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CONTENTS.

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

ILLUSTRATIONS.

POWER RESOURCES OF SNAKE RIVER BETWEEN HUNTINGTON, OREGON, AND LEWISTON, IDAHO.

By WILLIAM GLENN HOYT.

INTRODUCTION.

Thousands of people are familiar with that part of Snake River where it flows for more than 300 miles in a general westward course across the plains of southern Idaho, but few have traversed the river where it flows northward and for 200 miles forms the boundary between Idaho and Oregon and for 30 miles the boundary between Idaho and Washington. Below the mining town of Homestead, Oreg., which is the end of a branch line of the Oregon Short Line Railroad, Snake River finds its way through the mountain ranges that seem to block its way to Columbia River in a canyon which, though not so well known, so majestic, nor so kaleidoscopic in color, is in some respects worthy of comparison with the Grand Canyon of the Colorado, for at some places it is deeper and narrower than the Grand Canyon at El Tovar. The Snake, unlike the Colorado, can be reached at many points through the valleys of tributary streams, and the early prospectors no doubt thoroughly explored all parts of the canyon. To traverse the river between Homestead, Oreg., and Lewiston, Idaho, is, however, a difficult undertaking, and there are only a few records of boat journeys through the entire stretch.

It has long been known that this portion of Snake River contains large potential water powers, but until recently no detailed surveys or examinations covering the entire stretch of the river had been made to determine their location or extent. A railroad has been proposed between Homestead and Lewiston which would provide a direct connection between the railroad systems of northern and southern Idaho.

One function of the Geological Survey is to determine the possible interference between transportation routes on land and potential water-power development, and the information set forth in this paper has a bearing on that problem.

In 1920 the topographic branch of the Geological Survey made a map of the river between Huntington, Oreg., and Lewiston, Idaho. The writer was detailed to accompany the party and to report on the power and other features. The party left Huntington August 3 and arrived at Lewiston November 3. A plane-table survey was made of 187 miles of the river on a scale of 2 inches to the mile. Five dam sites were surveyed in detail, and a contour map on a scale of 2 inches to the mile was made of an area of about 30 square miles constituting the divide between Snake and Salmon rivers in T. 26 N., R. 1 E. and R. 1 W. Boise meridian, Idaho.

Maps in three colors showing the results of these surveys have recently been published by the Geological Survey. The complete set of 17 sheets (A to Q), each about 19 by 20 inches, entitled "Plan and profile of Snake River, Lewiston, Idaho, to Huntington, Oregon," may be purchased for $1.70 from the Director of the Geological Survey, Washington, D. C. Although these maps are complete in themselves, the published information relative to the area covered by the maps is so scanty that it has been thought desirable to prepare this brief summary of the power possibilities and other features of the area. This text should be read in connection with the river survey maps described above, without which a thorough understanding of this part of Snake River can not be had. Those desiring a more complete description of the power possibilities of the lower Snake may consult copies of an illustrated manuscript report, from which this text has been compiled, on file in the district offices of the Geological Survey at 615 Idaho Building, Boise, Idaho; 406 Federal Building, Tacoma, Wash., and 606 Post Office Building, Portland, Oreg.; also at 3244 Interior Department Building, Washington, D. C.

ACKNOWLEDGMENTS.

The writer is indebted to a number of colleagues in the Geological Survey, especially to J. T. Pardee and A. C. Spencer, geologists, for valuable notes on the geology of the river with special reference to dam and tunnel sites, compiled from various sources; to F. F. Henshaw, district engineer, Portland, Oreg., for data relative to surveys by the State engineer of Oregon; and to C. G. Paulsen, district engineer, Boise, Idaho, for valuable stream-flow and other data. The survey party which the writer accompanied was composed of W. R. Chenoweth, topographer and chief of party; Leigh Lint and Perry Crawford, rodmen; George Lee, boatman; and John Clagston, cook.

PHYSICAL FEATURES.[1]

Though the greater part of the Snake River drainage basin lies in Idaho, the outer edge drains parts of Washington, Oregon, Nevada, Utah, and Wyoming. The river rises near the Continental Divide in the southern part of Yellowstone National Park and flows generally south through Jackson Lake, Wyo., which is used as a storage

[1] For a description of the plains of Snake River in southern Idaho above Weiser see Russell, I. C., U. S. Geol. Survey Bull. 199 and 217.

reservoir, to a point in T. 3 S., R. 46 E. Boise meridian. At this point, which is 125 miles below its source, the river enters Idaho and turns to flow northwest 71 miles to the junction with Henrys Fork of Snake River between St. Anthony and Idaho Falls. From this junction the river flows southwest for 100 miles and then in a general west and northwest direction for 270 miles to the boundary between Oregon and Idaho, 50 miles south of Weiser. At this point the river turns north, and for about 200 miles it forms the boundary between Idaho and Oregon and for 30 miles the boundary between Idaho and Washington. At Lewiston, Idaho, it is joined by the Clearwater, and thence it flows west 120 miles to its confluence with Columbia River. The total drainage area is about 108,000 square miles, of which 68,000 square miles lies upstream from Weiser, Idaho, near which the investigations outlined in this report were begun.

Between the Oregon Short Line bridge near Huntington, Oreg., the point where the survey began, and Homestead (mile 187.8 to mile 127.0 (from Lewiston), sheets F, G, and H, Snake River survey), the river is paralleled on the west bank by the Homestead branch of the Oregon Short Line Railroad. The track is 30 to 50 feet above the water surface. This part of the river valley is fairly well settled, and small towns have grown up along the railroad. Agriculture is the principal occupation, although Homestead, the largest town, owes its size to copper mines, and the smaller town of Gypsum to gypsum deposits. The towns serve as centers for small rural communities and as feeders to the cattle and sheep country that occupies the high lands east and west of the river. The valley is wide throughout this stretch. The river flows in a plain of alluvium, which is of unknown depth and consists of unconsolidated and more or less open-textured sand and gravel, chiefly deposited in water but locally including talus. The basalt which no doubt forms the bed of the river throughout its course can be seen in a structural depression between the axes of the Seven Devils and Cuddy mountains. The total fall throughout the 60-mile stretch between Huntington and Homestead is 375 feet, or an average fall of 6.2 feet to the mile. There are 19 well-defined rapids in this stretch, but they are fairly well spread out and offer no serious trouble to small boats. Scows, if heavily loaded, would have some difficulty because of the shallow places at rapids and sand bars.

