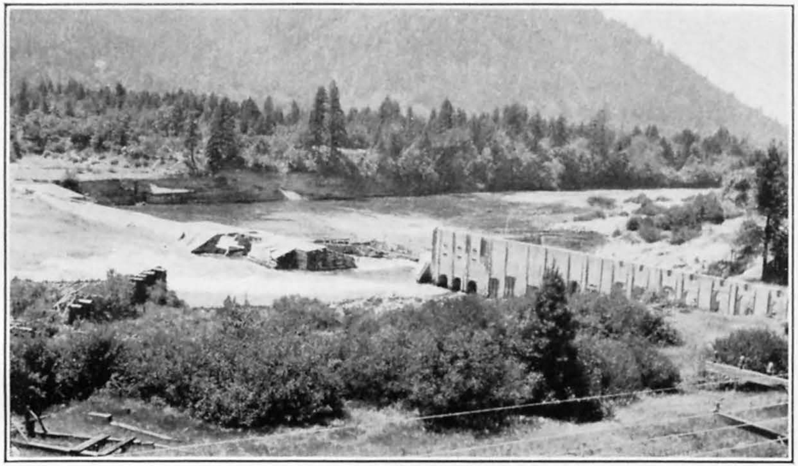
The Hell Gate dam site is in sec. 10, T. 35 S., R. 7 W., at the entrance to a narrow, rugged canyon in which the Rogue River flows on its way through the Coast Range. (See pl. 14, *B.*) Massive jointed green rock crops out on both abutments and probably lies not more than 30 feet below the surface of the river. A specimen from this site was examined under the microscope by C. S. Ross and was found to be a profoundly metamorphosed rock containing secondary epidote, clinozoisite, and actinolite. The site is excellent because seepage will cause no difficulty, and the rock is sufficiently strong to support a 200-foot dam.

The Taylor Creek site is farther downstream, in sec. 10, T. 35 S., R. 7 W. (See pls. 12 and 13, *B.*) Both upstream and downstream from this site the valley is wider, owing to the occurrence of soft black schist. The narrows at the spot selected for the dam is due to the outcropping of massive rock, which forms rugged cliffs on both sides of the stream. This rock is green and megascopically appears to be a metamorphosed conglomerate. The alteration has been so complete that all signs of the original sedimentary bedding planes have disappeared. This rock has a high crushing strength and would form excellent abutments for a dam 200 feet high. The joints are tight, and only ordinary precautions will be required to prevent leakage.

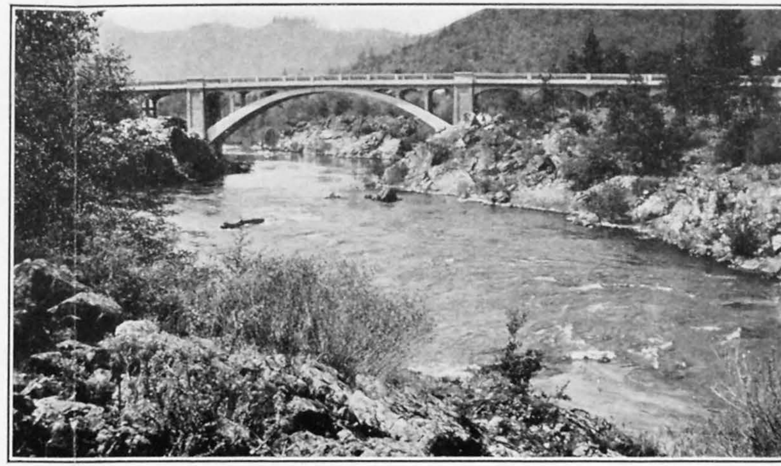
The physical conditions at the two sites are much the same. The sections are narrow, the abutments are massive, and the depth to bedrock in the river channel is probably not more than 25 to 30 feet. A 200-foot dam could be built at either place, and no trouble would be experienced in preventing seepage either around or under the dam. The Hell Gate site is slightly more accessible, as it is only 6 miles from Merlin, the nearest railroad station; the Taylor Creek site is about 9 miles from the railroad, but as a fairly good highway runs past both sites the difference is not great. As a dam at the lower site could be built 29 feet higher than one at the upper site with practically no greater damage it seems probable that the lower (Taylor Creek) site is preferable.

To flood to the 900-foot contour would require a 153-foot dam at Hell Gate or a 182-foot dam at Taylor Creek. The area flooded would be about 10,000 acres for either site. The features of the reservoir site have been described on page 62. This area lies directly below the town of Grants Pass; practically all the land below the 900-foot contour is cultivable and irrigable, and a large part of it is now in use for the raising of hops and orchard products. The agricultural value of the land is high, and its use for flowage can not be justified.

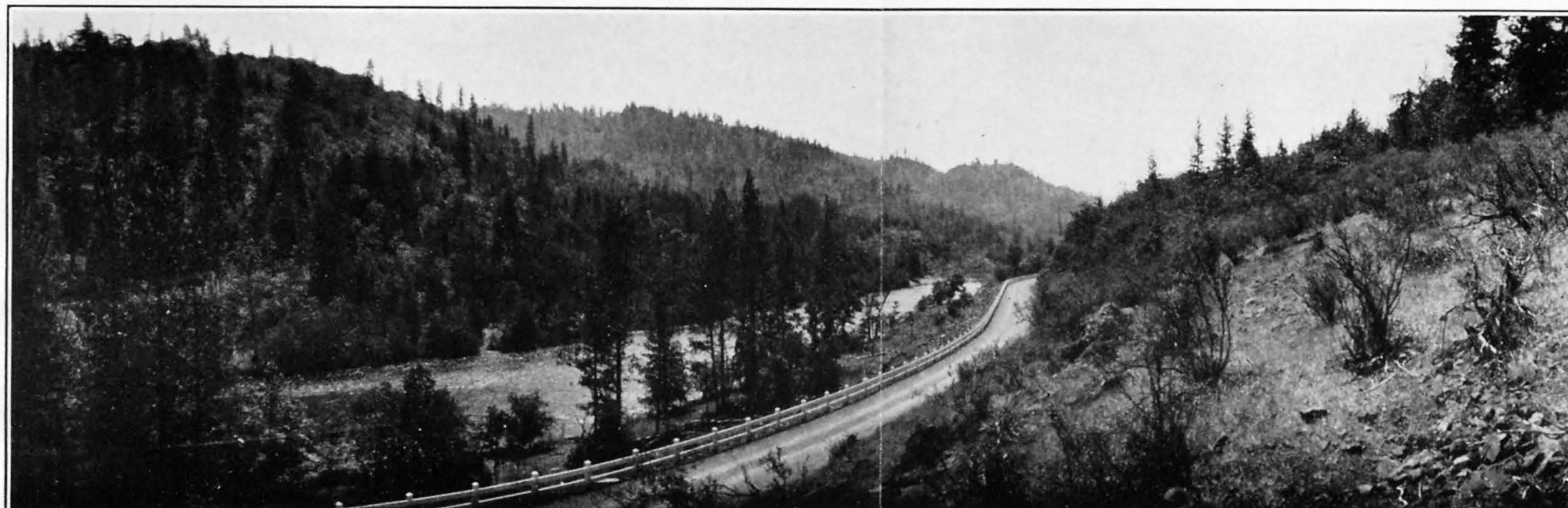
A dam could be built to raise the water 82 feet, to the 800-foot contour. This would flood only 560 acres of land, most of which lies in the narrow bottom of the canyon, where its value is low. It is doubtful whether the added power that could be produced by a greater head would pay for the additional damages incurred. Aside from the slight area of agricultural land flooded by an 82-foot dam the only additional damage would be the destruction of about 2 miles of highway and possibly two or three houses. The relocation of the highway would involve no particular difficulty.



