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WATER POWER POSSIBILITIES OF CRATER LAKE, LONG LAKE, AND SPEEL RIVER NEAR JUNEAU, ALASKA

By
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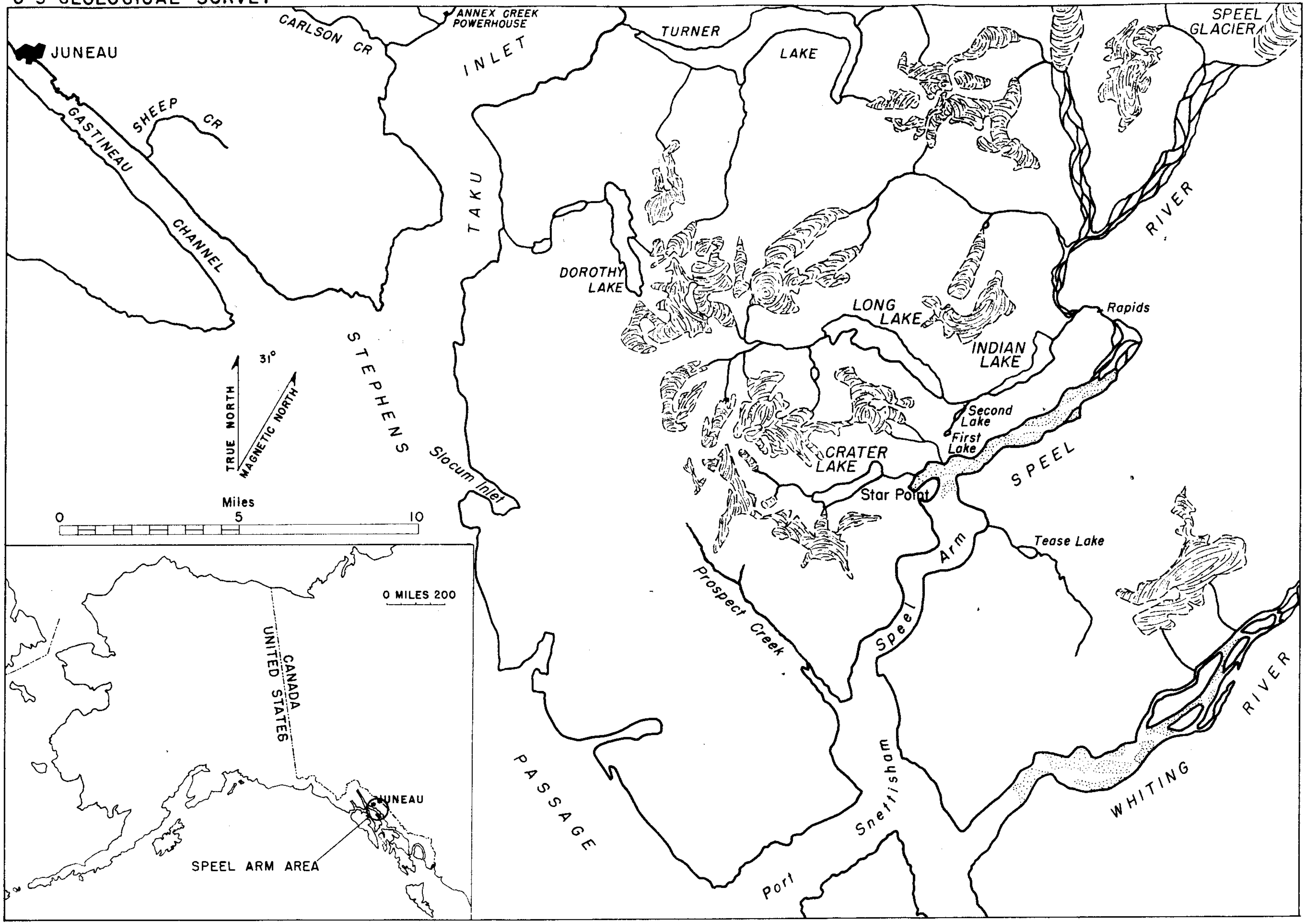

Figure 1. Location Map

WATER POWER POSSIBILITIES OF CRATER LAKE, LONG LAKE, AND SPEEL RIVER NEAR JUNEAU, ALASKA

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WATER POWER POSSIBILITIES OF CRATER LAKE, LONG LAKE, AND SPEEL RIVER NEAR JUNEAU, ALASKA

Introduction

This report is one of a continuing series intended primarily to assist in the classification of lands within the public domain as to their value in the development of hydroelectric power. It describes the power possibilities of sites on Crater Lake, Long Lake and the Speel River, Alaska, all of which are located within a relatively small area near the head of Speel Arm, 28 miles (airline) southeast of Juneau. It is estimated that approximately 48,000 kilowatts of power could be generated continuously at these sites with independent operation of the units, and that 63,000 kilowatts could be generated continuously if the units were designed and operated as a coordinated system.

Information is presented concerning the climate, streamflow, topography and other factors that are pertinent to development of water-power in this region. Recent topographic maps, surveys of the power sites, and geologic examinations were used in the preparation of the report.

Some investigations of these sites were made as early as 1913, and several applications for use of the sites were made to the U. S. Forest Service and to the

Federal Power Commission in the period from 1913 to 1927. The more recent investigations provide a better basis for estimating the power possibilities and for describing the physical conditions that would affect the construction and operation of power projects.

The utilization of a substantial part of the power that could be developed at the sites would depend largely on the creation of new industries. Some possibilities that have been suggested are the manufacture of wood pulp, and the manufacture of various products by electrochemical and electromettallurgical processes. Areas that are topographically suitable for the location of factories and the associated settlements are very limited at or near the power sites. A full development of the sites might require transmission of power 50 miles or more over rugged terrain to the vicinity of Juneau, where adequate space is available. This would involve a crossing of Taku Inlet with a submarine cable approximately 2 miles long.

Previous investigations and reports

Development of water-power near the Speel Arm was considered as early as 1913, and several applications were made to the Forest Service between 1913 and 1921, and later to the Federal Power Commission, for use of the power sites. Some stream gaging stations were established in connection with these applications. Information about the applications is given in a report entitled "Water Powers of Southeast Alaska", published jointly by the Federal Power Commission and Forest Service in 1947.

Some unpublished reports prepared for the determination of action on these applications are on file in the Regional Office of the Forest Service in Juneau or with the Federal Power Commission in Washington, D. C.

A number of reports entitled "Water-Power investigations in Southeastern Alaska" are given in U. S. Geological Survey Bulletins 662-B, 692-B, 712-B, 714-B and 722-B, by G. H. Canfield. These reports consist mainly of compilations of the streamflow records, and descriptions of the gaging stations. They include records of daily discharge for Speel River, Long River, Long Lake outlet and Crater Lake outlet for the periods of operation of the gaging stations between 1913 and 1920. There are detailed discussions concerning the operation of the gages, measuring conditions, and other factors that might have determined the accuracy of these early records.

A publication entitled "Report to the Federal Power Commission on the Water-Powers of Southeastern Alaska" by J. C. Dort of the Forest Service was issued in 1924 by the Federal Power Commission. This includes discussions of the possibilities of the Crater Lake and Long Lake power sites.

The records of monthly runoff to 1930 are summarized in Bulletin 836-C by Fred F. Henshaw, entitled "Surface Water Supply of Southeastern Alaska, 1909-1930. This was prepared in cooperation with the Federal Power Commission and Forest Service, and contains a discussion of factors having to do with runoff characteristics and power development.

The report of 1947, "Water Powers of Southeast Alaska" by the Federal Power Commission and U. S. Forest Service, describes a general plan of development for the Crater Lake, Long Lake and Speel River power sites that would result in the use of a large part of the potential power with the several units operated independently. Attention was called to several alternative possibilities in this plan, such as the use either of a common powerhouse or separate powerhouses for the three units; and the development of storage at the lakes either by drawdown of the surfaces or by the construction of dams. The power estimates were based on development of storage by a combination of the two methods, and are summarized as follows:

Site	Storage capacity acre-feet	Power capacity, horsepower Primary	Average
Crater Lake	85,000	9,200	13,800
Long Lake	220,000	31,500	31,500
Speel River	385,000	36,000	51,000
Total	690,000	76,700	96,300

As defined in the report, primary capacity is the power that could be generated by utilization of the regulated flow through the mean effective head at an over-all efficiency of 80 percent.

Geologic examinations of the three power sites were made by J. C. Miller of the U. S. Geological Survey in 1952. A report on these investigations is in preparation.

Maps

A map entitled "Plan, Long Lake, Crater Lake and Vicinity near Juneau, Alaska, Dam Sites" was published by the U. S. Geological Survey in 1952. The scale of the plan map is 1:24,000 and the contour interval is 20 feet. Contours are shown to about 200 feet above and 200 feet below the lake surfaces. The dam site maps are on scales of 1:1,200; 1:2,400; and 1:4,800, with a contour interval of 10 feet on land and under water. Maps are provided of the sites at the outlets of Crater Lake and Long Lake; of a site on the Speel River, and of a saddle where an auxiliary dam would be required for full development of the Speel River site.

The power sites and their related drainage basins are shown on the topographic maps of the quadrangles; Taku River A-5, A-6, B-5, and B-6, Alaska, and on Sheet No. 7 of the map of the international boundary between the United States and Canada. The maps of the Taku River quadrangles were published by the U. S. Geological Survey in 1951 on a scale of 1:63,360 and with contour interval of 100 feet. The international map was published by the Boundary Commission in 1923 on a scale of 1:250,000 and with contour interval of 250 feet.

Maps showing the waterways and terrain between Speel Arm and Juneau include those for the quadrangles: Juneau (Alaska-Canada), Sitka, Sumdum, and Taku River, Alaska, all on a scale of 1:250,000, and with varied contour intervals from 200 to 1,000 feet. Some of this region also is shown on the quadrangle maps: Juneau (B-1), on scale 1:63,360, Juneau (B-2), on scale 1:62,500; and on a special topographic map called Juneau and Vicinity, on scale 1:24,000.

Soundings in Taku Inlet, Gastineau Channel and a portion of Stephens Passage are shown on Chart 8235 of the U. S. Coast and Geodetic Survey. Soundings in Speel Arm, Port Snettisham and Stephens Passage near Port Snettisham are shown on Chart 8227. Both charts are published on a scale of 1:40,000, and the soundings are in fathoms. Some topography near the waterways is shown on Chart 8235 at a contour interval of 200 feet.

GEOGRAPHIC AND TOPOGRAPHIC FEATURES

Speel Arm extends northward about 6 miles from Port Snettisham, an inlet or bay of Stephens Passage, one of the waterways of the intricate system connecting with the Pacific Ocean. Port Snettisham is southeast of Juneau, connected by the waters of Stephens Passage and Gastineau Channel. The distance from Juneau to the upper end of Speel Arm by this water route is roughly 45 miles.

Speel Arm is only about 28 miles southeast of Juneau by airline, but this route is across rugged mountains and an arm of Stephens Passage called Taku Inlet, which is generally about 2 miles wide. The only practicable access to the vicinity of the power sites near Speel Arm is by boats or float planes.

The drainage basins of Crater Lake, and the Alaskan portion of the Speel River basin which includes the Long Lake basin, lie entirely in a mountainous region within the Tongass National Forest. About an eighth of the Speel River basin lies in Canada, and that portion is characterized by barren mountains and glaciers. At present there are no settlements or inhabitants in the drainage basins or nearby on Speel Arm. A small pulp mill was operated intermittently from 1921 to 1923 on the east side of Speel Arm across from Crater Lake near the former Speel River post office. The mill was operated directly by water-power developed by diversion from Tease Lake. The project had an installed capacity of 1,350 horsepower, and was operated under a license issued by the Federal Power Commission, for Project No. 4, that was revoked in 1935.

Crater Lake and Long Lake are located just north of the head of Speel Arm in adjacent, mountainous basins. The drainage areas are 11.4 and 30.2 square miles respectively. Crater Creek flows eastward directly from Crater Lake to Speel Arm, but the Long River flows from Long Lake northeastward through Indian Lake, joining the Speel River about 8 miles upstream from its mouth at the head of Speel Arm. The Speel River at the possible dam site just downstream from the Long River has a drainage area of 226 square miles. More than a third of this area is covered with glaciers, a few of which extend as valley glaciers down to altitudes below 1,000 feet. Much of the area, however, is occupied by ice fields and cirque glaciers, generally located between altitudes of 2,500 feet and 6,000 feet.

The glaciers above Crater Lake and Long Lake generally consist of cirque glaciers and glacierets located along the ridges between altitudes of about 3,000 feet and 4,500 feet.

The storage of water in the form of ice and snow varies from year to year and tends to increase in wet, cold years and decrease in dry, warm years. The areas of the glaciers may serve as crude measures of these natural reservoirs, and are summarized as follows:

Outlet of basin	Area in sq. mi. Basin	Area in sq. mi. Glaciers	Glacier area in percent of total
Crater Lake outlet	11.4	3.3	28.2
Long Lake outlet	30.2	8.2	27.2
Speel River at dam site	226.	83.6	37.0
Dorothy Creek at gage	15.2	3.6	23.7

Dorothy Creek is included in this tabulation because its record of runoff was used for estimating the runoff in the other basins for certain periods. Dorothy Creek basin is adjacent to the Long River basin to the northwest, and its drainage is westward into Taku Inlet.

The amount of precipitation as rain or snow depends partly on the altitude, and during winter months the runoff therefore may depend greatly on the areas in different ranges of altitude, particularly below certain minimum altitudes. Some information concerning the altitude characteristics of the several basins is summarized as follows:

Basin outlet	Area in sq. mi. below: 500 ft.	1000 ft.	1500 ft.	2000 ft.	2500 ft.	Area, sq.mi. above 2500 ft
Crater Lake	0	0	2.2	3.6	5.2	6.2
Long Lake	0	4.1	6.8	9.9	13.6	16.6
Long River gage	0.5	5.1	8.2	11.7	15.7	16.8
Speel River dam site*	11.7	22.2	34.8	52.6	71.6	121.9
Dorothy Creek gage	0.0	0.6	1.0	1.7	4.3	10.9

*The areas listed for this site are exclusive of the area above Long River gage

Steep mountain slopes extend down to tidewater on the Speel Arm, and generally are covered with usable timber up to an altitude of about 1,500 feet. At altitudes above about 2,500 feet the mountains are relatively barren, and are characterized by extensive exposures of glaciated rock, and by ice and snow fields.

