PRELIMINARY REPORT ON A WATER-POWER RECONNAISSANCE IN SOUTH-CENTRAL ALASKA.

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INTRODUCTION.

FIELD WORK AND ASSISTANCE.

A reconnaissance of the water supply of south-central Alaska with particular reference to water power was made by the writers in 1913. Field work began May 5 and was continued until November 25. The area covered extended from the Controller Bay region on the east to Kenai Peninsula on the west. The Copper River basin was studied in some detail as far north as Copper Center. Most of the important mining sections near Prince William Sound were visited and a hasty trip was made to the Willow Creek district.

This report is a brief preliminary statement of the data obtained and conclusions reached during the above reconnaissance. A more complete report giving the results in detail is now in preparation for publication as a water-supply paper.

It was beyond the scope of this investigation to visit all the streams in the different districts or to obtain sufficient data regarding their physical characteristics to make any accurate estimates of the amount of power that could be developed from them. It is hoped, however, that the results of this reconnaissance may form a basis for a more intelligent conception of the magnitude and distribution of the water powers in this portion of Alaska, for it is believed that they are now generally overestimated in the popular mind.

Special acknowledgments for gage readings and other services are due to the Copper River & Northwestern Railway Co., the Ellamar Mining Co., the Kennicott Mines Co., and Messrs. G. L. Banta, W. A. Dickey, S. M. Graff, Charles G. Hubbard, A. R. Ohman, C. I. Olsen, Herman Schmesar, and L. W. Storm.

METHODS OF INVESTIGATION.

The two features of a stream basin that control its water-power capacity are (1) the run-off and its variation throughout the year and (2) the head under which the water can be utilized at the wheels. A third feature, however, that will determine the practicability of the project on many Alaskan streams is the storage capacity that can be created above the point of diversion.

To determine the run-off from the basins studied measurements of discharge were made by a current meter, and where practicable gages were installed from which the elevation of the water surface was read at various intervals of time depending on the proximity of the observer. After making measurements of discharge at different gage heights the discharge at any gage height can be estimated by plotting the measurements on cross-section paper with discharges as abscissas and gage heights as ordinates and then drawing a curve through the plotted points. A rating table is then prepared showing the discharge for various gage heights. The reliability of this table depends on the accuracy of the discharge measurements and gage readings and also on the permanency of the stream channel. Where gage readings are not available the discharge is, of course, unknown except at the time of the engineer's visit, when discharge measurements were made. Such measurements are called miscellaneous and should be used with care in estimating the flow at other times, because of the rapid fluctuation that is characteristic of the streams. The records do not include the low-water season, which lasts from late in the fall until about the first of May.

The head in feet that can be obtained at the sites examined was determined either by aneroid barometer or from the following topographic maps:

Controller Bay region, scale 1: 62,500, contour interval 50 feet. (Price 35 cents.)
Chitina (reconnaissance), scale 1: 250,000, contour interval 200 feet. (Published in Bulletin 374.)
Nizina district, scale 1: 62,500, contour interval 50 feet. (Published in Bulletin 448.)
Valdez Bay and vicinity, scale 1: 62,500, contour interval 50 feet.
Ellamar and vicinity, scale 1: 62,500, contour interval 100 feet.
Kenai Peninsula (reconnaissance), scale 1: 250,000, contour interval 200 feet.
Willow Creek district, scale 1: 62,500, contour interval 100 feet.

It was entirely beyond the scope of this reconnaissance to determine the capacity of the reservoir sites. Lakes that might furnish natural storage were measured on existing maps, so far as they occur in surveyed areas. The areas of some lakes situated in unsurveyed districts were estimated merely by inspection and, of course, statements based on such estimates can be considered only roughly approximate.

No attempt was made to estimate the capacity of reservoirs that would be created by the construction of dams.

In the course of the reconnaissance the topography and rock formation at the outlet of lakes and other basins where it might be desirable to create storage reservoirs were hastily examined with reference to the possibility of constructing dams. Distances were measured by pacing where the sites were easily accessible; elsewhere they were estimated. Elevations were determined by hand level, by aneroid barometer, or by estimation.

Statements in this report relating to other physical features of the basins, such as forests, glaciers, general topography, and soil covering, are based either on actual observation by the writers or on information obtained from existing reports and maps prepared by other members of the Survey.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the run-off or discharge—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and discharge in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off (depth in inches) and acre-feet. The units used in this report are second-feet, second-feet per square mile, run-off (depth in inches), and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the following table of equivalents.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off (depth in inches)" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

An "acre-foot" is equivalent to 43,560 cubic feet and is the quantity required to cover an acre to the depth of 1 foot. The term is commonly used in connection with storage for irrigation work.

In the tables the column headed "Accuracy" shows the degree of reliability which the record of the mean monthly flow is believed to possess. "A" indicates that the mean monthly flow is probably accurate within 5 per cent, "B" within 10 per cent, "C" within 15 per cent, and "D" within 25 per cent. Special conditions are covered by the footnotes.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computation:

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 cubic foot of water weighs 62.5 pounds.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equals about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Second-feet} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

CLIMATE.

The climate within the area discussed in this report varies widely. Meteorologic data have been collected at many points in south-central Alaska, and some general conclusions can be drawn with considerable certainty. Most of the Weather Bureau stations, however, are situated near sea level, and the records are for that reason of considerably less value in estimating stream flow than they would be if the stations were situated where average conditions could be observed. The precipitation at the higher altitudes is believed to be much greater than at sea level, but no definite comparison can be made until observations have been made at the different elevations.

As most of the streams head in glaciers or perennial snows, temperature plays fully as important a part as precipitation in their discharge.

In the table below are summarized precipitation and temperature records at several localities in south-central Alaska. All the stations are near the coast except Copper Center, which is 70 miles inland from the head of Prince William Sound. The records show that the heaviest precipitation along the coast occurs during September, October, November, and December; farther inland the months of maximum precipitation are July, August, and September. The mean monthly temperature is below freezing for seven months in the year at Copper Center, and for four to six months on the coast. The average number of rainy days in a year is 63 at Copper Center, about 150 at Seward and Sunrise, from 150 to 200 at Valdez, and about 200 at Cordova and Katalla.

Records of snowfall are rather meager but indicate about 10 feet annually at Cordova, 12 feet at Valdez, 6 feet at Seward, and 3 feet at Copper Center. In the mountains the snowfall is much greater and accumulates in enormous drifts, which in sheltered spots last throughout the summer.

Summary of precipitation (inches) and temperature (°F.) at Weather Bureau stations in south-central Alaska.

Copper Center.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	0.57	0.46	0.17	0.07	0.39	0.86	1.56	1.12	1.13	0.96	0.76	0.74	8.79
Maximum temperature	49	49	49	64	80	96	87	87	80	66	49	50	....
Minimum temperature	−74	−55	−48	−26	18	22	22	20	3	−26	−46	−53	....
Mean temperature	−10.8	2.3	14.3	29.0	44.1	53.1	55.4	52.4	42.9	27.7	4.6	3.3	27.1

Cordova.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	9.86	9.23	8.82	9.80	9.84	6.67	6.30	11.69	19.91	20.21	11.47	13.97	137.77
Maximum temperature	47	58	61	70	72	80	86	80	84	72	60	49	....
Minimum temperature	2	4	1	15	28	34	33	40	31	26	11	5	....
Mean temperature	27.8	30.3	31.6	37.0	44.8	50.9	56.2	55.4	48.7	43.9	33.2	29.7	38.9

Fort Liscum.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	7.01	5.08	6.00	3.58	4.12	2.45	5.03	7.83	9.29	9.06	6.01	8.36	73.82
Maximum temperature	45	45	54	53	71	79	82	80	84	57	47	45	....
Minimum temperature	−14	−12	−8	2	25	30	32	30	17	10	0	−13	....
Mean temperature	20.7	21.8	26.1	27.8	41.8	49.8	52.0	50.1	44.9	35.8	29.1	23.9	35.2

Katalla.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	11.88	3.94	4.54	7.75	6.30	6.26	11.30	9.67	15.36	25.62	12.44	11.48	126.54
Maximum temperature	42	36	35	50	67	80	78	84	76	54	52	44	....
Minimum temperature	4	2	4	23	30	41	42	44	37	22	20	4	....
Mean temperature	19.0	23.5	23.1	35.8	44.2	50.0	55.0	59.4	52.0	41.7	34.4	32.0	39.2

Kenai.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	0.66	0.70	0.75	0.47	0.85	0.92	2.31	3.61	3.06	2.03	1.07	0.87	17.29

Seward.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	2.01	4.92	3.34	3.70	3.53	1.83	2.66	5.33	7.18	8.62	7.54	8.13	58.79
Maximum temperature	43	44	49	65	75	84	83	85	84	64	49	45	....
Minimum temperature	−11	−12	−7	10	26	32	40	33	27	11	9	−10	....
Mean temperature	19.0	27.0	31.3	36.5	43.5	45.8	54.1	54.4	48.7	39.0	31.1	25.8	39.5

Summary of precipitation (inches) and temperature (°F.) at Weather Bureau stations in south-central Alaska—Continued.

Sunrise.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	2.44	2.70	1.78	2.74	1.95	1.04	2.00	2.98	3.34	4.67	4.30	4.21	34.15
Maximum temperature	44	57	58	60	76	79	76	78	72	59	51	48	....
Minimum temperature	−29	−27	−23	−4	23	27	34	28	17	2	−15	−26	....
Mean temperature	10.4	19.4	24.9	33.0	43.1	49.8	53.6	51.6	44.3	34.1	22.6	17.7	33.5

Valdez.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	4.16	6.03	5.49	2.21	3.60	1.75	3.72	4.32	9.08	5.59	2.69	8.99	57.63
Maximum temperature	38	49	58	59	74	91	82	76	79	61	47	49	....
Minimum temperature	−27	−25	−9	−1	22	33	38	31	22	5	−3	−21	....
Mean temperature	11.5	18.6	25.3	35.2	45.2	53.4	57.0	58.3	48.9	36.2	25.2	18.5	36.1

CONTROLLER BAY REGION.

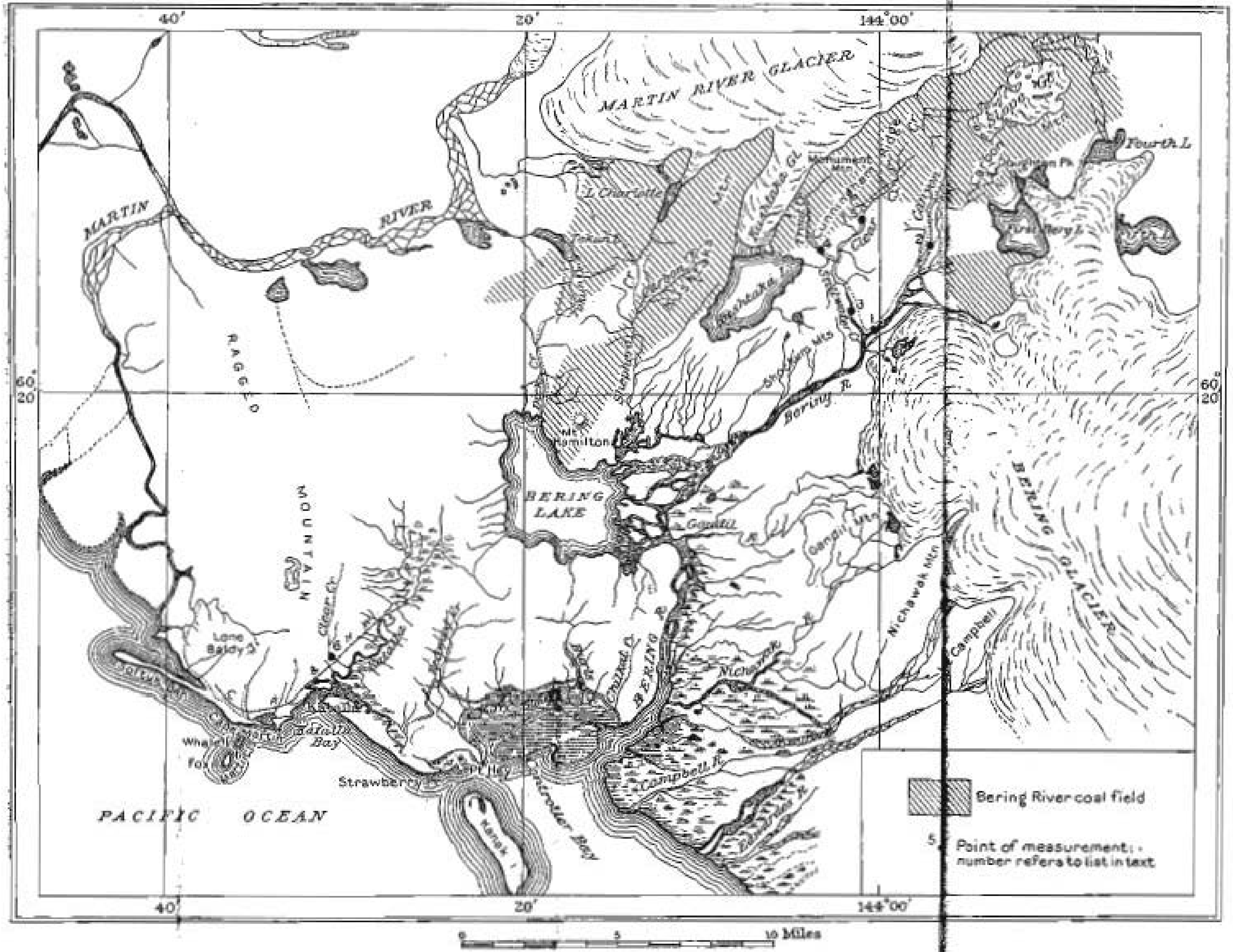
GENERAL FEATURES.