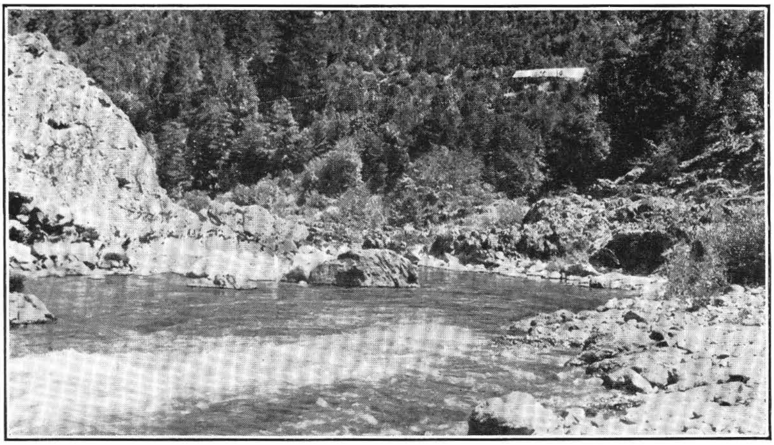
A. AMENT DAM, ROGUE RIVER ABOVE GRANTS PASS



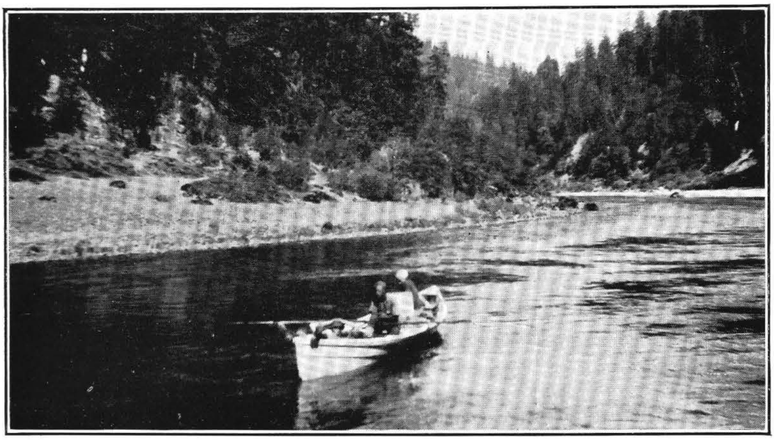
B. ROCK POINT DAM SITE, ROGUE RIVER BASIN



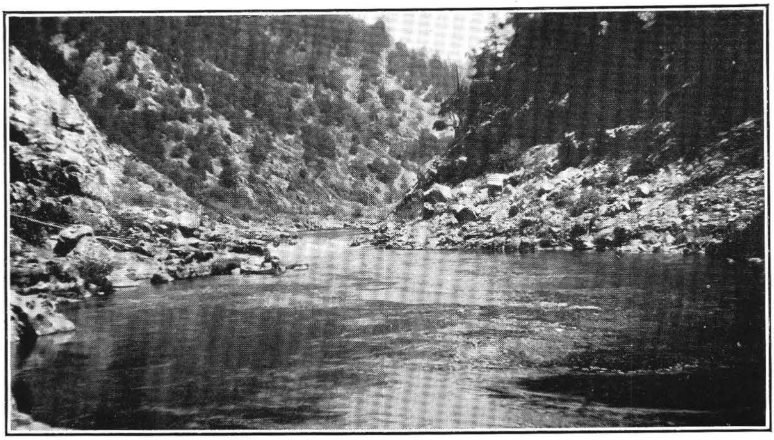
C. TRAIL CREEK DAM SITE, ROGUE RIVER BASIN



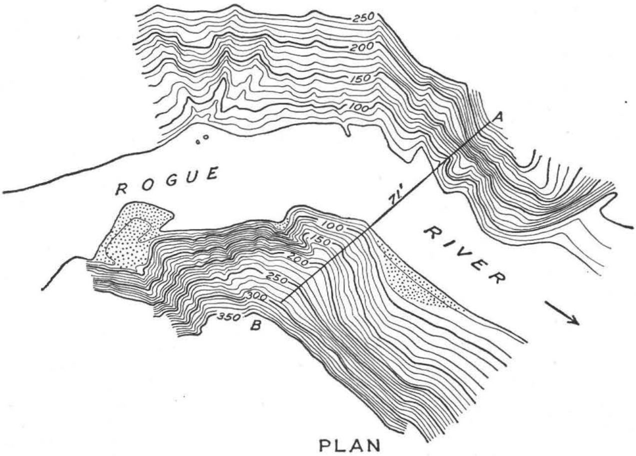
A. HORSESHOE BEND DAM SITE, ROGUE RIVER BASIN

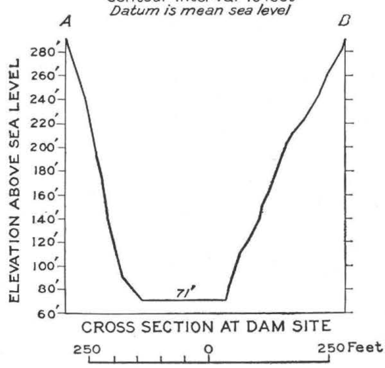


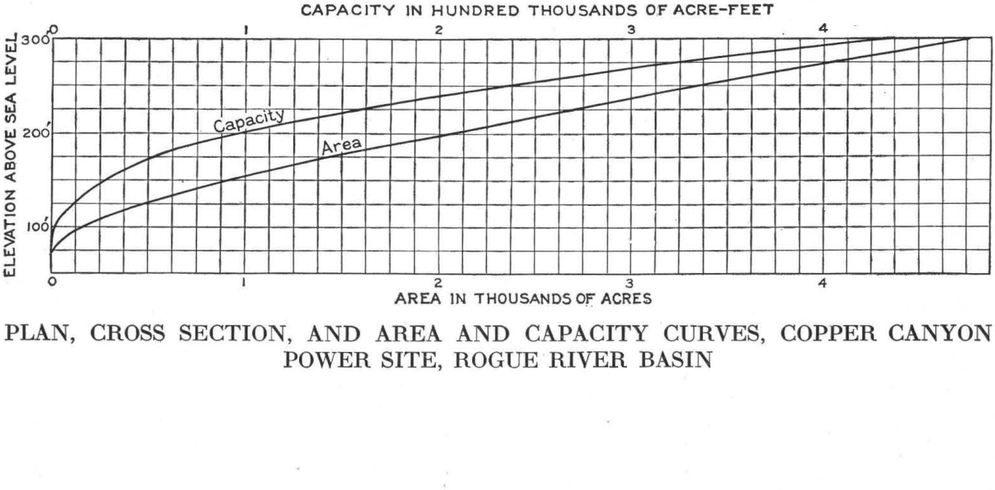
B. ROGUE RIVER 2 MILES ABOVE MULE CREEK



C. SWING BRIDGE DAM SITE, JUST BELOW GRAVE CREEK, ROGUE RIVER BASIN







PLAN, CROSS SECTION, AND AREA AND CAPACITY CURVES, COPPER CANYON POWER SITE, ROGUE RIVER BASIN

Potential power at undeveloped site 12RD 21

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1, 020	2, 970	6, 700	19, 500
Regulated flow	2, 400	2, 970	15, 700	19, 500

An overflow-type dam is suggested for this site, and the power house should probably be located on the left bank of the river in the cove about 0.1 mile below the dam, where it will be somewhat protected from the floods. The crest length of the dam will be 270 feet, and this length will not increase appreciably as the pond rises. An increase of about 30 feet in the level of the water above the dam will permit the passage of the probable maximum flood. The added area flooded by this rise of pond level will be between 1,100 and 1,200 acres, but as the flood will be of short duration and as it is to be expected at infrequent intervals the damage will be low.