Crater Lake, at an altitude of 1,022 feet, is less than a mile from Speel Arm. Long Lake a few miles to the northeast at an altitude of 814 feet, is less than two miles from Speel Arm. (The figures of altitude given in this report are referred to mean sea level. Elevations listed in the Federal Power Commission reports were measured from a datum about 8 feet higher; - the higher high-water plane). Conditions are favorable for development of storage capacity at each of these lakes. A storage reservoir also could be constructed with a dam on the Speel River at the site seven miles above its mouth. The maximum crest altitude that probably would be considered is roughly 300 feet. This would require an auxiliary dam in the saddle between the drainage to Long River and Speel Arm. Water could be conveyed from the reservoir near this dam, about half a mile to Speel Arm for development of power. The topography of the region thus is favorable to development of all three sites with relatively short diversion conduits or tunnels located within a small area. This circumstance has suggested the possibility of a common powerhouse located on the Speel Arm.

CLIMATE

The climate of Southeastern Alaska is described in several of the reports cited herein; notably the ones issued by the Federal Power Commission and Forest Service in 1924 and 1947.

The outstanding characteristics of the Juneau region are the heavy precipitation, and the relatively mild climate at sea level resulting from the proximity to the ocean. The winter temperatures at Juneau, November through February, are about the same as at Spokane, Washington, but the summer temperatures are substantially lower.

Records obtained at various altitudes near Juneau indicate that some mountain localities are much colder than the coastal points. For example, differences from the Juneau temperature of as much as 6°F were recorded in winter months at a nearby station at an altitude of 750 feet. The winter precipitation is predominantly rain at Juneau, but it occurs as snow over much of the mountain regions. Temperatures are lower than at Juneau, even at sea level, on waterways farther inland. The average temperature at Juneau for the 4-month period, November to February, is 31.4°F, but at Annex Creek on Taku Inlet 10 miles to the east it is only 26.9°F.

The mean annual precipitation near sea level varies from about 90 inches at Juneau to 115 inches at Annex Creek; and to about 150 inches on the Speel Arm 28 miles southeast of Juneau. This large variation evidently is caused by the pattern of moist air currents as modified by the local topography. In general there is also an increase in precipitation with increase in altitude. Records of runoff for Sheep Creek near Juneau indicate that the average precipitation on the drainage area is about 180 percent of that at Juneau. This small basin is 5 miles southeast of Juneau, and its mean altitude is about 2,000 feet. On the Crater Lake drainage basin the mean annual precipitation, as indicated by the runoff records, must be substantially greater than 200 inches or more than twice that at Juneau. The mean altitude of that basin is roughly 2,500 feet.

There is a pronounced seasonal variation in amount of precipitation, but no period of seasonal drought such as occurs in the Pacific Coast states. The mean precipitation at Juneau in June, the driest month, is about 4 inches, and monthly amounts less than 2 inches are rare. The wettest months are September and October when the mean precipitation is about 2.5 times that in the driest month.

As would be expected from the amount and frequency of precipitation, the Juneau area has considerable cloudiness and relatively few days of sunshine although there probably is less sunshine at Juneau than farther inland at the drainage basins near the Speel Arm. For example, during a 20-year period the number of clear days recorded 10 miles east of Juneau at Annex Creek, averaged 94 days a year, as compared with 54 at Juneau, although there is more precipitation at the Annex Creek station.

The magnitude of precipitation, its occurrence as snow on the mountains in winter months, and the relatively cloudy, cool summers account for the numerous glaciers of the region. Summer precipitation, cloudiness, and temperatures probably are somewhat interdependent, and the year-to-year variations in these factors partly account for changes in the amount of water stored as ice or snow in the glaciers. These changes in natural storage are reflected in variations of annual runoff with respect to the amount of precipitation. In summers that are relatively dry and warm the deficiency in rain runoff is balanced by increased melting of the glaciers in the basins near Speel Arm.

On the other hand, during wet, cool summers the additional rain runoff is offset by increased storage in the glaciers, so that these natural reservoirs have a noticeable equalizing effect on the annual runoff.

Fairly complete records of precipitation are available for Juneau for 1890-91; 1899-1902; and 1905 to date. Records are available for Annex Creek from 1917 to date; and at Speel River from 1915 to 1930. (The Speel River gage presumably was located on the east side of Speel Arm at the mouth of the creek draining Tease Lake. The Alaska Pulp and Paper Co., which operated a pulp mill at that place, made the precipitation measurements). The figures for Juneau from 1905 to 1915 indicate a very substantial deficiency with respect to the period 1916-54. If the records for the two periods were consistent, runoff from 1905 to 1915 undoubtedly would have been very low with respect to later runoff, and the period 1905-15 should be regarded as representative of a possible future period of similar deficiency. The precipitation recorded during the two water years ending September 30, 1910 and 1911 was especially low, being about 49 inches and 25 inches for 1910 and 1911 respectively. The minimum recorded during any water year since 1912 has been 65 inches.

The precipitation records for Juneau were compared with precipitation records for some other stations in southern Alaska, and these comparisons show that there was an abrupt and consistent change in the Juneau records about 1916. (The precipitation was estimated for a few months of missing record in the period, 1905-11, but this circumstance would not substantially affect the accuracy of the comparisons). For example, from 1905 to 1909 and from 1912 to 1915 the precipitation recorded at Juneau was about 45 percent of the amount recorded at Fortmann Hatchery, a station 200 miles southeast of Juneau. In the two-year period, 1910 and 1911, the catch at Juneau was only 27 percent of that at Fortmann Hatchery. But in an 11 year period since 1915 the catch was 66 percent of that at Fortmann Hatchery; a relative increase of roughly 45 percent. The Juneau record had a similar change in relation to that at Seward, a station far to the west. If the change was mainly due to a difference in measuring conditions at Juneau, as seems likely, the period from 1905 to 1915 may in fact have been slightly wetter than the following 38-year period when the average annual precipitation was 90 inches. As an index of wetness or of runoff it is believed therefore that the precipitation record after 1915 represents a fair sample of the long-time pattern. This record is shown in Table 6, page 62 , and a corresponding temperature record is shown in Table 7, page 63.

The records collected for Sheep Creek near Juneau, which drains a small area 5 miles southeast of Juneau, also provide a rough means for comparing the relative wetness of some of the early years with that of recent years. The annual figures are as follows:

Water year ending September 30	Runoff for Sheep Creek acre-feet	inches	Precipitation at Juneau inches
1911	26,000 1/	106	25. 2/
1912	29,500	121	62.6
1913	31,300	129	86.0
1917	36,700	150	95.2
1918	38,800	159	102.1
1919	39,100	160	97.0
1920	35,700	146	94.0
1947	40,840	177	103.1
1948	37,640	163	89.8
1949	41,070	179	111.2
1950	29,490	128	78.0
1951	25,830	112	65.0
1952	31,560	137	84.9

1/ 22,700 acre-feet recorded from January to September, the remainder was roughly estimated.

2/ 21.25 inches was recorded during 11 months exclusive of March 1911; that for March was roughly estimated.

Precipitation figures were compiled from Weather Bureau records, with totals rounded to the nearest tenth of an inch. Runoff records for the 3 separate periods are not strictly comparable owing to changes in measuring sections and gage equipment.

From 1947 to 1952 the relation of annual runoff in inches to the precipitation at Juneau is represented fairly well by the equation: $R = 1.8 P - 10$. The corresponding relations for the early periods differ considerably from this equation, and notably so in 1911 when the precipitation recorded at Juneau was grossly inconsistent with records of other stations. Although the early runoff records may not be closely comparable to those of the recent years it appears that the years 1911 to 1913 represented a period of deficiency in precipitation and runoff similar to that from 1950 to 1952.

The bulk of the precipitation results from relatively warm, moist winds from the Pacific Ocean which are forced to rise at the mountain barrier along the coast of Southeastern Alaska. These generally are of light to moderate force. Exceptionally strong winds occur when there is a westward flow of air from the inland mountains, notably through the waterways such as Taku Inlet in winter months. According to climatological summaries published by the Weather Bureau, winds of hurricane velocities sometimes occur in the fiords and mountain passes of the region.

FACTORS THAT WOULD AFFECT THE OPERATION OF POWER PLANTS

The Speel River carries a large quantity of sediment in suspension and as bed load, and this probably would be the most adverse factor in the operation and maintenance of a reservoir and generating station on that stream. G. H. Canfield, who made a number of discharge measurements, 1916 to 1918, reported that the swift current at the measuring section carried large quantities of sand in suspension. J. C. Miller, during his geologic examinations of 1952, noted that large quantities of sediment are carried by the stream and that the sand and gravel bars are changed rapidly by the increased flows during warm days. Most of the debris probably comes from two valley glaciers which feed the Speel River and a branch of the river, within about 10 miles of the Speel River dam site. The flow is in braided channels on the wide deposits of debris that occupy the bottom of the valleys downstream from the glaciers.

There is little basis for estimating the average amount of sediment carried by the Speel River and this would be difficult to determine by measurements since the load undoubtedly varies throughout each season and from year to year. Much of the material probably results from glacial erosion, so that the stream load may correspond roughly to the amount of rock that is thus being eroded.

If the load per unit of average discharge were the same as that of the Colorado River above Lake Mead, the annual amount might correspond to a volume of deposit in a reservoir of roughly 10,000 acre-feet a year. (The deposit in Lake Mead has been accurately determined for a 15-year period, as described by C. P. Vetter.[1/])

1/Vetter, C. P., 1953, Sediment problems in Lake Mead and downstream on the Colorado River, Trans. Am. Geophys. Union, Vol. 34, No. 2, pp. 249-256.

The sediment load of the Colorado River has long been regarded as outstandingly large. It may be much higher per unit of discharge than that of the Speel River since the character of the channel, the stream regimen , and the nature of the sediment are entirely different. A sediment load corresponding to a volume of, say, only 2,000 acre-feet a year probably would be very conspicuous in the Speel River, and perhaps would correspond to a high rate of erosion under portions of the glaciers that do the bulk of the work. Even this rate of sedimentation, however, would result in a considerable impairment of the Speel River reservoir within a 50-year period.

If a reservoir were constructed on the Speel River to a maximum altitude of 300 feet the total capacity would be about 370,000 acre-feet, of which about 234,000 acre-feet could initially be used for regulation, with storage releases from the auxiliary dam and with drawdown to an altitude of 235 feet. Some of the coarser sediments undoubtedly would be deposited in the upstream portion of the reservoir at altitudes above 235 feet, so that there would be a gradual impairment of the usable capacity from the outset. A similar impairment of the capacity of Lake Mead was found in the surveys reported by Vetter.

A considerable part of the runoff of the Speel River probably would be wasted in most years since the potential storage capacity, in what appears to be any feasible plan of development, is much less than that needed for control of the river. As the reservoir filled with sediment upstream from the Speel River dam an increasing amount of material would be passed through the reservoir at times of spill, so that the rate of deposition in the reservoir would gradually be reduced. It is probable, therefore, that the Long River arm of the reservoir would retain its usefulness as a settling basin for a long period after the storage capacity of the reservoir becomes too small for substantial regulation. For purposes of this report it is assumed that the usable capacity of the Speel River reservoir may be greatly impaired within the life of the project, and that production of power from Speel River water thereafter will depend largely on regulation from other plants in the system.

The sediment load not only would shorten the life of the reservoir but also might cause erosion or impairment of gates, conduits and turbines. Location of the outlet works for power releases on the Long River arm of the reservoir, with the spillway at the Speel River dam, should minimize this trouble.

The glaciers upstream from Crater Lake and Long Lake undoubtedly contribute some sedi ment that is carried into the lakes by Crater Creek and Long River. The appearance of the streams, however, indicates that the sediment load is proportionately much smaller than that of the Speel River. At the time of the river surveys during the summer season of 1951, Long River and Crater Creek above the lakes had a milky appearance suggestive of very fine silt or rock flour in suspension. whereas Speel River had a very conspicuous load of heavier sediments, both in suspension and in movement along the bed of the channel. There would be some impairment of the Crater Lake and Long Lake reservoirs by deposition at the upper ends, but this probably would not seriously affect the operation of the projects during a period of many years after construction. Much of the sediment would be deposited in the deeper parts of the lakes which are more than 400 feet in depth, and some would be carried through.

Ice would form on the surfaces of reservoirs at the three sites during the winter months, which would be the periods of drawdown. Depending on their total capacities, spill probably would not occur at the Long Lake and Crater Lake reservoirs until late summer, if at all, so that discharge of ice over the spillways would not be a problem. Spill over the Speel River dam in some years would occur as early as June when there might be some ice in the reservoir.

Snow avalanches are common in this region, and these might be a source of danger to structures such as surface penstocks, powerhouses, and transmission-line towers if these were located on or below steep mountain sides. The occasional high winds at the mountain passes and along the inlets would have to be taken into account in the design and location of transmission lines. Icing of transmission lines also might be a troublesome factor at the higher altitudes. In the operation of a power line from Annex Creek to Juneau it has been found desirable to heat the cables with periodic overloads to avoid accumulation of ice. This line crosses a ridge at an altitude of about 3,400 feet.

The operation of reservoirs at the three sites probably would affect fish life only to a minor extent. The only stream suitable for salmon spawning is the Speel River in the 7-mile reach downstream from the dam site. A cascade just below the dam site constitutes a natural barrier to their migration to the upper reaches of the river. The releases from a reservoir on the Speel River might have to be scheduled to provide water for fish life downstream, but no allowance has been made for this possibility in the power estimates of this report.

WATER SUPPLY

Records and estimates of runoff

Records of runoff that were considered in the preparation of this report are as follows:

Station	Drainage area Sq. Mi.	Period of record
Crater Lake Outlet near Juneau	11.4	Feb. 1913-Dec. 1920; June 1927-May 1933
Long Lake Outlet near Juneau	30.2	Feb. 1913-Nov. 1915
Long River near Juneau	32.5	Oct. 1915, Sept. 1924; Oct. 1926-June 1933; Oct. 1951-Sept. 1953
Speel River near Juneau	22.6	July 1916-Sept. 1918
Dorothy Creek near Juneau	15.2	Oct. 1929-Sept. 1941; Sept. 1942-Dec. 1943 June 1944-Sept. 1954
Sheep Creek near Juneau	4.3	Jan. 1911-Dec. 1913; Aug. 1916-Dec. 1920; Oct. 1946-Sept. 1952

The stream gaging stations were operated by the Geological Survey in cooperation with the Forest Service until April 30, 1921. The stations thereafter until September 1945 were operated by the Forest Service, or under supervision of the Forest Service. Beginning October 1945 the stations have been operated by the Geological Survey.

