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SURFACE WATER SUPPLY

OF

SEWARD PENINSULA, ALASKA

BY F. F. HENSHAW AND G. L. PARKER

WITH

A SKETCH OF THE GEOGRAPHY AND GEOLOGY

BY PHILIP S. SMITH

AND

A DESCRIPTION OF METHODS OF PLACER MINING

BY ALFRED H. BROOKS

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By F. F. HENSHAW and G. L. PARKER.

INTRODUCTION.

By ALFRED H. BROOKS.

SCOPE OF WORK.

This report presents the result of stream-flow measurements made in Seward Peninsula during the years 1906 to 1910, inclusive. The geography, geology, and meteorology of the peninsula are first briefly discussed, inasmuch as they have a controlling influence on the run-off, but in this introductory part of the report no attempt is made at a final analysis of the many geologic problems involved, which have been considered at greater length in the several reports of the United States Geological Survey[1] relating to Seward Peninsula.

[1] These reports include the papers listed below. All except those marked by an asterisk, which indicates that the Geological Survey's stock of the publication is exhausted, may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

Preliminary reports on the Cape Nome gold region, Alaska, by F. C. Schrader and A. H. Brooks. In a special publication. 1900. 56 pp.

A reconnaisance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900." 1901. 180 pp.

A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900."

A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper 2. 1902. 70 pp.

The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin 229. 1904. 61 pp.

*Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin 259. 1905. pp. 120-127.

The Fairhaven gold placers, Seward Peninsula, by F. H. Moffit. Bulletin 247. 1905. 85 pp.

The York tin region, by F. L. Hess. In Bulletin 284. 1906. pp. 145-157.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284. 1906. pp. 132-141.

The Kougarok region, by A. H. Brooks. In Bulletin 314. 1907. pp. 164-181.

*Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper 196. 1907. 52 pp.

Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin 314. 1907. pp. 182-186.

The Nome region, by F. H. Moffit. In Bulletin 314. 1907. pp. 126-145.

Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin 314. 1907. pp. 146-156.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314. 1907. pp. 157-163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328. 1908. 343 pp.

Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345. 1908. pp. 206-250.

The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin 345. 1908. pp. 251-267.

Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin 345. 1908. pp. 268-271.

Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906-7, by F. F. Henshaw. In Bulletin 345. 1908. pp. 272-285.

The general features of the topography herein described are also shown graphically on the map of the peninsula reproduced as Plate I (in pocket). This map is based on surveys made during the years 1900 to 1909, inclusive. Those who are interested in the details of the topography are referred to the several maps [1] which have been published by the Geological Survey.

The occurrence and distribution of the gold placers are summarized in the section devoted to geology. At present the mining of the placer gold is the only incentive to the utilization of the stream flow. Methods and costs of mining are briefly considered in the last section of this volume.

Plans were under consideration as early as 1903 for the systematic investigation of the water resources of Alaska, but the need of devoting the Alaskan appropriation to what was believed to be more important work prevented the prosecution of such an investigation. In 1906 a plan which contemplated the investigation of the water resources of the most important Alaska placer districts was formulated, but inasmuch as the funds available were sufficient to investigate only one area in the first year, the Nome district was chosen as that in which information concerning water resources would be of greatest value. In the following year similar investigations were begun in the Fairbanks district. The original plan contemplated

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358. 1908. 72 pp.

*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218. 1908. pp. 156.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358. 1908. 72 pp.

Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379. 1909. pp. 267-301.

The Iron Creek region, by P. S. Smith. In Bulletin 379. 1909. pp. 302-354.

Mining in the Fairhaven precinct, by F. F. Henshaw. In Bulletin 379. 1909. pp. 355-369.

Water-supply investigations in Seward Peninsula in 1908, by F. F. Henshaw. In Bulletin 379. 1909. pp. 370-401.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, by P. S. Smith. Bulletin 433. 1910. 227 pp.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska, by P. S. Smith and H. M. Eakin. Bulletin 449. 1911. 156 pp.

Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520. 1912. pp. 339-344.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533. (In preparation.)

[1] Such of the following maps as are for sale may be purchased from the Director of the Survey.

Seward Peninsula, northeastern portion of, topographic reconnaissance map of; scale, 1:250,000; by D. C. Witherspoon and C. E. Hill. In Bulletin 247. For sale at 50 cents each, or $30 a hundred.

Seward Peninsula, northwestern portion of, topographic reconnaissance map of; scale, 1:250,000; by T. G. Gerdine and D. C. Witherspoon. In Bulletin 328. For sale at 50 cents each, or $30 a hundred.

Seward Peninsula, southern portion of, topographic reconnaissance map of; scale, 1:250,000; by E. C. Barnard, T. G. Gerdine, and others. In Bulletin 328. For sale at 50 cents each, or $30 a hundred.

Seward Peninsula, southeastern part of; by D. C. Witherspoon, W J. Peters, H. M. Eakin, and others; scale, 1:250,000. In Bulletin 449.

Grand Central quadrangle; scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. For sale at 10 cents each, or $6 a hundred.

Nome quadrangle; scale, 1: 62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. For sale at 10 cents each, or $6 a hundred.

Casadepaga quadrangle; scale, 1: 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. For sale at 10 cents each, or $6 a hundred.

Solomon quadrangle; scale, 1: 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. For sale at 10 cents each, or $6 a hundred.

five seasons of observation in each district, but it has not been possible to adhere strictly to this plan. Even five years of observation by no means furnishes absolutely reliable data on minimum run-off, but it is believed that the results herein set forth will be sufficient for general purposes. They should, of course, be supplemented by more detailed records where large investments are to be made in projects depending for their success on the maintenance each year of a certain minimum flow.

The hydrometric surveys whose results are published in this report were carried on under the appropriation for the investigation of the mineral resources of Alaska by engineers detailed for this purpose from the water-resources branch of the Geological Survey. Credit should be given to John C. Hoyt, assistant chief hydrographer, who personally began these surveys in 1906 and has since that time supervised the technical part of the field work. Mr. Hoyt, in company with F. F. Henshaw, began investigations at Nome in June, 1906, conducting a reconnaissance northward to the Kigluaik Mountains (locally known as the Sawtooth Range), and covering the more important part of the producing placer district. A number of gaging stations were established by Mr. Hoyt before he left Alaska, early in August. The work was carried on by Mr. Henshaw for the remainder of the year and was continued by him with the help of one assistant during the three succeeding years. Stream-flow measurements have been limited each season to the period between the middle of June and the early part of October.

In 1907, after assisting Raymond Richards to start the work south of the Kigluaik Mountains, Mr. Henshaw proceeded to the Kougarok district, where he spent the greater part of the season. In 1908 A. T. Barrows was assigned to assist Mr. Henshaw as junior engineer, and spent most of his time during that season in the Nome and Kougarok regions. Mr. Henshaw worked in the Fairhaven district from July 23 until the severe frosts came, during the first week of September. The rest of September was spent in the southern part of the peninsula.

Messrs. Henshaw and G. L. Parker left Nome on June 13, 1909, for the Fairhaven district, by way of Nome River, Salmon Lake, Lanes Landing, and the head of the Kougarok, reestablishing on the way as many gaging stations as could be visited. New gaging stations were established on many of the larger streams of the northern slope of the mountains, and the work was left in charge of Mr. Parker. Mr. Henshaw returned by steamer from Candle to Nome, and spent the rest of the season in southern Seward Peninsula, giving special attention to the Nome, Kougarok, and Council districts.

In September, 1910, Mr. Parker, who had been investigating the water resources of the Fairbanks region, visited a number of gaging stations near Nome and obtained such data as various cooperating companies and individuals had collected earlier in the year. The records for 1910 are not so complete as those of the previous years, but they serve to extend the observations over a longer period and thus add value to the results.

This report has been prepared by Mr. Henshaw, with the assistance of Mr. Parker.

ACKNOWLEDGMENTS.

Except for the cordial cooperation of many residents of Seward Peninsula this work could not have been made so complete as it is with the comparatively small allotments that could be made to it. The mine and ditch operators were quick to realize the value of these investigations, and have at all times shown a cordial spirit in assisting the engineers by every means in their power. Many have rendered most valuable assistance in making gage readings, in furnishing stream-flow records made under private auspices, and in affording facilities to engineers during their periodic visits.

A complete list of all who have aided the work would be almost a roster of the placer-mine operators of the peninsula. Special thanks are due to the following persons and companies: In the Nome region: B. Deleray, manager, and the employees of the Miocene Ditch Co.; C. H. Munro, manager, and the employees of the Wild Goose Mining & Trading Co.; Japhet Lindeberg, president, and the employees of the Pioneer Mining Co.; the Cedric Ditch Co.; the Gold Beach Development Co.; the United Ditch Co.; W. L. Leland; J. E. Styers; Arthur Gibson; George M. Ashford, and Frank Waskey. In the Kougarok region: J. M. Davidson, president, and the employees of the Kougarok Mining & Ditch Co.; A. J. Stone, general manager, and the employees of the Taylor Creek Ditch Co.; Samuel Schram, manager, and the employees of the Pittsburg-Dick Creek Mining Co., and C. F. Merritt. In the Fairhaven district: Employees of the Fairhaven Water Co.; the Candle-Alaska Hydraulic Gold Mining Co., and L. A. Sundquist.

A considerable number of discharge measurements made by private engineers and others have been furnished to the Survey. Among those to whom special acknowledgment is due for furnishing data of this kind are C. H. Munro, W. H. Lanagan, A. B. Shutts, and R. G. Smith, of the Wild Goose Mining & Trading Co.; C. T. Law, of the Taylor Creek Ditch Co.; F. F. Miller and J. W. Warwick, of the Miocene Ditch Co., and H. M. Long and R. S. Dimmock, of the Candle-Alaska Hydraulic Gold Mining Co.

Thanks are also due to the many gage readers scattered throughout the peninsula, who have rendered efficient service. Specific acknowledgment is given to each reader under the record of the particular station with which he was connected.

TYPICAL TOPOGRAPHY, SEWARD PENINSULA.

A. UPPER GRAND CENTRAL RIVER VALLEY.

B. GLACIATED VALLEY NEAR MOUNT OSBORNE.

Those not familiar with the conditions of travel in Seward Peninsula can not realize at what expense of toil and hardship Mr. Henshaw and his assistants have worked. The travel was practically all on foot, and as each engineer had many gaging stations to visit some of the journeys made were little short of marvelous. The field season is short, and the engineers felt in duty bound to collect the greatest number of records possible. They have shown a spirit of self sacrifice which does high credit to them as individuals and to the profession to which they belong.

TOPOGRAPHY.

By Philip S. Smith.

Seward Peninsula forms the westernmost part of the mainland of Alaska. It lies just south of the Arctic Circle and has a maximum length east and west of about 225 miles and a width north and south of about 150 miles, including an area of about 20,000 square miles. The general features of this region are well shown by Plate I (in pocket) and by Plate II, but this graphic representation may be supplemented by brief verbal description.

The peninsula comprises three main topographic provinces—a lowland skirting much of the coast, an elevated region with a relief up to about 2,000 feet (Pl. II), and a belt of mountains having a maximum elevation of 4,700 feet (Pl. III). Although presenting these three different types of land forms, Seward Peninsula as a whole may be referred to the central plateau province of Alaska, which lies between the Alaskan or Pacific mountain system on the south and the Endicott or Rocky Mountain[1] system on the north.

The lowland province, which almost forms a girdle around the peninsula, shows by the character of its material that it was made by the deposition of stream and marine gravels on the floor of the sea and was subsequently uplifted, forming a coastal plain. This plain shows but slight relief, nowhere rising more than 300 feet above the sea, though its continuity is interrupted here and there, as at Topkok Head, Cape Nome, and Cape Prince of Wales, where the second province abuts on the coast. It is of recent origin, for it is but little dissected by the streams which flow across it. Its surface is covered with a rank growth of grass, but trees and even bushes are practically absent on the interstream areas, and stunted willows and alders form only a narrow fringe along the watercourses. Its width varies, but nowhere exceeds 25 miles.

By far the greater part of Seward Peninsula falls into the second physiographic division, the plateau province. This province is characterized by more or less elevated country, much dissected by streams, so that its general appearance is hilly. It occupies the northern and

[1] Brooks, A. H., Geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906, Pl. VII.

southern parts of the peninsula on either side of the mountain range. Collier [1] describes the portion south of the mountain as follows:

> To the south of the mountains is, as already stated, a highland mass whose summits range from 800 to 3,000 feet in elevation. The slopes of this upland are in many places broken by well-marked benches. * * * This highland area is essentially one of irregular topography with no well-defined system of ridges. The watercourses flow in broad, deeply cut valleys, whose slopes ascend gradually to the divides. The summits are rounded, but are broken by numerous rocky knobs, many of which are carved into fantastic shapes. These castellated peaks are very characteristic features of the topography, and their preservation plainly indicates the absence of regional glaciation. * * * The general trend of the larger valleys is north and south, and these block out broad ridges, whose margins are scalloped by the minor tributaries.

Many of the so-called mountains in Seward Peninsula—for instance, the York Mountains, in the western part—are merely dissected remnants of the general plateau just described. If mountains of this class are excluded, there appear to be only three distinct mountain ranges in Seward Peninsula, and perhaps even this number should be reduced, for the Kigluaik-Bendeleben Mountains and the Darby Range may be continuous. The only other range is that joining the divide between Kiwalik and Buckland rivers. The highest points in this range do not exceed 2,600 feet, and its average elevation is probably less than 2,000 feet.

The Kigluaik-Bendeleben Range has an average elevation of 3,000 to 3,500 feet, the highest points rising more than 4,000 feet (Pl. III, *B*). The range seems to be characterized by a single main ridge; that is, the slopes culminate in a single continuous divide, containing all the highest points, with no equally elevated ridges approximately parallel to it. The ridge line is fairly straight and exhibits but few irregularities. In general the range is unsymmetrical, with the culminating points nearer the abrupt northern side than the more gentle southern slope. This lack of symmetry is particularly noticeable in the Kigluaik Mountains, but is not so marked in the Bendeleben Mountains, for in the latter the line joining the highest points is almost symmetrically placed.

As has already been noted, the Darby Mountains may be considered as a southward continuation of the Kigluaik and Bendeleben mountains. This range rises to an average height of 2,500 to 3,000 feet and has features practically the same as those in the Kigluaik-Bendeleben Range already noted. The western slopes rise abruptly from a low plain not more than 400 feet above sea level, so that the relative relief is strong. The eastern slope is somewhat similar to the south side of the Kigluaik-Bendeleben Mountains, where the transition to the plateau province is not well marked, and the two grade into each other with no sharp line of demarcation.

The valleys in both these ranges have recently been occupied by alpine glaciers. These valleys are separated only by narrow ridges,

[1] Collier, A. J., and others, The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, p. 46.

and the knifelike character of many of the divides is perhaps the most striking feature of the mountains. Broad amphitheaters with nearly perpendicular cliffs rising a thousand feet or more at their heads are common in the mountain province and add much to the grandeur of the scenery. (See Pl. III.)

The position and physical features of the mountains have an important bearing on the water supply. As is explained more fully on pages 31–32, the mountains receive a much heavier precipitation than the lower areas and therefore yield a greater amount of water. Not only is the precipitation greater, but the snow stored in the deep glacial cirques maintains a more constant run-off throughout the summer than is afforded by areas where the stream flow is directly dependent upon the rainfall.

CLIMATE.

By F. F. HENSHAW and G. L. PARKER.

GENERAL FEATURES.

The meteorologic records of Alaska as a whole indicate a great diversity of climatic conditions. Abbe[1] in his discussion of climate in Alaska shows very clearly this diversity and outlines systematically the general relations of temperature and precipitation between certain geographic subdivisions, termed "provinces." Seward Peninsula lies between the "Bering Sea coast climatic province" and the "Arctic coast climatic province," as designated by Abbe. His analysis shows that the climate in this region is subject to considerable local variation, and data obtained since 1906 confirm his conclusion. The records also show a greater local difference in precipitation than in temperature, which is no doubt due chiefly to the fact that two mountain ranges, the Kigluaik and the Bendeleben, intercept a large percentage of the moisture in the winds blowing from Bering Sea. The rainfall in the portion of the peninsula lying north of the mountains is similar to that in the northern arid province; and the rainfall in the southern portion, though less, is not greatly at variance with the amount contributed to the Bering coast. The precipitation in the mountainous areas, however, is considerably greater, as is shown principally by the run-off of streams that have their source in the mountains, and to a less extent by actual rainfall observations. Specific acknowledgment is made to the Weather Bureau of the Department of Agriculture for many of the instrumental records included in this report.

In the following pages an attempt has been made to collect available data concerning temperature and precipitation. The accompanying tables summarize the records made in the region from 1877 to the close of 1910 and serve to show, in compact form, certain general characteristics that are considered in greater detail later.

[1] Abbe, Cleveland, jr., Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 189-200.

Daily mean temperature (°F.) at Nome for 1909.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.[a]	Aug.	Sept.	Oct.	Nov.	Dec.
1	- 5	1.5	- 9	0.5	36.5	34	......	55.5	43	28	19	7.5
2	7.5	12.5	-15	10	38	35	......	55	39.5	24	17	10.5
3	6	16.5	-18.5	5.5	36.5	39	......	46.5	42	26.5	19	11
4	18	12	-18.5	- 1.5	35	45	......	50	49.5	28.5	15.5	14.5
5	22.5	- 2	-18.5	- 2.5	33.5	40.5	......	43.5	56	25	14	9
6	25	3	-12.5	1.5	28.5	45	......	48	54	28	25.5	6.5
7	21.5	2	3	5	25.5	43	......	47.5	51.5	29.5	29	11
8	21.5	- 9.5	10	16	29	43	......	49.5	48.5	34	28	0.5
9	27	8.5	- 5	19	32	42	......	53.5	47	35.5	25.5	6
10	28	10	-12	18	32	39.5	......	45.5	47.5	29.5	24.5	3
11	19.5	12	4	21.5	29	38	......	47.5	45	27.5	26	-12.5
12	15.5	4.5	18.5	20	28	38	......	47.5	42	26.5	31	-16.5
13	2	8.5	11.5	18	30.5	45	......	48.5	43	21.5	29	- 3.5
14	- 9.5	8.5	13	16	34.5	41.5	......	54	45	20.5	25.5	0
15	-14	7	18	13.5	39.5	40.5	......	62	37.5	22.5	24.5	- 6.5
16	-10.5	6.5	18.5	16.5	37	49.5	......	57.5	36.5	23	23.5	- 5
17	-11	6.5	12.5	10	37.5	50.5	......	51.5	37.5	24	11	- 3.5
18	-15	- 9.5	0.5	19.5	35	51	......	48	32	27.5	13	6.5
19	-10	-17.5	2.5	34	38	46	......	50	34	26.5	20	14
20	-17.5	- 5.5	1.5	36	47	45.5	......	53.5	32	26	13	1
21	- 9	- 2.5	2.5	36.5	46	46.5	......	58.5	38	24.5	12	- 8.5
22	- 3	- 6.5	-10	31	39	37.5	......	57.5	40.5	29.5	6.5	-17
23	- 1	7.5	-12.5	31.5	44	43.5	......	50.5	39	33.5	8	-23
24	- 7	6.0	--14.5	33.5	39.5	41	......	51	40	34.5	15.5	-18
25	- 6.5	- 7.0	-25.5	28	32	42	......	49.5	36	35	9.5	3
26	-18.5	- 8.5	-16	30	32	42	......	48.5	32.5	33	3	23
27	-23	-16.5	-15	29	32	41.5	......	47	35	29.5	- 6.5	23
28	-15.5	-10	2	27	31.5	42	......	49	31	26	0.5	- 4.5
29	-13	......	9	30	33.5	41.5	......	48	29.5	26	- 0.5	-15.5
30	-18.5	......	0	35	34.5	40	......	46.5	26	27	7	13
31	-16.5	......	- 4	......	36.5	......	......	43	......	22	......	18.5
Mean	- .32	1.4	- 2.6	19.6	34.9	42.3	[a] 52.6	50.4	40.4	27.6	16.3	1.5

[a] Daily values for July are not available.

Daily mean temperature (°F.) at Nome for 1910.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.[a]
1	21	-32	- 5	17	28.5	38.5	48	46	53.5	33.5	29	......
2	13.5	-31	2.5	6	16	42.5	51.5	47	51	30	34	......
3	3.5	-13.5	- 5	0.5	18.5	39.5	51.5	41	51	26.5	29	......
4	16	3.5	-10.5	- 8	28.5	37	47	39.5	46	29	28.5	......
5	21	- 2.5	- 7	- 9	31.5	37	44.5	42.5	44.5	27.5	20.5	......
6	4.5	- 4.5	- 6.5	- 9	23.5	41.5	42.5	44	53	28.5	19	......
7	- 8	0	- 2	- 5	26.5	41.5	41	45	55.5	30	16	......
8	-22	6.5	- 5.5	1	33.5	37	43.5	43	50.4	33.5	25	......
9	- 7.5	18	5	- 8	34.5	35.5	39.5	46	52.5	36	25	......
10	-11.5	21.5	6	- 6.5	31	33.5	42.5	51	49	35	26	......
11	-14.5	7.5	2.5	- 8	26.5	36	44.5	53	46	34	25.5	......
12	6	-13.5	- 5	- 8	24	34	45.5	51	48.5	36.5	12	......
13	8	- 3.5	0	- 2.5	25.5	35.5	47.5	48.5	48	34.5	1	......
14	22.5	1	18	- 1.5	30	35.5	45	46	44.5	30.5	0.5	......
15	11.5	5	26	0.5	36.5	36	44.5	48	43.5	29	8	......
16	6.5	11	20.5	- 1	37.5	37	47	42.5	43.5	30	8	......
17	-10	19	3.5	8.5	33.5	33.5	43.5	47.5	34.5	37.5	23.5	......
18	-20.5	9	16	5.5	34	38	41.5	43	33	36.5	27.5	......
19	-20.5	10	25	7.0	35	40.5	43.5	45.5	35	33.5	30	......
20	-15	7	26	7.5	32	40.5	48.5	51	39	28.5	28	......
21	6	8.5	26	9.0	34	40	47.5	51	38.5	24.5	20	......
22	9	2	21.5	8.5	35	40	49	56.5	44	21	10	......
23	-10.5	2.5	18.5	19.5	37	38	48.5	52	45	14.5	9.5	......
24	-26	0.5	16.5	22.5	45	43.5	48.5	48	44.5	15.5	11.5	......
25	-23	7.5	9	27.5	44.5	49.5	46.5	49.5	45.5	16	11	......
26	-24	11.5	8	15	44.5	42	45.5	50	43.5	26	17.5	......
27	-25	11	5	9	35	47.5	50.5	55.5	43	30	26.5	......
28	-28	- 7.5	- 0.5	15	32.5	48	45	57	44	23	25.5	......
29	-23	......	-11	28	34.5	48.5	45	52	40.5	20	30	......
30	-23	......	-13	35.5	35.5	51	44.5	50	34	21.5	26.5	......
31	-24.5	......	5	......	35.5	......	47	53.5	......	29	......	......
Mean	- 6.0	1.9	6.1	5.9	32.2	39.9	45.8	48.3	44.8	28.4	20.1	[a] .56

[a] Daily values for December are not available.

PRECIPITATION.

When stream-gaging work was begun in the spring of 1906 it was necessary to obtain records of the rainfall at several places in order to find out the average precipitation over the general region. For this purpose precipitation stations were established at Nome, on the southern coast of the peninsula; at Salmon Lake, about 40 miles inland, south of the Kigluaik Mountains; at claim "No. 15 above," on Ophir Creek, near Council, in the eastern part of the region; and at Deering, on the northern coast of the peninsula. No records, however, were kept at Deering, and therefore all the data procured in 1906 were obtained from the area south of the mountains. In 1907 rain gages were placed at Black Point, near the head of Nome River; at the forks of Grand Central River, in the heart of the Kigluaik Mountains; and at Shelton and Taylor, north of the mountains. In 1908 the scope of the observations was extended and rainfall stations were established from the southern to the northern coast of the peninsula. Additional gages were placed at Iron Creek, near the east end of the Kigluaik Mountains; on Budd Creek, a tributary of American River; and at Candle, near the coast of Kotzebue Sound. In 1909 records were taken at Dahl instead of at Shelton. These stations were established by the Geological Survey and the equipment was furnished by the Weather Bureau. All records were kept by volunteer observers.

The location of these stations is shown on Plate I (in pocket) and other information in regard to them is summarized in the following table.

Seward Peninsula precipitation stations.

Station.	Designation on Plate I.	Latitude.	Longitude.	Elevation above sea level (feet).	Observers.	Date of records.[a]
		° ′	° ′			
Nome	A	64 30	165 24	40	Arthur Gibson	1906–910.
Ophir	B	64 59	163 39	200	C. Arnold, H. Leland, and W. H. Sirdevan.	1906, 1909, 1910.
Black Point	C	64 51	165 16	575	F. F. Miller and George Peters	1908, 1909, 1910.
Grand Central	D	64 58	165 14	690	Cornelius Edmunds, Fred Walford, and P. B. Chapman.	1907, 1908, 1909.
Salmon Lake	E	64 54	164 56	445	J. P. Samuelson and M. Donworth.	1906, 1907.
Iron Creek	F	65 00	164 39	290	Clyde Hager and George Lorimer.	1908, 1909.
Shelton	G	65 13	164 48	60	Lars Gunderson	1907, 1908.
Dahl	H	65 22	164 41	280	J. A. White	1909, 1910.
Taylor	I	65 42	164 48	550	A. E. Edgtvet and A. G. Schraeder.	1907, 1908.
Budd Creek	J	65 38	165 23	320	J. P. Samuelson	1908.
Candle	K	65 55	161 56	20	J. E. Fox, Ward Estey, and R. S. Dimmick.	1908, 1909, 1910.

[a] The only continuous records available are those at Nome, which extend from June 14, 1906, to date. The records at the other stations, in most part, were kept only during the summer months.

The results of the observations made at these stations have been tabulated below in order to show both the daily and the monthly precipitation. The tables of daily precipitation are of particular value, for they permit direct comparison with the daily discharge measurements of the streams given on pages 68–249. (See fig. 1.)

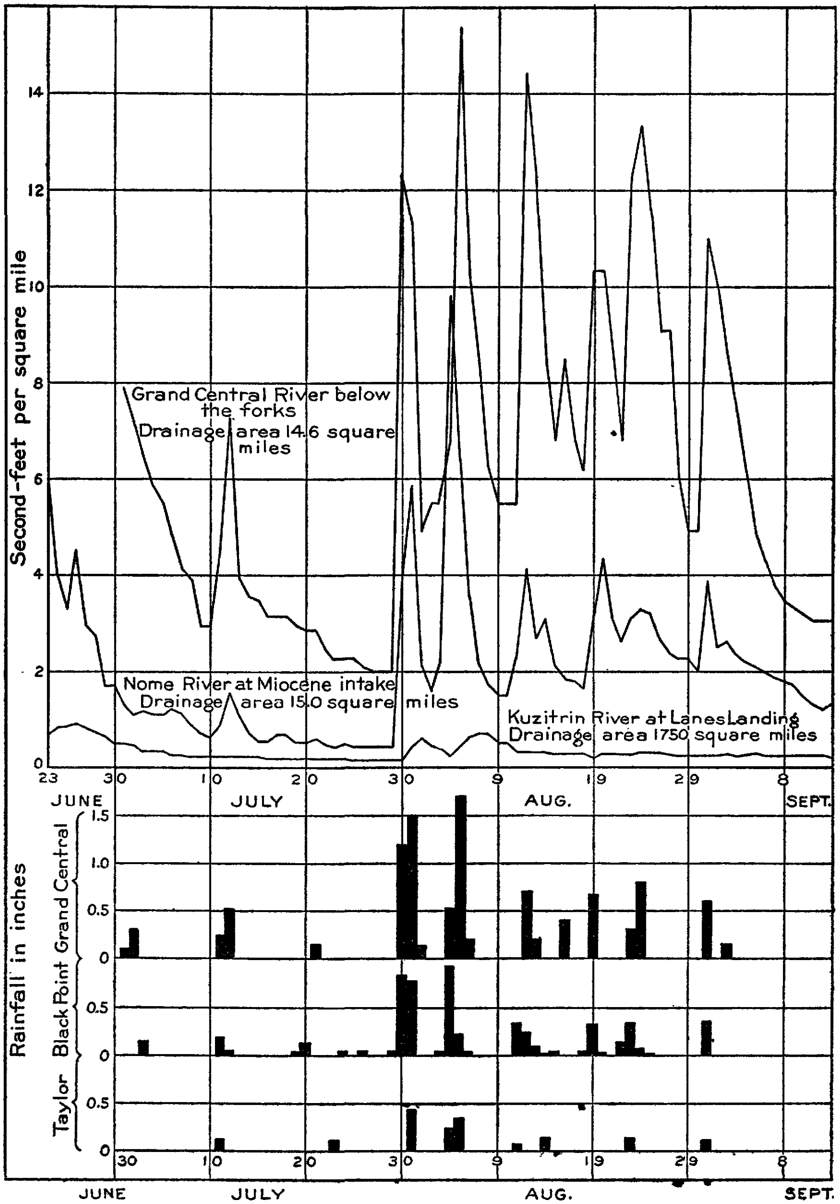


FIGURE 1.—Hydrograph of typical streams and rainfall stations on Seward Peninsula for 1908.

The summaries by years of monthly precipitation are important in showing the local variation in different parts of the peninsula and the difference in the precipitation of successive years.

Daily precipitation, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive.

Day.	July, 1906.			August.			September.		October.	November.	December.
	Nome.	Salmon Lake.	Ophir.	Nome.	Salmon Lake.	Ophir.	Nome.	Salmon Lake.	Nome.		
1								0.14		0.20	
2						Trace.	0.04			.12	
3		0.12									
4		.35			0.17	0.01					
5		.35		0.07	.07	.05			0.14		
6		.10	0.02		.23	.03					
7	[a]0.52	.17	.23	[b].41	.28						0.17
8	.37	2.32	1.30	Trace.				.01			
9	.92	.31	.19		.29	.08			.13		
10	.14	.25				.12					
11			.85			.01					
12	.04		.01		.10						
13			.02				.12				
14		.35	.01				.01	.03	.09		
15			.02								
16			.02								
17					.10		.14	.01			
18			.01				.16	.28			
19						.31	.23	1.06			
20					.57	.31	.28	.99			
21		.25	.01	.80			.04	.55			
22			.01					.16			
23	.08		.60	.22	.50	.22		.03			
24	.27	.35	.25								.74
25	.04		.01	.04	.01	.05					.24
26				.37	.78	.40			.23		.08
27			.01	.30	.23	.32			.34		
28				.14							
29				.15							.38
30											
31											.30
Total.	2.38	4.92	3.57	2.50	3.33	1.91	1.02	3.26	.93	.32	1.91
Snowfall, in inches									([c])	([c])	20.8

Day.	January, 1907.	February.	March.	April.	May.	June.			July.			
	Nome.					Nome.	Black Point.	Salmon Lake.	Nome.	Black Point.	Salmon Lake.	Grand Central.
1												
2	0.13											
3			0.52		0.05							
4	.40				.03							
5			.13		.39				0.03	0.12		[d]0.12
6	.95				.08	0.05	[d]0.07		.48	.35	0.54	[d].88
7			.36		.12	.08	[d].11		.30	.13		[d].14
8									.01	.14	.10	[d].24
9												
10	.23		.87								.10	
11									.03	.02	.12	[e].12
12									.02	.05		[e].16
13	.07								.07	.07	.10	[e].07
14	.26				.09				.01	.04	.10	[e].13
15	.28				.04					.02		[e].11

[a] Total, July 1–7.
[b] Total, Aug. 6–7.
[c] Most of the precipitation for October and November was in the form of snow; the snowfall was not measured. During June there was no measurable precipitation at any of the stations.
[d] Estimated by comparison of stations.
[e] July 10 to 16 the total was 0.66; July 17 to 25 the total was 1.49.
These amounts were distributed in proportion to the amount of rainfall at Black Point and Salmon Lake.

Daily precipitations, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Day.	June, 1908.			July.							August.	
	Nome.	Black Point.	Shelton.	Nome.	Black Point.	Grand Central.	Iron Creek.	Shelton.	Taylor.	Budd Creek.	Nome.	Black Point.
21						0.15		0.01				
22								.14	Tr.		0.07	0.16
23				0.01			0.06		0.11		.41	.37
24				Tr.	0.05						.05	.09
25				.02								.02
26					.04							
27									Tr.			
28										0.30		
29				.07	.06							
30				.80	.82	1.20	.79	.10		.21		
31				.37	.78	1.50	.56	.40	.45		.37	.34
Total	0.90	0.57	0.44	2.10	2.30	4.02	1.67	1.32	.68	.69	2.92	3.42

Day.	August, 1908, contd.					September.						October.
	Grand Central.	Iron Creek.	Taylor.	Budd Creek.	Candle.[a]	Nome.	Black Point.	Grand Central.	Iron Creek.	Taylor.	Candle.	Nome.
1	0.13								Tr.			
2						0.16		0.16		0.14	Tr.	
3				0.18							0.16	0.05
4	.52	0.42	0.25									.05
5	1.70	.13	.35									
6	.20			.44						.09	.04	
7												
8												
9						Tr.						
10												
11		.24	.09		0.10							
12	.70	.06			Tr.							
13	.20		Tr.	.30		.07	0.12	.24				
14			.15	.10	.03	Tr.						
15		.11				.12	.27		0.14			.25
16	.39					Tr.	.10					
17				.18								
18			Tr.		.02							.02
19	.67						.01		.16			.11
20						Tr.		.32				
21			Tr.			.08	.05					
22					.04	.09	.08	Tr.				
23	.30	.29	.15	.12	.10							
24	.80	.02										
25			Tr.	.18	Tr.							.45
26					.06							.04
27												.16
28									Tr.			
29												
30												
31	.60		.12	.37	.15							
Total	6.21	1.27	1.11	1.87	[b].50	.52	.63	.72	.30	[c].23	[d].20	1.13
Snowfall, in inches							3.9	9.0	3.4			10.5

[a] Gage installed Aug. 10.
[b] Aug. 11-31.
[c] Sept. 1-10.
[d] Sept. 1-9.

Daily precipitation, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Day.	November, 1908.	December.	January, 1909.	February.	March.	April.		May.			June.	
	Nome.					Nome.	Candle.	Nome.	Iron Creek.	Candle.	Nome.	Black Point.
1									0.04			
2				0.06		0.11			.01	0.07		
3									.01			
4												
5			0.08						.01			
6			.12									
7												
8					0.16	.05						
9		0.13										
10												
11						.14						
12		.04										
13								0.06	.01			
14							0.08		.03		0.08	
15	0.04							.09	.09 .03			Tr.
16		.11			.05				.03			
17									.03			
18							.03		Tr.			
19												
20	.07											0.05
21							.15					
22	Tr.											
23			.17	.07								
24		.08										Tr.
25	.10											.03
26												.02
27											.02	.07
28											.03	.13
29	Tr.	.17				.08					.18	.75
30	.05	.22				.07	.02				.57	.01
31												
Total	.26	.75	.37	.13	.21	.45	.28	.15	.26	.07	.88	1.06
Snowfall, in inches	3.5	11.75	3.0	2.0	2.75	5.0	Tr.	Tr.	Tr.	Tr.	......	......

Day.	June, 1909, con.		July.				August.				
	Iron Creek.	Candle.	Nome.[a]	Black Point.	Ophir.	Candle.	Nome.	Black Point.	Ophir.	Dahl.	Candle.
1		Tr.									
2											Tr.
3							0.33	0.42	0.40	0.10	
4							.28	.22		.01	0.36
5	Tr.	0.03				Tr.		Tr.			.02
6											Tr.
7									.09		Tr.
8			0.42	0.09		0.11	.11	.07	.40	.05	
9	Tr.			.16		.42	.38	.72	.58	.04	.40
10		.05					.13	.22			
11		.11									
12				.18		.12		.02			
13	Tr.	Tr.		.05			.24	.10	.20		
14		.03					.03				
15	Tr.	.08		.04							

[a] The daily values for July at Nome are incomplete, but the monthly total is correct.

Daily precipitation, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Day.	June, 1909, con.		July.				August.				
	Iron Creek.	Candle.	Nome.	Black Point.	Ophir.	Candle.	Nome.	Black Point.	Ophir.	Dahl.	Candle.
16		0.32		0.03		0.04					
17			0.02	.02							
18			.02								
19											
20		.03									
21											
22								0.02			Tr.
23	0.02					.05					
24											
25											
26											
27	.04			.07		.07	0.11	.08	0.12	0.01	
28		.12	.04				.05		.02		0.05
29		.05									
30		.02									
31											Tr.
Total.	[a].06	.84	.82	.64	0.00	.81	1.66	1.87	1.81	.21	.83

Day.	September, 1909.						October.		November.		December.	
	Nome.	Black Point.	Grand Central.	Ophir.	Dahl.	Candle.	Nome.	Candle.	Nome.	Ophir. ([b])	Nome.	Ophir. ([b])
1												
2											0.08	
3									Tr.			
4	0.04	0.02	0.01		0.01						.13	
5	.04	.14	.14						Tr.			
6									0.18			
7							0.05		.09			
8							.18					
9							.10	Tr.	.15			
10												
11									.26			
12								0.01				
13	.11	Tr.	.02	0.49	.05	0.12					.06	
14	.05	.17	.10			.11						
15						.07			.17			
16	.28	[c].14		[c].38	.03	.07						
17	.06					.05						
18		.01									Tr.	
19											.15	
20												
21	.05	.24		.14								
22	.02			.25		.02	.11					
23	.16			Tr.		Tr.	.24					
24	.15					.01	.39	.14	.23			
25						.02	.28				.06	
26							.10				.31	
27											.15	
28									Tr.			
29											.08	
30									.08		Tr.	
31											.20	
Total.	.96	[d].72	[e].27	1.26	.09	.47	1.45	.15	1.16	2.04	1.22	2.58
Snowfall, in inches							1.5	1	14	29	16	27

[a] Accuracy of record doubtful.
[b] Daily values not available.
[c] Water equivalent of snow.
[d] Total, September 1-21.
[e] Total, September 1-14.

Daily precipitation, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Day.	January, 1910.			February.		March.		April.		May.		
	Nome.	Ophir. (a)	Dahl.	Nome.	Ophir. (a)	Nome.	Ophir. (a)	Nome.	Ophir. (a)	Nome.	Ophir. (a)	Dahl.
1								0.11				
2												
3												
4	0.22		0.65									
5										0.12		
6	.07											
7										.03		
8										.06		
9	.06											
10				0.23		Tr.						1.00
11	.09		.48									
12	.15											
13												
14	.16		.32									
15												
16				Tr.		0.11				Tr.		
17				.09						.16		.02
18						.03				.13		
19						.09				.06		
20			.62			Tr.						
21	.19		.12							.07		
22										.07		
23								.11		.10		
24												
25								.27				
26												
27												
28												
29										.11		.04
30										.12		
31												
Total	.94	2.05	2.19	.32	0.29	.23	0.35	.49	0.55	1.03	0.40	1.06
Snowfall, in inches	13	27		3	3.2	2.4	5.8	5	7			

Day.	June, 1910.		July.			August.		September.			October.	November.	December.[a]
	Nome.	Candle.	Nome.	Black Point.	Candle.	Nome.	Black Point.	Nome.	Black Point.	Candle.	Nome.		
1		0.30	0.15					0.30	0.47	0.32		0.06	
2	0.05					0.31	0.04	.08	.34			.06	
3							.01			.15		.06	
4													
5		Tr.	.09			.07	.03	.04		.10			
6			.04			.20	.22	1.14	1.87				
7	.03		.04			.03	.05	.28	1.90	.15			
8			.05				.02	.68	.85	.04	0.17	.02	
9	.19		.04			.04	.14	.02	.03		.13	.01	
10	.07		.06		Tr.						.30	.08	
11	.04	Tr.			0.25			.02				.22	
12			.05			.04	.08				.09		
13	.02		.04			.03	.05				.21		
14	.04					.03	.16					Tr.	
15						.21	.21					.06	
16	.21	.35				.57	.40						
17		Tr.	.25		.10	.18	.66				.10		
18	.39	.22	.15		.20		.08						
19	.09	Tr.				.07							
20	.23	.17	1.06		.80				.05				

[a] Daily values not available.

Daily precipitation, in inches, at stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Day.	June, 1910.		July.			August.		September.			October.	November.	December.
	Nome.	Candle.	Nome.	Black Point.	Candle.	Nome.	Black Point.	Nome.	Black Point.	Candle.	Nome.		
21		0.02	0.04		0.10			0.37	0.60	Tr.			
22					.10	0.07	0.05	.26	1.04	0.25			
23			.38	0.11		.13	.28	.62	1.52	.05			
24						.37	.16	.16	.51	.15		Tr.	
25			.15	.12		.06		.07	.30	.02		0.06	
26	0.04			.06				.02	.10		0.04	.12	
27	.08	.14	.39	.14			.02					.24	
28	.07		.31	.08			.03						
29			.28	.27	.13								
30	.04			.01		.13	.05						
31						.07	.05				.04		
Total	1.59	1.20	3.57	[a].79	1.68	2.61	2.79	4.06	9.58	1.23	1.08	.99	0.56
Snowfall, in inches												10.8	4.8

[a] Total for July 22-31.

NOTE.—Monthly totals for Ophir from June to September may be found in the table below, giving a summary of monthly precipitation.

Summary of monthly precipitation, in inches, at stations in Seward Peninsula, 1906–1910, inclusive.

Station and year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	For period.
Nome:													
1906							2.38	2.50	1.02	0.93	0.32	1.91	9.06
1907	2.64	1.46	3.37	0.10	1.12	1.31	2.08	2.68	1.41	.16	.06	.30	16.69
1908	.43	.76	1.19	.02	.19	.90	2.10	2.92	.52	1.13	.26	.75	11.17
1909	.37	.13	.21	.45	.15	.88	.82	1.66	.96	1.45	1.16	1.22	9.46
1910	.94	.32	.23	.49	1.03	1.59	3.57	2.61	4.06	1.08	.99	.56	17.47
Mean	1.10	.67	1.25	.26	.62	1.17	2.19	2.47	1.59	.95	.56	.95	13.78
Ophir:													
1906							3.57	1.91					5.48
1909							00	1.81	1.26	[a]1.50	2.04	2.58	9.19
1910	2.05	.29	.35	.55	.40	[b].16	3.68	2.28	2.36				12.12
Mean							2.42	2.00					
Black Point:													
1907						2.62	1.94	2.85	3.26				10.67
1908					.40	.57	2.30	3.42	.63				7.32
1909						1.06	.64	1.87	[c].72				4.29
1910							[d].79	2.79	9.58				13.16
Mean						1.42	[d]1.63	2.73	[e]4.49				
Grand Central:													
1907							3.61	7.19	5.06				15.86
1908							4.02	6.21	.72				10.95
Mean							3.82	6.70	2.89				13.41
Salmon Lake:													
1906							4.92	3.33	3.26				11.51
1907						2.31	1.79	3.65	2.26				10.01
Mean							3.36	3.49	2.76				
Iron Creek:													
1908							1.67	1.27	.30				3.24
1909					.26	[a].06							.32
Shelton:													
1907							.71	1.33	.47				2.51
1908						.44	1.32						1.76

[a] Accuracy of records doubtful.
[b] Estimated by the observer.
[c] Sept. 1-21, inclusive.
[d] July 22-31, inclusive.
[e] Partial months not included in mean.

Summary of monthly precipitation, in inches, at stations in Seward Peninsula, 1906–1910, inclusive—Continued.

Station and year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	For period.
Dahl:													
1909								0.21	0.09				0.30
1910	2.19				1.06								
Taylor:													
1907							0.66	.96	1.17				2.79
1908							.68	1.11	[a].23				2.02
Mean							.67	1.04					
Budd Creek:													
1908							.69	1.87					2.56
Candle:													
1908								[b].50	[c].20				
1909	(.20)	(0.07)	(0.11)	0.28	.07	0.84	.81	.83	.47	0.15	(0.63)	(0.66)	5.12
1910						1.20	1.68	(1.16)	1.23				5.27
Mean, 1909–10						1.02	1.24	(1.00)	.85				

[a] Sept. 1–10, inclusive. [b] Aug. 11–31, inclusive. [c] Sept. 1–9, inclusive.

NOTE.—Values in parentheses are estimated by a comparison with the Nome data.

An analysis of stream-flow records makes possible a determination of the amount of water which flows from a basin in which a gaging station has been maintained. When this run-off is computed as depth in inches on the drainage area, it is directly comparable with precipitation records obtained in the same area, if the loss due to evaporation is taken into consideration. The discharge of the streams in Seward Peninsula during the period between the break-up and the freeze-up represents practically the total flow for the year, as the ice prevailing throughout the winter permits only a small underflow for that period. The following table summarizes the run-off of representative streams in the peninsula for the years covered by records. It is of value as an indirect index of the precipitation and serves to supplement the meager rainfall data available.

Summary of monthly run-off, in inches, at principal gaging stations in Seward Peninsula, 1906 to 1910, inclusive.

Station and year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	For period.
Ophir Creek, at Canyon-ditch intake:													
1909							0.83	0.85	[a]0.60				2.28
Pargon River,[b] at ditch intake:													
1909							1.97	1.38	[a].63				4.03
Nome River, at Miocene intake:[b]													
1906							4.25	3.88	4.88				13.01
1907							5.11	2.59	4.91				12.61
1908						[c]1.62	1.19	3.36	[d]1.30				7.47
1909						[e]3.93	2.16	1.19	.92				8.20
Mean							3.18	2.75	[f]3.57				

[a] Sept. 1 to 25, inclusive.
[b] Natural discharge.
[c] June 20 to 30, inclusive.
[d] Sept. 1 to 22, inclusive.
[e] June 15 to 30, inclusive.
[f] Partial months not included in mean.

Summary of monthly run-off, in inches, at principal gaging stations in Seward Peninsula, 1906 to 1910, inclusive—Continued.

Station and year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	For period.
Nome River, at Pioneer intake:[a]													
1908							1.21	3.80	[b]1.45				6.46
1909						[c]5.91	2.93	1.20	.94				10.98
1910						11.03	9.57	5.45	9.32				35.37
Mean							4.57	3.48	[d]5.13				
Grand Central River below the forks:													
1906						[e]2.00	14.64	6.73	9.25				32.62
1908							4.95	9.71	4.02				18.68
1909							7.98	4.18	[f]1.70				13.86
1910[g]						[h]11.97	26.40	12.68					51.05
Mean							13.49	8.32	[d]6.64				
Kruzgamepa River, at outlet of Salmon Lake:													
1906	(1.10)	(0.74)	(0.69)	(0.57)	12.19	14.73	7.90	3.66	6.19	(2.88)	(1.46)	(1.23)	53.44
1907	(.96)	(.74)	(.60)	(.54)	6.96	24.88	7.62	4.76	6.49	(2.06)	(1.19)	(.96)	57.85
1908	(.82)	(.65)	(.69)	(.54)	5.67	9.72	2.58	4.10	2.14	1.10	.90	(.89)	29.80
1909	(.82)	(.62)	(.55)	(.54)	4.77	11.60	4.78	2.04	1.44	.96	.80	.69	29.61
1910	(.69)	(.56)	(.55)	(.54)	2.58	10.06	14.00	6.77	12.97	2.64	(1.20)	(.82)	53.38
Mean	(.88)	(.66)	(.63)	(.57)	6.43	14.20	7.38	4.27	5.85	1.93	1.11	.92	44.83
Kuzitrin River, at Lanes Landing:[i]													
1908						2.26	.27	.40	.24				3.17
1909					[j]1.72	2.71	.44	.24	.20				5.31
1910					[k]1.53	3.84	1.81	1.24	1.75	[l].09			10.26
Mean						2.94	.84	.63	.73				
Kougarok River, at Homestake ditch intake:[a]													
1907							[m].18	.60	[n]1.34				2.12
1908							.15	.14	[o].09				.38
1909						[p].61	.24	.32	[q].08				1.25
Mean							[d].20	.35					
Kougarok River, above Coarse Gold Creek:													
1907							.17	.65	[n]1.14				1.96
1908							.14	.15	[r].07				.36
1909						[p].41	.29						.70
Mean							.20	.40					
Goodhope River, below Esperanza Creek:													
1909						[e].10	.23	.12	[s].07				.52
Kiwalik River, below Candle Creek:													
1909							.20	.14	.06				.40

NOTE.—Values in parentheses are estimated.

[a] Natural discharge.
[b] Sept. 1 to 22, inclusive.
[c] June 10 to 30, inclusive.
[d] Partial months not included in mean.
[e] June 24 to 30, inclusive.
[f] Sept. 1 to 21, inclusive.
[g] Estimated from discharge of Kruzgamepa River at outlet of Salmon Lake.
[h] June 15 to 30, inclusive.
[i] Lanes Landing and Shelton are identical.
[j] May 19 to 31, inclusive.
[k] May 22 to 31, inclusive.
[l] Oct. 1 to 8, inclusive.
[m] July 15 to 31, inclusive.
[n] Sept. 1 to 20, inclusive.
[o] Sept. 1 to 10, inclusive.
[p] June 20 to 30, inclusive.
[q] Sept. 1 to 16, inclusive.
[r] Sept. 1 to 12, inclusive.
[s] Sept. 1 to 26, inclusive.

From the foregoing observations on the precipitation certain facts of significance have been determined One of the most notable features is that the larger part of the precipitation at all stations occurs during the summer, from the last of May to the middle of October. Various estimates show that from two-thirds to three-fourths or more of the total yearly precipitation occurs during these months. For this reason the summer visitor gains the impression that the rainfall in this region is much greater than it actually is.

The average yearly precipitation at Nome since 1906 is 13.78 inches and the average yearly run-off of Kruzgamepa River at the outlet of Salmon Lake for 1906–1910 is 44.83 inches. The greater part of the drainage area of Kruzgamepa River lies within the Kigluaik Mountains, and it is safe to assume that the average yearly precipitation in the mountains for this same period exceeds 50 inches. The partly estimated precipitation at Candle for 1909 of 5.12 inches is a little over 50 per cent of that at Nome and only 17 per cent of the run-off of Kruzgamepa River for that year.

Totals for periods during which rainfall records were kept at the several stations have been compared with the totals for the same periods at Nome. The following list gives the average relation so determined in approximate percentages of the precipitation at Nome:

Ophir, slightly greater.
Black Point, about 130 per cent.
Grand Central, about 220 per cent.
Salmon Lake, about 160 per cent.
Shelton, about 50 per cent.
Taylor, about 40 per cent.
Candle, about 50 per cent.

A similar study of the run-off can be made only at those stations where the records extend from the break-up to the freeze-up. The average yearly run-off of Kruzgamepa River at the outlet of Salmon Lake for 1906–1910 is about 320 per cent and that of Kuzitrin River at Lanes Landing for 1909–10 is between 55 and 60 per cent of the average yearly precipitation at Nome for similar periods. The latter percentage is probably small, because it does not include the winter flow of the Kuzitrin, which, however, represents only a small percentage of the total flow. The winter flow of the Kruzgamepa was estimated. It is interesting to note that the run-off of Kuzitrin River at Lanes Landing or Shelton is a greater percentage of the precipitation at Nome than that given above for the rainfall station at the same place. This discrepancy can be accounted for by the fact that the precipitation is heavier in the higher areas within the drainage basin than at Shelton. The whole region is subject to local showers and storms, many of which are heavy in one valley and not felt in the next, and the precipitation from a general storm may be very unequally distributed. The percentages given above may therefore be considerably in error, especially as many of them were determined from records covering short periods.

The lack of uniformity in the amount of precipitation falling in different parts of the peninsula is probably due to the fact that southerly winds bring the heaviest rains and lose most of their moisture in passing over the mountains. In the summer of 1907 76 per cent of the rainfall at Grand Central was accompanied by winds from the southern quadrant, whereas only 40 per cent of the rainfall at Taylor was accompanied by winds from the same quadrant. The percentages for the other stations range between these extremes.

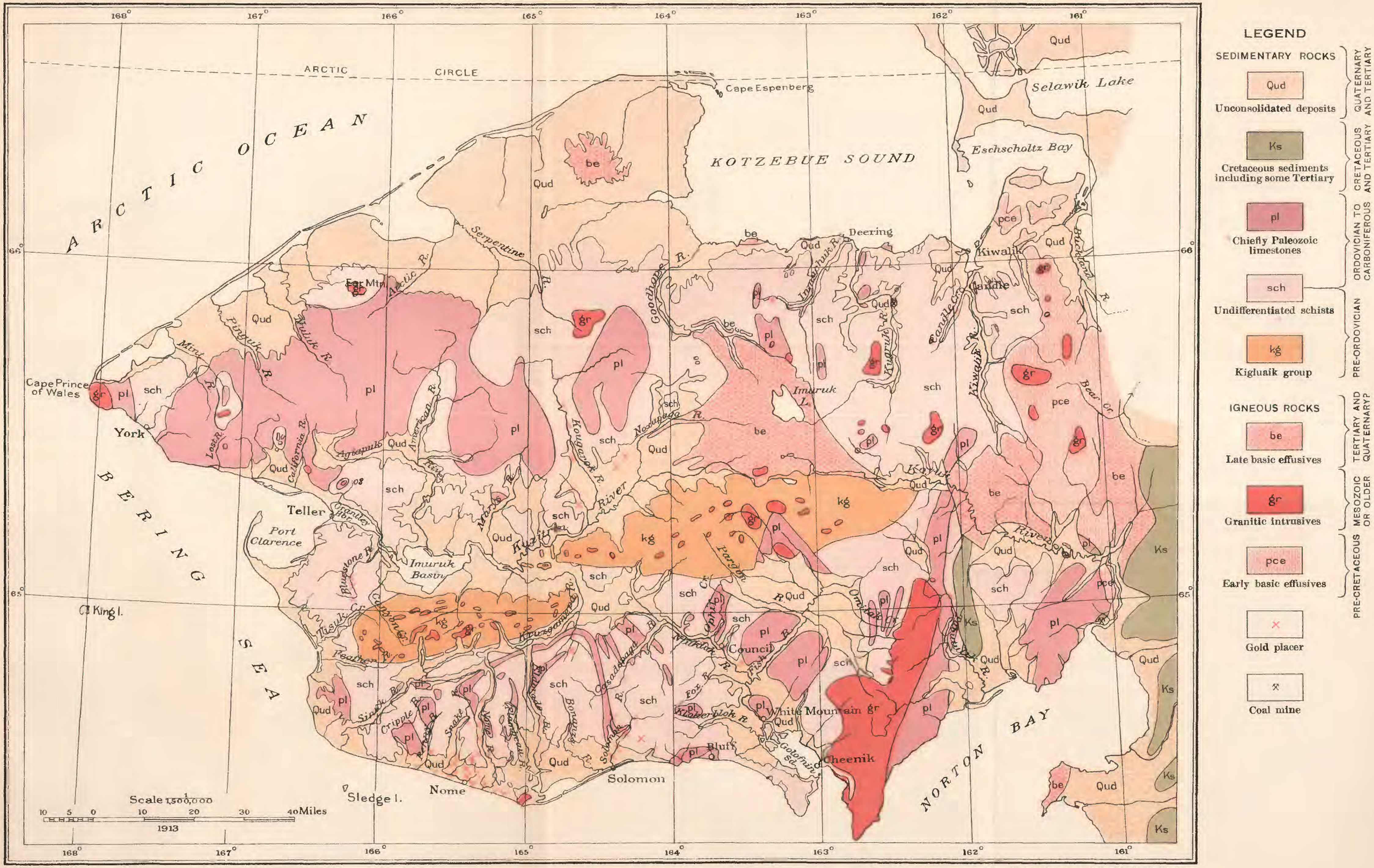
The precipitation and run-off data show that 1906, 1907, and 1910 were years of fairly good water supply and that 1908 and 1909 were years of drought. The total precipitation at Nome in 1909, 9.46 inches, is 69 per cent of the average for the period covered by records and only 54 per cent of the maximum of 17.47 inches which occurred in 1910. The same comparison applied to the run-off data of Kruzgamepa River for the same years gives percentages of 66 and 55 respectively. The maximum yearly run-off of the river from 1906 to 1910, however, was 57.85 inches, in 1907.

DESCRIPTIVE GEOLOGY.

By Philip S. Smith.

The many different rocks and deposits in Seward Peninsula may be grouped into three main divisions which, for convenience, will be called the sedimentary rocks, the igneous rocks, and the unconsolidated deposits. Each division is composed of several different members; for example, the sedimentary rocks consist of metamorphic and nonmetamorphic rocks, and these may be further subdivided, according to their lithology or structure, into schists, limestones, slates, sandstones, and conglomerates. It is not intended, however, to present in this paper, a detailed geologic report on Seward Peninsula, and the reader who desires that information should consult the publications of the United States Geological Survey primarily devoted to that subject.[1]

[1] The following are of greatest general importance, though the yearly "progress reports" are of value: Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, 343 pp. Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, 85 pp. Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles, Alaska: Bull. U. S. Geol. Survey No. 433, 1910, 234 pp. Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: Bull. U. S. Geol. Survey No. 449, 1911, 146 pp.



Compiled and arranged by Philip S. Smith

GEOLOGIC MAP OF SEWARD PENINSULA, ALASKA

SEDIMENTARY ROCKS.

The general distribution of the rocks that have been mapped in Seward Peninsula is shown in Plate IV. On this map the sedimentary rocks have been grouped in four divisions. These are, commencing with the oldest, the Kigluaik group, the undifferentiated schists, the Paleozoic limestones, and the Cretaceous and Tertiary conglomerates and sandstones.

The Kigluaik group consists of gneiss overlain by a heavy limestone, which, in turn, is overlain by biotitic and graphitic schists. It is most extensively developed in the Kigluaik and Bendeleben mountains, but some of the areas mapped as undifferentiated schist may include also members of this group. The sedimentary rocks of which it is composed are cut by granitic and basic dikes and stocks. The rocks show a complex history, inasmuch as an unconformity has been recognized between the lower and upper members. The lower limit of the Kigluaik is not known, and the group probably represents the oldest sedimentary rocks exposed in the region. No definite age has been assigned to the group except that it is undoubtedly pre-Ordovician. It is possible that it may even be pre-Cambrian.

The undifferentiated schists, as their name implies, are metamorphic rocks of complex origin, the stratigraphy of which has not been adequately determined and which, therefore, probably contain representatives of both higher and lower horizons. They are mainly quartzose chloritic schists, but include some subordinate limestones and some undistinguishable sheared igneous rocks. They occupy a greater area than any other of the rock divisions. The dominant structure is cleavage, so that in places precise determination of the attitude of the rocks is impossible. The topographic forms produced by the schists are not striking except where they stand at the summits of ridges, on which they form remarkable pinnacles.

Although these schists contain diverse members, it is believed that the larger part of them are older than the next higher division, and they may therefore be regarded as in part equivalent to the Kigluaik group. Moffit,[1] who has made the most detailed study of the undifferentiated rocks south of the Kigluaik Mountains, has stated that the schists at the head of Nome and Sinuk rivers probably overlie the Kigluaik group unconformably. If this is true it may mean that these rocks too are pre-Cambrian. Although there is no definite way of determining the lower limit of these rocks it seems probable that the schists as a whole are pre-Ordovician. The gold of most of the placers of Seward Peninsula has been derived from these schists.

[1] Moffitt, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 128-129.

In the western part of the peninsula, forming an area of 1,400 square miles, is a thick series of gray limestones which seem in places to overlie conformably schists belonging to the group of undifferentiated rocks. The structure of this area is complex, and the stratigraphy has not been determined. Collier[1] originally called this series of gray rocks the Port Clarence limestone and assigned it to Ordovician and Silurian time. Subsequent studies, however, have shown that these rocks have a much greater range in time than was at first supposed, and in the typical Port Clarence region late Cambrian fossils have been reported from them by Kindle. Correlations by other observers in remote portions of the field have referred to this series certain limestones of Devonian and Carboniferous age, and these inexact correlations indicate that more field work will be necessary to map satisfactorily the various members of this division. In the present report it has been necessary to group these diverse strata together under the head "Paleozoic limestones." Although this grouping obscures in a measure the precise geology of the region it serves to bring lithologically similar rocks together, and it also, in a broad way, permits the generalization that the heavy limestones, taken as a whole, lie above the schists, in general unconformably.

The following summary of the general character of the limestone in the western part of the peninsula was prepared by Knopf:[2]

> Here it comprises a thick volume of thin-bedded limestones of dense texture, generally unaffected by metamorphism. Four types of rock can be discriminated—an ash-gray variety, a dark lead-gray variety, magnesian and tremolitic phases, and an argillaceous banded variety. The first two are the commonest types and occur together in interstratified beds. The dark lead-gray limestone forms massive beds up to 6 feet thick, while the ash-gray variety, which is fine grained, like lithographic stone, is thin bedded and commonly breaks into thin slabs whose surfaces are covered with fucoid fragments. Some beds of fine-grained dolomite occur in the Port Clarence formation. Occasionally strata occur interbedded with the normal Port Clarence limestone which show numerous small prisms of tremolite in random orientation. This is the highest degree of metamorphism displayed by the formation except for purely local manifestations surrounding granitic intrusives.

As a rule, where limestone forms the country rock, much of the drainage is carried underground and consequently the amount of the available water is lessened. Here and there, however, near the base of the limestone, are springs which discharge an abnormal amount of water. Moonlight Springs, on Casadepaga River, form a striking example. Furthermore, this limestone makes very bad ditching ground, and its distribution is therefore an important economic factor. Owing to its hardness the limestone is usually difficult to excavate where it forms the bedrock of a placer deposit, and its

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[1] Collier, A. J., op. cit., p. 79.

[2] Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: Bull. U. S. Geol. Survey, No. 358, 1908, pp. 12-13.

weathered surface is usually so irregular that the recovery of gold from it is costly and laborious.

The next younger group of rocks belongs mainly to the Cretaceous system, though it may include some Tertiary sediments as well. The junction between the Cretaceous and the older rocks is really the eastern boundary of Seward Peninsula. East of that line the Cretaceous rocks extend practically without interruption beyond the mouth of the Koyukuk. West of the line several small areas, such as those east of the Tubutulik and on the Koyuk, mark infolded or infaulted blocks of the younger rocks. Although it is by no means proved, it is not unlikely that the two small coal areas on Kugruk and Sinuk rivers may be of the same age as this group, though they have formerly been provisionally correlated with the Tertiary.

The typical Cretaceous sediments, though much folded and faulted, are unaffected by metamorphism. At the base of the section lies a heavy bedded conglomerate, called the Ungalik conglomerate, made up of pebbles of the metamorphic rocks, the granites, and the older effusives. Conformably upon the conglomerates lie the sandstones and shales which have been called in the eastern part of the region the Shaktolik group.[1] These strata are made up mainly of comminuted volcanic rocks and quartz. The two divisions of the Cretaceous together form a stratigraphic section many thousand feet thick. Although of considerable geologic interest, these rocks are of small importance in the present discussion, for they are not notably placer bearing and they are absent from the parts of Seward Peninsula where mining has been successfully carried on.

IGNEOUS ROCKS.

The igneous rocks of Seward Peninsula present great diversity of character, but in the present paper they have been classified in only three main subdivisions, namely, the granitic intrusives, the pre-Cretaceous effusives, and the late basic effusives. Another subdivision exists, made up of the greenstones and metamorphic schists of igneous origin, but owing to the small scale of the map and to the lack of specific information about the areal distribution of these sheared igneous rocks throughout the peninsula, this group has been included with the undifferentiated schists. So far no definite connection between these various igneous rocks and the production of auriferous deposits has been proved; in fact, placer deposits are notably absent from the areas of igneous rocks.

[1] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: Bull. U. S. Geol. Survey, No. 449, 1911, pp. 55–60.

Granitic intrusive rocks are particularly abundant in the Kigluaik-Bendeleben and the Darby mountains and in the divide between Buckland and Kiwalik rivers. In the Kigluaik-Bendeleben Range the rock is a true granite, light colored, even grained, and unsheared, and offers strong resistance to normal weathering. These intrusive rocks cut the metamorphic schists and the Paleozoic limestones, but they form pebbles in the Ungalik conglomerate at the base of the Cretaceous system, so that their age is probably Mesozoic. The granites occur mainly as batholiths, but also, in the vicinity of the larger masses, form numerous dikes parallel to the secondary structure of the metamorphic rocks.

In the Darby Mountains the granitic rocks are diorites and granites. In composition the diorite ranges from a normal amphibole-plagioclase rock to one containing quartz and orthoclase in addition to the usual constituents. The plagioclase is apparently about midway in the albite-anorthite series. Accessory apatite, titanite, muscovite, and metallic minerals in small amounts were noted in several specimens that were studied microscopically. The granites are of two distinct types—one with a marked porphyritic development, and the other with an even grain similar to the granite from the Kigluaik-Bendeleben Mountains. The porphyritic granite is characterized by a coarse-grained mass of quartz orthoclase and a little biotite, the grains averaging about 0.2 inch in diameter. Large orthoclase crystals averaging about an inch and a half in length are scattered abundantly through the rock. Some inclusions of diorite have been found in the porphyritic granite, but elsewhere granites are included in diorites, so that an intricate and complex history is indicated for the period of intrusive activity.

In the divide between Buckland and Kiwalik rivers there is a series of andesites and associated rocks, unknown elsewhere in Seward Peninsula. These rocks have been designated on the map (Pl. IV) "Early basic effusives." They are entirely unmetamorphosed, are cut by granites, and form pebbles in the Ungalik conglomerate, so that an approximate determination of their age is not difficult. These rocks have been described by Moffit [1] as follows:

They are of a dark-gray or greenish color, and on an exposed surface have a spotted appearance due to the alteration of the feldspar phenocrysts. Both hornblende and pyroxene varieties were seen, the latter containing considerable olivine in addition to pyroxene, and showing the secondary mineral, iddingsite. Alteration of pyroxene to hornblende was also observed. The feldspar is a basic variety, labradorite or sometimes anorthite, giving as alteration products chlorite and epidote. Andesite breccias were found at various localities.

Effusive rocks of later geologic age are found at many places. Probably not all these flows are contemporaneous, but in a broad way

[1] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, p. 31.

it is believed that they mark essentially one period of volcanism. Thus, though many years elapsed between successive flows, there is strong reason for correlating them and for regarding them as synchronous in a geologic sense. Although practically all these rocks are surface flows, there are, of course, here and there dikes by which the flows were fed. All these rocks are characteristically olivine basalts having a vesicular structure.

The effusive rocks occur mainly in the eastern part of the peninsula and occupy an area of over 1,000 square miles. So recent are some of the flows that the surface is practically undissected, and the tongues of lava, as in the Noxapaga and Kuzitrin basins, still preserve the form they acquired as they flowed over the country. The region around Imuruk Lake, locally known as the "goose pastures," shows typical examples of these recent flows.

UNCONSOLIDATED DEPOSITS.

Gravels were deposited on the sea floor and on the land surface over a long period that began before the appearance of the volcanic effusives and continued for some time after the eruptions had ceased. These deposits have here been grouped together under the term "unconsolidated deposits." Their accumulation took place under conditions that varied greatly owing to the diversity of the physical features of the region from which they were derived and of the surface on which they were laid down. Some of the gravels were deposited on the sea floor and were modeled into form by waves and ocean currents. In other places the land waste was transported and laid down by streams. In still other places valley glaciers eroded their beds, transported fragments, and on melting left deposits characteristic of ice action. Some deposits have been worked upon by two or more agencies, and therefore show complex relations.

The unconsolidated deposits are presumably mainly of Pleistocene and Recent age. Some Tertiary fossils from the coastal plain at Nome have been determined by Dall, and some of the ancient stream gravels may also belong to the Tertiary period. The volume of the Tertiary deposits is undoubtedly much less than that of the Quaternary unconsolidated deposits.

Some of the deposits, especially in the surface portions of the coastal plain, consist of fine-grained bluish-gray muck, which contains a considerable amount of vegetal material and numerous beds and lenses of clear ice. Where the turf overlying the muck is removed the ice thaws rapidly and the material caves. Deposits of this type are very widespread and offer one of the greatest difficulties to ditch construction. (See p. 258.) In places this muck layer is only a few inches thick, but in others it has a measured thickness of more than 50 feet. Its origin is complex, and apparently it has been formed under different conditions in different places, so that no general statement can be made as to its mode of formation.

The unconsolidated deposits are most important from the standpoint of the placer miner, and as the utilization of the water supply is most closely bound up with placer operations more specific attention will be paid to this type of deposit in the following pages. The various forms in which the unconsolidated deposits are found will be more fully discussed in the section on types of placers (pp. 38–51), and the physical condition of the gravels will be described in greater detail in the sections on mining methods (pp. 269–303), and on ditch construction (pp. 255–269). A more complete description of this important class of deposits has already been published by Collier and others.[1]

Many if not most of the unconsolidated deposits are permanently frozen and present conditions not found in more temperate latitudes. No satisfactory explanation has yet been advanced to account for the distribution of the permanent frost, for patches of thawed and frozen ground are associated in relations so complex that it is impossible to frame a theory that will account for all the known facts. The presence or absence of permanently frozen material has an important effect in determining the method of mining the unconsolidated deposits that contain placers

GOLD PLACERS.

By Philip S. Smith.

NATURE AND ORIGIN.

This report was not prepared primarily for technical readers, and certain parts of it have been written especially for those unfamiliar with placer mining. To give an elementary conception of placers and placer mining, it may be stated that a placer is a deposit of disintegrated rock fragments more or less concentrated by various geologic processes, containing economically valuable minerals. The valuable minerals are separated from the worthless ones by taking advantage of some physical property peculiar to the material to be saved.

Placers have been formed under a variety of conditions and consequently have different characters and relations to the present topography. A number of different classifications based on some particular features might be made, but in the present paper a classification based mainly on the mode of origin and therefore indicating the topographic expression of the deposit will be adopted. According to this scheme the Seward Peninsula placers may be divided into

[1] Collier, A. J., and others, The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, pp. 85–94.

two main classes, residual and water-sorted, of which the latter is more important. There are gradations between the different types, and it might be impossible to place in their appropriate classes all known examples, but such difficulty is practically unavoidable in any systematic treatment.

RESIDUAL PLACERS.

Residual placers are those that have formed near a mineralized deposit practically without transportation. Ordinary weathering causes rocks to crumble and disintegrate, so that detritus collects at the bases of ledges. If the rock contains valuable minerals that are unaffected by solution and the other chemical processes connected with weathering the deposits thus formed may be of economic value. In the Council region, on one of the gulches tributary to Crooked Creek, a residual placer of this sort has been formed on the slope below a vein of auriferous quartz. The placers near the head of Bering Gulch in the Bluestone region may also belong to this class, although too little is known about them to permit final statement as to their character.

As there has been little transportation of residual deposits except the downhill creep of the material, little sorting has been effected, and consequently the gold content of the residual placer is usually only a little greater than that in the parent ledge from which it was derived, unless the process has been continued for a very long time. Placers of this type are therefore not widely distributed, are generally small, and, unless the rocks from which the valuable minerals were derived are very rich or weathering has been long effective, are not of sufficiently high tenor to warrant extensive development. Furthermore, most of these deposits occur at elevations so high above the drainage lines of the region that the cost of mining them is great.

WATER-SORTED PLACERS.

The more important placers are those in which water has effected a concentration, whereby the lighter material has been transported farther than the heavier, more valuable minerals. These placers may be divided into two main classes—those formed by flowing water, as in rivers, and those formed by shore action along the borders of the sea or large fresh-water lakes. For convenience in description the former will be called stream placers and the latter beach placers. In general, the stream placers are of fresh-water origin, and most of the beach placers were formed under marine conditions, though intermediate phases are not uncommon.

STREAM PLACERS.

Stream placers have heretofore been the main source of the gold of Seward Peninsula, and they will undoubtedly long continue to yield a large amount of the production. Classified by age and consequently by relative topographic position these deposits may be divided into modern and ancient. Obviously with terms so elastic the same deposit might be placed in different categories, the placing depending on the interpretation of the term modern. In this paper those placers that are practically in process of formation by the present streams or are so closely related to them that their origin is immediately connected with those streams are called modern, and the others are called ancient.

In most of the typical modern stream placers the auriferous gravels are not more than 5 to 10 feet thick. In places the workable deposits extend almost uninterruptedly along a creek, though with considerable range in tenor. Elsewhere the profitable placer or pay streak is discontinuous, rich spots alternating with poor ones. The gold in these placers, although it occurs in all portions of the deposit, is usually most abundant in the lower part. Where this bottom concentration has taken place on bedrock the particles of gold penetrate to a greater or less extent along the cracks and crevices, so that in places several feet of the rock floor must be carefully treated in order to recover the valuable minerals. At other places a clay layer just above the bedrock served as a floor on which concentration took place. The amount of placer gold on and in the bedrock is much less in such placers than in those where the clay is absent. In some deposits clay layers at intervals above the hard rock have served as floors on which gold has accumulated, and these are generally spoken of as "false bedrock."

The gravels of which the modern stream placers are composed are mainly of local derivation and have shapes determined by the water-sorting agency by which they have been formed. The character of the material over which the stream flows has, of course, a marked effect upon the resulting placer. In some places the existing streams flow on disintegrated bedrock, in others the rock is hard and practically unweathered, and in still others the present streams are flowing on old gravel deposits. Most of the small gulches and small side valleys which contain placers exemplify the first two conditions, but many of the larger rivers and the streams flowing across the coastal plain are carving their valleys in older gravel deposits, which, having been subjected to two or more processes, have features that indicate their more complex history.

The particular type of modern stream placer that has received the specific name "bar placer" is similar in most respects to an ordinary stream placer, except that, as its name implies, it is confined to the bars. As a result the auriferous gravels are rather thin, and because of the sorting of the gravels during the periods of high water the surface portion is usually the richest. Practically the bar placers are slight reconcentrations of the upper part of normal stream placers. Examples of this type may be found throughout Seward Peninsula. It should be noted that the ordinary stream placer may be made up of a great number of bars as the stream shifts its course, at one time building up and at another time cutting down. Bar placers grade so directly into stream placers that a differentiation would require greater refinement than is desirable in this report.

As is well known, the surface of the earth is subject to movements whereby relative uplift or depression is effected. Furthermore, changes in climate may cause the streams to lose or gain transporting efficiency. These and similar causes produce changes in the drainage lines whereby the streams are forced to cut new valleys or to fill up their former ones and take new courses. Traces of the earlier courses may be preserved as old river beds on the hillsides or as filled channels far below the level of the present drainage lines. If the gravels of these now vanished streams contain valuable minerals they may form workable deposits. The ancient stream placers on the hillsides are commonly called bench placers, but there is no distinctive name for the ancient deep placers. Figure 2 shows an ideal-

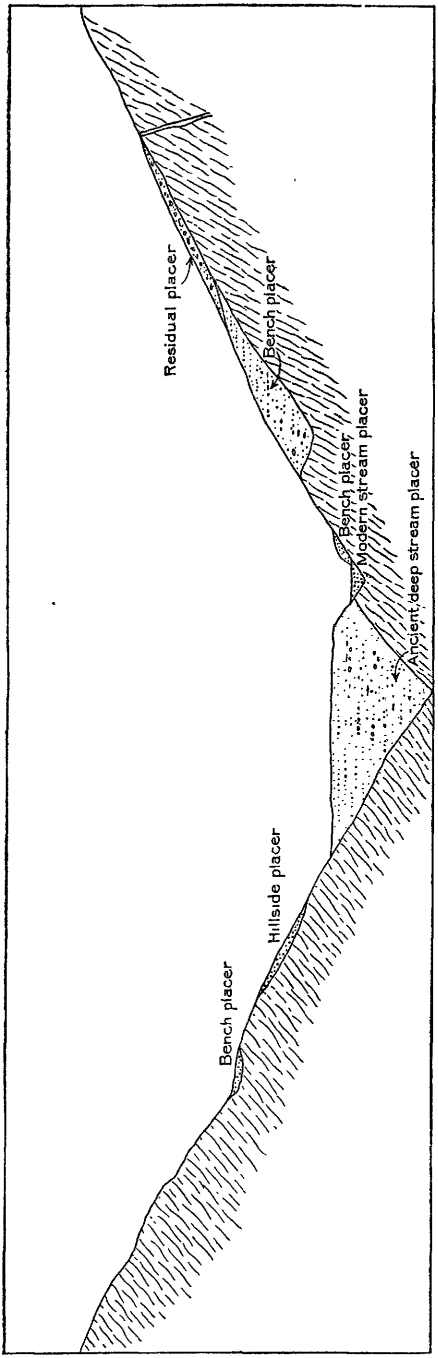


FIGURE 2.—Diagrammatic cross section of valley showing different types of placers.

ized cross section of a valley in which the various types of placers so far noted are diagrammatically represented.

Bench placers of this type are formed of material similar in most respects to the modern stream gravels. Owing to the long time that they have been subjected to weathering, however, the pebbles are more decomposed, and the deposits may be more or less covered with material that has crept down the slopes. Some of the bench placers

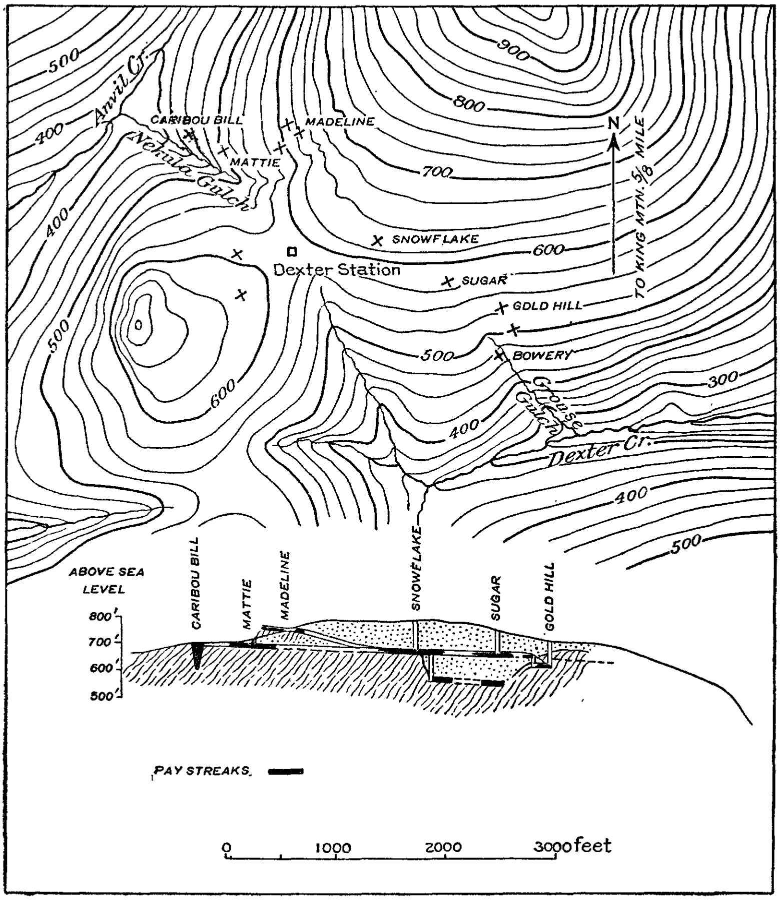


FIGURE 3.—Sketch map and profile of high bench gravels south of King Mountain.

indicate a simple history of only one period of formation, as, for instance, the upper bench placer shown near the left margin in figure 2. Others, however, show a complex history in their mode of formation, as, for example, the bench placer illustrated in the right-hand portion of the same diagram. These conditions are not ideal, but they may be observed in some of the productive placer mines. For instance, near the head of Dexter Creek shafts and underground workings have disclosed conditions represented in figure 3. As is shown in the cross section, a body of bench gravels 250 feet deep was discovered, in places showing a distinct stream-channel cross section. So long ago, however, was this deposit formed that it is now more than 500 feet above the sea, and the ancient drainage lines have been so obliterated that a reconstruction of the topography is almost impossible.

Bench placers are usually classified mainly according to topographic form or position. There are, according to Collier,[1] terrace benches, spur benches, pocket benches, and high benches. Some hillside placers are examples of bench placers, although others belong to the class of residual placers. The stream-deposited hillside placers are distinguished from other ancient bench placers because they have lost their topographic expression through the downhill creep of material subsequent to their formation. Each of these different kinds of bench deposit is represented by actual examples in the Seward Peninsula placer camps. Bench placers have been explored especially in the Nome, Council, and Candle regions, but are also important in the Solomon-Casadepaga, Bluestone, and Kougarok regions.

Certain stream bench deposits merge so closely into ancient shore deposits that no sharp line of separation can be drawn. Some distinct bench deposits are due to shore conditions, and these can be distinguished from the stream benches by their topographic expression, by the arrangement and character of the material of which they are composed, and some of them by the fossils they contain. Certain broad gravel deposits that stand at some elevation above the present streams show both fluviatile and shore features. Such deposits have been called gravel-plain placers. The deposits which show clearly that the dominant action producing the gravel plain has been other than fluviatile are treated in a later section (pp. 48–51). There are, however, large areas in the central part of Seward Peninsula where the complete history of the gravel-plain deposits has not been determined, but where from the evidence now at hand it seems probable that streams played the most important part in the deposition. As a rule these fresh-water gravel plains do not contain rich placer deposits, and though in the future they may become commercially important they do not at present contribute any notable amount to the gold production of the peninsula.

The other group of ancient stream placers, which, instead of standing above the level of the present drainage lines, as the benches do, lie below that level, have not received much attention, though examples are by no means uncommon. Practically all the larger rivers of the peninsula flow in filled valleys of older streams. For example, in

[1] Collier, A. J., and others, The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, p. 143.

the lower parts of Snake and Nome rivers the depth to bedrock is in places at least 50 feet below the river surface; on the Casadepaga holes 60 feet or more in depth have been sunk before reaching bedrock; no hole has yet reached bedrock in the lower parts of Kruzgamepa and Kuzitrin rivers, and in many parts of Fish and Niukluk rivers the depth to bedrock is more than 50 feet. Even more remarkable, however, is the deep drill hole that, starting at an elevation of about 200 feet above the sea opposite Council, was put down 250 feet before reaching bedrock. A hole on Penelope Creek, a tributary of the Casadepaga, was more than 90 feet deep, and the shaft on Alameda Creek, a tributary of the Koyuk, was started a little more than 100 feet above the sea and went down 190 feet without reaching bedrock. On Dahl Creek, in the Kougarok region, a hole 187 feet deep has been sunk within 50 feet of sea level without encountering bedrock. All these localities seem to have been originally ordinary stream valleys which were subsequently aggraded and then dissected by the existing streams. In places where conditions were favorable placer deposits were formed in these deep ancient stream courses, and with suitable machinery such deposits can be mined. The gold is usually in the lower part of the deposit, but, as in the modern stream placers where layers of clay occur, some concentration may be expected. Nearly all these ancient stream placers in Seward Peninsula, together with the overburden above them, are permanently frozen. It will be shown later that the presence or absence of frost is an important item in determining whether certain of these deposits can be worked and indicating what mining methods must be employed.

It is evident that there is a close genetic similarity between these placers and the bench placers, for the former mark old valleys that have been depressed, whereas the latter mark old valleys that have been elevated. It is perfectly conceivable that a deep placer in one part of a drainage basin might be equivalent in time of formation with a bench in another part, although no such examples have been recognized in the region. It will be clear, then, that no sharp line of differentiation can be drawn between the placers in these apparently antithetical positions with respect to the present streams.

BEACH PLACERS.

The main difference between stream placers and beach placers is due to the different agencies involved in the production of the two types. A stream placer has its long axis down the slope, parallel with the stream, whereas a beach placer is practically horizontal and extends parallel with the margin of the sea or lake in which it was formed. Like stream placers, the beach placers may be divided into two main groups, those now in process of formation and those produced in the past.

In Seward Peninsula no placers formed along the shores of existing lakes are known and the only examples of modern beach placers occur along the seashore. In parts of the coast where the waves break on rocky headlands the rocks are disintegrated and beaches may be developed. None of these places, however, have afforded economically important placers. Instead, the places where much gold has been won from the present beaches are those where the sea is breaking against the unconsolidated deposits of the Coastal Plain or where there are strong alongshore currents. In this way a reconcentration of previously sorted material is effected, and the result is a particularly rich deposit. Figure 4 shows diagrammatically an ideal section of the modern beach placers near Nome and illustrates the relation of these deposits to the sands, gravels, and clays of the Coastal Plain.

Beach placers are, as a rule, confined to the narrow strip of coast affected by waves and alongshore currents. Where the sea is erod-

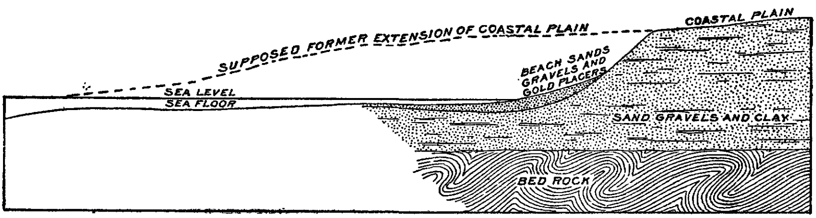


FIGURE 4.—Diagrammatic section of beach placers.

ing outcrops of hard rock the gold is mainly in and on bedrock, but where bedrock is deeply buried, as at Nome, concentration has been effected mainly on clay layers. The richest modern beach concentration in Seward Peninsula extended for about 10 miles to the east and west of Nome, and the pay streak was from 6 inches to 3 feet thick. The gold was in small flakes, averaging, according to Brooks, from 70 to 80 colors to the cent.[1] Most of the gold was bright and well worn. A considerable range in the tenor of the auriferous gravels was found as mining progressed, due, no doubt, to differences in the original conditions under which the Coastal Plain deposits were laid down and to their reassortment by the sea at the present time. Where concentration and reconcentration were most effective the richest placers were formed, and where these processes were relatively ineffective placers were absent. It is noteworthy, however, that traces of gold could be found practically everywhere along the beach and the question whether a certain area was minable was determined on purely commercial grounds.

[1] Brooks, A. H., and others, Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900: Special publication U. S. Geol. Survey, 1901, p. 87.

In addition to the beach placer proper, Collier[1] has pointed out that—

> Some fine gold is also found in the gently sloping floor of the sea, but since this is probably derived from the beach, it is more disseminated and finer than the beach gold and can not at present be regarded as forming a workable placer.

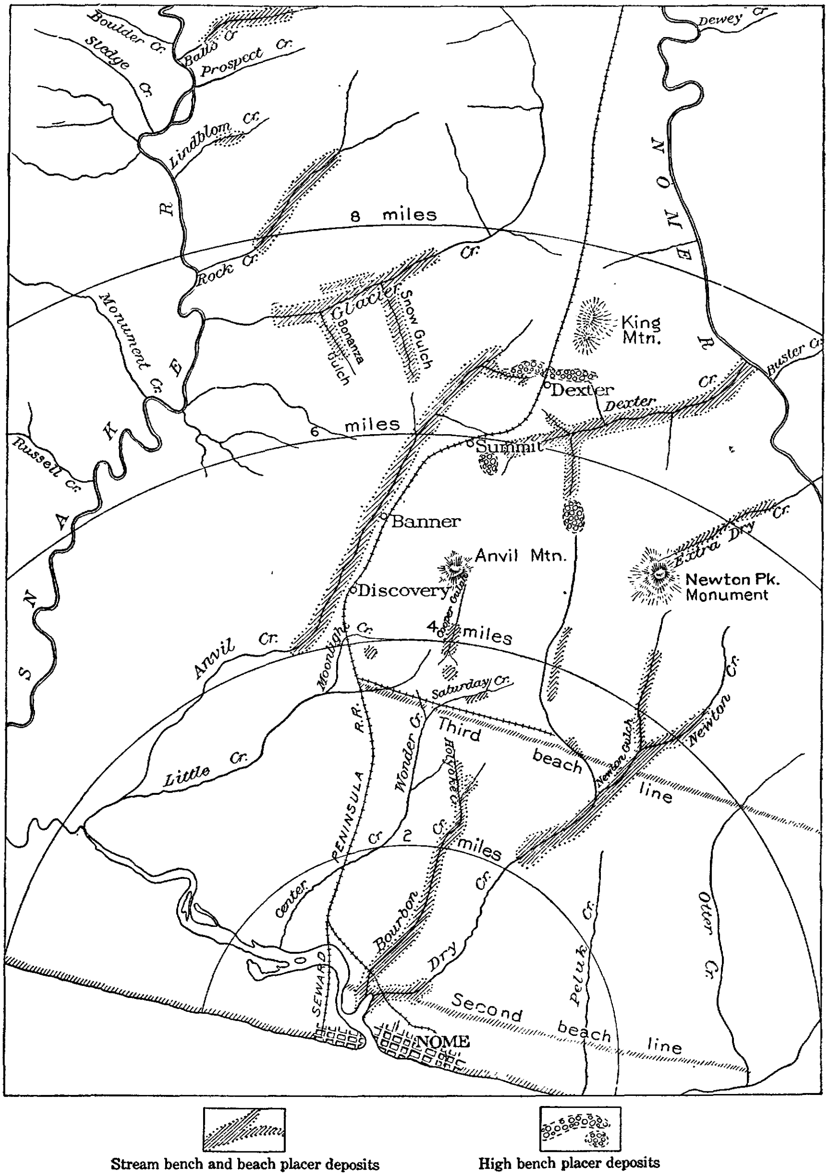


FIGURE 5.—Sketch map of Nome region, showing distribution of placers.

If, however, this material should subsequently be concentrated by waves and currents a valuable deposit might be produced. This

[1] Collier, A. J., The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, p. 145.

feature is, of course, of commercial importance only in the case of the ancient beaches the former seaward slope of which is now above sea level.

In describing the history of mining developments (p. 271) reference is made to the ancient beaches near Nome. These are striking examples of beaches which since their formation have undergone a complex history whereby their attitude with respect to sea level has been materially changed. Two particularly well-marked ancient shore placers, whose positions are shown by figure 5, have been mined. The same figure also shows, on a larger scale than Plate I, the distribution of the placers of different types in the vicinity of Nome.

These ancient beach placers differ in no genetic respect from the modern beach placers, but during the long time since their formation weathering and other geologic processes have combined to obliterate

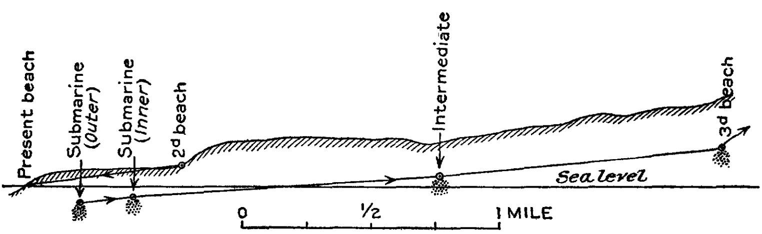


FIGURE 6.—Diagrammatic cross section showing beaches near Nome.

their original form and character. One of the ancient beaches, the so-called third beach, has no topographic expression; but the second beach, which is much younger, has a well-marked shore cliff in part of its length. Altogether six more or less definite beaches have been recognized near Nome. They have the following positions with respect to sea level: "Outer submarine beach," 34 feet below sea level; "inner submarine beach," about 20 feet below sea level; present beach at sea level; "intermediate beach," about 22 feet above sea level; "second beach," 38 feet; "third beach," about 78 feet. Figure 6 shows diagrammatically the position of these various beaches, both vertically and horizontally, with respect to the sea. The history of these ancient beaches seems to show a general period of sinking of the land during which the "outer" and "inner" submarine beaches, the "intermediate beach," the "third beach," and probably an unrecognized beach still farther inland were formed. This was followed by a general period of uplift in which the Coastal Plain emerged and the "second" beach, and later the present beach, were formed.

From the foregoing summary it is evident that certain beaches are comparable with the high benches of stream origin, whereas others—for example, the submarine beaches—are similar to the deep-stream gravels of the larger rivers already noted. Furthermore, it follows that the sorting and re-sorting of the Coastal Plain gravels has produced a gravel-plain deposit, mainly of marine origin but in part formed by streams. Because of their manner of origin part of the gravel-plain deposits of Seward Peninsula should be included in the group of ancient beach placers as well as in the class of ancient stream placers, and gradational phases between the two are to be expected.

DISTRIBUTION.

DEVELOPED PLACERS.

Reference has already been made, both by illustration and by description, to the places where auriferous deposits have been mined in Seward Peninsula. It is desirable to amplify these scattered references by indicating all the areas where productive placers have been found in order that the places where investigations of water supply are particularly necessary may be pointed out. In a subsequent section an attempt will be made to indicate in a broad way the localities where future demands for water are to be expected.

Probably the most satisfactory method of stating the distribution of the developed placers is the graphic representation on a map of the places where claims have been worked and gold produced. On Plate I (in pocket), Plate II (p. 12) and figure 5 (p. 46) all the known placers are shown, so far as the scales of the maps permit. It is not, of course, feasible or even desirable to indicate all the prospect holes and test pits that have been dug, and practically each placer symbol denotes a mine that has contributed to the gold production of the peninsula.

From the position of the symbols certain facts concerning the distribution of placers may be determined. Perhaps the most striking feature is the fact that they are widespread. At first sight they appear to be scattered from one end of the peninsula to the other and from the northern to the southern coast, but more detailed examination shows that in certain areas they are much more numerous than elsewhere. Productive placers have been found on nearly all the streams within a radius of 5 to 6 miles of Nome, and numerous bench and beach placers have been worked on the hillsides and on the coastal plain, as indicated in figure 5 (p. 46). Another area in which placers are particularly numerous is that near Ophir Creek in the Council region. Here also are found placers of many types, although there are no beach placers. In the Kougarok region placers are numerous, and many more would probably be developed if the water resources were adequate. Placers near Candle have yielded considerable gold.

Most of the Candle placers are of the bench type, and little mining has been done in the modern stream gravels of that area.

Placers have been developed in a great many other places, as, for example, in the Solomon and Casadepaga regions, in the Inmachuk basin, in the Bluestone region, and at Bluff, but their distribution is sufficiently evident from the map. The important relation between placers and bedrock geology, however, is not so evident. The more important placer areas are shown on the geologic map (Pl. IV, p. 32), from which it appears that practically all the placers occur in the areas occupied by the undifferentiated schists. No placers have been located in the areas formed exclusively of the Paleozoic limestones and associated rocks, and none have been developed in the Kigluaik group of schists and limestones. The Cretaceous sedimentary rocks, save in one small area near the extreme southeastern margin of the region mapped, have yielded no placers, and apparently, except under certain special conditions,[1] where these strata form the country rock search for auriferous deposits is likely to result in failure.

In the areas of igneous rocks no placers of economic importance have been found except around Bear Creek, a tributary of the Buckland, and Alameda Creek, a tributary of the Koyuk. This lack of placer deposits seems to be universal, whether the igneous rock is of the pre-Cretaceous granular variety abundant in the Kigluaik, Bendeleben, and Darby mountains, of the effusive type common in the Kiwalik-Buckland divide, or of the type present in the very recent basaltic flows so numerous in the central and eastern part of the peninsula. In this connection it should be pointed out that certain placers in northern Seward Peninsula which are covered with lava do not vitiate the generalization just made. At these places lava has been poured out subsequent to the formation of the old stream deposits, and therefore it is not at all surprising that when the lava covering is removed these deposits should be found to contain placers of sufficient value to justify mining.

PROSPECTIVE PLACERS.

The criteria for determining the places where commercially important placers will be found are necessarily derived from the facts presented by the placers already developed. It is realized that such deductions are necessarily liable to error, but in the absence of other data these are the only guides available. A study of the placers that have been mined[2] indicates that there are three essential factors nec-

[1] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: Bull. U. S. Geol. Survey No. 449, 1911, pp. 101-109.

[2] This matter has been discussed at some length by A. H. Brooks. See Bull. U. S. Geol. Survey No. 328, 1908, pp. 114-134.

essary for the formation of rich deposits, namely, a mineralized area in the vicinity, a period of disintegration whereby the vein matter is prepared for transportation, and a vigorous sorting of the material derived from the mineralized area.

A study of the geology of Seward Peninsula shows that the first of the above conditions, the presence of a mineralized area, is fulfilled in many parts of the peninsula. Only a small amount of mineralization is shown in the areas of igneous rocks or in those of the sedimentary rocks other than the undifferentiated schists, and therefore placers are most to be expected in areas occupied by these schists. Mineralization is particularly abundant in the black graphitic slates which occur along the borders of the Kigluaik and Bendeleben mountains and which in the Solomon region have been called the Hurrah slates.[1] In the black slates in the latter region quartz veins are so numerous that in certain specimens 13 veins have been counted in a linear inch of the rock.

A particularly favorable position for the formation of placers seems to have been near the contact of the undifferentiated schists and the overlying limestones. Sulphides of iron, copper, and lead, all to some extent auriferous, are found at or near this contact. As illustrations of placers formed in this position may be cited those of the Anvil-Dexter region, near Nome; the Bluff region, Ophir Creek, in the Council precinct; the Kougarok region; the Inmachuk area, in the Fairhaven precinct; and many other less productive regions throughout the peninsula.

The other factors noted as necessary for the production of rich placers—a period of weathering, followed by active sorting—may well be treated together. Under exceptional circumstances either of these processes may almost be dispensed with, as is shown by the residual hillside placers on Crooked Creek, in the Council region, where sorting has been reduced to a minimum, or by the small beach placers on the cliffed seacoast west of Bluff, where weathering has effected little preparation of the material and the accumulation is attributable almost entirely to sorting. If either of these factors is absent, however, the resulting placers are usually small. Of the two processes vigorous sorting is probably the more important.

Although it has not been definitely proved, there is undoubtedly a close relation between the richness of a placer and the effectiveness of sorting and reconcentration in previous cycles. This fact is shown in modern stream placers that traverse bench placers and in beach placers that are formed of reconcentrated marine and fluviatile deposits.

[1] Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles, Alaska: Bull. U. S. Geol. Survey No. 433, 1910, pp. 59-62.

It is practically impossible to state briefly where the processes of disintegration and transportation have been most active, as it is necessary to consider each area separately. Broadly speaking, however, the whole of Seward Peninsula, with the exception of the Kigluaik, Bendeleben, and Darby mountains, has been subjected to nearly uniform erosion. In these mountains glaciation, elsewhere unknown, has in general dispersed the previously disintegrated and sorted deposits, so that productive placers are absent. Not only have the deposits been removed in the area occupied by the ice, but outwash from the glacier, deposited by streams and in ponds and lakes formed perhaps behind ice barriers, has covered over and effectually hidden earlier deposits. Some of the gravel-plain deposits in the central portion of the peninsula have been formed in part of this outwash material.

