SUPERSEDED by Water Supply Paper 1529

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Preliminary Report on Waterpower resources of Cascade Creek, Scenery Creek, and Delta Creek near Petersburg, Alaska

By
J. L. Colbert
July 1955

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature

OPEN FILE

Johnson - Int. 3377

DEPARTMENT OF THE INTERIOR

INFORMATION SERVICE

GEOLOGICAL SURVEY

For Release to PM's, FEBRUARY 1, 1956

GEOLOGICAL SURVEY REPORTS ON POTENTIAL WATERPOWER SITES IN ALASKA RELEASED

Two engineering reports describing waterpower sites near Juneau and Petersburg, Alaska, with a combined potential capacity exceeding the present capacity of all existing hydroelectric installations in Alaska, have been released for public inspection Secretary of the Interior Douglas McKay announced today.

The sites investigated and reported on by engineers of the Geological Survey are on Crater Lake, Long Lake, and Speel River in the Speel Arm area near Juneau, and on Scenery Creek, Cascade Creek, and Delta Creek in the Thomas Bay area near Petersburg. Both reports describe the physical and climatic characteristics of the areas that relate to power development and discuss the water supply. Available records show that streamflow has a pronounced variation throughout the year as well as from year to year. Reservoir storage to equalize streamflow is necessary for a satisfactory plan of development.

Crater Lake and Long Lake near Juneau and Scenery Lake and Swan Lake (on Cascade Creek) near Petersburg provide four favorable opportunities for development of storage, according to the Survey report. These lakes range in elevation from 814 feet for Long Lake to 1,514 feet for Swan Lake. Water can be conveyed from lakes to powerhouse sites at tidewater by conduits of reasonable length.

All powerhouse sites are in rugged, isolated locations which do not provide satisfactory areas for the development of industrial sites and the supporting communities. Transmission lines from the powerhouse sites to points of use would be over very rugged terrain and would also entail submarine cable crossings.

The reports indicate a continuous power potential of 48,000 kilowatts for the sites near Juneau and 42,000 kilowatts for the sites near Petersburg. The total installed capacity of hydroelectric plants in Alaska is 60,000 kilowatts.

Copies of "Waterpower Possibilities of Crater Lake, Long Lake, and Speel River near Juneau, Alaska," by F. A. Johnson, and "Preliminary Report on Waterpower Resources of Cascade Creek, Scenery Creek, and Delta Creek near Petersburg, Alaska," by J. L. Colbert, are available for public inspection at the following offices of the Geological Survey: Library, 1033 General Services Bldg., Washington, D. C.; in California at 4 Homewood Place, Menlo Park; 724 Appraisers Bldg., San Francisco; and 529 Post Office and Court House, Los Angeles; 244 Federal Bldg., Tacoma, Washington; and in Alaska at 117 Federal Bldg., Juneau; 210 Glover Bldg., Anchorage; Wright Bldg., Palmer; and Brooks Memorial Mines Bldg., at College.

x x x

P.N. 93179

Contents

	Page
Abstract	3
Introduction	5
Purpose and scope	5
Acknowledgments	6
Previous investigations	6
Maps and photographs	7
Geography	8
Water rights	11
Factors affecting the design and operation of power projects	13
Ice	13
Debris	13
Slides	14
Sedimentation	14
Tides	15
Precipitation	15
Geology	15
Water Utilization	16
Present use	16
Future use	16
Water Supply	17
Climatology	17
Precipitation	17
Temperature	18
Winds	19
Sunshine	19
Evaporation	19
Runoff	22
Industrial water supply	28
Stream Regulation	30
Natural storage	30
Developed storage	30
Undeveloped storage	30
Water Power	37
Developed power	37
Undeveloped power	37
Cascade Creek power site	40
Falls Lake power site	44
Scenery Creek power site	45
Scenery Creek alternative development	50
Delta Creek power site	50
Market for power	56

Illustrations

Plate 1 Topographic map, Cascade Creek and vicinity.....In pocket

Following page

Figure 1. Location map..... 2
2. Cascade Creek valley (photo)..... 9
3. Scenery Creek valley (photo)..... 9
4. Delta Creek valley (photo)..... 9
5. Precipitation and temperature at Petersburg and discharge of Cascade Creek... 18
6. Flow duration curve, Cascade Creek..... 24
7. Area and capacity curves, Swan Lake, Scenery Lake, and Ruth Lake reservoir sites and cross sections of dam sites. 36
8. Point Agassiz area (photo)..... 38
9. Swan Lake dam site looking upstream (photo)..... 40
10. Falls Lake outlet (photo)..... 44
11. Scenery Lake outlet (photo)..... 45
12. Ruth Lake outlet (photo)..... 51

Tables

Page

Table 1. Mean monthly and annual temperatures in degrees F., Petersburg..... 20
2. Monthly and annual precipitation in inches, Petersburg..... 21
3. Mean monthly and annual flow in second-feet, Cascade Creek..... 25
4. Mean monthly and annual flow in second-feet, Scenery Creek..... 27
5. Year to year storages and flows, Swan Lake reservoir sites..... 33
6. Area and capacity, Swan Lake..... 43
7. Area and capacity, Scenery Lake..... 47
8. Area and capacity Ruth Lake..... 53
9. Power estimates in kilowatts..... 55

U S GEOLOGICAL SURVEY

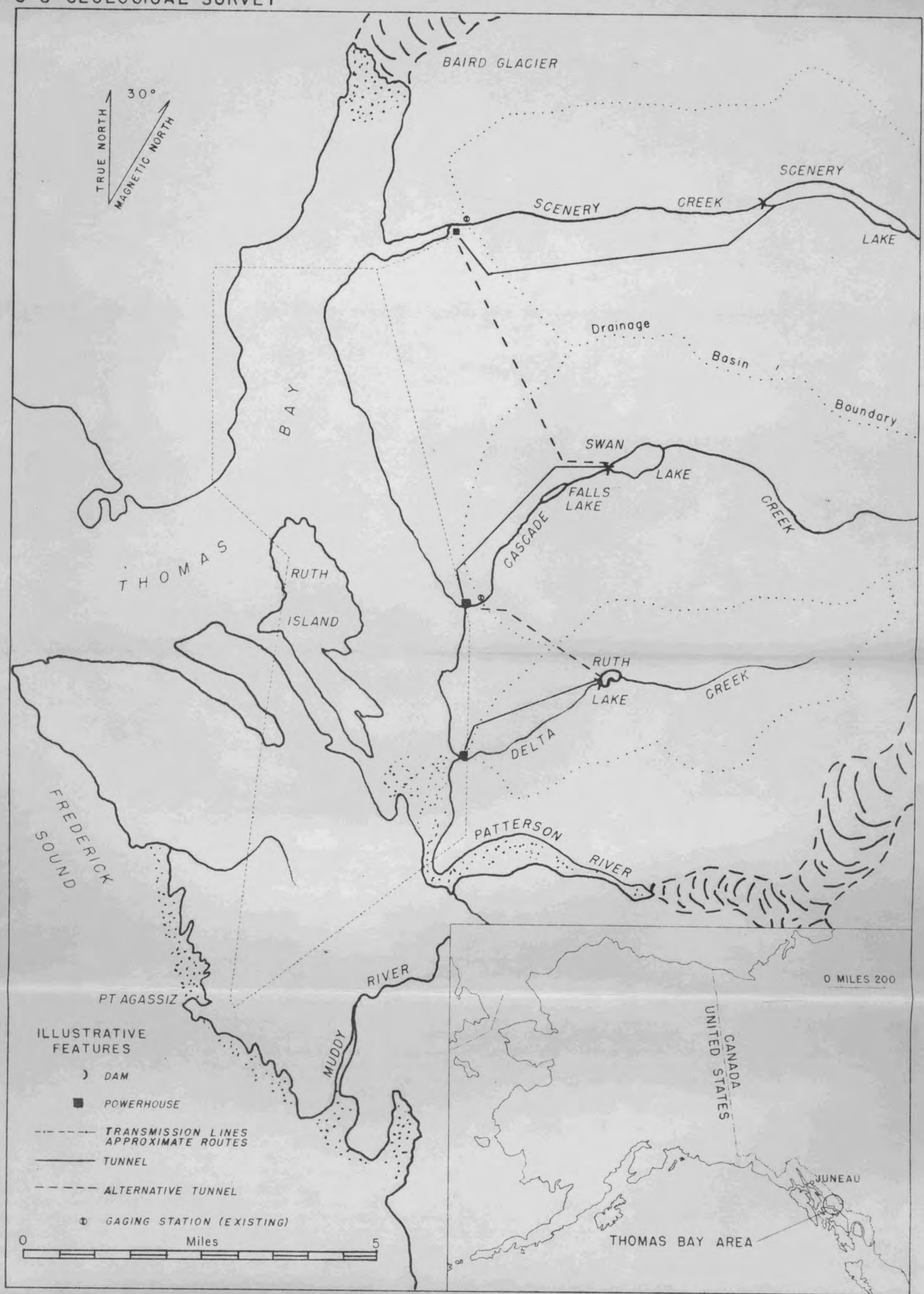

Figure 1- Location Map and Illustrative Scheme of Development

Abstract

The heavy precipitation and runoff, suitable storage sites near tidewater, and steep stream gradients are favorable to the development of hydroelectric power on the streams considered in this report. A geologic examination of the sites indicates that their development would not be hindered by any unusual geologic conditions.

On the basis of the 18 years of available streamflow records for Cascade Creek, it is estimated that 20,800 kilowatts of power could have been generated continuously on Cascade Creek; 13,300 kilowatts on Scenery Creek, and 7,900 kilowatts on Delta Creek. Conditions for power development on Delta Creek are not as favorable as on Cascade Creek or Scenery Creek in view of the size of the structures required in relation to the potential power.

The development of a substantial part of this power would depend upon the creation of new industries as the present power market is very limited. There is a heavy growth of timber near tidewater throughout this part of Alaska, and the utilization of this timber in the manufacture of wood pulp is the most likely industrial possibility.

The Cascade Creek, Scenery Creek, and Delta Creek drainage basins are in rugged mountainous terrain. There is little land in the immediate vicinity suitable for the location of industrial developments and the supporting communities, and the power would have to be transmitted to a more favorable area. A considerable area is available near Point Agassiz on Frederick Sound about 10 airline miles from the mouth of Scenery Creek and 5 airline miles from the mouth of Delta Creek.