Partial records are available for Crater Creek in the years 1921 to 1925, and are published in the report of the Federal Power Commission and Forest Service, 1947. This also lists some partial records for Long River for the years 1924 to 1926. Tables of monthly discharge are furnished in that publication for all periods of record through September 1945.

Records since September 1945 and some revised records for previous periods have not yet been published but are available in the files of the Geological Survey. Monthly and annual records of runoff for Crater Creek, Long River, Speel River and Dorothy Creek are listed in tables at the end of this report. Some estimates for periods of missing records also are included.

The bulk of the runoff at all of the stations occurs during the 6-month period, May to October, as a result of the melting of snow and ice and the moderate to heavy rainfall. At the higher stations runoff from November to April usually is very small, and in some dry, cold years the deficiency may extend from October through May. The winter flow results mainly from rain and occasional melt water, since there can be relatively little ground water.

There are fairly consistent relations between the monthly runoff of Crater Creek and Long River; Crater Creek and Dorothy Creek, and Long River and Dorothy Creek, during most of the months of overlapping records. Since periods of critical low flow occurred when records were not obtained on Crater Creek and Long River, estimates made from the monthly runoff relations are of value in providing at least a rough measure of the dependable water supplies at those sites. In cold winter periods the runoff from areas of different altitude characteristics may differ considerably in relative amount, and the ratio between two records then may have a noticeable correlation with the monthly mean temperatures as reflected by those at Juneau. Some of the estimates for Crater Creek were adjusted in accordance with this relation. The runoff of that creek is notably low in relation to that of Dorothy Creek in very cold months; the usual ratio dropping from about 1.35 to as low as 0.2.

The records for Long River in 1933, as previously published, appear to be inconsistent with the monthly relation curves, and also with the runoff to be expected under the conditions of precipitation and temperature of that year. It is likely that runoff in the water year 1933 was about the lowest during the past 40 years in basins where glacier storage is a substantial factor.

The 27-month record for the Speel River includes only about 12 months for which the runoff was fairly well determined by discharge measurements and gage heights; in other months the figures generally were estimated by comparison with the flow of Long River. Excepting estimated figures for three winter months, all plot within 15 percent of an average relation curve of the monthly runoff of the Speel River and the Long River, and most of the figures are within 10 percent. The flow of Speel River, exclusive of Long River, varies from about 5.4 times as much as Long River in months of high flow to about 3.3 times as much in winter months. Although the relation curve is based on scanty data it was used to estimate the monthly runoff of the Speel River in the water years 1916, 1919-22; 1932-36, and 1950-53. In the years 1933 to 1936 and 1950 the runoff of Long River also was estimated, so that the simulated record for Speel River may be only a crude representation of the historical runoff. The estimates are intended mainly to provide a rough measure of the water supplies to be expected during a future period of critical flow similar to those that occurred from about 1932 to 1934 and from 1950 to 1952.

During a 10-year period of overlapping records for Crater Creek and Long River the annual runoff in the two basins had a close correlation, as shown in Figure 2. The relation of the annual runoff at Long Lake outlet to that of Crater Creek, expressed in inches on the drainage areas, should be about the same as shown in Figure 2, since the drainage area at the Long River gage is only 7 percent more than that at the lake outlet. The records obtained for the water years 1914 and 1915 at Long Lake outlet, however, are grossly inconsistent with this relation. Gaging conditions both at Long Lake and Crater Lake were called unsatisfactory in 1914 and 1915; and this may account for the discrepancy. The records for those years were not used for estimating the power possibilities, but it is probable that the runoff in both years was above the average.

Relation of annual runoff to precipitation and temperature

Some of the annual values of runoff for the several basins differ greatly from the amounts to be expected from the precipitation. For example, the runoff of Dorothy Creek in the water year 1936 was substantially more than in 1949, although the precipitation at Juneau was only 85 percent of normal in 1936 whereas it was 122 percent of normal in 1949. In those years the precipitation at Annex Creek near the Dorothy Creek basin was comparable to that at Juneau, being 81 percent

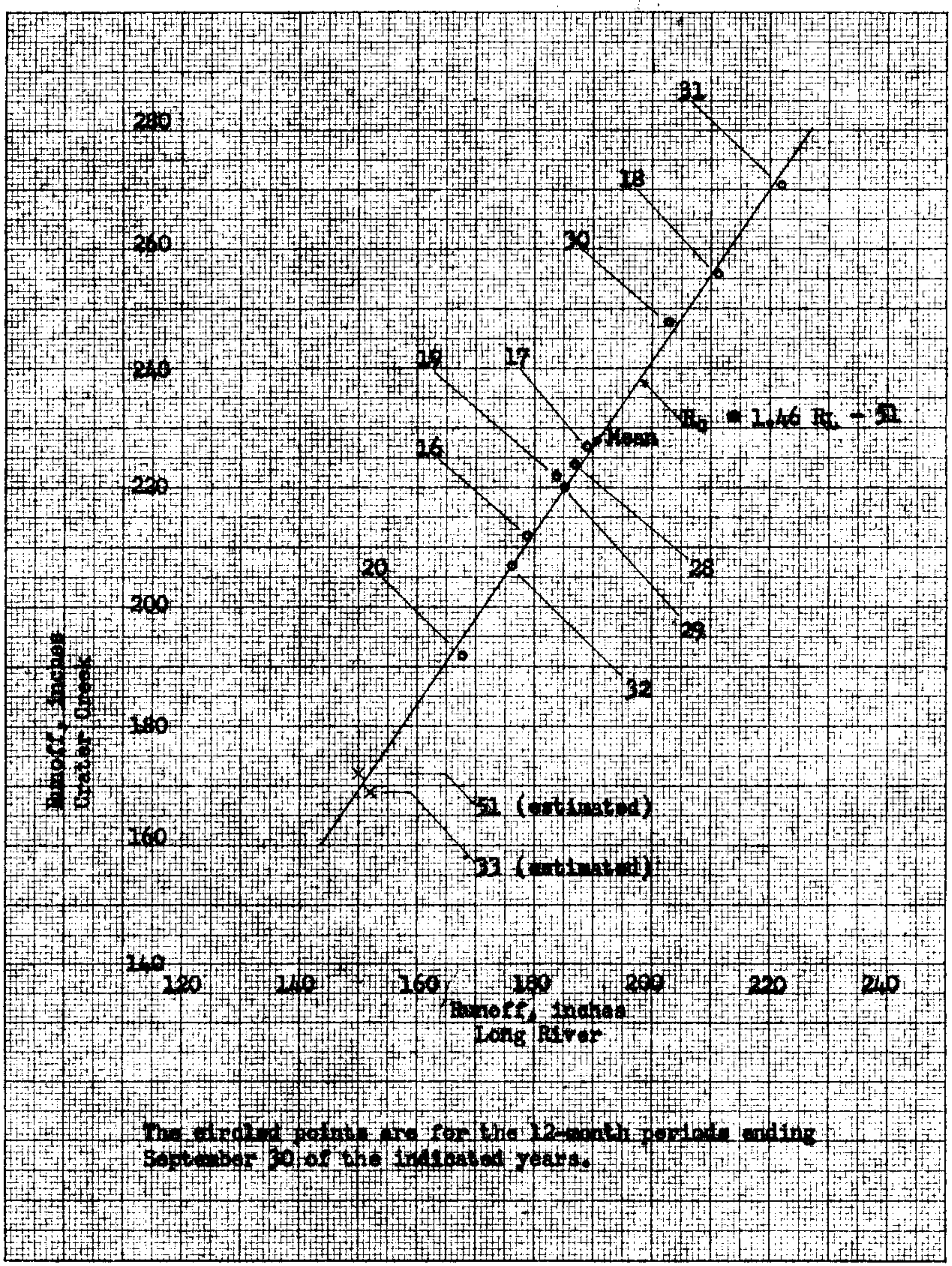


Figure 2. Relation of annual runoff of Crater Creek to that of Long River, near Port Snettisham, Alaska.

of normal in 1936 and 126 percent of normal in 1949, and there was a similar correspondence in most of the other years of record. It is unlikely, therefore, that abnormalities in the areal distribution of precipitation were largely responsible for the occasional abnormal relations of runoff to the precipitation indices. These evidently were caused mainly by abnormal changes in natural storage as ice or snow. The changes with respect to the annual precipitation may be due to several factors, which are discussed as follows:
1. Melt of glacier ice tends to be increased during clear, warm seasons and reduced in cloudy, cool seasons. The variation is partly due to the rate of melting of the snow cover and partly to the amount of heat intercepted by the exposed glacier. 2. Melt of glacier ice tends to vary according to the amount of antecedent snowfall. Snow constitutes effective insulation on the areas subject to ablation, and the duration of this insulation in summer months depends largely on its initial amount. 3. Melt of snow on or below the glaciers may be retarded in wet, cool years to the extent that substantial amounts may last throughout the summer, appearing as runoff in subsequent, drier years. 4. The amount of annual precipitation stored in the glaciers depends largely on the amount of snowfall, which may not be closely proportional to the amount of annual precipitation.

In occasional years it is to be expected that a combination of factors will result in a relatively large change in natural storage. In the water year 1949, for example, winter precipitation was the largest during the period of the runoff record, and was large in relation to the annual precipitation. Temperatures were substantially below normal during the period April to July, when there was an accumulated departure of minus 18°F at Annex Creek. The duration of the snow cover must have been favored both by its large amount and by the low temperatures, and melting of the glaciers must have been reduced accordingly. It is likely that some of the snow was carried over in transient storage to appear as runoff during the following dry year, and also that accumulation on the glacier was large in relation to the annual precipitation. As will be seen in Figure 3, the runoff of Dorothy Creek in 1949 was about 40 inches less than would be expected from the precipitation, which corresponds to a deficiency of 33,000 acre-feet.

The systematic effect of climatic variations on natural storage is apparent in the relation of the runoff of Dorothy Creek to precipitation and temperature indices, as shown in Figure 3. The straight line, $R = 1.54 P - 10$, represents the approximate relation that would exist if there were no systematic changes in natural storage.

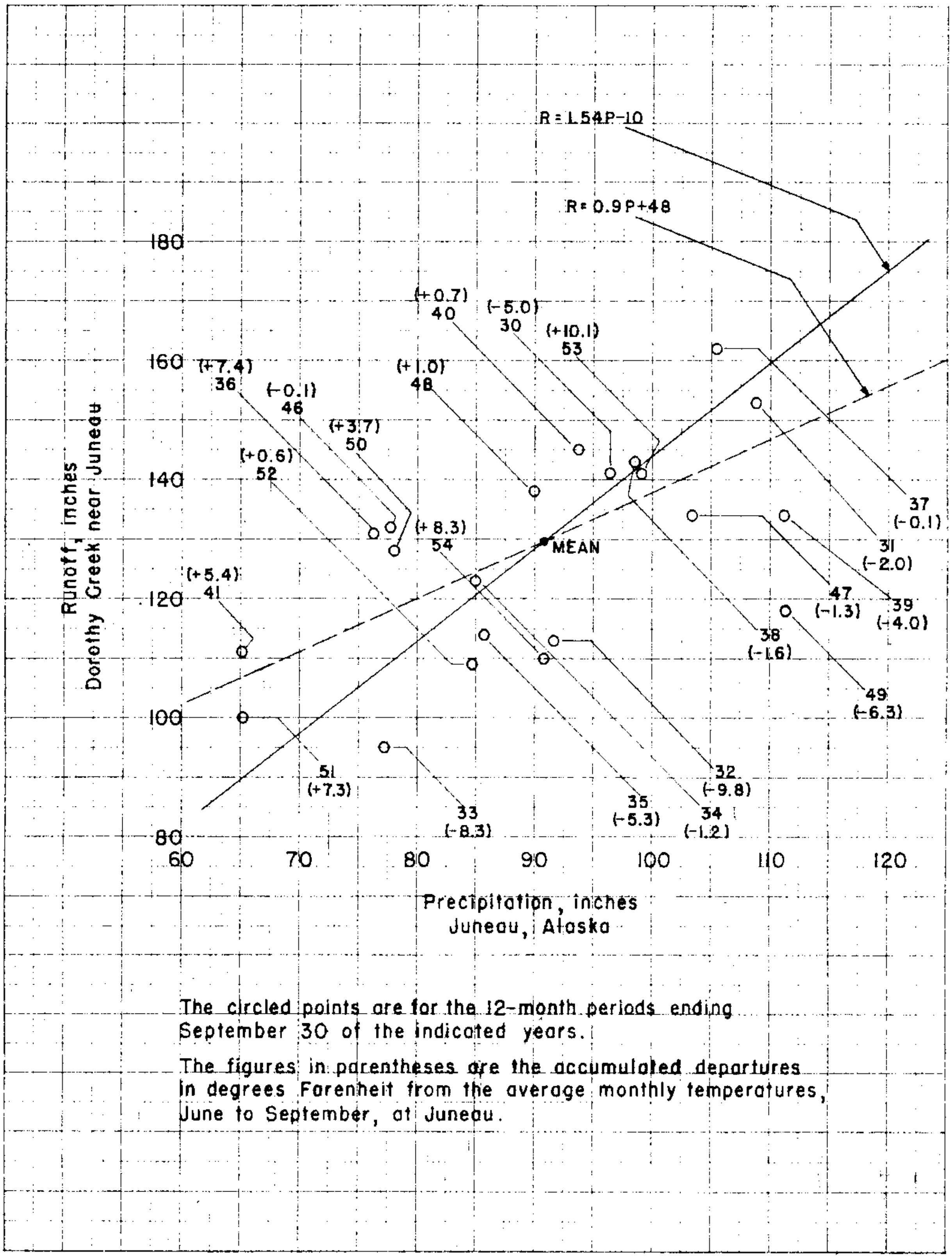


Figure 3. Relation of annual runoff of Dorothy Creek to annual precipitation at Juneau, Alaska.

In this equation 10 inches is a rough estimate of the annual loss to be expected from evaporation and transpiration; a factor which undoubtedly is small and relatively constant. It is apparent that an average of the data would be represented more closely by a line of much flatter slope; for example: $R = 0.9 P + 48$. In general there was an increase in runoff with respect to precipitation in the drier years and a decrease in the wetter years. Furthermore, runoff generally was relatively high with respect to precipitation when summer temperatures were above normal and low when the temperatures were below normal.

Runoff in relation to climatic trends

In addition to the year to year changes it is possible that climatic conditions during a considerable period may favor progressive changes in glacier storage. During the period from about 1880 to 1940 glaciers of Alaska generally have receded, according to Matthes,[2/] although many exceptions to this trend have been observed.