So far as known, no large body of standing water has occupied any of the interior part of the region in sufficiently recent times to have formed deposits of marine concentrated alluvium. Beach placers are therefore not to be sought for in this part of the peninsula. The temporary lakes noted in the preceding paragraph, formed as a result of glaciation, do not seem to have persisted at a constant elevation long enough to have effected any marked concentration through shore action.

DISCHARGE OF STREAMS.

By F. F. Henshaw and G. L. Parker.

TERMS USED.

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

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide and 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the table of equivalents on page 52.

The "miner's inch," the unit used in connection with placer mining, expresses the rate of flow of water through an orifice of a given size with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use, it has been defined by law in several States. The California miner's inch is in most common use in the United States and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to 1.5 cubic feet of water per minute, measured through any aperture or orifice." This miner's inch corresponds to the so-called "6-inch head" and is one-fortieth of a second-foot. The inch in most common use in Seward Peninsula is the "old California inch," which was the standard in that State prior to the passage of the act above quoted, and is equivalent to 1.2 cubic feet a minute, or one-fiftieth of a second-foot.

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

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

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

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

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 50 "old California miner's inches" (used prior to law of March 23, 1901).
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet, or 13.572 inches, deep.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one day equals 1.983 acre-feet.
100 California miner's inches equals 15.7 United States gallons per second.
100 California miner's inches for one day equals 4.96 acre-feet.
100 United States gallons per minute equals 0.223 second-foot.
100 United States gallons per minute for one day equals 0.442 acre-foot.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 mile equals 5,280 feet.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square nearly.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 horsepower equals 550 foot-pounds per second.

1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
$1\frac{1}{3}$ horsepower equals about 1 kilowatt.

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

DATA GIVEN.

The tables containing records of run-off for each drainage basin are preceded by a brief description of general conditions within the basin, covering such features as area, topography, watercourses, geology, forestation, rainfall, distribution of ground and winter ice, storage, and power possibilities.

The following data are given, so far as practicable, for each regular current-meter gaging station: Description of station, list of discharge measurements, table of daily gage heights and discharges including mean per square mile, and run-off, depth in inches on drainage area, for monthly periods or for shorter intervals at the beginning and end of the records.

In addition to statements regarding the establishment of current-meter stations and the location and character of gages and measuring sections, information is given in regard to any conditions which may affect the constancy of the relation of gage height to discharge, such as ice, shifting channel conditions, and backwater; also notes regarding diversions which decrease the total flow at the measuring section. Statements are also made regarding the accuracy and reliability of the data.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, gage height, and discharge in second-feet; also the name of the engineer where it is desired to give credit to cooperating parties.

The table of daily gage heights and discharges gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day, and the corresponding volume of discharge as found from the rating table. At stations that were easily accessible the gage was read in the morning and in the evening. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. All gage heights that are rendered more or less inaccurate by the presence of ice or by backwater from obstructions are published as recorded, with suitable footnotes. The rating is not applicable for such periods unless the proper correction to the gage heights is known and applied. Attention is called to the fact that the zero of the gage is placed at an arbitrary datum and has no relation to zero flow or to the bottom of the river. In general, the zero is located somewhat below the lowest known flow, so that negative readings shall not occur.

The discharge measurements and gage heights are the base data from which the rating tables and daily discharge tables are computed. The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable. It is not published in this report, but can be plotted from the gage heights and corresponding discharge in the manner indicated on page 57.

FIELD METHODS OF MEASURING STREAM FLOW.

There are three distinct methods of determining the flow of open-channel streams: (1) By measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir or dam; or (3) by measurements of the velocity of the current and of the area of the cross section. The method chosen depends on the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

Slope method.—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v=c\sqrt{rs}$. This formula has been utilized by Kutter, both in developing his formula for c and in determining the values of the coefficient n which appears therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for n to be used in Kutter's formula. The most common use of this method is in estimating the flood discharge of a stream when the only data available are the cross section, the slope as shown by marks along the bank, and a knowledge of the general conditions. It is seldom used by the United States Geological Survey and has never been applied in Alaskan work. For full information regarding the method the reader is referred to textbooks on hydraulics.

Weir method.—Relatively few stations are maintained at weirs or dams by the United States Geological Survey. The only weir records kept in Seward Peninsula were on streams on the north side of the Kigluaik Mountains. The weirs were installed by men cooperating with the Survey, and the data, which are here published, are the only records of discharge available on these streams. Standard types of sharp-crested and broad-crested weirs within the limits for which accurate coefficients have been experimentally obtained give accurate records of discharge if properly maintained.[1] The proper installation of weirs in the Alaskan work is out of the question on account of expense, the torrential character of the run-off, and the temporary nature of the stations.

[1] The determination of discharge over the different types of weirs and dams is treated fully in "Weir experiments, coefficients, and formulas" (Water-Supply Paper U. S. Geol. Survey No. 200) and in textbooks on hydraulics.

Velocity method.—Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements, in order that the data may have the required degree of accuracy. The stations are located, as far as possible, at such points that the relation between gage height and discharge will always remain constant for any given stage. In sparsely settled areas, such as those under consideration, the engineer is greatly handicapped in his selection by the necessity of finding an observer, and on many streams there is only one point where readings can be obtained.

A gaging station consists essentially of a gage for determining the daily fluctuations of stage of the river and a section where discharge

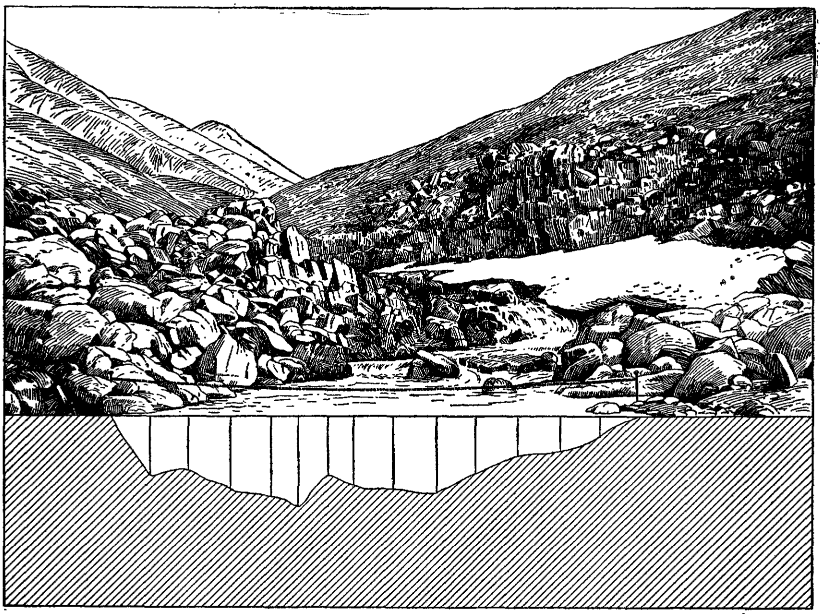


FIGURE 7.—Cross section of stream showing method of measuring.

measurements are made. On large streams some equipment, such as a bridge or cable, is necessary; on small streams the measurements can be made by wading at any convenient section near the gage.

The two factors required to determine the discharge of a stream past a section perpendicular to the mean direction of the current are the area of the cross section and the mean velocity of flow normal to that section.

In making a measurement with a current meter a number of points, called measuring points, are measured off above and in the plane of the measuring section at which observations of depth and velocity are taken. (See fig. 7.) These points are spaced equally for those parts of the section where the flow is uniform and smooth and are spaced unequally for other parts, according to the discretion and judgment of the engineer. In general the points should not be spaced farther apart than 5 per cent of the channel width, nor than the approximate mean depth at the time of measurement.

The measuring points divide the total cross section into elementary strips at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the average of the depths at the two ends times the width of the strip times the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.[1]

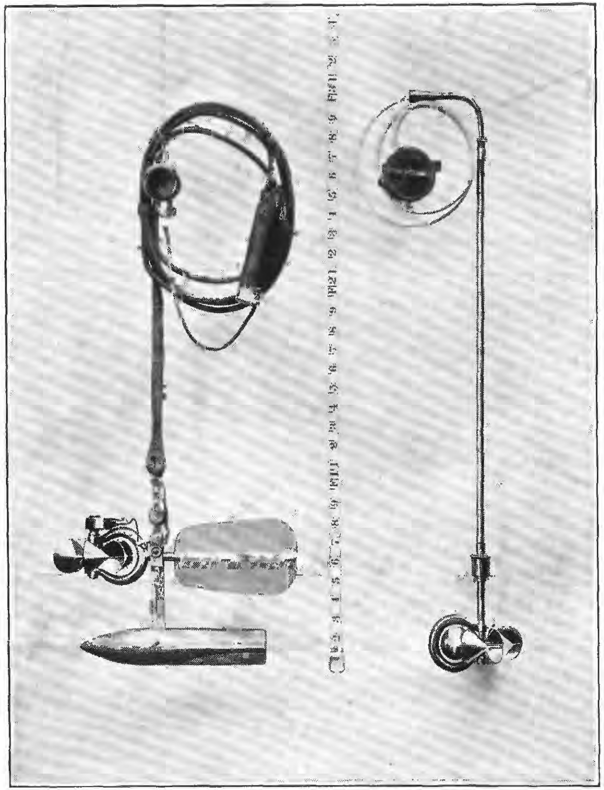
Depths for the determination of the area are obtained in wading measurements by sounding with the rod to which the meter is attached.

Two methods of determining the velocity of flow of a stream are in general use—the float method and the current-meter method.

The float method is now considered obsolete in the ordinary practice of the United States Geological Survey, but as float measurements can readily be made by the prospector the method is here described. The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, and it is affected but little by wind. In flood measurements good results can be obtained by observing the velocity of floating cakes of ice or débris. In all surface float measurements the observed velocity must be multiplied by 0.85 to 0.95 to reduce the surface velocity to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals. In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run"—a selected stretch of river or creek with an approximately uniform cross section from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined. The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

The Price current meter is now used almost to the exclusion of other types of meters by the United States Geological Survey in the determination of the velocity of flow of water in open channels, a use for which it is adapted under practically all conditions. The small Price acoustic and electric meters (Pl. V, *A*) were the types used in the work in Seward Peninsula. Briefly, the meter consists of

[1] For a discussion of methods of computing the discharge of a stream see Engineering News, June 25, 1908.



A. PRICE CURRENT METERS.

B. MEASURING GRAND CENTRAL RIVER.

six cups attached to a vertical shaft, which revolves on a conical hardened steel point when immersed in moving water. The number of revolutions is indicated acoustically or electrically. The rating, or relation between the velocity of the moving water and the revolutions of the wheel, is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From these data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval. The ratio of revolutions per second to velocity of flow in feet per second is very nearly a constant for all speeds, and is approximately 0.45.

Practically all the measurements with the acoustic meter were made by wading. Three methods of measuring the velocity were used. In the first the meter is held at the depth of the thread of mean velocity, which has been shown by extensive experiments to occur at about 0.6 of the total depth. In the second method the mean of the velocities taken at 0.2 and 0.8 depth is taken as the mean. In the third method the meter is held at mid depth, at about 0.1 of the total depth below the surface, and at the same distance above the bottom, and one-fourth of the sum of the top and bottom readings and twice the mid-depth reading is used as the mean. This method is not adapted to very shallow streams or to those with extremely rough beds.

The determination of the flow of an ice-covered stream is difficult, owing to the diversity and instability of conditions during the winter and also to lack of definite information in regard to the laws of flow of water under ice. The requirements of the work in Seward Peninsula have not necessitated the making of ice experiments.

OFFICE METHODS OF COMPUTING AND STUDYING DISCHARGE AND RUN-OFF.

At the end of each season the field or base data for current-meter gaging stations, consisting of daily gage heights, discharge measurements, and full notes, are assembled. The measurements are plotted on cross-section paper and rating curves are drawn wherever feasible. (See figs. 8 and 9.) The rating tables prepared from these curves are then applied to the tables of daily gage heights to obtain discharges, and from these the monthly discharge and run-off are computed.

Streams in general present throughout their courses to a greater or less extent all conditions of permanent, semipermanent, and varying conditions of flow. In accordance with the location of the measuring section with respect to these physical conditions, current-meter gaging stations may in general be divided into four classes: (1) Those with permanent conditions of flow, (2) those with beds that change only during extreme high water, (3) those with beds that change frequently but do not cause a variation of more than about 5 per cent in the discharge curves from year to year, and (4) those with constantly shifting beds. In determining the daily flow different office methods are necessary for each class.

The rating curves are drawn and studied with special reference to the class of channel conditions which they represent. The discharge measurements for all classes of stations, when plotted with gage heights in feet as ordinates and discharges in second-feet as abscissas, define rating curves which are generally more or less parabolic in form. For many stations curves of area in square feet and mean velocity in feet per second are also constructed to the same scale of

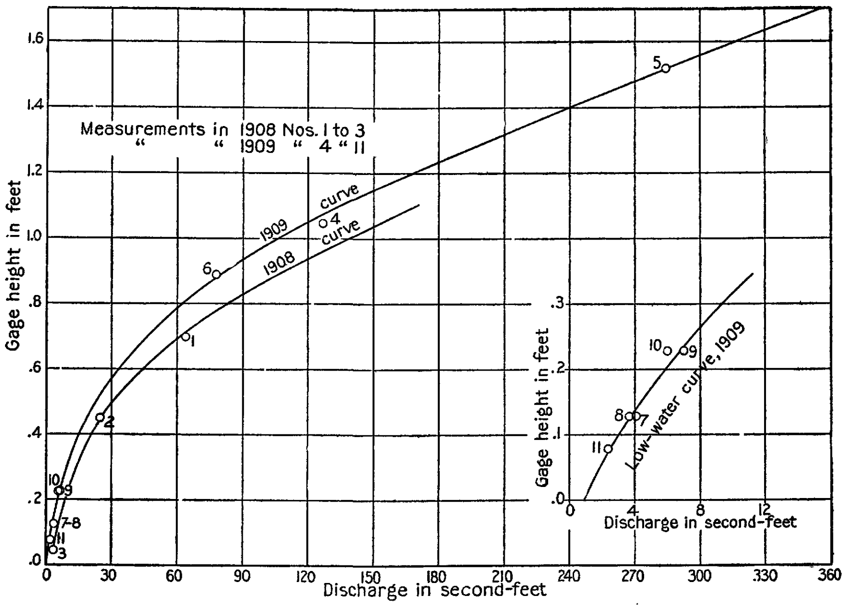


FIGURE 8.—Discharge curves for Henry Creek at mouth.

ordinates as the discharge curve. These are used mainly to extend the discharge curves beyond the limits of the plotted discharge measurements, and for checking, in order to avoid errors in the form of the discharge curve and to determine and eliminate erroneous measurements.

The following assumptions are made for the period of application of every rating table: (*a*) That discharge is a function of and increases gradually with the stage of a stream; (*b*) that the discharge is the same whenever the stream is at a given stage, and hence such changes in conditions of flow as may have occurred during the period of application are either compensating or negligible, except that the rating as stated in the footnote of each table is not applicable for the known presence of ice or other similar obstructions; (*c*) that increased and decreased discharge due to change of slope on rising and falling stages is either negligible or compensating.

As already stated, the gaging stations may be divided into several classes. Nearly all the stream-gaging stations in Seward Peninsula are of the second class, being located on streams whose beds change only during extreme high water. The typical river channel consists of a wide gravel bed, perhaps 100 yards or more across, which the stream fills at high stages and across which it meanders from side to side during low water. The detritus is generally well rounded and requires only a moderately high velocity to move it. A good-sized flood, especially if it occurs in the summer or early fall, when the

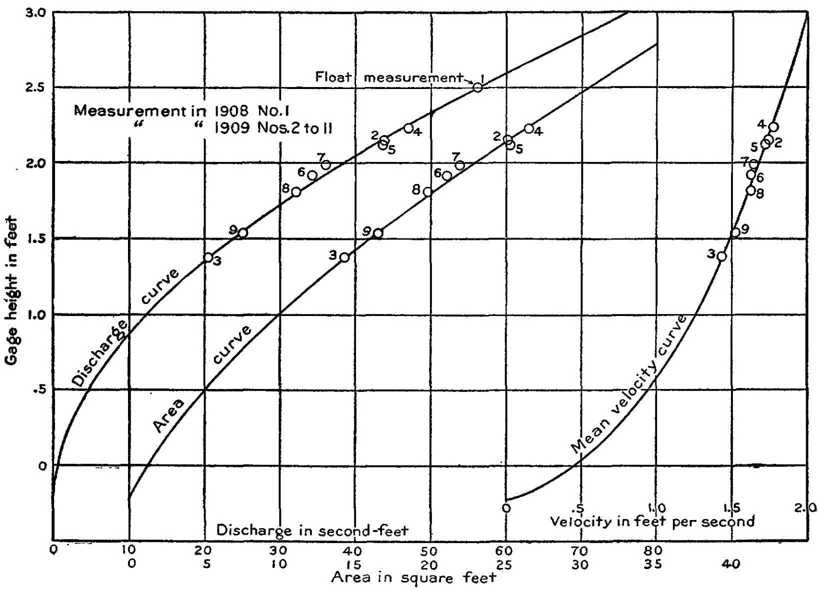


FIGURE 9.—Discharge, area, and mean velocity curves for Canyon ditch at intake.

ground is well thawed, may cause a radical change in channel conditions. In certain sections of the Alaska streams these changes take place, if at all, only during the highest floods, such as occur on an average of not more than once a year, and it is the aim to make use of these sections as far as possible for the location of gaging stations. It has generally been necessary to obtain frequent measurements at all stations to detect changes in channel and define the rating for each period between high stages.

There are few outcrops of bedrock on the rivers measured, and only here and there has it been possible to place a gage above one of these, thus eliminating changes in control and providing a station of the first class. Similar conditions occur locally in the lava country or in the heavily glaciated area in the mountains, where the stream beds are composed of large angular fragments. In these places it is usually difficult to find a satisfactory section where accurate measurements can be made.

Channels that are constantly shifting (class 4) are commonly found only where mining operations just above throw a large amount of coarse and fine débris into the stream. If it is possible to go downstream several miles from the mines a point can be selected where the coarse débris has all settled. The fine "slickens" which the stream still carries are deposited only in pools and not on the riffles, the permanency or shift of which is the largest factor in determining the stability of the relation of gage height and discharge.

Some stations on streams carrying much mining débris approximate the condition of the third class—that is, there is a deposition of sediment at low water which is carried out during the next flood. In such localities the change in the channel is small and temporary.

Good results can be obtained from stations of the fourth class only by frequent discharge measurements, the frequency varying from a measurement every two or three weeks to a measurement every day, according to the rate of diurnal change in conditions of flow. These measurements are plotted and a mean or standard curve drawn among them. It is assumed that there is a different rating curve for every day of the year, and that this rating is parallel to the standard curve with respect to their ordinates. On the day of a measurement the rating curve for that day passes through that measurement. For days between successive measurements it is assumed that the rate of change is uniform, and hence the ratings for the intervening days are equally spaced between the ratings passing through the two measurements. This method must be modified or abandoned altogether under special conditions.

ACCURACY AND LIMITATIONS OF THE DATA.

Practically all discharge measurements made under fair conditions are well within 5 per cent of the true discharge at the time of observation. Inasmuch as the errors of meter measurements are largely compensating, the mean rating curve when well defined is much more accurate than the individual measurements. Numerous tests and experiments have been made to test the accuracy of current-meter work. These show that where conditions are good it compares very favorably with the results from standard weirs.

The accuracy of the gage heights depends on the reliability of the observers and, owing to the general interest in and knowledge of the value of the data in Alaska, the readings are generally good.

It is obvious that one gage reading a day does not always give the mean height for that day. Almost invariably, however, errors from this source are compensating and virtually negligible in a period of a month, although a single day's reading may, when taken by itself, be considerably in error.

The maximum and minimum figures, from the very nature of collecting such data, are liable to considerable errors. The maximum value should be increased for many stations in considering designs for spillways, and the minimum value should be regarded as a mean for a group of seven days or more, rather than for one day.

The purpose of the work discussed in this report was to obtain data on the water supply available for hydraulic mining. Water to be of use for hydraulicking must be available under considerable pressure. When it is necessary to divert water from one basin into another, it must be taken out at an elevation high enough to allow it to be carried over the divides. The gaging stations, therefore, in order to give the desired results, had to be located at points near the headwaters, at considerable elevations, and some of them were far from any settlements. At many such localities it was impossible to find observers to take daily gage readings. Under such circumstances readings were made only at intervals of three or four days to a week. From these approximate daily discharges could be obtained with the aid of a hydrograph (see fig. 1, p. 20), by plotting time as ordinates and discharges in second-feet as abscissas and drawing an irregular curve through these points. As all the streams in any drainage basin are affected by practically the same climatic influences, they rise and fall synchronously, and their hydrographs, if plotted to the same scale of days, follow one another more or less closely. Advantage is taken of this fact to interpolate the discharges for days when records are missing on some of the streams in a basin. Results obtained in this way are rather rough but are believed to be of greater value than isolated discharge measurements for the days when the station was visited. In using them due allowance should be made for the uncertainties of the record.

For many streams on which only a few measurements were made, no estimate of daily discharge has been attempted.

The computations have, as a rule, been carried to three significant figures. Crelle's tables and the 20-inch slide rule have been generally used, and all calculations have been carefully checked. After the computations have been completed they are entered in tables and carefully studied and intercompared to eliminate or account for all gross errors so far as possible. Missing periods are filled in, so far as feasible, by means of comparison with adjacent streams. The attempt is made to complete periods of discharge, thus eliminating fragmentary and disjointed records. Full notes accompanying such estimates follow the discharge tables.

DRAINAGE AREAS.

Many persons desire records of steam flow at places other than that where the Survey's discharge measurements are made. In order that the engineer may estimate the flow at such a place, he must know the drainage area of the stream both at the point of measurement and at the point where the flow is desired. In order to supply this need to some extent, a table of drainage areas has been prepared for practically all the river basins of Seward Peninsula. The best available maps have been used—the maps of the Nome. Grand Central, Solomon, and Casadepaga quadrangles for the areas which they cover and the smaller-scale reconnaissance maps for the remainder of the peninsula. Portions of these reconnaissance maps differ considerably in accuracy, according to whether the topographic features were carefully surveyed or seen only at a distance and sketched in roughly. The accuracy of the areas as measured on the maps differs correspondingly. In general the portions of the maps showing the mountain areas surrounding the Fish River flats, the north side and east end of the Kigluaik Range, and the Serpentine River drainage basin are only approximately correct. Small areas are, of course, liable to much greater proportional errors than large ones.

In the table tributaries are shown by indention under the name of the stream into which they flow; for example, in the Fish River basin Pargon and Niukluk rivers flow into the Fish, American Creek and Casadepaga River into the Niukluk, etc.

Drainage areas in Seward Peninsula, Alaska.

Stream.	Locality.	Elevation.	Drainage area.
		Feet.	*Sq. miles.*
Koyuk River basin:			
Koyuk River	Below Knowles Creek		210
	Below Big Bar Creek		477
	Below First Chance Creek		648
Knowles Creek	Mouth		36
Big Bar Creek	do		62
First Chance Creek	do		133
Tubutulik River basin:			
Tubutulik River	Lower end of flats (Death Valley)		125
	Mouth		417
Fish River basin:			
Fish River	Lower end of flats	[a] 180	1,040
	Below Niukluk River	[a] 40	1,980
	White Mountain	0	2,110
Pargon River	Pargon (Wild Goose) ditch intake	[b] 730	20
	Miocene ditch intake	[b] 610	36
	Mouth	[a] 200	153
Niukluk River	Below Shoestring Creek	[a] 390	77
	Below Casadepaga River	[c] 150	552
	Below Goldbottom Creek	[a] 135	603
	Below Ophir Creek	[a] 100	715
	At Council (above Melsing Creek)	[a] 85	726
	Below Melsing Creek	[a] 80	756
	Mouth	[a] 40	825
American Creek	Below Auburn Ravine	[a] 600	13
	Below Game Creek	[c] 480	24

[a] From reconnaissance topographic maps. [b] From railroad or ditch levels.
[c] From topographic maps.

Drainage areas in Seward Peninsula, Alaska—Continued.

Stream.	Locality.	Elevation.	Drainage area.
Fish River basin—Continued.			
Fish River—Continued.			
Niukluk River—Continued.		*Feet.*	*Sq. miles.*
Casadepaga River	Above Upper Willow Creek	[a] 500	29
	Below Moonlight Creek	[b] 400	47
	Below Ruby Creek	[b] 310	64
	Below Lower Willow Creek	[b] 305	83
	Below Canyon Creek	[b] 270	114
	Below Goose Creek	[b] 240	132
	Below Penelope Creek	[b] 235	138
	Below Big Four Creek	[b] 195	195
	Below No Man Creek	[b] 195	201
	Mouth	[b] 155	236
Moonlight Creek	Ditch intake	[b] 485	.81
	Mouth	[b] 400	1.0
Ruby Creek	Ditch intake	[b] 460	2.9
	Mouth	[b] 310	6.0
Lower Willow Creek	Above Ridgeway Creek	[b] 400	15.4
	Mouth	[b] 305	19.0
Canyon Creek	Intake Canyon Creek Gold Mining Co.'s ditch.	[b] 510	4.6
	Below Boulder Creek	[b] 355	22
	Mouth	[b] 270	24
Boulder Creek	do	[b] 355	5.0
Goose Creek	Ditch intake	[b] 330	4.1
	Mouth	[b] 240	12.7
Penelope Creek	Ditch intake	[b] 400	3.5
	Mouth	[b] 235	6.2
Big Four Creek	2½ miles above Birch Creek	[b] 400	16.5
	Below Castle Creek	[b] 330	26
	Below Birch Creek	[b] 325	35
	Mouth	[b] 195	44
Castle Creek	¾ mile above mouth	[b] 400	4.2
	Mouth	[b] 330	4.7
Birch Creek	1 mile above mouth	[b] 400	8.1
	Mouth	[b] 325	9.2
No Man Creek	3 miles above mouth	[b] 400	4.7
	Mouth	[b] 195	7.1
Bonanza Creek	Mouth	[b] 180	20
Goldbottom Creek	Below Warm Creek		40
	Mouth	[c] 135	
Warm Creek	do		13.8
Ophir Creek	Canyon ditch intake	[c] 390	24
	Below Crooked Creek	[c] 230	31
	Below Guy Creek	[c] 210	41
	Below Dutch Creek	[c] 190	54
	Mouth	[c] 100	71
Crooked Creek	do	[c] 230	4.6
Guy Creek	do	[c] 210	2.5
Dutch Creek	do	[c] 190	12.0
Sweetcake Creek	do	[c] 120	8.6
Melsing Creek	do	[c] 80	30
Bear River	Trail crossing	[c] 100	33
Fox River	Dam site		15.2
	Edge of foothills		37
	Mouth	[c] 30	72
Klokerblok River basin:			
Klokerblok River	Topkok ditch intake	[b] 285	4.3
	Below Skookum River		58
	Mouth	0	129
O'Brien Creek	Topkok ditch intake	[b] 285	3.5
	Do	[b] 300	6.6
	Mouth		26
Goldbottom Creek	Topkok ditch intake	[b] 300	3.2
Topkok River basin:			
Topkok River	Mouth (not including Rock Creek)	0	14.5
Solomon River basin:			
Solomon River	Below Coal Creek	[b] 250	37
	Below Johns Creek	[b] 245	40
	Below East Fork	[b] 146	66
	Below Big Hurrah Creek	[b] 85	87
	Below Shovel Creek	[b] 45	120
	Mouth	0	134
Coal Creek	Ditch intake	[b] 480	9.5
	Mouth	[b] 250	27
Boise Creek	Ditch intake	[b] 475	3.3
Victoria Creek	do	[b] 470	2.9
Johns Creek	Mouth	[b] 245	3.4
East Fork	Ditch intake	[b] 307	9.1
	Mouth	[b] 146	17.2

[a] From railroad or ditch levels. [b] From topographic maps.
[c] From reconnaissance topographic maps.

Drainage areas in Seward Peninsula, Alaska—Continued.

Stream.	Locality.	Elevation.	Drainage area.
Solomon River basin—Continued.			
Solomon River—Continued.		*Feet.*	*Sq. miles.*
Big Hurrah Creek	Power ditch intake	a 295	2.2
	Midnight Sun intake	a 185	12.8
	Mouth	a 85	17.4
Tributary Creek	do	a 222	5.4
Shovel Creek	Above Mystery Creek	a 100	17.9
	Mouth	a 45	23
Eldorado River basin:			
Eldorado River	Below Venetia Creek		51
	Below Pajara Creek		114
	Mouth		128
Venetia Creek	do		21
Fox Creek	do		13.5
Flambeau River basin:			
Flambeau River	Elevation of Darling Creek divide	a 1,020	2.8
	Intake Flambeau Hastings ditch	a 285	8.4
	Mouth	0	63
Nome River basin:			
Nome River	Miocene ditch intake below Buffalo Creek	a 575	15
	½ mile above Dorothy Creek	a 450	25
	Seward ditch intake	a 408	28
	Pioneer ditch intake	a 320	37
	Below Hobson Creek	a 184	56
	Below Banner Creek	a 75	81
	Below Osborn Creek	a 20	142
	Mouth	0	160
Buffalo Creek	Minerva intake	a 1,000	3.8
	In canyon	a 760	4.4
	Campion ditch intake	a 610	8.2
	Mouth	a 577	8.5
David Creek	Miocene ditch intake	a 590	4.3
	Mouth	a 487	4.7
Dorothy Creek	½ mile above mouth	a 500	2.7
	Mouth	a 425	2.8
Alfield Creek	½ mile above mouth	a 425	4.4
	Mouth	a 375	4.5
Christian Creek	Above railroad	a 400	2.1
	Mouth	a 330	2.2
Hobson Creek	Miocene ditch intake	a 500	2.6
	Seward ditch intake	375	3.2
	Pioneer ditch intake	a 295	3.5
	Below Manila at Pioneer pipe crossing	a 270	5.1
	Mouth	a 184	5.6
Manila Creek	do	a 290	1.43
Banner Creek	do	a 75	3.0
Buster Creek	Below Goodluck Gulch	a 360	.60
	Below Lillian Creek	a 100	4.8
New Eldorado Creek	Mouth	a 387	5.6
Osborn Creek	Below Bonita Creek	a 387	10.5
	Peninsula Hydraulic Mining Co.'s intake	a 370	10.9
	French ditch intake	a 140	23
	Mouth	a 20	32
Bonita Creek	do	a 387	4.9
Snake River basin:			
Goldbottom Creek	do	a 225	7.8
Snake River	Below Grouse Creek	a 225	13.8
	Below North Fork	a 170	32
	Below Boulder Creek	a 85	58
	Below Glacier Creek	a 40	77
	Mouth	0	110
Grouse Creek	Miocene ditch intake	a 490	1.2
	Mouth	a 225	6.1
Cold Creek	Miocene ditch intake	a 485	1.6
North Fork	Mouth	a 170	15.9
Glacier Creek	Below Snow Gulch	a 120	6.9
	Mouth	a 40	8.1
Anvil Creek	Discovery	a 110	3.8
	Below Little Creek	a 10	10.2
Little Creek	Mouth	a 10	2.9
Penny River basin:			
Penny River	Sutton ditch intake (above Willow Creek)	b 120	19.0
	Mouth	0	36
Cripple River basin:			
Cripple River	Below Aurora Creek		8.4
	Cripple River Hydraulic Mining Co.'s ditch intake.	b 400	12.1
	Below Oregon Creek		34
	Below Arctic Creek		84
	Mouth		88

a From topographic maps. b From reconnaissance topographic maps.

Drainage areas in Seward Peninsula, Alaska—Continued.

Stream.	Locality.	Elevation.	Drainage area.
Sinuk River basin:		*Feet.*	*Sq. miles.*
Sinuk River	Level of ditch to Buffalo divide	[a] 1,025	3.4
	Below Upper Lake	[a] 770	6.2
	Lower measuring section, 1½ miles below Upper Lake.	[a] 700	8.2
	Below Windy Creek	[a] 520	31
	Above Glacial Lake outlet		73
	Below Stewart River		147
	Below American Creek		190
	Below Independence Creek		238
	Mouth	0	300
Windy Creek	Level of ditch from Buffalo divide	[b] 1,100	5.9
	Below Upper Lake	[a] 800	9.0
	Measuring section between lakes	[a] 670	12.0
	Mouth	[a] 520	18.0
North Star Creek	In canyon	[a] 900	2.3
	Mouth	[a] 540	2.8
Glacial Lake	Outlet		17
Stewart River	Below Slate Creek	[a] 575	6.4
	Below Lost Creek	[a] 564	11.2
	Below Silver Creek	[a] 505	20
	2 miles below Mountain Creek	[c] 400	36
	Mouth		53
Slate Creek	Measuring section	[a] 700	2.1
	Mouth	[a] 575	3.1
Lost Creek	do	[a] 564	4.8
Silver Creek	do	[a] 505	4.3
Tisuk River basin:			
Tisuk River	5 miles above McAdam Creek	[c] 400	9.6
	3 miles above McAdam Creek	[c] 200	20
Bluestone River basin:			
Bluestone River	Below Alder Creek		36
	Below Right Fork		77
	Mouth		117
Right Fork	do		37
Tuksuk Channel or Imuruk Basin drainage:			
Tuksuk Channel	do	0	4,230
Canyon Creek	Intake of proposed ditch to Gold Run	[c] 450	30
	Mouth		79
Cobblestone River	1½ miles below mouth of Oro Grande Creek.	[d] 500	58
	Mouth	0	84
Grand Central River basin:			
West Fork of Grand Central River	Pipe intake	[b] 1,010	2.8
	Ditch intake	[b] 850	5.4
	At the forks	[d] 690	7.7
Grand Central River	Gaging station below the forks	[d] 680	14.6
	Below Thompson Creek	[a] 550	23
	Below Nugget Creek	[a] 460	44
	Mouth	[a] 442	56
Crater Lake Outlet	½ mile below lake	[b] 925	1.8
North Fork Grand Central River.	Pipe intake	[b] 1,030	2.3
	Ditch intake	[b] 860	5.4
	1906 measuring section	[d] 750	5.5
	At the forks	[d] 690	6.9
Thompson Creek	Pipe-line crossing	[a] 720	2.5
Thumit Creek	Above mouth of canyon	[a] 800	.73
Nugget Creek	Miocene ditch crossing	[a] 785	2.1
	Below Copper Creek	[a] 610	5.4
	Mouth	[a] 465	6.5
Copper Creek	Miocene ditch intake	[a] 800	.85
	Mouth	[a] 615	1.2
Jett Creek	Miocene ditch intake	[a] 800	1.4
	Mouth	[a] 450	2.7
Morning Call Creek	Miocene ditch intake	[a] 900	1.32
	Below springs	[a] 700	1.90
	Mouth	[a] 445	4.1
Rainbow Creek	1 mile above mouth	[a] 600	1.81
Kruzgamepa River basin:			
Kruzgamepa River	Outlet of Salmon Lake	[a] 442	84
	Sliscovitch roadhouse, 1 mile below Crater Creek.	[d] 370	124
	Gaging station above Iron Creek	[b] 248	153
	Below Iron Creek	[b] 248	205
	Mouth	0	474

[a] From topographic maps.
[b] From railroad or ditch levels.
[c] From reconnaissance topographic maps.
[d] From barometer readings.

Drainage areas in Seward Peninsula, Alaska—Continued.

Stream.	Locality.	Elevation.	Drainage area.
Kruzgamepa River basin—Continued.			
Kruzgamepa River—Continued.		*Feet.*	*Sq. miles.*
Fox Creek	Mouth of canyon	[a] 550	11
	Mouth	[a] 442	12
Telegram Creek	do	[b] 630	5.4
Dome Creek	Below Eldorado Creek	[b] 630	11.2
	Below Hardluck Creek	630	12.3
Iron Creek	Below Left Fork		14.9
	Below Discovery Creek	[b] 475	23
	Below Canyon Creek	[b] 450	38
	Above Goldengate Mining Co.'s intake	[b] 425	40
	Above tunnel	[c] 280	50
	Mouth	[c] 248	52
Eldorado Creek	Gold Beach Development Co.'s ditch intake.	[b] 750	5.4
	Mouth	[b] 630	5.8
Discovery Creek	Gold Beach Development Co.'s ditch intake.	[b] 740	5.1
	Mouth	[b] 475	8.9
Canyon Creek	Gold Beach Development Co.'s ditch intake.	[b] 760	4.1
	Mouth	[b] 450	14
Kuzitrin River basin:			
Kuzitrin River	Lanes Landing	40	1,750
	Mouth		1,890
Noxapaga River	Below Berry Creek		160
	Above Goose Creek		340
Berry Creek	Mouth		70
Eldorado Creek	Trail crossing		30
Aurora Creek	Near mouth		28
East Fork	Mouth		82
Turner Creek	McKays intake		13
Boulder Creek	Claim "No. 5 above"		6.5
Marys River	Mouth	0	200
Kougarok River basin:			
Kougarok River	Below Washington Creek	[b] 860	16.7
	Homestake ditch intake	[c] 635	44
	Below Taylor Creek	[c] 433	171
	Below Henry Creek	[d] 410	225
	Head of big bend above Coarse Gold Creek	[c] 356	254
	Below Coarse Gold Creek	[c] 341	288
	Below North Fork	[c] 320	358
	Below Windy Creek	[c] 210	430
	Mouth	[d] 60	547
Washington Creek	do	860	6.3
Columbia Creek	do	[c] 670	11.6
Macklin Creek	Above intake	[c] 610	8.9
Homestake Creek	Ditch intake	[e] 480	2.9
	Mouth	[e] 440	5.4
Taylor Creek	North Star ditch intake	[c] 700	58
	Cascade ditch intake	[c] 580	73
	North Star ditch siphon	[d] 480	83
	Mouth	[c] 433	90
Henry Creek	Mouth	410	51
Arctic Creek	do	[d] 400	6.3
California Creek	do	[d] 390	3.9
Arizona Creek	do	[d] 375	10
Coarse Gold Creek	Below Jones Gulch		22
	Below Nugget Gulch		31
	Mouth	[c] 341	34
North Fork	Northwestern ditch intake	[d] 540	19.8
	Below Harris Creek		54
	Gaging station above Eureka Creek	[d] 370	66
	Mouth	[c] 320	71
Harris Creek	At claim 15		11.7
	Mouth		22
Eureka Creek	do	[d] 370	3.1
Left Fork	do		5.4
Windy Creek	Above Anderson Gulch		27
	Mouth	210	33
Quartz Creek	do		67
Coffee Creek	do		24
Agiapuk River basin:			
Agiapuk River	Below Allene Creek		324
	Below American River		930
	Mouth		1,120
Allene Creek	do		47

[a] From topographic maps.
[b] From barometer readings.
[c] From railroad or ditch levels.
[d] From reconnaissance topographic maps.
[e] Estimated.

Drainage areas in Seward Peninsula, Alaska—Continued.

Stream.	Locality.	Elevation.	Drainage area.
Agiapuk River basin—Continued.			
Agiapuk River—Continued.		*Feet.*	*Sq. miles.*
American River	Below Budd Creek		380
	Mouth		593
Budd Creek	At spring		58
	Below Windy Creek		108
	Mouth		114
Igloo Creek	do		130
Goodhope River basin:			
Right Fork	Mouth	a 260	80
Goodhope River	Below Esperanza Creek	a 100	194
	Below Humboldt Creek		437
	Mouth	0	500
Cottonwood Creek	Below Divide Creek	a 330	49
	Mouth	a 260	67
Divide Creek	do	a 330	10.6
Esperanza Creek	do	a 100	20
Humboldt Creek	do		110
Inmachuk River basin:			
Inmachuk River	Above Eureka Creek	a 210	8.6
	Below Hannum	a 175	44
	Below Pinnell River	a 140	142
	Below Logan Gulch	b 130	145
	Below Arizona Creek	b 125	160
	Above Cue Creek	a 60	177
	Mouth	0	240
Hannum Creek	Below Cunningham	a 500	11
	Below Milroy Creek	a 450	16
	Mouth	a 175	34
Pinnell River	do	a 140	96
Arizona Creek	do	b 125	12
Kugruk River basin:			
Imuruk Lake	Outlet	b 960	102
Kugruk River	Mouth of canyon	c 470	152
	Below Holtz Creek		396
	Above Reindeer Creek		556
	1 mile above Chicago Creek		578
	Mouth		893
Holtz Creek	do		141
Chicago Creek	Coal mine		32
Wade Creek (Burnt River)	2 miles above mouth		177
Kiwalik River basin:			
Kiwalik River	Above Quartz Creek		212
	Below Quartz Creek		336
	Below Hunter Creek		596
	Above Candle Creek		740
	Below Candle Creek	a 2	800
Quartz Creek	North Fork at proposed ditch intake	b 590	21
	South Fork at proposed ditch intake	b 580	26
	Below forks	d 570	56
	Mouth		124
Deer Creek	do	a 550	8.7
Gold Run	Proposed ditch intake	a 430	9.0
	Below Boulder Creek		21
	Mouth		29
Boulder Creek	Ditch intake		4.0
Glacier Creek	Candle ditch intake	b 409	10.0
	Below Rock Creek		14.0
	Mouth		35
Dome Creek	Candle ditch intake	b 383	9.0
	Siphon crossing	d 230	16
Hunter Creek	Proposed ditch intake	d 510	32
	1908 gaging station	d 500	37
	Below Left Fork		67
	Mouth		108
Candle Creek	Below Patterson Creek	b 130	37
	Mouth	a 2	60

a Estimated.
b From railroad or ditch levels.
c From reconnaissance topographic maps.
d From barometer readings.

DETAILED DESCRIPTIONS AND MEASUREMENTS.

FISH RIVER DRAINAGE BASIN.

DESCRIPTION.

Fish River is one of the largest streams in southern Seward Peninsula. It drains a large area south of the Bendeleben Mountains and discharges into Golofnin Sound. Its drainage area comprises 2,110 square miles above tide at White Mountain and is composed of two large basins of about equal size, that of Fish River proper to the east, and that of Niukluk River to the west. Fish River receives many large and important tributaries, of which Pargon River and Niukluk River with its tributaries, Casadepaga River and Ophir Creek, are economically the most important. These streams will receive separate consideration. Fish River rises in the heart of the Bendeleben Mountains and flows in a general southward direction. In its upper course it receives Boston Creek from the west and Mosquito Creek, Kathatulik and Etchepuk rivers, and Cache Creek from the east.

Oregon and Baker creeks are good-sized tributaries of Boston Creek. They rise in the mountains and occupy large U-shaped valleys similar to that of Boston Creek, carved out by former glaciers. The side streams in the mountains also occupy glaciated U-shaped valleys. Upper Fish River presents two very diversified types of topography—the mountains, which are high and rugged with elevations up to about 3,500 feet, and the Fish River flats, a lowland basin surrounded by mountains and hills. There is some timber along the river in the flats, but otherwise the drainage basin is largely barren of trees. The Omilak silver mine, located on Omilak Creek, tributary to Mosquito Creek, is the only mine in this area, and the only silver mine in this part of Alaska. The streams of this basin would furnish considerable power, but the area is, and probably always will remain, practically deserted.

The following is a list of miscellaneous measurements made in the Fish River drainage basin.

Miscellaneous measurements in Fish River drainage basin.

Date.	Stream.	Tributary to—	Locality.	Elevation.[a]	Discharge.	Drainage area.	Discharge per square mile.
1909				*Feet.*	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
Aug. 21	Boston Creek..	Fish River.....	1 mile above edge of mountains.	350	102	....	....
21	Baker Creek...	Boston Creek..	½ mile above edge of mountains.	450	2	....	....
21	Oregon Creek..	.....do..........	At edge of mountains...	700	11.1	....	....
Sept. 14	Fox River.....	Fish River.....	Dam site at Fox River roadhouse.	....	11.7	15.2	0.77

[a] Approximate.

PARGON RIVER DRAINAGE BASIN.

DESCRIPTION.

Pargon River rises in the heart of the Bendeleben Mountains, between the headwaters of Boston Creek on the east and Niukluk River on the west. After flowing southeastward through a U-shaped valley for about 15 miles it enters the Fish River flats, through which it winds for a somewhat longer distance, emptying into Fish River near the point where the latter stream leaves the flats. It drains a total area of 153 square miles, of which about 50 square miles lies within the mountainous area. Its principal tributaries are Dillon, McKelvie, and Helen creeks from the west and Decarey and Lanagan creeks from the east in the mountains, and Duncan and Ready Bullion creeks in the flats.

Its headwaters reach an elevation of about 2,800 feet. Chauik Mountain, at the head of Helen Creek, is 3,510 feet high. All the upper drainage basin of Pargon River has been glaciated, as is proved by the cirquelike heads of the valleys and the large deposits of morainic material at the mouths of the side canyons and of the main valley of the river. No glacial lakes have been formed and there are practically no springs within the area, but the high elevations serve to furnish a good water supply at all times during the mining season. The hills lying south of the lower course of the river are partly covered with a good growth of spruce, some of which has been used in flume construction on the Pargon ditch. The upper portion of the basin contains some thickets of alder, but is otherwise unforested. The divide between the extreme western portions of the Fish River flats, through which the Pargon flows, and the head of Ophir Creek is low, and advantage has been taken of it to divert the waters of Pargon River and its western tributaries into Ophir Creek, from which they are taken by a ditch lower down. The Pargon ditch is 11.2 miles long and has a capacity of about 36 second-feet in the lower portion. Gold has never been found in this basin in paying quantities, although considerable prospecting has been done.

No stream measurements were made on Pargon River or the ditch until 1909. Several gages had been installed on the ditch system of the Wild Goose Mining & Trading Co. in earlier years, and records are available on two of them. A number of measurements made by engineers of the company were of great assistance in defining the ratings. The following stations have been maintained in this basin:

Pargon River and Pargon ditch at intake, 1909.
Pargon ditch below McKelvie Creek, 1908–9.
Pargon ditch below Helen Creek, 1906–1909.

PARGON RIVER AND PARGON DITCH AT INTAKE.

This station, which was established July 1, 1909, is located at the intake of the Pargon ditch of the Wild Goose Mining & Trading Co. The records on the ditch show the quantity of water diverted from Pargon River; those on the river show the quantity that flows over the diversion dam; together they give the total discharge of the river available for the ditch. Records on this stream are also of considerable interest as showing the relative rates of run-off in the Bendeleben and Kigluaik mountains.

Dillon and Decarey creeks enter the river from the west and east, respectively, within a mile below the station; the tributaries above the station are unnamed. The results obtained on the ditch are excellent. No measurements of the river were obtained when there was any considerable amount of water running over the dam, and the gage readings prior to August 20, 1909, were taken from a gage which was poorly located. Records for the river are accordingly unsatisfactory, but the discharge over the dam is only a small portion of the total. There is probably a considerable amount of underground seepage past the station.

The lowest average discharge recorded for one week is 10.5 second-feet from July 28 to August 3, 1909, but there was probably a slightly lower minimum in 1908. No maximum values have been recorded.

Discharge measurements of Pargon River below intake of Pargon ditch in 1909.

[Elevation, 730 feet.]

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
Aug. 20	F. F. Henshaw	0.35	4.5
Sept. 18	....do	.25	1.5

Discharge measurements of Pargon ditch at intake in 1909.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
July 18	Lanagan and West	1.46	21.7
Aug. 20	F. F. Henshaw	1.41	20.3
Sept. 5	Lanagan and West	1.27	15.9
18	F. F. Henshaw	1.19	14.8

Daily gage height, in feet, and discharge, in second-feet, of Pargon River and Pargon ditch at intake for 1909.

[Drainage area, 20 square miles. Observer, E. Decarey.]

Day.	July.				August.				September.			
	River.		Ditch.		River.		Ditch.		River.		Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	0.85	48	....	0	....	1.0	0.94	8.6	0.22	1.0	1.35	18.6
2	.95	62	....	0	....	1.0	1.04	10.7	.22	1.0	1.33	18.0
3	.85	48	....	0	....	1.0	.92	8.2	.22	1.0	1.29	16.8
4	1.00	70	....	0	....	1.5	1.33	18.0	.22	1.0	1.29	16.8
5	.85	48	....	0	....	2.0	1.42	20.6	.22	1.0	1.27	16.3
6	1.10	89	....	0	....	1.0	1.25	15.8	.22	1.0	1.25	15.8
7	....	54	....	0	....	1.0	1.17	13.7	.22	1.0	1.23	15.2
8	.70	29	0.75	5.4	....	1.5	1.10	12.0	.22	1.0	1.19	14.2
9	.75	35	.75	5.4	0.75	35	1.42	20.6	.22	1.0	1.17	13.7
10	.70	29	.92	8.2	....	24	....	20.0	.22	1.0	1.17	13.7
11	.85	48	1.08	11.6	.55	16	1.33	18.0	.22	1.0	1.12	12.5
12	.75	35	1.08	11.6	.55	16	1.42	20.6	.22	1.0	1.12	12.5
13	.70	29	1.25	15.8	.70	29	1.33	18.0	.22	1.0	1.10	12.0
14	.55	16	1.42	20.6	.35	4.5	1.33	18.0	.28	2.3	1.31	17.4
15	.55	16	1.42	20.6	.45	9.0	1.33	18.0	.25	1.5	1.29	16.8
16	.45	9.0	1.42	20.6	.70	29	1.33	18.0	.28	2.3	1.35	18.6
17	....	7.0	1.46	21.7	.35	4.5	1.42	20.6	.25	1.5	1.23	15.2
18	.35	4.5	1.46	21.7	.35	4.5	1.42	20.6	.25	1.5	1.19	14.2
19	.35	4.5	1.54	24.1	....	4.5	1.42	20.6	.22	1.0	1.12	12.5
20	....	2.0	1.42	20.6	.35	4.5	1.42	20.6	.22	1.0	1.12	12.5
21	....	2.0	1.42	20.6	.30	2.8	1.42	20.6	.22	1.0	1.17	13.7
22	....	1.5	1.37	19.1	.25	1.5	1.39	19.7	.22	1.0	1.12	12.5
23	....	1.5	1.33	18.0	.22	1.0	1.35	18.6	.22	1.0	1.10	12.0
24	....	1.5	1.31	17.4	.22	1.0	1.33	18.0	....	1.0	....	12.0
25	....	1.5	1.17	13.7	.20	.7	1.31	17.4	.22	1.0	1.08	11.6
26	....	1.0	1.12	12.5	.20	.7	1.31	17.4	....	....	....	....
27	....	1.0	1.14	13.0	.20	.7	1.29	16.8	....	....	....	....
28	....	1.0	1.08	11.6	.20	.7	1.33	18.0	....	....	....	....
29	....	1.0	1.02	10.2	.20	.7	1.31	17.4	....	....	....	....
30	....	.7	.98	9.4	.25	1.5	1.39	19.7	....	....	....	....
31	....	.7	.94	8.6	.22	1.0	1.33	18.0	....	....	....	....
Mean.		22.5	....	11.7	....	6.54	....	17.5	....	1.16	....	13.4
Mean total..		34.2	....	....	....	24.0	....	....	....	14.6	....	....
Mean per square mile		1.71	....	....	....	1.20	....	....	....	.730	....	....
Run-off, depth in inches on drainage area......		1.97	....	....	....	1.38	....	....	....	.68	....	....

NOTE.—The combined discharges for the river and ditch give the total flow above the diversion dam. Values for the river are only approximate, as they were obtained from gage heights which were not of the highest accuracy by means of a rating table extended from measurements at low stages. They were computed in order to give a general idea of the total flow of the river.

PARGON DITCH BELOW McKELVIE CREEK.

Records at this station were begun July 1, 1908. The gage is located in a flume about 200 feet below the point where the McKelvie Creek lateral joins the main ditch and about 3 miles below the intake. The discharge of the ditch at this point shows the amount diverted from Pargon River and Dillon and McKelvie creeks, less the seepage in the upper 3 miles.

The flume is permanently founded on rock, and the rating developed in 1909 is believed to apply closely to gage readings obtained in 1908.

The lowest discharge recorded for one week is 8.16 second-feet, July 23 to 29, 1908. The capacity of this portion of the ditch is about 26 second-feet.

Discharge measurements of Pargon ditch below McKelvie Creek in 1909.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec. ft.*
July 18	Lanagan and West	1.60	26.1
Aug. 19	F. F. Henshaw	1.58	25.4
Sept. 5	Lanagan and Ayer	1.35	18.9
17	F. F. Henshaw	1.28	16.0
18	....do	.94	8.4
18	....do	1.24	14.5

Daily gage height, in feet, and discharge, in second-feet, of Pargon ditch below McKelvie Creek for 1908.

[Observer, E. Decarey.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	1.33	17.7	1.58	25.4	1.50	22.8
2	1.25	15.4	1.58	25.4	1.50	22.8
3	1.42	20.4	1.58	25.4	1.50	22.8
4	1.58	25.4	1.50	22.8	1.50	22.8
5	1.50	22.8			1.50	22.8
6	1.29	16.5	.75	5.0	1.58	25.4
7	1.29	16.5	1.58	25.4	1.58	25.4
8	1.17	13.4	1.58	25.4	1.58	25.4
9	1.08	11.2	1.58	25.4	1.58	25.4
10	1.08	11.2	1.58	25.4	1.58	25.4
11	1.17	13.4	1.58	25.4	1.54	24.1
12	1.17	13.4	1.58	25.4	1.54	24.1
13	1.17	13.4	1.58	25.4		
14	1.04	10.3	1.58	25.4		
15	1.04	10.3	1.58	25.4		
16	1.04	10.3	1.58	25.4		
17	1.04	10.3	1.58	25.4		
18	1.08	11.2	1.58	25.4		
19	1.00	9.4	1.58	25.4		
20	1.08	11.2	1.58	25.4		
21	1.04	10.3	1.54	24.1		
22	1.00	9.4	1.54	24.1		
23	1.00	9.4	1.54	24.1		
24	1.00	9.4	1.54	24.1		
25	.92	7.8	1.50	22.8		
26	.92	7.8	1.50	22.8		
27	.92	7.8	1.52	23.4		
28	.92	7.8	1.50	22.8		
29	.88	7.1	1.50	22.8		
30	1.58	25.4	1.50	22.8		
31	1.58	25.4	1.50	22.8		
Mean		13.3		23.1		24.1

Daily gage height, in feet, and discharge, in second-feet, of Pargon ditch below McKelvie Creek for 1909.

[Observer, E. Decarey.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.56	24.7	1.02	9.8	1.44	21.0
2			1.56	24.7	1.07	10.9	1.41	20.1
3			1.56	24.7	.99	9.2	1.36	18.6
4			1.56	24.7	1.50	22.8	1.33	17.7
5			1.58	25.4	1.49	22.5	1.36	18.6
6			1.58	25.4	1.36	18.6	1.33	17.7
7			1.57	25.0	1.25	15.4	1.29	16.5
8			1.58	25.4	1.21	14.4	1.28	16.3
9			1.56	24.7	1.12	12.1	1.22	14.6
10			1.58	25.4	0.62	3.3	1.20	14.1
11			1.58	25.4	1.58	25.4	1.21	14.4
12			1.57	25.0	1.60	26.0	1.21	14.4
13			1.58	25.4	1.58	25.4	1.17	13.4
14			1.56	24.7	1.58	25.4	1.36	18.6
15			1.59	25.7	1.59	25.4	1.35	18.3
16			1.57	25.0	1.57	25.0	1.35	18.3
17			1.56	24.7	1.58	25.4	1.32	17.4
18			1.60	26.0	1.58	25.4	1.25	15.4
19			1.58	25.4	1.58	25.4	1.21	14.4
20			1.54	24.1	1.58	25.4	1.16	12.8
21			1.51	23.1	1.58	25.4	1.17	13.4
22	1.38	19.2	1.44	21.0	1.56	24.7	1.19	13.8
23	1.42	20.4	1.42	20.4	1.52	23.4	1.19	13.8
24	1.58	25.4	1.28	16.3	1.50	22.8	1.19	13.4
25	1.56	24.7	1.23	14.9	1.47	21.9	1.13	12.4
26	1.50	22.8	1.17	13.4	1.45	21.3		
27	1.53	23.8	1.15	12.8	1.42	20.4		
28	1.50	22.8	1.11	11.8	1.46	21.6		
29	1.33	17.7	1.08	11.2	1.46	21.6		
30	1.47	21.9	1.08	11.2	1.46	21.6		
31			1.02	9.8	1.42	20.4		
Mean		22.1		21.5		20.6		16.0

PARGON DITCH BELOW HELEN CREEK.

Records have been kept in the flume across Helen Creek since 1906 by John Baker, the ditch walker. They show the amount of water that the ditch carries below Helen Creek, the lowest stream which it diverts. This point is about 4 miles above the outlet of the ditch into Ophir Creek. The loss by seepage in that distance is about 3 second-feet, which should be deducted from the discharges at the station to give the quantity of water delivered to the Canyon ditch on Ophir Creek. The lateral flume to Helen Creek enters the main ditch about 40 feet below the gage, which is located in the upper end of the flume, but the gage readings are believed to be a true index of the discharge below the junction. Measurements are made in the two flumes, and the sum gives the total discharge of the ditch.

The lowest recorded discharge for one week is 7.6 second-feet, July 24 to 29, 1908, but this value is believed to be 5 or 6 second-feet too small, as shown by comparison with records at other stations. The capacity of the ditch below Helen Creek is practically 36 second-feet.

Discharge measurements of Pargon ditch below Helen Creek in 1909.

Date.	Hydrographer.	Gage height.	Discharge. Above Helen Creek lateral.	Helen Creek lateral.	Total.
		Feet.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
Aug. 19	F. F. Henshaw	1.56	24.8	6.1	30.9
Sept. 17	do	1.27	15.5	5.8	21.3
19	do	1.19	12.7	5.6	18.3

Daily gage height, in feet, and discharge, in second-feet, of Pargon ditch below Helen Creek for 1906 and 1907.

[Observer, John Baker.]

Day.	1906 July. Gage height.	Discharge.	August. Gage height.	Discharge.	September. Gage height.	Discharge.	1907 July. Gage height.	Discharge.	August. Gage height.	Discharge.	September Gage height.	Discharge.
1			1.56	31.0	1.71	36.4			1.66	34.6	1.50	28.8
2			1.50	28.8	1.58	31.7			1.65	34.2	1.50	28.8
3			1.50	28.8	1.58	31.7			1.66	34.6	1.50	28.8
4			1.56	31.0	1.58	31.7			1.67	34.9	1.50	28.8
5			1.65	34.2	1.62	33.1			1.65	34.2	1.50	28.8
6			1.73	37.1	1.62	33.1			a1.62	16.6	1.48	28.1
7			a1.42	13.0	1.62	33.1			1.65	34.2	1.50	28.8
8			1.69	35.6	1.62	33.1			1.68	35.3	1.50	28.8
9			1.67	34.9	1.62	33.1			1.66	34.6	1.46	27.4
10			a1.71	18.2	1.62	33.1			1.62	33.1	a1.17	9.0
11			1.71	36.4	1.62	33.1			1.62	33.1		0
12			a1.71	18.2	1.42	26.1			1.67	34.9		0
13			a1.67	17.4	1.42	26.1			1.65	34.2		0
14			1.65	34.2	1.58	31.7			1.67	34.9		0
15				0	1.58	31.7	1.60	32.4	a1.62	16.6		0
16			a1.58	15.8	1.58	31.7	1.55	30.6	1.62	33.1		0
17			1.58	31.7	1.58	31.7	1.29	21.9	1.17	18.1		0
18			1.58	31.7	1.58	31.7	1.46	27.4	a0.83	4.5	1.00	13.2
19			1.58	31.7	a0.83	4.5	1.54	30.2	1.21	19.3	1.08	15.4
20			1.67	34.9		0	1.54	30.2	1.17	18.1	1.21	19.3
21	1.69	35.6	1.65	34.2	.83	9.0	1.42	26.1	1.12	16.6	1.27	21.2
22		0	1.62	33.1	1.00	13.2	1.56	31.0	1.08	15.4	1.40	25.4
23	1.73	37.1	1.58	31.7	1.00	13.2	1.56	31.0	1.38	24.8	1.38	24.8
24	1.67	34.9	1.58	31.7	1.00	13.2	a1.54	15.1	1.42	26.1	1.46	27.4
25	1.60	32.4	1.58	31.7	1.00	13.2	a1.54	15.1	1.42	26.1	1.46	27.4
26	1.71	36.4	a1.58	15.8			1.52	29.5	1.42	26.1	1.46	27.4
27	1.71	36.4		0			1.54	30.2	1.46	27.4	1.46	27.4
28	1.69	35.6		0			1.62	33.1	1.46	27.4	1.46	27.4
29	1.62	33.1	1.00	13.2			1.65	34.2	1.50	28.8	1.50	28.8
30	1.65	34.2	1.29	21.9			1.67	34.9	1.50	28.8	1.49	28.5
31	1.63	33.5	1.00	13.2			1.65	34.2	1.50	28.8		
Mn.		31.7		24.9		25.6		28.7		27.4		18.7

a Water turned out during day. Discharge taken as one-half of discharge corresponding to gage height.

Daily gage height, in feet, and discharge, in second-feet, of Pargon ditch below Helen Creek for 1908 and 1909.

[Observer, John Baker.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.							1908.						
1	1.58	31.7	1.58	31.7	1.71	36.4	16	0.92	11.1	1.67	34.9	1.62	33.1
2	1.42	26.1	1.58	31.7	1.71	36.4	17	.92	11.1	1.67	34.9	1.62	33.1
3	1.42	26.1	1.33	23.2	1.58	31.7	18	1.00	13.2	1.67	34.9	1.62	33.1
4	1.58	31.7	1.17	18.1	1.67	34.9	19	.92	11.1	1.67	34.9	1.58	31.7
5	1.50	28.8	......	......	1.67	34.9	20	.92	11.1	1.71	36.4	1.54	30.2
6	1.29	21.9	.92	11.1	1.67	34.9	21	.92	11.1	1.67	34.9	1.58	31.7
7	1.21	19.3	1.58	31.7	1.67	34.9	22	.92	11.1	1.67	34.9	1.58	31.7
8	1.17	18.1	1.62	33.1	1.67	34.9	23	.83	9.0	1.67	34.9	......	......
9	1.17	18.1	1.62	33.1	1.67	34.9	24	.83	9.0	1.69	35.6	......	......
10	1.17	18.1	1.62	33.1	1.67	34.9	25	.79	8.1	1.69	35.6	......	......
11	1.25	20.6	1.62	33.1	1.62	33.1	26	.75	7.3	1.67	34.9	......	......
12	1.25	20.6	1.71	36.4	1.62	33.1	27	.71	6.5	1.67	34.9	......	......
13	1.25	20.6	1.71	36.4	1.62	33.1	28	.71	6.5	1.67	34.9	......	......
14	1.00	13.2	1.71	36.4	1.62	33.1	29	.71	6.5	1.67	34.9	......	......
15	1.04	14.3	1.71	36.4	1.62	33.1	30	1.42	26.1	1.67	34.9	......	......
							31	1.00	13.2	1.67	34.9	......	......
							Mean.	......	16.2	......	31.8	......	33.6

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1	....	....	1.58	31.7	1.06	14.9	1.41	25.7
2	....	....	1.60	32.4	1.08	15.4	1.37	24.4
3	....	....	1.65	34.2	1.10	16.0	1.35	23.8
4	....	....	1.65	34.2	1.38	24.8	1.35	23.8
5	....	....	1.69	35.6	1.38	24.8	1.33	23.2
6	....	....	1.73	37.1	1.28	21.6	1.31	22.5
7	....	....	1.69	35.6	1.20	19.0	1.29	21.9
8	....	....	1.69	35.6	1.17	18.1	1.29	21.9
9	....	....	1.65	34.2	1.48	28.1	1.26	20.9
10	....	....	1.62	33.1	1.07	15.2	1.25	20.6
11	....	....	1.62	33.1	1.53	29.9	1.24	20.3
12	....	....	1.55	30.6	1.56	31.0	1.22	19.6
13	....	....	1.56	31.0	1.60	32.4	1.23	20.0
14	....	....	1.56	31.0	1.58	31.7	1.33	23.2
15	....	....	1.54	30.2	1.56	31.0	1.34	23.5
16	....	....	1.52	29.5	1.60	32.4	1.33	23.2
17	....	....	1.52	29.5	1.58	31.7	1.28	21.6
18	....	....	1.56	31.0	1.57	31.3	1.25	20.6
19	....	....	1.56	31.0	1.55	30.6	1.21	19.3
20	1.58	31.7	1.49	28.5	1.54	30.2	1.17	18.1
21	1.50	28.8	1.48	28.1	1.55	30.6	1.23	20.0
22	1.54	30.2	1.40	25.4	1.52	29.5	1.21	19.3
23	1.58	31.7	1.36	24.1	1.48	28.1	1.21	19.3
24	1.58	31.7	1.25	20.6	1.46	27.4	1.20	19.0
25	1.44	26.8	1.21	19.3	1.45	27.1	1.16	17.8
26	1.58	31.7	1.19	18.7	1.42	26.1	....	....
27	1.67	34.9	1.22	19.6	1.42	26.1	....	....
28	1.62	33.1	1.15	17.5	1.44	26.8	....	....
29	1.44	26.8	1.12	16.6	1.42	26.1	....	....
30	1.56	31.0	1.10	16.0	1.44	26.8	....	....
31	....	....	1.08	15.4	1.40	25.4	....	....
Mean	....	30.8	....	28.1	....	26.1	....	21.3

NOTE.—The gage is located in the flume across Helen Creek above the Helen Creek lateral, and the readings are assumed to be an index of the discharge below the junction, but when a large portion of the water is coming from Helen Creek the discharge may be greater for the same gage height. Discharges from about July 14 to 29, 1908, are questionable, because they are not consistent with those for the stations below and above. They may be 5 or 6 second-feet low.

MISCELLANEOUS MEASUREMENTS.

The following lists give the results of miscellaneous measurements made of streams and ditches in the Pargon River drainage basin.

Miscellaneous measurements in Pargon River drainage basin in 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.
				Feet.	*Sec.-ft.*	*Sq. m.*
Aug. 19	Pargon River	Fish River	Below Miocene intake.	610	[a] 26	36
Sept. 17	do	do	do	610	[a] 14.0	36
Aug. 19	Dillon Creek	Pargon River (from west).	Above Pargon ditch crossing.	720	4.0	
19	McKelvie Creek	do	Above Pargon ditch intake.	710	8.9	
Sept. 5	do	do	do	710	6.4	
18	do	do	do	710	4.5	
Aug. 19	Cawlfield Creek	Pargon River (from east).	Miocene ditch level	600	2.3	
22	Lanagan Creek	do	Above Miocene level	650	9.0	
Sept. 18	do	do	Below Miocene level	550	4.5	
Aug. 19	Helen Creek	Pargon River (from west).	In flume, at Pargon ditch intake.	700	6.1	
Sept. 17	do	do	do	700	5.8	
19	do	do	do	700	5.6	
Aug. 22	do	do	Miocene ditch crossing.	580	[b] 1.24	

[a] Not including Pargon ditch, the record below McKelvie Creek shows amount diverted past this station.
[b] Inflow below Pargon ditch intake.

Miscellaneous measurements of Pargon ditch in 1909.

Date.	Ditch.	Locality.	Gage height.	Discharge.
			Feet.	*Sec.-ft.*
Sept. 5	Pargon ditch	Above Dillon Creek		14.2
5	do	Below Dillon Creek		15.3
Aug. 19	do	1½ miles below Helen Creek	[a] 1.56	29.2
July 17	do	2 miles below Helen Creek	[a] 1.50	27.5
Sept. 5	do	Outlet into Ophir Creek	[a] 1.33	19.7
Aug. 19	McKelvie lateral	Near outlet		7.4
Sept. 5	do	do		3.9
18	do	do		3.0
Aug. 19	Helen Creek lateral	do	[a] 1.56	6.1
Sept. 17	do	do	[a] 1.27	5.8
19	do	do	[a] 1.19	5.6

[a] These gage heights refer to the Pargon ditch gage located about 40 feet above the outlet of the Helen Creek lateral.

NIUKLUK RIVER DRAINAGE BASIN.

DESCRIPTION.

Niukluk River, the large western tributary of Fish River, rises near Mount Bendeleben, at the west end of the Bendeleben Mountains, and flows in a general southeasterly direction to its junction with Fish River. It drains an area of 825 square miles, or nearly as much as that drained by the main river at the junction. Its upper drainage basin, like that of Fish River, presents a diversified topography, including as it does Mount Bendeleben, 3,760 feet in elevation, the highest peak in this portion of Seward Peninsula, and the highland surrounding it, as well as the flat lowland divide which stretches from Niukluk River to Kruzgamepa River on the west. Its principal tributaries are Kingsley and Shoestring creeks from the east in the mountains, Goldbottom, Ophir, and Melsing creeks lower down, and Libby River, American Creek, and Casadepaga River from the west. The basins of Casadepaga River, American Creek, and Ophir Creek will be described separately.

AMERICAN CREEK.

American Creek rises in the highlands north of the Casadepaga. In its upper course it has a moderate gradient and a rather wide gravel bed. After making a turn to the east it enters a steep canyon some 400 feet deep. Below this it enters the lowland previously noted and flows eastward into the Niukluk. Its principal tributaries are Auburn Ravine and Game Creek, both from the northeast above the canyon. Mining has been carried on in the basin of American Creek, notably on Auburn Ravine, but the production has not been great.

Records were kept on American Creek at two points during a part of the season of 1908 to obtain data of the amount of water available for sluicing. The upper station was located just below the mouth of Auburn Ravine, where channel conditions were somewhat shifting. Gage readings were obtained during part of July. The lower station was below Game Creek and above the canyon of American Creek. Gage readings were recorded for a few days in July and August. No measurements were obtained at the higher stages at either station.

Gage height, in feet, and discharge, in second-feet, of American Creek below Auburn Ravine for 1908.

[Drainage area, 13 square miles. Elevation, 600 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.	*Feet.*	*Sec.-ft.*	**Gage readings**—Continued.	*Feet.*	*Sec.-ft.*
July 9	0.40	2.0	July 15	0.40	2.0
July 18	.36	1.2	July 16	.37	1.4
Aug. 3	.43	2.0	July 17	.39	1.8
Sept. 17	.70	7.2	July 18	.38	1.6
			July 19	.39	1.8
Gage readings.			July 20	.41	2.2
July 10	.40	2.0	July 21	.38	1.6
July 11	.48	3.8	July 22	.37	1.4
July 12	.43	2.7	July 23	.35	1.0
July 13	.40	2.0	July 24	.35	1.0
July 14	.39	1.8	July 30	1.20	24.0

NOTE.—Mean discharges have been estimated as follows: July 9 to 31, 3.6 second-feet; Aug. 1 to 31, 4.1 second-feet.

Gage height, in feet, and discharge, in second-feet, of American Creek below Game Creek for 1908.

[Drainage area, 24 square miles. Elevation, 480 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.	*Feet.*	*Sec.-ft.*	**Gage readings**—Continued.	*Feet.*	*Sec.-ft.*
July 9	0.50	5.7	Aug. 1	0.70	19.0
July 18	.45	2.6	Aug. 2	.60	11.5
Aug. 25	.53	5.9	Aug. 3	.50	5.5
			Aug. 4	.50	5.5
Gage readings.			Aug. 5	1.10	53
July 29	.40	1.5	Aug. 6	.70	19.0
July 30	.60	11.5	Aug. 7	.60	11.5
July 31	1.00	44	Aug. 8	.50	5.5

NOTE.—Mean discharges have been estimated as follows: July 9 to 31, 5.5 second-feet; Aug. 1 to 31, 9.3 second-feet.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Niukluk River drainage basin.

Miscellaneous measurements in Niukluk River drainage basin in 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
Sept. 15	Niukluk River	Fish River	Above Ophir Creek.	100	296	644	0.46
Sept. 14	Melsing Creek	Niukluk River	Mouth	80	9.6	30	.32

CASADEPAGA RIVER DRAINAGE BASIN.

DESCRIPTION.

Casadepaga River, the largest western tributary of the Niukluk, rises south of Iron Creek and flows in a northeasterly direction, joining the main stream about 15 miles above Council. It drains an area of about 224 square miles composed largely of limestone and schist hills.

Its principal tributaries are Willow, Curtis, Ruby, Penelope, Big Four, and No Man creeks from the southeast and Moonlight, Lower Willow, Canyon, Goose, and Bonanza creeks from the northwest. Placer gold has been mined on the river and most of its tributaries.

Moonlight Creek is notable for the large limestone springs which furnish its principal water supply and which rise about a mile above its mouth. The Moonlight Creek ditch, which has its intake at the springs, is about 2 miles long and diverts water to bench claims on the left bank of the Casadepaga. It is 6 feet wide on the bottom and has a capacity of about 15 second-feet. Work has been done on this ditch at different times since 1902, but it is not complete and only a little water was carried through it in 1908.

Canyon Creek is another important confluent and supplies two ditches. One has its intake just below All Gold Creek, 4 miles above the mouth, and extends about 3½ miles along the left bank, picking up the flow of Boulder Creek. The other takes its water from a large spring just above the mouth of Boulder Creek, also on the left bank. There are also small ditches about 2 miles long on Ruby and Penelope creeks and a short ditch on Goose Creek.

The only gaging station that has been maintained on Casadepaga River is located below Moonlight Creek.

CASADEPAGA RIVER BELOW MOONLIGHT CREEK.

This station, which was established July 3, 1908, was located just below the mouth of Moonlight Creek, about half a mile above Curtis Creek and 6 miles above Lower Willow Creek. The records show the run-off of the upper part of the Casadepaga drainage basin and in connection with miscellaneous measurements indicate the water supply available for the Moonlight Creek ditch and the proposed extension to the upper Casadepaga. The low-water flow at this point comes largely from springs, the largest being those on Moonlight Creek. The stream is subject to quick and severe floods. The maximum discharge recorded is 1,080 second-feet, July 30, 1908, but this is believed not to be by any means a maximum flow. The low-water discharge in 1908 is uncertain, as no measurements of less than 40 second-feet were obtained, but the measurement of 1909 was made at a time of an equally severe drought, and the discharge obtained, 20 second-feet, is believed to represent nearly a minimum.

Discharge measurements of Casadepaga River below Moonlight Creek in 1908 and 1909.

[Elevation, 400 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 3	0.85	68	Sept. 17	.92	80
July 12	.75	48	1909.		
Aug. 5	1.40	246			
Aug. 26	.85	68	Aug. 29	....	20

Daily gage height, in feet, and discharge, in second-feet, of Casadepaga River below Moonlight Creek for 1908.

[Drainage area, 47 square miles. Observer, K. Karlin.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	110	0.9	76	......	60	21	.65	36	.7	42	......	......
2	......	70	.8	56	......	55	22	.6	30	......	42	......	......
3	0.85	66	.8	56	......	52	23	.55	25	......	75	......	......
4	1.0	100	......	100	......	50	24	.55	25	......	70	......	......
5	1.0	100	1.4	246	......	50	25	.5	20	......	70	......	......
6	.85	66	1.5	300	......	50	26	.5	20	.85	66	......	......
7	.8	56	.9	76	......	50	27	.5	20	......	60	......	......
8	.8	56	.8	56	......	50	28	.5	20	......	55	......	......
9	.8	56	.8	56	0.75	49	29	.5	20	......	52	......	......
10	.75	49	.8	56	......	48	30	2.8	1,080	......	50	......	......
11	.75	49	.9	76	......	45	31	1.7	420	......	70	......	......
12	.75	49	.9	76	......	42	Mean		92.1	......	78.7	......	51.9
13	.75	49	1.1	127	......	40							
14	.7	42	.9	76	......	38	Mean per square mile		1.96	......	1.67	......	1.10
15	.7	42	.9	76	......	42							
16	.65	36	.8	56	......	50	Run-off depth, in inches, on drainage area		2.26	......	1.93	......	.74
17	.7	42	.8	56	.95	88							
18	.65	36	.8	56	.9	76							
19	.6	30	.8	56	......	......							
20	.65	36	.8	56	......	......							

NOTE.—Some water was diverted past the station in Moonlight Creek ditch.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Casadepaga River drainage basin:

Miscellaneous measurements in Casadepaga River drainage basin in 1908 and 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
Aug. 29, 1909	Casadepaga River.	Niukluk River.	½ mile above Whisky Creek.	500	9.0	29	0.31
July 3, 1908	.....do	.....do	Above Moonlight Creek.	400	57	46	1.24
July 12, 1908	.....do	.....do	.....do	400	38	46	.83
Aug. 26, 1908	.....do	.....do	.....do	400	58	46	1.26
Sept. 17, 1908	.....do	.....do	.....do	400	72	46	1.57
Aug. 29, 1908	.....do	.....do	.....do	400	11.3	46	.25
Do	.....do	.....do	Below Moonlight Creek, including ditch.	400	20	47	.43
July 3, 1908	Moonlight Creek.	Casadepaga River.	Ditch intake	485	8.0	.81	(a)
July 12, 1908	.....do	.....do	.....do	485	7.6	.81	(a)
Aug. 5, 1908	.....do	.....do	.....do	485	17.0	.81	(a)
Aug. 26, 1908	.....do	.....do	.....do	485	10.2	.81	(a)
Sept. 17, 1908	.....do	.....do	.....do	485	6.5	.81	(a)
Aug. 29, 1909	.....do	.....do	.....do	485	6.7	.81	(a)
July 3, 1908	.....do	.....do	Mouth	400	11.2	1.0	(a)
July 12, 1908	.....do	.....do	.....do	400	10.1	1.0	(a)
Sept. 17, 1908	.....do	.....do	.....do	400	8.5	1.0	(a)
Aug. 29, 1909	.....do	.....do	.....do	400	8.9	1.0	(a)

[a] The discharge of Moonlight Creek comes from large limestone springs which probably receive much of their water from outside the surface drainage area of the creek.

Miscellaneous measurements in Casadepaga River drainage basin in 1908 and 1909—Con.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
Aug. 28, 1909	Ruby Creek		Mouth	310	1.8	6.0	0.30
Aug. 4, 1908	Lower Willow Creek.	Casadepaga River.	Above Ridgeway Creek.	400	a 6.0	15.4	.39
Aug. 26, 1908	....do	....do	....do	400	10.4	15.4	.68
Sept. 17, 1908	....do	....do	....do	400	17.0	15.4	1.10
Aug. 28, 1909	....do	....do	....do	400	5.8	15.4	.38
July 10, 1908	Canyon Creek	....do	Above intake, C. C. G. M. Co.'s ditch intake.	510	6.0	4.6	1.30
Aug. 28, 1909	....do	....do	....do	510	1.2	4.6	.26
July 11, 1908	....do	....do	Below Boulder Creek, including ditches.	355	15.4	22	.70
Aug. 3, 1908	....do	....do	....do	355	11.0	22	.50
Aug. 25, 1908	....do	....do	....do	355	22	22	1.00
Sept. 17, 1908	....do	....do	....do	355	27	22	1.23
Aug. 28, 1909	....do	....do	....do	355	9.4	22	.43
Do	Spring	Canyon Creek	At intake of McKay ditch.	395	6.4		
Do	Boulder Creek	....do	Mouth	355	.5	5.0	.11

a Estimated

OPHIR CREEK DRAINAGE BASIN.

DESCRIPTION.

Ophir Creek rises in the Bendeleben Mountains at the foot of Mount Chauik and flows southward to its junction with the Niukluk about 4 miles above Council. It drains an area of about 71 square miles of varied topography, comprising Mount Chauik, 3,510 feet in elevation, and several high limestone hills, as well as a large flat area near the head of the stream, which is a continuation of the lowland that stretches eastward and forms the Fish River flats. Its principal tributaries are Oxide, Crooked, Guy, and Sweetcake creeks from the west and Dutch Creek from the east.

The drainage basin of Ophir Creek is divided into an upper and a lower part, connected by a comparatively narrow canyon several hundred feet deep. The upper basin may possibly have formerly drained, through a channel now buried, across the low divide into Pargon River. If so, the stream which was at that time the head of Ophir Creek proper is now only one of its small tributaries. Ophir Creek flows over a rather wide deep-gravel bed at all points below the canyon. In some places where it crosses limestone the bedrock is broken and porous and the water sinks into it; at such points mining pits drain themselves when the creek is diverted away from its bed. This feature is most noticeable between claims "No. 6 above" and "No. 15 above." The water rises in the form of a spring on claim "No. 5 above." The drainage basin of Ophir Creek itself bears no timber, but it is covered with a thick growth of willows, alders, and birch.

Some of the slopes of the Melsing Creek basin, just south of Ophir Creek, are well timbered and furnish much good lumber for mining and building.

Ophir Creek, which lies well back from the coast and at a somewhat higher elevation than the coastal plain, has a slightly shorter season than Nome. The freeze-up usually occurs about the last of September.

The first discoveries of gold in Seward Peninsula were made on Ophir Creek in 1897, and since that time the stream has been a scene of constant mining activity. The total production of the creek to date has probably been some $6,000,000 or $8,000,000 in value.

Several ditches have been built to convey water for mining. The largest is the Canyon ditch of the Wild Goose Mining & Trading Co., which has its intake near the head of the canyon and extends down the right bank of the creek for about 17 miles. Some details referring to the ditch are given on page 257. The "22" ditch has its intake on claim No. 22, and extends along the left bank of the creek to the mouth of Dutch Creek and up Dutch Creek to claim No. 3. The "19" ditch diverts the water to the right bank and extends as far as the discovery claim. A ditch on Dutch Creek has its intake about 4 miles above the mouth and extends to bench claims on Ophir Creek just below the mouth of Dutch Creek, and similar ditches convey water for sluicing.

A fair reservoir site at the head of the canyon might be used for storing water to supply the ditches, but it has never been developed. The survey of this site made for the Wild Goose Mining & Trading Co. shows that a 60-foot dam 200 or 300 feet in length would flood an area of 92 acres and would hold 110,000,000 cubic feet, or 2,530 acre-feet.

The following stations have been maintained in this drainage basin:

Canyon ditch near intake, 1906-1909.
Canyon ditch above claim "No. 10 above," 1909.

OPHIR CREEK AT CANYON DITCH INTAKE.

Discharges for Ophir Creek above the canyon for the summer of 1909 have been obtained by subtracting the water discharged over the divide by the Pargon ditch from the quantity diverted by the Canyon ditch. There was practically no flow over the dam after July 1, and the seepage through the bedrock dam is so small as to be negligible. A small amount of water was diverted by a ditch from Portland Gulch, a tributary of Oxide Creek, over the divide at the head of Crooked Creek. This ditch was carrying 1.38 second-feet on August 23, but probably carried a much larger quantity during the early part of July. The minimum discharge of Ophir Creek recorded in 1909 was 9 second-feet July 29 to August 2. The records on the Pargon ditch below Helen Creek for the low water of 1908 are uncertain, so that the natural discharge of Ophir Creek can not be computed. It may have been lower than in 1909.

Daily discharge, in second-feet, of Ophir Creek at Canyon ditch intake for 1909.

[Drainage area, 24 square miles.]

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	27	9	15	21	12	18	13
2	27	9	16	22	15	17	19
3	25	11	15	23	13	18	18
4	24	19	15	24	12	17	19
5	23	13	16	25	11	16	16
6	23	13	15	26	10	17	....
7	25	12	15	27	10	16	....
8	21	13	14	28	11	16	....
9	24	25	14	29	9	16	....
10	26	38	14	30	9	16	....
11	23	21	14	31	9	16	....
12	26	19	14	Mean	17.2	17.7	15.5
13	23	24	14	Mean per square mile	.717	.738	.646
14	19	18	19	Run off, depth in inches, on drainage area	.83	.85	.60
15	19	20	16				
16	18	23	16				
17	17	21	19				
18	16	19	13				
19	15	19	15				
20	14	19	14				

NOTE.—These discharges were obtained by subtracting the discharge of the Pargon ditch below Helen Creek from that of the Canyon ditch at the intake and adding 3 second-feet, the approximate amount of water lost by seepage from the Pargon ditch below Helen Creek.

CANYON DITCH NEAR INTAKE.

Records of stage have been kept on the Canyon ditch about 1 mile below the intake by J. J. McKenzie, ditch walker, for four seasons. The records show the amount diverted from Ophir Creek, which includes not only the natural flow but also the discharge of the Pargon ditch. The gage is located in an earth section which is believed to be permanent, and the gage itself has probably remained unchanged since the records began. Measurements are made from a foot plank at the gage. Figure 9 (p. 59) shows the discharge, area, and mean-velocity curves derived from measurements at this station. The minimum weekly discharge recorded is 19.5 second-feet, July 23 to 29, 1908. The lowest week of 1909, July 28 to August 3, gave an average of 22.3 second-feet. The capacity of the ditch is practically 65 second-feet.

Discharge measurements of Canyon ditch near intake in 1908 and 1909.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
Sept. 8	W. H. Lanagan	10.1	23.5	2.40	2.50	[a] 56.4
1909.						
July 17	Lanagan and West	14.0	25.2	1.75	2.15	44.0
Aug. 2	Lanagan and Shutts	11.6	14.4	1.44	1.38	20.7
18	F. F. Henshaw	14.5	26.6	1.78	2.23	47.3
23	.....do	14.4	25.3	1.73	2.12	43.8
Sept. 5	Lanagan and Ayer	13.4	21.2	1.63	1.92	34.5
17	F. F. Henshaw	13.6	22.0	1.65	1.99	36.3
19	.....do	13.6	19.9	1.63	1.81	32.4
20	.....do	12.6	16.6	1.53	1.54	25.3

[a] Measured by floats in flume.

Daily gage height, in feet, and discharge, in second-feet, of Canyon ditch near intake for 1906 to 1909.

[Observer, J. J. McKenzie.]

Day.	June.		July.		August.		September.		October.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906.										
1			1.92	36.0	2.46	54.9	2.67	63.0	2.33	50.1
2			1.92	36.0	2.33	50.1	2.67	63.0	2.00	38.6
3			2.04	40.0	2.33	50.1	2.67	63.0	2.00	38.6
4			2.27	47.9	2.33	50.1	2.69	63.8	2.00	38.6
5			2.42	53.4	2.54	57.9	2.69	63.8	2.00	38.6
6			2.44	54.1	2.62	61.0	2.69	63.8	2.00	38.6
7			2.35	50.8	2.33	50.1	2.69	63.8	2.00	38.6
8			2.56	58.7	2.46	54.9	2.69	63.8	2.00	38.6
9			2.46	54.9	2.67	63.0	2.67	63.0	2.00	38.6
10			2.67	63.0	2.39	51.9	2.67	63.0		
11			2.67	63.0	2.67	63.0	2.67	63.0		
12			2.67	63.0	2.50	56.4	2.67	63.0		
13			2.67	63.0	2.33	50.1	2.67	63.0		
14			2.67	63.0	2.67	63.0	2.67	63.0		
15			2.67	63.0	2.08	41.3	2.67	63.0		
16			2.67	63.0	2.00	38.6	2.67	63.0		
17			2.17	44.4	2.50	56.4	2.67	63.0		
18			2.54	57.9	2.50	56.4	2.67	63.0		
19			2.54	57.9	2.50	56.4	2.67	63.0		
20			2.54	57.9	2.67	63.0	2.67	63.0		
21			2.62	61.0	2.67	63.0	2.67	63.0		
22			2.42	53.4	2.67	63.0	2.67	63.0		
23			2.62	61.0	2.67	63.0	2.67	63.0		
24			2.58	59.4	2.67	63.0	2.67	63.0		
25			2.62	61.0	2.42	53.4	2.67	63.0		
26			2.67	63.0	2.67	63.0	2.67	63.0		
27			2.58	59.4	2.67	63.0	2.67	63.0		
28	1.83	33.2	2.58	59.4	2.67	63.0	2.67	63.0		
29	1.83	33.2	2.58	59.4	[a]2.42	26.7	2.67	63.0		
30	1.83	33.2	2.56	58.7	2.67	63.0	2.67	63.0		
31			2.54	57.9	2.67	63.0				
Mean		33.2		56.3		56.0		63.1		39.9

Day.	1907						1908					
	June.		July.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1							2.08	41.3	2.17	44.4	2.67	63.0
2							1.67	28.4	2.04	41.0	2.67	63.0
3							1.83	33.2	2.04	40.0	2.67	63.0
4			2.00	38.6			1.75	30.7	2.33	50.1	2.67	63.0
5			2.25	47.2			1.75	30.7	2.25	47.2	2.62	61.0
6			2.50	56.4			1.83	33.2	2.42	53.4	2.54	57.9
7			2.58	59.4			1.83	33.2	2.50	56.4	2.50	56.4
8			2.58	59.4			1.67	28.4	2.54	57.9	2.50	56.4
9			2.58	59.4			1.67	28.4	2.58	59.4	2.42	53.4
10			2.62	61.0			1.58	25.9	2.58	59.4	2.42	53.4
11							1.67	28.4	2.58	59.4	2.42	53.4
12							1.75	30.7	2.58	59.4	2.33	50.1
13							1.58	25.9	2.58	59.4	2.33	50.1
14							1.58	25.9	2.58	59.4	2.33	50.1
15							1.46	22.8	2.58	59.4	2.58	59.4
16							1.46	22.8	2.33	50.1	2.42	53.4
17							1.46	22.8	2.58	59.4	2.37	51.5
18							1.46	22.8	2.58	59.4	2.25	47.2
19							1.33	19.9	2.58	59.4	2.29	48.6
20	1.83	33.2					1.58	25.9	2.54	57.9	2.08	41.3

[a] Water turned out in afternoon. Discharge for day taken as one-half of discharge corresponding to gage height.

Daily gage height, in feet, and discharge, in second-feet, of Canyon ditch near intake for 1906 to 1909—Continued.

Day.	1907						1908					
	June.		July.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
21	2.21	45.8			2.58	59.4	1.50	23.8	2.50	56.4	2.42	53.4
22	2.33	50.1			2.58	59.4	1.37	20.7	2.50	56.4	2.08	41.3
23	2.33	50.1			2.58	59.4	1.37	20.7	2.50	56.4		
24	2.42	53.4			2.58	59.4	1.33	19.9	2.67	63.0		
25	2.42	53.4			2.58	59.4	1.33	19.9	2.67	63.0		
26	2.46	54.9			2.58	59.4	1.33	19.9	2.67	63.0		
27	2.33	50.1			2.58	59.4	1.33	19.9	2.67	63.0		
28	2.37	51.5			2.58	59.4	1.25	18.1	2.58	59.4		
29	2.50	56.4			2.58	59.4	1.25	18.1	2.50	56.4		
30	2.50	56.4					1.67	28.4	2.46	54.9		
31							2.17	44.4	2.50	56.4		
Mean		50.5		54.5		59.4		26.3		56.1		54.1

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			2.50	56.4	1.38	21.0	1.98	38.0
2			2.50	56.4	1.38	21.0	1.96	37.3
3			2.50	56.4	1.50	23.8	1.92	36.0
4			2.48	55.6	2.04	40.0	1.92	36.0
5	1.25	18.1	2.48	55.6	1.88	34.8	1.92	36.0
6	1.25	18.1	2.52	57.2	1.78	31.6	1.88	34.8
7	1.25	18.1	2.52	57.2	1.67	28.4	1.85	33.8
8	1.25	18.1	2.42	53.4	1.65	27.8	1.81	32.5
9	2.00	38.6	2.48	55.6	2.32	49.7	1.79	31.9
10	2.08	41.3	2.50	56.4	2.33	50.1	1.79	31.9
11	2.21	45.8	2.42	53.4	2.27	47.9	1.77	31.3
12	2.21	45.8	2.42	53.4	2.29	48.6	1.75	30.7
13	2.25	47.2	2.36	51.2	2.42	53.4	1.75	30.7
14	2.17	44.4	2.25	47.2	2.40	52.6	2.02	39.3
15	2.08	41.3	2.21	45.8	2.28	48.3	1.92	36.0
16	2.08	41.3	2.17	44.4	2.38	51.9	1.92	36.0
17	2.08	41.3	2.14	43.4	2.31	49.4	1.97	37.6
18	2.08	41.3	2.17	44.4	2.25	47.2	1.75	30.7
19	2.08	41.3	2.14	43.4	2.23	46.5	1.77	31.3
20	2.08	41.3	2.04	40.0	2.21	45.8	1.69	28.9
21	2.21	45.8	1.96	37.3	2.19	45.1	1.73	30.1
22	2.29	48.6	1.96	37.3	2.16	44.0	1.91	35.7
23	2.38	51.9	1.85	33.8	2.12	42.7	1.86	34.1
24	2.38	51.9	1.71	29.5	2.07	41.0	1.88	34.8
25	2.17	44.4	1.62	27.0	2.04	40.0	1.76	31.0
26	2.17	44.4	1.58	25.9	2.04	40.0	[a]1.50	11.9
27	2.33	50.1	1.62	27.0	2.02	39.3		
28	2.50	56.4	1.55	25.1	2.05	40.3		
29	2.50	56.4	1.45	22.6	2.02	39.3		
30	2.50	56.4	1.42	21.9	2.04	40.0		
31			1.41	21.6	1.98	38.0		
Mean		41.9		43.1		41.0		33.0

[a] Water turned out in afternoon Discharge for day taken as one-half of discharge corresponding to gage height.

NOTE.—The gage and channel conditions are believed to be permanent. No record was kept between July 10 and Sept. 21, 1907, but the ditch was full practically all the time. The records do not cover the full period at the beginning of 1906 and 1908, water having been turned in early in June both years.

CANYON DITCH ABOVE CLAIM "NO. 10 ABOVE."

This station, which was established July 10, 1909, is located above the penstock taking water for use on claim "No. 10 above," which was the first diversion from the ditch in 1909. The records thus show the amount of water delivered to the mines.

The gage, which was located in the middle of the ditch, was difficult to read on account of waves, and the records are accordingly liable to some error.

Discharge measurements of Canyon ditch above claim "No. 10 above" in 1909.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
July 10	Shutts and Anderson	1.45	37.8
14	.....do	1.28	33.3
19	Lanagan and Shutts	1.28	33.2
26	Shutts and Anderson	.80	16.1
Aug. 18	F. F. Henshaw	1.44	42.8
24	.....do	1.29	36.2
Sept. 15	.....do	1.26	34.5

Daily gage height, in feet, and discharge, in second-feet, of Canyon ditch above claim No. 10 for 1909.

[Observers, J. Anderson and C. Leslie.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.64	11.4	1.34	35.4	16	1.20	30.1	1.53	42.8	1.27	32.8
2			.62	10.8	1.31	34.3	17	1.24	31.6	1.51	42.0	1.30	33.9
3			.68	12.5	1.30	33.9	18	1.21	30.5	1.48	40.8		27.5
4			1.20	30.1	1.30	33.9	19	1.20	30.1	1.48	40.8		28.1
5			1.08	25.8	1.31	34.3	20	1.14	27.9	1.42	38.5		25.7
6			1.10	26.5	1.24	31.6	21	1.04	24.3	1.43	38.9		26.9
7			.99	22.5	1.24	31.6	22	.99	22.5	1.40	37.7	1.24	31.6
8			.98	22.2	1.20	30.1	23	1.00	22.9	1.38	36.9	1.22	30.9
9			1.24	31.6	1.18	29.4	24	.90	19.3	1.33	35.0	1.26	32.4
10	1.45	39.6	1.46	40.0	1.18	29.4	25	.84	17.4	1.33	35.0	1.19	29.7
11	1.39	37.3	1.33	35.0	1.18	29.4	26	.80	16.1	1.33	35.0	1.00	22.9
12	1.40	37.7	1.44	39.3	1.14	27.9	27	.80	16.1	1.34	35.4		
13	1.30	33.9	1.50	41.6	1.14	27.9	28	.78	15.5	1.39	37.3		
14	1.24	31.6	1.57	44.4	1.34	35.4	29	.70	13.0	1.40	37.7		
15	1.20	30.1	1.49	41.2	1.29	33.5	30	.68	12.5	1.38	36.9		
							31	.65	11.6	1.36	36.2		
							Mean.		25.1		33.6		30.8

NOTE.—Discharges from Sept. 18 to 21 were interpolated. No record was kept before July 10.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements of Ophir Creek and the ditches diverting water from it:

Miscellaneous measurements in Ophir Creek drainage basin in 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
Sept. 20	Ophir Creek	Niukluk River	Above intake of "22" ditch.	220	7.1		
20	do	do	Above intake of "22" ditch including Ophir Creek water in Canyon ditch.	220	17	38	0.45
20	do	do	Below intake of "19" ditch.	200	*a*.5		
Aug. 18	"22" ditch	Diverts from Ophir Creek on claim "No. 22 above."	At intake	220	3.3		
24	do	do	do	220	3.3		
Sept. 20	do	do	do	220	2.3		
Aug. 18	"19" ditch	Diverts from Ophir Creek on claim "No 19 above."	do	210	5.7		
24	do	do	do	210	5.8		
Sept. 20	do	do	do	210	4.3		
Aug. 25	Hot Air ditch	Diverts from Ophir Creek on claim "No. 10 above."	On claim "No. 4 above."	160	11.3		
23	Stitch ditch	Diverts from Portland Gulch, tributary of Oxide Creek.	At outlet	550	1.38		

a Estimated.

Miscellaneous measurements of Canyon ditch in 1909.

Date.	Locality.	Hydrographer.	Gage height.	Discharge.
			Feet.	*Sec.-ft.*
Aug. 23	Below Crooked Creek flume	F. F. Henshaw		40.6
July 10	Below claim "No. 10 above"	Shutts and Anderson	1.80	29.7
14	do	A. B. Shutts	1.50	21.5
Aug. 18	do	F. F. Henshaw	1.74	33.4
24	do	do	1.64	28.7
Sept. 15	do	do	1.58	25.1
July 14	Above claim "No. 6 above"	Shutts and Anderson	1.83	20.9
Aug. 1	do	Shutts and Burton	1.54	10.3
18	do	F. F. Henshaw	2.03	30.4
Sept. 15	do	do	1.90	26.7
16	do	do	1.84	24.6
July 10	Below claim "No. 6 above"	Shutts and Anderson	1.80	25.5
Sept. 15	do	F. F. Henshaw		14.0
July 10	Below claim "No. 4 above"	Shutts and Anderson	.96	6.80
14	do	do	.71	2.19
Aug. 13	do	A. B. Shutts	.37	.00

SOLOMON RIVER DRAINAGE BASIN.

DESCRIPTION.