The Controller Bay region (see Pl. V) occupies an area of about 500 square miles, bounded by the Chugach Mountains on the north, Bering Glacier on the east, the Pacific Ocean on the south, and the Copper River delta on the west. The region is exceedingly varied in topography. It is made up of southern spurs from the Chugach Mountains and isolated peaks to the south ranging from 1,000 to 3,000 feet high, with many low swampy areas and numerous lakes.

Katalla, the post office and commercial center for the entire region, is situated on the north shore of Katalla Bay about 10 miles east of Controller Bay. Supplies are landed by small launches from ocean-going vessels, which anchor about half a mile from the shore. Katalla is one of the proposed outlets for the Bering River coal fields, which lie from 20 to 30 miles northeast of the town. There are also two producing oil wells tributary to Katalla.

But few data are available regarding the climate of this region. (See p. 158.) The yearly precipitation probably averages over 100 inches, with a rather heavy snowfall. The summers are cool and cloudy and the winters are moderate.

Spruce and hemlock are the principal trees. They occur in heavy stands and reach diameters of 2 to 3 feet. The best timber lies along the foothills below an elevation of 1,000 feet. The United States Forest Service makes an approximate estimate of 2,130,000,000 feet board measure for the stands on Ragged Mountain and in the vicinity of Martin River and Bering Lake.



MAP OF THE CONTROLLER BAY REGION.

STREAM FLOW.

MEASURING POINTS.

The following list gives the locations at which discharge measurements were made in 1913 in the Controller Bay region. The numbers refer to Plate V:

1. Bering River above Stillwater Creek.
2. Canyon Creek at mouth.
3. Stillwater Creek 1 mile above mouth.
4. Trout Creek one-fourth mile above mouth.
5. Clear Creek at Cunningham's camp.
6. Clear Creek near Katalla.

MISCELLANEOUS MEASUREMENTS.

No daily records of stream flow have been kept in the Controller Bay region. Several miscellaneous measurements that were made in 1913 are listed in the following table:

Miscellaneous measurements in Controller Bay region in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
July 11	Bering River	Controller Bay	Above Stillwater Creek.	3,950		
11	Canyon Creek	Bering River	Mouth	179		
11	Stillwater Creek	do	1 mile above mouth	858		
11	Trout Creek	Stillwater Creek	¼ mile above mouth	126	2.3	5.48
11	Clear Creek	do	Cunningham's camp	37	6.3	5.87
13	do	Katalla River	1 mile above mouth	151	6.8	22.1

WATER POWER.

Bering River is the principal stream in the Controller Bay region. It and its tributaries drain the western part of the area in which the coal fields are located. The run-off is derived largely from the Bering River and Martin River glaciers.

The principal water-power sites in this region are on Bering River at the outlet of First Berg Lake and Stillwater Creek at Kushtaka Lake outlet. At the former site a head of about 650 feet could be obtained by carrying water from First Berg Lake through Carbon Mountain in a tunnel about a mile in length. From a measurement made on July 11, 1913, it is estimated that the discharge at the outlet of the lake on that date was about 3,000 second-feet. A flow of 3,000 second-feet with an efficiency of 70 per cent at the wheel would develop 155,000 horsepower. The measurement mentioned was made in the season of maximum run-off, and as no winter records are available it is difficult to estimate the amount of power that could be developed during that season; but inasmuch as with the head available (650 feet) over 5,000 horsepower could be produced for every 100 second-feet of discharge, it seems reasonable to predict that by drawing on storage from the lake, 5,000 to 10,000 horsepower could be produced throughout the year.

Kushtaka Lake has an area of 4.7 square miles. Its level could be raised from 20 to 30 feet by a dam at the outlet, thus obtaining a storage capacity of 60,000 to 90,000 acre-feet. A fall of at least 35 feet below the normal lake level could be obtained by carrying the water in a pressure pipe for a distance of about 1 mile. Under that head, with an efficiency of 70 per cent, about 275 horsepower could be realized at the wheel for every 100 second-feet of discharge. The only information regarding the flow consists of the one discharge measurement listed in the table. Considering the storage that could be created it is estimated that from 500 to 1,000 horsepower could be developed at minimum flow in the winter and from 1,000 to 2,000 horsepower from May until October.

A few hundred horsepower could probably be developed on some of the smaller streams for five or six months in the year, but it is doubtful if sufficient storage could be created to make possible the development of more than very small power in the winter.

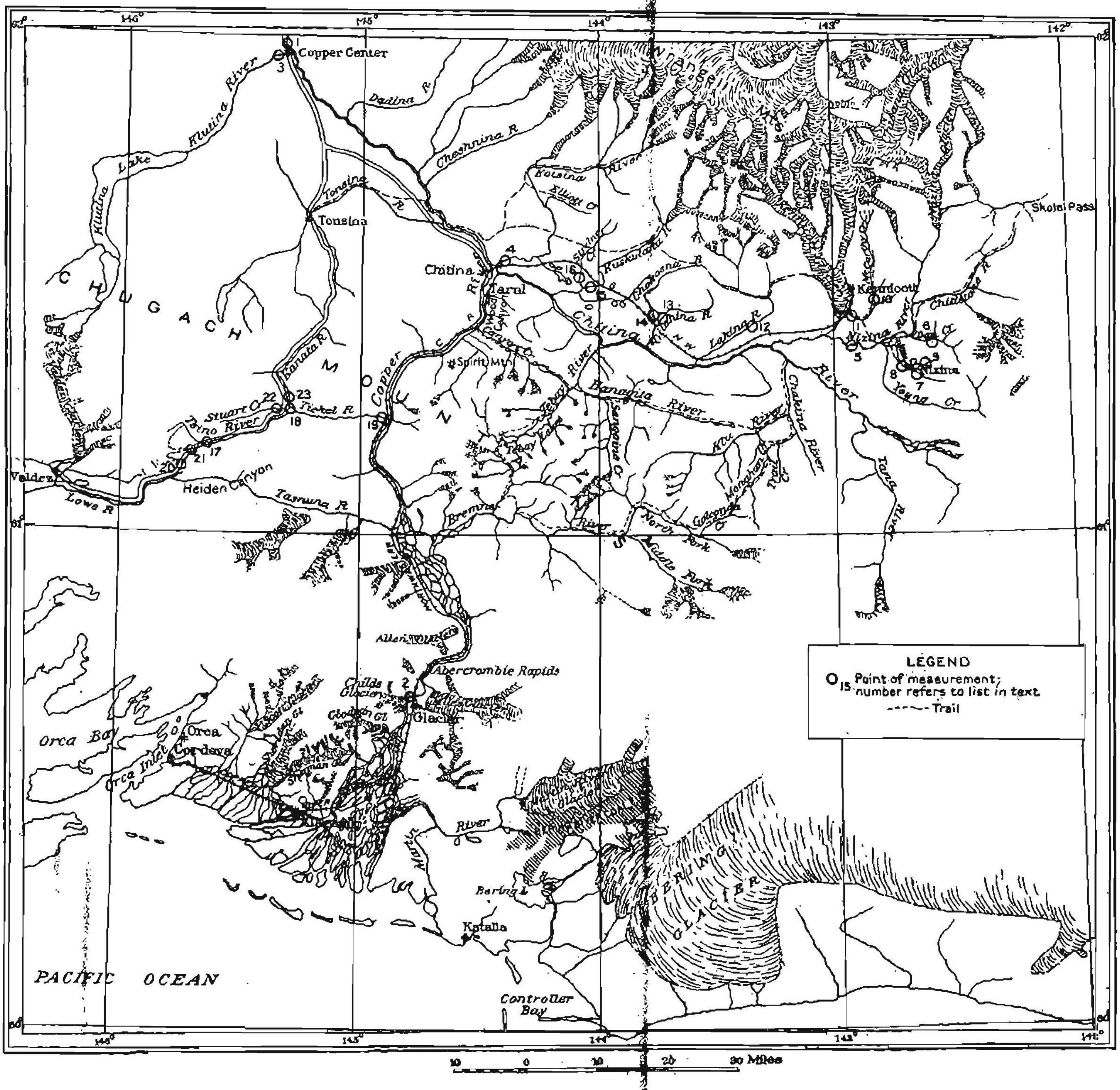
The only market that can be foreseen for these powers is the energy that will eventually be required in connection with the mining of the coal beds. Coal of good quality will then be available at a comparatively low cost, and the poorer coal that would not be suitable for the open market will offer a fuel for local power development so cheap that water power will have to be produced in the most economical manner if it is to become a successful competitor.

COPPER RIVER DRAINAGE BASIN.

GENERAL FEATURES.

The Copper River drainage basin, which contains valuable gold and copper deposits, occupies an area of about 23,000 square miles in the southeast corner of the main body of Alaska. (See Pl. VI.) It may be divided into four physiographic provinces—the Chugach Mountains on the south, the Wrangell Mountains on the east, the Alaskà Range to the north, and the Copper River Plateau on the west.

Copper River rises in Copper Glacier, on the north slope of the Wrangell Mountains, and enters the Pacific Ocean about 150 miles (in an air line) to the south. Its principal tributaries, named in downstream order, are Slana, Chistochina, Gakona, Gulkana, Tazlina, Klutina, Tonsina, Tiekel, and Tasnuna rivers from the north and west, and Sanford, Klawasi, Nadina, Dadina, Chetaslina, Cheshnina, Kotsina, Chitina, and Bremner rivers from the east.



MAP OF THE COPPER RIVER BASIN.

The source of the Copper is at an elevation of about 3,600 feet, making an average gradient for its entire course of about 12 feet to the mile. From Copper Center to the ocean there is a total fall of 1,000 feet, giving a mean fall of about 6.7 feet to the mile.

The topography of the basin is decidedly varied. The Wrangell Mountains occupy the northeastern portion of the basin and form its most conspicuous feature. The most prominent summits are Mount Sanford (16,208 feet), Mount Blackburn (16,140 feet), Mount Wrangell (14,905 feet), Mount Regal (13,400 feet), and Mount Drum (12,000 feet). The range is covered with a connected system of glaciers whose tentacle-like arms spread out from the many peaks and reach down at numerous points to elevations of 4,000 to 1,500 feet.

Within the plateau region, which it enters about 65 miles from its source, the Copper and its tributaries have cut deep channels varying from a few feet to 500 or 600 feet below the general plateau level. The plateau is made up largely of sand, gravel, and clay.

