PROVINCE OF BRITISH COLUMBIA

REPORT

OF THE

WATER RIGHTS BRANCH

OF THE

DEPARTMENT OF LANDS

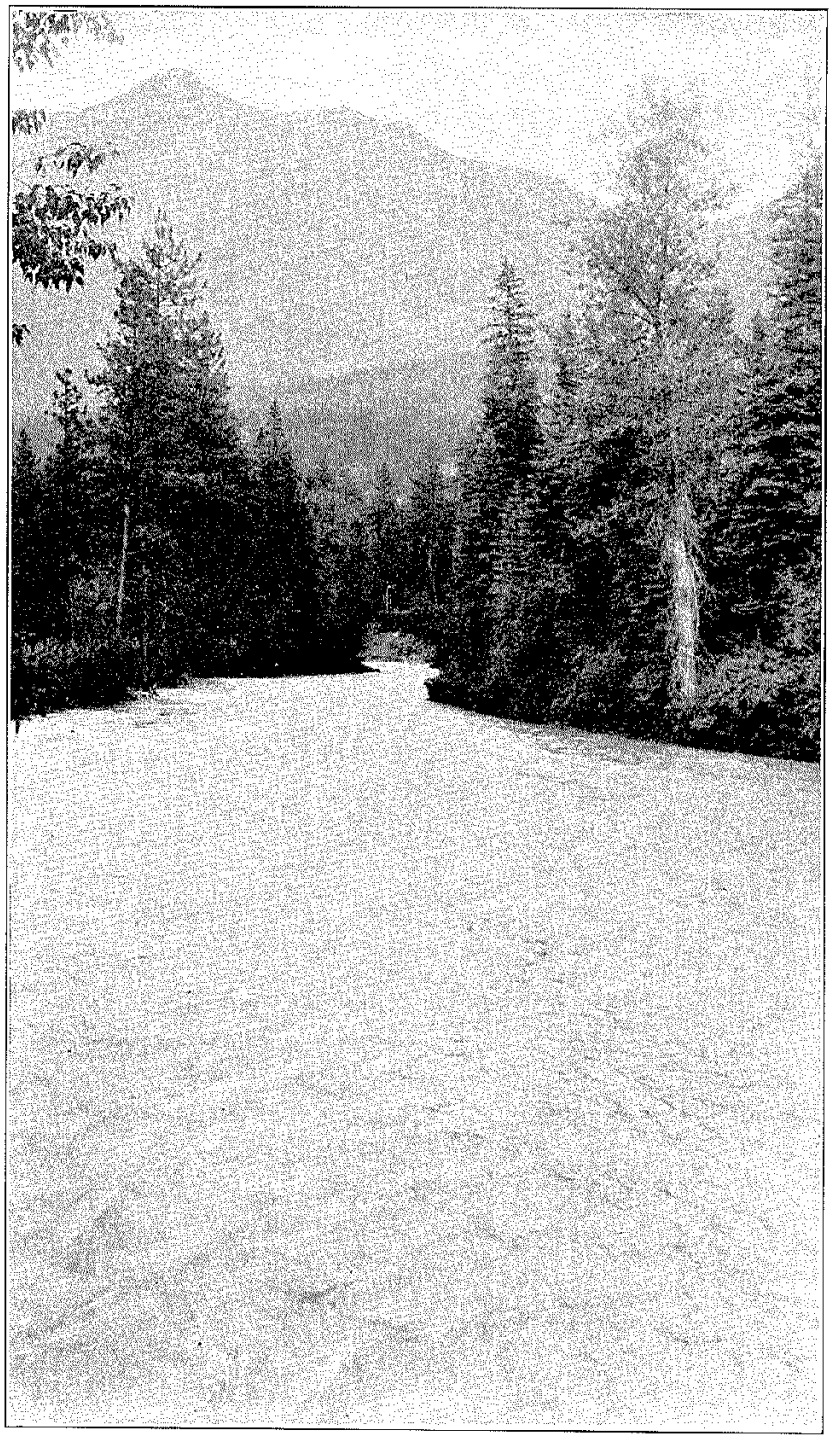
HON. WILLIAM R. ROSS, K.C., Minister

FOR THE YEAR ENDING DECEMBER 31ST

1912

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA.
PRINTED BY
AUTHORITY OF THE LEGISLATIVE ASSEMBLY.

VICTORIA, B.C.:
Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.
1913.



Looking up Sheep Creek, East Kootenay.

PROVINCE OF BRITISH COLUMBIA

REPORT

OF THE

WATER RIGHTS BRANCH

OF THE

DEPARTMENT OF LANDS

HON. WILLIAM R. ROSS, K.C., Minister

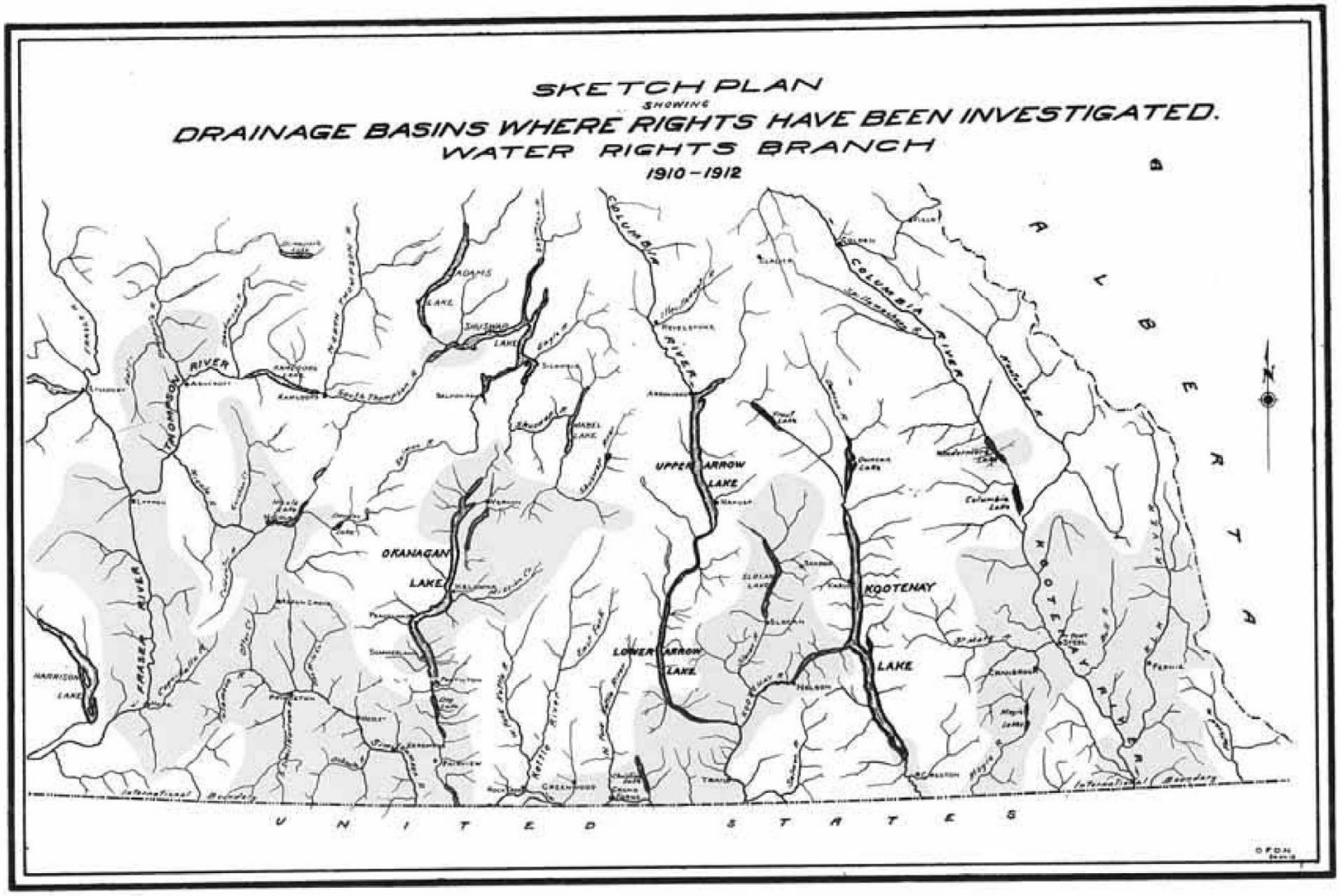
FOR THE YEAR ENDING DECEMBER 31ST

1912

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA.

PRINTED BY
AUTHORITY OF THE LEGISLATIVE ASSEMBLY.

VICTORIA, B.C.:
Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.
1913.


SKETCH PLAN
SHOWING
DRAINAGE BASINS WHERE RIGHTS HAVE BEEN INVESTIGATED.
WATER RIGHTS BRANCH
1910 - 1912
ALBERTA
UNITED STATES
THOMPSON RIVER
FRASER RIVER
COLUMBIA RIVER
KOOTENAY RIVER
OKANAGAN LAKE
UPPER ARROW LAKE
LOWER ARROW LAKE
KOOTENAY LAKE
ADAMS LAKE
SHUSWAP LAKE
HARRISON LAKE
KAMLOOPS
GREENWOOD
INTERNATIONAL BOUNDARY

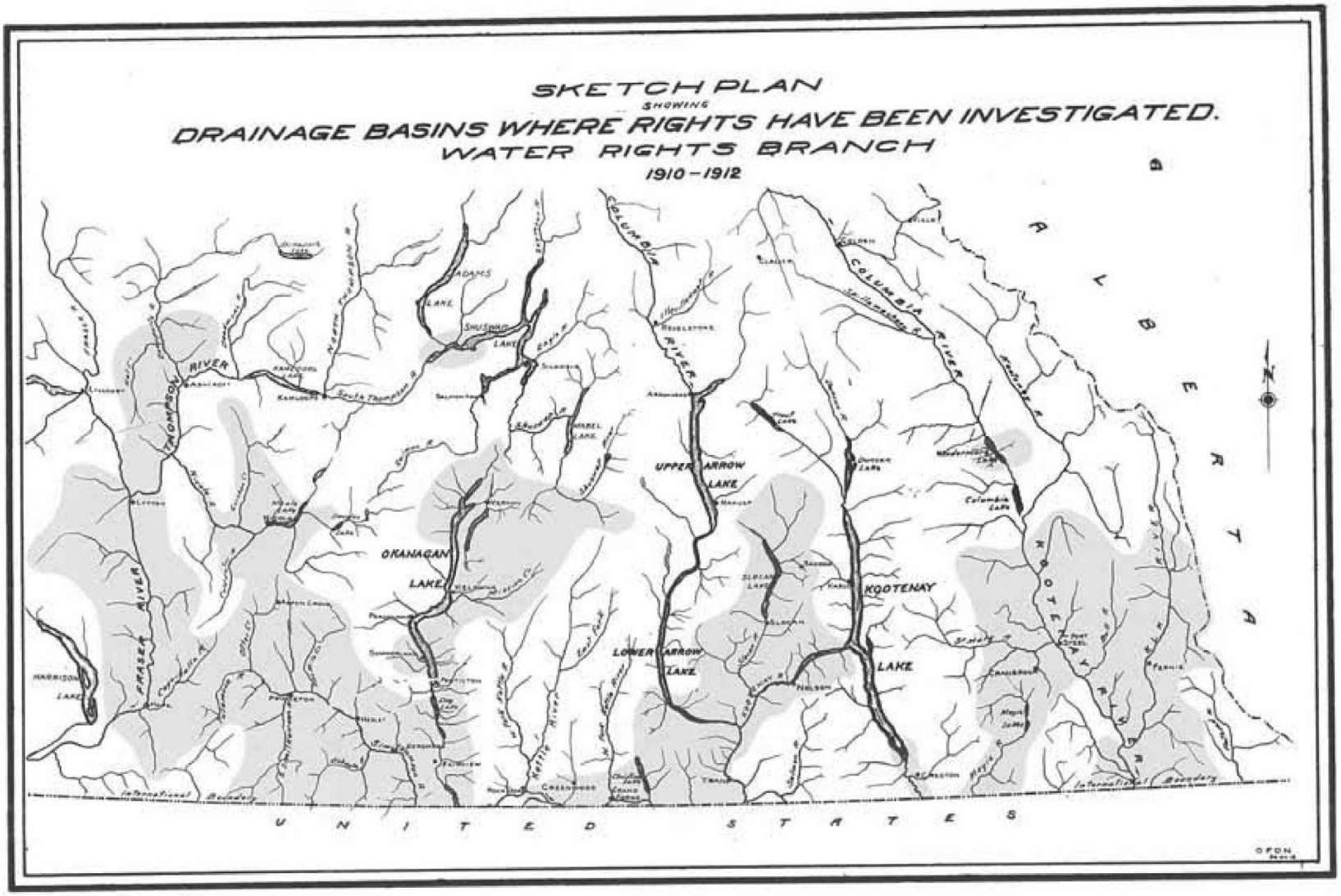

SKETCH PLAN
SHOWING
DRAINAGE BASINS WHERE RIGHTS HAVE BEEN INVESTIGATED.
WATER RIGHTS BRANCH
1910 – 1912
ALBERTA
UNITED STATES
COLUMBIA RIVER
FRASER RIVER
THOMPSON RIVER
OKANAGAN LAKE
UPPER ARROW LAKE
LOWER ARROW LAKE
KOOTENAY LAKE
KOOTENAY RIVER
ADAMS LAKE
SHUSWAP LAKE
HARRISON LAKE
Columbia Lake
Windermere Lake
Kootenay Lake
International Boundary

TABLE OF CONTENTS.

DEPARTMENT OF LANDS,
WATER RIGHTS BRANCH,
VICTORIA, B.C., December 31st, 1912.

The Hon. William R. Ross, K.C.,
Minister of Lands.

SIR,—I have the honour to transmit herewith a report reviewing the work of the Water Rights Branch for the year 1912, and presenting for your consideration some of the problems involved in water administration in this Province. Allowance must be made for the fact that this Branch is still in process of reorganization, and that therefore this report does not assume the unified form which might otherwise be possible. Acknowledgment is made to H. W. Grunsky, an expert of the United States Department of Agriculture, whose temporary services you have secured, and under whose direction the report has been compiled.

I have the honour to be,
Sir,
Your obedient servant,
J. F. ARMSTRONG,
Acting Comptroller of Water Rights.

REPORT OF THE WATER RIGHTS BRANCH.

REPORT OF THE ACTING COMPTROLLER OF THE WATER RIGHTS BRANCH.

The Hon. William R. Ross, K.C.,
Minister of Lands, Victoria, B.C.

December 31st, 1912.

SIR,—I have the honour to report concerning the administration of the Water Rights Branch of the Department of Lands. On my assuming office, the "Water Act, 1909," had been in force for two years and a half. Surveys had been made of portions of the Province, but the results, while containing information which will be of use later, were not such as would assist in the early determination of the water rights of individual holders. The Board of Investigation had heard and determined certain water-right claims, but had established no principles which would aid in the decision of the mass of water rights which were to come before it. None of the information which had been obtained by surveys was tabulated, and only part of the records issued by the local Water Commissioners had been tabulated.

The Water Rights Branch had commenced work without precedents to guide it, and the organizations had to be created as necessity arose. It was evident that much of the work was tentative, and would have to be changed if experience proved it unsuited to the conditions of the Province. The alterations made by the "Water Act" in the policy and procedure under the water laws of the Province were not yet understood by the public at large, or even by the majority of the officials entrusted with its administration. These alterations were not as great as they were supposed to be, but the arrangement of the "Water Act," and even its wording, was so different from those of the former Acts as to require much study to duly appreciate the great improvements made.

Matters had been allowed to drag in consequence of difficulties arising in the administration of the Act, which had not been foreseen, and in some of the water districts numbers of applications remained in arrears. The new Act was very exacting in some matters of procedure, and few of the applications complied with all the requirements and many had therefore to be refused. In some districts the Water Commissioners issued licences under the easy system which had led to the granting of so many imperfect records in the past. It was soon apparent that uniformity could not be secured unless the licences were issued from a central office. It was also evident that a water licence should be clear and precise, and that clearness and precision could not be obtained without a close inspection of the application, and a careful consideration of the use to which the water was to be put. There should be no doubt as to what stream was to be tapped, as to what priority was accorded to the licence, and as to what lands it should be appurtenant. It was carelessness in preparing the old records which had led to so much trouble in the past, and every effort should be made to prevent similar complications in the future.

It was therefore determined to recommend amendments to the Act that would:—

(1.) Simplify the notices which were to be posted and published:

(2.) Give the applicant a short delay in which to file the information to which the public was entitled, and a longer delay in which to pay the fees and prove to the Department that the water could be beneficially used for the purpose stated:

(3.) Set a fixed time within which plans of the works for the diversion, carriage, and storage of the water should be submitted to the public and to the Department, and a fixed time for the commencement and the completion of these works:

(4.) Entrust to one official the issue of licences and permits and the granting of the other water privileges:

(5.) Enable the Executive to grant a certificate of the approval of its undertaking to a company or municipality before the plans of works had been completed:

(6.) Entrust to the Comptroller of Water Rights the approval of the plans of the works to be constructed:

(7.) Provide a summary procedure on complaints for illegal diversion of water and other offences by a licensee:

(8.) Provide for the inspection of dams and other structures which are alleged to be dangerous.

These changes required the amendment of many sections; in fact, Parts V. and VI. had to be recast. The changes in policy were few, but those in procedure were many and important. These amendments having been enacted in February, 1912, forms were prepared suited to the new procedure, for the few printed forms which had been used previously were now obsolete. The use of these forms is not imperative; they are, however, very useful to the public and save much labour in the office. I am attaching to this report copies of the most important forms, showing how they should be used. (*See* page 100.)

The Minister having determined that expert advice should be obtained before determining the policy that should be followed on several questions on which there are differences of opinion, these questions have been studied with care, and applications which would be affected by the policies have been held in abeyance. Many other applications are held until the Board of Investigation has adjudicated on records granted before 1909.

The reports of the engineers will show the nature and extent of the work done in the field, and the report of the Chief Clerk shows the clerical work done in the head office of the Branch.

In the matter of applications for licences, our object is to grant a licence which will show clearly the rights and obligations of the licensee, and to place in the office of each Water Recorder a map which will show each stream on which one or more records have been granted, and each parcel of land to which a water licence is appurtenant. When these maps are completed a search will be an easy matter, as each Water Recorder will have a list of all records on each stream in his division. At present this information is not available, and it may be some time before the maps of a district will be complete, but progress is being made. The necessary data is being obtained during each summer and is compiled and mapped the following winter.

A map is attached to this report which shows the drainage-areas of the smaller streams in which hydrographic surveys have been made. These will cover most of the drainage-areas in the Fernie, Cranbrook, Nelson, Slocan, Similkameen, Osoyoos, and Nicola Districts, and a few of the drainage-areas in the Golden, Kamloops, and Yale Districts. These surveys have so far been confined to the examination of the portions of these drainage-areas in which water was being put to beneficial use in order that the Board may be enabled to adjudicate on the rights on these streams. Surveys on this system will be commenced in other districts during the coming year. The district engineers will continue their investigation by examinations of the headwaters and the storage capacities of the streams in their districts. The Dominion Government has been carrying on extensive surveys in the Railway Belt, and it is expected that the reports of their engineers will be published shortly. These will also be of great value to the Board and to the public.

It has been found that the boundary-lines between the water districts as at first gazetted are inconvenient for the purpose of administration, as several drainage-areas are situated partly in one and partly in another district, requiring that applications and notices should be filed and published in both districts. Where it can conveniently be done, I would recommend a change on those lines so as not to divide the drainage-areas of small streams.

The report of the experts who have been inquiring into the organization and duties of this Branch recommends that divisional engineers be appointed to have charge of one or more water districts and that they be entrusted with the duties relating to the distribution of water which, under sections 289 and 289A and some other sections of the Act as amended in 1912, devolved upon Water Recorders. They would also attend to the measuring of streams and report on the applications for new licences, so that the central office could at all times have the latest data when adjudicating on applications.

THE BOARD OF INVESTIGATION.

The principal duty of the Board is the adjudication of rights acquired through records obtained under the laws in force before 1909. The first of these laws was contained in regulations issued under the "Goldfields Act" of 1859. These regulations provided for an application to the Gold Commissioner, stating the name of the applicant, the ditch-head, the quantity of water, the locality where the water should be used, the general nature of the works required, and the time when such works should be completed. They also provided for forfeiture in case of non-use, for the sale of water at a uniform price where sale was allowed, for beneficial use of the water, and for a penalty for waste.

In 1871 the "Gold-mining Act" required in addition a notice to be posted; it restricted the sale of water and provided for the filing of objections to a grant, and for compensation for damage done to private property. The Land Ordinance of 1870, which was a consolidation of earlier Acts, provided that persons lawfully entitled to hold a pre-emption, and lawfully occupying and *bona fide* cultivating land, might divert water for agricultural purposes on obtaining a record from the Commissioner; that priority of right should depend upon priority of record; that all assignments of a pre-emption should convey the water recorded; that a record should not be granted until a notice had been posted containing the name of the applicant, the quantity of water, the place of diversion and the object thereof, and that no person should have exclusive right to the use of the water, whether the same flowed naturally through or over his land or not, except such record were made. Had the Commissioners insisted on the fulfilment of these requirements before making a record, much litigation and trouble would have been avoided. They, however, did not do so, but granted records to some persons who were not entitled to them, records which did not specify the stream, records which did not state the point of diversion, records which did not state the quantity to be diverted, and many records which did not state definitely where the water was to be used.

In 1886 an Act was passed providing that records which had been "honestly but imperfectly made" should under certain circumstances be valid, but unfortunately no endeavour was made to improve the procedure and imperfect records were still issued.

In 1897 the "Water Clauses Consolidation Act" was passed. This was a great improvement on the previous laws. It defined more clearly the persons and corporations which were entitled to water records; it provided procedure for hearing applications and objections thereto; and it defined the rights and liabilities of record-holders more precisely than had been done before. Standard forms of notices and records were printed and used, and from that time the records contained more complete details, but many of the record forms were not filled in with sufficient precision. The Commissioners failed to recognize the trouble that might arise from the use of such expressions as "the Douglas Ranch" instead of saying "Lots 75 and 86," and the "Ajax Group" instead of naming the individual mineral claims; from not describing the stream in such a way as to distinguish it from other streams in the vicinity; and from not exacting proof that due notice had been given of the application. The consequence was that records were still imperfectly though honestly made.

In the "Water Act" of 1909 provision was made for the creation of a Board for the purpose of hearing the claims of all persons holding records, or claiming to hold records, of water or other rights under any former public Act or Ordinance.

A Board was therefore named which held its first meeting in Trail on May 19th, 1910. Subsequent meetings were held in Victoria, at 150-Mile House, Alkali Lake, Nelson, Kamloops, Penticton, Okanagan Falls, Summerland, Naramata, and several adjourned meetings at Victoria and Trail during the year 1910 and the beginning of 1911.

Up to May 2nd, 1911, 122 orders were passed, cancelling records and directing the issue of licences in lieu of the records which had been confirmed. Since that date meetings have been held as follows:—

In 1911.—At Victoria on August 29th, September 11th, October 9th, 16th, and 26th, and December 11th; and at Kelowna on November 23rd to 30th.

In 1912.—At Victoria on January 13th, February 5th, 15th, 20th, and 27th, March 5th, 6th, and 7th, April 9th and 10th, May 8th and 10th, and November 25th; Vancouver, January 11th; Kelowna, April 17th and 18th; Summerland, April 19th; Peachland, April 22nd; Okanagan Centre, April 24th; Vernon, April 26th and 27th; Lumby, April 29th; Nelson, May 16th; Kaslo, May 21st; Procter, May 23rd; Slocan Junction, May 24th; Slocan City, May 25th; Silverton, May 27th; New Denver, May 28th; Sandon, May 29th; Duncan, July 2nd; Grand Forks, August 6th; Greenwood, August 7th; Princeton, August 9th; Keremeos, August 10th; Fairview, August 12th; Penticton, August 13th; Ashcroft, August 28th and 29th; Lytton, December 4th and 5th.

The Board commences the investigation of claims to water rights on a stream by inserting in the British Columbia Gazette and a local newspaper a notice that all persons holding such rights should file their claims before a certain day, but it is found that not a quarter of the record-holders comply with this notice. The next step is the service on each record-holder of a notice that a meeting will be held when the claims will be heard. At these meetings many persons attend, but few of them are provided with the necessary proof of their claims, and

many objections are made which cannot be heard immediately, as the claimants had not had any notice of the objections and were not prepared to meet them. Even at this stage of the proceeding many of the record-holders have not filed statements of their claims.

As many of the records were imperfectly but honestly made, it is the duty of the record-holder to furnish the information which will enable the Board to cure the imperfections. This comprises: The correct name of the grantee; the correct name of the stream; the purpose to which the water is to be applied; the land on which it is to be used; the quantity of water which can be beneficially used. In order to assist the record-holder in obtaining this information, the Board causes a search to be made of the books of the Department of Lands to ascertain what, if any, lands the grantee named in the record appeared to lawfully occupy at the date of the record. The result of these searches is at the disposal of claimants.

In the meantime the engineers have made a hydrographic survey of the stream and of the lands on which the water is being used. These surveys take much time and are expensive; the plans made from them can be consulted by the interested parties and are of great value in determining conflicting rights.

At the meetings at Kelowna 296 records were considered by the Board, about 1,500 parcels of land being affected. Some objections were heard at the time and others were heard later. Most of these objections have been determined, while a few are awaiting further evidence. The relative priority has easily been determined, but the quantity of water to be allotted to each parcel of ground has been a difficult question, as the Board had no data as to the nature of the soil, or as to the extent to which the water had been put to beneficial use. It was therefore determined late in 1912 to concentrate several of the hydrographic parties in Kelowna to obtain further information. The reports from these parties are being compiled, and the Board will soon be able to lay the results before the claimants, and after another hearing adjudications will be made. The claims heard at the other meetings will be dealt with in a similar manner.

The number of claims filed being so few compared with the number of records, an agent of the Board was sent through the Kamloops, Cariboo, Lillooet, and Nicola Districts to assist claimants in the preparation of their claims, and it is expected that the Board will be able to deal more expeditiously with the claims in those districts.

Your Department has, during the past year, contributed to the carrying forward of the investigation respecting the water-powers of the Province under the auspices of the Conservation Commission of Canada, and to be published by it. The work has been in charge of Arthur V. White, engineer of the Commission. As it is the policy of the Commission to cover areas that have heretofore been largely unexplored in a very general way, the investigation fits in quite well with the more detailed surveys of water-powers which have lately been undertaken by the Water Rights Branch in charge of Mr. Gray Donald.

The work of the Conservation Commission is preliminary in character, and is calculated to be merely an indication of the water-power possibilities of those parts of the Province which are covered. On the other hand, the aim of the surveys undertaken by the Province is to accumulate more complete data concerning stream-flow, hydraulic head, and the character of the available sites for water-power development. It is readily understood that it would not be possible to carry on this latter work in parts of the Province widely separated from one another, and that it will take several years to complete it; therefore the work which Mr. White has undertaken will be of considerable value in determining what points should receive a closer examination by the Provincial survey parties, and in securing an early tabulation of the available water-power possibilities.

Mr. White has had several parties working in the Coast District from Powell River in and out of the various inlets along the coast to Bella Coola. These parties used a launch to transport them from one base to another, working from the base established inland as far as might be necessary. It is understood that the results of Mr. White's work are in course of preparation for publication, and will appear in a report of the Conservation Commission on "The Water-powers of Western Canada," which should be available shortly.

I have the honour to be,
Sir,
Your obedient servant,

J. F. ARMSTRONG,
Acting Comptroller of Water Rights.

APPLICATIONS UNDER ACT OF 1909.

Water District.	Applications for Licences, Part V.	Applications for Approval of Plans.	Number of Permits issued.	Number of Licences issued.
Victoria	156	23	38	57
Vancouver	22	2	..	..
Alberni	29	3	4	9
New Westminster	78	7	10	66
Yale	21	..	1	..
Kamloops	166	..	2	73
Nicola	26	..	..	33
Similkameen	75	3	1	101
Osoyoos	94	8	5	161
Nelson	2	..	..	141
Slocan	36	..	..	1
Revelstoke	7	..	..	..
Cranbrook	52	3	2	72
Golden	41	1	1	83
Lillooet	59	..	2	32
Cariboo	44	1	1	41
Fort George	5	..	1	..
Fort Fraser	..	..	..	..
Omineca	4	..	..	3
Stikine	..	..	..	..
Atlin	2	..	..	7
Nanaimo	3	..	..	3
Skeena	37	2	1	23
Totals	959	53	69	906

ORDERS IN COUNCIL UNDER "WATER ACTS" PASSED SINCE 1909.

Establishing reserves	27
Approving of undertaking	21
Extending time for undertakings	6
Regarding clearing of streams	5
Granting permission to expropriate	4
Establishing water districts	3
Regarding the Board of Investigation	2
Miscellaneous	21
Total	89

IRRIGATION'S PART IN THE FUTURE UPBUILDING OF BRITISH COLUMBIA.

BY SAMUEL FORTIER.

(The author of this paper, Dr. Samuel Fortier, Chief of "Irrigation Investigations," a branch of the United States Department of Agriculture, Washington, D.C., was engaged in an advisory capacity by Hon. W. R. Ross, Minister of Lands, for the summer of 1912, in connection with the reorganization of the Water Rights Branch. Dr. Fortier spent sixty days in the Province, and while here he made a close study of the local institutions connected with waters and water administration. The present article gives some general observations made by Dr. Fortier incidentally during his stay. Its breadth of view is apparent, and it is well worthy the careful reading of all persons interested in the future development of British Columbia.)

It was fortunate that in the rechristening of that most interesting of all the Provinces of Canada it should be called British Columbia. It was notice to the other countries of the New World that Canada was to have its Columbia too. In both the geography and the literature of that part of the New World lying south of the 49th parallel of latitude there is much to remind one of the famous explorer. The names of institutions and edifices, lakes and rivers, cities and countries, trace their origin to Columbus. It is not so in the North. In the wide expanse of territory comprising the Dominion of Canada there are few reminders of him who discovered the continent. I repeat, British Columbia is well named. Columbian in spirit and enterprise; Columbian in the extent and variety of its natural resources; and Columbian in the advantages of its geographical position; but British in language and laws; British in the solidarity of its institutions; and British in the intelligence and perseverance of its people.

I have been asked to write a brief paper on some phase of the broad subject of irrigation as applied to British Columbia. In attempting to do so, I shall deal mainly with the influence which irrigation is likely to exert in the industrial development of the Province. Since irrigation is still in its infancy in this part of the Pacific Coast, I shall be unable to call attention to vast areas of reclaimed land, or to large revenues derived from irrigated products. I can only direct attention to what irrigation has accomplished in some of the Western States, and draw the inference that a like development awaits British Columbia. One has a right to assume that the same kind of people, working under similar laws and institutions, will obtain like results in the reclamation of arid and semi-arid lands, providing there are no material differences in the many factors which enter into successful farming under irrigation. As a matter of fact, such differences do exist. Climate and soils, crops and markets, vary widely, not only between countries and states, but between localities and even farms. If one country possessed all the favourable conditions, no comparison could be drawn; but, as will be shown later, the favourable and unfavourable conditions are shared in very much the same proportion by the Western States and the Province of British Columbia. It will therefore be in order to point out what irrigation has done for the upbuilding of the Western States, and to say to the sister commonwealth to the north, "You can do as well."

PRESENT DEVELOPMENT.

When compared with other leading industries, irrigated agriculture ranks low in British Columbia. Even though complete and accurate statistics were available, they would merely show how seemingly unimportant are the total revenues from irrigated lands. For more than half a century the mines of the Province have been producing gold and silver, lead and copper, coal and coke in steadily increasing quantities. The annual value of the mineral production is now over $32,000,000, and the claim is made that by far the greater part of the mineral lands have not been prospected. In a similar manner it might be shown that the total revenues derived from the sale of timber exceeds the revenues derived from all other soil products combined.

It is apparent that in the industrial development of the Province thus far there is little to indicate that irrigated agriculture will one day become the dominant industry. The output from the mines and forests, the yearly catch of salmon, the extension of grain-growing on dry farms, the enormous cost of civic improvements, the rapid increase in manufactured articles, and improvements in transportation facilities have drawn the attention of the people away from this basic industry. The prominence attained by other industries has cast a shadow (for the time being) on diversified farming under irrigation. Now, I do not believe irrigated agriculture will long occupy a subordinate position, and this brief article will have served its purpose if it tends to prove this assertion.

TREND OF DEVELOPMENT IN THREE WESTERN STATES.

A clearer vision of what British Columbia may become in the future may therefore be obtained by glancing at the progress made in agriculture in the one-time mining States of Montana, Colorado, and California, and noting the trend of their development.

Montana is known as the treasure State on account of the value of its minerals; but the time is rapidly approaching when the hay and grain, the fruits, and the vegetables grown on the farms will be worth much more than the gold and silver, the copper, and the lead taken from the mines. While there has been considerable increase in the mineral production during the last twenty years, it has not kept pace with the agricultural development. In 1890 the mineral production had a value of approximately $43,000,000; in 1910 it was nearly $54,000,000. Agricultural statistics seldom agree, but, discounting overestimates, the revenue which Montana now derives annually from field crops, live stock and their products amounts to approximately $65,000,000. This estimate includes products from both irrigated and unirrigated lands, but the rapid progress made in irrigation development may be realized from the fact that in 1909 nearly five times as many acres of land were irrigated as in 1889, twenty years previous. The importance of agriculture is also seen from the fact that the value of all crops in 1909, according to the census, was over $19,000,000 greater than it was ten years previous. The value of all minerals and timber amounts, at the present time, to about $57,000,000 annually. Regarded as State assets, the revenues from the mines, forests, and the grazing lands are practically fixed. Instead of increasing, there is a possibility of decrease. Twenty years hence less money may come from these sources. Fortunately for the State, there is scarcely any limit to the wealth which can be produced from the soil when it is properly cultivated and irrigated.

Colorado, until recently, was likewise looked upon as a mining State. It is still rich in minerals, but the wealth derived from crops and live-stock far exceeds that from the mines. In 1889 the total mineral production of Colorado was a trifle more than $33,000,000. In 1909, twenty years later, the output of gold and silver had not materially increased, but the larger output from the coalfields raised the aggregate to $40,000,000. No accurate statistics are available of the value of farm crops in 1889, but in the decade from 1899 to 1909 there was an increase in the value of farm crops of over $34,000,000.

California teaches a similar lesson. In 1849 and 1850 the gold-diggers were greatly troubled about a supply of fresh vegetables. Few imagined that any produce of that kind could be grown on the banks of the Sacramento River and its tributaries, and some of the more optimistic congratulated themselves that the Hawaiian Islands were so near, since vegetables might be brought by boat from these Islands to supply the miners. That was sixty-two years ago, and it is interesting to compare the dearth of fresh vegetables and fruits of that early period with the abundant crops of the present.

According to a recent report by H. T. Cory, C.E., the farm value of products of the soil for 1911 marketed by the producer, and for the most part shipped out of the State, reached the total of $406,000,000. This estimate included a number of items, such as live-stock and their products, cider and vinegar, wine and brandy, hides and tallow, fruits and vegetables, marketed in cities, which are not usually classified as farm crops. Taking the conservative figures of the United States census, one finds the staple field crops of 1909 valued at $153,000,000. From the same authority it is learned that the increase in these crops during the ten-year period from 1899 to 1909 was nearly $58,000,000. With an approximate area of 100,000,000 acres, less than 3 per cent. of this area is irrigated; but the character and quantity of the crops grown under irrigation are such that more than one-third of the value of the principal crops of the State was derived from the comparatively small irrigated area.

The output from the farms now far surpasses that from the mines, yet mining is still one of the important industries of the State. There has been a fairly gradual increase in the gold and silver production during the past twenty years, in which time its value has about doubled. Petroleum now constitutes over one-half of the total value of the mineral production. This, with the manufacture of cement, brought the total value in 1910 up to $70,000,000.

The statistics given in the foregoing paragraphs, although incomplete, bring out two facts in regard to the trend of development in the so-called mining States across the line. The first of these is the dependence that may be placed on the mineral wealth of the West. It seems to follow that when the production of one mineral falls off, that of another is increased so as to

maintain unbroken the upward trend of total production. A few references may help to confirm this statement. The value of petroleum in California has increased from a trifle more than one-third of a million dollars in 1889 to nearly $36,000,000 in 1910. In 1890 Colorado mined 4,500,000 tons of coal, while in 1910 the tonnage was 17,000,000 tons. In Montana the mining and smelting of copper-ores have of late added greatly to the total mineral revenues of the State.

A second fact brought out with even greater clearness is the importance of agriculture in these States, which were formerly largely dependent on mines. The increase of agricultural production in both the irrigated and non-irrigated districts has been remarkable. More especially is this true of the rapid expansion of the irrigated area and the large investment in irrigation-works.

To the people of British Columbia there is a lesson in the industrial development of the whole West during the past ten or twenty years. That lesson in brief is simply this: The Province ought to strive to maintain in the highest degree of efficiency its leading industries of mining, forestry, fisheries, and manufacturies; but, while abating no interest in these, it should also strive to lay a broad and safe foundation for irrigated agriculture; such a policy to be adopted with the full assurance that the wealth derived from the soil will, in a comparatively short time, exceed that now derived from the mines, and will eventually exceed that from all other industries combined.

THE IMPORTANCE OF IRRIGATION TO BRITISH COLUMBIA.

There is an area in British Columbia south of the 52nd parallel of north latitude larger than the entire State of Colorado. While this southern belt represents less than one-third of the total territory in the Province, it is by far the most valuable from an agricultural point of view, since it comprises the bulk of the land susceptible of irrigation where the most valuable crops will be raised in the future. In making this statement, I have no desire to discount the wheat-producing possibilities of the great central belt lying between the 52nd and 56th parallel, or the agricultural possibilities of the northern belt between the 56th and 60th parallels. I have never travelled through these central and northern belts, and know nothing of their capabilities; but I am familiar in a measure with the southern belt, and have formed a high opinion of what can there be accomplished under favourable conditions.

This southern belt, in respect to its arable lands, may be considered in three divisions: First, in much of it the rainfall is too small and uncertain to make diversified dry-farming profitable. Other portions resemble our semi-arid belt, where farming without irrigation is a gamble, good harvests being produced in seasons of abundant rainfall, and little more than the seed being returned in seasons of drought. There are still other portions which are plentifully supplied with moisture from the clouds. As time goes on, and a larger area is intensively farmed, I believe the need of supplementing the natural rainfall by irrigation in all these districts will be more keenly felt. In other words, many of the districts which are now thought to possess sufficient rainfall will be in part irrigated. At least, this has been true of localities to the south. A few instances only are here given.

The average rainfall of the Sacramento Valley, California, is more than 20 inches, yet the need of supplemental irrigation is now apparent, and large investments are being made to provide water-supplies.

For many years the fruit-growers of the Santa Clara Valley, California, depended solely on the rainfall, which averaged about 16 inches yearly. A dozen or more years ago irrigation practice began, and the larger yields and better quality of fruit produced under irrigation have led to the utilization of all sources of water-supply, and about 70 per cent. of the total area in orchards is now irrigated.

At the Town of Bozeman, Montana, located near the upper end of Gallatin Valley, the average annual precipitation over a period of twenty-two years was 19 inches, the bulk of which fell in the form of soft snow and rain during the spring and early summer months, when it was most needed by the farmer. Notwithstanding this heavy precipitation, irrigation has long been practised in this valley. The available water-supply is now utilized, and large yields of cereals, grasses, and other crops attest to the value of supplemental irrigation.