A drawdown of 10 feet at this site would provide 5,000 acre-feet of stored water, which could be used through an average head of 78 feet at this site and a total head of 663 feet including sites lower down. On the assumption that there would be no drawdown at the lower sites and that the period of drawdown at this site would average three months, the net gain at all sites would amount to 1,500,000 kilowatt-hours if there were no regulation of the flow above this site and to less than 1,000,000 kilowatt-hours if all proposed reservoirs above were constructed. If the sites lower down on the river were not developed it would not pay to draw down the head for any considerable period, as the loss of power due to loss of head would soon equal the power obtained from the stored water.

SWING BRIDGE POWER SITE (12RD 22)

A dam at the Swing Bridge site, in the NE. ¼ sec. 2, T. 34 S., R. 8 W., just below Grave Creek, would flood to an altitude of 700 feet and create a head of 107 feet. (See pl. 21, *C*.)

A fine-grained green rock of igneous origin containing nodules 3 to 6 inches in diameter crops out as rocky ledges and cliffs on both abutments. A specimen of one of these nodules was determined under the microscope by C. S. Ross to be a greatly altered volcanic rock containing much epidote, with the feldspar phenocrysts almost completely broken down into a secondary aggregate but remaining fairly firm and coherent. Such a rock, although considerably altered, makes an excellent foundation for any dam of practicable height. Slight leakage may occur through the joints in the rock unless a small amount of cement grouting is done, but grouting is not absolutely necessary, for the seepage will not increase with time. The abutments are exposed, and the depth to bedrock in the channel is probably not over 20 feet.

The pond formed will be long and narrow and will flood no valuable lands. The only damage incident to development will be the inundation of about 0.7 mile of highway, 3 miles of trail, and a few houses.

To make the site readily accessible it would be necessary to build about 5 miles of highway connecting the dam with the highway already constructed as far as Almeda; or a road might be built down Grave Creek from the railroad station at Leland to the dam site, a distance of possibly 9 miles.

Potential power at undeveloped site 12RD 22

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,030	3,130	8,800	26,800
Regulated flow	2,410	3,130	20,600	26,800

The crest length of the dam, which should probably be of an overflow section, is about 500 feet. A rise in pond level of about 20 feet would enable the probable maximum flood to be passed if the entire crest were used as a spillway. In order, however, that the power house, which will be set into the bank directly below the dam, may not be injured by the extreme flow, some gates should be provided to throw the greater portion of the water to the opposite side of the river.

A drawdown of 40 feet at this site would make available 15,500 acre-feet of stored water, which could be used through an average head of about 90 feet at this site and a total head of 568 feet including sites lower down. Assuming that there would be no drawdown except at this site and that the period of drawdown would be three months, the net gain from drawing down the pond level would amount to 3,500,000 kilowatt-hours at all sites, without storage above; but if all the proposed storage sites were developed the loss of power due to loss of head would equal the total gain from the use of stored water and it would not pay to draw down the head. If the site were developed as a single unit with no storage above, it would not pay to draw down the head except for short periods.

HORSESHOE BEND POWER SITE (12RD 23)

By constructing a rock-filled dam at Horseshoe Bend, in the SW.¼ sec. 23 and the NW.¼ sec. 26, T. 33 S., R. 9 W., to flood to the 580-foot contour, a head of 128 feet would be created.

The site selected for the dam is at a horseshoe bend where the river flows around a narrow low ridge of blue quartzite. (See fig. 14 and pl. 21, *A*.) The two abutments are cliffs of the quartzite, which crops out continuously across the low-stage channel, except near the end of the ridge, where it may be 30 feet below the water surface. The quartzite is shot through with quartz veins, and on the east abutment there is a quartz vein about 6 feet wide that forms a low short hogback. Metamorphism has nearly obliterated the bedding planes that formerly existed in the sediments. The rock is strong; no difficulty should be experienced with seepage under or around the dam.

A slight excavation would expose the abutments, and the depth to bedrock in the river channel is probably not more than 25 feet. A concrete dam might be as economical as the rock-fill type suggested, but owing to the presence of rock suitable for a dam and the comparative inaccessibility of the site, a rock-fill dam appears preferable, especially as the low point in the promontory around which the river flows can be used as a natural spillway.

Aside from the flooding of a short length of trail no damage will be done by this development.