Soon after leaving the plateau region the Copper enters the Chugach Range and for the remainder of its course the flood plain reaches to steep mountain slopes on either side.

Chitina River, the largest tributary of the Copper, drains an area of 6,260 square miles. It rises in the St. Elias Range near the international boundary and flows northwestward for over 100 miles to the Copper. The largest tributaries of the Chitina enter from the north and emanate principally from the south slope of the Wrangell Mountains. Named in order downstream they are Nizina, Lakina, Gilahina, and Kuskulana rivers. The Chitina basin is bounded on the south by the Chugach Mountains, from which the main affluents are Tana, Chakina, and Tebay rivers.

The Copper River basin lies within two distinct climatic provinces. The northern part, including the Chitina River basin, though south of the Alaskan Range is similar to the interior region of Alaska, being separated from the Pacific coast province by the Chugach Mountains. The climate is characterized by a low precipitation of both rain and snow. The summers are pleasant with moderate temperatures and many clear days. The winters are nearly as rigorous as those of the Yukon basin farther north.

Below Chitina River the Copper traverses the Chugach Range and passes through rapidly changing climatic conditions. The precipitation increases, with heavy rainfall and many cloudy days in the summer and deep snow in the winter. The range in temperature is not nearly as great as in the upper basin.

The Copper River basin as a whole is but poorly timbered. Spruce is the principal species and occurs up to an altitude of 3,000 feet. Most of it is small and scrubby, though small stands of trees reaching diameters of 2 feet occur here and there along the Chitina and some of the tributaries of the Copper within the plateau region. There is practically no timber of commercial value along the Copper River valley below Chitina. Between Cordova and the delta of the Copper, near Eyak Lake, Eyak River, and Sheridan Glacier, there are good stands of spruce and hemlock which are estimated by the Forest Service to contain a total of 425,000,000 to 635,000,000 feet board measure.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1913 in the Copper River basin. The numbers refer to Plate VI.

1. Copper River at Copper Center.
2. Copper River at Miles Glacier.
3. Klutina River at Copper Center.
4. Kotsina River near mouth.
5. Nizina River above Kennicott River.
6. Dan Creek above hydraulic plant.
7. White Creek above Jolly Gulch.
8. Chititu Creek below Rex Creek.
9. Rex Creek above hydraulic plant.
10. McCarthy Creek above Nikolai Creek.
11. McCarthy Creek near McCarthy.
12. Lakina River at railroad crossing.
13. Gilahina River at railroad crossing.
14. Chokosna River at railroad crossing.
15. Kuskulana River at railroad crossing.
16. Strelna Creek at railroad crossing.
17. Tsina River below Ptarmigan Creek.
18. Tsina River at mouth.
19. Tiekel River at mouth.
20. Ptarmigan Creek at upper canyon.
21. Ptarmigan Creek at lower canyon.
22. Stuart Creek at mouth.
23. Kanata River at mouth.

DAILY RECORDS.

Daily gage height, in feet, and turbidity (silica parts per million) of Copper River near Copper Center, Alaska, in 1913.

Day.	June.	July.		August.		September.		October.		November.	
	Gage height.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.
1		17.6		19.5	1,500	15.2	350	14.3	150	13.0	120
2		17.4		18.7	1,500	15.0	250	14.3	110	13.0	130
3		17.4		18.1	1,500	15.0	180	14.2	150	13.0	130
4		17.6		17.6	800	14.8	200	14.2	110	12.8	130
5		18.0		17.4	800	14.7	200	14.1	130	12.8	120
6		18.6	1,500	17.3	500	14.6	180	14.0	130	12.8	120
7		18.5	900	17.2	800	14.5	180	14.0	130	12.8	110
8		18.4	800	17.0	800	14.4	200	13.8	130	12.7	110
9		18.1	600	16.8	600	14.3	180	13.6	130	12.6	110
10		17.8	600	16.7	500	14.2	180	13.6	130	12.6	110
11		17.8	600	16.6	800	14.1	180	13.4	110	12.6	100
12		17.6	500	16.3	500	14.0	180	13.3	110	12.6	100
13		17.4	350	16.2	500	14.0	180	13.4	110	12.6	85
14		17.3	400	16.2	500	13.9	180	13.6	130	12.7	95
15		17.3	400	16.1	800	13.9	110	14.0	130	12.8	85
16		17.4	500	15.9	600	13.9	100	13.8	150	12.7	85
17		17.2	500	15.8	500	13.8	110	13.7	150	12.6	100
18	16.7	17.0	500	15.6	500	13.8	110	13.6	150	12.8	95
19	17.0	16.9	350	15.6	500	13.7	130	13.4	150	12.6	100
20	17.0	16.5	300	15.8	350	13.7	100	13.6	150	12.5	95
21	16.8	16.5	400	16.0	500	13.7	100	13.5	150	12.5	95
22	16.7	16.4	300	16.1	800	13.7	100	13.5	130	12.5	80
23	17.0	16.6	350	16.0	800	13.7	120	13.5	130	12.5	85
24	17.8	16.8	350	16.2	800	14.0	110	13.4	130	12.6	80
25	18.1	17.3	400	16.5	800	14.4	150	13.2	130	12.6	85
26	18.0	18.4	1,500	16.7	800	14.5	250	13.3	120	12.5	85
27	18.1	19.0	3,000	16.6	600	14.4	200	13.2	120	12.6	80
28	17.7	19.8	3,000	16.5	500	14.4	110	13.0	120	12.8	75
29	17.9	20.4	3,000	16.1	500	14.4	200	13.0	120	12.8	90
30	17.8	20.2	3,000	15.8	350	14.3	150	12.9	120	13.0	95
31		20.1	3,000	15.6	250			13.0	150		

Daily discharge, in second-feet, of Copper River at Miles Glacier for 1913.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		186,000	142,000		40,100		16		216,000	78,700			
2				70,400			17				44,000		
3		197,000					18						
4					27,500		19			70,400	43,200		
5							20		128,000				
6		179,000	106,000	50,000			21				47,200		
7					27,500		22		127,000				
8		198,000					23		117,000	98,600	114,000		
9				40,100			24						
10		178,000					25				139,000		
11			113,000				26		142,000				
12						17,400	28		152,000	174,000			
13							28						
14							29	205,000	178,000		106,000		
15		192,000	82,600				30	208,000					
							31			82,600			

Daily discharge, in second-feet, of Klutina River and McCarthy Creek for 1913.

Day.	Klutina River at Copper Center. (Drainage area, 1,040 square miles.)					McCarthy Creek near McCarthy. (Drainage area, 71 square miles.)						
	June.	July.	Aug.	Sept.	Oct.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	......	7,300	3,960	3,160	2,070	......	......	427	170	91	170	......
2	......	7,060	3,960	2,860	2,070	......	......	485	174	90	154	......
3	......	7,060	3,720	2,770	2,010	......	......	495	210	91	139	37
4	......	6,820	3,720	2,510	1,950	......	......	544	210	84	93	......
5	......	6,820	3,720	2,430	1,950	......	......	544	226	83	76	24
6	......	6,820	3,720	2,280	1,830	......	......	465	437	......	91	......
7	......	6,820	3,720	2,200	1,720	......	......	437	362	......	76	......
8	......	7,300	3,720	2,070	1,720	......	539	344	418	......	44	......
9	......	7,300	3,600	1,950	1,580	......	519	326	451	......	76	......
10	......	6,820	3,720	1,830	1,440	......	389	282	380	......	37	......
11	......	6,820	3,720	1,830	1,350	......	353	250	226	......	37	......
12	......	6,820	3,840	1,780	1,350	......	418	218	218	......	37	......
13	......	6,820	3,840	1,720	1,310	......	654	242	210	......	......	......
14	......	6,820	3,720	1,620	1,270	......	700	266	154	......	......	......
15	......	6,820	3,720	1,620	1,200	......	684	254	145	......	......	......
16	......	6,600	3,490	1,580	1,170	......	654	230	151	......	......	......
17	4,660	6,370	3,270	1,530	1,170	......	564	238	151	......	......	......
18	4,660	6,160	3,160	1,480	1,140	......	664	202	170	......	......	......
19	4,820	5,750	3,060	1,480	1,140	......	798	151	174	......	......	......
20	5,000	5,550	3,060	1,440	1,140	......	504	134	158	......	......	......
21	5,000	5,360	3,060	1,400	1,140	......	634	145	186	61	......	......
22	5,000	5,170	3,060	1,350	1,140	......	669	206	186	63	......	......
23	5,170	5,000	3,060	1,620	1,140	......	777	206	202	480	......	......
24	5,170	4,820	3,270	1,830	1,140	......	876	250	170	624	......	......
25	5,550	4,820	3,380	1,890	1,140	......	644	226	167	485	......	......
26	5,950	4,820	3,490	2,070	1,140	......	609	258	158	451	......	......
27	6,820	4,820	3,490	2,070	1,140	......	574	437	161	290	......	......
28	7,060	4,820	3,600	2,140	1,140	......	504	242	158	......	......	......
29	7,300	4,510	3,490	2,140	1,010	191	519	246	151	574	......	......
30	7,300	4,090	3,490	2,140	1,080	......	446	226	97	210	......	......
31	......	3,960	3,380	......	1,050	......	......	186	97	......	......	......
Mean	5,680	6,030	3,520	1,960	1,390	......	595	296	211	......	85.8	......
Mean per square mile	5.46	5.80	3.39	1.88	1.34	......	8.38	4.17	2.97	......	1.21	......
Run-off (depth in inches on drainage area)	2.84	6.69	3.91	2.10	1.54	......	7.17	4.81	3.42	......	.54	......
Accuracy	C	C	C	C	D	......	A	A	A	......	A	......

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements in Copper River drainage basin in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Nov. 9	Kotsina River	Copper River	Near mouth	200	447	0.45
Nov. —	Nizina River	Chitina River	Above Kennicott River.	492	865	.57
May 31	Dan Creek	Nizina River	Above hydraulic plant.	37	40	.92
June 1	While Creek	Chititu Creek	Above Jolly Gulch	14.1	9.4	1.50
3	Chititu Creek	Nizina River	Below Rex Creek	53	24	2.21
3	Rex Creek	Chititu Creek	Above hydraulic plant.	18.4	9.5	1.94
Nov. 5	McCarthy Creek	Kennicott River	Above Nikolai Creek.	21	48	.44
June 9	Lakina River	Chitina River	Railroad crossing	a 1,750	124	14.11
Oct. 3	do	do	do	22[illegible]	124	1.81
31	do	do	do	99	124	.80
June 10	Gilahina River	do	do	212	56	3.79
Oct. 2	do	do	do	81	56	1.45
June 10	Chokosna River	Gilahina River	do	241	43	5.62
11	do	do	do	172	43	4.[illegible]
Oct. 1	do	do	do	69	43	1.60
May 23	Kuskulana River	Chitina River	do	145	221	.66
June 11	do	do	do	603	221	2.73
Oct. 1	do	do	do	b 500	221	2.26
Nov. 7	do	do	do	130	221	.59
June 11	Strelna Creek	Kuskulana River	do	46	25	1.84
27	do	do	do	55	25	2.20
Sept. 30	do	do	do	24	25	.96
Nov. 6	do	do	do	3.3	25	.13
Oct. 20	Tsina River	Tiekel River	Below Ptarmigan Creek.	87		
Nov. 9	do	do	do	50		
10	do	do	Mouth	134	161	.83
June 13	Tiekel River	Copper River	do	5,820	408	14.3
July 1	do	do	do	8,480	408	20.8
Sept. 10	do	do	do	819	408	2.01
Oct. 17	Ptarmigan Creek	Tsina River	Below lake at head of upper canyon.	11.9	7.7	1.55
Nov. 8	do	do	do	2.8	7.7	.36
Oct. 18	do	do	2 miles above mouth at head of lower canyon.	22	16	1.38
Nov. 11	do	do	do	23	16	1.44
Oct. 19	Stuart Creek	do	Mouth	14.8		
Nov. 10	do	do	do	8		
Oct. 19	Kanata River	Tiekel River	do	146	175	.83
Nov. 10	do	do	do	69	175	.39
July 26	Salmon Creek	Alaganik Slough	Below forks c	119		

a Float measurement. b Estimated. c See Pl. V.