Mention might also be made of the 700,000 acres of rice that were irrigated in 1911 in the Gulf States, where the annual rainfall is from 45 to 55 inches, and of the rapid extension of irrigation along the Atlantic seaboard from Florida to New York to prevent the loss of valuable crops in times of drought.

These and many other cases which might be cited show that the practice of irrigation is spreading rapidly in the United States, and that the localities in which the annual rainfall was considered ample ten or fifteen years ago are now largely dependent on irrigation for their supply of soil-moisture. British Columbia is reasonably certain to have a like experience. It would therefore seem wise, in classifying the arable lands of the southern belt, not to confine the arid and semi-arid portions within too narrow limits.

As I have stated, Colorado contains fewer acres than that part of British Columbia lying south of the 52nd parallel. The national forests in Colorado comprise nearly one-fourth of the total area, and all is mountainous with the exception of some 22,000,000 acres of arable lands, which receive on an average about 14 inches of precipitation. In 1909 2,750,000 acres were irrigated, or approximately two-thirds of all improved farm lands. A conservative estimate of the annual revenues derived from crops, live-stock and their products would be $85,000,000, of which 80 per cent. was produced on irrigated lands.

I am pointing out some of the achievements of Colorado for the purpose of calling attention to the agricultural possibilities of southern British Columbia. All the crops that are now grown in Colorado can be produced in British Columbia. Its nearness to the Pacific Ocean, the presence of large bodies of inland waters, and the low altitude render it particularly well adapted to deciduous-fruit raising. The time is not far distant, I believe, when the output from the orchards of this part of the Province will exceed that from all the mines. It is more than likely, however, that horticulture will be developed at the expense of other equally important branches of agriculture. The orchards of Colorado produce less than $5,000,000 annually, but the farmers receive $6,000,000 a year for sugar-beets, $15,000,000 for cereals, and $17,000,000 a year for alfalfa and other forage crops. Inasmuch as the climate and soil of southern British Columbia are favourable to fruit-raising, no good reason can be advanced why it should not be a leading industry. At the same time, the growing of leguminous and cereal crops should not be neglected. It will not pay, for example, to export fruit and import dairy and meat products. Such a policy would tend to enrich the railroads at the expense of both the producer and the consumer.

THE PRESENT NECESSITY.

If it be true that the most profitable farming over a large part of southern British Columbia is dependent on irrigation, then it will be well for the people of the Province to consider with the greatest care the many factors which enter into the successful production of crops under irrigation. In the brief space at my disposal I can allude only to a few of these.

Water is perhaps of first importance. The amount of the available water-supply is the standard by which we measure the ultimate production of arid and semi-arid lands. Even now we can look forward to the time when California, with its abundant natural resources, will be greatly handicapped by reason of the lack of water. Out of something like 21,000,000 acres susceptible of irrigation, there is only water enough for 10,000,000 acres. Colorado is credited with a larger area of arable land, but it is doubtful if more than 6,000,000 acres can ever be irrigated. The extent of arable land in Montana is quite as large, but all the available water-supply is likely to be exhausted when 5,000,000 acres are watered.

Water in the West needs to be conserved perhaps more than any other natural resource. The Province of British Columbia acted wisely, therefore, when it passed the "Water Act" of 1909. This Act, although lacking in many essential features, contains the fundamental principles of a modern code of water laws. In making provision for the settlement of existing rights, it warded off many of the evils of litigation and paved the way for the establishment of an important industry on a secure foundation. The progress made since the enactment of this law in safeguarding the Province by placing limitations on the amount of water which a record-holder can use has been slow on account of the difficulties to be overcome. It is necessary for the Water Branch first to collect all the facts pertaining to the records before the final decision can be safely reached. A vast amount of accurate information is now gathered, and when certain policies are clearly defined and proper methods of procedure adopted, the Comptroller of Water Rights will be in a position to proceed rapidly with the issuance of licences. Meantime, those who are suffering in not having claims to water settled should strive to be patient, since overhasty action on the part of the Government officials might cause irreparable injury to innocent parties.

In a paper delivered before the Western Canada Irrigation Association last August, I referred to the need of more agencies for the reclamation of the arid and semi-arid lands of the Province. With a few exceptions, all development of this kind has been done by individuals and commercial canal companies. If so restricted in the future, I do not believe progress in irrigation will be as rapid or as secure as it might otherwise be. Some method should be devised and enacted into law by which the farmers and land-owners of a district could unite for the purpose of constructing and operating the works necessary for the irrigation of their lands.

Again, I believe it would pave the way for more rapid and more successful settlement under irrigation systems if land with a water right could be purchased from companies at a lower figure. A considerable reduction might be possible if such systems could be more cheaply constructed. The managers of new irrigation enterprises might profit by imitating the policy of railroad companies in building lines through newly settled territories. Wooden trestles and other structures of a temporary character are first installed. During the initial period of operation the location is frequently changed, and it is not until location, grade, and other conditions have become reasonably well fixed that permanent improvements are made. Now, on the other hand, in the establishing of irrigation-works in an untried field, engineers have advised the installation of permanent structures. They have recommended the best that the Western States possess in the way of systems, regardless of the fact that it has taken more than fifty years of persistent and well-directed effort to reach the present stage of excellence.

In a rather long experience with irrigation channels and structures, I have seldom found that any ditch or canal or even structure, except it be a dam, is operated for many years without being subjected to more or less radical change. Not infrequently an increase in capacity is called for, but changes in design, location, and grade are likewise common. At other times a system is devised and constructed for the irrigation of a tract of land under one ownership. In course of time the tract is subdivided and sold in smaller parcels. It usually follows that the system that is adapted to a single ownership is a misfit when applied to a number of land-owners. For the reasons stated, as well as for others which might be advanced, there is a decided advantage in keeping down the first cost of water rights by introducing cheap structures at the start, and substituting better ones for these only after a permanent regime has been established.

This policy, if adopted, might result in more use of lumber and less of concrete, but even this change might be beneficial until the present price of cement is greatly reduced. The manager of one of the larger irrigation projects near Kelowna informed me last August that the cement which was then being used by his company in large quantities on construction-work cost $3.55 per barrel. A month or so later the United States Reclamation Service received bids from reliable firms to furnish cement of the best quality for less than $1 per barrel. I hesitate to recommend that the Province establish cement-manufactories in different parts of southern British Columbia, but in view of the fact that cement can be manufactured at a profit for less than $1 per barrel, some radical measure should be taken to lessen the price now charged.

The most serious handicap to farming under irrigation in British Columbia is the clearing of the land. The pioneers of eastern Canada solved this problem in a very laborious and slow way. Some plan should be devised by which the settlers in southern British Columbia could take advantage of the best and most effective method of getting rid of a worthless tree-growth. The owner of a small tract of land which will produce, when cleared, cultivated, and irrigated, a gross yearly revenue of even $30 per acre cannot afford to wait until the stumps rot out. In this connection, I have to suggest that some branch of the Government be given authority and funds to make a thorough investigation of the most effective means of clearing land. The work can readily be arranged for in co-operation with individuals, corporations, or communities, and a fair price for clearing experimental tracts returned to the Government in the way of labour performed, materials furnished, or money paid.

SAMUEL FORTIER.

WATER LEGISLATION AND ADMINISTRATION IN BRITISH COLUMBIA.

BY H. W. GRUNSKY.

The problems that arise to confront the Government of British Columbia in the course of placing its water administration on a satisfactory basis are manifold, difficult, and yet of the utmost importance. They concern the utilization and conservation of a great natural resource —one might confidently say "the greatest," if the demands of the future are to be considered. Within the next generation transmuted water-power will not only be turning the spindles of the manufactories of the Province, but will be furnishing the bulk of the heat, light, and transportation. Significant as is this statement, it is nevertheless questionable whether the use which will be made of water in agriculture will not exceed in importance all other uses combined, excluding only that for domestic purposes.

In a study of this question it is well to remember that the conservation of the waters, unlike that of other natural resources, is best secured by utilization. Not only are other exhaustible sources of energy, such as coal, wood, and oil, preserved thereby, but the use of water in a beneficial way means development, which, once started, generally continues indefinitely. The problem of any Government, therefore, is so to frame and administer its water laws as to secure not only the earliest possible use of its waters, but the highest and best use; this to be determined always with a mind keenly alive to the interests of the public at large.

In the space here allotted it will be possible to touch briefly upon only one or two of the more important questions arising in connection with the "Water Acts" and their administration. The special aim will be to keep in mind the efficacy of the Statutes in securing "beneficial use" of the waters, this being the basic principle upon which all others are founded. A backward glance will be valuable in aiding us to see more clearly the present-day difficulties.

AIM OF EARLY ACTS.

Under the common law of England the principle existed that the public and those living on the banks of streams had a right to have the waters of the streams flow by in their channels practically as they did in a state of nature. Certain uses for drinking and other ordinary purposes were permitted to those who had lawful access, but these uses were not such as would materially affect the flow of streams of any considerable size. An owner of land adjacent to the stream, called a "riparian proprietor," could prevent the diversion of its waters to lands not touching the stream, irrespective of whether he himself had a use for the water or not, such diversion being considered a damage to his estate.

It is readily seen that the above principle is not at all adapted to the needs of a new country where irrigation and mining are practised. In fact, nearly all the commonwealths on the western side of the American Continent have evolved systems of law that permitted the diversion of stream-waters for useful purposes to either riparian or non-riparian lands, even to the point of exhausting the entire flow.

The successive Acts of this Province may be compared to a whittling process as far as the right of the riparian owner to have the stream flow bank-high in its channel is concerned. The cutting down, moreover, began early.

ACT OF 1859.

Even in the days of the Colony the rulers appreciated the fact that the greatest development of this far western land lay in putting the waters to a beneficial use. In 1859 a Proclamation was issued by Governor Douglas, known as the "Goldfields Act," and later, rules and regulations were published thereunder with certain sections relating to ditch privileges.

The requirements there laid down are almost as stringent as any contained in modern Statutes, and were, no doubt, better carried out in practice. If a man wished a water right, he must state in his application the quantity desired, the locality of distribution, and the time within which his works were to be completed. If he refused, or neglected to take, within the time mentioned in his application, or within such further time as the Gold Commissioner might allow, the whole of the water applied for, he was deemed entitled, at the end of the time granted, only to the quantity actually taken by him, and the surplus could be granted by the Crown to another person.

This requirement ensured development. A man could not in those days play the "dog-in-the-manger" act. He had either to build his works, or to step aside and let some one else take his place. Were it not for the title of the Act, which seems to confine it and the regulations to ditch privileges used in connection with gold-mining, the sections here referred to might be taken as a complete abrogation of the common law doctrine in this Province.

STATUTES OF 1871.

The Revised Statutes of 1871 gave to every pre-emptor "lawfully occupying and *bona fide* cultivating land" the right to divert from streams "adjacent to or passing through such land, for agricultural or other purposes," any water not already recorded or appropriated, upon obtaining the written authority of the Commissioner to that effect. It is worth noting that the party who was thus privileged to secure a water right must be actually occupying and cultivating the land. A mere land speculator could not, under the wording of this Statute, secure a record.

Moreover, the Statutes made it plain that riparian owners and occupants were not to have any permanent rights in and to the use of waters without records, for it contains the following language: "No person shall have any exclusive right to the use of such water, whether the same shall flow naturally through or over his land, except such record shall have been made."

This at once and for all time decided for British Columbia that there was to be no such expansion of the riparian-rights doctrine here as had taken place in some of the States across the line. There many of the Courts, without the aid of Statutes, had expanded the old common-law natural right of the riparian owner, which permitted him to use the waters of the stream about his home, or at most upon a small garden or meadow, until it included the right to irrigate large bodies of arid land.

These Statutes further made priority of right to any water privilege depend upon priority of record, and, in case of dispute, gave the Commissioner of the district the authority to decide the question in a summary manner, without a jury, or, if desired by either party, with a jury of five men. Notices in writing had to be posted on the district Court-house only when interested parties objected, and compensation was required for any damage caused in connection with a right of entry for ditch purposes. The Act provided that when a man conveyed or assigned his pre-emption rights to another, all recorded water privileges in any manner attached to the land pre-empted went to the new owner, whether this was mentioned in the instrument of transfer or not.

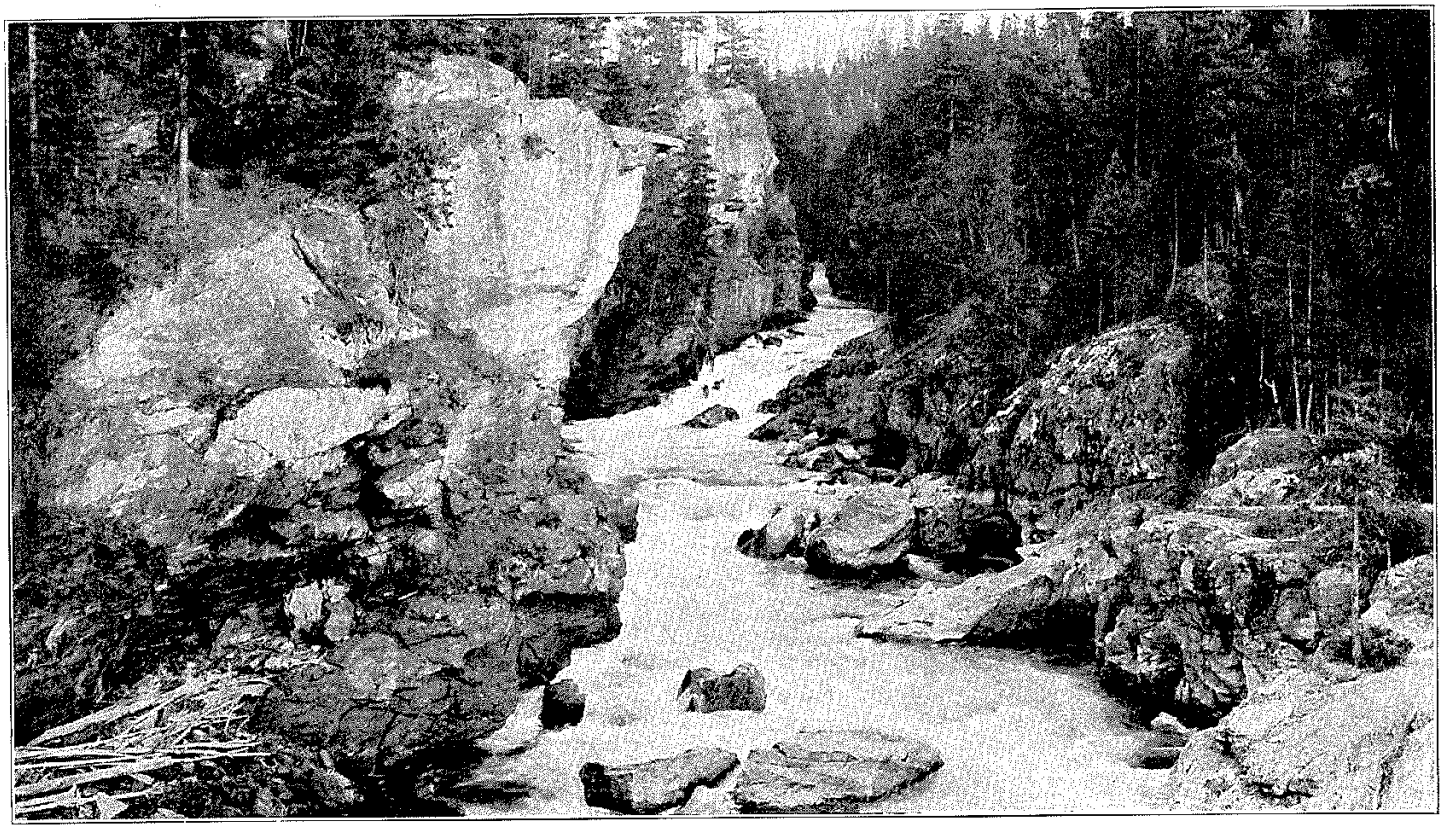
One of the defects of this and other Acts following it was that water records were not required to specify the land upon which the water was to be used. A great deal of trouble has been caused to later administrations by the omission of this simple detail. Even to-day much time must be spent in endeavouring to identify early records as belonging to particular parcels of land. Thus the benefit of the clause above referred to regarding assignments was largely nullified in practice.

Perhaps the most interesting section of the Act is that which relates to the beneficial use of the water. It is as follows: "Every owner of a ditch or water privilege shall be bound to take all reasonable means for utilizing the water taken by him; and if he shall wilfully take and waste any unreasonable quantity of water, it shall be lawful for the Commissioner to declare all rights to the water forfeited."

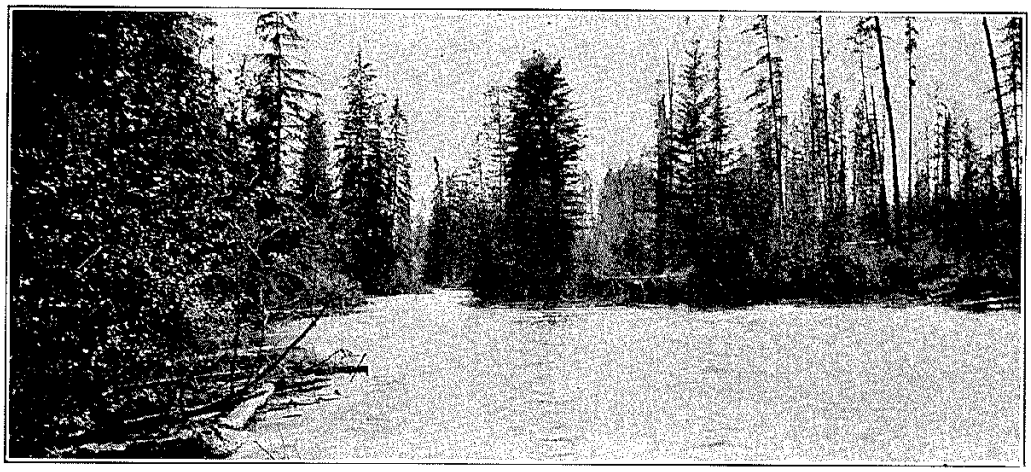
The major part of the Act thus seems to have been devoted to enabling a particular class of farmers—namely, those whose lands bordered upon streams—to use the waters of these streams for agricultural purposes. There is one section in the Act, however, devoted to "water privileges for mining or other purposes." Such privileges might be claimed, if not already lawfully appropriated, by obtaining a grant or licence from the Commissioner of the district, and previous to taking any lands which might be damaged by the privilege, paying a reasonable compensation to the owners thereof.

EFFECT OF EARLY STATUTES.

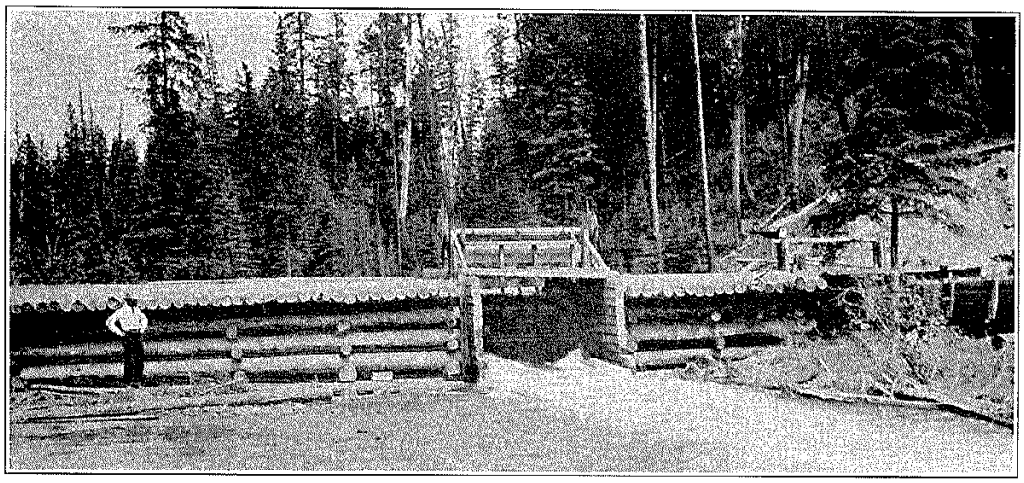
If it were not intended to proceed beyond the Statutes just reviewed, it must be admitted that the old common-law idea of having the stream flow by in its banks according to immemorial custom had received severe treatment. The waters had not been declared to be in the Crown; nevertheless, the Crown proceeded to demonstrate its power over the matter by granting them



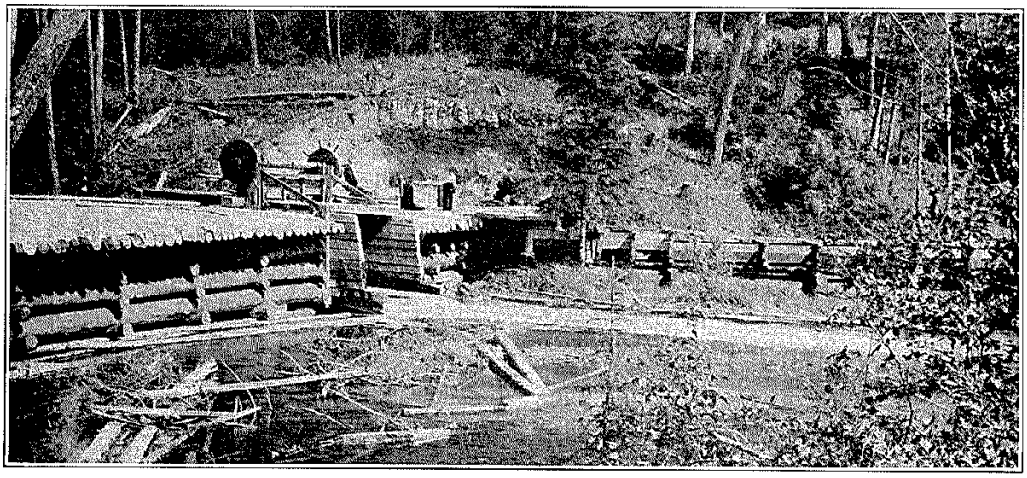
Shuswap River near proposed site of Couteau Hydro-Electric Co.'s Power-house.



View above Dam, Baynes Lake Project, Rock Creek.



Diversion Dam for Baynes Lake Project.



Down-stream view of Dam and Flume, Baynes Lake Project.

to whatever parties it pleased, and it forbade all others to use them without a grant. The public right to use the waters for domestic or stock supply where there was access by a public road or reserve seems not to have been interfered with, and has, in fact, been expressly reserved in all the later Acts.

The negative legislation was, then, complete from the start; no one could get any kind of a private water privilege without a record. The positive legislation, however, came by degrees, and the main distinction in succeeding Acts seems to have been in defining more particularly what classes of persons should be entitled to divert water, and for what purposes, and what preliminary formalities were necessary to obtain records. Prior to 1892, if I am not mistaken, only agriculturists and miners were specifically mentioned as the privileged classes who could procure records for the use of water, thus reducing the natural flow of the stream; and whenever the agriculturists are mentioned, it is also stated that they must be lawfully occupying and *bona fide* cultivating lands.

ACT OF 1892.

In 1892 an Act was passed, the "Water Privileges Act"; declaring the right to the use of all waters not at that time recorded and appropriated to be in the Crown. The date of the passage of this Act compares favourably with the dates when similar Acts were passed in the Western States. However, as already explained, British Columbia had long ago made it plain through her legislation that the Crown had assumed the right to control and grant the use of the waters. This Act declared the truth in specific words, and gave companies and persons holding water privileges a method by which they could gain entry upon the lands of others and proceed with the construction of their works. In order that a company might take advantage of this, it must be empowered under a special Act of the Province to divert or use the water for the purpose intended. It is regrettable that the Act did not go on to enumerate the classes of persons who were entitled to procure records for water privileges. This shortcoming in all previous Acts was supplied in the Act of 1909.

ACT OF 1897.

In 1897 all clauses contained in former legislation relating to water were consolidated into one Act. This was the beginning of the modern "Water Act," and must take a high place as an example of legislation for conservation. The aim was well expressed in the preamble, wherein it was stated that "it is necessary and expedient . . . . to provide for the due conservation of all water and water-power, ... and to provide means whereby such water and water-power may be made available to the fullest possible extent in aid of the industrial development and of the agricultural and mineral resources of the Province."

The Act confirmed to the Crown all unrecorded water, which was made to include "all water for the time being unappropriated or unoccupied or not used for a beneficial purpose." Every privilege acquired under the Act was made conditional upon reasonable use for the purposes for which such privilege was conferred. For the first time every owner of land, irrespective of whether the land was located on the bank of a stream or otherwise, was specially given a right to secure a record and divert running water for one of a number of purposes.

The record-holder who did not proceed to utilize his privilege could not expect much consideration from this Act if its provisions were enforced. Here are some of its conditions: If the construction of ditches, flumes, and works required for the diversion of water was not commenced within sixty days of the date when the record was made, or within such further time as the Commissioner might allow, and then prosecuted with diligence, the record might be cancelled for non-use.

Every record-holder was required to take all reasonable means of utilizing the water granted to him, and if he wilfully wasted or took water in excess of his requirements the Commissioner might cancel or reduce the record, or impose any necessary conditions. An appeal was permitted to the Supreme or County Court from any decision rendered by a Commissioner.

This Act was not without its weak points. Such an important duty as deciding upon the quantity of water required by a record-holder was left to the Commissioner of Lands and Works, an official already burdened with duties. Furthermore, there was no special arm of the Central Government to deal with water matters.

ACT OF 1909.

Great laxity in the making of records and no real supervision over the use of water had resulted from legislation prior to 1909, notwithstanding that the principles embodied in many of the Acts were excellent. The district officials appear not to have realized the value of the water privileges which it was their duty to guard. The granting of rights was such an easy matter that, when an application came in for "50 inches" out of a stream, the record was more than likely made out for 500 inches at the Water Recorder's suggestion, inasmuch as the larger amount "did not cost any more."

As early as 1886 a Statute had been passed which expressly recognized that many records had been "honestly but imperfectly made," and gave to the Court the power to validate such of the above as were deemed by it entitled to recognition. The issuance of defective grants was not prevented by this legislation, however, and there had been little cancellation or cutting down of records under Acts passed prior to 1909.

The aim of the Act of 1909 was to supply the machinery for properly reviewing and defining existing rights, and at the same time for more closely guarding grants of new rights. Some provision was also made for public supervision over the diversion of stream-waters.

The theory underlying the Act was that every water-user in the Province, whether the privileges held were old or new, should have his right clearly determined and specified. For the purpose of examining old rights of every nature and description a tribunal was created, called the "Board of Investigation." The Minister of Lands was empowered to cause such stream-measurements to be made and other data of a preliminary nature to be collected as might be required for the adjudications of the Board. An official, now called the "Comptroller of Water Rights," also a member of the Board, was given supervision over new grants of water privileges, which were henceforth to be called "licences." Old records made under former Acts were to be replaced by licences as fast as the Board could adjudicate upon them.

The Act still left such important matters as the inspection of dams, the regulation of water-delivery, the restraining of waste, and the determination of a proper duty of water in the hands of local officials. These officials were in many cases Government Agents with manifold duties, more or less tied down to offices, and not qualified to undertake the new line of work.

The present administration has under contemplation the appointment of engineers who are to reside in their respective districts and attend to all matters such as those enumerated above. This will be accomplished as soon as suitable amendments to the Act have been adopted.

THE WATER LICENCE.

In every Province or State that has a statutory system governing the use of water, the final step in the acquirement of a water privilege is the issuance of a document to the water-user as evidence of his title. This document has been aptly termed a "water patent." It is in some respects different from a land patent, inasmuch as it is subject to cancellation, providing the holder does not comply with certain conditions laid down with respect to the use of the water. The comparison is none the less useful in calling to mind the fact that in the issuance of these documents the Province is finally disposing of one of its most valuable natural resources. The utmost care is therefore required on the part of the officials administering the "Water Act" to grant rights in such a way as to secure the greatest possible utilization of the waters.

The records issued in the past, which are still accepted as having unquestioned precedence over other rights in many localities without sign of development by their owners, have undoubtedly been an impediment to development in British Columbia. What profit is it to the Province to declare for use and smite the riparian-right doctrine with the one hand, and with the other create a class of record-holders who claim a preferred stock in all the stream-waters and can develop or not at will? The only sound policy is one which will make certain before the water patent is issued that use has been made of the privilege. This is taken care of in Part III. of the present Act, which deals with the issuance of licences to replace old records. On page 102 will be found a proposed form of water licence which is in accord with the above policy.

Where no works have been constructed, the Board, in its determination of rights, has no discretion, but is directed by the Act to "fix a time in which to begin, and a further time in which to complete, the construction of such works as the Board shall order; and he (the record-holder) shall not be entitled to a licence in substitution of his record unless and until such works have been so commenced and completed." (Sec. 44.) This clearly makes the completion of

works a prerequisite to the obtaining of a licence, and "works" is defined by the Act so as to include all "drains, ditches, canals, and any and all contrivances for holding, carrying, and conducting water or other works which are authorized to be constructed."

It is my opinion that this definition of the term "works" applied to section 44, from which I have quoted, necessitates the clearing of lands and the building of the smallest field laterals before a licence can be granted; for where is one to stop and declare the system completed, if not at the end of the smallest lateral ditch? Even if this is not involved in the definition, the section quoted reads, "such works as the Board shall order," and in that case the matter reduces itself to a question of policy for the administration. On page 103 will be found a proposed form of order for an irrigation right where no works have been constructed.

In dealing with the determination of rights held under old records, then, the provisions of the present Act are ample to ensure beneficial use. Not so, however, with the acquirement of new rights under the Act, which is dealt with in Part V.

The final document handed to the water-user as evidence of his title under this part, also unfortunately termed a "licence" (*see* section 74), is one given upon the approval of the plans and application. This is not sufficient. Either the Act, or the rules and regulations to be adopted thereunder, should go further. Proof of the completion of the works and of the actual application of the water to the land should be required, as in the case of licences replacing old records; and, in case all is satisfactory to the Comptroller of Water Rights, a certificate should be issued showing such completion of works and application of the water. This certificate would then constitute the water-user's patent.

REASONS FOR REQUIRING BENEFICIAL USE.

In the foregoing discussion the reasons for adhering strictly to the policy of beneficial use have already been indicated. If the ownership of all water is in the Crown, it is evident that the Crown must have some system of book-keeping by which it may know in whose hands the use of the water is placed. When a water patent is issued, the quantity indicated in the patent should be charged against the source of supply; and when the entire volume produced by that source is appropriated, no more patents should issue.

Under the plan herein advocated, the certificates issued by the Water Branch will show the quantity of water that is actually in use at a given time; while if licences are issued for irrigable areas it will necessitate a new taking of stock at some future time to see what parties have completed their appropriations and what have not. Under the latter plan the Province may be compelled, in the course of fifteen years or more, to reopen its adjudications, as has been done in Colorado; but under the former plan an adjudication once made is good for all time, unless there is an abandonment of the right.

In those cases coming before the Board where works have not been completed, the Board is to set a time in which the party must begin work, and a further time when the works shall be completed and the water applied to a beneficial use. The Board thus awards to the party a right which is conditional upon certain things to be done on his part, and leaves it to the Comptroller to see that conditions are fulfilled, and after they are so fulfilled to issue a licence for the quantity directed.

In fixing the time for completion of irrigation systems, it is my opinion that the officials of this Province can afford to be most liberal. It is admitted that every case must stand upon its individual merits, but, speaking generally, the special difficulties existing here in the way of clearing and levelling lands, and building irrigation structures, and the undeveloped nature of the country seem to me to make such a course advisable. I believe that as high as eight to ten years may be allowed for final completion in some cases, provided reasonable diligence is shown on the part of the applicant from year to year, and always securing him the full benefit of a *pro rata* right for that part of the lands which he has brought under irrigation.

It is believed that the plan herein proposed, if adopted, will give the greatest kind of impetus to development. Why should a man hold a right to the exclusion of others if he has no idea of reducing his right to possession within a reasonable time. With a liberal time granted for the clearing of his lands the settler is protected; but the investor who is merely holding for a speculation may be induced to sell to another who is ready to undertake development. One of the chief differences between water and other natural resources is that in its greatest use lies its most complete conservation. The policy herein set forth will, if adopted, place a premium upon use.

THE "WATER ACT" AND IRRIGATION COMPANIES.

While the present Act is very explicit in defining the powers and privileges of municipalities, power companies, and companies supplying water for domestic use, there is scarcely any mention of irrigation companies, which might lead one to infer that the Act was hostile to them. While this is presumably not intended, there are indications that the principle of making the licence appurtenant to the land is so strong in British Columbia that the company which is to barter and sell water for irrigation purposes is altogether excluded. This position is believed to be eminently right. Yet there is no reason why the Act should not make a place for companies organized on lines that take care of the question of appurtenancy. It is not inconsistent with the spirit of the 1909 Act for private companies to go into the reclamation business in British Columbia if they organize in such a way that eventually the land, water right, and canal system are all passed over to the purchasers. This is coming to be the common type of company in the North-western States. Land is sold on long-term payments, but the price is made to include the cost of the entire system and water rights, with a safe margin on the company's investment, interest being charged on deferred payments. Each purchaser of land is issued a certificate of stock in a water-users' company for as many shares as he purchases acres of land. When purchasers above a certain percentage have completed their payments, usually 70 to 80 per cent., the irrigation system is turned over to the water-users' company for operation and maintenance. The water is appurtenant to the land, and a transfer of land carries with it both the water right and the stock in the water-users' company.

When all payments have been completed, the company which undertook the project disappears and leaves in its place a full-fledged mutual water company. Under the next heading will be considered the formation of mutual companies by the land-owners themselves.

MUTUAL COMPANIES.

The mutual water company has been one of the most successful forms of organization in the irrigation of lands in southern California, and, indeed, in all the arid sections across the line. Many such companies supply projects covering areas reaching into the tens of thousands of acres. It is surprising that so few of these are to be found in British Columbia.

From an advance copy of an article on mutual water companies by C. E. Tait, engineer in charge of "United States Irrigation Investigations," Los Angeles, California, I glean the following suggestions: No special legislation seems to have been passed to encourage this form of co-operation, but the companies appear to have been formed under the law for the incorporation of private companies. Three or more persons may incorporate. Articles as prescribed by law are filed with the county and State authorities, whereupon the latter issues a certificate of incorporation. The articles should declare the purpose broadly, and should state that the water is not to be sold for profit. The corporation then adopts by-laws consistent with the constitution and laws of the State, regulating the service and defining the relations of the stockholders to the company. The suggestion is made by Mr. Tait that the water should be capitalized at a figure that will cover the entire cost of making it available for the irrigation of the land exclusive of the operating expense. This usually includes cost of real estate, water rights, rights-of-way, construction of works, engineering, and all incidentals to preparing the system for service. Shares of stock of small face value are convenient and require less dealing in fractional shares than those of larger denomination. The water, or the shares representing the water, should be made appurtenant to the land to be irrigated by the system. There is a disadvantage in a member owning more shares than necessary for the irrigating of his land, as the stock is assessed for the maintenance of the system, and this, together with appurtenance, prevents speculation in stock. Regarding revenues, the most satisfactory plan is to assess the stock for maintenance and permanent improvements and to have the water-charge meet operating expenses. This rental or charge, when it does not exceed operating expenses, is consistent with the stated purpose of a mutual or non-profit company, and it not only fairly apportions the cost of water-delivery among the members, but it also very effectually induces economy in the use of water. It is adjusted annually by the directors in consideration of whether a surplus or a deficit was produced the previous year.

CARRYING COMPANIES AND LAND COMPANIES.

Unfortunately for the Province, it seems to me, the ownership of its irrigation systems has been separated from that of the land. Instead of two ventures—i.e., the investment in the land and the investment in the canal system going hand-in-hand—we find two sets of interested parties in the field. The one set cares only to see the value of the land enhanced, while the other is interested in charging such prices for its water as will bring a return on its investment. This is all wrong, and the carrying company unfortunately has to bear the brunt of the situation. It is a well-known fact that the moment an irrigation enterprise is launched existing land-values in its neighbourhood are enhanced thereby, and as the process of reclamation goes on prices double and treble. This is true of any particular parcel of land, whether the owner thereof subscribes for water or not.

To carry this thought a step further, take, for example, two adjoining 40-acres tracts under a system such as those in vogue in British Columbia. The owner of the one tract goes on the land, puts in all the capital he possesses, clearing, levelling, and planting what he can. He subscribes for water from the carrying company as fast as he is able to do so, and he is the best kind of advertiser for the land company, since he proceeds to demonstrate to the public what the land will do. The owner of the other tract simply makes his investment and does nothing in the way of improvement. He is, perhaps, a speculator, and at the end of a few years he sells his land at a large increase. It is evident that the rise in value was produced by the digging of the canals and the hard work of clearing, yet, while the speculator has paid nothing to the support of the canal system, his percentage of profit on his investment is greater than that of the settler.

A similar comparison to that above may be drawn between the land company and the carrying company. I do not say it was intentional on the part of large landholders, in subdividing their tracts, to foist an onerous burden upon others. It may have been because they lacked the ready cash. At any rate, the ownership of the carrying companies was distributed among different individuals from those composing the land companies, and in different proportions. In some instances, I believe, a good deal of capital from the Home-country was brought into these carrying companies. They have undoubtedly been the developers of the country; yet, as is the case with the settler, they have the heavy end of the load to carry. Not only are the physical and natural conditions of the country unfavourable for the construction and operation of canal systems, but, as has been pointed out, owing to the obstacles confronting the settler, the carrying companies are compelled to wait through a long period of years before getting customers in sufficient numbers to pay for the upkeep of their systems. In the meantime, even though but a few scattered clearings have been made, the richness of the soil when supplied with water has been demonstrated, land-values have gone up, and the land company is in a position to reap the benefit.

The carrying company of British Columbia is exclusively a water company. I submit that the plan of divided ownership of land and water systems is not the best. One of the fundamental principles of the "Water Act," which as a piece of legislation is universally praised, is the inseparability of the water right and the land upon which the water is used. Wherever this principle has been adopted, water-users have prospered and communities have flourished; while, on the other hand, where individuals and corporations have been permitted to buy up water rights wholesale, thus coming between nature's sources of supply and the water-users, unsatisfactory conditions have prevailed.

If, however, the ownership of water rights by the water-users will lead communities to prosper, so likewise will the ownership of the water systems. Is there any necessity for a corporation or individual standing perpetually between the water-user and the source of supply, whether it be for the purpose of sale of the water itself or for carriage only? True there may be public supervision in the future, but it takes a long time in any new country for systems of public supervision to become really effective, and it would be much better to avoid the necessity for them.

While the construction of works or the guarantee of the indebtedness of companies by the Government of British Columbia seems inadvisable, there is, nevertheless, an urgent need in the Province for a new kind of organization or institution through the medium of which reclamation-work may be carried on. The private company is practically the only agency in this field at the present time outside of individuals and partnerships.

On the other hand, in the United States, the trend of irrigation development in recent years has been decidedly away from private control of systems and in the direction of some form of co-operative ownership. Experience has seemed to teach that private control means endless friction, and it is coming to be difficult in most of the States to launch enterprises that fail to provide for the eventual taking over of the canals and structures by the landholders themselves. In the State of Oregon, for instance, as shown by the figures of the recent irrigation census, over 90 per cent. of the irrigation-works are either owned by water-users or will pass into the hands of water-users' associations when the settlers have paid for the land. Practically the same condition prevails in the other States where irrigation is practised.

It is worth noting that, while the bulk of the reclamation-work in the States has been carried on by individuals, partnerships, and numerous small co-operative associations, several forms of organization made possible by Statute have played an important part in extending irrigated agricultural areas. Among these may be mentioned mutual water companies, irrigation districts (or water municipalities), "Carey Act" companies, and reclamation-service projects. In all these forms of organization it is contemplated that the irrigation systems shall eventually be owned and operated by the water-users themselves.