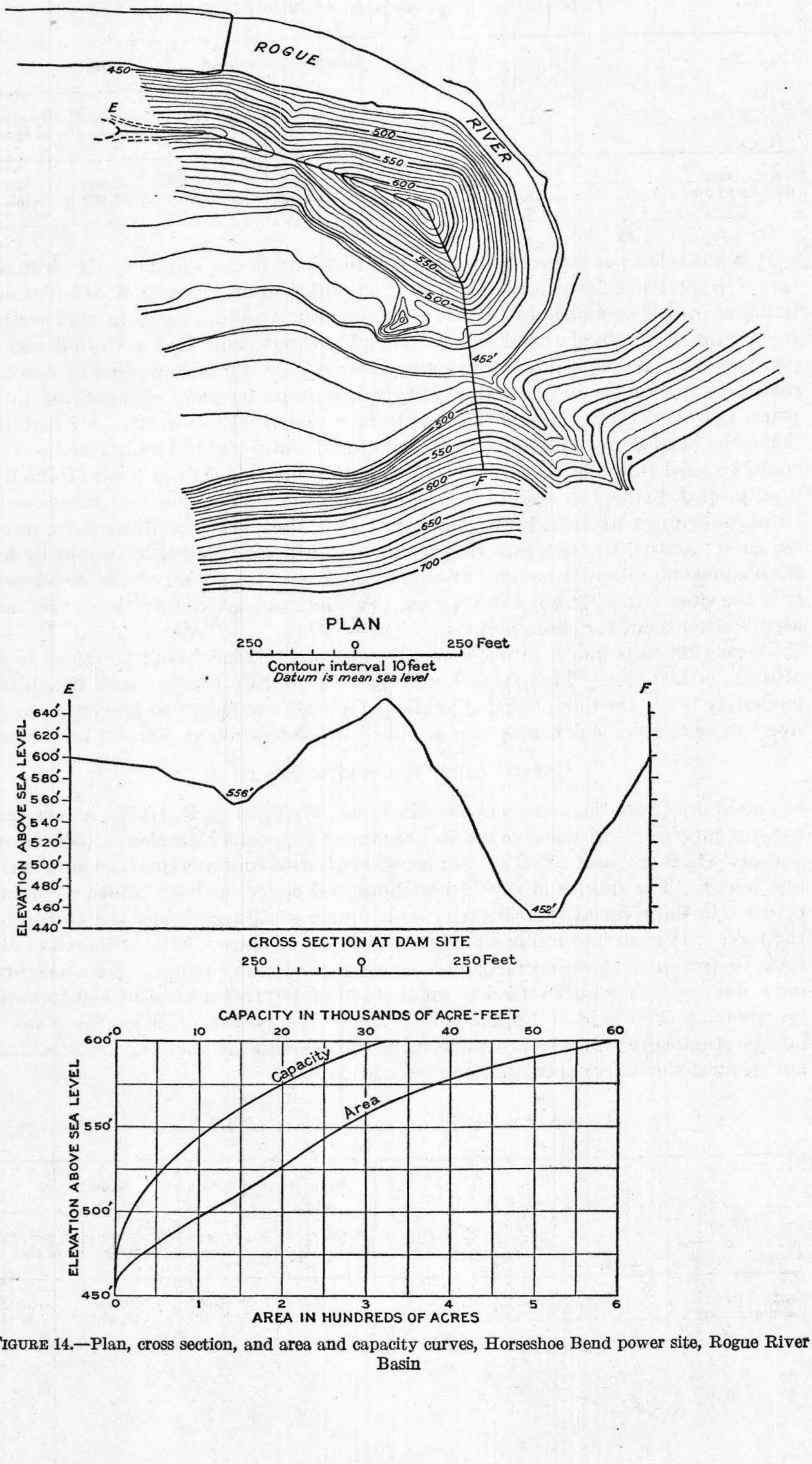


FIGURE 14.—Plan, cross section, and area and capacity curves, Horseshoe Bend power site, Rogue River Basin

Potential power at undeveloped site 12RD 23

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,060	3,200	10,800	32,800
Regulated flow	2,440	3,200	25,000	32,800

It is possible to construct a spillway 450 feet long in the saddle of the promontory. By cutting down the high part of the ridge to an altitude of 570 feet and building up the low part to the same height and installing gates in this section the maximum probable flood can be passed without exceeding a 15-foot rise in pond level. The bank down which the water will be run is composed of massive rock with few faults and probably will require no protection. If plucking takes place, however, the bad spots can readily be repaired with cement. By drawing down the head 30 feet 10,000 acre-feet of stored water would be obtained. This could be used through a head of 115 feet at this site and a total head of 465 feet if all proposed sites below were developed. On the assumption that there would be no drawdown at sites lower down and that the period of drawdown would be three months, the net gain from drawing down the pond level would be less than 1,000,000 kilowatt-hours. If all proposed reservoirs above were developed, or if the sites below were not developed, it would not pay to draw down the head at this site except for short periods.

To prevent any danger of overflow the crest of the dam should be raised to an altitude of 600 feet. The power house may be built on the flat rock bench immediately below the dam, but it should be at a height sufficient to prevent damage due to backwater, which may rise as much as 45 feet above normal low water.

STAIRS CREEK POWER SITE (12RD 24)

The Stairs Creek dam site is in the SE. ¼ sec. 17, T. 33 S., R. 10 W., in a rugged canyon carved out of massive diorite, an ancient igneous intrusion. (See fig. 15 and pls. 21, *B*, 23, and 25, *B*.) In places the diorite contains quartz veins and a few joints. The diorite is exposed without soil cover on both abutments, but bedrock in the river at this site may lie as much as 40 feet below the surface of the river. It is an admirable site for a dam, both because of the strength of the rock, its freshness at the surface, and the absence of many joints. By constructing a dam at this point to flood to an altitude of 440 feet a head of 150 feet will be created. The land to be flooded all lies in the bottom of a narrow canyon and is practically worthless. Aside from the flooding of about 3 miles of trail and several shacks no actual damage would be done.

Potential power at undeveloped site 12RD 24

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,100	3,250	13,200	29,000
Regulated flow	2,480	3,250	29,800	39,000

As the crest length of the dam will be only about 320 feet, considerable difficulty will be experienced in passing the expected floods. By constructing the headrace canal along the left bank and designing the outer wall as an overflow section the effective spillway length may be increased to about 450 feet. If the central 200 feet of the dam is constructed as a gate section with the gate sills 20

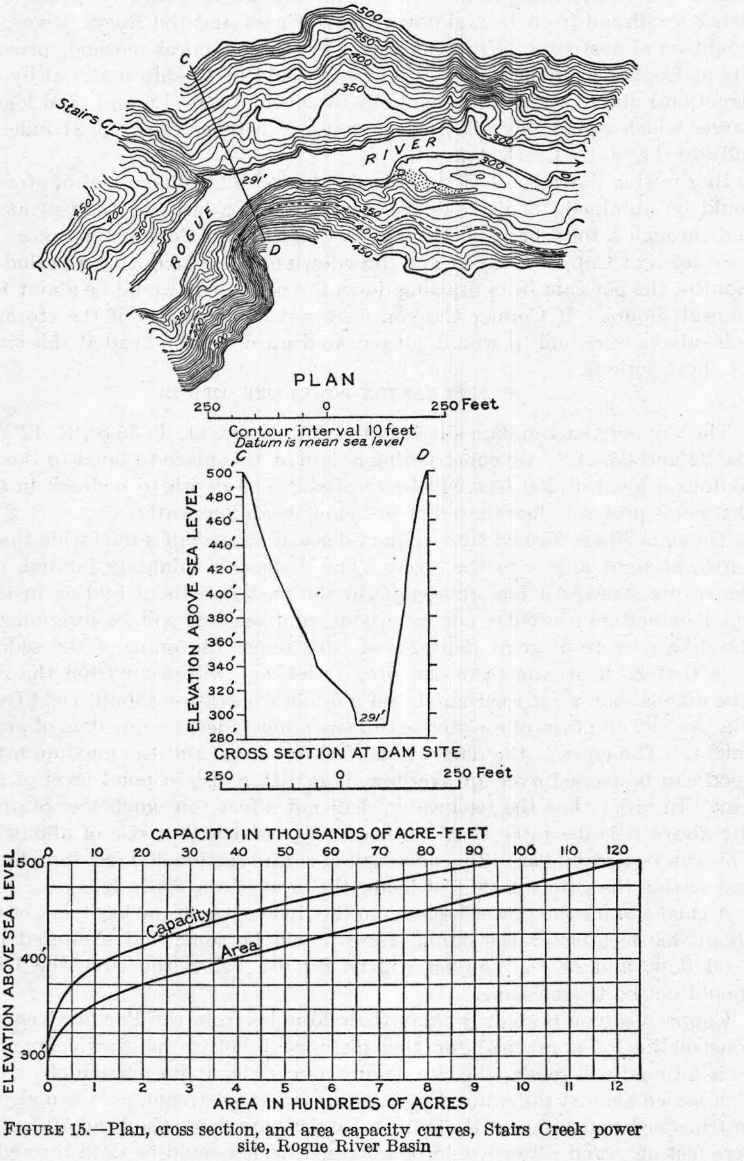


FIGURE 15.—Plan, cross section, and area capacity curves, Stairs Creek power site, Rogue River Basin

feet below the crest of the remainder of the dam the flood can be passed with an increase in pond level of about 13 feet. The power house can be built on the left side of the river on the bench that lies 250 feet below the dam. To prevent possible damage by scour the structure should be placed near the rear of the bench, and a substantial wall should be constructed between it and the spillway.