Solomon River enters Bering Sea about 40 miles east of Nome. It flows in a southward course for about 20 miles and drains an area of 134 square miles. The greater part of its basin consists of an upland in which there are limestone hills reaching an elevation of some 1,600 feet. This upland merges into a coastal plain about 3 miles wide, lying just back of the beach. The principal tributaries are Johns and Shovel creeks from the west and Coal Creek, East Fork, and Big Hurrah Creek from the east. There are many small tributaries, some of which are important as gold-producing streams. The basin contains much limestone, and springs emerging from limestone occur on Shovel Creek, East Fork, and other tributaries. The stream beds are mostly wide and shallow. Most of the shallow gravels thaw during the summer and freeze in the winter, though there are some places where the ground a few feet below the surface remains unfrozen throughout the year. There are practically no trees within the basin, aside from willows and alders.

Mining has been carried on to some extent on Solomon River and practically all its tributaries. Ditches convey water for hydraulicking on the upper river and on Coal Creek, East Fork, Big Hurrah Creek, and Shovel Creek. These have been used principally to run hydraulic elevators. The most important mining operations within the basin are carried on by the use of dredges. Solomon River is especially adapted to dredging on account of its thawed river bed, moderate depth of gravel, and favorable bedrock. Considerable power could be developed to run dredges operating on the river by building diverting ditches, but no such power has yet been utilized. One gaging station on Solomon River below East Fork was maintained in this basin during portions of the seasons of 1908 and 1909. The data obtained are of value for showing the available water supply for power development and for use in making comparisons of run-off in contiguous drainage basins.

SOLOMON RIVER BELOW EAST FORK.

This station is located below the mouth of East Fork near the roadhouse and just above the bridge of the Council City & Solomon River Railroad, at an elevation of 146 feet. Daily records of the amount of water carried by the East Fork ditch, which diverts water past the station, were not obtained, but enough measurements were made to permit an estimate of the flow to be added to the amount recorded at the Solomon River station to determine approximately the natural discharge of the river. The flow below East Fork is fairly well maintained, especially the portion supplied by East Fork, which has many limestone springs. In 1908 the gage was located in a broad, shallow portion of the stream which shifted somewhat, and results for that year are therefore not of the highest accuracy. In 1909 the gage was located on a well-confined channel just above the roadhouse, and the records for that year are good. At low water practically all the flow contributed by the East Fork was carried past the station by the East Fork ditch.

The minimum flow recorded at this station for one week was 32.4 second-feet, for July 23 to 29, 1908, but the river got nearly as low in 1909. Probably very little water was diverted past the station in the ditch at this time. The highest discharges recorded at the station represent only a small percentage of the maximum discharge occurring during flood periods.

Discharge measurements of Solomon River below East Fork in 1908 and 1909.

[Elevation, 146 feet.]

Date.	Gage height.	Dis-charge.	Date.	Gage height.	Dis-charge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 4	0.42	63	Aug. 16	0.38	66
July 12	.37	67	Aug. 26	.21	39
Aug. 6	.90	303	Sept. 13	.16	37
Aug. 27	.30	88			

Daily gage height, in feet, and discharge, in second-feet, of Solomon River below East Fork for 1908 and 1909.

[Drainage area, 66 square miles. Observers, George Gage and J. P. Samuelson.]

Day.	1908				1909			
	July.		August.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
1			0.55	162			0.18	37
2			.39	115			.17	36
3			.31	95			.16	35
4	0.48	81	.72	224			.18	37
3	.47	79	1.53	682			.18	37
6	.46	77	.85	280			.18	37
7	.46	77	.51	150				37
8	.41	65	.38	112				36
9	.42	68						35
10	.40	63						34
11	.39	61						33
12	.42	68						32
13	.35	54					.14	32
14	.36	55					.30	53
15	.34	52					.15	34
16	.32	48			0.38	66	.16	35
17	.32	48			.32	56	.32	56
18	.27	40			.29	52	.25	46
19	.24	36			.28	50		46
20	.27	40			.25	46		46
21	.25	37			.25	46		46
22	.23	34			.23	43		46
23	.22	33			.22	42	.33	58
24	.23	34			.21	40	.36	63
25	.22	33			.20	39		
26	.21	31			.20	39		
27	.20	30			.20	39		
28	.22	33			.20	39		
29	.22	33			.20	39		
30	1.23	375			.18	37		
31	1.55	692			.18	37		
Mean		84.9		228		44.4		41.1
Mean of East Fork ditch		6.5		10		3.7		4.5
Mean total		91.4		238		48.1		45.6
Mean per square mile		1.38		3.61		.729		.691
Run-off, depth in inches on drainage area		1.44		1.07		.43		.62

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Solomon River drainage basin:

Miscellaneous measurements in Solomon River drainage basin from 1907 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Gage height.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Feet.*	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
Aug. 27, 1909	Solomon River	Bering Sea	Above Coal Creek	250	....	2.1	10	0.21
Oct. 1, 1907	do	do	Below Johns Creek	245	....	51	40	1.28
July 4, 1908	do	do	do	245	0.66	60	40	1.50
July 12, 1908	do	do	do	245	.43	37	40	.92
Aug. 6, 1908	do	do	do	245	1.15	190	40	4.75
Aug. 27, 1908	do	do	do	245	.52	61	40	1.52
Sept. 18, 1908	do	do	do	245	.55	57	40	1.42
Aug. 27, 1909	do	do	do	245	....	22	40	.55
Aug. 16, 1909	do	do	Above East Fork	146	*a* .38	52	49	1.06
Aug. 26, 1909	do	do	do	146	*a* .21	26	49	.53
Sept. 13, 1909	do	do	do	146	*a* .16	23	49	.47
Aug. 27, 1909	Coal Creek	Solomon River.	At mouth	250	....	16.3	27	.60
Aug. 16, 1909	East Fork	do	do	146	....	18.4	17.2	1.07
Aug. 27, 1909	do	do	do	146	....	16.2	17.2	.94
Sept. 13, 1909	do	do	do	146	....	13.5	17.2	.78
Aug. 6, 1909	Big Hurrah Creek.	do	do	85	....	19.3	17.4	1.11
Aug. 17, 1909	East Fork ditch.	Diverts from East Fork.	At intake	307	.84	9.6	....	....
Aug. 27, 1909	do	do	do	307	.78	*b* 8.4	....	....
Sept. 13, 1909	do	do	do	307	.79	*b* 8.6	....	....
July 4, 1908	do	do	Near mouth of East Fork.	290	....	11.9	....	....
July 12, 1908	do	do	do	290	....	0.0	....	....
Aug. 6, 1908	do	do	do	290	....	7.5	....	....
Aug. 27, 1908	do	do	do	290	....	12.6	....	....
Sept. 18, 1908	do	do	do	290	....	12.7	....	....
Aug. 17, 1909	do	do	do	290	.64	4.6	....	....
Aug. 26, 1909	do	do	do	290	.53	2.9	....	....
Sept. 14, 1909	do	do	do	290	....	0.0	....	....
Sept. 24, 1909	do	do	do	290	1.01	*b* 12.5	....	....
Aug. 16, 1909	do	do	Above penstock, near Big Hurrah Creek.	280	....	2.4	....	....
Sept. 18, 1908	Midnight Sun ditch.	Diverts from Big Hurrah Creek.	Near mouth of Big Hurrah Creek.	160	....	18.6	....	....
Aug. 16, 1909	do	do	do	160	....	6.7	....	....

a Gage below East Fork. *b* Computed from gage reading.

ELDORADO RIVER DRAINAGE BASIN.

Eldorado River rises in a low pass near Salmon Lake and flows southward with moderate grade for about 40 miles into the lagoon back of Port Safety. It drains an area of about 128 square miles, comprising elevations up to about 2,300 feet. Mining has been carried on to some extent on Venetia and Beaver creeks, tributary from the east. A ditch was begun in 1909, with which it was proposed to take water from the river just below the mouth of Venetia Creek and to carry it along the right bank and across Flambeau River to ground in the vicinity of Hastings Creek, but the project has never been carried out. The ditch would have delivered the water at a very low elevation, and it is doubtful if the supply would have been sufficient. The following measurements have been made of Eldorado River below Venetia Creek:

August 14, 1906, discharge 44 second-feet.
September 17, 1907, discharge 225 second-feet.

FLAMBEAU RIVER DRAINAGE BASIN.

Flambeau River is a small unimportant stream that rises about 20 miles back from the coast and drains an area between the lower courses of Nome and Eldorado rivers. Little mining has been done in its basin. The Flambeau-Hastings ditch has its intake at the mouth of Hazel Creek, near the head of the river, at an elevation slightly greater than 200 feet, and the plan for it contemplated its extension to Hastings Creek near Cape Nome. It was started in 1906, but only about 12 miles of 8 to 10 foot ditch has been completed. A small ditch extends from a point about 1 mile above La Spray Creek to Hazel Creek.

NOME RIVER DRAINAGE BASIN.

DESCRIPTION.

Nome River is formed by the junction of Buffalo and Deep Canyon creeks and flows southward about 40 miles, entering Bering Sea about 3 miles east of Nome. It drains a long narrow basin comprising a total of about 160 square miles. The headwaters of the stream lie in the Kigluaik Mountains, which rise to elevations a little higher than 3,000 feet. The hills bounding the basin on either side are long, nearly straight ridges, especially the one to the west, and are broken by several low divides, through which water has been or can be diverted from adjoining drainages into ditches along the slopes of Nome River. The Nugget and Buffalo divides lie to the east and west, respectively, of the head of this basin, and separate it from the Grand Central and Sinuk River basins.

On Hobson Creek, a tributary of the Nome, there are limestone springs which yield a good supply of water at all times during the open season and continue to flow well into the winter. Most of this water is diverted during the summer for mining, but during the winter it finds its way down Nome River and freezes in the form of overflow below the mouth of Hobson Creek. The gravels of Nome River are deep and in part, at least, unfrozen. Gold has been found and considerable mining done on Dorothy, Dexter, Buster, and Osborne creeks, and to a less extent on Boer, Hobson, Banner, and other creeks. Four large ditches have been built to divert the water of Nome River for hydraulic mining. Named in the order of their diversions, they are the Campion, Miocene, Seward, and Pioneer ditches. The Campion ditch extends from Buffalo Creek to Dorothy Creek, where its water has been used for running an elevator. The other three ditches, which extend to mining ground on the creeks near Nome, are described in detail on pages 107–108 126, 135, and 257.

There are no storage facilities for maintaining the flow in these ditches, so that all depend on the natural discharge of the river. Some water power could be developed on the river, especially on lower Buffalo Creek, where there is a considerable amount of concentrated fall, together with a well-maintained flow, but the demand has never justified development.

Records of discharge of Nome River and the ditches have been kept since 1906, and the basin has been covered more thoroughly than any other in Seward Peninsula. The following stations have been maintained in the Nome River drainage basin.

Nome River above Miocene ditch intake, 1906–1908.
Nome River below Miocene ditch intake, 1909.
Nome River below Pioneer ditch intake, August 21 to 31, 1907, 1908–1910.
David Creek at Miocene ditch intake, 1907 and 1909.
Hobson Creek at Miocene ditch intake, 1907–1909.
Hobson Creek below Manila Creek, 1907–1909.
Campion ditch at Black Point, 1906–1909.
Miocene ditch at Black Point, 1906–1910.
Miocene ditch at Clara Creek, 1907 and 1909.
Miocene ditch above Hobson Creek, 1907–1910.
Miocene ditch below Hobson Creek, 1907–1910.
Miocene ditch at the flume, 1906–1910.
David Creek ditch opposite Black Point, August, 1906, 1907–1909.
Seward ditch at intake, 1907–1910.
Seward ditch below Hobson branch, 1909.
Seward ditch at Dexter Creek, 1909–10.
Seward ditch above Newton Gulch, 1909–10.
Hobson branch above Seward ditch, 1909.
Pioneer ditch at intake, August 21 to 31, 1907, 1908–1910.

NOME RIVER ABOVE MIOCENE DITCH INTAKE.

This station, which was established July 3, 1906, was located just below the junction of Buffalo and Deep Canyon creeks and above the intake of the Miocene ditch. It was maintained until the end of 1908, when it was discontinued on account of the shifting character of the channel. Records at this point show the amount of water available for the Miocene ditch. The flow is affected by four ditches—the Campion ditch, which diverts water above the station, and the Jett Creek, Grand Central, and David Creek ditches, which bring in water above the station from streams outside of the drainage basin.

The river channel at the station is a broad, deep gravel bed, and there is probably considerable seepage through it which is not measured. Gage heights were somewhat affected, especially in 1907 and 1908, by changes in the diversion dam and artificial changes in the stream bed, so that records are not as good as is desirable. The mimimum discharge for a week was 4.6 second-feet, July 23 to 29, 1908.

Discharge measurements of Nome River above Miocene ditch intake from 1906 to 1909.

[Elevation, 575 feet.]

Date.	Hydrographer.	Gage height.	Discharge.
1906.		*Feet.*	*Sec.-ft.*
June 28	Hoyt and Henshaw	0.15	28
July 3	.....do	.00	21
6	F. F. Henshaw	.45	56
14	Hoyt and Henshaw	.40	50
14	.....do	.82	117
Aug. 3	F. F. Henshaw	−.01	21
23	Henshaw and Miller	.87	121
23	.....do	.70	87
1907.			
June 21	Henshaw and Richards	1.25	135
22	.....do	1.25	141
30	.....do	1.09	95
July 10	F. F. Henshaw	.96	120
12	R. Richards	.78	74
17	.....do	.60	43
Aug. 4	Henshaw and Miller	.44	37
4	.....do	.36	37
7	R. Richards	.25	25
17	.....do	.75	82
17	.....do	.68	72
Sept. 4	.....do	.54	48
9	.....do	.96	124
1908.			
June 20	Henshaw and Barrows	1.09	84
20	.....do	1.10	80
July 9	Henshaw and Miller	.16	10
Aug. 13	A. T. Barrows	.85	62
30	F. F. Miller	.58	46

Daily gage height, in feet, and discharge, in second-feet, of Nome River above Miocene ditch intake for 1906–1908.

[Observer, F. F. Miller.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906.						
1		25	0.02	22	0.61	76
2		23	.00	21	.57	70
3	0.00	21	−.01	20	.52	64
4	.25	37	−.02	20	.46	57
5	.48	59	−.04	19.0	.42	52
6	.31	42	−.04	19.0	.40	50
7	.28	39	+.09	26	.36	46
8	1.31	244	+.04	23	.30	41
9	1.50	314	−.02	20	.27	39
10	.85	119	.00	21	.21	34
11	.58	71	.26	38	.18	32
12	.60	74	.34	45	.18	32
13	.50	61	.28	39	.18	32
14	.61	76	.10	26	.15	30
15	.56	69	.04	23	.12	27
16	.49	60	.03	22	.10	26
17	.45	56	.02	22	.10	26
18	.38	48	.00	21	.32	43
19	.26	38	.00	21	.70	89
20	.16	30	.38	48	1.22	214
21	.14	29	.41	51	1.12	186
22	.13	28	.42	52	.83	115
23	.36	46	.87	123	.82	112
24	.31	42	.53	65	.74	97
25	.26	38	.48	59	.65	82
26	.18	32	.80	108	.60	74
27	.12	27	1.14	191	.54	66
28	.09	26	.78	104	.52	64
29	.06	24	.72	93	.52	64
30	.04	23	.70	89	.50	61
31	.02	22	.62	77		
Mean		59.5		49.3		66.7

Daily gage height, in feet, and discharge, in second-feet, of Nome River above Miocene ditch intake for 1906–1908—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.								
1			1.19	121	0.51	41	0.57	51
2			1.06	102	.49	39	.50	44
3			1.03	97	.48	40	.50	44
4			0.94	92	.45	38	.53	47
5			.94	92	.33	35	.48	42
6			1.08	118	.33	32	.46	43
7			1.04	125	.27	26	.41	40
8			.90	98	.28	27	.44	42
9			.84	88	.27	26	.92	116
10			.88	105	.22	25	1.68	362
11			.92	105	.22	25	1.29	222
12			.78	74	.22	26	.90	119
13			.80	75	.20	25	.79	98
14			.75	66	.24	27	.77	95
15	2.14	460	.65	52	.20	26	.78	97
16	1.44	192	.65	50	.51	50	.66	77
17	1.29	148	.64	47	.74	80	.60	68
18	2.12	450	.64	47	.70	74	.58	66
19	1.60	240	.72	56	.64	66	.58	66
20	1.36	168	.80	66	.60	61	.50	56
21	1.26	140	.94	87	.52	52	.51	57
22	1.29	148	.70	55	.50	48	.32	39
23	1.28	145	.71	56	.46	43	.42	48
24	1.66	261	.69	54	.46	43	.43	49
25	1.56	228	.66	52	.42	40	.38	44
26	1.55	225	.64	51	.62	60	.35	42
27	1.38	174	.56	42	.67	67	.32	39
28	1.26	140	.50	39	.60	58	.31	38
29	1.31	153	.48	37	.62	60	.32	39
30	1.20	125	.52	41	.78	82	.36	42
31			.56	45	.62	56		
Mean		212		72.1		45.1		74.4
1908.								
1			0.53	29	0.70	44	0.70	58
2			.37	19.6	.55	32	.70	56
3			.36	19.2	.48	28	.68	53
4			.32	17.3	1.35	146	.64	50
5			.31	16.9	1.09	93	.60	46
6			.33	17.8	.92	68	.56	41
7			.30	16.4	.62	40	.55	40
8			.23	13.2	.52	33	.53	39
9			.18	11.0	.46	30	.49	36
10			.15	9.7	.40	27	.44	31
11			.18	11.0	.65	43	.40	28
12			.28	15.5	.95	73	.38	26
13			.20	11.8	.82	59	.39	27
14			.14	9.3	.78	55	.35	23
15			.10	7.6	.64	42	.42	28
16			.10	7.6	.62	40	.40	26
17			.12	8.4	.60	38	.40	26
18			.10	7.6	.56	35	.40	26
19			.08	7.0	.80	56	.38	25
20	1.10	86	.08	7.0	.85	62		23
21	1.02	75	.08	7.0	.80	60		23
22	.98	70	.05	6.0	.71	51		22
23	1.02	75	.02	5.0	.82	63		
24	.78	48	.02	5.0	.88	69		
25	.66	38	.00	4.4	.78	63		
26	.85	55	.00	4.4	.71	55		
27	.64	37	.00	4.4	.68	51		
28	.69	40	.00	4.4	.62	48		
29	.58	33	.00	4.4	.60	48		
30	.62	35	1.00	75	.58	44		
31			1.07	87	.78	66		
Mean		59.2		15.2		53.6		34.2

NOME RIVER BELOW MIOCENE DITCH INTAKE.

This station was established June 15, 1909, to take the place of the station above the intake. The discharge at this point is affected by the same diversions as at the upper point, with the additional diversion of the Miocene ditch. The gage was not read during extreme low water, but the discharge was estimated from the amount in the river, which was assumed to decrease slightly as the water fell in the ditch. The discharge obtained, by adding to these records the amount of water passing Black Point in the Miocene ditch, is directly comparable to the data of discharge obtained at the station above the intake during the years 1906–1908.

Discharge measurements of Nome River below Miocene ditch intake in 1909 and 1910.

[Elevation, 575 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec.-feet.*	1909—Continued.	*Feet.*	*Sec.-feet.*
June 15	1.70	238	Aug. 9	0.46	9.7
July 16	.20	2.3			
Aug. 3	.16	2.2	1910.		
Aug. 9	.59	16.2	Sept. 18		29

Daily gage height, in feet, and discharge, in second-feet, of Nome River below Miocene ditch intake for 1909.

[Observer, F. F. Miller.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.82	36		2.0		2.0
2			.82	36		2.0		2.0
3			1.00	60	0.16	2.0		1.9
4			.86	41		2.3	0.15	1.9
5			.85	40		2.2		2.0
6			.82	36		2.1		2.0
7			.71	26		2.1		2.0
8			.72	27		2.1		1.9
9			.67	23	.42	8.1		1.9
10			.56	14.8		7.0		1.9
11			.32	4.9	.20	2.5		1.9
12			.34	5.5		2.2		1.9
13			.24	3.2		2.4		1.9
14			.20	2.5		2.4		1.9
15	1.70	238	.20	2.5		2.3		1.9
16	1.80	271	.20	2.5		2.3		1.9
17	1.25	111	.20	2.5		2.2		1.9
18	1.20	99	.20	2.5		2.2		1.9
19	1.17	93	.20	2.5		2.2		1.9
20	1.11	80	.20	2.5		2.2		
21		73	.20	2.5		2.2		
22		66	.20	2.5		2.2		
23	1.00	60		2.5		2.1		
24	.75	30		2.4		2.1		
25	.35	5.8		2.4		2.1		
26	.35	5.8		2.3		2.1		
27	.54	13.6		2.3		2.1		
28	1.05	69		2.2		2.1		
29	1.50	177		2.2		2.1		
30	1.05	69		2.1		2.1		
31				2.1		2.1		
Mean		91.3		12.8		2.52		1.93

NATURAL DISCHARGE OF NOME RIVER AT MIOCENE DITCH INTAKE.

The natural discharge of Nome River above the Miocene ditch intake is affected by four ditches—the Campion ditch, which diverts water above the station, and the Jett Creek, Grand Central, and David Creek ditches, which bring water into the river above the station from streams outside of the drainage area. Therefore to determine the natural flow of the river or the quantity of water which would have been carried at this point had there been no diversion into or out of the drainage area in consideration, it is necessary to add to the records of discharge above the intake the amount of water carried past the station by the Campion ditch and to subtract from this sum the total discharge of the other three ditches. For 1909 the discharge of the river above the intake is determined by adding to the records obtained below the intake the discharge of the Miocene ditch at Black Point. The discharge computed in the manner outlined above is given in the following tables for the four years 1906 to 1909.

The maximum recorded discharge of 349 second-feet for this period, which occurred September 10, 1907, was probably exceeded in September, 1910. The lowest discharge for one week was 6.4 second-feet, July 23–29, 1908.

Natural daily discharge, in second-feet, of Nome River at Miocene ditch intake for 1906–1908.

[Drainage area, 15 square miles.]

Day.	1906			1907			1908			
	July.	Aug.	Sept.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	20	23	65	121	29	40	....	20	32	37
2	18	22	56	102	29	34	....	15.9	24	39
3	16	21	54	97	29	33	....	17.5	33	35
4	31	21	48	92	29	36	....	16.6	146	33
5	51	20	45	92	26	32	....	17.0	96	31
6	42	20	43	118	23	35	....	18.0	53	30
7	47	27	39	132	18.2	31	....	16.6	32	28
8	244	25	34	103	21	31	....	13.3	26	27
9	314	23	36	90	22	104	....	11.6	22	26
10	119	25	35	109	19.5	349	....	9.8	22	22
11	65	50	33	107	19.5	218	....	12.7	34	19.0
12	67	54	34	70	21	122	....	24	62	18.0
13	55	49	36	73	19.7	89	....	16.3	40	19.0
14	58	35	33	61	22	84	....	10.8	46	15.4
15	52	30	31	50	19.2	96	....	8.5	31	20
16	43	27	29	49	36	74	....	8.4	28	19.4
17	39	26	29	38	64	67	....	9.9	27	19.4
18	33	26	40	41	59	51	....	9.7	25	18.7
19	30	24	90	46	47	53	....	8.6	47	18.0
20	27	46	230	54	40	49	86	8.7	65	17.3
21	29	48	194	70	32	45	86	9.0	46	16.5
22	29	53	114	44	31	30	81	7.1	39	15.0
23	46	121	109	42	30	27	89	6.1	46	....
24	43	63	92	38	29	21	60	6.8	49	....
25	40	55	80	37	26	39	49	6.3	48	....
26	32	101	76	36	49	39	67	6.5	40	....
27	26	191	70	28	55	36	44	6.5	36	....
28	27	104	66	28	44	35	41	6.3	34	....
29	24	93	66	25	45	34	26	6.1	34	....
30	24	79	62	32	71	25	26	59	30	....
31	23	65	....	35	44	....	....	88	58	....
Mean	55.3	50.5	65.6	66.5	33.8	66.0	59.5	15.5	43.6	23.8
Mean per square mile	3.69	3.37	4.37	4.43	2.25	4.40	3.97	1.03	2.91	1.59
Run-off, depth in inches on drainage area	4.25	3.88	4.88	5.11	2.59	4.91	1.62	1.19	3.36	1.30

Natural daily discharge, in second-feet, of Nome River at Miocene ditch intake for 1909.

[Drainage area, 15 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1		52	7.4	10.9	21	73	17.8	14.1	12.8
2		50	8.2	11.4	22	66	16.0	13.7	12.8
3		74	13.0	11.1	23	72	13.7	13.1	17.2
4		58	19.1	12.2	24	45	11.0	12.5	30
5		57	12.6	13.3	25	26	10.7	11.7	16.0
6		51	10.4	13.8	26	27	10.5	12.3	13.2
7		41	10.1	12.8	27	27	10.4	13.1	13.2
8		45	8.2	10.4	28	89	11.4	13.7	12.4
9		43	39	10.3	29	184	10.0	13.1	12.0
10		33	37	10.4	30	86	8.8	11.9	12.0
11		24	16.3	9.9	31		9.5	12.1	
12		27	9.9	9.2	Mean	99.2	28.1	15.5	12.4
13		29	24	9.4	Mean per square mile	6.61	1.87	1.03	.827
14		25	27	13.3					
15	238	22	23	11.9	Run-off, depth in inches on drainage area	3.93	2.16	1.19	.92
16	271	24	17.8	13.2					
17	111	22	14.8	12.8					
18	99	23	13.9	12.5					
19	93	22	14.5	11.7					
20	80	20	13.6	11.6					

NOME RIVER BELOW PIONEER DITCH INTAKE.

This station was established July 9, 1907, and records were obtained for 11 days in that year and during the entire seasons of 1908, 1909, and 1910. It is located below the Pioneer intake and below all diversions from the upper river, so that it shows the amount of unappropriated water in Nome River at this point. By adding to these records the discharge of the Miocene, Seward, and Pioneer ditches and deducting the discharge of the two ditches over the Nugget divide, the natural flow at this point has been computed. Conditions were good and the record obtained is reliable. The highest flood recorded was caused by the rain of September 10, 1910, and gave a maximum discharge of 920 second-feet on the 11th. The highest discharge recorded in the spring was 578 second-feet June 25, 1910, but the discharge may have been greater than this in other spring floods. The minimum natural flow was 19.0 second-feet for the week July 23 to 29, 1908. The actual discharge below the ditch reached a minimum of 1 second-foot in 1909; this amount represented the seepage through the dam.

Discharge measurements of Nome River below Pioneer ditch intake from 1907 to 1910.

[Elevation, 320 feet.]

Date.	Hydrographer.	Gage height.	Discharge.
1907.		*Feet.*	*Sec.-ft.*
July 9	F. F. Henshaw	1.89	132
18	R. Richards	1.58	58
Aug. 9	.....do	1.13	3.0
20	.....do	1.39	25
29	.....do	1.49	46
1908.			
July 10	F. F. Henshaw	0.41	1.4
1909.			
June 15	Henshaw and Parker	1.70	277
July 16	F. F. Henshaw	.33	1.8
Aug. 2	.....do	.30	2.0
1910.			
Sept. 18	G. L. Parker	.60	77
21	.....do	.47	58

Daily gage height, in feet, and discharge, in second-feet, of Nome River below Pioneer ditch intake for 1907–1910.

[Observers, employees of Pioneer Mining Co., 1908; Chris. Johnson, 1909; C. Chanceberg, 1910.]

Day.	August, 1907.		1908					
			July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1				2.0	0.66	23.0	0.70	28.0
2				2.0	.42	2.0	.58	12.8
3				2.0	.45	3.6	.48	3.9
4				2.0	1.18	125	.45	2.0
5				1.5	1.90	310	.45	2.0
6				1.5	1.10	106	.45	2.0
7				1.5	.58	14	.45	2.0
8				1.5	.42	2.0	.45	2.0
9				1.0	.42	2.0	.45	2.0
10				1.0	.45	3.6	.45	2.0
11			0.40	1.0	.45	3.6	.45	2.0
12			.40	1.0	1.05	94	.45	2.0
13			.41	1.5	1.05	94	.45	2.0
14			.40	1.0	.98	79	.45	2.0
15			.40	1.0	.70	28	.45	2.0
16			.40	1.0	.45	2.0	.45	2.0
17			.40	1.0	.45	2.0	.45	2.0
18			.40	1.0	.45	2.0	.45	2.0
19			.40	1.0	.72	31	.45	2.0
20			.41	1.5	.46	2.6	.45	2.0
21	1.40	28	.42	2.0	.45	2.0	.45	2.0
22	1.30	16	.42	2.0	.45	2.0		
23	1.30	16	.42	2.0	.88	58		
24	1.25	11.0	.42	2.0	1.18	125		
25	1.25	11.0	.42	2.0	.98	79		
26	1.55	52	.42	2.0	.88	58		
27	1.60	62	.42	2.0	.60	15.0		
28	1.57	56	.42	2.0	.45	2.0		
29	1.52	47	.42	2.0	.45	2.0		
30	1.75	94	.85	52	.45	2.0		
31	1.55	52	1.50	205	.80	43		
Mean		40.5		9.74		42.5		3.84

Daily gage height, in feet, and discharge, in second-feet, of Nome River below Pioneer ditch intake for 1907–1910—Continued.

Day.	1909							
	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.30	180	0.30	1.0	0.30	1.0
2			1.18	150	.30	1.0	.30	1.0
3			1.20	155	.30	1.0	.30	1.0
4			1.20	155	.30	1.0	.30	1.0
5			1.10	130	.30	1.0	.30	1.0
6			1.00	106	.30	1.0	.30	1.0
7			0.90	83	.30	1.0	.30	1.0
8			.78	58	.30	1.0	.30	1.0
9			.68	40	.30	1.0	.30	1.0
10	2.20	430	.65	36	.30	1.0	.30	1.0
11	2.18	424	.45	11.0	.30	1.0	.30	1.0
12	2.15	415	.50	16.0	.30	1.0	.30	1.0
13	1.98	364	.38	5.6	.30	1.0	.30	1.0
14	1.88	334	.35	3.6	.30	1.0	.30	1.0
15	1.80	310	.30	1.0	.30	1.0	.30	1.0
16	1.95	355	.30	1.0	.30	1.0	.30	1.0
17	1.82	316	.30	1.0	.30	1.0	.30	1.0
18	1.76	298	.30	1.0	.30	1.0	.30	1.0
19	1.82	316	.30	1.0	.30	1.0	.30	1.0
20	1.65	268	.30	1.0	.30	1.0	.30	1.0
21	1.48	225	.30	1.0	.30	1.0	.30	1.0
22	1.40	205	.30	1.0	.30	1.0	.30	1.0
23	1.15	142	.30	1.0	.30	1.0	.30	1.0
24	1.05	118	.30	1.0	.30	1.0	.58	26
25	0.88	79	.30	1.0	.30	1.0	.30	1.0
26	.80	62	.30	1.0	.30	1.0	.30	1.0
27	1.05	118	.30	1.0	.30	1.0	.30	1.0
28	1.12	135	.30	1.0	.30	1.0	.30	1.0
29	1.75	295	.30	1.0	.30	1.0		
30		238	.30	1.0	.30	1.0		
31			.30	1.0	.30	1.0		
Mean		259		37.0		1.00		1.89

Day.	1910									
	June.		July.		August.		September.		October.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	2.9	460	2.3	460	1.2	155	1.0	106	0.85	138
2	3.35	570	2.4	490	1.45	218	1.2	155	.85	138
3	3.35	570	2.25	445	1.2	155	1.05	118		
4	2.9	530	2.0	370	1.0	106	.85	72		
5	2.7	470	1.95	355	.9	83	.8	62		
6	2.7	470	1.85	325	.95	94	2.55	542		
7	3.05	570	1.65	268	.9	83	3.4	910		
8	2.5	420	1.65	268	.8	62	2.25	534		
9	2.15	370	1.5	230	.7	43	1.8	396		
10	1.75	280	1.35	192	.7	43	1.6	336		
11	1.4	195	1.65	268	.8	62	1.55	322		
12	1.25	168	1.7	280	.85	72	1.4	279		
13	1.1	130	1.6	255	.95	94	1.25	238		
14	1.0	106	1.65	268	.9	83	1.1	199		
15	1.0	106	1.55	242	1.0	106	.95	162		
16	1.1	130	1.5	230	.9	83	.85	138		
17	1.15	142	1.5	230	1.7	280	.7	103		
18	1.1	130	1.55	242	1.4	205	.6	81		
19	1.85	325	1.25	168	1.05	118	.5	60		
20	2.4	490	2.15	415	1.0	106	.5	60		

Daily gage height, in feet, and discharge, in second-feet, of Nome River below Pioneer ditch intake for 1907–1910—Continued.

Day.	1910									
	June.		July.		August.		September.		October.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
21	1.9	340	1.95	355	0.95	94	0.6	81		
22	1.7	280	1.55	242	.9	83	1.2	225		
23	1.9	340	1.4	205	1.1	130	2.4	580		
24	2.0	370	1.15	142	1.15	142	1.95	441		
25	2.65	578	1.15	142	.95	94	1.85	411		
26	2.55	542	1.3	180	.9	83	1.55	322		
27	2.45	508	1.5	230	.8	62	1.35	266		
28	2.45	508	1.7	280	.85	72	1.2	225		
29	2.2	430	1.8	310	.9	83	1.05	186		
30	2.25	445	1.45	218	.8	62	.95	162		
31			1.3	180	.65	36				
Mean		366		274		103		259		138

NOTE.—It has been assumed that the shift in the channel between the 1909 measurements and those in 1910 occurred during the high water of September, 1910, and the 1909 rating has been used up to September 6. The results are subject to considerable uncertainty.

Natural daily discharge, in second-feet, of Nome River at Pioneer ditch intake, 1907 to 1910.

[Drainage area, 37 square miles.]

Day.	August, 1907.	1908			1909				1910			
		July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1		53	92	117		241	27	30	460	460	196	187
2		45	50	101		211	28	28	570	490	259	235
3		41	54	89		222	41	27	570	445	197	201
4		38	198	82		228	42	26	530	370	153	156
5		37	406	75		196	33	29	470	355	146	146
6		35	191	73		186	35	29	470	325	161	571
7		35	100	69		169	30	26	570	268	158	920
8		33	75	68		147	37	26	420	268	138	534
9		32	63	65		130	64	27	370	243	118	414
10		27	64	62	430	117	74	26	280	219	123	354
11		29	86	58	424	96	44	26	195	300	139	352
12		36	190	58	415	99	41	26	168	315	147	304
13		32	185	61	364	81	48	28	130	287	171	263
14		26	167	53	334	67	52	30	106	301	161	231
15		22	118	61	310	58	47	28	106	277	186	216
16		22	84	63	355	60	44	29	130	281	151	206
17		20	81	54	316	58	40	27	142	281	351	173
18		20	76	48	298	52	38	27	130	294	293	155
19		19.4	126	48	316	54	36	26	325	224	204	132
20		21	93	46	268	52	37	29	490	471	189	127
21	98	21	47	44	236	46	35	32	340	410	178	140
22	86	20	83	46	219	43	34	32	280	307	166	268
23	89	18.8	144		162	40	32	43	340	272	212	610
24	81	19.1	209		174	38	32	76	370	211	226	469
25	86	19.2	165		138	36	31	40	578	212	177	439
26	129	19.1	142		120	35	33	33	542	235	165	371
27	133	19.1	100		178	34	33	33	508	267	146	325
28	126	18.9	85		192	30	31	31	508	315	140	284
29	114	18.7	84		338	29	30	30	430	339	136	249
30	168	121	79		303	30	31	30	445	249	123	225
31	124	291	140			32	29			218	119	
Mean	112	39.0	122	65.5	280	94.1	38.4	31.0	366	307	175	309
Mean per square mile	3.03	1.05	3.30	1.77	7.57	2.54	1.04	.838	9.89	8.30	4.73	8.35
Run-off, depth in inches on drainage area	1.24	1.21	3.80	1.45	5.91	2.93	1.20	.94	11.03	9.57	5.45	9.32

DAVID CREEK AT MIOCENE DITCH INTAKE.

David Creek is the first large tributary of Nome River below the junction of Buffalo and Deep Canyon creeks. Its valley has a northwestern exposure and holds a considerable amount of snow well into the summer. A branch of the Miocene ditch diverts all the water from the creek at low stages and carries it up the left bank of Nome River, discharging it into a small stream which enters the river above the main intake of the Miocene ditch. The discharge of the ditch was measured about 1½ miles below the intake. (See p. 121.) On July 29, 1906, the seepage in this distance was found to be 0.5 second-foot. The discharge of David Creek during low-water periods has therefore been found by adding 0.5 second-foot to the measured discharge of the ditch. For certain other periods the discharge of David Creek has been estimated as a percentage of that of Nome River, varying from 35 to 45, according to the season. The discharges for 1907, a wet year, and for 1909, a dry year, have been obtained in this manner.

Daily discharge, in second-feet, of David Creek at Miocene ditch intake for 1907 and 1909.

[Drainage area, 4.3 square miles.]

Day.	1907			1909			
	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	55	12.9	12.1	....	21	3.8	3.8
2	40	12.1	11.4	....	20	3.5	3.7
3	36	13.7	13.7	....	30	3.5	3.7
4	53	12.0	13.7	....	23	4.7	3.6
5	53	11.7	12.4	....	22	4.4	3.5
6	76	11.0	12.1	....	20	4.1	3.4
7	72	10.7	11.8	....	19	3.8	3.3
8	49	10.1	10.7	....	18	3.6	3.2
9	40	10.1	35	....	16.7	7.6	3.2
10	45	9.6	107	....	14.1	6.7	3.2
11	50	9.6	70	....	15.4	5.7	3.2
12	31	9.6	39	....	14.1	6.7	3.1
13	34	9.6	28	....	9.3	7.6	3.0
14	28	9.4	26	....	8.3	7.1	2.9
15	23	9.4	30	95	7.2	6.6	3.1
16	23	13.7	22	90	8.3	6.1	3.2
17	19	25	20	44	7.2	5.7	3.1
18	21	23	15.4	40	9.3	5.5	3.0
19	24	15.4	17.0	37	6.3	5.3	2.9
20	30	15.4	14.5	32	5.0	5.0	3.2
21	45	16.3	14.5	30	5.0	4.7	3.8
22	22	16.3	12.6	26	5.0	4.5	3.8
23	22	12.4	11.8	29	5.0	4.3	5.2
24	20	12.1	11.1	20	4.9	4.3	9.0
25	13.7	12.4	10.4	19	4.9	4.2	4.8
26	13.7	20	10.3	18	4.8	4.2	4.0
27	12.1	22	9.9	17	4.7	4.1	4.0
28	11.4	18	9.4	36	4.5	4.1	3.7
29	12.9	18	9.4	74	4.5	4.0	3.6
30	12.9	30	8.8	34	4.3	3.9	3.6
31	12.9	20	....	....	4.0	3.9	....
Mean	32.3	14.6	21.0	40.1	11.2	4.94	3.69
Mean per square mile	7.51	3.40	4.88	9.33	2.60	1.15	.858
Run-off, depth in inches on drainage area	8.66	3.92	5.44	5.55	3.00	1.33	.96

HOBSON CREEK AT MIOCENE DITCH INTAKE.

Hobson Creek is one of the most interesting and valuable streams in the Nome region. It rises south of Dorothy Creek, flows southward, and discharges into Nome River about 18 miles from the seacoast. It is about 4 miles long and very steep. Its only important tributary is Manila Creek, which becomes dry at low water. Hobson Creek is notable for the large limestone springs from which it receives its water. The highest of these springs emerges just above the dam at the Miocene ditch crossing. Above them a trench has been dug across the stream to solid rock at a low stage, and no flow was intercepted. Between the dam and the mouth of Manila Creek there are many springs, none of them very large, but giving an aggregate discharge nearly equal to that above the Miocene intake.

At low water the Miocene ditch obtains nearly half its water supply from Hobson Creek. Laterals have also been built to the other ditches, that to the Seward lying on the east bank and the Pioneer branch on the west bank.

The water from Hobson Creek is valuable not only on account of its remarkably uniform flow but also on account of its high temperature, which prevents the formation of slush ice during cold nights and makes it possible to run the ditches somewhat longer than they could be run with Nome River water alone.

The discharge of the springs which rise just above the Miocene intake into the bed of Hobson Creek was found during the seasons of 1907 and 1908 by taking the difference of the discharge of the ditch above and below the dam across Hobson Creek and adding to it the observer's estimate of the overflow, which at no time amounted to a very large proportion of the total. During 1908 practically no water was wasted. On May 11, 1909, a gage was established below the dam. The records obtained from this gage and the difference in the discharge of the ditch above and below the dam furnish the basis for determining the flow of the creek in 1909. Records were kept of the ditch in 1910, but as a large amount of water was spilled, of which no record was kept, the discharge of the creek can not be computed. The maximum discharge recorded at this point was caused by the melting of the snow and amounted to 60 second-feet on June 11, 1909. The maximum discharge from the springs alone was about 25 second-feet in the spring of 1907. The minimum for one week was 6.1 second-feet for July 25 to 31, 1909.

Discharge measurements of Hobson Creek at Miocene ditch intake in 1909 and 1910.

[Elevation, 500 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
May 11	0.00	[a] 0.12	July 15	0.07	0.46
June 14	.72	23			
June 14	.75	23	1910.		
June 14 [b]	.30	3.7	Sept. 18	....	8.7
June 14	.85	37			

[a] Estimated by J. W. Warwick. [b] Water shut off at dam.

Daily discharge, in second-feet, of Hobson Creek at Miocene ditch intake for 1907 and 1908.

[Drainage area, 2.6 square miles.]

Day.	1907				1908			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	....	25.5	20.4	17.7	....	14.3	6.7	12.8
2	....	24.9	18.7	17.3	....	11.1	6.6	12.5
3	....	23.8	19.1	17.3	....	10.6	6.4	12.5
4	....	22.7	19.3	17.7	....	8.5	6.7	12.5
5	....	22.7	19.2	17.3	....	8.2	8.8	12.7
6	....	21.1	18.9	16.9	....	8.1	9.1	12.7
7	....	19.6	19.4	16.5	....	7.8	10.2	13.0
8	....	25.8	17.3	17.9	....	8.7	8.5	12.1
9	....	24.5	18.1	16.6	....	7.6	7.9	11.8
10	....	22.7	18.2	18.2	....	7.9	8.0	11.0
11	....	23.0	16.2	20.0	....	7.5	8.7	11.1
12	....	24.0	16.7	20.5	....	6.2	9.6	10.6
13	....	23.0	16.4	21.0	....	6.9	10.3	10.2
14	....	23.0	16.4	21.9	....	7.3	11.7	9.8
15	....	19.7	16.3	20.3	....	7.2	11.4	9.9
16	....	23.1	16.9	20.6	....	7.1	12.3	9.5
17	....	21.4	14.7	20.6	....	7.6	11.9	8.1
18	....	23.2	14.7	20.7	....	7.6	12.2	7.4
19	....	22.3	14.3	20.3	13.8	7.7	12.5	7.1
20	....	22.6	14.3	19.5	12.0	6.6	17.8	7.3
21	....	23.0	15.4	19.7	10.0	6.9	12.0	6.2
22	....	21.1	14.7	18.3	10.0	6.6	12.4	6.8
23	....	22.3	14.3	22.3	10.0	6.4	13.1	6.5
24	....	23.5	16.8	20.6	10.0	6.6	13.1	....
25	....	22.7	18.3	19.5	12.0	6.6	14.1	....
26	....	24.2	17.3	19.3	12.3	6.2	14.1	....
27	....	21.8	17.3	17.7	12.6	6.0	14.1	....
28	26.7	21.4	17.3	19.0	13.3	5.7	14.1	....
29	25.8	20.2	17.7	19.3	14.1	5.7	13.8	....
30	25.0	20.9	17.7	19.7	15.7	6.2	14.4	....
31	....	21.2	17.7	....	....	6.3	13.1	....
Mean	25.8	22.6	17.1	19.1	12.2	7.5	11.0	10.2
Mean per square mile	9.92	8.69	6.58	7.35	4.69	2.88	4.23	3.92
Run-off, depth in inches on drainage area	1.11	10.02	7.59	8.20	2.09	3.32	4.88	3.35

Daily gage height, in feet, and discharge, in second-feet, of Hobson Creek at Miocene ditch intake for 1909.

[Drainage area, 2.6 square miles. Observers, Oscar Munson and C. D. McDermitt.]

Day.	May.		June.		July.		Aug.	Sept.
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Discharge.	Discharge.
1			0.89	40	0.42	21	9.5	7.6
2			.85	35	.40	20	9.0	6.9
3			.88	39	.38	22	8.3	6.8
4			.82	31		18.1	6.2	6.4
5			.92	44		17.1	5.7	6.6
6			.91	42		17.4	8.0	6.2
7			.81	30		17.0	8.2	6.4
8			.72	22		16.4	8.2	6.4
9			.80	29		16.4	8.0	6.5
10			.85	35		16.1	8.3	6.1
11	0.00	0.12	1.02	60		16.1	9.2	6.4
12	.00	.12	.85	35		16.1	6.2	6.4
13	.00	.12	.88	39		16.1	6.2	6.3
14	.00	.12	.84	34		15.5	7.2	7.2
15	.02	.19	.78	27		15.9	6.3	6.3
16	.04	.26	.88	39		15.0	6.2	6.4
17	.04	.26	.76	25		15.1	7.1	7.1
18	.08	.54	.59	23		12.0	8.4	6.1
19	.16	1.3	.61	25		13.4	8.4	6.0
20	.38	5.8	.30	21		12.4	7.5	6.8
21	.42	7.1		18.8		15.7	6.9	6.8
22	.36	5.3		17.4		13.6	7.1	5.9
23	.41	6.7		14.9		11.5	7.6	5.9
24	.41	6.7		14.6		12.4	7.4	6.4
25	.39	6.1		14.6		13.7	7.6	5.9
26	.35	5.0		15.1		10.7	7.6	6.4
27	.34	4.7		15.4		11.3	7.7	6.4
28	.38	5.8	.30	18.8		10.6	7.6	6.4
29	.40	6.4	.59	27		11.0	8.0	6.0
30	.50	9.7	.42	24		10.2	8.1	6.0
31	.86	36				9.9	7.0	
Mean		5.16		28.5		14.8	7.57	6.43
Mean per square mile		1.98		11.0		5.69	2.91	2.47
Run-off, depth in inches on drainage area		1.55		12.27		6.56	3.36	2.76

HOBSON CREEK BELOW MANILA CREEK.

Measurements were begun in 1907 to determine the total discharge of Hobson Creek below Manila Creek, its principal tributary. Simultaneous measurements were made of the creek and all its diversions below the Miocene ditch level, including the laterals to the Seward and Pioneer ditches, and Deschamps ditch, which diverts just below Manila Creek. In the following table these several factors and their total are tabulated, together with the run-off per square mile and the ratio of the discharge at this point to that at the Miocene intake. This ratio varies from 1.66 to 2.85. The natural discharge of Hobson Creek below Manila Creek may be approximated for any day desired during the period covered by discharge records of the creek at the Miocene ditch intake. To do this the ratio indicated in the table for the date nearest to that of the day desired should be applied to the discharge of Hobson Creek at Miocene ditch intake for the day desired.

Discharge measurements of Hobson Creek below Manila Creek from 1907 to 1909.

[Drainage area, 5.1 square miles. Elevation, 270 feet.]

Date.	Point of measurement.						Discharge per square mile.	Hobson Creek below Manila Creek. / Miocene intake.
	Miocene intake.	Seward lateral.	Pioneer lateral.	Deschamps ditch.	Below Manila Creek.	Total.		
1907.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Ratio.*
July 2	24.9	0.0	0.0	0.0	25.0	49.9	9.79	2.00
9	24.5	5.2	.0	.0	21.0	50.7	9.94	2.07
19	22.3	5.2	.0	.0	17.7	45.2	8.86	2.03
Aug. 9	18.1	4.3	.0	.0	10.7	33.1	6.49	1.83
Sept. 28	19.0	4.5	5.8	.0	5.0	34.3	6.73	1.81
1908.								
June 19	[a] 13.8	7.1	6.1	1.8	8.4	27.1	5.31	1.96
July 10	7.9	3.1	2.6	.0	5.0	18.6	3.65	2.35
Aug. 12	9.6	6.1	5.0	3.4	3.3	27.4	5.37	2.85
Sept. 1	12.8	5.3	4.8	2.0	5.2	30.1	5.90	2.35
1909.								
June 14	[b] 21.0	.0	.0	.0	34.8	34.8	6.82	1.66
July 15	15.9	5.5	4.3	.2	7.5	33.4	6.55	2.10
Aug. 1	9.5	3.2	2.3	3.3	2.9	21.2	4.16	2.23
10	8.3	3.8	1.7	.0	4.2	18.0	3.53	2.17
Sept. 12	6.4	2.5	.85	.0	4.9	14.6	2.86	2.28

[a] 3.7 second-feet diverted in ditch.
[b] Discharge at 10 a. m., when measurement was made below; no water diverted.

CAMPION DITCH AT BLACK POINT.

The Campion ditch diverts water from Buffalo Creek about half a mile above its mouth, at an elevation of 610 feet. It extends along the right bank of Nome River for about 4 miles to Dorothy Creek, where the water is used for mining or is discharged into the creek. The station was established July 7, 1906, to determine the discharge of the ditch and the amount of water diverted for it at the gaging station on Nome River. It is located just above the Miocene ditch cabin at Black Point, about 1½ miles below the intake. The records of the amount of water diverted in 1906 to 1909 are practically complete. The maximum discharge shown by the records occurred August 11, 1906, and was 27.5 second-feet. This is about 7 second-feet more than the ditch can carry safely, and the greatest amount diverted is ordinarily about 20 second-feet. The minimum weekly discharge recorded at a time when the ditch was carrying all the water of Buffalo Creek was 3.4 second-feet for July 23 to 29, 1908.

Discharge measurements of Campion ditch at Black Point, 1906 to 1909.

Date.	Hydrographer.	Gage height.	Discharge.
1906.		*Feet.*	*Sec.-ft.*
July 7	F. F. Henshaw	0.80	11.9
20	.....do	.60	8.86
21	.....do	.70	10.2
Aug. 2	.....do	.67	9.70
11	Henshaw and Miller	1.36	27.5
18	.....do	.76	12.0
23	.....do	1.10	19.6
31	F. F. Henshaw	1.00	16.8
1907.			
July 10	F. F. Henshaw	.88	9.93
12	Raymond Richards	.35	2.70
17	.....do	.79	8.20
Aug. 4	Richards and Miller	1.04	13.9
1908.			
June 20	Henshaw and Barrows	.52	7.64
July 9	Henshaw and Miller	.35	5.03
Aug. 29	F. F. Miller	.71	11.3
1909.			
July 29	F. F. Miller	.10	2.19
Aug. 2	F. F. Henshaw	.23	3.71
9	.....do	.39	6.86
9	.....do	.20	3.71

Daily gage height, in feet, and discharge, in second-feet, of Campion ditch at Black Point for 1906–1909.

[Observer, F. F. Miller.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	0	0.69	10.1	0.98	16.5	......	......	1.00	12.8	1.10	15.7
2	......	0	.68	10.0	.90	14.5	......	......	1.00	12.8	1.12	16.3
3	......	0	.65	9.5	1.02	17.5	......	......	1.00	12.8	1.12	16.3
4	......	0	.62	9.0	1.04	18.0	......	......	.99	12.5	1.10	15.7
5	......	0	.56	8.2	1.00	17.0	......	......	.95	11.5	1.06	14.5
6	......	7.0	.61	8.9	1.02	17.5	......	......	.90	10.3	1.11	16.0
7	0.88	14.1	.69	10.1	.96	16.0	0.71	6.8	.92	10.8	1.08	15.1
8	......	0	.70	10.3	.96	16.0	.58	5.1	.96	11.8	1.06	14.5
9	......	0	.73	10.9	1.00	17.0	.80	8.3	.98	12.3	1.16	17.4
10	......	0	.77	11.7	1.08	19.0	.81	8.5	.90	10.3	.82	8.7
11	......	0	1.13	20.4	1.07	18.8	.66	6.0	.90	10.3	.65	5.9
12	......	0	1.05	18.2	1.02	17.5	.52	4.4	.94	11.3	.93	11.0
13	......	0	1.09	19.2	1.06	18.5	.77	7.8	.94	11.3	1.00	12.8
14	......	0	1.02	17.5	1.02	17.5	.69	6.5	.98	12.3	.91	10.5
15	......	0	.92	15.0	.98	16.5	.66	6.0	.89	10.1	.97	12.0
16	......	0	.80	12.3	.93	15.2	.73	7.1	1.08	15.1	.92	10.8
17	......	0	.80	12.3	.92	15.0	.70	6.7	.99	12.5	.97	12.0
18	......	0	.78	11.9	.90	14.5	.95	11.5	1.09	15.4	1.01	13.1
19	......	7.0	.75	11.3	1.10	19.5	.84	9.1	1.01	13.1	1.06	14.5
20	......	13.0	.80	12.3	.98	16.5	.90	10.3	.98	12.3	1.18	18.0
21	......	14.0	.76	11.5	.50	7.5	.94	11.3	1.03	13.6	.98	12.3
22	......	15.0	1.01	17.2	.60	8.7	.88	9.9	1.04	13.9	.99	12.5
23	......	15.0	1.16	21.3	.75	11.3	.93	11.0	1.02	13.4	......	0
24	......	15.0	.99	16.8	.72	10.7	.89	10.1	1.02	13.4	.98	12.2
25	.92	15.0	.93	15.2	.91	14.8	.88	9.9	1.00	12.8	.99	12.5
26	.78	11.9	1.15	21.0	.96	16.0	.89	10.1	1.09	15.4	1.06	14.5
27	.75	11.3	1.16	21.3	1.02	17.5	.83	8.9	1.08	15.1	1.04	13.9
28	.82	12.7	1.14	20.7	.98	16.5	.86	9.5	1.06	14.5	1.03	13.6
29	.78	11.9	1.09	19.2	.95	15.8	.91	10.5	1.05	14.2	.98	12.2
30	.76	11.5	1.00	17.0	.94	15.5	1.05	14.2	1.12	16.3	......	0
31	.72	10.7	.99	16.8	......	......	1.07	14.8	1.08	15.1	......	......
Mean	......	12.3	......	14.4	......	15.8	......	9.0	......	12.9	......	12.5

Daily gage height, in feet, and discharge, in second-feet, of Campion ditch at Black Point for 1906–1909—Continued.

Day.	1908								1909			
	June.		July.		August.		September.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.62	9.6	0.49	7.1	0.35	5.0	0.15	2.8	0.38	6.7
2			.62	9.6	.46	6.7	.70	11.2	.19	3.4	.40	7.1
3			.63	9.8	.69	11.0	.62	9.6	.24	4.2	.40	7.1
4			.58	8.8		.0	.56	8.4	.28	4.9	.44	8.0
5			.55	8.2		.0	.65	10.2	.28	4.9	.42	7.5
6			.50	7.3		.0	.75	12.3	.26	4.5	.40	7.1
7			.44	6.3	.82	13.9	.62	9.6	.26	4.5	.40	7.1
8			.38	5.4	.72	11.6	.60	9.2	.28	4.9	.34	6.0
9			.34	4.9	.62	9.6	.59	9.0	.28	4.9	.34	6.0
10			.32	4.7	.72	11.6	.55	8.2	.30	5.2	.34	6.0
11			.52	7.7	.80	13.4	.50	7.3	.10	2.2	.32	5.6
12			.82	13.9		.0	.50	7.3	.10	2.2	.30	5.2
13			.60	9.2	.48	7.0	.48	7.0	.40	7.1	.30	5.2
14			.45	6.5	.86	17.8	.46	6.7	.44	8.0	.42	7.5
15			.36	5.2	.79	13.2	.50	7.3	.42	7.5	.40	7.1
16			.34	4.9	.74	12.1	.55	8.2	.40	7.1	.44	8.0
17			.34	4.9	.70	11.2	.55	8.2	.40	7.1	.42	7.5
18		4.0	.34	4.9	.68	10.8	.50	7.3	.40	7.1	.40	7.1
19		6.0	.28	4.2		.0	.48	7.0	.44	8.0	.40	7.1
20	0.50	7.3	.27	4.1	.84	14.4	.46	6.7	.42	7.5		
21	.70	11.2	.28	4.2	(.82)	13.9	.40	5.7	.44	8.0		
22	.70	11.2	.18	3.1	.80	13.4			.42	7.5		
23	.81	13.6	.15	2.8	.68	10.8			.40	7.1		
24	.74	12.1	.20	3.3	.68	10.8			.40	7.1		
25	.70	11.2	.20	3.3	.74	12.1			.40	7.1		
26	.78	13.0	.20	3.3	.81	13.6			.40	7.1		
27	.66	10.4	.20	3.3	.78	13.0				7.3		
28	.65	10.2	.16	2.9	.73	11.9			.42	7.5		
29	.68	10.8	.14	2.7	.70	11.2			.44	8.0		
30	.70	11.2		.0	.68	10.8			.40	7.1		
31			.48	7.0		.0			.38	6.7		
Mean		10.2		5.67		9.43		8.16		6.08		6.78

NOTE.—The mean discharge for the period July 28 to 31, 1909, was 3.8 second-feet.

MIOCENE DITCH SYSTEM.

DESCRIPTION.

The Miocene ditch system includes 31 miles of main ditch and 31 miles of lateral feeders and distributing ditches, 8 miles of which are under construction. This ditch diverts water from upper Glacier Creek, upper Snake River, Nome River and its tributaries, and the Grand Central River drainage basin for use on claims along lower Glacier, Dexter, and Anvil creeks.

The first section of this system was built in 1901, from upper Glacier Creek to Snow Gulch, this being the first ditch in Seward Peninsula. In 1902 an extension was made from the "X" to Hobson Creek, and in 1903 the ditch was extended to the head of Nome River, these three sections constituting the main line of the system, with a length of 31 miles. The elevation of the intake is 572 feet and that of the lower end 420 feet, giving a fall of 152 feet. This fall varies at different points along the ditch, ranging from 3.17 to 7 feet to the mile. There are two siphons, one at Dorothy Creek, 24 inches by 300 feet, which carries about 40 second-feet, and one at Manila Creek, 40 inches by 1,000 feet. Below Willow Creek there is a 1,100-foot flume. The main ditch has an average width of 8 feet above and 10 feet below Hobson Creek, and a capacity of 60 second-feet. The mean flow is about 40 second-feet.

The water is delivered from the end of the ditch on claims along Glacier Creek; on Anvil Creek by a tunnel 1,800 feet long and 4 by 6 feet in cross section, built in 1903 and 1904; and on Dexter Creek by a ditch from the "X" around the south side of King Mountain.

The lateral feeders, in order up the ditch, are: (1) From upper Glacier Creek to the "X" (this was the upper portion of the first section of the main ditch); (2) from Grouse and Cold creeks to flume; (3) from upper New Eldorado Creek to Buster Creek (it was originally intended to connect this feeder with the main ditch by a siphon across Nome River, but in 1907 it was extended to producing ground on Buster Creek); (4) the David Creek ditch, which empties into Nome River above the intake; (5) the Jett Creek ditch, which takes water from Jett and Copper creeks and carries it over the Nugget divide; (6) the Grand Central ditch, which is under construction (this ditch diverts water from Nugget Creek and will tap the headwaters of Grand Central River).

Discharge data have been collected at five points on the main ditch and on three of the laterals, as indicated in the list on page 92. Records on the Nugget and Jett Creek branches are included with the others, although these ditches are located in the Grand Central River drainage basin.

MIOCENE DITCH AT BLACK POINT.

This station was established July 1, 1906, and complete records have been kept of the amount of water diverted by the ditch since that date, except from October 1 to 12, 1906, when no record was kept. Although there is a small amount of leakage between the intake and the station, the records may be taken without appreciable error as indicating the amount of water diverted from the river. Measuring conditions are good and the channel is practically permanent. The maximum diversion was 51.5 second-feet in 1910; and the lowest discharge for one week, when all the water of Nome River was diverted, was 4.1 second-feet, for July 23 to 29, 1908.

Discharge measurements of Miocene ditch at Black Point, 1906 to 1910.

Date.	Hydrographer.	Gage height.	Discharge.
1906.		*Feet.*	*Sec.-ft.*
July 7	F. F. Henshaw	.83	31.8
12	Henshaw and Miller	.89	34.1
21	F. F. Henshaw	.71	27.5
27	Henshaw and Miller	.68	25.7
29	.....do	.46	20.6
Aug. 2	F. F. Henshaw	.39	18.1
11	Henshaw and Miller	1.20	44.7
23	F. F. Henshaw	1.30	48.3
Sept. 11	Henshaw and Miller	.85	30.7
25	.....do	1.10	38.2
1907.			
July 4	Raymond Richards	.51	21.8
10	.....do	.57	24.2
17	.....do	.79	29.6
Aug. 2	Henshaw and Miller	.96	36.4
6	F. F. Miller	.62	25.1
16	Richards and Miller	.92	33.5
16	Raymond Richards	1.13	42.5
1908.			
July 9	Henshaw and Miller	−.15	7.2
9	F. F. Henshaw	.00	9.9
Aug. 13	A. T. Barrows	1.16	44.5
29	F. F. Miller	1.10	40.0
1909.			
June 22	F. F. Miller	.09	12.3
26	.....do	.70	31.5
July 17	F. F. Henshaw	.79	31.7
17	.....do	.78	32.7
Aug. 2	.....do	−.18	7.0
9	.....do	1.03	41.0
9	.....do	1.08	44.3
1910.			
Sept. 18	G. L. Parker	1.01	36.8

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch at Black Point for 1906–1910.

[Observers, F. F. Miller, 1906-1909; George Peters, 1910.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	0.70	27	0.40	18.8	1.20	43.5	......	......	1.05	38.8	1.15	42.2
2	.70	27	.38	18.5	1.20	43.5	......	......	.98	36.5	1.15	42.2
3	.60	24	.35	18	1.20	43.5	0.52	22.3	.91	34.2	1.15	42.2
4	.85	31.5	.34	17.8	1.20	43.5	.50	21.7	.85	32.2	1.15	42.2
5	.95	34.8	.33	17.7	1.20	43.5	.50	21.7	.80	30.7	1.15	42.2
6	.88	32.4	.34	17.8	1.20	43.5	.45	20.4	.68	27.0	1.15	42.2
7	.85	31.5	.52	21.6	1.17	42.4	.40	19.2	.61	24.9	1.04	38.4
8	......	0	.48	20.6	1.04	37.9	.48	21.1	.64	25.8	1.08	39.8
9	......	0	.37	18.3	1.00	36.5	.48	21.1	.61	24.9	1.10	40.5
10	......	0	.40	18.8	.98	35.8	.50	21.7	.52	22.3	.80	30.7
11	.50	21	.81	30.3	.82	30.6	.50	21.7	.52	22.3	.48	21.1
12	1.00	36.5	.82	30.6	.80	30	.50	21.7	.52	22.3	.98	36.5
13	1.00	36.5	.96	35.1	.80	30	.50	21.7	.50	21.7	1.15	42.2
14	1.00	36.5	.60	24	.76	28.8	.50	21.7	.55	23.1	1.08	39.8
15	1.20	43.5	.50	21	.72	27.6	.80	30.7	.45	20.4	1.00	37.1

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch at Black Point for 1906–1910—Continued.

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
16	1.10	40	.50	21	.66	25.8	.80	30.7	.90	33.8	1.00	37.1
17	1.10	40	.45	19.9	.64	25.2	.80	30.7	1.15	42.2	1.00	37.1
18	1.10	40	.39	18.6	.78	29.4	.80	30.7	1.15	42.2	1.00	37.1
19	.92	33.7	.46	20.1	.80	30	.80	30.7	1.15	42.2	1.08	39.8
20	.70	27	.86	31.8	.58	23.4	.80	30.7	1.16	42.6	1.15	42.2
21	.70	27	1.12	40.7	.69	26.7	.80	30.7	1.16	42.6	1.08	39.8
22	.62	24.6	1.03	37.6	.92	33.7	.80	30.7	1.16	42.6	1.15	42.2
23	.85	31.5	1.17	42.4	1.00	36.5	.80	30.7	1.10	40.5	1.15	42.2
24	.95	34.8	1.19	43.2	.96	35.1	.80	30.7	1.08	39.8	1.06	39.1
25	.92	33.7	1.20	43.5	1.05	38.2	.85	32.2	1.02	37.7	1.00	37.1
26	.75	28.5	1.17	42.4	1.06	38.6	.86	32.6	1.15	42.2	1.04	38.4
27	.62	24.6	1.16	42.1	1.22	44.2	1.00	37.1	1.16	42.6	.98	36.5
28	.54	22.2	1.20	43.5	1.20	43.5	.94	35.1	1.16	42.6	.94	35.1
29	.50	21	1.20	43.5	1.20	43.5	.94	35.1	1.16	42.6	1.02	37.7
30	.45	19.9	1.20	43.5	1.20	43.5	.96	35.8	1.15	42.2	1.12	41.2
31	.42	19.2	1.20	43.5			1.10	40.5	1.15	42.2		
Mean		27.4		29.2		35.9		28.0		34.4		38.7

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1			0.78	30.1	1.05	38.8	1.15	42.2
2			.46	20.8	0.73	28.6	1.15	42.2
3			.30	16.4	.66	26.4	1.15	42.2
4			.22	14.5	.82	31.3	1.15	42.2
5			.21	14.2	.98	36.4	1.05	38.8
6			.16	13.1	1.15	42.2	0.92	34.5
7			.13	12.5	1.12	41.2	.86	32.6
8			−.01	9.7	.89	33.5	.89	33.5
9			−.06	8.8	.77	29.8	.79	30.4
10			−.14	7.4	.68	27.0	.76	29.5
11			−.12	7.8	1.10	40.5	.66	26.4
12			.18	13.6	1.15	42.2	.55	23.2
13			.00	9.9	1.15	42.2	.67	26.7
14			−.08	8.5	1.15	42.2	.54	22.9
15			−.14	7.4	1.15	42.2	.75	29.2
16			−.17	6.9	1.01	37.4	.74	28.8
17			−.18	6.7	.96	35.8	.61	24.9
18			−.19	6.6	.98	36.4	.52	22.3
19			−.26	5.5	1.15	42.2	.54	22.9
20			−.24	5.8	1.15	42.2	.45	20.4
21			−.29	5.0		0	.45	20.4
22			−.35	4.2	1.15	42.2	.44	20.1
23			−.36	4.1	1.15	42.2		
24	0.15	12.9	−.34	4.3	1.15	42.2		
25	.52	22.3	−.34	4.3	1.15	42.2		
26	.58	24.0	−.34	4.3	1.15	42.2		
27	.58	24.0	−.34	4.3	1.15	42.2		
28	.74	28.8	−.38	3.8	1.15	42.2		
29	.70	27.6	−.38	3.8	1.15	42.2		
30	.81	31.0	.82	31.3	1.05	38.8		
31			1.00	37.1	1.15	42.2		
Mean		24.4		10.7		37.3		29.8

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch at Black Point for 1906–1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			0.80	33.3	−0.14	7.5	−0.10	8.2
2			.80	33.3	− .16	7.2	− .10	8.2
3			.80	33.3	+ .08	11.6	− .12	7.9
4			.80	33.3	.34	18.2	− .12	7.9
5			.80	33.3	.07	11.4	− .04	9.3
6			1.00	40.4	− .03	9.5	.00	10.0
7			1.00	40.4	− .04	9.3	− .06	8.9
8			1.05	42.2	− .08	8.6	− .15	7.4
9			1.10	44.0	1.01	40.8	− .16	7.2
10			1.10	44.0	1.10	44.0	− .16	7.2
11			1.10	44.0	.66	28.4	− .17	7.0
12			1.10	44.0	.44	21.1	− .20	6.5
13			1.05	42.2	.66	28.4	− .20	6.5
14			.88	36.1	.69	29.5	− .12	7.9
15			.75	31.6	.56	25.0	− .17	7.0
16			.82	34.0	.36	18.7	− .15	7.4
17			.74	31.2	.24	15.4	− .15	7.4
18			.82	34.0	.20	14.3	− .15	7.4
19			.70	29.8	.18	13.8	− .20	6.5
20			.58	25.7	.14	12.9		
21			.52	23.7	.12	12.5		
22			.46	21.8	.11	12.2		
23	0.10	12.0	.38	19.3	.09	11.8		
24	.35	18.4	.28	16.5	.05	11.0		
25	.60	26.4	.26	15.9	.00	10.0		
26	.70	29.8	.25	15.6	.02	10.4		
27	.70	29.8	.23	15.1	.04	10.8		
28	.70	29.8	.13	12.7	.05	11.0		
29	.25	15.6	.05	11.0	− .02	9.6		
30	.80	33.3	− .08	8.6	− .05	9.1		
31			− .12	7.9	− .03	9.5		
Mean		24.4		29.0		15.9		7.66

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1			0.80	31.0	1.40	51.5	16		5.0	1.25	46.2	.93	35.3
2			.87	33.3	1.36	50.1	17	0.00	10.0	1.26	46.6	.98	37.0
3			.84	32.3	1.40	51.5	18	.06	11.2	1.34	49.4	1.00	37.7
4			.84	32.3	1.40	51.5	19	.15	13.0	1.38	50.8	1.00	37.7
5			.85	32.6	1.40	51.5	20	.23	14.7	1.39	51.2	1.00	37.7
6			.88	33.6		0.0	21	.28	15.8	1.40	51.5	1.00	37.7
7			.93	35.3		.0	22	.45	20.4	1.40	51.5		10.0
8			1.03	38.7		.0	23	.47	20.9	1.40	51.5		.0
9			1.06	39.7		5.0	24	.45	20.4	1.39	51.2		.0
10			1.14	42.5	0.10	12.0	25	.46	20.6	1.40	51.5	.40	19.0
11			1.20	44.5	.10	12.0	26	.48	21.2	1.40	51.5	.45	20.4
12			1.30	48.0	.10	12.0	27	.48	21.2	1.39	51.2	.45	20.4
13			1.30	48.0	.36	17.9	28	.45	20.4	1.38	50.8	.80	31.0
14			1.30	48.0	.46	20.6	29	.45	20.4	1.39	51.2	.80	31.0
15			1.30	48.0	.90	34.3	30	.45	20.4	1.40	51.5	.80	31.0
							31	.55	23.2	1.40	51.5		
							Mean		17.4		45.1		25.2

NOTE.—The mean discharge for the period Oct. 1 to 3, 1910, was 3.91 second-feet.

MIOCENE DITCH AT CLARA CREEK.

This station was established July 7, 1907, and records were kept during 1907 and a part of 1909 only. There is practically no inflow between Black Point and this point, except during rains, so that a comparison of the records here with those at the station above shows the loss by seepage between the two. The greatest diversion was 35.2 second-feet in 1907. Practically no water reached the section in the lowest water of 1908.

Discharge measurements of Miocene ditch at Clara Creek, 1907 to 1909.

Date.	Hydrographer.	Gage height.	Discharge.
1907.		*Feet.*	*Sec.ft.*
July 9	F. F. Henshaw	0.50	18.2
18	Raymond Richards	.79	27.7
Aug. 9	.....do	.60	21.1
20	.....do	.91	35.2
29	.....do	.92	34.7
Sept. 27	F. F. Henshaw	.88	34.1
1908.			
Sept. 1	A. T. Barrows	.87	35.2
1909.			
July 16	F. F. Henshaw	1.34	29.0
Aug. 2	.....do	.50	4.14
10	.....do	1.45	34.6
Sept. 13	G. L. Parker	.35	1.97

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch at Clara Creek for 1907 and 1909.

[Observers, employees of Miocene Ditch Co.]

Day.	1907						1909					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.89	33.5	0.92	35.2			0.55	5.1	0.52	4.6
2			.85	31.5	.92	35.2			.50	4.2	.50	4.2
3		a 18.0	.84	31.0	.92	35.2			.78	10.0	.45	3.4
4		a 19.0	.80	29.0	.92	35.2			.92	14.2	.40	2.6
5		a 19.0	.78	28.1	.92	35.2			.68	7.6	.55	5.1
6		a 19.0	.66	23.1	.91	34.6			.62	6.4	.48	3.9
7	0.52	18.8	.60	21.0	.89	33.5			.30	1.4	.40	2.6
8	.55	19.6	.58	20.4	.88	33.0				11.0	.40	2.6
9	.50	18.2	.55	19.6	.92	35.2			1.10	20.5	.40	2.6
10	.54	19.3	.52	18.8	.69	24.2			1.50	36.0		2.5
11	.56	19.9	.50	18.2	.70	24.5			1.20	24.0		2.4
12	.46	17.2	.50	18.2	.88	33.0			.98	16.3		2.2
13	.50	18.2	.48	17.7	.95	37.0			1.08	19.8	.35	2.0
14	.51	18.5	.52	18.8	.95	37.0			1.22	24.8		
15	.71	25.0	.48	17.7	.94	36.4			1.05	18.8		
16	.82	30.0	.72	25.4	.91	34.6	1.35	30.0	.98	16.3		
17	.75	26.8	.92	35.2	.91	34.6	1.32	28.8	.85	12.0		
18	.82	30.0	.91	34.6	.91	34.6	1.22	24.8	.80	10.5		
19	.79	28.6	.90	34.0	.92	35.2	1.28	27.2	.78	10.0		
20	.79	28.6	.91	34.6	.85	31.5	1.25	26.0	.75	9.2		
21	.81	29.5	.90	34.0	.95	37.0	1.08	19.8	.72	8.5		
22	.82	30.0	.90	34.0	.88	33.0	1.02	17.7	.70	8.0		
23	.80	29.0	.90	34.0	.88	33.0	1.00	17.0	.68	7.6		
24	.80	29.0	.88	33.0	.92	35.2	.95	15.2	.62	6.4		
25	.80	29.0	.91	34.6	.90	34.0	.92	14.2	.60	6.0		
26	.82	30.0	.92	35.2	.92	35.2	.90	13.5	.60	6.0		
27	.88	33.0	.92	35.2	.88	33.0	.85	12.0	.60	6.0		
28	.88	33.0	.92	35.2	.84	31.0	.70	8.0	.60	6.0		
29	.83	30.5	.92	35.2	.88	33.0	.65	7.0	.60	6.0		
30	.89	33.5	.92	35.2	.88	33.0	.65	7.0	.58	5.6		
31	.92	35.2	.92	35.2			.55	5.1	.55	5.1		
Mean		25.4		28.7		33.7		17.1		11.3		3.13

a Estimated from Black Point records.

MIOCENE DITCH ABOVE HOBSON CREEK.

This station was established in the spring of 1907, and readings on the gage have been continued since that time. The records show the amount of water delivered by the Nome River ditch at the Hobson dam, and are used in connection with the records below the dam to obtain the discharge of Hobson Creek.

The grade of the ditch is high, the current swift, and the channel rough, but fairly good results have been obtained. The maximum amount of water delivered was 43.3 second-feet in 1910. There was no water at all in the ditch during the latter part of the dry period of 1908.

Discharge measurements of Miocene ditch above Hobson Creek, 1907–1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 9	0.88	17.6	Sept. 1	1.40	33.6
July 19	1.25	25.7	1909.		
Aug. 9	.98	18.8	July 15	1.15	23.8
Aug. 29	1.38	35.4	Aug. 1	.34	3.60
Sept. 17	1.36	31.7	Sept. 13	.09	.78
Sept. 28	1.30	31.8			
1908.			1910.		
July 10	.28	3.37	Sept. 17	1.74	36.2
Aug. 12	1.38	31.2	Sept. 22	1.60	33.5

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch above Hobson Creek for 1907–1910.

[Observer, C. D. McDermitt.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.							1907.						
1	......	....	1.37	33.1	1.38	33.5	16	1.17	25.9	1.02	20.8	1.36	32.8
2	......	....	1.31	31.0	1.38	33.5	17	1.21	27.4	1.39	33.8	1.36	32.8
3	0.80	14.7	1.30	30.6	1.38	33.5	18	1.20	27.0	1.38	33.5	1.37	33.1
4	.90	17.3	1.20	27.0	1.38	33.5	19	1.20	27.0	1.38	33.5	1.38	33.5
5	.90	17.3	1.18	26.3	1.38	33.5	20	1.16	25.6	1.38	33.5	1.35	32.4
6	.90	17.3	1.04	21.5	1.38	33.5	21	1.21	27.4	1.38	33.5	1.39	33.8
7	.93	18.1	.97	19.3	1.35	32.4	22	1.21	27.4	1.38	33.5	1.39	33.8
8	.77	13.9	.95	18.7	1.31	31.0	23	1.23	28.1	1.37	33.1	1.29	30.2
9	.89	17.0	.99	19.9	1.39	33.8	24	1.24	28.4	1.29	30.2	1.39	33.8
10	.90	17.3	.90	17.3	1.42	34.9	25	1.22	27.7	1.30	30.6	1.39	33.8
11	.89	17.0	.88	16.8	......	.0	26	1.22	27.7	1.38	33.5	1.39	33.8
12	.85	16.0	.86	16.3	1.34	32.0	27	1.33	31.7	1.38	33.5	1.35	32.4
13	.89	17.0	.84	15.7	1.40	34.2	28	1.33	31.7	1.38	33.5	1.27	29.5
14	.89	17.0	.92	17.9	1.40	34.2	29	1.28	29.9	1.38	33.5	1.30	30.0
15	1.22	27.7	.80	14.7	1.37	33.1	30	1.27	29.5	1.38	33.5	1.35	32.4
							31	1.38	33.5	1.38	33.5	......	....
							Mean	......	23.6	......	27.4	......	31.8

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch above Hobson Creek for 1907–1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1	....	....	0.94	19.3	1.25	28.3	1.39	32.7
2	....	....	.81	15.7	1.10	23.8	1.40	33.0
3	....	....	.65	11.4	1.05	22.4	1.40	33.0
4	....	....	.56	9.3	1.15	25.3	1.40	33.0
5	....	....	.56	8.4	1.32	30.4	1.34	31.0
6	....	....	.50	7.9	1.34	31.1	1.26	28.6
7	....	....	.44	6.6	1.32	30.4	1.26	28.6
8	....	....	.35	4.7	1.25	28.3	1.28	29.2
9	....	....	.38	5.3	1.14	25.0	1.22	27.4
10	....	....	.32	4.1	1.14	25.0	1.20	26.8
11	....	....	.32	4.1	1.30	29.8	1.08	23.2
12	....	....	.54	8.8	1.36	31.7	1.02	21.6
13	....	....	.45	6.8	1.36	31.7	1.10	23.8
14	....	....	.32	4.1	1.36	31.7	.95	19.6
15	....	....	.28	3.4	1.38	32.4	1.12	24.4
16	....	....	.24	2.7	1.32	30.4	1.25	28.3
17	....	....	.16	1.4	1.31	30.1	1.18	26.2
18	....	....	.16	1.4	1.30	29.8	1.05	22.4
19	....	....	.10	.5	1.40	33.0	1.02	21.6
20	....	....	.12	.8	1.38	32.4	.98	20.4
21	....	....	.12	.8	....	.0	.90	18.2
22	....	....	....	.2	1.38	32.4	.90	18.2
23	....	....	....	.1	1.38	32.4	.80	15.4
24	....	....	....	.1	1.38	32.4	....	....
25	0.80	15.4	....	.1	1.35	31.4	....	....
26	.81	15.7	....	.0	1.35	31.4	....	....
27	.80	15.4	....	.0	1.35	31.4	....	....
28	.90	18.2	....	.0	1.35	31.4	....	....
29	1.02	21.6	....	.0	1.35	31.4	....	....
30	1.04	22.1	.61	10.4	1.32	30.4	....	....
31	....	....	1.24	28.0	1.39	32.7	....	....
Mean	....	18.1	....	5.4	....	29.0	....	25.5
1909.								
1	....	....	1.26	27.2	0.31	3.2	0.25	2.4
2	....	....	1.24	26.6	.28	2.8	.25	2.4
3	....	....	1.24	26.6	.28	2.8	.20	1.8
4	....	....	1.21	25.7	.90	16.8	.20	1.8
5	....	....	1.20	25.4	.62	9.5	.30	3.0
6	....	....	1.32	29.0	.48	6.2	....	2.0
7	....	....	1.32	29.0	.20	1.8	....	1.8
8	....	....	1.34	29.6	....	.0	....	1.8
9	....	....	1.34	29.6	.92	17.4	....	1.5
10	....	....	1.35	29.9	1.48	33.8	....	1.8
11	....	....	1.35	29.9	1.17	24.5	....	1.5
12	....	....	1.35	29.9	.92	17.4	....	1.2
13	....	....	1.35	29.9	.92	17.4	.09	.8
14	....	....	1.25	26.9	1.16	24.2	....	.8
15	....	....	1.18	24.8	.95	18.2	....	.8
16	....	....	1.21	25.7	.88	16.2	....	.8
17	....	....	1.14	23.6	.68	10.9	....	.8
18	....	....	1.05	21.0	.60	9.0	....	.8
19	....	....	1.15	23.9	.60	9.0	....	.8
20	....	....	1.07	21.6	.58	8.5	....	....
21	....	....	.83	14.8	.55	7.8	....	....
22	....	....	.80	14.0	.54	7.6	....	....
23	0.75	12.7	.84	15.1	.50	6.6	....	....
24	.82	14.6	.76	13.0	.42	5.0	....	....
25	1.05	21.0	.70	11.4	.40	4.6	....	....
26	1.15	23.9	.68	10.9	.40	4.6	....	....
27	1.15	23.9	.62	9.5	.38	4.3	....	....
28	1.15	23.9	.60	9.0	.40	4.6	....	....
29	1.10	22.4	.49	6.4	.35	3.8	....	....
30	1.09	22.1	.46	5.8	.30	3.0	....	....
31	....	....	.38	4.3	.30	3.0	....	....
Mean	....	20.6	....	21.0	....	9.84	....	1.51

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch above Hobson Creek for 1907–1910—Continued.

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1	......	......	1.40	26.6	1.92	43.3	17	0.92	13.5	1.85	40.9	1.74	37.2
2	......	......	1.40	26.6	1.92	43.3	18	1.00	15.5	1.85	40.9	1.75	37.6
3	......	......	1.45	28.1	1.88	41.9	19	1.10	18.2	1.85	40.9	1.76	37.9
4	......	......	1.60	32.7	1.88	41.9	20	1.20	20.9	1.85	40.9	1.77	38.2
5	......	......	1.60	32.7	1.90	42.6	21	1.18	20.4	1.85	40.9	1.75	37.6
6	......	......	1.55	31.2	1.00	15.5	22	1.20	20.9	1.85	40.9	1.65	34.3
7	......	......	1.50	29.6	......	.0	23	1.18	20.4	1.85	40.9	1.65	34.3
8	......	......	1.55	31.2	......	.0	24	1.18	20.4	1.85	40.9	1.12	18.7
9	......	......	1.58	32.1	1.10	18.2	25	1.12	18.7	1.85	40.9	1.08	17.7
10	......	......	1.60	32.7	1.10	18.2	26	1.18	20.4	1.82	39.9	1.28	23.1
11	......	......	1.68	35.3	1.52	30.2	27	1.08	17.7	1.85	40.9	1.50	29.6
12	......	......	1.65	34.3	1.35	25.2	28	1.00	15.5	1.85	40.9	1.48	29.0
13	......	......	1.75	37.6	1.35	25.2	29	1.00	15.5	1.85	40.9	1.56	31.5
14	......	......	1.75	37.6	1.45	28.1	30	1.10	18.2	1.85	40.9	1.61	33.0
15	......	......	1.75	37.6	1.75	37.6	31	1.30	23.7	1.90	42.6	......	......
16	0.95	14.2	1.75	37.6	1.75	37.6	Mean	......	18.4	......	36.7	......	29.6

NOTE.—The mean discharge for the period Oct. 1 to 3, 1910, was 33.8 second-feet.

MIOCENE DITCH BELOW HOBSON CREEK.

Records at this station were begun in the spring of 1907 and are complete to 1910. The discharge includes that of the Nome River ditch and of Hobson Creek. In dry years like 1909 more than half the total amount of water comes from the latter source. In the fall slush ice does not affect the flow at this point as soon as at the other stations on the ditch, because the warm water from Hobson Creek keeps the temperature above freezing point. The maximum diversion was 59.9 second-feet in 1910; the minimum flow for one week, all of which was furnished by Hobson Creek, occurred July 23 to 29, 1908, and was 6.2 second-feet.

Discharge measurements of Miocene ditch below Hobson Creek, 1907 to 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 2	1.60	24.8	July 15	2.12	39.0
July 9	2.08	39.1	July 15	2.11	38.3
July 19	2.30	46.8	Aug. 1	1.22	13.2
July 24	2.38	49.4	Sept. 13	.93	6.95
Sept. 27	2.38	51.8			
			1910.		
1908.			Sept. 17	2.78	61.0
June 19	.64	3.70	Sept. 22	2.57	51.2
July 10	1.14	11.3			
Aug. 12	1.08	9.24			
Aug. 12	2.14	40.4			
Sept. 1	2.30	45.0			

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch below Hobson Creek for 1907–1910.

[Observer, C. D. McDermitt.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.							1907.						
1	1.63	25.5	2.46	53.5	2.40	51.2	16	2.29	47.0	2.03	37.7	2.30	47.4
2	1.60	24.9	2.36	49.7	2.39	50.8	17	2.31	47.8	2.33	48.5	2.30	47.4
3	1.74	28.3	2.36	49.7	2.39	50.8	18	2.32	48.2	2.32	48.2	2.31	47.8
4	2.10	40.0	2.27	46.3	2.40	51.2	19	2.31	47.8	2.31	47.8	2.31	47.8
5	2.10	40.0	2.25	45.5	2.39	50.8	20	2.30	47.4	2.31	47.8	2.34	48.9
6	2.05	38.4	2.11	40.4	2.38	50.4	21	2.30	47.4	2.34	48.9	2.33	48.5
7	2.03	37.7	2.06	38.7	2.34	48.9	22	2.33	48.5	2.32	48.2	2.32	48.2
8	2.09	39.7	1.98	36.0	2.34	48.9	23	2.38	50.4	2.30	47.4	2.33	48.5
9	2.14	41.5	2.04	38.0	2.38	50.4	24	2.38	50.4	2.29	47.0	2.38	50.4
10	2.10	40.0	1.95	35.5	2.45	53.1	25	2.34	48.9	2.34	48.9	2.35	49.3
11	2.10	40.0	1.89	33.0	......	0	26	2.38	50.4	2.39	50.8	2.37	50.1
12	2.10	40.0	1.89	33.0	2.33	48.5	27	2.46	53.5	2.39	50.8	2.37	50.1
13	2.10	40.0	1.86	32.1	2.40	51.2	28	2.45	53.1	2.39	50.8	2.33	48.5
14	2.10	40.0	1.93	34.3	2.37	50.1	29	2.37	50.1	2.40	51.2	2.35	49.3
15	2.30	47.4	1.83	31.0	2.30	47.4	30	2.38	50.4	2.40	51.2	2.37	50.1
							31	2.49	54.7	2.40	51.2	......	......
							Mean	......	43.8	......	45.3	......	47.9

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1	......	......	1.96	33.6	2.00	35.0	2.30	45.5
2	......	......	1.76	26.8	1.80	28.0	2.30	45.5
3	......	......	1.60	22.0	1.75	26.5	2.30	45.5
4	......	......	1.46	17.8	1.80	28.0	2.30	45.5
5	......	......	1.42	16.6	2.12	39.2	2.25	43.8
6	......	......	1.40	16.0	2.15	40.2	2.18	41.3
7	......	......	1.34	14.4	2.16	40.6	2.19	41.6
8	......	......	1.30	13.4	2.05	36.8	2.18	41.3
9	......	......	1.28	12.9	1.94	32.9	2.12	39.2
10	......	......	1.20	12.0	1.85	29.8	2.08	37.8
11	......	......	1.18	11.6	2.10	38.5	1.98	34.3
12	......	......	1.36	15.0	2.18	41.3	1.88	30.8
13	......	......	1.27	13.7	2.20	42.0	1.97	34.0
14	......	......	1.17	11.4	2.24	43.4	1.84	29.4
15	......	......	1.13	10.6	2.25	43.8	1.98	34.3
16	......	......	1.09	9.8	2.22	42.7	2.08	37.8
17	......	......	1.04	9.0	2.20	42.0	1.98	34.3
18	......	......	1.04	9.0	2.20	42.0	1.85	29.8
19	0.82	5.7	.99	8.2	2.30	45.5	1.82	28.7
20	1.00	8.3	.94	7.4	2.29	45.2	1.79	27.7
21	1.10	10.0	.96	7.7	1.20	12.0	1.68	24.4
22	1.10	10.0	.90	6.8	2.28	44.8	1.70	25.0
23	1.10	10.0	.88	6.5	2.30	45.5	1.30	13.4
24	1.10	10.0	.89	6.7	2.30	45.5	......	......
25	1.20	12.0	.89	6.7	2.30	45.5	......	......
26	1.80	28.0	.86	6.2	2.30	45.5	......	......
27	1.80	28.0	.84	6.0	2.30	45.5	......	......
28	1.90	31.5	.82	5.7	2.30	45.5	......	......
29	2.02	35.7	.82	5.7	2.20	42.0	......	......
30	2.08	37.8	1.34	14.4	2.28	44.8	......	......
31	......	......	1.98	34.3	2.31	45.8	......	......
Mean	......	18.9	......	12.8	......	39.5	......	35.3

NOTE.—The mean discharge for the period June 28–30, 1907, was 25.8 second-feet.

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch below Hobson Creek for 1907–1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			2.15	40.7	1.22	12.7	1.10	10.0
2			2.14	40.4	1.18	11.8	1.06	9.3
3			2.22	43.1	1.15	11.1	1.02	8.6
4			2.24	43.8	1.60	23.0	1.00	8.2
5			2.22	43.1	1.32	15.2	1.08	9.6
6			2.31	46.4	1.28	14.2	1.00	8.2
7			2.30	46.0	1.10	10.0	1.00	8.2
8			2.30	46.0	1.00	8.2	1.00	8.2
9			2.30	46.0	1.68	25.4	.99	8.0
10			2.30	46.0	2.19	42.1	.98	7.9
11			2.30	46.0	1.94	33.7	.98	7.9
12			2.30	46.0	1.62	23.6	.96	7.6
13			2.30	46.0	1.62	23.6	.93	7.1
14			2.20	42.4	1.87	31.4	.99	8.0
15			2.15	40.7	1.65	24.5	.93	7.1
16			2.15	40.7	1.58	22.4	.94	7.2
17			2.09	38.7	1.42	18.0	.98	7.9
18	1.05	9.1	1.92	33.0	1.40	17.4	.92	6.9
19	1.10	10.0	2.05	37.3	1.40	17.4	.91	6.8
20	1.40	17.4	1.95	34.0	1.35	16.0		
21	1.45	18.8	1.84	30.5	1.30	14.7		
22	1.40	17.4	1.75	27.6	1.30	14.7		
23	1.75	27.6	1.72	26.6	1.28	14.2		
24	1.80	29.2	1.68	25.4	1.21	12.4		
25	2.00	35.6	1.67	25.1	1.20	12.2		
26	2.10	39.0	1.55	21.6	1.20	12.2		
27	2.11	39.3	1.52	20.8	1.19	12.0		
28	2.10	39.0	1.48	19.6	1.20	12.2		
29	2.00	35.6	1.40	17.4	1.18	11.8		
30	2.11	39.3	1.35	16.0	1.15	11.1		
31			1.28	14.2	1.10	10.0		
Mean		27.5		35.2		17.4		8.04

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1	1.00	6.6	2.50	49.6	......	58.8	16	1.95	30.6	2.68	56.2	2.70	56.9
2	1.10	8.1	2.35	44.2	2.75	58.8	17	2.05	33.9	2.62	53.9	2.68	56.2
3	1.10	8.1	2.52	50.3	2.74	58.4	18	1.95	30.6	2.72	57.6	2.72	57.6
4	1.50	17.5	2.55	51.4	2.76	59.1	19	1.90	29.1	2.75	58.8	2.74	58.4
5	1.70	23.1	2.50	49.6	2.78	59.9	20	1.80	26.0	2.75	58.8	2.74	58.4
6	1.70	23.1	2.45	47.8	......	30.0	21	1.98	31.6	2.75	58.8	2.60	53.2
7	1.90	29.1	2.50	49.6	......	.0	22	2.06	34.2	2.74	58.4	2.32	43.2
8	1.90	29.1	2.55	51.4	......	.0	23	2.08	34.9	2.74	58.4	1.60	20.2
9	2.00	32.2	2.58	52.5	1.10	8.1	24	2.10	35.6	2.75	58.8	2.22	39.7
10	1.80	26.0	2.60	53.2	2.40	46.0	25	2.10	35.6	2.74	58.4	2.29	42.2
11	1.80	26.0	2.62	53.9	2.40	46.0	26	2.20	39.0	2.75	58.8	2.30	42.5
12	2.10	35.6	2.62	53.9	2.40	46.0	27	2.08	34.9	2.76	59.1	2.40	46.0
13	1.85	27.6	2.62	53.9	2.50	49.6	28	1.75	24.6	2.75	58.8	2.55	51.4
14	1.85	27.6	2.65	55.0	2.55	51.4	29	2.00	32.2	2.75	58.8	2.60	53.2
15	1.90	29.1	2.70	56.9	2.70	56.9	30	2.30	42.5	2.78	59.9	2.60	53.2
							31	2.30	42.5	2.76	59.1		
							Mean.		28.6		55.0		45.4

NOTE.—The mean discharge for the period June 29–30, 1910, was 5.6 second-feet; that for the period Oct. 1–3, 1910, was 52.6 second-feet.

MIOCENE DITCH BELOW THE FLUME.

Gage heights were kept at this point for the Miocene Ditch Co. before any measurements were made, but those prior to 1906 were all lost in the San Francisco fire. Records are practically complete from 1906 to 1910. This is the lowest regular station on the ditch. It is located at the lower end of the flume, just below the Grouse Creek branch and 9.2 miles above the "X" where the ditch branches, one fork going to Dexter Creek and the other to Glacier Creek. The gage heights for 1906 and earlier years were kept a few feet above the lower end of the flume. Since then the gage has been located about 100 feet below, in the earth section of the ditch. The maximum discharge of 64 second-feet occurred in 1910, and the minimum flow for a week was 4.2 second-feet July 23 to 29, 1908.

Discharge measurements of Miocene ditch below the flume, 1906 to 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.			1908.		
July 4	0.95	29.8	July 11	0.83	12.1
July 27	1.08	36.5	Aug. 11	1.63	35.9
Aug. 2	.81	28.3	Aug. 30	1.78	42.1
Sept. 11	1.50	43.9	Aug. 31	1.86	44.2
Sept. 25	1.85	58.2			
Sept. 26	1.65	48.3	1909.		
			July 15	1.52	40.2
1907.			July 31	.70	12.0
July 2	1.58	36.1	Aug. 10	1.40	35.3
July 3	1.51	32.2	Sept. 12	.50	6.32
July 19	1.99	50.1			
July 23	2.09	55.3	1910.		
Aug. 10	1.63	32.6	Sept. 17	2.11	53.7
Aug. 29	2.05	50.8			
Sept. 28	2.02	50.0			

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch below the flume for 1906–1910.

[Observers, J. W. Warwick, 1906–1909; O. Carlson, 1910.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906.												
1	0.98	31.6	0.82	27.2	1.71	51.5	1.56	33.5	2.05	52.0	2.02	50.8
2	.95	30.8	.81	27	1.71	51.5	1.56	33.5	2.00	50.0	2.00	50.0
3	.92	29.9	.84	27.8	1.70	51.2	1.56	33.5	1.92	46.8	2.00	50.0
4	1.00	32.1	.89	29.1	1.70	51.2	1.74	39.6	1.86	44.4	2.00	50.0
5	1.08	34.3	.90	29.4	1.70	51.2	1.75	40.0	1.82	42.8	2.00	50.0
6	1.09	34.5	.91	29.7	1.69	50.9	1.75	40.0	1.78	41.2	2.00	50.0
7	1.12	35.3	.93	30.2	1.66	50.1	1.70	38.0	1.70	38.0	1.99	49.6
8	(a)	0	.98	31.6	1.68	50.6	1.77	40.8	1.68	37.3	1.98	49.2
9	(a)	0	.90	29.4	1.63	49.2	1.80	42.0	1.69	37.7	2.04	51.6
10	(a)	0	.88	28.9	1.54	46.7	1.86	44.4	1.63	35.6	2.10	54.0
11	.79	26.4	1.01	32.4	1.49	45.3	1.77	41.0	1.58	34.0	(a)	0
12	1.10	34.8	1.13	35.6	1.46	44.5	1.80	42.0	1.56	33.5	1.98	49.2
13	1.26	39.1	1.23	38.3	1.45	44.2	1.85	44.0	1.54	32.9	2.02	50.8
14	1.29	39.9	1.02	32.6	1.41	43.2	1.85	44.0	1.58	34.0	2.12	54.8
15	1.28	39.7	.94	30.5	1.40	42.9	1.92	46.8	1.50	31.8	2.10	54.0
16	1.39	42.6	.92	29.9	1.34	41.3	1.80	42.0	1.71	38.4	2.10	54.0
17	1.35	41.6	.91	29.7	1.31	40.5	1.95	48.0	1.96	48.4	2.10	54.0
18	1.35	41.6	.87	28.6	1.47	44.8	1.95	48.0	1.95	48.0	2.11	54.4
19	1.28	39.7	.86	28.3	1.48	45.1	1.95	48.0	1.92	46.8	2.12	54.8
20	1.19	37.2	1.10	34.8	1.52	46.2	1.95	48.0	1.94	47.6	2.10	54.0
21	1.16	36.4	1.29	39.9	1.58	47.8	2.00	50.0	1.95	48.0	2.13	55.2
22	1.11	35.1	1.28	39.7	1.65	49.8	2.00	50.0	1.93	47.2	2.08	53.2
23	1.19	37.2	1.32	40.7	1.61	48.7	2.02	50.8	1.92	46.8	2.04	51.6
24	1.09	34.5	1.40	42.9	1.60	48.4	1.99	49.6	1.92	46.8	2.09	53.6
25	1.26	39.1	1.44	44	1.71	51.5	2.01	50.4	1.95	48.0	2.09	53.6
26	1.17	36.7	1.55	47	1.63	49.2	2.05	52.0	2.00	50.0	2.08	53.2
27	1.07	34	1.34	41.3	1.75	52.6	2.08	53.2	2.04	51.6	2.08	53.2
28	.98	31.6	1.46	44.5	1.76	52.9	2.06	52.4	2.01	50.4	2.03	51.2
29	.95	30.8	1.51	45.9	1.79	53.7	2.04	51.6	2.04	51.6	2.03	51.2
30	.91	29.7	1.56	47.3	1.80	54	2.00	50.0	2.06	52.4	2.04	51.6
31	.88	28.9	1.50	45.6	......	....	2.03	51.2	2.03	51.2	......	....
Mean	......	31.8	......	35.2	......	48.4	......	45.1	......	44.0	......	50.4

a Ditch broken by heavy rains.