IRRIGATION DISTRICTS OR WATER MUNICIPALITIES.

In my opinion, a proper irrigation-district law, embodying the best that is in the laws of such States as California, Idaho, and Colorado, would go far toward relieving the situation in this Province at the present time. There is no necessity for coupling the feature of Government guarantee of bonds with such a law, and it does not exist in any of the States. However, the greater the safeguards in the way of public supervision which could be thrown about the districts, the stronger it would make them in the eyes of capital, and the better it would be for the districts.

The Modesto and Turlock Districts of California are successful examples of irrigation districts where systems have been built and are owned and operated by farmers. The two together embrace 250,000 acres. Every acre of this land is taxed not only for the building of the systems, but for the annual maintenance and operation charges, and this regardless of whether water is used or not. Moreover, substantially one-fourth of the district taxes are paid, in the case of the Modesto District, by the City of Modesto. Only nine years ago this was a ramshackle town, with dilapidated sidewalks and fences, and with a general appearance that bespoke a lack of prosperity on the part of its people. In 1903 water was turned into the Modesto Canal. Almost from the day of this event the town assumed a prosperous air, and to-day it is a modern city, with concrete sidewalks and parking strips, splendid business blocks, fine substantial school buildings, a handsome library, and attractive homes.

Both the districts named encountered many trying changes of fortune in the early years of their history, due principally to the animosity of some of the land-holders within their boundaries, who imagined that the taxes to be imposed by the districts would ruin them. Exactly the reverse happened, land-values advanced three and four times in value within a few years after the canals were in operation, and nowhere to-day is there a more prosperous farming community than in the central valley of California around Modesto and Turlock. These districts survived because the projects were undertaken on sound lines, while many others failed because they were launched without due caution and without State supervision.*

CONCLUSION.

British Columbia is still in its infancy when irrigation, mining, lumbering, and other industries are considered. On page 51 is shown a table giving totals of irrigated and irrigable areas of agricultural land in the fractional part of the Province investigated by the engineers of the Water Rights Branch. Reference to the figures will show the small percentage of the possible irrigable area which has been actually brought under the water of irrigation ditches and canals. Those who know of the wealth of the mines and forests of the Province depict a similar situation as to the primitive state of development of the mining and lumbering industries.

*A complete history of the Modesto and Turlock Districts may be procured by writing for Bulletin 158, Part III. (separate), of the Office of Experiment Stations. Address the Division of Publications, United States Department of Agriculture, Washington, D.C.

Yet in laws and regulations already adopted for the supervision of these industries British Columbia is conceded to be in the front rank.

It may not be out of place to suggest here, also, that the spirit of the present administration is in keeping with the progressive nature of this legislation.

Only a few of the problems connected with water rights have been indicated in this review. In launching into a complete administrative system for the waters a large task was undertaken. Fortunately, the mistakes made by the States across the line can be largely avoided by British Columbia. One by one the complex problems are being solved, and it is thought that but a little time will be required to see the administration of the waters, like the legislation, become an example to many of the older commonwealths.

H. W. GRUNSKY.

SHALL WATER LICENCES BE PERPETUAL?

BY O. C. MERRILL.

(The following comments, forming part of a letter received at the Water Rights Branch from the author of the present water-power regulations of the United States Forestry Service, throw considerable light on the question of whether water privileges should be granted in perpetuity. They are published with the consent of the writer.)

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
SAN FRANCISCO, CALIF., January 2nd, 1913.

DEAR SIR,—I have examined a copy of the Provincial "Water Act, 1909." The licences granted under that Act appear to be perpetual franchises, provided only the licensee does not abandon his project or violate the terms of the licence. Under paragraph 116, chapter 48, municipalities are given the power to expropriate recorded water for "municipal purposes only." Since this paragraph, as well as those immediately following, are under the sub-heading, "Special Powers and Privileges of Municipalities using Water for Domestic Purposes," it would seem that the right of expropriation runs only for domestic water-supply purposes, and that, for example, a municipality could not condemn a hydro-electric system and then operate it as such, should it desire to do so. This right, however, may be given under general law. The point I have in mind is this: If water franchises are perpetual and are subject only to the general right of expropriation that the Province and presumably its municipalities possess, such franchises have a money value that their possessors will not be slow to take advantage of, either in respect to a valuation for purposes of sale or to a valuation for purposes of rate-making (I use the word "rate" throughout in its American, not its English, sense), even though such franchises or licences may be free gifts of the Province.

I believe that one of the most important features of a proper administration of water-power grants is the prevention of the capitalization of such grants. This can ordinarily be done only by limiting the duration of the franchise or grant. If, for example, a franchise is granted for forty years with the provision that at the end of every ten years or every five years the Province or its municipalities may purchase the property and works at an appraised valuation, the franchise, as such, ceases to have any value at the expiration of such periods, and the Province or its municipalities would pay for the property only, without any franchise value attached; or, if the licence is made indeterminate, as under the Wisconsin law—that is, if it runs indefinitely (not perpetually)—so long as the law and the conditions of the licence are complied with and until the Province or some municipality elects to take over the property at an appraised valuation, the franchise value again automatically disappears with an offer on the part of the public to purchase, and the public is not required to buy back from the company something which the same public originally gave to the company gratis.

There is a similar application in the matter of rate-fixing. I note in paragraph 124 of the "Water Act" that the rates of water-supply companies may be reduced whenever the earnings exceed 20 per cent. upon the "paid-up capital of the company." Just what would be considered "paid-up capital," and whether there is any similar provision of law with respect to water-

power companies, I do not know; but if there is such provision, and if the capitalized value of a water licence may be a part of the capital upon which the company may compute this 20 per cent., it is evident that the public will be obliged to pay interest upon what it gave for nothing to the company.

If, on the other hand, there is no limit, except that fixed by competition or by the business sense of the company's managers, to which rates may be raised, it makes very little immediate difference whether water licences are capitalized or not, because the rates will be, in any event, all that the traffic will bear; but the time is bound to come everywhere when public utility corporations will have their rates and services regulated by public authority, and it is the duty of the administrators of the present not to saddle upon the future a capitalized value of the free gifts of the present.

It is under the conditions outlined in the last paragraph that I would make exception to the general rule of an administration charge only. Water-power sites and water rights have a commercial value far in excess of what is likely to be represented by the capitalization of an annual charge made solely for the purpose of defraying administration expenses. If there is no governmental machinery by which power companies can be required to limit their rates to a fair return upon the capital actually invested, leaving entirely out of such capital the value of the public lands occupied, the water rights leased, and the Provincial franchise, then I would make the annual tariff high enough to secure at least the current interest rate upon the value of the public lands, water rights and franchises, such value being fixed by considering the lands, water rights and franchises as appertaining to or being part of the property as a "going business." If an amount so fixed did not make a fair distribution between the public and the private property involved, then it would seem to me that a division of gross receipts in the same ratio as the property ownership might be both reasonable and feasible.

This would not be strictly a gross receipt tax, since the percentage would vary to suit the individual case. It would be rather a method for securing for the Province the "economic rent" of the public lands and water rights which are being used by private corporations. Unless it is possible to secure this "economic rent" indirectly by preventing capitalization of the lands and water rights and by regulating rates to a fair return on the capital actually invested, I am personally strongly in favour of securing it by the direct method of licence-charges. In a comparatively new country, like all this Western Coast, I believe that capital should secure a generous return on all legitimate investments, but in no country—new or old—do I believe that capital should be allowed to exploit the property of the people or earn an income upon their generosity.

Very truly yours,

O. C. MERRILL,
Chief Engineer.

THE COLLECTION AND FILING OF HYDROGRAPHIC DATA.

BY E. DAVIS.

December 23rd, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—The fundamental principle underlying practically all of the hydrographic work undertaken by the Province of British Columbia to date, in respect to the "Water Acts," is the fact that a record was made in the books of a particular Government Agent granting a right to a particular person to use a certain quantity of water out of a certain creek, river, or lake, as the case may be. Using this as a base from which to start, it was necessary to obtain copies of every record which had been granted by the various Government Agents, and after these were obtained they were sorted out into groups called precincts, for convenience in handling in the office and in the field. The boundaries of these precincts, as far as possible, are defined by watersheds, and generally include the land drained by a number of small streams, as the watersheds of streams on which the records were granted are not of a very large area.

VAGUENESS OF OLD RECORDS.

In trying to sort out the records into the precincts, considerable work was necessary to find where the lands were situated for which the records were granted, the records merely stating in a great number of cases, after mentioning the name of the grantee, that the water was to be used on "his farm." A great deal of this information was obtained from the books of the Lands Department, but a great many records had to be left for the engineer who was working in that particular district to find from local knowledge the whereabouts of the man's holdings.

Armed with a copy of most of the water records in his particular district, the engineer took the field, his duty being to make a report of every record investigated, and, where necessary, make a survey on the ground of all the lands belonging to the water-record grantee. Each record was investigated on its own merits, whether for use for power, for mine or mill, generating electricity, irrigation or domestic purposes, etc., as the case may be. In the case of a power-installation, the intake was located with reference to some legal corner post, the capacity of the ditch or flume calculated, the mill or power-station located, as also the point where the water was returned to the creek. In the case of water used for irrigation purposes, the point of intake and the line of the ditch were located and plotted on a map, also the total possible amount of land which can be irrigated from the present ditch, and, in cases where the old ditch has a steep grade, the land which might be irrigated should a new ditch be dug at a higher level. The land actually irrigated from the present ditch was surveyed and plotted on the map, and any information respecting the character of the land which would assist the Board of Investigation in intelligently adjudicating on the various rights was also noted and put in the report.

SURVEY PARTIES.

The survey parties during 1911 consisted of a camp composed of an engineer, as chief and instrument-man, two rodmen, two axemen, and a cook. During 1912 more parties were in the field and were smaller than 1911. Each party consisted of an engineer and his assistant, who acted as rodman and axeman, but if there was heavy cutting to do the engineer was empowered to engage help. Meals were generally obtained at various ranches, and only the tents and personal gear were carried. The cost of each party during 1912 was considerably less than during 1911, although the field covered was quite as large this year as during the 1911 season.

METHOD OF SURVEY.

The method used in locating ditches and intakes was generally by a compass survey with a transit, unless it was found that local attraction affected the compass-needle, when deflecting angles had to be resorted to. Comparative elevations were obtained by vertical angles, and distances were measured by the stadia hairs in the telescope of the transit. After each record had been investigated and surveyed, the plat, showing the information obtained—viz., intake ditches, irrigable land, and irrigated land—was made to a scale of 20 chains to the inch, unless

the details could not be shown to that scale, when a larger scale was used, and attached to the copy of record together with the report, and then sent to headquarters at Victoria. When received in Victoria, these reports and maps were filed away in boxes hereafter described.

DISCHARGE MEASUREMENTS.

In each district the engineers made discharge measurements of the streams on which they had investigated the records whenever it was possible for them to do so without seriously interrupting the other work. Where possible, weirs were built, and ranchers were asked to take readings periodically. In nearly every case the ranchers willingly undertook to do this work, and seemed to take great interest in the measurements of the waters. Where the stream was of such a size that a weir was impracticable, the velocity of the water was measured by a current-meter and its discharge calculated. A gauge was set in a convenient spot in the river-bank and readings taken periodically of the height of the water. These gauge heights are of no use until the rating curve is made, but when such a curve is constructed from numerous meter-readings, the gauge heights can be used to calculate the discharge during the period in which they were taken. By this method no time is lost. Most of the engineers were supplied with a Gurley No. 623 current-meter. The results of these measurements have been compiled in order that they may assist the Board of Investigation when adjudicating the water rights.

FILING OF ENGINEERS' REPORTS.

The system of filing the records, reports, and maps sent in by the engineers in the field is as follows: As before mentioned, each district is divided into precincts for convenience, and a copy of each record, known to be in that particular precinct, is placed in a folder. In this folder all the information which the Department has gathered in respect to this particular record is placed, so that should any inquiries be made the full information is available at once.

In each precinct-box the folders are grouped together according to the streams to which they appertain, so that when the Board of Investigation adjudicates upon the rights on a particular stream, the information is grouped in a convenient form for that purpose.

SYSTEM OF INDEXING.

Owing to the fact that inquiries are constantly being made by persons either respecting claims which they have sent in to the Department, or about the old records they understand are appurtenant to their land, it has necessitated the compilation of several indexes, so that, however meagre the inquiry is, the Department is able to trace the matter.

It is evident, owing to the looseness with which old records were drawn, as already explained, that any system of filing and indexing must be unsatisfactory with respect to such records until the Board has held its investigations and has substituted clear-cut and well-defined licences for vague and meaningless records.

However, if an inquiry pertaining to one of these old records gives the date and the district office at which the record was issued, it can be traced through the counterfoils of the original records, which are kept in chronological order; and these are also indexed under the record-grantee's name.

INDEX BY STREAMS.

There is also an index by streams for each water district. As the investigations of the Board proceed, and duplicate names of streams are avoided by an official rechristening, this index will be most valuable. However, owing to the frequent repetition of common names for streams, even in the same localities, and to a confusion of ideas as to the correct names of many small creeks, this index has not been of much help in the tracing of old rights.

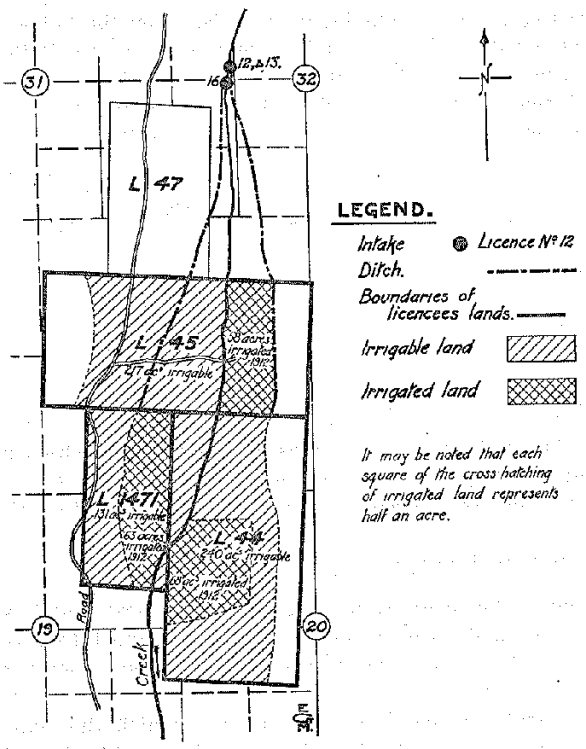
Another index frequently consulted in looking up old rights is that which gives the names of claimants for water rights who have filed claims before the Board. By means of this index the Department can locate the file in which all the papers relating to the particular right are placed. New applications for rights are also indexed as they come in; the index referring to the file, reference to which will show the status of the application.

INDEX ACCOMPANYING MAPS.

Perhaps the best index, after all, in the following-up of rights, will be that accompanying the maps which are being completed as fast as possible for each stream system. To these

maps, as described on another page, will be attached a table giving cross-reference to the files for each parcel of land that is platted. By means of these maps, which are to be constantly kept up to date, if the land concerning which an inquiry is made is accurately described, all available information in the hands of the Department concerning the status of the water right can be easily referred to.

TYPICAL SECTION OF A WATER RIGHTS MAP.



In making inquiries respecting their water rights held under Acts prior to the 1909 "Water Act," or to statements of claim, the public could greatly facilitate the work of the Department by giving the date, original grantee's name, and the water district in which the record was granted.

OFFICE MAPS.

The maps. which are being made in Victoria and which are called "Water Rights Maps," are made up from the information contained in the engineers' reports and maps. Commencing at the mouth of the stream, the maps work up-stream, and in case one map is not sufficient, other maps are made showing the continuation higher up, until all the water rights are shown. These maps are drawn to a scale of 20 chains to an inch. This size—33½ by 23 inches—permits of them being bound together in a portfolio, so that they always lie flat and will be easy to handle. A typical section of a water-rights map is shown herewith and is self-explanatory.

Attached to the maps and to form a part thereof is a table made up as follows:—

Licence No.	Date.	Licensee.	Purpose.	Quantity of Water.	Lands.	Irrigated Area.	Total Irrigable Area.	Date set for Completion of Works.

The object of this table is to show at a glance all information respecting the water rights on accompanying map and is self-explanatory. It will also be very useful in giving information to an applicant for a licence, as it will show him, besides certain fixed quantities, the area of land which may be brought under irrigation within the time set by the Board of Investigation or Comptroller of Water Rights, as the case may be. In course of time reliable data regarding stream-flow will be available, and when these are obtained an applicant for a licence can be told exactly what water is unrecorded in a particular stream. Prior to this time, when the more complete data on stream-flow is obtained, while the applicant cannot get full information regarding unrecorded waters, he can be told the maximum area of land which may be irrigated before his land could be supplied.

MAPS FOR PUBLIC INSPECTION.

For the purpose of inspection by the public of the maps of the Department relating to streams upon the waters of which the Board of Investigation is about to adjudicate, a copy is

made of the map, as above indicated, and some additional data is shown as well. The proposed intake of those records which have not been utilized up to the present is shown on such maps in the position as described in the body of the record, by a circle of 1/10 inch in diameter. Any lands which have been irrigated, but for which there does not appear to be a record on file in the books of the Department, are also shown on the map open for inspection. It is the intention that when the uncompleted rights, i.e., those under which no works have been constructed prior to the time of the sitting of the Board of Investigation, are completed—that is, when the holders of the records have compiled with the order of the Board—these various details, such as location of ditch-line, etc., will be entered on the original copy of the map on file in Victoria, and will be classed as completed rights, for which licences will be issued in lieu of the old records. Attached to each of the maps, and to form a part thereof, is a table made up as follows:—

Dominant Land.	Water Record.		Intake.	Creek or Source.	Claimant.	Irrigable Land claimed.	Irrigable Land surveyed.	Irrigated Land claimed.	Irrigated Land surveyed.
	No.	Date.							

The object of this table is to show at a glance the various sources of supply from which a particular piece of land may be irrigated, and also the area, in acres, which the claimant states can be irrigated from a particular source, as well as the area reported by the Department's engineer.

Plats attached to Licences.

After the Board of Investigation has issued the order cancelling the old record and has directed the Comptroller of Water Rights to issue a licence in place thereof, it is the intention to attach to and to form a part of the licence a plat to a scale of 20 chains to 1 inch, showing or describing,—

(*a.*) For an irrigation licence, the particular piece of land or lands to which the right is appurtenant, the location of intake, the irrigated lands (by cross-hatching), and a concise description of the works:

(*b.*) For a power licence, the point of intake, point of return, and a concise description of the works:

(*c.*) For a domestic licence, the point of intake, place of use, and a concise description of the works:

(*d.*) For a storage licence, the location of storage reservoir, and a concise description of the works.

Status of Licences issued.

Owing to the great number of old records which have to be adjudicated upon by the Board of Investigation before the status of licences issued subsequent to March, 1909, is clearly defined, the work of the hydrographic staff has been confined chiefly to the investigation of these old records; but in due course all licences which are in good standing will be surveyed and the maps of the Department kept completely up to date. These maps will be of inestimable value in the issuing of licences, and also to the public, in order to see how each individual piece of land is being irrigated, and what progress is made in the utilization of the waters of the Province.

I have, etc.,

E. Davis,

Engineer, Water Rights Branch.

OFFICE PROCEDURE.

BY C. A. POPE, CHIEF CLERK.

All correspondence and documents are dealt with under a system recommended by the filing expert. Letters on receipt are numbered consecutively and indexed in the register under the names of each party affected. When a letter opens a new subject, the number given the letter becomes the file number. When a letter refers to a subject to which a file number has previously been assigned, this file number is also marked on it. The letters are next entered in the register of numbers, which shows to what file any particular letter has been attached. The letters are now attached to their respective files and handed to the Chief Clerk.

Files relating to matters not yet completed are kept in trays corresponding to the various districts in which the water rights are situate, and are placed numerically under the initial number. When a file or application is completed, it is transferred to a case in the vault and is filed permanently under the same number.

The correspondence previous to 1912 is being renumbered and brought under the new system as rapidly as possible. All the applications for licences under Part V. and Part XI. and applications for approval of plans and of undertakings have been brought under the new system.

APPLICATIONS FOR LICENCES UNDER PART V.

The notice and application are filed in the local office in duplicate, and one copy is forwarded to the head office by the Recorder, with a report giving the date of filing and any further information of which the Comptroller should be advised.

Upon receipt of the application, it is dealt with by the correspondence clerk in the same manner as the general mail matter and handed to the Chief Clerk, who notes any protests and extraordinary features. It is then passed to the application clerk to be entered and checked. The main points requiring checking are the description of the stream and dominant land and the dates of staking, filing, and publication. When it has been entered in the application register and in the stream index of water rights, a letter is prepared asking for the fees, for the information required by section 61 of the Act, and for any further particulars that may be necessary. This is done to assist the applicant in completing the statement required by section 61.

When this statement is returned, it is compared with the notices and applications, and if it is in order and the fees have been paid the application and all correspondence are submitted to the Comptroller for adjudication.

After adjudication the permit is written in triplicate, checked by the Chief Clerk, and signed by the Comptroller. The original and a receipt for the fees and the rental to the 1st day of June of the next year are sent to the applicant. A covering letter is sent to the applicant, drawing his attention to the procedure to be followed in making application for an approval of plans, and to the fact that, unless the application for approval is filed within the time stated in the permit, the permit lapses automatically. The duplicate is sent to the local Recorder's office with instructions for its filing and for the collection of future rentals. The remaining copy is filed and indexed in this office. Forms for the application for approval of plans are sent to the applicant with the permit.

APPLICATIONS FOR APPROVAL OF PLANS.

The application for approval of plans is checked to see that the requirements as to publication and the service of notices have been complied with, and it is passed to the engineers for their inspection. A note is made by them of any defects, deficiencies, or necessary alterations, and the applicant is advised thereof.

When the plans have been found sufficient and objections have been disposed of, the Comptroller grants the approval in the form of an order which is sent to the applicant, a copy is sent to the local Recorder, and a copy is filed in this office.

APPROVAL OF AN UNDERTAKING.

If an undertaking requires the approval of the Lieutenant-Governor in Council, the petition is sent to this office, where it is checked and a report thereon prepared for the Minister.

MISCELLANEOUS APPLICATIONS AND INQUIRIES.

Many other applications are received requiring special procedure, such as:—

For apportionment of a record, under section 82:
For change of point of diversion, under section 81:
For fixing quantity to which a riparian owner is entitled, under section 66:
For renewal of a licence, under section 255:
For an interim licence, under section 253:
For amendment of a licence, under section 319:
For right-of-way over Crown lands, under section 221:
For approval of security before entering on private lands, under section 225.

Special directions are sent for each case. Circulars and form letters have been prepared for the applications which occur most frequently.

OBJECTIONS TO APPLICATIONS.

A great many protests are received. If the ground of objection is considered by the Comptroller of sufficient importance, a copy of the protest is sent to the applicant and the objector is advised. If the ground of objection is not considered sufficient to warrant an inquiry, the objector is so notified.

STREAM INDEX OF WATER RIGHTS.

This is at present in a card index for each district arranged alphabetically as to names of streams. All records, licences, permits, applications, and private Acts relating to water rights are indexed therein, but the card system has not been found satisfactory, and a loose-leaf index is being compiled to replace it. When finished it will be a complete gazetteer of the streams of the Province; it will also show every water right on the drainage-basin of a stream and its tributaries.

INDEX OF CLAIMS TO BOARD OF INVESTIGATION.

There is an index for each water district in which every claim is indexed as soon as received. The 5,000 claims now on file are so indexed that any particular claim or record can be readily found.

OTHER INDEXES AND REGISTERS.

A register of all licences issued, arranged numerically and indexed alphabetically.

A register of all applications for licences under Part V. of the Act, arranged according to district.

A register of all applications under Part XI. of the Act (clearing streams).

I have, etc.,

C. A. POPE, *Chief Clerk.*

WATER-POWER INVESTIGATIONS IN THE COLUMBIA RIVER DRAINAGE-BASIN. (PROGRESS REPORT.)

BY G. GRAY DONALD.

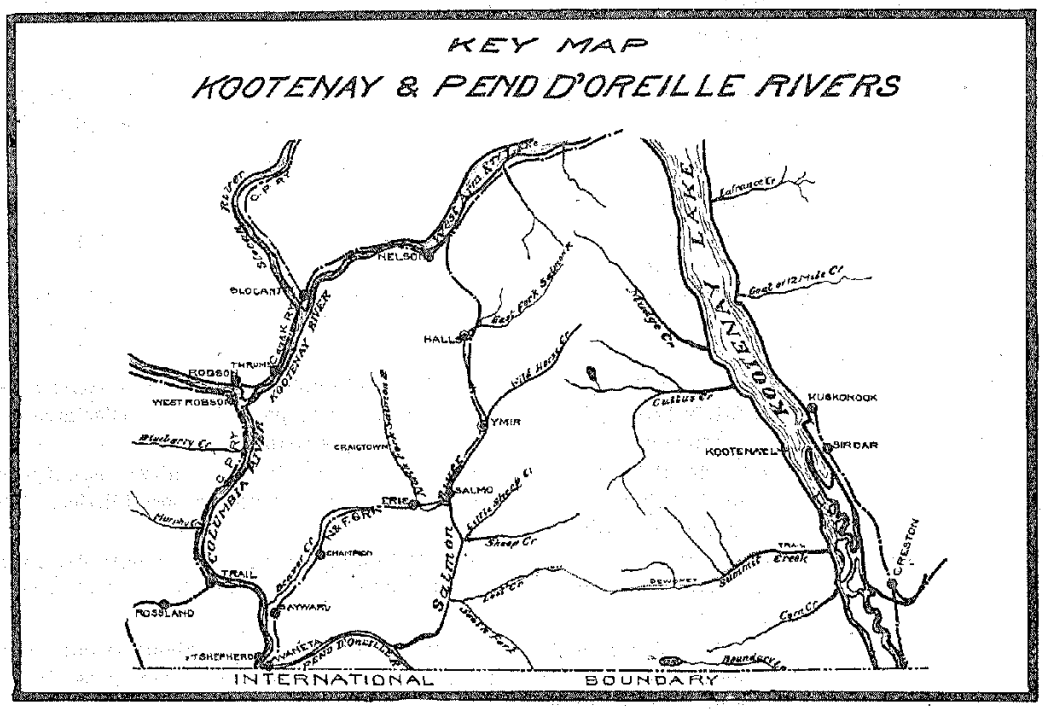
December 31st, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—Two sections were covered: (*a*) From the International Boundary to Castlegar; and (*b*) the Big Bend, from Kinbasket Lake to Gold Creek West, or Goldstream. A reconnaissance survey shows that there are not any water-power possibilities on this river between the International Boundary and Castlegar.

Gauging-stations have been established and arrangements made for continuous readings at Waneta and Castlegar. The new Government bridge at Trail offers good facilities for the metering of the river, and measurements taken there on November 26th gave 19,800 second-feet; on December 20th the discharge had fallen to 17,000 second-feet. Systematic measurements will be continued until high- and low-water extremes have been ascertained, and the discharge at the various stages determined.

The investigations round the Big Bend were taken up as a reconnaissance to determine the scope of future operations.



The Dominion Government, under Mr. Aylmer's direction, had a strong party in the field on this section with the object of determining the navigability of the Columbia, and, as their investigations would necessarily cover the same ground, the energies of the reconnaissance party were confined to the tributaries, the Dominion Government camp being, through the courtesy of Mr. Aylmer, used as a base for supplies.

Cummins Creek rises in the Rocky Mountains and joins the Columbia River about eight miles below Kinbasket Lake. It was investigated for about two miles and a quarter. The fall averages 180 feet per mile. The discharge on September 29th was 171 second-feet.

Extensive beaver meadows are reported on the upper waters, giving indications of storage possibilities. Assuming the low-water flow to be 120 second-feet, 4,300 horse-power could be developed.

Goose Grass Creek rises in the Selkirks and empties almost opposite Cummins Creek. It was investigated for two miles and a half. The fall averages 520 feet per mile. On September 29th the discharge was 21 second-feet. This stream is probably glacier-fed, and is of doubtful value for all-the-year-round industrial operations.

Yellow Creek rises in the Selkirks and empties into Columbia River twelve miles below Kinbasket Lake. It was investigated for a distance of nine miles, where there are falls 736 feet high; for a distance of four miles down-stream from the falls the average fall is estimated at 500 feet per mile. The discharge on October 8th was 30 second-feet. The elevation is probably too great for the power possibilities to be of any commercial value.

Wood River rises in the Rocky Mountains and empties into the Columbia River at the Bend. It was investigated for five miles and a half. The fall is slight for the first four miles, at the end of which it enters a canyon 7,840 feet long, in which the fall is 278 feet. Discharge on October 12th was 440 second-feet. An extensive flat above the canyon indicates storage possibilities.

Canoe River joins the Columbia River at the Bend, flowing from the north, and is navigable for about fifty miles. It does not present any economical power possibilities on its lower reaches. The discharge on October 14th was 1,350 second-feet.

Harvey Creek is a tributary of Canoe River about eight miles from its mouth, rising in the Rocky Mountains. It was investigated for two miles and a half. The fall averages 245 feet per mile. On October 16th the discharge was 140 second-feet.

Boulder Creek is a tributary of Canoe River about fifteen miles from its mouth, rising in the Rocky Mountains. It was investigated for 5,500 feet. The fall averages 330 feet per mile. The discharge on October 22nd was 87 second-feet.

Nagle Creek rises in the Gold Range and joins Columbia River eight miles below Boat Encampment. There is a short canyon near the mouth with about 40 feet of fall. The discharge on October 25th was 128 second-feet. It is reported to have little fall for several miles above the canyon.

Soard Creek rises in the Gold Range and empties into Columbia River about ten miles below Boat Encampment. It was investigated for 3,300 feet, with average fall of 350 feet per mile. The discharge on October 26th was 103 second-feet.

Mica Creek rises in the Selkirks and empties into Columbia River about twelve miles below Boat Encampment. There are no indications of power possibilities. On October 29th the discharge was 30 second-feet.

Maloney Creek rises in the Gold Range and empties into Columbia River about sixteen miles below Boat Encampment, is fairly level, with no indication of power possibilities. Discharge on received later indicate the existence of falls about three miles up-stream.

Big Mouth Creek rises in the Selkirks and empties into Columbia River about twenty-five miles below Boat Encampment, is fairly level, and has no indication of power possibilities. The discharge on October 29th was 250 second-feet.

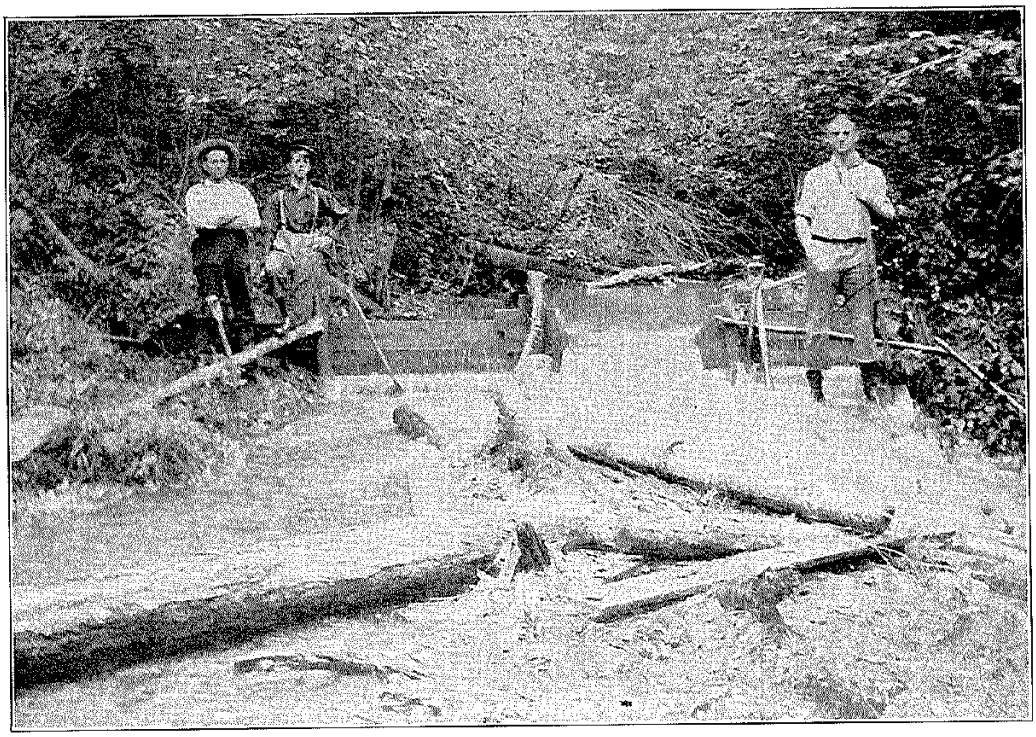
Flat Creek rises in the Gold Range and empties into Columbia River about twenty-five miles below Boat Encampment, is fairly level, with no indication of power possibilities. Discharge on October 29th was 200 second-feet.

Horn Creek rises in the Gold Range and empties into Columbia River about twenty-eight miles below Boat Encampment, is fairly level, and has no indication of power possibilities. Discharge on November 4th was 51 second-feet.

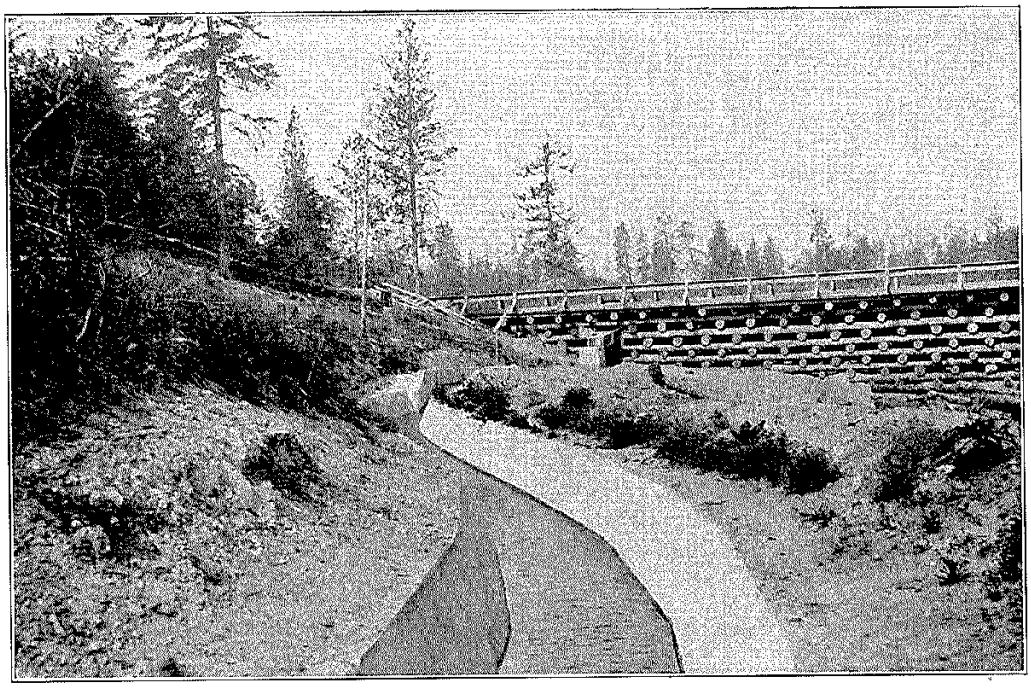
Gordon Creek rises in the Gold Range and empties into Columbia River about 31½ miles below Boat Encampment. The estimated fall is 50 feet per mile for six miles. Discharge on November 2nd was 25 second-feet.

Davie Creek rises in the Selkirks and empties into Columbia River opposite Gordon Creek. It is a precipitous stream with a flow of 7 second-feet on October 31st.

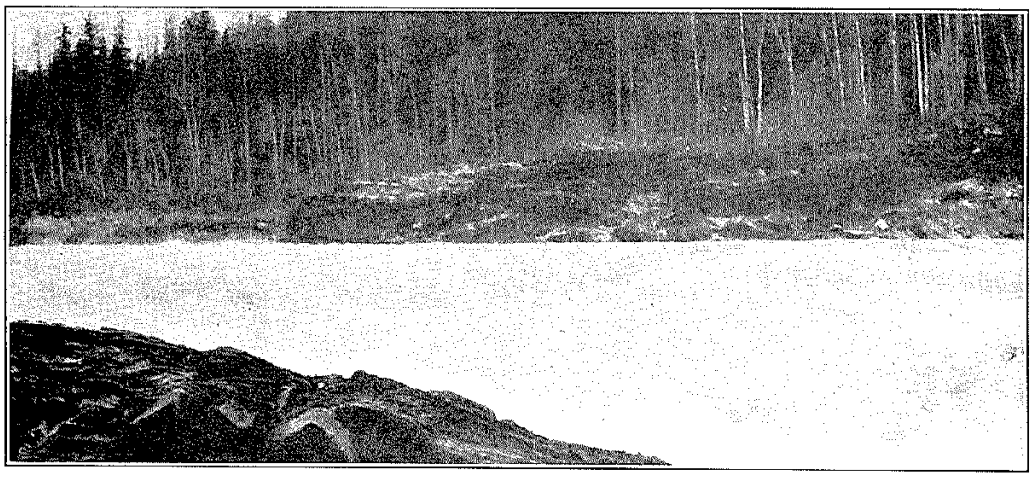
Gold Creek West, or Goldstream, rises in the Selkirks and empties into Columbia River about fifty-five miles north of Revelstoke. It was investigated throughout the length of the canyon, which extends from the mouth for a distance of 9,190 feet. The average fall is 160 feet per mile. Discharge on November 11th was 430 second-feet. Meadows above the canyon give indication of storage possibilities. Falls are reported to exist on the upper waters. There is some settlement along this stream.



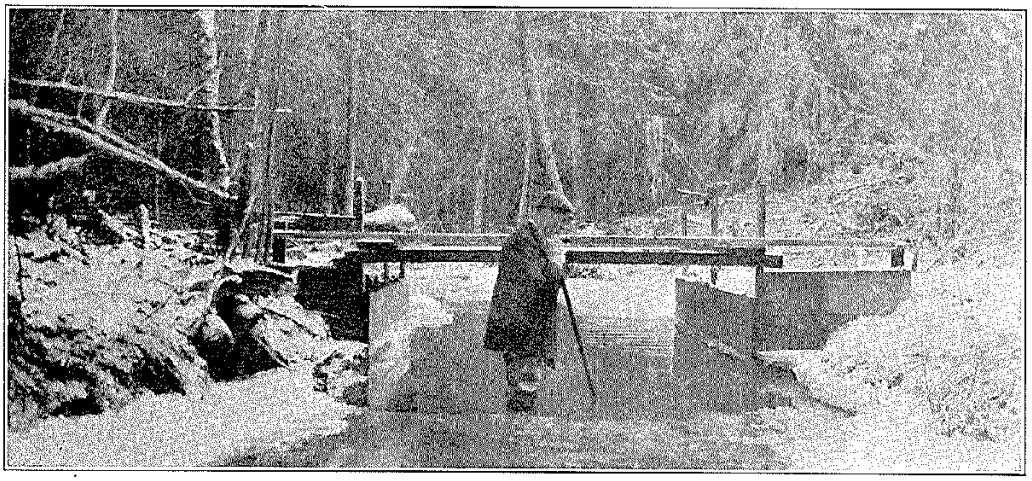
Cippoletti Weir, Maguire Creek, during construction.