Backwater conditions during heavy floods will be severe, and a rise of 40 to 50 feet in the normal tail-water level may be expected. This rise may be somewhat decreased by improving the channel farther downstream, but as the duration of the flood is normally short it is doubtful whether added expense would be justified.

The site is extremely inaccessible, and though it would be possible to construct a railroad from Leland down Grave Creek and the Rogue River, the cost would be almost prohibitive. A much more economical method, provided the site at Copper Canyon is first developed, would be to ship material by the construction railroad which must be built to develop that site and then load it into barges which would carry it on slack water a distance of about 21 miles, practically to the Stairs Creek dam site.

By drawing down the head of this site 40 feet 22,000 acre-feet of stored water could be obtained. This could be used through a head of 130 feet at this site and through a total head of 330 feet at this site and Copper Canyon. With no drawdown at Copper Canyon and drawdown at this site during a period of three months, the net gain from drawing down the pond level would be about 1,250,000 kilowatt-hours. If Copper Canyon were not developed or if the storage reservoirs above were built it would not pay to draw down the head at this site except for short periods.

COPPER CANYON POWER SITE (12RD 25)

The Copper Canyon dam site is in the SW. ¼ sec. 11, T. 35 S., R. 12 W. (See pls. 22 and 25, *A*.) By constructing a dam at this place to flood to the 270-foot contour a head of 200 feet will be created. The depth to bedrock in the river channel is probably less than 30 feet below mean low water.

The dam site is formed by a dike of dense diabase half a mile wide that strikes north, at right angles to the river. The diabase is minutely jointed, owing to the severe stresses it has undergone in the past periods of folding in this area, but it is neither vesicular nor cavernous, and seepage will be insignificant. As the dike rises from great depths and cuts across the grain of the sedimentary beds that lie upstream from the site, no leakage will occur from the reservoir. The dike is somewhat weathered, but a 5-foot excavation should yield fresh rock. The geology and type of rock make this site almost ideal for any dam of practicable height. The crest of the dam will be 550 feet long, and the maximum probable flood can be passed over an overflow dam with a rise in pond level of about 27 feet. In order that the backwater shall not affect too much the Stairs Creek site above it is desirable that the flood be passed with a rise of about 10 feet. This can be accomplished by constructing a gate section 400 feet long in the dam and setting the gate sills 20 feet below the crest of the spillway.

A good site for the power house is in the little cove on the left bank of the river about 300 feet below the dam. Here it will be somewhat sheltered from the flood flow, and as the canyon widens rapidly below the cove the backwater should not be troublesome.

Copper Canyon is slightly more than 20 miles from the Pacific Ocean and the construction of a railroad for this distance involves no particular difficulty. This railroad will render the site readily accessible, and a portion of its cost may be assessed against the Stairs Creek dam, farther upstream, as it can also be used to transport materials for that site. By drawing down the head 70 feet 207,000 acre-feet of stored water would be obtained, which could be used through a head of 168 feet. If the period of drawdown were four months and if none of the storage sites above were developed, the net gain from the use of the stored water would be 16,000,000 kilowatt-hours.

The damage due to the development of this site would be the flooding of 400 acres of good agricultural land, of about 20 miles of trail, of the settlements of Agness and Illahe (see pl. 24, *A*), and of a few isolated shacks and farms. The amount to be paid for damages will be but a small proportion of the total cost of construction. The surface area of the pond created will be about 3,900 acres, most of which lies in the bottom of a narrow canyon or on the steep hillsides. The slack water of the pond will extend about 21 miles up the Rogue River and 13 miles up the Illinois River.

Potential power at undeveloped site 12RD 25

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	1,220	5,150	19,500	82,400
Regulated flow	4,850	5,150	77,600	82,400

SOUTH FORK POWER SITE (12RD 27)

Water for the South Fork power project will be diverted from the South Fork of the Rogue River just above the boundary of the Cascade National Forest, at an altitude of about 3,300 feet. Half a mile of conduit and a mile of tunnel will lead to a power-house site on the Middle Fork, where a head of 660 feet can be obtained. This head might be increased by diverting higher up on the South Fork, provided the discharge does not decrease rapidly upstream. Records of run-off on the South Fork near the proposed point of diversion are available for 1925 to 1928. The water from this plant together with the flow of the Middle Fork would be carried by conduit to a point above the dam of the Prospect plant, the flow of Mill, Bar, and Red Blanket Creeks being diverted into the same conduit.

The natural Q90 flow at this site is about 65 second-feet and the Q50 flow 170 second-feet; 3,430 horsepower could be developed for 90 per cent of the time and 8,980 horsepower for 50 per cent of the time.

RANCHERIA POWER SITE (12RD 28)

By diverting the waters of Willow Creek and Rancheria Creek at the forks and carrying the water along the left bank of Butte Creek on the 2,540-foot contour to Butte Falls a head of 200 feet can be obtained. The flow available is practically the same as at the gaging station at Butte Falls. By constructing a canal along the same contour from the North Fork of Butte Creek to Butte Falls the flow would be increased by about 37 second-feet for 90 per cent of the time. This diversion from the North Fork would allow the water from that creek to be used for irrigation by the Eagle Irrigation District and for power in the plants proposed on its canals. About 5 miles of conduit of 120 second-feet capacity would be required from Rancheria Creek and about 2 miles of canal of about 50 second-feet capacity would be required from the North Fork of Butte Creek. A logging road follows Butte Creek above Butte Falls.

The natural Q90 flow at this site is 133 second-feet and the Q50 flow 160 second-feet; 2,130 horsepower could be developed for 90 per cent of the time and 2,560 horsepower for 50 per cent of the time.

31558°—32——7

McNEIL CREEK POWER SITE (12RD 30)

The McNeil Creek power site is on the canal of the Eagle Point Irrigation District. A plant could be built at the McNeil Creek siphon in the E. ½ sec. 36, T. 34 S., R. 1 E., to operate under a head of 330 feet; or by putting in a pressure pipe from the canal to Butte Creek in sec. 30, T. 34 S., R. 2 E., a head of 440 feet could be obtained. Both these sites could be operated only during the nonirrigation season. During the irrigation season the water could be used for power at two drops, one of 60 feet and one of 300 feet. The low flow on Butte Creek comes in August, September, and October, and this is also true of the Rogue River. The irrigation demand in these months is not very heavy, and it might pay to build the plant in sec. 30 on Butte Creek because of the extra 100 feet of head during the low-water season. This extra head would increase the minimum potential power by about 1,000 horsepower, provided the North Fork of Butte Creek is diverted into Butte Creek above the point of diversion of the Eagle Point Irrigation District. The canal for this purpose would be about 2 miles long and would increase the low flow by about 37 second-feet. With a head of 440 feet this would add 1,300 horsepower to the capacity of the site. The capacity of the site as given below is based on the assumption of three plants, one of 60-foot head and one of 300-foot head to be used during the irrigation season and one of 330-foot head to be used during the nonirrigation season and to take the excess flow during the irrigation season.