WATER POWER.

The topography of the Copper River basin is in many respects favorable for the development of water power. The Wrangell and Chugach mountains give a heavy grade and many waterfalls to the streams emanating from them. They also contribute a heavy stream flow in the summer due to the melting of glaciers and accumulated snow banks from the previous winter. Natural storage sites in the form of lakes and ponds are not numerous, however, nor is the opportunity for the creation of large storage basins by dams particularly favorable.

In the winter the run-off becomes very low and it is doubtful if north of the Chugach Range the development of water power will be found practicable during that season. It is difficult without more data to make even an approximate statement regarding the period during which the flow of the streams and the temperature would permit the operation of a power plant in that region, but from the best information available it appears that the extreme limits of time for the successful operation of such a plant would be from about the first of May until the first of December. The same limits of operating time would also probably apply to the tributaries of the lower Copper unless considerable storage could be obtained.

The most natural sites for power development on the main Copper River are at Wood Canyon, about 6 miles below the Chitina, and at Abercrombie Rapids, about 10 miles above the delta. A head of 40 to 50 feet could probably be obtained at each locality, thus affording opportunity for producing between 4,500 and 5,700 theoretical horsepower for each 1,000 second-feet of flow. The lowest flow measured in 1913 at the gaging station at Miles Glacier bridge was 17,400 second-feet on November 12. That probably represented the minimum flow since about the middle of May of that year. The discharge at Wood Canyon on the same date was probably about 15,000 second-feet, as the drainage area here is about 15 per cent less than at the measuring section. The only inflow of consequence between the rapids and the measuring section is that from Miles Glacier. Both sites would be expensive to develop, and silt and ice would introduce serious operating problems. At the rapids the river is flanked on the east side by a moraine which might render the construction of stable headworks particularly difficult.

In the Chitina River basin good dam sites occur on many of the tributaries. Nizina and Kuskulana rivers flow through rock canyons in their lower stretches. It is estimated that 4,000 to 5,000 horsepower could be developed on the Nizina and at least 1,000 horsepower on the Kuskulana. Both sites would require high masonry dams, and provision would have to be made for passing immense quantities of silt, sand, and gravel. Power could be developed on McCarthy Creek and Lakina River by diverting the water to a conduit and carrying it down the valley a sufficient distance to obtain the desired pressure. McCarthy Creek has an average grade of about 100 feet to the mile and the Lakina about 70 feet to the mile. It is estimated that for each 100 feet fall at least 150 horsepower could be developed on the former stream and 500 horsepower on the latter. Tebay River falls over 1,000 feet between the Hanagita Valley and the Chitina, a distance of about 6 miles. There are several lakes in the headwater region which might afford considerable storage, but no measurements of flow have been made on the Tebay. Many smaller tributaries of the Chitina afford opportunity for the development of a few hundred horsepower.

Kotsina River and other branches of the Copper that head in the Wrangell Mountains also afford favorable sites for power development.

Klutina River has a grade of about 30 feet to the mile in its lower course. Its flow is regulated to a remarkable degree by Klutina Lake, which has an area of 51 square miles. The discharge on October 31, 1913 (see p. 166), was sufficient to develop about 80 horsepower for each foot of fall.

Of the lower Copper River tributaries the Tiekel is perhaps the principal power stream. It is formed by the union of Tsina and Kanata rivers. Between the forks and the Copper, a distance of about 15 miles, it falls about 750 feet. The flow on September 10, 1913, was sufficient to produce about 65 horsepower for each foot of fall. Natural dam sites occur on the Tsina. On Ptarmigan Creek, which is a tributary of the Tsina, there is a particularly favorable site at falls near the mouth for the development of a few hundred horsepower.

Besides the Tiekel there are many smaller branches of the Copper that flow from the Chugach Mountains on which power could be developed, but no measurements of flow have been made on these streams.

All stream-flow data that are available for this basin are shown in the tables already given. The estimates of power capacities are based on meager information and should be considered only roughly approximate. They apply only to the period from the beginning of the open season in May until about the first of November. As previously stated, it is doubtful if it would be practical to use water power in this basin after the first of December at the latest.

In the mountainous regions the transmission of electricity would be very difficult and expensive because of the heavy snowfall and steep, rocky slopes. High winds prevail in the lower Copper River valley and in many of the tributary valleys during much of the winter.

Most of the tributaries of the Copper head in glaciers and during the summer carry large quantities of sand and silt, which must be provided for in the construction of dams.

At the present time, with coal costing \$8 to \$12 or more a ton at the coast and crude oil at \$2 a barrel, hydroelectric power would probably be much cheaper than steam, even though the plant could be operated but six or seven months in the year, but in view of the many difficulties in the way of developing water power, such as the short season and consequent necessity for auxiliary steam power, the great variation in stream flow, the costs of transmission, and the presence of silt and ice, it does not seem probable that large water-power plants will have much advantage over steam plants if the cost of fuel is reduced to as low a figure as should be expected when the Bering River coal fields are opened. In inaccessible regions where the costs of transportation would make fuel unduly expensive the small water powers will no doubt be of considerable value if energy is there needed for mining or other purposes.

PRINCE WILLIAM SOUND REGION.

GENERAL FEATURES.

Prince William Sound (see Pl. VII) is an irregular-shaped bay reaching northward from the head of the Gulf of Alaska. Along its shores there are gold and copper mines. The sound extends from Cordova on the east to the head of Passage Canal on the west, a distance of 102 miles. In a north-south direction it reaches from the head of College Fiord to the lower end of Montague Island, a distance of 104 miles. The entrance to the sound lies between Hinchinbrook and Montague islands. The shore line is broken by a succession of fiords, bays, and inlets, and many islands are scattered about the sound, particularly in its western part.

The topography of the mainland is particularly rugged. The coast is rocky and precipitous and rises rapidly to the summit of the Chugach Mountains, which nearly encircle the sound. Most of the higher valleys are occupied by glaciers, many of which extend down to sea level. The peaks near the coast are mostly from 2,000 to 5,000 feet in elevation. Farther north, toward the axis of the range, they reach altitudes of over 10,000 feet.

Grant and Higgins [1] state that "the topography of Prince William Sound is that of a maturely eroded mountainous district with the forms of river erosion modified by ice erosion. Into such a district the sea has come, filling the main basin of the sound and extending far up the valleys that lead into it."

The streams entering the sound drain small areas, and most of them are only from 1 to 5 miles long. Lowe River is probably the largest. It is 30 miles long and drains an area of less than 200 square miles. Practically without exception the streams rise in snow fields and glaciers. Their flow is subject to wide variations from summer to winter. The rapid melting of the glaciers and snow banks, together with a heavy rainfall in the summer, produces high rates of run-off. In the fall and winter the flow from the accumulated ice and snow in the mountains rapidly decreases, and the precipitation comes mostly in the form of snow. There is some rainfall and melting of snow during the winter, but the winter flow probably depends largely on the draining of underground channels. The prevailing rock forma-

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 15, 1910.

tion is slate and graywacke with only a thin covering of soil and other loose material. The opportunity for underground storage is therefore likely to be slight, and such sources would as a rule become quickly exhausted as soon as the inflow from the surface was cut off by low temperature.

The mainland shores and most of the islands of Prince William Sound are generally covered with a thick growth of trees up to elevations of 1,000 feet or more. Spruce is the prevailing growth and some of it is of a size and quality to produce a good grade of sawed lumber. Much of it, however, is stunted and of an inferior quality. The United States Forest Service estimates that there is nearly 3,500,000,000 feet board measure of timber in the Prince William Sound region.

The principal use of the timber resources of this region will probably be for the production of wood pulp. The timber is said to be suitable for that purpose, and the possibilities for the successful introduction of the pulp industry have been considered, but so far as is known steps have not yet been taken toward the construction of mills. The manufacture of wood pulp has recently been commenced in southeastern Alaska where one small mill was being erected in the summer of 1913, and reports indicate that the extent of such operations will be increased in the near future.

The forests of Prince William Sound are all included in the Chugach National Forest, which is under the control of the Forest Service of the United States Department of Agriculture. The local administration of this forest is in charge of the forest supervisor at Ketchikan, who has a suboffice at Cordova. Such timber as it is considered advisable to cut within the forest will be sold by the Forest Service at a price not less than the appraised value. Lots exceeding $100 in value must be advertised for 30 days and sold to the highest bidder.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams tributary to Prince William Sound in 1913. The numbers refer to Plate VII.

1. Salmon Creek below forks.[1]
2. Power Creek near Cordova.[2]
3. Humpback Creek near Cordova.
4. Snyder Falls Creek at mouth.
5. Wesley Falls Creek at elevation 600 feet.
6. Parsons Falls Creek at mouth.
7. Robinson Falls Creek at mouth.
8. Unnamed stream tributary to Sheep Bay.
9. Unnamed stream tributary to Port Fidalgo.
10. Unnamed stream tributary to Fish Bay.
11. Unnamed stream tributary to Fish Bay.
12. Chisna Creek at mouth.
13. Horsetail Falls Creek at mouth.
14. Lagoon Creek at mouth.
15. Reynolds Creek at elevation 250 feet.
16. Gladhaugh Creek at elevation 250 feet.
17. Gladhaugh Creek at elevation 125 feet.
18. Bottle Creek at mouth.
19. Duck River at mouth.
20. Solomon Gulch above upper dam.
21. Solomon Gulch at mouth.
22. Lowe River at lower end of Heiden Canyon.
23. Mineral Creek between Brevier and Glacier creeks.
24. Mineral Creek at lower canyon.
25. Brevier Creek at elevation 150 feet above that of mouth.
26. Glacier Creek at elevation 100 feet above that of mouth.
27. East Fork of Mineral Creek at elevation 900 feet above that of mouth.
28. Gold Creek above falls.
29. Gold Creek at mouth.
30. Uno Creek at mouth.
31. McAlister Creek at mouth.
32. Unnamed creek tributary to Eaglek Bay.
33. Dans Creek at Golden.
34. Avery River near Golden.
35. Lagoon Creek at lake outlet.
36. Hobs Creek at mouth.
37. Hummer Creek at mouth.
38. Unnamed creek tributary to Hummer Bay.

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[1] Salmon Creek enters the Pacific Ocean east of Prince William Sound through Alaganik slough.

[2] Power Creek enters the Pacific Ocean east of Prince William Sound through Eyak Lake and Eyak River.

DAILY RECORDS.

Daily discharge, in second-feet, of Power and Humpback creeks for 1913.

Day.	Power Creek near Cordova.					Humpback Creek near Cordova.				
	July.	Aug.	Sept.	Oct.	Nov.	May.	June.	July.	Aug.	Sept.
1										
2							75			
3								85	48	
4										
5									55	
6								96		
7		433					75			
8		698						85		
9		[a]1,030		187					127	15.0
10		633	147	154	96					
11		496	147	149	106			75		
12		450	240	140	359					
13		441	314				73		40	
14		656	617		193					
15			638		132					
16								96	31	
17										
18									31	
19		311					71	169		
20		325				41		200		
21		336				41			31	
22		363								
23		351					75			
24		385						102		
25	418	393			240				31	
26	674	427							59	
27		[a]2,360				87				
28						76	75	51		
29								127	90	
30	496							108		
31	418									

[a] Approximate.

Daily discharge, in second-feet, of Duck River and Bottle Creek for 1913.