INTRODUCTION

Purpose and scope

The area which is considered in this report is on the mainland of Southeastern Alaska between Baird Glacier on the north and Patterson River on the south. Scenery Creek, Cascade Creek, and Delta Creek are the major streams emptying into Thomas Bay. The investigations of these three drainage basins in the Thomas Bay area have been made as a part of the regular authorized program of the U. S. Geological Survey to classify the public lands in the United States and Alaska as to their value for water-power development. The field investigations were begun during the season of 1949 when Scenery Creek, Scenery Lake, and Scenery Lake dam site were mapped by F. F. Lawrence. Field work was continued during the summer of 1950 by J. L. Colbert, when vertical control for photogrammetric map compilation was obtained, Swan Lake dam site was mapped, and soundings were made on Swan Lake and Ruth Lake to show underwater contours. In the summer of 1951, J. C. Miller, accompanied by J. L. Colbert, made a preliminary geologic examination of the three drainage basins to evaluate the geologic feasibility of dam sites, reservoir sites, and tunnel routes. Miller's report entitled "Geology of Power Sites on Scenery Creek, Cascade Creek and Delta Creek, Alaska," is

available for public inspection in offices that are listed further on in this report.

Acknowledgements

Special acknowledgement is due to the offices of the U. S. Forest Service in Juneau and Petersburg for the loan of equipment and facilities during each of the three field seasons spent in the Petersburg vicinity. The Alaska Communications System office in Petersburg deserves much credit for the skillful and efficient handling of all radio communications to and from field camps in the Thomas Bay area.

Previous investigations

A report to the Federal Power Commission entitled Water-powers of Southeastern Alaska[1/] was written by

1/Dort, J. C., Water-powers of Southeastern Alaska: Federal Power Commission, 1924

J. C. Dort of the U. S. Forest Service in 1924. This report gives a brief discussion of many developed and undeveloped sites in Southeastern Alaska. A plan is proposed for Cascade Creek development but no mention is made of Scenery Creek or Delta Creek.

The geology of the Thomas Bay area is partially described in Survey Bulletin 800.[2/] Streamflow records for the period 1918 to 1928, for Cascade Creek have

2/Buddington, A. F., and Chapin, Theodore, Geology and mineral deposits in Southeastern Alaska: U.S. Geol. Survey Bull. 800, 1929

been published in U. S. Geological Survey Bulletin 836-C.[3]

3/Henshaw, F. F., Surface Water supply of Southeastern Alaska: U.S. Geol. Survey Bull. 836-C, pp. 188-191, 1932

Brief discussions of the power possibilities of these three streams and others in Southeastern Alaska are included in the joint report by the Federal Power Commission and U. S. Forest Service.[4]

4/Fed. Power Comm. and U. S. Forest Service, Water Powers of Southeast Alaska, 1947

A report on Scenery Creek by Lawrence[5] furnished much of the basic data and general information for the present report. Streamflow records for Cascade Creek

5/Lawrence, F. F., Water-power resources of Scenery Creek near Petersburg, Alaska, 1950. (Manuscript report in files of U. S. Geol. Survey. Opened to public inspection, July 6, 1950).

since October 1946 and for Scenery Creek since September 1949 are available in the U. S. Geological Survey office in Juneau and are included in this report under the section on Water Supply.

Maps and photographs

There are no public land surveys of the area. A planimetric map, scale 1:40,000, of the creek basins was prepared by the Topographic Division of the U. S. Geological Survey from aerial photos taken in 1948. This map was used for drainage area computations. Photographs included in this report were taken by F. F. Lawrence, J. L. Colbert, and the U. S. Forest Service.

A tabulation of maps and aerial photographs which show the area discussed follows.

MAPS AND AERIAL PHOTOGRAPHS

	Contour Interval	Scale	Published by	Remarks
Cascade Creek & Vicinity, Alaska	40 ft.	1:24,000	U. S. Geol. Survey	From Baird Glacier south to Patterson Glacier & 3 to 6 miles inland
Chart 8210, Thomas, Farragut, and Portage Bays, Alaska	100 ft.	1:40,000	U. S. C. & G. S.	Contouring only approximate
Tongass National Forest	-	1 inch = 12 miles	U. S. Forest Service	No contours shown
Sheets 5 & 6 Cape Muzon to Mt. St. Elias	250 ft.	1:250,000	International Bdry. Commission	
Petersburg quadrangle, Alaska	200 ft. 250 ft. 1000 ft.	1:250,000	U. S. Geol. Survey	Maps available from U. S. Geol. Survey Federal Center Denver, Colorado
Sumdum quadrangle, Alaska - Canada	200 ft. 250 ft. 1000 ft.	1:250,000	U. S. Geol. Survey	do
Aeronautical Chart No. 138 Mt. Fairweather, Alaska		1:1,000,000	U. S. C. & G. S.	
AERIAL PHOTOGRAPHS				
1929 U. S. Navy		1:20,000		Negatives stored in office of Topog. Div. of U.S.G.S.
1948 U. S. Navy S.E.A. Series		1:40,000		

GEOGRAPHY

The three stream basins considered in this report are on the mainland on the east side of Thomas Bay. This area is 20 to 25 miles northeast of Petersburg, which is on Mitkof Island, and 100 miles southeast from Juneau. Petersburg has a population of about 1,600, most of whom are engaged in the fishing industry and related services. Scenery Lake is on Scenery Creek, Swan Lake on Cascade Creek, and Ruth Lake on Delta Creek. The lakes and their valleys are similar in form and drainage pattern in that the flow is to the west and the lakes have their longest dimension in an east-west direction. In general, the lakes are deepest in the eastern portion. The outlet of each lake is roughly three miles inland from the coast, and the gradients of the creeks to tidewater are very steep. Cascade Creek flows through Falls Lake which is about ½ mile in length and about a mile below Swan Lake.

The relative position and size of the three stream basins are shown on figure 1. Aerial views of the basins are shown on figures 2, 3 and 4.

U. S. Forest Service trails to Swan Lake and Ruth Lake extend up the creek valleys. It is necessary to

use a boat maintained by the U. S. Forest Service to travel the half mile length of Falls Lake in the route of the Cascade Creek Trail. The trails are difficult but passable.

The entire area is within the Tongass National Forest, and, except on the rock slopes, is covered with a moderately heavy growth of spruce and hemlock of pulp grade. Above an altitude of 1,500 feet the timber is classed as non-commercial because of its scrubby, dwarfed, and sub-alpine nature. On the sides of the valleys the trees are larger and some yellow cedar may be found. There is a dense undergrowth of blueberry, salmon berry, fern and devil club. In the slide areas, willow and tangled alder form an almost impassable barrier. Timber line is at about the 2,500 foot level. It has been estimated that 75 percent of the commercial timber lies within 2½ miles of tide-water.

The headwaters of the three creeks generally are at altitudes above 4,000 feet, and there are peaks near the eastern boundaries of the Scenery Creek and Cascade Creek basins higher than 6,000 feet. There are glaciers in the higher regions of each of the three basins.

According to the U. S. Coast and Geodetic Survey chart 8210, depths in Thomas Bay are as much as 600 feet, and large tugs could reach the mouths of the

Figure 2 Cascade Creek Valley, Falls Lake and Swan Lake
(Forest Service photo, 1929)

Figure 3 Scenery Cove, Scenery Creek Valley and Scenery Lake
(Forest Service photo, 1929)

Figure 4 Ruth Lake looking eastward up Delta Creek Valley.

various creeks. Swan Lake and Scenery Lake are readily accessible by float planes, but Ruth Lake is too deeply set in a small high-walled canyon to be served by plane.

The following table summarizes the drainage area in the basins and shows other pertinent data.

	Drainage area, square miles			Altitude of lake surface (feet)	Surface area (acres)	Maximum depth (feet)
	above mouth	above gaging sta.	above outlet of lake			
Scenery Creek	33.6	30.0	21.1	957	544	227
Cascade Creek	23.1	23.0	18.9	1,514	570	400+
Delta Creek	10.3	-	7.9	1,353	55	91

The tidal data for Thomas Bay as furnished by the U. S. Coast and Geodetic Survey in a letter of May 17, 1949 are as follows:

	Feet
Highest tide (estimated)	20.5
Higher high water	16.1
Mean high water	15.1
Half tide level (mean sea level)	8.35
Mean low water	1.6
Lower low water	0.0
Lowest tide (estimated)	-4.5
Mean range of tide	13.5

The mainland is extremely rugged and offers very little in the way of a favorable site for industrial development at or in the immediate vicinity of the power sites. Some consideration might be given to an area a few hundred feet square in the lower end of the Scenery Creek valley. The flat area at the

mouth of Scenery Creek as shown on the Cascade Creek and Vicinity map merges into tide-flat land. The possibility of filling in this tidal area to create the necessary land for an industrial site might be worthy of some investigation. However, it is small in size and the steep rock walls of the valley limit any future expansion.

The ruggedness of the mainland near the three creeks makes it necessary to transmit the power to a more favorable location for industrial sites and the supporting community. Such an area is available near Point Agassiz about 7 miles airline southwest of Cascade Creek and 10 miles airline northeast of Petersburg. (See figure 8.)

WATER RIGHTS

There are no territorial or Federal statutes in effect governing the appropriation of water. The only territorial regulation required is the demonstration of the right to do business in Alaska. The applicant must pay taxes assessed and must comply with general statutes.

The Federal Water Power Act of 1920 and later the Federal Power Act of 1935 governs water-power development on all federally owned lands and federally controlled waterways.

The general procedure and requirements for the purpose of securing permits or licenses governing water-power development are printed in a publication of the Federal Power Commission, entitled "Rules of Practice and Regulations With Approved Forms, Effective June 1, 1938."

In general anyone can apply for a permit or license provided that he conforms to the required procedures.

FACTORS AFFECTING THE DESIGN AND OPERATION OF POWER PROJECTS

Ice

Temperatures at Petersburg average below freezing for three months each year and have averaged below freezing in the five months from November through March. Ice has been observed on Scenery Lake as late as June and it is likely that Swan Lake and Ruth Lake would also be ice-covered later in the season as well. Thus ice is a factor to be considered in the design of dams, penstocks, power houses and outlet works. The reservoir would, in general, be drawn to its lowest level at about the time when the spring breakup of the ice would occur.