Between Homestead and the mouth of Kinney Creek (mile 127 to mile 115.6, sheet F), the valley and the river narrow gradually; there is little bench land, and the country contains few inhabitants. A wagon road on the west bank between Homestead and Ballards Landing, about 2.7 miles long, connects with the ferry at Ballards and running eastward over the mountain connects with the road to Gypsum, which follows up the valley of Indian Creek. The next ferry on the river is at Pittsburg Landing, 47 miles farther down. The road on the Oregon side continues downstream to a point opposite Limepoint Creek, 5 miles below Homestead. From this point a fair trail continues to a ranch at the mouth of Lynch Creek, across the river from Kinney Creek (mile 115.5, sheet F). The average fall of the river in this stretch is 7.2 feet to the mile. There are five well-defined rapids, all of which may be safely run with a small boat even though fairly well loaded. Below Homestead the columnar basalt is not noticeable near the river, the side walls changing to rocks of the older basaltic series. These older rocks are much better adapted for foundations than the more recent basalt above Homestead. The river no longer traverses an alluvial plain, and no doubt there are better opportunities to uncover bedrock, but all the rapids are caused by débris washed in by the tributaries, and consequently no estimate is made as to the probable distance of bedrock below the water surface.

Near Kinney Creek (mile 115.6, sheet F) the river enters a canyon generally known as Hell's Canyon. To one in the bottom of the canyon the size is not evident, but a study shows that in cross section the canyon is entirely comparable with any part of the Grand Canyon of the Colorado, being deeper and narrower from rim to rim than the far more famous canyon in Arizona. In the stretch below Kinney Creek the canyon is cut through a huge uplifted mass from which the Wallowa, Seven Devils, and adjoining mountains have been carved. If this cut were filled the river would find an outlet westward across the plains of southern and central Oregon to Deschutes River long before it would rise high enough to follow its present course northward. The upper 2,500 feet or more of the canyon walls consists largely of Columbian lava; the lower parts consist of the older rocks, chiefly greenstone, with smaller quantities of argillite, slate, schist, and limestone. Aside from the impressive boldness and height of the steep walls, perhaps the most striking feature of the canyon is the extreme roughness of the solid rock faces. Where not vertical the walls are in many places badly ruptured and much steeper than the angle of repose, a condition generally conducive to rock slides or avalanches. This condition would make blasting for construction especially hazardous at many places and would also tend to impose a very heavy maintenance charge on any railroad through the canyon. The river in this section narrows in places to less than 100 feet in width and appears from a distance like a small mountain stream. The average fall through Hell's Canyon is 12.8 feet to the mile. There are 12 very well-defined rapids in this stretch; those at the mouths of Kinney Creek, Squaw Creek, Buck Creek, and Thirtytwo Point Creek are especially rough, and all are dangerous to navigate at any stage of water.

Between Rush Creek and Kloptant Creek (mile 92 to mile 77, sheets D and E), the valley and river are generally wider than the section through Hell's Canyon. The rocks apparently contain minerals, as claim monuments and evidences of old workings were observed at short intervals. Benches on which ranches have been established are more numerous. The largest ranch in this stretch is the Brockman ranch, at the mouth of Temperance Creek, which is connected by means of a summit trail along the Oregon side a considerable distance back from the river with Pittsburg Bar, from which a good road extends over the divide between Salmon and Snake rivers to Whitebird, Idaho. There are six rapids in this stretch, but all of them can be easily run by small boats and during favorable stages by high-power motor boats, which occasionally run from Lewiston as far upstream as the Brockman ranch.

Between miles 77 and 74 (sheet D) the valley widens to nearly 4,000 feet at a level 300 feet above the river surface, compared to a width of 700 feet or less upstream and downstream. This is the only opening of any size in the canyon. At Pittsburg Bar or Pittsburg Landing (mile 75.6) there is a ferry that connects the cattle and sheep country with a fairly good road to Whitebird. There are several fair-sized ranches in the opening; the largest is on the Idaho side and contains tracts irrigated by water diverted from Kloptant and Kinney creeks. Until recently the raising of cattle has been the principal industry, but sheep are now being introduced. The river through this stretch has an average fall of 11 feet to the mile; the rapids, of which there are three, can be run with a small boat.

One mile downstream from Pittsburg Bar the side walls again close in, and between Pleasant Valley and High Ridge creeks (mile 74 to mile 67, sheet D) the river flows in a narrow V-shaped canyon, almost boxed. The side walls are composed of the older basaltic series, covered in part with talus slopes. The sides are steep, and vertical bluffs at short intervals make travel along either bank almost impossible. There is little bench land and few ranches. The average fall of the river is 7.8 feet to the mile. Four well-defined rapids occur in this stretch, all of which can be easily navigated.

Between High Ridge Creek and Thorn Creek (mile 67.1 to mile 60.4, sheet D) the river has a westerly course and is generally wider than above and the side walls open somewhat and are not so high. The columnar basalt is again exposed at the water's edge. There is considerable bench land, part of which is being irrigated from small tributaries. The average fall is 7.9 feet to the mile. There are four rapids, all of which may be navigated.

Between Thorn Creek and Cherry Creek (mile 60.4 to mile 46, sheets C and D), the river narrows and except for an occasional strip of bench land and flows in a canyon almost boxed and difficult of access except by boat. Imnaha River, the largest tributary from the Oregon side below the mouth of Powder River, enters the Snake 52.5 miles above Lewiston; and Salmon River, the only tributary of any size from the Idaho side below Weiser River, enters 49 miles above Lewiston. Both of these large tributaries flow in narrow canyons, that of Imnaha River being almost boxed. A short distance up Imnaha River is the Eureka mine, which is no longer being operated. A tunnel of considerable size and length has been driven into the south wall of the Imnaha Canyon, and a narrow-gage railroad, portions of which are still in place, constructed to a stamp mill on Snake River a short distance below the mouth of the Imnaha. Copper and silver were the principal products of the mine, which is the largest mine directly in the canyon below Homestead, and if good transportation facilities were available this and many other claims would probably be worked. On the bench across from the mouth of Salmon River and at one or two other places above the mouth of the Imnaha are large sheep sheds. Supplies are brought to these sheds and wool taken out by high-powered motor boats running to Lewiston. The average fall of the river in this stretch is only 8.7 feet to a mile. There are seven rapids, which with skill and good luck can be run by small boats if empty or lightly loaded, but for complete safety of food and camp equipment several short portages are necessary. The river below the mouth of Salmon River does not appear considerably larger than above, although its flow is about two-thirds greater. The canyon walls are almost without exception composed of the older basaltic series, with a few intrusions of granite. The rocks are hard and flintlike and show little surface weathering.

Between Cherry Creek and Lewiston (mile 46 to mile 0, sheets A, B, C) the canyon walls recede and become much lower and the river gradually widens to nearly 1,000 feet. Columnar basalt forms a considerable part of the side walls, although near the mouth of China Garden Creek (mile 37) granite has been quarried for building stone, and opposite the mouth of Grand Ronde River there are large deposits of limestone. Grand Ronde River enters from the Washington side at mile 29.5. Regular boat service is maintained between Lewiston and this point and during certain portions of the year is extended to Pittsburg Bar and points upstream. At the mouth of Captain John Creek there is a ferry connecting with a road to Asotin, Clarkston, and Lewiston. The average fall of the river in this 46-mile stretch is 2.7 feet to the mile. There are 10 well-defined rapids, all of which are spread out and can be easily navigated. At Lewiston Clearwater River enters and the Snake turns westward to the Columbia.