Day.	Duck River at Galena Bay.								Bottle Creek at Galena Bay. (Drainage area, 12 square miles.)			
	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	May.	June.	July.	Aug.
1		272					608			127	148	84
2		350	540		608					123	142	77
3				412			100			138	144	60
4						390		64		181	148	56
5		445	560		507					215	152	54
6				476			70			238	140	66
7		533								204	131	59
8			573		573					210	127	54
9										267	119	66
10		608		540				59		238	108	90
11			608							181	99	59
12	76		601	445		149	196			159	99	52
13	85	573			540				155	257	99	46
14									140	262	90	35
15			573	340					135	250	90	30
16	97	507				40	212	40	179	245	108	24
17		594							166	226	118	20
18				293					210	215	138	19
19	118		560			608	107		179	181	181	21
20		573					164	111	127	206	362	20
21	122			412					138	181	274	22
22			608		760				152	210	192	27
23	136					164			181	192	159	35
24		608		445					148	181	138	27
25			608				136		127	178	116	29
26	161								116	174	108	215
27		573		800					215	170	103	462
28	196					44		50	206	177	99	362
29			608				122		181	159	94	108
30		507			507				138	148	87	46
31			594						127		82	40
Mean									159	196	135	76.3
Mean per square mile									13.3	16.3	11.2	6.36
Run-off (depth in inches on drainage area)									9.40	18.2	12.9	7.33
Accuracy									B	B	B	B

Daily discharge, in second-feet, of Gladhaugh Creek at elevation 250 feet in 1913.

Date.	Discharge.	Date.	Discharge.
May 14	10.2	June 19	9.8
16	11.3	July 13	4.0
20	9.0	26	9.4
24	10.2	Aug. 2	2.4
31	13.3	Oct. 8	2.0
June 6	14.1		

Daily discharge, in second-feet, of Gold and Uno creeks for 1913.

Day.	Gold Creek near Valdez. (Elevation, 800 feet; drainage area, 9.5 square miles.)			Uno Creek at mouth, near Valdez. (Drainage area, 5 square miles.)				
	Sept.	Oct.	Nov.	May.	Aug.	Sept.	Oct.	Nov.
1						30	34	
2						26	24	
3		78	42			24	19.3	
4		78	23			19.7	21	
5		78	17.8		58	17.7	25	
6		58	17.8		64	16.6	19.7	
7		39	14.6		60	14.5	18.1	
8	35	30		6.3	73	13.8	14.2	
9	38	30	12.0		70	13.8	13.8	
10	30	28			58	12.6	13.2	
11	35	23			56	12.9	11.4	
12	49				47	16.6	12.3	
13	78	21			48	44	8.1	
14	101	21			48	51		
15	108	17.8			44	49		
16	94	17.8			40	38		
17	78	17.8			40	30		
18	63	16.4			40	26		
19	67	17.8			39	27		
20	63				48	22		2.5
21	63	17.8			52	30		
22	85	18.4			48	37		
23		17.8			45	80	7.2	
24		16.7			47	85		
25		14.6			47	52		
26		14.6			54	46		
27					62	29		
28	165	13.1			70	27		
29	152				50	36		
30		17.0			51	37		
31					38			
Mean					51.7	32.1		
Mean per square mile					10.3	6.42		
Run-off (depth in inches on drainage area)					10.3	7.16		
Accuracy					C	C		

Daily discharge, in second-feet, of Davis Creek, Avery River, and Hobo Creek for 1913.

Day.	Davis Creek at mouth, near Port Wells.					Avery River at mouth, near Port Wells.				Hobo Creek at mouth, near Port Wells.			
	Aug.	Sept.	Oct.	Nov.	Dec.	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.
1		77		32	11.6		129	255	204		44		
2		77		50	11.3		93	194	535				
3		63		32	11.3		79	151	160				
4		52		32	11.2		70	146	93				
5		46		54	11.1		61	142	83				
6		43		48	11.		64	104	67				
7	172	42		45	11.2	199	64	93	58				
8	270	40		39	11.	415	61	73	56	88			
9	437	40	46	37	10.7	337	61	64	53	110			
10	281	38	41	36	10.6	255	58	58	48	94		24	
11	200	77	36	19.1	10.5	229	56	56	51	72			
12	160	135	32	17.6	10.4	194	61	47	61	71			
13	140	184	26	17	12.2	199	101	44	56	64			
14	135	239	26	17	14.5	199	204	44	53	62			
15	137	248	25	16.5	17.4	199	393	44	48	56			
16	133	352	26	16.1	20	189	255	42	48	58			
17	142	316	27	17.4	21	199	174	38	47	56			
18	135	133	88	20	22	199	151	36	46	49			
19	113	231	346	20	29	194	260	489	46	47			19.2
20	117	184	200	21	32	199	194	101	46	51			
21	133	129	77	a 21	33	309	133	120	48	52			
22	151	396	226	20	32	255	315	271	46	54			
23	155	664	197	19	28	229	999	112	46	52			
24	146		95	18	21	421	912	104	45	52			
25	184		67	17	21	365	622	73	44	52			
26	242		48	16	21	229	371	58	44	58			
27	504		45	15	20	744	229	56	46	119			
28	418		43	14	19.6	315	250	48	58	104			
29	189		41	13	19.1	204	371	73	53	102			
30	146		21	a 12	18.6	179	651	489	48	89			
31	113		17.4		18.4	133		224		46			
Mean	198	165	78.1	25.1	17.8	264	248	124	77.9	69.1			
Accuracy	B	B	B	C	C	C	B	B	B	B			

a Gage heights affected by ice Nov. 21-30. Discharges for that period interpolated.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements in Prince William Sound region in 1913.

Date.		Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
					Sec. ft.	*Sq. miles.*	*Sec. ft.*
July	29	Snyder Falls Creek.	Rude River	Mouth	99		
	28	Wesley Falls Creek.	do	Elevation, 600 feet	79		
	29	Parsons Falls Creek.	do	Mouth	a 150		
	29	Robinson Falls Creek.	do	do	8.3		
July	30	Unnamed creek	Sheep Bay	Elevation, 700 feet	a 75		
Aug.	2	do	Port Fidalgo	Mouth	205		
	2	Falls (?) Creek	Fish Bay	Below forks	70		
	1	Unnamed creek	do	Elevation, 900 feet	3.7		
	1	Chisna Creek	Landlock Bay	Mouth	4.2	0.9	4.67
	1	Horsetail Falls Creek.	do	do	4.2	.7	6.00
July	31	Lagoon Creek	do	do	67		
Oct.	8	do	do	do	20		
Nov.	18	do	do	do	14.4		
July	31	Reynolds Creek	do	Elevation, 250 feet	12.7	1.2	10.58
Oct.	8	do	do	do	3.3	1.2	2.75
Nov.	18	do	do	do	2.4	1.2	2.00
Aug.	2	Gladhough Creek	Virgin Bay	Elevation, 125 feet	3.5	1.0	3.50
Oct.	8	do	do	do	2.9	1.0	2.90
Nov.	18	do	do	do	2.0	1.0	2.00
May	7	Solomon Gulch	Port Valdez	Elevation, 550 feet	12.7		
	9	do	do	do	16.0		
Nov.	24	do	do	Mouth	a 35		
Oct.	17	Lowe River	do	Foot of Heiden Canyon.	92	b 50	1.82
	24	Mineral Creek	do	Between Brevier and Glacier creeks, at elevation 650 feet.	26		
May	10	do	do	At lower canyon; elevation, 100 feet.	79	39	2.03
Oct.	24	do	do	do	74	39	1.90
Nov.	24	do	do	do	37	39	.95
Oct.	24	Brevier Creek	Mineral Creek	Elevation, 100 feet above that of mouth.	4.4	4.9	.90
	24	Glacier Creek	do	Elevation, 150 feet above that of mouth.	2.0		
	24	East Fork of Mineral Creek.	do	Elevation, 1,000 feet above that of mouth.	2.6	3.8	.68
Aug.	10	Gold Creek	Port Valdez	Elevation, 950 feet	202	9.0	22.40
May	8	do	do	Mouth	12.1	10.0	1.21
Nov.	24	do	do	do	6.5	10.0	.65
May	8	McAllister Creek	Shoup Bay	do	2.4	2.5	.96
Aug.	9	Unnamed Creek	Eaglek Bay	Above falls, at elevation 200 feet.	656		
Oct.	11	do	do	do	38		
Aug.	8	Lagoon Creek	Harrison Lagoon	At lake outlet; elevation, 300 feet.	83		
Nov.	20	do	do	do	9.0		
Aug.	8	Hummer Creek	Hummer Bay	Mouth	240		
	8	Unnamed Creek	do	do	160		

a Estimated. b Approximate.

WATER POWER POSSIBILITIES.

The water powers of Prince William Sound are as a rule small but widely distributed. In the northern part of the sound, from Cordova to Port Wells, which was examined in some detail, almost every bay or inlet has one or more tributary streams on which small water powers could be developed for six or eight months during the year.

The months of low-water flow are January to April, and during that time most of the streams reach a very low stage. There are but few streams on which more than 200 or 300 horsepower could be developed at minimum flow, and it is doubtful if there is a single stream on which a plant of over 1,000 horsepower could be operated continuously without storage. There are, however, numerous sites where small to medium-sized reservoirs could be created, and thus many of the streams could be made to yield at least a small output throughout the year. One of the most favorable sites for storage is at Silver Lake, on Duck River near Galena Bay. Nearly the entire run-off of this basin could probably be controlled by a dam at the outlet of the lake. The lake is situated between 1 and 2 miles from tidewater, at an elevation of about 250 feet. It is estimated that a uniform output of 4,000 to 5,000 horsepower might be obtained.

Power Creek, a tributary of Eyak Lake, offers the best opportunity for the development of water power near Cordova. About 300 feet head is available. The minimum flow for six months in the year is estimated to be not less than 75 second-feet. That would produce about 1,800 horsepower with an efficiency of 70 per cent at the wheel. At times during the remaining six months of the year the capacity might become 50 to 75 per cent less. Some storage could be obtained by a dam at the upper end of the gorge.

So far as is known to the writers there are between Cordova and Port Valdez no sites other than Silver Lake where sufficient storage could be created to permit the development of more than 100 to 200 horsepower at minimum flow in the winter. A possible exception to the above statement might be made for a stream entering the head of Fish Bay, sometimes known as Falls Creek. It heads in a large glacial cirque about 2 miles from the coast and falls almost vertically over an escarpment estimated to be between 1,500 and 2,000 feet in elevation. In view of the high pressure that could be obtained at this point it has been considered a relatively large power site. The discharge of the creek on August 2, 1913, at a point about a mile below the foot of the falls was approximately 40 second-feet. The streams were all at a high summer stage on that date. No measurements of flow have ever been made at the head of the falls, but it is believed that, considering the high elevation, the flow might become almost entirely shut off during the three or four months of coldest weather.

The principal streams entering Port Valdez on which power could be developed are Solomon Gulch, Lowe River, and Mineral, Gold, and Uno creeks. No reservoir sites of importance exist on any of these streams except Solomon Gulch, on which two hydroelectric plants with an aggregate rated capacity of about 700 horsepower have been installed. A total fall of about 500 feet is available and if all the storage that it would be practicable to create was utilized, possibly 1,000 horsepower could be developed at all seasons.

Lowe River is one of the largest streams entering Prince William Sound. Water could be diverted at the head of Heiden Canyon, and in a distance of about 6 miles a head of over 900 feet could be obtained. The drainage area above the canyon is about 30 square miles and ranges in elevation from 1,500 to 7,000 feet. From about the middle of May until October several thousand horsepower could no doubt be developed, but the high elevation of the basin might involve so great a decrease in run-off and temperature as to render it impracticable to operate during the winter.

A few hundred horsepower could be developed on the East Fork of Mineral Creek, on Gold Creek, and on Uno Creek from about the first of May until about the first of November, but for much of the remainder of the year the output would probably be less than 100 horsepower.

No investigation was made of the water powers between Port Valdez and Port Wells except on an unnamed stream which enters the west side of Eaglek Bay. The stream drains a hanging valley in which are a series of small lakes and falls directly into salt water over a nearly vertical rock bluff about 200 feet high. There is a good dam site at the outlet of the lake, and probably sufficient storage could be created for 500 to 1,000 horsepower to be developed throughout the year.

Davis Creek and Avery River enter Port Wells near Golden post office. Both streams have small reservoir sites and concentrated fall near tidewater. On Davis Creek there is a fall of about 140 feet between Davis Lake and tidewater, a distance of about half a mile. With the storage that could be created by a dam at the outlet of the lake the flow would probably be sufficient to produce at least 300 horsepower at all seasons.