The design and construction of transmission lines will be influenced by icing conditions. The use of submarine cable would be one method of avoiding much of the ice hazard.

Debris

If there is to be no clearing of reservoirs there must be ample provision for trash racks or other protection for tunnel intakes and spillways. The accumulation of blow-downs and the debris of seasonal slides must be considered even if the reservoir is cleared up to the maximum water line.

Slides

The steep slopes adjacent to the dam sites and powerhouse sites, and the heavy precipitation combine to create a very real threat of slides to any hydraulic features built in the Thomas Bay area. The possibility of interrupted service as a result of such slides make it necessary to provide for protection of all features which would be subjected to slide damage. The threat to a surface conduit for water supply lines, and to power-houses could be minimized by employing tunnels and underground structures. A notable example of the type of construction is the Kitimat project of the Aluminum Company of Canada. The threat to transmission lines might be largely avoided by selecting a route across Thomas Bay, which would involve some use of submarine cables, but which would bypass much of the mountainous terrain.

Sedimentation

During the summer a few of the streams above the lakes have slightly milky appearance suggesting the presence of rock flour in suspension. However, the possibility of the limiting of the useful life of the projects by the silting in of the reservoirs does not appear to warrant any extra provision of reservoir space. The dead storage below the proposed intake levels should be ample to provide for many years of silt accumulation.

Tides

Thomas Bay has a mean tidal range of 13.5 feet which would influence tailrace construction. Access construction of roads and docks would likewise be influenced by the tides.

Precipitation

The precipitation at Petersburg averages 108 inches per year, about half of which is snow, and it is heavier at the higher elevations in the Thomas Bay area. The heavy snow load would have to be considered in the design and construction of any buildings and of the transmission lines. Heavy precipitation would also have a tendency to affect the speed and efficiency of outside work during project construction.

GEOLOGY

The geology of the three basins was examined during the 1951 field season by J. C. Miller of the Mineral Classification Branch of the Geological Survey. A report by Miller entitled "Geology of Water-Power Sites on Scenery Creek, Cascade Creek, and Delta Creek, near Petersburg, Alaska," is available in open file.

According to this report there appear to be no adverse geologic conditions which would restrict construction of the works required for power development. A comprehensive discussion of the geology appears in the above-mentioned report.

WATER UTILIZATION

Present use

At the present time these creeks are not being utilized in any way. Salmon have not been observed in any of the creeks and it is doubtful that they enter Thomas Bay to any extent. However, shrimp trawlers operate in the bay with considerable success.

Future use

The most probable use of the three streams in the Thomas Bay area would be for the development of hydroelectric power to be used by the forest products industries, primarily in the production of pulp and paper. The relatively untouched stands of spruce and hemlock of Southeastern Alaska form a huge source of supply for the paper industry.

WATER SUPPLY

Climatology

Precipitation: Long term weather records nearest to the Thomas Bay area are at Petersburg, on Mitkof Island, about 20 miles to the southwest. Incomplete precipitation and temperature records are available from 1927 to the present time. Precipitation and temperature records were obtained by the field parties while working in the Thomas Bay area during the 1949, 1950 and 1951 field seasons. Records for Juneau date back to 1884 but are incomplete prior to 1912. Both Juneau and Petersburg are at sea level but are separated by about 120 miles, so that a close correlation of the year-to-year precipitation is not to be expected. However, the general trend of the two records is consistent for the overlapping periods and the Juneau record therefore can be used as a rough index to possible critical periods not covered by the Petersburg records. The driest periods of record at Juneau since 1915 were the water years 1941 and 1951. Lesser amounts of precipitation were recorded at Juneau in some years prior to 1915 but the records for those years are not comparable with the later ones,[1/] and probably do not represent much drier periods than

1/Federal Power Commission and U. S. Forest Service, Water Powers of Southeast Alaska, p. 19, 1947.

1941 and 1951. The temperature and precipitation

records for Petersburg are shown graphically in Figure 5 and are listed in Tables 1 and 2.

The months of least precipitation, May, June, and July, contribute only 15 percent of the total precipitation; June being the driest month. Precipitation for the period of September through January is about 60 percent of the total for the year. The average seasonal snowfall at Petersburg is 95 inches.

Temperature: Winters in Southeastern Alaska are relatively mild and summers are cool. July is the warmest month with an average temperature at Petersburg of 56 degrees, but the temperature very seldom exceeds 75 degrees. January is the coldest month with an average temperature of 29 degrees at Petersburg, however, freezing temperatures may be expected from October through May. The cloud cover is generally quite heavy which tends to equalize day and night temperatures.

Figure 5 shows a comparison of precipitation and temperature at Petersburg with the measured runoff at Cascade Creek. There is a closer relation between temperature and runoff than between precipitation and runoff, because much of the runoff is from melting snow and ice. The amount of storage in snow or ice of glaciers is dependent upon precipitation and temperature so that there may be a delay of months or years in the corresponding runoff.

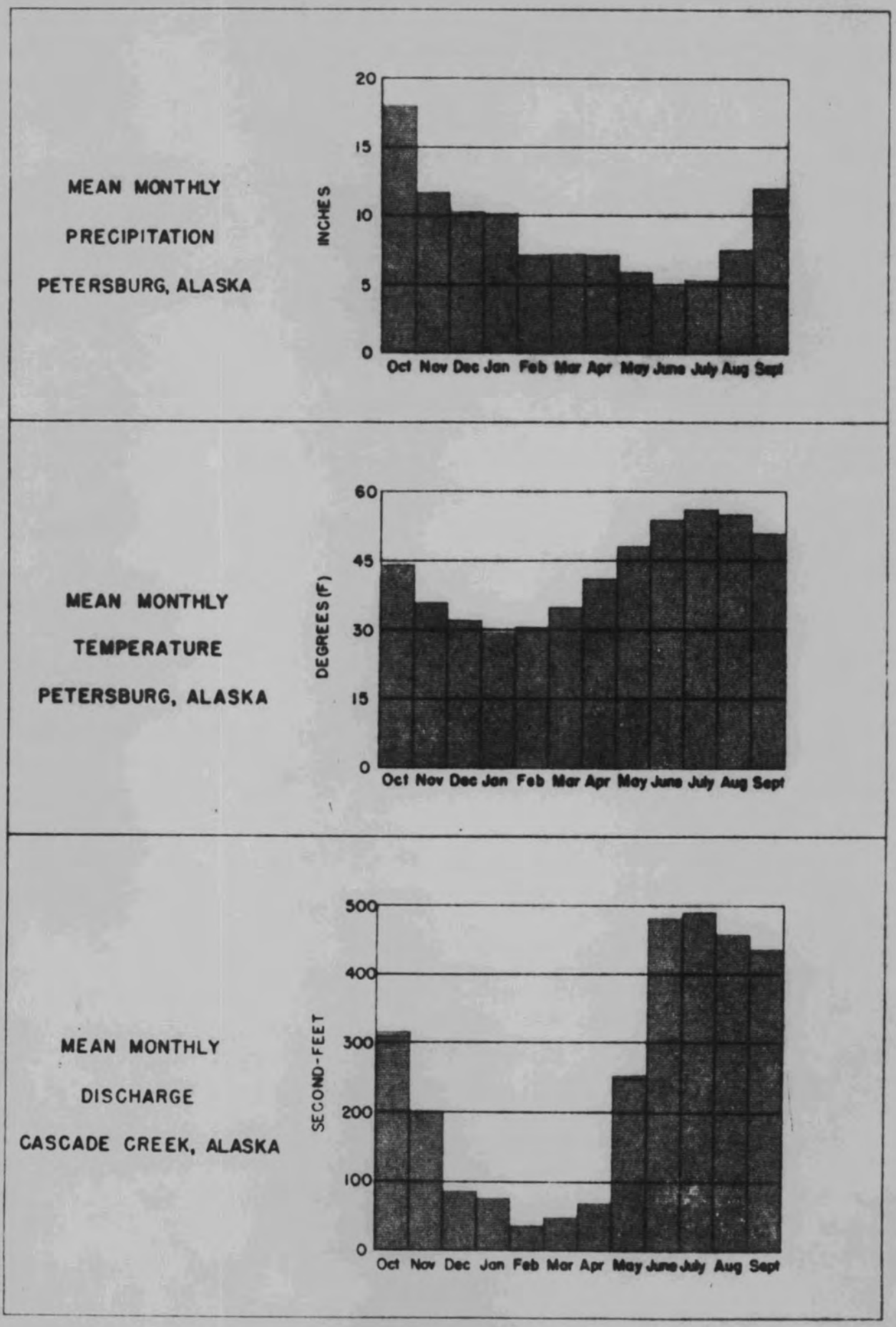

Figure 5 Precipitation and Temperature at Petersburg and Discharge of Cascade Creek

Winds: The winds in the Southeastern Alaska area are generally from the south throughout the year. Occasionally in the winter the winds will be from the north and will bring lower temperatures to the area, especially in the northern part. Light to moderate force winds are normal, but occasionally winds at the mouths of prominent passes and fiords reach hurricane force. In November of 1952 the gage house and cableway at the Scenery Creek station were destroyed by falling trees in a windstorm. Thus while strong winds are uncommon they have occurred in the Thomas Bay area.

Sunshine: In a region having as much precipitation as Southeastern Alaska, very little sunshine is to be expected. Records at Juneau indicate that the sun shines about one-third of the possible time. May usually has the highest amount of sunshine and October the least. Occasionally periods of clear weather up to three weeks in length are observed during the summer. North of Juneau the cloudiness decreases slightly with a corresponding increase in sunshine.