EXPLORATION.

Lewis and Clark, the first white men known to have seen Snake River, reached the confluence of Clearwater and Snake rivers October 10, 1805, and Columbia River six days later. In May of the following year, on their return, they retraversed the Snake as far as Lewiston and thence went eastward along the Clearwater and tributaries. In 1811 two detachments of the Astor party, under the leadership of Wilson Price Hunt and Ramsay Crooks, having left their horses at what is now St. Anthony and lost their boats in the rapids of the Snake near the present city of Twin Falls, attempted to follow down the Snake on foot. In the vicinity of the Seven Devils, at the upper end of Hell's Canyon, they were forced to turn back in December of that year. The Hunt party, which was on the Idaho side of the river, effected a crossing near the mouth of Weiser River, and with the Crooks party, which had been following on the Oregon side, went up Burnt River and finally reached the Columbia.

Although the central Northwest as a whole has made a progressive growth, the Snake River canyon between Homestead and Lewiston, owing to its inaccessibility and lack of agricultural possibilities, remains practically the same as before the coming of the white man. Between 1880 and 1890 examinations and surveys were made by the Corps of Engineers, United States Army, to determine the feasibility of navigation on the Snake, but they reported invariably that the river was unfavorable for navigation. During May, 1895, when the river was at flood stage, Capt. W. P. Gray, of Pasco, Wash., with a crew of 13 men, ran the steamer *Norma*, a stern-wheeler 165 feet long, 35 feet wide, and 6 feet 6 inches deep, from Huntington Bridge to Lewiston. The trip was made without loss of life or the destruction of the boat, but Captain Gray's description of it would not warrant the statement that the river can be safely navigated. During 1911 engineers for the Northwestern Railroad Co., a subsidiary of the Oregon Short Line Co., made a location survey for a railroad between Homestead and Lewiston. Before completing the work the party lost the personal effects of all the men and nearly all the boats. The location stakes of this party, however, were seen at many places throughout the canyon ten years later by the writer.

Engineers, geologists, and topographers have at different times made surveys and investigations at several places along the river.

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Plan and profile of Snake River, Lewiston, Idaho, to Huntington, Oreg., U. S. Geol. Survey, 1923.

Data showing flow of Snake River, collected by the Geological Survey in cooperation with State and public-utility officials, are contained in the following water-supply papers:

Year.	No.	Year.	No.	Year.	No.
1899	*38	1907–8	*252	1916	*443
1900	51	1909	272	1917	*463
1901	*66, *75	1910	292	1918	483
1902	85	1911	312	1919–20	513
1903	100	1912	*332B	1921	[a] 533
1904	135	1913	*362B	1922	[a] 553
1905	178	1914	*393	1923	[a] 573
1906	*214	1915	*413		

[a] In preparation.

CLIMATE.

As the valley of Snake lies west of the Continental Divide, it is exposed to winds from the Pacific Ocean, which contribute materially to the mildness of the climate. Local chinooks also play an important part in ameliorating winter temperatures. The extreme cold waves that occur in middle western Canada and the adjacent part of the United States are seldom felt in the basin of the Snake, which is cut off by high mountains on the east. The mean temperature between Lewiston and Weiser, Idaho, is from 50° to 55° F.; the mean summer temperature is 70° to 80°, with daily maxima of 100° to 110°. The summer temperature in the canyons, owing to their shelter from the winds and the radiated heat from the rock surface, is invariably higher than it is on the uplands. In the winter, however, owing to the influence of the water and protection from winds, the temperature is higher in the canyons than on the plains, snow lies on the ground for only a few days at a time, and complete ice cover rarely forms. The summer days are hot, but owing to the extreme dryness the heat is seldom oppressive. Under the prevailing clear skies radiation is rapid, and the nights are nearly always cool. Warm nights occur when the sky is clouded and radiation from the heated ground and rocks is checked. At the higher altitudes in the Seven Devils and other ranges the mean yearly temperature ranges from 36° to 40° and the peaks are flecked with snow the greater part of the year. Nearly the entire basin lies outside the path of general storms, and the valleys may be classified as arid. The mean annual precipitation is about 15 inches in the canyon, but in the mountains adjacent to the river it amounts to about 40 inches.

STUDIES OF STREAM FLOW.

The water of Snake River and its tributaries, before it reaches the power section extending downstream from Huntington, contributes largely to the welfare of southern Idaho and southeastern Oregon. Without the use of water for irrigation the plains area of this semiarid region would be almost a desert. By irrigation much of this arid land has been made into excellent farming communities, furnishing homes for thousands of people and annually producing crops worth millions of dollars. The use and control of the water for irrigation has already had a marked effect upon the regimen of the river, and as additional development takes place further changes will occur. These changes in the regimen of the river will continue as long as lands susceptible of irrigation remain in the basin and water flows in the river available for such use. Naturally it is impossible to predict with certainty the extent to which future irrigation is feasible within the Snake River basin. Owing to the combination of fertile soil, favorable climate, and accessible water, irrigation as practiced in this basin has been very successful. The science of irrigation has now been so highly developed that there is every reason to believe that eventually all lands within the basin which are susceptible of successful irrigation at a reasonable cost will be brought under cultivation. Unfortunately the unappropriated waters of Snake River are insufficient to supply all the arable lands that are susceptible of irrigation. It is estimated that tracts amounting to at least 1,500,000 acres in the basin upstream from Homestead, Oreg., are so situated that they could be irrigated if water were available. It seems apparent, therefore, that at some future time irrigation systems will be constructed which, by means of storage, will use practically the total annual flow of Snake River above Milner, Idaho, the lowest point of practical diversion other than by pumping. Many new irrigation projects, as well as extensions to old ones, have been proposed. The project that will probably be constructed first and that will have the greatest effect upon the flow of Snake River is a large storage reservoir at American Falls. In making the accompanying estimates of the probable future discharge of Snake River it has been assumed that by reason of the construction of the reservoir at or above American Falls, with the incident diversions, there will be no appreciable flow past Milner at any time of the year and that diversion for irrigation from surface tributaries of the Snake will use all the normal summer flow and on many of them the flood flow. However, owing to an unusual geologic condition existing on the plains of southern Idaho, a well-sustained flow may be expected to occur in the stretch downstream from Homestead, regardless of any future storage on or diversion from Snake River above Milner. There is practically no surface run-off from the area lying north of Snake River between Henrys Fork and Malad River, a distance of more than 250 miles. The underground run-off from this area, augmented by seepage losses from the irrigation districts adjacent to the river on the north, reaches the Snake apparently without loss in the famous groups of springs in the canyon between Twin Falls and the mouth of Malad River and amounts to a continuous inflow of more than 5,000 second-feet.