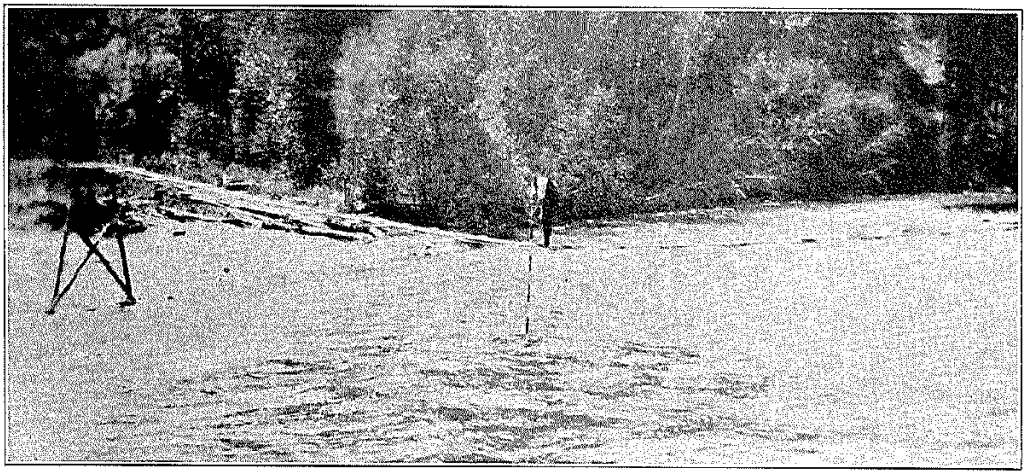
Concrete-lined Canal and Dam of Kelowna Irrigation Co.



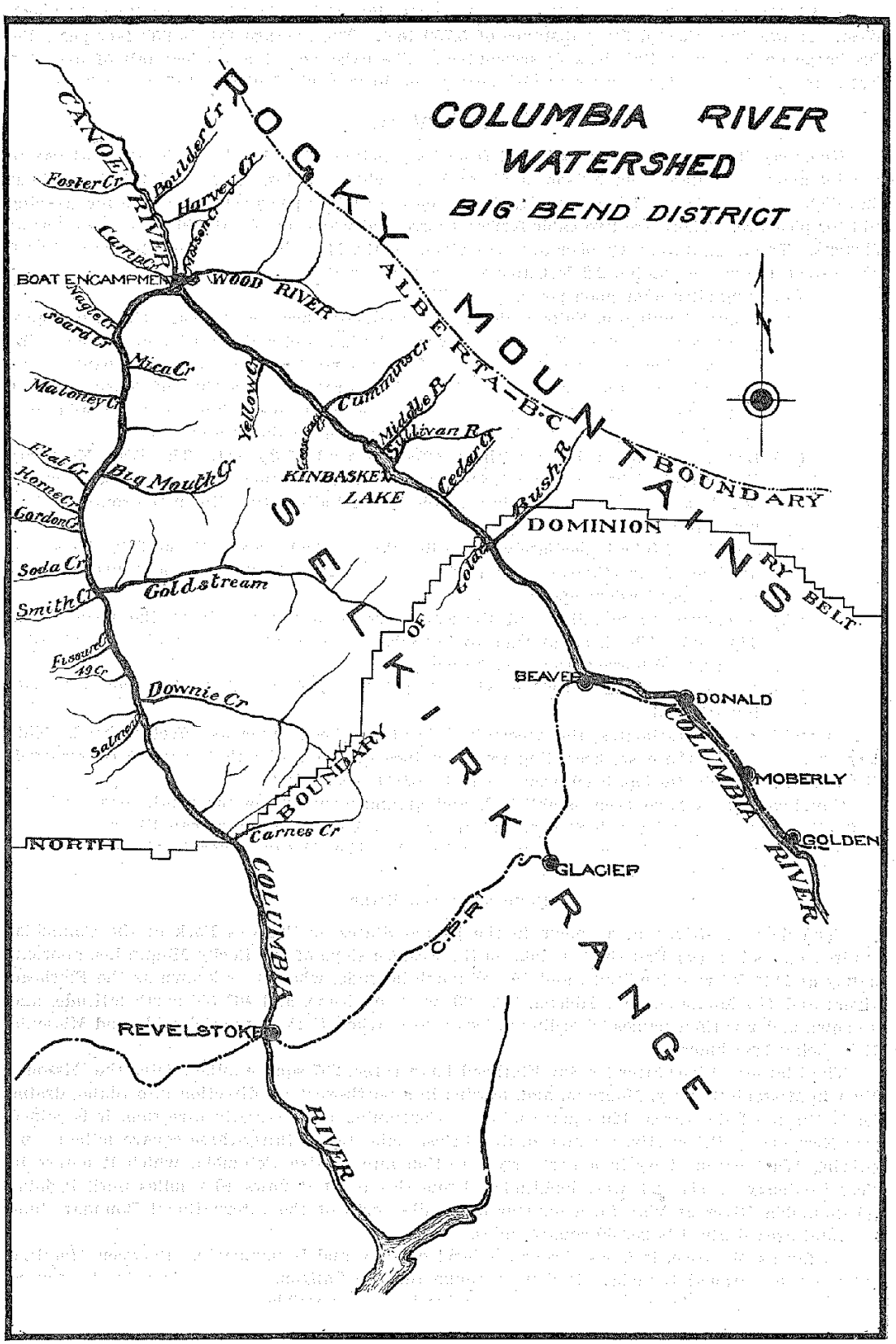
Pend d'Oreille River, at Fifteen-mile Creek.



Measuring Flume on Josephs Creek, near Cranbrook.



Gauging Mission Creek, near Kelowna.


COLUMBIA RIVER
WATERSHED
BIG BEND DISTRICT
ROCKY MOUNTAINS
SELKIRK RANGE
ALBERTA-B.C. BOUNDARY
BOUNDARY
DOMINION
BELT
RY
OF
BOAT ENCAMPMENT
WOOD RIVER
CANOE RIVER
Foster Cr
Boulder Cr
Harvey Cr
Jasper Cr
Campbell Cr
Eagle Cr
Board Cr
Mica Cr
Maloney Cr
Yellow Cr
Cummins Cr
Middle R
Sullivan R
Cedar Cr
Bush R
KINBASKET LAKE
Flat Cr
Big Mouth Cr
Horne Cr
Gordon Cr
Soda Cr
Goldstream
Smith Cr
Fissure Cr
Downie Cr
Salmon
Carnes Cr
NORTH
COLUMBIA
C.P.R.
REVELSTOKE
RIVER
GLACIER
BEAVER
DONALD
COLUMBIA
MOBERLY
GOLDEN
RIVER

3

Smith Creek rises in the Gold Range and empties into Columbia River opposite Gold Creek West. It was investigated for a distance of 5,750 feet. The average fall is 250 feet per mile. Discharge on November 10th was 73 second-feet. The existence of a vertical fall of over 150 feet is reported on the upper waters; also beaver meadows would indicate storage facilities.

KOOTENAY RIVER.

Kootenay River has been investigated from its junction with the Columbia at Castlegar to a point about six miles from Nelson, a distance of eighteen miles. The total fall throughout that distance is 330 feet. It is not navigable, but on the various pools boats are used for crossing and for pleasure. There are two cable-ferries (horse and wagon); one at Brilliant, the other at Thrums. The discharge on October 31st (as given by Mr. Muerling) was from 10,000 to 12,000 second-feet, the gauge reading 2.2 feet above average low water.

The following sites offer good power possibilities:—

(*a.*) Upper Bonnington Falls, which have an effective head of 62 feet. They are appropriated by the West Kootenay Power and Light Co. and the City of Nelson. The company has permanent works for 30,000 horse-power on the north bank. Two 5,000-kilowatt units are installed and in operation. The City of Nelson has its works on the south bank, and they also are in full operation. The city and company jointly appropriate all the available power on these falls:

(*b.*) Lower Bonnington Falls, with an effective head of 34 feet. The West Kootenay Power and Light Co. has a 5,000-horse-power installation on the north bank, which is held as auxiliary to the plant at the Upper Falls. The site on the south bank is not appropriated:

(*c.*) A series of falls immediately above Bonnington Pool, Lots 2628 and 303. The head at time of investigation was 77 feet on a length of 3,200 feet, and 42,000 horse-power may be developed:

(*d.*) A canyon three miles and three-quarters from the mouth of the river (near Thrums). The head at time of investigation was 42 feet in a distance of 5,300 feet; 23,000 horse-power may be developed:

(*e.*) A site at Granite Bridge, six miles below Nelson, which has not yet been investigated.

In making these estimates, the ascertained head has been taken as effective head. This may or may not be the case, according to the nature of the works that may be constructed. The low-water discharge has been assumed to be 6,000 second-feet.

Gauging-stations have been established, and arrangements made for continuous readings, at Brilliant, Thrums, and South Slocan, and at Crescent Valley for the Slocan River.

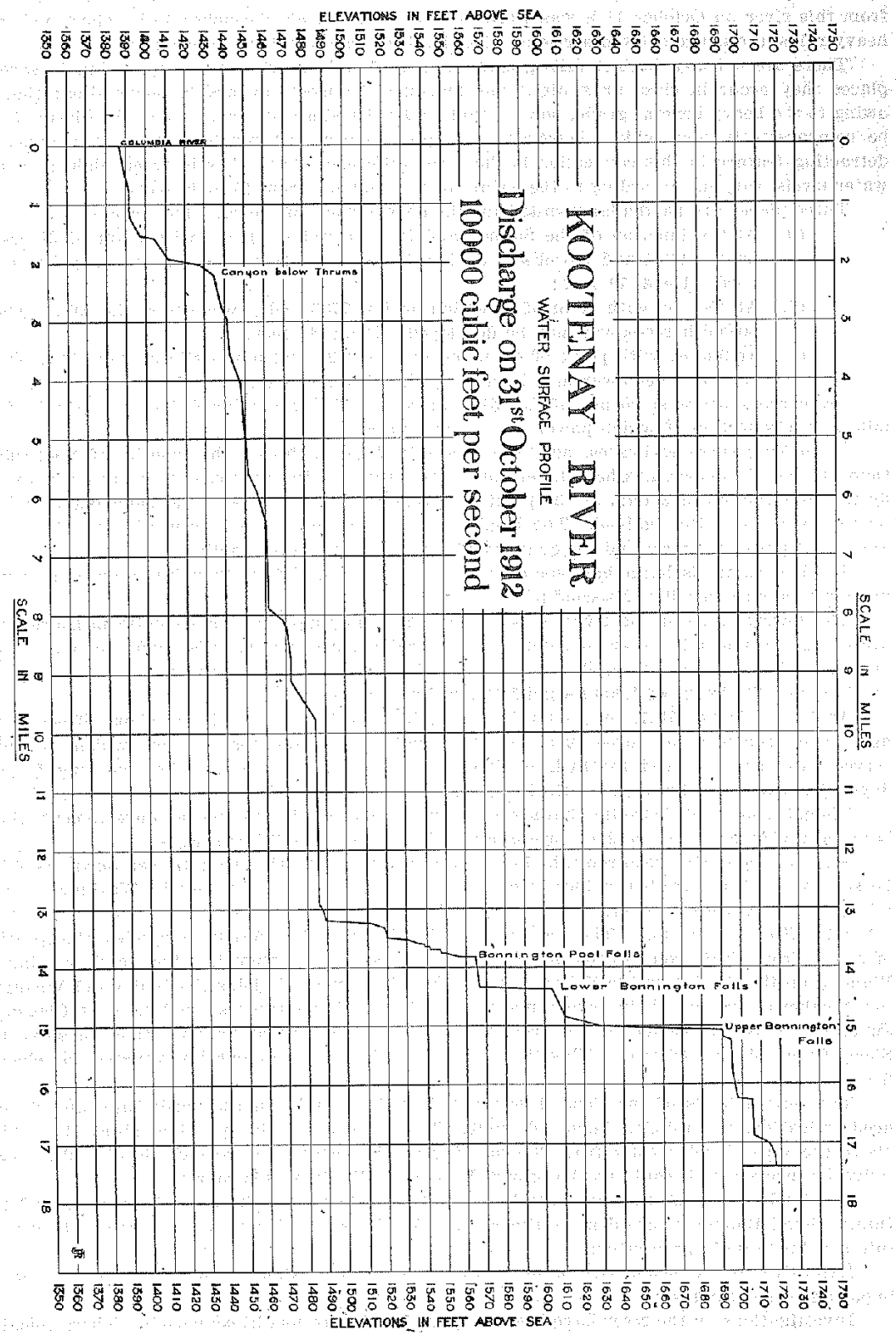
None of the tributaries have been investigated. The Slocan River is the only one of importance on the ground covered.

PEND D'OREILLE RIVER.

Pend d'Oreille River, also known in the United States as Clarke's Fork of the Columbia, has its sources in: (*a*) British Columbia on the western slope of the Rocky Mountains, approximately at 114° 52′ west longitude, and 49° 20′ north latitude, where it is known as the Flathead River; and (*b*) Montana, near Helena, 112° 20′ west longitude, and 46° 35′ north latitude, and is known under various names according to locality—Clarke's Fork of the Columbia and Missoula River being best known.

The Flathead River after leaving Flathead Lake (area, 207 square miles) joins the Missoula River in Missoula County, Montana, and, flowing in a north-westerly direction into Idaho, drains Pend d'Oreille Lake (area, 129 square miles). Continuing in a westerly direction, it is joined near Newport by Priest River, which drains Priest Lake (area, thirty-three square miles), and entering Washington, flows in a northerly direction into British Columbia, which it enters in West Kootenay at 117° 23′ west longitude. From this point it flows 16¼ miles until it joins the Columbia River at Waneta, a quarter of a mile north of the International Boundary-line. The total area drained is 25,300 square miles.

As far as Metaline, it flows through a level country and is navigable. Between Metaline and the International Boundary it flows through the Zee Canyon. From this point its course lies through a succession of canyons where navigation is impossible.


KOOTENAY RIVER
WATER SURFACE PROFILE
Discharge on 31st October 1912
10000 cubic feet per second
ELEVATIONS IN FEET ABOVE SEA
SCALE IN MILES
COLUMBIA RIVER
Canyon below Thrums
Bonnington Pool Falls
Lower Bonnington Falls
Upper Bonnington Falls

During its course of 16¼ miles in British Columbia it has a fall of 423 feet. The discharge from this river on October 11th was 10,232 second-feet, and on November 15th, when, owing to heavy rains, the gauge showed a rise of 1.25, the discharge was 13,084 second-feet.

There are not any distinct falls greater than 10 feet in height on this river, but in several places they occur in close proximity, thus marking the most favourable power-sites; though, owing to the heavy general grade, power could be developed almost every mile. The head would be comparatively low, which, however, is amply compensated for by the great volume. A detracting feature in this connection is the great difference that exists between high- and low-water levels, varying, according to the nature of the channel, from 15 to 40 feet.

Three places are particularly suited for the development of power. They are:—

(*a.*) At the junction of the Salmon and Pend d'Oreille Rivers, with point of diversion on Lot 9284 and power-site on Lot 7735, where 48,000 horse-power may be developed. Head, 74 feet:

(*b.*) At 15-mile, with point of diversion on Lot 7735 and power-site on Lot 9525, where 30,000 horse-power may be developed. Head, 47 feet:

(*c.*) At 9-mile, with point of diversion on Lot 9423 and power-site on Lot 5127, where 29,500 horse-power may be developed. Head, 44 feet.

From the south-west corner of Lot 5127 there is a fairly regular fall of 145 feet in four miles, on any section of which power may be generated.

In making these estimates, only the ascertained head, during the months of September, October, and November, has been taken into consideration. In every case this can be increased by the construction of a dam at the point of diversion, and the possible development increased by the extra head thus gained. The height of any such dam would naturally depend on the amount of power required and the quantity of water it is proposed to divert.

The low-water discharge has been estimated at 7,000 second-feet; though the lowest measurement yet taken gives 10,232 second-feet.

The lowest stage of the river is said to occur in February, and systematic measurements are being continued in order to determine the regimen accurately. Flathead, Pend d'Oreille, and Priest Lakes afford unequalled storage facilities. One foot of storage in each of these lakes would give a discharge of 1,000 second-feet for three months.

At 7-mile, on Lot 5127, very extensive gold-mining works were installed about fifteen years ago. They consisted of three turbines actuating three rotary force-pumps, which, in turn, served five monitors used for hydraulicking. They were closed down after working for six days. The works and plant are still in place.

Though the Pend d'Oreille shows such a great adaptability for power development, there is not any visible market in the immediate vicinity. The possibilities are:—

(1.) *Mining.*—The requirements in the Sheep Creek District may be set down as 4,000 horse-power, with a gradually increasing demand. The Metaline District in Washington may also prove a future consumer.

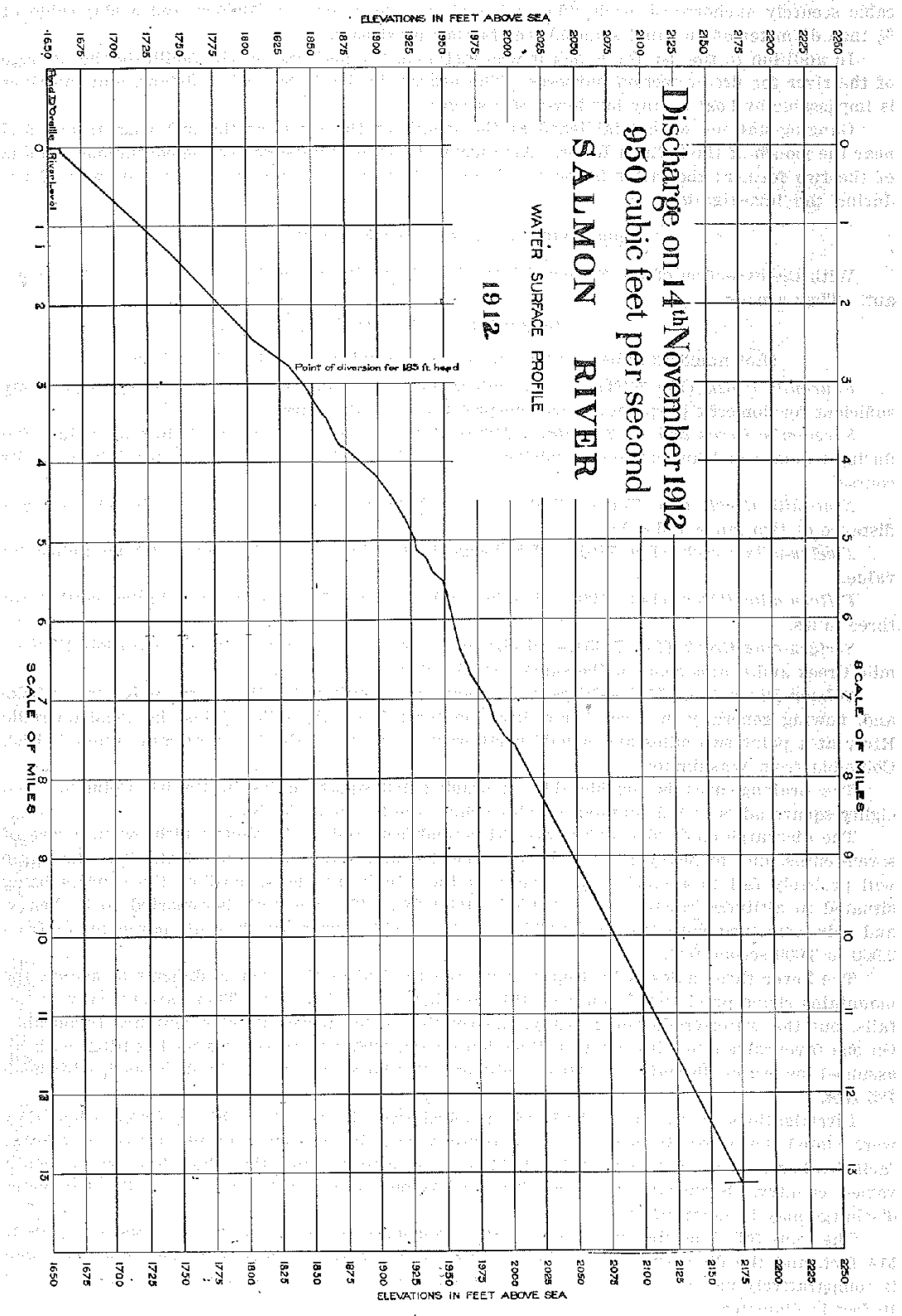
(2.) *Electric Traction.*—The Canadian Pacific Railway has nearly completed the location of a line from Trail, southwards along the west bank of the Columbia River, and crossing at Waneta, up the Pend d'Oreille Valley as far at Metaline, where it joins the Idaho and Washington Northern Line, which in turn connects with the Spokane International Line at Clagstone Junction. This scheme includes a branch line from the mouth of Salmon River to serve the Sheep Creek Mining District. This line, if built, will be most favourably situated for electrification.

The settled lands of the Pend d'Oreille Valley lie entirely on the north bank and do not need irrigation, the rainfall being adequate. They are, generally speaking, situated so high above the water-level, mostly from 400 to 600 feet, that access to the river is difficult. Were irrigation necessary, it could not be provided economically from this source.

The lands (area, 29.6 square miles) enclosed between the south bank of the river and the International Boundary, are densely timbered, and, with so much water-power available, constitute a valuable pulp proposition.

Extensive limestone-deposits occur in the valley which might form the foundation of an important cement-industry.

Investigations on the river have been completed as far as conditions permit. There remains to be ascertained: (*a*) The flood-levels; (*b*) the discharge at various heights; and arrangements have been made, having this in view, as changes in the river give opportunity.


Discharge on 14th November 1912
950 cubic feet per second
SALMON RIVER
WATER SURFACE PROFILE
1912
Point of diversion for 185 ft. head
Bend D'Orville (River Level)
ELEVATIONS IN FEET ABOVE SEA
SCALE OF MILES
0 1 2 3 4 5 6 7 8 9 10 11 12 13
1650 1675 1700 1725 1750 1775 1800 1825 1850 1875 1900 1925 1950 1975 2000 2025 2050 2075 2100 2125 2150 2175 2200 2225 2250

A permanent metering-station has been established on Lot 7193. It consists of a 1¼-inch cable securely anchored on each side, and having a clear span of 610 feet and a stay-cable of ⅝ inch diameter of an equal span 50 feet farther up-stream.

In addition to the use for which it was installed, the main cable will facilitate the passage of the river for fire-protection purposes. The nearest bridge is ten miles distant, and the river is impassable by boat at any but low-water stages.

Gauging-stations were established at the mouth of the river, at the metering-station, and near the mouth of the Salmon River. Arrangements have been made for the continuous reading of the two former; the latter is too far from settlement to be read regularly, but was of use during the investigations.

TRIBUTARIES OF THE PEND D'OREILLE RIVER.

With the exception of the Salmon River, the tributaries of the Pend d'Oreille are unimportant. They are:—

North Bank from West to East.

(Lot numbers indicate location of junction with Pend d'Oreille River.)

Four-mile Creek (Lot 7193).—Of no industrial value, and during summer and autumn only sufficient for domestic purposes; short and precipitous in its course.

Seven-mile Creek and its Tributary, Myers Gulch (Lot 5127).—Of no industrial value, and during summer and autumn only sufficient for domestic purposes; short and precipitous in its course.

Nine-mile Creek (Lot 7741).—Sufficient for domestic purposes only. It is settled for a distance of two miles and a half.

Twelve-mile Creek (Lot 7191).—Discharge in October ½ second-foot. Of no industrial value.

Fifteen-mile Creek (Lot 8190).—Discharge in October 1.2 second-feet. Valley settled for three miles.

Sixteen-mile Creek (Lot 7735).—Discharge in October 1.7 second-feet. It parallels Fifteen-mile Creek and drains some of the same settled lands.

Salmon River (Lot 9750).—Rises in the mountains south of the West Arm of Kootenay Lake and, flowing generally in a southerly direction for thirty-eight miles, joins the Pend d'Oreille River at a point two miles and a half north-west from where the latter stream enters British Columbia from Washington.

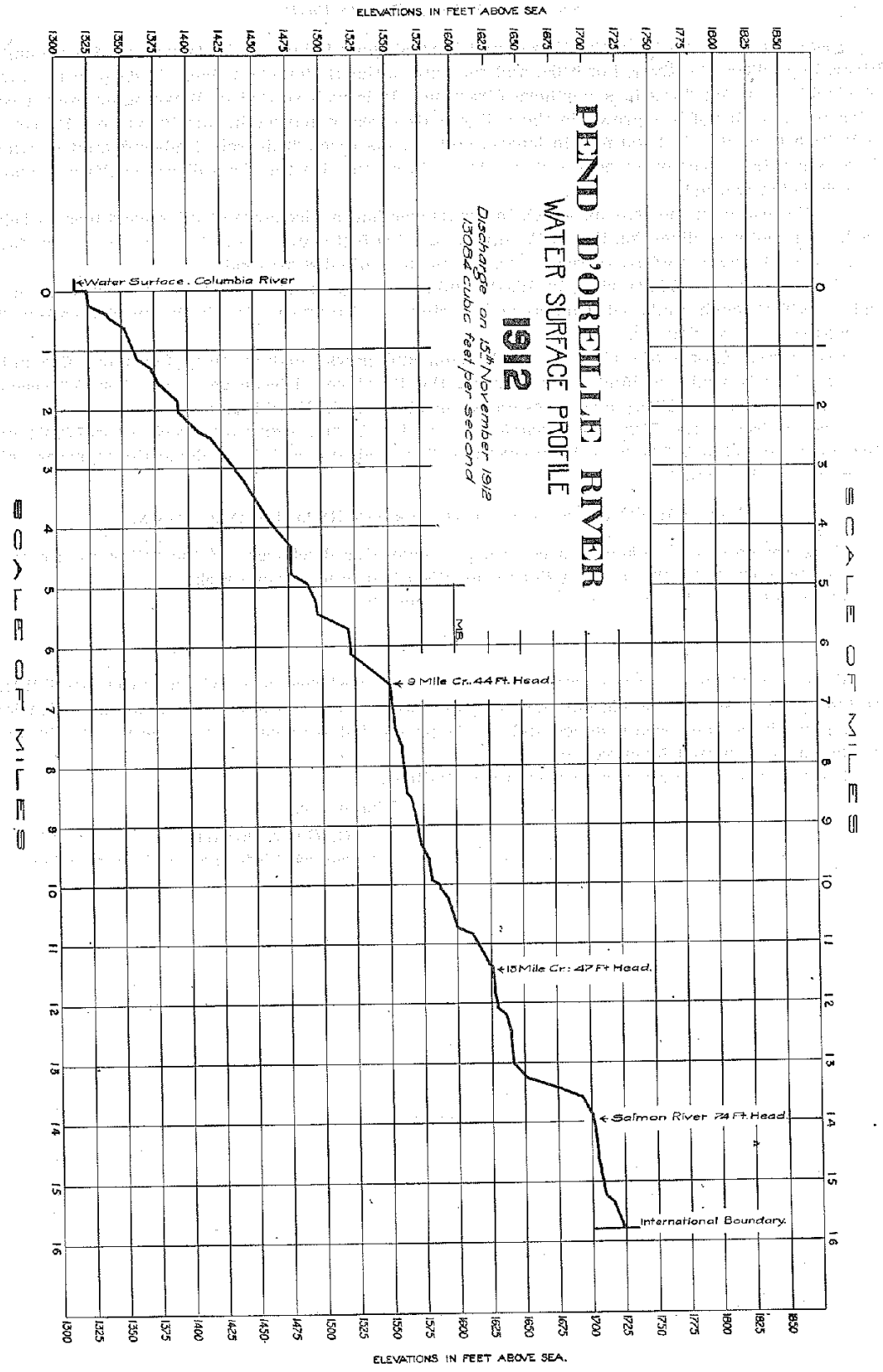
The drainage-area is considerable, embracing 483 square miles in British Columbia and eighty square miles in Washington, in which State the South Fork rises.

The discharge on October 26th was 404 second-feet, and on November 14th, when a rise of seven-tenths, due to heavy rains, occurred, the discharge was 950 second-feet. The discharge will probably fall to a much lower figure as the winter advances, most of the sources being situated in altitudes ranging from 4,000 to 6,000 feet. The snowfall is reported to be heavy, and this, combined with the great drainage-area, should bring the flood-discharge up to from 2,000 to 3,000 second-feet.

The lower three miles is in deep canyon, and the bed of the river is difficult of access, the mountains rising precipitously on each side to a height of 2,000 feet. There are not any actual falls, but the water-grade being heavy, the conditions for power development are favourable. On one favourable site with point of diversion on Lot 9282 and power-site on Lot 9182, with an assumed low-water discharge of 300 second-feet, 5,000 horse-power may be developed, with head 185 feet.

Investigations on this river had only reached from its mouth to Sheep Creek when they were closed down for the season. As a consequence, the existence, or otherwise, of storage facilities has not been determined, but it is reasonable to presume that they do exist in such a varied country. Systematic measurements are being continued in order that the low-water discharge may be determined.

The total fall from the junction with the Pend d'Oreille River to mouth of Sheep Creek is 514 feet, and the distance twelve miles. Between the South Fork and Sheep Creek the land is comparatively flat, and is heavily timbered, mostly with cedar, and many trees run to 8 and 10 feet in diameter.


PEND D'OREILLE RIVER
WATER SURFACE PROFILE
1912
Discharge on 15th November 1912
13084 cubic feet per second
ELEVATIONS IN FEET ABOVE SEA
SCALE OF MILES
←Water Surface, Columbia River
←9 Mile Cr. 44 Ft. Head.
←15 Mile Cr: 47 Ft Head.
←Salmon River 74 Ft. Head.
International Boundary.
MB
ELEVATIONS IN FEET ABOVE SEA.
SCALE OF MILES

South Bank from West to East.

Cedar Creek comes in on the Nelson and Fort Sheppard Railway lot lying between Columbia River, Pend d'Oreille River, Lot 9408, and the International Boundary-line. It rises in the State of Washington and flows in a northern direction. It is well settled in Washington, and a considerable quantity of hay grown in the valley finds a ready market in this Province. Its course in British Columbia is 1,800 feet in length, and it runs through densely timbered land in which there is a fair proportion of good cedar. At its junction with the Pend d'Oreille River a placer lease is being worked.

All the water in the stream, which in September had a discharge of 9.7 second-feet, is being used. The point of diversion lies in Washington, 1,600 feet south of the International Boundary-line. A good wagon-road traverses the valley on the United States side.

Bear Creek (Lot 7742) rises in Washington and flows north-westerly for about two miles and a half through timbered land after entering the Province. Discharge in September, 3.8 second-feet. No settlement.

Fish Creek (Lot 7734) rises in Washington and flows north-westerly for about five miles through densely timbered land after entering the Province. Discharge in October, 5.3 second-feet. No settlement. There are mines on the headwaters in Washington.

Fraser Creek (Lot 7728), *Mackenzie Creek* (Lot 7729), *Harcourt Creek* (Lot 7729), and *Russian Creek* (Lot 7733) have inconsiderable flow and are useful for domestic purposes only. They are on timbered land.

LOWER MAINLAND SECTION OF THE FRASER RIVER DRAINAGE-BASIN.

Measurements were taken to ascertain the low-water discharges of the following streams: Fraser River, Chehalis River, West Fork Chehalis River, and Silver Creek.

The results are shown in tabulated form on page 106.

VANCOUVER ISLAND.

Measurements of certain streams on the east and west coasts on which power possibilities are known to exist were taken, but the conditions were not favourable for further investigation.

The work has now been resumed and will be prosecuted systematically. The results obtained are shown in tabulated form on page 106.

The two coasts are given under separate headings.

I have, etc.,

G. GRAY DONALD,

Engineer in charge of Water-power Investigation.

DESCRIPTION OF WORK AT HYDROGRAPHIC STATION NEAR NELSON.

BY H. F. MEURLING.

Comptroller of Water Rights,
Victoria, B.C.

December 19th, 1912.

SIR,—Although my work does not come directly within the scope of that undertaken by the Water Rights Branch, as you have requested that I give a few details which might be of interest to the general reader in connection with the hydrographic work being done on the Kootenay River near Nelson, I beg to submit the following:—

This station is a boat-station—that is, the observations are taken from a boat anchored by means of a rope to a wire cable strung across the channel. The stretching of the cable across involved considerable labour on account of the velocity of the current at the time, and the length of the span, some 1,200 feet.

Before the wire cable could be stretched across it was necessary to establish communication between the two banks by means of a rope. This was done in the following manner: The end of the coil of rope was made fast to a tree on the south bank, the slack being carried along the side of the cliff clear of trees and other obstructions which lay between the two banks. The coil was then placed in the boat, which was manned by two good oarsmen and myself ready to pay out on the rope. The boat was rowed up-stream for some hundred yards, then turned sharply toward the other bank, and by paying out the rope as fast as the current and the speed of the boat could take it, we managed to make the other end fast to a tree on the north bank before the current had obtained full force on the same.

We failed three times to make the north bank and had to let go the rope, not being strong enough to hold it against the force of the current; and twice we lost part of the rope because of the current coiling it around submerged rocks, compelling us to cut it so as to save at least part of it.

The station had to be located at a point in the river where the waters are always agitated and where any work in a boat is accomplished under difficult circumstances. I was fortunate, however, in having the help of several young men who had been accustomed to sport in boats and sailing-craft, and were capable of being taught to work in boats as well, but I must confess to a feeling of relief when it was done without the slightest accident.

After having brought down wire cable on its reel, double and single blocks and tackle, and having picked out a growing tree on each bank to hold the cable when in position, I rigged up a system of double blocks on the north bank through which the cable could run from its reel. Two reliable men were stationed there to pay out on the same. I then made the end of the rope fast to the cable about 100 feet in from the end, and gave a sign to six men on the south bank to commence pulling on a system of double tackle rigged up there for that purpose.

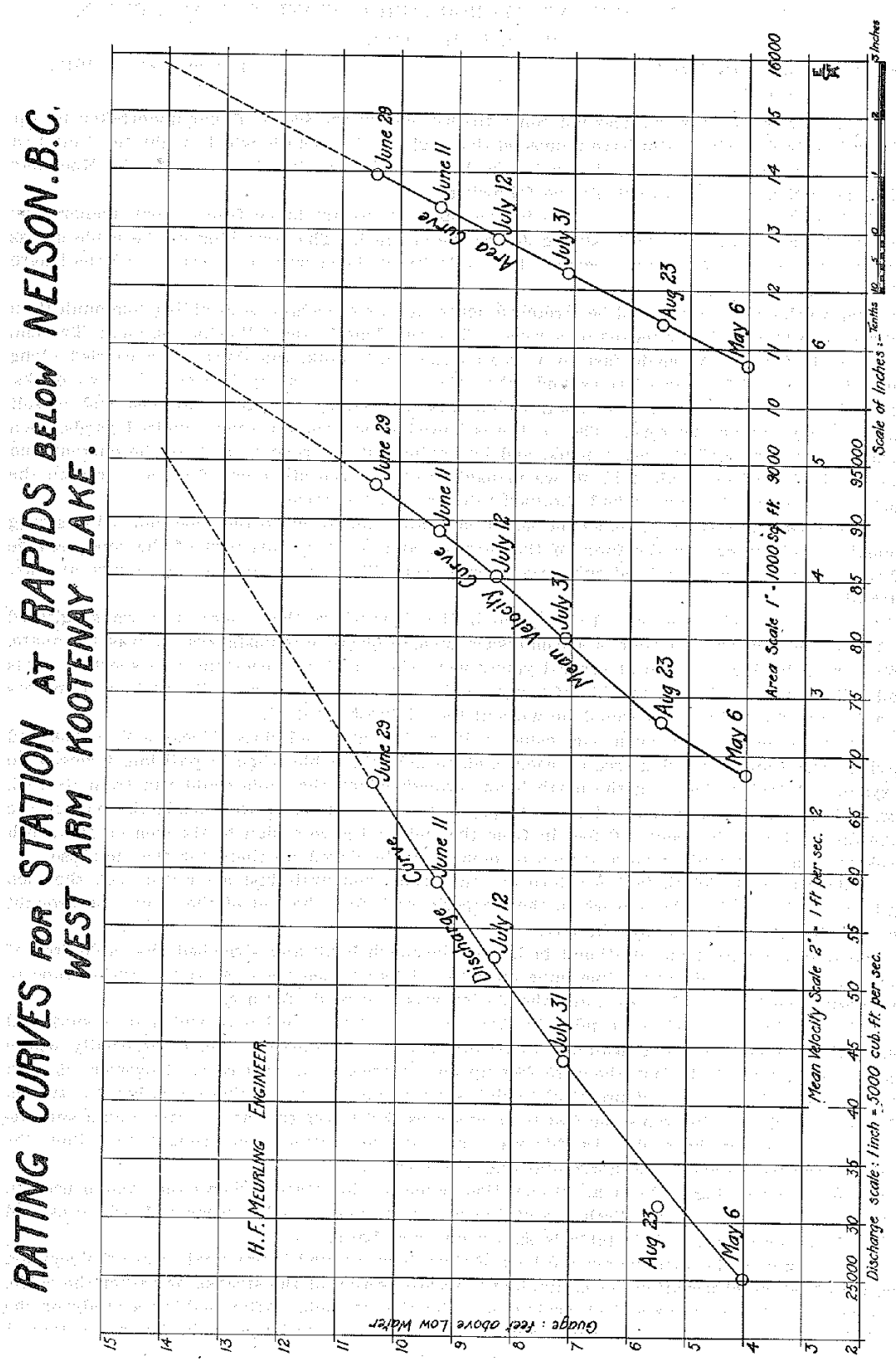
This was at 1 o'clock in the afternoon, and from then until just after 6 o'clock the men had one of the hardest day's work in their experience before the end of the cable was brought on the cliff and made fast for the day.

Next day I rigged up additional tackle on the north bank and stretched the cable free of the water, equipping it with a line hung on clips. This enabled me to shift the anchor-rope to any desired position on the cable, and the station was now ready for use.

The weight of a cable suspended in this manner and the tension to which it is subjected necessitates some kind of a deadman to steady any tree or derrick erected, especially where the cable must be made fast about 25 feet up on the tree, as in this case. However, as both banks were rocky, it was not practical to sink such an anchor, and I therefore rigged a system of double tackle, making the same fast to sling strops tied to the tree at the base, and a suitable height for carrying the cable. In this way part of the tension was brought to follow the trunk of the tree, and not the horizontal line of the cable.

The accompanying table of an observation taken at this station shows the system used in calculating the velocity and discharge of the whole section from the measured velocities and sounded cross-sections. (This table is shown on page 120.)

On account of the swift water and lack of time, it was found impractical to use the common method of taking observations—i.e., dividing the cross-section of the stream, or rather the cable, into 20- or 25-foot sections and observing the velocities at each. After making a study of the conditions, and with the knowledge gained from former experience with flowing waters, I


RATING CURVES FOR STATION AT RAPIDS BELOW NELSON. B.C.
WEST ARM KOOTENAY LAKE.
H.F. MEURLING ENGINEER
Gauge: feet above Low Water
Discharge scale: 1 inch = 5000 cub. ft. per sec.
Mean Velocity Scale 2" = 1 ft per sec.
Area Scale 1" - 1000 sq. ft.
Scale of Inches :- Tenths
Discharge Curve
Mean Velocity Curve
May 6
June 11
June 29
July 12
July 31
Aug 23

decided to use an old system which I had used on the Congo River in Africa, and which I had found would give very good results for practical purposes, where time and money are of consequence.