2/Matthes, Francois E., 1942, Chapt. V of Hydrology, edited by O. E. Meinzer, McGraw-Hill Book Co., Inc., pp. 198-201.

If the glaciers in the region of Speel Arm have been diminished during the past years the runoff may have been augmented by some ice melt which in a future period might not be available. For example if temperatures should become consistently lower the snow-line would be lowered and there would be a reduction in the rate of glacier change between the two periods.

Two large valley glaciers of the Speel River basin are shown on the map of the International boundary prepared from surveys of 1906 to 1909; and also on the recent quadrangle maps compiled from aerial photographs of 1948. The termini of these glaciers are shown at about the same location on both maps, indicating that there probably has not been a major change in the volume of the glaciers during that 40-year period.

STORAGE SITES

Conditions are relatively favorable at Crater Lake and Long Lake for constructing reservoirs adequate for substantial control of the runoff. A reservoir can be constructed on the Speel River for partial regulation, but much of the considerable debris load would be deposited in the reservoir and would cause some impairment of the usable capacity from the outset. Storage at the three sites could be used either for regulation of the units operated as separate generating stations, or for system regulation in a coordinated plan of development. The coordinated plan would require greater plant facilities but would provide for greater utilization of the potential power, and for a substantial use of Speel River water without considerable storage on that stream.

Crater Lake reservoir site

Crater Lake is three-quarters of a mile from tidewater, and is at an altitude of 1,022 feet. The lake is two miles long and has a surface area of 503 acres. It is bounded by steep mountain sides except at the upper end, where a delta has formed, and the steep slopes extend underwater for over 300 feet. The lake is drained by Crater Creek which flows eastward in a series of cascades mainly on bedrock, about a mile to the Speel Arm. The channel at the lake outlet is 30 feet wide and is in bedrock.

The sides of the canyon downstream from the outlet are topographically suitable as abutments for a dam to at least 200 feet above the lake surface. The width of the canyon at that altitude is about 500 feet. The creek drops 50 feet in a distance of 200 feet from the lake outlet, and 30 feet of that fall is concentrated in the first 50 feet. The rock on the north side of the creek also slopes sharply downstream from a narrow ridge at the outlet section. Because of these topographic features the site may be more suitable for an arch dam or buttressed dam than one of the gravity type. The topography is favorable for a development of storage capacity by tapping the lake with a tunnel outlet. A considerable amount of usable capacity thus could be obtained by damming the lake outlet, by drawdown, or by a combination of the two methods. The potential capacities

A - Crater Lake looking west from east end of lake.

B - Looking southwest at outlet of Crater Lake.

Figure 4

and the corresponding surface areas are shown in Table 1.

J. C. Miller found from his examination that no very unusual geologic problems are likely to be encountered in the construction of a dam and tunnel. The rock at the dam site was considered to be suitable for the foundation of a masonry dam, or one of flexible-type construction such as a rock-fill dam, to a height at least 100 feet above the lake surface. Rock for the latter could be quarried near the site, but it might be necessary to bring in aggregate for concrete from Speel Arm. Construction of an access road would be difficult because of the very steep terrain, and investigation may show that a tramway would be preferable.

The average discharge of Crater Creek for the 31 years of recorded and estimated runoff was 190 second-feet, which corresponds to an average annual runoff of approximately 138,000 acre-feet. (See table 8, page 64) A storage capacity of about 135,000 acre-feet would have been required for complete utilization of this runoff in a schedule of uniform monthly releases. This capacity is available between the present lake surface and an altitude 200 feet higher; or, as an example of combined damming and drawdown, between altitudes 100 feet above the lake surface and 162 feet below. Storage capacity of only 76,000 acre-feet would provide for a regulated flow of 171 second-feet, or 90 percent of the average discharge. This amount

Table 1

Crater Lake reservoir site

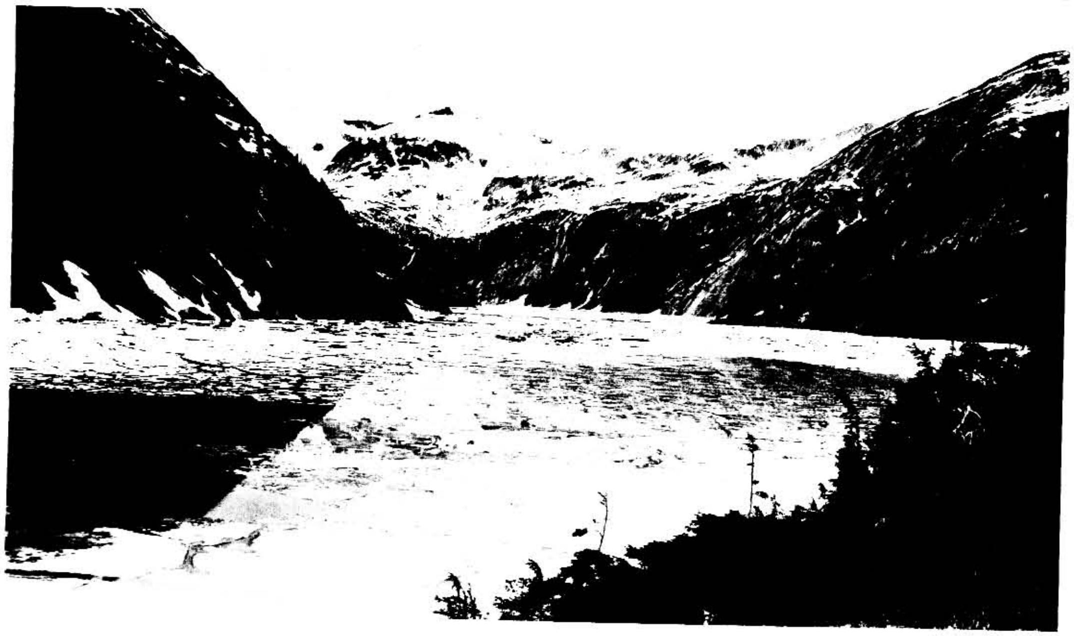
Altitude, feet	Area, acres	Capacity, acre-feet
800	320	89,100
820	338	82,500
840	353	75,600
860	363	68,400
880	376	61,000
900	392	53,400
920	410	45,300
940	423	37,000
960	436	28,400
980	447	19,600
1,000	465	10,500
1,022 (Lake surface)	503	0
1,040	570	9,600
1,060	633	21,700
1,080	675	34,800
1,100	723	48,800
1,120	764	63,600
1,140	792	79,200
1,160	818	95,300
1,180	847	111,900
1,200	885	129,200

is available, for example, between altitudes 60 feet above the lake surface and 84 feet below. In an actual schedule of operation the releases probably would be varied somewhat in accordance with the head and the load demand. The illustrative reservoirs, with capacities divided equally above and below the present lake surface, would provide for a uniform generation of power equal to that obtainable from the average regulated flow through the gross head of approximately 1,005 feet that could be utilized below the altitude of the lake surface.

If the reservoir were designed for only partial control of the runoff, and with a dam at the outlet, it would be necessary to provide spillway capacity adequate to pass the maximum discharge that might occur. The peak discharges of Crater Creek often occur in the wet months, September or October, when storage would tend to be at a maximum. The maximum discharge of record was 3,100 second-feet in September 1927, which corresponds to the relatively high unit rate of 260 second-feet a square mile. In comparison, the maximum recorded on nearby Dorothy Creek from 1929 to 1953 was 1,780 second-feet in November 1949, or 115 second-feet per square mile.

Long Lake reservoir site

Long Lake is a mile and a half from tidewater, and is at an altitude of 814 feet. The lake is 4 miles in length and has an area of 1,324 acres. It is



A - Ice on Long Lake looking northwest.

B - Looking south at island in outlet of Long Lake.

Figure 5

bounded by steep mountain sides except at the upper end, and the steep slopes extend under water for more than 300 feet. The Long River valley upstream from the lake has been filled with glacial debris to an average width of about 2,000 feet for a distance of 3 miles. The 900-foot contour crosses the valley about 2 miles upstream from the lake. At the outlet of the lake the river flows in two channels around a rock island for 200 feet, and it falls 500 feet in a cascade from the head of the island to a point 1,500 feet southeast. The river then flows eastward on a flatter gradient several miles by way of Indian Lake to the Speel River.

The hillsides at the outlet section are topographically suitable as abutments for a dam to an altitude of 900 feet, where the width of the valley is 700 feet. The width at stream level between the steep hillsides is 250 feet, including the rock island which extends generally about 10 feet above the stream and is 150 feet wide. The channel in a distance of 200 feet from the head of the island drops 70 feet, and in a distance of 450 feet it drops 140 feet. The rock on the right bank slopes sharply downstream below a narrow ridge at the outlet section so that the terrain is generally unfavorable as a base for a gravity dam. It appears to be more suitable for an arch dam, or a buttressed dam, Long Lake is topographically suitable for the development of storage capacity by drawdown; and as at

Crater Lake a considerable amount of usable capacity could be obtained by damming the lake outlet, by drawdown, or by a combination of the two methods. The potential capacities and the corresponding surface areas are shown in Table 2.

J. C. Miller found from his geologic examination that the rock in the region of the lake outlet has numerous faults and joints, and that considerable excavation and grouting might be required to prevent leakage. Alternatively it may be found that a higher dam farther downstream would be preferable, if the fractures at the outlet section extend to considerable depth, although the downstream topography is not as favorable for abutments. The geologic examination revealed that a tunnel for diversion of water from Long Lake to a powerhouse on Speel Arm would intersect one or more zones of disturbed rock.

For access to the lake a road might be constructed from Speel Arm about a mile and a half to a point near Long River at an altitude between 200 and 300 feet. Because of the steep slope it would be difficult to extend this up to the lake, and a short tramway might be preferable. Sand and gravel at the upstream end of the lake may be the best source of concrete aggregate, and if so transport by water probably would be the more practicable method, since the construction of

Table 2

Long Lake reservoir site

Altitude, feet	Area, acres	Capacity, acre-feet
600	844	230,900
620	901	213,400
640	940	195,000
660	982	175,800
680	1,022	155,800
700	1,069	134,900
720	1,109	113,100
740	1,143	90,600
760	1,187	67,200
780	1,227	43,100
800	1,276	18,100
814 (Lake surface)	1,324	0
820	1,438	9,000
840	1,637	39,800
860	1,826	74,400
880	1,977	112,400
900	2,089	153,100

a road on the steep mountain sides would be extremely difficult.

The average discharge of the Long River at the gaging station for the 31 years of recorded and estimated runoff was 458 second-feet. (The runoff figures are listed in table 9, page 65). The corresponding discharge at the lake outlet as computed according to the ratio of drainage areas was 432 second-feet, which is equivalent to an average annual runoff of 310,000 acre-feet. A storage capacity of 317,000 acre-feet would have been required for complete control of the runoff on a schedule of uniform monthly releases. This amount of capacity is available, for example between the altitudes of 679 feet and 903 feet, with the reservoir volume divided equally below and above the present lake surface. According to the estimated figures of runoff the reservoir would have been empty in April 1936 and full in October 1940. A uniform flow of 390 second-feet, or 90 percent of the average discharge, could have been obtained with the much lesser capacity of 150,000 acre-feet, which, for example, is available between the altitudes 733 and 860 feet. The reservoir would have been full in October 1932 and empty in May 1934.

In an actual schedule of operation the releases probably would be varied somewhat in accordance with the head and the load demand. The illustrative reservoirs would provide for uniform generation of power equal to that obtainable from the average regulated flow utilized through the head of approximately 806 feet that is available below the altitude of the lake surface. This would necessitate a maximum monthly release of about 520 second-feet with the larger reservoir, and 432 second-feet with the smaller.

If a dam were constructed at Long Lake outlet, sufficient spillway capacity would be required for the maximum discharge that might occur. During the periods, 1916 to 1933, and 1952 and 1953, the maximum recorded discharge at the gaging station was 6,000 second-feet which occurred in September 1927. This corresponds to the unit rate of 185 second-feet a square mile.

Speel River reservoir site

The Speel River enters a narrow canyon half a mile downstream from the mouth of Long River, and about eight miles upstream from the head of Speel Arm. The canyon reach, which is about half a mile long, constitutes the only favorable dam site on the river. Both upstream and downstream the stream flows on a wide deposit of glacial materials. The stream at medium-low stages is at an altitude of 165 feet just upstream from the gorge, and it drops to an altitude of about 20 feet just downstream. High tides extend 5 miles up the river from its mouth at Speel Arm.

A - Speel River dam site gorge looking west upstream.

B - On north end of First Lake, looking south at Saddle dam site.

Figure 6

The canyon sides are favorable for the abutments of a dam at a section a few hundred feet downstream from the head of the gorge, where the width is 700 feet at an altitude of 300 feet. At medium-low stages the river at this section flows in a channel less than 50 feet wide between steep rock sides, and is at an altitude of 160 feet. The range of stage at the former gaging station just upstream from the gorge was recorded as 28 feet during the period 1915 to 1918. At stages above 175 feet overflow occurs through a 150-foot channel along the left side of the canyon, separated from the low-water channel by a narrow, rock ridge.

A dam to an altitude of 300 feet would back water up the Speel River valley about 6 miles, and up the Long River basin 4½ miles to a saddle between the basin and Speel Arm. At this place, called the Saddle dam site, an auxiliary dam would be required, since the lowest point is at an altitude of 248 feet. The saddle consits of a wide deposit of alluvium and glacial materials of unknown depth, under a thick cover of muskeg moss. There is a uniform slope on each side of the low point of the saddle up to an altitude of 300 feet, where the width is 1,100 feet, and there are rock exposures on steeper slopes above this altitude. A very small auxiliary dam would be required in a narrow channel northwest of the principal structure for a reservoir altitude of 300 feet. Just southwest of the saddle, or on the downstream side of the Saddle dam site, there is a sharp drop of 80 to 100 feet in a distance of 100 to

150 feet. On the upstream side there is a small body of water called First Lake, 200 feet northeast of the saddle, at a surface altitude of 234 feet. This, and a somewhat larger body of water, called Second Lake, are in a short valley, tributary to the Long River above Indian Lake. First Lake extends 1,200 feet to its outlet, and is drained by a creek 500 feet in length to Second Lake, with a total fall of 41 feet. The depth at the center of First Lake is more than 45 feet. The location and design of a dam might be determined somewhat by these topographic features on both sides of the saddle, particularly if bedrock is at considerable depth.