From records of flow collected at gaging stations maintained by the Geological Survey in cooperation with the States of Idaho, Oregon, and Washington and public-utility companies, the present and future flow in the Snake River canyon between Homestead and Lewiston is estimated as follows:

Estimated flow of Snake River between Homestead and Lewiston, in second-feet.

	Present.		Minimum future.[a]	
	90 per cent of time.	50 per cent of time.	90 per cent of time.	50 per cent of time.
Between Homestead and mouth of Salmon River	8,000	16,500	6,900	11,200
Between mouth of Salmon River and Lewiston	15,000	21,500	12,200	16,300

[a] Not considering increase in flow which may result below Milner on account of irrigation with water stored at American Falls or above, storage on Salmon River, or any diversions from the Salmon River basin into the Snake River basin for either power or irrigation.

During the period 1911 to 1920 the minimum daily flow and the minimum mean monthly flow of Snake River at Weiser occurred nine times during August and once during September. A minimum flow of 5,500 second-feet occurred August 28 and 29, 1915, and August 1, 1919. The minimum monthly flow was 6,060 second-feet in August, 1915. The next larger minimum monthly flow, 6,180 second-feet, occurred during August, 1919. The minimum mean flow for two consecutive months occurred in August and September, 1915, and amounted to 6,300 second-feet, and the next larger occurred in August and September, 1919, and amounted to 6,420 second-feet. The minimum mean flow for a three-month period occurred in July to September, 1915, and was 6,580 second-feet. The next larger occurred in July to September, 1919, and was 6,600 second-feet. The normal low-water period occurs without exception during the later part of the irrigation season and lasts for about three months. The total inflow between Weiser and the mouth of Salmon River during the irrigation season probably does not exceed 150 second-feet. This inflow comes principally from the basins of Powder, Burnt, and Imnaha rivers. The minimum flow of Salmon River, unlike that of the middle Snake, occurs during the winter; consequently the minimum flow of Snake River below the mouth of Salmon River is comparatively large. From a study of the flow of Snake River at Weiser, of Salmon River at Whitebird, and of Snake River as recorded by the United States Weather Bureau gage at Lewiston, it is estimated that the absolute minimum flow of Snake River below the mouth of Salmon River is about 7,000 second-feet, and that the minimum mean monthly flow is between 8,000 and 9,000 second-feet.

The earliest flood at Weiser during the period 1911 to 1920 was 58,400 second-feet and occurred March 22, 1916; the latest was 63,400 second-feet and occurred June 24, 1918; the largest was 73,800 second-feet and occurred June 15, 1912. Records collected by engineers of the Idaho Power Co. during the period 1908 to 1913 indicate that on March 3 and 4, 1910, a flow of about 130,000 second-feet occurred at the site of the Ox Bow power plant. The peak at

Weiser on this date must have been somewhat above 100,000 second-feet. This flood was due to the fact that a heavy snow cover on the basin between Weiser, Idaho, and Copperfield, Oreg., was suddenly melted by a chinook accompanied by rain. It is believed that the maximum flood at Weiser is about 150,000 second-feet. Almost without exception the maximum stage occurs on Snake River at Weiser and at Lewiston and on Salmon River at Whitebird within the same two or three day period. This coincidence is very significant, as the resulting flood in the canyon below the mouth of the Salmon must be nearly the sum of the maximum flow of the Snake above the Salmon and of the Salmon. A study of the records indicates that a flood of 300,000 second-feet may be expected in Snake River below the mouth of the Salmon.

DEVELOPED POWER.

The only developed power on the river between Weiser and Lewiston is at the Ox Bow, near Copperfield, Oreg. (developed plant No. 12HK 1 [2]). In sec. 9, T. 7 S., R. 48 E. Willamette meridian, Snake River makes a decided bend and forms a horseshoe 1,200 feet across and 3.5 miles around. At this site the Idaho Power Co. operates a plant the construction of which was begun during 1907. A concrete-lined tunnel was cut through the solid rock of the ridge. The tunnel is about 26 by 26 feet in cross section, and there are extensive concrete structures at both ends. The portal at the intake end is about 90 feet wide and 50 feet high and is equipped with motor-operated steel gates. The tunnel discharges into a concrete forebay that forms part of the power house. The hydraulic equipment consists of two 48-inch double-runner horizontal Leffel turbines, made by S. Morgan Smith, having a rated capacity of 6,200 horsepower each under the head for which they were designed. The electrical equipment consists of a Westinghouse 3,600 kilovolt-ampere horizontal-type generator driven by a 5,000-horsepower Morse chain consisting of eight chains, each 21 inches wide. The distance between the centers of the shafts is 12 feet. The head varies, but the average is probably 17 feet; the average output is about 1,800 kilowatts. The output at this plant may be increased by building a dam below the intake, thus increasing the flow through the tunnel and the head on the wheels. The feasible height of a dam at this point is limited by the railroad that cuts across the Ox Bow through a tunnel upstream from the power tunnel, at an altitude of about 45 feet above the water.

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[2] Numbers are those used in the records of the Geological Survey.

UNDEVELOPED POWER.

Snake River has certain general features that make it a possible source of large blocks of power. The flow is well sustained, the gradient is steep, the cross section is comparatively narrow, and the geologic formation in the canyon would probably make good foundations for a dam of any height. On the other hand, construction would be difficult and undoubtedly expensive, for the working quarters would be cramped and material would have to be transported long distances. The river is also subject to large floods, and the problem of by-passing flood water both during construction and after the dam is completed will require very careful engineering. In developing many of the sites a railroad to transport materials will be necessary, and if the project has to bear this expense in addition to the cost of the power development the unit cost per horsepower will be high. If, however, a railroad is constructed between Homestead and Lewiston at such a height that it will not interfere with the development of water power, the construction of dams will be facilitated. High dams will probably be more feasible than low dams, but, on the other hand, if dams are built so high that flood waters can not pass with safety over the crests, tunnels or other artificial spillways will have to be constructed at great cost. No sites were found at which it would be possible to construct large rock-filled dams and divert at small expense flood waters through short tunnels across narrow necks. Even if such sites were found, the problem of making rock dams water-tight would be difficult, for comparatively little silt is carried in the water and there is little dirt on the river bottom or sides that could be moved.

As far as known there are no available records of borings to determine the depth to bedrock in the canyon. Until detailed geologic investigations and borings are made to determine depth to and character of bedrock and side walls, the sites here described should be classified as tentative.