A fall of about 100 feet could be obtained on Avery River in a distance of about half a mile. The flow is considerably greater than that of Davis Creek, but less storage could be created and the power capacity during the winter might even be less than that of Davis Creek.

A small plant could be cheaply installed at the mouth of Lagoon Creek, on the west side of Port Wells. The creek falls about 300 feet in a distance of 1½ to 2 miles, and about 100 feet fall is concentrated in the last 500 feet of its course. A flow of 90 second-feet as measured at an elevation of 300 feet on November 20, 1913, would develop about 70 horsepower for each 100 feet fall. The flow during the winter would undoubtedly become much lower.

There are said to be several good water powers in the western part of the sound south of Port Wells, but no data regarding their size and accessibility are available.

The above estimates should be considered as only roughly approximate. More complete measurements of flow, particularly during the winter, should be made before final plans for developments are worked out.

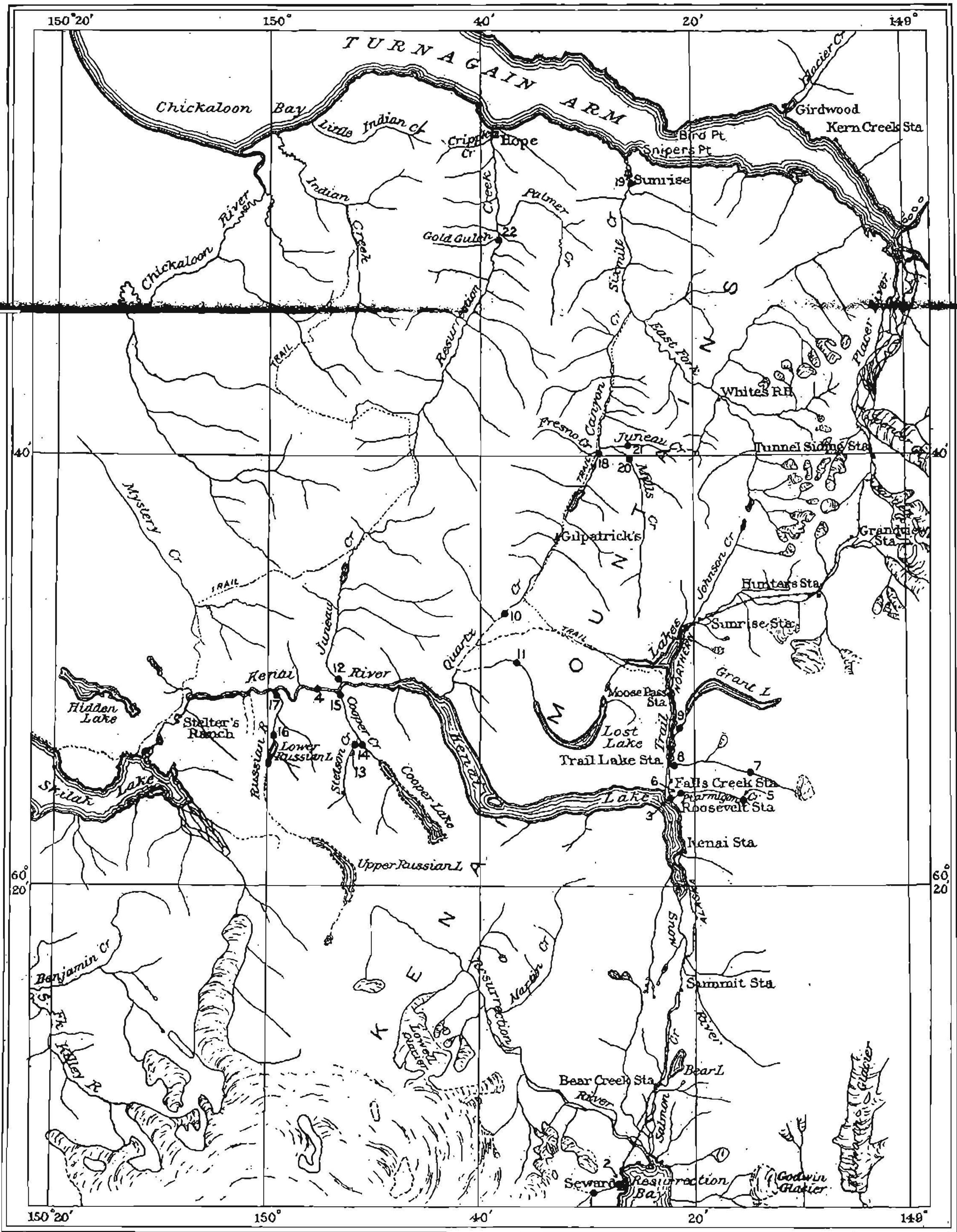
The transmission of electricity is one of the most serious difficulties that will be encountered in utilizing these water powers. Steep, rocky mountain slopes, dense growths of bush and trees, heavy snowfall and snowslides, glaciers, and broken shore lines are some of the obstacles to be overcome. Unless a market can be created for the power within a short distance of its source, it will probably never become of much value. There are, however, good harbor facilities in nearly all parts of the sound, so that ocean-going boats can be anchored within easy transmission distances from the powers. Submarine cable is now being manufactured that will carry electric current at a pressure of over 20,000 volts. Considerable cable with a capacity of 200 to 300 amperes for 11,000 volts working pressure has been used. Such cable, though expensive, might be practical for use in crossing narrow bays and inlets instead of running long land lines around them, or in reaching from island to mainland or from island to island. It might also be of service in crossing glaciers, where an overhead line would be very expensive to maintain.

The manufacture of wood pulp should offer a particularly suitable use for the water powers of this region, because of the fact that both the timber and the power sites are located near tidewater. It is claimed that pulp logs can be towed a distance of 150 to 200 miles at a permissible cost, thus eliminating the necessity of transmitting electricity for long distances to the mills. Any one water power in Prince William Sound would, under such conditions, be within reach of the entire timber supply.

KENAI PENINSULA.

GENERAL FEATURES.

Kenai Peninsula (see Pl. VIII) projects from the Alaska mainland into the north-central part of the Gulf of Alaska. It has an area of approximately 9,000 square miles, most of which lies between meridians 148° and 152° west longitude and parallels 59° and 61° north latitude. The peninsula is bounded by Prince William Sound on the east, the Pacific Ocean on the south, and Cook Inlet on the west. On the north it is joined to the mainland by a strip about 12 miles in width, which separates Portage Bay and Turnagain Arm. These bodies of water are arms of Prince William Sound and Cook Inlet, respectively. Kenai Peninsula has a shore line more than a thousand miles long. It contains gold placer and lode deposits.



6 ● Point of measurement; number refers to list in text

0 5 10 20 Miles

MAP OF THE EASTERN PART OF KENAI PENINSULA.

The surface of the peninsula presents two widely differing physiographic features. About three-fourths of its area, lying in the eastern, central, and southern parts, is occupied by the high, rugged Kenai Mountains, 5,000 to 7,000 feet in elevation, and valleys deeply cut by the action of the former ice sheet which covered the area and remnants of which are still found in the higher portions of the peninsula. The remaining fourth consists of a broad lowland about 25 miles wide, which slopes from an elevation of about 1,800 feet on the south, near Kachemak Bay, to an elevation of about 50 feet on the north.

The Kenai Mountain divide lies close to the eastern and southeastern side of the peninsula, so that the drainage flows principally toward the west and north and the streams flowing into the Pacific Ocean and Prince William Sound are short. The largest of the streams on the southeast side is Resurrection River, which is about 25 miles in length, drains an area southwest of Kenai Lake, and flows through a wide gravel-floored valley into the head of Resurrection Bay. Kenai River, the largest stream on the peninsula, drains its entire central portion and discharges into Cook Inlet at Kenai. Its drainage area includes two large lakes, Skilak and Kenai, and also numerous smaller ones on its upper tributaries. Kasilof River drains Tustumena Lake and enters Cook Inlet a short distance south of Kenai. Tustumena Lake is about 22 miles long and averages 6 miles in width. It is fed by several streams, some of which have their sources in the large glaciers in the Kenai Mountains. Two small streams, Chickaloon and Big Indian rivers, drain a portion of the Kenai lowland and discharge into Chickaloon Bay near the west end of Turnagain Arm. The principal streams entering Turnagain Arm from the mountainous area of the peninsula are Resurrection and Sixmile creeks and Placer River.

The fact that streams draining areas of rugged mountainous relief have steep gradients and waterfalls makes it obvious that the eastern portion of the peninsula would afford much more favorable opportunities for the development of water power than the western portion. Moreover, gold mining, which is the most important industry of the peninsula and which at this time presents the most promising market for water power, is confined to the mountainous area. The investigation of the water supply of the peninsula was carried on only in its eastern portion.

Kenai Peninsula is heavily timbered in most of its valleys up to elevations of 1,200 to 1,500 feet above sea level. Spruce is the most plentiful variety and the most valuable for commercial uses, but hemlock, poplar, birch, cottonwood, willow, and alders are found in some localities. Timber suitable for fuel is abundant below altitudes of 1,500 feet, but the supply that is valuable for saw logs is limited to small areas below 1,000 feet in elevation.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams in Kenai Peninsula in 1913. The numbers refer to Plate VIII.

1. Lowell Creek above pipe intake.
2. Lowell Creek at mouth.
3. Kenai Lake at Roosevelt.
4. Kenai River at Kenai Dredging Co.'s camp.
5. Ptarmigan Creek at lake outlet.
6. Ptarmigan Creek at mouth.
7. Falls Creek at intake of Skeen-Lechner ditch.
8. Falls Creek at railroad crossing.
9. Grant Creek at mouth.
10. Quartz Creek at Fairman's cabin.
11. Lost Creek 3 miles below lake outlet.
12. Juneau Creek at mouth.
13. Stetson Creek at mouth.
14. Cooper Creek above Stetson Creek.
15. Cooper Creek at mouth.
16. Russian River one-fourth mile below lower lake outlet.
17. Russian River at mouth.
18. Canyon Creek above Mills Creek.
19. Sixmile Creek at Sunrise.
20. Mills Creek 2 miles above mouth.
21. Juneau Creek above upper ditch intake.
22. Resurrection Creek above Gold Gulch.

DAILY RECORDS.

Gage height of Kenai Lake, 1913, and discharge of Kenai River, 1913–14.