This method consists in confining the observations taken to vital points—that is, to points where, for some reason or other, the velocity of the current changes. Selection of these points requires experience and a knowledge of the bottom and other conditions. From velocities thus taken the probable increase or decrease from point to point may be calculated, and thus probable values for the velocities in theoretical 20-foot sections may be obtained, and from the latter the discharge of the 20-foot sections is calculated. By summing them up, the discharge of the sections as a whole is obtained, as well as the mean velocity of the section.

These values of discharge, mean velocity, and area—the latter being calculated from the profile of the cross-section obtained by sounding—are then plotted on cross-section paper and respectively joined into curves called the rating curves of that station. From these curves the discharge, mean velocity, and area can be obtained at any stage of the water above low water. I append a copy of the rating curves for this station as far as they are completed—i.e., 4 feet above low water. Observations were taken below this stage, but are not yet calculated. The curves as shown are based on measurements which cover the full rise of the water this year, as well as the probable values for any further rise. (*See* dotted curves, page 42.)

A study of these curves shows that the observation on May 6th gives a greater value for the discharge at 4 feet above low water than what may be expected at the same stage in September or October, judging by the value given from the observation on August 23rd. This is only natural when it is remembered that the observation on May 6th was taken during flood, and the one in the fall during ebb, and that the velocity and thereupon depending discharge is greater at flood than at ebb.

The mean velocity curve shows that somewhere down-stream from the station, and near enough to affect the flow at the station, there exists a bar, tending to pond the water flowing against it, and that this ponding is effective to a certain depth, or rather elevation. Having sounded and investigated the bottom and conditions below the station in connection with my other work, I find that there is in fact an obstruction of this character, and it is this which forms the rapids. The elevation of the crest of the obstruction corresponds to a depth of from 6 to 7 feet above low water, showing cause for the form of the velocity curve to that stage, after which it resumes its natural form. The area curve is practically a straight line, showing that the cross-section is constant and does not undergo any change from high to low water, or vice versa.

A few words should perhaps be said about the soundings made in the vicinity of the station. This is work which requires both good judgment and practice to give fair results in swift waters. The method used was as follows:—

The instrument-station—a hub connected with some known point, such as a section or lot corner, by a traverse—was chosen so that the angle of sight from the telescope should make as small an angle as possible with the horizontal. When everything was ready, the lead having been checked, the lead-line checked as to stretching or crimping, and the range established, the boat, manned by four men—two oarsmen, one sounder, and one rodman and recorder—was sent out.

The boat was then rowed up-stream past the range and was carried by the current down close to the range. At the proper moment a sign was given from the instrument to steady the boat, and, following further signs to row up or drift down, as the case might be, it was placed and kept on the range by the boatmen. At this juncture a sign to heave the lead was given, and, the rodman having at the same time raised his rod, the distance was taken by stadia. This operation had, of course, to be repeated several times, until satisfactory results were obtained.

When the depth had been read on the lead-line, it was, if the distance was too long to communicate direct with the instrument, recorded by the rodman, and the boat was then ready to move farther out. The greatest difficulty I had was to teach the men to heave the lead standing up in the boat. This takes considerable practice in rough or swift water, and requires men used to work in a boat, who are hard to find at an inland station such as this.

I have, etc.,

HARRY F. MEURLING,
Civil Engineer.

SUITABLE DESIGNS FOR SMALL HEADGATES.

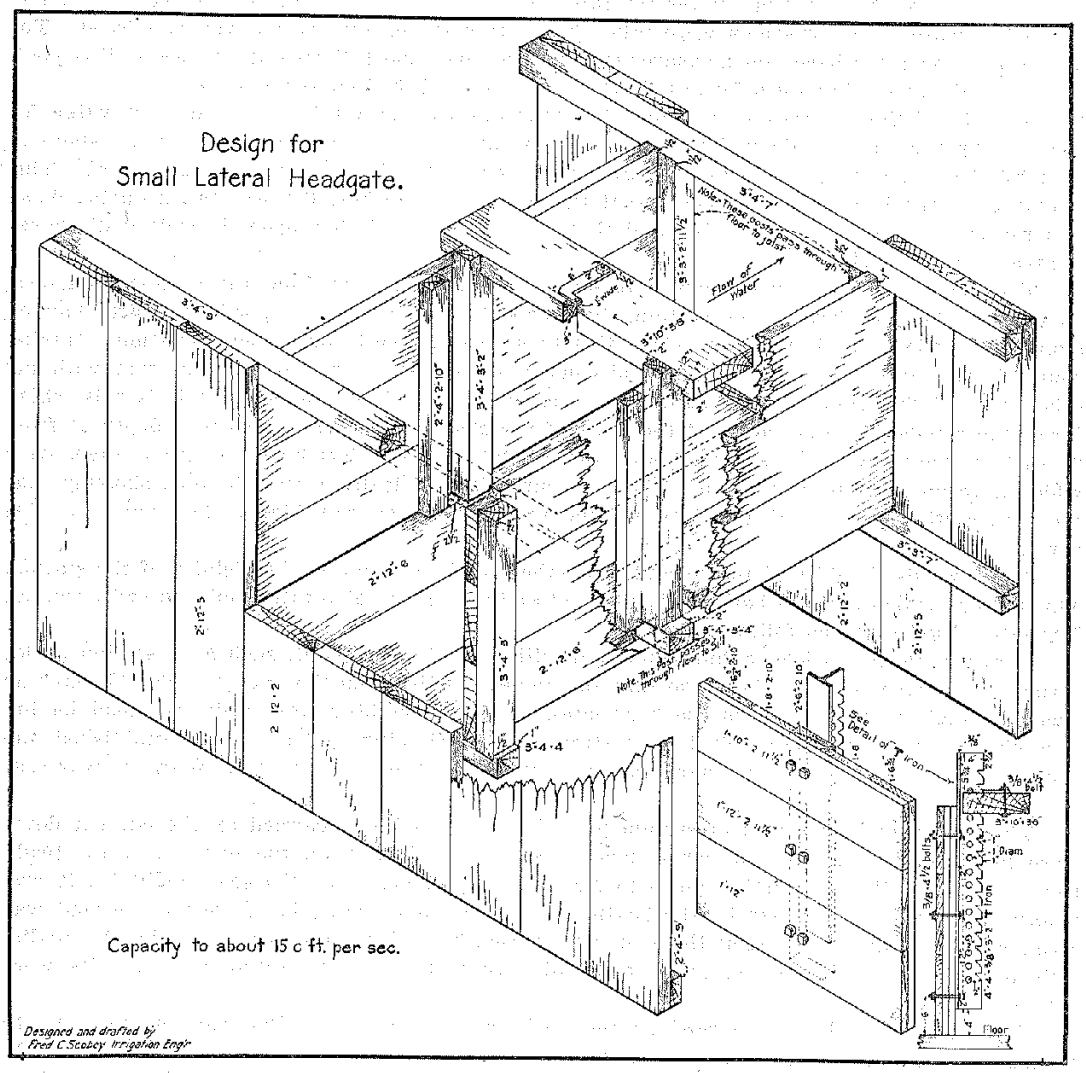
By FRED. C. SCOBEY.

(The author of the following letter has had much practical experience among the irrigators of Wyoming; it is therefore hoped that his recommendations upon simple headgate structures may be of some use to the water-users of British Columbia. The letter is written with a knowledge of British Columbia conditions.)

WASHINGTON, D.C., December 5th, 1912.

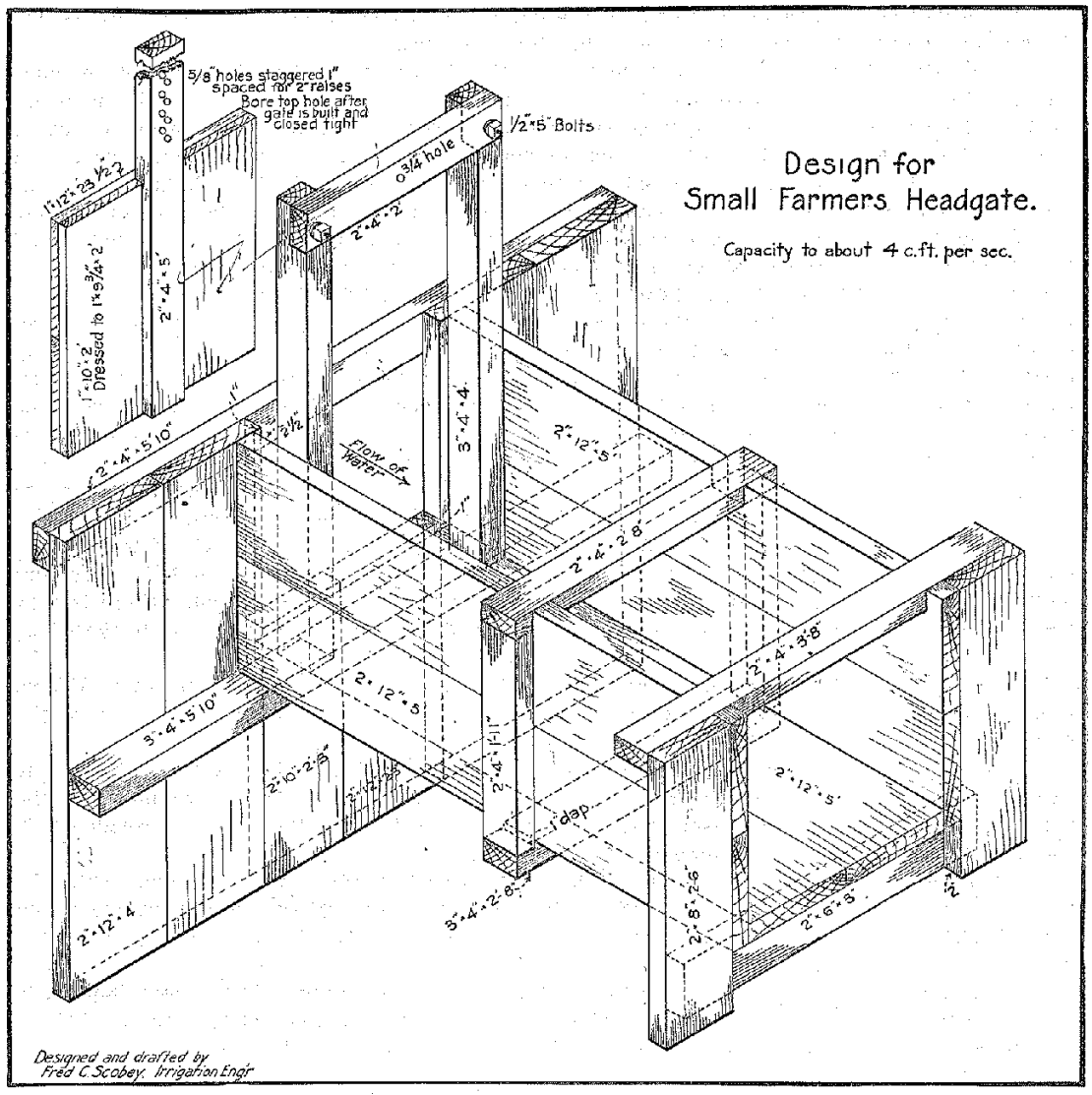
DEAR MR. GRUNSKY,—Regarding small lateral headgates and delivery-gates, Dr. Fortier tells me that your conditions are about the same as they are in Colorado and Wyoming, the canals taking water from mountain-streams which do not carry heavy silt except in times of flood.

I would not advise trying to embody a measuring-device directly in the gate structure, but would put a Cippoletti weir from 20 to 50 feet below the gate, in a straight channel, at a point where the velocity towards the gate can be reduced, either by baffle-boards or by widening the



ditch above the weir so as to form a pool. A measurement directly in the gate structure is only approximate, as there are so many conditions of velocity, contraction, eddies, etc., that the present data as expressed in formulæ derived from experiments are not based on the conditions usually found in a gate structure.

At points where small heads are to be delivered and it is desirable not to break the continuity of the canal-bank, I would suggest a tube of ordinary sewer-pipe with a small wood or iron gate. This type of gate is found in Bulletin 229 of the Office of Experiment Stations, United States Department of Agriculture, and is quite extensively used throughout northern Colorado.



It is best to make the wood or concrete face conform to the position the canal-bank will assume after some years of operation—that is, nearly vertical at the water-line, but with a flatter slope at the bottom. This is the general form that canal-banks assume after some years of operation, and after weeds and grass have grown on the tops of the levees.

I am enclosing plans of two styles of wooden gates. I have assumed that you would not want to install concrete in the beginning because of first cost. It is also probably better in a new country to put in wood, for the reason that the system ten years from now may demand the gates to be of a different size, or placed at far different points in the canals because of the changes in the plats of land. Wood will last for a period of from eight to twelve years, and by that time the operating department of any system can fully determine more exact data with which to install the permanent structures.

One of these plans covers a small farmer's or consumer's headgate, and will deliver up to about 4 second-feet in the farmer's ditch below the gate, under favourable conditions of grade

and size, and assuming that the water in the lateral leading to the gate is of such a depth that the gate-box can be kept full of water.

You will note that the two inside planks of the front wings extend inside of the inner face of the side walls 1 inch. This forms the front guides. Also the two planks in the front cut-off wall under the floor extend up in front of the floor-boards 1 inch. This will make a tighter gate.

There will be a tendency to disregard the dapping of timbers, but the added stiffness will more than repay for the few minutes necessary for this work.

I suggest that the holes in the stem be slightly staggered, so that there is not so much danger of the wood splitting out and the holes connecting up into a long slot. If the holes are made ⅝ inch in diameter, with their centre lines staggered 1 inch, and the hole in the cap at the top of the gate-guides be made ¾ inch in diameter, there will be play enough so that a ½-inch iron pin with a ring at one end can be inserted. If a lock is desired, the end of the pin can be punched for a thin-tongue padlock after the pin has been slightly flattened at the end.

The other plans show a box structure 3 feet wide and 3 feet high. A bill of lumber and iron is given for the gate as shown, and also for exactly the same kind of construction for a gate 4 feet wide and 3 feet high, and for a gate 4 feet wide and 4 feet high.

I would not recommend using the same construction for greater dimensions than those just mentioned, as the sills, posts, and caps should be made heavier, and the cut-off walls should extend farther down into the ground. A sandy soil may demand greater depth for the last-mentioned walls and wings than I have shown on the plans, even for the small structures. Such things as this must be decided for each case. In southern California this type of box is made of 1-inch redwood for the sides, bottom, and wings; but for your lumber I would not use any timber lighter than 2-inch stuff, as herein indicated, since it will be subject alternately to wetting and drying, and the 1-inch stuff will warp badly under these conditions.

A great deal of the general success of the gate structures shown in both of these plans depends on the dirt around it being well puddled in—that is, shovelled around the structure while water is at hand, so that the dirt may be well tamped into place as mud. There is very little danger of such a gate "going out," whereas if dry dirt is placed around the gate the whole box is liable to be washed out.

If you find that it is not convenient to make the stem for the lateral headgates of T-iron, then it may be made of angle-iron with almost the same degree of satisfaction, and you will find the cost of boring to be less than for a T-iron.

The advantage for this type of gate-lift is that the stem does not need to be double the length of the height of the gate-shutter, and also the guides do not need to extend twice the height of the shutter, for the reason that there are no holes through the shutter through which water will lead, and the gate is supported from behind.

The ditch-tender is furnished with a short iron crowbar, about 2½ feet long, which he inserts under the notches in the back of the iron gate-stem and raises the gate by prying on the foot-plank. As a rule, the gate can be lifted by hand, the bar being used only when the gate sticks.

I believe that this covers as much detail as is possible at long range. It is nearly impossible to standardize structures so that there will not be minor changes dictated by local conditions, and this must be borne in mind by any one building gates after standard plans.

Trusting this data will be of some service to you,

FRED. C. SCOBEY,
Irrigation Engineer in charge of U.S. Irrigation Investigations in the State of Wyoming.

FARMER'S HEADGATE. CAPACITY UP TO ABOUT 4 SECOND-FEET (DEPENDING ON GRADE AND CONDITION OF THE DITCH BELOW THE GATE).

Bill of Lumber.

Use.	Pieces.	Dimensions.	Feet, B.M.
Side boards	4	2″ x 12″ x 5′	40
Floor	2	2″ x 12″ x 5′	20
Front wings	4	2″ x 12″ x 4′	32
Front cut-off wall	1	2″ x 12″ x 2′ 3″	5
,, ,, ,,	1	2″ x 10″ x 2′ 3″	4
Cap	1	2″ x 4″ x 5′ 10″	4
Joist	1	3″ x 4″ x 5′ 10″	6
Gate-posts	2	3″ x 4″ x 4′	8
Cap for gate-posts	1	2″ x 4″ x 2′	1
Sill	1	3″ x 4″ x 2′ 8″	3
Cap	1	2″ x 4″ x 2′ 8″	2
Posts	2	2″ x 4″ x 1′ 11″	3
Lower wings	2	2″ x 12″ x 2′ 6″	10
Cut-off sill	1	2″ x 6″ x 3′	3
Cap	1	2″ x 4″ x 3′ 8″	3
Bolts	2	½″ x 6″	..
Gate-stem	1	2″ x 4″ x 5′	3
Gate-boards	2	1″ x 12″ x 23½″	4
,,	2	1″ x 10″ x 2′	4
		Total feet, B.M.....	155

Two bolts ½″ x 5″, with washers for each end.

HEADGATE FOR SMALL LATERAL. CAPACITY UP TO ABOUT 15 SECOND-FEET (DEPENDING ON GRADE AND CONDITION OF THE LATERAL BELOW GATE).

(As per Plans in Drawing. Bottom, 3 feet wide; sides, 3 feet high.)

Bill of Lumber.

Use.	Pieces.	Dimensions.	Feet, B.M.
Side boards	6	2″ x 12″ x 6′	72
Floor	3	2″ x 12″ x 6′	36
Front wings	6	2″ x 12″ x 5′	60
Front cut-off wall	3	2″ x 12″ x 2′	12
Joist	1	2″ x 4″ x 9′	6
Sill	1	3″ x 4″ x 4′	4
,,	1	3″ x 4″ x 3′ 4″	4
Posts	2	3″ x 4″ x 3′	6
Cap (front wings)	1	3″ x 4″ x 9′	9
Lower wings	4	2″ x 12″ x 5′	40
Lower cut-off wall	3	2″ x 12″ x 2′	12
Joist	1	3″ x 3″ x 7′	5
Posts	2	3″ x 3″ x 2′ 11½″	5
Cap	1	3″ x 4″ x 7′	7
Front guides	2	2″ x 4″ x 2′ 10″	4
Rear guides	2	3″ x 4″ x 3′ 2″	6
Foot-plank	1	3″ x 10″ x 3′ 8″	10
Gate-boards	1	1″ x 10″ x 2′ 11½″	3
,,	2	1″ x 12″ x 2′ 11½″	6
,,	2	1″ x 8″ x 2′ 10″	4
,,	2	1″ x 6¾″ x 2′ 10″	4
,,	1	2″ x 6″ x 2′ 10″	3
		Total feet, B.M.....	318

T-iron—One piece 4″ x 4″ x ⅜″ x 3′ 2″, bored as per detail.
Bolts—Seven ⅜″ x 4½″, with washers for each end.

HEADGATE FOR SMALL LATERAL. CAPACITY UP TO ABOUT 20 SECOND-FEET (DEPENDING ON GRADE AND CONDITION OF LATERAL BELOW GATE).

(As per Plans in Drawing, except 4 feet wide instead of 3 feet wide.)

Use.	Pieces.	Dimensions.	Feet, B.M.
Side boards	6	2″ x 12″ x 6′	72
Floor	4	2″ x 12″ x 6′	48
Front wings	6	2″ x 12″ x 5′	60
Front cut-off wall	4	2″ x 12″ x 2′	16
Joist	1	2″ x 4″ x 10′	7
Sill	1	3″ x 4″ x 5′	5
,,	1	3″ x 4″ x 4′ 4″	5
Posts	2	3″ x 4″ x 3′	6
Cap (front wings)	1	3″ x 4″ x 10′	10
Lower wings	4	2″ x 12″ x 5′	40
Lower cut-off wall	4	2″ x 12″ x 2′	16
Joist	1	3″ x 3″ x 8′	6
Posts	2	3″ x 3″ x 2′ 11½″	5
Cap (lower wings)	1	3″ x 4″ x 8′	8
Front guides	2	2″ x 4″ x 2′ 10″	4
Rear guides	2	3″ x 4″ x 3′ 2″	6
Foot-plank	1	3″ x 10″ x 4′ 8″	13
Gate-boards (front)	1	1″ x 10″ x 3′ 11½″	4
,, ,,	2	1″ x 12″ x 3′ 11½″	8
,, (back)	2	1″ x 10″ x 2′ 10″	5
,, ,,	2	1″ x 10¾″ x 2′ 10″	5
,, ,,	1	2″ x 6″ x 2′ 10″	3
		Total feet, B.M.	352

T-iron—One piece 4″ x 4″ x ⅜″ x 3′ 2″, bored as per detail.
Bolts—Seven ⅜″ x 4½″, with washers for each end.

HEADGATE FOR LATERAL. CAPACITY UP TO ABOUT 28 SECOND-FEET (DEPENDING ON GRADE AND CONDITION OF LATERAL BELOW GATE).

(As per Plans in Drawing, except 4 feet wide and 4 feet high instead of 3 feet wide and 3 feet high. Cut-off and wing walls 1 foot deeper).

Use.	Pieces.	Dimensions.	Feet, B.M.
Side boards	8	2″ x 12″ x 6′	96
Floor	4	2″ x 12″ x 6′	48
Front wings	6	2″ x 12″ x 7′	84
Front cut-off wall	4	2″ x 12″ x 3′	24
Joist	1	2″ x 4″ x 10′	7
Sill	1	3″ x 4″ x 5′	5
,,	1	3″ x 4″ x 4′ 4″	5
Posts	2	3″ x 4″ x 4′	8
Cap (front wings)	1	3″ x 4″ x 10′	10
Lower wings	4	2″ x 12″ x 7′	56
Lower cut-off wall	4	2″ x 12″ x 3′	24
Joist	1	3″ x 3″ x 8′	6
Posts	2	3″ x 3″ x 3′ 11½″	7
Cap (lower wings)	1	3″ x 4″ x 8′	8
Front guides	2	2″ x 4″ x 3′ 10″	5
Rear guides	2	3″ x 4″ x 4′ 2″	8
Foot-plank	1	3″ x 10″ x 4′ 8″	13
Gate-boards (front)	1	1″ x 10″ x 3′ 11½″	4
,, ,,	3	1″ x 12″ x 3′ 11½″	12
,, (back)	2	1″ x 10″ x 3′ 10″	7
,, ,,	2	1″ x 10¾″ x 3′ 10″	7
,, ,,	1	2″ x 6″ x 3′ 10″	4
		Total feet, B.M.	448

T-iron—One piece 4″ x 4″ x ⅜″ x 4′ 2″, bored as per detail (for additional foot).
Bolts—Seven ⅜″ x 4½″, with washers for each end.

WATERSHEDS OF BRITISH COLUMBIA.

THEIR CHARACTERISTICS AND POSSIBILITIES.

INTRODUCTION TO REPORTS OF ENGINEERS OF THE WATER RIGHTS BRANCH.

The field-work which has begun pursuant to the "Water Act" of 1909 in connection with the investigation of rights held under old records has now been carried into many of the more important drainage-basins of the Province, especially those south of the Railway Belt. The engineers conducting this field-work have collected a rich fund of information, much of which will be of interest to those desirous of becoming better acquainted with the physical geography of British Columbia.

Aside from the work of a purely technical character, such as the surveying of lands appurtenant to water records and the measurement of the flow of streams, the investigations have necessitated the gathering of many practical and interesting facts. It is these facts, particularly, which it has been the aim to collate in the reports of the engineers appearing in the following pages.

It should be noted that each report as originally filed was accompanied by such stream-measurements as were available. For the sake of the continuity in the description, this tabulated matter for all the districts has been grouped and printed separately at the end of the reports. A reference is given in each case, however, to the page on which the hydrographic data for the particular valley or drainage-basin will be found.

For convenience in reference the same arrangement has been adopted in all the reports, and is as follows:—

(1.) General physical characteristics:
(2.) Timber and vegetation:
(3.) Irrigated and irrigable areas:
(4.) Soil:
(5.) Temperature, precipitation, and altitude:
(6.) Utilization of stream-waters:
(7.) Nature of Surveys.

A question will be likely to arise in the minds of readers concerning the relation of the above topics to water administration. Yet there is not one that does not come either directly or indirectly within the scope of the preliminary work that is necessary before adjudications can be made under the Act of 1909. Long in advance of the time when the Board of Investigation is to have its sittings in any particular valley or district, the engineer is sent into the field and proceeds to gather the evidence which is to enable the Board to arrive at its judgment.

He must, of necessity, spend considerable time in one locality, and he is thus enabled to become thoroughly familiar with its physical features. His first work is usually to locate points of diversion. Frequently ditches are not yet constructed, and he must then follow the creeks and travel across the country beyond the beaten trails or roads. Likewise, in estimating irrigable areas, he must often penetrate a rough and timbered country with his lines.

He must also estimate the cost of clearing the land of its standing timber or stumpage, and must report upon the general slope and the smoothness or roughness of the surface. These facts are required in order to enable the Board to fix a time in which the owner of a water record, or licence, shall complete his works and bring his land under irrigation.

The soil must also be investigated by the engineer in respect of its physical properties to assist the Board in arriving at a proper duty of water. It is plain that a soil composed of a coarse, sandy loam, with a gravel subsoil, will require several times more water than a heavy clay soil with a hard-pan a few feet beneath the surface. Yet so frequent are the changes that the engineers often report three or four different grades of soil in a small valley.

The crops grown are to be reported upon. It is evident that in a district that is set out to orchards a higher duty of water (which is another way of saying a smaller quantity) will suffice than for lands planted to timothy and clover or alfalfa. Again, land which is planted to garden-truck and intensively cultivated will require more water than that upon which hay or grain is grown. While the latter crop receives one or two irrigations, the former is periodically watered throughout the season.

Precipitation is to be considered. It is important to know not only the annual rain and snowfall, but its distribution throughout the months of the year, and especially through the months when irrigation is practised. The object of this is to enable the Board to decide upon the quantity of irrigation-water which is needed to supplement the rainfall. This is especially important in a Province such as British Columbia, within the boundaries of which clearly defined belts are found, some of which are classed as "dry," others as "semi-arid," and still others as "humid."

Altitude and temperature data are not so closely connected with these investigations as the factors already mentioned, but such figures as were easily obtainable by the engineers have been included in the reports which follow, in order to complete the description. It is interesting to note that the valleys of British Columbia generally have a much lower altitude than those of the United States to the south, particularly Montana, Idaho, Oregon, Wyoming, and Colorado. Much agricultural development in these States takes place above the 3,000-foot elevation, while in British Columbia very little of the valley land reaches the 3,000-foot mark, and most of it is below the 2,000-foot elevation. It is thought that this difference, together with the nearness to the ocean, more than compensates, as far as agricultural possibilities are concerned, for the more northerly geographical position of British Columbia.

Perhaps the most important work of the engineer in connection with administration under the "Water Act" is the measurement of streams. In many instances the problem of the Board will be to divide the water equitably among claimants, and it cannot do this intelligently unless the flow of streams is ascertained. It is also necessary to have this information at hand when the question of granting a new right arises, since the Comptroller of Water Rights is not presumed to issue licences in excess of the capacity of the stream.

In reference to the utilization and conservation of the waters of the Province, the engineer has to play a part which will become more and more important as the years go by. In connection with his reports upon irrigation, power, mining, and other rights, he must determine whether the waters are used beneficially—that is to stay, without waste. This necessitates a study of the customs of water-users. For instance, in the case of irrigation, farmers may be using the continuous flow of many small streams, increasing the losses by seepage, evaporation, and other means, when by the system of rotation in the use of a larger stream the water could be greatly conserved. Such matters are bound to receive more attention in the near future when a shortage of water is generally felt and the people come to realize the necessity for public supervision in its use.

FIGURES ON IRRIGATION.

This is the first attempt, even in a vague way, to collect figures which will indicate the possibilities of the Province with respect to irrigated agriculture. The figures for land classed as irrigable are mere approximations, and being made by different engineers the personal equation enters the calculation to a certain extent. It is the opinion of the writer, however, that irrigable areas are more under- than over-estimated in a new country, and that, with few exceptions, the figures in the table in the column headed "Irrigable" will be found to be under the mark rather than above it.

IRRIGATED AND IRRIGABLE AREAS.

Name of Drainage-basins reviewed in Reports of Engineers.	Square Miles of Drainage-basins reviewed by Engineers.	Square Miles of same Drainage-basins to which Estimates apply.	Acres under Irrigation.	Acres in addition which are Irrigable.
Fraser River Valley in Railway Belt and Thompson Valley to Spence's Bridge	2,700	2,700	2,150	35,000*
Part of Thompson and Bonaparte Watersheds	710	710	2,899	8,200
Part of Nicola River Watershed	2,100	338	7,870	18,000
Part of Okanagan Watershed near Vernon	2,400	700	17,000	48,800
Part of Okanagan Watershed near Kelowna	750	400	9,682	30,000
Part of Okanagan Watershed west side of lake	1,000	1,000	6,875	54,100†
Part of Okanagan Watershed, Naramata to Boundary	800	600	4,274	37,800‡
Similkameen River Watershed in British Columbia	2,850	1,700	1,896	42,100§
Part of Kettle River Watershed	3,160	627	3,562	13,700
Arrow Lakes and part of Columbia River Watershed	3,560	378	2,331	3,700
Part of Kootenay River Watershed west of Selkirks	3,600	100	786‖	900‖
Slocan River Watershed	1,365	150	200‖	2,100‖
Part of Upper Columbia Watershed	1,500	1,500	1,041¶	148,000
Part of Kootenay River Watershed east of Selkirks and north of Wardner	3,410	2,500	5,455	215,400
Part of Kootenay River Watershed east of the Selkirks and south of Wardner	3,050	1,352	3,811	81,600
Totals	32,955	14,755	69,832	739,400

* Includes the Fraser Valley from Ruby Creek on the right bank and Jones Creek on the left bank to boundary of Railway Belt below Lillooet.
† Includes three Indian reserves (Nos. 1, 9, and 10) totalling 28,777 acres.
‡ Exclusive of west side of Okanagan River from Penticton to Okanagan Falls.
§ Only parts of irrigable land surveyed. Greater part estimated.
‖ These figures are not for comparison, as part only of the irrigable and irrigated lands were surveyed.
¶ This figure is not for comparison, as a part only of irrigated lands was surveyed.

The above figures apply to such drainage-basins or parts of drainage-basins only as were investigated by the engineers. The area of the entire Province has been estimated at 395,000 square miles. Approximately 50,000 square miles of the above total lie within or south of the Railway Belt, and up to date the investigations of the Water Rights Branch have been confined to this section. The territory embraced within the descriptions of the watersheds, which are to follow, has an area of about 33,000 square miles. Not even this latter area has been sufficiently covered by the engineers to enable them to give figures for all of it. In short, the above figures and estimates apply only to about 14,755 square miles, or less than 4 per cent. of the entire area of the Province.

It may be suggested by some that the area already investigated is the best part of British Columbia. However that may be, it is at the present time the most settled part, excluding the large cities of the Coast District. On another page is found an article by Dr. S. Fortier, of the United States Department of Agriculture, who, looking at the subject from an entirely different point of view, leads us to have confidence in "irrigation's part in the future upbuilding of British Columbia." The figures given above will, it is hoped, be an additional argument in support of the theme which Dr. Fortier has chosen.

PHYSICAL FEATURES AFFECTING IRRIGATION.

While this Province, with its wonderful combination of rivers, lakes, timber-covered mountains, and sheltered valleys, offers rare inducements to a highly desirable class of settlers, there are factors to be reckoned with here which make it exceedingly difficult to launch irrigation enterprises. The very rugged and broken character of the country, which is an asset from

a scenic point of view, renders the building of canals and other irrigation structures more expensive. The fact that the valleys are small means that fewer acres of land can be served from any one system, and each acre must bear a larger proportion of expense in first cost and also in maintenance and operation charges.

The principal obstacle, however, to the rapid extension of agricultural and irrigated areas is the timber-growth. It would probably not be far out of the way to estimate the clearing and levelling of the average raw land in British Columbia to make it suitable for farming purposes at $70 per acre. The removal of this growth constitutes one of the hardest tasks ahead of the people of the Province, and one of the most pressing problems for the attention of the administration. The clearing process, undertaken in the ordinary way, is a slow one, and even in those instances where tracts have been sold in subdivisions and occupied by settlers only a beginning has been made. The average settler clears only a few acres a year.

Therefore, while the soil is rich, the water-supply for the most part abundant, and the climate of the valleys generally suitable for the production of fruit, berries, and garden-truck of a wide range, a little patience is needed on the part of the people of British Columbia to see their Province reach the high position agriculturally which will one day be attained

H. W. GRUNSKY.

REPORT ON PART OF WATERSHEDS OF FRASER AND THOMPSON RIVERS.

December 30th, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—Pursuant to instructions received, I beg to submit herewith a report on the watershed of that portion of the Fraser River lying within the Railway Belt, together with part of the watershed of the Thompson River, from Spence's Bridge to the junction with the Fraser River, investigated by me during the past season.

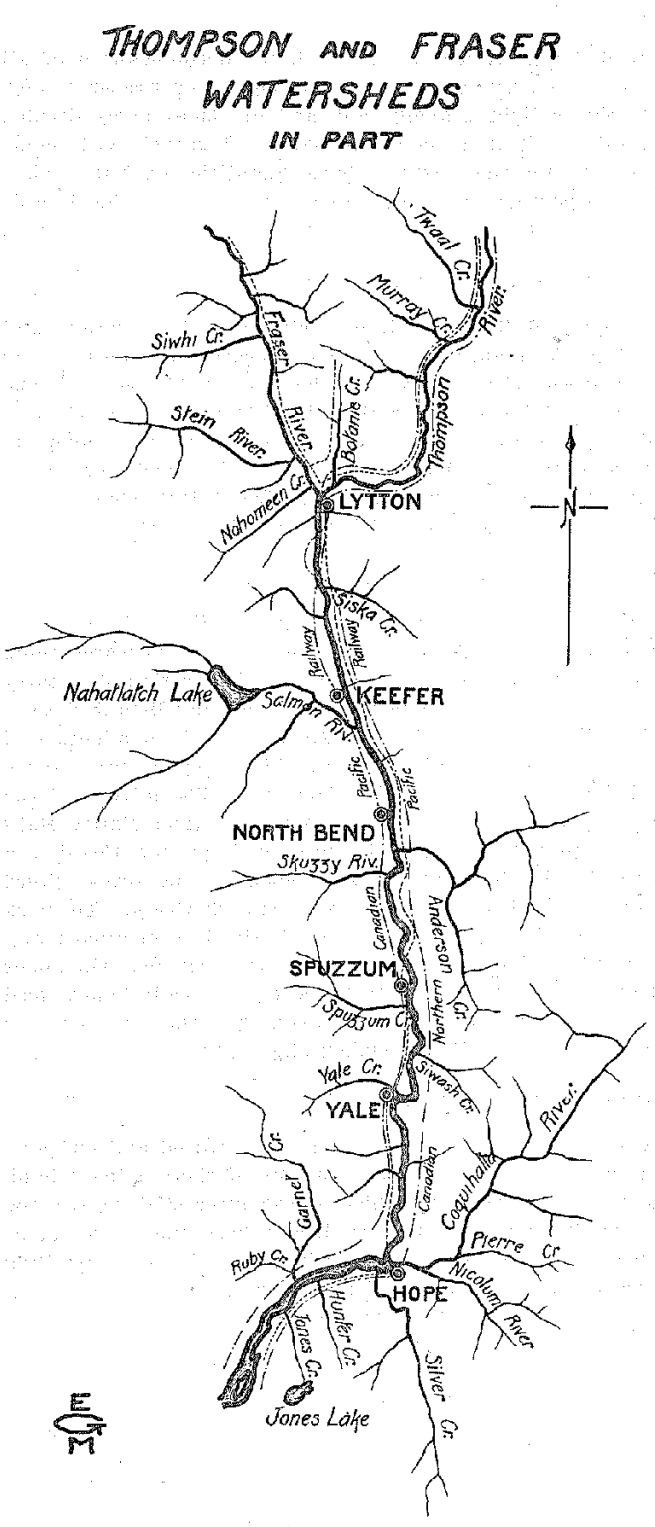
GENERAL PHYSICAL CHARACTERISTICS.

The section of country under review lies wholly within what is known as the Railway Belt, and comprises an area of approximately 2,700 square miles. The greater part of this country is very mountainous, particularly that portion from the Town of Hope northwards to Lytton. The canyon of the Fraser River begins at Yale, which was the head of navigation in the old gold-mining days, and continues without a break to Cisco, a point five miles south of Lytton. There are numerous streams tributary to the Fraser River; the larger and more important being, on the left bank, Jones Creek, Silver Creek, and the Coquihalla River, the drainage-basins of which, together with sundry smaller streams, constitute what is known as the Hope Water Precinct. Farther north there is the Anderson River, in the Siwash Water Precinct. This stream is practically unexplored, even mining prospectors leaving it very much alone. North of this there are numerous small tributaries to the Fraser River, until at Lytton we have the Thompson River, this being the largest of the tributaries.

On the right bank of the Fraser River there are even a larger number of tributaries. Commencing with Ruby Creek in the south, we have Emory Creek, Texas Bar Creek, Yale Creek, with the old mining town of Yale on the right bank, forming the Ruby Water Precinct. Then Spuzzum Creek and Skuzzy Creek, forming the Spuzzum Water Precinct. Then we come to the Salmon or Nahatlatch River, a large stream with a drainage-basin of approximately 144 square miles. This, with a few smaller streams, forms the Keefers Water Precinct. North of this we have the Stein River, forming, with sundry smaller streams, the Stein Water Precinct.

There are no wide valleys in any of the country so far mentioned, except up Silver Creek and the Coquihalla River. The former has an extensive tract of valley land, some 15,000 to 20,000 acres being land that one day will no doubt be used for agricultural purposes. The upper valleys of the Coquihalla are even more extensive, some estimates placing the future agricultural land at about 30,000 acres. Apart from this, there are extensive flats on the banks of the Fraser

River from Hope south and west to Jones Creek and Ruby Creek. North of Hope there are no valleys or benches worth mentioning until the Thompson River is crossed, and in the Botanie Water Precinct there are numerous valleys and benches.



From Hope there are high mountains on both sides of the Fraser River. Through the canyon these mountains rise from the water to 5,000 and 7,000 feet. The Stein Mountains are 8,000 and 9,000 feet; the Stein River and some of the other streams are glacier-fed all the year through.

TIMBER AND VEGETATION.

The character of the timber and vegetation varies greatly throughout the district. Both Hope and Ruby Water Precincts have large areas of valuable timber, principally fir, cedar, spruce, tamarac, pine, and hemlock. The lower flats on the banks of the Fraser River are densely covered with bush of all kinds. To the north this changes, and there is very little timber of market value through the canyon. The Salmon River is on exception to this, there being some very fine timber around Nahatlatch Lake and up some of the branches to the stream. Above Cisco the hills are covered with small black-pine.

IRRIGATED AND IRRIGABLE AREAS.