No dam-site surveys were made in the stretch of the river paralleled by the railroad between Huntington and Homestead. In this stretch the side walls consist of more or less columnar basalt and the river flows in an alluvial plain of unknown depth. The height of any dams in this stretch would be limited by the railroad, which is 25 to 50 feet above the water surface. On account of the geologic conditions the cost of construction would be high. Three sites were found above Homestead, however, which may be worth further investigation. They are the first three of the sites described below.

In the tables showing potential power the symbols "Q90" and "Q50" indicate flow or power available 90 per cent of the time and 50 per cent of the time. The horsepower is based on an over-all efficiency of 70 per cent and a reduction of head during high-water periods.

Site 12HK 1 (mile 145.3, sheet G): In a section extending from a point between the SE. ¼ sec. 2, T. 17 N., R. 5 W. Boise meridian, Idaho, to a point in the SE. ¼ sec. 25, T. 8 S., R. 47 E. Willamette meridian, Oreg., basalt appears on both sides of the river, and this section may constitute a dam site. The altitude of low water is approximately 1,798 feet and that of the railroad about 1,834 feet. A dam having a head of 25 feet, if properly equipped with gates for handling flood flows, could probably be maintained without interference with the railroad. The width of the section at the water surface is about 370 feet and at the 1,830-foot contour about 620 feet. A 25-foot dam would back the water about 7 miles. Whether this site is feasible will depend largely upon the porosity of the columnar basalt on the Oregon side and the depth of alluvial fill over the bedrock.

Potential power at site 12HK 1.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	16,000	26,400
With ultimate use of river for irrigation	6,900	11,200	13,800	17,900

Site 12HK 2 (mile 143.3, sheet G): In a section extending from a point in sec. 36, T. 18 N., R. 5 W. Boise meridian, Idaho, to a point in sec. 19, T. 8 S., R. 48 E. Willamette meridian, Oreg., basalt occurs on both sides of the river. This section constitutes a poor site and is probably not worth further investigation. The altitude of the river at low water is about 1,783 feet, and that of the railroad is about 1,820 feet. The width of the section at the water surface is about 220 feet and at the 1,820-foot contour about 640 feet. A dam having a head of 25 feet, if properly equipped with flood gates, could be maintained without material interference with the railroad. Water would be backed upstream about 5 miles and would drown out site 12HK 1. Of the two sites 12HK 1 seems to have the better physical features.

Potential power at site 12HK 2.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	16,000	26,400
With ultimate use of river for irrigation	6,900	11,200	13,800	17,900

Site 12HK 3 (mile 135.7, sheet G): In a section extending from a point in the SE. ¼ sec. 29, T. 19 N., R. 4 W. Boise meridian, Idaho, to a point in the SE. ¼ sec. 16, T. 7 S., R. 48 E. Willamette meridian, Oreg., fairly compact basalt occurs on both sides of the river, and this section constitutes the best site observed between Huntington and the Ox Bow. The railroad passes the abutment on the Oregon side through two short tunnels. The basalt on the Idaho side seems particularly compact; on the Oregon side it is slightly seamed. The altitude of the water at low and high stages is 1,712 and 1,727 feet; that of the railroad is 1,756 feet. The width of the section at the water surface is 250 feet and at the 1,750-foot contour 430 feet. A dam 30 feet in height might be maintained without material interence with the railroad. Such a dam would back water 4 miles and would not interfere with other sites upstream.

Potential power at site 12HK 3.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	19,200	33,000
With ultimate use of river for irrigation	6,900	11,200	16,500	22,400

Site 12HK 4 (mile 123.2, sheet F): From a point in the NW. ¼ sec. 23, T. 20 N., R. 4 W. Boise meridian, Idaho, to a point in the NW. ¼ sec. 12, T. 6 S., R. 48 E. Willamette meridian, Oreg., rock crops out on both sides of the river. The rock appears to be badly seamed and fractured at the surface, and considerable would have to be removed before compact rock would be reached. The altitude of the water surface at low water is 1,620 feet; at ordinary high water, 1,635 feet; and at maximum high water, 1,650 feet. The width of the section at the water surface is 240 feet and at the 1,670-foot contour 520 feet. The head that can be developed at this site is limited by the altitude of the railroad at Homestead (about 1,680 feet) and by the tail water of the Ox Bow power plant. Water could be raised to an altitude of 1,670 feet and a head of 50 feet obtained.

Potential power at site 12HK 4.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	32,000	59,400
With ultimate use of river for irrigation	6,900	11,200	27,600	40,300

Site 12HK 5 (Nelson Creek site, mile 120.8, sheets F and J): At this site, which is on unsurveyed land 1 mile downstream from the boundary between Wallowa and Baker counties, Oreg., a survey was made on a scale of 1 inch = 200 feet, with a contour interval of 10 feet. (See map on sheet J.) The site was surveyed largely because of the narrow cross section. The side walls are but slightly fractured. On the Idaho side the rock slope breaks at about 70 feet above the water, and a grass-covered slope extends at an angle of 45° up several hundred feet to a nearly vertical rock face. The abutment on the Idaho side is apparently bedrock and not a slide, as it is apparently in many other places. The rock wall on the Oregon side extends at a uniform slope for several hundred feet. The altitude at low water is 1,607 feet; at ordinary high water, 1,622 feet; at maximum high water, about 1,630 feet. The head at the site is limited by the altitude of the railroad at Homestead and of the tailrace of the Ox Bow power plant. A head of 65 feet could be obtained without interference with either the railroad or the power plant, but such development would drown out site 12HK 4.

Potential power at site 12HK 5.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	41,600	79,200
With ultimate use of river for irrigation	6,900	11,200	35,900	53,800

Site 12HK 6 (mile 118.7, sheet F): This site lies between Spring Creek, on the Oregon side, and Eckels Gulch, on the Idaho side, and extends from a point in the SW. ¼ sec. 31, T. 21 N., R. 3 W. Boise meridian, Idaho, to a point on unsurveyed land in Oregon. Though the rock walls are badly seamed and fractured, a compact surface could be easily uncovered. The river is pooled and apparently is deep. The low-water altitude at the site is 1,595 feet. No detailed surveys were made here. The cross section ranges from 190 feet at the water surface to 430 feet at the 1,700-foot contour. Any development at this site should contemplate the full use of the river to the Ox Bow plant. A head of 75 feet can be obtained without interference with the railroad or the Ox Bow plant. Such a development would flood the valley to the 1,670-foot contour and drown out sites 12HK 4 and 12HK 5.