NOTE.—The mean discharge for the period June 28 to 30, 1907, was about 28 second-feet.

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch below the flume, for 1906-1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1			1.54	33.5	1.49	31.9	1.83	43.2
2			1.35	27.4	1.34	27.1	1.84	43.6
3			1.20	22.8	1.29	25.6	1.84	43.6
4			1.08	19.2	1.42	29.6	1.81	42.5
5			1.04	18.1	1.66	37.4	1.78	41.5
6			1.01	17.2	1.66	37.4	1.72	39.5
7			.92	14.6	1.63	36.4	1.68	38.1
8			.90	14.0	1.57	34.4	1.69	38.5
9			.83	12.0	1.48	31.6	1.66	37.4
10			.81	11.5	1.40	29.0	1.59	35.1
11			.82	11.8	1.54	33.5	1.51	32.5
12			.94	15.2	1.54	33.5	1.45	30.6
13			.88	13.4	1.74	40.2	1.52	32.8
14			.76	10.2	1.75	40.5	1.50	32.2
15			.72	9.1	1.76	40.8	1.52	32.8
16			.67	7.9	1.73	39.8	1.60	35.4
17			.65	7.5	1.70	38.8	1.52	32.8
18			.64	7.3	1.69	38.5	1.46	30.9
19	0.70	8.6	.61	6.6	1.77	41.2	1.42	29.6
20	.74	9.6	.58	6.0	1.76	40.8	1.36	27.8
21	.89	13.7	.59	6.2	.94	15.2	1.32	26.5
22	.91	14.3	.54	5.2	1.76	40.8	1.27	25.0
23	.81	13.2	.50	4.4	1.79	41.9	.59	6.2
24	.88	13.4	.50	4.4	1.84	43.6		
25	1.07	18.9	.51	4.6	1.84	43.6		
26	1.29	25.6	.49	4.2	1.83	43.2		
27	1.44	30.3	.48	4.0	1.81	42.5		
28	1.49	31.9	.48	4.0	1.80	42.2		
29	1.52	32.8	.48	4.0	1.78	41.5		
30	1.59	35.1	.95	15.4	1.79	41.9		
31			1.51	32.5	1.86	44.2		
Mean		20.6		12.1		37.0		33.8
1909.								
1			1.62	43.6	0.66	10.7	0.60	8.9
2			1.60	42.8	.62	9.5	.60	8.9
3			1.63	43.9	.68	11.3		8.3
4			1.64	44.3	.98	20.8		8.0
5			1.61	43.2	.81	15.3		9.2
6			1.68	45.8	.72	12.5		7.8
7			1.66	45.1	.62	9.5		7.8
8			1.65	44.7	.50	6.4		7.7
9			1.65	44.7	1.01	21.7	.55	7.6
10			1.65	44.7	1.42	36.1		7.1
11			1.65	44.7	1.28	31.1	.51	6.6
12			1.63	43.9	1.03	22.4	.50	6.4
13			1.59	42.4	1.02	22.1		6.2
14			1.54	40.5	1.15	26.5		7.6
15			1.46	37.6	1.04	22.8		6.2
16			1.48	38.3	.97	20.4		9.0
17			1.42	36.1	.89	17.9	.68	11.3
18			1.37	34.3	.84	16.3		7.5
19	0.49	6.2	1.37	34.3	.82	15.6	.53	7.2
20	.86	16.9	1.30	31.8	.79	14.7		
21	.99	21.1	1.21	28.6	.77	14.1		
22	.99	21.1	1.14	26.2	.75	13.4		
23	1.18	27.5	1.11	25.1	.73	12.8		
24	1.29	31.4	1.03	22.4	.69	11.6		
25	1.40	35.4	.98	20.8	.69	11.6		
26	1.50	39.0	.96	20.1	.67	11.0		
27	1.54	40.5	.93	19.2	.66	10.7		
28	1.57	41.7	.91	18.5	.69	11.6		
29	1.57	41.7	.82	15.6	.67	11.0		
30	1.47	37.9	.74	13.1	.62	9.5		
31			.70	11.9	.61	9.2		
Mean		30.0		33.8		15.8		7.86

Daily gage height, in feet, and discharge, in second-feet, of Miocene ditch below the flume, for 1906–1910—Continued.

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1	0.68	8.2	2.13	54.2	2.35	62.8	16	1.42	29.7	2.21	57.4	2.15	55.0
2	.80	11.2	1.96	47.8	2.36	63.2	17	1.54	33.6	2.16	55.4	(a)	53
3	.85	12.6	2.06	51.6	2.38	64.0	18	1.54	33.6	2.35	62.8	(a)	53
4	.92	14.5	2.15	55.0	2.38	64.0	19	1.55	34.0	2.35	62.8	(a)	53
5	1.04	18.0	2.10	53.1	2.38	64.0	20	1.75	40.6	2.37	63.6	(a)	53
6	1.15	21.2	2.09	52.7	......	0	21	1.62	36.3	2.38	64.0	(a)	53
7	1.32	26.4	2.08	52.3	......	0	22	1.72	39.6	2.38	64.0	(a)	53
8	1.35	27.4	2.10	53.1	......	0	23	1.71	39.2	2.36	63.2	(a)	53
9	1.25	24.2	2.10	53.1	1.24	23.9	24	1.70	38.9	2.35	62.8	(a)	53
10	1.22	23.3	2.12	53.9	1.98	48.6	25	1.70	38.9	2.33	62.1	(a)	53
11	1.38	28.4	2.12	53.9	1.90	45.6	26	1.70	38.9	2.35	62.8	(a)	53
12	1.40	29.0	2.18	56.2	1.90	45.6	27	1.70	38.9	2.35	62.8	(a)	53
13	1.36	27.7	2.20	57.0	1.92	46.3	28	1.70	38.9	2.32	61.7	(a)	53
14	1.37	28.0	2.20	57.0	1.92	46.3	29	1.58	34.9	2.30	60.9	(a)	53
15	1.45	30.6	2.20	57.0	2.15	55.0	30	1.99	48.9	2.30	60.9	(a)	53
							31	1.96	47.8	2.31	61.3	......	......
							Mean	......	30.4	......	57.9	......	47.5

a According to the observer, the gage height for the interval Sept. 17–30, 1910, averaged 2.10.

NOTE.—The discharge for June 30, 1910, was 10.7 second-feet.

DAVID CREEK DITCH OPPOSITE BLACK POINT.

This station was maintained for a part of August, 1906, and whenever water was diverted during the seasons of 1907 to 1909. It was first located just above the point where the water is dropped into a small gully, through which it reaches Nome River. In 1907 it was moved up to the railroad crossing, its present location. The capacity of the ditch was about 14 second-feet in 1906 and was increased to 20 second-feet in the spring of 1907. The maximum diversion was 16.5 second-feet in 1907. The discharge was less than 1 second-foot at one time in 1908, but the exact minimum was not determined.

Discharge measurements of David Creek ditch opposite Black Point, 1906 to 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*
July 3	....	3.50	July 25	0.79	13.0
July 29	....	6.42	Do	.83	13.7
Aug. 3	....	4.40	Aug. 3	.69	11.5
Aug. 23	0.51	7.88			
Do	.41	5.38	1908.		
Do	.49	7.60	July 9	.37	3.08
Do	.63	10.1	Aug. 13	.90	14.3
Do	.78	13.7			
Do	.81	13.7	1909.		
Do	.68	11.4	July 16	.55	7.69
			Aug. 2	.28	2.95
1907.			Aug. 9	.49	6.48
July 17	.50	8.93			

Daily gage height, in feet, and discharge, in second-feet, of David Creek ditch for 1906–1909.

[Observer, F. F. Miller.]

Day.	August, 1906.		1907					
			July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	...	...	...	...	0.75	12.4	0.70	11.6
2	...	...	...	...	.70	11.6	.65	10.9
3	...	...	...	...	.80	13.2	.80	13.2
4	0.35	4.4	...	...	.69	11.5	.80	13.2
5	.35	4.4	...	...	.67	11.2	.72	11.9
6	.35	4.4	...	...	.62	10.5	.70	11.6
7	.42	5.8	...	...	.60	10.2	.68	11.3
8	.38	5.0	...	...	.56	9.6	.60	10.2
9	.37	4.8	...	...	.56	9.6	.60	10.2
10	.37	4.8	...	...	.52	9.1	.50	8.9
11	.38	5.0	...	...	.52	9.1	.55	9.5
12	.40	5.4	...	...	.52	9.1	...	0
13	.38	5.0	...	...	.52	9.1	...	0
14	.35	4.4	...	...	.50	8.9	...	0
15	.34	4.3	...	...	.50	8.9	...	0
16	.33	4.1	...	...	.80	13.2	...	0
17	.39	5.2	0.50	8.9	.82	13.5	...	0
18	.31	3.7	.52	9.1	.80	13.2	.90	14.9
19	.29	3.3	.50	8.9	.90	14.9	.99	16.5
20	.40	5.4	.60	10.2	.90	14.9	.85	14.0
21	.38	5.0	.60	10.2	.95	15.8	.85	14.0
22	.50	7.5	.60	10.2	.95	15.8	.73	12.1
23	.52	7.9	.80	13.2	.72	11.9	.68	11.3
24	.48	7.1	.80	13.2	.70	11.6	...	10.6
25	.54	8.3	.80	13.2	.72	11.9	.58	9.9
26	.77	13.2	.80	13.2	.72	11.9	.57	9.8
27	.34	4.3	.70	11.6	.75	12.4	.54	9.4
28	.40	5.4	.65	10.9	.75	12.4	.50	8.9
29	.41	5.6	.75	12.4	.75	12.4	.50	8.9
30	.78	13.4	.75	12.4	.75	12.4	.45	8.3
31	.80	13.8	.75	12.4	.75	12.4	...	...
Mean	...	6.1	...	11.3	...	11.8	...	9.0

NOTE.—These discharges are believed to represent the total flow of the creek from Aug. 3 to 20, 1906, and from about July 23 to Sept. 8, and Sept. 19 to 30, 1907.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1	...	...	0.62	7.4	0.68	8.6	0.82	12.1
2	...	...	.42	3.8	.48	4.7	...	12.1
3	...	...	.40	3.5	...	.0	.82	12.1
4	...	...	.40	3.5	...	.0	.82	12.1
5	...	...	.40	3.5	...	.0	.82	12.1
6	...	...	.40	3.5	...	.0	.78	11.0
7	...	...	.40	3.5	.68	8.6	.74	10.0
8	...	...	.40	3.5	...	9.2	.72	9.5
9	...	...	.37	3.1	...	9.6	.66	8.2
10	...	...	.39	3.4	.75	10.2	.64	7.8
11	...	...	.46	4.4	.80	11.5	...	8.0
12	...	...	.34	2.7	...	0	.66	8.2
13	...	...	.36	3.0	.90	14.3	...	8.0
14	...	...	.40	3.5	...	13.4	.64	7.8
15	...	...	.36	3.0	.84	12.6	.60	7.0
16	...	...	.36	3.0	.84	12.6	.60	7.0
17	...	...	...	2.5	...	12.0	.60	7.0
18	...	...	.28	2.0	.80	11.5	.60	7.0
19	...	...	.28	2.0	...	0	.58	6.6
20	...	...	...	1.8	...	0	...	6.0

Daily gage height, in feet, and discharge, in second-feet, of David Creek ditch for 1906–1909—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
21				1.8	0.80	11.5		6.0
22				1.6		11.5		5.0
23				1.4	.80	11.5		
24				1.2	.82	12.1		
25			0.20	1.2		11.8		
26	0.20	1.2		1.0	.80	11.5		
27	.40	3.5		1.0		11.5		
28	.70	9.0		.8		11.5		
29	.70	9.0		.8	.80	11.5		
30	.60	7.0	.70	9.0	.82	12.1		
31				0		0		
Mean		5.9		2.8		8.2		8.7
1909.								
1			0.60	8.8		3.3		3.3
2			.60	8.8	0.28	3.0	0.30	3.2
3				7.8	.28	3.0		3.2
4			.50	6.7	.36	4.2		3.1
5			.50	6.7		3.9		3.0
6			.90	16.2		3.6		2.9
7			.90	16.2		3.3		2.8
8				16.2	.29	3.1	.26	2.7
9			.90	16.2	.52	7.1		2.7
10			.80	13.6		6.2		2.7
11			.85	14.9	.42	5.2	.26	2.7
12			.80	13.6		6.2		2.6
13			.60	8.8	.52	7.1		2.5
14			.55	7.8		6.6	.23	2.4
15			.50	6.7		6.1		2.6
16			.55	7.8		5.6	.26	2.7
17			.50	6.7	.42	5.2		2.6
18			.60	8.8		5.0		2.5
19			.45	5.8		4.8		2.4
20			.38	4.5		4.5		
21			.38	4.5		4.2		
22				4.5		4.0		
23			.38	4.5	.34	3.8		
24	0.32	3.5		4.4		3.8		
25		6.2		4.4		3.7		
26	.60	8.8		4.3		3.7		
27	.90	16.2	.36	4.2		3.6		
28		0		4.0		3.6		
29		0		4.0		3.5		
30	.60	8.8	.34	3.8		3.4		
31				3.5		3.4		
Mean		6.2		8.0		4.4		2.8

JETT CREEK DITCH.

The Jett Creek ditch was constructed during 1906 to divert the water of Jett and Copper creeks over the Nugget divide. The water was turned in from Copper Creek July 20 and from Jett Creek August 18 of that year, and the ditches have been used during the greater part of each succeeding summer except in 1910, when there was an ample supply without this diversion. The water was occasionally turned out during wet periods of 1906–1909.

A few miscellaneous measurements were made in 1906. In July, 1907, before the water was turned in, a gage was established which was read during 1907 and 1909. It was located just below the junction of the two branches and shows practically the exact amount of water delivered from this source over the Nugget divide. The maximum diversion was 8.2 second-feet in 1907. The ditch can be made to hold somewhat more than this amount of water, but when water is available from the two creeks it is not needed on Nome River. No water reached the outlet during the dry period of 1908.

Discharge measurements of Jett Creek ditch below siphon, 1906 to 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*
Aug. 29		4.63	July 31	1.21	3.59
Aug. 31		7.31	Do	0.75	0
Sept. 2		9.22			
Sept. 7		7.19	1908.		
Sept. 10		5.30	July 9	.86	.50
Sept. 14		3.90			
			1909.		
1907.			July 17	1.00	2.72
July 31	1.59	8.12	Aug. 3	.75	.52
Do	1.38	5.29			

Daily gage height, in feet, and discharge, in second-feet, of Jett Creek ditch for 1907 and 1909.

[Observer, A. D. Jett.]

Day.	1907						1909					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.59	8.1	1.50	6.9				0.5		1.0
2			1.50	6.9	1.50	6.9		4	0.72	0.4		1.0
3			1.45	6.2	1.50	6.9		4		.8		1.0
4			1.40	5.6	1.45	6.2		4	.82	1.1	0.80	.9
5			1.35	5.0	1.45	6.2		4		1.0		.9
6			1.33	4.8	1.45	6.2		4		1.0		.9
7			1.33	4.8	1.45	6.2		4		1.3		.9
8			1.33	4.8	1.50	6.9		4		3.0		.8
9			1.25	3.9	1.60	8.2		4	1.20	4.8		.7
10			1.25	3.9		0		8	1.50	8.2		.7
11			1.25	3.9		0		7		7		.6
12	1.15	3.0	1.25	3.9	1.60	8.2		6		5		.6
13	1.35	5.0	1.30	4.4	1.60	8.2		5		3		.5
14	1.32	4.6	1.30	4.4	1.60	8.2		4	.92	2.0		.5
15	1.15	3.0	1.30	4.4				3		2.1		.4
16	1.20	3.4	1.55	7.6				3	.95	2.2		.4
17	1.15	3.0	1.50	6.9			1.00	2.7		2.2		.4
18	1.18	3.2	1.60	8.2				2.5		2.2		.4
19	1.19	3.3	1.60	8.2				2.3	.95	2.2		.4
20	1.30	4.4	1.55	7.6			0.95	2.2		2.1		
21	1.42	5.9	1.50	6.9				2.1		2.0		
22	1.22	3.6	1.45	6.2				2.0		1.9		
23	1.32	4.6	1.45	6.2				1.9		1.8		
24	1.38	5.4	1.50	6.9			.90	1.8		1.7		
25	1.40	5.6	1.50	6.9				1.6		1.6		
26	1.45	6.2	1.45	6.2				1.5		1.5		
27	1.45	6.2	1.50	6.9				1.3		1.4		
28	1.42	5.9	1.55	7.6				1.2		1.3		
29	1.45	6.2	1.55	7.6				1.0		1.2		
30	1.50	6.9	1.50	6.9				.8		1.1		
31	1.59	8.1	1.50	6.9				.7		1.0		
Mean		4.9		6.1		6.1		3.0		2.2		.7

GRAND CENTRAL DITCH.

The Grand Central ditch was started in 1905 and more or less construction work has been carried on each succeeding year. The ditch crosses Nugget Creek a few hundred feet from its outlet and has diverted the waters of this stream during the greater part of the five seasons, 1906 to 1910. Miscellaneous measurements made of Nugget Creek in 1906, showing the amount diverted, are given on page 173. A gage was established just below the creek crossing, July 9, 1907, before the water was turned in, and was read during that season and in 1909. The discharge of the ditch was at times less than 1 second-foot in both 1908, when no regular readings were made, and in 1909.

Discharge measurements of Grand Central ditch at intake, 1907 to 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 9	1.39	5.35	July 9	1.04	.71
Do	1.28	3.68	1909.		
Do	1.18	1.27	July 17	0.80	1.85
Do	1.47	6.64	Aug. 3	.73	1.05

Daily gage height, in feet, and discharge, in second-feet, of Grand Central ditch, for 1907 and 1909.

[Observer, A. D. Jett.]

Day.	1907						1909					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.34	4.4	1.50	8.0		8		1.1		1.7
2			1.34	4.4	1.50	8.0		7	0.72	1.0		1.7
3			1.32	4.0	1.45	6.8		7		1.0		1.6
4			1.32	4.0	1.45	6.8		6		1.0	0.78	1.6
5			1.32	4.0	1.45	6.8		6		1.0		1.6
6			1.30	3.6	1.45	6.8		5		1.1		1.5
7			1.30	3.6	1.45	6.8		5		1.2		1.5
8			1.28	3.3	1.50	8.0		4	.75	1.3		1.4
9	1.45	6.8	1.28	3.3	1.60	10.6		4	.90	3.2		1.4
10	1.34	4.4	1.25	2.8	1.70	13.4		4	1.00	4.8		1.3
11	1.34	4.4	1.25	2.8		0		3		4.6		1.3
12	1.38	5.2	1.28	3.3		0		3		4.4		1.2
13	1.38	5.2	1.27	3.1	1.70	13.4		3		4.2		1.2
14	1.45	6.8	1.30	3.6	1.70	13.4		2.0	.95	4.0		1.1
15	1.35	4.6	1.30	3.6	1.70	13.4		2.0		3.2		1.1
16	1.35	4.6	1.50	8.0	1.70	13.4		2.0	.85	2.5		1.0
17	1.31	3.8	1.50	8.0	1.70	13.4	0.80	1.8		2.5		1.0
18	1.40	5.6	1.55	9.3	1.70	13.4		1.8		2.5		1.0
19	1.46	7.0	1.55	9.3	1.60	10.6		1.8	.85	2.5		1.0
20	1.48	7.5	1.60	10.6	1.60	10.6	.80	1.8		2.4		
21	1.65	12.0	1.60	10.6	1.60	10.6		1.8		2.4		
22	1.47	7.3	1.55	9.3	1.55	9.3		1.8		2.3		
23	1.48	7.5	1.50	8.0	1.55	9.3		1.7		2.3		
24	1.46	7.0	1.55	9.3	1.55	9.3		1.7		2.2		
25	1.40	5.6	1.50	8.0	1.50	8.0		1.6		2.2		
26	1.38	5.2	1.50	8.0	1.50	8.0		1.6		2.1		
27	1.36	4.8	1.50	8.0		8.0		1.5		2.1		
28	1.33	4.2	1.50	8.0		8.0		1.5		2.0		
29	1.32	4.0	1.55	9.3		8.0		1.4		1.9		
30	1.32	4.0	1.50	8.0		8.0		1.3		1.9		
31	1.34	4.4	1.50	8.0				1.2		1.8		
Mean		5.7		6.2		9.0		3.1		2.3		1.3

Note.—The mean discharge for the period June 28 to 30, 1909, was 9 second-feet.

SEWARD DITCH SYSTEM.

DESCRIPTION.

The Seward ditch, built in 1905–6, diverts the water from Nome River just below Dorothy Creek at an elevation of 470 feet, and from Hobson Creek about half a mile below the Miocene intake. It extends down the west side of Nome River and around the south slope of Newton and Anvil peaks nearly to Anvil Creek, having a total length of about 37 miles. The ditch was originally planned to have a bottom width of 14 feet, and most of the rock work was built for that width. The rest of the ditch was made 10 feet wide, except at the lower end, where it is 8 feet. The water is carried across Hobson and Clara creeks by 42-inch wood-pipe siphons having lengths of 1,050 and 800 feet. The ditch is further described on page 257. Records were begun at the intake in 1907, and additional stations were established at several points farther down the ditch in 1909. A list of these stations is given on page 92. The records, especially those of 1909, indicate the amount of water lost by seepage from a ditch of this character. The data have been analyzed and are presented on pages 263–269.

SEWARD DITCH AT INTAKE.

A gage was established at this point in 1906 and a few measurements were made, but the regular readings were not begun until 1907. The records show the amount of water diverted from Nome River by this ditch. Measuring conditions are good, but the channel at the gage is sandy and somewhat shifting, so that the relation of gage height to discharge has not been stable, and the records are accordingly somewhat uncertain for short periods. The maximum diversion was 34 second-feet in 1908 and the minimum for one week 9.0 second-feet, from July 23 to 29 of the same year.

Discharge measurements of Seward ditch at intake, 1906 to 1910.

Date.	Hydrographer.	Gage height.	Discharge.
1906.		*Feet.*	*Sec.-ft.*
Aug. 18	F. F. Henshaw	0.76	25.0
30	....do	1.03	37.8
30	....do	1.14	40.8
30	....do	1.32	51.4
30	....do	1.63	69.4
30	....do	1.18	43.2
30	....do	.81	26.2
1907.			
July 11	Raymond Richards	.55	19.1
18	....do	.72	23.2
24	....do	.82	25.7
1908.			
June 20	Henshaw and Barrows	.96	31.9
July 10	F. F. Henshaw	.32	9.59
Aug. 13	A. T. Barrows	1.00	33.0
30	F. F. Miller	.89	29.6
Sept. 2	A. T. Barrows	1.00	34.5
1909.			
July 16	F. F. Henshaw	.38	13.0
Aug. 2	....do	.27	9.36
10	....do	.88	33.1
Sept. 13	G. L. Parker	.44	16.2
22	....do	.60	21.9
1910.			
Sept. 15	R. G. Smith	1.23	19.9
18	G. L. Parker	1.36	23.8
21	....do	1.29	21.2

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch at intake for 1907–1910.

[Observers, T. Tallason, 1907, 1909, 1910; employee of Wild Goose Mining & Trading Co., 1908.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.							1907.						
1	......	......	0.85	27.2	0.90	29.0	16	0.70	22.5	0.88	28.3	0.84	26.9
2	......	......	.85	27.2	.89	28.6	17	.70	22.5	.88	28.3	.85	27.2
3	......	......	.85	27.2	.89	28.6	18	.70	22.5	.85	27.2	.85	27.2
4	......	......	.80	25.4	.89	28.6	19	.75	23.8	.84	26.9	.82	26.2
5	......	......	.74	23.6	.88	28.3	20	.75	23.8	.84	26.9	.82	26.2
6	......	......	.72	23.0	.88	28.3	21	.75	23.8	.84	26.9	.78	24.8
7	......	......	.71	22.8	.89	28.6	22	.75	23.8	.84	26.9	.78	24.8
8	......	......	.72	23.0	.88	28.3	23	.75	23.8	.87	27.9	.80	25.4
9	......	......	.74	23.6	.85	27.2	24	.75	23.8	.87	27.9	.80	25.4
10	......	......	.72	23.0	.81	25.8	25	.80	25.4	.90	29.0	.80	25.4
11	0.60	20.1	.72	23.0	......	0	26	.82	26.2	.90	29.0	.80	25.4
12	.62	20.5	.71	22.8	.82	26.2	27	.82	26.2	.85	27.2	.80	25.4
13	.65	21.3	.78	24.8	.85	27.2	28	.88	28.3	.85	27.2	.75	23.8
14	.65	21.3	.77	24.5	.84	26.9	29	.82	26.2	.87	27.9	.74	23.6
15	.70	22.5	.71	22.8	.84	26.9	30	.85	27.2	.89	28.6	.75	23.8
							31	.85	27.2	.89	28.6	......	......
							Mean	......	23.9	......	26.1	......	25.7

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1	....	....	0.72	22.6	0.85	27.8	1.00	34.0
2	....	....	.62	18.9	.62	18.9	1.00	34.0
3	....	....	.62	18.9	.64	19.6	1.00	34.0
4	....	....	.58	17.6	.72	22.6	.92	30.6
5	....	....	.54	16.3	.92	30.6	.85	27.8
6	....	....	.50	15.0	1.00	34.0	.88	29.0
7	....	....	.50	15.0	1.00	34.0	.81	26.2
8	....	....	.49	14.7	.88	29.0	.80	25.8
9	....	....	.49	14.7	.75	23.8	.77	24.6
10	....	....	.36	10.7	.74	23.4	.70	21.8
11	....	....	.46	13.7	1.00	34.0	.68	21.1
12	....	....	.54	16.3	1.00	34.0	.70	21.8
13	....	....	.50	15.0	1.00	34.0	.70	21.8
14	....	....	.42	12.4	1.00	34.0	.60	18.2
15	....	....	.35	10.4	1.00	34.0	.75	23.8
16	....	....	.32	9.6	.95	31.9	.72	22.6
17	....	....	.30	9.0	.88	29.0	.59	17.9
18	....	....	.30	9.0	.86	28.2	.52	15.6
19	....	....	.30	9.0	1.00	34.0	.54	16.3
20	0.93	31.1	.32	9.6	1.00	34.0	.52	15.6
21	.89	29.4	.31	9.3	1.00	34.0	.56	16.9
22	.90	29.8	.30	9.0	1.00	34.0	.55	16.6
23	.90	29.8	.29	8.8	1.00	34.0	.50	15.0
24	.90	29.8	.30	9.0	1.00	34.0	....	....
25	.90	29.8	.30	9.0	1.00	34.0	....	....
26	.88	29.0	.30	9.0	1.00	34.0	....	....
27	.90	29.8	.30	9.0	1.00	34.0	....	....
28	.90	29.8	.30	9.0	1.00	34.0	....	....
29	.84	27.4	.29	8.8	1.00	34.0	....	....
30	.86	28.2	.94	31.5	.95	31.9	....	....
31	....	....	.96	32.3	1.00	34.0	....	....
Mean	....	29.4	....	13.6	....	31.1	....	23.1

NOTE.—The water was turned into the ditch June 9, 1908.

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch at intake for 1907–1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1	....	....	0.60	20.2	0.26	9.5	0.44	16.3
2	....	....	.60	20.2	.34	11.7	.42	15.7
3	....	....	.68	23.2	.51	17.0	.41	15.3
4	....	....	.80	28.0	.38	12.8	.40	15.0
5	....	....	.67	22.9	.40	13.4	.42	15.7
6	....	....	.77	26.8	.48	17.6	.45	16.6
7	....	....	.92	32.8	.50	18.3	.40	15.0
8	....	....	.92	32.8	.45	16.6	.40	15.0
9	....	....	.90	32.0	.75	27.8	.42	15.7
10	....	....	.80	28.0	.70	25.8	.40	15.0
11	....	....	.83	29.2	.42	15.7	.40	15.0
12	....	....	.80	28.0	.50	18.3	.40	15.0
13	....	....	.58	19.5	.48	17.6	.45	16.6
14	....	....	.43	14.4	.42	15.7	.45	16.6
15	....	....	.39	13.1	.45	16.6	.46	17.0
16	....	....	.36	12.2	.45	16.6	.40	15.0
17	....	....	.36	12.2	.45	16.6	.40	15.0
18	....	....	.32	11.1	.46	17.0	.40	15.0
19	....	....	.30	10.5	.42	15.7	.38	14.4
20	....	....	.30	10.5	.48	17.6	.50	18.3
21	....	....	.30	10.5	.45	16.6	.54	19.7
22	....	....	.30	10.5	.42	15.7	.50	18.3
23	....	....	.26	9.5	.41	15.3	.80	29.8
24	0.50	16.7	.26	9.5	.42	15.7	.70	25.8
25	.45	15.0	.26	9.5	.41	15.3	.65	23.8
26	.50	16.7	.26	9.5	.46	17.0	.52	19.0
27	.50	16.7	.28	10.0	.45	16.6	.48	17.6
28	.50	16.7	....	10.0	.42	15.7	.47	17.2
29	.50	16.7	.28	10.0	.40	15.0	....	....
30	.57	19.2	.31	10.8	.45	16.6	....	....
31	....	....	.31	10.8	.40	15.0	....	....
Mean	....	16.8	....	17.4	....	16.5	....	17.3

Day.	July.		August		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.						
1	....	....	....	0.0	1.17	26.0
2	....	....	....	.0	1.15	25.3
3	....	....	....	.0	1.25	29.0
4	....	....	....	.0	1.28	30.1
5	....	....	0.85	15.5	1.25	29.0
6	....	....	1.05	21.8	....	.0
7	....	....	1.30	30.9	....	.0
8	....	....	1.30	30.9	....	.0
9	....	8.0	1.25	29.0	....	.0
10	0.90	17.0	1.30	30.9	....	.0
11	1.04	21.5	1.30	30.9	....	.0
12	1.14	24.9	1.28	30.1	....	.0
13	1.05	21.8	1.22	27.9	....	.0
14	1.08	22.8	1.25	29.0	....	4.0
15	1.10	23.5	1.30	30.9	.88	16.4
16	1.10	23.5	.93	18.0	.98	19.6
17	1.08	22.8	.90	17.0	1.00	20.2
18	1.08	22.8	1.30	30.9	1.06	22.2
19	1.10	23.5	1.25	29.0	1.00	20.2
20	1.10	23.5	1.30	30.9	1.00	20.2
21	1.10	23.5	1.30	30.9	....	10.0
22	1.30	30.9	....	30.0	....	3.0
23	1.38	34.0	1.25	29.0	....	.0
24	1.28	30.1	1.30	30.9	....	.0
25	1.32	31.7	1.28	30.1	....	.0
26	....	16.0	1.28	30.1	.73	12.0
27	....	.0	1.30	30.9	.82	14.6
28	....	.0	....	15.0	.88	16.4
29	....	.0	....	.0	.90	17.0
30	....	.0	....	8.0	.88	16.4
31	....	.0	1.23	28.2	....	....
Mean	....	18.3	....	22.5	....	11.7

Note.—The discharge for October 1, 1910, was 17.0 second-feet.

SEWARD DITCH BELOW HOBSON BRANCH.

This station was maintained during 1909 and 1910. Gage heights were taken in the flume to the penstock of the Hobson Creek siphon, which is located just below the point where the Hobson Creek lateral enters the main ditch. Measurements were made of the main ditch and the branch separately, and the discharges added to give the total at the gage.

The maximum recorded discharge of 42.0 second-feet, July 10, 1909, may be too large. The minimum record of 10.7 second-feet occurred during the week of July 28 to August 3, 1909, but the discharge probably reached a lower stage in 1908.

Discharge measurements of Seward ditch below Hobson branch in 1909 and 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec.-ft.*	1910.	*Feet.*	*Sec.-ft.*
July 15	0.85	15.3	Sept. 16 [a]	1.23	29.2
Aug. 1	.70	11.2	Sept. 21	1.04	21.9
Aug. 10	1.07	27.1			
Sept. 13	.78	13.1			

a Measurement made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch below Hobson branch for 1909–10.

[Observers, J. Sliscovitch, 1909; G. Justice, 1910.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			1.00	22.6	0.68	10.4	0.80	14.2
2			.85	16.2	.68	10.4	.80	14.2
3				25.0	.68	10.4	.80	14.2
4				31	.90	18.2	.80	14.2
5				27	.78	13.6	.80	14.2
6				30	.70	11.0	.80	14.2
7				34	.88	17.4	.80	14.2
8				34	.90	18.2		13.9
9				33	.90	18.2	.78	13.6
10				30	1.10	27.2	.80	14.2
11				30	.81	14.6	.78	13.6
12			.90	18.2	.88	17.4	.78	13.6
13			1.15	29.6	.90	18.2	.78	13.6
14			.90	18.2	.85	16.2	.82	15.0
15			.85	16.2	.88	17.4	.80	14.2
16			.90	18.2	.88	17.4	.80	14.2
17			.85	16.2	.82	15.0	.80	14.2
18			.85	16.2	.80	14.2	.80	14.2
19			.75	12.6	.80	14.2	.80	14.2
20			.75	12.6	.80	14.2	1.05	24.9
21			.75	12.6	.82	15.0	1.10	27.2
22			.75	12.6	.80	14.2	1.10	27.2
23			.72	11.6	.80	14.2	1.10	27.2
24	0.85	16.2	.72	11.6		14.2	1.10	27.2
25	.90	18.2	.72	11.6	.80	14.2	1.20	32.0
26	.90	18.2	.70	11.0	.80	14.2	1.10	27.2
27	1.10	27.2	.70	11.0	.80	14.2	1.05	24.9
28	.90	18.2	.68	10.4	.80	14.2	1.15	29.6
29	1.05	24.9	.70	11.0	.80	14.2		
30	.90	18.2	.70	11.0	.80	14.2		
31			.70	11.0	.80	14.2		
Mean		20.2		19.2		15.2		18.4

NOTE.—Gage heights for the period July 3-11, 1909, are doubtful. The values given are estimated from the discharge at the intake.

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch below Hobson branch for 1909–10—Continued.

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1	......	......	0.70	9.0	1.10	23.5	16	1.10	23.5	1.38	36.5	1.20	28.0
2	......	......	.75	10.5	1.22	28.9	17	1.15	25.8	1.18	27.1	1.12	24.4
3	......	......	.65	7.8	1.15	25.8	18	1.00	19.5	1.40	37.5	1.22	28.9
4	......	......	.60	6.5	1.20	28.0	19	1.00	19.5	1.40	37.5	1.20	28.0
5	......	......	.92	16.3	1.22	28.9	20	1.02	20.3	1.40	37.5	1.18	27.1
6	......	......	1.20	28.0	......	9.8	21	1.00	19.5	1.40	37.5	1.00	19.5
7	......	......	1.18	27.1	......	.0	22	1.18	27.1	1.40	37.5	.55	5.4
8	......	......	1.25	30.4	......	.0	23	1.25	30.4	1.40	37.5	.85	13.8
9	......	......	1.30	32.7	......	.0	24	1.28	31.8	1.38	36.5	.98	18.7
10	0.95	17.5	1.35	35.1	......	.0	25	1.32	33.7	1.38	36.5	.88	14.8
11	1.10	23.5	1.32	33.7	......	.0	26	.80	12.0	1.38	36.5	1.00	19.5
12	1.20	28.0	1.38	36.5	......	.0	27	.65	7.8	1.40	37.5	1.10	23.5
13	1.20	28.0	1.35	35.1	......	4.5	28	.65	7.8	1.40	37.5	1.12	24.4
14	1.10	23.5	1.32	33.7	.70	9.0	29	.65	7.8	......	.0	1.10	23.5
15	1.10	23.5	1.35	35.1	1.15	25.8	30	.62	7.0	......	.0	1.10	23.5
							31	.68	8.5	.95	17.5	......	......
							Mean	......	20.3	......	28.0	......	16.9

NOTE.—The discharge for Oct. 1, 1910, was 18.7 second-feet.

SEWARD DITCH BELOW DEXTER CREEK FLUME.

This station, which was maintained during 1909 and 1910, is located in the flume across Dexter Creek, 15.5 miles below Hobson Creek, and 9.7 miles above Newton Gulch. The measurements were made in the flume, at the lower end of which the gage was located, and the records are reliable.

A maximum diversion of 30.6 second-feet was recorded August 27, 1910, and a minimum for one week of 4.6 second-feet, which amount, plus leakage, represented the total supply available from Nome River at that time, occurred July 28 to August 3, 1909.

Discharge measurements of Seward ditch below Dexter Creek flume in 1909 and 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec. feet.*	1910.	*Feet.*	*Sec. feet.*
June 10[a]	0.45	3.77	Sept. 17	1.63	26.1
July 31	.55	4.99			
Aug. 12	.83	10.4			
Sept. 10	.80	9.34			

[a] Measurement made by Munro and Lanagan.

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch below Dexter Creek flume, for 1909–10.

[Observer, Geo. E. Huff, 1909; employee of Wild Goose Mining & Trading Co., 1910.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			0.95	12.9	0.52	4.5	0.78	9.2
2			.90	11.8	.52	4.5	.78	9.2
3			.90	11.8	.50	4.2	.75	8.6
4			.92	12.2	.82	10.0	.75	8.6
5			.90	11.8	.75	8.6	.82	10.0
6			.90	11.8	.70	7.6	78	9.2
7			.90	11.8	.62	6.2	.75	8.6
8			.95	12.9	.78	9.2		8.1
9			1.05	15.2	.80	9.6	.70	7.6
10	0.50	4.2	1.20	18.8	.80	9.6	.78	9.2
11		3.9	1.15	17.6	.78	9.2	.78	9.2
12	.45	3.6	1.15	17.6	.78	9.2	.75	8.6
13	.40	3.0	1.16	17.8	.85	10.7	.75	8.6
14	.40	3.0	.90	11.8	.86	10.9	.78	9.2
15	.25	1.4	.85	10.7	.82	10.0	.78	9.2
16	.20	1.0	.78	9.2	.74	8.4	.80	9.6
17	.65	6.7	.76	8.8	.72	8.0	.90	11.8
18	.65	6.7	.70	7.6	.72	8.0	.85	10.7
19	.65	6.7	.71	7.8	.75	8.6	.92	12.2
20	.65	6.7	.65	6.7	.75	8.6	.88	11.4
21	.80	9.6	.68	7.2	.75	8.6	1.10	16.4
22	.95	12.9	.62	6.2	.75	8.6	1.20	18.8
23	.90	11.8	.61	6.0	.78	9.2	1.22	19.3
24	.80	9.6	.58	5.5	.78	9.2	1.28	20.8
25	.90	11.8	.58	5.5	.75	8.6	1.28	20.8
26	.90	11.8	.54	4.8	.72	8.0	1.10	16.4
27	.85	10.7	.52	4.5	.80	9.6	1.10	16.4
28	1.40	23.8	.52	4.5	.82	10.0		
29	.80	9.6	.54	4.8	.82	10.0		
30	.80	9.6		4.9	.80	9.6		
31			.55	5.0	.80	9.6		
Mean		8.00		9.85		8.60		11.8

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch below Dexter Creek flume for 1909-10—Continued.

Day.	July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
1910.						
1			1.22	16.3		0.0
2			1.40	20.5		.0
3			1.20	15.8	1.45	21.8
4			1.15	14.8	1.55	24.2
5			1.05	12.6	1.55	24.2
6			1.35	19.3		25.0
7			1.32	18.6		19.0
8			1.35	19.3		19.0
9			1.52	23.5		12.0
10	0.60	4.8	1.45	21.8		21.0
11	1.20	15.8	1.45	21.8		17.0
12	1.20	15.8	1.48	22.5		17.0
13	1.28	17.6	1.52	23.5		14.0
14	1.22	16.3	1.55	24.2		21.0
15	1.30	18.1	1.60	25.5	1.45	21.8
16	1.30	18.1	1.58	25.0	1.50	23.0
17	1.40	20.5	1.45	21.8	1.50	23.0
18	1.35	19.3	1.45	21.8	1.45	21.8
19	1.32	18.6	1.62	26.0	1.60	25.5
20	1.32	18.6	1.68	27.5	1.70	28.0
21		19.0	1.70	28.0	1.65	26.8
22	1.30	18.1	1.72	28.5	1.35	19.3
23	1.40	20.5	1.62	26.0	1.60	25.5
24	1.50	23.0	1.75	29.3	1.60	25.5
25	1.50	23.0	1.72	28.5	1.62	26.0
26	1.55	24.2	1.75	29.3	1.60	25.5
27	1.10	13.7	1.80	30.6	1.55	24.2
28	1.22	16.3		.0	1.65	26.8
29	1.20	15.8		.0	1.65	26.8
30	1.25	17.0		.0	1.65	26.8
31	1.10	13.7		.0		
Mean		17.6		20.1		21.0

NOTE.—The discharge for Oct. 1, 1910, was 26.8 second-feet.

SEWARD DITCH ABOVE NEWTON GULCH.

This is the lowest regular station on the Seward ditch. The records here give the amount of water delivered to the mining operations on Newton Gulch and at points below. The gage was established a few hundred feet above the penstock of the pipe leading to the mine early in the spring of 1909 and records were kept during that year and in 1910. The ditch was practically dry near the end of July, 1909. The maximum amount delivered, as shown by the records, was 25.2 second-feet on September 8, 1910.

Discharge measurements of Seward ditch above Newton Gulch in 1909 and 1910.

Date.	Hydrographer.	Gage height.	Discharge.
1909.		*Feet.*	*Sec.-ft.*
June 24	Lanagan and Shutts	1.00	8.36
July 30	F. F. Henshaw	.36	.26
Aug. 10	Ayer and Smith	1.18	11.9
12	F. F. Henshaw	.82	5.80
Sept. 10	G. L. Parker	.76	3.87
1910.			
July 23	W. H. Lanagan	1.07	13.9
Aug. 26	Smith and Jarvis	1.38	22.7
Sept. 16	G. L. Parker	1.35	22.3

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch above Newton Gulch for 1909 and 1910.

[Observers, N. Bell, 1909; employee of Wild Goose Mining & Trading Co., 1910.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			1.01	8.7	0.59	2.1	0.81	5.2
2			1.01	8.7	.38	.4	.81	5.2
3			1.02	8.9	.69	3.4	.79	4.8
4			1.02	8.9	.91	6.9	.68	3.2
5			1.02	8.9	.85	5.8	.65	2.8
6			1.02	8.9	.72	3.8	.66	3.0
7			1.02	8.9	.69	3.4	.64	2.7
8			1.16	11.4	.85	5.8	.64	2.7
9			1.24	13.0	.88	6.4	.62	2.5
10			1.29	14.0	1.18	11.8	.70	3.5
11			1.39	16.1	1.15	11.2	.79	4.8
12			1.21	12.4	.84	5.9	.76	4.4
13			1.26	13.4	.90	6.7	.75	4.2
14			1.08	9.9	.88	6.4	.81	5.2
15			.98	8.2	.79	4.8	.80	5.0
16			.91	6.9	.78	4.7	.79	4.8
17			.89	6.6	.76	4.4	.89	6.6
18			.84	5.7	.71	3.6	.82	5.3
19			.76	4.4	.72	3.8	.78	4.7
20			.68	3.2	.70	3.5	.92	7.1
21			.64	2.7	.75	4.2	1.10	10.3
22			.64	2.7	.65	2.8	1.24	13.0
23			.64	2.7	.61	2.3	1.26	13.4
24	1.00	8.5	.60	2.2	.78	4.7	1.34	15.0
25	1.00	8.5	.54	1.6	.64	2.7	1.35	15.2
26	1.01	8.7	.50	1.2	.72	3.8	1.12	10.7
27	1.04	9.2	.49	1.1	.78	4.7	1.24	13.0
28	1.12	10.7	.52	1.4	.80	5.0		
29	1.21	12.4	.42	.6	.88	6.4		
30	1.01	8.7	.28	.1		5.8		
31			.32	.1	.81	5.2		
Mean		9.53		6.56		4.91		6.60

Daily gage height, in feet, and discharge, in second-feet, of Seward ditch above Newton Gulch for 1909 and 1910—Continued.

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1			0.88	9.7		4.0	16			1.25	19.0	1.35	22.0
2			.95	11.2		2.7	17			1.25	19.0	1.32	21.1
3			.92	10.6		2.7	18			1.22	18.2	1.39	23.3
4			.85	9.0	1.25	19.0	19			1.25	19.0	1.40	23.6
5			.80	8.0	1.29	20.2	20			1.25	19.0	1.38	23.0
6			1.10	14.9	1.38	23.0	21			1.30	20.5	1.38	23.0
7			1.00	12.4	1.05	13.6	22			1.30	20.5	1.10	14.9
8			1.05	13.6	1.45	25.2	23			1.28	19.9	1.39	23.3
9			1.18	17.1	1.19	17.3	24	1.05	13.6	1.32	21.1	1.28	19.9
10			1.10	14.9	1.23	18.5	25	1.18	17.1	1.32	21.1	1.30	20.5
11			1.10	14.9	1.29	20.2	26	1.20	17.6	1.38	23.0	1.28	19.9
12			1.10	14.9	1.15	16.2	27	.85	9.0	1.39	23.3	1.35	22.0
13			1.15	16.2	1.00	12.4	28	1.10	14.9		4.0	1.34	21.7
14			1.20	17.6	1.08	14.4	29	1.18	17.1		.0	1.35	22.0
15			1.25	19.0	1.28	19.9	30	.98	11.9		.0	1.36	22.4
							31	.90	10.1		.0		
							Mean.		13.9		14.6		18.4

NOTE.—The discharge for October 1, 1910, was 11.0 second-feet.

HOBSON BRANCH OF SEWARD DITCH.

This station, which was maintained regularly only during 1909, was located near the outlet of the lateral and shows the amount of Hobson Creek water which the Seward ditch receives.

Additional measurements are given in connection with the discharge of Hobson Creek below Manila Creek, on page 105.

The maximum recorded diversion, 9.3 second-feet, which represents practically the capacity of the ditch, occurred just after the water was turned out of the Miocene ditch in the fall of 1909, when the total flow of Hobson Creek was diverted into the Seward ditch. The minimum of 2.5 second-feet occurred just before this.

Discharge measurements of Hobson branch of Seward ditch in 1909 and 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec.-ft.*	1910.	*Feet.*	*Sec.-ft.*
July 15	0.68	5.23	Sept. 16[a]	1.02	9.52
Aug. 1	.56	3.13			
Aug. 10	.60	3.80			
Sept. 14	.50	2.52			

[a] Measurement made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of Hobson branch of Seward ditch for 1909.

[Observer, U. Sliscovitch.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1				5.0	0.55	3.2	0.55	3.2
2			0.65	4.6	.55	3.2	.55	3.2
3			.70	5.5	.55	3.2	.50	2.5
4			.80	7.4	.60	3.8	.50	2.5
5			.80	7.4	.55	3.2	.50	2.5
6			.80	7.4	.55	3.2	.50	2.5
7			.70	5.5	.55	3.2	.50	2.5
8			.70	5.5	.60	3.8		2.5
9			.70	5.5	.55	3.2	.50	2.5
10			.70	5.5	.60	3.8	.50	2.5
11			.70	5.5	.58	3.5	.50	2.5
12				5.5	.58	3.5	.50	2.5
13			.70	5.5	.60	3.8	.50	2.5
14				5.5	.58	3.5	.50	2.5
15				5.5	.55	3.2	.50	2.5
16			.70	5.5	.55	3.2	.50	2.5
17			.68	5.2	.55	3.2	.50	2.5
18			.68	5.2	.55	3.2	.50	2.5
19			.68	5.2	.55	3.2	.50	2.5
20			.68	5.2	.55	3.2	.90	9.3
21			.62	4.1	.55	3.2	.90	9.3
22			.62	4.1	.55	3.2	.85	8.4
23			.62	4.1	.55	3.2	.85	8.4
24	0.70	5.5	.60	3.8		3.0	.88	8.9
25	.70	5.5	.60	3.8	.52	2.8	.85	8.4
26	.70	5.5	.60	3.8	.55	3.2	.88	8.9
27	.70	5.5	.60	3.8	.55	3.2	.88	8.9
28	.70	5.5	.60	3.8	.55	3.2	.88	8.9
29	.80	7.4	.60	3.8	.55	3.2		
30	.70	5.5	.58	3.5	.55	3.2		
31			.55	3.2	.55	3.2		
Mean		5.77		5.00		3.18		4.58

PIONEER DITCH SYSTEM.

DESCRIPTION.

The Pioneer ditch, begun in 1905 and completed in 1907, has its intake on Nome River just below the mouth of Christian Creek, about 3 miles below the Seward intake, at an elevation of about 330 feet. It has a total length of 38 miles and extends to Anvil Creek. There are three siphons, composed of two lines of 30-inch riveted steel pipes—one 545 feet long across Hobson Creek, one 1,050 feet long across Banner Creek, and one 755 feet long across Dexter Creek. Several narrow gulches and gullies eroded by waste water from the other ditches are crossed by flumes.

PIONEER DITCH AT INTAKE.

A station was established at the intake of the ditch in 1907, and a record of 11 days was obtained in that year. For the three seasons 1908 to 1910 the records have been practically complete. The gage is located a short distance below the intake and measurements are made near this point. The tables given below show the total amount of Nome River water diverted into the ditch, and, in conjunction with the record on Nome River below the intake and on Miocene and Seward ditches, give the natural flow of the river. The maximum recorded diversion was 38.1 second-feet on August 12, 1908. The minimum for a week was 7 second-feet during July 23 to 29 of the same year.

Discharge measurements of Pioneer ditch at intake, 1907 to 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 18	1.22	18.7	June 15	0.21	3.34
July 24	1.35	22.2	Do	.87	[b] 22.9
Aug. 9	1.19	16.8	July 16	.86	21.1
Aug. 20	1.41	24.3	Aug. 2	.60	11.8
Aug. 29	1.44	25.6	Aug. 10	1.02	29.3
1908.			1910.		
July 10 [a]	.83	8.78	Sept. 18	.74	14.4
Aug. 30 [a]	1.30	24.5			

[a] Measurement made by F. F. Miller. [b] Measurement made during a rise in stage of 0.16 foot.

Daily gage height, in feet, and discharge, in second-feet, of Pioneer ditch at intake for 1907–1910.

[Observers, employees of Pioneer Mining Co., 1907–8; Chris. Johnson, 1909; C. Chanceberg, 1910.]

Day.	August, 1907.		1908.					
			July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1				17.0	1.20	20.5	1.52	33.3
2				16.0	1.01	14.3	1.54	34.1
3				15.0	1.00	14.0	1.45	30.5
4			1.00	14.0	1.28	23.7	1.36	26.9
5			.98	13.4	1.52	33.3	1.31	24.9
6			.95	12.5	1.48	31.7	1.29	24.1
7			.95	12.5	1.45	30.5	1.25	22.5
8			.95	12.5	1.28	23.7	1.21	20.9
9			.92	11.6	1.15	18.8	1.20	20.5
10			.91	11.3	1.12	17.7	1.18	19.8
11			.90	11.0	1.36	26.9	1.15	18.8
12			.90	11.0	1.64	38.1	1.15	18.8
13			.85	9.5	1.55	34.5	1.16	19.1
14			.81	8.3	1.50	32.5	1.15	18.8
15			.79	7.8	1.50	32.5	1.12	17.7
16			.80	8.0	1.41	28.9	1.12	17.7
17			.80	8.0	1.40	28.5	1.09	16.7
18			.78	7.6	1.29	24.1	1.05	15.5
19			.80	8.0	1.55	34.5	1.04	15.2
20			.82	8.6	1.50	32.5	1.00	14.0
21	1.43	25.0	.81	8.3	1.38	27.7	.95	12.5
22	1.40	24.0	.78	7.6	1.32	25.3		
23	1.42	24.7	.75	7.0	1.52	33.3		
24	1.42	24.7	.75	7.0	1.52	33.3		
25	1.48	26.8	.75	7.0	1.50	32.5		
26	1.48	26.8	.75	7.0	1.50	32.5		
27	1.40	24.0	.75	7.0	1.52	33.3		
28	1.38	23.4	.75	7.0	1.41	28.9		
29	1.30	20.8	.75	7.0	1.36	26.9		
30	1.39	23.7	1.38	27.7	1.32	25.3		
31	1.36	22.7	1.42	29.3	1.56	34.9		
Mean		24.2		11.1		28.2		21.1

Daily gage height, in feet, and discharge, in second-feet, of Pioneer ditch at intake for 1907–1910—Continued.

Date.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1	....	....	0.82	20.2	0.60	12.7	0.52	10.3
2	....	....	.90	23.2	.60	12.7	.50	9.7
3	....	....	1.00	27.0	.66	14.7	.50	9.7
4	....	....	.98	26.2	.71	16.4	.50	9.7
5	....	....	.95	25.1	.60	12.7	.51	10.0
6	....	....	.99	26.6	.59	12.4	.51	10.0
7	....	....	1.00	27.0	.56	11.5	.50	9.7
8	....	....	1.00	27.0	.60	12.7	.50	9.7
9	....	....	1.00	27.0	.90	23.2	.50	9.7
10	....	....	.98	26.2	.92	24.0	.50	9.7
11	....	....	1.00	27.0	.68	15.3	.50	9.7
12	....	....	.95	25.1	.67	15.0	.49	9.4
13	....	....	.99	26.6	.72	16.7	.50	9.7
14	....	....	.92	24.0	.70	16.0	.56	11.5
15	....	....	.86	21.7	.70	16.0	.50	9.7
16	....	....	.87	22.1	.68	15.3	.57	11.8
17	....	....	.82	20.2	.67	15.0	.50	9.7
18	....	....	.80	19.5	.64	14.0	.50	9.7
19	....	....	.80	19.5	.64	14.0	.50	9.7
20	....	....	.78	18.8	.62	13.4	.49	9.4
21	0.54	10.9	.76	18.1	.62	13.4	.55	11.2
22	.64	14.0	.74	17.4	.62	13.4	.60	12.7
23	.60	12.7	.71	16.4	.60	12.7	.58	12.1
24	.97	25.9	.69	15.7	.60	12.7	.92	24.0
25	.87	22.1	.65	14.4	.60	12.7	.69	15.7
26	.72	16.7	.65	14.4	.59	12.4	.62	13.4
27	.76	18.1	.64	14.0	.60	12.7	.65	14.4
28	.95	25.1	.64	14.0	.56	11.5	.60	12.7
29	.95	25.1	.62	13.4	.56	11.5	....	....
30	.96	25.5	.62	13.4	.54	10.9	....	....
31	....	....	.74	17.4	.52	10.3	....	....
Mean	....	19.6	....	20.9	....	14.1	....	11.2

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1	......	......	0.72	13.5	0.80	16.0	21	0.65	11.4	0.80	16.0	0.78	15.4
2	......	......	.72	13.5	.80	16.0	22	.70	12.9	.80	16.0	.58	9.5
3	......	......	.72	13.5	.80	16.0	23	.70	12.9	.80	16.0	......	.0
4	......	......	.75	14.4	.80	16.0	24	.90	19.2	.80	16.0	.55	8.7
5	......	......	.75	14.4	.80	16.0	25	.90	19.2	.80	16.0	.60	10.0
6	......	......	.75	14.4	.70	12.9	26	.90	19.2	.80	16.0	.75	14.4
7	......	......	.72	13.5	......	8.0	27	.90	19.2	.80	16.0	.75	14.4
8	......	......	.72	13.5	......	.0	28	.90	19.2	.80	16.0	.75	14.4
9	......	5.0	.75	14.4	......	.0	29	.70	12.9	.80	16.0	.75	14.4
10	0.60	10.0	.80	16.0	......	.0	30	.70	12.9	.80	16.0	.75	14.4
11	.60	10.0	.80	16.0	......	.0	31	.72	13.5	.80	16.0	......	......
12	.60	10.0	.80	16.0	......	.0	Mean	......	13.2	......	15.3	......	9.4
13	.60	10.0	.80	16.0	......	.0							
14	.60	10.0	.80	16.0	......	.0							
15	.65	11.4	.80	16.0	......	.0							
16	.70	12.9	.80	16.0	.60	10.0							
17	.75	14.4	.70	12.9	.70	12.9							
18	.70	12.9	.80	16.0	.75	14.4							
19	.72	13.5	.80	16.0	.75	14.4							
20	.65	11.4	.78	15.4	.75	14.4							

NOTE.—The mean discharge for Oct. 1–2, 1910, was 14.4 second-feet.

MISCELLANEOUS MEASUREMENTS.

The following lists give the results of miscellaneous measurements of streams and ditches in the Nome River drainage basin:

Miscellaneous measurements in Nome River drainage basin, 1906 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
July 16, 1909	Nome River	Bering Sea	Above Miocene intake.	575	36	15	2.40
Aug. 3, 1909	do	do	do	575	9.4	15	.63
June 17, 1906	do	do	½ mile above Dorothy Creek.	450	39	25	1.56
Aug. 2, 1909	do	do	Below Seward intake, seepage through dam only.	408	3.3		
Aug. 12, 1908	do	do	Below Hobson Creek, not including ditches.	184	78	56	
June 28, 1906	Buffalo Creek	Nome River	In canyon, above Hudson Creek.	760	18.1	4.4	4.11
July 6, 1906	do	do	do	700	23	4.4	5.23
Aug. 3, 1906	do	do	do	700	9.1	4.4	2.07
July 29, 1906	David Creek	do	Above Miocene intake.	590	7.4	4.3	1.72
June 20, 1908	do	do	do	590	21	4.3	4.88
June 16, 1906	Dorothy Creek	do	Above Campion ditch spillway, near mouth.	425	5.1	2.8	1.82
July 29, 1906	do	do	do	425	3.0	2.8	1.07
Aug. 18, 1906	do	do	do	425	2.9	2.8	1.04
Aug. 2, 1909	Alfield Creek	do	¼ mile above mouth.	410	4.5	4.4	1.02
Sept. 14, 1909	do	do	½ mile above mouth, including ditch.	500	3.3	4.4	.75
Aug. 2, 1909	Christian Creek	do	Above railroad	380	2.1	2.1	1.00
Sept. 14, 1909	do	do	do	410	1.4	2.1	.67

Miscellaneous measurements of Miocene ditch and laterals in 1906 and 1909.

Date.	Ditch.	Point of measurement.	Gage height.	Discharge.
			Feet.	*Sec.-ft.*
Aug. 23, 1906	Main ditch	Above Dorothy Creek siphon		39.5
Sept. 25, 1906	do	do		41.4
Aug. 30, 1907	do	do		40.9
Aug. 16, 1908	do	do		40.2
Aug. 13, 1908	do	Below Dorothy Creek siphon		38.4
Aug. 15, 1908	do	do		37.3
Sept. 1, 1908	do	1 mile above Hobson Creek		31.4
Aug. 30, 1908	do	Above the "X"		43.3
July 20, 1908	Glacier branch	Above Snow Gulch		31.9
Aug. 11, 1909	Dexter branch	Above Grass Gulch	1.00	11.4
Aug. 12, 1909	do	do	.85	10.0
Sept. 11, 1909	do	do	.51	3.1
June 28, 1906	Grand Central ditch	Below Nugget Creek		.96
July 12, 1906	do	do		6.8
Aug. 11, 1906	do	do		3.0
Aug. 29, 1906	do	do		8.6
Sept. 2, 1906	do	do		6.8
Sept. 7, 1906	do	do		6.1
Sept. 14, 1906	do	do		4.4
Aug. 31, 1906	Jett Creek ditch	Above Copper Creek siphon		8.3
July 17, 1909	do	do		1.3
July 21, 1906	do	Outlet		2.4
Aug. 11, 1906	do	do		.8
Aug. 29, 1906	do	do		4.6
Aug. 31, 1906	do	do		7.3
Sept. 2, 1906	do	do		9.2
Sept. 7, 1906	do	do		7.2
Sept. 10, 1906	do	do		5.3
Sept. 14, 1906	do	do		3.9
July 31, 1907	Copper Creek ditch	Junction with Jett Creek ditch		3.5
July 17, 1909	do	do		1.2
July 2, 1907	Grouse Creek ditch	Near outlet		11.7
Sept. 28, 1907	do	do		5.8
Aug. 31, 1908	do	do		4.8
July 15, 1909	do	do		2.5
Aug. 30, 1908	Upper Glacier Creek feeder	Above the "X"		2.3

NOTE.—For other miscellaneous measurements of Miocene ditch, see list of seepage measurements on p. 267.

Simultaneous discharge measurements of both branches of Miocene ditch below the "X," 1907 to 1909.

Date.	Glacier branch.	Dexter branch.	Total.	Date.	Glacier branch.	Dexter branch.	Total.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
June 26, 1907	8.8	0.0	8.8	Aug. 30, 1908	26.8	16.1	42.9
July 6, 1907	27.6	16.0	43.6	July 14, 1909	26.6	13.0	39.6
July 19, 1907	31.5	14.0	45.5	July 31, 1909	2.7	6.8	9.5
Sept. 4, 1907	34.3	13.0	47.3	Aug. 11, 1909	18.8	12.8	31.6
July 11, 1908	5.5	4.2	9.7				

Miscellaneous measurements of Seward ditch, 1908–9.

Date.	Point of measurement.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
Aug. 30, 1908	Above Clara Creek siphon		24.9
Sept. 2, 1908	.....do		30.4
Do	Below Hobson Branch		33.1
June 10, 1909	Above Banner Creek	0.40	.6
July 14, 1909	.....do	1.18	14.4
July 31, 1909	.....do	.88	7.6
Aug. 11, 1909	.....do	1.12	13.2
Sept. 17, 1910	.....do	1.72	26.1
Aug. 12, 1909	Extra Dry Creek	1.09	9.5
Sept. 10, 1909	.....do	1.03	8.3
Aug. 12, 1909	Lost Creek		7.8
June 4, 1909	Below Dry Creek	1.20	16.0
June 6, 1909	.....do	.75	6.1

Miscellaneous measurements of Pioneer ditch and lateral in 1909 and 1910.

Date.	Point of measurement.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
Aug. 1, 1909	Above Hobson Branch		11.0
Aug. 12, 1909	Extra Dry Creek	0.70	11.8
Sept. 10, 1909	.....do	.48	7.4
July 14, 1909	Little Creek	1.17	20.7
July 30, 1909	.....do	.70	6.5
Do	.....do	.71	6.3
Sept. 10, 1909	.....do	.60	4.2
Sept. 16, 1910	.....do	1.07	23.5
July 15, 1909	Hobson branch at outlet		4.3
Aug. 1, 1909	.....do		2.3
Aug. 10, 1909	.....do		1.7
Sept. 12, 1909	.....do		.85

SNAKE RIVER DRAINAGE BASIN.

DESCRIPTION.

Snake River drains an area of 110 square miles, largely within the upland area, and empties into Bering Sea at Nome. The river is not important in point of water supply, but its lower basin contains some important gold placers, notably those of Glacier, Anvil, and Little creeks. Other tributaries, of less interest economically, are North Fork, Bangor, Boulder, and Sunset creeks from the west and Grouse Creek from the east. The main stream above Grouse Creek is called Goldbottom Creek. Some mining has been done on several of the upper tributaries, as well as on the streams nearer Nome. Ditches have been built to divert water for hydraulicking from North Fork, Bangor, Divining, Twin Mountain, and Glacier creeks.

One gaging station was maintained on Snake River above Glacier Creek in 1907.

SNAKE RIVER ABOVE GLACIER CREEK.

This station was established June 25, 1907, just above the mouth of Glacier Creek, to determine the discharge of Snake River and the relation of the run-off from its drainage basin to that from areas in and near the Kigluaik Mountains.

The station is located at an elevation of only about 40 feet. A large quantity of water is ordinarily diverted into Glacier Creek by the Miocene ditch and enters Snake River just below the station. Except for a small amount carried over the divide at the Miocene flume from Grouse and Cold creeks, the discharge at the measuring point is unaffected by diversion.

Unfortunately these records were obtained during a year of high water, so that they are not well adapted for making comparisons. A lower discharge was shown by a measurement made July 12, 1908, and comparison with records on Nome River indicates that the minimum later in the month was not far from 25 second-feet.

Discharge measurements of Snake River above Glacier Creek in 1907 and 1908.

[Elevation, 40 feet.]

Date	Gage height.	Discharge.	Date.	Gage height	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
June 25	1.88	527	June 18	0.85	132
July 3	1.20	168	July 12	.45	45.8
July 20	1.13	147			
Aug. 10	0.89	72.2			
Sept. 3	1.01	112			

Daily gage height, in feet, and discharge, in second-feet, of Snake River above Glacier Creek for 1907.

[Drainage area, 69 square miles. Observer, A. H. Clambey.]

Date.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.35	235	1.05	120	1.08	129
2			1.30	212	1.02	111	1.05	120
3			1.25	191	1.00	105	1.05	120
4			1.18	163	1.00	105	1.05	120
5			1.22	178	.96	94	1.04	117
6			1.32	221	.95	91	1.03	114
7			1.50	308	.96	94	1.02	111
8			1.35	235	.94	89	1.08	129
9			1.25	191	.92	83	1.08	129
10			1.25	191	.92	83	1.15	152

Daily gage height, in feet, and discharge, in second-feet, of Snake River above Glacier Creek for 1907—Continued.

Date.	June.		July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
11			1.28	204	0.91	80	1.90	540
12			1.25	191	.90	77	1.68	408
13			1.20	170	.98	99	1.52	319
14			1.20	170	.97	97	1.47	293
15			1.18	163	.90	77	1.50	308
16			1.10	135	1.04	117		
17			1.12	142	1.10	135		
18			1.10	135	1.10	135		
19			1.18	163	1.05	120		
20			1.18	163	1.00	105		
21			1.20	170	1.05	120		
22			1.18	163	1.01	108		
23			1.16	156	.99	102		
24			1.22	178	1.00	105		
25	1.90	540	1.30	212	1.02	111		
26	1.85	510	1.22	178	1.08	129		
27	1.80	480	1.18	163	1.10	135		
28	1.55	335	1.12	142	1.10	135		
29	1.45	283	1.08	129	1.10	135		
30	1.40	258	1.08	129	1.10	135		
31			1.05	120	1.08	129		
Mean		401		177		108		207
Mean per square mile		5.81		2.56		1.56		3.00
Run-off, depth in inches on drainage area		1.30		2.95		1.80		1.67

PENNY RIVER DRAINAGE BASIN.

DESCRIPTION.

Penny River rises about 18 miles back from the seacoast and empties into Bering Sea about 10 miles west of Nome. Its drainage basin lies between the Snake and Cripple river basins and has a total area of 36 square miles. The Penny basin, which reaches a maximum elevation of about 2,000 feet, is relatively long and narrow, most of the tributaries, except Willow Creek, being short and steep.

A small amount of mining has been carried on along the lower river. The Sutton ditch diverts water from the river at a point about half a mile above the mouth of Willlow Creek, to the second beach line, about 3 miles east of the mouth of Penny River, near Jess Creek. Two other ditches have been begun, one having its intake about 7 miles above the Sutton intake and the other just below.

PENNY RIVER AND SUTTON DITCH AT INTAKE.

Gaging stations were maintained on the river and ditch during the mining season of 1907. One measurement on each was made in 1906.

The gages were located just below the dam and were read by employees of the United Ditch Co. Some shifting took place at both points, and no measurements were obtained at high stages on the river, but the data are accurate enough for ordinary comparisons.

Discharge measurements of Penny River and Sutton ditch at intake, in 1906 and 1907.

[Elevation, 120 feet.]

Date.	Penny River.		Sutton Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
Aug. 1		6.2		29.7
1907.				
July 4	1.11	31	1.20	28.2
Do	.82	12.6	1.49	44.2
July 22	1.30	42	1.11	24.6
Sept. 1	.99	16.3	1.32	37.6

Daily gage height, in feet, and discharge, in second-feet, of Penny River and Sutton ditch at intake for 1907.

[Drainage area 19 square miles. Observers, Peter Pedersen and E. B. Holdridge.]

Day.	July.				August.				September.			
	River.		Ditch.		River.		Ditch.		River.		Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		71		29		85		0	1.0	19	1.3	35
2		56		29		85		0	1.0	19	1.3	35
3		41		29		85		0	1.0	19	1.3	35
4	1.1	26	1.2	29		85		0	1.0	19	1.3	35
5	1.1	[illegible]	1.2	29		85		0	.9	14	1.3	35
6	1.3	44	1.25	32	1.6	79	0.8	9	.9	14	1.3	35
7	2.2	152	1.2	29	1.4	55	.8	9	.9	14	1.3	35
8	1.6	79	1.2	29	1.1	26	1.0	18	.9	14	1.3	35
9	1.3	44	1.25	32	1.1	26	1.0	18	1.0	19	1.3	35
10	1.3	44	1.2	29	.8	10	1.2	29	2.1	140	1.3	35
11	1.3	44	1.2	29	.8	10	1.2	29	1.8	103	1.3	35
12	1.2	34	1.2	29	.7	7	1.2	29	1.6	79	1.3	35
13	1.4	55	1.2	29	.7	7	1.2	29	1.0	19	1.3	35
14	1.5	67	1.2	29	.7	7	1.2	29	1.0	19	1.3	35
15	1.2	34	1.1	23	.6	4	1.2	29	1.8	103	.5	0
16	1.2	34	1.1	23	1.4	55	1.2	29	1.8	103	.5	0
17	1.2	34	1.1	23	1.2	34	1.2	29	1.7	91	.8	9
18	1.2	34	1.1	23	1.1	26	1.2	29	1.3	44	1.3	35
19	1.5	67	1.1	23	.9	14	1.25	32	1.3	44	1.3	35
20	1.3	44	1.1	23	.8	10	1.3	35	1.3	44	1.3	35
21	1.5	67	1.1	23	1.0	19	1.25	32	1.3	44	1.3	35
22	1.3	44	1.1	23	.9	14	1.25	32	1.2	34	1.3	35
23	1.2	34	1.1	23	.8	10	1.3	35	1.1	26	1.3	35
24	1.4	55	1.1	23	.8	10	1.3	35	1.1	26	1.3	35
25	1.4	55	1.0	18	1.0	19	1.5	47	1.1	26	1.3	35
26	1.6	79	1.0	18	1.3	44	1.2	29	1.1	26	1.3	35
27	1.5	67	1.0	18	1.3	44	1.2	29	1.0	19	1.3	35
28	1.5	67	1.0	18	1.3	44	1.2	29	.9	14	1.3	35
29	1.4	55	.9	13	1.2	34	1.2	29	.9	14	1.3	35
30	1.5	67	.8	9	1.2	34	1.2	29	.8	10	1.3	35
31	1.6	79	.7	6	1.1	26	1.2	29				
Mean		54.8		23.9		35.3		23.8		33.9		31.8
Mean total	78.7				59.1				65.7			
Mean per square mile	4.14				3.11				3.46			
Run-off, depth in inches on drainage area	4.77				3.58				3.86			

Discharge measurements of Penny River at Highline intake, 1906-7.

[Elevation 410 feet.]

Date.	Discharge.	Per cent of Sutton intake.	Date.	Discharge.	Per cent of Sutton intake.
1906.	*Sec.-ft.*		1907.	*Sec.-ft.*	
Aug. 1	7.8	22	July 22	15.9	24
			Aug. 30	15.6	28

CRIPPLE RIVER DRAINAGE BASIN.

DESCRIPTION.

Cripple River enters Bering Sea about 12 miles west of Nome and drains an area of about 88 square miles. The basin is one-sided in character, for the principal tributaries, Upper Oregon, Slate, Aurora, Oregon, and Arctic creeks, all enter from the east.

Little systematic mining has been done except on Oregon Creek and Hungry Creek, one of its tributaries. Two ditches have been built. The Cripple River Hydraulic Mining Co.'s ditch has its intake just below Aurora Creek and extends down the right bank of the river for about 11 miles. The Cedric ditch is described below.

CEDRIC DITCH ABOVE PENSTOCK.

The Cedric ditch was built in 1905 to divert water for mining on Oregon, Hungry, Trilby, and Nugget creeks. It diverts water from Josie and Jessie creeks (tributary to Stewart River) into the Cripple River basin and after passing the divide picks up water from Upper Oregon (two forks), Slate, and Aurora creeks, which are its principal feeders, also from Daisy Swift Creek, Snowshoe Gulch, and three other small gulches. It has a total length of about 19 miles and a width of 4 to 8 feet. The elevation of the head is about 870 feet and of the outlet 790 feet. The capacity of the lower half is about 25 second-feet. Water is carried across Oregon Creek near the outlet by a siphon 2,970 feet long, consisting of 30-inch riveted steel pipe. There are about 6 miles of distributing ditches at the lower end.

The following measurements were made to determine the amount of water available for the ditch:

Water available for Cedric ditch in 1906 and 1907.

Stream.	1906.			1907.
	July 15-17.	July 30-31.	Aug. 19.	Aug. 31.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
Josie Creek	3.0	1.5	1.1	[a] 2.0
Irene Creek	1.0	[a] .8	[a] .4	[a] 3.0
Jessie Creek	[b] 3.2	1.5	.6	[a] 3.0
Upper Oregon Creek	[b] 6.8	2.6		[a] 3.5
Slate Creek	4.0	2.0		3.1
Aurora Creek	4.8	2.1		2.4
Daisy Swift Creek	.5			
Total available for ditch	18.3	10.5		17.0

[a] Estimated. [b] Measured below ditch level; only about half this amount is available for the ditch.

A regular station was established July 22, 1907, to determine the total flow of the ditch. The gage was located just above the penstock of the siphon across Oregon Creek. Part of the water was used in a giant connected with the bottom of the siphon and part was used for hydraulicking about one-fourth mile beyond the siphon up Oregon Creek.

Discharge measurements of Cedric ditch above penstock in 1907.

Date.	Gage height.	Dis-charge.
	Feet.	*Sec.-ft.*
July 22	0.80	10.3
Aug. 30	.78	8.59
Aug. 31	.76	7.92
Sept. 19	.10	0

Daily gage height, in feet, and discharge, in second-feet, of Cedric ditch above penstock for 1907.

[Observer, F. S. Smith.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.00	13.1	0.95	12.2	16			1.05	14.0	1.02	13.5
2			1.02	13.5	.85	10.2	17			1.05	14.0	1.05	14.0
3			1.02	13.5	.98	12.7	18			1.08	14.6	1.05	14.0
4			1.05	14.0	.88	10.8	19			1.15	16.0		0
5			.95	12.2	.95	12.2	20			1.08	14.6		0
6			.88	10.8	.95	12.2	21			1.10	15.0		0
7			.80	9.3	.98	12.7	22	0.80	9.3	1.10	15.0		0
8			.92	11.6	.95	12.2	23	.88	10.8	.95	12.2	.65	6.6
9			.90	11.2	1.05	14.0	24	1.00	13.1	.95	12.2	.68	7.1
10			.90	11.2	1.20	16.9	25	.98	12.7	1.05	14.0	.60	5.7
11			.88	10.8	1.25	17.8	26	1.00	13.1	1.20	16.9	.60	5.7
12			.90	11.2	1.15	16.0	27	.90	11.2	1.10	15.0	.62	6.1
13			.95	12.2	1.05	14.0	28	.88	10.8	1.05	14.0	.58	5.4
14			.98	12.7	1.02	13.5	29	1.00	13.1	1.00	13.1	.52	4.5
15			.98	12.7	1.10	15.0	30	1.10	15.0	.85	10.2	.50	4.2
							31	1.05	14.0	.80	9.3		
							Mean.		12.3		12.9		9.6

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Cripple River drainage basin.

Miscellaneous measurements in Cripple River drainage basin in 1906 and 1907.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
July 15, 1906	Cripple River..	Bering Sea....	Below Aurora Creek, including Cedric ditch.	450	22	8.4	2.62
July 16, 1906	Slate Creek....	Cripple River.	Cedric ditch intake....	840	4.0	....	....
July 30, 1906	.....do.........	.....do........	.....do................	840	2.0	....	....
Aug. 31, 1909	.....do.........	.....do........	.....do................	840	3.1	....	....
July 16, 1906	Aurora Creek..	.....do........	.....do................	830	4.8	....	....
July 30, 1906	.....do.........	.....do........	.....do................	830	2.1	....	....
Aug. 31, 1907	.....do.........	.....do........	.....do................	830	2.4	....	....
July 16, 1906	Upper Oregon Creek.	.....do........	Below forks...........	750	6.8	....	....
July 30, 1906	.....do.........	.....do........	Below forks, including ditch.	750	3.8	....	....

SINUK RIVER DRAINAGE BASIN.

DESCRIPTION.

Sinuk River rises on the southern slope of the Kigluaik Range, adjacent to the headwaters of Grand Central River and of Thompson and Buffalo creeks. It flows in a southwesterly direction, entering Bering Sea near Cape Rodney. The upper portion of its drainage basin is mountainous. Some of the peaks reach elevations of more than 3,000 feet and the river itself rises at an elevation of over 1,000 feet. The upper valley contains a large amount of glacial débris and rock slide. Near the mouth of Stewart River, which is the principal tributary, the river enters a lowland basin. The principal tributaries to the upper stream are Windy Creek and the outlet of Glacial Lake from the north, and Stewart River from the south. North Star Creek lies between Windy Creek and upper Sinuk River and is tributary to the former.

Little mining has been done in this basin, though gold has been found on a few streams. The only ditch which has been built to divert the water from its tributaries is the Cedric, which extends from Josie, Irene, and Jessie creeks over the divide from Cripple River. Upper Sinuk River could be diverted into Nome River either over the Buffalo divide, which has an elevation of 1,012 feet, or by way of Stewart River over the Silver Creek divide at a slightly lower level.

Either of these diversions would require so much expensive and difficult construction that they have never been seriously considered.

Grand Central River and its tributaries, with their low-water flow reenforced by storage, will probably furnish as much additional water as the development of the Nome region will require, at a smaller cost than that at which it could be obtained from Sinuk River and Windy Creek. If a large body of ground adapted to hydraulic mining should be discovered in the Sinuk River basin, the river will furnish a good supply of water at a high level.

It has been proposed to construct a ditch from upper Sinuk River to Irish Hill, an area of bench placer deposits near Washington Creek, a headwater tributary from the south of Cripple River, but this would require a long and expensive waterway.

Sinuk River and its tributaries, on account of the rather high elevations at which they rise, are affected by the freezing of their headwaters much sooner than Nome River and somewhat earlier than Grand Central River, which continues to receive warm water from springs after the surface begins to freeze. On September 22, 1907, Sinuk River had nearly gone dry on account of cold weather, and the discharge of Windy Creek had been noticeably affected, although the flow of Nome and Grand Central rivers had not been appreciably reduced.

The following gaging stations were maintained during 1907, and readings on the gages were obtained about once a week. Measurements had been made at the same points in 1906, but not often enough for an estimate of daily discharge to be made.

Upper Sinuk River at elevation 700 feet.
Windy Creek at elevation 650 feet.
North Star Creek at elevation 900 feet.

UPPER SINUK RIVER AT ELEVATION 700 FEET.

This station was originally located just below a small lake where fair measurements could be made. A gage was set on July 1, 1907, but the channel shifted so greatly that readings were of no value. It was reestablished about 1½ miles downstream on August 8, and a new measuring section was selected near the gage.

The results are only approximate but serve to give a general idea of the regimen of the stream.

Daily gage height, in feet, and discharge, in second-feet, of upper Sinuk River at elevation 700 feet, for 1907.

[Drainage area, 8.2 square miles.[a] Observer, Elmer Ackerson.]

Day.	July.	August.		September.		Day.	July.	August.		September.	
	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	[b]70	......	36	......	55	21	100	......	54	......	24
2	60	......	35	1.38	[d]46	22	60	......	54	1.21	[e]7
3	54	......	34	......	40	23	56	1.34	[d]37	......	......
4	40	......	31	......	50	24	48	......	34	......	......
5	48	......	29	......	40	25	42	......	32	......	......
6	[b]52	......	26	1.32	[d]83	26	38	......	50	......	......
7	46	......	24	......	30	27	[b]36	......	62	......	......
8	42	1.28	[c]26	......	28	28	29	1.40	[c]55	......	......
9	42	......	25	......	60	29	24	......	80	......	......
10	60	......	25	......	160	30	28	......	100	......	......
11	80	......	24	......	114	31	32	......	70	......	......
12	70	1.27	[d]24	......	90	Mean	52.3	......	45.0	......	53.7
13	[b]75	......	24	......	75	Mean per square mile	8.44	......	5.49	......	6.55
14	62	......	24	1.48	[c]65	Run-off, depth in inches on drainage area	9.73	......	6.33	......	5.36
15	52	......	22	......	58						
16	44	......	60	......	52						
17	40	......	100	......	46						
18	50	......	82	1.41	[b]41						
19	60	1.49	[c]70	......	35						
20	80	......	46	......	32						

[a] Elevation, 770 feet, and drainage area, 6.2 square miles during July.
[b] Measurement at elevation, 770 feet.
[c] Measurement at elevation, 700 feet.
[d] Computed from gage reading.
[e] Estimated; slush ice running.

NOTE.—Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of Nome and Grand Central rivers.

WINDY CREEK AT ELEVATION 650 FEET.

Windy Creek, the first large tributary of Sinuk River, lies between the main ridge of the Kigluaik Mountains and the headwaters of the Sinuk. It adjoins West Fork of Grand Central River, from which it may be reached by crossing a high divide. The topography is very rough, the creek disappearing in places among the large bowlders which form its bed.

The gaging station was located about 2 miles above the mouth of the creek. Measurements were made between the two lakes lying just below Mosquito Pass. This was the only practicable measuring section, but conditions were very poor. The gage was located in a permanent section just below the lower lake.

Daily gage height, in feet, and discharge, in second-feet, of Windy Creek at elevation 650 feet, for 1907.

[Drainage area, 12 square miles. Observer, Elmer Ackerson.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	1.36	a 128		60		72
2		96		56	1.15	a 67
3		90		52		56
4		100		50		64
5		112		42		54
6		120		34	1.05	a 43
7		116		32		38
8		114	1.01	b 35		36
9		120		34		80
10		130		34		200
11		140		32		140
12		125	1.00	a 33		110
13	1.36	b 128		33		90
14		105		33	1.20	a 79
15		85		32		70
16		74		90		64
17		66		125		56
18		70		100	1.08	a 50
19		80	1.21	b 88		45
20		100		60		40
21		130		70		30
22		80		72		c 15
23		76	1.06	a 45		
24		72		42		
25		68		40		
26		60		68		
27	1.13	b 57		80		
28		48	1.14	b 70		
29		40		90		
30		50		120		
31		56		82		
Mean		91.5		59.2		68.1
Mean per square mile		7.62		4.93		5.68
Run-off, depth in inches on drainage area		8.78		5.68		4.65

a Computed from gage reading. b Measurements. c Estimated; slush ice running.

NOTE.—Other discharges were obtained in the same manner as those of Sinuk River.

NORTH STAR CREEK AT ELEVATION 900 FEET.

North Star Creek drains a high cirque lying between the basins of Windy Creek and Sinuk River. The gaging station was located about half a mile above the mouth of the canyon, where measuring conditions were fair and the channel only slightly shifting. The results are only approximate but serve the purpose of indicating the behavior of the stream in a general way.

Daily gage height, in feet, and discharge, in second-feet, of North Star Creek at elevation 900 feet, for 1907.

[Drainage area, 2.3 square miles. Observer, Elmer Ackerson.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	1.36	a 28		8		7
2		20		7	0.92	b 4.5
3		16		7		4
4		13		6		7
5		14		5		6
6	1.26	a 16		5	.94	b 4.8
7		14		4		4
8		13	0.94	a 4.8		4
9		14		5		4
10		16		5		40
11		20		5		30
12		22	.97	b 5.3		20
13	1.33	a 23		5		14
14		17		5	1.08	b 7.8
15		14		5		7
16		12		15		7
17		10		25		6
18		13		16	1.00	b 5.7
19		17	1.10	a 8.3		5
20		24		7		4
21		30		8		3
22		20		8	0.75	c 2.0
23		16	0.97	b 5.2		
24		13		5		
25		10		4		
26		8		8		
27	1.03	a 5.5		12		
28		5	1.13	a 9.1		
29		4		14		
30		5		20		
31		6		10		
Mean		14.8		8.3		8.0
Mean per square mile		6.43		3.61		3.87
Runoff, depth in inches on drainage area		7.41		4.16		3.16

a Measurements. b Computed from gage reading. c Estimated; slush ice running.

NOTE.—Other discharges were obtained in the same manner as those of Sinuk River.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Sinuk River drainage basin:

Miscellaneous measurements in Sinuk River drainage basin, 1906 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
June 27, 1906	Sinnk River	Bering Sea	Below upper lake	770	33	6.2	5.32
July 6, 1906	do	do	do	770	37	6.2	5.97
July 20, 1906	do	do	do	770	36	6.2	5.81
Aug. 3, 1906	do	do	do	770	20	6.2	3.23
Aug. 10, 1906	do	do	do	770	24	6.2	3.87
Sept. 5, 1909	do	do	do	770	12.4	6.2	2.00
June 21, 1906	Windy Creek	Sinuk River	Level of ditch from Buffalo divide.	1,100	49	5.9	8.30
June 27, 1906	do	do	do	1,100	17.1	5.9	2.90
July 13, 1906	do	do	Between lower lakes	670	48	12.0	4.00
Aug. 3, 1906	do	do	do	670	32	12.0	2.67
Aug. 10, 1906	do	do	do	670	a 35	12.0	2.92
Sept. 6, 1906	do	do	do	670	a 32	12.0	2.67
Sept. 5, 1909	do	do	do	670	20	12.0	1.67
Sept. 15, 1909	do	do	do	670	a 18	12.0	1.50
June 27, 1906	North Star Creek.	Windy Creek	In canyon	900	9.8	2.3	4.26
July 6, 1906	do	do	do	900	18.1	2.3	7.87
July 13, 1906	do	do	do	900	16.4	2.3	7.13
July 20, 1906	do	do	do	900	3.9	2.3	1.70
Aug. 3, 1906	do	do	do	900	3.0	2.3	1.30
Aug. 10, 1906	do	do	do	900	2.9	2.3	1.26
Sept. 5, 1909	do	do	do	900	1.93	2.3	.84
July 15, 1906	Stewart River	Sinuk River	Below Mountain Creek	400	74	36	2.06
July 17, 1906	do	do	do	400	49	36	1.36
July 30, 1906	do	do	do	400	a 26	36	.72

a Estimated from reading on reference point.

Miscellaneous measurements in Sinuk River drainage basin, 1906 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. m.*	*Sec.-ft.*
Aug. 12, 1906	Stewart River.	Sinuk River..	Below Mountain Creek	400	11.4	36	.32
July 15, 1906	Slate Creek [a]...	Stewart River.	Near level of Divide Creek divide.	680	6.7	2.1	3.19
July 17, 1906	.....do........	.....do.......	.....do...............	640	4.4	2.1	2.10
July 30, 1906	.....do........	.....do.......	.....do...............	700	2.8	2.1	1.33
Aug. 19, 1906	.....do........	.....do.......	.....do...............	700	2.2	2.1	1.05
July 15, 1906	Josie Creek....	.....do.......	Cedric Ditch intake...	870	[b] 3.0	....	....
July 17, 1906	.....do........	.....do.......	.....do...............	870	3.0	....	....
July 29, 1906	.....do........	.....do.......	.....do...............	870	1.5	....	....
Aug. 19, 1906	.....do........	.....do.......	.....do...............	870	1.1	....	....
July 15, 1906	Irene Creek....	.....do.......	.....do...............	860	[b] 4.0	....	....
July 17, 1906	.....do........	.....do.......	.....do...............	860	1.0	....	....
July 30, 1906	.....do........	.....do.......	.....do...............	860	.8	....	....
Aug. 19, 1906	.....do........	.....do.......	.....do...............	860	[b] .4	....	....
July 15, 1906	Jessie Creek....	Durant Creek.	.....do...............	860	4.0	....	....
July 16, 1906	.....do........	.....do.......	¼ mile below ditch.....	800	3.5	....	....
July 17, 1906	.....do........	.....do.......	.....do...............	800	3.2	....	....
July 30, 1906	.....do........	.....do.......	Cedric Ditch intake...	860	1.5	....	....
Aug. 19, 1906	.....do........	.....do.......	.....do...............	860	.6	....	....

[a] Slate Creek enters Stewart River from the north about 2 miles below its head.
[b] Estimated.

TRIBUTARIES OF IMURUK BASIN.

FALL, POND, AND GLACIER CREEKS AND SNOW GULCH.

Fall, Pond, and Glacier creeks and Snow Gulch are short, swift streams which rise in glacial cirques on the north side of a spur of the Kigluaik Mountains and flow into the south side of Imuruk Basin. There are good-sized lakes on Fall and Pond creeks at an elevation of a little more than 1,200 feet, and smaller lakes near the heads of Pond and Glacier creeks at higher elevations.

Weirs were installed on these creeks in the fall of 1906 by W. L. Leland. The one on Fall Creek was 24 feet long and the others each 12 feet. On account of the unfavorable locality and the formation of the stream bed, it was necessary to construct low weirs, which were without a free fall, and which permitted considerable leakage.

On September 5, 1906, a measurement was made of each of the streams, except Pond Creek, which through its whole course flows over bowlders so rough that a measurement is practically impossible. These measurements were referred to the weirs and coefficients derived, from which rating tables were made out. The daily discharges computed for the period for which readings on the weirs were thus made are available, but they are only approximate.

Discharge measurements of Fall and Pond creeks and Snow Gulch in 1906.

Date.	Stream and locality.	Elevation.	Height on weir.	Discharge.
		Feet.	*Inches.*	*Sec.-ft.*
Sept. 5	Fall Creek below lake........................	1,208	5	34
5	Glacier Creek below lake........................	1,212	4	10
5	Snow Gulch........................	1,212	3¼	9.7

Daily discharge, in second-feet, of Fall, Pond, and Glacier creeks for 1906.

Day.	Fall Creek.	Pond Creek.[a]	Glacier Creek.	Day.	Fall Creek.	Pond Creek.[a]	Glacier Creek.
Aug. 9	32	....	....	Aug. 20	37	23	....
Aug. 11	45	....	....	Aug. 21	40	27	....
Aug. 12	45	....	....	Aug. 22	45	21	....
Aug. 13	54	....	....	Aug. 23	112	62	....
Aug. 14	45	23	....	Aug. 24	83	48	....
Aug. 15	40	21	....	Sept. 3	....	26	....
Aug. 16	37	16	....	Sept. 4	....	21	11
Aug. 18	32	16	....	Sept. 5	34	16	10
Aug. 19	34	....	....				

[a] The discharges for Pond Creek are based on the same rating as those for Glacier Creek, but it is not certain just how closely this rating is applicable.

COBBLESTONE RIVER.

Cobblestone River rises on the north side of the mountains, opposite the head of Windy Creek, from which it is separated by a low divide called Mosquito Pass, and flows northward into Imuruk Basin. It is about 20 miles long and drains an area of 84 square miles. Practically the entire drainage area has been glaciated and is very rough and rugged. Most of the tributaries enter from the west; the largest, Oro Grande Creek, joins the main stream about 6 miles below Mosquito Pass. This basin is seldom visited either by travelers or by prospectors. Placer gold has not been found along its course, but there are some deposits of graphite in the mountains near the head of the stream.

Cobblestone River, in common with the other streams north of the mountains, could furnish a large amount of water power. The most feasible project is thought to exist near its lower course, where a head of 400 to 500 feet could be developed and a partly controlled flow obtained. Two measurements were made of the river about 1½ miles below Oro Grande Creek, at an elevation of about 500 feet, in order to obtain a general idea of the run-off from this area and the amount of water available for power development. The results of the measurements are as follows:

August 17, 1908, 227 second-feet.
September 16, 1909, 127 second-feet.

The later measurement is probably below the normal flow, because the headwaters begin to freeze at about this date.

GRAND CENTRAL RIVER DRAINAGE BASIN.

DESCRIPTION.

Grand Central River drains a high, rugged area of 51 square miles lying in the heart of the Kigluaik Mountains. West Fork, which may be considered the head of the main stream, rises south of Mount Osborn, flows in an easterly direction for about 4 miles, and is joined by North Fork. Below this junction the river flows southeastward for about 8 miles and enters the upper end of Salmon Lake. The principal tributaries are North Fork, Gold Run, and Rainbow Creek from the northeast, and Crater Lake outlet, Thompson, Thumit, Nugget, Jett, and Morning Call creeks from the southwest and south. The upper basin is surrounded by mountains 3,000 to 4,000 feet or more high, including Mount Osborn, the highest point in Seward Peninsula, which reaches an elevation of about 4,700 feet.

Practically the whole drainage basin has been glaciated. The lower valley is filled to a great depth with gravel and outwash material. Soundings taken in Salmon Lake near the upper end indicate depths up to 139 feet, and it is probable that bedrock lies at a still greater depth. There are well-defined moraines near the mouth of each of the tributary gulches in the mountains, that of Thompson Creek being especially distinct. These moraines consist of masses of angular fragments, gravel, and finer materials. Their surfaces are very irregular and contain many small depressions which form lakes during wet seasons and drain dry during the periods of drought. Some of the valleys present a steplike appearance caused by a periodic retreat of the glaciers. Several basins of glacial origin contain small lakes, the largest of which are Crater Lake, tributary to West Fork, and the lake at the head of Gold Run. There are no less than half a dozen well-defined cirques in the basin, the most notable being the one at the head of North Fork, which is probably the most impressive scenic feature of Seward Peninsula. The vertical rock walls rise on three sides of the cirque to elevations of 2,000 to 3,000 feet above the river and the small glacier in which it heads. The glaciers have disappeared from the heads of the valleys so recently that the alders which abound in the lower part of the drainage basin do not seem to have had time to establish themselves in the upper valleys, which are bare of vegetation, except for a few mosses and grasses.

The snow, protected from the direct rays of the sun by the steep walls of the valleys, is retained well into the summer. The highest water from the melting snow usually occurs late in June and the run-off from this source is well maintained until about the middle of July. The low water is thus delayed until a later period than on Nome River and streams farther south. The minimum stage for the summer usually occurs just before the freeze-up in September. The season is short on account of the high elevation. The streams freeze fully a week earlier than Nome River, and the period in which ditches can be operated is a week or 10 days shorter on each end of the season. This period will not average more than 70 or 80 days unless the snow is removed from the ditch at heavy cost in the early summer. The lowest rock exposed by the cutting of the streams and glaciers at the head of Grand Central River is a massive limestone, which furnishes many springs and helps to maintain the flow of the river. The largest spring is on North Fork, about a mile above the junction, at an elevation of about 860 feet.

The Grand Central drainage basin is separated from that of Nome River by the Nugget divide, which has an elevation of 785 feet. This elevation makes possible the diversion of practically all the water from the head of the river and its tributaries into the Nome River basin, where it can be made available for mining. Two conduits for the purpose of making such diversions have been started, the Grand Central branch of the Miocene ditch and the wood-stave pipe line of the Wild Goose Mining & Trading Co., both of which are described elsewhere. (See pp. 108, 263.) It is proposed to reenforce the low-water flow of the streams by means of storage, which may be obtained on Crater Lake and possibly on the Gold Run lake. Mining operations have never been carried on in this basin, and very little prospecting has been done except on one or two lodes near Copper Creek.

Grand Central River and its tributaries could be made to furnish abundant water power if occasion demanded, but its waters are of more value for hydraulic mining and have been developed for such use. Gold Run is the best adapted to power development of all the tributaries, as a fall of nearly 1,000 feet could be obtained with only about 2 miles of flume and pipe leading from the lake. The flow is fairly well maintained and could be supplemented during periods of low water by water stored in the lake.

The following stations have been maintained in the Grand Central River drainage basin:

West Fork of Grand Central River at pipe intake, 1906-7.
West Fork of Grand Central River at ditch intake, 1906-7.
West Fork of Grand Central River at the forks, 1907-1909.
Grand Central River below the forks, 1906, 1908-1910.
Grand Central River below Nugget Creek, 1906.
Crater Lake outlet, 1906-1909.
North Fork of Grand Central River at pipe intake, 1906-7, 1909.
North Fork of Grand Central River near ditch intake, 1906.
North Fork of Grand Central River at the forks, 1907.
Gold Run near mouth of canyon, 1906-7.
Thompson Creek near ditch intake, 1906-1909.

WEST FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

West Fork drains an area of 7.7 square miles lying between Mount Osborn on the north and the headwaters of Sinuk River and Windy Creek on the south. It joins North Fork at an elevation of about 700 feet to form Grand Central River proper. Its basin is diversified by cirques, lakes, moraines, and rapidly falling streams. Its principal tributary is Crater Lake outlet, which enters from the south about half a mile above the mouth. There are several small springs in the stream valley just above the mouth of the lake outlet. A lateral of the Wild Goose pipe line about 1½ miles long has its intake on West Fork at an elevation of about 1,010 feet and extends to Crater Lake.

Measurements were begun near the intake in 1906, to determine the amount of water available for the lateral, and have been continued at intervals since that time. A gage was established in 1907, and some readings were made in that year and in 1909. Daily discharges have been computed by means of a hydrograph and by comparisons with data at stations farther down the stream for 1906 and 1907.

Daily gage height, in feet, and discharge, in second-feet, of West Fork of Grand Central River at pipe intake, for 1906 and 1907.

[Drainage area, 2.8 square miles.]

Day.	1906 (discharge).			1907					
	July.	August.	September.	July.		August.		September.	
				Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	a 19	12	22	....	....	....	14	....	13
2	18	12	19	....	....	....	14	....	15
3	15	12	16	....	....	....	14	....	15
4	18	14	12	....	....	....	14	....	11
5	....	14	9	....	....	....	12	0.88	b 11.5
6	....	a 12	9	....	....	0.86	a 11.3	....	11
7	....	12	8	....	....	....	12	....	12
8	....	10	8	....	31	....	15	....	13
9	....	9	a 7.3	....	29	....	15	....	20
10	....	8	7	1.27	a 47	....	13	....	74
11	a 45	9	7	....	48	....	13	....	54
12	72	11	7	....	29	....	13	....	40
13	52	10	7	....	30	.91	b 13.7	....	28
14	45	9	6	....	26	....	14	....	25
15	32	8	6	....	24	....	12	....	25
16	27	8	6	....	22	....	52	1.02	b 23
17	32	a 7.6	6	....	20	....	35	....	17
18	27	8	7	....	22	....	19	....	13
19	20	8	....	....	26	....	14	....	12
20	20	7	....	....	31	....	18	....	12
21	23	12	....	....	44	....	20	....	12
22	a 15	16	....	....	29	....	18	....	10
23	44	30	....	....	26	....	14	....	11
24	32	a 18.5	....	....	24	....	12	....	....
25	a 25	15	....	....	24	.90	a 12	....	....
26	19	19	....	a .98	a 19.3	....	12	....	....
27	19	27	....	....	18	....	12	....	....
28	16	24	....	....	15	....	11	....	....
29	14	24	....	....	12	....	39	....	....
30	13	22	....	....	18	....	33	....	....
31	12	22	....	....	20	....	26	....	....
Mean	27.0	13.9	9.4	....	26.4	....	17.6	....	20.5
Mean per square mile	9.64	4.96	3.36	....	9.43	....	6.29	....	7.32
Run-off, depth in inches on drainage area	8.96	5.72	2.25	....	8.42	....	7.25	....	6.26

a Measurements.

b Estimate based on gage readings. Other discharges are obtained by taking about the same percentage of the flow at elevation 860 feet as was found on the dates of measurements. Gagings on June 19, 1906, gave 28 second-feet, and on June 26, 26 second-feet.