Evaporation: Because of the frequent cloud cover and heavy precipitation with resultant high humidity, the evaporation and transpiration losses from the drainage basins in the Thomas Bay area probably are small. The lakes forming natural reservoirs in each basin are subject to such evaporation as may occur from their

Table 1

Monthly and annual temperature in degrees F.
at
Petersburg, Alaska

Year a/	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1931	40.8	38.6	40.2	38.8	36.3	34.8	43.8	47.6	55.5	57.6	56.2	50.8	45.1
32	43.5	33.8	31.9	29.6	28.2	34.7	41.6	47.5	50.1	53.5	53.4	49.1	41.4
1938	46.8	35.8	28.1	32.0	25.8	35.2	41.6	47.6	51.4	54.3	54.7	54.2	42.3
39	46.7	37.4	33.0	32.8	27.4	33.2	39.2	46.6	52.7	55.6	53.4	50.0	42.3
1940	42.2	37.7	39.2	33.2	30.8	37.2	44.6	48.2	53.5	57.4	54.6	51.8	44.2
41	46.4	34.9	35.5	31.9	33.0	40.2	46.2	48.8	56.6	58.7	59.0	52.2	45.3
42	46.3	36.6	30.0	36.2	36.2	36.1	43.2	52.2	55.8	56.2	56.6	52.1	44.8
43	45.1	32.8	26.9	22.2	33.4	32.3	41.7	46.8	53.6	53.7	54.2	51.4	41.2
44	44.2	41.6	38.2	35.9	33.7	34.6	42.6	47.4	53.9	55.7	54.7	50.2	44.4
1945	46.8	38.1	32.8	34.6	33.0	36.2	39.0	50.0	51.8	53.8	55.0	49.4	43.4
46	44.1	29.0	31.0	33.1	33.5	34.6	39.4	50.6	56.6	54.8	53.4	50.4	42.5
47	41.2	31.6	25.9	23.6	28.3	35.6	39.8	49.4	53.3	56.6	54.0	50.8	40.8
48	43.6	38.6	35.0	33.4	24.8	32.4	36.2	48.0	56.5	56.6	54.4	47.5	42.2
49	42.6	35.6	22.1	27.6	22.5	35.5	40.4	46.0	49.2	54.1	53.6	51.9	40.1
1950	43.4	42.7	-	10.5	31.4	35.0	38.3	44.2	55.1	54.2	55.9	50.1	-
51	40.7	26.7	33.3	24.0	26.9	28.9	39.5	47.2	52.8	59.2	55.8	51.8	40.6
52	40.0	35.6	25.3	20.4	31.6	33.2	38.5	45.7	51.3	55.4	55.2	50.2	40.2
53	46.3	38.5	35.1	21.6	35.3	33.8	41.2	48.4	55.0	57.0	55.0	49.5	43.0
Max.	46.8	42.7	40.2	38.8	36.3	40.2	46.2	52.2	56.6	59.2	59.0	54.2	
Min.	40.0	26.7	22.1	10.5	22.5	28.9	36.2	45.7	49.2	53.5	53.4	47.5	
Mean	43.9	35.9	32.0	29.0	30.7	34.6	40.9	47.9	53.6	55.8	54.9	50.7	

a/ Water year, October 1 - September 30.
Note: Data from U. S. Weather Bureau published records.

Table 2

Precipitation in inches
at
Petersburg, Alaska

Year a/	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ann.
1927	17.64	6.55	13.67	3.33	6.43	11.10	5.11	5.65	2.49	2.94	6.58	11.96	93.45
1931	21.34	21.12	21.27	11.85	12.05	6.53	8.61	10.01	5.31	5.72	11.74	11.82	147.37
32	18.51	6.75	6.23	14.25	16.20	4.94	3.55	5.96	8.19	6.74	3.80	17.48	112.60
1938	19.47	7.03	10.68	15.11	9.63	5.97	8.11	8.69	7.03	4.30	3.71	16.31	116.04
39	13.87	11.37	14.92	12.33	7.92	5.41	8.69	5.93	4.09	5.81	10.05	13.02	113.41
1940	22.13	18.95	12.98	8.27	3.67	11.27	6.29	7.53	7.48	3.30	16.66	9.69	128.22
41	14.62	10.49	7.64	8.60	2.43	5.28	4.79	7.03	6.19	5.52	1.05	7.79	81.43
42	21.17	16.44	5.40	16.07	4.63	10.41	6.06	1.68	1.73	3.35	4.37	8.56	99.87
43	18.08	7.34	10.51	12.86	8.74	3.03	8.19	5.43	1.20	8.55	9.87	13.26	107.06
44	15.28	22.99	18.96	12.06	2.85	11.90	5.68	7.74	5.09	3.84	7.83	5.77	119.99
1945	29.05	13.49	8.77	9.01	7.78	9.91	5.88	4.52	8.74	10.30	2.09	9.88	119.42
46	24.94	5.32	5.72	6.92	6.14	6.69	8.54	1.82	2.46	8.52	11.15	12.79	101.01
47	13.80	10.14	10.16	9.75	5.24	11.12	10.33	4.64	6.41	3.59	8.17	15.25	108.60
48	11.51	9.65	13.69	13.48	4.67	5.97	1.10	3.88	3.08	6.63	8.03	17.27	98.96
49	23.96	14.40	9.16	13.77	5.98	4.44	13.71	5.90	6.33	3.21	5.62	11.87	118.35
1950	21.04	15.53	4.26	1.49	8.20	2.76	5.77	7.67	1.49	8.71	9.56	14.72	101.20
51	8.23	6.20	7.34	9.21	4.57	6.98	6.57	3.91	6.34	3.00	3.94	5.33	71.62
52	8.99	7.15	5.51	10.89	7.10	4.64	11.10	6.40	4.61	5.92	10.08	15.00	97.39
53	17.30	11.49	7.58	4.08	12.46	8.41	7.20	7.38	2.68	2.17	9.21	11.64	101.60
Mean	17.94	11.70	10.23	10.18	7.19	7.20	7.12	5.88	4.79	5.37	7.55	12.07	107.22

A/ Water year, October 1 - September 30 Note: Data from U. S. Weather Bureau published records.

water surfaces, and since the available runoff records are for points downstream from the lakes, they include the effect of this natural loss.

Runoff

Streamflow records for Cascade Creek are available from 1918 to 1928 and 1947 to date. From 1915 to 1921 the operation of the gage was on a cooperative basis between the U. S. Forest Service and the Geological Survey. The Forest Service continued to operate the station from 1921 to 1928 when operations were discontinued. The Geological Survey reestablished the station in September 1947, and the records are continuous from that time. No streamflow information for Scenery Creek was available until September 1949, when a gaging station was established by the Geological Survey. The station is 300 feet above the junction with the South Fork Scenery Creek. The station was destroyed by windblown trees in November 1952, rebuilt in the fall of 1953, and damaged by ice in January or February of 1954. Plans are being made to rebuild the station in the spring of 1956 if funds are available.

During the water year, 1951, precipitation generally was deficient over Southeastern Alaska and this probably was one of the most adverse years of record for water supplies. The precipitation recorded both at Petersburg and Juneau during that year was about the least of record since 1915. The early precipitation records for

Juneau evidently are not comparable to those after 1915, and although lesser amounts were recorded there from 1910 to 1912 it seems unlikely that the areal precipitation was much less than in 1951. Judging from other streamflow records for stations in Southeastern Alaska, deficiencies in water supplies similar to that of 1951 may have occurred in the water years 1933 and 1910, and on the average perhaps may be expected less than ten years in one hundred. The records for Cascade Creek and Scenery Creek for the water year 1951 therefore provide a fairly reliable measure of the water supplies during the driest years.

The computations in this report were based on figures of monthly runoff at the lake outlets which were estimated from streamflow records of Cascade Creek by the application of constant factors. About one-fifth of the drainage area at the Cascade Creek gaging station has an altitude ranging from near sea level to 1500 feet, whereas the drainage area above the Swan Lake outlet is higher. Because of the general occurrence of winter precipitation as snow above certain altitudes, it is obvious that there must be a greater concentration of snow-melt runoff at the lake outlet than at the gage and a lesser amount of runoff from rainfall during the winter months. No attempt was made to allow for this difference since quantitative data are lacking as to seasonal distribution and the relative amount of runoff

at different altitudes.

Monthly runoff for Cascade Creek at the gaging station is shown in table 3 and in the graphs in figures 5 and 6. The mean runoff for the period of record is 245 cfs. This is equivalent to 177,000 acre-feet per year, 10.6 second-feet per square mile, or 145 inches depth of runoff. The period of least runoff is from December through April which, on the average, accounts for only 11 percent of the annual runoff. The period of greatest runoff is the four months from June through September when 63 percent of the runoff occurs. The maximum recorded flow for Cascade Creek was 3,280 cfs in September 1947 and the minimum was 11 cfs in March 1948. The maximum mean monthly flow was 684 cfs in September 1924 and the minimum was 18.6 cfs. The maximum flows are likely to occur in August and September when the maximum melt water and the increasing autumnal precipitation coincide.

A notable feature of the runoff from the Cascade Creek basin is that it exceeds the precipitation recorded at Petersburg by 35 percent. This undoubtedly is due largely to a considerable increase in precipitation with an increase in altitude. About 82 percent of the Cascade Creek basin is above an altitude of 1,500 feet whereas Petersburg is practically at sea level.