Potential power at site 12HK 6.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	48,000	92,400
With ultimate use of river for irrigation	6,900	11,200	41,400	62,700

Site 12HK 7 (Thirtytwo Point Creek site, mile 112.2, sheets F and J): This site extends from a point about 2,000 feet upstream from the mouth of Thirtytwo Point Creek on unsurveyed land. A survey was made of the site on a scale of 1 inch=400 feet. (See sheet J.) The side walls come fairly close together, and though they are badly seamed and fractured on the surface, a reasonable amount of excavation should uncover compact rock. The wall on the Idaho side is nearly vertical and appears more compact than the more sloping and broken Oregon wall. The altitude of low water is 1,520 feet and of high water about 1,556 feet. The water is pooled at the site by the obstruction that causes the Pine Tree Rapids, at the mouth of Thirtytwo Point Creek. The maximum head at this site is one that would flood the valley to an altitude of 1,670 feet, or a head of 150 feet. Such a development would drown out sites 12HK 4, 12HK 5, and 12HK 6, lying between this point and the Ox Bow plant.

Potential power at site 12HK 7.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	96,000	185,000
With ultimate use of river for irrigation	6,900	11,200	83,000	125,000

Site 12HK 8 (Granite Creek site, mile 101, sheet E): This site is about 2,500 feet upstream from the mouth of Granite Creek. The section extends from a point in sec. 12, T. 23 N., R. 3 W. Boise meridian, to a point in Oregon on unsurveyed land. The canyon wall on the Idaho side is massive and compact, but that on the Oregon side is broken and covered with slide rock, so that considerable excavation would be necessary to uncover a compact surface. This site was not surveyed. The cross section increases from 200 feet at the water surface to 1,000 feet at the 1,700-foot contour. The type of development will depend upon the head desired, which will depend in turn upon the cost of one high-head development as compared with two or more low-head developments. For the purpose of this report a high-head development is considered. The maximum head possible at the site without interference with the Ox Bow plant is 280 feet, which would drown out sites 12HK 4, 12HK 5, 12HK 6, and 12HK 7. The fall between sites 12HK 7 and this site is 130 feet, which should be the minimum head utilized.

Potential power at site 12HK 8, with a head of 280 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	179,000	356,000
With ultimate use of river for irrigation	6,900	11,200	154,000	242,000

Site 12HK 9 (mile 97.2, sheet E): This site is 6,000 feet upstream from the mouth of Saddle Creek and extends from a point in sec. 31, T. 24 N., R. 2 W. Boise meridian, Idaho, to a point on unsurveyed land in Oregon. The abutment on the Idaho side is a rock point about 175 feet high with a saddle about 140 feet high, which may be a slip and not bedrock. It will be necessary to make borings or geologic examinations to determine whether the Idaho side wall will provide satisfactory abutments. The wall on the Oregon side is little fractured. The altitude of low water at this site is 1,343 feet. No survey was made of the site. The cross section ranges from 275 feet at low water to 1,160 feet at the 1,700-foot contour. Any development at this site would drown out site 12HK 8, 4 miles upstream. Development to a head of 325 feet, backing the water to the Ox Bow plant, is assumed to be the most feasible, and the following estimates are based on this head.

Potential power at site 12HK 9, with a head of 325 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	208,000	415,000
With ultimate use of river for irrigation	6,900	11,200	180,000	280,000

Site 12HK 10 (Squaw Creek site, mile 95.7, sheets E and J): This site extends from a point in sec. 20, T. 24 N., R. 2 W. Boise meridian, Idaho, to a point on the Oregon side in unsurveyed land. It is at the head of a decided rapid, which may be caused by bedrock rather than by débris washed in by side drainage, and if this is true the site is worthy of special consideration, as it is the only rapid observed between Huntington and Lewiston where bedrock may be close to the water surface. This site has the further advantage that one-half the channel is out of water at low stages, thus facilitating the placing of foundations. The side walls, though seamed, are not openly fractured. The altitude of the water at low and medium stages is 1,320 and 1,352 feet. A survey was made of the site on a scale of 1 inch=400 feet. (See sheet J.) A head of 350 feet would flood the valley to the Ox Bow plant and drown out sites 12HK 4 to 12HK 9, inclusive.

Potential power at site 12HK 10, with a head of 350 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	224,000	450,000
With ultimate use of river for irrigation	6,900	11,200	193,000	305,000

Site 12HK 11 (Hominy Creek site, mile 83.5, sheet E). This site is 1,200 feet upstream from the mouth of Salt Creek and extends from a point in sec. 36, T. 26 N., R. 2 W. Boise meridian, Idaho, to a point on the Oregon side on unsurveyed land. At this locality the river makes a sharp bend to the west and back again. Although the section is wide and the rock on the Oregon side is badly broken up on the surface, it is possible that an earth and rock-filled dam could be constructed in the bend and flood water taken care of through tunnels driven about 2,000 feet through the solid rock point. The altitude of the water surface is about 1,197 feet; width at water surface, 600 feet; width at 1,700-foot contour, about 2,500 feet. A dam 475 feet high would back water to the Ox Bow plant.

Potential power at site 12HK 11.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q50	Q50
With present flow	8,000	16,500	304,000	608,000
With ultimate use of river for irrigation	6,900	11,200	262,000	412,000

Site 12HK 12 (Corral Creek site, mile 77.4, sheets D and J): A dike of gneissoid granite about 20 feet thick cuts through the older rocks at a point about 400 feet upstream from the line between secs. 4 and 9, T. 26 N., R. 1 W. Boise meridian, Idaho, and extends to a point in sec. 33, T. 2 N., R. 51 E. Willamette meridian, Oreg. The canyon walls on both sides rise nearly vertically a thousand feet or more above the surface of the water. The rock on both sides is fairly free from surface fractures, and it is believed that a very small amount of excavation would disclose bedrock that would be impervious under any head. A special survey of this site was made on a scale of 1 inch=400 feet. (See sheet J.) The altitude of the water surface is 1,145 feet. The width of cross section ranges from 300 feet at low water to 1,400 feet at the 1,700-foot contour. The size of development at this site may depend somewhat upon the scheme for developing power by means of a tunnel diverting water from Salmon River. (See power scheme 12JJ 1, p. 48.) If this tunnel is constructed without a diversion dam in Salmon River and the diverted water is used to augment the flow of the Snake, the altitude of the top of the dam would be about 1,586 feet, or 440 feet above low water. Such a development would leave about 80 feet of undeveloped head below the Ox Bow plant, which could be developed by means of site 12HK 5 or 12HK 6. If the water from Salmon River is diverted by means of a diversion dam and used to increase the flow of the Snake, the site could be developed to the 1,670-foot contour, creating a head of 540 feet. If the Salmon River tunnel project contemplates the direct diversion into water wheels on the Snake, the site may be developed up to a 540-foot head, provided the tailrace from the tunnel project is downstream from the Corral Creek site. The estimates of potential horsepower are based on the full development to a head of 540 feet without reference to the Salmon diversion scheme.

Potential power at site 12HK 12.