Gage heights and discharge of West Fork of Grand Central River at pipe intake in 1909 and 1910.

[Elevation 1,010 feet.]

Date.	Hydrographer.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Measurements.			**Gage readings.**		
1909		*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 10	Smith and Lane...	0.90	32	July 14........................	0.70	15.0
Aug. 5	F. F. Henshaw....	.52	7.3	Aug. 4........................	.65	12.5
8	.....do............	.48	5.1	Sept. 2........................	.37	3.2
Sept. 21	G. L. Parker.......	.26	1.56	Sept. 10........................	.34	2.6
1910						
Sept. 5	Lanagan and Smith	....	11.5			
14	R. G. Smith.......	....	19.4			

WEST FORK OF GRAND CENTRAL RIVER AT DITCH INTAKE.

The Miocene ditch when completed will divert the water from West Fork near the mouth of Crater Lake outlet at an elevation of about 850 feet. On June 19, 1906, measurements were begun just above the mouth of the lake outlet, to determine the amount of water available for the ditch, and the gage was established July 2 of that year. Regular readings were made until the end of 1907, when the station was discontinued in favor of one just above the forks, described elsewhere. Measuring conditions at the station are excellent, but as the channel is of a shifting character the results are somewhat doubtful for certain periods.

The minimum recorded discharge for one week was 20.3 second-feet, for September 12 to 18, 1906, but a much lower stage was reached in 1908 and 1909.

Discharge measurements of West Fork of Grand Central River at ditch intake, 1906 to 1910.

[Elevation, 850 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*
June 19....................	....	40	July 16....................	1.18	51
June 26....................	....	38	July 26....................	1.13	44
July 1....................	....	29	Aug. 6....................	1.01	32
July 10....................	1.65	115	Aug. 25....................	1.18	35
July 11....................	1.53	86	Sept. 5....................	1.18	39
July 22....................	1.20	38	Sept. 16....................	1.37	48
July 24....................	1.41	58			
July 25....................	1.34	50	1910.		
Aug. 6....................	1.12	31	Sept. 4[a]....................	....	36
Aug. 16....................	1.01	23	Sept. 14[a]....................	....	44
			Sept. 20....................	....	33
1907.					
July 8....................	1.30	69			

[a] Measurements made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of West Fork of Grand Central River at ditch intake for 1906 and 1907.

[Drainage area, 5.4 square miles. Observers, J. E. Styers and Cornelius Edmunds.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	29	1.12	30	1.27	44	......	......	......	45	1.20	41
2	1.10	23	......	30	1.24	40	......	......	......	44	1.25	47
3	1.00	22	......	30	1.20	36	......	......	......	43	1.10	31
4	1.10	23	......	34	1.12	30	......	......	......	43	1.15	36
5	1.80	162	......	34	1.08	27	......	......	1.08	39	1.15	36
6	......	......	1.12	30	1.05	25	......	......	1.06	37	1.15	36
7	......	......	1.15	32	1.05	25	......	......	1.08	39	1.12	33
8	......	......	1.11	29	1.02	23	1.30	69	1.15	47	1.10	31
9	......	......	......	26	1.01	23	......	65	1.15	47	1.35	61
10	1.65	116	1.02	23	1.00	22	1.51	107	1.09	40	1.85	149
11	1.53	86	1.05	25	1.00	22	......	110	1.10	41	1.75	109
12	1.75	144	1.10	28	1.00	22	......	65	1.10	41	1.60	84
13	1.60	103	1.08	27	.98	21	......	68	1.12	43	1.45	59
14	1.55	90	1.05	25	.95	20	......	60	1.12	43	1.40	52
15	1.45	70	......	24	.92	19	......	54	1.07	38	1.40	52
16	1.40	61	1.01	23	92	19	1.18	51	1.49	103	1.37	48
17	1.45	70	1.00	22	.92	19	......	45	1.43	77	1.32	42
18	1.40	61	1.00	22	1.00	22	......	50	1.38	60	1.30	40
19	1.30	47	1.00	22	......	......	......	60	1.25	43	1.28	38
20	1.30	47	.98	21	......	......	......	70	1.35	56	1.28	38
21	1.35	54	1.12	30	......	......	......	100	1.40	63	1.27	37
22	1.20	36	1.20	36	1.60	a103	......	65	1.35	56	1.22	32
23	1.52	83	1.39	60	......	......	......	58	1.25	43	......	35
24	1.41	63	1.21	37	......	......	......	54	1.20	37	......	......
25	1.33	51	1.16	33	......	......	1.20	54	1.18	35	......	......
26	1.25	42	1.22	38	......	......	1.13	45	1.19	36	......	......
27	1.25	42	1.35	54	......	......	......	42	1.20	37	......	......
28	......	39	1.30	47	......	......	......	34	1.18	35	......	......
29	1.20	36	1.30	47	......	......	......	28	1.50	98	......	......
30	1.15	32	1.27	44	......	......	1.10	41	1.48	82	......	......
31	1.14	31	......	44	......	......	......	45	1.38	66	......	......
Mean		62.0	......	32.5	......	25.5	......	60.0	......	50.2	......	50.7
Mean per square mile		11.5	......	6.02	......	4.72	......	11.1	......	9.30	......	9.39
Run-off, depth in inches on drainage area		11.5	......	6.94	......	3.16	......	9.90	......	10.7	......	8.03

a Not included in mean.

NOTE.—Discharges for 1907 have been computed from four rating tables on account of the shifting channel conditions, and are somewhat uncertain. Discharges for days between July 8 and August 5, when the gage was not read, were obtained by the aid of a hydrograph.

WEST FORK OF GRAND CENTRAL RIVER AT THE FORKS.

This station was established July 8, 1907, in order to show the total flow of West Fork above its junction with North Fork, and records were maintained during the three years following. Measurements were made below the forks and the discharge of North Fork subtracted to give that of West Fork, except at extreme low water, when good measurements may be made in a short section of smooth water just above the junction.

The lowest mean discharge for one week was 15.6 second-feet, September 15 to 21, 1909. The values for all except the last day of this period were interpolated, but the mean is probably near the true average discharge for the week on account of the gradual decrease in supply due to freezing near the head of the stream.

Discharge measurements of West Fork of Grand Central River at the forks in 1907–1910.

[Elevation, 690 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 10	1.88	107	Sept. 4	1.55	47
July 16	1.77	80	Sept. 26	1.40	23
July 26	1.74	77			
Aug. 5	1.65	50	1909.		
Aug. 13	1.61	46	July 18	1.10	33
Aug. 26	1.71	61	Aug. 5	.96	25
Sept. 5	1.62	44	Aug. 8	.95	24
Sept. 17	1.70	61	Sept. 4	.89	17.7
1908.			1910.		
July 8	1.44	26	Sept. 4[a]	1.22	50
July 15	1.42	25	Sept. 14[a]	....	54
Aug. 14	1.65	77	Sept. 20	....	37

[a] Measurements by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of West Fork of Grand Central River at the forks for 1907–1909.

[Drainage area, 7.7 square miles. Observers, Cornelius Edmunds, 1907; Walford, Letson, and Chapman, 1908–9.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.							1907.						
1	......	......	1.72	66	1.82	93	21	......	140	1.82	93	1.59	41
2	......	......	1.71	64	1.78	82	22	......	90	1.78	82	1.54	34
3	......	......	1.70	61	1.63	47	23	......	80	1.72	66	1.61	44
4	......	......	1.70	61	1.72	66	24	......	76	1.65	50	......	......
5	......	......	1.65	50	1.68	57	25	1.75	74	1.64	48	......	......
6	......	......	1.60	42	1.68	57	26	1.75	74	1.63	47	......	......
7	......	......	1.60	42	1.76	77	27	1.70	61	1.64	48	......	......
8	1.93	129	1.62	45	1.84	99	28	1.65	50	1.65	50	......	......
9	......	95	1.64	48	2.07	179	29	1.60	42	2.32	276	......	......
10	1.88	112	1.62	45	2.70	406	30	1.68	57	2.38	291	......	......
11	......	125	1.62	45	2.37	287	31	1.70	61	.88	115	......	......
12	......	90	1.65	50	2.12	197	Mean		84.5	......	81.0	......	100
13	......	95	1.62	45	1.82	93	Mean per square mile		11.0	......	10.5	......	13.0
14	......	88	1.65	50	1.80	87	Run-off, depth in inches on drainage area		9.82	......	12.1	......	11.1
15	......	80	1.62	45	1.80	87							
16	1.77	79	1.88	112	1.74	71							
17	......	70	2.00	154	1.70	61							
18	......	75	1.92	125	1.67	54							
19	......	85	1.88	112	1.62	45							
20	......	100	1.78	82	1.61	44							

Daily gage height, in feet, and discharge, in second-feet, of West Fork of Grand Central River at the forks for 1907–1909—Continued.

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.						
1		70	1.62	67	1.60	60
2		62	1.55	48	1.59	58
3		55	1.60	60	1.55	48
4		48	1.65	77	1.53	43
5		40	1.90	170	1.50	36
6		35	1.72	101		34
7		32	1.60	60		32
8	1.44	28	1.60	60		31
9	1.42	25	1.53	43		30
10	1.42	25	1.50	36		29
11	1.49	35		36	1.45	29
12	1.65	77	1.90	170		29
13	1.50	36	1.75	112		29
14	1.43	26	1.68	87		29
15	1.42	25	1.60	60	1.45	29
16	1.42	25	1.60	60		28
17	1.42	25	1.55	48		27
18	1.43	26	1.55	48		26
19	1.40	22	1.70	94		26
20	1.40	22	1.65	77	1.43	26
21	1.40	22	1.60	60		25
22	1.39	21	1.60	60		24
23	1.35	18	1.70	94		23
24	1.37	20	1.60	60		22
25	1.35	18	1.68	87	1.40	22
26	1.35	18	1.65	77	1.40	22
27	1.35	18	1.60	60		22
28	1.37	20	1.45	29		22
29	1.38	20	1.40	22		22
30	1.80	130		22		22
31	1.90	170	1.66	80		
Mean.		39.2		69.8		30.2
Mean per square mile.		5.09		9.06		3.92
Run-off, depth in inches on drainage area.		5.87		10.4		4.37

Day.	July.		August.		September	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.						
1		122	0.96	25	0.90	19.0
2		118	.98	28	.90	19.0
3		118	1.03	36	.89	18.1
4		112	1.05	39	.90	19.0
5		106	1.01	33	.91	20
6		110	1.00	31	.90	19.0
7		107	.98	28	.90	19.0
8		104	.96	25	.89	18.1
9		101	1.10	50	.89	18.1
10		98	1.14	60	.89	18.1
11		94	1.05	39	.88	17.2
12		90	1.00	31	.88	17.2
13		81	1.04	37	.89	18.1
14		72	1.02	34	.88	17.2
15		60	1.01	33		17
16		52	1.00	31		16
17	1.10	50	.99	30		16
18	1.10	50		29		16
19	1.10	50		28		15
20	1.10	50		28		15
21	1.08	46		27	.85	14.5
22	1.06	41		26		
23	1.03	36		26		
24	1.00	31		25		
25	1.01	33		24		
26	1.00	31		24		
27	1.00	31		21		
28	.98	28		20		
29	.99	30		20		
30	.98	28		22		
31	.97	27		20		
Mean.		68.0		30.0		17.5
Mean per square mile.		8.83		3.90		2.27
Run-off, depth in inches on drainage area.		10.18		4.50		1.77

GRAND CENTRAL RIVER BELOW THE FORKS.

This station, which was established July 1, 1906, shows the total discharge of upper Grand Central River available for diversion over the Nugget divide. The gage is located just below the point where the waters from the two forks meet. Measurements were made about a quarter of a mile below the gage at a point where conditions for measurements are good. No gage heights were observed at this point in 1907, for the reason that records were kept on both West Fork and North Fork near their junction, but the channel was found to be more stable here than at the North Fork station, and observations were therefore resumed in 1908. The discharge for a part of 1910 has been estimated for comparison with other records. This discharge is computed from the inflow to Salmon Lake, which is determined by records of the flow of Kruzgamepa River at the outlet of the lake.

A record of the maximum discharge of the river would be of considerable value, but the flow can only be estimated. The discharge for July 8, 1906, estimated from the outflow and rise of Salmon Lake, is 1,160 second-feet. The maximum must have been at least one-third greater. The observer estimated the maximum gage height on that date to be 4 feet, but this estimate is likely to be in error because the gage did not extend high enough to record this stage. It indicates, however, that a maximum crest discharge of 1,500 second-feet, or approximately 100 second-feet to the square mile of drainage area, is not improbable. As the discharge at Salmon Lake was considerably greater in the flood of September, 1910, the discharge of Grand Central River must also have exceeded that noted above. The minimum discharge recorded for one week, September 15 to 21, 1909, is 30 second-feet. The discharge for each day except the last day of this period was interpolated, but the mean is probably nearly the true average discharge for the week, because the supply gradually decreased as the water froze near the head of the stream.

Discharge measurements of Grand Central River below the forks, 1906 to 1910.

[Elevation, 680 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 1	0.95	63	July 8	0.73	56
July 11	1.40	180	July 15	.68	50
July 24	1.29	140	Aug. 14	1.10	123
July 24	1.22	129	Sept. 4	.90	71
July 26	1.10	101	Sept. 26	.57	33
Aug. 7	.89	66	1909.		
Aug. 17	.79	54	July 11[a]	1.10	125
1907.			July 18	.79	64
July 10	1.33	145	Aug. 4	.67	52
July 16	1.20	121	Aug. 8	.54	40
July 26	1.19	119	Sept. 4	.46	32
Aug. 5	1.02	85	1910.		
Aug. 13	.97	72	Sept. 4[a]	....	89
Sept. 5	1.06	89	Sept. 15[a]	....	106
			Sept. 20	....	65

[a] Measurements made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of Grand Central River below the forks for 1906 and 1908–1910.

[Drainage area, 14.6 square miles. Observers, J. E. Styers and Fred Walford, 1906, 1908; Letson and Chapman, 1909–10.]

Day.	1906								1908					
	June.		July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	......	0.95	63	0.90	67	1.10	100	......	115	0.85	72	1.25	146
2	......	......	.90	56	.90	67	1.05	91	......	105	.90	80	1.17	125
3	......	......	.95	63	.90	67	1.00	82	......	95	.90	80	1.10	108
4	......	......	1.05	80	.95	74	.95	74	......	85	1.00	99	1.01	90
5	......	......	......	190	......	74	.93	72	......	80	1.45	225	.90	71
6	......	......	......	140	.90	67	......	67	......	70	1.20	150	......	62
7	......	......	......	140	.98	79	......	63	......	60	1.10	123	......	55
8	......	......	......	1,160	.94	73	......	59	0.74	57	.96	91	......	50
9	......	......	......	760	.90	67	.80	55	.62	43	.90	80	......	48
10	......	......	1.70	300	......	65	......	54	.62	43	.90	80	......	46
11	......	......	1.45	198	......	66	.78	53	.80	65	......	80	.68	44
12	......	......	......	280	......	68	.75	50	1.03	106	1.40	210	......	44
13	......	......	1.45	198	......	65	.75	50	.75	58	1.30	180	......	44
14	......	......	1.42	187	......	62	.75	50	.70	52	1.10	123	......	44
15	......	......	......	168	......	59	.72	48	.68	50	1.00	99	.68	44
16	......	......	......	160	.81	56	.71	47	.65	46	1.10	123	......	43
17	......	......	1.40	180	.79	54	......	47	.65	46	1.00	99	......	42
18	......	......	1.10	100	......	54	......	54	.65	46	.95	90	......	41
19	......	......	1.05	91	......	53	......	180	.62	43	1.20	150	......	40
20	......	......	1.10	100	.78	53	......	420	.60	41	1.20	150	.64	40
21	......	......	1.10	100	......	65	......	510	.60	41	1.10	123	......	39
22	......	......	1.00	82	......	59	1.72	310	.55	36	1.00	99	......	38
23	......	......	1.28	143	......	210	......	200	.52	33	1.30	180	......	37
24	......	150	1.29	145	1.08	96	......	200	.52	33	1.35	195	......	36
25	......	140	1.18	118	1.02	86	......	170	.52	33	1.33	169	.59	35
26	......	120	1.10	100	......	140	......	110	.50	31	1.20	132	.57	33
27	......	110	......	100	......	210	......	130	.48	29	1.20	132	......	33
28	......	100	1.10	100	1.25	135	......	100	.48	29	1.00	88	......	33
29	......	90	1.00	82	1.25	135	......	90	.48	29	.90	71	......	33
30	......	75	1.00	82	1.15	111	......	80	1.30	180	.90	71	......	33
31	......	......	.90	67	1.12	104	......	......	1.25	165	1.30	160	......	......
Mean	......	112	......	185	......	85.2	......	121	......	62.7	......	123	......	52.6
Mean per square mile	......	7.67	......	12.7	......	5.84	......	8.29	......	4.29	......	8.42	......	3.60
Run-off, depth in inches on drainage area	......	2.00	......	14.64	......	6.73	......	9.25	......	4.95	......	9.71	......	4.02

Daily gage height, in feet, and discharge, in second-feet, of Grand Central River below the forks for 1906 and 1908–1910—Continued.

Day.	1909						1910 [a]							
	July.		August.		September.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		200	0.55	41	0.48	34				660		180		160
2		195	.58	44	.47	33				600		190		150
3		195	.68	55	.46	32				550		220		140
4		185	.76	65	.47	33				520		210		95
5		175	.71	58	.50	36				480		170		95
6		180	.60	46	.49	35				450		140		
7		170	.56	42	.49	35				380		160		
8		160	.54	40	.48	34				370		140		
9		145	1.05	122	.46	32				280		140		
10		134	.94	97	.45	31				260		120		
11	1.10	123	.79	70	.45	31				170		110		
12		116	.70	57	.44	30				210		110		
13		110	.74	63	.46	32				210		160		
14		88	.80	71	.46	32				240		170		
15		75	.75	64		32		140		260		240		
16		64	.70	57		31		110		260		310		
17	.78	62	.67	54		31		100		260		320		
18	.84	71		52		30		120		240		290		
19	.86	74		50		29		73		270		220		
20	.85	72		48		29		71		280		170		
21	.78	62		47	.41	28		270		340		150		
22	.76	60		45				290		380		120		
23	.72	60		43				310		390		120		
24	.69	51		42				360		390		120		
25	.68	50		40				340		350		96		
26	.67	49		40				340		340		100		
27	.66	48		36				390		310		110		
28	.68	50		36				530		270		100		
29	.62	43		38				590		210		98		
30	.60	41		42				720		220		94		
31	.56	37		39						190		99		
Mean		101		53.0		31.9		297		334		161		128
Mean per square mile		6.92		3.63		2.18		20.1		22.9		11.0		8.77
Run-off, depth in inches on drainage area		7.98		4.18		1.70		11.97		26.40		12.68		1.63

[a] Gage heights were not recorded in 1910. The discharges are estimated by taking 34 per cent of the computed inflow to Salmon Lake. This inflow is derived from the rise and fall of the lake and the outflow as recorded at the station on Kruzgamepa River at the outlet of Salmon Lake.

GRAND CENTRAL RIVER BELOW NUGGET CREEK.

Measurements were begun at this station in June, 1906, and records were kept during the greater part of that season in order to determine the amount of water flowing from Grand Central River into Salmon Lake. This station is below all important tributaries except Jett, Morning Call, and Rainbow creeks. Measurements were made by wading. The condition of the channel was excellent and the records taken are good. They may not represent the total flow of the river, however, for the valley is wide and the gravel bed is deep and must permit considerable seepage. The maximum discharge during the flood of July 8, 1906, is estimated at 1,500 second-feet. The minimum discharge for one week, September 11 to 17, 1906, was 100 second-feet. No records were kept after 1906, for the data are not of special value.

Discharge measurements of Grand Central River below Nugget Creek in 1906.

[Elevation, 460 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 24		313	Aug. 28	1.10	324
June 30	0.57	148	Sept. 9	.46	121
July 7	.98	286	Sept. 14	.36	101
Aug. 4	.46	123			

Daily gage height, in feet, and discharge, in second feet, of Grand Central River below Nugget Creek for 1906.

[Drainage area, 44 square miles, Observer, A. W. Peterson.]

Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.	Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.
1	0.50	132		120	0.80	220	21	0.60	157	0.55	144		980
2	.95	120		120	.75	204	22		130	.50	132		690
3		120		130	.65	172	23		210	1.50	535		380
4		120		140	.60	157	24		210	.80	220		380
5		250		140	.60	157	25		160	.70	187		320
6		190		130	.55	144	26	.50	132	1.05	310		200
7	1.00	290		140	.50	132	27		128	1.50	535		250
8		1,500		140	.50	132	28		124	1.10	330		200
9		1,000		135	.45	120	29		120	.95	272		200
10		750		130	.42	114	30		115	.90	255		190
11		600		130	.40	109	31		110	.80	220		
12		545	0.50	132	.40	109	Mean		311		183		243
13		450	.50	132	.38	105							
14		380	.50	132	.35	100							
15		350	.40	109	.35	100	Mean per square mile		7.07		4.16		5.52
16		290	.42	114	.30	90							
17		270	.45	120	.30	90							
18		250	.40	109	.40	109							
19		230	.35	100		350	Run-off depth in inches on drainage area		8.15		4.80		6.16
20		200	.50	132		800							

NOTE.—The discharge for days on which the gage height was not recorded, is estimated from the discharge of Kruzgamepa River at the outlet of Salmon Lake and of Grand Central River below the forks. The mean discharge for the period June 24–30 was 190 second-feet.

CRATER LAKE OUTLET.

Crater Lake lies in a depression at a glacial cirque, at an elevation of 973 feet. Its outlet is a short, swift stream which flows over a rough rocky bed having a grade of nearly 300 feet to the mile. Only one measuring section could be found that would give even fair results. Measurements were begun at this point on June 19, 1906, and a gage was established July 2. The channel is probably permanent, except during extreme high water. The conditions for measurements are poor, but fairly good results have been obtained. The lake, which covers 47 acres, is too small in proportion to the discharge to have any appreciable effect in regulating the flow of the stream. No good values for the maximum discharge are available, but it will probably exceed 150 second-feet. The lowest recorded discharge was 1.9 second-feet at the end of September, 1908, but comparisons with other records in this basin seem to indicate a lower stage in 1909.

Discharge measurements of Crater Lake outlet, 1906 to 1910.

[Elevation, 925 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
June 19	......	14.2	July 8	0.88	7.9
June 26	......	23.7	July 15	.88	6.1
July 1	......	13.6	Aug. 14	1.07	19.6
July 10	1.55	59.0	Sept. 4	.80	7.6
July 22	.96	12.0	Sept. 26	.43	1.87
July 24	1.10	21.0			
Aug. 6	.90	7.1	1909.		
Aug. 8	.98	13.0	June 28[a]	......	24.4
Aug. 16	.80	5.6	July 10[b]	1.04	20.7
Sept. 9	.73	4.3	July 17	.86	9.8
			Aug. 4	.54	2.3
1907.			Do	.56	2.7
July 8	1.32	36.0	Aug. 5	.72	5.4
July 16	1.18	21.0	Do	.92	12.4
July 26	1.13	16.7			
July 30	1.04	13.7	1910.		
Aug. 6	1.00	10.0	Aug. 16[a]	......	23.7
Aug. 13	.99	10.6	Sept. 4[b]	.97	13.3
Aug. 25	.95	8.0	Sept. 14[b]	......	10.5
Sept. 5	.93	7.5	Sept. 20	......	4.1

[a] Measurement made by C. H. Munro and W. H. Lanagan. [b] Measurement made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of Crater Lake outlet for 1906–1909.

[Drainage area, 1.8 square miles. Observers, J. E. Styers and Cornelius Edmunds, 1906-7; Walford, Letson, and Chapman, 1908-9.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	14	0.85	7	0.98	13	......	......	......	20	1.03	11.8
2	1.00	14	......	7	.94	10	......	......	......	20	1.10	16.0
3	1.00	14	......	8	.90	9	......	......	......	17	1.08	14.7
4	1.15	25	......	8	.82	6	......	......	......	17	1.15	19.7
5	1.65	69	......	9	.78	5	......	......	1.04	12.3	.93	7.4
6	......	......	.90	9	.78	5	......	......	1.03	11.8	.90	6.4
7	......	......	.95	11	.78	5	......	......	.95	8.0	.85	5.2
8	......	......	.96	12	.75	4.5	1.32	36	1.03	11.8	.83	4.8
9	......	......	......	10	.73	4.3	......	28	1.02	11.2	.80	4.2
10	1.55	59	.90	9	.71	4.1	1.27	31	1.02	11.2	1.05	12.8
11	1.25	33	.90	9	.69	3.9	......	36	1.03	11.8	1.90	106
12	1.45	50	1.00	14	.68	3.8	......	26	1.02	11.2	1.75	88
13	1.30	37	.95	11	.65	3.5	......	30	1.04	12.3	1.40	46
14	1.15	25	.90	9	.65	3.5	......	26	1.04	12.3	1.40	46
15	1.10	21	......	7	.61	3.1	......	22	1.01	10.7	1.35	40
16	1.15	25	.80	5.5	.61	3.1	1.18	22	1.41	47	1.00	10.2
17	1.10	21	.80	5.5	.61	3.1	......	20	1.40	46	.97	8.9
18	1.05	17	.79	5.5	.75	4.5	......	22	1.30	34	.95	8.0
19	1.00	14	.80	5.5	......	......	......	26	1.20	24	.94	7.7
20	1.00	14	.78	5	......	......	......	30	......	20	.92	7.0
21	1.05	17	1.01	15	......	......	......	40	......	19	.82	4.6
22	.96	12	1.01	15	1.40	[a]46	......	30	......	16	.75	3.5
23	1.06	18	1.22	31	......	......	......	24	......	13	.75	3.5
24	1.10	21	1.02	15	......	......	......	22	......	10	......	......
25	1.05	17	1.00	14	......	......	1.17	21	.95	8.0	......	......

[a] Not included in mean.

Daily gage height, in feet, and discharge, in second-feet, of Crater Lake outlet for 1906–1909—Continued.

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
26	1.02	15	1.10	21	......	......	1.13	18.2	1.36	41	......	......
27	1.00	14	1.12	23	......	......	......	18	1.37	42	......	......
28	......	12	1.10	21	......	......	......	15	1.35	40	......	......
29	.90	9	1.05	17	......	......	......	12	1.45	52	......	......
30	.88	8	1.00	14	......	......	1.04	12.3	1.35	40	......	......
31	.88	8	......	13	......	......	......	17	1.30	34	......	......
Mean		22.3	......	11.8	......	5.2	......	24.4	......	22.1	......	21.0
Mean per square mile		12.4	......	6.56	......	2.89	......	13.6	......	12.3	......	11.7
Run-off, depth in inches on drainage area		12.4	......	7.56	......	1.93	......	12.1	......	14.2	......	10.0

Day.	1908						1909					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	20	1.10	21	0.95	11.5	......	24	0.68	4.6	0.56	2.7
2	......	18	.90	9.0	.93	10.5	......	23	......	5.2	.52	2.4
3	......	16	1.05	18	.90	9.0	......	23	.80	7.5	......	2.3
4	......	14	1.10	21	.86	7.8	......	22	.76	6.5	.50	2.2
5	......	12	1.50	63	.75	5.0	......	22	.72	5.5	.57	2.8
6	......	11	1.20	30	......	4.5	......	22	.80	7.5	.58	3.0
7	......	10	1.00	14	......	4.0	......	22	......	5.7	.56	2.7
8	0.88	8.4	.95	11.5	......	3.5	......	21	.68	4.6	.54	2.5
9	.85	7.5	.95	11.5	......	3.0	......	21	.87	10.4	.52	2.4
10	.83	6.9	.90	9.0	......	3.0	1.04	20.9	......	10.2	.51	2.3
11	.90	9.0	......	9.0	.60	3.0	......	20.0	.86	10.0	.51	2.3
12	1.10	21	1.30	40	......	3.0	1.02	19.2	......	9.0	.50	2.2
13	1.00	14	1.15	26	......	2.9	......	17.0	.87	10.4	.51	2.3
14	.95	11.5	1.10	21	......	2.9	.91	12.2	......	10.6	.50	2.2
15	.90	9.0	1.00	14	.58	2.9	......	11.1	......	9.3	......	2.2
16	.86	7.8	1.00	14	......	2.8	.86	10.0	......	7.2	......	2.1
17	.88	8.4	.90	9.0	......	2.7	.86	10.0	......	6.8	......	2.0
18	.90	9.0	.90	9.0	......	2.6	.87	10.4	......	6.5	......	2.0
19	.89	8.7	1.10	21	......	2.5	.90	11.6	......	6.1	......	1.9
20	.85	7.5	1.00	14	.53	2.5	......	10.8	......	5.8	......	1.8
21	.85	7.5	1.00	14	......	2.4	.82	8.3	......	5.6	......	1.6
22	.85	7.5	.90	9.0	......	2.3	......	8.3	......	5.3	......	......
23	.80	6.0	1.10	21	......	2.2	......	8.2	......	5.0	......	......
24	.83	6.9	1.10	21	......	2.1	.75	6.2	......	4.7	......	......
25	.78	5.6	1.08	20	.47	2.1	......	5.6	......	4.5	......	......
26	.76	5.2	1.00	14	.43	1.9	.70	5.0	......	4.5	......	......
27	.75	5.0	1.00	14	......	1.9	......	5.0	......	3.5	......	......
28	.75	5.0	.90	9.0	......	1.9	.70	5.0	......	3.0	......	......
29	.78	5.6	.85	7.5	......	1.9	.72	5.5	......	3.0	......	......
30	1.20	30	.80	6.0	......	1.9	.70	5.0	......	3.5	......	......
31	1.50	63	1.00	14	......	......	......	4.2	......	3.0	......	......
Mean		12.2	......	17.2	......	3.7	......	13.5	......	6.29	......	2.28
Mean per square mile		6.78	......	9.56	......	2.06	......	7.50	......	3.49	......	1.27
Run-off, depth in inches on drainage area		7.82	......	11.0	......	2.30	......	8.65	......	4.02	......	.99

NORTH FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

North Fork rises in a great cirque carved out of the northeastern slope of Mount Osborn by the former glacier, and flows eastward and southward to its junction with West Fork to form the main river. The high precipitation which the steep, mountainous walls of its drainage area receive and the water derived from the melting snow banks and the glacier in the cirque, together with the flow of springs along the middle and lower course of the stream, operate to give North Fork a very large and well-maintained flow throughout the season. The run-off per square mile at this point is greater than that of any other stream in Seward Peninsula.

According to present plans, a lateral of the Wild Goose pipe will take water from this fork at an elevation of about 1,030 feet and conduct it along the right bank of the stream to a point near the forks, where it will cross the West Fork and discharge into Crater Lake. Measurements were begun in 1906 above the proposed pipe intake in order to show the amount of water available for this purpose, and a gage was installed in 1907, but on account of the torrential and shifting character of the stream the gage readings are not a true index of the discharge. For this reason the measurements have been used only in connection with a hydrograph and comparative data for estimating the discharge for 1906–7. In 1909 a gage was installed about half a mile below the proposed pipe intake, and a sufficient number of readings were made to afford an estimate of daily discharge.

The lowest mean discharge for a period of one week, as indicated by these records, is 10.7 second-feet, September 15 to 21, 1909. The values for all except the last day of this period are interpolated, but the mean is probably near the true discharge for the week on account of the gradual decrease in supply due to freezing near the head of the stream.

Discharge measurements of North Fork of Grand Central River at pipe intake in 1909 and 1910.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1909.	*Feet.*	*Sec.-ft.*	1910.	*Feet.*	*Sec.-ft*
July 11 [a]	....	36	Sept. 4 [a]	0 40	29
July 18	0.43	27	Sept. 15 [a]	....	30
Aug. 5	.20	14.3			
Aug. 8	.15	13.0			
Sept. 4	.12	11.6			

[a] Measurements made by R. G. Smith.

Daily discharge, in second-feet, of North Fork of Grand Central River at pipe intake for 1906 and 1907.

[Drainage area, 2.3 square miles.]

Day.	1906			1907			Day.	1906			1907		
	July.	Aug.	Sept.	July.	Aug.	Sept.		July.	Aug.	Sept.	July.	Aug.	Sept.
1	21	22	31	......	30	46	21	35	24	......	64	67	25
2	21	22	a 31	......	34	32	22	30	27	......	41	67	15
3	21	22	27	......	29	25	23	33	45	......	40	62	18
4	22	24	27	......	29	32	24	48	a 28	......	37	48	......
5	......	24	28	......	a 27	36	25	37	30	......	37	a 43	......
6	......	21	26	......	25	27	26	a 33	30	......	a 38	54	......
7	......	a 23	23	......	25	22	27	34	50	......	33	55	......
8	......	25	22	a 42	25	21	28	38	50	......	28	44	......
9	......	23	a 19	37	25	74	29	28	53	......	26	110	......
10	......	25	20	40	23	171	30	32	40	......	28	98	......
11	......	24	19	56	23	140	31	21	36	......	30	61	......
12	......	20	17	48	23	76	Mean	30.3	27.4	22.2	39.0	43.5	46.5
13	......	20	18	52	22	52	Mean per square mile	13.2	11.9	9.65	16.9	18.9	20.2
14	......	21	19	40	24	49							
15	......	21	18	33	20	47							
16	......	20	18	33	51	a 41	Run-off, depth in inches on drainage area	7.86	13.7	6.46	15.1	21.8	17.3
17	......	a 19	17	30	61	35							
18	......	20	19	34	52	32							
19	......	19	......	40	42	28							
20	31	20	......	48	51	26							

a Measurements. Other discharges are obtained by taking about the same percentage of the flow at the lower station as was found on the dates of measurements. This varied from 70 to 90 per cent. Gagings on June 20, 1906, gave 30 second-feet, and on June 26, 1906, 43 second-feet. The flow from July 5 to 19, 1906, probably exceeded 35 second-feet.

Daily gage height, in feet, and discharge, in second-feet, of North Fork of Grand Central River at pipe intake for 1909.

[Drainage area, 2.3 square miles. Observers, Letson and Chapman.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	60	......	13	......	12	21	0.32	20	......	17	......	9
2	......	58	0.20	14	......	12	22	......	19	......	17	......	......
3	......	56	......	24	0.13	12	23	......	18	......	16	......	......
4	......	54	.52	34	.12	12	24	......	15	......	16	......	......
5	......	53	.20	14	......	15	25	......	15	......	15	......	......
6	......	51	......	14	......	14	26	.20	14	......	14	......	......
7	......	50	.18	14	......	13	27	......	14	......	13	......	......
8	......	47	.15	15	.13	12	28	......	14	......	12	......	......
9	......	44	......	34	......	12	29	.25	16	......	12	......	......
10	......	40	.32	20	......	12	30	......	14	......	13	......	......
11	......	36	......	18	......	12	31	.12	12	......	12	......	......
12	......	33	.27	17	......	12	Mean		31.2	......	17.4	......	12.0
13	......	31	......	24	......	13	Mean per square mile		13.6	......	7.56	......	5.22
14	......	29	.33	20	.16	13							
15	......	27	......	19	......	12							
16	......	25	.31	19	......	12	Run-off, depth in inches on drainage area		15.68	......	8.72	......	4.08
17	......	24	......	18	......	11							
18	......	25	......	18	......	11							
19	0.43	27	......	18	......	10							
20	......	26	......	17	.06	10							

NORTH FORK OF GRAND CENTRAL RIVER NEAR DITCH INTAKE.

A proposed lateral to the Miocene ditch has its intake on the North Fork at an elevation of 860 feet. There was no good measuring section near the point of diversion, but in 1906 measurements were made and several gage readings were obtained by measuring from a reference point farther downstream at an elevation of about 750 feet.

The discharges obtained in this manner and those obtained by subtracting the combined flow of West Fork at the ditch intake and at Crater outlet from the flow of the river below the forks furnished the basis for estimates of daily discharges for part of that year. As there is no appreciable inflow between the proposed intake and the measuring section the records show the amount of water available for the Miocene ditch.

Daily gage height, in feet, and discharge, in second-feet, of North Fork of Grand Central River near ditch intake for 1906.

[Drainage area, 5.5 square miles.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	23	......	30	......	44	21	......	(45)	......	(32)	......	......
2	......	(23)	......	30	0.92	b 44	22	0.85	a 38	......	(36)	1.5	b c 120
3	......	(23)	......	30	......	38	23	......	42	......	(60)	......	......
4	......	(25)	......	32	......	38	24	......	61	0.85	b 37	......	......
5	......	......	......	32	......	40	25	.95	a 47	......	40	......	......
6	......	......	......	29	......	37	26	.90	b 42	......	(40)	......	......
7	......	......	0.81	b 32	......	33	27	......	45	......	(67)	......	......
8	......	......	......	33	......	31	28	......	50	......	67	......	......
9	......	......	......	31	.76	b 27	29	......	38	......	71	......	......
10	......	......	......	33	......	28	30	......	42	......	54	......	......
							31	......	28	......	48	......	......
11	1.10	a 67	......	32	......	27							
12	......	......	......	27	......	(26)	Mean	......	d 39.9	......	36.7	......	e 31.6
13	......	......	......	27	......	26							
14	......	......	......	28	......	27							
15	......	......	......	28	......	26	Mean per square mile	......	7.25	......	6.67	......	5.75
16	......	......	.76	a 27	......	25							
17	......	......	.74	b 25	......	25							
18	......	......	......	27	......	27							
19	......	......	......	25	......	......	Run-off, depth in inches on drainage area	......	4.58	......	7.69	......	3.85
20	......	40	......	27	......	......							

a Measurements.
b Estimates based on gage readings.
c Not included in mean.
d Mean for 17 days.
e Mean for 18 days.

NOTE.—These values were obtained by subtracting the sum of the discharges at the West Fork and Crater Lake station from the flow below the forks. For the days for which this method does not give consistent results the discharges are based on the West Fork flow and are in parentheses. From July 5 to 19 the flow did not fall below 40 second-feet. The flow on June 26 was 43 second-feet.

NORTH FORK OF GRAND CENTRAL RIVER AT THE FORKS.

This station was established July 8, 1907, to replace the one at the ditch intake, where the discharge is practically the same as at this point. Gage readings were obtained only during 1907, after which the station was discontinued in favor of the one below the forks. For 1908 and 1909 the discharge of North Fork at the forks may be obtained by subtracting the discharge of West Fork at the forks from that of the river below the forks. Measuring conditions are fairly good, but the channel shifts slightly at times. Several measurements have been made since regular measurements at this station were discontinued.

Discharge measurements of North Fork of Grand Central River at the forks, 1907 to 1910.

[Elevation, 690 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 8	1.31	65	July 15		25
July 16	1.19	41	Aug. 14		46
July 25	1.23	47	Sept. 4		24
July 26	1.20	45			
Aug. 5	1.11	34	1909.		
Aug. 13	1.07	28	July 18		31
Aug. 26	1.36	70	Aug. 8		15.4
Sept. 6	1.18	36			
Sept. 16	1.44	56	1910.		
			Sept. 4 [a]		39
1908.			Sept. 15 [a]		51
July 8		30	Sept. 20		28

[a] Measurement made by R. G. Smith.

Daily gage height, in feet, and discharge, in second-feet, of North Fork of Grand Central River at the forks for 1907.

[Drainage area, 6.9 square miles. Observer, Cornelius Edmonds.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.16	38	1.32	65
2			1.20	42	1.22	46
3			1.15	36	1.14	35
4			1.15	36	1.22	46
5			1.12	33	1.25	51
6			1.10	31	1.16	38
7			1.10	31	1.10	31
8	1.31	62	1.10	31	1.07	28
9		46	1.10	31	1.50	110
10	1.25	50	1.08	30	2.25	364
11		70	1.10	31	2.10	260
12		60	1.10	31	1.68	117
13		65	1.08	30	1.52	73
14		50	1.11	32	1.50	68
15		41	1.05	27	1.49	66
16	1.19	41	1.34	69	1.44	57
17		38	1.40	83	1.40	49
18		42	1.35	72	1.37	45
19		50	1.28	56	1.32	39
20		60	1.34	69	1.30	36

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
21		80	1.44	94	1.29	35
22		51	1.44	94	1.10	21
23		50	1.41	86	1.18	25
24		46	1.32	65		
25	1.22	46	1.30	60		
26	1.20	42	1.37	76		
27	1.19	41	1.38	78		
28	1.14	35	1.31	62		
29	1.11	32	1.74	187		
30	1.14	35	1.66	161		
31	1.16	38	1.42	88		
Mean		48.8		61.0		74.1
Mean per square mile		7.07		8.84		10.7
Run-off, depth in inches, on drainage area		6.31		10.19		9.15

NOTE.—Discharges for days during the period July 8–25, when gage was not read, were obtained by the aid of a hydrograph.

GOLD RUN NEAR MOUTH OF CANYON.

Gold Run enters Grand Central River from the east about 2 miles below the forks. It drains a high cirque which heads against the crest of the mountains that rise between North Fork and Fox Creek. Near the head of the cirque is a small lake having an area of 15 to 20 acres. This lake is formed by a natural dam whose upper part is composed of loose rocks and bowlders, through which the water from the lake flows out, appearing in the valley several hundred feet below. Below the lake the creek falls rapidly to a point near the mouth of a canyon and emerges on a large alluvial fan of coarse, loose material, into which the water sinks except during floods. The gaging station is located in a short, fairly smooth section of the creek near the mouth of the canyon just above the alluvial fan. Measurements were begun June 20, 1906, and the gage was established July 12. Occasional readings have been taken and discharges are estimated for 1906 and 1907. These estimates give a general idea of the volume of the stream. The individual measurements are good, for conditions at the section are better than the average for this class of streams.

No record was obtained during the low-water periods of 1908 and 1909, except the measurement of September 21, 1909. The discharge for one week during the open season has probably reached as low a stage as 8 second-feet.

Daily gage height, in feet, and discharge, in second-feet, of Gold Run near mouth of canyon for 1906.

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		14		18		30				24		22
2		[a] 13		18	0.95	[b] 26				24		25
3		13		18		23				22		25
4		20		20		20				22		30
5				24		17			1.24	[b] 22	1.22	[b] 20
6				30		16				19		16
7			1.03	[b] 34		15				16		14
8			.90	[b] 22		14	1.57	[a] 72		18		13
9			.89	[b] 21		13		60		18		13
10				20	.71	[a] 12		80		15		25
11		52		20		12		86		15		120
12	1.21	[a] 69		24		12		65		15		90
13		55		22		11		70		15		70
14		45		20		11		60	1.16	[a] 16		60
15		40		18		11		48		13		50
16		38	.81	[b] 17		10	1.40	[b] 42		50	1.38	[a] 26
17		42	.80	[b] 16.5		10		38		55		24
18		24		16		12		42		48		22
19		20		16				48		40		20
20		22		15				54		60		18
21		23		28				70		75		14
22	.84	[a] 18.5		34				45		75		11
23	1.00	[b] 30		50				40		70		10
24		30		34				35		60		
25	1.00	[a] 30	.99	[b] 29				32		56		
26	.93	[b] 24		44				32	1.58	[b] 74		
27		24		68				24		76		
28		21	1.13	[a] 51				20		60		
29		20		40			1.20	[b] 18		90		
30		19		36			1.25	[a] 23		70		
31		18		32				24		40		
Mean		29.0		27.6		15.3		47.0		41.1		32.1

[a] Measurements.
[b] Estimates based on gage heights. Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of the other streams in the vicinity. Gagings made on June 20, 1906, gave 22 second-feet and on June 25, 24 second-feet.

Discharge measurements of Gold Run near mouth of canyon, 1908–1910.

[Elevation, 800 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 8	1.18	12.3	Aug. 7	0.13	15.2
Aug. 15		30	Sept. 3	.11	[b] 14
Sept. 4		14.1	Sept. 21	—.12	5.4
1909.			1910.		
July 19	.24	21	Sept. 4 [a]		26
Aug. 4	.43	47	Sept. 19		9.1

[a] Measurement made by R. G. Smith. [b] Discharge was estimated from gage height.

THOMPSON CREEK NEAR DITCH INTAKE.

Thompson Creek enters Grand Central River from the west about 2 miles below the forks. It drains a small glacial cirque that is almost surrounded by steep, rocky walls, which reach elevations of 2,500 to 3,500 feet. Measurements were begun June 25, 1906, and a gage was established July 22. The gage is located near the trail crossing about half a mile above the mouth of the creek. Measurements were made fully one-fourth mile farther upstream, at an elevation of 720 feet, to show the amount of water available at the level of the Miocene ditch. The gage was read occasionally during 1906, 1907, and 1909 and daily during most of 1908. The records are rather unsatisfactory on account of poor conditions for measurement, slight shifts in channel, and the infrequency of gage readings, but they are sufficiently accurate to give a general idea of the behavior of the stream.

A minimum recorded discharge for one week—2.4 second-feet—occurred September 24–30, 1908.

Discharge measurements of Thompson Creek near ditch intake, 1906–1910.

[Elevation, 720 feet.]

Date.	Hydrographer.	Gage height.	Discharge.
1906.		*Feet.*	*Sec.-ft.*
June 25	Hoyt and Henshaw		42
July 2	.....do		11
12	J. C. Hoyt		52
24	F. F. Henshaw	1.42	25
25	.....do	1.41	23
Aug. 9	.....do	1.19	12.5
Sept. 10	.....do	1	6.2
1907.			
July 8	Henshaw and Richards	1.55	49
30	Raymond Richards	1.44	32
Aug. 14	.....do	1.34	20
Sept. 6	.....do	1.14	9.6
17	.....do	1.25	12.6
1908.			
July 8	F. F. Henshaw	.91	12.9
15	A. T. Barrows	.89	14.5
Aug. 15	.....do	.90	12.9
Sept. 4	.....do	.80	7.1
26	F. F. Henshaw	.49	2.4
1909.			
June 28	Munro and Lanagan		38
July 11	Smith and Lane	1.26	57
17	F. F. Henshaw	.86	15.4
17	.....do	.86	13.8
Sept. 1	.....do	.62	3.7
21	G. L. Parker	.53	2.2
1910.			
Sept. 19	.....do		5.5

Daily gage height, in feet, and discharge, in second-feet, of Thompson Creek near ditch intake for 1906–1909.

[Drainage area, 2.5 square miles. Observers, Walford and Letson, 1908–9.]

Day.	1906						1907					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		11		9		19				30		16
2		[a] 11		9		14				27		17
3		11		10		12				23		16
4		16		10		8				20		22
5				11		7				15		12
6				15		7			1.24	[b] 13	1.14	[a] 9.6
7			1.39	[b] 22.5		7				9		8
8			1.22	[b] 14		6	1.55	[a] 49		13		7
9			1.19	[a] 12.5	1	[b] 6.2		45		13		7
10				11	1	[a] 6.2	1.69	[b] 82		13		15
11		36		11		6		87		13		100
12		[a] 52		17		6		60		13		80
13		40		14		6		50	1.24	[b] 13		50
14		30		12		5		40	1.34	[a] 20		50
15		24		11		5		34		15		42
16		28	1.11	[b] 9.6		5	1.45	[b] 32		50		14
17		23	1.12	[b] 10		5		30		50	1.25	[a] 12.6
18		19		10		6		34		39		11
19		16		10				40		29		10
20		16		9				46		25		9
21		18		20				55		25		6
22	1.20	[b] 13		20				44		23		5
23		21		40				35		18	.99	[b] 5
24	1.42	[a] 25	1.40	[b] 23				30		13		
25	1.41	[a] 23		21			1.42	[b] 28	1.15	[b] 9		
26	1.29	[b] 17.5		28			1.47	[b] 35	1.47	[b] 35		
27		16		30				34		35		
28		14		28				31		35		
29		11	1.44	[b] 25.4				27		40		
30		11		22			1.44	[a] 32		34		
31		10		20				34		30		
Mean		20.5		16.6		7.6		42.2		23.9		22.8
Mean per square mile		8.20		6.64		3.04		16.9		9.55		9.12
Run-off, depth in inches on drainage area		7.62		7.66		2.10		15.1		11.0		7.80

[a] Measurements.

[b] Estimates based on gage heights. Other discharges were obtained by plotting a hydrograph passing through the known points and following the rise and fall of Crater Lake outlet, whose basin adjoins that of Thompson Creek and is of a similar character.

Daily gage height, in feet, and discharge, in second-feet, of Thompson Creek near ditch intake for 1906–1909—Continued.

Day.	1908						1909					
	July.		August.		September.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		32	1.00	18	0.98	17		36		5.5		4.0
2		29	.90	13	.85	11.0		36		7.6		3.7
3		26	.90	13	.85	11.0		36	0.78	9.9		3.6
4		24	1.00	18	.80	9.0		34	.86	14.5	0.60	3.5
5		21	1.20	35		7.0		32	.75	8.5		4.0
6		18	1.10	25		6.0		34		7.4		3.5
7		16	.90	13	.66	5.2		32	.70	6.2		3.2
8	0.91	14	.85	11.0	.66	5.2		30	.70	6.2	.56	2.8
9	.81	9.4	.80	9.0	.66	5.2		28		21		2.8
10	.81	9.4	.80	9.0	.65	5.0		27		16		2.8
11	.95	16		9.0	.65	5.0	1.30	57	.80	10.8		2.8
12	1.10	25	1.20	35		4.8		21		8.5		2.9
13	.90	13	1.05	22		4.6		15	.78	9.9	.57	3.0
14	.83	10.2	1.00	18		4.4	.72	7.1		13.0		3.0
15	.80	9.0	.90	13	.61	4.2		14		12.2		2.8
16	.82	9.8	.95	16		3.9		15		11.5		2.7
17	.82	9.8	.80	9.0		3.7	.88	15.8	.80	10.8		2.6
18	.85	11.0	.80	9.0		3.5	1.00	25		10.0		2.5
19	.85	11.0	1.20	35		3.3	.95	21		9.3		2.4
20	.80	9.0	1.00	18	.54	3.1	.88	15.8		8.5		2.3
21	.75	7.5	.90	13		2.9	.84	13.3		7.8	.53	2.3
22	.73	6.9	.80	9.0		2.8	.82	12.0		7.0		
23	.70	6.0	1.25	42		2.7	.81	11.4		6.2		
24	.70	6.0	1.30	50		2.6	.72	7.1		5.5		
25	.70	6.0	1.20	35	.50	2.5	.80	10.8		4.8		
26	.68	5.6	1.00	18	.48	2.3		10.0		4.0		
27	.70	6.0	.90	13		2.3		8.5		3.8		
28	.70	6.0	.80	9.0		2.3	.72	7.1		3.5		
29	.70	6.0	.80	9.0		2.3	.73	7.6		3.5		
30	1.30	50	.79	8.7		2.3		7.0		4.5		
31	1.25	42	1.10	25				6.2		4.2		
Mean		15.2		18.7		4.9		20.4		8.45		3.01
Mean per square mile		6.08		7.48		1.96		8.16		3.38		1.20
Run-off depth in inches on drainage area		7.01		8.62		2.19		9.41		3.90		.94

NUGGET, JETT, AND MORNING CALL CREEKS.

Nugget Creek rises north of the Nugget divide between the Grand Central River and Nome River drainage basins, and discharges its waters into Grand Central River about 2 miles above Salmon Lake. Its only tributary is Copper Creek. Jett and Morning Call creeks rise in the high ridge just north of Salmon Lake and flow northward, entering Grand Central River near its mouth. All three streams are torrential, and their continuous flow is maintained by rains that fall after the snow has melted. The basin of Nugget Creek faces the south and therefore does not retain the winter snows so long as the others, which face the north. Morning Call Creek flows for some distance over limestone, into which a large part of the flow sinks, to reappear as springs at an elevation of about 750 feet. The discharge of Nugget Creek is diverted by the Grand Central branch, and that of Jett and Nugget creeks by the Jett Creek branch of the Miocene ditch. Measurements were made primarily to determine the discharge of the creek at the points of diversion.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Grand Central River drainage basin:

Miscellaneous measurements in Grand Central River drainage basin from 1906 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per sq. mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
July 10, 1907	Spring	North Fork of Grand Central River.	Near proposed ditch intake.	850	3.8		
Sept. 5, 1907	do	do	do	850	7.5		
Sept. 4, 1909	do	do	do	850	4.6		
June 28, 1909	Thumit Creek	Grand Central River.	Near ditch intake	800	8.0	0.73	11.0
July 15, 1909	do	do	do	800	3.1	.73	4.25
June 18, 1906	Nugget Creek	do	Above Miocene intake	785	1.8	2.1	.86
June 19, 1906	do	do	do	785	1.6	2.1	.76
June 21, 1906	do	do	do	785	4.4	2.1	2.10
June 28, 1906	do	do	do	785	.96	2.1	.46
July 12, 1906	do	do	do	785	6.8	2.1	3.24
Aug. 11, 1906	do	do	do	785	3.0	2.1	1.43
Aug. 29, 1906	do	do	do	785	8.6	2.1	4.10
Sept. 2, 1906	do	do	do	785	6.8	2.1	3.24
Sept. 7, 1906	do	do	do	785	6.1	2.1	2.91
Sept. 14, 1906	do	do	do	785	4.4	2.1	2.10
June 19, 1906	do	do	Below Copper Creek	600	15.6	5.4	2.89
June 21, 1906	do	do	do	600	19.0	5.4	3.52
June 19, 1906	Copper Creek	Nugget Creek	Above Miocene intake	800	8.7	.85	10.2
July 21, 1906	do	do	do	800	2.8	.85	3.30
Aug. 31, 1906	do	do	do	800	6.6	.85	7.77
Sept. 10, 1906	do	do	do	800	2.4	.85	2.82
July 9, 1907	do	do	do	800	9.4	.85	11.1
June 18, 1906	do	do	Near mouth	700	3.8	1.2	3.17
June 19, 1906	do	do	do	700	6.9	1.2	5.75
June 21, 1906	do	do	do	700	11.6	1.2	9.62
July 12, 1906	do	do	do	700	11.3	1.2	9.47
June 20, 1906	Jett Creek	Grand Central River.	Near Miocene intake	700	14.9	1.5	9.93
July 2, 1906	do	do	do	700	4.4	1.5	2.93
July 12, 1906	do	do	do	700	14.3	1.5	9.53
July 21, 1906	do	do	do	800	5.8	1.4	4.14
Aug. 31, 1906	do	do	do	800	8.3	1.4	5.93
Sept. 10, 1906	do	do	do	800	4.2	1.4	3.00
June 24, 1906	do	do	½ mile above mouth	500	10.0	2.6	3.85
June 20, 1906	Morning Call Creek.	do	Above Miocene ditch level.	900	2.5	1.32	18.9
Aug. 9, 1906	do	do	do	900	.0	1.32	.0
June 20, 1906	do	do	Below springs	700	36	1.90	18.9
July 2, 1906	do	do	do	700	10.0	1.90	5.26
July 12, 1906	do	do	do	700	21	1.90	11.1
June 24, 1906	do	do	½ mile above mouth	500	27	3.9	6.92
June 22, 1906	Rainbow Creek	do	1 mile above mouth	600	3.4	1.81	1.88

KRUZGAMEPA RIVER DRAINAGE BASIN.

DESCRIPTION.

Kruzgamepa River, locally known as Pilgrim River, rises in Salmon Lake, at an elevation of 442 feet, and has a total length of about 45 miles. It flows northeastward and northward for about 18 miles to a point 8 miles southeast of Shelton, where it swings westward and crosses a flat lowland basin north of the Kigluaik Mountains, finding its outlet in Imuruk Basin. Grand Central and Kruzgamepa rivers really form but one stream, but they are known by different names, and as their physical features are somewhat variant they have been treated separately in this report.

The upper portion of Kruzgamepa River and Salmon Lake occupy a broad valley filled with gravel and other glacial débris to an unknown depth. The lake is of glacial origin and has an area of 1,860 acres at its present level. If raised to a level of 475 feet, it would cover 3,610 acres, and at 500 feet 4,620 acres. The glacier which formed it left a mass of morainic material at the lower end, through which the river has cut a narrow gap about 150 feet wide at the river level and 500 feet wide 30 feet higher.

Fox and Jasper creeks are the only important tributaries of Salmon Lake proper. About 4 miles below the lake, south of the mountains, Crater Creek enters the river from the northwest. This creek rises in glacial cirques and flows through a gravel-filled U-shaped valley with a heavy fall, especially near the head. Some of the mountains comprising the main ridge of this portion of the Kigluaik Mountains reach an elevation of nearly 4,000 feet. Crater Creek resembles Grand Central River in most of its characteristics, and its flow is approximately equal to that of Grand Central River below the forks. Grouse, Big, and Homestake creeks, which are much smaller than Crater Creek, also enter the main stream from the northwest. Slate, Iron, and Sherette creeks are the only important streams entering from the southeast.

North of the mountains the river follows a meandering course 2 or 3 miles north of morainic foothills which flank the slopes of the Kigluaik Range. This area of high elevation is drained by Pass, Smith, Grand Union, Osborn, and several unnamed creeks.

On the upper end of the river the ice usually breaks up about May 20. Lower down it remains frozen until a somewhat later date. The lake outlet does not freeze until December, but farther downstream ice forms overflows much earlier. Before spring these overflows work upstream almost to the lake and reach a depth of 15 feet or more in places.

Mining operations have been carried on along Iron, Slate, and Homestake creeks, but Iron Creek is the only stream which has produced any considerable amount of gold.

Salmon Lake provides an excellent storage reservoir for developing power and for mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically impossible, owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugger divide into the Nome River basin. By raising the water of the lake to an elevation of 500 feet the shortest tunnel line would be between 5 and 6 miles long, and if any allowance were made for drawing on the storage water could not be brought through to the Nome Valley at an elevation greater than about 450 feet. The mouth of the tunnel would be near Dorothy Creek, and the loss in grade between that point and Nome would bring the water so low that it could not be used to any extent for hydraulicking. Even if the water could be brought to the vicinity of Nome under a sufficient head for hydraulicking, the great cost and difficulty of building so long a tunnel would make the feasibility of the plan very doubtful. The possibility of using water from Salmon Lake for the development of power was investigated during 1905 and 1906, but for various reasons the project was not taken up. The general features and value of this power development are discussed on page 252.

Kruzgamepa River is one of the best power streams in Seward Peninsula on account of the availability of good dam sites. Aside from the site at Salmon Lake, there is one just below the mouth of Crater Creek and one below Iron Creek, but power has never been developed on account of the distance of transmission, the cost of installation, and the uncertainty of the market.

The following gaging stations have been maintained on Kruzgamepa River and its tributaries:

- Kruzgamepa River at outlet of Salmon Lake, 1906–1910.
- Kruzgamepa River above Iron Creek, 1908.
- Dome Creek below Hardluck Creek, part of 1907.
- Iron Creek below Canyon Creek, part of 1907.
- Iron Creek above the tunnel, 1908–9.
- Iron Creek at mouth, 1909.
- Iron Creek flume at intake, 1909.
- Pass Creek below the dam site, 1908–1910.
- Smith Creek below Swift Creek, parts of 1908–9.

KRUZGAMEPA RIVER AT OUTLET OF SALMON LAKE.

This station was established May 28, 1906, by J. P. Samuelson. A standard gage was installed June 23 and records have been kept during the greater part of each season since that date. It is located just below the outlet of Salmon Lake and the records show the total outflow available for storage and power development. Measuring conditions here are excellent. All low-water measurements were made by wading. High-water measurements were made by floats in 1906 and in the early part of 1907. On June 28, 1907, a cable was installed near the gage and was used for high-water measurements during the remainder of that year. The channel shifts slightly during extreme floods, but remained practically permanent from 1908 to 1910. As the flood records at this point are of especial value on account of the possibility of storage, an effort was made to begin the readings as early in the spring as possible. A little surface ice forms at the station during November, but the readings of the gage are not affected materially until about the middle of December. During the winter the river does not freeze to the bottom, as many other streams in this section do, so that when the water begins to run in the spring the ice is lifted and carried away, leaving the channel clear.

The maximum recorded discharge of 4,300 second-feet occurred during the flood of September, 1910, probably on the 8th. The lowest recorded discharge was 51 second-feet in December, 1909. The absolute minimum should occur about April 1 and is probably a little less than 40 second-feet in ordinary years.

Separate tables of gage heights and discharges are given for the station for the reason that the periods covered by records in 1908 to 1910 are too long to permit the data to be placed in a single table.

The fact that storage is available in Salmon Lake makes the determination of the total yearly run-off at this station desirable. The discharge for missing periods of each year has been estimated and a summary of monthly discharge, including totals in acre-feet, follows the tables showing daily gage height and discharge. In order to show the natural discharge of the drainage area the quantity of water diverted over the Nugget divide into the Nome River basin has been added to the monthly discharge determined from the records at the station. A table is also included to indicate the available storage in Salmon Lake in acre-feet for each foot of rise in the lake surface between elevations 442 and 501 feet.

Discharge measurements of Kruzgamepa River at outlet of Salmon Lake from 1906 to 1910.

[Elevation, 442 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1906.	*Feet.*	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*
May 28 [a]	5.45	3,450	June 28	1.78	991
May 29 [a]	5.00	3,140	July 2	1.56	751
May 31 [a]	3.60	2,350	July 4	1.30	567
June 1 [a]	3.05	1,910	July 14	1.37	616
June 23	1.22	425	Aug. 2	.65	304
June 29	1.00	353	Aug. 14	.39	232
June 30	.93	315	Aug. 23	.89	438
July 9 [b]	3.18	2,340	Sept. 6	.68	330
Do	3.02	2,090	Sept. 11	2.52	1,520
July 10 [b]	2.68	1,760	Sept. 12	2.19	1,310
Aug. 4	.38	212	Sept 20	.76	358
Aug. 15	.37	209			
Aug. 25	.70	312	1908.		
Aug. 26	.80	371	July 16	.30	148
Aug. 28	1.02	458	Sept. 5	.50	220
Sept. 1	.85	373	Sept. 27	.04	110
Sept. 7	.52	248	Oct. 2	.00	89
Sept. 17	.27	175	Oct. 3	.00	89
Sept. 21 [b]	2.38	1,550			
Sept. 23 [b]	2.06	1,120	1909. [c]		
Sept. 24 [b]	1.80	925	July 19	1.52	237
			Sept. 1	1.09	124
1907.			Sept. 5	1.07	117
June 16 [b]	2.97	2,050			
June 17 [b]	2.56	1,640	1910.		
June 28	1.88	1,020	Sept. 23	1.92	1,050

[a] Float measurements by J. P. Samuelson.
[b] Partial float measurements.
[c] During October to December, 1908, and throughout 1909 the datum of the gage was 1.0 foot lower than at other periods.

Daily gage height, in feet, of Kruzgamepa River at outlet of Salmon Lake for 1906–1910.

[Observers, J. P. Samuelson and M. Donworth, 1906-7; J. Jacobsen, 1908, 1910; J. Jacobsen and A. W. Peterson, 1909.]

Day.	May.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Oct.
1906.						1907.					
1		3.05	0.82	0.48	0.86	1		1.70	0.69	1.14	0.30
2		3.75	.72	.42	.81	2		1.58	.65	1.00	.23
3		3.90	.70	.38	.74	3		1.44	.62	.90	.21
4		4.20	.70	.36	.69	4		1.28	.61	.82	.20
5		3.75	.80	.38	.65	5		1.20	.60	.77	.19
6		3.20	1.10	.38	.60	6		1.20	.55	.73	
7		2.45	1.10	.40	.53	7		a1.50	.48	.62	
8			1.92	.40	.49	8		a1.45	.45	.58	
9			3.05	.40	.46	9		a1.40	.45	.71	
10			2.60	.36	.41	10		a1.35	.44	1.25	
11			2.20	.35	.39	11		a1.30	.44	2.50	
12			1.95	.35	.37	12		a1.25	.42	2.26	
13			1.85	.36	.34	13		a1.30	.40	1.98	
14			1.55	.34	.31	14		1.35	.40	1.59	
15			1.45	.36	.30	15	3.30	1.26	.38	1.40	
16			1.25	.35	.28	16	2.99	1.15	.40	1.26	
17			1.12	.32	.26	17	2.47	1.10	.69	1.10	
18			1.08	.30	.27	18	2.72	1.02	.94	.98	
19			.98	.26	.52	19	3.02	1.00	.97	.86	
20			.90	.32	1.34	20	2.80	1.00	.90	.74	
21			.82	.39	2.35	21	2.32	1.18	.88	.72	
22			.85	.42	2.40	22	2.08	1.18	.90	.62	
23		1.20	.82	.66	2.11	23	2.00	1.12	.89	.54	
24		1.25	.85	.71	1.78	24	2.08	1.08	.82	.54	
25		1.20	.82	.70	1.58	25	2.22	1.05	.78	.50	
26		1.12	.80	.76	1.38	26	2.30	1.02	.80	.48	
27		1.10	.72	.90	1.22	27	2.28	.98	.88	.46	
28	5.45	1.05	.70	1.02	1.08	28	2.12	.80	.84	.42	
29	5.00	1.02	.62	1.05	.98	29	1.95	.72	.86	.38	
30	4.05	.92	.55	.99	.88	30	1.78	.62	1.18	.34	
31	3.60		.50	.94		31		.60	1.20		

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.								1908.							
1		0.95	0.75	0.50	b1.03	0.86		16		0.30	0.80	0.30	0.90	0.86	
2		.90	.70	.50	.97	.86		17		.30	.75	.30	.89	.86	
3		.85	.60	.50	1.00	.85	0.84	18		.30	.65	.30	.88	.86	
4		.75	.60	.50	1.02	.85		19		.25	.65	.30	.88	.85	
5		.70	1.05	.50	1.06	.85		20		.20	.65	.25	.88	.85	
6		.60	1.15	.45	1.00	.84		21	1.30	.25	.60	.25	.88	.85	
7		.55	1.00	.40	.98	.84		22	1.15	.20	.60	.25	.88		
8		.50	.90	.40	.96	.84	.84	23	1.15	.20	.60	.20	.88		
9		.45	.75	.40	.96	.84		24	1.15	.20	.65	.10	.87	.85	
10		.40	.65	.35	.95	.84		25	1.10	.15	.70	.05	.88		
11		.40	.65	.30	.94	.84		26	1.15	.15	.70	.00	.88		
12		.45	.80	.30	.92	.84		27	1.10	.10	.65	.05	.88		
13		.40	.85	.30	.91	.85	.84	28	1.15	.00	.60	.04	.89	.85	
14		.40	.85	.30	.88	.85		29	1.05	.00	.60	.03	.90		
15		.35	.85	.30	.90	.85		30	1.00	.10	.55	.03	.89		
								31		.55	.50		.88		

a Estimated on a basis of rainfall. b Datum lowered 1 foot.

Daily gage height, in feet, of Kruzgamepa River at outlet of Salmon Lake for 1906–1910—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.								
1	......	......	2.44	1.11	1.09	0.90	0.80	......
2	......	......	2.41	1.10	1.06	.90	.78	0.66
3	......	2.90	2.40	1.06	1.05	.88	.77	......
4	......	2.81	2.34	1.12	1.04	.87	.76	......
5	......	2.84	2.28	1.14	1.07	.86	.75	......
6	......	2.80	2.30	1.16	1.07	.85	.75	......
7	......	2.88	2.26	1.11	1.06	.84	.74	......
8	......	2.82	2.19	1.04	1.05	.84	.74	......
9	......	2.78	2.12	1.08	1.03	.85	.73	......
10	......	......	2.09	1.34	1.03	.76	.74	.65
11	......	......	2.00	1.32	1.03	.75	.74	......
12	......	......	1.96	1.30	1.03	.75	.75	......
13	......	......	1.90	1.30	1.03	.75	.75	......
14	......	2.83	1.80	1.29	1.03	.74	.74	......
15	......	2.81	1.69	1.30	1.01	.75	.73	......
16	......	2.82	1.62	1.22	1.01	.75	.73	......
17	......	2.83	1.57	1.23	.98	.70	.72	.65
18	......	2.88	1.51	1.25	.95	.72	.72	......
19	......	2.84	1.48	1.24	.94	.70	.72	......
20	......	2.82	1.48	1.25	.95	.70	.72	......
21	......	2.75	1.39	1.23	.98	.70	.70	......
22	......	2.70	1.35	1.21	1.00	.68	.70	......
23	......	2.69	1.28	1.18	1.04	.66	.69	......
24	......	2.75	1.25	1.16	1.00	.68	.69	
25	3.50	2.62	1.26	1.14	.99	.75	.68	......
26	......	2.40	1.25	1.13	.97	.80	.68	......
27	......	2.30	1.25	1.08	.96	.85	.68	......
28	......	2.30	1.21	1.08	.95	.90	......	......
29	......	2.58	1.15	1.11	.93	.90	......	......
30	......	2.50	1.11	1.16	.92	.85	......	......
31	......	......	1.10	1.12	......	.80	......	......

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1910.								1910.							
1	......	1.65	2.88	1.34	0.85	1.01	0.10	16	......	1.00	1.54	1.44	......	0.22	......
2	......	1.70	2.82	1.30	.94	.88	.10	17	......	.90	1.56	1.61	......	.20	......
3	......	1.75	2.72	1.34	.98	.81	.09	18	......	.88	1.54	1.66	......	.20	......
4	......	1.75	2.62	1.34	.90	.74	.09	19	......	.76	1.58	1.56	......	.19	......
5	......	1.70	2.51	1.26	.86	.64	.08	20	......	.67	1.62	1.40	......	.18	......
6	......	1.72	2.40	1.16	.88	.57	.07	21	......	1.04	1.75	1.26	......	.17	......
7	......	1.78	2.24	1.13	2.50	.52	......	22	......	1.32	1.90	1.12	......	.15	......
8	......	1.82	2.14	1.08	5.00	.48	......	23	......	1.52	2.00	1.02	1.73	.14	......
9	......	1.69	1.94	1.04	......	.44	......	24	......	1.74	2.04	.95	2.40	.14	......
10	......	1.66	1.80	.96	......	.41	......	25	1.45	1.82	2.00	.86	......	.13	......
11	......	1.52	1.54	.89	......	.37	......	26	1.35	1.87	1.97	.81	......	.13	......
12	......	1.40	1.46	.85	......	.34	......	27	1.45	1.98	1.89	.80	1.88	.12	......
13	......	1.24	1.42	.92	......	.31	......	28	1.55	2.26	1.78	.77	1.63	.12	......
14	......	1.16	1.44	1.00	......	.28	......	29	1.65	2.50	1.61	.74	1.46	.12	......
15	......	1.10	1.50	1.18	......	.24	......	30	1.65	2.82	1.52	.71	1.22	.11	......
								31	1.55	......	1.42	.70	......	.11	......

Daily discharge, in second-feet, of Kruzgamepa River at outlet of Salmon Lake for 1906–1910.

[Drainage area, 84 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1906.						1906.					
1	....	1,920	272	239	387	16	....	817	582	200	180
2	....	2,760	241	221	364	17	....	761	511	197	175
3	....	2,950	235	209	336	18	....	705	490	185	178
4	....	3,360	235	203	316	19	....	649	441	175	252
5	....	2,760	265	209	300	20	....	593	405	191	634
6	....	2,080	380	209	280	21	....	537	369	212	1,410
7	....	1,320	380	215	256	22	....	481	382	221	1,460
8	....	1,260	1,030	215	242	23	....	425	369	304	1,200
9	....	1,210	2,130	215	233	24	....	448	382	324	930
10	....	1,150	1,640	203	218	25	....	425	369	320	787
11	....	1,100	1,280	200	212	26	....	389	360	344	658
12	....	1,040	1,060	200	206	27	....	380	328	405	566
13	....	985	985	203	197	28	3,450	360	320	460	490
14	....	929	768	197	188	29	3,140	348	288	475	441
15	....	873	702	202	185	30	2,580	308	262	446	396
						31	2,350	....	245	423	....

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1907.						1907.					
1	....	875	326	522	205	16	2,040	528	235	588	....
2	....	791	312	450	188	17	1,530	500	326	500	....
3	....	696	302	405	182	18	1,770	460	423	441	....
4	....	599	298	373	180	19	2,070	450	436	389	....
5	....	555	295	354	178	20	1,850	450	405	344	....
6	....	555	280	340	....	21	1,390	544	397	337	....
7	....	735	259	302	....	22	1,180	544	405	302	....
8	....	702	250	289	....	23	1,110	511	401	277	....
9	....	670	250	334	....	24	1,180	490	373	277	....
10	....	640	247	582	....	25	1,300	475	358	265	....
11	....	610	247	1,560	....	26	1,370	460	365	259	....
12	....	582	241	1,330	....	27	1,350	441	397	253	....
13	....	610	235	1,090	....	28	1,210	365	381	241	....
14	....	640	235	798	....	29	1,070	337	389	229	....
15	2,360	588	229	670	....	30	935	302	544	217	....
						31	....	295	555	....	....

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1908.								1908.							
1	......	375	295	210	97	70	67	16	......	156	315	156	76	70	......
2	......	355	275	210	87	70	67	17	......	156	295	156	74	70	......
3	......	335	242	210	92	68	67	18	......	156	258	156	73	70	......
4	......	295	242	210	96	68	67	19	......	144	258	156	73	68	......
5	......	275	418	210	103	68	67	20	......	132	258	144	73	68	......
6	......	242	465	196	92	67	67	21	550	144	242	144	73	68	......
7	......	226	395	182	89	67	67	22	465	132	242	144	73	68	......
8	......	210	355	182	86	67	67	23	465	132	242	132	73	68	......
9	......	196	295	182	86	67	67	24	465	132	258	110	72	68	......
10	......	182	258	169	84	67	67	25	440	121	275	101	73	68	......
11	......	182	258	156	82	67	67	26	465	121	275	92	73	68	......
12	......	196	315	156	79	67	67	27	440	110	258	101	73	68	......
13	......	182	335	156	78	68	67	28	465	92	242	99	74	68	......
14	......	182	335	156	73	68	......	29	418	92	242	97	76	68	......
15	......	169	335	156	76	68	......	30	395	110	226	97	74	68	......
								31	......	226	210	......	73	......	......

Daily discharge, in second-feet, of Kruzgamepa River at outlet of Salmon Lake for 1906–1910—Continued.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1909.								
1	....	1,000	674	127	123	87	71	53
2	....	980	656	125	117	87	68	52
3	....	980	650	117	115	84	67	52
4	....	917	614	130	113	82	65	52
5	....	938	579	134	119	81	64	52
6	....	910	590	139	119	79	64	52
7	....	966	568	127	117	77	63	51
8	....	924	530	113	115	77	63	51
9	....	896	491	121	111	79	61	51
10	....	903	475	184	111	65	63	51
11	....	910	430	179	111	64	63	51
12	....	917	412	173	111	64	64	51
13	....	924	385	173	111	64	64	51
14	....	931	340	170	111	63	63	51
15	....	917	296	173	107	64	61	51
16	....	924	272	153	107	64	61	51
17	....	931	255	156	101	57	60	51
18	....	966	235	160	96	60	60	....
19	....	938	226	158	94	57	60	....
20	100	924	226	160	96	57	60	....
21	300	875	198	156	101	57	57	....
22	500	840	187	150	105	55	57	....
23	700	833	168	143	113	52	56	....
24	900	875	160	139	105	55	56	....
25	1,100	784	163	134	103	64	55	....
26	1,100	650	160	132	100	71	55	....
27	1,100	590	160	121	98	79	55	....
28	1,100	590	150	121	96	87	54	....
29	1,000	758	136	127	92	87	54	....
30	1,000	710	127	139	91	79	53	....
31	1,000	....	125	130	....	71	....	....

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1910.								1910.							
1	......	600	1,880	614	362	435	125	16	60	430	734	674	395	153	......
2	......	630	1,820	590	403	376	125	17	150	385	746	777	340	148	......
3	......	740	1,720	614	421	344	123	18	150	376	734	812	300	148	......
4	......	740	1,620	614	385	316	123	19	150	324	758	746	260	146	......
5	......	a 800	1,520	568	367	279	121	20	210	292	784	650	225	143	......
6	......	854	1,420	513	376	255	119	21	210	450	875	568	250	141	......
7	......	896	1,280	496	1,510	239	......	22	210	602	980	491	300	136	......
8	......	924	1,190	470	4,300	226	......	23	290	722	1,060	440	861	134	......
9	......	833	1,010	450	3,300	213	......	24	370	868	1,100	408	1,420	134	......
10	......	812	910	412	2,400	204	......	25	450	924	1,060	367	2,000	132	......
11	......	722	734	380	1,700	193	......	26	410	959	1,040	344	1,400	132	......
12	......	650	686	362	1,200	184	......	27	450	1,040	973	340	966	130	......
13	......	557	662	394	800	176	......	28	520	1,290	896	328	791	130	......
14	a 40	513	674	430	600	168	......	29	560	1,510	777	316	686	130	......
15	40	480	710	524	450	158	......	30	560	1,820	722	304	546	127	......
								31	480	......	662	300	......	127	......

a Discharge was affected by ice, and the values are estimated.

Monthly discharge of Kruzgamepa River at outlet of Salmon Lake, 1906 to 1910.

[Drainage area, 84 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
1906.						
January			80	0.95	1.10	4,920
February			60	.71	.74	3,330
March			50	.60	.69	3,070
April			50	.60	.67	2,980
May	3,450	a 50	888	10.6	12.19	54,600
June	3,360	308	1,110	13.2	14.73	66,000
July	2,130	235	575	6.85	7.90	35,400
August	475	175	266	3.17	3.66	16,400
September	1,460	175	466	5.55	6.19	27,700
October	390		210	2.50	2.88	12,900
November			110	1.31	1.46	6,540
December			90	1.07	1.23	5,530
The year	3,450		330	3.92	53.44	239,000
1907.						
January			70	.83	.96	4,300
February			60	.71	.74	3,330
March			50	.60	.69	3,070
April			40	.48	.54	2,380
May	a 2,500	a 40	507	6.04	6.96	31,200
June	a 2,600	935	1,870	22.3	24.88	111,000
July	875	295	555	6.61	7.62	34,100
August	555	229	347	4.13	4.76	21,300
September	1,560	217	489	5.82	6.49	29,100
October	205		150	1.79	2.06	9,220
November			90	1.07	1.19	5,360
December			70	.83	.96	4,300
The year	2,600		358	4.27	57.85	259,000
1908.						
January			60	.71	.82	3,690
February			50	.60	.65	2,880
March			50	.60	.69	3,070
April			40	.48	.54	2,380
May	a 1,100	a 40	413	4.92	5.67	25,400
June	a 1,100	395	732	8.71	9.72	43,600
July	375	92	188	2.24	2.58	11,600
August	465	210	299	3.56	4.10	18,400
September	210	92	161	1.92	2.14	9,580
October	103	72	80.0	.95	1.10	4,920
November	70	67	68.1	.81	.90	4,050
December	67		65	.77	.89	4,000
The year	1,100		184	2.19	29.80	134,000
1909.						
January			60	.71	.82	3,690
February			50	.60	.62	2,780
March			40	.48	.55	2,460
April			40	.48	.54	2,380
May	1,100	40	348	4.14	4.77	21,400
June	1,000	590	874	10.4	11.60	52,000
July	674	125	349	4.15	4.78	21,500
August	184	113	149	1.77	2.04	9,160
September	123	91	108	1.29	1.44	6,430
October	87	52	70.0	.83	.96	4,300
November	71	53	60.6	.72	.80	3,610
December	53		50	.60	.69	3,070
The year	1,100		183	2.18	29.61	133,000
1910.						
January			50	.60	.69	3,070
February			45	.54	.56	2,500
March			40	.48	.55	2,460
April			40	.48	.54	2,380
May	560	a 40	188	2.24	2.58	11,600
June	1,820	292	758	9.02	10.06	45,100
July	1,880	662	1,020	12.1	14.00	62,700
August	812	300	493	5.87	6.77	30,300
September	4,300	a 225	977	11.6	12.97	58,100
October	435	127	192	2.29	2.64	11,800
November	125	a 65	91	1.08	1.20	5,410
December			60	.71	.82	3,690
The year	4,300		330	3.92	53.38	239,000

a Estimated.

Storage available at Salmon Lake for each foot of rise between elevations 442 and 501 feet.

Elevation.	Storage.	Elevation.	Storage.	Elevation.	Storage.	Elevation.	Storage.
Feet.	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*
442	0	457	32,900	472	86,500	487	134,000
443	1,860	458	35,500	473	89,900	488	138,000
444	3,780	459	38,200	474	93,300	489	142,000
445	5,720	460	40,900	475	96,800	490	146,000
446	7,750	461	43,700	476	100,000	491	150,000
447	9,800	462	46,500	477	104,000	492	154,000
448	11,900	463	49,400	478	108,000	493	159,000
449	14,000	464	52,300	479	101,000	494	163,000
450	16,200	465	55,300	480	105,000	495	167,000
451	18,400	466	58,300	481	109,000	496	172,000
452	20,700	467	61,400	482	114,000	497	176,000
453	23,000	468	64,500	483	118,000	498	181,000
454	25,400	469	67,700	484	122,000	499	185,000
455	27,800	470	70,900	485	126,000	500	190,000
456	30,300	471	83,200	486	130,000	501	194,000

KRUZGAMEPA RIVER ABOVE IRON CREEK.

This station was established June 22, 1908, to obtain data on the flow of lower Kruzgamepa River and especially the flow past the lower end of the Iron Creek tunnel. It is half a mile above the mouth of Iron Creek and below all tributaries entering the river from the south side of the Kigluaik Mountains. No water is diverted out of the drainage basin except a small amount from the Nugget divide. The gage was located near the junction of two channels, which were measured separately by wading; the channel below the gage shifted during moderately high water, so that the records are only fairly reliable. The minimum recorded discharge for one week was 181 second-feet August 23–29, 1908. The discharge for the corresponding period at Salmon Lake was 114 second-feet.

Discharge measurements of Kruzgamepa River above Iron Creek in 1908.

[Elevation, 248 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 22	1.65	592	July 17	1.00	230
June 23	1.60	597	Aug. 23	1.80	446
July 1	1.51	512	Sept. 28	1.20	194
July 8	1.10	322	Sept. 30	1.13	160

Daily gage height, in feet, and discharge, in second-feet, of Kruzgamepa River above Iron Creek for 1908.

[Drainage area, 153 square miles. Observer, A. C. Stewart.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.53	536	1.91	681	1.82	456
2			1.42	476	1.73	576	1.76	425
3			1.36	445	1.71	566	1.76	425
4			1.26	395	2.00	735	1.73	410
5			1.21	370	2.12	808	1.68	385
6			1.14	338	1.96	533	1.64	365
7			1.11	324	1.82	456	1.60	345
8			1.10	320	1.81	450	1.60	348
9			1.06	304	1.76	425	1.58	336
10			1.01	284	1.66	375	1.52	309
11			1.02	288	1.71	400	1.49	296
12			1.12	278	1.85	472	1.41	264
13			1.08	262	2.01	560	1.41	264
14			1.03	242	1.91	506	1.41	264
15			1.00	230	1.85	472	1.46	284
16			.99	226	1.80	445	1.50	300
17			.98	223	1.76	425	1.51	304
18			.97	220	1.72	405	1.40	260
19			.96	216	1.71	400	1.40	260
20			.97	220	1.74	415	1.34	236
21			.96	216	1.70	395	1.38	252
22	1.65	602	.93	206	1.68	385	1.36	244
23	1.62	586	.92	202	1.75	420	1.32	228
24	1.64	597	.90	195	1.96	533	1.32	228
25	1.76	663	.87	186	1.90	500	1.28	214
26	1.71	636	.84	177	1.86	478	1.31	224
27	1.78	674	.82	171	1.82	456		207
28	1.74	652	.82	171	1.76	425	1.20	190
29	1.67	614	.80	165	1.74	415	1.16	178
30	1.59	570	1.27	342	1.68	385	1.13	169
31			2.12	808	1.71	400		
Mean		622		291		481		289
Mean per square mile		4.15		1.94		3.21		1.93
Run-off, depth in inches, on drainage area		1.39		2.24		3.70		2.15

IRON CREEK DRAINAGE BASIN.

DESCRIPTION.

Iron Creek is the largest tributary of Kruzgamepa River in point of drainage area and is the most important from a miner's standpoint. It rises near the head of Willow Creek, a tributary of the Casadepaga, and flows in a general northward direction for about 20 miles, entering the Kruzgamepa about 12 miles below Salmon Lake. Its basin joins that of Eldorado River on the west and that of American Creek on the east. It drains an area of 52 square miles, composed largely of limestone and schist hills which reach a maximum elevation of about 2,300 feet. The elevation at the mouth of Eldorado Creek is about 630 feet; at the mouth of Canyon Creek, 450 feet; and at its junction with the Kruzgamepa, 248 feet. The naming of the main stream is peculiar in that the upper, middle, and lower sections bear different titles. The upper portion, above the mouth of Eldorado Creek, is known as Telegram Creek. Below Eldorado and above Left Fork—a small tributary from the east flowing from the sides of Iron Mountain—the stream is designated Dome Creek, and the remainder of the course constitutes Iron Creek proper. Hardluck Creek is a small tributary of Dome Creek from the east. The principal tributaries of Iron Creek are Discovery and Canyon creeks from the west. Below Canyon Creek are Pajaro, Rabbit, Sidney, Benson, Bobs, Easy, Bertha, and Stella creeks, which are small but which produce more or less gold.

Several ditches have been built to divert the flow of Iron Creek. The Gold Beach Development Co. constructed two in 1906. One has intakes on Eldorado and Discovery creeks and extends to Discovery claim, just below the mouth of Discovery Creek. The other has its intake on Canyon Creek and delivers water into the same penstock as the first. The water diverted in this manner was used to a small extent for mining in the bed of Iron Creek in 1906–7. Two other ditches were begun but never completed. One of these had its intake at the head of Dome Creek. The other project proposed to divert water from Rock and Slate creeks, tributaries of Kruzgamepa River, over Matthews Gap at the head of Barney Creek.

The Golden Gate Mining Co. constructed a ditch and flume line from a point about a mile below the mouth of Canyon Creek to Easy Creek, but it has fallen into disuse. A small ditch diverts the flow of a spring on the south side of Iron Mountain to Easy Creek.

DOME CREEK BELOW HARDLUCK CREEK.

Since 1900 Dome Creek, the middle portion of Iron Creek, has been the scene of small-scale mining operations resulting in a considerable production of gold. A ditch was started at the head of the creek in 1906 by the Gold Beach Development Co., but was never completed.

Records were begun below Hardluck Creek August 1, 1907, but were discontinued because the gage was washed out on August 18. A temporary gage was installed later and two measurements were referred to it. The data are only approximate, as no low-water measurements were obtained.

Daily gage height, in feet, and discharge, in second-feet, of Dome Creek below Hardluck Creek for 1907.

[Drainage area, 12.3 square miles; observer, A. H. Moore.]

Date.	August.		Date.	August.	
	Gage height.	Discharge.		Gage height.	Discharge.
1	0.40	25	11	0.20	12
2	.39	24	12	.22	13
3	.38	23	13	.26	15
4	.37	22	14	.26	15
5	.34	20	15	.28	16
6	.31	18	16	.55	54
7	.30	17	17	.70	101
8	.27	15			
9	.24	14	Mean		24.5
10	.22	13	Mean per square mile		1.22
			Run-off, depth in inches on drainage area		.77

IRON CREEK BELOW CANYON CREEK.

A gaging station was established August 1, 1907, on Iron Creek below the mouth of Canyon Creek, and records were obtained during the same period as those on Dome Creek. The records, though somewhat uncertain, are of value as indicating the amount of low-water flow in 1907. The discharge at this point is about the same as at the station above the tunnel.

Daily gage height, in feet, and discharge, in second-feet, of Iron Creek below Canyon Creek for August, 1907.

[Drainage area, 38 square miles.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1	2.10	52	11	1.90	33
2	2.10	52	12	1.90	33
3	2.10	52	13	1.90	33
4	2.10	52	14	1.90	33
5	2.08	50	15	2.00	41
6	2.08	50	16	2.18	62
7	2.08	50	17	2.45	100
8	2.05	47			
9	2.02	43	Mean		48.5
10	2.00	41	Mean per square mile		.97
			Run-off, depth in inches on drainage area		.61

NOTE.—These discharges are only approximate as no low-water measurements were made.

IRON CREEK ABOVE THE TUNNEL.

About half a mile above its mouth Iron Creek makes a bend toward the Kruzgamepa and comes within about a quarter of a mile of that stream. A tunnel was driven between the two streams during the winter of 1907–8 and a flume was constructed in it in 1908–9. The difference in water level at the two ends of the tunnel is 29 feet, 13 feet of which was utilized in constructing the tunnel to a grade of 1 per cent. It was planned to extend the tunnel and flume under the bed of Iron Creek in order to sluice the gold gravel through the flume and dispose of the tailings in Kruzgamepa River.

A gaging station was established June 22, 1908, above the tunnel to obtain the amount of water available for sluicing. Records at this point are unaffected by diversion and give practically the total flow of Iron Creek. During the later part of 1908 the gage heights were influenced by the building and raising of a dam to divert the water into a canal which carried it away from the tunnel entrance. In 1909 the gage was read beginning July 20. The gage heights were affected by the deposition of mud and by changes in the dam, so that discharges have been obtained by the indirect method. The discharge at this point for the early part of the season has been computed from the records kept at the railroad bridge and in the flume. The maximum discharge recorded was 1,160 second-feet, June 16, 1909, at the bridge station. The minimum for one week was 16.9 second-feet, for September 4 to 10, 1909.

Discharge measurements of Iron Creek above tunnel in 1908 and 1909.

[Elevation, 280 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
June 22	1.25	100	Sept. 29	0.83	31
June 23	1.37	118			
July 1	1.10	70	1909.		
July 2	.98	59	June 16 [a]	3.30	1,160
July 9	.70	34	July 27	.39	24
July 18	.60	24	Aug. 31 [b]	.37	20
Aug. 24	1.22	77	Aug. 31 [c]	.37	17.4
Sept. 28	.98	40	Sept. 4 [b]	.36	16

[a] Measured at railroad bridge and 20 second-feet added for flume diversion. The gage height was estimated from a high-water mark.
[b] Measured near mouth.
[c] Measured above gage.

Daily gage height, in feet, and discharge, in second-feet, of Iron Creek above the tunnel for 1908-9.

[Drainage area, 50 square miles. Observers, A. C. Stewart, 1908: George Lorimer, 1909.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1	....	....	1.11	73	1.00	59	1.02	55
2	....	....	.79	39	.80	40	.98	51
3	....	....	.82	42	.77	38	.97	50
4	....	....	.76	37	.78	38	.92	46
5	....	....	.76	37	1.76	213	.90	44
6	....	....	.76	37	1.16	70	.88	43
7	....	....	.72	34	.99	52	.91	45
8	....	....	.72	34	.90	44	.91	45
9	....	....	.70	32	.88	43	.88	43
10	....	....	.64	28	.82	38	.85	40
11	....	....	.66	29	.92	46	.99	40
12	....	....	.66	29	1.02	55	.92	36
13	....	....	.61	26	1.11	64	.89	34
14	....	....	.62	26	1.11	64	.86	33
15	....	....	.58	24	1.02	55	.86	33
16	....	....	.57	23	1.15	68	1.02	42
17	....	....	.58	24	.96	49	1.02	42
18	....	....	.56	23	.92	46	1.12	50
19	....	....	.56	23	1.05	58	.99	40
20	....	....	.54	21	.96	49	1.00	41
21	....	....	.54	21	.92	46	1.04	44
22	1.34	112	.53	21	.91	45	.90	35
23	1.26	97	.51	20	1.19	73	.85	32
24	1.39	122	.50	19	1.15	68	.95	38
25	1.32	108	.50	19	1.06	59	.82	30
26	1.20	87	.50	19	1.00	53	.90	35
27	1.28	101	.51	20	.96	49	....	38
28	1.27	99	.50	19	.93	47	.98	40
29	1.06	67	.50	19	.92	46	.83	31
30	1.16	80	1.50	146	.90	44	....	25
31	....	....	1.72	202	1.06	59	....	....
Mean	....	97.0	....	37.6	....	77.4	....	40.0
Mean per square mile	....	1.94	....	.75	....	1.15	....	.80
Run-off, depth in inches on drainage area	....	.65	....	.86	....	1.33	....	.89

Daily gage height, in feet, and discharge, in second-feet, of Iron Creek above the tunnel for 1908-9—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1				194	0.31	19	0.39	19
2				129	.30	19	.35	17
3				149	.41	24	.37	18
4				138	.52	30	.38	17
5				123	.42	24	.39	17
6				122	.39	23	.35	16
7				121	.44	25	.38	17
8				94	.38	22	.38	17
9				89	.80	50	.38	17
10				83	.82	50	.37	17
11				84	.63	36	.39	17
12				66	.60	34	.41	18
13				63	.72	42	.56	25
14				50	.65	37	.52	23
15				45	.52	29	.51	23
16		1,160		40	.52	29	.51	23
17		516		35	.50	28	.61	28
18		509		32	.49	27	.55	25
19		514		28	.49	26	.45	20
20		418	0.34	24	.48	26	.46	21
21		283	.34	24	.50	27	.42	19
22		347	.32	23	.48	26	.41	18
23		240	.39	26	.47	25		
24		162	.35	24	.50	27		
25		153	.32	23	.48	26		
26		181	.32	23	.40	22		
27		223	.40	27	.42	23		
28		311	.42	26	.40	20		
29		641	.40	24	.45	23		
30		180	.32	20	.38	19		
31			.36	22	.38	19		
Mean		389		63.6		27.6		19.6
Mean per square mile		7.78		1.27		.552		.392
Run-off, depth in inches on drainage area		4.34		1.46		.64		.32

IRON CREEK AT MOUTH.

A gage was established on the Seward Peninsula Railway bridge just above the mouth of Iron Creek on June 16, 1909, in order to obtain a record of a portion of the spring run-off. The Iron Creek flume was diverting water past this station until August 3. Readings at this point were used only till July 14, as the records above the tunnel are better after this date. Measurements during high water were made from the railway bridge and during low water by wading. Measuring conditions were good and the curve is well defined from the zero value to the maximum discharge. The combined discharge of the creek at this station and of the flume are given with the records for the station above the tunnel.

Discharge measurements of Iron Creek at mouth in 1909.

[Elevation, 248 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 16	4.55	1,140	Aug. 31 [a]	2.05	20.0
June 17	3.60	499	Aug. 31 [b]	2.05	17.4
July 27 [a]	1.78	5.9	Sept. 4 [a]	2.01	16.0

[a] Measured at mouth. [b] Measured above tunnel, 1 mile above mouth.

Daily gage height, in feet, and discharge, in second-feet, of Iron Creek at mouth for 1909.

[Observer, O. E. Wheeler.]

Day.	June.		July.		Day.	June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			2.88	180	17	3.61	506		
2			2.65	114	18	3.60	500		
3			2.72	132	19	3.60	500		
4			2.68	121	20	3.40	400		
5			2.62	106	21	3.10	265		
6			2.60	101	22	3.25	332		
7			2.60	101	23	3.00	225		
8			2.48	75	24	2.78	148		
9			2.45	70	25	2.75	140		
10			2.42	64	26	2.85	170		
11			2.42	64	27	2.95	206		
12			2.32	47	28	3.15	288		
13			2.30	44	29	3.80	620		
14			2.20	31	30	2.85	170		
15					31				
16	4.55	1,140			Mean		374		89.3

IRON CREEK FLUME AT INTAKE.

This station was established June 17, 1909, to determine the amount of water diverted by the flume. The gage was located at the intake of the flume just above the tunnel entrance, its zero being about 0.2 foot above the bottom of the flume. Measurements were made at the gage and records were kept until August 3, when the flume became blocked by the caving of its walls. It has not been reopened.

Discharge measurements of Iron Creek flume at intake in 1909.

[Elevation, 280 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 17	0.45	9.64	July 20	1.05	22.6
Do	.45	9.82	July 27	.80	17.2

Daily gage height, in feet, and discharge, in second-feet, of Iron Creek flume at intake for 1909.

[Observer, George Lorimer.]

Day.	June.		July.		August.		Day.	June.		July.		August.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.68	14.4	0.82	17.5	17	0.45	9.9	0.95	20.6		
2			.72	15.2	.82	17.5	18	.42	9.4	.95	20.6		
3			.80	17.0	.95	20.6	19	.68	14.4	.95	20.6		
4			.82	17.5			20	.85	18.2	1.02	22.3		
5			.78	16.6									
							21	.85	18.2	.98	21.3		
6			.95	20.6			22	.70	14.8	.95	20.6		
7			.92	19.9			23	.72	15.2	.95	20.6		
8			.90	19.4			24	.65	13.8	1.00	21.8		
9			.90	19.4			25	.62	13.2	.98	21.3		
10			.90	19.4									
							26	.52	11.2	.95	20.6		
11			.91	19.6			27	.78	16.6	.95	20.6		
12			.90	19.4			28	1.05	23.0	.95	20.6		
13			.88	18.9			29	.98	21.3	.84	18.0		
14			.88	18.9			30	.45	9.9	.80	17.0		
15			.90	19.4			31			.86	18.4		
16		20.0	.95	20.6			Mean.		15.3		19.4		18.5

PASS CREEK BELOW DAM SITE.