Day.	Daily gage height, in feet, of Kenai Lake at Roosevelt for 1913.					Daily discharge, in second-feet, of Kenai River at Kenai Dredging Co.'s camp for 1913–14.					
	Aug.	Sept.	Oct.	Nov.	Dec.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1		8.67	9.25	7.08			4,280	5,040	1,920	1,070	740
2		8.36	9.06	7.42			3,960	4,900	2,160	1,070	740
3		8.30	8.96	7.38			3,640	4,760	2,300	1,120	740
4		8.12	8.85	7.33			3,640	4,480	2,300	1,160	820
5		7.90	8.71	7.35			3,320	4,340	2,440	1,160	820
6		7.66	8.58	7.32			3,160	4,200	2,440	1,160	740
7		7.62	8.29	7.26			3,000	3,780	2,440	1,160	660
8		7.53	8.12	7.16			2,720	3,500	2,160	1,160	580
9		7.44	7.98	7.01			2,860	3,360	2,160	1,120	504
10		7.34	7.80	6.82			2,160	3,090	2,040	1,070	580
11		7.24		6.73			2,320	2,800	1,920	1,070	580
12		7.19		6.71			2,320	2,600	1,920	980	504
13		7.14		6.68			2,200	2,400	1,920	980	504
14		7.04	7.16	6.66			2,080	2,320	1,800	940	504
15		6.88	7.09	6.65	5.03		1,960	2,200	1,800	900	504
16		6.90	6.98	6.63			1,960	2,080	1,800	900	542
17		6.82	6.95	6.60			1,850	2,080	1,680	900	660
18	8.89	6.78	6.95	6.53		4,620	1,850	2,080	1,560	900	580
19	8.81	6.73	6.91	6.48		4,620	1,740	1,960	1,560	940	542
20	8.82	6.69	6.86	6.41		4,620	1,740	1,960	1,460	1,020	504
21	8.88	6.89	6.83	6.40		4,620	1,960	1,850	1,460	1,020	504
22	9.02	7.24	6.77	6.32		4,620	2,320	1,850	1,410	980	504
23	9.08	7.40	6.72	6.26		4,980	2,570	1,740	1,360	1,070	504
24	9.14	7.64	6.60	6.09		4,980	2,830	1,800	1,360	1,070	504
25	9.14	8.62	6.53	6.00		4,980	4,200	1,510	1,360	980	504
26	9.12	9.34	6.49	5.93		4,980	5,180	1,560	1,260	980	580
27	9.13	9.90	6.41	5.90		5,160	6,070	1,560	1,160	900	580
28	9.15	9.90	6.35	5.79		5,160	6,070	1,560	1,160	900	504
29	9.09	9.78	6.32	5.72		4,980	6,070	1,560	1,160	900	504
30	8.80	9.63	6.52	5.66		4,620	5,620	1,920	1,070	820	504
31	8.72		6.81			4,440		1,920		820	504
Mean						4,810	3,190	2,670	2,050	1,010	582
Maximum						5,160	6,070	5,040	2,440	1,160	820
Minimum						4,440	1,740	1,510	1,070	820	504
Run-off in acre-feet						134,000	190,000	164,000	122,000	62,100	35,800
Accuracy						B	B	B	B	C	C

Daily discharge, in second-feet, of Falls and Quartz creeks and Russian River for 1913.

Day.	Falls Creek [a] at railroad crossing near Roosevelt. (Drainage area, 15 square miles.)				Quartz Creek [b] at Fairman's cabin. (Drainage area, 30 square miles.)				Russian River [c] at mouth. (Drainage area, 60 square miles.)		
	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.
1		34	38	23		66	72	66		115	260
2		34	20	15		63	66	61		110	235
3		30	34	13		61	66	56		105	225
4		20	34	15		56	78	56		95	250
5		20	42	14		54	78	55		85	288
6		20	34	13		55	72	52		78	266
7		20	30	10		54	66	52		78	240
8		18	26			50	66			78	225
9		15	25			50	64			75	225
10		14	23			48	61			70	225
11		13	26			48	56			65	200
12		13	24			48	52			62	200
13		11	22			48	52			60	175
14		11	20			48	52			57	175
15		11	20			48	52			57	150
16		9	18			46	52			57	150
17	52	15	18			46	54			57	125
18	52	13	16			44	48			57	125
19	50	14	16			44	56			57	125
20	50	15	16			44	54		120	57	100
21	60	15	18			44	50		124	57	100
22	70	20	18			44	48		136	57	96
23	72	86	11			78	48		152	75	94
24	69	173	11		82	135	48		144	152	94
25	72	312	10		82	135	46		132	384	90
26	62	130	10		78	117	46		132	510	90
27	62	74	10		85	108	48		132	489	90
28	52	57	10		92	92	48		128	412	88
29	52	47	20		85	85	44		124	340	88
30	42	42	42		82	78	66		120	282	182
31	38		26		66		72		115		180
Mean	57.0	43.5	22.2	14.7	81.5	64.6	57.5	56.9	130	141	166
Mean per square mile	3.80	2.90	1.48	.980	2.72	2.15	1.92	1.90	2.17	2.35	2.77
Run-off (depth in inches on drainage area)	2.12	3.24	1.71	.26	.81	2.40	2.21	.49	.97	2.62	3.19
Accuracy	B	C	C	B	B	B	B	B	B	B	C

[a] The gage heights were affected by ice Oct. 13-20 and 26-29. Discharges are estimated for those periods.
[b] The gage heights were affected by ice Oct. 12-15 and 27. Discharges are estimated for those periods.
[c] Discharges interpolated Aug. 29 and 31; Sept. 1-2, 4, 9-10, 12-13, and 20; Oct. 4, 9-21, 23-28, and 31.

Daily discharge, in second-feet, of Sixmile and Mills creeks for 1913.

Day.	Sixmile Creek[a] at mouth. (Drainage area, 258 square miles.)				Mills Creek[b] 2 miles above mouth. (Drainage area, 25 square miles.)			
	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.
1		780	970	1,020		94	87	51
2		700	970	780		87	87	43
3		665	825	700		81	75	
4		630	970	665		75	87	
5		600	920	600		75	87	
6		600	825	570		69	101	
7		570	780	545		69	73	
8		570	740	495		63	67	
9		545	665	545		61	63	
10		545	630	600		61	55	
11		520	570	570		58	55	
12		520	570	495		55	55	
13		520	520	470		58	55	
14		520	495	470		53	50	
15		545	520	450		53	50	
16		545	520	430		53	45	
17		545	520	450		53	45	
18		545	495	450		53	45	
19		600	570	450		56	45	
20		630	520	450		53	50	
21		570	495	450		53	62	
22		630	495	430		56	53	
23		825	495	430		108	51	
24		1,420	470	430		143	48	
25		5,000	470	430	143	203	46	
26		2,220	430	430	136	187	45	
27	1,590	1,420	545	430	157	129	45	
28	1,270	1,140	545	400	136	101	45	
29	1,020	970	470	400	115	101	45	
30	920	1,020	1,500	400	108	101	87	
31	870		970		101		58	
Mean	1,130	897	661	514	128	82.1	60.1	
Mean per square mile	4.38	3.48	2.56	1.99	5.12	3.28	2.40	
Run-off (depth in inches on drainage area)	.81	3.88	2.95	2.22	1.33	3.66	2.77	
Accuracy	A	A	A	A	C	C	C	

[a] The gage heights were affected by ice Nov. 17–30. Discharges for that period are estimated.
[b] The gage heights were affected by ice Oct. 12–20 and 26–28. Discharges are estimated for those periods.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements on Kenai Peninsula in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Aug. 15	Lowell Creek	Resurrection Bay	Above pipe intake	58		
Oct. 28	....do	....do	....do	18.8		
28	....do	....do	Mouth	9.3		
Aug. 16	Ptarmigan Creek	Kenai Lake	500 feet below lake outlet.	156		
Oct. 10	....do	....do	....do	95		
11	....do	....do	Mouth	92		
20	....do	....do	....do	71		
Aug. 17	Falls Creek	Trail Creek	Intake of Skeen-Lechner ditch.	[a] 35		
Oct. 10	....do	....do	....do	[a] 14.3		
9	Grant Creek	....do	Mouth	155		
18	....do	....do	....do	84		
17	Lost Creek	Kenai River	3 miles below lake	61	22	2.79
6	Juneau Creek	....do	Mouth	103	63	1.63
24	....do	....do	....do	58	63	.92
Aug. 21	Stetson Creek	Cooper Creek	....do	35	8.0	4.39
21	Cooper Creek	Kenai River	Above Stetson Creek.	137	35	3.91
Oct. 6	....do	....do	Mouth	210	47	4.47
24	....do	....do	....do	104	47	2.21
Aug. 20	Russian River	....do	Lower lake outlet	132	55	2.40
25	Canyon Creek	Sixmile Creek	Above Mills Creek	[b] 90	28	3.21
Sept. 4	....do	....do	....do	[b] 60	28	2.13
Oct. 14	....do	....do	....do	44	28	1.56
Aug. 25	Juneau Creek	Mills Creek	Above upper ditch intake.	23	4.4	5.23
Sept. 23	Resurrection Creek.	Turnagain Arm	Above Gold Gulch	120	105	1.14

[a] Includes flow of ditch. [b] Includes flow of ditch diverting from Fresno Creek.

WATER POWER.

The topography of the mountainous area of Kenai Peninsula, in common with that of most of the Alaskan coast, is favorable for the development of water power. The water supply, as determined principally by the climate and the character and distribution of precipitation, is large and fluctuates widely in summer; in the winter it is much reduced. Usually the minimum flow of a stream determines the magnitude of the development which should be made upon it. Therefore it is of advantage if the stream has natural storage or if artificial storage can be provided, for thereby the minimum flow on a given stream can be increased and the possible capacity of the plant made greater. There are many streams which would furnish sufficient water from May 1 to October 31 for plants of 1,000 to 2,000 horsepower, depending upon the minimum flow alone, but there are few, if any, streams whose flow in the other six months of the year would be adequate for the development of more than a few hundred horsepower without storage. Except in the Kenai Valley few locations exist where artificial development of storage is possible. If winter power were demanded in excess of what could be obtained from the natural flow of the streams, it would have to be supplied from some other source.

The several lakes of the Kenai Valley have some tendency to regulate the flow of the streams rising in them, and the possibility of developing more storage upon them furnishes a means for increasing this regulatory effect. Dams could be constructed at any of the lake outlets, and the sites at some of them are exceptionally favorable. It seems probable that dams could be constructed on Ptarmigan and Grant lakes at a reasonable expense which would hold in reservoirs nearly the entire annual run-off from their respective tributary drainage areas. Thus the available power of the streams could be used at nearly a constant rate throughout the year, or it could be drawn upon as desired. If winter power is desirable and if the necessary expense is justified, the advantage of such a water supply over one obtained from the natural flow of a stream is obvious.

Kenai River falls approximately 310 feet between Kenai and Skilak lakes, and the fall is distributed about as follows: 60 feet from the outlet of the lake to the Kenai Dredging Co.'s camp, a distance of about 3½ miles; 70 feet from the camp to Russian River, a distance of 3 miles; and 180 feet in the remaining 9½ miles. There are no falls on Kenai River, and rowboats pass down it safely at ordinary stages, but the grade is concentrated in rapid stretches where the current is relatively swift. The discharge has been estimated from August 18, 1913, to January 31, 1914. The minimum flow for that period was 504 second-feet, and the average flow for the three following months would probably be considerably less. The estimated discharge would develop about 40 horsepower for each foot of fall with an efficiency of 70 per cent at the wheel.

Ptarmigan and Grant creeks probably offer the best power sites on Kenai Peninsula. A head of about 300 feet is available on Ptarmigan Creek and about 215 feet on Grant Creek. It is thought that by constructing storage dams at least 1,000 horsepower could be developed throughout the year on Ptarmigan Creek and 1,500 horsepower on Grant Creek.

Other streams on which reservoir sites of smaller capacities exist are Lost Creek, Cooper Creek, and Russian River, on which heads of 800 feet, 500 feet, and 170 feet, respectively, could be obtained. It is estimated from the measurements of flow that from about the first of May until the first of November from 500 to 1,000 horsepower could be developed on each of these streams. How much storage could be obtained is unknown, but it would probably not be sufficient to assure continuous winter operation of plants of more than 400 to 500 horsepower.

There are many other streams in the eastern part of Kenai Peninsula that would afford good opportunities for the operation of plants of various capacities less than 1,000 horsepower for six or seven months in the year, but the general lack of reservoir sites makes them of considerably less importance for winter operations than those already noted. The above estimates are only roughly approximate and are intended to give only a general idea of the water-power conditions. More extended and complete records of stream flow and surveys of reservoir sites should be available before final plans for development are made.

The proposition of connecting the possible water-power developments of this valley into a single hydroelectric system is not here considered in detail. The available data are far too inadequate for reaching conclusions as to its feasibility, which could be determined only by extensive survey and studies of the water supply. The most important power sites in this valley lie within a radius of 15 miles. If storage were fully developed and power plants installed where practicable, their interconnection by electric transmission lines would furnish means for obtaining the maximum output of power from the available water supply and its most uniform distribution through the year. It seems most probable that any market for power which is likely to arise in this region would demand continuous power. The primary purpose of the reservoirs would be to replenish the flow and hence the power output of the period from November 1 to April 30. Any water in excess of this requirement could be utilized for increasing the uniformity of the flow if that were desired. The run-off available at the various plants, the amount of storage, and the potential value of the water stored in the different reservoirs, as determined by the head through which it would act, would be the principal factors in determining the procedure in the operation of the plants or the release of water from the reservoirs. It seems probable that even with storage reservoirs developed to their utmost capacity the power output in summer could considerably exceed that of the winter. The construction, operation, and maintenance of eight or ten power plants, such as this proposition would involve, would probably make the cost for the power so great as to exclude it from the class of cheap power, and only a great growth of industry in this region would warrant such a development. On the other hand, there are no serious difficulties in the construction required and the region is easily accessible. Plans for extensive water-power development should take cognizance of the fact that there are large deposits of lignitic coal in the western half of the peninsula that might be used in generating power.