	Flow in second-feet.		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8, 000	16, 500	345, 000	700, 000
With ultimate use of river for irrigation	6, 900	11, 200	298, 000	475, 000

Site 12HK 13 (Imnaha River site, mile 52.7, sheet C): A special dam-site survey was made by engineers of the State of Oregon [3] from a point about 700 feet upstream from the mouth of Imnaha River, about on the line between sec. 25, T. 29 N., R. 4 W., and sec. 30, T. 29 N., R. 3 W., to a point in sec. 24, T. 4 N., R. 48 E. Willamette meridian, Oreg. The altitude of the water surface is 953 feet. The length of the dam at the water surface is 180 feet; at the 1,200-foot contour, about 943 feet. Detailed surveys and careful engineering investigation might show that it would be possible to discharge flood water into Imnaha River canyon near its mouth, or to use an overflow dam and place the power house in Imnaha Canyon. Development at this site should not be permitted to drown out the Corral Creek site (12HK 12); consequently the head is limited to about 190 feet.

Potential power at site 12HK 13, with a head of 190 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8, 000	16, 500	122, 000	238, 000
With ultimate use of river for irrigation	6, 900	11, 200	105, 000	161, 000

Site 12HN 1 (Mountain Sheep site, mile 50.7, sheets C and J): A special dam-site survey was made from a point immediately upstream from Mountain Sheep Creek, in sec. 23, T. 29 N., R. 4 W. Boise meridian, Idaho, to a point in sec. 11, T. 4 N., R. 48 E. Willamette meridian, Oreg. (See sheet J.) This section is typical of many sites from the mouth of Salmon River as far downstream as the mouth of Cottonwood Creek, in sec. 18, T. 30 N., R. 4 W. The rock walls

[3] Oregon's opportunity in national preparedness, State Engineer of Oregon, 1916.

have no open fractures and should withstand any pressure. It is possible that a better site might be found immediately above the mouth of Salmon River, into which flood water could be discharged through tunnels. Development in this stretch of the river would drown out the Imnaha site (12HK 13) but should not drown out the Corral Creek site (12HK 12). Consequently the head is limited to about 220 feet.

Potential power at site 12HN 1, with a head of 220 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	8,000	16,500	140,000	277,000
With ultimate use of river for irrigation	6,900	11,200	121,000	187,000

Site 12HN 2 (Coon Hollow site, mile 41.5, sheet C): A dam-site survey has been made by the Engineering Department of the State of Oregon[4] at a section immediately below Coon Hollow, extending from a point in sec. 18, T. 30 N., R. 4 W. Boise meridian, Idaho, to a point in Oregon on unsurveyed land. It is not believed to be better adapted for power development than many other sites below the mouth of Salmon River but probably was chosen because it marks the lower end of the narrow portion of the canyon. The rock at this site is of the older basaltic series and should hold against any pressure. The altitude of the water surface at low water and at extreme flood stage is about 872 and 920 feet. The width of the cross section ranges from 320 feet at the water surface to 760 feet at 1,100-foot contour. This site will probably be developed with a high dam, and if so, provision should be made for using the entire fall between the site and the Corral Creek site (12HK 12). If this method of development is followed a head of 260 feet can be obtained. Such a dam would back water up Salmon River to sec. 34, T. 31 N., R. 2 W. Boise meridian, Idaho.

Potential power at site 12HN 2, with a head of 260 feet.

	Flow (second-feet).		Horsepower.	
	Q90	Q50	Q90	Q50
With present flow	15,000	21,500	312,000	430,000
With ultimate use of river for irrigation	12,200	16,300	254,000	326,000

Salmon-Snake diversion scheme: In T. 26 N., Rs. 1 E. and 1 W. Boise meridian, Idaho, Snake and Salmon rivers are less than 8

[4] Oregon's opportunity in national preparedness, State Engineer of Oregon, 1916.

miles apart. The altitude of Salmon River is 465 feet higher than that of the Snake, and this head could be used for power development by driving a tunnel through the divide. During the season of 1920, in connection with the Snake River surveys, a survey of this divide was made on a scale of 2 inches = 1 mile. (See sheet I.)

The mountain slope [5] on the east side of the divide is almost completely mantled by angular rock fragments, so that bedrock can not be observed. The material is largely granitic. Observations along Salmon River and the presence of greenstone in the loose material indicate that the rocks on the Salmon side of the divide consist of greenstone intricately and irregularly intruded by fine-grained granite, and a tunnel would probably encounter these two kinds of rock alternately. On the Snake River side of the divide greenstone is thought to predominate with a few dikes of granite. The most suitable place for the outlet of a tunnel from Salmon River would be in either sec. 4 or sec. 9, T. 26 N., R. 1 W.. where the rock is largely greenstone with some intrusive granite.

During 1921 detailed surveys were made of sites for possible diversion dams at the mouth of Poodle Dog Creek (12JJ 1), in secs. 22 and 23, T. 26 N., R. 1 E., and at the mouth of Rhett Creek (12JJ 2), in sec. 2, T. 26 N., R. 1 E., and sec. 35, T. 27 N., R. 1 E.[6]

It is believed that the most feasible location for a tunnel would be between the mouth of Poodle Dog Creek on Salmon River and Corral Creek on Snake River. At the Poodle Dog site it would be possible either to construct a diversion dam about 1,000 feet above the mouth of Poodle Dog Creek and extend a canal or pipe line 1,300 feet long to the heading of the proposed tunnel, 300 feet below Poodle Dog Creek, or to construct a diversion dam below the tunnel heading and divert directly into the tunnel.

At the upper site the altitude of the water surface is 1,599 feet;[7] width, 302 feet. The altitude of the proposed headwater at this site is 1,692 feet, and the width 510 feet. At the lower site the altitude of the water surface is 1,595 feet; width, 344 feet. The altitude of the proposed headwater at this site is 1,692 feet, and the width 542 feet.

The next most feasible location for a diversion dam is immediately below Rhett Creek (12JJ 2). Salmon River at this point is paralleled by a new north-south State highway, which has been blasted out of solid rock on the right bank, at a height of about 45 feet above the water surface. The altitude of the water surface is 1,550 feet;

[5] From observations by A. C. Spencer, of the U. S. Geological Survey.

[6] Maps of dam sites on Salmon River are contained in a manuscript report entitled "Water-power resources of Salmon River," by W. G. Hoyt, copies of which are open for public inspection at the offices of the Geological Survey, Interior Department Building, Washington, D. C., and at 615 Idaho Building, Boise, Idaho.

[7] Corrected to correspond to sea level datum. Plan and profile maps of Salmon River as published in Water-Supply Paper 347 and included in manuscript reports are not based on sea level datum.

width, 311 feet. A diversion dam to raise the water to the 1,692-foot contour, the same as proposed for the diversion dam at Poodle Dog Creek, would contain nearly twice as much yardage as that at the Poodle Dog Creek site, besides flooding more of the highway; for this reason the estimate of potential power was based on the tunnel scheme with the tunnel heading at the Poodle Dog site.