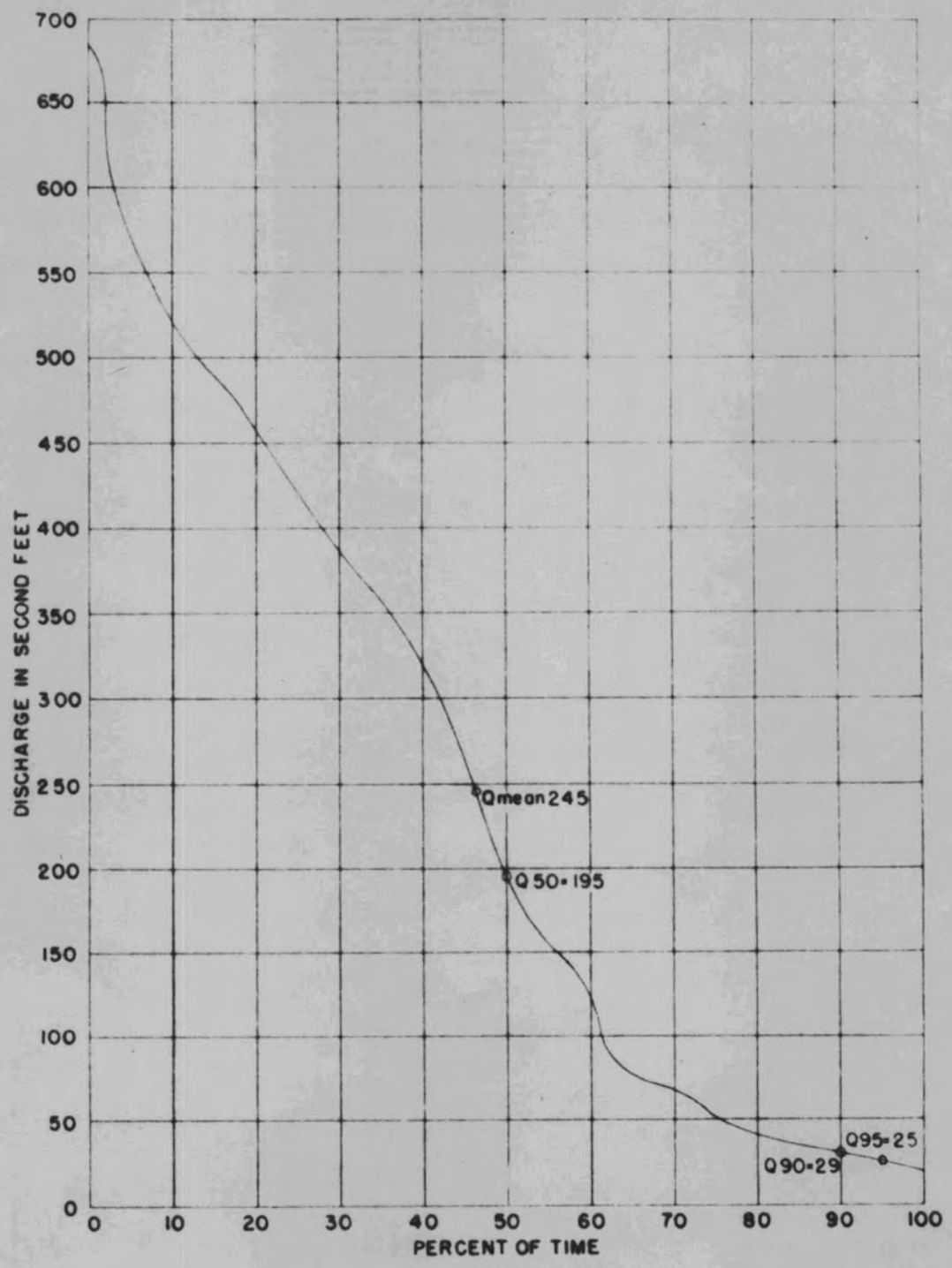

Figure 6. Flow Duration Curve, Cascade Creek for the Period 1918-1928, 1947-1953

Table 3

Monthly and annual discharge, in cfs
of
Cascade Creek near Petersburg, Alaska

Year	a/ Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1918	589	657	73.8	65.9	27.3	20.3	50.5	195	482	532	656	400	314
19	376	185	90.8	161.0	27.0	27.4	74.6	155	322	476	571	487	248
1920	334	102	72.5	77.9	60.0	32.7	34.1	99.4	441	549	676	332	235
21	158	128	34.8	33.1	41.2	40.3	34.5	200	510	432	370	403	199
22	566	124	147	50.0	25.0	20.0	65.0	181	310	473	502	395	240
23	252	253	64.3	27.7	41.1	54.8	90.1	248	511	450	507	555	255
24	385	238	78.0	36.5	25.0	44.7	65.0	292	594	529	517	684	291
1925	357	204	85.3	18.6	20.0	24.9	33.3	334	488	623	451	315	248
26	210	184	346	405	74.1	139.0	272.0	288	410	412	326	231	276
27	389	162	135	54.0	20.0	31.2	32.5	165	551	481	420	530	249
28	299	84.5	32.4	141	48.7	66.0	71.7	365	571	588	442	424	262
1947	189	227	38.1	42.9	41.1	187	164	327	510	389	369	527	251
48	188	160	72.3	85.9	40.1	26.7	25.3	349	496	403	357	484	224
49	217	146	48.2	45.4	24.8	34.8	60.6	290	445	495	460	455	228
1950	376	372	61.5	25.0	20.0	22.7	26.8	164	518	504	388	428	243
51	140	85.5	48.8	41.8	25.6	29.1	44.9	291	584	487	332	285	200
52	244	112	66.9	33.2	32.6	30.1	46.7	258	438	615	465	522	239
53	473	159	63.1	33.0	30.3	29.8	42.8	350	458	389	412	385	236
Mean	319	199	86.5	77.0	34.7	48.3	68.6	253	480	490	457	436	246
Max.	589	657	346	405	74.1	187	272	365	594	623	676	684	
Min.	80.3	84.5	32.4	18.6	20.0	20.0	25.3	99.4	310	389	326	231	

a/ Water year, October 1 - September 30

Note: Records after 1950 are subject to revision.

A flow duration curve, figure 6, based on the 18 years of available record show the following values of streamflow in second-feet at the gage on Cascade Creek: Q 95 = 25, Q 90 = 29, Q 50 = 195, Q mean = 245.

The area at the outlet of Swan Lake is 82 percent of the area at the gaging station. Since the upper part of the basin probably is the more productive, it was assumed in this report that 85 percent of the recorded runoff originated above the lake outlet. Available records of Scenery Creek runoff are brief and discontinuous and indicate that the unit runoff for Scenery Creek during the water years of 1950, 1951 and 1952 was about 92 percent of that for Cascade Creek. (See table 4.) Since the drainage area at Scenery Lake is about 11 percent larger than at Swan Lake, it was assumed that the runoff at the outlet of Scenery Lake is the same as at the outlet of Swan Lake.

Streamflow records have not been obtained on Delta Creek. Because its basin is adjacent to that of Cascade Creek and is of similar topographic form, Delta Creek has been assumed to have the same runoff per square mile as Cascade Creek. Drainage areas of each stream and lake are shown on page 10. The areas of the entire drainage basin of Delta Creek and of Ruth Lake at the outlet are 45 percent and 35 percent

Table 4

Monthly and annual discharge, in cfs
of
Scenery Creek, Alaska
at gaging station

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1950	469	473	80.0	35.0	25.0	30.0	44.6	275	555	569	476	569	301
51	205	112	60.0	55.0	33.0	38.0	91.3	351	631	549	372	375	240
52	313	139	71.7	42.0	47.8	57.1	112.0	319	468	698	532	580	282
Total	987	724	211.7	132.0	105.8	125.1	247.9	945	1,654	1,816	1,380	1,524	823
Mean	329	241	70.6	44.0	35.3	41.7	82.6	315	551	605	460	508	274

Note: Records after 1950 are subject to revision.

respectively, of the drainage area of Cascade Creek. Assuming the unit runoff to be equal to that at the Cascade Creek gage, the total runoff from Delta Creek is 45 percent of Cascade Creek and in second-feet is as follows: Q 95 = 11, Q 90 = 13, Q 50 = 88, Q mean = 110. The runoff at the outlet of Ruth Lake is assumed as 40 percent of the runoff at the outlet of Swan Lake, and this factor has been applied to determine storage requirements for Ruth Lake. (See section on Undeveloped Storage). The factor corresponds closely with the ratio between the drainage areas above the respective lake outlets.

Industrial water supply

The pulp and paper industry requires a supply of fresh water for processing and this supply could be obtained from Delta Creek. It would be necessary to regulate the flow to provide a dependable supply, and this would require a dam at the outlet of Ruth Lake. A diversion downstream would be required to divert water to a pipeline that would carry the water to the industrial development. The minimum regulated flow at the outlet of Ruth Lake would be 78 cfs, with complete utilization in a period like 1947 to 1953. If this quantity of water were diverted from Delta Creek, it would supply about 35,000 gpm or 50 mgd. Based on the average consumption of water at several plants in

Washington, this supply is sufficient for the production of about 800 tons of pulp and paper per day.

The pipeline from Delta Creek would cross Patterson River near its mouth and then on to the industrial area for a total length of about 6 miles. The terrain along the conduit route varies from steep rocky slopes near Delta Creek and the shifting sands of the Patterson River bed to the muskeg areas on Point Agassiz. In the event that a supply greater than that from Ruth Lake is needed, the pipeline could be extended 2 miles to Cascade Creek. With regulation for power development on Cascade Creek the dependable water supply there would be more than adequate for industrial requirements. Cascade Creek might therefore be considered as a sole source of industrial water if further investigations show that a development on Delta Creek would not be practicable.

The possibility of the development of ground water for the industrial needs should also be considered. If this were possible the difficult problem of bringing water from Delta Creek or Cascade Creek could be avoided. In this connection, an aerial reconnaissance over the Point Agassiz - Thomas Bay area was made on August 30, 1952 by D. J. Cederstrom, district geologist of the Ground Water Branch of the Geological Survey. Although

his inspection was brief and from the air, Mr. Cederstrom suggested that the valleys of the Patterson and Muddy Rivers offer some prospect of ground water development and are worthy of further investigation.

STREAM REGULATION

Natural storage

Natural storage in the Scenery Creek, Cascade Creek, and Delta Creek drainage basins is largely confined to the main lakes. Falls Lake is a small lake about 18 acres in area lying two miles upstream from the mouth of the Cascade Creek. The storage in this lake is negligible. Upper Scenery Lake, one mile upstream from Scenery Lake, has an area of approximately 230 acres. Accumulating snow fields and glaciers in the basins may also be considered as natural storage. Considering the geology of the basins, little or no ground water is available.

Developed storage

There are no developed storage sites in the three drainage basins under consideration.

Undeveloped storage

The utilization of the three streams under consideration will require the development of storage to equalize the streamflow throughout the year. The distribution of the annual runoff is such that only about 11 percent of the runoff occurs in the 5 months

from December through April, whereas 63 percent occurs in the 4 months from June through September. Each of the three basins offer good storage possibilities in the lakes and their upper valleys. These storage sites are discussed in the following paragraphs. Area and capacities for each lake are shown in tables 6, 7 and 8, and area and capacity curves together with cross sections at the dam sites are shown in figure 7.

As one means of analyzing the storage requirements a departure-from-mean curve was plotted for the estimated flow at the outlet of Swan Lake. The mean flow used was that for the 18 years of record through 1953 even though this record was not continuous. The flows available and storages required to maintain these flows, as determined from this curve for Swan Lake, were considered applicable to Scenery Lake and Ruth Lake when modified by the ratios of their respective drainage areas to the drainage area at the outlet of Swan Lake. (See section on Runoff). As another means of analyzing the storage requirements, a hypothetical operating schedule with a constant draft for each month of record balanced against the runoff at the lake outlet was computed for the carry-over storage analysis.