J. C. Miller found from his geologic examination that the rock at Speel River dam site is suitable for the foundation of a dam of the suggested height, and he envisioned no unusual problems in construction. At the Saddle dam site it was not clear whether the abrupt downstream slope represented a section of the valley fill or a rock formation covered with a layer of alluvium and glacial deposits. For the purpose of this report it is assumed that a dam can be constructed to a crest altitude of 300 feet, but that a much higher structure may not be practicable. The design evidently will depend largely on the depth to bedrock and the character of the overlying materials.

The potential capacity of the reservoir site can be determined only roughly from the available maps, which are on a scale of 1:63,360 and with a contour interval of 100 feet. The capacities and corresponding surface areas, thus determined, are as follows:

Table 3

Altitude, feet	Area, acres	Capacity, acre-feet
165	0	0
200	2375	42,000
250	3284 (interpolated)	183,000
300	4192	370,000
350	4993 (interpolated)	600,000
400	5794	869,000

Water could be diverted at Saddle dam site, which is less than half a mile from tidewater at Speel Arm. The outlet works could be located below the present surface of First Lake, and with a little excavation at the outlet of the lake the reservoir could be drawn down to an altitude of 235 feet, or about the present lake altitude. This would provide for a usable capacity of 234,000 acre-feet below an altitude of 300 feet.

With a diversion at the Saddle dam the Long River arm of the reservoir would be effective as a settling basin between the Speel River valley and the outlet works. The potential capacity of this arm of the reservoir between the surface of Indian Lake, at an altitude of 177 feet, and a crest altitude of 300 feet is about 88,000 acre-feet. Only 35,000 acre-feet would be usable capacity above an altitude of 235 feet, and

53,000 acre-feet would be dead storage above the altitude of Indian Lake. The dead storage capacity probably would be increased substantially by the underwater volume of Indian Lake, which has a surface area of 520 acres.

The Speel River had an average discharge of 2,740 second-feet during the 2-year period of record, 1917 and 1918. During the 16 years for which the runoff was recorded or estimated the average discharge was 2,430 second-feet, which may be slightly less than a long-time average. The corresponding average that would have been available after complete diversion of Long River water at the lake is 2,000 second-feet. (The figures of adjusted runoff are shown in Table 10, page 66). During the dry water years, 1933 and 1951, the estimated average discharge, exclusive of Long River, was approximately 1,650 second-feet, corresponding to a runoff of approximately 1,200,000 acre-feet a year. With a usable storage capacity of 234,000 acre-feet a dependable monthly flow of 870 second-feet could have been obtained in such years, and at least 10 percent more in many of the wetter years.

A spillway would be required either at the Speel River or at the Saddle dam with capacity sufficient to pass the maximum discharge that might occur. During the period of record, 1915 to 1918, the maximum discharge was estimated as 35,600 second-feet. A discharge of that order of magnitude would be difficult to control on the half-mile slope between the Saddle dam site and the Speel Arm since there is no natural channel of substantial size. Furthermore it would be undesirable to pass the excess water over the Saddle dam because this would favor the transport of sediments into the Long River arm of the reservoir and through the powerhouse. For these reasons it would be preferable to locate the spillway at the main dam on the Speel River.

WATER POWER DEVELOPMENT

Power at the sites near Speel Arm might be generated for use near Juneau, where sizeable industrial sites are available. This would necessitate a transmission line roughly 50 miles in length over rugged terrain, including 2 high ridges and an underwater crossing of Taku Inlet. Since the cost of transmission would be relatively high, such a plan might not be practicable without the combined development of several sites for a substantial amount of power. The transmission costs and losses would be minimized if the plants near Speel Arm were operated at a high load factor. This would be practicable if peaking capacity could be had at existing or proposed plants near Juneau, or if the nature of the future industrial development favors a uniform load demand.

A partial development of one or more of the sites near Speel Arm might be considered if the power could be used in the vicinity. The area suitable for factory sites and settlements is rather small, but there is some land near the head of Speel Arm that might be used. The possibility of snow avalanches should be investigated before selection of a site. There are several possibilities for partial utilization of the potential power at each of the three power sites, some of which would involve relatively minor construction.

The power possibilities listed in the following sections were based on several illustrative plans. An optimum plan evidently can be determined only after additional field investigations, and after comparative study of the numerous methods for development of the storage capacity and diversion of the water. The potential power was computed on the assumption that the regulated flow could be utilized through the mean gross head for generation of electric power at an over-all efficiency of 80 percent. In kilowatts this is given by the equation $P = 0.068\ Q\ H$, where Q is the regulated flow in second-feet and H is the mean head in feet. An allowance for friction losses in the conduits was not made.

Crater Lake power site

It would be possible to divert water from Crater

Lake reservoir and convey it about 4,500 feet to the southeast by the shortest route to a powerhouse at tidewater. This site is half a mile southwest of the mouth of Crater Creek on the Speel Arm. The diversion could be accomplished by a tunnel and surface penstock of about equal lengths, although it might be necessary to use a tunnel penstock if the area is subject to avalanches. Alternatively, it would be possible to convey the water about 7,500 feet eastward by tunnel and penstock to a powerhouse on Speel Arm about 2,000 feet west of the mouth of Glacier Creek. This could be used as a common powerhouse for the Crater Lake, Long Lake, and Speel River units.

For estimating the potential power it was assumed that impulse wheels would be used in the Crater Lake unit, set a few feet above the highest tide elevation or at an altitude of 17 feet. Three general plans of development are considered, differing as to the method of storage development. The required storage would be developed by (1) a dam at the lake outlet to raise the lake above its natural elevation; (2) a combination of a dam to raise the lake level and a diversion tunnel to lower the lake below its natural level; and (3) a diversion tunnel for lowering the lake. Under each of these three general plans three variations are considered, - Plans A, B, and C, differing as to the assumed amount of storage capacity and the regulated flow thus attainable. Plan A represents complete control of the runoff, with the mean regulated flow equal to the average discharge, 190 cfs. Plan B is for a mean regulated flow of 171 cfs, or 90 percent of the average; and Plan C is for complete control in a water year of critical low flow such as 1951, when the average discharge was 145 cfs. The potential power and related data for the several possibilities are summarized in the following table 4.

Plan 3A clearly would be out of question, not only because of the small gain in power but also because of the excessive drawdown.

Under Plan C, with storage capacity of 50,000 acre-feet and with uniform generation according to the tabulated amounts there would have been spill in all years except 1951. A continuous generation of 105 percent of the tabulated amounts for the several illustrative schemes could have been obtained except during 2 years of the 31, - 1934 and 1951, when the deficiencies would have been only 5 percent and 3 percent respectively. Secondary power of this dependability could not be obtained under Plan B, since there would be periods of several years, like 1932 to 1936, when no surplus water would be available.

Long Lake power site

Water could be conveyed from the Long Lake reservoir about 9,700 feet southward by way of a tunnel and penstock to a powerhouse on the Speel Arm,

Table 4

Crater Lake power site, potential power and related data

Plan	Reservoir capacity (acre-feet)	Reservoir altitude, operating range, (feet)	Mean head, (feet)	Regulated flow (cfs)	Continuous power (kilowatts)
1. Storage capacity developed by dam at lake outlet to raise lake above its natural level.					
A	135,000	1022-1206	1,108	177-209	14,300
B	76,000	1022-1135	1,085	163-184	12,600
C	50,000	1022-1102	1,066	140-154	10,500
2. Storage capacity developed by combination of dam at lake outlet and a diversion tunnel for drawing the lake down, with the capacity equally divided above and below its natural level.					
A	135,000	860-1122	1,005	170-222	13,000
B	76,000	938-1082	1,005	153-204	11,700
C	50,000	963-1063	1,005	137-152	9,900
3. Storage capacity developed entirely by drawing lake below its natural level.					
A	135,000	620-1022	860	162-271	11,100
B	76,000	840-1022	937	146-181	10,800
C	50,000	904-1022	963	139-157	9,500

that could also be used for the Crater Lake and Speel River units. The waterway from Long Lake reservoir would require 8,000 feet of tunnel and 1,700 feet of penstock. The mountain sides above the powerhouse site extend up to an altitude of nearly 5,000 feet in a distance of 2 miles, and there is a glacier on the upper part of the slope. It seems possible that snow avalanches might constitute a hazard in this region, and if so the penstock and powerhouse might have to be constructed underground.

Alternatively, water could be conveyed from Long Lake to the southeast by way of a short tunnel and penstock to a powerhouse at the edge of Second Lake, for utilization down to an altitude of 194 feet. This would require only 2,000 feet of tunnel and 1,000 feet of penstock and would provide for the development of about three-quarters of the head between Long Lake and tidewater. The remainder could be developed by diversion from Second Lake by way of a tunnel and penstock 4,000 feet southward to the Speel Arm, although at proportionately greater cost for the powerhouse and waterway.

If the Speel River reservoir should be constructed, water could be conveyed from Long Lake by way of 1,500 feet of tunnel and 800 feet of penstock to a powerhouse at an altitude of 300 feet near the assumed maximum flowage line of the reservoir. The

Long River water then would be included in releases from that reservoir for generation in a powerhouse at Speel Arm, about 3,000 feet from the reservoir.

For estimating the potential power it was assumed that with reaction turbines and draft tubes the head could be developed down to the average tailwater level. With a powerhouse located at Second Lake this would permit development down to an altitude of 194 feet. With a powerhouse at the Speel River reservoir the average tailwater altitude was assumed as 290 feet or 300 feet depending on whether that reservoir would be used for regulation or for diversion purposes only. The head below the reservoir was computed from the mean surface altitude of 270 feet with drawdown, and from an altitude of 300 feet without drawdown. The tailwater altitude at the Speel River powerhouse was assumed to be 8 feet; - the higher high-water plane.

Water from Long Lake reservoir could be utilized accordingly through different average heads, depending on the nature of the development. The average gross head between the present lake surface and Second Lake is 620 feet. The average gross head between Long Lake and Speel Arm, through the Speel River reservoir, would be 786 feet with drawdown, or 806 feet without drawdown of the Speel River reservoir. A head of 806 feet also would be available with a direct diversion from the lake to Speel Arm.

For estimating the potential power, three plans were considered, Nos. 1, 2 and 3, for different methods of storage development. Under each of these general plans three variations were considered, - Plans A, B, and C, differing as to the assumed amount of storage capacity and the regulated flow thus attainable. Plan A represents complete control of the runoff, with the mean regulated flow equal to the average discharge, 432 cfs. Plan B is for a mean regulated flow of 390 cfs or 90 percent of the average discharge. Plan C is for complete control in a water year of critical low flow such as 1951, when the average discharge was 334 cfs. The potential power and related data for the several possibilities are summarized in the following table 5, for maximum utilization of the head below Long Lake reservoir.

With development in two stages, the relative amount of power that could be generated in each unit would depend on the mean reservoir level at Long Lake. In Plan No. 1, 66 percent of the power would be generated in the unit below Long Lake reservoir and 34 percent in the unit below Speel River reservoir, if the latter were operated at maximum pool level. In Plan No. 2 the corresponding amounts would be about 64 percent and 36 percent; and in Plan No. 3, 62 percent and 38 percent.

Table 5

Long Lake power site, potential power and related data

Plan	Reservoir capacity acre-feet	Reservoir altitude, operating range, feet	Mean head, feet	Regulated flow, cfs	Continuous power, kilowatts
1. Entire storage capacity developed by dam at lake outlet to raise lake above its natural level.					
A	317,000	814-970*	895	400-480	26,300
B	150,000	814-899	852	370-411	22,600
C	104,000	814-876	839	323-348	19,000
*Extrapolated					
2. Storage capacity developed by combination of a dam at lake outlet and a diversion tunnel for drawing the lake down, with the capacity equally divided above and below its natural level.					
A	317,000	679-903	806	390-519	23,700
B	150,000	733-860	806	369-432	21,400
C	104,000	773-847	806	322-352	18,300
3. Storage capacity developed entirely by drawing lake below its natural level.					
A	317,000	490*-814	671	360-601	19,700
B	150,000	683-814	754	364-435	20,000
C	104,000	708-814	765	317-365	17,400

*Extrapolated
Plan 3A is clearly out of question.

The relative amount of power generated in each plant would be somewhat different if the Speel River reservoir were operated for regulation. In that event there would also be a reduction of about 3 percent in all of the tabulated amounts of total power, due to the loss of head in the reservoir.

In a scheme for partial development to Second Lake the potential power would range from about 80 percent of the tabulated amounts for Plan No. 1, to 75 percent of those for Plan No. 3.

Under Plan C, with 104,000 acre-feet of capacity and with uniform generation according to the tabulated amounts for Plans 1, 2 and 3, there would have been some waste of water in all years except 1951. It would have been possible to obtain 105 percent of the tabulated amounts continuously except in 3 years of the 31; 1934, 1951 and 1952, and then the maximum deficiency would have been only 3 percent. Under Plan B, with 150,000 acre-feet of storage capacity and with uniform generation according to the tabulated amounts, spill would not have occurred during continuous periods of several years, as from October 1932 to October 1936, and from November 1949 to October 1951. Power in excess of that available 100 percent of the time therefore would not have been very dependable.

<u>Speel River power site</u>

With only a small diversion dam it would be possible to divert unregulated flows from the channel above the Speel River dam site for utilization through the head of about 150 feet that is available between the diversion point and the channel half a mile downstream. However, the maintenance and operation of the outlet works and other hydraulic equipment might be very difficult because of the heavy load of sediment. Furthermore, the topography is not favorable for the construction of a powerhouse at the lower end of the canyon. A more practicable development of power at the Speel River site probably would necessitate the construction of a dam sufficiently high for concentration of a moderate amount of head, and for providing an adequate settling basin. Generation of power from the unregulated flows would be practicable if the energy output could be firmed up from other sources, but storage regulation would be essential for generation of a substantial amount of dependable power at the site.

A dam to an altitude of about 200 feet would back water up the Long River valley and cover Second Lake, from which point a diversion could be made by way of about a mile of tunnel and penstock to the Speel Arm. A dam to an altitude of 235 feet would back water over First Lake, within 3,000 feet of Speel Arm near the mouth of Glacier Creek. For the purpose of this report it is assumed that the reservoir would be constructed to an altitude of 300 feet, with dams at the Speel

River site and at the Saddle dam site, so that a usable capacity of 234,000 acre-feet could be obtained above an altitude of 235 feet. The diversion from First Lake to Speel Arm near Glacier Creek then could be made by means of about 3,000 feet of tunnel and penstock, or mainly by pipe lines if desired.