The altitude of Salmon River is 1,600 feet (sea level datum); of Snake River, 1,145 feet; theoretical head, 465 feet. The horizontal distance at the 1,600-foot contour is 7.38 miles (39,000 feet). The following schemes of development are possible:

1. A low-head diversion dam in Salmon River without appreciably raising the water surface, a tunnel to Snake River, and a power house at the outlet of the tunnel.

2. A high diversion dam in Salmon River, a tunnel, and a power house on the Snake.

3 and 4. Either scheme 1 or scheme 2 with a dam in Snake River at Corral Creek raising the headwater to the altitude of the tunnel outlet, discharging the water diverted from Salmon River into the pond, and utilizing the flow of the Snake and the Salmon in one power house.

It is assumed that the tunnel should be designed to carry the flow available in Salmon River for 50 per cent of the time, or 5,300 second-feet. The horsepower that could be generated under the various schemes is set forth below:

Scheme 1. Low diversion dam and 39,000-foot tunnel:		
Altitude of low water in Salmon River	feet	1,600
Head loss in tunnel and diversion works	do	25
Altitude of low water in Snake River	do	1,145
Head	do	430
Flow 90 per cent of the time	second-feet	3,800
Flow 50 per cent of the time	do	5,300
Horsepower 90 per cent of the time		130,000
Horsepower 50 per cent of the time		183,000
Scheme 2. 100-foot diversion dam in Salmon River:		
Head	feet	530
Horsepower 90 per cent of the time		161,000
Horsepower 50 per cent of the time		225,000
Scheme 3. Low diversion dam on Salmon River, dam on Snake River creating head of 430 feet, combined flow:		
Flow 90 per cent of the time	second-feet	15,000
Flow 50 per cent of the time	do	21,500
Horsepower 90 per cent of the time		516,000
Horsepower 50 per cent of the time		730,000
Scheme 4. Diversion dam on Salmon River and dam on Snake River, creating a head of 530 feet, based on continual flow of Snake and Salmon rivers:		
Horsepower 90 per cent of the time		636,000
Horsepower 50 per cent of the time		910,000

The diversion of the water of Salmon River into Snake River would entirely destroy the power value of five excellent power sites on the Salmon between Whitebird and the mouth, at which 176,600 horsepower could be developed for 90 per cent of the time and 247,800 horsepower for 50 per cent of the time. On the assumption of a gradual growth of a market for power, the lower sites on Salmon River have characteristics that would seem to warrant their construction first. If, however, there should arise a market for a block of power exceeding 300,000 horsepower, the demand might be more cheaply met by the tunnel scheme than by the construction of a series of dams and power houses.

The diversion of water would very materially lower the cost of highway or railroad construction in the Salmon Valley below Whitebird, and the drying up of the channel for the greater part of the year would allow placer mining in a stretch of the river that is undoubtedly rich with gold.

If a market ever exists for over 600,000 continuous horsepower it could be met as described by the construction of the tunnel in connection with the full development of the Corral Creek site on Snake River (12HK 2), which would make possible the development, under one roof, of 636,000 horsepower for 90 per cent of the time and 910,000 horsepower for 50 per cent of the time.

The following table summarizes the estimates above given:

Estimates of power at undeveloped power sites on Snake River between Huntington, Oreg., and Lewiston, Idaho.

[Based on static head and over-all plant efficiency of 70 per cent.]

Site.	Distance upstream from Lewiston (miles).	Maximum head (feet).	With existing flow.				With regulated flow.			
			Discharge.		Horsepower. [a]		Discharge.		Horsepower. [a]	
			Q90	Q50	Q90	Q50	Q90	Q50	Q90	Q50
12HK 1	145.3	25	8,000	16,500	16,000	26,400	6,900	11,200	13,800	17,900
12HK 2	143.3	25	8,000	16,500	16,000	26,400	6,900	11,200	13,800	17,900
12HK 3	135.7	30	8,000	16,500	19,200	33,000	6,900	11,200	16,500	22,400
12HK 4	123.2	50	8,000	16,500	32,000	59,400	6,900	11,200	27,600	40,300
12HK 5	120.8	65	8,000	16,500	41,600	79,200	6,900	11,200	35,900	53,800
12HK 6	118.7	75	8,000	16,500	48,000	92,400	6,900	11,200	41,400	62,700
12HK 7	112.2	150	8,000	16,500	96,000	185,000	6,900	11,200	83,000	125,000
12HK 8	101.0	280	8,000	16,500	179,000	356,000	6,900	11,200	154,000	242,000
12HK 9	97.2	325	8,000	16,500	208,000	415,000	6,900	11,200	180,000	280,000
12HK 10	95.7	350	8,000	16,500	224,000	450,000	6,900	11,200	193,000	305,000
12HK 11	83.5	475	8,000	16,500	304,000	608,000	6,900	11,200	262,000	412,000
12HK 12	77.4	540	8,000	16,500	345,000	700,000	6,900	11,200	298,000	475,000
12HK 13	52.7	190	8,000	16,500	122,000	238,000	6,900	11,200	105,000	161,000
12HN 1	50.7	220	8,000	16,500	140,000	277,000	6,900	11,200	121,000	187,000
12HN 2	41.5	260	15,000	21,500	312,000	430,000	12,200	16,300	254,000	326,000
Salmon-Snake tunnel	77.4	530	3,800	5,300	161,000	225,000	3,800	5,300	161,000	225,000
					861,000	1,430,000			750,000	1,080,000

[a] Equivalent to 0.08 times the head times the discharge.

NOTE.—Total includes only those sites which will utilize full fall of river, namely, sites 12HK 1, one-half of 12HK 2, 12HK 3, 12HK 12, 12HN 2, and Salmon-Snake tunnel site with a 100-foot diversion dam in Salmon River.

The industrial development of the Northwest during the next few decades will no doubt be enormously increased. To keep pace with the demands for additional power, sites will have to be developed, and the sites at which power can be developed and delivered to the market most cheaply will naturally be developed first. There are sites on Columbia and Deschutes rivers at which larger blocks of power could be developed and which lie nearer the present market on the coast than those on the Snake. Near the Spokane market are sites on Clark Fork and Kootenai river. The power demands of Montana can possibly be met for years by development on Flathead River, and the upper Snake will be used to meet demands of southern Idaho. All these sites are nearer present markets than those on the lower section of Snake River between Homestead and Lewiston, and, other things being equal, they will probably be developed first. If, however, a new market should be made, or it is found that power can be developed and delivered from the sites on the Snake at a lower cost than from the other sites, their early development will naturally follow.