Little has been done in the way of irrigation in this district. In the lower portion the expense of clearing the heavy timber and thick bush, together with the lack of transportation facilities, no doubt was the chief factor in the want of enterprise and lack of development shown by the settlers. Below Hope not much irrigation-water is required and very little is used at present. When the land is cleared, water will be needed more and used to a greater extent. Throughout the whole country under review there is a little over 2,150 acres now under irrigation. Additional to this, and including the Indian reserves, some 35,000 acres of land can be classed as irrigable. This does not include Crown lands. Apart from the valleys of the Coquihalla River and Silver Creek previously mentioned, there is about

7,200 acres of good land, chiefly in the Botanie Water Precinct, available for homesteading. This land is of no value at present owing to lack of water for irrigation. Conservation of water in some of the mountain lakes will open up some thousands of acres of good land.

SOIL.

The soil also varies throughout the district. A heavy, rich soil, the decomposition of all kinds of vegetation for countless years past, is prevalent throughout the Lower Fraser Valley, in Hope and Ruby Precincts. North of this a light gravelly soil, and in places finely divided volcanic ash, is generally found, underlaid by alternate layers of sand and gravel, with sometimes a subsoil of clay. This kind of soil means the waste of large quantities of water when open ditches are used for irrigation. This is particularly the case with the creeks in the Botanie Water Precinct, where the waste of water through seepage has been a constant source of trouble.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

The lower portion of the district, Hope and Ruby, is similar with regard to climate and precipitation to the Coast Country. At Hope the highest registered temperature during the year 1910 was 105 degrees and the lowest 2 degrees, with a mean for the year of 47 degrees. The total precipitation for the same period was 53.37 inches. The altitude of Hope Town is 150 feet above sea-level. A radical change in climate is apparent from Cisco up the river, and a complete change in the character of the vegetation is noticed. The winters are colder, spells of below-zero weather being usual. Summers generally are warm and dry. The C.P.R. elevation at Lytton is 695 feet above sea-level. The mountains in the neighbourhood rise to 9,000 feet.

UTILIZATION OF STREAM-WATERS.

With regard to the utilization of stream-waters, this lies in the future. Up to date a little irrigation is being indulged in, as previously mentioned, but in no other manner is water being used. From close study during the past season, I am of the opinion that this section of country under review will experience considerable mining development in the not-far-distant future. The mountains bordering and the creeks tributary to the Fraser River are rich in minerals of all kinds. Particularly is this the case on the left bank of the river. Little beyond prospecting has been done up to date, because of the lack of transportation facilities. The advent of the Canadian Northern Pacific Railway, coming down the left bank, the Kettle River Valley Railway, and the Victoria, Vancouver and Eastern Railway, both building down the Coquihalla River from the Similkameen, will mean the development of many good mining propositions. This is particularly the case in the neighbourhood of Hope, and also Siwash Creek. To work the mines, cheap electric power will be required; and this could be obtained from almost any of the tributaries to the Fraser River mentioned in the early part of this review. On Jones Creek, the Coquihalla River, and Salmon River private corporations have already commenced investigations with a view to using the water for power purposes. Apart from the three streams mentioned, there is much valuable water-power lying idle throughout the district.

NATURE OF SURVEYS, ETC.

During the past season my work was confined to the determining of irrigated and irrigable areas under existing water rights. This was obtained by stadia traverse of the dominant land. I did no stream-gauging, because almost all the creeks in which I was interested were being examined and regularly gauged by the Dominion Government Hydrographers, under Mr. P. A. Carson, of Kamloops. I confined my measurements to the various irrigation-ditches, installing weirs and taking regular readings to ascertain the capacity of the ditches, and also to obtain an idea as to the amount of water used by the different irrigators. The data in the table on pages 106 and 107 was supplied by the Dominion Hydrographers.

INDIAN RESERVES.

Before closing this review, I would like to say a word about the Indian reserves throughout my district. Through the Fraser Valley from Hope to a point about twenty miles north of Lytton, and including the Botanie Water Precincts, 19,483 acres are held by the Indians as

reserves. A large number of these reserves are quite small in area, 10 to 40 acres being common. In many cases no Indians are living on the reserves, and they are not even used for summer camps for fishing. In almost all cases they are blocking the development of land that, if held by whites, would be equal to the best in the Province. In the neighbourhood of Lytton, in both the Stein and Botanie Precincts, a little irrigation is indulged in by the Indians. But, taking into consideration the thousands of acres held by them in these precincts, all first-class land, and the fact that in the Stein Precinct there is an abundance of water, the area they have under cultivation amounts to very little.

I have, etc.,

P. DE LAUTOUR,
Engineer, Water Rights Branch.

PART OF THOMPSON AND BONAPARTE WATERSHEDS.

December 23rd, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—In compliance with your request, I beg to submit the following report on hydrographic surveys made in the watershed of the Thompson and Bonaparte Rivers during the seasons of 1911 and 1912.

GENERAL PHYSICAL CHARACTERISTICS.

The area included in these surveys extends on the north to Scotty Creek, on the south to Spence's Bridge, on the east to the Thompson and Bonaparte Rivers (taking in Semlin Valley as far as Eight-mile Creek), and on the west to Hat Creek and its tributaries, and contains approximately 632 square miles. This district is characterized by a combination of mountains, high table-lands or benches, valleys, and streams. The mountains and benches have a good growth of timber, chiefly fir and pine, but there is no undergrowth on these parts, and the native grasses therefore grow luxuriantly and afford good pasturage for numerous herds of cattle. The benches are as a rule comparatively level, sloping gently to the streams, and could be irrigated and made very productive, the cost being governed by the length of the canal required.

The principal streams watering these valleys are briefly described in turn.

Bonaparte River runs through a long and well-settled valley, and contains sufficient water to supply all the land in its valley, flowing into the Thompson River at Ashcroft.*

Hat Creek rises in Blue Earth Lake in the mountains at an elevation of 5,000 feet, and after a course of thirty-five miles flows into Bonaparte River. There are many fine bench lands on this creek, but none as yet occupied. The cost of irrigating them would, of course, be greater than that of the valleys, but certainly not prohibitive.

Cache Creek rises in the Arrowstone Hills at an elevation of 3,500 feet, and flows into the Thompson River after a course of about twelve miles. It is from this creek that Semlin Valley is watered.

Oregon Jack Creek rises in the mountains, and after a course of twelve miles flows into the Thompson. There are some fine benches on this creek covered with a fine growth of timber, chiefly fir, but all this bench land is enclosed in the Dominion Forest Reserve. The banks of this creek, as well as those of the others mentioned, are thickly fringed with willows and poplars. The waters of this creek are used upon land lying adjacent to the Thompson River, principally upon a large and well-cultivated ranch, known as the Basque Ranch, on which very fine crops of potatoes are raised.

---

* There has not been sufficient work done in the Valley of Bonaparte River, briefly alluded to above, to enable me to give a comprehensive description; also much of the land watered by Hat Creek, Cache Creek, and Scotty Creek lies in the Bonaparte Valley; but there is a large and important area of land still to be hydrographically surveyed. The river rises in Bonaparte Lake, and after a course of seventy miles falls into the Thompson River at Ashcroft.

Cornwall Creek and Eight-mile Creek, two small creeks flowing into the Thompson River, contain no bench lands of any extent. The water of these creeks is used for irrigation only. There is not sufficient water in Eight-mile Creek to irrigate the land dependent upon it. There are, however, two very good storage-basins in Semlin Lake and Cultus Lake where a large body of water might be stored.

Scotty Creek, flowing into the Bonaparte, and Venables Creek, flowing into the Thompson, both take their course through narrow gorges in the mountains and water the lands in their respective valleys. They have no benches of any account. In Venables Lake will be found a fine storage-basin in which a very considerable quantity of water can be stored.

The chief characteristic of all these creeks consists in the great fluctuations of their waters, falling from a torrent in the spring to a very low condition in midsummer. They are also liable to sudden and considerable rises in the summer, due to rain-storms in the mountains, in which they originate. The valleys are generally narrow, averaging from one to three miles in width.

TIMBER AND VEGETATION.

The benches and hills are covered with a fine growth of timber, chiefly fir and pine. The cost of clearing would be light, as the trees are far apart, with no undergrowth, and with many open glades. Where there are no trees sage-brush is generally found, and on all the ranges there is a luxuriant growth of bunch-grass, upon which large herds of cattle find pasture.

SOIL.

The valleys are all very fertile, the soil being a sandy loam and capable of producing almost any vegetable, fruit, or grain that can be grown in a temperate climate. By some of the settlers very fine fruit is raised; noticeably by Mr. Semlin in the Semlin Valley, and Mr. P. Parke in the Bonaparte Valley. Mr. Semlin has raised this season some of the finest apples and plums, and those raised by Mr. P. Parke would compare favourably with any fruit on this continent. He also produces large quantities of pure white honey. In the Semlin Valley were observed also splendid crops of potatoes, beans, and oats. In fact, all these valleys are fit to produce all kinds of crops, of cereals, vegetables, and fruits. It must be noted, however, that the settlers in these valleys are not farmers, but cattlemen, and their chief aim is to produce sufficient feed for their cattle during the winter. The chief crops of all these valleys are, therefore, timothy, alfalfa, clover, and oats, all of which grow luxuriantly.

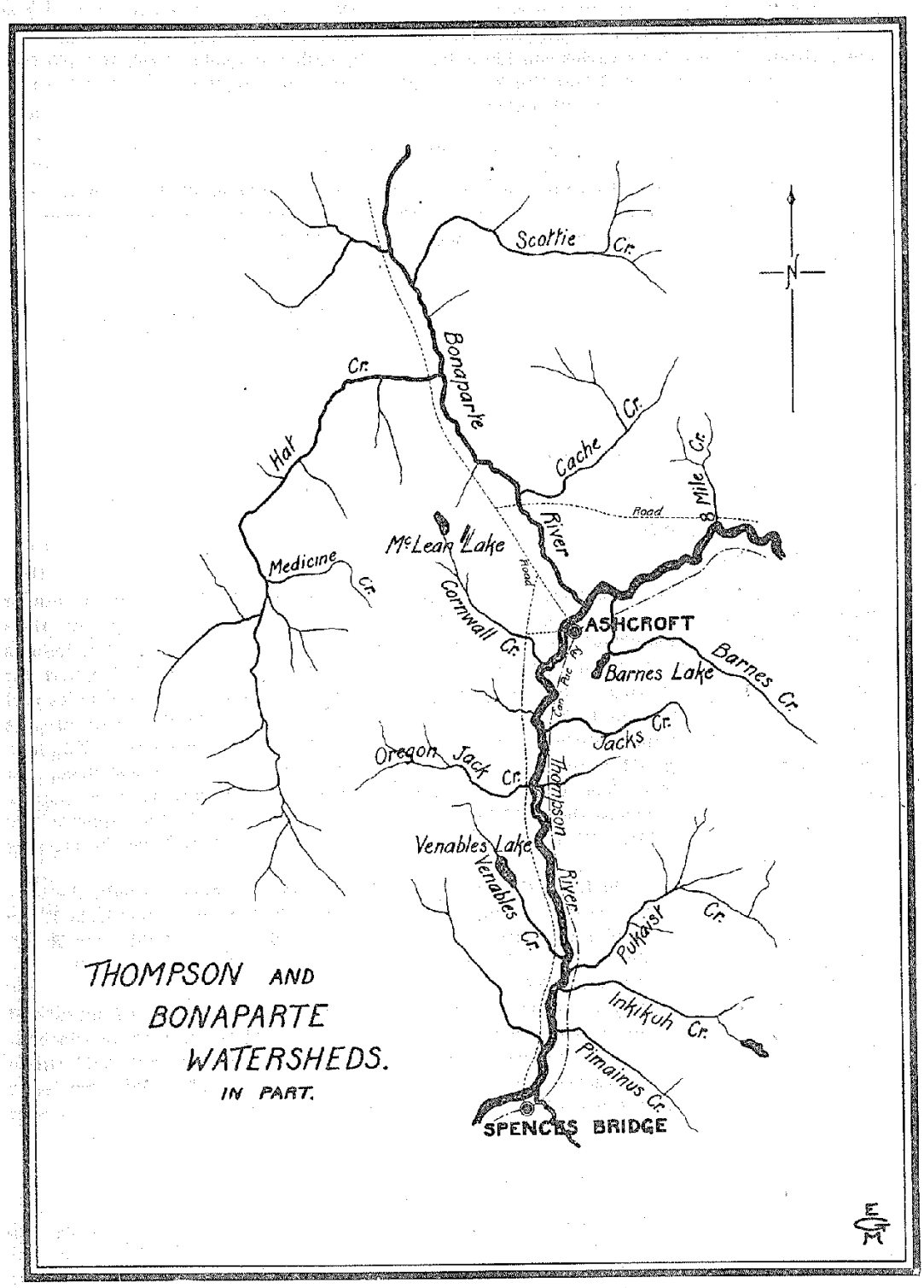
IRRIGATED AND IRRIGABLE AREAS.

The following table may be found useful in giving irrigated and irrigable areas in the various valleys investigated, also the approximate irrigable acreage on the benches, as well as the length of streams and area drained in square miles:—

Stream.	Length, Miles.	Irrigated Area, Acres.	Irrigable Area, Acres.	Irrigable Benches, Approximate.	Drainage-area, Square Miles.
Hat Creek	35	1,184	2,132	1,000	330
Oregon Jack Creek....	12	335	1,476	490	50
Cache Creek	12	895	1,345	240	96
Cornwall Creek	8	136	416	220	93
Eight-mile Creek	6	105	168	100	43
Venables Creek	6	169	230	200	20
Scotty Creek	14	75	183	...	78

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

The temperature of these valleys is very even and varies very little in the summer, and the same may be said of the winter temperature, although there is generally a week or ten days in the summer of extensive heat, and likewise in winter we have a week or two of extreme cold, going down to 20 or 25 below zero, Fahrenheit. In the summer the nights are cool, and the dry, bracing air makes the heat bearable even in the hottest time. The precipitation in the lowlands


Scottie Cr.
N
Bonaparte
Cr.
Hat
Cr.
Cache
Cr.
8 Mile
Cr.
Road
River
McLean Lake
Medicine
Cr.
Road
Cornwall Cr.
ASHCROFT
Barnes Lake
Barnes Cr.
Jacks Cr.
Oregon Jack Cr.
Thompson
River
Venables Lake
Venables
Cr.
Pukaist
Cr.
Inkikuh Cr.
Pimainus Cr.
SPENCES BRIDGE
THOMPSON AND
BONAPARTE
WATERSHEDS.
IN PART.

is very light, generally only a few light showers falling in the spring. The dewfall is also very light, being hardly perceptible; but the snowfall is generally heavy, varying from 1 to 3 feet in depth, according to the altitude. The rainfall on the higher ranges is steady and plentiful.

The altitude of the valleys varies considerably. Semlin Valley at Cache Creek is 1,480 feet, Cornwall Valley is 1,560 feet, and Hat Creek Valley at its junction with Bonaparte is 1,900 feet, and rises to 3,000 feet near Blue Earth Lake.

NATURE OF SURVEYS.

The Dominion engineers had set up gauges and taken measurements on all the above streams, and being instructed not to duplicate any of their work, I therefore took very few measurements of streams, devoting my attention chiefly to the measurement of irrigation-ditches. Such stream-measurements as were made will be found on page 107 in convenient form for reference.

I have, etc.,

W. R. PILSWORTH, M.Can.Soc.C.E.,
Engineer, Water Rights Branch.

NICOLA RIVER WATERSHED.

December 23rd, 1912.

Comptroller of Water Rights,
Victoria, B.C.

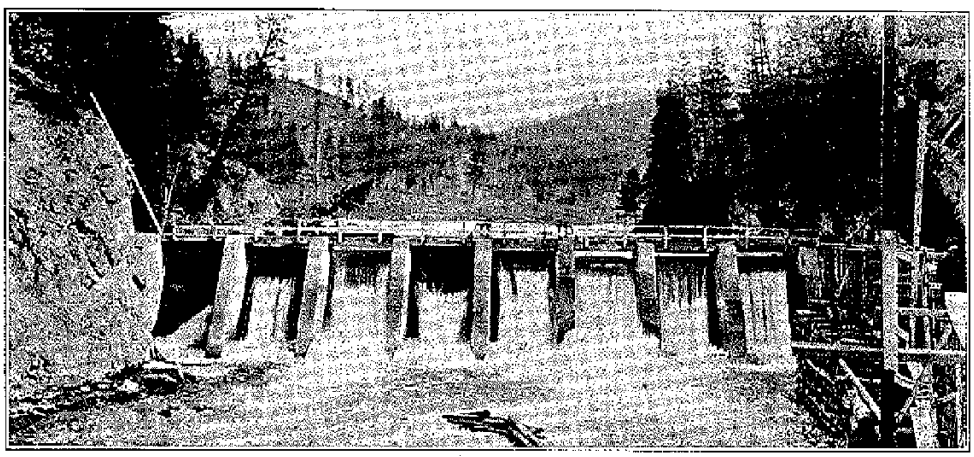
SIR,—Pursuant to instructions, I take pleasure in submitting the following report concerning the Nicola River Watershed. The Nicola River rises on the west slope of the Okanagan Hills and drains some 2,100 square miles of country between there and Spence's Bridge, where it joins the Thompson River. The drainage-basin divides easily into two sections, which I will refer to as the upper and lower basins. The upper basin has an area of about 940 square miles and ranges in elevation from 2,100 to 4,500 feet. The principal streams rising in this basin are the Upper Nicola River, Moore and Quilchena Creeks, all of which flow into Nicola Lake. The lake is about thirteen miles long and more than a mile across at its widest part, with a surface area of approximately 6,900 acres. The valleys are generally narrow, averaging from a quarter to half a mile wide, except where they widen to one and a half or two miles on approaching the lake; the benches are wide, with gentle slopes, but generally lie too far above the streams for simple irrigating.

Considering the size of Nicola Lake, the area of arable land on its shores is small, the hills rising abruptly from the shore almost all round. In the lower basin I include the Nicola River as it emerges from the lake, and its tributaries, the chief of which are the Coldwater River, Clapperton, Guichon, and Spius Creeks. These streams drain about 1,100 square miles, the elevations ranging between 1,600 and 5,500 feet.

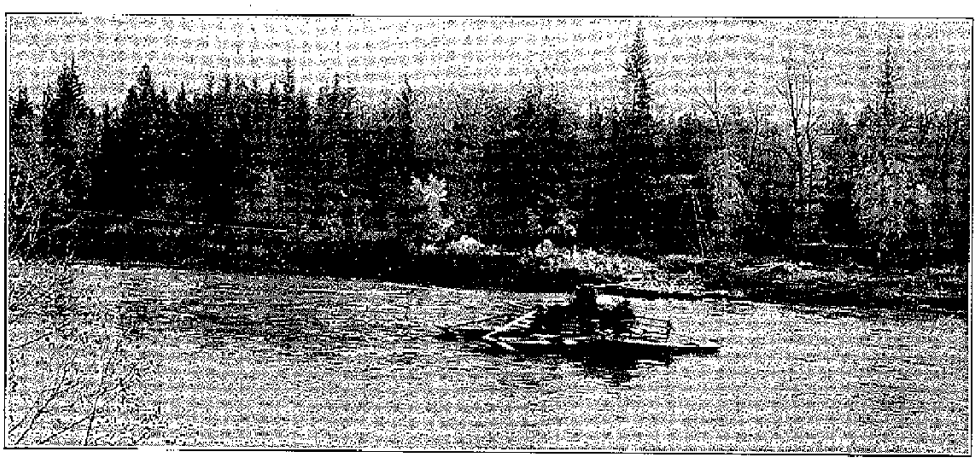
Leaving the lake, the valley opens to a width of from one to one and a half miles and continues so for about eight miles, then from a half to one mile would be an average width as far as Spius Creek. After this point the valley narrows down to from a quarter to half a mile wide, the greater portion being reserved for Indians. From the mouth of the Coldwater River to Spius Creek there is an absence of bench lands, the hills rising directly from the river meadows on either side. A branch of the C.P.R. runs through the valley from Spence's Bridge to Nicola.

TIMBER AND VEGETATION.

The upper basin may be described as a series of open rolling hills covered with bunch-grass and patches of sage-brush. The bottom lands are overgrown with willows and cottonwood, and occasionally scattered pine and fir trees are seen on the hills. Part of the lower basin is similar to the above, but the Coldwater slopes are well wooded in parts, and on Spius Creek extensive logging operations are going on. There is not much marketable timber on Guichon Creek, but the black-pine is thick in parts. The bottom lands are covered with willows and bushes.



Concrete Dam holding water for floating logs, C.P.R. Sawmill, Bull River, near Wardner.



Ferry across Kootenay River, near Gateway.

Wheat grown on irrigated land at Coutlee, Nicola Valley, B.C.

IRRIGATED AND IRRIGABLE AREAS.

The following table shows the irrigable area for which water is recorded and the proportion of this that is under irrigation. The fourth column is a rough estimate of the additional area that could be irrigated under properly constructed works:—

Name of Stream.	Irrigated Land, Acres.	Irrigable under Water Rights, Acres.	Estimated Additional Area that could be irrigated.	Remarks.
Nicola River	3,712	6,643	1,500	From Nicola to mouth of Spius Creek.
Spius, Manning, Roberts, Richardson, Smith, and Gordon Creeks, small tributaries to Nicola River	188	896	700	Small mountain creeks tributaries of Nicola River.
Clapperton Creek	1,403	3,240	1,000	
Coldwater River north of Voght Creek	960	2,234	700	
Courtney Lake, Gody Creek, and adjacent mountain lakes	107	285	700	
Upper Nicola River	600	850	2,000	At lake end only, Guichon Ranch and Residence.
Quilchena Creek	900	1,430	1,000	
Moore Creek	...	2,660	...	Beaver Ranch Co. only.
Totals	7,870	18,238	7,600	

The predominant soil throughout the valley is a sandy loam, although in the timbered sections a decayed vegetable soil is frequent, and heavy loams and clay are found in places. The subsoil is generally gravel. The quick run-off in the spring has brought down big deposits of sand and gravel to the lower lands.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

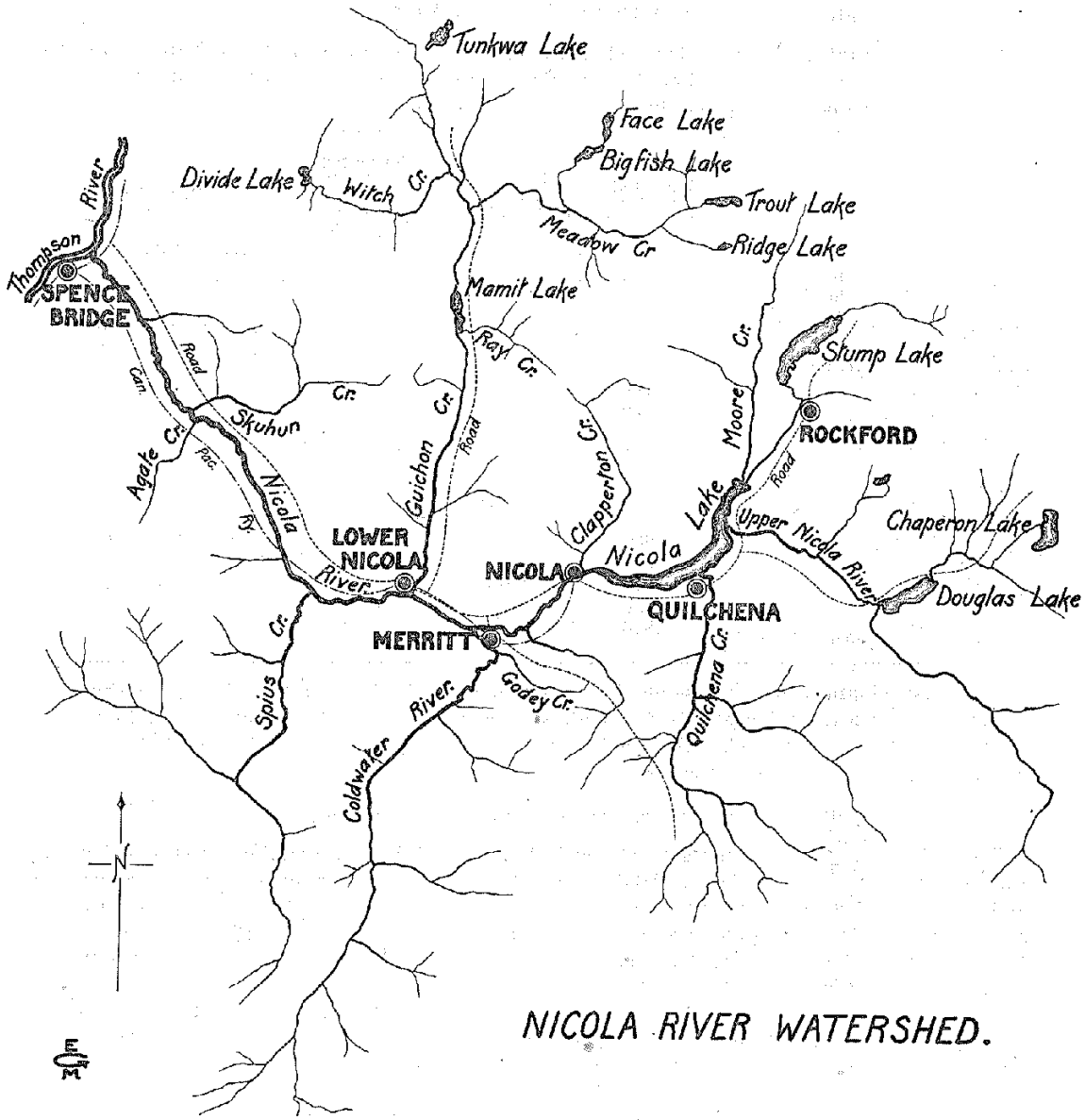
The highest temperature on record at Nicola Lake is 92.5 degrees, and the lowest —36 degrees, the mean annual temperature being 42.6 degrees. An average summer temperature in the valleys would be about 75 degrees and the winter about 5 degrees, with occasional dips to —20 or 25 degrees. In the higher altitudes the winter is more severe, and generally the stock have to be fed for three months in winter. Average monthly and annual precipitation figures for Nicola Lake covering the years from 1878 to 1912 are as follows:—

Precipitation average, 1878 to 1912 (computed from Readings supplied by E. Baynes Reed, Esq.).—January, 1.24; February, 0.70; March, 0.65; April, 0.47; May, 1.13; June, 1.30; July, 0.94; August, 0.84; September, 0.95; October, 0.79; November, 1.09; December, 1.04. Annual, 11.14.

Like the temperature, these figures on precipitation would differ in the higher lands, which range up to 5,500 feet. At present no data are available for these lands. The absence of forest-growth in the upper basin tends to a quick run-off with the melting snow. The elevation of Nicola Lake is 2,120 feet.

UTILIZATION OF STREAM-WATERS.

The land in the lower main valley and on the border of Nicola Lake is well suited to mixed farming. Hay, clover, alfalfa, cereals, vegetables, Indian corn, and apples have been successfully grown. The soil is well suited to fruit-growing, although in a few instances only has an attempt been made to grow apples for home use. There seems to be no reason why the hardier varieties should not do well. The Upper Country is open and well suited to stock-raising. The Douglas Lake Cattle Company farms and grazes more than 110,000 acres, and several other large stock-ranchers operate in these valleys. Hay, oats, etc., supplying winter food for stock, are the only crops raised in the Upper Country. The irrigation methods practised throughout the valley are not those that lead to great success. The water is carelessly handled and a good deal is wasted, and some excellent lands are soured by overirrigation. The valleys have an ample



water-supply, but as the land becomes more thickly settled conservation will be necessary. As above mentioned, there is a quick-run off, so that the water gets away early in the year, before it is really wanted. No storage-works being constructed on the principal streams, the ranchers have nothing in reserve when the creeks dry out. Land-values are still comparatively low in the Nicola Valley, and it is worth the consideration of intending settlers.

NATURE OF SURVEYS.

Mr. de Lautour took the first party into this valley in June, 1911, the season's work being devoted to the investigation of water records and the division of irrigable and irrigated lands. Similar work was continued this year from June till September. During the latter month gauges and metering-stations were established on the Nicola River, Clapperton, Shooter, and Quilchena Creeks. The work was closed down at the end of September. All available hydrographic data for this watershed is given on pages 107 and 108.

I have, etc.,

J. F. ROWLANDS,

Engineer, Water Rights Branch.

OKANAGAN WATERSHED NEAR VERNON.

December 30th, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I beg to submit a report on hydrographic work done in the vicinity of Vernon in the years 1910, 1911, and 1912, together with a brief description of the watershed.

GENERAL PHYSICAL CHARACTERISTICS.

Vernon is 1,300 feet above sea-level and is situated about four miles from the Okanagan Lake, at the confluence of several valleys. North and south-west runs the Okanagan Valley, eastward the Coldstream Valley, and to the north-east is the valley of the B.X. or Deep Creek. These valleys contain only small creeks, which are used for irrigation to their utmost capacity at certain periods of the year. The population of Vernon is about 3,000, with 1,000 more in its immediate vicinity. Ten miles north of Vernon the southern boundary of the Railway Belt crosses the Okanagan Valley. The hydrographic surveys of the Province have not, however, been extended to that part of the Railway Belt. The district generally consists of high plateaux, 4,000 to 5,000 feet above sea-level, intersected by steep-sided valleys, in which are numerous lakes. The creeks rise in the plateaux and feed the lakes.

The principal creek is that on the east. It rises in the plateaux on the north-east, and, running in a southerly direction as Nelson Creek, changes its name on reaching the main valley to the Coldstream Creek, and flows into the north end of Long or Kalamalka Lake three miles from Vernon. On leaving Long Lake, it is known as Long Lake Creek, and passing through Vernon it flows into Okanagan Lake at its East Arm, with an approximate length of twenty miles. There is no cultivation on this stream above where it enters the main or Coldstream Valley. From there westward the valley is about a mile and a half wide, with steep, uncultivated sides of bunch-grass and cleared and cultivated bottom land. The Coldstream Creek is joined on the south by Bessette, Brewer, Larch, and Deer Creeks, and on the north by Hog Gulch Creek and Swan Lake Creek.

On the north-east of Vernon the B.X. or Deep Creek rises on the same plateaux as the Coldstream Creek, and flows in a south-westerly direction into Swan Lake. From Swan Lake it is known as Swan Lake Creek, which joins Long Lake Creek below the town. It has a total length of about fourteen miles. Swan Lake Creek is joined on the north by Deer Creek and on the south by Brookside Creek. It runs in a deep narrow valley until within two miles of Vernon, the sides clothed in heavy brush, and with very little cultivated land. Its waters are used to irrigate the B.X. bench on the north-east of the city. The canal of the White Valley Irrigation Company, known as the Grey Canal, also brings water for use upon the land covered by the above-mentioned creeks. This will be referred to again.

From Nelson Creek eastwards the Coldstream Valley is continued as the White Valley, with a fall to the east. At the Town of Lumby, sixteen miles from Vernon, Jones Creek, Harris Creek, Creighton Creek, and Blue Springs Creek join, and flow, as Harris Creek, in a north-easterly direction, into Shuswap River, which empties into Mable Lake. The three first-mentioned creeks rise in the plateaux on the south. Blue Spring Creek rises in the valley and is very small in quantity. Above Lumby the creeks are used for irrigation, but below Lumby no irrigation-water is used from the main creek. Vance Creek joins Harris Creek on the north. There is very little bench land in the district. That in the neighbourhood of Jones Creek is under the Grey Canal, or private ditches. The cultivation is generally confined to the bottom lands.

The Shuswap River is said to have its source to the north of Sugar Lake rather than in the lake itself. Then, carrying its waters through the lake, it describes a semicircular course, and flows into Mable Lake. It is a fine stream, but is very little used for irrigation. On its south side it is joined by Cherry Creek. This also is very little used for irrigation, though a small combined scheme is proposed by residents of Camagna. Cherry Creek is joined on the south by Fall Creek, about forty-five miles to the east of Vernon.

TIMBER, SOIL, AND CLIMATE.

The chief varieties of timber found in the district are fir, pine, birch, and cottonwood, with occasional patches of cedar, all of moderate size. The soil varies from that of a light friable one of volcanic origin in the Coldstream Valley to a moderately stiff clay. The temperature, which is taken at the Coldstream Valley, ranges from 50 degrees minimum to 100 degrees maximum (Fahrenheit) in summer, and from 20 degrees below zero minimum to 40 degrees above zero maximum in winter. The precipitation is from 12 to 15 inches per annum.

IRRIGATED AND IRRIGABLE AREAS.

The following tabulation shows the acreages which are being irrigated on the various streams where surveys have been made, and gives an approximate estimate of the irrigable land wherever it was found possible to make one:—

Locality.	Acres under Irrigation.	Acres in Addition which are Irrigable.
Vernon and Coldstream Municipalities	12,730	8,770
Harris Creek Valley	726	15,854
Shuswap River Valley	44	13,916*
Cherry Creek Valley	..	5,300
Okanagan Centre and Woods Lake	3,500	4,900
Total	17,000	48,800

* Estimated.

UTILIZATION OF STREAM-WATERS.

Vernon forms the distributing centre of an important agricultural district. The chief crops are fruit, hay, and garden products, with small quantities of hops and cereals. Large acreages are now under fruit, and when the trees are matured it will be one of the principal fruit-growing districts of the Province. The creeks being small and of variable flow, the Grey Canal has been constructed to supplement them.

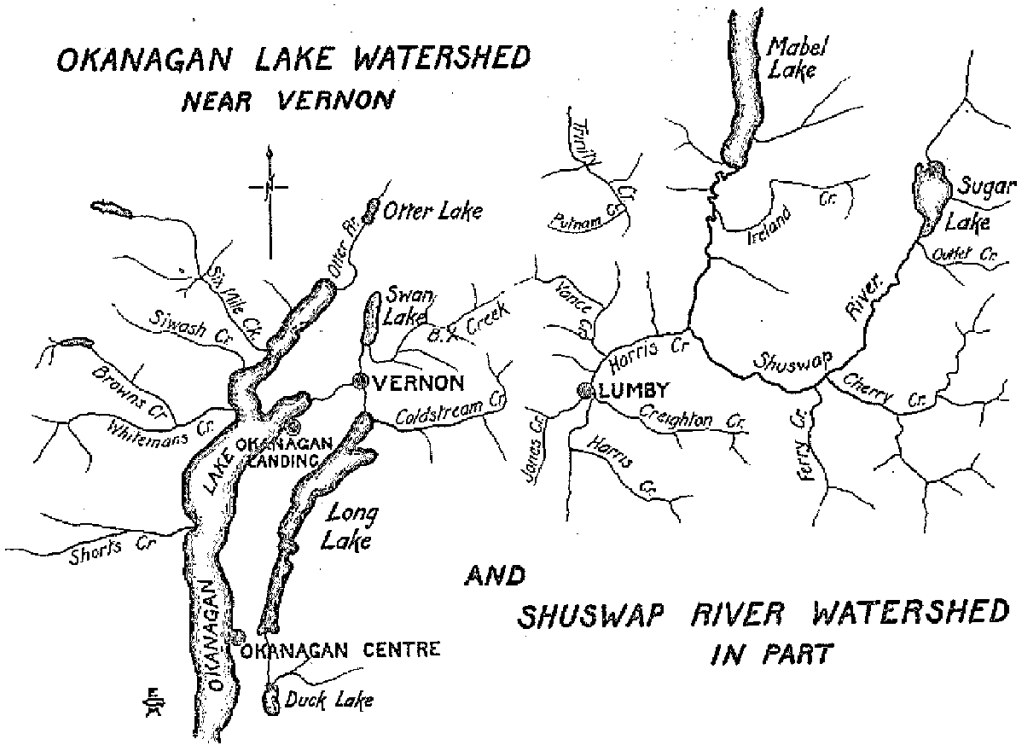
The White Valley Irrigation and Power Company, the owner of this canal, has used Lakes Haddo and Aberdeen on the plateau to the south side of the Coldstream Valley as its reservoirs, and the natural course of Jones Creek to its headgates, which are situated on Jones Creek about twelve miles from Vernon. By siphoning twice across the valleys the water is taken almost to Okanagan Landing, on the East Arm of Okanagan Lake, by this canal.

The completion of this system has given a great impetus to the fruit-growing industry, which in a few years will be a most important one. From Okanagan Landing to Nelson Creek, a distance of fifteen miles, and for several miles on the north of the city, many hundreds of acres are in orchard, cultivated on scientific principles. This district was formerly taken up with general farming, such as the growing of hay and cereals and stock-raising, but these have now been crowded farther up the valleys by fruit-culture, and form the staple industries of the Lumby, Rollings Lake, Reiswig, Camagna, and Richlands Districts, and of the neighbourhood around Shorts, Whiteman's, Siwash, and Six-mile Creeks, on the west of Okanagan Lake.

In addition to the White Valley Irrigation and Power Company mentioned above, an irrigation system from Vance Creek was proposed in 1911 by a syndicate, which has acquired several thousand acres in the neighbourhood of Vance Creek and Rollings Lake. At Richlands a land company has put in a system from Fall Creek to irrigate the large tract of land in its possession; and at Whiteman's Creek the Beanpark Land Company has acquired a large acreage on the benches, and proposes to put in an irrigation system from Whiteman's Creek. Near the junction of Harris Creek and Shuswap River, the Couteau Power Company proposes to erect a hydro-electric power station on the latter, and has obtained a charter. The undertaking has now been purchased by the Canadian Northern Railway.

As the water in the creeks is of such small quantity, and the flow is of short annual duration, it would be of great advantage if those creeks which are used for irrigation could have their headwaters impounded in the spring. The plateaux mentioned previously could be used with great advantage for this purpose. The undulating surface lends itself naturally to utilization,

since it affords opportunity for the construction of reservoirs of considerable extent and at moderate cost, though at too great an expense for the ordinary rancher to undertake. The City of Vernon takes its water-supply from the B.X. Creek. The Coldstream Municipality, of 17,000 acres, put in a domestic water-supply in 1911 from Nelson Creek. There are no records held for power or mining which are in use in this district, except for one sawmill at Lumby.



From the south end of Long Lake, including both sides of Woods Lake and down to and including Okanagan Centre, a rapidly increasing settlement is taking place. Irrigation systems from the neighbouring mountain lakes supply water for ranching and domestic purposes. The Woods Lake Fruitlands Company have an irrigation system from Island Lake that is now owned by the lot-owners. At Okanagan Centre a good water-supply is obtained from Beaver Lake. This supplies irrigation and domestic water to the Townsite of Okanagan Centre and the neighbouring fruit-orchards. By referring to the tabulation accompanying this report, it will be seen that there are close to 5,000 acres of irrigable land in addition to some 3,000 acres already under water. Besides this, there are several small pumping plants being installed along the Okanagan Lake shore northward from Okanagan Centre to irrigate say 200 acres from the lake.

NATURE OF SURVEYS.

Party No. 3 began work in June, 1910. Its work has been chiefly confined to investigating the water records issued prior to 1909. No gauging-stations have been established, but the water in ditches and creeks, all of small quantity, has been measured by floats. In 1910 a considerable amount of contouring and levelling was carried out to show irrigable areas; but in 1911 and 1912 this was discontinued, and "spot" levels were given instead to indicate the lay of the land, taken by stadia measurements. In 1912 a thorough investigation was made of the value of Adams Lake and the Lower Adams River for hydro-electric purposes. Reports and plans of all work done have been sent to headquarters.

The district around Notch Hill was also investigated by Party No. 3, and as it will not be covered in any other report I will refer to it briefly here. The water records issued prior to 1909 were investigated in the Pass Creek District, and in the Adams and Ducks Precincts, in the neighbourhood of Notch Hill and Scotch Creek. These are within the Railway Belt, except

at Pass Creek. The creeks near Notch Hill are small and quite insufficient for the demand upon them. The district consists of side-hills, facing north, running down to Shuswap Lake. The principal crops are fruit, hay, and vegetables, with small quantities of cereals. Scotch Creek, which flows into the Shuswap Lake on the north, is not yet used for irrigation. Near the mouth is a fine alluvial flat, which is partly cleared, and a combined scheme of the owners is on foot to irrigate the cleared areas.