About a mile of tunnel and penstock would be required for conveyance of water from First Lake to the powerhouse site on Speel Arm, 2,000 feet west of Glacier Creek, that also could be used for the Crater Lake and Long Lake units. The advantage of a common powerhouse would have to be weighed against the substantially greater requirement for waterways. With individual powerhouses an aggregate of less than 2 miles of tunnel and penstock would serve for conveyance of water from the three reservoirs; whereas more than 4 miles would be required with a common powerhouse.

It was estimated that a dependable flow of 870 second-feet could be obtained with 234,000 acre-feet of capacity. This possibility is based on the assumption that the Long River may be completely utilized in a separate development. With a range from 235 feet to 300 feet, the average reservoir altitude would be approximately 270 feet, and it is assumed that the head could be developed down to an altitude of 8 feet. The corresponding power, estimated to be available 100 percent of the time, is 15,500 kilowatts. This could have been obtained in water years like 1933 and 1951. In 9 years of 10, on the average, at least 17,000 kilowatts could have been generated continuously.

A continuous generation of 15,500 kilowatts corresponds to average monthly releases of from 780 second-feet to 1,000 second-feet, varied in accordance with the reservoir level. Sedimentation would gradually reduce the usable capacity of the reservoir, and the dependable power would be reduced accordingly. For example, with a capacity of 117,000 acre-feet, or half of the original amount, only about 10,000 kilowatts could be generated continuously.

Possibilities for a combined development

The Crater Lake, Long Lake and Speel River power plants could be designed and operated as a combined unit for the generation of substantially more dependable power than could be obtained by individual operation of the plants. In such a system the runoff could have been fully utilized in water years of minimum flow such as 1933 and 1951, and 30 percent more dependable power thus could have been generated. The increase was computed in relation to the three units operated independently, with the storage capacities at the lakes of the amounts listed under Plan B, created by combined damming and drawdown as illustrated in tables 4 and 5.

For the purpose of an illustrative comparison it was assumed that the combined units would be designed for 100,000 acre-feet of usable storage capacity at the Crater Lake site; 250,000 acre-feet at the Long Lake site; and 234,000 acre-feet at the Speel River site. The surface altitudes of the reservoirs and related data are as follows:

Reservoir	Capacity, acre-feet	Surface altitude feet	Mean altitude* feet
Crater Lake	100,000	908 to 1,102	1,022
Long Lake	250,000	709 to 886	814
Speel River	234,000	235 to 300	270

*Weighted mean altitude, corresponding to mean contents.

A mean gross head of 1,005 feet would be available in the drop from the Crater Lake reservoir down to an altitude of 17 feet. A mean gross head of 524 feet would be available in the drop from the Long Lake reservoir down to the mean tailrace altitude at the Speel River reservoir, estimated as 290 feet; and a mean gross head of 262 feet would be available in the drop from the Speel River reservoir down to a mean tailrace altitude of 8 feet, or the higher high-water plane.

In a coordinated schedule of operation most of the load would be carried by releases from the Crater Lake and Long Lake reservoirs during the winter, and by releases from the Speel River reservoir during the summer. The power possibilities were compiled herein on the assumption that the entire load would be carried by releases from the Speel River reservoir after the reservoir was substantially filled in the summer.

The regulated flows and powerhouse requirements then would be about as follows:

Power plant	Maximum regulated flow*, second-feet	Maximum generation*, kilowatts
Crater Lake	296	18,000
Long Lake	655	20,000
Speel River	3,540	63,000

*The maximum regulated flows and the maximum generation refer to the amounts for a load factor of 100 percent. The maximum releases from the Crater Lake and Long Lake reservoirs were computed on the assumption that they would be made at times of minimum pool level; those from the Speel River reservoir were computed for nearly a maximum pool level, or a head of 282 feet, since the reservoir would be nearly full at the times of maximum release in the summer.

An operation schedule for the critical period, September 1950 to April 1952 is listed in Table 12, p.68

The assumed method of operation is somewhat arbitrary, and is intended mainly for illustrative purposes. It would have been possible, for example, to have scheduled the releases so that the Speel River unit would have carried a greater part of the load when the Crater Lake and Long Lake reservoirs were at minimum stages, and thus to have minimized the maximum draft on those reservoirs.

A continuous generation of 63,000 kilowatts could have been maintained from September 1950 to April 1952, and during that critical period all of the storage and inflow would have been utilized. Under the same schedule, the reservoirs would have been full in October 1932, almost empty in May 1934, and full in October 1934.

A maximum of 48,000 kilowatts could have been generated continuously with independent operation of the Speel River plant and of the Crater Lake and Long Lake plants in accordance with the illustrative Plan 2B, with two-stage development of the Long River unit. Thus an increase of 31 percent or about 15,000 kilowatts could have been obtained with the three units designed and operated as a combined system. Such a plan would necessitate roughly a proportional increase in total storage and transmission-line capacity, but a disproportional increase in waterway and powerhouse capacity. Under the illustrative schedule releases from the Crater Lake and Long Lake reservoirs would have been increased 45 percent and 65 percent respectively, and the releases from the Speel River reservoir would have been increased about 350 percent. This latter increase would be due partly to the scheduling of the entire load on the one plant at times, and partly to the much greater utilization of Speel River water that would be possible under the coordinated scheme of operation. The greatly increased size of waterway required for these purposes would make it desirable to use the shortest route to tidewater, which at the nearest place is about 2,800 feet from a possible diversion point at the Speel River reservoir.

In the scheme for individual operation of the plants, 48,000 kilowatts of power could have been generated continuously without any excess generating capacity. In the scheme for combined operation, 101,000 kilowatts of capacity would have been required for an average generation of 63,000 kilowatts. Some of this excess capacity, however, could have been used for diurnal peaking with but slight modification in the schedule of monthly storage releases. For example, the energy required for a moderate peak load could have been supplied entirely by releases from the Speel River reservoir during 5 or 6 months of the winter period, and by releases from one or more of the three reservoirs during the remainder of the year. No additional waterway or generating capacity would have been required. During critical periods such as 1950 to 1952 there would have been some waste of water, or generation of secondary power, since the schedule for complete utilization called for continuous operation of the Speel River plant at full capacity for a short time in order to avoid spill. The releases then required from the other reservoirs for peaking would have been relatively small, however, and a daily load factor in the order of 75 percent could have been maintained with but little reduction in the average generation of dependable power.

An additional advantage of a system designed for coordinated operation of the units is the circumstance that the dependable power would not be greatly reduced by a substantial sedimentation of the Speel River reservoir. For an illustration of this possibility it was assumed that at some indefinite time in the future sedimentation would have reduced the usable capacity of the Speel River reservoir to a few thousand acre-feet, but that the usable capacities of the Crater Lake and Long Lake reservoirs would be the same as initially. The available head below the Crater Lake reservoir then would be the same as before, but operation of the Speel River reservoir at maximum pool level would reduce the mean head available between the Long Lake and Speel River reservoirs from 524 to 514 feet, and would increase the mean head available below the Speel Reservoir from 262 feet to 292 feet. Operation of the three units for maximum generation of continuous power during a period like 1950 to 1952 then would have resulted in the following requirements:

Power plant	Maximum regulated flow, second-feet	Maximum generation, kilowatts
Crater Lake	314	19,000
Long Lake	740	23,500
Speel River	2,940	58,500

Under the assumed schedule of operation all of the load would have been carried by the Speel River plant during summer months of adequate flow. The maximum releases from the Crater and Long Lake reservoirs would have occurred at stages slightly higher than the minimum pool levels.

An operation schedule for the critical period, September 1950 to April 1952 is listed in table 13, p. 69

A somewhat greater amount of waterway and powerhouse capacity would have been required at the Crater Lake and Long Lake units than under the assumed schedule with full use of the initial capacity of the Speel River reservoir. This increase would have provided for full use of the storage and inflow at the lake sites during the critical period from September 1950 to April 1952, but water would have been wasted at the Speel River site during 2 months of that period. A total powerhouse capacity of 101,000 kilowatts would have been required for a continuous generation of 58,500 kilowatts of power.

As before, it would have been possible to operate the coordinated system so as to provide a moderate amount of daily peaking without additional facilities for that purpose and with but a slight reduction in the average generation of dependable power. During the winter and spring months of low flow when generation at the lake units would be at or near a maximum, this could be accomplished by daily re-regulation of releases from Long Lake reservoir in the Speel River reservoir. Adequate pondage capacity for that purpose could be obtained by a slight drawdown or by use of flash boards, since only a few thousand acre-feet would be required. During the high-water season the peak load also could be carried in the same way by the Speel River unit, except in the few months when that plant would be operated at or near capacity. Releases from the Crater Lake and Long Lake reservoir then would be required to supply part of the energy for peak load use. It is estimated that the system could be operated at a daily load factor of 75 percent and with an average generation of 56,000 kilowatts, 100 percent of the time.

Transmission line routes

A substantial development of the Crater Lake, Long Lake and Speel River sites would necessitate transmission of power to a place where a considerable amount of suitable terrain is available for factories and communities. For this purpose sites at or near Juneau have been considered in several of the early proposals. Suitable areas in other parts of the region are very limited since the waterways are generally bounded by precipitous mountains.

Two general transmission routes have been considered between Speel Arm and Juneau. One roughly parallels the shorelines of Speel Arm, Port Snettisham and Stephens Passage to a point near the mouth of Taku Inlet. Power would be transmitted thence by submarine cable across Taku Inlet, and by overhead line along Taku Inlet and Gastineau Channel to Juneau. The length of this route is roughly 53 miles with a submarine crossing 4 miles in length at the mouth of Taku Inlet, or roughly 59 miles with a crossing, 1.7 miles long, at about the narrowest section of the inlet, near Dorothy Creek 4 miles to the north.

The second transmission route provides a short cut between Port Snettisham and Stephens Passage. As before, the transmission line from the power plants would be located southward along the west side of Speel Arm and Port Snettisham, about 10 miles to Prospect Creek. From this point to Slocum Inlet on Stephens Passage the route would differ by following a somewhat direct course 12 miles across the mountains. The distance around the peninsula by the first route is about 23 miles.

Most of a line crossing the peninsula could be located at altitudes below 1,000 feet in the valleys of Prospect Creek and of the drainage area tributary to Slocum Inlet. This route crosses a pass at an altitude of about 2,600 feet between the two basins, and for about a mile and a half is on steep slopes. Reconnaissance examinations by the U. S. Forest Service suggest that most of the hazards from snow slides, winds, and icing would be in the region of the pass.

The location of the line between Slocum Inlet and Juneau may depend partly on whether the Dorothy Lake power site is developed. This possibility has been considered as early as 1927, and has been studied recently by the Bureau of Reclamation. The most direct route from a powerhouse near the mouth of Dorothy Creek across Taku Inlet and along the waterways to Juneau would be about 17 miles in length, including 1.7 miles of the submarine crossing. This is about the narrowest part of Taku Inlet. The best location for a submarine crossing, however, might depend on other characteristics of the waterway and on features of the adjacent terrain that would affect towerline construction.

Transmission lines located along the waterways would cross some regions subject to snowslides and some regions where high winds can occur, especially along Taku Inlet. It is generally considered that the lines would have to be located several hundred feet above the water to avoid regions subject to wind-blown spray.

SUMMARY

The topography and location of the Crater Lake, Long Lake and Speel River power sites are such that a number of different methods of development would be possible. A total of about 48,000 kilowatts of power could be generated continuously in one plan for independent development of the three sites, and as much as 63,000 kilowatts could be generated continuously in a comparable plan for combined development of the sites.

Close estimation of construction costs is outside of the scope of this report and furthermore it would be essential to have additional field data before such could be made. A primary need would be for subsurface explorations, especially at the Long Lake and Saddle dam sites. It also would be essential to obtain additional records of the runoff of the Speel River, and some quantitative information about the sediment load of that stream.

The relation of the climate to the runoff and to the variations of natural storage as snow or ice was considered in this report mainly for guidance in making estimates of runoff, and for appraising the reliability of some of the available records. Some forecasting of seasonal runoff would be of value in the operation of hydroelectric plants, and for that purpose there may be a future need for climatological data more closely related to the power sites than the records that are presently available.

As judged from preliminary consideration, the possibilities of the power sites near Speel Arm are sufficiently attractive to warrant further investigation when the need for a considerable amount of power in the Juneau area becomes apparent. Alternatively, it might prove to be feasible to develop a lesser block of power at one or more of the sites for limited industrial use in the vicinity of Speel Arm. In either case, the development of power will depend largely on new industries, and probably on ones that do not necessarily require power of the lowest cost.

Table 6

Monthly and annual precipitation, Juneau, Alaska

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1916	9.1	8.6	8.9	0.9	6.7	3.3	4.8	4.2	6.0	5.0	6.5	12.2	76.2
17	14.6	8.0	7.9	10.3	5.9	4.2	1.7	3.5	5.3	10.5	11.1	12.3	95.3
18	18.6	16.8	6.4	8.6	5.8	4.3	5.9	5.6	3.8	2.3	11.5	12.4	102.0
19	14.0	15.0	10.3	11.4	3.1	4.4	6.5	5.0	3.7	6.4	5.9	11.4	97.1
1920	12.5	9.9	7.7	14.3	10.1	4.6	4.6	6.1	4.9	1.4	9.7	8.2	94.0
21	10.9	5.6	6.0	4.1	8.9	6.5	4.0	6.1	1.9	7.1	7.9	8.6	77.6
22	11.6	6.0	12.7	11.6	3.8	5.1	10.9	5.1	2.7	3.2	9.2	10.3	92.2
23	6.5	11.4	2.2	5.2	13.4	8.0	5.4	3.2	1.4	4.1	6.9	16.5	84.2
24	8.7	11.7	13.1	6.8	7.2	7.5	8.9	7.4	1.0	8.2	8.0	18.8	107.3
1925	12.7	9.5	4.3	5.8	3.7	6.5	6.2	4.3	4.9	7.6	7.7	8.7	81.9
26	8.9	11.7	10.1	11.6	5.8	8.7	7.6	3.7	2.6	4.0	2.9	3.3	80.9
27	13.5	3.2	14.4	3.8	4.3	8.6	4.0	3.9	1.9	1.4	5.5	10.4	74.9
28	13.6	3.6	7.5	13.5	5.3	6.7	4.7	6.2	0.9	4.6	6.1	8.4	83.1
29	11.4	9.0	10.4	9.1	7.2	6.2	3.3	4.7	4.2	4.8	5.1	5.5	80.9
1930	17.3	17.6	4.6	0.9	8.6	10.1	4.0	3.9	3.8	6.3	9.5	9.8	96.4
31	14.5	13.2	12.9	9.1	8.3	3.4	7.4	8.6	5.1	5.7	11.3	9.4	108.9
32	15.9	7.8	5.6	11.8	9.3	2.8	2.8	4.9	10.6	5.8	2.5	11.8	91.6
33	9.7	7.0	5.4	6.0	6.7	3.9	7.1	4.6	6.9	3.7	11.7	4.6	77.3
34	14.1	13.2	0.9	14.9	7.6	4.6	6.6	2.8	3.9	3.4	7.8	5.2	85.0
1935	12.3	5.6	4.4	5.9	7.5	3.2	5.0	7.6	4.7	7.2	10.4	11.9	85.7
36	5.9	11.2	9.3	4.9	2.4	7.7	7.2	5.6	0.5	6.5	2.8	12.3	76.3
37	18.7	25.9	9.1	5.6	3.8	6.1	5.8	5.8	4.8	8.2	11.6	9.9	115.3
38	14.8	6.4	7.0	10.3	6.1	5.7	5.7	8.2	8.9	7.3	4.9	13.2	98.5
39	9.9	12.1	11.7	10.2	8.4	9.1	4.8	5.6	4.6	8.4	12.2	14.1	111.1
1940	19.1	13.1	9.7	4.0	2.2	5.2	3.3	6.4	6.1	4.5	10.8	9.3	93.7
41	9.7	6.8	6.2	6.4	1.6	6.2	5.0	3.8	5.2	7.3	1.3	5.6	65.1
42	16.2	11.5	5.0	10.6	7.5	7.9	4.6	1.7	6.0	6.2	7.6	8.4	93.2

Table 6 - con't.