Pass Creek is fairly typical of the creeks on the north side of the Kigluaik Range. It rises opposite the heads of Gold Run and Fox Creek in a glacial cirque, the flat base of which lies at an elevation of about 1,700 feet and contains a small glacier. A difficult but practicable pass from the cirque to the head of Gold Run at an elevation of about 2,400 feet furnishes the name of the creek. Below the cirque is a steep escarpment over which the creek drops nearly 400 feet into a small lake that fills the valley to the rock walls on either side. Below this point the creek has a more gradual grade down to a third flat area, which lies 200 feet below the lake and constitutes the top of a morainic mass almost all of which extends beyond the body of the mountain front. This is bordered by ridges which rise 200 to 300 feet above this flat on either side in the form of lateral moraines of the former glacier. Below the two lakes which occupy the lower end of this flat the creek drops about 1,000 feet in less than 2 miles. Thus Pass Creek combines two favorable factors for the development of power—a large amount of concentrated fall and feasible storage facilities. There are two dam sites near the lower end of the lakes on the third flat. One of these would be suitable for a low dam, and the other for a high dam for storing the flow of the creek. A project now contemplated involves reenforcing the flow of Pass Creek by diverting water from other streams to the west and conducting it to the lake by means of a flume and ditch along the mountain side.

The gaging station was established below the lakes on the third flat July 10, 1908, and records were kept during parts of three years.

The gage used in 1908 was located nearly a mile below the lake at a much lower elevation, but there is practically no inflow in this distance. Another gage was established in 1909 in a permanent rock section about 100 feet below the lakes and near the proposed dam site. The measurements have all been made near the second gage. Special care is required to obtain good results, because measuring conditions are poor. The minimum recorded flow of Pass Creek occurs after the headwaters freeze, near the end of the mining season. The flow probably ceases entirely during the winter. The maximum recorded discharge, 190 second-feet on September 7, 1910, is only an approximate value, but it is probable that the greatest discharge in the four years from 1907 to 1910 occurred on that date.

Discharge measurements of Pass Creek below the dam site from 1907 to 1909.

[Elevation, 1,100 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge
1907.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 29		18.1	Aug. 7	1.18	21.0
1908.			Sept. 3	1.05	15.7
July 20	0.90	23.8	Sept. 19	.86	7.7
Aug. 18	1.05	29.6			

Daily gage height, in feet, and discharge, in second-feet, of Pass Creek below the dam site for 1908–1910.

[C. F. Merritt, observer.]

Day.	1908				1909					
	July.		August.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.50	60				10	1.10	17
2			1.20	39			1.05	15		15
3			.90	22				20		13
4			1.10	33				32		13
5			2.00	101				29	1.05	15
6			1.40	53				26		15
7			1.20	39			1.17	21		15
8			1.10	33				17	1.05	15
9				31			1.50	41		15
10	0.90	22		31				38		14
11		30		31				34		14
12		38	1.70	76				30		13
13		28	1.30	46				32		13
14		26	1.00	28			1.40	34		12
15		26	1.20	39				30		12
16		25	1.10	33				26		11
17		25	1.00	28			1.20	22		10
18		22	1.05	30			1.17	21		8
19		22					1.15	20	.86	7.7
20	.90	22					1.15	20		
21		20						20		
22	.80	18						20		
23	.80	18						19		
24	.60	12			1.10	17	1.12	18		
25	.70	14				16	1.05	15		
26	.65	13				15	1.05	15		
27	.65	13				14		16		
28		13				13	1.07	16		
29		13				12		22		
30	2.0	101				11	1.30	28		
31	2.0	101				10	1.25	25		
Mean		28.3		41.8		13.5		23.6		13.0

NOTE.—Discharge for days on which gage was not read was obtained by the aid of a hydrograph.

Daily gage height, in feet, and discharge, in second-feet, of Pass Creek below the dam site for 1908–1910—Continued.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.								
1			1.1	35		30	1.1	35
2				34	2.1	108	1.15	38
3			1.05	32		35	1.0	30
4				28	1.0	30		26
5			.9	25		28	.85	23
6				22	1.05	32	2.3	126
7			1.25	44	1.1	35	2.9	190
8			.7	17		30	2.2	117
9			.7	17		34	2.0	99
10			.7	17	1.15	38	1.8	83
11			.9	25	1.2	41	1.5	60
12				25	1.25	44	1.3	47
13			.9	25	1.2	41	1.2	41
14				23		40	1.1	35
15			1.2	41		40		30
16			1.05	32		40		26
17			1.0	30	1.25	44		22
18			.95	28		43		18
19				25		42	.6	14
20				30		41	.6	14
21	0.8	21	1.3	47		40	.55	13
22	.8	21		35	1.3	47		
23	1.7	75	1.0	30		45		
24		75	1.0	30	1.25	44		
25	1.7	75	1.1	35	1.1	35		
26	1.6	67	1.2	41	.9	25		
27	1.8	83		35	.9	25		
28	1.5	60	1.5	60	.85	23		
29	1.3	47	1.35	50	.8	21		
30	1.25	44	1.05	32		25		
31				28	1.2	41		
Mean		56.8		31.5		38.3		51.8

NOTE.—No measurements were made during 1910, but it is thought that channel conditions and gage datum remained the same as in 1909. The discharge for days, with missing gage heights, was estimated by a comparison of Smith Creek and Pass Creek gage heights and the natural flow of Nome River at Pioneer intake. The discharge for gage heights above 1.5 is only approximate.

SMITH CREEK BELOW SWIFT CREEK.

Smith Creek is one of the largest streams on the north side of the mountains and probably has a larger discharge at an elevation of about 1,100 feet than any other stream in Seward Peninsula. It rises in an immense cirque opposite the heads of North Fork of Grand Central River and Gold Run. Below the level base of the cirque the stream falls with a fairly uniform grade to the flats bordering Kruzgamepa River, so that it affords no storage facilities. Swift Creek is a small stream that drains a high cirque west of Smith Creek.

A gaging station was established July 10, 1908, at a low elevation below the foothills. The original gage was washed out by high water near the end of July and a new gage, established July 30 at the same point, was read during 1909. Measurements were made just below Swift Creek in a deep, smooth section of the stream. There is probably much underground seepage at the gage but not at the measuring section. The results are believed to be of fair accuracy.

Discharge measurements of Smith Creek below Swift Creek from 1907 to 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
1907.			1909.		
July 29		40	Aug. 6	0.70	37
			Sept. 2	.54	22
1908.			Sept. 3	.49	19.9
July 20	1.00	47	Sept. 18	.24	9.4
Aug. 18	.70	40			

Daily gage height, in feet, and discharge, in second-feet, of Smith Creek below Swift Creek for 1908 and 1909.

[C. F. Merritt, observer.]

Day.	1908				1909					
	July.		August.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.00	77			0.50	20	0.60	28
2			.90	64			.55	24	.55	24
3			.90	64			.65	32	.50	20
4			1.00	77			.80	48	.50	20
5			1.30	124				42	.70	37
6			1.20	108			.70	37	.65	32
7			.90	64			.65	32	.65	32
8			.80	51			.60	28	.55	24
9				48			1.85	231		23
10	0.80	27		48			1.40	140		22
11		58		48				120		22
12		80	1.40	140				104		20
13		36	1.10	92			1.10	88		19
14		36	.90	64			1.87	56	.47	18
15		36	1.00	77			.80	48	.47	18
16		34	.90	64			.70	37		16
17		35	.80	51			.65	32		14
18		36	.70	40			.67	34	.24	9.4
19		38					.67	34		
20	1.00	47					.65	32		
21		36					.65	32		
22	.80	27					.67	34		
23	.80	27			0.60	28	.60	28		
24	.70	19				26	.55	24		
25	.70	19				25	.50	20		
26	.75	23				25	.47	18		
27	.65	16				24	.47	18		
28		16				23	.60	28		
29		16				22	.80	48		
30	1.80	171				21	.80	48		
31	1.60	137			.50	20	.65	32		
Mean		44.1		72.3		23.8		50.0		22.1

MIDDLE, OSBORN, AND WEST END CREEKS.

These three streams drain high cirques on the north side of the Kigluaik Mountains west of Smith Creek. The two last named rise on the north slopes of Mount Osborn. Grand Union Creek lies between Middle and Osborn creeks and at its head is a pass leading over the range to the head of North Fork of Grand Central River. All these streams are similar in a general way to those just described.

Gages were established on Middle, Osborn, and West End creeks in 1909. Two measurements were made on each and a few gage readings were obtained by members of the Survey and by C. F. Merritt. The records give a general idea of the discharge available in these streams for high-head power development.

Discharge of Middle, Osborn, and West End creeks in 1909.

MIDDLE CREEK AT ELEVATION ABOUT 400 FEET.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.	*Feet.*	*Sec.-ft.*	**Discharge from gage heights**—Continued.	*Feet.*	*Sec.-ft.*
Aug. 6	0.52	10.0	Aug. 6	0.55	10.6
Sept. 19	.04	2.67	Aug. 14	.65	12.6
			Aug. 22	.45	8.6
Discharge from gage heights.			Sept. 2	.34	6.7
			Sept. 4	.45	8.6
July 23	.51	9.8	Sept. 5	.35	6.8
Aug. 3	.35	6.8			

OSBORN CREEK AT ELEVATION ABOUT 900 FEET.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.			**Discharge from gage heights.**		
Aug. 6	0.56	16.3	July 22	0.60	17.5
Sept. 20	.12	6.14	Aug. 3	.45	13.6
			Aug. 6	.55	16.2
			Aug. 14	.70	20.2
			Aug. 22	.70	20.2
			Sept. 6	.50	14.8

WEST END CREEK AT ELEVATION ABOUT 1,050 FEET.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.			**Discharge from gage heights.**		
Aug. 6	0.05	15.4	July 22	0.20	23.6
Sept. 20	—.17	6.18	Aug. 3	.05	15.4
			Aug. 6	.05	15.4
			Aug. 14	.25	26.8
			Aug. 22	.20	23.6
			Sept. 6	.05	15.4

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Kruzgamepa River drainage basin.

Miscellaneous measurements in Kruzgamepa River basin from 1906 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
Sept. 1, 1909	Kruzgamepa River	Imuruk Basin	1 mile below Crater Creek.	370	188	124	1.52
July 28, 1909	do	do	Above Iron Creek.	248	239	153	1.56
Aug. 31, 1909	do	do	do	248	255	153	1.67
June 24, 1906	Jasper Creek	Salmon Lake	½ mile above mouth.	480	11.6		
June 22, 1906	Fox Creek	do	Mouth of canyon	550	99	11.0	9.00
Aug. 16, 1906	do	do	do	550	17.3	11.0	1.57
Sept. 5, 1908	do	do	do	550	26	11.0	2.36
Sept. 19, 1907	Slate Creek	Kruzgamepa River	Level of ditch to Matthews Gap.	900	11.3		
Do	Rock Creek	Slate Creek	do	900	9.0		
Aug. 5, 1906	Crater Creek	Kruzgamepa River	Intake of proposed ditch to Salmon Lake.	550	67		
Aug. 15, 1906	do	do	do	550	57		
Aug. 27, 1906	do	do	do	550	290		
Sept. 1, 1906	do	do	do	550	110		
Sept. 8, 1906	do	do	do	550	55		
Sept. 16, 1906	do	do	do	550	39		
June 29, 1907	do	do	do	550	217		
July 3, 1907	do	do	do	550	131		
July 15, 1907	do	do	do	500	141		
Aug. 2, 1907	do	do	do	550	89		
Aug. 23, 1907	do	do	do	550	185		
Sept. 12, 1907	do	do	do	550	245		
June 21, 1908	do	do	do	550	76		
July 19, 1909	do	do	do	550	95		
Sept. 1, 1909	do	do	do	550	54		
Sept. 19, 1907	Willow Creek	do	Level of ditch to Matthews Gap.	900	3.3		
July 17, 1908	Big Creek	do	Edge of mountains.		14.2		
Aug. 14, 1906	Dome Creek	Iron Creek	Below Hardluck Creek, including ditch.	630	10.1	12.3	.82
Sept. 15, 1906	do	do	do	630	10.2	12.3	.83
Aug. 30, 1909	do	do	do	630	4.5	12.3	.37
Aug. 14, 1906	Iron Creek	Kruzgamepa River	Below Canyon Creek.	450	17.1	38	.45
Sept. 15, 1906	do	do	Above Golden Gate Mining Co.'s ditch.	425	26	40	.65
July 18, 1908	do	do	do	425	23	40	.58
Aug. 30, 1909	do	do	do	425	[a] 11.3	40	.28
Aug. 13, 1906	Eldorado Creek	Dome Creek	Gold Beach Development Co.'s ditch intake.	750	4.5	5.4	.83
Sept. 15, 1906	do	do	do	750	5.6	5.4	1.04
Aug. 13, 1906	Discovery Creek	Iron Creek	do	740	1.25	5.1	.25
Sept. 15, 1906	do	do	do	740	2.3	5.1	.45
Aug. 13, 1906	Canyon Creek	do	do	760	1.3	4.1	.32
Aug. 30, 1909	Spring	Iron Creek from south.	In ditch	460	2.2		
Sept. 16, 1906	Gold Beach Development Co.'s ditch.	Eldorado and Discovery creeks.	At penstock	730	5.9		
Aug. 1, 1907	do	do	do	730	10.0		
Aug. 22, 1907	do	do	do	730	9.8		
Sept. 16, 1906	do	Canyon Creek	do	730	1.1		
July 29, 1907	Grand Union Creek	Kruzgamepa River	Below springs	650	12.7		
Sept. 2, 1909	do	do	do	650	5.6		

[a] Poor measuring conditions; discharge probably too small.

KUZITRIN RIVER DRAINAGE BASIN.

DESCRIPTION.

Kuzitrin River and its tributaries drain an area aggregating about 1,890 square miles, in the central portion of Seward Peninsula. The two forks of the main stream rise in the lava beds just north of the Bendeleben Mountains and flow west to Imuruk Basin. Kuzitrin River receives a number of large tributaries, including Noxapaga River, Garfield Creek, and Kougarok River from the north and Minnie, Ella, Bonanza, Birch, and Belt creeks from the south. The drainage basin is very diversified, both topographically and geologically. At the south lie the Bendeleben Mountains, a rugged range with many sharp peaks and glaciated valleys. North of them is a large lowland basin divided into two parts, one on the lower river near Imuruk Basin, the other above Lanes Landing, known as the Kuzitrin Flats, which merges toward the east into a plateau formed of the lava flows. North of the flats lies the Kougarok region, including, as the name is commonly used, not only the drainage basin of Kougarok River, but the adjoining territory as well. This region is in general a high plateau in which the rounded summits of the hills have elevations varying from 1,200 feet just north of the flats to 1,600 feet at the divide between the Kougarok drainage basin and the streams which flow northward into the Arctic. Above this plateau rise several mountain masses, including Kougarok Mountain, at the head of Kougarok River, 2,980 feet in height; Midnight Mountain, north of Taylor Creek, 2,650 feet; Baldy Mountain, south of North Fork; and others.

The run-off from the Kuzitrin drainage basin varies with the topography. It is high in the Bendeleben Mountains, very low in the flats, and increases slightly, if at all, farther north in the plateau area. The rainfall and run-off in the Kougarok region vary greatly from year to year, and in dry years are very small indeed. The basin contains a few lakes, which fall into two classes—those in the lowland area, many of which are merely lagoons or old cut-off meanders of the river, and those farther east, which were produced by the lava flows. None are so located as to be available for storage. There is no timber within the drainage basin except a few cottonwoods along the lower course of the river in the flats, though willows and alders are, as usual, well distributed. The ground is for the most part frozen and covered with a mantle of ice and muck, especially in the northern portion of the basin, where thawed ground is almost lacking.

Kuzitrin River usually breaks up at Lanes Landing late in May and runs clear of ice early in June. It freezes over at this point about the last week in September, but at the head of the Kougarok the freeze-up comes about a week earlier.

Noxapaga River rises near Imuruk Lake and flows westward and southward, draining a total area of nearly 500 square miles at its junction with the Kuzitrin in the flats. Its principal tributaries are East Fork and Berry, Aurora, and Turner creeks. It drains a plateau area, none of which reaches an elevation much greater than 2,000 feet. Most of the eastern portion of the drainage basin has been covered with a lava flow, and this portion furnishes practically all the discharge of the river at low water. The western portion of the drainage basin includes several streams on which mining operations have been conducted, especially Boulder Creek, a tributary of Turner Creek, where five or six claims have been worked intermittently and a considerable amount of gold extracted. The only ditch built in the Noxapaga basin has its intake on Turner Creek and extends around the rolling hills to the east for about 17 miles to Goose Creek. On account of the very meager water supply available, the ditch has been practically abandoned.

Kuzitrin River is navigable for flat-bottomed boats and scows for about 60 miles, and Noxapaga River can be used for horse boats, carrying 2 or 3 tons, up to the mouth of Turner Creek. Most of the supplies for the Kougarok and Noxapaga regions have been brought in from Teller in this manner. Kougarok River is of so great importance with reference to mining that its basin is described separately (pp. 200–201). A gaging station was maintained on Kuzitrin River at Lanes Landing from 1908 to 1910.

KUZITRIN RIVER AT LANES LANDING.

This station was established July 3, 1908, at Lanes Landing (Shelton post office), about 25 miles in a direct line above the mouth of the river, though the distance by the stream is considerably greater. It is below all important tributaries and shows practically the entire run-off of the drainage basin. The river flows over a broad gravel bed, but as this bed is probably frozen throughout except a thin layer of gravel in immediate contact with the stream, there can be no great amount of underground seepage. The channel at the station is somewhat shifting and results are therefore likely to be slightly in error. Measurements are made by wading or from a boat. The gage has been located at the north end of the railroad trestle which extends across the river, and which is carried out by the high water and ice every spring. Records have been kept at this station for the three years, 1908–1910, beginning with the break-up in the spring. The gage heights recorded early in the spring are undoubtedly affected by backwater due to ice lower down, and the corresponding discharges have therefore been reduced. As the extent of this backwater is not known, the discharges are liable to large errors, but inaccuracy during this period is of minor importance, for it is information as to the low-water flow in the summer and the approximate total for the year that is desired. The maximum discharge recorded was 10,500 second-feet on June 1 and 2, 1910. The gage height was higher in the later part of May, but it is thought that the effect of backwater was greater than on June 1 and 2. A minimum of 235 second-feet occurred August 1 to 3, 1909.

Discharge measurements of Kuzitrin River at Lanes Landing, 1908–1910.

[Elevation, 40 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
June 29	5.61	922	June 18	7.66	5,150
July 6	5.00	452	July 20	4.07	349
July 7	4.90	432	July 26	3.86	270
July 19	4.54	330	Sept. 3	3.90	283
Aug. 1	5.58	993			
Aug. 20	4.65	421	1910.		
			Sept. 25	10.32	3,450
			Sept. 27	9.80	2,460

Daily gage height, in feet, and discharge, in second-feet, of Kuzitrin River at Lanes Landing for 1908–1910.

[Drainage area, 1,750 square miles; observers, Albert Lokke, 1908; Carl L. Lokke, 1909-10.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1		6,000	5.5	830	5.6	1,040	4.7	448
2		6,000	5.4	745	5.35	802	4.75	474
3	9.0	6,020	5.25	628	5.25	722	4.7	448
4	9.35	6,620	5.2	590	4.75	425	4.75	474
5	9.15	6,280	5.3	665	5.25	722	4.8	500
6	9.55	6,960	5.0	465	5.7	1,140	4.7	448
7	9.25	6,440	4.95	440	5.8	1,240	4.75	474
8	8.4	5,000	4.8	365	5.65	1,190	4.75	474
9	8.1	4,490	4.8	365	5.35	895	4.65	424
10	7.8	3,980	4.8	365	5.3	850	4.65	424
11	7.7	3,810	4.75	360	4.95	590	4.6	400
12	7.75	3,900	4.75	380	4.9	560	4.55	378
13	7.75	3,900	4.8	420	4.9	560	4.5	357
14	7.7	3,810	4.75	410	4.9	560	4.55	378
15	7.7	3,810	4.7	400	4.8	500	4.5	357
16	7.75	3,900	4.6	357	4.75	474	4.5	357
17	7.35	3,230	4.6	357	4.7	448	4.65	424
18	7.3	3,150	4.6	357	4.7	448	4.85	530
19	7.15	2,910	4.6	357	4.5	357	4.9	560
20	7.0	2,670	4.55	336	4.65	424	4.85	530
21	6.25	1,640	4.5	315	4.6	400	4.8	500
22	6.15	1,510	4.55	336	4.6	400	4.7	448
23	5.95	1,280	4.5	315	4.6	400	4.7	448
24	6.1	1,450	4.55	336	4.7	448	4.55	378
25	6.15	1,510	4.45	296	4.75	474	4.45	337
26	6.2	1,570	4.45	296	4.75	474	4.3	280
27	6.1	1,450	4.4	278	4.7	448		
28	5.95	1,280	4.4	278	4.65	424		
29	5.75	1,060	4.35	262	4.6	400		
30	5.55	875	4.4	278	4.6	400		
31			5.25	722	4.6	400		
Mean		3,550		416		600		433
Mean per square mile		2.03		.238		.343		.247
Run-off, depth in inches on drainage area		2.26		.27		.40		.24

Daily gage height, in feet, and discharge, in second-feet, of Kuzitrin River at Lanes Landing for 1908-1910—Continued.

Day.	May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.										
1			8.20	6,120	5.68	1,930	3.75	235	3.90	285
2			8.80	7,200	5.32	1,460	3.75	235	3.90	285
3			8.50	6,660	5.28	1,400	3.75	235	3.90	285
4			8.30	6,300	5.12	1,200	3.82	257	3.90	285
5			7.85	5,490	5.12	1,200	4.00	325	3.98	317
6			8.00	5,760	5.15	1,240	4.00	325	4.00	325
7			7.70	5,220	5.30	1,430	3.95	305	3.95	305
8			7.15	4,260	4.92	976	3.95	305	3.92	293
9			6.95	3,920	4.85	905	4.02	334	3.92	293
10			7.10	4,180	4.80	855	4.35	505	3.90	285
11			7.45	4,780	4.65	718	4.90	955	3.88	278
12			7.85	5,490	4.62	692	4.78	836	3.90	285
13			7.75	5,310	4.48	587	4.60	675	3.90	285
14			7.55	4,950	4.40	535	4.40	535	3.92	293
15			7.62	5,080	4.32	487	4.30	475	4.05	348
16			7.70	5,220	4.28	464	4.18	410	4.08	361
17			7.82	5,440	4.22	431	4.08	361	4.12	380
18			7.66	5,150	4.18	410	4.02	334	4.15	395
19	[a] 9.70	4,000	7.30	4,520	4.12	380	3.98	317	4.12	380
20	9.75	5,000	6.85	3,760	4.10	370	3.92	293	4.08	361
21	10.45	6,000	6.85	3,760	4.05	348	3.90	285	4.02	334
22	10.25	7,000	6.65	3,420	4.00	325	3.90	285	4.00	325
23	[a] 10.20	8,000	6.18	2,670	3.98	317	3.90	285	3.95	305
24	9.30	8,100	5.95	2,320	3.95	305	3.85	268	3.95	305
25	8.80	7,200	5.68	1,930	3.92	293	3.85	268	3.95	305
26	8.40	6,480	5.35	1,500	3.85	268	3.85	268	3.95	305
27	8.10	5,940	5.30	1,430	3.85	268	3.85	268	3.90	285
28	7.95	5,670	5.52	1,720	3.82	257	3.85	268	3.90	285
29	7.85	5,490	5.72	1,990	3.80	250	3.85	268	3.88	278
30	7.95	5,670	5.95	2,320	3.80	250	3.85	268	3.82	257
31	8.20	6,120			3.80	250	3.85	268		
Mean		6,210		4,260		671		363		310
Mean per square mile		3.55		2.43		.383		.207		.177
Run-off, depth in inches on drainage area		1.72		2.71		.44		.24		.20

[a] Gage heights were affected by backwater from May 19 to 23, and the discharge was estimated for this period.

Daily gage height, in feet, and discharge, in second-feet, of Kuzitrin River at Lanes Landing for 1908–1910—Continued.

Day.	May. Gage height.	May. Discharge.	June. Gage height.	June. Discharge.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.	October. Gage height.	October. Discharge.
1910.												
1	......	....	14.7	9,500	11.1	4,690	8.65	1,010	8.55	905	8.75	1,120
2	......	....	14.4	9,300	11.0	4,520	8.35	718	10.2	3,180	8.4	760
3	......	....	14.95	10,500	10.7	4,010	10.15	3,100	10.5	3,670	8.05	505
4	......	....	14.8	10,500	10.35	3,420	10.3	3,340	10.3	3,340	7.75	348
5	......	....	13.85	9,630	10.15	3,100	9.9	2,700	9.9	2,700	7.75	348
6	......	....	13.4	8,820	10.0	2,860	9.5	2,100	10.65	3,920	7.85	395
7	......	....	12.6	7,380	10.0	2,860	9.5	2,100	11.55	5,490	7.8	370
8	......	....	12.45	7,110	10.0	2,860	9.8	2,550	11.6	5,580	7.9	420
9	......	....	12.2	6,660	10.0	2,860	9.4	1,960	11.45	5,310	......	....
10	......	....	11.8	5,940	9.9	2,700	9.2	1,690	11.1	4,690	......	....
11	......	....	11.25	4,950	9.4	1,960	9.15	1,620	10.7	4,010	......	....
12	......	....	10.7	4,010	9.4	1,960	9.05	1,500	10.3	3,340	......	....
13	......	....	10.5	3,670	9.5	2,100	8.85	1,240	10.0	2,860	......	....
14	......	....	10.2	3,180	9.45	2,030	8.7	1,060	9.9	2,700	......	....
15	......	....	9.9	2,700	9.45	2,030	8.6	955	9.75	2,480	......	....
16	......	....	9.7	2,400	9.45	2,030	9.4	1,960	9.5	2,100	......	....
17	......	....	9.55	2,180	9.3	1,820	10.2	3,180	9.4	1,960	......	....
18	......	....	9.4	1,960	9.45	2,030	10.3	3,340	8.9	1,300	......	....
19	......	....	10.85	4,260	9.55	2,180	10.3	3,340	8.75	1,120	......	....
20	......	....	12.55	7,290	9.5	2,100	10.05	2,940	8.8	1,180	......	....
21	......	....	12.6	7,380	11.4	5,220	9.65	2,320	8.7	1,060	......	....
22	14.95	3,000	11.95	6,210	11.1	4,690	9.35	1,890	8.55	905	......	....
23	15.2	3,100	12.2	6,660	10.5	3,670	9.2	1,690	9.3	1,820	......	....
24	15.55	3,800	11.5	5,400	10.1	3,020	9.05	1,500	10.25	3,260	......	....
25	16.0	5,000	11.7	5,760	9.75	2,480	9.05	1,500	10.3	3,340	......	....
26	17.3	8,000	12.0	6,300	9.8	2,550	9.2	1,690	10.0	2,860	......	....
27	17.4	9,000	11.8	5,940	9.7	2,400	8.95	1,360	9.75	2,480	......	....
28	17.45	10,000	11.45	5,310	9.5	2,100	9.0	1,430	9.45	2,030	......	....
29	17.4	10,000	11.2	4,860	9.35	1,890	8.7	1,060	9.15	1,620	......	....
30	16.4	10,000	11.2	4,860	9.1	1,560	8.6	955	8.95	1,360	......	....
31	15.65	10,000	......	....	8.8	1,180	8.45	808	......	....	......	....
Mean	......	7,190	......	6,020	......	2,740	......	1,890	......	2,750	......	533
Mean per square mile	......	4.11	......	3.44	......	1.57	......	1.08	......	1.57	......	.305
Run-off, depth in inches on drainage area	......	1.53	......	3.84	......	1.81	......	1.24	......	1.75	......	.09

NOTE.—The gage heights were affected by backwater from May 22 to June 4. The discharge was estimated for this period.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Kuzitrin River drainage basin.

Miscellaneous measurements in Kuzitrin River basin from 1907 to 1909.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. mi.*	*Sec.-ft.*
Aug. 16, 1907	Noxapaga River	Kuzitrin River	Above Goose Creek.	62	340	0.18
June 30, 1908	do	do	do	126	340	.37
July 21, 1908	do	do	do	67	340	.20
Sept. 8, 1908	do	do	do	71	340	.21
Aug. 29, 1909	do	do	do	31	340	.091
Aug. 27, 1909	Eldorado Creek	Noxapaga River	Trail crossing	2.1	30	.070
Aug. 29, 1909	Aurora Creek	do	Near mouth	2.0	28	.071
Aug. 15, 1907	Turner Creek	do	Ditch intake	.7	13	.054
June 29, 1908	do	do	do	4.1	13	.32
July 20, 1908	do	do	do	.6	13	.046
Sept. 8, 1908	do	do	do	1.6	13	.12
Aug. 30, 1909	do	do	do	.5	13	.038
Aug. 15, 1907	Boulder Creek	Turner Creek	Claim No. 5	[a].8	6.5	.12
July 1, 1908	do	do	do	3.4	6.5	.52
July 21, 1908	do	do	do	.9	6.5	.14
Aug. 28, 1909	do	do	do	.5	6.5	.077
July 30, 1908	Birch Creek	Kuzitrin River	Edge of foothills	122		

[a] Estimated.

KOUGAROK RIVER DRAINAGE BASIN.

DESCRIPTION.

Kougarok River drains a large area lying in the central portion of Seward Peninsula and empties into Kuzitrin River about 8 miles above Lanes Landing. It rises southeast of Kougarok Mountain and flows eastward to the mouth of Macklin Creek, where it makes a sharp bend to the right and follows a southeasterly course to its mouth. The largest tributaries are Taylor Creek and North Fork from the east and Henry, Coarse Gold, and Windy creeks from the west. Of less importance are Washington, Columbia, Macklin, Homestake, Goose, California, Arctic, Arizona, Louisa, Galvin, and Dan creeks and Left Fork. Quartz Creek, which empties into the river below those named above, and its tributaries, Coffee, Dahl, Checkers, Carrie, and Independence creeks, were up to 1909 the most important gold producers of the region, but have a very small run-off except at times of heavy rain.

The river and all its tributaries reach a very low stage during periods of deficient rainfall. During 1908 and 1909 seasons of particularly severe drought were experienced. The water supply for

1907 was probably near the normal, although the total run-off for the summer may be a little above the average; that of 1910 was well sustained throughout the season, as is shown by the record of Henry Creek, the only one available for this year.

Mining has been done on Kougarok River and many of its tributaries since 1900. Eight ditches have been built to divert the waters of Kougarok River and its tributaries for hydraulic mining, and many others to obtain water for sluicing. There are two ditches on the upper Kougarok, two on Taylor Creek and one each on Henry, Arizona, and Coarse Gold creeks and on North Fork. There is no practicable water-power prospect in the basin, for storage is lacking and the minimum flow is altogether too small. A favorable site for power development could be had at the bend just above Coarse Gold Creek if the water supply were not so meager.

The principal tributaries are further discussed in connection with the gaging station descriptions.

Records have been obtained at the following points in the drainage basin:

Kougarok River and Homestake ditch at intake, 1907–1909.
Kougarok River below Henry Creek, 1909.
Kougarok River above Coarse Gold Creek, 1907–1909.
Taylor Creek at Cascade intake, 1907.
Henry Creek at mouth, 1908–1910.
Coarse Gold Creek near mouth, 1909.
North Fork above Eureka Creek, 1908–9.
Homestake ditch at penstock, 1907.
North Star ditch above siphon, 1907

KOUGAROK RIVER AND HOMESTAKE DITCH AT INTAKE.

These stations were established July 15, 1907, in order to determine the total flow of upper Kougarok River and the amount diverted by the Homestake ditch. The gage on the river is located on the left bank about 150 feet below the dam which diverts the water into the ditch, and the ditch gage is directly opposite, on the right side of the ditch. Measurements of both river and ditch are made by wading at points near the gages. Those made on the river are liable to error on account of poor measuring conditions. The records are inaccurate for certain periods because both channels shifted considerably. The total monthly discharge of the river has been found by combining the values for the ditch and the river below the intake, and daily values can be obtained in the same way. From evidence at hand it seems probable that discharges of 600 to 1,000 second-feet have occurred at the station. The lowest recorded discharge was 2.9 second-feet, from July 24 to August 3, 1909.

Discharge measurements of Kougarok River at Homestake intake in 1907–1909.

[Elevation, 635 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 15	1.24	18.0	June 27	0.76	31
July 15	1.13	6.6	July 3	.53	9.5
July 20	1.08	2.0	July 26	.05	.5
Aug. 9	.92	3.1	Sept. 10	.13	1.8
Aug. 12	.90	2.2			
Aug. 19	.92	3.3	1909.		
Aug. 22	1.64	82	June 21	1.58	262
Sept. 1	.89	.5	July 23	.40	3.4
Sept. 4	1.34	42	Sept. 1	.39	5.3
Sept. 10	2.47	303			
Sept. 11	1.98	153			

Discharge measurements of Homestake ditch at intake in 1907–1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 15	0.51	11.6	June 27	0.22	6.9
July 15	.45	10.2	June 27	.24	6.6
July 15	−.05	.4	July 3	.29	6.4
July 20	.36	8.1	July 26	.10	2.0
July 29	.20	5.7	Sept. 10	.15	3.2
Aug. 12	−.04	1.5			
Aug. 19	.28	7.4	1909.		
Aug. 19	.27	7.3	June 21	−.06	.5
Aug. 22	.62	17.6	Sept. 1	.29	5.3
Aug. 22	.75	23			
Sept. 10	.44	12.0			

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River and Homestake ditch at intake for 1907–1909.

Drainage area, 44 square miles; observers, employees of Kougarok Mining & Ditch Co., 1907–8; Frank Dolan, 1909.]

Day.	July.				August.				September.			
	River.		Ditch.		River.		Ditch.		River.		Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.												
1						0.4	0.25	6.8	1.01	10.8	0.62	17.8
2						.4	.15	4.8	1.15	22	.66	19.4
3						.4	.18	5.3	1.12	20	.68	20.2
4						.4	.32	8.5	1.35	42	.64	18.6
5						.4	.28	7.5	1.57	71	.58	16.3
6						.4	.20	5.7	1.44	53	.64	18.6
7						.4	1.6	4.9	1.28	35	.64	18.6
8						.4	.10	3.8	1.16	23	.65	19.0
9					0.92	3.2	.06	3.2	1.78	110	.69	20.6
10					.90	2.2	−.02	2.0	2.56	336	.55	15.2
11					.90	2.2	−.03	1.8	1.86	124	.62	17.8
12					.90	2.2	−.04	1.7	1.54	67	.65	19.0
13					.89	1.7	−.06	1.5	1.33	40	.66	19.4
14					.90	2.2	−.06	1.5	1.17	24	.66	19.4
15	1.24	18		0	.91	2.7	−.08	1.2	1.74	99	.66	19.4
16		3.0		13.0	.91	2.7	−.08	1.2	1.50	61	.68	20.2
17		3.0		12.0	.91	2.7	+.04	2.8	1.22	29	.69	20.6
18		3.0		10.0	.92	3.2	.12	4.2	1.11	18.9	.70	21.0
19		3.0		9.0	.92	3.2	.28	7.5	1.04	13.2	.62	17.8
20	1.08	2.9	0.36	8.0	.91	2.7	.18	5.3	1.10	18.0	.30	8.0
21	1.05	2.0	.40	9.0	1.40	48	.60	17.0				
22	1.04	1.6	.31	6.7	1.71	93	.61	17.4				
23	1.00	.4	.34	7.4	1.58	72	.61	17.4				
24	1.20	14.0	.62	15.4	1.17	24	.63	18.2				
25	1.03	1.3	.55	15.2	1.54	67	.58	16.3				
26	1.00	.4	.49	13.2	1.28	35	.59	16.6				
27	.88	.4	.42	11.1	1.22	29	.66	19.4				
28	.89	.4	.26	7.1	1.09	17	.62	17.8				
29		.4	.22	6.2	.96	5.8	.61	17.4				
30		.4	.21	5.9	.95	5.0	.69	20.6				
31		.4		6.4	.89	.5	.57	16.0				
Mean		3.2		9.2		13.9		8.9		60.8		18.3
Mean total		12.4				22.8				79.1		
Mean per square mile		.28				.52				1.80		
Run-off, depth in inches on drainage area		.18				.60				1.34		

NOTE.—Discharges for July 16 to 19 are estimated. All water was carried in the ditch from July 26 to Aug. 8, inclusive, except the seepage through the diversion dam, which was estimated. During this time about 2 second-feet was turned out of the first waste gate to furnish a sluice head for operators who were working in the river bed below.

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River and Homestake ditch at intake for 1907–1909—Continued.

Day.	July.				August.				September.			
	River.		Ditch.		River.		Ditch.		River.		Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.												
1	0.61	15.6	0.15	3.1	0.22	5.6	0.40	8.3	0.10	1.2	0.52	11.5
2	.55	11.2	.28	5.6	.03	.3	.18	3.6	.10	1.2	.35	7.2
3	.42	3.7	.29	5.8	.04	.4	.16	3.3	.24	6.8	.49	10.6
4	.41	3.2	.28	5.6	.03	.3	.20	3.9	.23	6.2	.59	13.7
5	.40	2.7	.22	4.3	.03	.3	.41	8.6	.12	1.8	.64	9.3
6	.49	7.2	.14	2.9	.03	.3	.40	8.3	.11	1.5	.31	6.2
7	.48	6.7	.20	3.9	.03	.3	.38	7.8	.16	3.1	.35	7.2
8	.12	1.8	.22	4.3	.19	4.1	......	0	.17	3.4	.20	3.9
9	.10	1.2	.20	3.9	.17	3.4	......	0	.15	2.8	.14	2.9
10	.10	1.2	.20	3.9	.03	.3	.19	3.7	.10	1.2	......	0
11	.09	1.1	.23	4.5	.03	.3	.16	3.3	......	......	......	......
12	.09	1.1	.20	3.9	.90	0	.10	2.3	......	......	......	......
13	.10	1.2	.20	3.9	−.02	0	.08	2.0	......	......	......	......
14	.09	1.1	.18	3.6	−.02	0	.08	2.0	......	......	......	......
15	.09	1.1	.18	3.6	−.02	0	.49	10.6	......	......	......	......
16	.09	1.1	.18	3.6	.00	0	.37	7.6	......	......	......	......
17	.09	1.1	.20	3.9	−.02	0	.22	4.3	......	......	......	......
18	.07	.8	.14	2.9	.00	0	.14	2.9	......	......	......	......
19	.06	.6	.14	2.9	.00	0	.12	2.6	......	......	......	......
20	.06	.6	.12	2.6	.04	.4	.50	10.9	......	......	......	......
21	.08	.9	.14	2.9	.01	.1	.30	6.0	......	......	......	......
22	.07	.8	.12	2.6	.01	.1	.18	3.6	......	......	......	......
23	.07	.8	.12	2.6	.01	.1	.20	3.9	......	......	......	......
24	.06	.6	.10	2.3	.01	.1	.32	6.5	......	......	......	......
25	.05	.5	.10	2.3	.01	.1	.32	6.5	......	......	......	......
26	.04	.4	.10	2.3	.04	.4	.54	12.1	......	......	......	......
27	.05	.5	.12	2.6	.00	0	.32	6.5	......	......	......	......
28	.04	.4	.13	2.8	.05	.5	.17	3.4	......	......	......	......
29	.04	.4	.12	2.6	.05	.5	.13	2.8	......	......	......	......
30	.04	.4	.12	2.6	.04	.4	.08	2.0	......	......	......	......
31	.05	.5	.12	2.6	.05	.5	.12	2.6	......	......	......	......
Mean	......	2.3	......	3.4	......	.61	......	4.9	......	2.9	......	7.3
Mean total	......	5.7	......	......	......	5.5	......	......	......	10.2	......	......
Mean per square mile	......	.13	......	......	......	.125	......	......	......	.23	......	......
Run-off, depth in inches on drainage area	......	.15	......	......	......	.14	......	......	......	.09	......	......

NOTE.—The mean discharge of the river for the period June 27–30 was 32.8 second-feet; that of the ditch for the same period was 7.1 second-feet.

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River and Homestake ditch at intake for 1907–1909—Continued.

[Observer, Frank Dolan.]

Day.	June.		July.				August.				September.			
	River.		River.		Ditch.		River.		Ditch.		River.		Ditch.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.														
1				45			0.38	2.9			0.36	3.9	0.30	5.3
2				35			.38	2.9			.38	4.8	.42	8.1
3				30			.38	2.9			.40	5.7	.19	3.3
4				22			.78	34.0	0.35	6.4	.35	3.5	.15	2.7
5				18			.51	8.4	.40	7.6	.36	3.9	.15	2.7
6				17			.41	3.8	.15	2.7	.36	3.9	.05	1.4
7				15			.38	2.9			.34	3.2		
8				12			.38	2.9				3.0		
9			0.46	6.0	0.27	4.7	1.12	93.0	.75	18.9	.33	2.9		
10			.42	4.3	.20	3.4	.78	39.0	.81	22.0	.33	2.9		
11				7.0			.44	7.9	.72	17.6		3.0		
12				6.0			.39	5.3	.39	7.4		3.1		
13				5.0			.38	4.8	.17	3.0		3.2		
14				5.0			.36	3.9	.12	2.3		3.3		
15				5.0			.38	4.8			.35	3.5	.25	4.4
16				4.0			.38	4.8			.38	4.8	.15	2.7
17				4.0			.38	4.8						
18				4.0			.38	4.8						
19				4.0			.36	3.9						
20		120		3.5			.36	3.9						
21		150		3.5			.36	3.9						
22		85		3.5			.36	3.9						
23		70	.40	3.4			.36	3.9						
24		50	.38	2.9			.36	3.9						
25		45	.38	2.9			.36	3.9						
26		40	.38	2.9			.36	3.9						
27		40	.38	2.9			.36	3.9						
28		40	.38	2.9			.36	3.9						
29		36	.38	2.9			.40	5.7						
30		40	.38	2.9			.40	5.7						
31			.38	2.9			.40	5.7						
Mean		65.1		9.21	.26			9.35		2.84		3.66		1.91
Mean total		65.1		9.47				12.2				5.57		
Mean per square mile		1.48		.215				.277				.127		
Run-off, depth in inches on drainage area		.61		.24				.32				.08		

NOTE.—Discharges for June 20 to July 8, 1909, have been estimated from the records on Kougarok River below Henry Creek and above Coarse Gold Creek. They are only approximate, on account of daily fluctuations, but are included in order to furnish data for comparison with other stations.

KOUGAROK RIVER BELOW HENRY CREEK.

This station was established June 29, 1909, by C. T. Law, engineer for the Taylor Creek Ditch Co., and the gage readings and most of the measurements were furnished by him. Two gages were used, the one originally installed being influenced by backwater on July 29 from a mining dam which was built just below. Inasmuch as the new gage was not established until August 13, the intervening records are only approximate. The low-water data are uncertain, on account of water being stored in the lower ends of ditches for intermittent sluicing during the dry periods, a condition which produced a very irregular flow in the river at this point. The gage was read only twice a day, and the recorded mean gage height may vary considerably from the actual mean gage height. A minimum discharge of 7 second-feet occurred during the week August 22 to 28.

Discharge measurements of Kougarok River below Henry Creek in 1909.

[Elevation, 410 feet.]

Date.	Hydrographer.	Gage height.	Discharge.	Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
July 4[a]	C. T. Law	1.11	128.0	Aug. 13	C. T. Law	0.70	34.0
July 8[a]	....do	.77	54.0	Aug. 19	....do	.54	8.7
July 18[a]	....do	.50	21.0	Aug. 29	....do	.52	9.8
July 22	F. F. Henshaw	.37	9.4	Aug. 31	G. L. Parker	.62	21.0
July 24	....do	.42	10.7	Sept. 18	C. T. Law	.85	57.0

[a] Measured by floats.

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River below Henry Creek for 1909.

[Drainage area, 225 square miles; observer, C. B. Atwater.]

Day	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	1.10	125	0.57	9	0.64	24	21	0.40	10	0.50	8		
2	1.12	130	.57	9	.70	33	22	.38	9	.49	8		
3	.95	91	.57	9	.69	32	23	.40	10	.48	7		
4	1.04	111	.66	18	.66	27	24	.40	10	.48	7		
5	.95	91	.86	48	.61	20	25	.37	9	.48	7		
6	.92	84	.74	27	.64	24	26	.34	8	.47	6		
7	.88	76	.68	20	.60	18	27	.36	8	.48	7		
8	.78	56	.60	12	.59	17	28	.37	9	.48	7		
9	.76	53	.82	40	.59	17	29	.57	9	.52	10		
10	.83	66	1.28	113	.59	17	30	.57	9	.58	16		
							31	.57	9	.62	21		
11	.74	49	1.18	83	.58	16							
12	.71	44	.96	35	.58	16	Mean		40.3		21.8		28.2
13	.66	36	.95	33	.57	14							
14	.58	26	.67	28	.62	21							
15	.58	26	.60	18	.83	54	Mean per square mile		.179		.097		.125
16	.54	21	.58	16	.87	61							
17	.50	17	.58	16	.79	47							
18	.50	17	.57	14	.80	49							
19	.48	16	.56	13			Run-off, depth in inches on drainage area		.21		.11		.08
20	.46	14	.53	10									

NOTE.—Discharge during the interval July 29–Aug. 13 is only approximate. The mean discharge for June 29–30 was 146 second-feet.

KOUGAROK RIVER ABOVE COARSE GOLD CREEK.

Between the mouths of Taylor Creek and North Fork Kougarok River has a meandering course, with well-marked benches along most of the distance. At the mouth of Coarse Gold Creek it makes a bend which brings two points that are more than 2 miles apart by the river within 560 feet of each other in a straight line. A tunnel through this neck would drain the gravels in the bend and make them accessible for working. If it were not that the run-off at this locality is very small, it would furnish a fair power site. The difference in level of the water surface at the two points is about 17 feet, and an outcrop of rock which crosses the river just below the proposed tunnel intake would make a fairly good dam site.

A gaging station was established above the bend July 15, 1907, and readings were made during the remainder of the season. In 1908 and 1909 no one was available to make the readings at this point, so a gage was established near the roadhouse 200 or 300 feet above the mouth of Coarse Gold Creek. Conditions at this location were not so permanent as at the upper gage, and, as fewer measurements were obtained, the results are not nearly as good as those for 1907. The station was discontinued July 31, 1909, in favor of the station below Henry Creek, which gives practically the same record. The highest discharge recorded was 1,240 second-feet on September 10, 1907, when the gage height was estimated from high-water marks, as the observer was absent. Very much higher floods are known to have occurred on the river. The minimum discharge at the end of July, 1909, was 9 second-feet, and the river may have reached a still lower stage in September.

The discharge at this station gives the flow past the intake of the tunnel and also the amount of water that could be diverted by a low-line ditch to Dahl Creek. Such a ditch is proposed, and if built, will have its intake on Kougarok River below Dreamy Gulch and on Henry Creek near the mouth. It will extend to Dahl and Coffee creeks, more than 30 miles. Only a small percentage of the water enters the river between these proposed intakes and the gaging station.

Discharge measurements of Kougarok River above Coarse Gold Creek from 1907 to 1909.

[Elevation, 341 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 14	1.11	89	June 26	1.38	302
July 21	.86	51	July 25	.15	9.9
July 23	.74	36			
July 30	.64	33	1909.		
Aug. 8	.44	18.9	June 20	2.77	453
Aug. 14	.40	16.7	July 21	1.26	11.2
Aug. 23	2.22	460	July 21	1.27	10.4
Aug. 26	1.95	323	July 24	1.26	9.8
			Aug. 31	1.36	20

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River above Coarse Gold Creek for 1907–1909.

[Drainage area, 254 square miles. Observers, C. Ellis, 1907; Charles Brooks and J. Turner, 1908–9.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.						
1			0.70	35		210
2			.63	31		230
3			.60	29		205
4			.63	31		280
5			.60	29		500
6			.57	27	2.15	430
7			.50	23	2.10	400
8			.46	21	1.80	270
9			.38	16		600
10			.38	16	3.50	1,240
11			.38	16		550
12			.37	16		350
13			.39	17	1.80	270
14	1.09	86	.40	17	2.23	478
15	1.03	75	.40	17		600
16	.98	67	.43	19		380
17	.90	54	.50	23		270
18	.94	60	1.03	75		200
19	.90	54	1.12	92		160
20	.84	47	1.08	84		130
21	0.82	45	1.68	229		
22	.82	45	2.25	490		
23	.75	39	2.22	472		
24	1.14	96	2.19	454		
25	1.58	200	2.22	472		
26	1.20	109	1.99	341		
27	1.06	81		280		
28	.83	46		240		
29	.70	35		210		
30	.66	33		360		
31	.72	37		190		
Mean		67.2		141		388
Mean per square mile		.26		.56		1.53
Run-off, depth in inches on drainage area		.17		.65		1.14

NOTE.—Discharges for days when gage was not read were estimated with the aid of a hydrograph.

Day.	1908								1909			
	June.		July.		August.		September.		June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.85	96	0.45	36	0.58	51			2.3	250
2			.75	76	.42	32	.58	51			2.1	180
3			.56	49	.38	28	.62	57			2.1	180
4			.56	49	.42	32	.68	65			2.1	180
5			.56	49	.45	36	.62	57			2.1	180
6			.52	44	.60	54	.52	44			2.05	164
7			.50	41	.62	57	.42	32			2.0	147
8			.45	36	.48	39	.35	26			1.9	119
9			.42	32	.45	36	.38	28			1.75	83
10			.35	26	.40	30	.30	21			1.7	73
11			.40	30	.38	28	.22	15			1.6	55
12			.42	32	.35	26	.20	13			1.55	47
13			.35	26	.40	30						42
14			.30	21	.32	23						32
15			.32	23	.35	26						26
16			.25	17	.40	30						23
17			.42	32	.38	28					1.35	20
18			.38	28	.35	26					1.3	14
19			.32	23	.35	26						14
20			.32	23	.32	23			2.8	470	1.3	14
21			.32	23	.38	28				400		13
22			.28	19	.52	44				330		11
23			.35	26	.48	39				270	1.25	10
24			.30	21	.40	30			2.15	197		10
25			.22	15	.32	23				188		10

Daily gage height, in feet, and discharge, in second-feet, of Kougarok River above Coarse Gold Creek for 1907-1909—Continued.

Day.	1908								1909			
	June.		July.		August.		September.		June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
26	1.36	285	0.25	17	0.40	30			2.1	180		9
27	1.05	150	.20	13	.45	36			2.1	180		9
28	1.10	166	.20	13	.42	32			2.1	180		9
29	.92	112	.25	17	.32	23			2.1	180		9
30	.85	96	.30	21	.38	28			2.15	197		9
31			.38	28	.45	36						9
Mean		162		31.2		32.1		38.3		252		62.9
Mean per square mile		.64		.12		.13		.15		.992		.248
Run-off, depth in inches on drainage area		.12		.14		.15		.07		.41		.29

TAYLOR CREEK AT CASCADE INTAKE.

Taylor Creek is the longest tributary of Kougarok River and is larger than the main stream at their junction. It rises near the headwaters of Noxapaga and Goodhope rivers and flows in a southwesterly direction. Its principal tributaries are Midnight, Solomon, Jim, Brown, Rock, and Arizona creeks. Two ditches have been built on Taylor Creek—the North Star, with its intake about 3 miles above Solomon Creek, and the Cascade, which diverts water about 5 miles farther downstream.

A gaging station, established at the Cascade intake July 17, 1907, to determine the total water supply available for the two ditches, is located about 100 yards above the diversion dam of the lower ditch. During August and September a part of the discharge of the creek was diverted past the station in the North Star ditch, and this amount has been added to give the total flow of the creek.

Discharge measurements of Taylor Creek at Cascade intake in 1907.

[Elevation, 580 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 17	0.67	16.0	Aug. 10	0.49	4.6
July 24	1.65	185	Aug. 21	1.95	268
July 26	.93	43	Aug. 24	1.30	91

Daily gage height, in feet, and discharge, in second-feet, of Taylor Creek at Cascade intake for 1907.

[Drainage area, 73.4 square miles. Observer, Percy Baldwin.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1				7	1.12	67	21		13	1.60	164		
2				7	1.24	87	22		12	1.48	136		
3				7	1.15	72	23		10	1.38	114		
4				6	1.25	89	24	1.65	186	1.25	89		
5				6	1.55	152	25		80	1.65	178		
6				6	1.36	110	26	.93	43		147		
7				5	1.25	89	27		25	1.39	116		
8				5	1.00	50	28		13		98		
9				4.6	1.24	87	29		8	1.20	80		
10			0.49	4.6	2.40	430	30		8	1.65	178		
11				4	1.80	220	31		8	1.20	80		
12				4	1.45	129	Mean		29.9		52.2		111
13			.31	2.5	1.30	98	North Star ditch mean		.0		2.0		8.0
14			.42	3.9	1.15	72							
15		20	.47	4.6	1.60	164	Mean total		29.9		54.2		119
16		18	.50	5.0	1.30	98	Mean per square mile		.407		.738		1.62
17	0.67	16	.57	9.2	1.15	72							
18		20	.84	32	1.00	50	Run-off, depth in inches on drainage area		.26		.85		1.20
19		15	1.15	72		45							
20		13	.95	44		35							

NOTE.—Discharges for days on which the gage was not read were obtained by the aid of a hydrograph.

HENRY CREEK AT MOUTH.

Henry Creek, which enters Kougarok River about 2 miles below the mouth of Taylor Creek, is the largest tributary from the west and in dry weather furnishes the steadiest high-level water supply in the Kougarok drainage area. Its headwaters lie south of the upper Kougarok River and adjoin those of Budd Creek on the west. Lincoln Creek, which rises between Henry and Coarse Gold creeks, is the most important tributary. Lillian Creek enters from the north, about 4 miles from the mouth.

The Henry Creek ditch, which was built by the T. T. Lane Co. in 1905 and 1906, extends from Henry Creek about 2 miles above the mouth of Lincoln Creek to a point near the mouth of Homestake Creek and has a total length of 10¼ miles. An additional 3¼ miles would divert Lincoln Creek. No water was running in the ditch between 1907 and 1909. In 1910 from 1 to 5 second-feet was used from the ditch for hydraulicking during most of the season. It is now the property of the Taylor Creek Ditch Co.

Measurements were made at the ditch intakes and also at the mouth. The total flow at ditch level on the dates when it was measured was about 70 per cent of that at the mouth, and it has been estimated as the same proportion for days when measurements were made only at the mouth.

Discharge measurements of Henry and Lincoln creeks, 1907.

Date.	Henry Creek at mouth.	At ditch level.		
		Henry Creek.	Lincoln Creek.	Total.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
July 16		10.0	8.2	18.2
July 25	22.0	7.4	8.0	15.4
July 30	9.6			6.8
Aug. 9	8.2			5.7
Aug. 13	6.8	2.7	2.3	5.0
Aug. 20	12.0	5.0	3.3	8.3
Aug. 23	60			42
Aug. 26	34			24
Aug. 29	27			19
Sept. 6	55			38
Sept. 12	99	41	42	83

NOTE.—Measurements of the amount of water available for the Henry Creek ditch from Lillian Creek are given in the list of miscellaneous measurements on page 220.

A gaging station was established at the mouth of Henry Creek on June 21, 1908, and readings have been kept during each succeeding summer. The channel is fairly permanent and the rating curve is well defined. (See fig. 8, p. 58.) Measuring conditions are good, and the records are reliable with the exception of those for 1910, which are somewhat uncertain, because no measurements were made. The highest recorded discharge was 449 second-feet, September 6, 1910; the lowest was 1.7 second-feet on September 12 and 13, 1909.

Discharge measurements of Henry Creek at mouth in 1908 and 1909.

[Elevation, 410 feet.]

Date.	Hydrographer.	Gage height.	Discharge.	Date.	Hydrographer.	Gage height.	Discharge.
1908.		*Feet.*	*Sec.-ft.*	1909.		*Feet.*	*Sec.-ft.*
June 28	Henshaw and Barrows	0.70	64	June 21	G. L. Parker	1.52	284
July 3	A. T. Barrows	.45	25	June 22	do	.89	78
July 25	do	.05	4.0	July 22	F. F. Henshaw	.13	4.1
1909.				Do	do	.13	3.7
June 21	F. F. Henshaw	1.05	127	Aug. 13	C. T. Law	.23	7.0
				Do	do	.23	6.0
				Aug. 31	G. L. Parker	.08	2.4

Daily gage height, in feet, and discharge, in second-feet, of Henry Creek at mouth for 1908-1910.

[Drainage area, 51 square miles. Observers, James B. McGilvrey, 1908; C. B. Atwater, 1909; C. T. Law, 1910.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1				43	0.28	13.0	0.20	9.2
2			0.54	37	.13	6.4	.28	13.0
3			.46	27	.10	5.3		12.5
4			.46	27	.16	7.5	.26	12.0
5			.38	19.5	.30	14.0		11.0
6			.34	16.6	.37	18.7		10.0
7			.32	15.3	.36	18.0		9.0
8			.28	13.0	.36	18.0	.17	7.9
9			.27	12.5	.21	9.7		6.6
10			.25	11.5	.13	6.4		5.3
11			.28	13.0	.10	5.3	.05	4.0
12				12.2		5.3		
13			.25	11.5	.10	5.3		
14				10.4		6.0		
15			.20	9.2	.13	6.4		
16			.18	8.4		5.9		
17			.18	8.4		5.4		
18				7.4		4.9		
19			.13	6.4	.06	4.3		
20			.13	6.4	.20	9.2		
21			.15	7.1		8.6		
22			.11	5.7		8.1		
23			.10	5.3	.16	7.5		
24			.07	4.5	.20	9.2		
25				4.3		9.0		
26				4.1		8.8		
27	1.00	138	.05	4.0	.18	8.4		
28	.70	62		3.9	.15	7.1		
29		56		3.7	.11	5.7		
30		50	.03	3.5	.08	4.8		
31			.11	5.7		7.0		
Mean		73.7		11.9		8.4		9.1
Mean per square mile		1.45		.233		.165		.178
Run-off, depth in inches on drainage area		.22		.27		.19		.07
1909.								
1			0.70	46	0.06	2.2	0.10	3.0
2			.64	38	.06	2.2	.10	3.0
3			.57	30	.10	3.0	.10	3.0
4			.60	33	.26	7.9	.09	2.8
5			.54	27	.30	9.3	.09	2.8
6			.54	27	.19	5.5	.10	3.0
7			.46	19.8	.12	3.6	.08	2.6
8			.40	15.0	.09	2.8	.06	2.2
9			.44	18.2	.46	19.8	.06	2.2
10			.42	16.6	.58	31	.06	2.2
11			.38	13.9	.43	17.4	.05	2.0
12			.36	12.7	.36	12.7	.04	1.7
13			.29	9.0	.26	7.9	.04	1.7
14			.28	8.6	.20	5.8	.10	3.0
15			.26	7.9	.16	4.7	.12	3.6
16			.20	5.8	.14	4.1	.12	3.6
17			.20	5.8	.12	3.6	.11	3.3
18			.20	5.8	.10	3.0	.10	3.0
19			.19	5.5	.08	2.6		
20			.18	5.2	.08	2.6		
21	1.26	188	.15	4.4	.07	2.4		
22	1.01	109	.13	3.8	.06	2.2		
23		84	.15	4.4	.06	2.2		
24	.78	59	.15	4.4	.05	2.0		
25	.70	46	.10	3.0	.05	2.0		
26	.70	46	.08	2.6	.04	1.7		
27	.74	52	.10	3.0	.04	1.7		
28	.76	56	.10	3.0	.04	1.7		
29	.70	46	.08	2.6	.06	2.2		
30	.70	46	.08	2.6	.09	2.8		
31			.07	2.4	.08	2.6		
Mean		73.2		12.5		5.65		2.71
Mean per square mile		1.44		.245		.111		.053
Run-off, depth in inches on drainage area		.54		.28		.13		.04

Daily gage height, in feet, and discharge, in second-feet, of Henry Creek at mouth for 1908–1910—Continued.

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1910.							1910.						
1			0.32	16		155	21	1.60	323	0.40	20		
2			.32	16	1.65	342	22	.88	82	.35	17		
3			.40	20	1.15	166	23	.58	34	.35	17		
4			.38	19	.80	65	24	.59	35	.45	23		
5	1.10	145	.28	14	.70	48	25	.88	82	.60	37		
6	1.05	128	.28	14	1.95	449	26	.70	48	.55	32		
7	1.03	121	.25	13	1.70	359	27	.55	31	.40	20		
8	.87	76	.28	14	1.70	359	28	.60	36	.40	20		
9	.77	56	.32	16	1.25	200	29	.55	31	.35	17		
10	.70	45	.35	17	.75	56	30	.45	22	.30	15		
							31	.39	18	.30	15		
11	.82	65	.35	17	.80	64							
12	.80	61	.30	15	.85	75	Mean.		72.7		24.9		160
13	.83	68	.30	15	.80	64	Mean per square mile		1.43		.49		3.14
14	.73	50	.30	15	.75	56							
15	.70	46	.72	52	.72	51							
16	.65	42	.80	65	.70	48	Run-off, depth in inches on drainage area		1.44		.56		1.87
17	.60	36	.90	87									
18	.91	89	.70	49									
19	.56	32	.60	37									
20	1.14	162	.50	27									

NOTE.—The estimated discharge of the Henry Creek ditch was added to the discharge corresponding to the gage height for each day to determine the natural flow. As no measurements were made in 1910, the 1909 rating was used on the assumption that channel conditions remained the same throughout the two seasons.

COARSE GOLD CREEK NEAR MOUTH.

Coarse Gold Creek rises opposite the headwaters of Marys River, flows in a northeasterly direction for about 16 miles, and enters Kougarok River just below the big bend previously mentioned. The upper portion of the creek is relatively flat, the lower portion has a grade of 40 to 80 feet to the mile.

The Galvin ditch, constructed in 1907, has its intake about 5 miles above the mouth and is built along the south slope of the valley, picking up the flow of Jones Gulch and Nugget Gulch. It extends about 5 miles to Twobit Gulch, a small tributary of Kougarok River, where a head of nearly 300 feet is obtained.

Miscellaneous measurements were made in 1907 and 1908, and in 1909 a station was established and gage readings obtained. Records at this point show the water available for the ditch, as practically the whole flow can be diverted. On account of poor measuring conditions and a considerable shift in the channel only approximate results were obtained.

A minimum discharge of 0.9 second-feet occurred for the week July 21 to 27, 1909.

Discharge measurements of Coarse Gold Creek near mouth in 1907–1909.

[Elevation, 341 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1908.	*Feet.*	*Sec.-ft.*
July 21		7.8	June 26		30
Aug. 12		3.0	June 28		35
Aug. 23		44	July 26		1.4
Aug. 26		29			
Aug. 28		30	1909.		
Sept. 6		29	June 20	1.12	50
Sept. 8		22	....do	1.34	76
Sept. 15		156	July 21	.28	.9
			Aug. 31	.30	.8

Daily gage height, in feet, and discharge, in second-feet, of Coarse Gold Creek near mouth for 1909.

[Drainage area, 34 square miles. Observer, Chas. Graf.]

Date.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1					0.30	1.3	0.34	1.7
2					.30	1.3	.32	1.2
3					.32	1.7	.32	1.2
4					.34	2.1	.32	1.2
5					.37	2.8	.33	1.5
6					.36	2.5	.32	1.2
7					.36	2.5	.31	1.0
8					.36	2.5	.31	1.0
9					.43	4.4	.30	.8
10					.44	4.7	.30	.8
11					.46	5.3	.30	.8
12					.51	7.0	.30	.8
13					.49	6.0	.31	1.0
14					.48	5.6	.55	8.0
15					.47	5.3		
16					.46	4.9		
17					.44	4.3		
18					.41	3.5		
19					.40	3.2		
20	1.23	61			.39	2.9		
21	1.00	37	0.28	.9	.39	2.9		
22	.76	19		.9	.38	2.7		
23	.58	9.7		.9	.38	2.7		
24	.49	6.3	.27	.8	.39	2.9		
25	.59	10.1	.30	1.3	.40	3.2		
26	.88	27	.28	.9	.40	3.2		
27	1.02	39	.28	.9	.42	3.8		
28		40	.29	1.1	.44	4.3		
29		30	.30	1.3	.46	4.9		
30		30	.28	.9	.34	1.7		
31			.29	1.1	.30	.8		
Mean		28.1		1.0		3.4		1.6
Mean per square mile				.03		.10		.05
Run-off, depth in inches on drainage area				.01		.12		.03

NOTE.—About 6 second-feet of water was diverted into the Galvin ditch June 20–30. This amount is not included in the discharges given above. There was also a small amount of water running in the ditch August 9–12.

NORTH FORK ABOVE EUREKA CREEK.

North Fork is formed by the junction of French and Alder creeks and enters Kougarok River from the east about a mile below the mouth of Coarse Gold Creek. Its principal tributaries are Harris, Baldy, Monument, Queen, Magnet, and Eureka creeks. Harris Creek is dry during low water for the lower 4 miles, as the water flows underground through the limestone which forms its bed. On the upper portion of North Fork the water also flows underground at low stages and comes to the surface in the form of a spring about a mile above the mouth of Harris Creek.

In 1906 the Northwestern Development Co. began a ditch which has its intake just below the junction of French and Alder creeks, extends along the north bank about 3 miles, and then crosses in a siphon to the south bank. Six miles of ditch is completed.

Miscellaneous measurements were made above Eureka Creek in 1907, and on June 29, 1908, a regular gaging station was established there. Readings were obtained during the next two seasons and the records are good, except during a short period in July, 1909, when the gage was affected by backwater from a mining dam. A new gage was set farther up stream on July 22, 1909. As no high-water measurements were obtained after this date the maximum discharges for the later part of 1909 are uncertain.

The lowest recorded discharge for one week is 7.9 second-feet, July 24 to 30, 1908. No extreme high water was recorded.

Discharge measurements of North Fork above Eureka Creek, 1907 to 1909.

[Elevation, 370 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 22		13	June 20	1.48	102
Aug. 15		9.6	July 22	[a] .70	[b] 9.0
Aug. 27		103	Do	[a] .70	[c] 9.0
Sept. 7		70			
Sept. 15		122			
1908.					
June 29	1.25	37			
July 2	1.15	26			
July 25	.67	7.9			

[a] The gage was reset July 22 at a different section. The reading of the old gage was estimated at 0.64 for this stage.
[b] Measured above Eureka Creek.
[c] Measured below Eureka Creek. The discharge of Eureka Creek was negligible.

Daily gage height, in feet, and discharge, in second-feet, of North Fork above Eureka Creek for 1908–9.

[Drainage area, 66 square miles Observer, A. Martell.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.						
1	0.70	8.4	0.68	8.1	0.72	8.8
2	1.35	50	.66	7.8	.72	8.8
3	1.30	43	.68	7.8	.71	8.6
4	1.25	37	.70	8.4	.70	8.4
5	1.25	37	.72	8.8	.70	8.4
6	1.25	37	.85	11.6	.70	8.4
7	1.13	25	.84	11.4	.70	8.4
8	.95	15.0	.80	10.3	.70	8.4
9	.88	12.5	.77	9.7	.68	8.1
10	.88	12.5	.78	9.9		
11	.85	11.6	.77	9.7		
12	.80	10.3	.78	9.9		
13	.80	10.3	.74	9.2		
14	.80	10.3	.70	8.4		
15	.80	10.3	.68	8.1		
16	.75	9.4	.68	8.1		
17	.74	9.2	.68	8.1		
18	.76	9.5	.68	8.1		
19	.70	8.4	.68	8.1		
20	.70	8.4	.68	8.1		
21	.70	8.4	.67	7.9		
22	.70	8.4	.68	8.1		
23	.70	8.4	.70	8.4		
24	.70	8.4	.70	8.4		
25	.67	7.9	.68	8.1		
26	.66	7.8	.68	8.1		
27	.66	7.8	.68	8.1		
28	.66	7.8	.67	7.9		
29	.65	7.6	.67	7.9		
30	.68	8.1	.66	7.8		
31	.71	8.6	.73	9.0		
Mean		15.0		8.7		8.5
Mean per square mile		.23		.13		.13
Run-off, depth in inches on drainage area		.27		.15		.04

NOTE.—The mean discharge for June 29–30 was 23.4 second-feet.

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1909.								
1			0.96	21	0.67	8.4	0.72	9.5
2			.90	17.1	.67	8.4	.72	9.5
3			.91	17.7	.68	8.6	.72	9.5
4			.87	15.9	.68	8.6	.72	9.5
5			.84	14.6	.67	8.4	.73	9.7
6			.81	13.4	.67	8.4	.72	9.5
7			.78	12.5	.67	8.4	.71	9.2
8			.76	11.9	.68	8.6	.71	9.2
9			.74	11.4	.74	9.9	.70	9.0
10			.77	12.2	1.30	47	.70	9.0
11			.74	11.4	1.45	78	.70	9.0
12			.74	11.4	.92	15.4	.70	9.0
13			.72	10.8	.90	14.5	.69	8.8
14			.68	9.8	.86	13.2		
15			.68	9.8	.82	11.9		
16			.66	9.4	.80	11.3		
17			.66	9.4	.80	11.3		
18			.66	9.4	.78	10.8		
19				9.3	.77	10.6		
20	1.60	120		9.2	.75	10.2		
21	1.58	115		9.1	.76	10.4		
22	1.28	55	a.70	9.0	.74	9.9		
23	1.15	36	.70	9.0	.72	9.5		
24	1.11	32	.69	8.8	.71	9.2		
25	1.02	25	.70	9.0	.71	9.2		
26	1.01	24	.70	9.0	.71	9.2		
27	1.01	24	.70	9.0	.71	9.2		
28	1.01	24	.69	8.8	.73	9.7		
29	1.02	25	.68	8.6	.73	9.7		
30	.96	21	.67	8.4	.72	9.5		
31			.67	8.4	.71	9.2		
Mean		45.5		11.1		13.4		9.26
Mean per square mile		.690		.168		.203		.140
Run-off, depth in inches on drainage area		.28		.19		.23		.07

a A new gage was set farther upstream to avoid the effect of back-water from a mining dam.

DITCHES.

HOMESTAKE DITCH AT PENSTOCK.

The Homestake ditch of the Kugarok Mining & Ditch Co. was begun in 1905 and completed in 1907. It diverts the water from the upper Kougarok, near Mascot Gulch, and extends along the left bank of the river to a point opposite the mouth of Homestake Creek, having a total length of 7½ miles. The water is carried across Macklin Creek in a siphon 843 feet long, of 36 and 34 inch pipe.

Above Macklin Creek the ditch is built into the rocky bluffs of close-grained schists and slates for about 1 mile. Below the siphon some ground ice was encountered, as well as a large amount of loose rock mixed with ice and frozen muck, which gave much trouble. Nearly half the length of the ditch had to be lined with sod, some parts requiring both sides and bottom of this material. In 1907 a lateral ditch was built to Macklin Creek. It is 6,300 feet long and 4 feet wide on the bottom.

The water was used during the latter part of 1906 in the bed of the river just above Taylor Creek. A waste ditch was formed by a retaining wall built on one side of the channel, but at times this was overtopped and the workings flooded. The discharge of the river at such times is estimated at 600 to 800 second-feet.

During the season of 1907 the water was used on the John L. bench claim, on the right bank of the river below Homestake Creek. A head of about 150 feet is available on this claim. In 1908 and 1909 only a small amount of work was done, owing to lack of water.

A gaging station was maintained above the penstock during a portion of 1907 to determine the amount of water used at the mine. The gage was located about half a mile above the penstock, above the backwater caused by shutting off the water at the mine, which caused the water to overflow the weir and run out at the lower end of the ditch. No record was kept in 1908 or 1909, because of the small amount of water delivered.

Discharge measurements of Homestake ditch above penstock in 1907.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 20		5.5	Aug. 22	1.47	15.0
July 29		2.2	Aug. 26	1.60	17.9
Aug. 21	1.19	9.1	Sept. 11	1.74	21
Do	1.49	15.6			

Daily gage height, in feet, and discharge, in second-feet, of Homestake ditch above penstock for 1907.

[Observer, John Watson.]

Day.	August.		September.		Day.	August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			1.76	21.5	16			1.74	21.1
2			1.70	20.2	17			1.76	21.5
3			1.62	18.4	18			1.76	21.5
4			1.75	21.3	19			1.68	17.8
5			1.54	16.7	20			1.15	8.4
6			1.70	20.2	21	1.34	12.3		
7			1.70	20.2	22	1.48	15.4		
8			1.70	20.2	23	1.54	16.7		
9			1.72	20.6	24	1.54	16.7		
10			1.52	16.2	25	1.60	18.0		
11			1.74	21.1	26	1.60	18.0		
12			1.75	21.3	27	1.56	17.1		
13			1.76	21.5	28	1.58	17.6		
14			1.76	21.5	29	1.58	17.6		
15			1.76	21.5	30	1.68	19.8		
					31	1.70	20.2		
					Mean		17.2		19.6

NORTH STAR DITCH ABOVE SIPHON.

The North Star ditch of the Taylor Creek Ditch Co. was begun in 1905 and completed in 1907. It diverts water from Taylor Creek about 12 miles above its mouth and about 3 miles above the mouth of Solomon Creek. The ditch lies on the left bank for the first mile, then crosses the creek in a flume and continues on the right bank to a point 7 miles below the intake. Here it crosses Taylor Creek in a siphon 2,600 feet long, which is described more fully on page 262. Below the siphon the ditch receives the flow of Rock Creek and continues to Arctic Creek, having a total length of 15.2 miles.

Water was turned into the ditch at the intake about August 5, but was not run through the siphon until about the 20th. The water was used on the Thorson bench, on the left bank of Kougarok River, and for stripping on Dreamy Gulch, a small tributary from the east.

The station above the siphon was established August 21, 1907, to determine the amount of water diverted past the gage at the Cascade intake. The quantity used at the mines includes in addition the discharge of Rock Creek.

Discharge measurements of North Star ditch above siphon in 1907.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Aug. 10		[a]2.9	Sept. 5	1.14	7.1
Aug. 21	1.05	5.0	Sept. 13	1.24	9.7
Aug. 24	.50	0.0	Do		[a]7.9

[a] Measured at intake.

Daily gage height, in feet, and discharge, in second-feet, of North Star ditch above siphon for 1907.

[Observer, employee of Taylor Creek Ditch Co.]

Day.	August.		September.		Day.	August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			1.21	8.8	16			1.28	11.3
2			1.16	7.5	17			1.22	9.2
3			1.11	6.2	18			1.22	9.2
4			1.16	7.5	19				
5			1.18	8.0	20				
6			1.17	7.8	21	1.05	5.2		
7			1.18	8.0	22	1.04	5.0		
8			1.14	7.0	23	1.09	5.8		
9			1.14	7.0	24		.0		
10			1.28	11.3	25	1.18	8.0		
11			1.30	12.0	26	1.14	7.0		
12			1.22	9.2	27	1.05	5.2		
13		[a]1.5	1.25	10.2	28	1.15	7.2		
14			1.24	9.9	29	1.18	8.0		
15			1.30	12.0	30	1.14	7.0		
					31	1.16	7.5		
					Mean		6.0		9.0

[a] Estimated.

CASCADE DITCH.

The Cascade ditch was built in 1906. It diverts water from Taylor Creek about 7 miles above its mouth and 110 feet lower than the North Star ditch. For the first quarter of a mile the ditch lies on the left bank of the creek; it then crosses to the right bank in a flume about 60 feet long, and extends within half a mile of the mouth of Taylor Creek, having a total length of 6¼ miles. The flow of the ditch was very irregular during 1907, on account of breaks, repairs, and interruption of work at the mine. The water was used to run a hydraulic elevator in the bed of Taylor Creek. The water supply of the ditch was insufficient for this purpose during the first two weeks of August, and the pit was flooded on account of insufficient wasteway capacity most of the time after August 20.

A list of measurements of the discharge of the ditch is given on page 221.

MISCELLANEOUS MEASUREMENTS.

The following pages contain a list of miscellaneous measurements made in the Kougarok River drainage basin:

Miscellaneous measurements in Kougarok River basin from 1907 to 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
July 27, 1907	Kougarok River...	Kuzitrin River...	Below Washington Creek.	860	4.5	16.7	0.27
Aug. 12, 1907	.....do............	.....do...........	.....do.............	860	2.2	16.7	.13
Sept. 9, 1907	.....do............	.....do...........	.....do.............	860	122	16.7	7.30
July 26, 1907	.....do............	.....do...........	Above Taylor Creek.	433	18.5	81	.23
July 29, 1907	.....do............	.....do...........	.....do.............	433	8.0	81	.099
Aug. 10, 1907	.....do............	.....do...........	.....do.............	433	5.1	81	.063
July 24, 1909	.....do............	.....do...........	.....do.............	433	4.0	81	.049
July 25, 1908	.....do............	.....do...........	Below Coarse Gold Creek.	341	11.3	288	.039
Aug. 12, 1907	Washington Creek.	Kougarok River.	At mouth...........	860	.13	6.3	.021
Sept. 9, 1907	.....do............	.....do...........	.....do.............	860	40	6.3	6.35
July 27, 1907	Columbia Creek...	.....do...........	Near mouth.........	670	1.5	11.6	.13
Sept. 9, 1907	.....do............	.....do...........	.....do.............	670	19.0	11.6	1.64
Aug. 19, 1907	Macklin Creek.....	.....do...........	Above intake.......	610	5.5	8.9	.62
Aug. 22, 1907	.....do............	.....do...........	.....do.............	610	18.6	8.9	2.09
Sept. 11, 1907	.....do............	.....do...........	.....do.............	610	20	8.9	2.25
June 27, 1908	.....do............	.....do...........	.....do.............	610	3.8	8.9	.43
Aug. 22, 1907	Homestake Creek..	.....do...........	Near mouth, including ditch.	440	7.0	5.4	1.30
Sept. 6, 1907	.....do............	.....do...........	.....do.............	440	8.7	5.4	1.61
July 17, 1907	Taylor Creek......	.....do...........	At North Star ditch intake.	700	12	58	.21
July 24, 1907	.....do............	.....do...........	.....do.............	700	174	58	3.00
Aug. 10, 1907	.....do............	.....do...........	.....do.............	700	3.8	58	.066
Sept. 13, 1907	.....do............	.....do...........	.....do.............	700	94	58	1.62
Aug. 30, 1909	.....do............	.....do...........	At North Star ditch siphon, including ditch.	480	8.5	83	.10
July 17, 1907	.....do............	.....do...........	At mouth, including ditches.	433	18.0	90	.20
July 26, 1907	.....do............	.....do...........	.....do.............	433	46	90	.51
July 29, 1907	.....do............	.....do...........	.....do.............	433	9.6	90	.11
Aug. 10, 1907	.....do............	.....do...........	.....do.............	433	7.2	90	.080
July 24, 1909	.....do............	.....do...........	.....do.............	433	2.8	90	.031
Aug. 9, 1909	.....do............	.....do...........	.....do.............	433	6.6	90	.073
Aug. 10, 1909	.....do............	.....do...........	.....do.............	433	103	90	1.14
July 16, 1907	Lillian Creek......	Henry Creek.....	Above Henry Creek ditch.	670	1.0	......	....
Aug. 20, 1907	.....do............	.....do...........	.....do.............	670	.6	......	......
Sept. 12, 1907	.....do............	.....do...........	.....do.............	670	6.0	......	......
July 21, 1907	Arctic Creek.......	Kougarok River..	Near mouth.........	400	.6	6.3	.095
Aug. 26, 1907	.....do............	.....do...........	.....do.............	400	1.5	6.3	.24
Sept. 6, 1907	.....do............	.....do...........	.....do.............	400	3.0	6.3	.48
Aug. 29, 1907	California Creek...	.....do...........	.....do.............	390	1.1	3.9	.28
Do.......	Arizona Creek.....	.....do...........	Near mouth, including ditch.	400	3.3	10	.33
Sept. 8, 1907	.....do............	.....do...........	.....do.............	400	6.2	10	.62
July 21, 1907	Coarse Gold Creek.	.....do...........	Below Jones Gulch..	......	5.6	22	.25
July 30, 1907	.....do............	.....do...........	Below Nugget Gulch	......	3.5	31	.11
Aug. 8, 1907	.....do............	.....do...........	.....do.............	......	3.4	31	.11
Aug. 12, 1907	.....do............	.....do...........	.....do.............	......	3.0	31	.97
July 22, 1907	North Fork........	.....do...........	Below junction of French - Alder Creek.	540	2.5	19.8	1.26
Aug. 15, 1907	.....do............	.....do...........	.....do.............	540	.7	19.8	.035
Aug. 27, 1907	.....do............	.....do...........	.....do.............	540	31	19.8	1.57
Sept. 7, 1907	.....do............	.....do...........	.....do.............	540	17.0	19.8	.86
Aug. 30, 1909	.....do............	.....do...........	.....do.............	540	.7	19.8	.035
July 22, 1907	Harris Creek.......	North Fork......	At Claim 15.........		1.0	11.7	.086
June 20, 1909	Eureka Creek......	.....do...........	Near mouth, including ditch.	370	5.4	3.1	1.74
July 5, 1908	Left Fork..........	Kougarok River..	Near mouth.........	370	1.8	5.4	.33
July 13, 1907	Windy Creek......	.....do...........	Above Anderson Gulch, including ditch.	......	9.0	27	.33
July 31, 1907	.....do............	.....do...........	.....do.............	......	4.8	27	.18
Aug. 8, 1907	.....do............	.....do...........	.....do.............	......	3.0	27	.11
June 25, 1908	.....do............	.....do...........	.....do.............	......	15.2	27	.56
June 29, 1908	.....do............	.....do...........	.....do.............	......	8.5	27	.31
July 24, 1908	.....do............	.....do...........	.....do.............	......	2.1	27	.078
June 19, 1909	.....do............	.....do...........	.....do.............	......	20	27	.74
July 26, 1909	.....do............	.....do...........	.....do.............	......	1.2	27	.044
Sept. 2, 1909	.....do............	.....do...........	.....do.............	......	1.9	27	.070
July 12, 1907	Coffee Creek.......	.....do...........	Below Wonder Gulch.	......	.5	......	....

Miscellaneous discharge measurements of ditches in Kougarok River drainage basin from 1907 to 1909.

Date.	Ditch.	Diverts from—	Locality.	Discharge.
				Sec.-ft.
Sept. 9, 1907	Irving	Kougarok River	At intake	12.4
June 27, 1908	Homestake	do	Above penstock	1.9
Do	do	do	do	5.8
June 28, 1908	do	do	do	8.3
Sept. 10, 1908	do	do	do	.8
Aug. 19, 1907	McMonagle	do	Below intake	3.0
Do	Dolan and McFadden	do	do	2.5
Do	Blocker and Sayle	do	do	3.0
Sept. 11, 1907	do	do	do	4.1
Aug. 19, 1907	Macklin branch	Macklin Creek	do	4.0
Aug. 22, 1907	Okdurok	Homestake Creek	Below pipe line	3.0
Sept. 6, 1907	do	do	do	2.3
Aug. 30, 1909	North Star	Taylor Creek	Below siphon	7.4
Sept. 3, 1909	do	do	do	4.5
Sept. 15, 1909	do	do	do	8.7
Aug. 10, 1907	Cascade	do	Flume near intake	4.4
Aug. 18, 1907	do	do	Near penstock	5.8
Aug. 21, 1907	do	do	do	4.5
Sept. 5, 1907	do	do	do	7.1
Aug. 29, 1907	Arizona Creek	Arizona Creek	Below intake	1.8
Sept. 8, 1907	do	do	do	1.8
June 20, 1909	Galvin	Coarse Gold Creek	Above penstock	5.8
Do	do	do	do	7.6
Do	Eureka Creek	Eureka Creek	Near outlet	1.2
July 31, 1907	Windy Creek	Windy Creek	Above Anderson Gulch	1.8
Aug. 8, 1907	do	do	do	1.0
June 25, 1908	do	do	do	2.1
June 29, 1908	do	do	do	1.5
July 24, 1908	do	do	do	1.3
July 26, 1909	do	do	do	1.0
Sept. 2, 1909	do	do	do	.4

AMERICAN RIVER DRAINAGE BASIN.

American River, the North Fork of the Agiapuk, drains a large area west of the Kougarok basin. Measurements were made only on Budd Creek, the tributary on which the most extensive development work has been done.

Budd Creek rises northwest of Kougarok Mountain and flows southeastward to the mouth of Eldorado Creek, thence southwestward to American River above the forks. The waters of Budd and Eldorado creeks sink into the limestone which forms their beds and after flowing from 2 to 4 miles underground appear as springs. Windy Creek is a large tributary from the south, on which some mining has been done.

In 1907 a ditch was built on the north bank of Budd Creek by the Ottumwa Gold Mining Co. It takes its water just below the spring and extends to a point below the mouth of Windy Creek, a distance of 8 miles. A head of about 160 feet is obtained.

The following measurements were made August 31, when the water was at about as low a stage as it reached during the season, as the rains began later here than in the Kougarok basin:

Budd Creek below spring, drainage area, 58 square miles; discharge, 25 second-feet.

Budd Creek below Windy Creek, drainage area, 108 square miles; discharge, 39 second-feet.

SERPENTINE RIVER DRAINAGE BASIN.

DESCRIPTION.

Serpentine River drains a large area of the Arctic slope of Seward Peninsula lying north of the Kougarok and American River basins. It rises on the western slope of Midnight Mountain and flows in a northwesterly direction for about 45 miles to its mouth, where it empties into Shishmaref Inlet, a large, shallow lagoon lying inside of the barrier beach that fringes the coast. It receives the waters of North and South forks and a number of other small tributaries rising in the divide between the Bering Sea and Arctic Ocean drainage basins. The lower portion of the river meanders across the broad flats which border the Arctic, and it is probable that the river has been named from its tortuous course in this section.

Schlitz Creek with its tributary, Reindeer Creek, forms the true head of the river. A ditch about 8 miles long was surveyed by the Kougarok Mining & Ditch Co., with which it was proposed to divert the flow of these creeks over a divide to the head of Macklin Creek. The low-water flow of the streams, however, proved to be so small that practically no constructive work was done. Hot Springs Creek rises in an area of granite hills north of Midnight Mountain and flows westward into the main stream. Bryan Creek rises in the divide east of Kougarok Mountain and flows northeastward into the Serpentine. Dick Creek, upon which gold has been found in paying quantities, is its principal tributary, and enters from the south. A ditch built by the Pittsburg-Dick Creek Mining Co. in 1906 and 1907 to divert the waters of Bryan Creek extends along the north bank of Dick Creek for about 6½ miles to the mouth of the creek, where a head of 170 feet is obtained. Quartz Creek rises west of Kougarok Mountain and flows northward to the main river. Bismark Creek is a small tributary of Quartz Creek, which rises just east of Kougarok Mountain. In 1907 the Pittsburg-Dick Creek Mining Co. began the construction of a ditch to divert the water from this creek over the divide to Bryan Creek, where it is picked up by the Bryan Creek ditch. This ditch was completed to Bismark Creek in 1908 and a small amount of construction work was done toward Quartz Creek. The Quartz Creek ditch is about 350 feet higher in elevation than the Bryan Creek ditch.

As there are no good maps of the Serpentine River basin, drainage areas and accurate elevations can not be stated for any of the streams. The only gaging station maintained in this basin was on Quartz Creek above Bismark Creek during August, 1907.

QUARTZ CREEK ABOVE BISMARK CREEK.

A gage was established on Quartz Creek July 28, 1907, about a mile below the proposed intake and about the same distance above Bismark Creek. This point is some 200 feet lower in elevation than the intake, and for this reason probably not more than 75 per cent of the discharge at the station is available for the ditch. Most of the low-water flow comes from springs, which help to maintain a better run-off than on neighboring streams. The low-water flow was probably considerably less in 1908 and 1909 than in 1907, when the records were obtained.

Gage heights, in feet, and discharge, in second-feet, of Quartz Creek above Bismark Creek for 1907.

[Observer, S. G. Revelas.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Measurements.			**Gage readings**—Contd.		
July 19		8.2	Aug. 5	0.60	9.0
July 28	0.60	9.0	Aug. 7	.61	9.6
Sept. 2	.80	25.0	Aug. 9	.62	10.2
			Aug. 11	.60	9.0
Gage readings.			Aug. 13	.62	10.2
			Aug. 15	.62	10.2
Aug. 1	.61	9.6	Aug. 17	.64	11.4
Aug. 3	.60	9.0	Aug. 19	.64	11.4

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Serpentine River drainage basin:

Miscellaneous measurements in Serpentine River drainage basin in 1907.

Date.	Stream.	Tributary to—	Locality.	Discharge.
				Sec.-ft.
Aug. 11	Schlitz Creek	Serpentine River	Near proposed intake	0.7
Sept. 4	do	do	do	13
Aug. 11	Reindeer Creek	Schlitz Creek	do	1.9
Sept. 4	do	do	do	13
July 19	Bryan Creek	Serpentine River	Near intake	4.2
July 27	do	do	do	6.0
July 28	do	do	do	6.5
Sept. 2	do	do	do	15.5
July 19	Bismark Creek	Quartz Creek	½ mile below intake	1.7
July 28	do	do	Intake	2.8

GOODHOPE RIVER DRAINAGE BASIN.

DESCRIPTION.

Goodhope River drains an area of 500 square miles, comprising the western part of the Fairhaven mining district, which rises among the lava flows a few miles northwest of Imuruk Lake. The main stream is formed by the junction of Right Fork with Cottonwood Creek and flows in a general westerly and northwesterly course to Goodhope Bay. Its total length is about 50 miles. Esperanza, Placer, and Humboldt creeks, in the western portion of the basin, and Cottonwood Creek and its tributaries, Trail, Divide, and Noyes creeks, from the northeast, are the principal confluents. These streams have coarse gravel beds, which in places are so loose that almost all the low-water flow sinks into the gravel. This condition is especially notable on Cottonwood Creek just above its junction with Right Fork.

The greater part of the basin embraces an area of interbedded limestone and schist, covered with lava, into which the river has cut a comparatively narrow and deep valley with well-defined lava rims on either side. Below Placer Creek the valley broadens and merges with the flats bordering Kotzebue Sound.

Right Fork occupies a narrow canyon cut in the lava and receives water from lava springs, which may derive a part of their supply from Imuruk Lake. These springs furnish most of the discharge of the river during low stages, and their water, in the form of ice storage or "glacier" piled up during the winter, serves to augment the discharge considerably until the middle of July each year.

Some gold was found on Esperanza Creek during the summer of 1908, and prospecting and mining have been carried on in a small way since that time. If the returns obtained on Esperanza Creek should warrant it, a ditch 12 to 15 miles in length could be built to divert water from Right Fork below the springs. Records of flow obtained during 1909 indicate that an average of about 15 second-feet and a minimum of about 9 second-feet was available during the low-water period of that year for this purpose. A head of about 180 feet could be obtained at the mouth of Esperanza Creek for hydraulicking.

A station was maintained on Goodhope River, below Esperanza Creek, in 1909.

GOODHOPE RIVER BELOW ESPERANZA CREEK.

This station was established June 24, 1909, at a point about 50 feet below the mouth of Esperanza Creek and about 4 miles above Placer Creek. The data obtained here are valuable as a basis for estimating the amount of water available from Right Fork below the springs for hydraulic mining on and near Esperanza Creek.

The flat gravel bed of the river at the gaging station afforded good measuring sections and remained permanent throughout the period that records were kept.

The period of extreme low water occurred during the interval between August 20 and the beginning of the freeze-up. The minimum normal flow was recorded August 26 as 13 second-feet. The minimum flow of 10.4 second-feet for the season, which was registered September 13, was probably due in part to the drought and in part to the low temperature.

Discharge measurements of Goodhope River below Esperanza Creek in 1909.

[Elevation, about 100 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 24	1.18	89	July 21	0.46	27
July 21	.40	24	Aug. 26	.21	12.9

Daily gage height, in feet, and discharge, in second-feet, of Goodhope River below Esperanza Creek for 1909.

[Drainage area, 194 square miles. Observer, Isaac Hatta.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			0.90	63	0.35	20	0.23	14.0
2			.90	63	.36	21	.23	14.0
3			1.00	72	.30	17.5	.22	13.5
4			.90	63	.44	26	.21	13.0
5			.90	63	.43	25	.21	13.0
6			.85	58	.40	23	.21	13.0
7			.95	68	.31	18.0	.21	13.0
8			.80	54	.35	20	.20	12.5
9			.65	41	.39	22	.20	12.5
10			.85	58	.52	31	.19	12.1
11			.85	58	.55	34	.19	12.1
12			.75	50	.45	26	.18	11.7
13			.65	41	.41	24	.15	10.4
14			.60	37	.39	22	.20	12.5
15			.55	34	.39	22	.25	15.0
16			.55	34	.35	20	.30	17.5
17			.50	30	.31	18.0	.31	18.0
18			.55	34	.30	17.5	.28	16.5
19			.50	30	.30	17.5	.25	15.0
20			.45	26	.25	15.0	.23	14.0
21			.41	24	.29	17.0	.20	12.5
22			.40	23	.30	17.5	.21	13.0
23			.40	23	.29	17.0	.21	13.0
24	1.20	91	.40	23	.29	17.0	.21	13.0
25	1.00	72	.39	22	.25	15.0	.20	12.5
26	1.00	72	.37	21	.21	13.0	.19	12.1
27	1.10	81	.35	20	.25	15.0		
28	1.20	91	.31	18.0	.25	15.0		
29	1.00	72	.30	17.5	.25	15.0		
30	.85	58	.31	18.0	.23	14.0		
31			.38	22	.27	16.0		
Mean		76.7		39.0		19.7		13.4
Mean per square mile		.395		.201		.102		.069
Run-off, depth in inches on drainage area		.10		.23		.12		.07

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Goodhope River drainage basin:

Miscellaneous measurements in Goodhope River basin in 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
June 25	Right Fork	Goodhope River	At mouth	260	38	80	0.48
July 21	do	do	do	260	18.1	80	.23
Aug. 26	do	do	do	260	12.4	80	.16
June 25	Cottonwood Creek	do	Above Divide Creek.	330	[a] 10.4	38	.27
July 21	do	do	do	330	[a] 2.3	38	.061
Aug. 26	do	do	do	330	[a] .78	38	.021
June 25	Divide Creek	Cottonwood Creek	At mouth	330	4.9	10.6	.46
July 21	do	do	do	330	1.74	10.6	.16
Aug. 26	do	do	do	330	.27	10.6	.025
June 24	Esperanza Creek	Goodhope River	do	100	2.8	20	.14
July 21	do	do	do	100	[b] .25	20	.012

[a] Cottonwood Creek has considerable underflow through the gravel, so that measurements probably give too small discharge.
[b] Discharge estimated.

INMACHUK RIVER DRAINAGE BASIN.

DESCRIPTION.

Inmachuk River rises against the head of Trail Creek, a tributary of the Goodhope, flows northeastward, and empties into Kotzebue Sound at Deering. Its principal tributaries are Hannum Creek, from the northwest, and Pinnell River, from the south, each of which has a larger drainage area that the main stream above the junction. Arizona, Fink, Washington, West, Cue, and Mystic creeks are small tributaries below the mouth of Pinnell River.

Hannum Creek occupies a deep and rather narrow valley. Its principal tributaries are Cunningham, Milroy, and Collins creeks. Pinnell River rises in a broad, flat swamp, or ''goose pasture,'' formed by the lava flow. About 6 or 8 miles from its source the river has cut down through the lava, forming a deep narrow canyon in which it drops 250 to 300 feet in about half a mile. Its principal tributaries are Magnet, June, Perry, and Old Glory creeks and Snow Gulch.

A striking feature of Inmachuk Valley is the lava rim which extends down the Pinnell from the canyon, following the left side of the valley for several miles, then crossing to the the right side and extending down the Inmachuk to the coastal plain. It also extends up Hannum Creek nearly to its head. Below the canyon the rim is in general 300 to 400 feet above the level of the stream.

The basins of Hannum Creek, Old Glory Creek, and Inmachuk River below Pinnell River contain placers which have been worked since 1900.

The only well-sustained water supply in this basin available at sufficient elevation for hydraulic mining is that furnished by limestone springs yielding 8 or 9 second-feet, the discharge from which enters the Inmachuk about 3 miles below its head and about the same distance above the mouth of Hannum Creek. During periods of low water the flow of these springs represents the total flow of the river above Hannum Creek. A dam was built below them in 1909, and a ditch was started for diverting the water but was not completed, owing to a controversy in regard to the ownership of the water right. A ditch having its intake on Hannum Creek at the mouth of Cunningham Creek was constructed in 1907. The amount of water available at this point is contributed principally by melting snow, and consequently the supply has not been adequate for mining except on a small scale. The Fairhaven ditch, which diverts water from Lake Imuruk at the head of Kugruk River into the Inmachuk basin, is described in detail on pages 235–236.

A gaging station was maintained on Inmachuk River below Logan Gulch during the summer of 1909.

INMACHUK RIVER BELOW LOGAN GULCH.

This station was established June 26, 1909, at the Fairhaven pipeline crossing about half a mile below Logan Gulch and half a mile above Arizona Creek. The records kept during 1909, with the miscellaneous measurements, furnish a basis for a study of run-off in this drainage basin during an extremely dry year. Water was wasted into Logan Gulch from the lower penstock of the Fairhaven ditch, varying in amount from 0.5 second-foot to 6 or 8 second-feet. This water promoted the thawing of the ground ice along the banks of Logan Gulch and resulted in a considerable quantity of muck being deposited in the river bed. This muck caused shifting of the channel, a condition which renders the data only approximate. Readings were obtained from a gage about 400 feet above the gage at the pipeline crossing after August 11. At this point channel conditions were much more favorable, so that discharges from this date to the end of the season are fairly accurate.

The extreme low-water rating is very unsatisfactory because of the conditions mentioned, but it is thought that the discharge of 13 second-feet for July 28 is not far from the true minimum.

Discharge measurements of Inmachuk River below Logan Gulch in 1909.

[Elevation, 130 feet.]

Date.	Gage height.			Date.	Gage height.		
	Upper gage.	Lower gage.	Discharge.		Upper gage.	Lower gage.	Discharge.
	Feet.	*Feet.*	*Sec.-ft.*		*Feet.*	*Feet.*	*Sec.-ft.*
June 26	1.51	2.06	93	Aug. 6	.94	1.66	24
June 27	1.45	1.98	93	Aug. 8	.93	1.61	23
July 12	1.30	1.90	53	Aug. 10	1.21	2.03	50
July 19	1.16	1.61	38	Aug. 24	[a] 1.23	....	25
July 23	1.11	1.59	34				

[a] The upper gage was reset Aug. 11 at the same section with a datum 0.32 foot lower.

Daily gage height, in feet, and discharge, in second-feet, of Inmachuk River below Logan Gulch for 1909.

[Drainage area, 145 square miles. Observers, employees of Fairhaven Water Co.]