On the west of Okanagan Lake, the water records on Short's Creek, Whiteman's Creek, Siwash Creek, and Six-mile Creek have been investigated, and also along the lake-shore. These records all lie near the lake. This district is treated in another report.

All available hydrographic data for the territory embraced within this report will be found on pages 108 and 109.

I have, etc.,

W. R. C. MORRIS, M.Inst.C.E.,
Engineer, Water Rights Branch.

OKANAGAN WATERSHED NEAR KELOWNA.

January 8th, 1913.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I have the honour to hand you a report on the Okanagan Watershed near Kelowna. This report includes the drainage-basins of Mill Creek, Mission Creek, and Sawmill Creek, and embraces an area of about 400 square miles. It is compiled from data collected by the following engineers; G. Gray Donald and E. Davies in 1910, and W. R. C. Morris, C. Varcoe, O. Bergoust, J. F. Rowlands, and M. C. Brotherton in 1912.

GENERAL PHYSICAL CHARACTERISTICS.

For about a mile and a half back from the lake the country is flat. It then rises in a series of benches, gradually becoming covered with timber, and eventually reaching an elevation of 6,000 to 7,000 feet on the divide.

The following are the principal creeks in this district:—

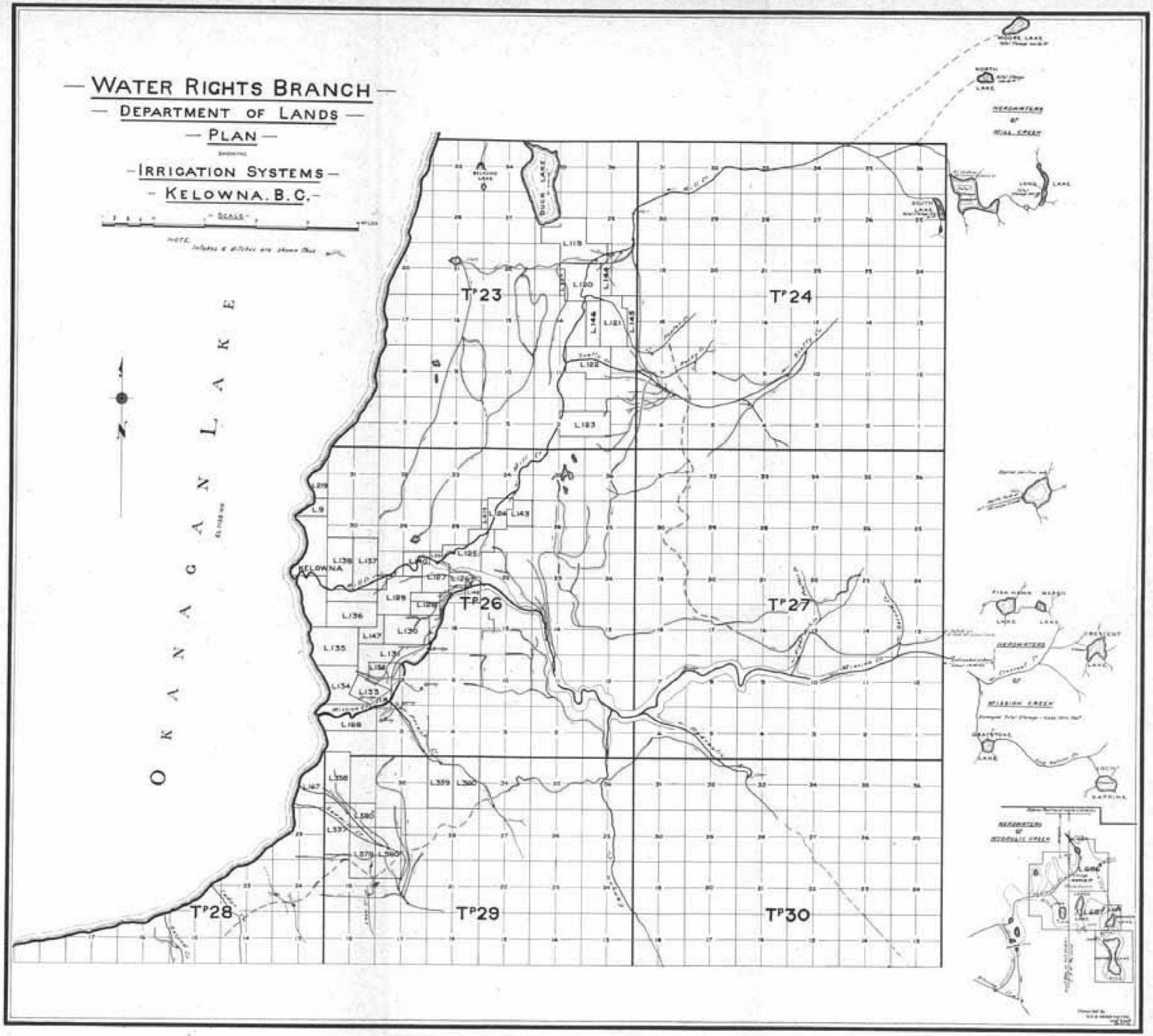
(1.) Mission Creek, the tributaries of which are Eight-mile, Priest, Canyon, and Hydraulic Creek, rises in the Gold range of mountains which forms the divide between the Okanagan and Kettle River Valleys, and flows in a westerly direction, and empties into Okanagan Lake about three miles south of Kelowna. Its approximate length is forty miles and its catchment-area about 250 square miles. There are at present no storage-works on the main stream, but it possesses some excellent reservoir-sites, one of which, situated in Section 11, Township 26, has a storage-capacity of 2,318 acre-feet. Another in Section 1, Township 26, has a storage-capacity of 3,435 acre-feet. Several lakes at the headwaters would provide a storage of 15,250 acre-feet. In all, storage could be provided for some 21,000 acre-feet.

At the headwaters of Hydraulic Creek, the South Kelowna Land Company has created a storage reservoir with a capacity of 8,670 acre-feet.

The Belgo-Canadian Fruit Lands Company's storage reservoir is situated on the North Fork. No figures of its capacity are available.

(2.) Mill Creek, with its tributaries, Scotty and Poplar Creeks, rises also in the Gold Range, and flows in a south-westerly direction to empty into the Okanagan Lake at Kelowna. It has an approximate length of twenty-five miles and a catchment-area of about seventy-five square miles. There are several storage-sites, one of which, on the main stream, is utilized by the Kelowna Irrigation Company, and has a capacity of 2,500 acre-feet. Several lakes at the headwaters would provide storage for some 1,806 acre-feet.

(3.) Sawmill Creek rises on the Okanagan and Kettle River Valley divide, and is some ten to fifteen miles in length. Its catchment-area is limited and there appear to be no suitable reservoir-sites.



The catchment-areas generally are covered with a fairly heavy growth of timber and rise to an elevation of between 6,000 to 7,000 feet. The creeks are all snow-fed and have a very quick run-off, starting when the snow melts in March and reaching their maximum discharge about the beginning of June, after which they diminish very rapidly. This will be seen by a study of the discharge measurements given on pages 109 and 110. This quick run-off points to the necessity of providing for the early flood-waters.

IRRIGATED AND IRRIGABLE AREAS.

The following table gives the irrigable and irrigated areas under the various creeks:—

Name of Creek.	Irrigated Area, Acres.	Irrigable Area, Acres.
Mission Creek and its tributaries	4,067	17,000
Mill Creek and its tributaries	5,103	9,900
Sawmill Creek, Cedar Creek, and Second Creek	512	3,100
Total	9,682	30,000

TIMBER AND VEGETATION.

The timber consists for the most part of fir, pine, tamarac, and a small quantity of spruce. There is very little vegetation on the lower benches, while up in the timber there is a considerable growth of native grasses and underbrush.

SOIL.

The soil of this district varies greatly. On the flats adjacent to the lake one finds a rich black loam, and on the bench lands a light sandy loam with a gravel subsoil.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

The climate is mild and dry. The springs open early. The summers are warm and dry and the winters mild, with only an occasional dip to zero. The average mean temperature is about 46 degrees. The mean precipitation over a number of years averages 12.62 inches.

UTILIZATION OF STREAM-WATER.

Water for irrigation purposes is more generally used in and around Kelowna, perhaps, than in any other part of British Columbia. A study of the map accompanying this report will show how extensive the irrigation operations are.

Four important companies are engaged in putting in irrigation systems, namely: The Kelowna Irrigation Company from Mill Creek, the Belgo-Canadian Fruit Lands Company on the North Fork of Mission Creek, the South Kelowna Land Company from Hydraulic Creek, and the Kelowna Land and Orchard Company from Canyon Creek. These companies will be spending some $2,000,000, all told. The construction is being done in a substantial and up-to-date manner, special attention being paid to preventing leakage and loss in transit.

Kelowna is situated on the east side of Okanagan Lake, about half-way between Vernon and Penticton. The City of Kelowna is a distributing centre for a large and populous agricultural district.

The principal crops grown are apples, pears, plums, cherries, and small fruits, also the following vegetables: Tomatoes, onions, and potatoes. For all these it would be hard to find a soil or climate more suitable than is found here.

Attention is being given to tobacco-growing, which is proving a remunerative crop.

Above an elevation of about 2,000 feet are some fine hay meadows, and there are a few instances of dry-farming. The results from these would tend to show that there are great possibilities for this class of farming.

A project is on foot for consolidating, if possible, all water rights in and around Kelowna and forming a water municipality. A reference to the accompanying map and the noting of the immense number of small irrigation systems would seem to point to the necessity for some such measure to economize and make the utmost use of all available water.

NATURE OF SURVEYS.

The first hydrographical work was done in this district in 1910. This consisted of a contoured survey of Township 26, a traverse of part of Mission Creek and Mill Creek, and a survey of the storage-sites at the headwaters of Mission Creek.

In 1912 the headwaters of Scotty Creek were investigated, and numerous parties were put in the field throughout the whole district to survey the land under irrigation. This additional work was rendered necessary by the recent adoption of the policy that licences shall be issued for only such acreages as are actually under irrigation.

All available stream-discharge measurements for the district covered by this report will be found on pages 109 and 110.

I have, etc.,

O. F. D. NORRINGTON,

Engineer, Water Rights Branch.

REPORT ON THE OKANAGAN WATERSHED ON WEST SIDE OF OKANAGAN LAKE.

December 31st, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—Herewith I beg to submit a report on the watershed on the west side of Okanagan Lake from Trout Creek northwards to head of lake.

GENERAL PHYSICAL CHARACTERISTICS.

The country covered in this report, approximately 1,000 square miles in extent, though somewhat rugged from general appearances and broken up by high hills and rocky bluffs, embraces some of the most promising land in the Province of British Columbia. Particularly is this the case in the neighbourhood of Summerland, Peachland, and Westbank. A range of hills running almost parallel with the lake, rising to an elevation varying from 5,000 to 7,000 feet, and extending from the lake-shore in places to a distance of about twenty miles back from the lake; bench lands, in some places bordering on Okanagan Lake, in others lying a short distance back from the lake; extensive valleys up the creeks and high plateaux farther back in the hills: this constitutes the general formation of the country.

Several useful creeks, having their sources in lakes and marshes in the hills, discharge their waters into Okanagan Lake on the west side. The most important of these are: Trout Creek, two miles south of Summerland; Deep Creek and Trepannier Creek, with the thriving settlement of Peachland between them; Powers Creek, the sources of supply for the settlement of Westbank; Bear Creek, Shorts Creek, and Whiteman's Creek.

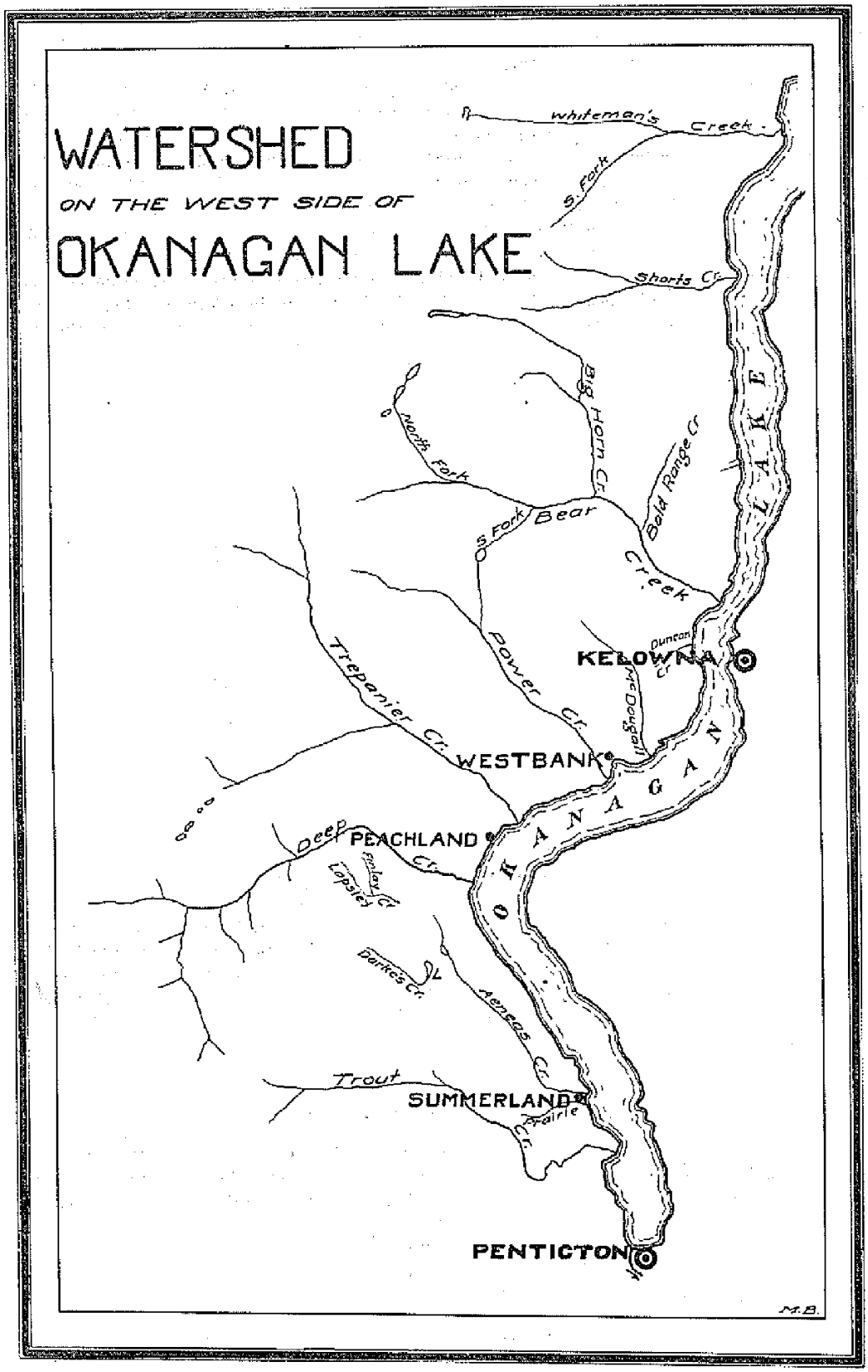
There are large areas of land up many of the creeks that will at some future date be used for agricultural purposes. At present the greater part of these areas are heavily timbered and the expense of clearing would be large. Up to an elevation of about 2,000 feet above sea-level the land of this section of country will some day be used for fruit. Above that elevation it can be used for grazing purposes. Coal of a good quality has been found up Shorts Creek and rapid development is expected.

TIMBER.

Pine, with a mixture of fir, is found at all elevations in this section of country. Above the 3,000-foot elevation this is interspersed with tamarac, spruce, cottonwoods, and cedar in the creek-beds and bordering the lakes and swamps. On the hillsides small black-pine is usual. There is little in the way of small brush, such as one meets with in the Coast region.

IRRIGATED AND IRRIGABLE AREAS.

Considerable development has taken place in and around Summerland and Peachland. Extensive irrigation systems from Trout Creek supply water to about 6,000 acres of fruit lands.


WATERSHED
ON THE WEST SIDE OF
OKANAGAN LAKE
Whiteman's Creek
S. Fork
Shorts Cr.
Big Horn Cr.
North Fork
Bald Range Cr.
S. Fork Bear Creek
Duncan Cr.
KELOWNA
McDougall
Power Cr.
Trepanier Cr.
WESTBANK
PEACHLAND
Deep Cr.
Finley Cr.
Lapsley
Darke's Cr.
Aeneas Cr.
Trout
SUMMERLAND
Prairie Cr.
PENTICTON
OKANAGAN LAKE
M.B.

A considerable acreage of irrigable land is also available. Irrigation systems from Deep Creek and Trepannier Creek supply Peachland and neighbourhood with water for some of the finest peach and apple orchards in the country.

At Westbank less development has taken place, owing, no doubt, to the fact that two Indian reserves, 3,300 acres in extent, absolutely block proper access to Okanagan Lake. There is a large acreage here, exclusive of the above-mentioned Indian reserves, that would make ideal fruit lands if put under irrigation. The natural source of supply would appear to be Powers Creek, which can be termed the southern boundary of Westbank. However, this creek carries such a small volume of water, the drainage-basin being limited in area during the greater part of the year, that I doubt if it will be used to any extent in the future, except as a subsidiary supply. The proper development of Westbank depends on a water supply on a somewhat extensive scale from Bear Creek, the northern boundary. Some 20,000 acres of irrigable land could be made productive by this means. North of Westbank and up the Okanagan Lake to Whiteman's Creek there are numerous small holdings that are under irrigation, notably at the mouth of Bear Creek and Shorts Creek, all showing thriving orchards and prosperous-looking homes.

The following is an estimate of irrigated and irrigable areas from Trout Creek northwards to the head of Okanagan Lake, including Indian Reserves Nos. 1, 9, and 10, all lying under the 2,000-foot elevation:—

Place.	Irrigated.	Non-irrigated, but irrigable.
Summerland	3,000	4,000
Peachland	2,000	3,000
Westbank	500	19,200
Bear Creek	300	1,000
Shorts Creek	200	500
Mordens Creek	16	50
Hope Creek	4	20
Norris Creek	17	30
Whitman's Creek	91	1,500
"	131*	400*
Siwash Creek, Six-mile Creek to Head of Okanagan Lake	616	24,400
Total	6,875	54,100

* Indian reserve.

SOIL.

The soil of this region is for the most part particularly adapted to fruit-culture. Whitish clay silt and rich sandy loam predominate, with here and there patches of vegetable mould. A peculiarity of the loam and silt is that it is very finely divided and formed by the erosion of rocks rich in mineral qualities. In the high-cut banks of the lake-shore, particularly in the neighbourhood of Summerland, may still be seen the regular strata of sedimentary deposits laid by restless action of water in other days. This wealth of mineral deposit, particularly the nitrates and phosphates, gives great strength to the soil, while its finely divided condition specially favours the delicate rootlets of the young fruit-trees. At higher elevations, above 2,000 feet, the soil generally is of a more gravelly nature and poorer quality.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

This section of the Okanagan country, though not within what is termed the Dry Belt in British Columbia, is nevertheless semi-arid. The precipitation varies in succeeding years, some winters bringing a heavy snowfall, followed by spring and summer rains. Again, the snowfall will be light and no rainfall for weeks at a time. In the high hills heavy snow is the rule every winter. Hence the several important streams carry a good supply of water all the year through. The average spring and summer rainfall amounts to about 10 inches, the total precipitation averaging about 13 inches for the district per annum.

The temperature in summer is warm, frequently rising to 80 and even 90 degrees in the shade during the months of July and August. Spring and fall weather is generally delightful.

The winters are cold, dry, and bracing, with brilliant sunshine the greater part of the time. Generally during the winter two cold snaps, each of a few days' duration, during which the mercury drops to several degrees below zero, are to be expected.

The altitude of Okanagan Lake is 1,135 feet. The finest orchards are from 50 to 500 feet above this level. On the divide between the Okanagan and the Nicola country the hills rise to 5,000 and 7,000 feet.

UTILIZATION OF STREAM-WATERS.

Up to the present time water has been used for irrigation purposes only, with the exception of Trepannier Creek. Here the Peachland Municipality has installed a power plant, supplying the town with electric light, and sundry private concerns with power for industrial purposes. Like all the mountain creeks in British Columbia, those on the west side of Okanagan Lake have a heavy fall. Nevertheless, excellent facilities for the storage of water are generally available. This will undoubtedly be undertaken to a much greater extent in the near future, there being thousands of acres of first-class land, ideal for fruit-culture, awaiting irrigation-water. All the creeks mentioned in this report supply water for irrigation purposes, but only to a small extent, and with the construction of dams and other conservation works a large and regular supply of water would be available.

NATURE OF SURVEYS, ETC.

A comprehensive hydrographic survey of Bear Creek was carried out by F. R. Johnson, B.C.L.S., of Vernon, B.C., during the summer of 1910. The stream was gauged at different points, as were the most important tributaries. The work was confined mainly to a stadia traverse from mouth to source, but was not completed, owing to a late start (June), and to heavy snows in the month of September and October at about the 5,000-foot elevation.

The hydrographic survey of part of Trout Creek was commenced by J. A. Kirk, B.C.L.S., of Summerland, B.C., in 1910. The water rights on this creek were investigated by H. A. Icke, A.M.Can.Soc.C.E. Prairie Creek, Aeneas Creek, Powers Creek, Shorts or Biche Creek, Whiteman's Creek, Siwash Creek, and Six-mile Creek have also been under investigation by the engineers of the Water Branch in 1911 and 1912.

All available stream-discharge measurements for the district covered herein will be found on page 110.

I have, etc.,

P. DE LAUTOUR,
Engineer, Water Rights Branch.

OKANAGAN WATERSHED FROM NARAMATA TO BOUNDARY.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—In accordance with your instructions, we have the honour to hand you a report on that portion of the Okanagan Valley lying between Naramata and the International Boundary, and draining an area of approximately 800 square miles.

GENERAL PHYSICAL CHARACTERISTICS.

A large part of the territory embraced in this report is mountainous in character. The Okanagan River flows out of Okanagan Lake in a southerly direction through Dog, Vaseaux, and Osoyoos Lakes, ultimately joining the Columbia River in the State of Washington. Between Okanagan and Dog Lakes the river has very little fall, and leaving Dog Lake in a series of rapids known as the Okanagan Falls, it enters Vaseaux Lake three miles and a half below. Emerging from this lake, it flows rapidly southward, entering Osoyoos Lake about six miles north of the boundary.

In the vicinity of Naramata and Penticton the irrigable land consists, for the most part, of benches about one mile wide, lying between the lake and the foot-hills of the Okanagan and Kettle River Valley divide. At Okanagan Falls the benches widen, narrowing again when McIntyre Creek is reached. South of McIntyre Creek the valley widens into broad open slopes, reaching its maximum width at Fairview, where the benches on either side of the river are about two miles wide. These benches have an elevation above the river-bed of 75 to 500 feet.

On the east side of the valley are numerous creeks. These are mostly mountain-streams rising in the divide between the Okanagan and Kettle River Valleys and flowing west into the Okanagan River. These creeks all show evidence of high flood during a period of six weeks or two months in the spring, and, with the exception of Penticton Creek and Incameep Creek, dwindle away to almost nothing, or dry up altogether in the summer. Many of these also have a tendency to sink and rise again, with in some cases quite a flow of water in the hills and none below, in other cases vice versa. Their drainage-basins lie in broken mountainous country at an elevation of from 4,000 to 7,000 feet.

A brief description of a few of the most important creeks on the east side follows:—

Shoot Creek, which empties into Okanagan Lake about four miles north of Naramata, is the most important creek on the east side of the lake between Penticton and Kelowna. It shows evidence of considerable flow at times, and offers several excellent storage-sites, one of which is Shoot Lake, which has an area of about 60 acres, and is situated on the North Fork about six miles inland at an elevation of 3,470 feet.

Penticton Creek, flowing into Okanagan Lake at Penticton, has a catchment-area of some eighty square miles, which is mostly covered with a heavy growth of timber. For about two months in the spring this creek assumes the importance of a river, and must carry at times between 140 and 280 cubic feet per second. About eighteen miles up this creek, the Southern Okanagan Land Company has a large storage reservoir at an elevation of 5,280 feet. This reservoir has an area of 67.2 acres and a capacity of about 700 acre-feet. The dam is 850 feet long.

Ellis Creek, flowing into the Okanagan River between Okanagan Lake and Dog Lake, ranks in importance with Penticton Creek, and, like it, has a very large flow in the spring, which dwindles down to about 3 cubic feet per second in the summer. The catchment-area is about 100 square miles. The Southern Okanagan Land Company has a dam situated about two miles up the creek at an elevation of 1,542 feet, and has created two large storage reservoirs sixteen to eighteen miles up. There are still great possibilities of further storage.

Keogan Creek, which is a large and important one, is capable of supplying water for the irrigation of a considerable area.

McIntyre Creek, emptying into the Okanagan River two miles below Vaseaux Lake, has a large flow in the spring, but in the summer there is practically no water in its lower part.

Incameep Creek enters the north end of Osoyoos Lake from the east, and serves the Indian reserve through which it passes. Its flow is rapid and its course is precipitous, the greater part being through narrow canyons. On reaching the benches near Inkameep Indian Village, it shrinks in volume, being at times dry in the summer months, but always reappearing as a good stream near its junction with the lake.

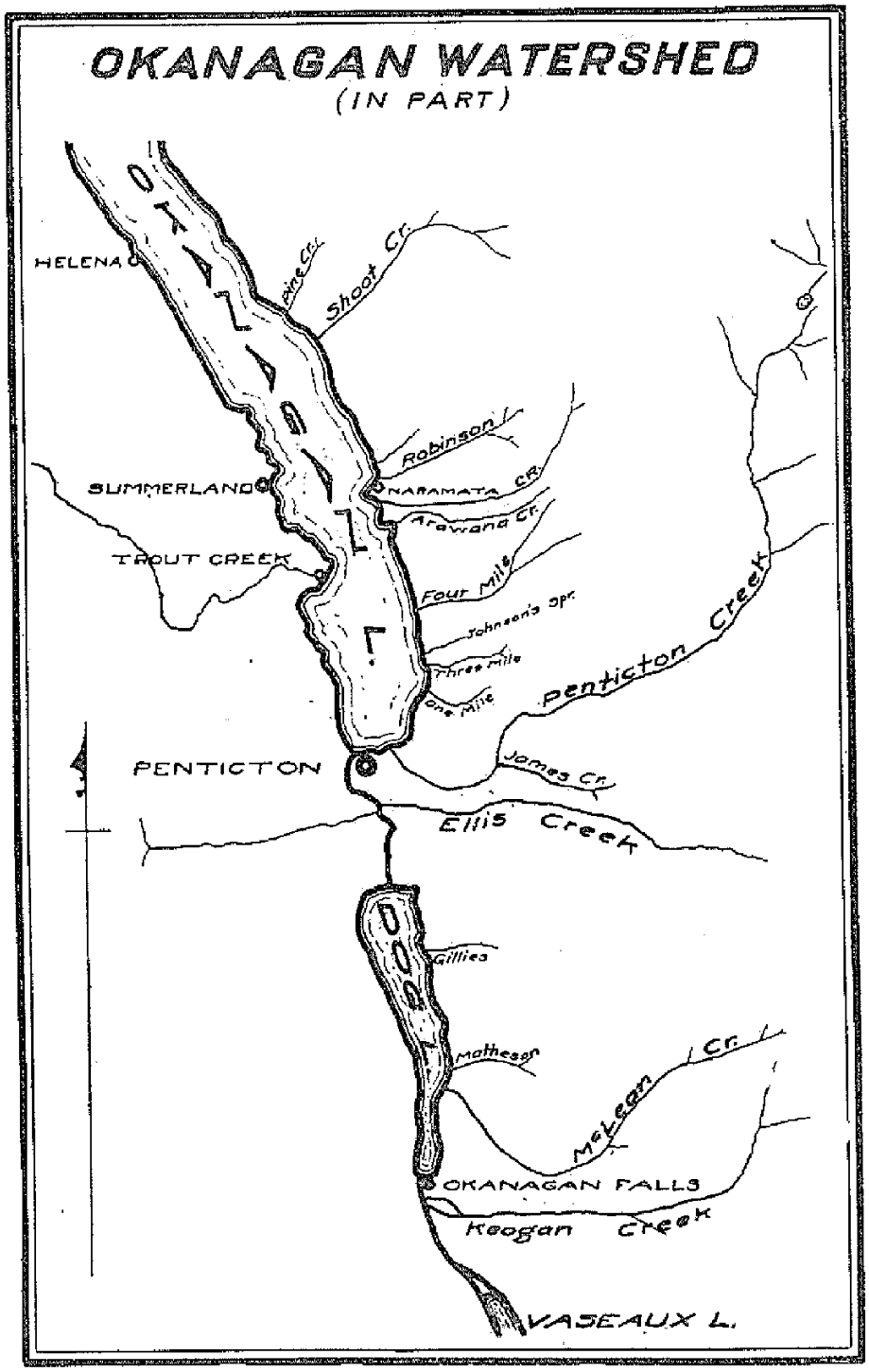
The creeks on the west side of the valley south of Dog Lake are small and capable of irrigating only a portion of the adjacent land. Among these, Meyers Creek is the most important, rising in the vicinity of Twin Lakes, on the Okanagan and Similkameen River divide, and flowing into the Okanagan River four miles south of Vaseaux Lake. For a distance of two miles on Meyers Flat this creek flows underground. There are several small lakes near the headwaters of Meyers Creek and its tributaries which are capable of providing limited storage.

TIMBER AND VEGETATION.

The timber consists, for the most part, of pine with some tamarac and fir, and is confined to the higher altitudes, except for a scattered growth on some of the benches. Above an elevation of about 3,000 feet the country becomes covered with a heavy growth of jack-pine. The bench lands are bare, except for a slight growth of bunch-grass and sage-brush. Amongst the timber native grasses are found.

SOIL.

The soil is similar to a great extent throughout the whole valley, consisting of a sandy loam, deep, and easily worked. In places it is more or less gravelly, and towards the south end of the valley—i.e., near Osoyoos Lake—it is quite sandy.



IRRIGABLE AND IRRIGATED AREAS.

The following table shows a summary of areas in the district covered by this report:—

Locality.	Irrigated Area, Acres.	Irrigable Area, Acres.	Remarks.
Naramata and vicinity, 1910	400	2,500	Irrigated from Shoot Creek and adjacent creeks.
Penticton and vicinity, 1910	2,000	4,000	Irrigated from Penticton and Ellis Creeks.
Okanagan Falls and vicinity	740	3,300	Irrigated from McLean and Keogan Creeks.
McIntyre Creek and vicinity	228	1,700	
Indian Reserve No. 1	436	9,300	Irrigated from Inkameep, Wolf, and Atsiklak Creeks.
White Lake and Myers flat	330	5,100	Irrigated from Meyers Creek and branches.
East of Osoyoos Lake, south of reserve	80	1,400	Irrigated from Haynes and adjacent creeks.
Rest of Okanagan Valley south of McIntyre Creek	60	14,800	
Totals	4,274	42,100*	

* This does not include Kaleden vicinity nor Penticton Indian Reserve, as surveys are not complete.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

Records on climatic conditions are very meagre, but in a general way it may be stated that in vicinity of Penticton the precipitation was 13.33 inches in 1909, this being looked upon as a fairly average year, and that the average mean temperature, as shown by available records, is 46 degrees. As one goes southward, the precipitation decreases and the extremes of temperature become slightly greater. At Fairview the precipitation for 1910 was 4.67 inches, and temperatures ranged between the extremes of 99.5 and —4 degrees, the mean being 50.5 degrees. As this was an exceptionally dry year, 6 to 8 inches would probably represent the average yearly rainfall more correctly.

Altitudes vary from 920 feet at Osoyoos Lake to 1,135 feet above sea-level at Okanagan Lake, the benches varying in elevation from 75 to 500 feet above the river-bottom.

UTILIZATION OF STREAM-WATERS.

In the whole of this district irrigation is necessary and is being carried on to a considerable extent. At Naramata, Penticton, Okanagan Falls, Kaleden, and Vaseaux Lake, different companies have put in extensive works, bringing a considerable area under irrigation, in addition to which there are a great many small works put in by individuals on creeks throughout the valley. The crops grown are apples, pears, peaches, plums, apricots; and so fertile is the soil when proper irrigation is provided that most fruits and vegetables will grow to perfection. A considerable quantity of hay is also grown in the district. The Municipality of Penticton has installed a system of waterworks for domestic supply.

NATURE OF SURVEYS.

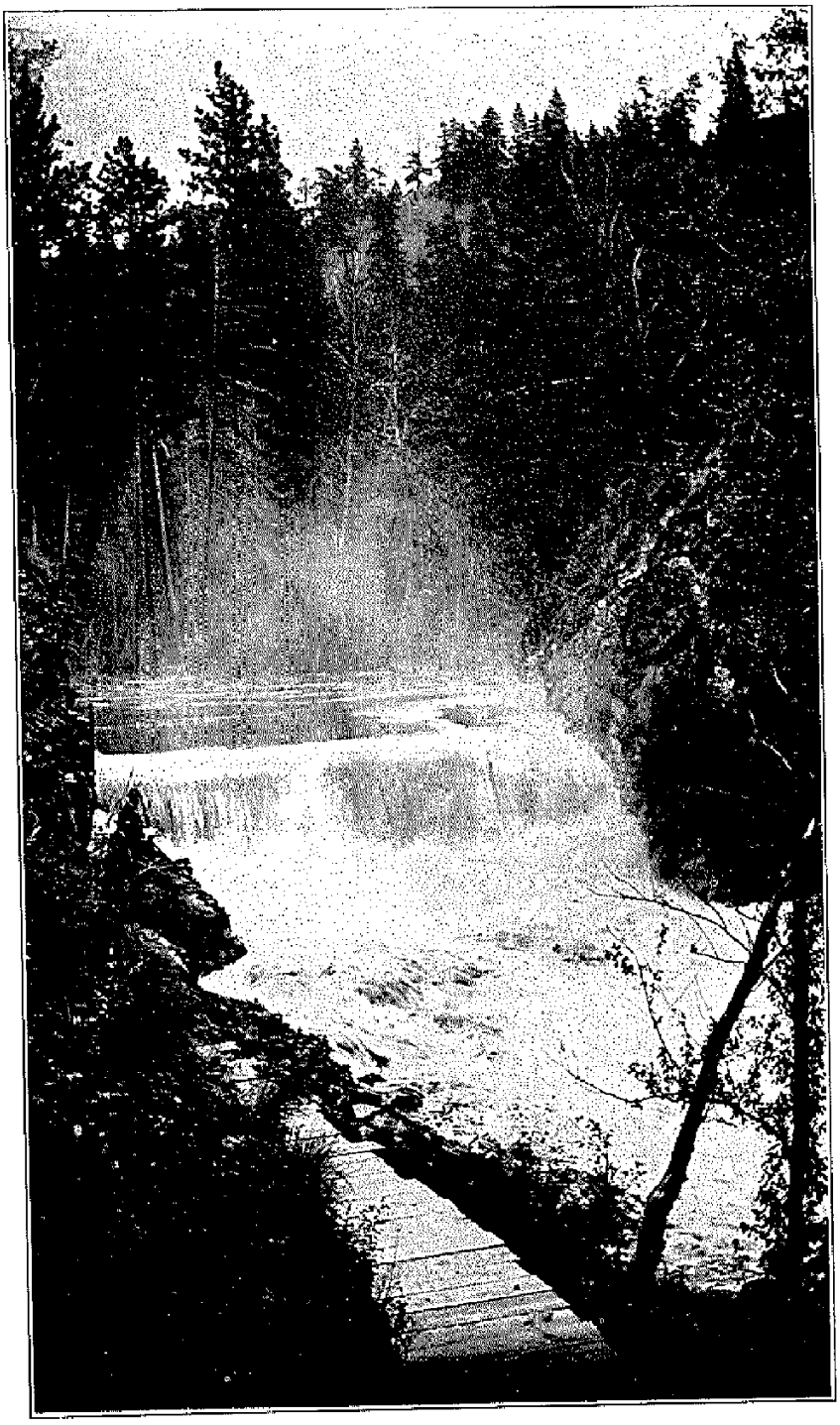
The first hydrographic survey in this district was undertaken in 1910 by Mr. J. C. Dufresne's party. The work was principally confined to obtaining the irrigated and irrigable areas, streams being gauged when surveying in the vicinity.

This report has been compiled from data obtained by the following engineers: J. C. Dufresne, O. F. D. Norrington, W. H. Ricardo, O. J. Bergoust, and M. C. Brotherton.

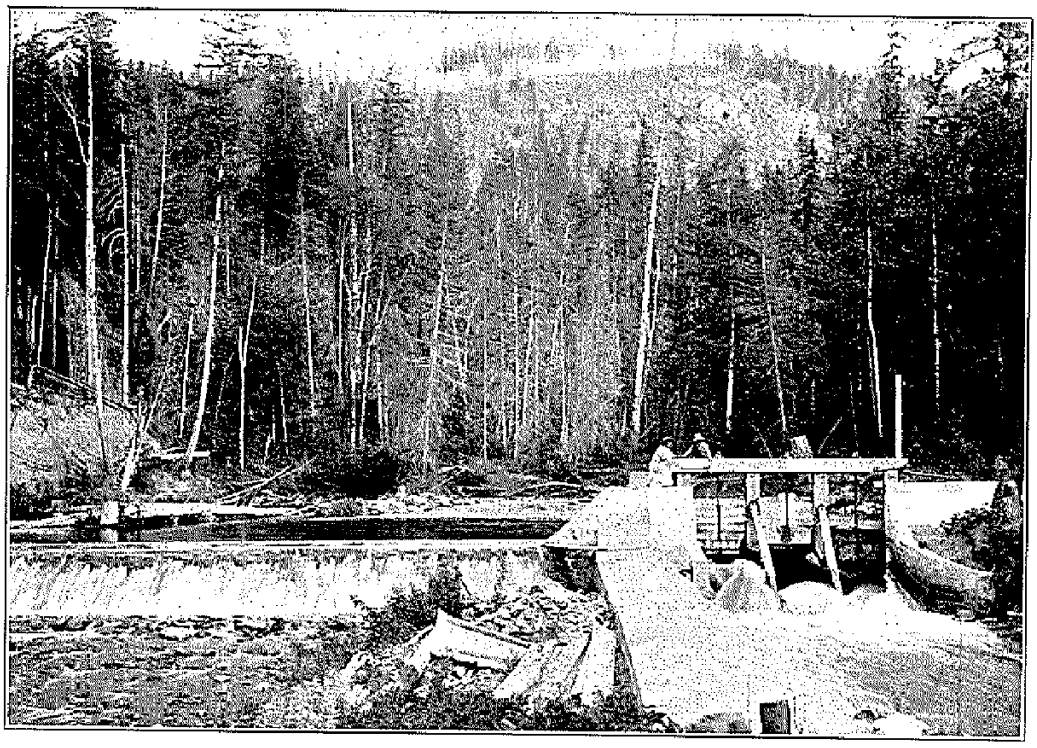
A table of stream discharges will be found on pages 110 and 111.