Regulation was considered on a year-to-year basis, and also on a basis of carry-over storage for several

years. In making the storage analysis, a full reservoir was assumed at the beginning of the period and a uniform draft from storage was assumed throughout the period. With draft started in October or November of each year the maximum drawdown would be reached in May or June. At this time runoff would exceed the draft and the reservoir would begin to refill. Drafts maintained on a year-to-year basis would have varied from 170 cfs to 245 cfs. The storage required to maintain these flows varied from 18,000 acre-feet to 64,000 acre-feet, depending on the runoff as well as the distribution throughout the year. Table 5 shows a list of the storages which would have been required and the corresponding flows which would have been attainable for each year of record.

An annual-use method of storage operation probably would not be practicable for power purposes unless there were standby sources of energy such as fuel-electric plants, for use in the drier years. A system designed for uniform generation of hydroelectric power might be more suitable for Alaskan conditions. Two schedules of operation for this purpose therefore were considered in detail herein; one for complete control in periods such as 1947 to 1953; and one for a somewhat lesser utilization of the water supplies.

Table 5

Storages and flows for Cascade Creek at Swan Lake
assuming year to year regulation from
Differential Mass Diagram
plotted on basis of mean flow 1918-1951
and mean flow 1952 and 1953

Period From	To	Flow Available	Storage Required
1 Dec. 1917	1 Nov. 1918	224	58,000
1 Nov. 1918	1 Nov. 1919	207	50,000
1 Nov. 1919	1 Oct. 1920	192	57,000
1 Oct. 1920	1 Nov. 1921	193	59,000
1 Nov. 1921	1 Dec. 1922	184	46,000
1 Dec. 1922	1 Nov. 1923	228	55,000
1 Nov. 1923	1 Nov. 1924	245	64,000
1 Nov. 1924	1 Oct. 1925	202	53,000
1 Oct. 1925	1 Nov. 1926	242	18,000
1 Nov. 1926	1 Nov. 1927	205	56,000
1 Nov. 1927	1 Oct. 1928	220	56,000
1 Oct. 1946	1 Oct. 1947	205	47,000
1 Oct. 1947	1 Oct. 1948	195	50,000
1 Oct. 1948	1 Dec. 1949	194	64,000
1 Dec. 1949	1 Oct. 1950	184	50,000
1 Oct. 1950	1 Oct. 1951	170	50,000
1 Oct. 1951	1 Nov. 1952	218	64,000
1 Nov. 1952	1 Oct. 1953	183	48,000

A storage capacity equal to 68 percent of the 18 year mean annual runoff, 103,000 acre-feet, would be sufficient to completely utilize the flow from 1918 to 1928, providing a constant rate of 212 cfs. During the more critical period, 1947 to 1953, a storage capacity of 79,000 acre-feet would provide a constant flow of 196 cfs. If the storage were limited to 79,000 acre-feet, the flow of 196 cfs would have been available throughout both periods of record with some surplus flow in five of the years between 1918 to 1928. A constant flow of 176 cfs, or 90 percent of the average flow from 1947 to 1953 could have been obtained with only 53,000 acre-feet of storage.

The development of storage on Swan Lake or Scenery Lake could be accomplished by one of three methods;

1. Construction of a dam at the lake outlet to raise the lake above its natural level;
2. Drawing the lake below its natural level;
3. A combination of these two methods

At Swan Lake 79,000 acre-feet of storage capacity could be created, for example, by raising the lake 105 feet to the 1,619 foot elevation or drawing it 160 feet below its present natural level. (See area and capacity table, table 6.) The mean elevation of the reservoir created by a dam would be 1,583 feet, and the mean elevation of the reservoir developed by drawdown would

be 1,477 feet. Storage by means of a dam would give a mean head 7 percent greater than that if drawdown were used to develop storage. Many combinations of damming and drawdown of course would be possible.

A storage capacity of 53,000 acre-feet could be attained by raising the lake 75 feet to the 1,589 foot elevation, or drawing it down 102 feet to the 1,412 foot elevation. The mean elevation of a reservoir created by a dam would be 1,555 feet. The use of a dam would provide a head 6 percent greater than the head available with drawdown.

For Scenery Lake the development of 79,000 acre-feet of storage capacity would require raising the lake about 110 feet to the 1,067 foot elevation or drawing it below the normal elevation in combination with a dam. (See table 7.) It is necessary to extrapolate beyond the available information to determine capacities of this magnitude. Soundings made on Scenery Lake in 1949 complete the underwater topography to the 900 foot elevation and indicate relatively little storage below 800 feet. If all capacity is developed by a dam, the mean reservoir elevation would be about 1,018 feet.

Raising the lake to the 1,036 foot elevation, or 79 feet, would create 53,000 acre-feet of storage sufficient for regulating the flow at 176 cfs or 90

percent of the average of 196 cfs. The mean pool level would be 1,000 feet. Drawing the lake down to the 843 elevation or 114 feet would provide 53,000 acre-feet of storage with a mean pool level of 905 feet. The head provided by a dam would be 11 percent greater than the head available with a system of drawdown.

Soundings made on Ruth Lake in 1950 show it to be relatively shallow; the greatest observed depth was 91 feet. Tapping of the lake to develop storage capacity probably would not be justified since the subsurface volume is only about 2,400 acre-feet, and it would be necessary to construct a dam for creation of sufficient storage for substantial regulation of the streamflow. (See Table 8). A capacity of 32,000 acre-feet would have been required for complete utilization of the runoff in a period like 1947 to 1953, with a uniform regulated flow of 78 cfs. A uniform flow of 90 percent of this amount or 70 cfs could have been maintained with only 21,000 acre-feet of capacity for regulation. Raising the lake 238 feet to the 1,591 foot elevation would provide 32,000 acre-feet of storage with a mean pool level of 1,503 feet. Raising the lake 179 feet to the 1,532 foot elevation would provide 21,000 acre-feet of storage with a mean pool level of 1,463 feet.

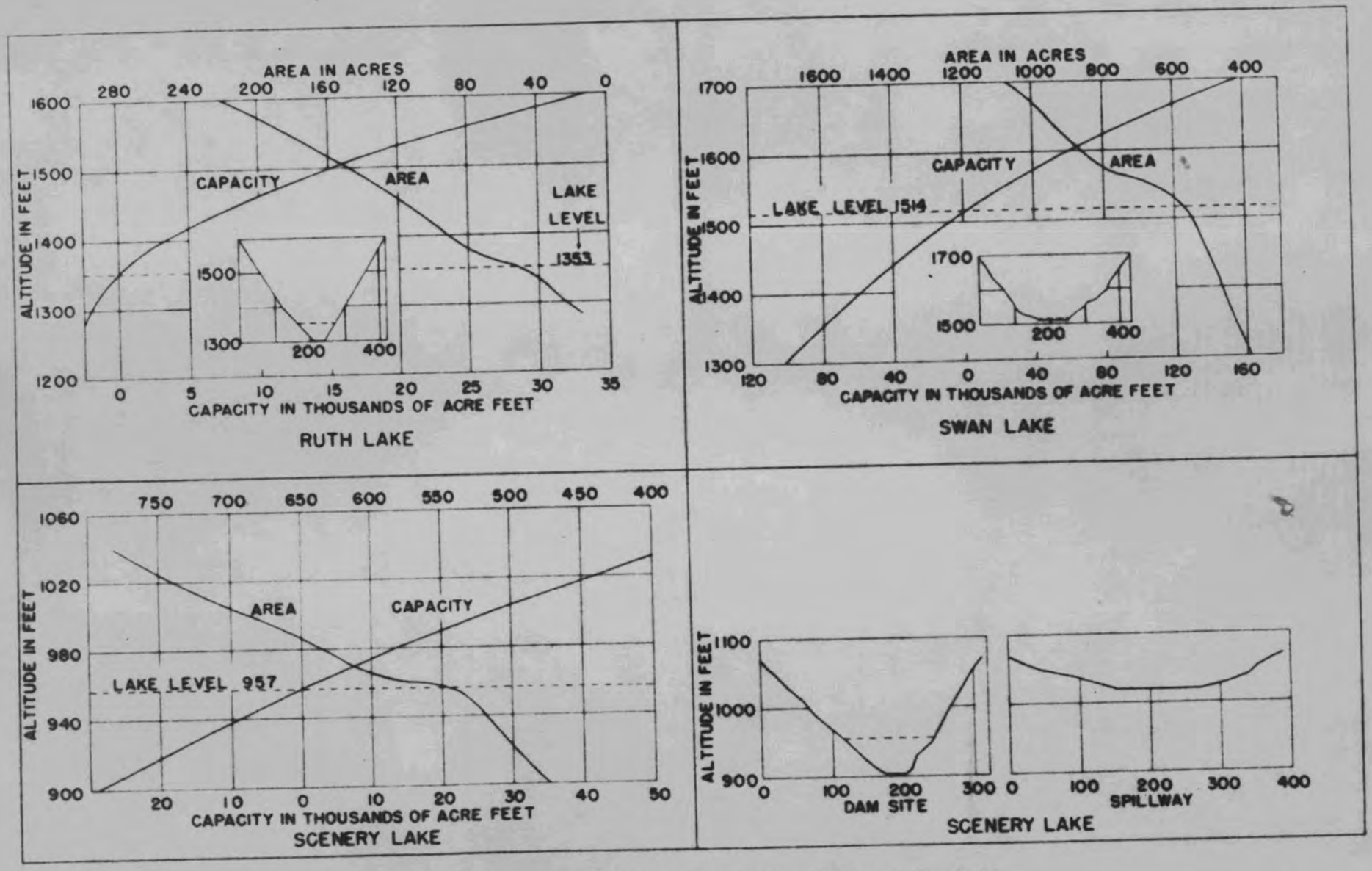

Figure 7 Area and Capacity Ruth Lake, Swan Lake, and Scenery Lake Reservoir Sites and Cross Sections of Dam Sites

WATER POWER

Developed Power

There are no power developments on the streams considered in this report.

Undeveloped Power

The evaluation of the potential power of the three streams under consideration is based on an illustrative plan of development which in turn is based on several general assumptions which are mentioned in the following paragraphs.