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1943	17.2	5.1	4.6	10.3	5.4	2.9	8.2	3.6	3.5	8.7	11.9	16.8	98.2
44	15.0	13.4	18.5	9.2	3.6	8.4	4.1	6.1	3.7	3.1	6.6	5.0	96.7
1945	15.8	10.5	6.1	5.4	8.8	9.3	5.2	2.5	5.6	11.5	4.5	12.1	97.3
46	15.2	4.0	4.8	6.8	4.4	6.5	7.8	3.6	1.4	6.8	8.3	8.1	77.7
47	13.3	12.5	6.1	8.7	3.4	11.2	7.3	5.7	4.2	3.3	9.9	17.8	103.4
48	10.6	11.9	8.6	11.1	2.4	5.8	0.5	5.1	4.0	7.2	5.2	17.6	90.0
49	16.6	20.2	7.1	15.4	2.6	5.6	10.0	5.1	7.4	5.3	5.7	10.3	111.3
1950	14.8	12.0	5.1	1.2	3.1	3.3	4.5	6.2	1.6	9.9	5.4	10.9	78.0
51	7.0	4.2	4.8	4.0	4.8	7.0	10.1	3.8	6.1	4.1	3.8	5.5	65.2
52	5.4	6.8	5.3	6.5	5.9	6.8	7.8	10.5	3.6	4.0	8.0	14.1	84.7
53	17.3	12.4	5.7	3.6	11.6	9.0	7.2	4.2	4.3	3.6	9.4	10.8	99.1
54	20.9	5.4	13.8	5.2	11.7	4.3	3.6	4.2	2.0	4.7	1.7	8.8	86.3
Mean	13.2	10.2	7.8	7.8	6.1	6.2	5.8	5.2	4.2	5.7	7.4	10.5	90.1

The figures were taken from climatological records of the Weather Bureau, U. S. Department of Commerce. The published figures were rounded to the nearest tenths and added to obtain the annual totals.

a/ Oct. 1 - Sept. 30

Table 7

Average monthly and annual temperatures, Juneau, Alaska

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1916	41.3	35.0	32.0	15.8	32.1	29.3	43.8	48.7	55.4	57.5	55.8	50.8	41.5
17	44.8	37.0	29.0	23.0	27.2	33.4	41.9	47.1	51.9	52.7	54.6	50.5	41.1
18	42.2	37.4	14.6	30.1	27.4	27.6	37.8	45.8	54.0	59.7	54.4	52.2	40.3
19	42.4	37.5	31.6	32.0	30.1	28.2	42.4	46.2	51.5	54.9	55.6	51.8	42.0
1920	40.4	30.4	29.6	22.4	34.8	31.6	36.8	45.2	53.2	58.8	53.4	48.6	40.4
21	41.0	37.0	31.1	24.5	31.4	30.8	41.0	47.2	56.6	54.0	54.3	50.4	41.6
22	44.4	33.2	34.6	31.5	23.8	31.4	39.6	46.4	53.2	54.0	55.0	49.0	41.3
23	43.8	38.2	28.0	26.5	32.4	32.8	41.7	48.2	54.6	59.4	58.9	50.6	42.9
24	46.0	40.8	32.0	30.4	32.8	36.8	38.0	47.8	55.8	54.6	55.3	48.8	43.3
1925	42.2	36.6	27.6	19.9	27.2	33.0	38.8	48.0	52.9	55.7	55.0	50.8	40.6
26	45.5	40.4	38.2	39.6	35.0	40.8	43.8	49.0	57.4	57.6	57.6	50.6	46.3
27	45.8	37.6	32.4	29.2	32.0	35.9	34.0	46.6	55.0	58.8	58.4	50.6	43.0
28	41.9	27.9	25.0	33.0	35.0	32.2	39.0	45.6	55.7	56.3	53.2	49.4	41.2
29	43.6	38.8	34.4	30.7	31.1	35.1	38.0	47.2	54.2	55.3	56.1	52.2	43.1
1930	45.8	39.0	30.3	23.4	29.2	32.0	39.8	46.4	52.6	54.8	55.6	50.2	41.6
31	40.3	37.0	39.0	37.6	36.2	32.8	43.2	46.0	54.7	55.1	55.6	50.8	44.0
32	43.4	33.6	32.8	27.9	24.3	33.7	43.1	46.4	49.4	53.4	56.8	48.8	41.1
33	44.2	31.8	27.1	24.0	28.6	32.6	39.2	48.2	51.4	53.9	55.2	49.4	40.5
34	38.5	39.4	13.0	29.0	37.0	36.2	42.4	49.2	52.6	57.6	55.9	50.9	41.8
1935	44.0	36.8	29.4	23.2	37.0	28.0	39.6	45.4	53.2	55.2	53.7	50.8	41.4
36	39.4	34.2	34.0	26.6	15.0	32.3	42.0	48.0	60.4	57.4	57.8	50.0	41.4
37	46.9	42.2	27.8	27.8	29.4	38.0	40.6	47.0	55.7	55.1	54.6	52.7	43.2
38	47.4	37.2	26.0	31.9	24.2	36.2	42.0	47.0	51.0	54.7	56.8	54.1	42.4
39	48.3	37.6	32.3	33.6	26.5	31.8	38.2	46.4	54.6	56.4	53.6	49.6	42.4
1940	41.2	38.3	39.9	32.8	32.2	35.6	45.4	49.0	53.1	58.8	54.8	52.2	44.4
41	45.8	33.8	34.8	31.2	33.6	39.6	45.2	49.2	56.1	56.7	59.8	51.0	44.7
42	43.5	35.0	29.5	38.0	35.8	34.8	42.5	53.3	55.4	57.7	56.9	53.1	44.6

Table 7 - con't.

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1943	45.2	31.4	23.8	23.6	29.2	33.4	42.4	48.1	55.2	55.4	55.4	51.0	41.2
44	45.6	42.6	38.6	36.4	34.0	34.6	41.8	47.9	56.4	56.8	56.4	53.2	45.4
1945	47.1	37.8	35.0	34.6	32.8	36.2	37.8	50.0	51.8	53.3	55.2	49.4	43.4
46	44.0	28.8	31.6	33.8	33.4	34.4	38.2	49.4	57.9	55.2	53.7	51.3	42.6
47	41.8	32.8	24.0	23.9	28.0	37.3	39.6	48.6	54.0	57.2	55.4	50.3	41.1
48	45.0	39.3	36.8	34.6	24.0	30.4	37.0	49.0	56.1	57.9	55.6	49.6	42.9
49	42.8	34.0	23.2	28.4	21.6	37.6	39.6	46.7	50.0	54.8	54.4	52.7	40.5
1950	43.1	42.0	25.2	18.0	25.3	35.2	38.0	44.9	57.9	55.6	57.4	51.0	41.1
51	41.5	26.1	32.5	22.6	25.6	27.2	40.2	47.3	52.9	61.8	57.3	53.5	40.7
52	41.3	36.1	28.1	19.0	33.2	34.7	38.6	45.6	53.8	57.7	56.4	50.9	41.3
53	47.0	40.4	36.2	20.6	36.2	33.8	42.0	50.9	59.7	59.7	57.5	51.4	44.6
54	45.5	37.2	35.9	23.0	26.8	34.6	36.2	50.2	56.4	57.1	60.0	53.0	43.0
Mean	43.7	36.2	30.4	28.0	30.0	33.6	40.3	47.7	54.4	56.4	55.9	51.0	42.3

The figures were taken from climatological records of the Weather Bureau, U. S. Department of Commerce.

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Table 8

Monthly and annual runoff in thousands of acre-feet
Crater Creek near Juneau, Alaska

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1916	11.4	2.7	2.0	1.1	1.0	1.2	2.6	5.5	22.0	22.8	28.5	28.0	129
17	16.6	3.0	2.0	2.2	2.5	1.4	1.4	8.7	18.1	27.1	33.1	21.5	138
18	15.4	14.9	2.2	2.0	0.9	0.8	1.2	7.9	20.6	29.6	36.3	24.5	156
19	12.4	7.9	4.0	4.2	0.8	0.7	2.8	7.3	12.9	25.6	31.4	25.0	135
1920	12.9	4.0	2.8	6.2	2.0	1.0	1.2	3.3	10.5	25.0	32.7	15.6	117
21	8.8	5.8	1.2	1.4	1.9	1.4	6.0	9.0	17.5	22.5	23.0	17.5	116
22	17.5	4.6	6.4	2.0	0.6	0.5	2.4	9.4	17.0	25.0	29.0	21.0	135
23	11.0	12.0	2.2	1.4	1.6	2.5	4.0	10.0	16.0	25.0	26.5	32.0	144
24	13.5	12.0	5.0	1.7	1.0	2.0	3.0	14.0	23.5	33.5	29.0	29.0	167
28	8.3	2.9	1.5	5.4	1.8	2.5	2.5	11.9	22.7	32.5	23.2	20.4	136
29	11.9	6.7	5.0	4.7	1.1	3.0	1.7	5.6	22.7	25.8	24.8	20.6	134
1930	28.5	13.2	3.7	0.3	0.5	0.9	2.0	6.4	18.3	25.8	29.8	21.4	151
31	13.8	15.2	9.0	4.2	5.7	1.4	2.7	13.0	23.9	25.6	29.1	21.5	165
32	20.5	4.3	1.7	1.2	1.2	0.9	2.0	6.5	16.9	22.3	22.5	25.5	126
33	19.4	2.5	1.6	0.7	0.7	1.0	0.7	7.0	12.0	20.5	22.0	14.5	103
34	14.0	12.5	0.4	0.5	1.0	1.2	1.6	5.0	20.0	23.0	33.8	20.0	133
1935	17.5	6.5	2.6	0.4	0.8	0.8	0.9	4.5	13.0	32.5	25.5	16.0	121
36	16.8	3.7	5.6	0.7	0.1	1.2	2.3	9.1	25.5	24.8	22.6	28.6	141
37	38.0	23.0	5.0	1.0	0.6	1.9	1.4	5.5	24.0	21.0	25.0	27.0	173
38	32.0	6.5	1.8	2.6	1.0	5.0	1.5	10.0	16.0	23.0	20.0	31.0	150
39	19.0	6.0	3.4	2.0	0.8	1.1	0.7	6.0	16.0	28.0	36.0	21.0	140
1940	21.0	11.0	6.0	1.6	1.9	1.2	3.0	9.5	17.0	27.0	34.0	25.0	158
41	18.5	4.5	2.4	1.0	1.4	4.0	4.5	8.0	20.0	27.0	18.0	12.0	121
46	33.0	3.5	1.0	1.2	1.0	1.3	1.3	11.5	23.0	22.0	27.0	18.0	144
47	16.0	7.7	0.8	0.7	0.7	6.9	1.7	10.0	22.0	22.0	20.0	31.0	140
48	18.0	7.0	5.0	2.4	0.6	0.9	1.0	11.0	26.0	25.0	23.0	31.0	151
49	13.5	8.0	0.9	1.4	0.2	1.4	1.2	9.5	17.0	23.0	25.0	22.0	123
1950	14.0	28.0	1.3	0.2	0.4	0.8	1.4	6.0	17.5	24.0	21.0	24.0	139

Table 8 - con't.

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1951	8.0	1.1	0.9	0.4	0.5	0.7	1.1	7.5	22.0	27.0	18.0	18.0	105
52	12.0	3.2	1.0	0.2	1.0	1.0	1.8	6.8	14.5	25.4	24.0	26.9	118
53	27.0	12.7	2.4	0.2	1.3	1.4	1.9	14.0	23.0	25.0	27.0	21.0	157
Mean	17.4	8.3	2.9	1.8	1.2	1.7	2.0	8.4	19.1	25.4	26.5	22.9	138

The records from 1916 to 1920, and 1928 to April 1933 were taken from Geological Survey Bulletin 836, and the Forest Service-Federal Power Commission report of 1947. The monthly figures were rounded to the nearest tenth and added; the annual figures were rounded to three significant figures.

The figures for the years 1921 to 1924 were estimated from the records of monthly runoff of Long River, and those from May 1933 to September 1953 were estimated from the records of monthly runoff of Dorothy Creek.