The natural Q90 flow at this site is 133 second-feet and the Q50 flow 160 second-feet; 3,830 horsepower could be developed for 90 per cent of the time (head 360 feet) and 4,220 horsepower for 50 per cent of the time (head 330 feet).

KERBY POWER SITE (12RD 34)

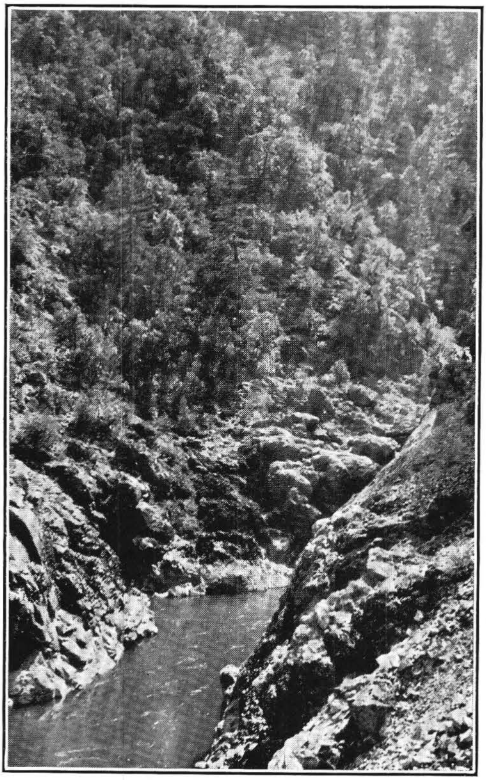
A power plant is proposed to be located on the Illinois River just below the Kerby Dam, in sec. 29, T. 38 S., R. 8 W. The Kerby Reservoir and its alternative dam sites have been described on pages 64–65. (See fig. 11 and pls. 14, *A*, 15, *A*, and 16, *A*.) As it would be necessary for the turbines to operate under a variable head, this plant would not be as efficient as the others, but the assumed efficiency of 70 per cent would probably cover the loss of power due to the variation. It has been assumed that the dam would be located at the lower or Josephine Creek site. If the dam were built at the upper Kerby site the dam at Fall Creek would be raised 20 feet to use the additional head. The maximum power available at Kerby would be 22,000 horsepower, which would come in July, during the beginning of very low water. The head available would vary from 180 to 55 feet, with 5 feet fall between the tail water at Kerby and the head water from Fall Creek. The maximum altitude of the head water would be 1,360 feet, altitude of the tail water, 1,180 feet.

The potential power available at this site when operated primarily for storage for sites below, is as follows:

Potential power at undeveloped site 12RD 34

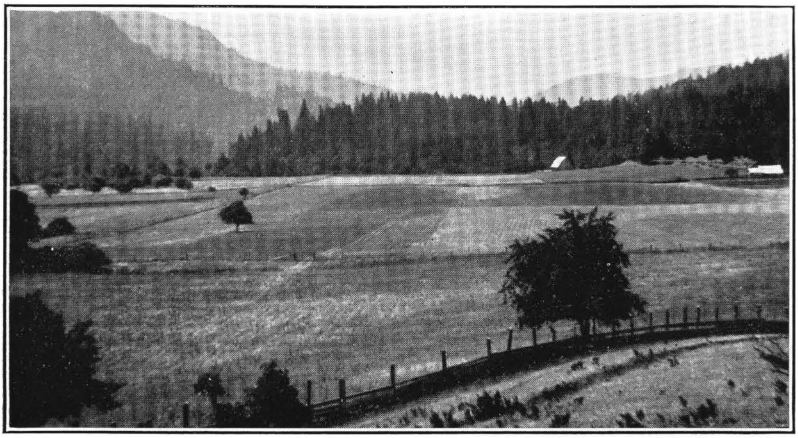
[Normal year]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	38	850	523	11,700
Regulated flow	0	1,070	0	6,500

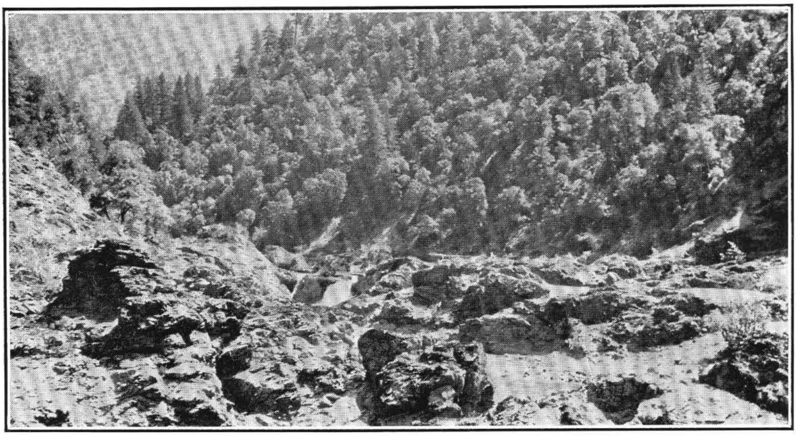


A. ROGUE RIVER BELOW THE MOUTH OF STAIRS CREEK

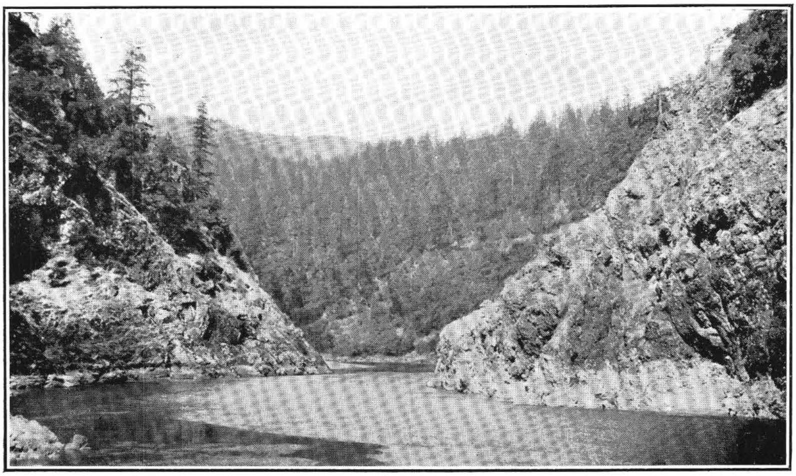
B. MULE CREEK CANYON, ROGUE RIVER, THREE-QUARTERS OF A MILE ABOVE STAIRS CREEK



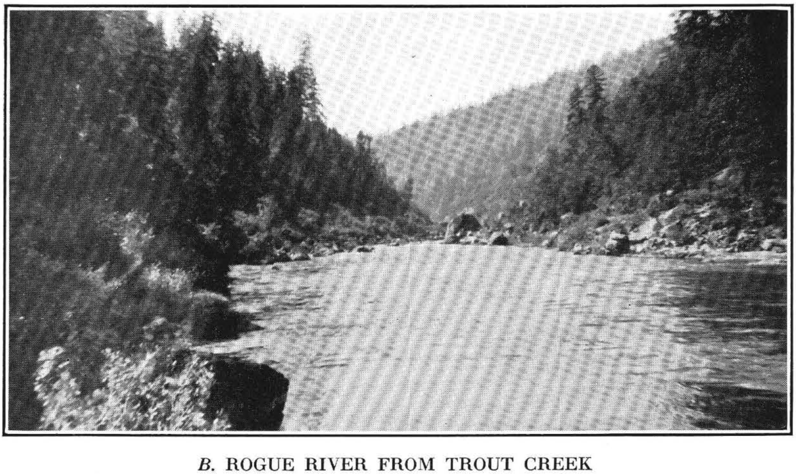
A. AGRICULTURAL LAND IN ROGUE RIVER VALLEY NEAR ILLAHE



B. ILLINOIS RIVER AT FALL CREEK DAM SITE



A. COPPER CANYON DAM SITE, ROGUE RIVER BASIN



B. ROGUE RIVER FROM TROUT CREEK

The above table would seem to indicate more power without than with regulation, but with regulation the period during which no power would be available would come during January, when the flow at Kerby would be entirely cut off and the entire load carried by plants below; on the other hand, with regulation the maximum amount of power would come during the low-water period, July to September, when the stored water would be released.