Date.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	....	....	1.85	72	1.45	18	1.15	22
2	....	....	1.90	74	1.38	16	1.15	22
3	....	....	1.85	68	1.40	16	1.15	22
4	....	....	1.90	70	1.40	15	1.15	22
5	....	....	1.90	68	1.82	34	1.15	22
6	....	....	1.90	66	1.68	25	1.15	22
7	....	....	1.80	58	1.78	32	1.15	22
8	....	....	1.70	50	1.61	23	1.15	22
9	....	....	2.15	77	1.80	35	1.20	24
10	....	....	2.00	65	2.00	48	1.20	24
11	....	....	1.90	56	1.48	44	1.15	22
12	....	....	2.15	70	1.20	24	1.15	22
13	....	....	1.95	56	1.30	30	1.15	22
14	....	....	1.80	47	1.25	27	1.20	24
15	....	....	1.80	48	1.20	24	1.20	24
16	....	....	1.70	42	1.20	24	1.15	22
17	....	....	1.70	43	1.15	22	1.15	22
18	....	....	1.55	34	1.10	19	1.20	24
19	....	....	1.59	37	1.10	19	1.15	22
20	....	....	1.50	32	1.00	15	1.10	19
21	....	....	1.50	31	1.10	19	....	....
22	....	....	1.58	34	1.10	19	....	....
23	....	....	1.60	34	1.30	30	....	....
24	....	....	1.35	22	1.23	26	....	....
25	....	....	1.25	18	1.20	24	....	....
26	2.06	93	1.22	16	1.10	19	....	....
27	1.98	93	1.20	15	1.10	19	....	....
28	1.90	82	1.10	13	1.20	24	....	....
29	1.90	80	1.18	14	1.10	19	....	....
30	1.85	74	1.28	15	1.15	22	....	....
31	....	....	1.38	17	1.15	22	....	....
Mean	....	84.4	....	43.9	....	24.2	....	22.4
Mean per square mile	....	.582	....	.303	....	.167	....	.154
Run-off, depth in inches on drainage area	....	.11	....	.35	....	.19	....	.11

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Inmachuk River drainage basin:

Miscellaneous measurements in Inmachuk River basin in 1908 and 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
July 26, 1908	Inmachuk River.	Kotzebue Sound..	Above Eureka Creek.	210	8.5	8.6	0.99
Aug. 15, 1908	.....do	.....do	.....do	210	7.5	8.6	.87
July 19, 1909	.....do	.....do	.....do	210	10.9	8.6	1.27
Aug. 7, 1909	.....do	.....do	.....do	210	9.4	8.6	1.09
Aug. 26, 1909	.....do	.....do	.....do	210	8.3	8.6	.97
Aug. 8, 1909	.....do	.....do	Above Pinnell River.	140	9.8	46	.21
July 26, 1908	.....do	.....do	Below Pinnell River.	140	19.0	142	.13
Aug. 15, 1908	.....do	.....do	.....do	140	16.4	142	.12
Aug. 22, 1908	.....do	.....do	.....do	140	14.3	142	.10
Aug. 21, 1908	.....do	.....do	Above Cue Creek..	60	[a] 38	177	....
Aug. 8, 1909	.....do	.....do	.....do	60	[b] 56	177	....
July 26, 1908	Hannum Creek	Inmachuk River..	Below Milroy Creek.	450	1.05	16.0	.066
Do	.....do	.....do	At mouth	175	2.3	34	.068
Aug. 15, 1908	.....do	.....do	.....do	175	2.9	34	.085
July 19, 1909	.....do	.....do	.....do	175	3.5	34	.10
Aug. 8, 1909	.....do	.....do	.....do	175	1.77	34	.052
Aug. 25, 1909	.....do	.....do	.....do	175	2.0	34	.059
July 26, 1908	Pinnell River..	.....do	.....do	140	5.2	96	.054
Aug. 15, 1908	.....do	.....do	.....do	140	4.1	96	.043
July 19, 1909	.....do	.....do	.....do	140	6.6	96	.069
Aug. 7, 1909	.....do	.....do	.....do	140	3.1	96	.032
Aug. 25, 1909	.....do	.....do	.....do	140	3.2	96	.033

[a] This includes about 25 second-feet from the Fairhaven ditch.
[b] This includes about 42 second-feet from the Fairhaven ditch.

KUGRUK RIVER DRAINAGE BASIN.

DESCRIPTION.

Kugruk River rises in Imuruk Lake and flows in a northeasterly and northerly direction for about 60 miles, emptying into Kotzebue Sound near Deering. Imuruk Lake lies on top of the lava plateau that occupies a large area in the central part of Seward Peninsula, at an elevation, as near as can be determined from barometer readings, of 960 feet. It has an area of 31 square miles and a drainage basin of 102 square miles. Below the lake the river is relatively flat for 3 or 4 miles. It then breaks over an escarpment at the edge of the lava and flows through a canyon about 2 miles in length which has been cut in places 300 feet deep and 1,000 feet wide. The fall in the canyon amounts to nearly 250 feet to the mile. At its lower end the river is probably at about the level which it occupied before the extrusion of the lava flow, nearly 550 feet below the level of the lake. The canyon affords a favorable location for a plant to develop electric power, for water from the lake can be diverted through the upper end of the Fairhaven ditch or through a waterway parallel with it for about 4½ miles and then through a pipe line to the lower end of the canyon, where a pressure of about 500 feet can be obtained.

The principal tributaries of Kugruk River are Lava Creek from the south, in the canyon; Holtz, Mina, Montana, Reindeer, and Chicago Creeks from the east; and Ruby, Gold Bug, and Wade creeks, the last locally known as Burnt River, from the west. Chicago and Reindeer creeks are probably the most important of these tributaries, having near their mouths coal mines, which have been worked extensively. Gold has been found in paying quantities on the river only at Discovery claim, just above the mouth of Chicago Creek. Some mining has been done on Spruce, Mina, and Chicago creeks, but the total production is small.

There is a large body of auriferous ground in the river valley between Mina and Chicago creeks which, if the gold is present in fair quantity and uniformly distributed, may prove profitable for dredging, as there is a large amount of cheap fuel available at the coal mines near by.

Spruce timber is found in the northern part of the Kugruk River drainage basin, especially along Holtz Creek and some of its tributaries, but it is too far from the mining areas to be of much value.

The upper section of the Fairhaven ditch lies within the Kugruk River drainage basin. Data on the flow of the ditch are presented on pages 235–239.

The following gaging stations have been maintained in this basin:

Kugruk River below Fairhaven ditch intake, 1909.
Kugruk River above Reindeer Creek, 1909.
Chicago Creek at coal mine, 1908.

IMURUK LAKE.

Imuruk Lake, which has an area of 31 square miles and a drainage basin of 102 square miles, is the largest body of fresh water in Seward Peninsula. It lies on top of a lava plateau at an elevation of 960 feet. The drainage basin is relatively flat, as the maximum elevation is only about 1,600 feet. A low gap in the divide between the lake and the head of Right Fork of Goodhope River rises only a few feet above the lake. The Fairhaven ditch takes practically all its water from the lake, and the amount of water available is therefore of considerable interest. The inflow can be computed for two periods of approximately 12 months each, August 16, 1906, to August 13, 1907, and October 1, 1907, to September 25, 1908. During the first period the water was shut off entirely at the outlet and the water level rose 2.17 feet. As there was more water in the lake than was needed, the gates were then opened and a large flow allowed to escape until about October 1, when the gates were again closed. During the second period the water surface rose 1.53 feet. A considerable loss of water occurred during part of June on account of the failure of one of the gates, and water was running in the Fairhaven ditch from July 1 to September 25. The total outflow is estimated as follows:

June, 10 days, 75 second-feet.
July 1-20, 12.5 second-feet.
July 21 to September 25, 30 second-feet.

From these data the total run-off of the drainage area for these periods has been computed.

Water supply available from Imuruk Lake, 1906-1908.

[Elevation, 960 feet; drainage area, 102 square miles.]

	Aug. 16, 1906, to Aug. 13, 1907.	Oct. 1, 1907, to Sept. 25, 1908.
Rise of lake surface ... feet..	2.17	1.53
Equivalent water supply ... acre-feet..	43,100	30,400
Outflow ... do....	0	6,400
Total water supply ... do....	43,100	36,800
Mean annual discharge ... second-feet..	60	51
Discharge for 100-day season ... do....	217	186
Run-off from drainage area ... inches..	7.9	6.8

NOTE.—These values differ somewhat from those previously published because the area of both the lake and the drainage basin have been revised in accordance with more accurate measurements.

A gage was established at the outlet of the lake July 19, 1909, and readings were obtained for about two months in connection with the record of outflow in the ditch and river.

These records show a fall of 0.85 foot in the lake surface during 64 days. The outflow during the period was 6,130 acre-feet, enough to have raised the lake 0.31 foot. This leaves a depth of 0.54 foot (6.5 inches) to be accounted for by evaporation and by leakage through the lava.

Daily gage height, in feet, of Imuruk Lake near outlet for 1909.

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	......	3.05	2.6	11	......	2.8	2.3	21	3.1	2.7	......
2	......	3.1	2.6	12	......	2.8	2.3	22	3.25	2.8	......
3	......	3.2	2.4	13	......	2.7	2.3	23	3.1	2.6	......
4	......	3.05	2.4	14	......	2.7	2.3	24	3.1	2.6	......
5	......	3.1	2.4	15	......	2.8	2.3	25	3.2	2.6	......
6	......	2.9	2.4	16	......	2.8	2.5	26	3.4	2.6	......
7	......	2.9	2.4	17	......	2.8	2.3	27	3.1	2.6	......
8	......	2.9	2.4	18	......	2.8	2.3	28	3.2	2.6	......
9	......	2.7	2.4	19	3.15	2.8	2.3	29	3.05	2.6	......
10	......	2.9	2.4	20	3.2	2.8	2.3	30	3.2	2.6	......
								31	3.1	2.6	......

NOTE.—The gage heights fluctuated somewhat on account of changes in the direction and velocity of the wind.

KUGRUK RIVER BELOW FAIRHAVEN DITCH INTAKE.

A station was established about 50 feet below the diversion dam of the Fairhaven ditch July 14, 1909, for the purpose of determining the leakage under the dam and the waste from overflow of flashboards. On account of the roughness of the stream bed an accurate rating for the small amount of water lost in this way was not possible, but the rating obtained is sufficiently accurate to be used for determining the total run-off from the lake during the season.

Discharge measurements of Kugruk River below Fairhaven ditch intake in 1909.

[Elevation, 960 feet.]

Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*
July 14	1.71	65.4
Do	1.38	38.6
Do	.42	1.0

Daily gage height, in feet, and discharge, in second-feet, of Kugruk River below Fairhaven ditch intake for 1909.

[Observer, Max Sinkspiel.]

Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.	Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.
1			0.60	3.7	0.42	1.0	16	0.42	1.0	0.42	1.0	0.42	1.0
2			.65	4.7	.42	1.0	17	.42	1.0	.42	1.0	.42	1.0
3			.65	4.7	.42	1.0	18	.45	1.4	.42	1.0	.42	1.0
4			.70	5.7	.42	1.0	19	.45	1.4	.42	1.0	.42	1.0
5			.70	5.7	.45	1.4	20	.45	1.4	.42	1.0	.42	1.0
6			.70	5.7	.45	1.4	21	.50	2.0	.42	1.0		
7			.70	5.7	.42	1.0	22	.50	2.0	.42	1.0		
8			.70	5.7	.42	1.0	23	.42	1.0	.45	1.4		
9			.42	1.0	.42	1.0	24	.42	1.0	.45	1.4		
10			.42	1.0	.42	1.0	25	.45	1.4	.45	1.4		
11			.42	1.0	.42	1.0	26	.45	1.4	.48	1.8		
12			.42	1.0	.42	1.0	27	.50	2.0	.45	1.4		
13			.42	1.0	.42	1.0	28	.50	2.0	.45	1.4		
14	0.42	1.0	.42	1.0	.42	1.0	29	.50	2.0	.45	1.4		
15	.42	1.0	.42	1.0	.42	1.0	30	.60	3.7	.45	1.4		
							31	.60	3.7	.45	1.4		
							Mean	1.69		2.21		1.04	

KUGRUK RIVER ABOVE REINDEER CREEK.

This station was established June 28, 1909, at the upper coal mine, about half a mile above the mouth of Reindeer Creek, to obtain data in regard to range of stage and run-off during the summer months. The discharge comes almost entirely from the area below the outlet of Imuruk Lake, except for short periods when water was wasted from the dam at the lake outlet or from the Fairhaven ditch between the intake and camp 2 upper section. The channel shifted slightly during August, but sufficient measurements were obtained to render the results good.

A minimum normal flow of 29 second-feet occurred during the later part of August and in September before the freeze-up. It is estimated that 18 to 19 second-feet of this amount was supplied from the springs in the canyon. Records at this point are directly comparable with the measurements made in 1908 above Chicago Creek, as the discharge of Reindeer Creek is negligible.

Discharge measurements of Kugruk River above Reindeer Creek in 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
June 28	1.21	182	Aug. 11	0.54	56
July 10	.91	117	Do	.52	49
July 24	.56	46	Aug. 23	.56	55
Aug. 1	.52	37			

Daily gage height, in feet, and discharge, in second-feet, of Kugruk River above Reindeer Creek for 1909.

[Drainage area, 454 square miles.[a] Observer, George Wallin.]

Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	1.10	158	0.52	38	0.50	46
2	.90	114	.50	34	.50	46
3	.90	114	.60	53	.50	46
4	.90	114	.60	56	.60	65
5	.90	114	.60	59	.50	46
6	.80	93	.60	62	.40	29
7	.90	114	.60	65	.40	29
8	.90	114	.50	46	.40	29
9	.80	93	.50	46	.40	29
10	.91	116	.60	65	.40	29
11	.90	114	.52	50	.40	29
12	.90	114	.52	50	.40	29
13	.90	114	.50	46	.40	29
14	.80	93	.50	46	.40	29
15	.80	93	.50	46	.50	46
16	.80	93	.50	46	.50	46
17	.80	93	.50	46	.40	29
18	.70	73	.70	85	.40	29
19	.70	73	.80	105	.40	29
20	.60	53	.80	105	.40	29
21	.60	53	.70	85	.40	29
22	.50	34	.65	75	.40	29
23	.53	40	.56	57	.40	29
24	.56	45	.50	46	.40	29
25	.70	73	.50	46	.40	29
26	.60	53	.50	46	.32	19
27	.60	53	.40	29	.32	19
28	.50	34	.40	29	.35	23
29	.50	34	.40	29	.30	17
30	.50	34	.50	46	....	16
31	.50	34	.50	46	....	....
Mean	....	82.1	....	54.3	....	31.9
Flow from Imuruk Lake[b]	....	5.1	....	14.5	....	6.0
Mean natural flow of drainage area below Imuruk Lake	....	77.0	....	39.8	....	25.9
Mean per square mile	....	.170	....	.088	....	.057
Run-off, depth in inches on drainage area	....	.20	....	.10	....	.06

[a] This area does not include that of Imuruk Lake.

[b] The flow from Imuruk Lake finding its way into the river is composed of two parts. The amount spilled by the Fairhaven ditch between the intake and camp 2, upper section, and the amount seeping under and spilling over the flashboards. The former is estimated by comparing the ditch records at the two points and the latter is represented by the records of the river below the intake.

Note.—The mean discharge for the period June 28-30 was 173 second-feet.

CHICAGO CREEK AT COAL MINE.

A Cippoletti weir with a 1-foot crest was installed in Chicago Creek just above the coal mine and about a mile above the mouth, on August 24, 1908, to determine the low-water flow. Records were desired of the amount of water available for use in condensers of the proposed steam-power plant at the coal mine which was under consideration at that time. Observations were continued until the weir was washed out by high water on September 15. The highest discharges recorded are only approximate, as they were greater than the weir was adapted to measure, but the low-water record is fairly good.

Daily gage height, in feet, and discharge, in second-feet, of Chicago Creek at coal mine for 1908.

[Drainage area, 32 square miles. Observer, C. A. Melbern.]

Day.	August.		September.		Day.	August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			0.22	0.35	19				
2			.20	.30	20				
3			.33	.64					
4			.60	1.56	21				
5			.60	1.56	22				
					23				
6			.70	1.97	24	0.12	0.14		
7			.75	2.19	25	.12	.14		
8			.60	1.56					
9			.42	.92	26	.11	.12		
10			.38	.79	27	.13	.16		
					28	.11	.12		
11			.35	.70	29	.10	.11		
12			.32	.61	30	.10	.11		
13			.30	.55	31	.09	.09		
14			.30	.55					
15					Mean		.12	1.02	
16					Mean per square mile		.0037	.032	
17					Run-off, depth in inches on drainage area		.001	.02	
18									

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Kugruk River drainage basin:

Miscellaneous measurements in Kugruk River basin in 1908 and 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec. ft.*	*Sq. mi.*	*Sec.-ft.*
Aug. 17, 1908	Kugruk River	Kotzebue Sound.	At mouth of canyon.	470	31	152	
July 15, 1909	do	do	do	470	36	152	
Aug. 4, 1909	do	do	do	470	a 34	152	
July 28, 1908	do	do	Above mouth of Chicago Creek.		33	578	0.057
Aug. 14, 1908	do	do	do		31	578	.054
July 28, 1908	Wade Creek (Burnt River).	Kugruk River	Near mouth		1.6	177	.009
Aug. 14, 1908	do	do	do		.93	177	.005
June 27, 1909	do	do	do		26	177	.15
July 11, 1909	do	do	do		12	177	.068
July 23, 1909	do	do	do		3.1	177	.018
Aug. 2, 1909	do	do	do		1.31	177	.007
Aug. 11, 1909	do	do	do		1.44	177	.008
Aug. 24, 1909	do	do	do		.72	177	.004

a Includes 14 second-feet from Fairhaven ditch and Lake Imuruk.

FAIRHAVEN DITCH SYSTEM.

DESCRIPTION.

The Fairhaven ditch is located within two drainage basins, the upper section in that of Kugruk River and the lower section in that of Inmachuk River, and is therefore described separately. The ditch takes its water from Imuruk Lake, which lies at an elevation of about 960 feet above sea level. A dam 500 feet long and 5 feet high has been built to form a storage reservoir, and this will hold the total inflow at the lake for two years if necessary. The ditch is in three sections. The upper section, 17 miles long, lies on top of the lava and extends from the lake around the head of Wade Creek to the divide between Wade Creek and Pinnell River, where the water is dropped into a channel emptying into a sink hole in the lava, apparently connected by an underground passage with Wade Creek. The water is diverted from Wade Creek into Pinnell River by the middle section of the ditch, which is about half a mile long. The distance between the upper and lower ditches is about 6½ miles, and the drop is estimated at 140 feet. The lower section of the ditch extends from the intake on Pinnell River along the right side of the valley to a point a few hundred feet below Logan Gulch, a small tributary of the Inmachuk above Arizona Creek, and has a length of about 19 miles, making the total length of the ditch 36½ miles.

The ditch has a grade of 4.2 feet to the mile and was built 11 feet wide on the bottom. The grade line was located 1 foot below the surface of the ground on the lower side and a 4-foot lower bank was provided. The removal of 1 or 2 feet of the upper moss and soil put the bottom of the ditch into a mixture of ground ice and muck, much of which was almost clear ice. This material thawed when the water was turned in, and as a result a large part of the bottom of the ditch has settled at least 2 feet and the ditch has widened in many places to 15 or 20 feet or more. As the upper bank thawed, material was thrown against the lower bank to protect it and to keep the water from getting under it. Practically all the upper ditch and at least three-fourths of the lower ditch is built in frozen ground of this character. These sections have been difficult and expensive to maintain and caused considerable interruption in the delivery of water during 1909 and 1910. Where the lower ditch is built around the steep gulches that carry the eastern tributaries of the Pinnell the northerly slopes of the gulches are covered with muck, but the southerly slopes are made up of a more solid clay and of decomposed mica schist. Along the upper ditch lava bowlders are present in the muck from the surface to bedrock, and at a few places the material encountered was composed of angular fragments of lava with only a little soil between them. Above and below Snow Gulch, the lowest tributary of Pinnell River which the ditch crosses, are short pieces of rockwork. The rock is much shattered and could have been loosened with picks if it had not been frozen. Much difficulty was experienced in making the rockwork water tight on account of the lack of good sod, as the surface covering is commonly decayed moss or peat containing much fibrous matter and little earthly material, and will float even though saturated with water, so that it is necessary to weight it down with rocks when it is used on the bottom of the ditch.

The ditch was built under contract, and construction was begun early in 1906. The upper section and more than half of the lower section had been built by October 12, when work had to be suspended for the year. The construction was completed in July, 1907, and water was run through the ditch for a short time in September of the same year. The pressure pipe leading from the penstock below Logan Gulch to the mine has a total length of 10,600 feet and gives a head of 530 feet on bedrock at the Utica group of claims. This head was greater than was found practicable for use, and a second penstock was built to reduce it to 330 feet. The following gaging stations were maintained during 1909:

Upper section: Fairhaven ditch at intake; Fairhaven ditch at Camp 2.
Lower section: Fairhaven ditch at Snow Gulch.

FAIRHAVEN DITCH AT INTAKE OF UPPER SECTION.

A gage was established on Fairhaven ditch about 100 feet below the diversion dam on Kugruk River on July 14, 1909, and records were kept of the amount of water diverted during the remainder of the season. Measuring conditions were good and the channel permanent. One reading a day was obtained. The maximum diversion was 61.8 second-feet, near the end of the season.

Discharge measurements of Fairhaven ditch at intake of upper section in 1908 and 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 23		12.2	July 15	1.02	40
Aug. 18		27.2	July 15	.62	23
			Aug. 4	1.29	55
1909.					
July 14	0.83	33			

Daily gage height, in feet, and discharge, in second-feet, of Fairhaven ditch at intake of upper section for 1909.

[Observer, Max Sinkspiel.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.00	40.0	1.21	50.6	16	0.92	36.1	1.08	44.0	1.33	57.0
2			1.12	46.0	1.12	46.0	17	.92	36.1	1.12	46.0	1.21	50.6
3			1.21	50.6	1.21	50.6	18	1.00	40.0	1.25	52.8	1.21	50.6
4			1.29	54.9	1.21	50.6	19	1.08	44.0	1.25	52.8	1.29	54.9
5			1.25	52.8	1.21	52.6	20	1.12	46.0	1.17	48.6	1.29	54.9
6			1.25	52.8	1.21	50.6	21	1.12	46.0	1.08	44.0		
7			1.21	50.6	1.21	50.6	22	1.12	46.0	1.08	44.0		
8			1.25	52.8	1.21	50.6	23	1.08	44.0	1.21	50.6		
9			1.00	40.0	1.21	50.6	24	.17	9.7	1.21	50.6		
10			1.42	61.8	1.21	50.6	25	.17	9.7	1.21	50.6		
11			1.25	52.8	1.17	48.6	26		.0	1.17	48.6		
12			1.17	48.6	1.17	48.6	27	.33	13.3	1.17	48.6		
13			1.33	57.0	1.29	54.9	28	.79	30.1	1.17	48.6		
14	0.83	31.9	1.33	57.0	1.21	50.6	29	1.00	40.0	1.21	50.6		
15	.75	28.3	1.08	44.0	1.42	61.8	30	.79	30.1	1.21	50.6		
							31	.96	38.0	1.21	50.6		
							Mean		31.6		49.8		51.7

FAIRHAVEN DITCH AT CAMP 2, UPPER SECTION.

This station was established July 13, 1909, opposite Camp 2, about 4½ miles below the intake. Measuring conditions were good, but the bottom of the ditch, which was composed of mud, shifted considerably. Daily discharges for July and August were obtained by the indirect method for shifting channels. As no measurements were made in September, the gage heights observed during that month can not be interpreted in terms of discharge. The maximum discharge diverted past the station during the period recorded was 46.5 second-feet near the end of August.

Discharge measurements of Fairhaven ditch at Camp 2, upper section, in 1908 and 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 24		12.5	July 15	0.93	37
			Aug. 4	1.02	46
1909.			Aug. 4	.98	43
July 13	0.78	30			

Daily gage height, in feet, and discharge, in second-feet, of Fairhaven ditch at Camp 2, upper section, for 1909.

[Observer, Max Sinkspiel.]

Day.	July.		August.		Day.	July.		August.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1			1.01	43.0	16	0.85	33.2		0
2			1.03	46.2	17	.85	33.2		0
3			1.05	[a]42.3	18	.87	34.2	0.92	[a]32.6
4			1.03	46.2	19	.97	39.2	.50	21.8
5			1.02	45.6	20	1.03	42.3	.62	27.3
6			1.04	46.7	21	1.05	43.3	.67	29.7
7			1.04	46.7	22	1.05	43.3	.77	[a]30.3
8			1.04	46.7	23	.85	[a]24.8	.92	42.3
9			.92	[a]33.8	24	.14	7.2	.96	[a]37.0
10			1.10	[a]35.2	25		0	.96	44.4
11			1.02	45.6	26		0	.98	45.5
12			1.04	46.7	27	.30	11.8	1.00	[a]41.6
13	0.80	30.8	.94	41.5	28	.68	26.9	1.00	[a]41.6
14	.79	30.3	1.04	[a]38.0	29	.91	38.0	1.00	[a]46.5
15	.77	[a]23.3	1.04	[a]29.2	30	.85	35.0	1.00	46.5
					31	.93	39.0	.96	[a]42.5
					Mean		28.2		37.5

[a] The flow was not continuous throughout the day. Water was turned out above Camp 2 for making repairs in the ditch.

FAIRHAVEN DITCH AT SNOW GULCH.

A gage was established and records begun by Robert Horn on June 14, 1909, at Snow Gulch, near the lowest camp on the lower section of the ditch. The gage was located near the waste gate just below the gulch. Records at this point show practically the amount of water delivered by the ditch at the penstock about 4 miles below. The maximum quantity delivered in 1909 was 45.7 second-feet near the end of the season.

Discharge measurements of Fairhaven ditch at Snow Gulch, in 1908 and 1909.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 25		12.0	July 12	1.18	29.3
Aug. 20		[a]22.7	July 19	1.36	35.5
1909.			Aug. 2	1.51	40.4
June 27	0.74	19.3	Aug. 5	1.57	42.6

[a] The discharge was less than normal on account of water being turned out for a few hours on Aug. 18, 1908.

Daily gage height, in feet, and discharge, in second-feet, of Fairhaven ditch at Snow Gulch, for 1909.

[Observer, Robert Horn.]

Day.	June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1			1.02	25.1	1.44	37.9	1.38	35.8
2			1.01	24.9	1.50	40.0	1.42	37.2
3			.97	23.9	1.44	37.9	1.27	32.2
4			1.07	26.4	1.40	36.5	1.29	32.8
5			1.02	25.1	1.54	41.5	1.50	40.0
6			1.06	26.2	1.54	41.5	1.56	42.3
7			1.10	27.2	1.56	42.3	1.58	43.0
8			1.12	27.8	1.55	41.9	1.60	43.8
9				5.0	1.57	42.7	1.60	43.8
10			1.12	27.8	1.41	36.8	1.48	39.3
11			1.10	27.2	1.39	36.2	1.27	32.2
12			1.17	29.2	1.55	41.9	1.62	44.6
13			1.17	29.2	1.56	42.3	1.58	43.0
14	0.92	22.8	1.19	29.7	1.53	41.1	1.65	45.7
15		0	1.21	30.3	1.25	31.6	1.56	42.3
16	.92	22.8	1.08	26.7	.94	23.2	1.31	33.4
17	.71	18.8	1.21	30.3	.46	14.4	1.46	38.6
18	.65	17.7	1.23	30.9	.29	11.6	1.58	43.0
19	.69	18.4	1.34	34.5	.75	19.5	1.56	42.3
20	.83	21.0	1.42	37.2		0	1.54	41.5
21	.71	18.8	1.48	39.3	1.02	25.1	1.58	43.0
22	.58	16.4	1.47	39.0	1.12	27.8		
23	.50	15.0	1.50	40.0	1.27	32.2		
24	.38	13.1	.62	17.2	1.52	40.8		
25	.31	12.0	.42	13.7	1.54	41.5		
26	.47	14.5		10.0	1.50	40.0		
27	.68	18.2		3.0	1.54	41.5		
28	.79	20.2		0	1.42	37.2		
29	.85	21.4	1.08	26.7	1.42	37.2		
30	.96	23.7	1.35	34.8	1.54	41.5		
31			1.40	36.5	1.56	42.3		
Mean		17.3		26.0		34.4		40.0

MISCELLANEOUS MEASUREMENTS.

Measurements were made along the ditch in 1908 to determine the discharge and seepage losses. (See p. 268.) In 1909 they were made at two points on the lower ditch which were intended for regular stations, but which could not be rated on account of shifting channel conditions and insufficient measurements. Miscellaneous measurements made in 1909 are given in the following table:

Miscellaneous measurements of Fairhaven ditch in 1909.

Date.	Point of measurement.	Discharge.	Date.	Point of measurement.	Discharge.
		Sec.-ft.			*Sec.-ft.*
July 13	Camp 1, lower section	29	July 12	Above penstock	30
Aug. 3	....do	40	Aug. 6	....do	41
June 26	Above penstock	14.5	Aug. 10	....do	17

KIWALIK RIVER DRAINAGE BASIN.

DESCRIPTION.

Kiwalik River, the largest river on the north side of Seward Peninsula, rises in a low ridge which separates the Kiwalik drainage basin from that of the Koyuk, flows northward for nearly 70 miles, and empties into Spafarief Bay, a southeasterly projection of Kotzebue Sound. The river traverses a flat lowland area several miles in width for the lower 30 miles of its course, except for a few miles above Candle, where the valley narrows to less than half a mile. Below Candle the river widens again into a lagoon, covering a large area of mud flats, which are exposed at low tide.

The tributaries from the west drain rather narrow basins, roughly parallel, and separated by long, low ridges. The principal streams from this side are Canoe Creek, Gold Run, and Glacier, Dome, Bonanza, Eldorado, Candle, and Minnehaha creeks. Glacier Creek is the largest of these in point of water supply. It rises on the easterly slope of Monument Mountain, the highest point in the Fairhaven district, and flows into the Kiwalik about 25 miles from its mouth. Limestone springs furnish practically all the low-water discharge, and the water from the melting "glacier" which is formed below them during the winter materially increases the flow until late in July each year.

Gold Run enters the Kiwalik about 2 miles above the mouth of Glacier Creek and also derives a part of its discharge from springs, which, however, do not give so well sustained a flow as those on Glacier Creek. During the summer of 1909 the combined low-water flow of these two streams was only about 2.5 second-feet. The other streams on this side have an exceedingly small run-off during periods of low water. Candle Creek, which has a drainage area of 60 square miles at the mouth, frequently reaches a stage of zero flow.

The largest tributaries from the east are Quartz and Hunter creeks, which rise in a mountainous mass separating the basin of Kiwalik River from that of Buckland River. Quartz Creek, which joins the main stream at a point about 6 miles above the mouth of Glacier Creek, has a larger drainage area than any other stream flowing into Kiwalik River. Its basin is in general hilly and even rough and mountainous at its eastern and southern borders. The basin has only a thin surface covering of moss, and as the slopes are steep the water derived from rains runs off rather rapidly. This stream flows over a bed of loose gravel which probably thaws to a considerable depth during the summer, so that there may be an appreciable underflow.

Hunter Creek drains an area north of Quartz Creek, opposite the headwaters of Bear Creek, a tributary of Buckland River, and flows through a rather narrow, tortuous valley into Kiwalik River, about

8 miles below the mouth of Quartz Creek. The drainage basin resembles that of Quartz Creek in a general way, but is not quite so high and mountainous. Most of the discharge comes from the small tributaries from the south which rise in the high ridge adjoining the Quartz Creek drainage basin. Hunter Creek yields a smaller but somewhat more uniform flow than Quartz Creek, probably because its headwaters are lower and do not receive so many showers during the summer.

Lava Creek is a small tributary from the east draining a flat lava area north of Hunter Creek. Its run-off is small except during the high-water period in the spring and immediately following a rain.

A belt of spruce timber and willow brush follows the river from a point near its head to the mouth of Eldorado Creek and extends up Quartz Creek to the forks and along the south side of Gold Run. Along the river below Eldorado Creek and in the valley of Hunter Creek the spruce is lacking, but willow is abundant and of heavy growth.

Owing to the very low grade of the river bed, which probably does not average more than 5 feet to the mile except at the headwaters, it is impossible to divert water from the river for hydraulicking. A ditch was built during 1907 by the Candle-Alaska Hydraulic Gold Mining Co. to gather the water from Glacier and Dome creeks and carry it to a point near Candle for use in mining the gold-bearing gravels of Candle Creek. During the summers of 1908 and 1909, from the later part of July to the end of the season, the water supply from Glacier and Dome creeks was insufficient for hydraulicking except on a very small scale.

A second ditch line has been surveyed from Quartz and Hunter creeks to Candle Creek. It is proposed to divert the water through 65 miles of ditch and 14,000 feet of pipe line, and to deliver it 303 feet above the mouth of Candle Creek. If this ditch is built it will have intakes on the forks of Quartz Creek about 2 miles above their junction and will extend along the left side of the valley for about 7 miles. It will then cross Quartz Creek in a siphon and continue around the ridge between Quartz and Hunter creeks to a point on the left bank of Hunter Creek, where it will be joined by a lateral diverting the water from Hunter Creek. Another siphon will conduct the water to the right bank of Hunter Creek, whence it will be carried along the east side of the Kiwalik Valley by ditch to a point about 3 miles above Candle. Here the water will be siphoned across the river and carried by ditch around to the left bank of Candle Creek.

Placer-mining operations have been conducted on Candle Creek since 1901 and have yielded a large percentage of the total production of the Fairhaven precinct. The creek is about 18 miles long and has been mined for the greater part of its length. The principal producing ground up to 1910 lies between Patterson and Jump creeks and extends into the third tier of benches on the left side of the valley. Gold has also been found in benches on the right side near the mouth of the creek. Operations on Candle Creek have generally been handicapped and often stopped altogether by lack of water. Mining operations have also been conducted in a small way on Glacier and Gold Run creeks.

Measurements were made and records kept where observers could be found during 1908 and 1909 for the purpose of determining the amount of water available for the two ditch systems described above.

Stations were maintained as follows:

Kiwalik River below Candle Creek, 1909.
Quartz Creek below the forks, 1909.
Glacier Creek at intake, 1908–9.
Dome Creek at siphon crossing, July, 1909.
Hunter Creek at proposed intake, 1908–9.

KIWALIK RIVER BELOW CANDLE CREEK.

A gage was set in the river at the end of the main street in the town of Candle, about 300 yards below the mouth of Candle Creek, June 29, 1909. Records were obtained from this date to the freeze-up.

Ground sluicing on John Bull Hill, just above Candle, during the early part of the season caused a large amount of muck to be deposited in the river bed, a condition which, in conjunction with the slight grade of the river, resulted in so considerable a shift in the channel that it was necessary to employ the indirect method of deriving the discharge from the gage heights recorded. Difficulty was also experienced in getting correct gage readings on account of the tide backing up into the river at this point. Owing to these unfavorable conditions the results for part of the summer are only approximate, but the data are valuable as furnishing an index of the run-off in this drainage basin. A minimum normal flow of 36 second-feet for the season is recorded for August 3. The low-water flow during the latter part of September was caused by the water freezing at the heads of the upper tributaries.

Discharge measurements of Kiwalik River below Candle Creek in 1908 and 1909.

[Elevation, 2 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-feet.*	1909.	*Feet.*	*Sec.-feet.*
July 29		33	July 7	1.99	280
Aug. 1		43	July 8	2.02	290
Aug. 13		137	July 25	1.23	52
Aug. 25		70	July 30	1.22	51
Sept. 9		126	Aug. 14	1.87	209
			Aug. 15	1.72	167
1909.			Aug. 18	1.40	86
June 29	1.67	182	Aug. 23	1.27	57
July 6	1.56	133			

Daily gage height, in feet, and discharge, in second-feet, of Kiwalik River below Candle Creek for 1909.

[Drainage area, 800 square miles. Observer, W J. Young.]

Day.	July Gage height.	July Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.
1	1.85	239	......	41	1.19	47
2	1.90	254	1.13	39	1.19	47
3	1.80	217	1.11	36	1.18	45
4	1.78	207	1.12	38	1.19	47
5	1.60	147	1.13	39	1.19	47
6	1.55	130	1.19	47	1.23	52
7	2.04	298	1.20	48	1.24	54
8	1.98	275	1.30	63	1.19	47
9	1.80	208	1.39	80	1.18	45
10	1.71	175	1.22	51	1.18	45
11	1.90	238	2.28	362	1.18	45
12	1.86	225	2.40	409	1.26	57
13	1.75	188	2.08	286	......	62
14	1.69	169	1.87	212	1.32	67
15	1.70	172	1.72	165	1.21	50
16	1.55	126	1.62	137	1.19	47
17	1.53	121	1.52	110	1.23	52
18	1.48	109	1.41	84	1.22	51
19	1.54	123	1.38	78	1.22	51
20	1.49	110	1.37	76	1.21	50
21	1.30	68	1.30	63	1.10	35
22	1.31	67	1.31	65	1.11	36
23	......	62	1.27	58	1.10	35
24	1.25	56	1.21	50	1.00	24
25	1.22	51	1.17	44	.96	21
26	1.23	52	1.18	45	.95	20
27	1.24	54	1.20	48	.91	17
28	1.23	52	1.28	60	.90	16
29	......	52	1.23	52	.88	15
30	1.22	51	1.22	51	.87	14
31	1.16	43	1.23	52	......	......
Mean	......	140	......	96.4	......	41.4
Mean per square mile	......	.175	......	.120	......	.052
Run-off, depth in inches on drainage area	......	.20	......	.14	......	.06

NOTE.—The mean discharge for the period June 29–30 was 202 second-feet.

QUARTZ CREEK BELOW THE FORKS.

This station was established July 6, 1909, about 1½ miles below the forks and about 2 miles above the mouth of Deer Creek. The discharge obtained from the records here gives the amount of water available for the proposed ditch, as there is practically no inflow between the station and the proposed intake. The measuring conditions were excellent and there was no shifting of the channel during the summer, so that the results obtained are good.

The minimum flow recorded prior to the freeze up was 9.2 second-feet for the week July 28 to August 3, and this probably represents extreme low water for a summer season.

Discharge measurements of Quartz Creek below the forks in 1909.

[Elevation, 570 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
July 6	2.77	199	Aug. 20	1.80	16.8
July 27	1.72	11.9	Do	1.80	16.7
Do	1.72	12.6			

Daily gage height, in feet, and discharge, in second feet, of Quartz Creek below the forks for 1909.

[Drainage area 56 square miles. Observer, Jack Beltz.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	......	80	1.62	8.8	1.75	14.1	21	......	25	1.79	16.3	1.62	8.8
2	......	80	1.59	8.0	1.73	13.0	22	......	20	......	16.0	1.65	9.8
3	......	70	1.60	8.2	1.72	12.5	23	......	15	1.78	15.7	1.66	10.1
4	......	55	1.70	11.4	1.70	11.4	24	......	12	1.78	15.7	1.68	10.8
5	......	45	1.85	19.9	1.69	11.1	25	......	12	1.77	15.2	1.66	10.1
6	2.77	[a]199	1.77	15.2	1.68	10.8	26	......	12	1.76	14.6	1.50	6.0
7	......	150	1.76	14.6	1.67	10.4	27	1.72	12.2	1.76	14.6	1.45	5.2
8	......	100	1.74	13.6	1.66	10.1	28	1.66	10.1	1.80	16.8	......	5.0
9	......	70	2.03	36	1.65	9.8	29	1.65	9.8	1.80	16.8	......	5.0
10	......	120	2.90	242	1.65	9.8	30	1.65	9.8	1.80	16.8	......	5.0
11	......	110	2.40	96	1.64	9.5	31	1.65	9.8	1.77	15.2	......	......
12	......	100	2.32	79	1.64	9.5	Mean	......	58.1	......	30.9	......	10.5
13	......	85	......	61	1.64	9.5							
14	......	75	......	44	1.74	13.6							
15	......	80	1.93	26	1.80	16.8	Mean per square mile	......	1.04	......	.552	......	.188
16	......	70	1.92	25	1.76	14.6							
17	......	55	1.85	19.9	1.77	15.2							
18	......	45	1.84	19.3	1.77	15.2							
19	......	35	1.83	18.7	1.70	11.4	Run-off, depth in inches on drainage area	......	1.20	......	.64	......	.21
20	......	30	1.80	16.8	1.64	9.5							

[a] Measurement was obtained after a heavy rain.

NOTE.—Discharges from July 1-26 were estimated with the aid of a hydrograph following the rise and fall of Kiwalik River below Candle Creek.

GLACIER CREEK ABOVE INTAKE OF CANDLE DITCH.

A station was established about 100 feet above the intake of the Candle ditch July 31, 1908, to determine the amount of water available for the ditch. During 1908 channel conditions remained constant and good results were obtained, but circumstances combined to make the data obtained during 1909 only approximate. Mining and prospecting above the intake caused great changes in the stream bed above the intake so that the 1908 gage could not be used, and as the water was turned in and out of the ditch alternately throughout the season it was difficult to obtain records below the intake. Up to about August 1 of each year Glacier Creek has a diurnal variation due to the melting of the "glacier." The minimum flow in 1908 was 1.7 second-feet, August 16–18 and 19, and the minimum of 1909 before the freeze up, was recorded during the later part of August and the first of September, when the discharge remained at 1.5 second-feet for some time. The discharge was still lower after the stream began to freeze in September.

Discharge measurements of Glacier Creek above intake of Candle ditch in 1908 and 1909.

[Elevation, 409 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
July 31	1.20	5.8	July 1	1.58	7.8
Aug. 9	1.00	1.9	July 2	1.50	5.4
Sept. 3	1.03	2.3	July 28		2.7
Sept. 4	1.01	2.0	July 29		2.1
			Aug. 17		1.6

Daily gage height, in feet, and discharge, in second-feet, of Glacier Creek above intake of Candle ditch for 1908.

[Drainage area, 10 square miles; observer, C. O. Mason.]

Day.	July.		August.		September.		Day.	July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1		14.0	1.06	2.9	1.01	2.1	21		2.5	1.00	1.9		
2		12.0	1.02	2.2	1.01	2.1	22		2.5	1.00	1.9		
3		10.0	1.02	2.2	1.02	2.2	23		2.5	1.04	2.5		
4		8.5	1.04	2.5	1.01	2.1	24		2.5	1.02	2.2		
5		6.9	1.10	3.5	1.01	2.1	25		2.5	1.01	2.1		
6		5.5	1.12	4.0	1.03	2.4	26		2.0	1.00	1.9		
7		6.2	1.04	2.5	1.01	2.1	27		2.0	1.00	1.9		
8		6.4	1.02	2.2	1.01	2.1	28		2.0	1.00	1.9		
9		4.5	1.00	1.9	1.00	1.9	29		2.0	1.00	1.9		
10		4.4	1.00	1.9	1.04	2.5	30		2.0	1.00	1.9		
11		5.8	.99	1.8	1.04	2.5	31	1.20	5.8	1.01	2.1		
12		5.1	1.01	2.1	1.02	2.2	Mean		4.67		2.15		3.35
13		4.8	1.00	1.9	1.02	2.2	Mean per sq. mile		.467		.215		.335
14		4.4	1.00	1.9	1.02	2.2	Run-off, depth in inches on drainage area		.54		.25		.25
15		3.6	.99	1.8	1.07	3.0							
16		2.9	.98	1.7	1.19	5.6							
17		2.9	.99	1.8	1.25	7.3							
18		2.9	.98	1.7	1.28	8.2							
19		2.9	.98	1.7	1.22	6.4							
20		2.9	1.01	2.1	1.20	5.8							

Daily discharge, in second-feet, of Glacier Creek above intake of Candle ditch for 1909.

[Drainage area, 10 square miles. Observers, Ed Hansen, Joe Venus, and B. A. Harrison.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	50	7.0	2.2	1.6	21	16	2.7	1.5	1.4
2	60	5.7	2.2	1.6	22	16	2.6	1.5	1.4
3	64	3.8	2.2	1.6	23	15	2.6	1.5	1.4
4	60	3.0	2.5	1.6	24	16	2.4	1.6	1.4
5	60	3.0	3.0	1.6	25	10	2.5	1.6	1.3
6	60	2.9	2.4	1.6	26	8	2.4	1.5	1.3
7	50	2.8	2.4	1.5	27	11	2.4	1.5	1.3
8	35	2.9	2.4	1.5	28	13	[b] 2.4	1.5	1.3
9	25	3.0	3.5	1.5	29	10	2.4	1.5	1.3
10	20	3.3	5.0	1.5	30	6	2.3	1.5	1.3
11	36	3.2	4.0	1.5	31		2.3	1.5	
12	52	3.1	3.0	1.5					
13	63	2.9	2.9	1.6	Mean	35.3	3.01	2.13	1.43
14	68	2.8	2.0	1.7	Mean per square mile	3.53	.301	.213	.143
15	63	2.9	1.8	1.8	Run-off, depth in inches on drainage area	3.94	.35	.25	.16
16	76	2.8	1.6	1.6					
17	33	2.8	1.6	1.4					
18	[a] 26	2.9	1.5	1.4					
19	39	2.8	1.5	1.4					
20	34	2.8	1.5	1.4					

[a] Snow nearly gone. [b] "Glacier" nearly gone.

NOTE.—Discharges for June are based on float measurements made by H. M. Long and R. S. Dimmick.

DOME CREEK AT SIPHON CROSSING.

A gage was set about 25 feet below the siphon crossing on Dome Creek, July 1, 1909, for determining the amount of water which could be delivered into the Dome Creek lateral at the intake, about 3 miles above. Measurements at the two points seem to indicate that there is little or no inflow between the intake and the siphon crossing during periods of low water. It was not possible to obtain gage heights except during July. The discharge of 0.5 second-feet at the end of July was probably as low as any during the season.

Discharge measurements of Dome Creek at siphon crossing, in 1908 and 1909.

[Elevation, 230 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec. feet.*	1909.	*Feet.*	*Sec. feet.*
July 31		0.69	July 1	0.78	4.2
Aug. 9		.54	July 29	.48	.55
Aug. 11		.43	Aug. 16	.48	.48
Sept. 5		1.72			
Sept. 6		1.88			

Daily gage height, in feet, and discharge, in second-feet, of Dome Creek at siphon crossing, for July, 1909.

[Drainage area, 16 square miles. Observer, H. M. Long.]

Day.	Gage height.	Discharge.	Day.	Gage height.	Discharge.
1	0.78	4.2	21	0.50	0.6
2	.79	4.4	22	.50	.6
3	.75	3.6	23	.50	.6
4	.70	2.9	24	.49	.6
5		2.8	25		.6
6		2.7	26	.49	.6
7		2.6	27		.5
8		2.5	28		.5
9		2.3	29	.48	.5
10	.65	2.2	30	.47	.5
			31		.5
11	.62	1.7			
12		1.7	Mean		1.30
13		1.5	Mean per square mile		.081
14		1.3	Run-off, depth in inches on drainage area		.09
15		1.1			
16		.9			
17		.7			
18	.52	.7			
19	.52	.7			
20	.51	.7			

HUNTER CREEK NEAR DITCH INTAKE.

A station was established on Hunter Creek just above the mouth of Spruce Creek, which enters the main stream about 2 miles below the proposed ditch intake, on August 14, 1908, and gage readings were obtained for a portion of August and September. On July 5, 1909, the station was reestablished about one-fourth mile below the intake. The results obtained show the amount of water available for the proposed ditch from Hunter Creek to Candle Creek. The channel was permanent and the measuring conditions were good. Considerable water flows under the gravel on the lower part of the creek, but it is thought that the underflow is not appreciable at the station, so that the discharge obtained represents the total amount that can be diverted at the ditch intake.

The low-water period for 1908 probably came before the station was established. The mean minimum flow recorded for one week was 2.9 second-feet from July 28 to August 3, 1909. The absolute minimum recorded was 2.5 second-feet August 1 and 2, 1909, but a lower stage was probably reached near the end of September.

Discharge measurements of Hunter Creek near ditch intake, in 1908 and 1909.

[Elevation, 500 feet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*
Aug. 4	0.60	6.5	July 5	1.13	12.2
Aug. 4	.60	6.7	July 5	1.15	15.1
Aug. 6	.88	16.7	July 27	.82	3.6
Aug. 6	.88	17.8	July 27	.82	3.6
Aug. 26	.65	7.3	Aug. 19	.82	3.4
Aug. 27	.64	7.4			
Sept. 1	.72	10.3			

Daily gage height, in feet, and discharge, in second-feet, of Hunter Creek near ditch intake, for 1908.

[Drainage area, 37 square miles. Observer, F. Riley.]

Day.	August.		September.		Day.	August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1		8.0	0.70	9.0	21	0.58	6.1		
2		8.0	.71	9.4	22	.58	6.1		
3		7.0	.80	13.0	23	.60	6.5		
4	0.62	7.0	.85	15.8	24	.62	7.0		
5	.80	13.0	.82	14.1	25	.62	7.0		
6	.88	17.4	.81	13.6	26	.68	8.5		
7	.85	15.8	.72	9.8	27	.62	7.0		
8	.72	9.8	.70	9.0	28	.60	6.5		
9	.75	11.0	.65	7.8	29	.60	6.5		
10		9.0	.61	6.8	30	.60	6.5		
					31	.61	6.8		
11		8.0	.61	6.8					
12		8.0	.61	6.8	Mean		8.1		11.9
13		7.0	.60	6.5					
14		7.0	.61	6.8	Mean per square mile		.22		.32
15	.68	8.5	.61	6.8					
16	.62	7.0	.85	15.8	Run-off, depth in inches on drainage area		.25		.24
17	.58	6.1	.95	21.8					
18	.60	6.5	1.02	26.6					
19	.58	6.1	.91	19.1					
20	.58	6.1	.80	13.0					

Daily gage height, in feet, and discharge, in second-feet, of Hunter Creek near ditch intake, for 1909.

[Drainage area, 32 square miles. Observer, James Flood.]

Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.
1	......	14.0	0.75	2.5	......	3.3
2	......	14.0	.75	2.5	......	3.3
3	......	13.0	.78	2.9	......	3.0
4	......	13.0	.91	5.5	......	3.0
5	1.12	12.9	.98	7.5	......	3.0
6	1.12	12.9	.92	5.8	......	2.8
7	1.09	11.6	.89	5.0	......	2.8
8	1.10	12.0	.86	4.4	......	2.8
9	1.20	16.6	1.06	10.4	......	2.6
10	1.15	14.3	1.24	18.7	......	2.6
11	1.10	12.0	1.14	13.8	......	2.5
12	1.08	11.2	1.06	10.4	......	2.4
13	1.04	9.7	1.01	8.5	......	2.6
14	1.00	8.1	.96	6.9	......	3.6
15	.98	7.5	.94	6.4	......	4.2
16	.95	6.6	.90	5.2	......	3.7
17	.92	5.8	.90	5.2	......	3.6
18	.92	5.8	.86	4.4	......	3.5
19	.90	5.2	.82	3.6	......	3.2
20	.88	4.8	.82	3.6	......	2.8

Day.	July. Gage height.	July. Discharge.	August. Gage height.	August. Discharge.	September. Gage height.	September. Discharge.
21	0.85	4.2	0.82	3.6	......	2.6
22	.82	3.6	......	3.5	......	2.4
23	.92	5.8	......	3.5	......	2.4
24	.88	4.8	......	3.2	......	2.4
25	.85	4.2	......	3.0	......	2.2
26	.81	3.4	......	3.2	......	2.0
27	.82	3.6	......	3.2	......	1.8
28	.80	3.2	......	3.3	......	1.6
29	.80	3.2	......	3.5	......	1.6
30	.80	3.2	......	3.5	......	1.6
31	.78	2.9	......	3.3	......	......
Mean	......	8.16	......	5.48	......	2.73
Mean per square mile	......	.255	......	.171	......	.085
Run-off, depth in inches on drainage area	......	.29	......	.20	......	.09

NOTE.—Discharges from August 22 to September 30 are estimated with the aid of a hydrograph following the rise and fall of Quartz Creek.

MISCELLANEOUS MEASUREMENTS.

The following is a list of miscellaneous measurements made in the Kiwalik River drainage basin.

Miscellaneous measurements in Kiwalik River basin in 1908 and 1909.

Date.	Stream.	Tributary to—	Locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
				Feet.	*Sec.-ft.*	*Sq. mi.*	*Sec.-ft.*
Aug. 27, 1908	North Fork of Quartz Creek.	Kiwalik River	Proposed ditch intake.	590	13.4	21	0.64
Aug. 30, 1908	do	do	do	590	8.7	21	.41
Aug. 27, 1908	South Fork of Quartz Creek.	do	do	580	13.1	26	.50
Aug. 30, 1908	do	do	do	580	8.6	26	.33
Aug. 27, 1908	Deer Creek	Quartz Creek	Near mouth	550	6.1	8.7	.70
Aug. 10, 1908	Gold Run	Kiwalik River	Proposed ditch intake.	430	1.43	9.0	.16
Sept. 4, 1908	do	do	do	430	1.90	9.0	.21
July 2, 1909	do	do	do	430	3.20	9.0	.36
July 28, 1909	do	do	do	430	1.04	9.0	.12
Aug. 16, 1909	do	do	do	430	1.20	9.0	.13
Aug. 10, 1908	Boulder Creek	Gold Run	At proposed ditch intake.	......	.20	4.0	.050
Sept. 24, 1908	do	do	do	......	.30	4.0	.075
July 2, 1909	do	do	do	......	.47	4.0	.12
Sept. 5, 1908	Dome Creek	Kiwalik River	At ditch intake	383	2.4	9.0	.27
July 29, 1909	do	do	do	383	.39	9.0	.043
June 30, 1909	Eldorado Creek	do	At siphon crossing.	......	2.4	......	......
Aug. 12, 1908	Burnside Creek	Eldorado Creek	do	......	.07	......	......
July 29, 1908	Candle Creek	Kiwalik River	At mouth	2	.0	60	.00
Aug. 13, 1908	do	do	do	2	.50	60	.008
Aug. 25, 1908	do	do	do	2	2.6	60	.043
Sept. 9, 1908	do	do	do	2	1.71	60	.028
June 29, 1909	do	do	do	2	6.3	60	.105
July 6, 1909	do	do	do	2	.72	60	.012
July 8, 1909	do	do	do	2	.86	60	.014
July 10, 1909	do	do	do	2	7.2	60	.12
July 30, 1909	do	do	do	2	.0	60	.00
Aug. 14, 1909	do	do	do	2	.30	60	.005

BEAR CREEK DRAINAGE BASIN.

DESCRIPTION.

Bear Creek rises opposite the headwaters of Quartz and Hunter creeks and flows southeastward for about 20 miles into West Fork of Buckland River. Its principal tributaries are Eagle, Polar, Split, Bob, and Cub creeks from the west, and May, Camp, and Sheridan creeks from the east. Placers are being developed at several places in the basin. The Bear Creek ditch has its intake just below the mouth of May Creek and extends along the right bank nearly to Split Creek, diverting water from Eagle and Polar creeks.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements were made in 1908 of Bear, Eagle, and Polar creeks at the ditch intake and of the other principal streams near their mouths.

Miscellaneous measurements in Bear Creek drainage basin, 1908.

Date.	Stream and locality.	Discharge.	Date.	Stream and locality.	Discharge.
		Sec.-ft.			*Sec.-ft.*
Aug. 6	Bear Creek at intake	1.6	Aug. 28	Polar Creek at intake	2.1
Aug. 28	do	.4	Aug. 31	do	2.3
Aug. 31	do	.5	Aug. 5	Split Creek at mouth	16.0
Aug. 29	Bear Creek above Cub Creek.	19.2	Aug. 28	do	4.0
Aug. 5	Eagle Creek at intake	1.2	Aug. 31	do	3.3
Aug. 28	do	1.4	Aug. 29	Bob Creek at mouth	5.9
Aug. 31	do	1.2	Do	Cub Creek at mouth	12.3
Aug. 5	Polar Creek at intake	2.9			

WATER POWER.

By F. F. Henshaw.

GENERAL CONDITIONS.

None of the many localities in Seward Peninsula where water-power developments are possible have yet been utilized. In the past the high price of fuel, and consequently of power, has directed attention to several power sites, but up to 1910 little was accomplished at any of these beyond surveys and stream measurements. The promoters of these enterprises have probably not been too hesitant about entering upon power development which would call for a large investment, with a market for the product as yet both limited and uncertain. It has been estimated by Mr. Brooks (p. 296) that the total horsepower of all the dredges of the peninsula in 1910 was 2,500, and it is probable that all other uses of power will require less than 1,000 horsepower. In this estimate the water power used in hydraulic mining and hydraulic elevators is, of course, not taken into account.

One of the largest power plants on the peninsula is that of the electric-light plant at Nome, which is run by steam, consuming coal. In the past considerable power was used in connection with underground mining in the vicinity of Nome, each mine generating its own power (pp. 298–299) with coal, gasoline, or fuel oil. These mines also used a large amount of steam for thawing the ground; indeed, the amount of fuel required for this purpose is usually much greater than that needed for hoisting the gravel. The amount of power used in underground mining has varied widely from year to year and of late has declined very considerably. The dredges are the greatest power users at present and promise a still greater field for the future, for each dredge requires from 150 to 250 horsepower to run its bucket chain, pumps, and lines. (See pp. 292–297.)

Coal for these operations cost in 1909 from $18 to $25 or $30 a ton, delivered at the dredge, but fuel oil is cheaper per heat unit. It is probable that the cost per horsepower used on the dredge will average close to $100 for the season, making an aggregate expenditure of some $250,000 a year for power.

It should also be noted that practically all the power is used within 10 miles of the Bering Sea coast, which is the zone of comparatively cheap fuel. Moreover, fuel oil is getting cheaper every year, and hence there is likely to be strong competition between steam plants and water-power plants. If the production of California oil continues to increase, it is quite possible that fuel oil may be landed at Nome at $2, or even as low as $1 a barrel. T. M. Gibson [1] has recently expressed the opinion that a fuel-oil plant at Nome could furnish power at a cost of $7.50 per horsepower month. It is doubtful whether a hydroelectric plant at any of the most favorable sites in the peninsula could compete with this rate.

In the central part of the peninsula imported fuels will always be much higher than on the coast, and here the commercial possibilities of water-power development are better. There is, however, another possible source of comparatively cheap power in the lignite deposits of the Chicago Creek coal field. A plant located at the coal mine might be able to furnish power in competition with a hydroelectric plant, which, moreover, would at certain times in the year be at a disadvantage with a steam plant. Ditches furnishing water for hydraulic mining can be used on an average only from early in June until about the first week in October—that is, not more than four months, though water-power plants can probably be so constructed that their main conduits would not be subject to so great interruptions in service or delay in opening as the ordinary ditch, in which event the period of operation would be limited largely by the water supply of the stream used and by the climatic conditions.

[1] Gibson, T. M., Nome dredges in 1910: Min. and Sci. Press, vol. 102, 1910, p. 23.

The spring break-up usually occurs about the middle of May, and the freeze-up may be expected by the middle of October, thus giving an operating period of about five months for an average plant. A plant located at the outlet of a large body of stored water, such as Salmon Lake, might be operated for a longer period, possibly during the entire year. Unless a plant were supplied from such a natural reserve, however, it probably could not be operated for more than six or seven months, at the most. If the power from a hydroelectric plant were to be used only for dredging and other forms of open-cut mining, it would, of course, be needed only during the summer months. Low water in dry years, such as 1908 and 1909, would be another handicap to power development, the more so because the low-water periods come in July and August, at about the time when the maximum power load would have to be provided for.

Next to the streams draining large lakes, the best for power development are those rising in the Kigluaik Mountains, for they have the steadiest flow and the largest amount of concentrated fall. Unfortunately, these streams also have the shortest season, as the freeze-up on them comes early and reduces the flow to a minimum for the open season, even before the cold weather would necessitate suspending the operation of a power plant.

There is little basis for estimating the cost of water-power development in Seward Peninsula, but it would no doubt be high, both in aggregate and per horsepower, as compared with the States. There are no exceptionally favorable localities where water power can be developed at low cost, such as a fall with a high sheer drop or a dam site in a narrow gorge, combined with a well-sustained flow.

The future of water-power development within the peninsula depends on the mining industry. If dredging continues to increase as it has during the past few years, especially if dredging ground is developed in the central part of the peninsula, some of the water powers described in the following pages may have value. Chances are good that workable lode deposits may be found whose exploitation would enlarge the market for power, though water-power plants are likely to find strong competitors in the plants using mineral fuels, particularly oil.

The operating cost of water powers is generally much less than that of steam powers, but the initial investment is much greater. In view of the many uncertainties connected with power development in this field, the likelihood of any extensive developments, under conditions that can now be foreseen, is not great.

POWER SITES.

Of the two power sites which have been investigated most thoroughly, one is located on Kruzgamepa River at the outlet of Salmon Lake about 40 miles in a direct line from both Nome and

Solomon, and the other at Pass and Smith creeks, north of the mountains and about 10 miles farther from the present centers of distribution.

The proposed development at Salmon Lake is one involving the use of a large volume of water under a low head. The plans formulated by the Salmon Lake Power Co. in 1905 and 1906, when it had this project under consideration, are of sufficient interest to be described somewhat in detail.

Salmon Lake has been formed by the damming of Kruzgamepa River by morainic material brought down by the glaciers which formerly occupied the valleys of the Kigluaik Mountains and extended some distance beyond their flanks. The outlet of the lake has been cut through this moraine, and a dam site has been formed, about 150 feet long at the bottom and about 600 feet long at an elevation of 50 feet above the present lake surface. The morainic material is composed largely of gravel and angular fragments of no great size and was evidently in part laid down in water, as it shows a certain degree of stratification and is interbedded with clays and silts. It is not unlikely that there may be, at a reasonable distance below the surface, a stratum of bowlder clay or other impervious material on which a cut-off wall could be founded, but so far as known to the writer the existence of such a stratum has not been demonstrated. The plan contemplated the building of a concrete core wall supported on either side by hydraulic fill. Gravel is abundant on the east end of the site at sufficient elevation above the proposed crest so that it could readily be sluiced in to form the dam. It was proposed to divert the water of Crater Creek, which enters Kruzgamepa River about 4 miles below the lake by ditch around the south slopes of the Kigluaik Mountains and by pipe to the dam site, and to use this water to move and distribute this gravel in the dam by the hydraulic method. The water could also be used in hydraulic elevators to sink the trench in which the core wall would be built.

The discharge from the lake was to be conducted through the dam in wood-stave pipes laid in concrete, which would end in a power house built at a lower toe of the dam. Special precautions were to be taken to enable the plant to run all winter. The tailrace was to consist of long pipes which would extend some distance below the power house. It would be necessary to give the water sufficient velocity in the pipes so that it would not freeze and cause backwater on the turbines. The operation of this proposed power plant during the winter would probably present a problem whose solution would require considerable time and study.

The north side of the Kigluaik Mountains is drained by a series of creeks which rise in high glacial cirques, have a rapid fall, and carry a good volume of water throughout the summer season. Their basins have all been subjected to heavy glaciation, which has resulted in the formation of numerous cirques and lakes. The gradient of many of the creeks is broken into flat portions separated by steep torrential stretches. A great mass of morainic débris lies beyond the flanks of the mountains, and it is over this deposit that the creeks have their greatest fall. The aggregate water power of all these streams is enormous, perhaps as much as 40,000 or 50,000 horsepower for normal low-water conditions.

At two localities these creeks present especially favorable conditions for power development. All these streams have been surveyed by private engineers with a view to determining their water-power possibilities, and measurements of their discharge have been made by the Geological Survey.

Pass and Smith creeks are probably the most favorably situated for furnishing electric energy. The valley occupied by Pass Creek was filled within recent geologic time by a glacier, as is shown by the topography of the valley floor. This glacier built up a flat-topped moraine which extends out nearly a mile from the mountain front. On top of the moraine, at an elevation of about 1,100 feet, are two lakes, both of which are favorably located to provide storage. Below the lower lake the creek falls nearly 1,000 feet in 2 miles. Smith Creek lies west of Pass Creek, and although it presents no storage facilities it has a large volume of flow at a high elevation. The power development planned for these creeks provided for a dam below the lakes on Pass Creek, in order to create a large reservoir, and a main pipe line laid from this to the power plant, which would be located in the flat 2 or 3 miles below this point and about the same distance from tidewater on lower Kruzgamepa River. The waters of Smith Creek would be diverted at an elevation of about 1,200 feet and led through a flume constructed along the mountain side into the storage basin on Pass Creek.

As shown by the discharge record of these two streams, the combined low-water flow could be maintained at 50 second-feet all summer with a few thousand acre-feet of storage. This would generate about 4,500 continuous horsepower, and the development could be increased either by raising the dam or by diverting additional water from creeks farther west. Either alternative would be rather costly and only a careful investigation of the engineering problem involved would indicate which one is the cheaper. The maximum possibility of this plant would probably be about 10,000 continuous horsepower during a working season of 120 to 140 days. It would not be possible to run the plant during the winter, and the period of successful operation would probably extend from late in May until about the middle of October.

Cobblestone River is the largest stream on the north side of the mountains, but it rises at a considerably lower elevation than the streams just described and its fall is, therefore, not nearly so steep. This fact renders it much less favorable for power development, as the cost of a project depends to a great degree on the length of pipe required for a given head.

Fall and Pond creeks lie west of the Cobblestone and flow into the south side of the Imuruk Basin. In some ways they are counterparts of Pass Creek. Each flows, at an elevation of about 1,200 feet, through a lake, below which there is a large amount of concentrated fall. About 2 miles of pipe on Pond Creek and about 4 miles on Fall Creek would be required to obtain a head of 1,000 feet. It would be possible to construct two pipes, one on the east side of Fall Creek and the other on the west side of Pond Creek, around the hills on a hydraulic grade line and to discharge the water into a common pressure pipe which would have to be from 1 to 1½ miles long to obtain 1,000 feet head. Another alternative would be to run a tunnel about 2 miles long through the mountains from the lake on Fall Creek to that on Pond Creek. Whether this would be cheaper than pipes led around the mountain side, even if it is feasible, is doubtful.

From the discharge of the two streams, given on pages 150–151, it would seem that with a moderate amount of storage a discharge of 80 second-feet, which would produce about 7,000 continuous horsepower, could be maintained continuously throughout the summer. Both Glacier Creek and Snow Gulch, which lie to the east of Pond Creek, have a well-maintained flow, and their waters could be diverted into this system by flumes of moderate length. A large volume of storage could be obtained at the lake on Fall Creek if it were required, and the maximum possible development at this site would probably be somewhat greater than that on Pass and Smith creeks.

The water-power possibilities of the Bendeleben Mountains are rather large in the aggregate, but are much less favorable than those of the Kigluaik Mountains. The streams of this area have a lower gradient and a smaller volume of flow than those of the higher mountains to the west, and storage facilities are practically lacking.

North of the mountains favorable power sites are very rare. On Kougarok River just above Coarse Gold Creek there is a wide bend which brings two points nearly 2½ miles apart by river within less than 600 feet in a direct line. A tunnel between these points would make available a head of about 17 feet in addition to the height of the diversion dam. The great drawback to this site is the fact that the low-water flow of the river is very small, falling below 20 second-feet practically every year. At a favorable site on Noxapaga River, a short distance above Goose Creek, the river drops about 95 feet in a little less than 2 miles. The minimum flow in an ordinary year seems to be about 60 second-feet, though a discharge of only 33 second-feet was measured in 1909. The latter figure would make only about 250 horsepower available. The falls have been formed by a lava flow which dammed the river and has produced a lake several miles long. If the project were feasible, a considerable volume of storage could be created by building a dam at the head of the falls, but this point is isolated and no large body of placer ground is known in the vicinity, so that a demand for the power is not probable.

A large amount of power could be developed at one point in the Fairhaven district, namely, on Kugruk River below Imuruk Lake. The locality is described in connection with the river description. (See p. 229.) The amount of power that could be generated at this point is probably large. The total water supply available from Imuruk Lake for a season of 120 days is given as about 250 second-feet (p. 231). The Fairhaven ditch will never require more than 60 or 80 second-feet of this amount, so that at least 170 second-feet will be left for possible water-power developments. The head that could be obtained is nearly 500 feet, which would indicate that about 7,500 hydraulic horsepower could be developed through the mining season, an amount far in excess of any possible demands in this region.

In general it may be said that there are in Seward Peninsula water powers favorably situated for hydroelectric development amounting to some 30,000 or 40,000 horsepower, besides a much greater amount of power which could never be considered feasible either commercially or as a matter of engineering.

DITCHES.

By F. F. Henshaw.

INTRODUCTION.

The construction of ditches in Seward Peninsula has had to face many unfavorable conditions and difficulties peculiar to the frozen north, but in spite of these handicaps more than 400 miles of ditch having a capacity of 20 second-feet or over have been built. These waterways have constituted an important field of investment and the mining operations dependent on them have contributed a large quota to the gold production of the area.

The first ditch was built from upper Glacier Creek to Snow Gulch in 1901, and as extended in 1902 and 1903 formed the present Miocene system. The next long ditch to be built was the Canyon ditch, on

Ophir Creek, which was also begun in 1901 and finished in 1903. The greatest activity in ditch building began in 1905 and lasted until about 1907. During this period about two-thirds of the total length of ditches now existing in Seward Peninsula were constructed.

The principal difficulties that ditch builders in Seward Peninsula have had to face have been due to the frozen condition of the ground, the difficulty and expense of transportation, and the shortness of the working season. Of these the frozen ground is peculiar to the north and has probably been the greatest drawback to rapid and economical construction.

The following list has been prepared to give the salient features of the larger ditches in Seward Peninsula. The data given are not altogether complete and are for certain ditches only approximate; for instance, the capacity of a given ditch will vary from point to point and will change materially from year to year, increasing if the repair work is thoroughly and carefully done, and decreasing if the ditch is built in bad ground and is neglected.

Only ditches which have capacities of approximately 20 second-feet or more, and which may therefore be regarded as having a part in large-scale operations, are listed. Ditches that have been started and then abandoned, even though several miles may have been built, are not considered. Accordingly, many ditches included in former lists [1] are omitted.

[1] Water-supply investigations in Alaska: Water-Supply Paper U. S Geol. Survey, No. 218, 1908, pp. 75-76 and 95.

Ditches for hydraulic mining in Seward Peninsula.

Name.	Diverts from—	Extends to—	Date completed.	Length.	Bottom width.	Fall per mile.	Capacity.	Pressure obtained.
Wild Goose Mining & Trading Co:				*Miles.*	*Feet.*	*Feet.*	*Sec.-ft.*	*Feet.*
Pargon	Pargon River, Dillon, McKelvie, and Helen creeks.	Ophir Creek divide	1905	11	8	4.22	30	....
Canyon	Ophir Creek	Mouth of Sweetcake Creek	1903	17	10	3.17–4.22	70	150–225
Nineteen	do	do	1902	7	6	....	20	75
Wilson & Kimball—Hot Air	do	Claim "No. 3 above"	....	3	8	....	25	40
Casadepaga Development Co	Moonlight Creek	Opposite Monument Creek	1908	2	6	3.17	20	120
Canyon Creek Gold Mining Co	Canyon Creek	Sunshine Creek	1906	5	4	5.28	15	180
Topkok Ditch Co	Klokerblok and Skookum rivers	Daniels Creek	1905	3.5	5.5	5.28	30	....
Solomon River Ditch Co	Coal Creek	Solomon River	1905	6.8	8	....	30	240
Solomon Mines & Water Power Co.	East Fork	Mouth of Big Hurrah Creek	1905	8	8	....	30	190
Midnight Sun Mining & Ditch Co.	Big Hurrah Creek	Rock Creek	....	8.5	8	....	25	120
Nome-Montana-New Mexico Mining Co.	California Creek	Mystery Creek	1909	15	6–7	5.28	30	300
Campion Mining & Trading Co	Buffalo Creek	Dorothy Creek	1903	4	6	7.5	25	170
Miocene Ditch Co	Nome River & Hobson Creek	Glacier, Anvil, and Dexter creeks	1903	35	8–10	3.17–6.34	40–55	380
Seward Ditch Co	Nome River below Dorothy Creek	Anvil Creek	1906	38	10	3.17	32	[a] 274
Pioneer Mining Co	Nome River above Clara Creek	do	1907	38	8	3.17	30	[a] 200
Peninsula Hydraulic Co	Osborn Creek above Cuss Creek	3 miles below Willow Creek	1907	8	10	5.28	50	180
V. A. Julian	Osborn Creek 3 miles below New Eldorado Creek.	Lower Osborn Creek	1908	4.25	5–6	5.28	20	125
Arctic Placer Mining & Milling Co.	Last Chance Creek	Bangor Creek	1908	8	6	....	20	190
United Ditch Co	Penny River	Beach near Jess Creek	1905	6	12–20	3.17	40	[a] 90
Cedric Ditch Co	Headwaters of Cripple River	Oregon and Hungary creeks	1905	19	4–8	4.22	25	150
Cripple River Hydraulic Mining Co.	Cripple River	Fox Gulch	1909	11	8–10	4.22	50	150
Wild Goose Mining & Trading Co.—Pipe Line.	Grand Central River and Crater Lake	Nugget Divide	([b])	8	[c] 3½	15	60	....
Miocene Ditch Co	Grand Central River	do	([b])	8	8	5.28	60	....
Irving Mining Co	Kougarok River	Opposite Columbia Creek	1907	4.4	6	4.22	15	160
Kugarok Mining & Ditch Co	do	Opposite Homestake Creek	1907	7.5	8	3.17–4.22	25	160
Taylor Creek Ditch Co.—North Star.	Taylor Creek	Arctic Creek	1907	15	8–10	3.69–4.22	40	200
Cascade Mining & Ditch Co	do	Claim No. 3, Taylor Creek	1907	6.25	5½	4.22	12	110
Taylor Creek Ditch Co	Henry Creek	Homestake Creek	1910	10.25	6	3.17	15	210
Galvin Ditch Co	Coarse Gold Creek	Twobit Gulch	1907	5	8	4.22	20	300
Brady & Wood	Windy Creek	Anderson Gulch	1909	4	6	4.22	15	150
Ottumwa Gold Mining Co	Budd Creek at Spring	Budd and Windy creeks	1907	8	9	4.22	30	160
Arctic Mining & Trading Co	Agipuk and California rivers	Sunset Creek	1906	38	8	....	30	212
Pittsburg-Dick Creek Mining Co	Bryan Creek	Dick Creek	1907	6.5	6	4.22	15	170
Do	Quartz Creek	Bryan Creek divide	([d])	8	8	4.22	20	....
Fairhaven Water Co	Imuruk Lake	Inmachuk River	1907	36	11	4.22	40–60	530
Candle Alaska Hydraulic Gold Mining Co.	Glacier Creek	Candle Creek	1908	33.25	6–8	3.70	20	249

[a] Above sea level at outlet. [b] Under construction. [c] Diameter. [d] Incomplete.

METHODS OF CONSTRUCTION.

Ditches are constructed by several different methods, according to the conditions of the ground encountered. Horses have been used for the work wherever possible. In one method the ground is first prepared by removing the moss and turf from a strip 40 or 50 feet wide on either side of the ditch. This should be done, if possible, the summer before actual construction is begun, in order that the ground may thaw more readily. Actual construction begins with plowing (see Pl. II, p. 12), after which some of the material is moved with a grader from the upper side of the ditch to the lower bank until a practically flat bench is produced. The cut is then excavated with horse scrapers down to grade, and the material piled up on the lower bank. The ditch is finished by hand, and both bottom and bank are trimmed to an even grade and alignment. (See Pl. VI.) The method above described is practicable where the ground contains only small or medium sized rocks and is about the cheapest and most rapid that can be used, but it requires exceptionally favorable conditions to make it a success. Where the ground is naturally unfrozen or can be made to thaw easily, and where other conditions are similar to those encountered in a temperate climate, no difficulty is experienced.

Wherever the ground is frozen muck, or so-called "glacier," it melts rather slowly when exposed to the air, and the work of excavation must be done by hand while it thaws. The best practice is to keep exposed as large an area as possible and to remove the soil in thin layers. Practically all the ditches north of the mountains were built by this method.

More or less rock work has to be done on all the ditches. Some of them have had to pass around cliffs of practically solid rock where the construction required a large amount of blasting (Pl. VII). Rock cuts offer no problems not met in other fields except in the method of making the ditch tight, which is done by the use of a peculiar tough and tenacious sod abundant in many places in the north. The sod is cut with mattocks into pieces 1 to 2 feet square and placed in the ditch, bottom up. Two layers are usually placed in the bottom, breaking joints as well as possible, and the whole is carefully and solidly tamped into place. The sides of the ditch are made tight with a sod wall, the pieces being laid one above another, bottom up. Where the sod is above the water line part of the time, the grass usually continues to grow and its living roots bind the material more closely and firmly together. The best sod, and the only kind which fully meets the requirements, is that containing grass roots and very little moss, for the moss is less tenacious and decays more rapidly. Grass, however, is not abundant in many places, and it is

A. CANDLE DITCH, FAIRHAVEN DISTRICT.

B. HOMESTAKE DITCH, SHOWING SOD WORK.

ROCK CUT AROUND CAPE HORN ON MIOCENE DITCH.

therefore often necessary to use sod of inferior quality, with correspondingly unsatisfactory results. For example, on the Fairhaven ditch there is a great deal of rockwork and much frozen ground which becomes very soft on thawing, and a great deal of sod was needed. Sod could be found only in small isolated patches, and much of it had to be taken from the river bottoms far below the line of the ditch at considerable expense. In the Kougarok region, however, sod is fairly abundant and has been used very freely, and in southern Seward Peninsula sod of a good quality can usually be found. Plate VI, *B*, shows a typical portion of a ditch protected by sod as described above.

Canvas has been used in some places to line ditches, but it is expensive and is reported to be not wholly satisfactory. If it is disturbed after it is once laid down, it is likely to be torn, in which event it becomes practically useless.

In ground composed largely of frozen muck or ground ice special methods and precautions must be used. This material when it thaws leaves a soft residue, largely mud and decomposed vegetable matter, which may be only 20 or 30 per cent of the original volume. Water flowing across such material causes it to thaw rapidly, and consequently when a ditch is built through it precautions must be taken to prevent too much thawing. Where the muck is present the portion nearest the surface usually contains much more earthy matter than that just below, and in many places there is a layer of blue clay just beneath the moss. The vegetable matter close to the surface is also less completely decayed and therefore more solid and tenacious than that lower down. If this surface covering is allowed to remain in place and the ditch built over it by building up the lower bank with sod and with material stripped from the top, good results can usually be obtained. When the stripping is carried to just about the right depth, the water, after being turned into the ditch, will cause the ground to thaw a little. The bottom will settle a few inches, and then the ditch practically builds itself, so that eventually the water is carried in a section entirely below the surface of the ground, and the ditch can not leak, because its sides are all soft, finely divided material, mostly muck and clay, backed by solid and impervious frozen ground. These ideal conditions are generally aimed at by ditch builders but are attained only at certain localities and by special care in building and watchfulness in maintaining the ditch.

Most of the Fairhaven ditch was built in 1906 before builders had gained much experience with ground of this character. Through a large part of its course it passes over ground that is permanently frozen. The ditch was built under a contract which called for a cut of 12 inches below the ground surface of the lower bank, and the contractors were held rigidly to the specifications. As a result, all the surface covering was removed, and the ditch bottom was made in frozen ground containing only a small percentage of solid material. When the water was turned in this frozen muck thawed and the ditch settled in some places 3 or 4 feet. The material thus melted yielded enough solid matter so that in many places a fairly good bottom resulted and the thawing did not progress any farther. At other points the ditch bottom practically sank "out of sight." The water cut under the lower bank and bad breaks resulted.

The Candle ditch, a view of which is shown in Plate VI, *A*, was built in a drainage basin adjacent to that in which the Fairhaven ditch is located and encountered much ground of a similar character but apparently containing a somewhat higher percentage of solid matter. It is smaller than the Fairhaven ditch and was built with a cut on the lower bank of about 8 or 9 inches. This ditch has settled in a great many places, but when the writer last visited it, in 1909, it was on the whole in somewhat better condition than the Fairhaven ditch. In one section where the ground had cut badly the ditch had evidently been given an excessive grade, and the water attained a velocity sufficient to scour away the fine material as it thawed. As a result a deep cut was eroded, and only the fact that this occurred on flat ground prevented a bad break.

The necessity of keeping the grade of the ditch and the velocity of the water low in ground of this character is very important and can not be too strongly emphasized. The Fairhaven ditch was laid out with a grade of 4.22 feet to the mile, and as it was designed to carry water to depths of 2 feet or more the resulting velocities were rather high, a condition which contributed in no small degree to the cutting that resulted in the soft ground. The grade of the Candle ditch was only 3.69 feet to the mile and the ditch itself is of smaller dimensions, so that the resulting velocities were lower and the difficulties encountered correspondingly less.

In many places a ditch in ground of this character should not be given a grade greater than 2½ feet to the mile. The ditch can be built wide and with a shallow cut. It will then "make itself" at a very small expense, and the low velocity resulting will tend to give a permanent and satisfactory waterway.

FLUMES.

It has been the object of most ditch builders in the north to minimize the use of flumes because of the high price of lumber, with the result that this form of construction is much less common than in ditches in the States. (See Pl. VIII, *A* and *B*.)

A. FLUME ON OPHIR CREEK.

B. FLUME OF TOPKOK DITCH, NEAR BLUFF.

Flumes are unsatisfactory for two or three reasons. In the first place the lumber generally has to be imported. Its cost laid down at Nome or at other landing places is heavy, and the cost of freighting it into the interior where it is to be used is often still heavier. The cost of the flume lumber used on the Pargon ditch in the Council country is said to have been nearly $200 a thousand feet. In the eastern part of the peninsula native lumber can be used for the trestles and collars, but it is so poor in quality that it should not be used for the flume itself.

Another objection to a flume is that it is less permanent than an earth ditch. The waterway is out of commission and exposed to the elements for eight or nine months in the year. In many places, too, especially in the mountains, the country is subject to snowslides, which may wreck considerable sections of a flume, though they would have little effect on a ditch. The Pargon flume has suffered damage on several occasions from slides. Snowdrifts may pile on the flume to considerable depth, and the snow as it settles will break the trestles, crush the bottom, and spread the sides. The part of the Golden Gate ditch on Iron Creek, which was built as flume, was rendered practically useless by the snows of the first winter after it was built, largely by the settling of heavy drifts upon it.

The difficulty of obtaining proper foundations presents a third problem. The settling of a ditch bottom or bank 2 or 3 or even 6 or 8 inches is not a serious matter, particularly if the settlement is fairly uniform throughout a considerable section; but any considerable settling of the foundation of a flume will open joints, loosen the bottom, and cause the flume not only to leak but perhaps even to fall to pieces.

As previously stated, the Pargon ditch, in the Council district, is composed largely of flumes, the total length of this form of construction being 13,372 feet. The longest continuous stretch extends most of the way from McKelvie Creek to Helen Creek. The flume is 8 feet wide and 2 feet deep and is set on a grade of 4.22 feet to the mile, the same as the earth sections of the waterway. Dressed lumber 1⅛ inches thick was used, battened with 2 by ½ inch strips. The trestles, stringers, and collars are all of native spruce, which was cut near Duncan Creek, sawed in a portable mill installed for the purpose, and hauled to the Pargon during the winter of 1904–5. The flume is laid mostly over a talus of heavy blocks of granite and schist. The subfoundations were solid most of the way, but no mudsills were used and the trestlework was poorly built and improperly braced, so that the conduit gets out of order frequently. In 1909 the average depth of water that could be carried had been reduced to about 16 inches owing to damage done to the flume.

One of the most notable examples of successful flume construction over frozen ground that has been seen by the writer is the Miocene ditch. This flume is 1,100 feet long and has a width of 8 feet and a depth of 28 inches. It was constructed in 1901, and until 1906 or 1907 it retained practically perfect alignment, both horizontal and vertical. No extensive repairs were necessary on it until 1909. In putting in the foundation trenches were dug 3 or 4 feet deep in the frozen ground, which was practically all ice. A sill was laid in the bottom of the trench and the uprights fastened to this sill. The excavated material was then replaced in the trenches and allowed to freeze again into its original condition. Sod was carefully placed over the trench, the uprights were then sawed off to grade, and the flume constructed on them. Even with all these precautions, however, at the end of about eight years the flume was in such bad shape that extensive repairs had to be made.

SIPHONS AND PIPE LINES.

Siphons have been used extensively to cross side streams in order to save expense and distance and loss of water by seepage. They vary in size from small ones containing a few hundred feet of 16 to 18 inch pipe to one more than 2 miles long on the Candle ditch across Eldorado and Burnside creeks. Riveted steel pipe has been used in most of the construction, though wood-stave pipe was employed for two siphons, 42 inches in diameter and 1,050 and 800 feet long, which were built to carry the waters of the Seward ditch across Hobson and Clara creeks. The pipe was of the continuous-stave, steel-banded style, similar to that used on the Grand Central pipe line, which will be described later.

The first large siphon built, that of the Miocene ditch across Manila Creek, is about 1,000 feet in length and is composed of 40-inch steel pipe with joints riveted throughout. It has a capacity of 60 second-feet.

The siphon on the North Star ditch of the Taylor Creek Ditch Co. extends across the valley of Taylor Creek about 2 miles above its mouth. It is composed of heavy 40-inch steel pipe, is 2,600 feet long, and is riveted throughout, there being no slip joints. The pipe is carried across the creek on a suspension bridge about 100 feet long. The difference in water level in the ditch at the ends of the siphon is 19 feet and the pressure head at the bottom 150 feet. The capacity of the siphon is nearly 60 second-feet.

In most of the other siphons on Seward Peninsula the joints have been made without riveting. In making slip joints the pipe whose end is of larger diameter is heated by placing burlap dipped in kerosene around it and igniting it. The pipes are then driven together by means of a heavy ram, which is directed against a driving plate covering the opposite end of the pipe. The ram is handled by two men, or, if the pipe is large, is swung from a tripod. The slip joints are driven to give an overlap of 4 to 6 inches, depending on the size of the pipe. This method is cheaper and much more rapid than riveting, although a little more pipe is required on account of the greater overlap given to the unriveted joints. In long lines of pipe there is some tendency for the pipe to heave with the expansion and contraction due to changes in temperature, and this may even proceed so far as to cause some of the joints to fall apart; but it can be minimized by keeping the pipe full practically all the time, as the water has a nearly constant temperature. The pipe should also be covered with sod, moss, or earth in order to further protect it. In long pipes like that of the Candle ditch, which are driven with slip joints, two sections will occasionally pull apart. In such a contingency it is usually necessary to make a lead joint, a process too well known to need description here.

Only one conduit line, the Grand Central pipe line of the Wild Goose Mining & Trading Co., has been constructed entirely of pipes. Continuous wood-stave pipe 42 inches in diameter was used, except for a few hundred feet at the intake where the diameter was 48 inches. The staves are 6 inches wide, 1½ inches thick, and rounded to fit the hoops. The pipe is laid along a shelf cut in the hillside and afterwards back filled, the pipe being covered and protected with rock and earth. Wrought-iron bands one-half inch in diameter, threaded on both ends, were used. The bands are spaced about 1 foot apart where the pipe is on the hydraulic grade line and are placed closer where depressions have to be crossed in order to give sufficient strength to resist the pressure. The pipe has its intake on Crater Lake, and branches extend from the North and West forks of Grand Central River to the lake.

The pipe had not been completed at the time of the last visit made by a member of the Survey to the Grand Central basin. Accordingly the pipes had not been tested in actual operation, so it is not known just how this form of construction will be found adapted to conditions in Alaska.

SEEPAGE LOSSES.

By G. L. Parker.

The amount of seepage which may be expected in a ditch built under the conditions which exist in Seward Peninsula is of such importance that a special study of this subject is desirable. It is difficult, however, to arrive at a satisfactory determination of these losses on account of the inflow into the ditches from the drainage area above them. Storage facilities are not available in this region except in the Fairhaven ditch system, and the ditches run at full capacity only during periods when the ground is well saturated with water from rains or melting snow. The flow of a ditch is augmented at such times by the discharge of a number of small streams, which contribute volumes of water small in individual amount but rather large in the aggregate. The surface flow of these streams is in general too small to measure and does not represent the actual amount of water reaching the ditches from them because it does not include the underflow through the gravel beds. The side streams are practically dry during low-water periods, and the supply at the head of the ditches is materially reduced, so that the depth of water running in the ditches is lowered. Owing to a reduced wetted perimeter the amount of leakage is somewhat smaller for low-water periods, and seepage determined under these conditions will not give true values for ditches running at full capacity.

The character of the country over which ditches are built constitutes the principal element affecting the loss by seepage. A great diversity of surface conditions and of formations exists in Seward Peninsula, but the method usually followed in building ditches in this region results in making the leakage throughout their length fairly uniform. The use of sod, as noted on page 258, for lining portions of ditches built around rocky points, over loose rocks, or through decomposed schist, slate, ground ice, and other material unsuitable for ditch walls, makes the loss much less than would otherwise be experienced. The sod when properly placed becomes covered with silt deposits from the water, so that the loss in these sections is probably not much greater than that of parts constructed over more favorable ditching ground. Ditches built over frozen muck such as is often encountered in the northern part of the peninsula ordinarily have small seepage losses, for the bottom and sides of the ditches are composed of fine sediment backed by solid frozen material that renders them almost impervious.

It is obvious that the percentage of loss by seepage is much greater during periods of drought than when the water supply is well sustained. Consideration of the losses at such intervals is therefore very important. The extreme low water experienced during the open season of 1909 makes the discharge records of ditches obtained for that year especially valuable for this purpose. The data for the Miocene and Seward ditches have been analyzed to show the amount of water lost between stations, and the results are presented below in the form of tables. Means for 10-day periods were used in preparing the tables in order to eliminate compensating errors in gage readings and to avoid discrepancies arising from lack of uniformity in flow for single days at the various stations. Continuous records were also obtained at three points on the Fairhaven ditch in 1909, but the flow fluctuated so greatly on account of the frequent breaking of the upper ditch that comparisons of records do not give consistent results as regards seepage losses.

Seepage losses of Miocene ditch in 1909.

Dates (inclusive).	Station.	Distance between stations.	Distance from intake.	Average discharge.	Loss.	Loss per mile.
		Miles.	*Miles.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
June 23–July 2	Black Point		1.0	26.2		
Do	Above Hobson	12.0	13.0	21.8	4.4	0.37
July 3–12	Black Point		1.0	39.9		
Do	Above Hobson	12.0	13.0	28.5	11.4	.95
July 13–22	Black Point		1.0	31.0		
Do	Above Hobson	12.0	13.0	22.6	8.4	.70
Do	Below Hobson		13.0	37.1		
Do	Below the flume	4.1	17.1	35.0	[a] 4.3	1.05
July 23–Aug. 1	Black Point		1.0	13.0		
Do	Clara	7.0	8.0	10.4	2.6	.37
Do	Above Hobson	5.0	13.0	8.9	1.5	.30
Do	Below Hobson		13.0	19.9		
Do	Below the flume	4.1	17.1	17.7	[b] 3.9	.95
Aug. 2–11	Black Point		1.0	18.9		
Do	Clara	7.0	8.0	13.5	5.4	.77
Do	Above Hobson	5.0	13.0	11.6	1.9	.38
Aug. 12–21	Black Point		1.0	19.2		
Do	Clara	7.0	8.0	14.6	4.6	.66
Do	Above Hobson	5.0	13.0	13.9	.7	.14
Aug. 22–31	Black Point		1.0	10.5		
Do	Clara	7.0	8.0	6.3	4.2	.60
Do	Above Hobson	5.0	13.0	4.7	1.6	.32
Sept. 1–10	Black Point		1.0	8.2		
Do	Clara	7.0	8.0	3.4	4.8	.69
Do	Above Hobson	5.0	13.0	2.0	1.4	.28
Sept. 11–19	Black Point		1.0	7.1		
Do	Above Hobson	12.0	13.0	.9	6.2	.52

[a] The actual difference is increased by 2.2 second-feet, the estimated discharge of the Grouse Creek branch for this period.
[b] The actual difference is increased by 1.7 second-feet, the estimated discharge of the Grouse Creek branch for this period.

Summary of loss per mile, in second-feet, of Miocene ditch in 1909.

Between—	June 23 to July 2.	July 3 to July 12.	July 13 to July 22.	July 23 to Aug. 1.	Aug. 2 to Aug. 11.	Aug. 12 to Aug. 21.	Aug. 22 to Aug. 31.	Sept. 1 to Sept. 10.	Sept. 11 to Sept. 19.	Mean for period.
Black Point and Clara				0.37	0.77	0.66	0.60	0.69		0.62
Clara and Hobson				.30	.38	.14	.32	.28		.28
Hobson and point below the flume			1.05	.95						1.00
Black Point and Hobson	0.37	0.95	.70	.34	.61	.44	.48	.52	0.52	.55

Seepage losses of Seward ditch in 1909.

Dates (inclusive).	Station.	Distance between stations.	Distance from intake.	Average discharge.	Loss.	Loss per mile.
		Miles.	*Miles.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
June 24–July 3	Intake		0.0	18.1		
Do	Above Hobson branch	7.1	7.1	14.4	3.7	0.52
Do	Below Hobson branch		7.1	20.0		
Do	Dexter Creek	15.5	22.6	12.3	7.7	.50
Do	Newton Gulch	9.7	32.3	9.3	3.0	.31
Do	Intake to Newton Gulch	32.3			14.4	.45
July 4–July 13	Intake		.0	28.0		
Do	Above Hobson branch	7.1	7.1	23.6	4.4	.62
Do	Below Hobson branch		7.1	29.7		
Do	Dexter Creek	15.5	22.6	14.8	14.9	
Do	Newton Gulch	9.7	32.3	11.6	3.2	.33
Do	Intake to Newton Gulch	32.3			22.5	
July 14–July 23	Intake		.0	11.4		
Do	Above Hobson branch	7.1	7.1	9.7	1.7	.24
Do	Below Hobson branch		7.1	14.7		
Do	Dexter Creek	15.5	22.6	8.2	6.5	.42
Do	Newton Gulch	9.7	32.3	5.4	2.8	.29
Do	Intake to Newton Gulch	32.3			11.0	.34
July 24–Aug. 2	Intake		.0	10.1		
Do	Above Hobson branch	7.1	7.1	7.3	2.8	.39
Do	Below Hobson branch		7.1	10.9		
Do	Dexter Creek	15.5	22.6	4.8	6.1	.39
Do	Newton Gulch	9.7	32.3	1.1	3.7	.38
Do	Intake to Newton Gulch	32.3			12.6	.39
Aug. 3–Aug. 12	Intake		.0	18.3		
Do	Above Hobson branch	7.1	7.1	13.2	5.1	.72
Do	Below Hobson branch		7.1	16.6		
Do	Dexter Creek	15.5	22.6	8.3	8.3	.54
Do	Newton Gulch	9.7	32.3	6.4	1.9	.20
Do	Intake to Newton Gulch	32.3			15.3	.47
Aug. 13–Aug. 22	Intake		.0	16.6		
Do	Above Hobson branch	7.1	7.1	12.3	4.3	.61
Do	Below Hobson branch		7.1	15.6		
Do	Dexter Creek	15.5	22.6	9.0	6.6	.43
Do	Newton Gulch	9.7	32.3	4.5	4.5	.46
Do	Intake to Newton Gulch	32.3			15.4	.48
Aug. 23–Sept. 1	Intake		.0	15.8		
Do	Above Hobson branch	7.1	7.1	11.1	4.7	.66
Do	Below Hobson branch		7.1	14.2		
Do	Dexter Creek	15.5	22.6	9.3	4.9	.32
Do	Newton Gulch	9.7	32.3	4.6	4.7	.48
Do	Intake to Newton Gulch	32.3			14.3	.44
Sept. 2–Sept. 11	Intake		.0	15.4		
Do	Above Hobson branch	7.1	7.1	11.4	4.0	.56
Do	Below Hobson branch		7.1	14.0		
Do	Dexter Creek	15.5	22.6	8.8	5.2	.34
Do	Newton Gulch	9.7	32.3	3.5	5.3	.55
Do	Intake to Newton Gulch	32.3			14.5	.45
Sept. 12–Sept. 21	Intake		.0	16.3		
Do	Above Hobson branch	7.1	7.1	12.6	3.7	.52
Do	Below Hobson branch		7.1	16.5		
Do	Dexter Creek	15.5	22.6	10.8	5.7	.37
Do	Newton Gulch	9.7	32.3	5.8	5.0	.52
Do	Intake to Newton Gulch	32.3			14.4	.45
Sept. 22–Sept. 27	Intake		.0	22.4		
Do	Above Hobson branch	7.1	7.1	19.0	3.4	.48
Do	Below Hobson branch		7.1	27.6		
Do	Dexter Creek	15.5	22.6	18.8	8.8	.57
Do	Newton Gulch	9.7	32.3	13.4	5.4	.56
Do	Intake to Newton Gulch	32.3			17.6	.54

Summary of loss per mile, in second-feet, of Seward ditch in 1909.

Between—	June 24 to July 3.	July 4 to July 13.	July 14 to July 23.	July 24 to Aug. 2.	Aug. 3 to Aug. 12.	Aug. 13 to Aug. 22.	Aug. 23 to Sept. 1.	Sept. 2 to Sept. 11.	Sept. 12 to Sept. 21.	Sept. 22 to Sept. 27.	Mean for period.
Intake and Hobson branch	0.52	0.62	0.24	0.39	0.72	0.61	0.66	0.56	0.52	0.48	0.53
Hobson branch and Dexter Creek	.50		.42	.39	.54	.43	.32	.34	.37	.57	.42
Dexter Creek and Newton Gulch	.31	.33	.29	.38	.20	.46	.48	.55	.52	.56	.40
Intake and Newton Gulch	.45		.34	.39	.47	.48	.44	.45	.45	.54	.44

Measurements were made at several points along the Miocene ditch and branches at different times during 1906 to ascertain the loss or gain in discharge between specified points. The measurements of July 3–4 and July 27 were made during low-water periods, and those of September 11–12 when the ditch was carrying considerably more water. In 1908 two sets of similar measurements were made along the Fairhaven ditch. The first set was taken when the discharge of the ditch was small and the second when the supply at the intake was fluctuating somewhat, so that neither quite represents normal conditions. The supply of the Fairhaven ditch is drawn from water stored in Imuruk Lake, so that it is possible to keep the ditch running at its full capacity irrespective of rain or drought. The following tables are included to show the results derived from the measurements along the two ditches:

Seepage measurements of Miocene ditch in 1906.