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Table 9

Monthly and annual runoff in thousands of acre-feet,
Long River near Juneau, Alaska

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1916	32.4	8.1	6.0	3.1	2.8	3.1	7.7	15.6	51.4	52.6	65.8	61.9	310
17	37.2	8.6	5.3	5.4	7.2	3.2	4.0	20.6	41.4	61.2	79.3	54.9	328
18	40.1	39.3	5.8	6.0	2.3	1.6	4.2	18.4	44.3	65.8	75.0	63.1	366
19	31.0	20.4	11.1	12.9	3.0	3.1	7.4	19.0	32.4	53.1	64.6	59.5	318
1920	32.3	11.4	7.9	11.1	5.4	2.8	3.1	14.4	34.5	56.4	73.8	38.1	291
21	23.4	15.6	3.7	4.2	5.3	4.2	6.6	23.9	42.5	52.3	52.7	42.1	276
22	42.3	12.4	17.1	5.6	1.7	1.5	6.9	24.9	42.0	56.1	64.6	49.3	324
23	29.3	31.1	6.4	3.8	4.7	7.2	11.0	26.8	43.1	57.2	59.8	67.8	348
24	34.6	31.0	13.6	4.8	2.9	5.5	8.0	35.4	54.1	71.9	64.6	64.3	391
28	21.3	7.5	3.1	11.4	7.9	7.4	13.0	34.1	48.5	66.4	54.5	49.4	324
29	32.3	21.7	19.4	12.1	2.4	6.5	4.9	21.4	49.2	54.4	51.4	44.9	321
1930	66.4	28.9	8.9	1.2	2.5	3.7	8.1	19.5	42.4	55.3	66.4	48.8	352
31	33.7	33.3	20.2	9.4	14.7	3.2	7.4	30.1	57.2	58.7	67.0	48.9	384
32	42.4	10.8	5.2	3.4	3.2	3.7	6.4	22.0	45.0	50.5	53.9	58.0	304
33	41.1	7.3	5.0	4.0	3.0	1.6	4.5	26.0	38.0	55.0	49.0	30.0	264
34	29.0	26.0	7.0	1.6	2.0	3.0	4.0	20.0	54.0	58.0	80.0	43.0	328
1935	37.0	14.0	9.0	3.0	1.6	3.5	3.5	18.0	41.0	83.0	57.0	34.0	305
36	35.0	10.0	15.0	3.5	2.0	4.0	7.0	31.0	62.0	55.0	49.0	66.0	340
37	91.0	50.0	19.0	5.0	3.0	5.0	5.5	22.0	60.0	45.0	55.0	63.0	434
38	74.0	14.0	9.5	8.5	7.0	11.5	4.5	34.0	47.0	51.0	44.0	73.0	378
39	41.0	12.0	10.0	7.0	4.5	3.5	5.0	23.0	50.0	64.0	87.0	44.0	351
1940	46.0	23.0	13.0	5.5	6.5	3.0	7.5	33.0	49.0	61.0	79.0	57.0	384
41	39.0	12.0	7.0	3.5	4.5	8.0	10.0	28.0	54.0	61.0	38.0	24.0	289
46	78.0	9.0	4.0	3.0	2.2	3.5	3.5	37.0	58.0	47.0	63.0	39.0	347
47	33.0	21.0	5.5	5.0	3.0	15.0	9.0	33.0	57.0	48.0	43.0	71.0	344
48	37.0	15.0	11.0	7.5	3.5	3.0	2.5	36.0	62.0	56.0	50.0	72.0	356

1949	28.0	20.0	7.5	6.5	2.5	3.5	6.0	32.0	47.0	49.0	57.0	48.0	307
50	29.0	66.0	7.5	2.5	1.5	2.0	2.5	23.0	49.0	53.0	45.0	54.0	336
51	16.0	6.5	3.0	3.5	2.5	3.0	5.0	27.0	57.0	61.0	38.0	38.0	260
52	19.1	7.7	5.6	2.3	2.2	3.0	8.9	27.0	43.6	64.2	58.9	65.7	308
53	69.1	26.5	7.4	3.6	3.7	3.0	5.0	35.2	56.1	57.2	62.6	52.4	382
54	55.9	8.5	8.6	4.4	16.0	3.7	3.0	20.0	44.8	50.2	38.8	54.7	309
Mean	40.5	19.6	9.0	5.4	4.3	4.4	6.1	25.7	48.7	57.2	59.0	52.5	332

With exception of a revised figure for April 1921 the records previous to December 1932 were taken from Geological Survey Bulletin 836, and the Forest Service-Federal Power Commission report of 1947. The monthly figures were rounded to the nearest tenths and added to obtain the totals.

The figures for the period December 1932 to September 1951 were estimated from the records of monthly runoff of Dorothy Creek.

The figures for October 1951 to September 1954 are from unpublished records of the Geological Survey and are subject to revision.

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Table 10

Monthly and annual runoff in thousands of acre-feet,
Speel River near Juneau, Alaska,
exclusive of Long River.

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1916	150	31	22	11	10	11	30	64	250	280	367	308	1,534
17	141	37	20	16	21	7	16	84	171	288	444	250	1,495
18	220	172	25	17	8	7	17	78	192	321	380	362	1,799
19	140	84	44	52	10	10	28	80	150	260	330	300	1,488
1920	150	43	30	44	20	10	11	60	160	250	380	180	1,337
21	100	64	13	15	19	15	70	100	200	250	260	200	1,306
22	200	50	70	20	6	5	26	110	200	280	330	230	1,527
1932	200	44	19	12	11	13	24	90	210	240	260	290	1,413
33	190	24	18	16	12	5	16	110	180	270	230	120	1,191
34	130	110	23	5	7	12	16	85	260	290	480	200	1,618
1935	170	58	36	10	6	12	12	75	190	450	280	150	1,449
36	160	40	62	12	6	14	26	140	310	270	230	330	1,600
1950	130	330	28	8	5	7	8	100	230	260	210	260	1,576
51	63	24	10	12	9	10	18	120	280	310	160	160	1,176
52	80	30	18	7	7	10	35	120	200	320	290	330	1,447
53	350	120	24	12	13	10	18	160	280	250	300	230	1,767
Mean	161	79	29	17	11	10	23	98	216	287	308	244	1,495

The figures for the periods October 1915 to June 1915, and from October 1918 to September 1953 were estimated from the records of monthly runoff of Long River near Port Snettisham. All monthly figures were rounded to the nearest unit, and added to obtain annual totals.

Table 10 - con't.

The figures represent the runoff at the Speel River dam site exclusive of the runoff at the Long River gaging station. They were used in this report as estimates of the runoff that would have been available at the Speel River power site after complete diversion of the runoff of Long River at Long Lake outlet. The small inflow between the lake outlet and the Long River gaging station was disregarded.

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Table 11

Monthly and annual runoff in thousands of acre-feet,
Dorothy Creek near Juneau, Alaska

Water Year a/	O	N	D	J	F	M	A	M	J	J	A	S	Annual
1930	21.0	9.0	4.0	0.7	0.7	1.3	2.9	4.6	11.7	20.3	22.9	16.8	115.9
31	12.0	11.5	6.2	2.9	3.9	1.4	2.0	7.2	19.6	19.1	22.2	17.9	125.9
32	12.9	3.8	1.0	1.1	0.8	0.8	1.6	4.3	14.9	17.8	17.3	16.3	92.6
33	13.2	2.5	1.4	1.2	0.9	0.6	1.3	5.3	8.9	15.4	16.5	10.9	78.1
34	10.4	9.4	2.0	0.6	0.7	0.9	1.2	3.7	14.9	17.0	25.0	14.9	100.7
1935	13.2	4.9	3.3	1.0	0.6	1.1	1.1	3.3	9.8	24.3	18.8	12.1	93.5
36	12.4	3.4	5.1	1.1	0.7	1.2	2.1	6.7	18.9	18.4	16.7	21.2	107.9
37	28.0	16.9	7.0	1.5	0.8	1.4	1.6	4.1	17.7	15.4	18.4	20.2	133.0
38	23.6	5.1	3.0	2.6	2.1	4.2	1.3	7.7	12.2	17.2	15.1	23.3	117.4
39	14.3	4.4	3.4	2.0	1.3	1.1	1.4	4.5	13.4	21.0	26.8	15.3	108.9
1940	15.9	8.4	4.6	1.6	1.9	1.0	2.2	7.1	12.9	19.7	24.8	18.8	118.9
41	13.7	4.2	2.0	1.1	1.3	2.8	3.2	5.8	15.0	19.9	13.3	8.8	91.1
43	15.5	3.2	1.9	2.3	1.1	2.5	3.7	5.8	13.5	23.6	20.8	22.8	116.7
1945	19.7	8.3	5.2	1.2	0.8	1.5	1.6	7.2	14.5	20.3	16.1	18.4	114.8
46	24.5	2.8	1.2	0.9	0.8	1.1	1.1	8.6	16.8	16.3	20.4	13.7	108.2
47	11.9	7.7	1.6	1.4	1.0	5.3	2.8	7.3	16.6	16.3	14.9	22.8	109.6
48	13.0	5.3	3.9	2.2	1.1	1.0	0.8	8.2	19.1	18.7	16.8	23.0	113.1
49	10.0	7.3	2.3	1.9	0.8	1.1	1.7	7.1	12.3	16.7	18.9	16.5	96.6
1950	10.6	21.1	2.2	0.8	0.6	0.7	0.8	4.5	12.9	17.7	15.4	18.0	105.3
51	6.0	1.9	0.9	1.1	0.8	1.0	1.4	5.6	16.7	19.8	13.3	13.5	82.0
52	8.9	2.7	1.4	1.1	1.0	0.9	1.3	5.0	10.7	18.8	17.8	19.9	89.5
53	20.1	9.4	2.0	1.2	1.1	1.3	1.4	7.2	14.8	19.5	20.5	16.9	115.4
54	14.5	5.5	1.9	1.6	5.8	1.5	1.0	4.2	12.2	15.2	12.7	14.2	90.3
Mean	15.0	6.9	2.9	1.5	1.3	1.6	1.7	5.9	14.3	18.6	18.5	17.2	105.4

Table 11 con't.

The figures for the period 1930 to 1941 were taken from the Forest Service-Federal Power Commission report of 1947; those for the period 1943 to 1954 are from unpublished records of the Geological Survey. The monthly figures were rounded to the nearest tenth, and added to obtain the annual totals.

The gaging station was damaged in November 1941, and although some records were published in the 1947 report for the period 1941 to 1945 they were found to be subject to correction and the revised figures for 1943 and 1945 are listed here.

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Table 12

Coordinated operation schedule for average generation of 63,000 kw
(All quantities in thousands of acre-feet)

Month		Speel River Res. In-flow	Draft	Stor-age	Con-tents	Crater Lake Res.* In-flow	Draft	Stor-age	Con-tents	Long Lake Res.* In-flow	Draft	Stor-age	Con-tents
1950	S	260	214	+46	234	92	0	+92	384	150	0	150	750
	O	63	63	0	234	31	58	-27	357	45	93	-48	702
	N	24	50	-26	208	4	58	-54	303	18	106	-88	614
	D	10	50	-40	168	3	58	-55	248	8	106	-98	516
1951													
	J	12	50	-38	130	2	58	-56	192	10	106	-96	420
	F	9	50	-41	89	2	58	-56	136	7	106	-99	321
	M	10	50	-40	49	3	58	-55	81	8	106	-98	223
	A	18	50	-32	17	4	58	-54	27	13	106	-93	130
	M	120	120	0	17	29	20	+ 9	36	74	74	0	130
	J	280	159	+121	138	84	19	+65	101	159	36	+123	253
	J	310	214	+96	234	104	0	+104	205	170	0	+170	423
	A	160	160	0	234	69	18	+51	256	106	36	+70	493
	S	160	160	0	234	69	18	+51	307	106	36	+70	563
	O	80	80	0	234	46	46	0	307	54	88	-34	529
	N	30	50	-20	214	12	58	-46	261	22	106	-84	445
	D	18	50	-32	182	4	58	-54	207	15	106	-91	354
1952													
	J	7	50	-43	139	1	58	-57	150	6	106	-100	254
	F	7	50	-43	96	4	58	-54	96	6	106	-100	154
	M	10	50	-40	56	4	58	-54	42	8	106	- 98	56
	A	35	84	-49	7	7	49	-42	0	25	81	- 56	0
	M	120	120	0	7	26	26	0	0	75	68	+ 7	+7

Table 12 - con't.

*The figures for the Crater Lake and Long Lake reservoirs are expressed in terms of water having the same amount of energy at the level of the Speel River reservoir; thus the equivalent drafts from storage in the three reservoirs can be readily totalled and are equal in potential power to 214,000 acre-feet a month, or 3,540 cfs utilized through the average head below the Speel River reservoir. (No allowance was made for differences in lengths of the months). At average reservoir levels the available heads below the Crater Lake and Long Lake reservoirs would be, respectively, 3.84 and 3.00 times that below the Speel River reservoir. The listed figures for the lake reservoirs thus should be divided by these factors to obtain the actual quantities.

In practice, the drafts would be varied in accord with changes in head, but the same uniform power output could be obtained.

Table 13

Coordinated operation schedule for average generation of 58,500 kw
(All quantities in thousands of acre-feet)

	Speel River Res.			Crater Lake Res.*				Long Lake Res.*			
Month	In-flow	Draft	Con-tents	In-flow	Draft	Stor-age	Con-tents	In-flow	Draft	Stor-age	Con-tents
1950											
S	260	177	234	82	0	+82	345	139	0	+139	690
O	63	63	234	28	40	-12	333	42	75	- 33	657
N	24	24	234	4	53	-49	284	16	101	- 85	572
D	10	10	234	3	58	-55	229	8	110	-102	470
1951											
J	12	12	234	2	57	-55	174	9	109	-100	370
F	9	9	234	2	58	-56	118	7	111	-104	266
M	10	10	234	3	58	-55	63	7	110	-103	163
A	18	18	234	3	55	-52	11	12	105	- 93	70
M	120	120	234	26	20	+ 6	17	68	38	+ 30	100
J	280	178	234	76	0	+76	93	146	0	+146	246
J	310	178	234	93	0	+93	186	157	0	+157	403
A	160	160	234	62	6	+56	242	98	12	+ 86	489
S	160	160	234	62	6	+56	298	98	12	+ 86	575
O	80	80	234	42	42	0	298	50	56	- 6	569
N	30	30	234	11	49	-38	260	20	99	- 79	490
D	18	18	234	4	53	-49	211	14	107	- 93	397
1952											
J	7	7	234	1	59	-58	153	6	112	-106	291
F	7	7	234	4	59	-55	98	6	112	-106	185
M	10	10	234	3	57	-54	44	7	111	-104	81
A	35	35	234	6	50	-44	0	23	93	- 70	+11
M	120	120	234	23	0	+23	+23	69	58	+ 11	+22

Table 13 - con't.

*The figures for the Crater Lake and Long Lake reservoirs are expressed in terms of water having the same amount of energy at the level of the Speel River reservoir. At average reservoir levels the available head below the Crater Lake reservoir is 3.45 times that below the Speel River reservoir, and the available head below the Long River reservoir is 2.76 times that below Speel River reservoir.