WILLOW CREEK DISTRICT.

GENERAL FEATURES.

The Willow Creek district (see fig. 2) is the area which includes the gold fields lying about 20 miles northeast of Knik, a settlement on Knik Arm of Cook Inlet. The district contains about 90 square miles and contains the divide between Little Susitna River and the South Fork of Willow Creek, a tributary of Susitna River. This divide is the southwestern extension of the Talkeetna Range. The center of the district is at about 149° 20′ west longitude and 61° 40′ north latitude.

The topography of the district is varied, the surface forms ranging from the steep, craggy mountains in the northern part to the much

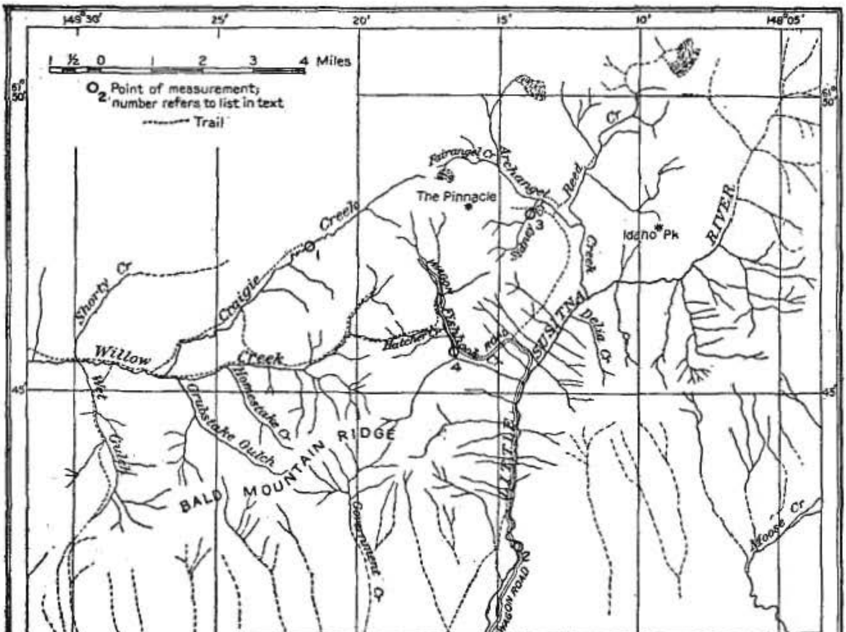


FIGURE 2.—Map of the Willow Creek district.

less rugged ridge known as Bald Mountain in the southern part. Several of the peaks exceed 5,000 feet in elevation. The valleys are V-shaped glacial troughs ranging in elevation from 1,500 to 3,500 feet. High in these valleys the slopes are heavily strewn with coarse glacial débris, broken rock, and talus. The large proportion of void spaces in this material affords an excellent reservoir of the summer water supply. Ice forms in them during the winter and by gradual thawing in the summer is an important factor in the distribution of stream flow at a time when it is of commercial value for the development of water power for the quartz mills. Practically all snow disappears from the district during the summer. There are scattered small glaciers at the head of Archangel Creek and one larger one at the head of the main branch of Little Susitna River.

A feature of the Willow Creek district which is of considerable economic significance is the scarcity of timber suitable either for fuel or for building. The lumber supply is plentiful and good in the lower parts of the valleys of Willow Creek and Little Susitna River, but on the former it does not extend above Wet Gulch and on the latter above a point about 2 miles below the mouth of Fishhook Creek. Alders and willows fringe the mountain sides to a considerably higher elevation, but they stop some distance below the quartz mills. Mining timber and wood for fuel must be hauled from 4 to 8 miles up steep grades. This increases the cost of the wood to a degree which almost prohibits its use for fuel.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams in the Willow Creek district in 1913. The numbers refer to figure 2.

1. Craigie Creek at Gold Bullion mill.
2. Little Susitna River at mile 28.
3. Sidney Creek at lake outlet.
4. Fishhook Creek at mile 33½.

DAILY RECORDS AND MISCELLANEOUS MEASUREMENTS.

Daily discharge, in second-feet, of Craigie Creek at Gold Bullion mill for 1913.

[Drainage area, 2.8 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	18	20	11	12	21	34	14	16	3.8
2	18	24	10	11	22	40	16	12	10
3	25	26	10	9.8	23	40	14	11	44
4	32	30	10	8.6	24	39	14	10	26
5	37	28	9.6	7.8	25	34	14	11	16
6	40	26	14	7.0	26	31	20	23	7.1
7	42	22	12	6.4	27	36	18	46	4.2
8	47	22	12	6.0	28	34	18	24	3.7
9	53	22	11	5.6	29	25	15	18	3.7
10	47	24	11	5.3	30	18	12	12	7.6
11	36	40	10	5.0	31	....	12	15	....
12	38	24	9.2	4.2	Mean	38.4	20.1	13.7	8.32
13	42	28	9.0	4.0					
14	45	22	8.0	4.2	Mean per square mile	13.7	7.18	4.89	2.97
15	54	18	7.4	4.6					
16	55	16	4.4	4.5	Run-off (depth in inches on drainage area)	15.29	8.28	5.64	3.31
17	53	16	6.6	4.9	Accuracy	B	B	B	B
18	51	14	7.8	4.6					
19	49	12	26	4.2					
20	41	22	26	3.9					

NOTE.—These discharges were computed from weir records furnished by the Gold Bullion Mining Co.

Miscellaneous measurements in the Willow Creek district in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Sept. 10	Little Susitna River.	Cook Inlet	Mile 28	141	61	2.31
13	do	do	do	135	61	2.21
12	Sidney Creek	Archangel Creek	Lake outlet	1.88	1.1	1.71
12	Fishhook Creek	Little Susitna River.	Mile 33½	12.6	4.7	2.68

WATER POWER.

Up to the present time the only water-power developments which have been justified by the ore prospects of the Willow Creek region have been those situated directly at the mill sites, from the water supply available at those points. These mill sites are so far up the streams that the tributary drainage areas are too small to furnish the necessary supply for even the present small plants in dry seasons. Consequently the plants must be partly or wholly shut down at these times or the water power must be supplemented from other sources. The cost of auxiliary power in these inaccessible regions is so great as to be prohibitive unless the ore is very rich. At one of the mills it was stated that wood cost $40 a cord and that gasoline, which was there used, cost 70 cents a gallon at the mill. The development of water power in winter is impossible on these sites.

The easiest method of supplying the deficient power is by increasing the effective head at the plants. This can usually be accomplished easily, for the streams have heavy grades and much head can be obtained in comparatively short distances. In such a development there would usually be a small flow of water acting under a high head. Wheels for such installations as would be desired in this region are not carried in the regular stock of water-wheel manufacturers, but it is believed that if the conditions under which they were to operate were known, specially designed wheels could be procured which would give good results.

Another method of solving the power problem is to develop electric power on the lower stretches of the streams where the flow is larger and more dependable and transmit it to the property. A scheme has already been proposed for the mining companies of the region to cooperate in the development of hydroelectric power on Little Susitna River for their common use. In the vicinity of the mouth of Fishhook Creek the Little Susitna has a fall of about 150 feet to the mile. The valley in this portion varies from a U-shaped glacial trough to a narrow rock canyon and is everywhere filled with heavy granite bowlders. Concentrated fall and favorable topography make some locations better for power development than others. The most suitable type of development is probably a diversion dam, built only high enough to divert the required amount of water, and a combination of canal and pipe line for carrying it to the wheel.

The flow of the Little Susitna for six or seven months of the year under the head that it is possible to utilize would probably be ample for any power requirements that are likely to arise in this district. The discharge on September 13 at mile 28 was 135 second-feet, or 2.21 second-feet to the square mile. That flow would develop about 11 horsepower for each foot of fall, with an efficiency of 70 per cent at the wheel. With a flow of 0.5 second-foot to the square mile about 2.4 horsepower could be produced for every foot of fall.

Little is known of the winter flow of these streams, but to judge from the climatic conditions which prevail in this region it must fall to a very low stage. If winter operation was desirable and the stream flow was not found to be sufficient to provide the power, the closeness of the Matanuska coal fields affords a possible solution of the problem. When these coal fields are developed it should be possible to obtain at a comparatively low figure fuel for an auxiliary steam plant operating in conjunction with the hydroelectric plant.

Such a plant as is suggested would involve considerable expense, but there can be no question that it would have many offsetting advantages. The feasibility of the proposition depends on the future promise of the mining industry in the region. If the ore deposits are sufficiently large the outlay would be justified.

Except that it is more remote from the coal fields, a hydroelectric power could be generated on the lower part of Willow Creek quite as well as on the Little Susitna if the location of a central power plant in that vicinity should promise to be more convenient.

DEVELOPED WATER POWERS.

Controller Bay region.—No water power has been developed in the Controller Bay region.

Copper River basin.—A plant of 17-kilowatt capacity is used by the Great Northern Development Co. in connection with the development of its copper property. Possibly one or two other small plants have been installed in the Copper River basin.

Prince William Sound region.—The Cordova Power Co. has a plant on Humpback Creek, with a maximum capacity of 200 horsepower. The energy is used for light and power at Cordova.

The sawmill at Cordova uses three wheels with an aggregate capacity of about 150 horsepower.

The Northwestern Fishing Co. has one 36-inch and two 16-inch Pelton wheels at the Orca cannery; the operating head is 240 feet.

The Galena Bay Mining Co. has a plant on Bottle Creek, with a maximum capacity of 150 horsepower. This plant has been idle for several years, but was originally used in the development of a copper property.

The Alaska Water, Light & Telephone Co. and the Valdez Electric Co. have plants on Solomon Gulch, and the capacity of each is about 350 horsepower. The energy is used for light and power at Valdez.

A plant having a capacity of about 50 horsepower was installed on Glacier Creek, a small tributary of Mineral Creek, in the summer of 1913. The power will be used to operate a small stamp mill.

The Sea Coast Mining Co. began the construction of a plant on Uno Creek in 1913. A wheel capacity of 290 horsepower is contemplated.

A small sawmill was being operated at the mouth of Avery River by an overshot water wheel in the fall of 1913.

It is understood that a small water-power plant has been in operation on Latouche Island for several years, but no further information is available regarding it.

The capacity of most of these plants is undoubtedly considerably less during the winter months than that given.

Kenai Peninsula.—The only water-power plants on Kenai Peninsula, so far as is known to the writers, are that of the Seward Light & Power Co., which has a capacity of 150 horsepower and furnishes light and power for the town of Seward, and that of the Skeen-Lechner Mining Co. on Falls Creek, which develops about 75 horsepower and is used to operate a small stamp mill.

Willow Creek district.—Three water-power plants have been installed in the Willow Creek district for the operation of gold quartz mills. The Alaska Gold Quartz Mining Co. develops 15 to 20 horsepower on Fishhook Creek by a Pelton wheel under a head of 120 feet and uses the power to operate a 4-stamp mill. The Alaska Free Gold Mining Co. develops about 25 horsepower on Fishhook Creek by a Pelton wheel under a head of 35 feet and uses the power to operate a Lane mill. The Gold Bullion Mining Co. develops about 25 horsepower on Craigie Creek by a turbine wheel under a 28-foot head and uses the power to operate a 7-stamp mill. The water supply for these plants is sufficient for their operation only about three or four months during the summer.

Total development.—The maximum aggregate capacity of all water-power plants that were in operation in 1913 in the areas considered in this report was less than 2,000 horsepower. At low-water periods during the winter their aggregate capacity was undoubtedly less than 1,000 horsepower.