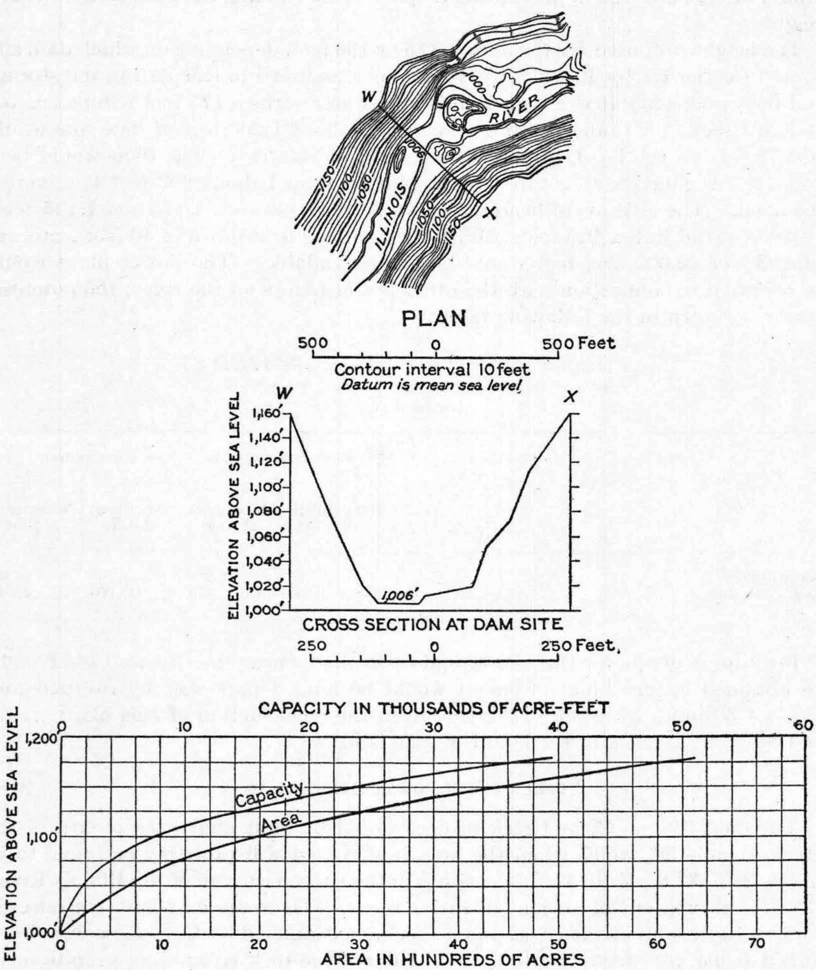


FIGURE 16.—Plan, cross section, and area and capacity curves, Fall Creek power site, Rogue River Basin

FALL CREEK POWER SITE (12RD 35)

The dam for the Fall Creek project would be located just above the falls at mile 39.7, in sec. 33, T. 37 S., R. 9 W. (See fig. 16 and pl. 24, *B*.)

In the vicinity of this site there is a complex of igneous and metamorphic rocks. The falls themselves seem to have resulted from differential erosion of diabase and serpentine. Upstream from the diabase there is a series of fine and coarse conglomerates greatly metamorphosed. The dark igneous rock that crops out at the dam site was determined by C. S. Ross to be a porphyritic andesite. In the conglomerate overlying this andesite there are cobbles of vesicular lava which suggest that the rock at the dam site is a surface flow and not an intrusive body. If so, it has been tilted and metamorphosed at the same time as the near-by conglomerates, and the whole mass has been changed into a compact, impermeable metamorphic series with only traces of the original character left. Joints are few. Bedrock occurs in the river bed and on both sides, so that no difficulties should be encountered in preventing seepage or in building the dam to the desired height.

The height proposed for the dam is 175 or 195 feet, depending on which dam site is used for the Kerby Reservoir. It has been assumed in calculating the storage and power capacity that a dam to raise the water surface 175 feet will be erected at Fall Creek. A tunnel 1.1 miles long with about 1,200 feet of pipe line would add 75 feet to the head, giving a total head of 250 feet. The dam would be a nonoverflow concrete structure with a spillway tunnel about 900 feet long across the bend. The altitude of head water would vary between 1,175 and 1,135 feet; altitude of tail water, 925 feet. With the assumed drawdown of 40 feet a storage capacity of 20,000 acre-feet would be made available. The power plant would be operated in connection with the other power plants on the river; the potential power is shown in the following table:

Potential power at undeveloped site 12RD 35

[Normal year]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	60	1, 330	1, 200	26, 600
Regulated flow	1, 300	1, 570	25, 000	27, 000

Rock for concrete for the dam would be available near the site, and sand could be obtained by crushing. Cement would be hauled part way by railroad and the last 30 miles by truck. Damage from the construction of this plant would be negligible, as most of the land is public land.

CLEAR CREEK POWER SITE (12RD 36)

The dam for the Clear Creek project would be built above the mouth of the creek at mile 30, which when the area is surveyed will probably be found to be in sec. 2, T. 37 S., R. 10 W. The site is in the rugged canyon of the Illinois River, which is carved out of ancient intrusive rocks. There are excellent exposures of rock on both sides of the river, and a specimen examined by C. S. Ross was determined to be very fresh diorite. It is a dark-blue rock resembling granite in its crystalline character and will afford an ideal foundation because of its great strength and impermeability. No difficulty should be experienced in building a dam of the desired height.

The height proposed is 190 feet, which would back the water to a point within 5 feet of the level of tail-water at the Fall Creek site. Half a mile of tunnel would add 30 feet to the head, the power house being located at mile 28.8. An additional 20 feet of head would be added by half a mile of pipe line, or this head could be developed by adding 20 feet to the height of the dam at Bald Mountain. This additional height of 20 feet at Bald Mountain would afford 8,900 acre-feet of pondage, which probably would be of considerable advantage, and it has therefore been assumed that this head will be developed at Bald Mountain. The total head at the Clear Creek site would be 220 feet. The altitude of head water at this site would vary between 920 and 880 feet and the altitude of tail water would be 700 feet. The storage capacity for 40-foot drawdown would be 16,500 acre-feet. The estimated flow at this site for a normal year is given in Table 10. The potential power when this site is operated in connection with other plants on the river would be as shown in the following table:

Potential power at undeveloped site 12RD 36

[Normal year]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	80	1,800	1,400	31,700
Regulated flow	1,750	2,010	30,600	33,300

It would be necessary to build about 10 miles of highway or 40 miles of railroad to reach this site, which is 10 miles below Fall Creek. The only construction material available at the site is rock which could be crushed to furnish sand. The lands that would be flooded by this project are on steep hillsides, practically all publicly owned.