Date.	Point of measurement.	Distance between points.	Distance from intake.	Discharge.	Gain.	Loss.	Loss per mile.
	Main ditch.	*Miles.*	*Miles.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
July 3	Nome River intake		0.0	21.0			
Do.	Above Hobson	13.0	13.0	15.8		5.2	0.40
July 4	do		13.0	20.5			
Do.	Below Hobson		13.0	31.0	10.5		
Do.	Above Grouse Creek branch	3.8	16.8	28.1		2.9	.76
Do.	Below flume	.3	17.1	29.8	1.7		
Do.	Above "X"	9.2	26.3	27.9		1.9	.21
July 27	Nome River intake		.0	28.0			
Do.	Black Point	1.0	1.0	25.7		2.3	2.30
Do.	Above Dorothy	2.8	3.8	26.2	.5		
Do.	Below Dorothy		3.8	26.0		.2	
Do.	Above Hobson	9.2	13.0	23.7		2.3	.25
Do.	Below Hobson		13.0	38.0	14.3		
Do.	Below Hobson, plus discharge of Grouse Creek branch			39.7	1.7		
Do.	Below flume	4.1	17.1	36.5		3.2	.78
Aug. 2	do		17.1	28.3			
Do.	Above "X"	9.2	26.3	26.3		2.0	.22
Sept. 11	Nome River intake		.0	29.8			
Do.	Black Point	1.0	1.0	30.7	.9		
Do.	Above Dorothy	2.8	3.8	30.3		.4	.14
Do.	Above Hobson	9.2	13.0	30.0		.3	.03
Do.	Below Hobson		13.0	44.4	14.4		
Do.	Below Hobson, plus discharge of Grouse Creek branch			46.8	2.4		
Do.	Below flume	4.1	17.1	43.9		2.9	.71
Sept. 12	do		17.1	[a] 43.0			
Do.	Above "X"	9.2	26.3	45.6	2.6		
	David Creek branch.						
July 29	Intake		.0	6.9			
Do.	Outlet	1.8	1.8	6.4		.5	.28
	Jett Creek branch.						
Sept. 10	Copper Creek ditch intake		.0	2.5			
Do.	Copper Creek ditch outlet	.5	.5	1.8		.7	1.40
Do.	Jett Creek ditch intake		.0	4.2			
Do.	Jett Creek ditch above Copper Creek ditch outlet	1.5	1.5	3.9		.3	.20
Do.	Jett Creek ditch below Copper Creek ditch outlet	1.5	1.5	5.7			
Do.	Jett Creek branch outlet	1.7	3.2	5.3		.4	.24

[a] Estimated.

Seepage measurements of Fairhaven ditch in 1908.

Date.	Point of measurement.	Distance between points.	Distance from upper intake.	Discharge.	Loss between stations.	Loss per mile.
		Miles.	*Miles.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
July 23	Intake of upper section		0.0	12.2		
July 24	Camp 2, upper section	4.5	4.5	12.5		
Do.	Camp 4, upper section	7.5	12.0	12.2	0.3	0.04
Do.	Intake of lower section	8.6	20.6	12.4		
July 25	Camp 2, lower section	6.9	27.5	12.2	.2	.03
Do.	Above Snow Gulch	8.0	35.5	12.0	.2	.02
Do.	Above Penstock	3.9	39.4	[a] 10.6	[a] .8	.20
Aug. 18	Intake of upper section		.0	27.2		
Do.	Camp 4, upper section	12.0	12.0	[b] 25.6		
Aug. 19	Intake of lower section	8.6	20.6	[b] 25.5	.1	.01
Do.	Camp 2, lower section	6.9	27.5	[b] 24.4	1.1	.16
Aug. 20	Above Snow Gulch	8.0	35.5	[b] 22.7	1.7	.21
Do.	Above Penstock	3.9	39.4	[b] 22.6	.1	.03
Aug. 22	....do		39.4	26.7		

[a] About 0.6 second-foot was spilled from the waste-gate below Snow Gulch.
[b] Discharge less than normal; water was turned out of ditch for a few hours Aug. 18 at a point 5 miles below upper intake for the purpose of repairing the ditch. The water again reached a normal stage above the penstock on Aug. 22.

An examination of the tables prepared from the discharge records of the Miocene and Seward ditches throughout the extremely dry season of 1909 shows mean losses per mile of 0.55 and 0.44 second-foot, respectively. The mean value for the Miocene ditch applies only to the upper 12 miles between Black Point and Hobson, but that for the Seward ditch applies to 32.3 miles of the waterway, or practically its entire length. The greatest average loss per mile, 1 second-foot, is shown on the Miocene ditch between Hobson and a point below the flume for the period July 13 to August 1 and can be accounted for by the fact that there is considerable rock construction between the two stations. The least mean loss per mile on the Miocene ditch occurred between Clara and Hobson and amounted to 0.28 second-foot. The mean loss per mile between stations on the Seward ditch apparently decreases from the intake to Newton Gulch; that between the intake and Hobson was greatest, amounting to 0.53 second-foot.

There is considerable variation between values for different 10-day intervals at the same stations, but they do not show so great a difference between fairly wet and extremely dry periods as might be expected, inasmuch as there must be some inflow into the ditches after rains. The rainfall for the season, however, was very small and well distributed as regards time (pp. 25–26), a condition which, in connection with the fact that the ground became exceedingly dry and required considerable moisture to saturate it, probably accounts for the decrease in the loss between stations not being more apparent after rains.

A study of the tables embodying the seepage measurements shows a decided difference in seepage in ditches in the southern and the northern portions of the peninsula. The leakage of the Fairhaven ditch, which is built over frozen muck, as mentioned above, is almost negligible, but that of the Miocene and Seward ditches is very appreciable. The losses along the Miocene ditch during the low water on July 3–4 and July 27 are in general larger than those for September 11–12, when a greater inflow was contributed from side streams. Except for short distances, such as between the intake and Black Point and on the Copper Creek branch, the greatest losses per mile, ranging between 0.71 and 0.78 second-foot for the three sets of measurements, occurred between Hobson and the flume. These values are somewhat smaller than those noted in the analysis of the 1909 data between the same stations, but this variation may be due to the much smaller water supply of the later year.

PLACER MINING.

By Alfred H. Brooks.

SOURCES OF INFORMATION.

In the foregoing pages the mode of occurrence and distribution of the placer gold have been briefly described and all the records bearing on stream flow have been presented and discussed. These data have been assembled in one volume to make them readily available to mining operators and engineers. It also seems desirable to consider briefly the application of these data to mining practice. To do this adequately would far exceed the space here devoted to the subject and would necessitate the collection of much more detailed information than is now available. Moreover, it is a subject properly within the field of the mining engineer rather than of the geologist. A brief statement of the salient features of the methods of mining will, however, at least serve the purposes of the general reader and may be not without interest to mining engineers and operators who are not familiar with this northern field. Those requiring technical details are referred to Purington's report [1] and to the many valuable articles which have appeared from time to time in the mining press.

Purington's report was based on investigations made in 1904, since when there has been a notable reduction in operating costs, chiefly due to cheaper transportation. Nevertheless, as a comparative study of Alaska placer-mining methods his publication still forms the standard reference work. Since Purington's investigations extensive ditch lines have been constructed in the peninsula, and the use of water under head has become far more general. Underground mining has also become one of the important features of the industry in the peninsula. The most important change, however, has come from the application of the dredge to mining certain types of deposits.

[1] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905. This publication is no longer in stock at the Geological Survey, but can be procured for 35 cents a copy from the Superintendent of Documents, Washington, D. C.

The data to be presented in the following pages are largely compiled from publications of the Geological Survey and technical journals. If this compilation serves no other purpose, it will at least bring together in convenient form notes now scattered through many different volumes, some of which are not readily accessible. Free use is here made of notes prepared for this report by Mr. Smith and Mr. Henshaw, some of which are quoted verbatim.

HISTORICAL SKETCH.

The writer has already published an account of the history of the placer-mining industry [1] in Seward Peninsula, and therefore only its most important features are here considered. Although alluvial gold is reported to have been discovered on the peninsula as early as 1865, there was no placer mining of any consequence until 1897. Gold was found on Anvil Creek, near the present site of Nome, on September 20, 1898, and the first large output from the mines of the peninsula was made in the following year. Absolutely reliable statistics of gold production are far from being complete, but the following table gives an estimate of the yearly output based on the best data available:

Production of gold and silver in Seward Peninsula, 1897–1910.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1897	725.63	$15,000	87	$52
1898	3,628.12	75,000	435	256
1899	135,450.00	2,800,000	16,254	9,752
1900	229,781.25	4,750,000	27,574	17,097
1901	199,822.61	4,130,700	24,579	14,747
1902	220,677.07	4,561,800	26,481	14,035
1903	215,994.38	4,465,000	24,171	13,052
1904	201,462.52	4,164,600	24,175	14,021
1905	232,200.00	4,800,000	27,864	16,997
1906	352,812.50	7,500,000	43,537	29,605
1907	338,625.00	7,000,000	25,497	16,828
1908	247,680.00	5,120,000	20,577	10,905
1909	206,077.50	4,260,000	20,871	10,853
1910	169,312.50	3,500,000	20,317	10,971
	2,764,249.08	57,142,100	302,419	179,171

Practically all the gold was taken from placers, although from 1903 to 1907 the Big Hurrah quartz mine produced some gold, and small outputs have been obtained from several lode prospects at different times.

A small amount of silver and lead was produced at the Omilak mine, in the Fish River basin, as early as 1881. Since then several shipments of ore have been made from this property. The above table shows that considerable silver has also been recovered from

[1] Collier, A. J., and others, The gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, pp. 10-39.

placer gold. The only other mineral resources that have been developed are some coal deposits in the Fairhaven district, which have been mined in a small way for local use since 1902, and the York tin deposits, which were first developed in 1900.

The accompanying diagram (fig. 10) graphically illustrates the fluctuations in the annual gold output, which, in turn, reflect the history of the mining industry. In 1897 and 1898 there were probably less than 200 prospectors and miners on the peninsula, and practically all the gold produced was taken from a few claims on Ophir Creek.[1] About 2,000 people came to Nome in 1899, attracted by the discovery of the previous year. The finding of gold on the present beach and the extraction of nearly a million dollars' worth in less than two months were the important events of the year. News of the wonderful deposits of the Nome beach was widely circulated

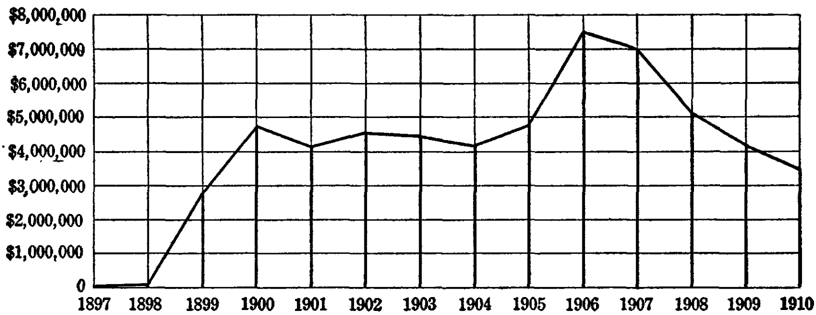


FIGURE 10.—Diagram showing gold production of Seward Peninsula, 1897–1910.

during the following winter and attracted a population of nearly 20,000 people in the summer of 1900, most of whom, however, left before the close of navigation. Beach mining continued during this year, and discoveries of creek placers in various parts of the peninsula were made.

From 1901 to 1904 there was little change in the gold output, but developments went on steadily in the various districts of the peninsula. Ditch and railway building was extensively carried on during this epoch. The marked advance in the gold output of 1905 and 1906 was due to the rich placers developed along the ancient beach lines near Nome. More important to the future of the placer-mining industry of the peninsula was the successful operating of gold dredges, which first took place during this period.

As bonanzas along the ancient beach lines became exhausted the gold output declined. The increased installation of large mining plants, especially dredges, has, however, continued, and there is good reason to believe that the annual gold production has nearly reached its minimum.

[1] About $1,500 worth of gold was extracted from Anvil Creek gravels by the use of a rocker in the later part of September, 1898.

COST OF PLACER MINING.

The general features of the placer-mining industry of Alaska are similar to those of other fields, modified more or less by the physical conditions of the northern region. A few of these conditions are favorable, but most of them are unfavorable, and their effect in total is to increase the cost of operating. Probably no two engineers who are familiar with mining operations in Seward Peninsula would agree as to the ratio between the cost of mining in this northern field and that in the States, and quantitative attempts at comparisons are of little value. It is probably safe to state, however, that in general placer-mining costs will be 50 to 200 per cent higher in the peninsula than in the Western States. The estimated cost of dredging can be cited as an example. This form of placer mining is said to cost from 3 to 10 cents a cubic yard in California,[1] as compared with 12 to 25 cents a cubic yard in Seward Peninsula. These costs do not include amortization charges or original investment for plant and mining property, which would be much higher in Seward Peninsula than in California. It will be safe to assume for other forms of mining that the unit costs would in general be much higher in Seward Peninsula than in California.

The comparatively high cost of mining in Seward Peninsula is directly or indirectly the result of its geographic position. It lies about 2,700 statute miles from Seattle its chief source of labor, fuel, and supplies, and the cost of transportation is a very considerable tax on the mining industry. If this only amounted to the actual cost of transporting by water a distance of 2,700 miles it would not add greatly to the expense of mining, but an additional charge is involved from the fact that the peninsula is open to navigation only from about the middle of June to the end of October. As a consequence all transportation has to be crowded into some four months. Moreover, the landing at Nome, where neither harbor nor wharves exist, has to be done during fair weather by the aid of lighters at heavy expense. These conditions are reflected in the freight rates. In the following table the freight rates from Seattle to Nome for the year 1910 are given:

Freight and passenger tariffs, Seattle to Nome, 1910.

Coal	$10 to $12.50 per ton.
Merchandise	12 to 15 per ton.
Lumber	14 to 27 per thousand.
Machinery	15 to 55 per ton.
Hay	17 to 22 per ton.
Grain	14 to 17 per ton.
Horses	60 to 75 per head.
Passengers, first-class	100 each.
Passengers, second class	65 each.

[1] Aubury, L. E., Gold dredging in California: Bull. California State Min. Bur. No. 36, 1905. Knox, W. M., Less-known gold dredges in California: Min. and Sci. Press, July 2, 1910, pp. 16-18. Janin, Charles, and Winston, W. B., Working costs of gold dredging in California: Min. and Sci. Press, July 30, 1910, pp. 150-151.

Ocean freight rates to Nome have been reduced in recent years, but not very notably. The reduction has, however, cut the price of coal, which in 1904 was from $17 to $30 a ton, to $15 or $20 in 1910. Until very recently the cost of crude oil at Nome was $3 a barrel, but at present (1911) it is reported to be $2 a barrel.

The most important reduction in cost of transportation has been within the peninsula. Exact figures are not available, but the construction of several railways[1] and the building of wagon roads have materially reduced the cost of transporting supplies from Nome and other points on the Bering Sea to inland camps. Brooks[2] has estimated that in 1909 the average cost of transporting a ton of supplies from the coast to mines in different districts of the peninsula varied from $80 to $200 in summer and from $3 to $50 in winter, and that the average cost for delivering a ton of supplies to the mines from the coast was about $20. It should be remembered, however, in considering these figures that a large part of the supplies was probably not hauled more than 10 miles. In other words, if the inland districts were developed on a large scale the average cost would be much higher.

There are few data on which to generalize regarding the cost of wagon and sled transportation in the peninsula. Prices for services, teams, and drivers fluctuate from year to year in accordance with demand and supply. The cost of haulage also varies according to locality. Where wagon roads have been built transportation cost is, of course, much less than where none exist. Sledding is possible in winter even where no wagon roads have been built, and in dry seasons it is possible to haul light loads over the tundra and along some of the water courses. During wet seasons, however, the country is practically impassable for wagons except along roads. Under present conditions it will probably not be safe to count the cost of transportation at less than $1 per ton-mile. Transportation by railway, where available, is least expensive.

Climate also affects mining costs. Open-cut mining is usually possible during less than a third of the year, although lately some dredges have been operated for 130 days.[3] This means that all plants are idle for two-thirds of the year, so that interest and other fixed charges must be paid from the returns of four months or less. The short working season also affects very considerably the price of labor. Each miner who is to be employed during the summer season only must be transported to and from the States every year at a cost which may add as much as a dollar a day to the cost of his work

[1] In 1910 there were 124 miles of railway on Seward Peninsula.

[2] Brooks, A. H., The mining industry in 1909: Bull. U. S. Geol. Survey No. 442, 1910, p. 25.

[3] In 1911 some dredges were operated until the last week in November, which gave a working season of 160 to 180 days.

during the operating season. This does not hold true, of course, of places where winter operations are possible, such as the ancient beach placers near Nome, which are now largely mined out. These deposits were exploited by drift mining, which in the past was an important industry in winter as well as in summer.

Except for the effect of transportation costs, wages on Seward Peninsula are not very different from those paid in many mining camps in the West.

Wages paid on Seward Peninsula have fluctuated so much that no definite statement of the wage scale is possible. Many of the men employed in summer have been brought from the States under contract, so that for some large ditch-building enterprises wages have been as low as $2.50 a day. The cost of board must be added to all these figures on wages. As a rule, however, wages for miners have ranged from $4 to $5 a day. There has usually been an abundance of labor for underground work in winter During the height of the "third beach" mining the winter wages were $4 to $5, but at other times they have usually not exceeded $2.50 to $3. Many of the dredging crews are brought from California and remain only during the open season. A recently published article[1] gives the following figures as a safe basis of estimate for the wage scale of a dredging crew: Winchman, $5; oiler, $4; fireman, $3.50 to $4; cook, $5.

In nothing has the reduction been greater than in the cost of food. In 1899 the average price for board was $2.50 to $3 a day; it is now (1911) probably less than $1.25. The cost of the subsistence of the Survey parties which have worked in the southern part of Seward Peninsula in the years 1905 to 1908 averaged about 85 cents a man a day. This covered the cost of provisions at Nome but did not include the cost of transporting them to camp or the wages of the cook. Little fresh meat was used, but, on the other hand, all supplies were bought at retail and the parties averaged only eight men. If the wages of the cook had been included, the cost would have been about $1.20.

The conditions of transportation and labor increase materially the first cost of mine equipment and hence the operating costs, if overhead charges are included. No direct comparisons with the States are possible, because costs differ so materially in accordance with locality, size of plant, and like factors. A plant erected near Nome will cost much less than one erected in the central part of the peninsula, where overland haulage of 25 to 50 miles may be necessary. Moreover, large plants cost proportionally less than small ones. One power plant erected near the beach will serve many dredges with less initial expense than if each dredge were operated from an independent source of power.

[1] Massey, G. B., Dredging conditions on the Seward Peninsula: Eng. and Min. Jour., Oct. 29, 1910, p. 863.

The stream gradients in Seward Peninsula are for the most part low, a condition which affects the cost of certain forms of mining by making available for use under head only a small part of the run-off and by necessitating special equipment for the disposal of tailings. Dredging and underground mining, of course, are not directly affected. The stream gradients of some of the best-known watercourses of the peninsula are presented in the following table, which is based on data from detailed topographic maps:

Examples of stream gradients in Seward Peninsula.

Stream.	Total distance from mouth of main stream.	Local distances.	Average fall per mile.
Nome region.			
Nome River:	*Miles.*	*Miles.*	*Feet.*
Mouth to 100-foot contour	19.55	19.55	5.1
100-foot contour to Dorothy Creek	34.45	14.9	22
Dorothy Creek to Deep Canyon Creek	37.85	3.4	45
Anvil Creek:			
Mouth to 100-foot contour	2.38	2.38	34
100-foot contour to Nekula Gulch	5.18	2.8	100
Glacier Creek:			
Mouth to 100-foot contour	1.6	1.6	38
100-foot contour to Abbe Gulch	5.8	4.2	77
Dexter Creek:			
Mouth to 100-foot contour	.6	.6	103
100-foot contour to Grass Gulch	2.4	1.8	139
Buster Creek:			
Mouth to 100-foot contour	1.2	1.2	52
100-foot contour to Good Luck Gulch	3.2	2.0	130
Solomon River basin.			
Solomon River:			
Mouth to 100-foot contour	11.0	11.0	9
100-foot contour to Montana Creek	18.7	7.7	30
Shovel Creek:			
Mouth to Adams Creek	6.1	6.1	35
Big Hurrah Creek:			
Mouth to Tributary Creek	3.5	3.5	38
Casadepaga River basin.			
Casadepaga River:			
Mouth to Dawson Creek	6.0	6.0	7
Dawson Creek to Lower Willow Creek	16.9	10.9	10
Lower Willow Creek to Johnson Creek	24.2	7.3	19
Big Four Creek:			
Mouth to Castle Creek	5.6	5.6	24
Castle Creek to Ivanhoe Creek	9.8	4.2	37

In the above table the gradients of each stream are given from the mouth to the highest point at which the average stream volume is sufficient to have value for placer mining. During the spring run-off and during wet seasons water for mining is available at still higher altitudes in the upper courses of the streams and on the small tributaries, which have, of course, steeper gradients. In the Nome region the streams usually have small volumes above the 350-foot contour. The streams in this district have a fall of about 100 feet to the mile between the 100-foot and 350-foot contours.

Absence of timber except in the eastern part of the peninsula is one of the factors contributing to increased cost. Practically all fuel and lumber has to be imported, except in the Council district, where some spruce is available both for cordwood and for lumber. At best, however, the trees are small, and the accessible timber is being rapidly depleted. A small coal field, in the Fairhaven district, with heavy beds of lignite has been a valuable source of fuel for local mining operations. The absence of timber is an advantage in both dredge and hydraulic mining, as it obviates the necessity of clearing the land before mining is begun.

Both in the Yukon and in the interior of Alaska permanent ground frost is encountered in many places within 2 feet of the surface and adds greatly to the difficulty of operating dredges. Fortunately the ground is by no means everywhere frozen, but the distribution of the ground ice is irregular and is not well understood. Up to the present time dredge operators have usually avoided frozen ground, but it seems probable that some means may be found to overcome this difficulty. The frozen ground is a very great advantage to underground mining, for it makes timbering and the pumping of seepage water unnecessary.

Mr. Henshaw's discussion of the water resources (pp. 249–255) clearly shows that they are inadequate to the needs of the mining industry. During wet summers a large amount of water is available, but the supply may fail during dry seasons. As a consequence, a mining plant which depends on this surplus water may remain idle for several successive years, and the expenses of the nonproductive years must be charged against the successful seasons. The comparatively small supply of water has necessitated the building of long ditches (pp. 255–263), which necessarily increase the cost of operations both from the additional investment involved and from expense of upkeep. These conditions have resulted in the extensive development of dredging enterprises, which require little water.

METHODS.

SOURCES OF INFORMATION.

The principal methods of placer mining in use in Seward Peninsula are here briefly presented, together with some fragmentary notes on unit costs and relative efficiency. Little exact information on mining costs in the peninsula is available, because few operators have records in such form as to permit determinations of actual unit costs. Most of the experienced operators, however, have determined the minimum values which can be profitably recovered by any given method of mining. This kind of information seldom yields exact data on unit costs. Purington's report includes a wealth of cost information, but much of it no longer applies because of the changed conditions of transportation which have lowered the expense of mining.

Small mining enterprises are giving way to those requiring large investments of capital, so that prospecting is becoming of increasing importance. On this subject the writer has little information, and the following extract is quoted from an article by J. P. Hutchins.[1] Certain data no longer applicable have been omitted from the extract.

PROSPECTING.

GENERAL CONDITIONS.

The subject of prospecting will be especially emphasized here, because probably three-fourths of the failures in placer mining are due to the fact that the equipment has been installed before the ground has been properly tested. Millions of dollars have been wasted through this cause, and there is still a lamentable tendency to install expensive mining plants with insufficient data as to the real value of the property under consideration. Operations of considerable magnitude are at the present time being undertaken where the gold content or the working cost per cubic yard is not known within 25 per cent of the real figures.

The popular conception of placer mining is extremely hazy. The mind of one who is uninitiated does not readily grasp its complexity. The general idea of a placer pictures a volume of material of no particular size, containing a high gold content, so rich that mining an inconsiderable amount of it will result in large dividends. As a matter of fact, such bonanzas are exceptional, and when they are found the public has no opportunity to invest, for the richness of the bonanza makes it unnecessary to seek outside capital. It may in general be safely concluded that in nearly all the enterprises that are presented for public investment comparatively low grade material is to be exploited. Such material yields only a small advance over the cost of mining. Therefore not only should the value of the metallic content be accurately determined by proper prospecting, but all conditions that influence operating cost should be carefully investigated.

The investigation of placer deposits is not a simple matter, particularly when accurate determination of the gold content and volume of large areas of low-grade material must be made. Such investigations should be carried on by one familiar with the conditions peculiar to the region. A mining engineer whose work has been done in other regions, no matter how capable, efficient, and experienced, is at a great disadvantage in the Far North, where the conditions encountered are in great part unique.

There are a large number of deposits that can be easily prospected by the average miner. Such are the small, rich, shallow placers that lend themselves particularly to one-man methods of operation. These can be investigated at a comparatively low cost, without expensive apparatus, and as the cost of operation is much less than the gold output, refined prospecting and engineering skill are not needed. It is lamentable that failures are being frequently made on such placers, for most of them can be easily avoided if a comparatively small amount of careful prospecting is done.

In lode mining it is usually difficult to determine the valuable content and volume of the lode without a large amount of costly excavating. In most placer mines, however, modern methods make it cheap to ascertain, within a comparatively small margin of uncertainty, the amount of gold in the ground to be exploited. This makes placer mining less of a speculation than lode mining, provided the necessary money is spent to prospect the ground thoroughly. Unfortunately the public at large is slow to realize this fact and the conscienceless or ignorant promoter too often procures financial backing for placer-mine equipment where only a most cursory and superficial examination has been made.

Proper prospecting involves the determination of the following more important factors: (1) Volume of pay alluvium; (2) extent, value, and distribution of pay streaks; (3) character of alluvium; (4) its degree of induration; (5) distribution and

[1] Prospecting and mining gold placers in Alaska: Bull. U. S. Geol. Survey No. 345, 1908, pp. 56–68.

character of bowlders; (6) distribution and character of clay; (7) depth of alluvium; (8) depth to ground water; (9) character of bed rock. In addition to these, in Alaska, there is the prime necessity of investigating the distribution and character of ground frost, both permanent and seasonal. All the above factors influence working cost.

To obtain information concerning the various factors which have been enumerated above as influencing the cost of mining, it is necessary to penetrate the placer deposit and thus learn its thickness, condition, and contents. This may be done in one of two ways—by drilling a hole through the gravels or by sinking shafts.[1]

By the drilling method small samples are obtained. Briefly, out of each drill hole a cylinder of material about 6 inches in diameter is obtained from grass roots to bed rock. A prospecting shaft 3 by 6 feet has a cross-sectional area about 50 times as great as that of the drill hole. Thus the volume of material obtained from the shaft is often 50 times as large as that from the drill hole. As a matter of fact, the usual proportion of samples is very much less than this, for often but a small part of the material excavated from shafts is tested. The writer has seen a sample taken from a shaft 10 by 10 feet and 20 feet deep that was actually smaller than would have been obtained in a drill hole in the same ground.

PROSPECTING BY CHURN DRILLS.

The essential features of the drill method of prospecting are sinking a pipe to bed rock and extracting and testing the material that is included within the pipe. Drilling may be done by machinery run by steam or gasoline engines, or by hand alone, or by combined hand and animal power.

POWER DRILLS.

The steam and gasoline drills are essentially alike in operation and equipment. Inasmuch as the gasoline engine is more delicate, less reliable, and less flexible in operation than the steam engine,[2] it is from these considerations alone inferior, although it may, on account of difficulty of transporting fuel and supplies, be preferable in some places.

The actual drilling with a power churn drill involves three operations: (1) Driving a pipe to obtain a core, (2) drilling this core to prepare it for pumping, and (3) pumping and hoisting this drilled material from the pipe and discharging it into a receptacle for testing. Each of these operations requires changes of tools and manipulation, and they are continued until the hole is finished. First, a heavy 6-inch pipe (weighing 20 pounds or more per foot) is driven into the ground 1 foot at a time by striking it on the upper end with a pair of driving clamps. These are clamped to the stem of the drill, which hangs inside the pipe from a cable sustained on the derrick of the drill by which the driving is being done. The drills, stem, etc., weigh about 1,000 pounds and strike about 55 blows per minute, raising and dropping the tool about 3 feet at each blow, though the length of blow can be adjusted to 18, 24, or 36 inches. It is obvious that a heavy blow can be struck and that the pipe must be strong and well prepared for such hard usage. A drive shoe is screwed to the bottom of the pipe. This is extra heavy and of metal sufficiently tough to penetrate gravel. A driving head is screwed to the top of the pipe to take the blows delivered by the driving clamps.

The cable can be reeled in or out while the driving or drilling or pulling is being carried on. After the pipe has been driven a foot or so, the driving clamps are removed and the core is drilled within a few inches of the bottom of the pipe. The drill is a

[1] For convenience of treatment all openings that permit the entrance of a man, such as vertical shafts, inclined shafts, drifts, upraises, winzes, vertical, inclined, and horizontal cuts, are included under the head of shafts.

[2] Since this was written the gasoline engine has been so improved and is now in such universal use that the above statement no longer holds true.—A. H. B.

chisel-shaped tool. Its action is to crush rather than to cut, and it breaks hard material, which is generally brittle, at a rapid rate—1 foot in 3 to 10 minutes in medium-sized loose to coarse indurated gravel. When the core has been drilled, it is pumped from the pipe. The vacuum pump, hanging on a different cable from that of the drill, has a length of about 8 feet and an inside diameter of about 4½ inches. A piston operates inside the barrel of the pump in the following manner: The pump is sustained by a rope attached to the piston at the upper end. When the pump is hanging on this rope, the piston is against a stop in the upper end of the pump barrel. In using the pump it is dropped suddenly into the pipe and slack line is allowed to pay out. The piston thus drops to the lower end of the pump barrel. The slack rope is reeled in rapidly, the plunger in sliding up inside the pump barrel creates a partial vacuum, and material is thus sucked in through the bottom of the pump and held by a plain flap or clack valve. When the piston strikes the stop at the upper end of the pump barrel, the pump is picked up and then hoisted from the pipe with its content of water and drilled material. There is an opening in the side of the pump barrel near the top, at such a height that the piston passes above it as it is hoisted to its stop. The pump is then emptied into a receptacle through this opening.

The methods of separating the gold from the materials obtained by drilling will not be discussed here in detail. Ordinarily the sample is panned or rocked, the various characters of the alluvium are observed and noted, the metallic content is saved and weighed, and the average value per cubic yard of the alluvium is calculated.

After the hole is finished the pipe is withdrawn from the ground by pulling. A pulling head is screwed to the top of the pipe, being so arranged that as the drill cable is alternately shortened and lengthened an upward blow is struck by the pulling hammer, which works inside the pipe. A blow almost if not quite as strong as that given in driving is thus obtained and the pipe is pulled from the ground. This is the hardest work the drill has to do and most of the breakages occur during this operation. Under average conditions, about 10 to 20 feet per day of 10 hours can be drilled in this way. * * *

A frozen condition of the alluvium makes peculiar operation necessary. Sinking with a drive pipe in frozen ground is often conducted by drilling about 8 to 10 inches below the drive shoe, driving for 12 inches, and then pumping. As it is difficult to drive in frozen ground an extra heavy pipe must be used; water heated by live steam from the boiler is kept in the drive pipe to prevent its freezing solidly in the ground. The pulling of the drive pipe from frozen ground is difficult and chain blocks are often used.

Frozen ground is frequently drilled by steam drills without using a drive pipe. Such procedure is justifiable only when the drilling is merely to locate a channel. It is not good practice to drill without a drive pipe if accurate determination of the gold content is to be made, as material is sloughed off the sides of the drill hole by the water thrown into the hole during the drilling, and thus inaccurate sampling is done. * * * As much as 75 feet is said to have been drilled in 10 hours.

HAND DRILLS.

The hand-drilling outfit consists of a casing (lighter than drive pipe) with a toothed cutting shoe screwed to the lower end. A platform is placed on top of the casing and men standing on the platform operate one of a variety of tools inside the casing, alternately raising and dropping the tool as in churn drilling. At the same time other men rotate the casing by means of poles attached to the platform, or a horse harnessed to a sweep. The casing with its cutting shoe, by its own weight and that of the platform and men standing on it, cuts into the ground, there being but little friction to overcome, as it is kept loose by rotation. A tool which drills and pumps material into its barrel simultaneously is generally used. Thus the casing is sunk and the material is drilled and pumped at one operation, with the same result that is obtained in the three operations of the power drill. Several kinds of pumps are used, equipped with ball or flap valves. The pump fits the casing and as the pump is dropped it causes a rush of water into the barrel from below, the drilled material being carried into the barrel and held there by the ball valve.

The casing is pulled from the ground by leverage; a pole 25 feet or more long can be used. As a matter of fact, it is seldom necessary to use much force, for the casing is rotated while being pulled and it is customary to pull it at the rate of 30 feet or more per hour. It is obvious that there will be less wear, tear, and breakage while using this device than with a steam churn drill. The means of sinking and withdrawing the pipe are easy and effective and they subject the pipe to much less severe usage; moreover, the process is more rapid. The hand churn drill is essentially a combination core and percussion drill. The cutting shoe obtains the core like a core drill, partly preparing it for drilling and pumping, while the tool works simultaneously by percussion on the core and as a pump.

This type of hand drill is well suited to prospecting in Alaska. When equipped to drill 30 feet deep the whole outfit weighs about 1,000 pounds It makes up into one-man packs with a maximum weight of less than 75 pounds each, and so is particularly advantageous in inaccessible districts. It will sink from 20 to 40 feet of 5-inch hole through medium-size gravel in 10 hours if not working at too great a depth. It does not work at depths of more than 75 feet without a spring pole or other device to help support the weight of the rod and tool. It requires 5 to 7 men or 5 men and 1 horse to run it, depending on the depth being drilled and the method of rotating the casing.

A more recent note on the use of the hand drill has been published by Henshaw.[1] The following extract is quoted from his report:

In 1908 the Wild Goose Mining & Trading Co. began the systematic development of its extensive properties on Ophir Creek. During the last two seasons the ground has been thoroughly prospected, mostly with the hand drill. The stream bed of Ophir Creek lends itself readily to the use of this machine. The gravels are of moderate depth, 8 to 15 feet as a rule, unfrozen, and contain no large rocks. A relatively light 5-inch drill was used, which could be operated by three men. It consisted primarily of a tripod, carrying a pulley, through which was passed a rope, to one end of which is attached the drilling tool and to the other the pump. The casing is driven by the impact of a rammer and not rotated except in pulling. It thus differs somewhat from the hand drill as described by Hutchins,[2] being lighter and simpler. A steam-power drill was first used for this work, but was given up in favor of the hand machine. In some parts of Ophir Creek, where the flow sinks into the bedrock at low water, shafts were used instead of drill holes, as the lack of water is an advantage in sinking them, while it practically prevents the use of the drill.

The following extract is a continuation of the quotation from Hutchins:

COMPARATIVE MERITS OF POWER AND HAND DRILLS.

Both of these drills have merits in their application to prospecting in Alaska. Rapidity, cost, and accuracy are the three prime considerations in any drill test.

The churn drill, operated by steam, works more rapidly when actually drilling, and so is well adapted to deep ground where moves are infrequent. Where there are many moves to be made, as in drilling shallow alluvium, particularly where the

[1] Henshaw, F. F., Mining in Seward Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, p. 361.

[2] Hutchins, J. P., Prospecting and mining gold placers in Alaska: Bull. U. S. Geol. Survey No. 345, 1908, p. 61.

surface is rough or swampy, the hand churn drill, because of its mobility, will often drill a greater number of feet in a given time than the steam churn drill. The hand drill, however, will not penetrate as large bowlders as will the steam drill.

The cost of operation per day of a hand churn drill in Alaska will be generally less than that for a steam churn drill and the expense for wear and tear and breakage is very much less.[1] There is very little lost time for breakage when using the hand drill.

The more inaccessible the deposit under investigation the greater will be the advantage in favor of the hand churn drill in operating cost.

The first cost of the hand churn drill at the factory is less than one-half that for the steam churn drill. Moreover, freight charges are much greater on the steam drill, which weighs with its equipment ten to fifteen times as much as the hand drill. Transportation into inaccessible districts in Alaska is very costly, and a steam drill at its destination may cost several times its factory price.

The core obtained by the hand churn drill with rotated casing is probably more nearly representative of the material being sampled than that obtained by driving the pipe of a steam drill. The hand drill needs but infrequent driving to sink the casing, and as the driving is done while the casing is being rotated it has a maximum effect and therefore less is required.

It may be said in general that where the deposit to be investigated is deep and accessible to supplies and machine shops and the surface is not very swampy the steam churn drill will do the cheaper and more rapid work; where the ground is shallow, swampy, or inaccessible the hand churn drill will give better results. Even if the hand drill were more costly to operate per day or per foot, it would still be a better and cheaper device for prospecting inaccessible areas where the expense for transportation, renewals, and repairs is very high.

SAMPLING.

The prime object of the drilling method in testing placer ground is to obtain a sample, which is a cylinder of material of a known diameter from the grass roots down to and into bedrock as far as ore [2] is found. A pipe is used to penetrate the deposit ahead of the drilling and pumping tools, being kept far enough in advance so that only the material subtended by the shoe on the pipe will be included in the core. The main essential of any sampling with a drill is to get only the material that is properly the core, neither more nor less. The whole operation must be conducted with this feature in mind, and all else should be sacrificed to attain accuracy in this respect. Any phase of operation that results in getting too much or too little core material introduces errors. The ratio of the volume of a sample from a drill hole to the volume of the material represented by the sample is about 1 to 100,000 when one drill hole per acre is sunk. Any errors are thus largely magnified in the calculations of average gold tenor. In sampling a lode the ratio of the volume of the sample to that of the lode is often 1 to 5,000.

Suppose that the drill operation is being conducted in 50-foot ground. Then the volume of the sample will be about one-third cubic yard, or about 50 pans of material. If the drilling is so done that each of 45 of these pans contains 1 milligram of gold, worth 0.06 cent, which ran in from outside the pipe and does not belong to the core, and if the other 5 pans of material indicate a gold tenor of 10 cents per cubic yard and this is the true average for the sample, then the apparent gold content will be 18 cents per cubic yard. If this hole were supposed to test an acre, it would indicate a gross gold content of $14,520, instead of $8,067, the true figure. This error results

[1] The writer has used this drill where there were no blacksmith shops. A grindstone and files were used to sharpen tools when necessary, and this was not frequent.

[2] Ore in its mining sense is material that has a valuable content sufficient to make it profitable to work it.

by obtaining an excess of gold of a total value less than 3 cents in a drill hole 50 feet deep. Thus a small error in testing ground may lead to a very large error in estimating the value when calculations are made. Such errors have been made in actual practice.

When large bowlders are encountered while prospecting with either steam or hand drills, it is necessary to drill below the pipe before it can be sunk. When this is necessary the pipe should be sunk through the drilled material before pumping is done, to insure against obtaining material not properly a part of the core.

DRILLING SEASON.

Prospecting by drilling can be done at all times of the year, even in winter. Areas that are marshy in summer can be more easily tested with a steam drill in winter, for then the surface is frozen and the heavy drill can be moved without miring. It is easier to drill a stream bed from the ice when the stream is frozen than to test it with the steam drill from a scow.

Seasonal frost interferes with drilling in winter, but ground permanently frozen can be drilled in winter as rapidly as in summer. Very cold weather is liable to cause inaccuracies in handling material from the pipe. A small tent warmed with a stove affords shelter for the panner and should be used.

RELIABILITY OF DATA PROCURED BY DRILLING.

If extensive work has been done in Alaska at any place where exploitation was preceded by close drilling, the information obtained, so far as the writer knows, has not been published, and therefore figures comparing prospecting and operating results in that Territory can not be given. It is possible, however, to give some data of value from other regions where drill holes have been checked by subsequent exploitation. In regions where ground has been tested by close and systematic drilling, the results of extensive subsequent mining have shown the reliability of this method of prospecting. A great amount of care must be exercised in any prospecting of alluvium in Alaska. Gold occurs generally in extremely irregular pay streaks. Any prospecting, to be reliable, must be of such scope as to delineate these pay streaks and to determine their bearing on the average gold content of the total volume of alluvium under investigation.

When the drill method is used to locate bonanzas and not to make a fair test of large areas of low-grade alluvium, the results give false averages. When prospecting with drills is properly done the results are reliable. Accuracy, however, has been sacrificed to speed in many tests, as where the drilling has been done without a pipe. The drill method has been badly abused and much of the information so acquired will prove unreliable; but there is no reason why drill prospecting should not be as trustworthy in Alaska as in the States, where results attained by well-conducted drilling are accepted without question.

PROSPECTING BY SHAFT.

Shaft prospecting consists in making openings of such size as permit a personal inspection of the alluvium. Under this general head will be included, for convenience, shafts, inclines, winzes, upraises, drifts, and horizontal, vertical, or inclined open cuts. The advantage of shaft prospecting is obviously that it permits a close inspection of the alluvium and the obtaining of large samples. Any peculiarities of the alluvium and bedrock can be examined in detail. Large samples tend to compensate for irregularities in the distribution of the metallic content and thus are more likely to indicate a true average of the material being tested. The material excavated from the openings is panned, rocked, or sluiced, and its metallic content is saved.

The reliability of the shaft method of prospecting is treated below. Some incongruous work has been done by the advocates of shaft prospecting, many of whom claim that it is a far superior method to that of drilling. They have sunk shafts and other openings of considerable size and then merely panned a very small proportion of the excavated material. The samples so panned were taken with little regard to the requirements for obtaining a fair average, and in a generally unsystematic and irregular way. Such inconsistencies are often seen and the advantage possible in getting large samples by shaft prospecting may be entirely lost by careless sampling of the excavated material.

CHOICE OF PROSPECTING METHOD.

Without regard to the geology, all Alaskan placers may be classified as shallow or deep. For convenience of consideration in this paper, all placers less than 25 feet deep are arbitrarily called shallow. Such placers, at or near sea level, if so wet as to require pumping, can be investigated with shafts while the pump is set on the surface of the ground. The practical limit of suction at sea level is about 25 feet. Placers deeper than 25 feet or of less depth and at higher altitude, if wet, must be drained by sinking pumps to the necessary depth. This necessitates a larger shaft to accommodate the pump, pipes, etc., and obviously will increase the cost per foot.

The choice of prospecting method is governed by a number of considerations, some of which are influenced by conditions foreign to the actual prospecting. For instance, a deposit well adapted to investigation by the steam drill may be so inaccessible as to make it good practice to use hand drills or shafts instead. The rapidity, cost, and accuracy are the governing factors in making a choice of method. Many deposits have features that make one method particularly applicable. In some places conditions are such that either the shaft or the drill method may be employed with equally good results; both may be used advantageously. The frozen condition of many of the Alaskan placers makes it possible to use the shaft method in alluvium which, if unfrozen, could be tested by shafts only at a large cost for pumping and timbering.

Where shallow narrow creek beds are to be prospected it is often good practice to make open cuts clear across the bed, or far enough to delimit the pay streak. Such creeks generally have extremely irregular pay streaks, and cuts of this character would determine the distribution of gold content with thoroughness. Work like this may be costly, but the compensating advantages often justify it.

In a shallower placer less than 10 feet deep and containing no water, or so little water that it can be easily bailed, prospecting can generally be more cheaply and rapidly done with shafts or open cuts than with drill holes sunk with a steam churn drill. Material can be thrown out of a shaft 10 feet deep and no timbering is ordinarily required if the shaft is kept free of water during the sinking. Only one man per shaft is required if there is only a small amount of bailing and if the gravel is unfrozen and easily broken down. * * *. Under such conditions the steam churn drill is at a disadvantage, for much time may be consumed in frequent moving from hole to hole. This is particularly true if the surface is so rough or marshy as to make moving difficult. The hand drill, being mobile, can be used advantageously in such shallow gravels, where it can generally drill 25 to 40 feet or more per day * * *.

If the alluvium to be tested has a depth of about 25 feet and is so wet as to require a steam pump, drill methods are more applicable than shafts. Such unfrozen gravel is generally loose or becomes loose on exposure to the air or by reason of water running into the shaft. Shaft sinking will be slow and costly, as close timbering and breast boarding or sheet piling may be necessary. Samples taken under such conditions are likely to be inaccurate, for running ground may enter the shaft. The fact that the material from the shaft is shoveled under water, possibly from a rough bedrock or from a soft bedrock, which may become sticky by reason of the man puddling it as he works, also introduces inaccuracies. Such conditions are not exceptional; on the contrary, they are generally encountered in prospecting the loose, low-lying gravels of stream beds. When greater depths are attempted in such ground, the same difficulties are encountered in greater degree; the cost of the work may be prohibitive and the samples so unreliable as to be worthless. Under such conditions the churn drill method is preferable. The circumstances that cause slow and costly progress and inaccurate sampling with shafts have no bad effect on steam or hand churn drills. In general, where the gravel is dry, as accurate or more accurate sampling can be done with shafts as with drill holes, but the presence of water in such volume as to require pumping makes drilling preferable.

It is often good practice to use both drill holes and shafts, the idea being to use only enough shafts to allow inspection of the physical character of the gravel, bedrock, etc., and to depend on the drill holes for the determination of the tenor, extent, and thickness of the gravel. If a certain sum is allotted for an examination, this sum will generally, on account of the greater cost of shaft prospecting in wet gravel, pay for the sinking of fewer shafts than drill holes. It is a question whether it is better to have a few large samples or many small samples from a deposit. The peculiar conditions of the alluvium under consideration must therefore be the determining factor.

The irregularity of gold distribution in the alluvium of Alaska makes careful prospecting necessary in order to determine the limits of the pay streaks. Many samples may thus be needed. As a general rule, drill holes are better suited to this work, for they can ordinarily be sunk more rapidly and more cheaply.

Where bench gravel is to be tested, cuts can be easily made. Vertical sampling is thus done, and this method has been used with good results. It is assumed that gravel in the same stratum or at the same perpendicular height above bedrock has the same general tenor and characteristics.

Prospecting has so far in this paper been treated as the obtaining of samples merely. Sometimes it may be conducted as a working test. This is particularly applicable where there is an available water supply. Thus cuts may be ground-sluiced through bench gravel and considerable amounts of material washed. Such cuts also permit subsequent sampling of the gravel section to good advantage. Inasmuch as this is a working test, data relative to operating cost may thus also be obtained.

A governing factor in the choice of the prospecting method is the kind of information that is required. Thus in testing alluvium thought suitable for hydraulicking, information concerning the section of gravel from grass roots to bedrock is desired, and generally this can best be obtained by sinking shafts or drill holes. In testing alluvium for drift mining little information is required in regard to any part of the gravel section except that adjacent to bedrock. Openings that follow this lower stratum will, of course, give a maximum of information with a minimum of excavation.

The last few years have witnessed many changes in the attitude of mine operators of Seward Peninsula toward systematic prospecting. Formerly prospecting was carried on for the most part incidentally to some development work and almost no attempt was made to evaluate the alluvium before installing mining plants; but now most of the large companies carry on systematic determinations of the character, dimensions, and gold content of the alluvium before installing mine equipment. Such procedure, always essential if success is to be assured, is especially important to dredging enterprises, which must be based on exact knowledge of amount of gold-bearing alluvium, distribution of values and of permanent ground

A. MINING WITH ROCKER ON BEACH AT BLUFF, 1900.

B. USING LONG TOM NEAR NOME

frost, and character of bedrock. With the prospecting methods now in use, the element of chance should be very largely eliminated from this form of mining.

MINING.

GENERAL PRINCIPLES.

The general principles of placer mining are very simple and will probably require no explanation to those who may have occasion to consult this volume. They consist of excavating the gold-bearing alluvium either by hand, by mechanical means, or by the aid of water under head, transporting the auriferous material to the sluice boxes, which can be accomplished by hand, by various mechanical devices using horses or steam power, or by the aid of water under head, and separating the gold from the dross in the sluice box, which requires water under head. The average grade of sluice boxes is a fall of 6 inches to 12 feet, or 220 feet to the mile. In hydraulic mining and in the use of scrapers, steam shovels, and dredges the excavating of the material and its transportation to sluice boxes is performed by one operation.

The Seward Peninsula placer-mining industry had its beginnings in the simplest form of mining with pick, shovel, and rocker, and from this stage it has passed gradually to operations requiring extensive equipment and large investments. The change from the simple to complex methods, however, has by no means been universal. A visitor to Nome can at almost any time see men mining and separating the gold from the beach or bar diggings with shovel and rocker (Pl. IX, *A*), while close at hand a dredge of the latest design (Pl. XVI), with a crew of a few men, is handling from 500 to 1,000 times as much gravel as the individual prospector. Many creek placers which annually yield gold are worked by hand, as were all the claims a dozen years ago. The most efficient method varies with the locality. A shallow creek placer of small areal extent and with a small amount of water, which may possibly be available during only a part of the season, can often be worked at a profit by the simpler methods, requiring no investment of capital, when a large mining plant on the same ground would be operated at a loss. With the rapid exhaustion of the bonanza deposits, however, the larger plants, which can profitably handle ground of low values, must be relied upon to maintain the annual gold output.

ROCKER AND LONG TOM.

The simplest appliance for mining and recovering gold from alluvium, which has been extensively used on Seward Peninsula, is the rocker. This mechanical device, which is illustrated in Plate IX, *A*, and figure 11, is so simple and well known that it needs no description. Its most extensive use was during the height of the beach mining near Nome in 1899, when more than a thousand people employed this simple device, and with its aid extracted nearly a million dollars' worth of gold in less than two months. It is needless to say that these conditions have long passed, and the use of the rocker is now largely confined to a few beach miners. For extracting gold from very rich and shallow placers the rocker is an effective instrument but much of the fine gold is lost in its use. Purington [1] estimates that two men can handle from 3 to 5 cubic yards of gravel with one rocker in a day of 10 hours.

The long tom (Pl. IX, *B*) is a device which had its origin in New Zealand beach mining. It is in effect a small sluice box with a grizzly at the top, as in a rocker. It is only a little more effective than the rocker, and its use at Nome was confined to the period of beach mining in 1899 and 1900.

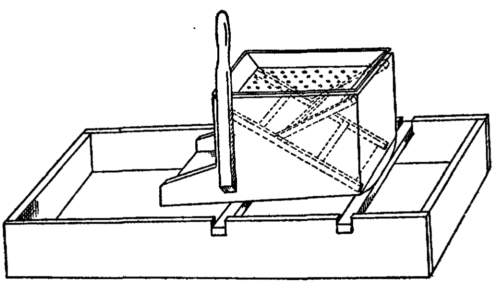


FIGURE 11.—A Klondike rocker.

OPEN-CUT MINING.

Open-cut mining properly embraces all ordinary mining operations except drifting, including dredging and hydraulicking, but these will be discussed under separate headings. In its simplest form such mining requires no equipment except pick, shovel, and sluice boxes, and no power except that of the water passing through the sluice boxes. (See Pl. X, *A*.) It is well adapted to rich, shallow gravels not more than 7 feet in depth, where the grade of the stream is sufficient for the sluice boxes and where the pit can be drained by a bedrock flume. The daily duty in this form of mining is probably from 5 to 8 cubic yards to the man. If the average is 6 cubic yards and the average price of labor is $5 a man, it will be evident that the handling of the gravel alone will cost 83 cents a cubic yard. To this must be added the cost of dead work and of the water supply. It is probable that there has been little profitable mining of this character where the value of the gold content was less than $2 a cubic yard. For the most part, the yield would probably be $3 or $4. Purington [2] states that the average cost of 10 plants which he investigated in Seward Peninsula in 1904 [3] was $1.87 a cubic yard. Such a general statement, however, is apt to be found in error when applied to an indi-

[1] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, p. 56.

[2] Op. cit., p. 38.

[3] In 1904 wages in Seward Peninsula were $5 a day and board, amounting to $6 or $7 a day.

A. OPEN-CUT MINING ON BENCH OF GLACIER CREEK.

B. GROUND-SLUICING ON GLACIER CREEK.

A. GROUND-SLUICING WITH HYDRAULIC GIANT ON ANVIL CREEK.

B. MINING WITH HORSE SCRAPERS ON GOLDBOTTOM CREEK.

vidual mine. For example, the management of one mine on Seward Peninsula reports that its average cost per cubic yard, using pick and shovel, was less than 50 cents.

Deeper ground may require two handlings of gravel before it reaches the sluice boxes by use of either a platform or a wheelbarrow. The result is to decrease the duty per man and to increase the cost of mining. In the absence of bedrock drain a pump may have to be used to get rid of seepage water, and this will also increase the cost. Where water is available and the stream gradient permits, the overburden can be groundsluiced off, thus reducing the amount of material handled with shovels. (See Pls. X, *B*, and XI, *A*.) That part of the overburden which is made up of humus and silt yields readily to a stream of water. The land is sometimes plowed before water is turned on. The absence of timber in the peninsula does away with the necessity of clearing the land before ground sluicing.

Various mechanical devices are used to supplement manual labor in open-cut mining. One of the simplest of these is the horse scraper, which may be used not only for excavating but also for transporting the gravels to the sluice boxes. (See Pl. XI, *B*.) Scrapers operated by steam or gasoline engines are also in extensive use, and the equipment can be installed without much expense. Both are effective where the ground to be mined is not too deep. In many places the combination of groundsluicing to reduce the bulk of the gravel with the use of horse or steam scrapers is economical and effective. Purington [1] has estimated that two horses and a driver can excavate and transport 75 feet to sluice boxes 30 to 40 cubic yards a day, an amount of work equivalent to the duty of 6 to 10 men. The capacity of a steam scraper is much larger and is estimated at 700 to 1,000 cubic yards a day.

The drag-line or bucket-scraper excavator has, so far as known to the writer, not been used in Alaska. The original cost of these machines is small compared with dredges, and they are, moreover, so light as to make their transportation possible to localities where the cost of transporting a dredge would be prohibitive. Several descriptions of the operating of these machines have been published in technical journals.[2] The most complete account of the application of this new excavator to placer mining which has come to the notice of the writer is one published by Hutchins.[3] As this machine seems destined to play a part in the mining industry of Seward Peninsula, the following statement is quoted from Hutchins's article:

> The drag-line excavator is a comparatively new machine and was evolved in the course of excavating ditches and canals in the vicinity of Chicago. It consists of a

[1] Purington, C. W., op. cit., p. 60.

[2] Bucket scraper for use in placer mining: Min. and Sci. Press, July 9, 1910, p. 43. Scraper bucket excavator in placer mining: Eng. and Min. Jour., Aug. 13, 1910, p. 315. Talbot, F. A., A new type of giant excavator: Eng. and Min. Jour., Sept. 17, 1910, p. 564.

[3] Hutchins, J. P., The drag-line excavator: Min. Mag., vol. 3, November, 1910, pp. 359-362.

car mounted upon wheels or rollers with a crane up to 100 feet in length. This crane can be raised or lowered by hand or power, thereby regulating the height of the dump. On the end of the car opposite to the crane there is a boiler working at about 110 pounds. This acts as a counterweight to the crane. The engine, about 10 by 12 inches, is geared to two drums, which are operated by friction clutches actuated by steam, compressed air, or by hand. These drums are geared so that one gives slow speed and heavy pull to the drag line while the other works the hoist line at faster speed. Two ropes lead from the two drums, namely, the hoist line to the end of the crane over a sheave and to a bucket and the drag line, through two "padlock" sheaves on the end of the car to a chain bridle on the bucket. The bucket may have a capacity up to 3 cubic yards. There is a sheave on the bail of the bucket and a short compensating rope that runs from the forward or digging end of the bucket over this sheave and out to the drag line. A swinging engine works through a rack and pinion to rotate the machine through a complete circle or operates through cables like the bull wheel of the swinging device of a derrick. In the latter case the crane can not swing through 360 degrees.

The operation is as follows: By means of the brake of the hoist-line drum the bucket is lowered into the material to be excavated. The drag-line friction is thrown in and the engine started. The bucket is thus dragged toward the car and it fills exactly as a scraper does. Since the 1½-cubic-yard bucket weighs 3,700 pounds and can be tilted by braking on the hoist-line drum and so tilting the digging teeth into the material, it excavates at a rapid rate even though digging 35 feet or more below the track upon which the car is sustained.

When the bucket is full the friction clutch is disengaged from the drag-line drum and engages the hoist drum; the bucket is hoisted, the brake being kept on the drag-line drum slightly so as to keep the compensating line taut. By keeping this line taut the bucket is maintained in an approximately horizontal position and the excavated material does not fall out of it. The bucket is hoisted and swung simultaneously to the dumping point; then the brake is released from the drag-line drum and the bucket immediately takes a vertical position, because it is articulated to the bale near the end opposite to the teeth, and the weight of the digging end plus the material in it make the bucket assume a vertical position. Thus a rapid discharge ensues.

This is the simplest type of bucket, and being easily described it has been selected from several for illustrating the working of the drag-line excavator buckets in general. There are others with devices that give more or less freedom of loading and dumping, besides extending or limiting the radius of dumping.

The bucket above described can only be dumped at a point directly under the end of the crane. A drag-line excavator with a 1.5 cubic yard bucket was installed last summer in eastern Siberia by C. W. Purington for the Orsk Goldfields (Ltd.), on a pile of tailing resembling in shape the slag pile at a smelter. It had an approximately level top 30 feet above the bed of a creek, in which it was piled with an approximately oval outline. This tailing had been discharged from dump carts pulled by horses. The excavator was placed on a track on top of the pile, and a 2½ foot sluice was installed on a grade of 8½ inches per 12 feet, or approximately 5.5 per cent, parallel to the excavator track and 50 feet distant from it.

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The excavator was provided with a crane 60 feet long, and so made a cut about 115 feet wide. Much of the time material was dug 30 feet below the track.

The rate of digging was about 30 cubic yards per hour, although water was nearly always scant, and it was not possible to work at top speed. * * * Two men per shift were required to run an excavator, an operator and a fireman; three men were needed on the track and to tend the sluice and dump. From 5 to 6 cords of wood per 24 hours were burned. Electric power has been used on drag-line excavators.

A. OPEN-CUT MINING WITH DERRICK AND BUCKET HOIST ON OPHIR CREEK.

B. PLACER MINING WITH TRACK AND INCLINE ON OPHIR CREEK.

A. OPEN-CUT MINING WITH HAND TRAMS ON OPHIR CREEK.

B. MINING WITH STEAM SHOVEL ON ANVIL CREEK.

Among other advantages this excavator has a large radius of action; it can dig a cut over 200 feet wide with a 100-foot boom. It can be moved more easily than a steam shovel, by dropping the bucket in the direction it is wished to move and, after removing the chucks, pulling on the drag line. More than 50 per cent of capacity can be obtained while moving by digging in a direction transverse to the line of track. The bucket is tight, so that there are no losses as with a dipper. It can excavate under water, and therefore is useful in exploiting wet creek beds, where it can be employed in conjunction with a sluice sustained on a scow or a plant consisting of screen, tables, and stacker sustained on a scow. With either of these latter arrangements mobility hardly inferior to that of a floating dredge can be secured and a plant to have 1,200 to 2,500 cubic yards capacity can be installed for about $15,000 to $40,000 in most of the known placer regions.

It seems possible that the drag-line excavator might be utilized to mine the alluvium of the present beach line and adjacent portions of the gravels underlying the tundra. Most of the mining on the present beach was done with rockers and much of the fine gold was lost.

If this material could be handled by mechanical means the remaining gold could probably be profitably recovered. Many of the tailings from the older beaches and other deposits could probably be economically mined by this method.

Where open-cut methods are used in mining deep gravels, or where sluice boxes are elevated to provide a dump for the tailings, steam bucket hoists (Pl. XII, *A*), derricks, or cars with inclines (Pl. XII, *B*) are used. If the operations are on a large scale and the distance to the sluice boxes warrants it, hand tramcars (Pl. XIII, *A*) are employed. Steam shovels (Pl. XIII, *B*) have also been used in connection with hand trams and inclines operated by steam. The description of these various devices is beyond the scope of this article.

HYDRAULIC MINING.

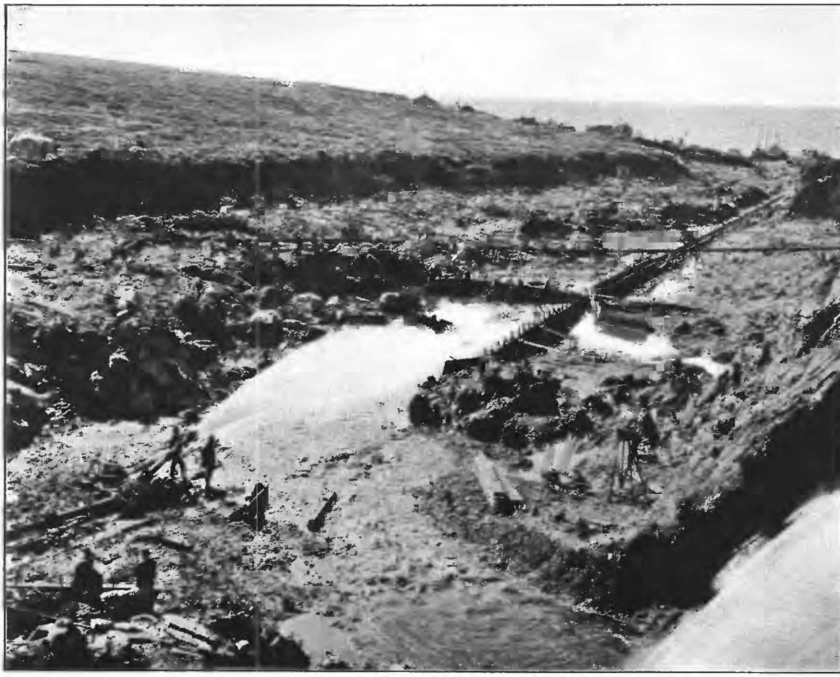
Hydraulic mining—comprising those operations in which water power alone is used to excavate the gravels and move them to the sluice boxes—has not been an important factor in the gold output of Seward Peninsula, partly because of the relatively small amount of water available under sufficient head, and partly because the stream gradients are such that some special device for the disposal of the tailings must usually be provided. Hydraulicking has, however, been extensively used to supplement other forms of mining, chiefly in ground sluicing (Pls. X, *B*, and XI, *A*) for the purpose of removing the overburden and concentrating the gold-bearing alluvium, which is subsequently shoveled or scraped into the sluice boxes. A number of hydraulic plants have been successfully operated, but they are rather exceptional in this province. In several districts hydraulic mines are operated during wet seasons. The discontinuance of operations during the dry part of the summer leaves a heavy burden of interest charges to be carried by the profits during the actual operations of the plant. The topography and water supply are such that water sufficient for hydraulic mining can usually be obtained only by long ditches, which require a large initial investment and considerable annual outlay for upkeep. (See pp. 255–263.) In spite of these drawbacks, extensive deposits of gravel on the peninsula will probably be worked by hydraulic means. At Daniels Creek a hydraulic mine (Pl. XIV, *A*) has been operated, except during dry weather, since 1905. Extensive benches along Kougarok River are admirably located for disposal of tailings, though the water supply is by no means ideal. The heavy bench deposits near Nome are in part so located that they could be hydraulicked by use of water from ditches already built, but at present the water is more valuable for other forms of mining.

The deposits on Grass Gulch, which form a part of this extensive gravel sheet, have been successfully mined in part by water which is pumped—a form of hydraulic mining which, as a rule, has not been commercially successful. This plant is described as follows by Henshaw in manuscript notes:

Grass Gulch is a small stream less than two claims in length, rising in the Anvil-Dexter divide. It has a steep gradient averaging in the portion mined about 300 feet to the mile. A practically constant discharge of 12 second-feet of water was delivered to the ground by the Dexter branch of the Miocene ditch, which intersects the upper claim. Of the 12 second-feet of water 2.4 second-feet was pumped to a reservoir near the divide at an elevation of 115 feet above the ditch. The water for the giants was delivered from this reservoir through a 2¾ or 3 inch nozzle. Pressure at the nozzle varied from about 100 feet to less than 60 feet. The giants were set frequently so as to be close to the face to be worked and were so directed that they not only loosened the gravel, but also drove it toward the sluices. From the superintendent at this mine it was learned that in one pit mined during 1908 the volume of gravel moved during a continuous run of 88 hours, with 120 miners' inches of water delivered to the giant, was about 2,800 cubic yards a day, or nearly 2 cubic yards a minute. This gives a duty of over 20 cubic yards of gravel per miner's inch of water per day, which is believed to be one of the highest duties recorded. The secret of making this high duty was to keep the giants and the slip flumes close to the face. This required a considerable force of men, but was more economical than using a larger volume of water.

ELEVATORS.

Another use of water under head has been in hydraulic elevators (Pl. XV). Experienced engineers have failed to come to an agreement regarding the advantages and disadvantages of this use of water, and, therefore, the writer's opinion can have no value. Without doubt many hydraulic elevators have been installed in the past under conditions which were not favorable to their use, and hence they were later rejected. On the other hand, a number of very successful plants have used hydraulic elevators for many years. The following data on the use of the hydraulic elevator are quoted from a manuscript prepared by Smith and Henshaw:



A. HYDRAULIC MINING ON DANIELS CREEK.

B. UNDERGROUND MINING IN FROZEN ALLUVIUM NEAR NOME.

HYDRAULIC ELEVATOR ON GLACIER CREEK.

The elevator will handle two-thirds to three-fourths of the amount of water used in the nozzle and lift it 12 or 13 per cent of the head under which the water acts. If the lift is increased the volume of the water handled is reduced, so that for a lift of 15 to 16 per cent only about one-third of the giant water can be handled. On the other hand reducing the lift below 10 per cent of the available head does not increase the amount of water that can be handled. It is evident that this method is particularly applicable to placers having an even bedrock floor with a flat slope where abundant water is available.

A typical example of mining with the hydraulic elevator is at the Miocene Ditch Co.'s property on Glacier Creek. (See Pl. XV.) This stream has a gradient of not more than 50 feet to the mile. The placer gravels are from 25 to 30 feet thick and are unfrozen, and the lift employed on the elevator has ranged from 40 to 50 feet. The pressure available at the nozzles in the bottom of the pit is from 350 to 380 feet, the greatest that has been used in Seward Peninsula.

The elevator is set near the middle of the stream bed, and a pit is worked upstream and to either side. On claim "No. 1 below" a pit 400 feet wide, 450 feet long, and about 30 feet deep was worked from one setting. Two giants with 3-inch nozzles were used, each discharging 200 miner's inches of water.[1] The 4½-inch nozzle on the elevator, discharging about 500 inches of water, was sufficient to handle this amount, as well as that which seeped into the pit.

The method generally used was to keep a nearly vertical face to the bank and to direct the stream from the giant against the base, thus loosening and caving the gravel and at the same time driving it toward the elevator. When the distance to the elevator was great, iron flumes were laid in trenches in the bedrock to facilitate the movement of the gravels. When practically all the gravel had been removed the bedrock was cleaned by pick and shovel work.

At different places variations of the method have been practiced. Where the bedrock is compact and the gold does not penetrate far it is not thought necessary to clean the bedrock more thoroughly than can be done with the hydraulic giant. The size of pit worked in one setting is also a variable feature, and the amount of water and the pressures obtained differ at almost every mine.

The hydraulic elevator and the dredge are the two methods of handling gravel that must be elevated, and the applicability of one or the other to a particular problem should be settled only by careful examination of the property by a mining engineer. Considered as a matter of power used to handle a given amount of ground the dredge is superior. A standard dredge with buckets of 5 cubic feet capacity will handle, say, 3,000 cubic yards a day, using 250 horsepower. An elevator plant using 1,000 miner's inches of water, or 20 second-feet, with a head of 300 feet, will, under favorable conditions, handle nearly the same amount. However, the potential energy used is about 600 horsepower, or more than twice that used by a dredge performing the same work. Furthermore, on account of the time that it takes to reset an elevator the elevator will not be able to maintain more than about two-thirds the continuous capacity of the dredge, and therefore the advantage of power in favor of the dredge is perhaps in the ratio of 3 or 4 to 1. Also the number of men necessary to run the elevator will be three or four times as great as is required to run the dredge. If the ditch required for the hydraulic mining is 25 miles long the cost of bringing water to the ground to be worked, together with the capitalized cost of maintenance, would aggregate approximately $300,000. A dredge of somewhat greater capacity could be installed for less than half of this amount.

If, however, the ground to be mined is permanently frozen and the gold has penetrated far into the crevices of a hard bedrock, or if the bedrock surface is very irregular, as is common where limestones occur, the use of the hydraulic elevator would probably prove most advantageous. It has been demonstrated that where there is much sticky

[1] The miner's inch used by the Miocene Ditch Co. was equal to 1.2 cubic feet a minute.

clay the material is more thoroughly broken up by hydraulic elevators than by the dredge. Theoretically the various devices used on dredges, such as revolving trommels and shaking screens, are supposed to break up the lumps of clay, but actual experience shows that in many places they fail to perform this task satisfactorily.

The particular value of the hydraulic-elevator method in recovering the gold from a hard or irregular bedrock surface is not so much in actually winning the gold as in leaving an open pit, the floor of which can be cleaned by hand as thoroughly as the gold content justifies. It is safe to say that on certain rich claims, such as those on portions of Ophir Creek, in the Council region, and in certain sections of the Inmachuk region where limestone forms an irregular floor on which the placer gravels were deposited, the increased saving of gold by this means will more than pay the total cost of mining with the hydraulic elevator. Mechanical elevators, which have been successfully employed in the Klondike placer district,[1] have not been used in Seward Peninsula.

DREDGING.

Several small dredges were brought to Nome during the excitement of 1900. These were for the most part designed to excavate the beach sands and were too light for any other use. In later years several dredges, both of dipper and bucket type, were constructed, and some of them did effective work in mining rich deposits, but in general they were not designed or adapted to do the real work of a gold dredge—that is, to handle efficiently a large amount of auriferous gravels which can not be economically mined in any other way. Although none of these earlier dredges achieved marked success, their operators should be credited with the pioneer work in this form of mining.

The present epoch of successful dredge mining dates from 1905, when the Three Friends dredge (Pl. XVI) on Solomon River, about 40 miles east of Nome, was installed, and the Blue Goose dredge at Ophir began to be operated. The Three Friends dredge was under the management of W. L. Leland, one of the leaders in ditch construction four years before. The success of this dredge was due largely to careful preparation before the machine was installed. The entire area of dredging ground was systematically prospected, so that the gold content, the depth and physical condition of the gravels, and the character of the bedrock were definitely known before the large investment necessary for the dredge was made. Had this example been followed by all dredging promoters most of the failures which have hurt the mining industry of the peninsula could have been avoided. The Three Friends dredge has been described as follows by Smith:[2]

Between Rock Creek and Johnson Gulch the ground is held by the Three Friends Mining Co., which is mining the gravels of the river by means of a large dredge of the Bucyrus type. The width of the valley floor at this place ranges from 400 to 600 feet. The depth of the gravel varies much, but is on the average between 15

[1] Rickard, T. A., Mechanical elevators: Min. and Sci. Press, Mar. 20, 1909, pp. 415–418.

[2] Smith, P. S., Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 433, 1910, pp. 158–159.

GOLD DREDGE ON SOLOMON RIVER NEAR MOUTH OF JOHNSON GULCH.

and 20 feet. This enterprise may be regarded in many ways as a model of the careful application of business principles to mining. The thorough and systematic prospecting of the ground by trenches and drill holes should serve as an example to all those contemplating mining by dredging.

The Three Friends Co.'s dredge was built in 1905 and began its first work in September of that year. It is similar in all essential respects to the dredges in use at Oroville, Cal. Each of the buckets is made of high-grade steel, weighs over 1,100 pounds, and has a capacity of 5 cubic feet. The gravels, after having been elevated by the buckets, are dumped on shaking screens, and the material which passes through is distributed to tables, where the values are retained. The coarse tailings are fed to an endless rubber-belt conveyor and are stacked in ridges at the rear of the dredge.

The freezing of the tailings and the conveyor belt in the late fall or early spring was prevented by covering the stacker with old canvas and running a small exhaust-steam pipe a short distance along the conveyor. By this means it has been possible to operate the dredge after the other creek operators have been forced to close down. The high cost of the coal used as fuel has led to the consideration of plans for a hydro-electric installation. In fact, the dredge was so constructed that the steam plant could be easily supplanted by electricity. Such a change would not only reduce the cost of power, but it would also permit increased production by reducing the time necessary for cleaning up.

A technical description of this dredge recently published by Rickard [1] gives some figures regarding the enterprise not heretofore available for publication. According to the article, the dredge cost $118,000 and was modeled after Exploration No. 2 dredge at Oroville, Cal. Its capacity is 3,700 cubic yards a day, and its cost of operation is estimated at about 10½ cents a cubic yard. If, however, the total cost is made to include not only the actual operating expense but also items to cover depreciation, maintenance, and amortization of the capital, the cost is brought up to 18 cents a cubic yard.

While these statements of the cost of handling the gravel are of great interest, it seems wise to interject a word of caution against applying these figures to all dredging enterprises in Seward Peninsula. It should be remembered that such low operating expenses are possible only under particularly favorable physical conditions. All the ground to be dredged was carefully tested in advance of actual mining, and the area and extent of permanently frozen ground outlined so that it could be avoided. Most of all, however, sufficient acreage was obtained to outlast the life of the dredge. By attention to this last detail the amortization charges per year were greatly reduced, for it is evident that such charges are much lower where the installation will have a life of 10 years than where it will have one of only 5 years. In the case of the dredge in question the company, according to Rickard, controls 4,000 acres, of which less than 100 have been dredged out in the three years that the company has been operating.

Still another fact that has contributed to the success of the work at this point has been that the bedrock over the larger part of the area is schist, which is much more easily excavated than the hard limestone which can be handled only by very powerful dredges.

Another dredge on Solomon River owned by the Nome-Montana-New Mexico Mining Co. is described by Smith as follows: [2]

Just above Johnson Gulch, upstream from the Three Friends Co.'s property, another dredge operated by a different company was installed during 1908 in the short space

[1] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 734-740.
[2] Op. cit., pp. 161-162.

of seven weeks. It was not a new dredge, having been originally in use near Hope, Alaska, but it had seen so little service as to be practically as good as new. Almost the entire first part of the summer was lost from actual productive work in assembling the dredge and it was after September before mining began. Work was carried on until the close of the open season, about the end of the third week of October, and a large amount of gravel was moved. The chance of comparing this dredge, which is of the Risdon type, with the modification of the Bucyrus farther downstream, is exceptionally good and should afford considerable data for a rigid examination of the efficiency of each type.

In operation the 5-foot buckets raise their load of gravel to the level of the upper deck of the dredge and dump it onto an inclined plate, which directs the material into a revolving trommel. The oversize from this is discharged into flat pans which form a bucket conveyor, and the tailings are stacked at the rear of the dredge. The finer material, after passing through a screen, is fed to tables covered with cocoa matting, on which are laid expanded-metal riffles. No quicksilver is used on the tables. The greater part of the gold is caught in the upper part of the tables, but the lighter material, after it has left the tables, is carried in a sluice with riffles, and a small additional saving may thus be effected.

According to Rickard,[1] the actual operating expense at this dredge, without allowing for depreciation, interest, or amortization, is a little over 14½ cents per cubic yard.

Two dredges near Nome, which were visited by Henshaw in 1908, are described by him as follows:[2]

Dredging bids fair to become an important factor in the working of the deposits of gold-bearing gravels in the coastal plain. Two large dredges were erected near Nome in 1908—one on Bourbon Creek near its junction with Dry Creek, the other on Wonder Creek just south of the third-beach line. The Bourbon dredge has a chain of 66 buckets, close connected, of 9 cubic feet capacity, and a nominal capacity of some 5,000 cubic yards a day. When first built, the bucket ladder was poorly balanced, and when digging near the water surface the heavy weight on the forward gantry sank the bow of the dredge so low that the deck was awash. When the machine was digging on bedrock, the bow was higher than the stern. This dredge was completed in August, 1908, and worked for a few days. An accident caused by the buckets coming into contact with the hull resulted in the sinking of the dredge, and it was not raised in time to start again that season. In 1909 the dredge was thoroughly overhauled, the bow gantry, the tackles for hoisting the ladder and spud, and the supports of the revolving trommel were strengthened, and the sluices were essentially modified. A 6-inch sand pump was installed, which is sufficient to handle the sluice water from one side only.

The gravel in the channel of Bourbon Creek is mostly fine, fully 70 or 80 per cent of the total passing through the screens. The sluices are ill adapted to handling so much fine material, and it has been found impracticable to fill the buckets more than half full. The ladder is arranged to dig to a depth of about 30 feet below the water level. Much of the ground is deeper than this and it may be found necessary to lower the water level in the pond by pumping. The strip of ground being worked was only about 180 feet wide, and it was sometimes found necessary to cut into tongues of frozen ground in order to keep a sufficient width of face, thus causing an excessive amount of wear of the buckets and machinery.

The second large dredge, on Wonder Creek, carries a chain of 40 buckets of 7 cubic feet capacity, open connected, on a ladder 100 feet in length, and is adapted to digging 40 to 45 feet below the water level. Wonder Creek is dry during a summer like 1909,

[1] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 734–740.
[2] Henshaw, F. F., Mining in Seward Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 357-358.

and water to float the dredge had to be obtained from one of the ditches. The bedrock is about 50 feet deep, and the water surface was kept about 10 feet below the ground level in order to reach it. The water in the pool was used over and over and became very thick and muddy. The gravels are nearly as fine as those in Bourbon Creek, about 70 per cent passing through the screens. Considerable difficulty was experienced by the grounding of the stern in the deposits of fine tailings, and it was found necessary to make two settings of the spud in order to use the entire width of the cut, nearly 300 feet, for dumping the tailings. A number of large bowlders and slabs of rock were encountered near bedrock, some of them at least 4 or 5 feet in length. These seemed to be handled without difficulty, but the dredge had to be stopped while they were removed from the buckets with a hoist block.

Both the Bourbon and Wonder Creek dredges are electrically driven with current generated from a power station located near the former. It was not learned just why the plant was built at this point instead of on the beach, where fuel could have been landed direct from the lighters instead of having to be hauled from 1 to 2 miles.

A dredge owned by the Blue Goose Mining Co. has been in operation in Ophir Creek for a number of years. This was one of the first dredges installed on the peninsula, and since 1905 has been steadily operated. It is described by Rickard [1] as follows:

The dredge has buckets of 5 cubic feet capacity, close connected, turning over a hexagonal upper tumbler and a pentagonal lower tumbler. The buckets empty into a hopper lined with steel plates, and thence the material passes over a sluice 4 feet wide and 22 feet long provided with cast-iron (Hungarian) riffles. Here as much as 90 per cent of the gold is caught. Then come two shaking screen tables, made of perforated plates, each 14 feet long and with a movement in opposite directions. The perforations are three-eighths and five-eighths inch, successively. On the screen tables there are obstructions or stops (made of cast iron) so as to retard the flow of the gravel and disintegrate any clay. The shaking screens have a 6-inch stroke, and the eccentrics run smoothly. Water is raised to the head of the top sluice by a 10-inch Morris sand pump, which also elevates the drip from the "save-all" in the well. The dredge is digging 14 feet under water; there is no bank above water except an occasional foot or two of old tailing from early ground-sluicing operations.

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When working full time, this dredge raises 1,000 cubic yards per day. It digs from 1 to 4 feet of bedrock, which is a soft schist. On the pontoon there is a machine shop, smithy, and mess room. The crew take their midday meal on board, and when the dredge is at work they must feel like the passengers on a Yukon steamer aground. During the season of 1907 this dredge worked for 110 days. The actual running time represented 69 per cent of the total time. The ground excavated represented 98,718 cubic yards; the total expenses were $31,672, and the value of the gold extracted was $83,144. Therefore the average yield was 84 cents and the average cost 32 cents per cubic yard. The season of 1908 will show about the same costs but a better yield of gold. The fuel consumed is wood, at the rate of 10 cords per day, at $10 per cord delivered. The total costs as given above include all repairs, equipment, and general expenses. The dredge cost $28,700; it was a small and poorly equipped machine, therefore repairs entail $5,000 each season.

Ten new dredges were installed on Seward Peninsula in 1910, of which number nine were operated for a part of the season. Seven dredges built in previous years were also operated. Three of these new dredges were installed in the region tributary to Nome, making

[1] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 736-738.

five in all for this district, of which four were operated in 1910. Four dredges were operated in the Solomon basin, of which two were built in 1910. Two new dredges and three old ones were operated in the Council region, and one new one in the Casadepaga basin. Details regarding the operations of all these dredges are not available at this writing. It appears, however, that the 16 dredges, including the 9 new ones, some of which were only completed in time for a brief test, were operated from 10 to 130 days, each averaging 58 days. The daily capacity of these dredges varies from 1,000 to 5,000 cubic yards, and they are equipped with a total of about 2,500 horsepower. The buckets vary in capacity from 2½ to 9 cubic feet; all but five have buckets holding 3½ cubic feet or less. Two are driven by electric power generated at the same plant; seven are equipped with steam power, of which four use coal, two crude oil, and one wood for fuel. The other dredges are equipped with gasoline engines. It is estimated that the 16 dredges operated handled between 1,200,000 and 1,500,000 cubic yards of gravel; had they all been able to operate to their full capacity, they should have handled at least twice as much. It is significant that the gravel handled by all other forms of placer mining on the peninsula in the year 1910 is roughly estimated to have totaled about 800,000 cubic yards. Complete returns are not available regarding the gold output of the dredges, but it is estimated to have a value of about $800,000. It seems probable that the average working season should be 110 to 130 days, instead of 90, as has been the case in the past. If this is true, the dredge production can be largely increased, even without any additional machines.

In 1911, 18 dredges were operated for a part or the whole of the season in Seward Peninsula, of which 5 were built during the summer of 1911. Seven of these were in the Nome region, seven in the Solomon River basin, and five in the Council district. In addition to these, five more dredges were in process of construction, of which three are in the Nome region and one each in the Council and Kougarok districts.

It is not impossible that the output of the dredges alone in Seward Peninsula may soon reach $2,000,000. There is hope, therefore, that the gold output of the peninsula in 1910 may be the minimum for some time to come.

As indicated above, the past few years have witnessed remarkably rapid development in gold dredging along the southern margin of Seward Peninsula. This form of mining has been successfully carried on by more than a dozen different companies, and further installation of machines is assured. Most of the operators consider the presence of any considerable amount of frozen ground a bar to successful dredging enterprises, but even though that may be true, the peninsula contains extensive deposits of auriferous alluvium that are suitable for dredging. No one can doubt that very large areas of auriferous gravels in the Seward Peninsula carry 25 cents or more in gold to the cubic yard. If these can be dredged at a cost of 15 or even 20 cents a yard, it will leave a considerable profit to the dredge. While no exact figures are available, it is probable that most of the ground thus far dredged has carried 30 to 80 cents a yard. Little attempt has been made so far toward introducing economies, and most of the operations have been carried on by one-dredge units. Centralization of administrative expenses, establishment of central-power plants conveniently located for fuel delivery, and standardization of dredges so as to make parts interchangeable should lead to considerable reduction of costs.

The problems of recovering gold by dredges from frozen ground remain for the engineer to solve. Rickard[1] reports the cost of thawing dredging ground in the Yukon basin with steam as 9½ to 12 cents a yard. These figures are based on the use of wood for fuel at a cost of $7 to $12 a cord, which is approximately equivalent to coal at $18 to $24 a ton. It would appear, therefore, that this cost should not be exceeded in Seward Peninsula. Another possible method of thawing the dredging ground is by exposure to the air. If the deposit is extensive enough to permit long open cuts, exposure to air and sun might thaw the ground rapidly enough to give the dredge sufficient material to work on while moving from one end of the cut to the other. A method of this kind has been used in the Klondike, where the cuts are made by hydraulic means and the water helps to thaw the ground. The gravel plain which stretches inland from the coast is the largest known auriferous deposit in Seward Peninsula, and probably in Alaska, and would seem to be a favorable field for the method of mining suggested above. The water supplied by the ditches already built will eventually be available for this form of excavating, when no longer used for mining the high-grade gravels. The bedrock surface is so close to sea level that means will have to be devised to elevate the material excavated by hydraulicking. This might be done advantageously by mechanical elevators, as fuel at Nome is comparatively cheap. It should be noted that much of this gravel is more than 60 feet in depth, and probably could not be dredged without groundsluicing off some of the overburden. The enterprise as a whole needs a very large amount of capital and requires careful investigation by competent engineers.

UNDERGROUND MINING.

Drift mining, the term used in Alaska to cover the operations of recovering auriferous gravels by underground work, includes sinking shafts, driving levels, and stoping. In the Kougarok region some of the bench deposits have been mined from adit tunnels, but in nearly

[1] Rickard, T. A., Dredging on the Yukon: Min. and Sci. Press, vol. 97, 1908, pp. 290–293, 354–357.

all other districts of Seward Peninsula it has been necessary to sink shafts and hoist the material. Drift mining differs from open-cut work in the fact that only the gravels carrying gold are excavated, the overburden being left in place. Most of the underground operations in the Seward Peninsula have been confined to frozen ground, so that little timbering and no pumping are necessary. Some of the rich ancient-beach deposits occur in the unfrozen ground, and these have been mined by underground methods, but at heavy expense.

Drift mining was in use in the Yukon camps before the discovery of the Klondike, but it was in the Klondike that it received its greatest development. It has been of great economic importance, because, as it can be followed in winter as well as in summer, it gave employment to the miners during the long closed season. It thus had the important effect of giving the population of the mining camps a greater degree of permanency. Drift mining began at Nome in the early days of the camp and steadily increased, so that by 1905 the annual output was over a million dollars in value. During the following winter the third-beach line was discovered, and as it was mined entirely by drift methods, this form of development soon overshadowed all others in the peninsula. In 1906 the value of the gold output from drift mining was probably about $4,000,000, but it has since declined, falling in 1910 to about $1,000,000. Drift mining has been confined chiefly to very rich deposits; hence there has been no great incentive to the improvement of methods and the introduction of economies. Moreover, the deposits were not only very rich but fairly regular in their occurrence. In this respect drift mining at Nome differed from that at Fairbanks, where determination of the location and dimensions of the pay streak entails heavy expense. On the other hand, unfrozen ground was encountered on the third-beach line, whereas at Fairbanks such ground is of unusual occurrence. The average depth of ground to bedrock at Fairbanks is probably twice that at Nome.

The operations of drift mining include the sinking of a shaft to bedrock and the driving of a drift along the pay streak (Pl. XIV, *B*). If the pay streak is narrow this drift might comprise the entire mine workings; if it is wide, the ground is blocked out by additional drifts and crosscuts. As most of the gravels mined by drifting are frozen, the thawing of the material before excavating is an important element in the operations. It has been roughly estimated that under average conditions one-third of the cost of operating, including the cost of mining and hoisting, is represented by the cost of fuel consumed in making steam for thawing. Some incomplete data indicate a coal consumption of 25 to 40 pounds for each cubic yard of gravel thawed.[1]

[1] These figures refer only to underground thawing. The fuel consumption in thawing in open cuts is probably only from 25 to 35 per cent as great.

A. HEADFRAME AND SLUICE BOXES FOR UNDERGROUND MINING OPERATIONS IN NOME.

B. SURFACE EQUIPMENT OF UNDERGROUND MINE NEAR NOME, USING AERIAL TRAM AND SELF-DUMPING BUCKET.

In the early days on the Yukon the sinking of shafts and driving of drifts was accomplished with the aid of wood fires or heated rocks. When underground mining on a large scale was begun in the Klondike the method of thawing by steam was devised. This consists, in effect, of introducing a jet of steam through so-called iron "points," which are driven into the frozen ground to depths varying from 5 to 20 feet. At Fairbanks, where this form of mining has reached its highest development, the points are usually driven from 2½ to 3 feet

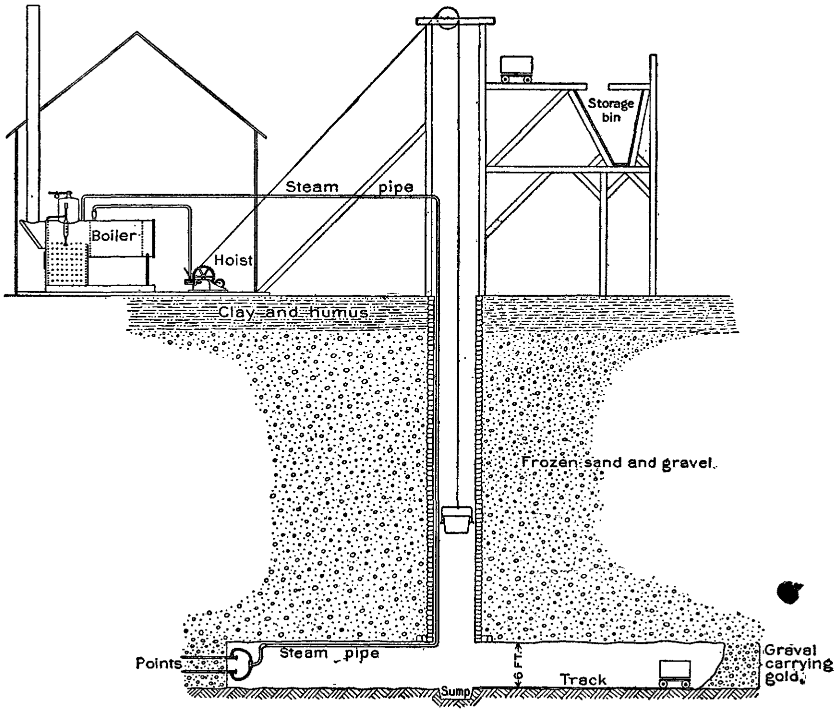

FIGURE 12.—Diagrammatic section of underground placer mine, showing method of hoisting and thawing with steam.

apart, and the duty of a point is from 3 to 3½ cubic yards during a period of eight to ten hours.[1]

Hoisting is now almost invariably done by steam or gasoline engines. The most common practice at Nome is to have the sluice boxes close to the headframe and connected by a tram. (See fig. 12.) The gravel is trammed from the working face to the shaft, hoisted, and then trammed to the sluice boxes (Pl. XVII, *A*). At some mines self-dumping buckets and aerial trams (Pl. XVII, *B*) are used; this is the ordinary practice at Fairbanks. The trolley cable is then

[1] Prindle, L. M., and Katz, F. J., The Fairbanks gold-placer region: Bull. U. S. Geol. Survey No. 379, 1909, p. 196.

usually swung between the headframe and a gin pole. This system has the advantage of being more mobile than the other and permits placing the dumps at any convenient locality.

Winter operations necessitate the accumulation of the gravel in dumps, which are placed over sluice boxes in order to avoid, so far as possible, the rehandling of the material. In some places the dumps freeze so solidly that partial rethawing by steam has to be resorted to.

Some successful underground mining has been carried on at Nome in thawed ground, but only where the gravel contained considerable gold. Such mining required timbering and usually pumping, both of which are expensive. In one or two mines artificial freezing has been employed, but no figures are available regarding the comparative cost of this practice and that of timbering and pumping. Where pumps have been installed the water from the pump is often used for sluicing. If it is not so used, sluicing water has to be provided from other sources. At many localities water is available during several weeks in the late spring for sluicing the winter dumps, but at other times it can be obtained only at heavy expense.

It is unfortunate that no cost sheets for an underground mining plant at Nome are available. Purington [1] reported the cost of underground mining on Seward Peninsula in 1904 as $3.66 a cubic yard. At Fairbanks in 1908, where wages, including board, were about $6 a day, and wood $10 a cord, the lowest cost for underground mining was about $3.50 a cubic yard.[2] At Nome fuel oil is less expensive than wood at Fairbanks, and in the winter of 1910 wages, including board, probably averaged about $4, so that it would appear that the cost of underground mining is considerably less than at Fairbanks. On the other hand, the only published figures that have come to the notice of the writer indicate higher unit cost than at Fairbanks. The following statement [3] is quoted from a recently published article:

> The labor union, carefully sizing up the situation early last winter, with rare good sense fixed the winter wage scale at $1 per day less than had prevailed during the three previous winters, and thus without any friction or dissatisfaction operators were able to secure good labor at $3 per day and board. This condition undoubtedly encouraged some of the operators to attempt the extraction of gravel that has been heretofore considered too low grade to handle. The average cost of working a 2 to 3 foot pay streak in frozen ground in the Nome district, placing the pay gravel in a dump on the surface and groundsluicing and shoveling it into sluice boxes in the spring, has been about $4 per yard, and operators have hesitated to attempt to mine ground that sampled less than 4 or 5 cents per pan, which is equal to $6 to $7.50 per cubic yard. During the past winter, however, much of the material hoisted averaged only 3 cents per pan,

[1] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905 p. 38.

[2] Prindle, L. M., and Katz, F. J., The Fairbanks gold-placer region: Bull. U. S. Geol. Survey No. 379 1909, pp. 198-199.

[3] Min. and Sci. Press, July 16, 1910, p. 88.

or $4.50 per yard. Louis Stevenson, superintendent for the Pioneer Mining Co., informs me that he has several thousand cubic yards of gravel in dumps this spring mined from a pay streak 7 or more feet thick which averages only $1.875 per yard and yet leaves a profit of $0.625 per yard, allowing for the usual cost of sluicing. This case, however, is exceptional, as pay streaks of this character are usually only 3 feet or less in thickness, which necessitates handling about 2 feet of waste, and as the work was done near an established camp it does not take into consideration the cost of equipment nor make any allowance for depreciation. Making all due allowances, however, it is still the most creditable showing yet made in this district and brings into the class of profitable ground much territory that has been heretofore considered too low grade to handle.

It should be noted that the above statement of costs applies only to the accessible parts of Seward Peninsula. The transportation charges to the inland camps will very materially affect the cost of underground work as well as of other forms of mining.

SUMMARY OF PLACER MINING.

Nearly $60,000,000 worth of gold[1] (p. 270) has been won from the placers of Seward Peninsula. Most of the gold output up to 1908 was derived from bonanzas, whose richness did not demand a close scrutiny of mining costs. As a large part of the known bonanza deposits are worked out, there is a strong incentive to develop methods which will permit extraction of the gold from the very extensive gravel deposits in the peninsula which carry low values. This has led to the installation of many dredges and to the development of other methods of mining at low cost. Considerable progress has been made in introducing economies, but much still remains to be done.

The steady progress in mining methods is reflected in the gradual decline of the average gold content of the gravels mined each year. Accurate figures of the average gold content are lacking, but the estimates in the following table are based on a careful study of all the available data. It should be noted that in the yardage of gravel mined the overburden which has been removed by groundsluicing or otherwise was not taken into account, only the material which has been passed through the sluice boxes being included.

Estimated average value of gold recovered per cubic yard from Seward Peninsula placers, 1898–1910.

1898–1904	$5.95
1905	5.15
1906	5.80
1907	5.00
1908	4.30
1909	2.80
1910	1.95

[1] Up to the close of 1910. The output of 1911 had a value of $3,100,000; that of 1912 about $3,000,000.

The high recovery for the year 1906 was due to the mining of the very rich placers along the third-beach line. The rapid decline in gold values in 1909 and 1910 is the result of the large yardage of gravel of relatively low tenor handled by the dredges.

The decline in the average gold content of the gravels mined, far from being discouraging, is one of the most hopeful features of the mining industry. It reflects credit on the operators who have so improved their practice as to permit the mining of placers which a few years ago would have been considered absolutely worthless. Every reduction in costs results in making available for profitable mining larger quantities of auriferous gravels, thus increasing the available gold reserves and assuring longer life to the placer-mining industry. The recovered values of $1.95 a cubic yard for 1910 may seem very low for Alaska placer mining, but it is extraordinarily high compared with the average recovery in the States, which for 1909 has been estimated by Waldemar Lindgren[1] to be about 12 cents a cubic yard.

In the foregoing pages several suggestions have been made as to economies that might be introduced. The cheapening of fuel will be a very important element and should be brought about by the enormously rapid increase in the output of oil from the California fields and by the much-desired early development of Alaska coal. If dredge mining developed on a sufficiently large scale in the central and northeastern districts cheap power might be obtained from a central plant located in the Chicago Creek coal field. Water-power development also might be an element in the problem. (See pp. 249–255.) For the dredges of the Bering Sea slope central stations located near tidewater, burning fuel oil, are likely to be the cheapest source of power. The building of railways and more particularly of wagon roads would also reduce the cost of mining. It does not seem likely that economies can or ought to be made in wages, though a reduction in the cost of labor might be effected by providing earlier steamers in the spring and later steamers in the fall to Nome. It seems probable that a steamer could be sent out from Nome in the fall later than has usually been the practice. It has also been suggested that a boat built especially for breaking ice might be able to plow through the ice of Bering Sea even in midwinter, but such an enterprise would, of course, not be economically feasible unless a very large number of additional dredges were built. If 50 large dredges were operated on the peninsula, however, an extra month's work in a season might increase the annual gold output a million dollars.

Cheaper transportation and fuel would decrease the expense of dredging and to a lesser extent the cost of other forms of mining.

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[1] Oral communication.

Mining engineers who have studied the question hold that mining costs can be reduced by the increased use of mechanical devices other than dredges.

The data presented go to show that the cost of placer mining in Seward Peninsula is much greater than in the States. It is also true, however, that the peninsula is far more easy of access than the Yukon region and, except for the absence of fuel, its physical conditions are more favorable to mining. Mining operations should therefore cost much less at Nome than at Fairbanks or in the Klondike. The Klondike has an advantage in its water supply, but in stream gradients there is little to choose between Fairbanks and Seward Peninsula.

The future of the placer-mining industry of the peninsula depends, of course, on the amount of placer ground remaining that can be profitably exploited. This, in turn, is a function of the cost of mining. No one can doubt that there are enormous deposits of gravel which carry 25 cents in gold to the yard, in such position that they can be mined only by mechanical means, particularly by dredges. What percentage of this gravel is unfrozen and therefore available for recovery under the present dredging practice can be determined only by careful prospecting. The most important problem for future dredge mining is to devise means to thaw the frozen auriferous alluvium at a cost sufficiently low to permit profitable extraction by dredges. Extensive creek placers, too shallow to work by dredges, probably carry higher values than the deposits mentioned above. Some of these deposits are so located with reference to water supply that they can be profitably hydraulicked, though elevating the tailings will in most localities be necessary. Lack of water, however, will always prevent any very large expansion of the hydraulic-mining industry. Underground mining is on the wane and the outlook for its expansion is not encouraging, although some extensive deposits of deep gravels at several localities have not yet been carefully prospected.

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