In view of the pronounced variation in streamflow throughout the year and the long period of low flow storage regulation will be essential for any substantial development of dependable water power. A run-of-river development seems so unlikely in this region that it was not considered in this report.

It was assumed for the purposes of this report that water would be conveyed under pressure from the reservoirs to the powerhouses, thus utilizing the maximum available heads. Because of the rugged terrain and the likelihood of snow avalanches, tunnels would be used rather than canals or pipelines.

The potential power was computed as follows:

$P = .068QH$, in which:
P = power in kilowatts
Q = flow in second-feet
H = mean operating head in feet

The mean operating head is defined herein as the drop between the lake at half-full level and the powerhouse

17 feet above mean sea level, or 5 feet above the highest estimated tide. The formula is based on an over-all efficiency factor of 80 percent.

An illustrative plan is presented to show the maximum power that could be developed continuously. Estimates also are presented for a somewhat lesser degree of utilization.

A plan for the development of Cascade Creek was outlined in the report by Dort, and plans for all three streams were outlined in the U. S. Forest Service-Federal Power Commission report. The plans considered herein are similar to the ones suggested in those reports; and some alternative possibilities also are discussed.

The power sites are described in the following sections. The potential power for these sites under various plans of development is shown in table 9 following the description of the sites.

Power generated at either Scenery Creek or Cascade Creek could be transmitted to the Point Agassiz area either by overland line around Thomas Bay or by submarine cable across Thomas Bay.

The overland route from Scenery Creek power plant would skirt the east shore of Thomas Bay, cross Cascade Creek at the mouth, and continue to Patterson River.

Figure 8 Point Agassiz area
Looking east from a point over
Frederick Sound at proposed
industrial site on mainland
east of Petersburg, Alaska

Then it would cross the river at or near the mouth and continue to an industrial area on Point Agassiz for a total distance of about 14 miles. The distance along this route from a powerhouse site on Cascade Creek is only about 8 miles; and from a powerhouse site on Delta Creek, about 6 miles. An alternative route from Scenery Creek combining overland lines with submarine cable to avoid most of the slide areas on the east side of Thomas Bay would be somewhat as follows: land line from the powerhouse to the mouth of Scenery Cove for 1.3 miles; submarine cable across Thomas Bay near the mouth of Scenery Cove for 2.3 miles, overland to Spurt Point nearest Ruth Island for about 3.1 miles, submarine cable for 1.5 miles to Ruth Island and then overland for the remaining 6.3 miles. This is a total length of about 14.5 miles. Using submarine cable for the crossing of Thomas Bay on a nearly direct route southwest from the mouth of Cascade Creek would reduce the total transmission line distance to about 7 miles; the submarine cable would be only about one mile in length. Maximum depths of the cable crossings in Thomas Bay would range from 360 to 600 feet. The main advantages of the underwater routes, in addition to their shorter lengths, are the probable lower maintenance costs, and lesser chances of interruption of service.

Cascade Creek Power Site

The development of dependable power on Cascade Creek would necessitate storage in Swan Lake, either by dam or drawdown, and a tunnel to deliver the water to a powerhouse at tidewater. Partial development could be attained by utilizing only that head which is available between Falls Lake as a fore-bay and tidewater.

Dam-site

There is a favorable dam site a few hundred feet below the outlet of Swan Lake where Cascade Creek flows in a narrow relatively shallow channel. (See figure 9.) The steep canyon sides are topographically suitable as abutments for a dam of any type, and Miller's report indicates that geologic conditions are favorable.

It would be necessary to raise the lake surface to an elevation of about 1,620 feet or 105 feet above the present level to create 79,000 acre-feet of storage capacity which is the amount needed for substantial control. The width of the canyon at the dam site is 305 feet at an elevation of 1,620 feet, and only 70 feet at the streambed. A storage capacity of 53,000 acre-feet could be obtained with a dam raising the lake surface 75 feet and having a crest length of about 265 feet. The topographic and geologic conditions are

Swan Lake Dam Site. Looking upstream from a point on left bank. (Composite from Forest Service photos)

Figure 9

such that a dam of any type could be constructed. Sufficient materials for rock fill or concrete aggregate probably are available in the vicinity.

The spillway should provide for flows in excess of 2800 cfs, which was estimated as the highest flow at the lake outlet during the period of streamflow records, and which occurred in September 1947. The steep slopes of the abutments and observed evidences of slides indicate that a tunnel type spillway through the north abutment rather than an open spillway probably should be considered.

Reservoir site

The Swan Lake reservoir site is steep-sided and moderately forested with spruce and hemlock of a sub-alpine type. No large timber trees are apparent. The undergrowth is mostly alder, devil-club, and salmon berry. Timber removed from the reservoir site would have little value, but clearing may be necessary for operational reasons. The lake is about one and three-fourths of a mile long and half a mile wide. A flat valley extends east from the upper end of Swan Lake for about a mile, and this would be within a reservoir created by damming the lake. The lake is quite deep, with some plunging depths just offshore in excess of 400 feet, as determined from soundings made in 1950.

Tunnels, penstocks, and powerhouse sites'

Topographic and geologic conditions indicate that the most favorable tunnel route from Swan Lake to tidewater would be on the north side of the valley. Such a location would have one or more changes in alignment to maintain adequate coverage of rock. No serious geologic difficulties are anticipated as the route passes through rock adequate in strength to

maintain tunnel openings. A route on the north side of the valley to a powerhouse on a flat bench at the mouth of Cascade Creek would be about 2.2 miles in length. If a powerhouse were located 3,500 feet north of the mouth of Cascade Creek the penstock length would be materially reduced, but underground construction of the penstock and powerhouse might be necessitated because of the extremely rough terrain.

As an alternative, the tunnel and penstock could be located to the northwest, terminating in a powerhouse for Scenery Lake development. Such a route would be about 3.5 miles long or 1.3 miles longer than to the mouth of Cascade Creek or to the point 3,500 feet north of the mouth. The additional cost of the longer tunnel would be offset somewhat by the advantage of having only one powerhouse with consequent lesser costs of construction, operation and maintenance. In addition to these savings there would be the advantage of having a single transmission line for power from each source. Installations at the lake would be the same in either case.

The tunnel would tap Swan Lake at an elevation of about 1,500 feet if a dam were built for storage of 79,000 acre-feet, or about 1,340 feet if drawdown storage is used. The gross heads would vary from 1,602 to 1,497 feet and 1,497 to 1,337 feet respectively for

the two possibilities. Mean operating heads would be about 1,566 and 1,460 feet, respectively. If storage is provided for a regulated flow equal to 90 percent of the average discharge the tunnel would tap the lake at about 1,500 feet if the reservoir is created by a dam, or at about 1,400 feet if the reservoir is provided by drawdown. The gross heads with a dam would vary from 1,572 feet to 1,497 feet and with drawdown from 1,497 feet to 1,395 feet respectively. The mean heads would be 1,538 feet and 1,448 feet respectively.

Falls Lake Power Site

An alternative to complete development of the Cascade Creek potential would be a partial development utilizing only the head from Falls Lake to tidewater as the steepest gradient of Cascade Creek is in this reach. The required tunnel length would be reduced by about one-third and the mean operating head and resultant power would be reduced about one-fourth.

In such a scheme, Swan Lake would serve as the storage reservoir, as before, with storage developed either by dam or drawdown. Falls Lake would serve as a forebay supplied by tapping Swan Lake at the appropriate depth with a short tunnel emptying into the channel of Cascade Creek. The mean operating head would be 1,140 feet. A view of the outlet of Falls Lake is shown in figure 10.

Figure 10. Falls Lake outlet

Since the cost of the storage reservoir, powerhouse, and transmission line would not be reduced proportionately to the reduction in head, the unit cost of the power in this alternative plan would be greater.

Scenery Creek Power Site

As previously mentioned in the section on Undeveloped Storage, the water supply and requirements for storage regulation at Scenery Lake have been assumed equal to those of Swan Lake. Maximum storage for carryover can be obtained at Scenery Lake only by a dam or a combination of a dam with some drawdown; drawdown alone would be insufficient. The entire potential head from Scenery Lake to tidewater could be developed, or it would be possible to utilize only that portion that is available in the steepest gradient of the stream.

Dam site

A dam for creation of a storage reservoir at Scenery Lake could be located either near the immediate outlet, or 400 to 500 feet downstream. The lake outlet is a narrow V-shaped notch with a steep rock hillside on the left side. Scenery Creek drops about 40 feet as a waterfall below this notch (See figure 11). The terrain inshore from the right bank is low and rolling for a distance of about 700 feet, where a steep rock wall could be used as the right abutment of a dam at the

Figure 11. Scenery Lake outlet

outlet section. The creek flows in a canyon for about 800 feet downstream from the lake. A ridge on the right bank starting about 400 feet downstream from the lake and paralleling the creek could be used as the right abutment of a main dam at this downstream site. It would be necessary to construct an auxiliary dam or dike across the low ground between the ridge and the rock wall to the northeast.

From a preliminary examination it appears that the rock is suitable for the foundation of a dam at either site, and that no unusual geologic problems are apt to be encountered. (See open file geologic report by J. C. Miller.)

A dam which would impound 79,000 acre-feet of water sufficient for hold-over regulation would have to raise the lake surface to an elevation of 1,067 feet. Such a dam at the lake outlet would be about 150 feet high in the streambed and about 930 feet along the crest. At a site 400 feet farther downstream, a dam would be about 170 feet high in the streambed and about 700 feet along the crest which would include about 400 feet of dike across a saddle. A reservoir capacity of 53,000 acre-feet would require dams of lesser dimensions at the same axes. At the lake outlet a dam raising the lake to an elevation of 1,036 feet would be about 120 feet high in the streambed and would be about 840 feet along the crest. At the downstream axis, a dam would

Table 7

Area and capacity Scenery Lake
Reservoir Site

Altitude (feet)	Area (acres)	Capacity (acre-feet)
800		1/ 69,000
820		1/ 62,000
840		1/ 54,000
860		1/ 46,000
880		1/ 38,000
900	473	28,800
920	496	19,100
940	518	9,000
2/ 957	544	0
960	570	1,600
980	634	13,600
1,000	685	26,800
1,020	739	41,000
1,040	781	56,200
1,060	3/ 814	72,100
1,080		1/ 89,000

1/Estimated from extension of capacity curve.
2/Lake surface
3/Area partly estimated; 1060 contour incomplete on map.

be about 140 feet high in the streambed and about 450 feet along the crest. Either a masonry or rock-fill dam could be built. Perhaps a combination of masonry in the streambed and rockfill in the dike section would be the most economical type of construction. Suitable material for either rockfill or concrete aggregate is available in the vicinity. At the lake outlet the downstream slope of the streambed is about 30 feet in 150 feet and the upstream slope is 12 feet in 100 feet. These gradients probably would be a factor in the design of a dam since they present a rather steep base.