BALD MOUNTAIN POWER SITE (12RD 37)

The dam for the Bald Mountain project would be located at mile 21.2, at an altitude of 525 feet, where the river starts its bend around Bald Mountain. When the land is surveyed this site will probably be in sec. 26, T. 36 S., R. 11 W.

The geology of this site was not studied because of the difficulty of reaching it, but a traverse made along the trail to Agness indicates that the site is probably satisfactory. About 5 miles upstream from the site the trail turns away from the river and makes a steep ascent to the top of Bald Mountain. The first outcrops of sandstone observed in the entire traverse made from the Falls Creek site were along the trail, about 2,500 feet above the river. The sandstone is altered, almost to a quartzite. Near the top of Bald Mountain there are a couple of small seeps, the water being brought to the surface by some shale beds that underlie the sandstone. From the top of the mountain the trail goes down a steep canyon wall by means of switchbacks. Along this trail were found chips of sandstone, and at Silver Creek a diabase dike is intruded into conglomerate, probably of Cretaceous age. Thus in the entire traverse nothing was found to suggest that the structure of the Bald Mountain dam site was anything but good.

The canyon of the river is narrow, and a small amount of surface stripping would probably expose good rock foundations. An overflow dam 170 feet high is proposed. This would back water within 5 feet of tail water of the Clear Creek plant. A tunnel 2.8 miles long under Bald Mountain would add an additional head of 255 feet, if the fall below an altitude of 270 feet were utilized in a plant at Copper Canyon, on the Rogue River. An additional head of 65 feet can be obtained with about the same length of tunnel provided the Copper Canyon dam is built to a lower height.

The head between the proposed Bald Mountain site and the backwater from the Copper Canyon site on the Rogue River could be developed by dams instead of by a tunnel, and a dam site was surveyed at mile 12.3, a short distance below Collier Creek. (See fig. 17.) This site may be taken as typical of this part of the Illinois River, as there are many good sites between it and the Bald Mountain site. An example of the use of a tunnel rather than a dam is afforded by a constructed plant in Georgia, where a tunnel 5,600 feet long was built to obtain a head of 100 feet. On the basis of the head per mile obtained by this tunnel, the tunnel under Bald Mountain could be 2.8 miles long if the Copper Canyon dam is built to the full height. The average continuous output at this constructed plant is less than 5,000 horsepower, compared with an average estimated output at the Bald Mountain site of 14,000 horsepower for each 100 feet of head.

No agricultural land would be flooded by this project, and practically the whole area is publicly owned. Head water at this site would fluctuate between an altitude of 695 and 655 feet, and the tail water would be at 270 feet. The storage capacity afforded by a drawdown of 40 feet would be 15,000 acre-feet.

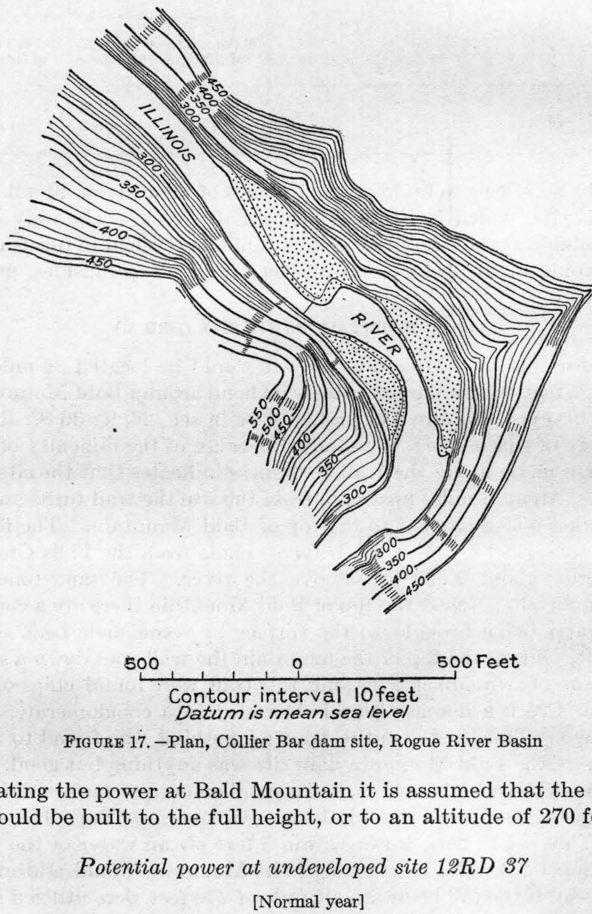


FIGURE 17.—Plan, Collier Bar dam site, Rogue River Basin

In calculating the power at Bald Mountain it is assumed that the Copper Canyon dam would be built to the full height, or to an altitude of 270 feet.

Potential power at undeveloped site 12RD 37

[Normal year]

	Flow (second-feet)		Horsepower	
	90 per cent of time	50 per cent of time	90 per cent of time	50 per cent of time
Natural flow	85	1,910	2,900	65,000
Regulated flow	1,770	2,290	60,300	78,000

MARKET

The location of each of the developed and undeveloped power sites in the Rogue River Basin is shown on the general map of the area (pl. 3) and the small-scale profile (pl. 4).

By constructing a trunk transmission line along the river all the sites can readily be linked into one unified system. The power output of this system will be so large that only a very small percentage of it can be absorbed in the immediate vicinity unless industries requiring large blocks of power locate near by. The electrification of the railroads in the basin would provide an outlet for a considerable block of power, but this would be only a small part of the power that can be obtained. Sites on the Illinois River and the lower Rogue River are close to the coast, where raw material could be brought by water. As an example, bauxite for the production of aluminum could readily be brought from South America to some port near the mouth of the Rogue River for treatment. This industry and other electrometallurgical processes requiring cheap power may soon be forced to the Pacific Northwest for a location. Such industries offer probably a more immediate market for the power available on the Rogue River than the public utilities of Portland or San Francisco, but if the power is not developed for industrial use in the vicinity there seems little question that it will be developed for public utilities in the not very distant future.

The power consumption of the United States doubles every eight or ten years. In the period from 1921 to 1928 the developed water power in California increased from 1,149,000 to 2,227,000 horsepower and in Oregon from 185,000 to 289,000 horsepower. Already most of the cheaper water-power sites in California are developed. It is conceivable, therefore, that power from sites on the Rogue River can be sold in California before many years elapse. San Francisco is 350 miles distant. Power from the Rogue River could be used in northern California, releasing power from plants in that region for use in San Francisco. Portland and cities in the Willamette Valley also will require more power, but there are large sites on the Columbia River that can be developed to supply this market, and these will compete with sites on the Rogue River as economical sources of power for metallurgical and similar industries. At present the most probable use for power from the Rogue River is in some manufacturing process requiring large amounts of cheap power or for public utilities in northern California.