The saddle area on the right bank of the stream below the lake outlet would furnish a natural spillway channel which could discharge to the streambed at a point about 2,000 feet downstream from the lake outlet. Flood flows of about the same volume as at Swan Lake or in the order of several thousand second-feet, could be expected.

Reservoir site

Scenery Lake is about two and a half miles long and a third of a mile wide. Raising the water surface of the lake would extend its length another half to three-quarters of a mile at the upper end. Like Swan Lake it is quite deep, with depths of 227 feet observed during soundings made in 1949. The steep slopes above the lake shore are moderately forested with spruce and hemlock. More of these trees are of timber size and

quality than those within the Swan Lake basin and some selective logging might be practical. General clearing of the entire reservoir area would be expensive because of the difficult terrain.

Tunnels, penstocks, and powerhouse sites

The most favorable tunnel route from Scenery Lake to tidewater as indicated by the topography and the geology, is on the south side of the valley. Several changes in alignment would be necessary to maintain rock cover. The tunnel would pass through quartz diorite for most of its length and no geologic difficulties which would be a hazard to tunnel construction are anticipated. The suggested route would be about 3.4 miles long and terminate in a penstock 1,500 feet long for the final drop to the powerhouse. A powerhouse could be built on the left bank of Scenery Creek about 700 feet downstream from the mouth of South Fork Scenery Creek. Some provision might be made to intercept the flow of the South Fork Scenery Creek to add to the total flow, although no allowance has been made for this possibility in the power estimates of this report.

The tunnel would tap Scenery Lake at about the 940-foot level if a dam were built, or at about the 830-foot level if drawdown is used to develop the 53,000 acre-feet of storage required for partial regulation. As mentioned in the chapter on Stream Regulation, there is not sufficient volume below the lake surface to furnish the

79,000 acre-feet of storage required for carry-over regulation. Gross heads with a dam impounding 79,000 acre-feet of water would vary from 1,050 to 940 feet with a mean of 1,001 feet. Gross heads with the lower dam would vary from 1,019 to 940 feet with a mean of 983 feet. Development of 53,000 acre-feet of storage by drawdown would provide heads varying from 940 to 826 feet, with a mean of 888 feet.

Scenery Creek Alternative Development

It is apparent from a study of the stream profile that two-thirds of the fall of Scenery Creek occurs in the first mile downstream from the lake. Thus a partial development of the stream could be made with a relatively short waterway. A tunnel on the north side of the valley 1.1 miles long would deliver the water to a penstock for the final drop to the powerhouse near mile 2.4 at elevation of 365 feet. The tunnel would be only a third as long yet the power output would be two-thirds as much as with complete development. However, the cost of other units such as the dam and the power house would not be reduced proportionately, and the transmission distance would be increased. The unit cost of power therefore might be as great as or greater than with a complete development utilizing all the head.

Delta Creek Power Site

As mentioned in the section on Undeveloped Storage, 32,000 acre-feet of storage would be required for substantially complete regulation of Delta Creek, and

21,000 acre-feet would be required for a somewhat lesser degree of regulation. A dam would be required at the outlet of Ruth Lake to provide either amount since the underwater volume of the lake is very small.

Dam site

The outlet of Ruth Lake offers a good dam site both topographically and geologically. Delta Creek is narrow and shallow at the lake outlet and flows through a V-shaped channel. (See figure 12). The stream gradient is quite steep just downstream from the lake and the walls of the canyon close in until they are nearly vertical.

Rock is exposed in both abutments. Boulders from rock slides from the steep slopes on either side of the outlet have accumulated in the streambed, but the depth to bedrock probably is not excessive. (See open file geologic report by J. C. Miller).

A dam which would raise the lake surface to the 1,591 foot elevation would be about 50 feet wide in the stream bed and have a crest length of about 470 feet. Such a dam would store 32,000 acre-feet of water, which would be sufficient for carry-over storage. A dam raising the lake level to the 1,532 foot elevation would have a crest length of about 400 feet and would store 21,000 acre-feet of water, sufficient for a substantial degree of regulation. Ample material is available for either rock fill or masonry construction of a Ruth Lake dam. The slope of the streambed from the dam site

Figure 12. Ruth Lake outlet

downstream is about 50 feet in 300 feet which constitutes a rather steep base.

The streamflow records obtained on Cascade Creek indicate that flows in excess of a thousand second-feet probably are to be expected on Delta Creek at the outlet of Ruth Lake. No natural spillway area is afforded by the canyon section, and in view of the prevalence of slides a tunnel type spillway probably should be considered.

Reservoir site

Ruth Lake is set in a steep-walled basin which is moderately forested with spruce and hemlock. Above the lake elevation of 1,353 feet the timber approaches the sub-alpine type and is not as valuable as timber in lower elevations. The lake is about half a mile long and about a thousand feet wide. Raising the lake to the 1,600 foot level would extend its length about a thousand feet. Service by float plane to the lake is not possible because of the difficulty of landing and taking off. Soundings made in 1950 indicated a maximum depth of 91 feet.

Tunnels, penstocks, and powerhouse site

Several tunnel routes are possible topographically and geologically. The three routes considered are all of about the same length. A tunnel to a penstock discharging at a powerhouse on tidewater at the mouth of

Table 8

Area and capacity Ruth Lake
Reservoir Site

Altitude (feet)	Area (acres)	Capacity (acre-feet)	
1,280	15	2,400	
1,300	26	2,000	
1,320	35	1,400	
1,340	44	600	
1,353	55	0	Lake surface
1,400	94	3,500	
1,440	113	7,600	
1,480	137	12,600	
1,520	165	18,600	
1,560	190	25,700	
1,600	222	33,900	

Delta Creek would be about 1.6 miles long. If a powerhouse were located 2,000 feet north of the mouth of Delta Creek, the penstock length would be about 15 percent shorter. A tunnel leading to a penstock and powerhouse on Patterson River would be about 1.7 miles long and the penstock would be about the same length as one to a powerhouse 2,000 feet north of the mouth of the creek. A fourth route appears to be the shortest; 1.5 miles long from Ruth Lake to a powerhouse at the mouth of Cascade Creek. This route would have the additional advantages of a slightly shorter penstock plus the economies of utilizing a common powerhouse with a development on Swan Lake, if such a development were made. Preliminary reconnaissance indicates no serious geologic difficulties would be encountered in tunnel construction. The materials through which tunnels would pass are of sufficient strength to maintain tunnel openings.

The tunnel would tap Ruth Lake about the 1,340 elevation. Gross heads would vary from 1,574 to 1,336 feet if a high dam is built to the 1,591-foot elevation, and from 1,515 to 1,336 feet if a lower dam were built to the 1,532-foot elevation. Mean heads would be 1,486 feet and 1,446 feet respectively.

The power possibilities of Delta Creek are not considered to be very attractive in view of the size of

Table 9

Summary of potential power and related data

	Plan A			Plan B			Plan C		
CASCADE CREEK	Head (feet)	Flow (cfs)	Power (Kil.)	Head (feet)	Flow (cfs)	Power (Kil.)	Head (feet)	Flow (cfs)	Power (Kil.)
Storage 79,000 a.f.	1566	196	20800	1460	196	19400	1140	196	15200
Storage 53,000 a.f.	1538	176	18400	1448	176	17300	1140	176	13600
SCENERY CREEK									
Storage 79,000 a.f.	1001	196	13300	-	-	-	653	196	8700
Storage 53,000 a.f.	983	176	11800	888	176	10600	635 540	176 176	7600 6500
DELTA CREEK									
Storage 32,000 a.f.	1486	78	7900						
Storage 21,000 a.f.	1446	70	6900						
Maximum total			42000 kw						

Plan A: Storage created by dams to raise the lake surfaces.
B: Storage created by diversion tunnels to draw down the lake surfaces.
C: Partial development on Cascade Creek by diversion from Falls Lake; and on Scenery Creek by location of powerhouse at elevation 365 feet.

the structures required relative to the potential power. From present information it appears that the development of substantial power in this area would be brought about by the needs of the pulp and paper industry. These industries require large volumes of process water. It is possible that this need could be supplied by the waters of Delta Creek. Unit costs of power from Delta Creek waters would be high, but if part of the cost of development could be allotted to the establishment of a dependable water supply, the unit costs of each would be reduced. Diversion from the tailrace of a Delta Creek power plant to a pipeline supplying the industry using the power would furnish a dependable supply of fresh process water. The power plant would then have to be located so that the remaining head between the tailrace elevation and the industrial plant elevation at or near sea level would be sufficient to carry the water to the industrial plant. The power head would be reduced accordingly.

MARKET FOR POWER

At the present time there is no available market for power that could be produced in the Thomas Bay area. The development of any industry in the market for such power probably would be coincident with the development of power. Considering the present untouched stand of

timber, the potential power of the area, and the demand for pulp and paper it seems logical that the pulp and paper industry would fit into this situation. The manufacturing of forest products and activities of the supporting communities probably constitutes the largest potential market for Thomas Bay power.

The total power of the three plants would be sufficient to produce about 18,000 tons of aluminum per year, but power for this industry must be cheap. It is doubtful if Thomas Bay power would be cheap enough to attract the aluminum industry.

The fishing industry, the largest in Alaska, does not require a large amount of power at present, but the expansion of freezing processes may increase this demand. The canneries are widely scattered and serving these established canneries would increase transmission costs to a point at which hydroelectric power would no longer be economical. The establishing of a large freezing and canning factory near to Thomas Bay would constitute a market for power. However, such a demand is likely to be seasonal corresponding to the fishing seasons. Expansion of the use of different varieties of fish other than seasonal salmon and halibut would extend the operating season of a cannery somewhat.

There are indications that mineral deposits are available in Southeastern Alaska although there has been little development of mining in this region. Any development of mining, along with related industries, could produce a demand for an appreciable amount of power.