We have, etc.,

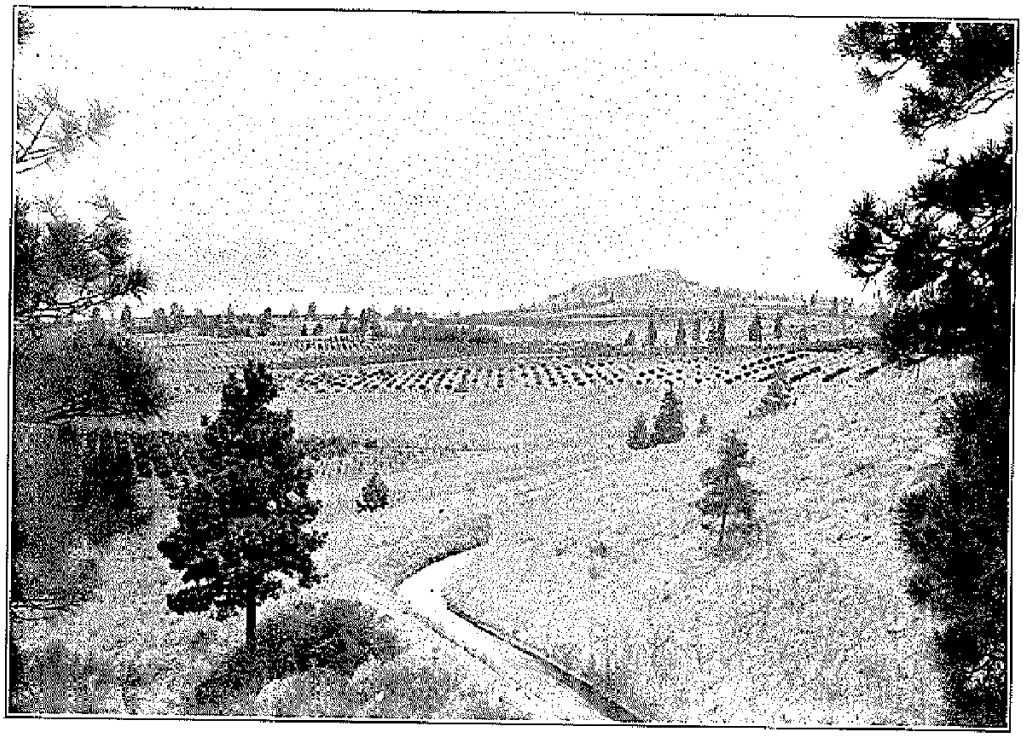
O. F. D. NORRINGTON,
O. J. BERGOUST,
Engineers, Water Rights Branch.



South Okanagan Land Co.'s Dam, near Penticton.



Headgates of White Valley Irrigation & Power Co.'s Canal, near Vernon.



Benches north of Penticton, showing Irrigation Canal.

THE SIMILKAMEEN RIVER WATERSHED.

Comptroller of Water Rights, December 31st, 1912.
Victoria, B.C.

SIR,—In compliance with your instructions, I submit herewith a report of hydrographic work done in the territory drained by the Similkameen River, together with a brief description of the watershed.

PHYSICAL CHARACTERISTICS.

The Similkameen River is a branch of the Okanagan River, which in turn is a part of the Columbia River drainage system. It rises in the Hope range of mountains, flows easterly and southerly for a distance of about 126 miles to its conjunction with the Okanagan River at Oroville, Washington. That part of the river which is in British Columbia drains a basin of about 2,850 square miles, which is located between the Hope Mountains on the west, the Nicola divide on the north, the Okanagan River divide on the east, and the International Boundary. It also drains about 475 square miles in Washington.

At Princeton, about eighty miles up-stream from Oroville, the main body of the river begins, being formed by the uniting of two streams of about equal size—namely, the Tulameen River and the South Fork of the Similkameen River.

The Tulameen River, which drains that part of the basin lying to the west and north of Princeton, flows through a deep canyon-like valley which in most places is barely wide enough for the river, though it widens in places, reaching a width of half to three-quarters of a mile. The more important tributaries are Granite and Otter Creeks. The former, entering from the south, flows through a narrow valley without great agricultural possibilities. It is well known as having been the centre of the placer-mining gold-rush in the late nineties. Otter Creek is sluggish, meandering through a valley averaging about a quarter of a mile in width and eighteen miles in length, which is devoted mostly to hay-raising. This valley forms the principal highway connecting the Tulameen with the Nicola, and is also the route chosen by the Great Northern Railway and Kettle Valley Railway for their lines to the Coast.

The South Fork of the Similkameen River drains a comparatively unsettled country to the south of Princeton. Within five or six miles of Princeton the bench on the westerly side of the river widens out in gentle slopes, merging with the plateau-like basin which surrounds Princeton. This plateau extends northward from Princeton for six to eight miles, and eastward along the main river for three miles.

At a point on the Similkameen River about three miles east of Princeton the valley becomes a narrow canyon 300 to 500 feet in width. This canyon continues eastward for about forty miles, nearly to the Town of Keremeos, and varies in width up to three-quarters of a mile, an average being about a quarter of a mile. The sides of the valley are abrupt and rocky, often rising 1,000 feet above the river-bottoms and sloping back to hills 4,000 to 6,000 feet above sea-level. Between the river-banks and the sides of the valley are several narrow arable benches from 75 to 100 feet higher than the river bottom. Several creeks of fair size empty into the Similkameen, the largest of these being the Ashnola River and Twenty-mile Creek.

From a point about two miles west of the Town of Keremeos the valley again widens out, continuing easterly and southerly to the International Boundary at an average width of a mile and a half, the widest part being about two miles. A great part of the valley from here to the boundary is taken up in bottom lands, which require little or no irrigation, and the gradual sloping bench lands, which extend for a width of about a half to three-quarters of a mile, would lend themselves to irrigation on a large scale. South of Susap Creek the benches on either side of the river narrow down and are more or less cut up. Keremeos, Nahumsheen, and Susap Creeks are the largest in this section. Keremeos Creek flows through a valley averaging a quarter of a mile in width for six miles, a great part of which is under cultivation. There is very little tillable land along the other two creeks, outside of the benches along the Similkameen River.

TIMBER AND VEGETATION.

The western end of the basin is fairly well timbered with pine on the benches and jack-pine on the summits. Fir and some cedar is also found up the creek-beds. Sage-brush is the native

growth on the benches in the vicinity of Keremeos, while bunch-grass may be found all through the basin. Alder, birch, cottonwood, and some fir is found on the river-bottom.

IRRIGATED AND IRRIGABLE AREAS.

The land irrigated up to the present time is that most easily reached by water from the creeks in their immediate neighbourhood, and for a great part is in small individual patches. The greater extent of irrigable land in the vicinity of Keremeos, however, and climatic conditions have encouraged the cultivation of land to such an extent that the normal minimum flow of Keremeos Creek is nearly all utilized, and also a part of the Ashnola River. The water from this stream is brought on to the land from a distance of eight miles by the Keremeos Land Co.'s ditch, which was designed to accommodate 2,000 acres. At present about 300 acres is being supplied from this source. Keremeos Creek supplies about 646 acres in the Keremeos Valley and benches near the Town of Keremeos Centre. A summary of land in Similkameen Valley under irrigation and that which it would be possible to irrigate, provided water is available, is given below. The acreages of irrigable areas were approximated where actual surveys have not been made.

Table of Irrigable Areas.

Location.	Irrigated, Acres.	Irrigable (estimated), Acres.
Tulameen Precinct	60	6,800
Princeton Precinct	156	10,000
Hedley Precinct	390	4,200*
Keremeos Precinct	1,290	23,000†
Total for Similkameen Valley	1,896	44,000

* This does not include land in Ashnola River bottom above the canyon.
† A large part of this is bottom land requiring very little, if any, irrigation.

SOIL.

The soil on the benches is sand and sandy loam, underlain with gravel-wash. In some localities the sand is more predominant, and in others the loam. In the bottom lands the sand is mixed with a black mould which is admirably adapted to the cultivation of hay, fruit, and all kinds of garden vegetables.

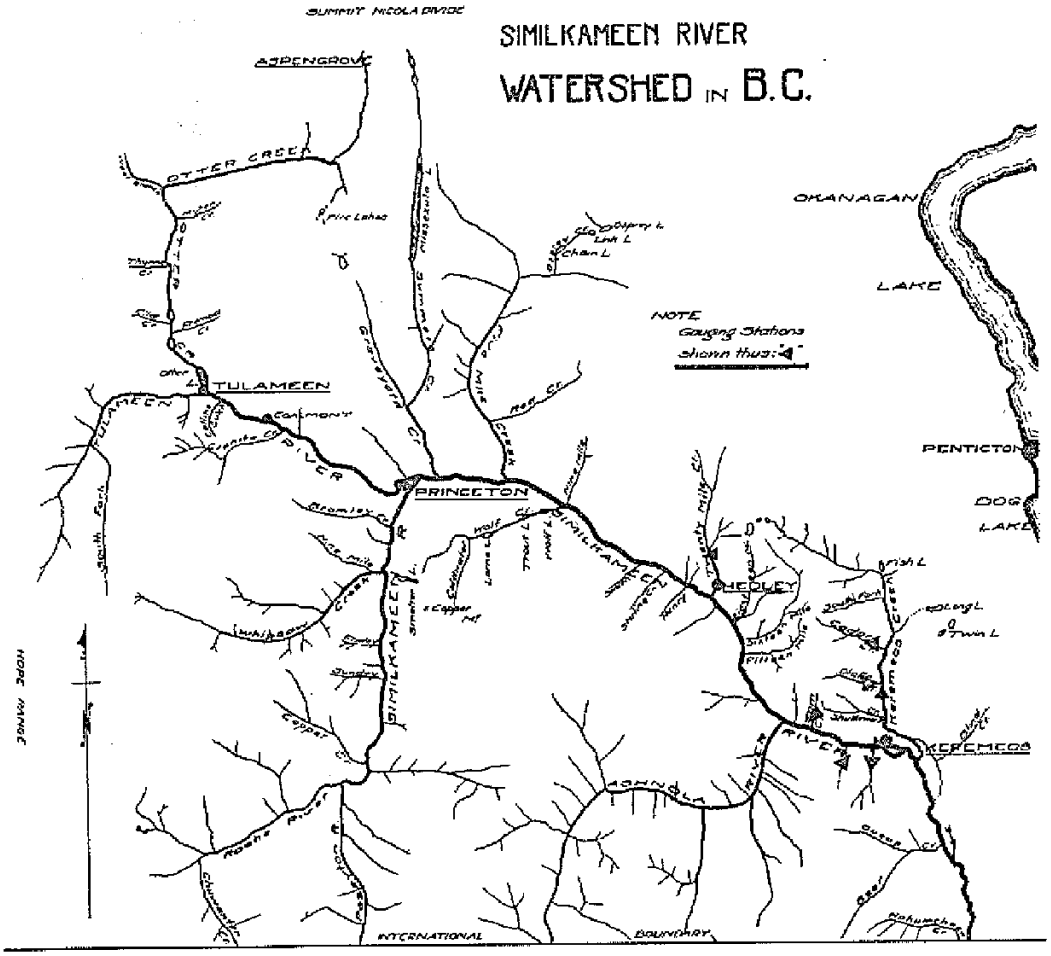
TEMPERATURE, PRECIPITATION, AND ALTITUDE.

The climate of the valley is fairly moderate, for, while the thermometer rises as high as 90° Fahr., and occasionally up to 95 or 100 degrees, the effect of the heat is tempered by the dryness of the air and by the cool breezes from the adjacent mountains, which make the nights compensatingly cool. As the altitudes vary from 1,200 feet above sea-level at the International Boundary to 2,100 feet at Princeton and 3,500 feet at the divide between Otter Creek and Nicola Valley, a somewhat varied climate is to be expected. At Princeton in a period of sixteen years the mean daily maximum for August was 81.03, whereas the mean daily minimum for January was 7.77, with a total annual rainfall of 31.05 inches. At Keremeos, altitude 1,400 feet, from records taken in 1891 to 1895, the mean daily maximum for warmest month was 83.9, and mean daily minimum for January 14.33, with 8 inches of total annual rainfall. These figures are obtained from the Dominion Meteorological Service, compiled by E. Baynes Reed, Superintendent of Victoria Meteorological Office.

UTILIZATION OF STREAM-WATERS.

The principal use of the waters is in irrigation. Very little has as yet been done in the way of power development. The Daly Reduction Co., at Hedley, has constructed a dam, and diverts water from Twenty-mile Creek into a flume 3 feet 8 inches by 4 feet 10 inches, which transmits the water to a power-house supplying the mill, mine, and town. Several different power-sites

on the Similkameen River, Ashnola River, and various creeks have been considered for development, but as yet no power plants have been constructed. With the opening-up of Copper Mountain Mining District, it is likely that the consequent demand for power will hasten its development on the Upper Similkameen River. Owing to the great fluctuations in the flow of the river and its tributaries, only a small part of the available water-power can be economically developed.



NATURE OF SURVEYS.

The investigation of the streams of this valley was undertaken primarily with a view to determining the area of land irrigated by and irrigable from the streams recorded, and accordingly no hydrographic work was done on streams where no water records existed. The work was confined to a survey of the lands appurtenant to records, and approximate measurements of the flow of creeks at the time of the survey. A start was made in the latter part of the season of 1912 towards accurate and continuous measurement of streams, by building weirs and establishing gauging-stations. The locations of these gauging-stations are shown on the accompanying sketch-map. At each of the gauging-stations for Keremeos Creek, Similkameen River, and Twenty-mile Creek, a cross-section was measured and flow determined with a Gurley acoustic current-meter. A gauge-rod was set, its elevation being referred to that of a bench-mark which was established in the vicinity of the section.

The weirs established were constructed substantially as follows: The location on the creek most suitable for backing up water 10 to 15 feet was selected, and a dam thrown across the creek-bed, constructed of logs spiked to cross-pieces. The whole was securely held in place by being cut well into the banks, and brush and earth puddled in on the up-stream side until the

underflow was stopped. The weir-board, in which a trapezoidal notch had been cut, was placed on the top log. The up-stream edge of the notch was lined with sheet iron. A gauge-rod fastened to a stake 6 to 8 feet back from the weir was placed so that its bottom was at the elevation of the crest of the weir. All the spaces between the logs were caulked with moss and gunny-sack cloth.

Weirs were placed on the following creeks:—

Olalla Creek	5-foot crest.
Cedar Creek	5-foot „
Sheep Creek	5-foot „
Goat Creek	4-foot „
Tom Creek	3-foot „
Shuttleworth Creek	8-inch „

After completing the weirs continuous readings were taken up to the close of the season, except on Shuttleworth Creek. Hydrographic work on Keremeos Creek and south of Keremeos, on the Similkameen River, was completed in 1911, and the upper part of Similkameen in 1912. A part of the work in the vicinity of Princeton and Tulameen was surveyed by M. C. Brotherton, and I am indebted to him for part of the data included in this report.

All hydrographic data may be found on pages 111, 112, and 113.

I have, etc.,

O. J. BERGOUST,
Engineer, Water Rights Branch.

KETTLE RIVER WATERSHED.

December 23rd, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I herewith submit the following report on the Kettle River Watershed:—

GENERAL CHARACTERISTICS.

The Kettle River and its tributaries drain what is known as the Gold Range, situated between the Okanagan and Columbia River Watersheds, extending northerly from the International Boundary a distance of sixty to eighty miles, and embracing an area of approximately 3,160 square miles. This area does not include that part of the watershed in the State of Washington.

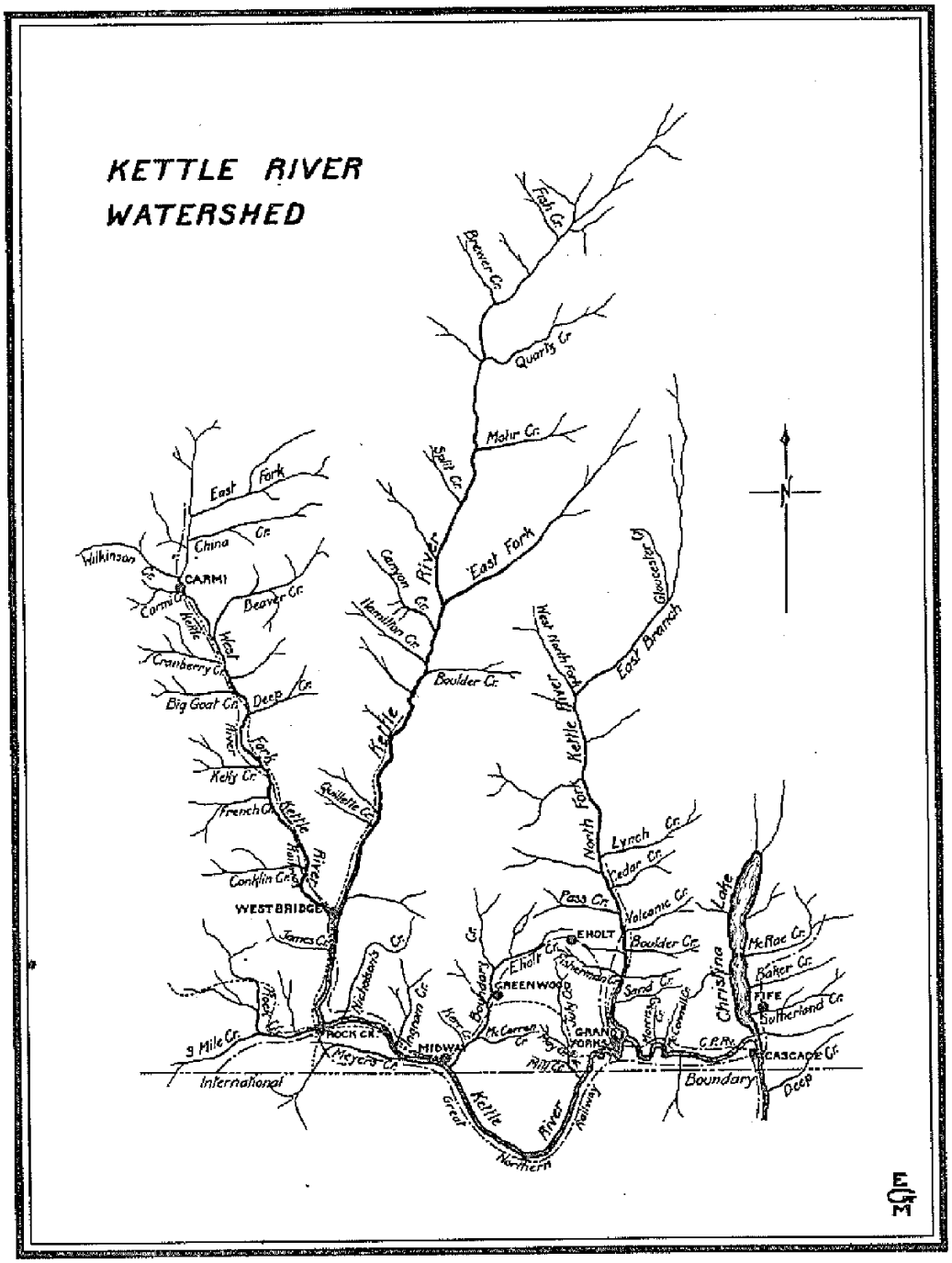
The following table gives the approximate lengths and drainage-areas of the principal streams:—

Stream.	Length, miles.	Drainage area, Square Miles.
Main River north of Westbridge	80	1,175
West Fork	52	637
Boundary Creek	20	126
North Fork	60	600
Christina Lake and streams flowing into it	...	193
Total length of main Kettle River in British Columbia	123	...
Total drainage-area in British Columbia	...	3,160

A map of the district under consideration is published herewith.

Speaking generally of the district, it might be stated that the bottom lands along the main river vary in width from half a mile to two and a half or three miles, averaging over a mile, reaching their maximum at Grand Forks. Besides the bottom lands, there is a large acreage of bench lands of varying altitudes.

The creeks in the vicinity of Grand Forks are all small, and their flow is light, excepting for a short period in the spring, when they become torrents. The quantity of water available in these creeks during the irrigation season is very small when compared to the amount of



irrigable land, and shows the necessity of storing the spring floods. This shortage is also noticeable at Nicholson Creek, on the north side of the Kettle River, near the Town of Rock Creek. The remainder of the district is well watered, and there is not the likelihood of a shortage until irrigation becomes more general than at present.

TIMBER AND VEGETATION.

The quantity of timber along the International Boundary and through the territory covered to date is small, the hills being quite bare in many places; but the northern part of the main river, the West Fork, and also the North Fork, are heavily timbered, considerable logging being carried on. The principal varieties are fir, cedar, tamarac, and pine.

Vegetation varies greatly throughout the district. In some places the hills are bare excepting for a short native grass, while in others there is a dense underbrush.

IRRIGATED AND IRRIGABLE AREAS.

In compiling the following table an estimate of all the land that could be beneficially irrigated from the various creeks has been made:—

Stream.	Irrigated Area, Acres.	Irrigable Area, Acres.	Remarks.
Deep Creek and tributaries	...	400	Altitude 2,800 to 3,300 feet, mostly steep side hills.
Sutherland Creek and tributaries	10	1,200	Land hilly.
Baker and McRae Creeks	...	350	Land hilly.
Moody Creek	13.5	475	Land slightly broken.
Kettle River	...	500	Acreage estimated. Vicinity of Cascade.
Kettle River	660	2,500	Irrigated and irrigable by pumping. Nothing over 100 feet above river considered.
Fourth July and tributaries	1,040	427	Altitude varies from 1,750 feet on lower benches to 2,350 feet on upper benches. Insufficiency of water without storage.
McConnell and Morrisey Creeks	535	460	Insufficiency of water from creek sources. Water augmented by pumping from the Kettle River. Plant capable of irrigating 120 acres.
Small creeks or Kettle River	330	2,330	80 per cent. irrigable by pumping from Kettle River when there is a shortage in creeks. About 50 per cent. irrigable land under cultivation.
Boundary Creek and tributaries	350	2,050	Altitude varies from 1,950 to 3,000 feet.
Myers Creek	129	400	A large area of irrigable land on upper waters. Amount unknown.
Ingram Creek	64	50	Additional irrigable area on upper benches. Insufficiency of water to irrigate it.
Rock Creek	430	600	Possible to augment water by pumping from the Kettle River.
Small creeks and Kettle River	...	2,000	Vicinity of Rock Creek. Amount estimated. Pumping feasible if power-line was constructed.
Totals	3,561.5	13,742	

SOIL.

The soils of the district are varied and include volcanic ash, silt, sandy loam, and heavy loam. The light soils, however, predominate. The subsoils are generally open, being composed principally of gravel and rock or "wash." In some places there is a clay or hard-pan.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

It is hardly possible to do justice to each locality with regard to temperatures, as there are not sufficient figures to form a mean. A fair average would be: Grand Forks, —15 to 100 degrees; Greenwood, —25 to 100 degrees; Midway, —25 to 100 degrees.

Owing to the irregular formation of the country the precipitation varies tremendously. In the mountains there is an annual snowfall of close to 20 feet, while only a few miles away in the valley the total precipitation would not be over 18 inches. There is not sufficient data available to form a mean for the whole district. The accompanying table gives the precipitation at Grand Forks for a period of three years, and although it is not enough to form a mean, yet it indicates that a fair average might be about 15 inches.

Precipitation at Grand Forks.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909..	...	...	...	...	...	...	...	...	1.18	1.17	1.67	0.92	...
1910..	0.83	1.11	1.03	0.29	1.21	1.45	0.08	0.04	0.82	0.75	1.45	2.16	11.82
1911..	1.49	0.89	0.54	0.83	3.43	2.78	0.49	0.52	0.85	0.08	2.51	2.84	17.25
1912..	2.05	1.55	0.15	1.31	1.78	2.13	2.81	2.28	1.10	0.75	...	...	...

NOTE.—The above figures were supplied by E. Baynes Reed, Esq., Superintendent Victoria Meteorological Office, whose courtesy is hereby acknowledged. The Observer was Mr. W. A. Cooper, Grand Forks.

The altitude of a place in this district affects the quantity of water necessary for irrigation purposes to a considerable degree. The higher the altitude, the less the necessity for irrigation. This is noticeable at Fife, Deep Creek, and in the vicinity of Greenwood, where the elevations vary from 2,500 to 3,000 feet, and good crops are raised without irrigation. In contrast to this might be mentioned Grand Forks, with an elevation of 1,750 feet, where irrigation, especially for some crops, is a vital necessity. Practically all the irrigated land is less than 2,000 feet in elevation.

UTILIZATION OF STREAM-WATERS.

In describing the use of water in this district, no attempt will be made to make special remarks on any one stream or river, but the district will be taken as a whole, and considered in localities, commencing in the eastern part and gradually moving west.

There is a considerable area of arable land in the vicinity of Cascade. Up to the present there are only a few areas under irrigation. Owing to the cost of clearing (which is very heavy in many places) the development is slow, and the settlers are scarcely justified in spending large sums on irrigation-works for the small amount of land under cultivation. The locality is well watered and eventually will have a large area under cultivation.

A few miles west of Cascade is the important district of Grand Forks. Grand Forks is the centre of the fruit-growing industry in the Boundary Country, over 2,000 acres being planted in apples, pears, plums, prunes, cherries, etc. Of this area, about two-thirds is in young orchards and does not need the same amount of irrigation as the full-bearing orchards. Besides the orchards, there is a large acreage in vegetables, hay, and a small quantity of alfalfa.

Along the main river there are a number of pumping plants which irrigate approximately 660 acres. The power used is electric and gasolene. The electric power is supplied by the Cascade Power and Light Co. at 3 cents per kilowatt hour. Most of these pumps have been installed during the last two years, and there is undoubtedly a promising future for this form of irrigation, considering the moderate cost of power.

The next locality of importance is that of Greenwood, which is chiefly confined to mining. There is only a small quantity of water used for irrigation purposes in the vicinity, but there is a large acreage which could be beneficially irrigated.

Rock Creek and vicinity has a very fair showing of irrigated lands for a young settlement. Most of the irrigated land is in hay meadows or young orchards. If cheap power were available a large acreage could be irrigated by pumping from the Kettle River.

Mining is of great importance in this district, and as a resulting factor large quantities of water are used for power and smelting purposes. Two smelters, one at Grand Forks and the other at Greenwood, are constantly using large quantities of water, the former also generating a large amount of its power.

The accompanying table gives the location and power generated by the hydro-electric plants in the district.

Power Plants.

Plant.	Locality.	Head, Feet.	Power Generated, Horse-power.	Where used.
Cascade Power & Light Co. ..	Cascade	155	5,200	Auxiliary to Bonnington Falls plant. Power used at Grand Forks, Phoenix, and Greenwood.
Granby Co.'s power and light ..	Grand Forks	30	700 (about)	Power and light purposes at Granby Smelter.
Greenwood City power and light	Boundary Falls	130	250	Lighting of the City of Greenwood.

NATURE OF SURVEYS.

The season of 1911 and part of 1912 was spent largely in determining the irrigated and irrigable areas of the various record-holders. Stream-measurements were made, but no permanent measuring-devices installed. Since August, 1912, not only have the irrigated and irrigable areas been surveyed, but notes have been taken with regard to soil, subsoil, timber, and general characteristics of the land under investigation.

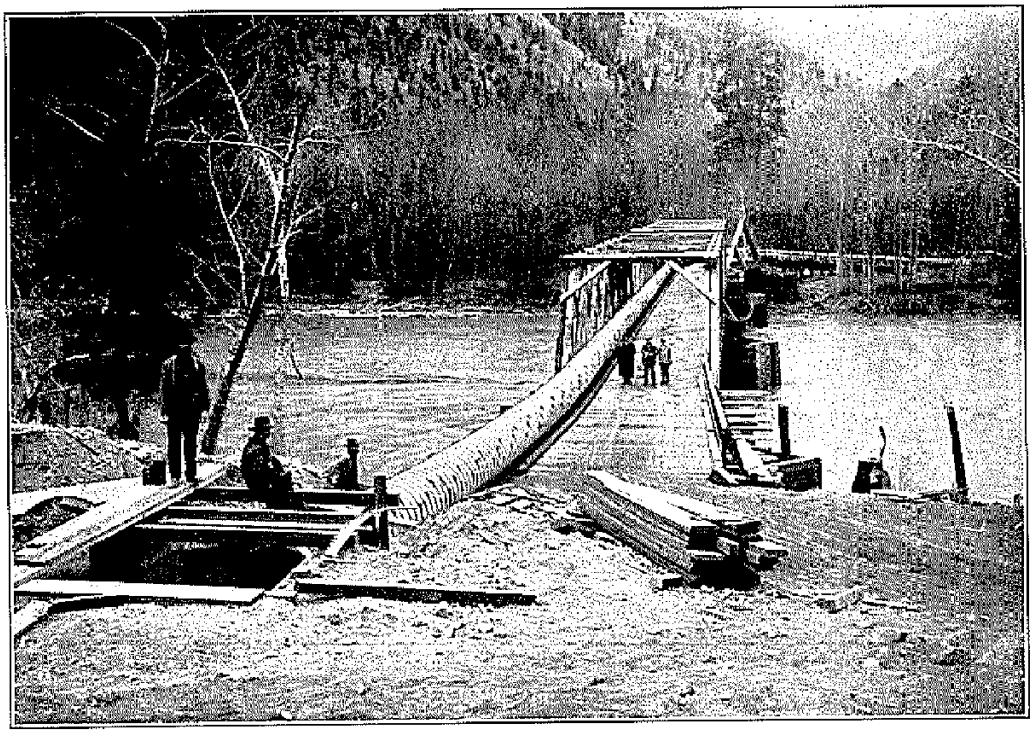
The following gauging-stations were established, all since August, 1912:—

4th July Creek ..... 3-foot Cippoletti weir.
May Creek ..... 2-foot ,,
Gibbs Creek ..... 2-foot ,,
Morrissey Creek ..... 3-foot ,,
McConnell Creek ..... 2-foot ,,
Kerr or Jolly Jack Creek .....1-foot ,,
McCarren Creek ..... 2-foot ,,
Myers Creek ..... 6-foot ,,
Ingram Creek ..... 2-foot ,,

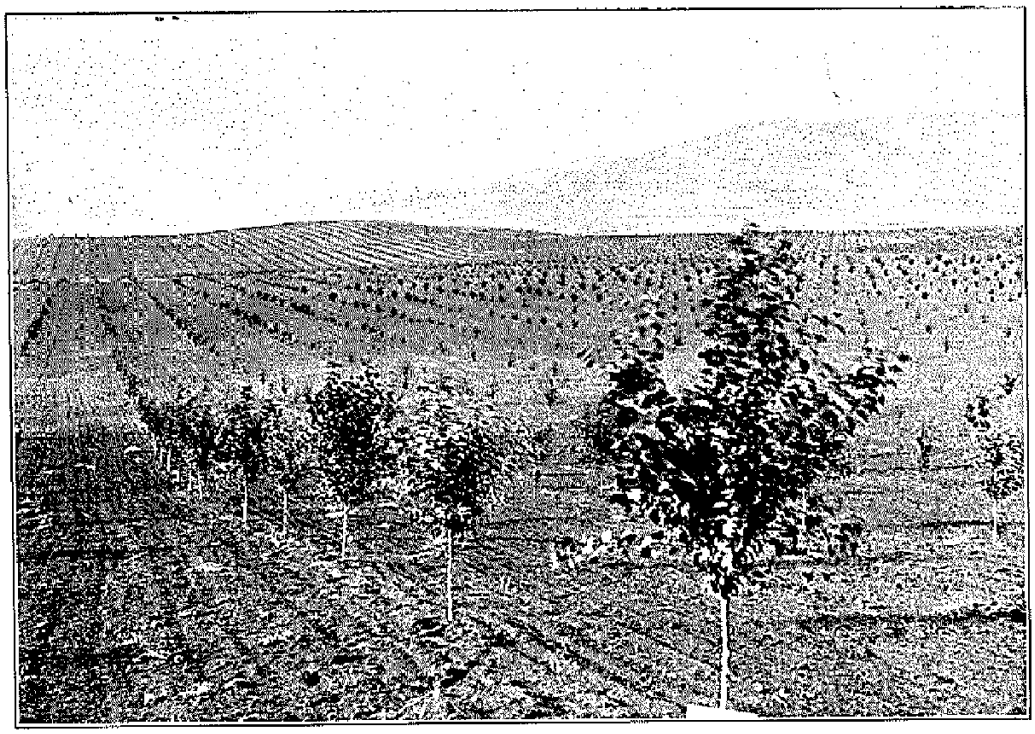
The position of these weirs can be easily determined by reference to the accompanying map. Hydrographic data under the head of "Stream Measurements" will be found on pages 113, 114, and 115.

I have, etc.,

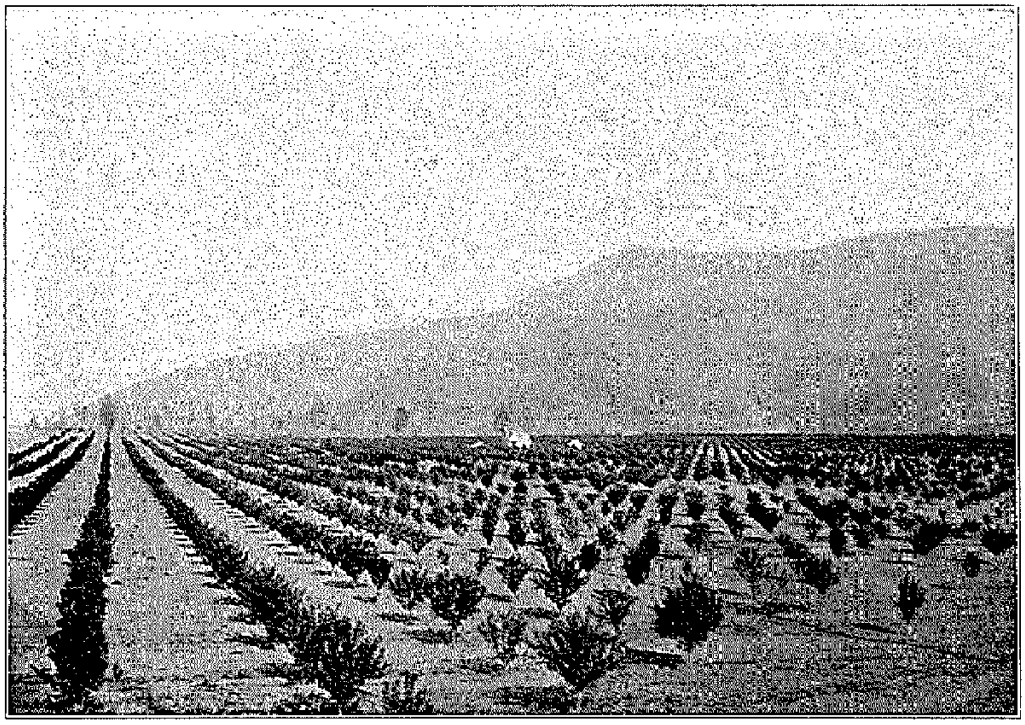
CLIFFORD VARCOE,
Engineer, Water Rights Branch.



Keremeos Land Co.'s 40-inch Water-main across bridge over Similkameen River.



New orchards on Benches north of B.X. Creek, near Vernon.



Cavert Orchard, Grand Forks, Irrigated from Fourth of July Creek.

Tobacco-crop, E. C. Armstrong's Ranch, at Keremeos, B.C.

ARROW LAKES AND PART OF THE COLUMBIA RIVER WATERSHED.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I herewith submit the following report on the above watershed, a map of which is published herewith. Only a small part of this large tract has been investigated by the Water Rights Branch, and, as it is therefore impossible to do justice to the district as a whole in the way of a report at the present time, only a brief summary will be here attempted.

GENERAL PHYSICAL CHARACTERISTICS.

The district under consideration comprises the Arrow Lakes and the southern part of the Columbia River, and has a length of approximately 135 miles, embracing a drainage-area of about 3,560 square miles. The arable and irrigable land along the river and lakes consists largely of a series of benches of varying extent and altitudes. In some places these benches stretch back from the water-front for a considerable distance, while in others they are narrow or disappear entirely, the mountains rising abruptly from the water's edge. Many of the larger creeks have their sources in the high mountains and are fed from snow or glaciers. This ensures a reasonable supply of water at all times.

TIMBER AND VEGETATION.

Apparently all the country at one time was heavily timbered. Fire has, however, deforested large areas and may have affected the natural conservation of moisture. Vegetation grows rapidly, and it is only a short time after a fire before there is a considerable growth of weeds, native grasses, and brush.

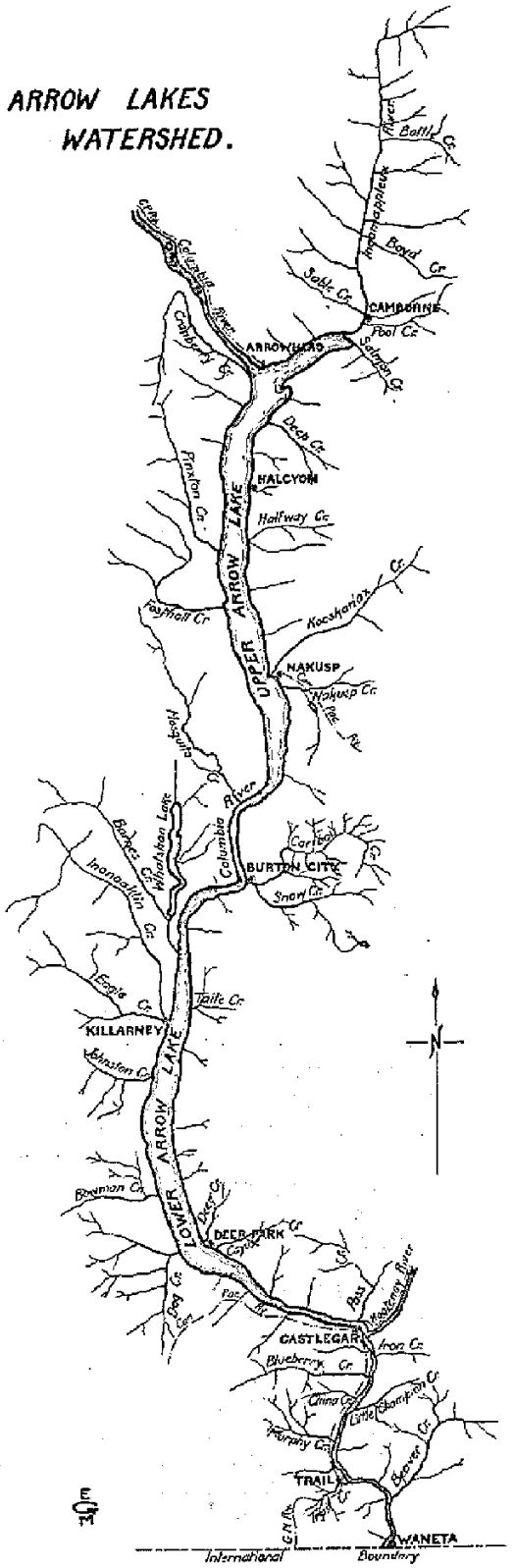
PRECIPITATION, TEMPERATURE, AND ALTITUDE.

The precipitation and temperature are practically the same as at Nelson, which gives a mean annual precipitation of 28.95 inches and a temperature from —7 to 97 degrees.

The land under cultivation and irrigated varies in altitude from 1,400 to 2,000 feet. The altitudes of the Arrow Lakes are as follows: Upper Arrow Lake, high water (1894), 1,494 feet; low water, 1,384 feet. Lower Arrow Lake, high water, 1,416 feet; low water, 1,382 feet.

IRRIGATED AND IRRIGABLE AREAS.

The following table is the nearest approximation which can be made, in a general way, to the cultivated, irrigated, and, in some cases, the irrigable areas in the principal localities. Where no figures are given it merely indicates that no data are available on which to base an estimate:—



Irrigated and Irrigable Areas.

District.	Under Cultivation, Acres.	Irrigated, Acres.	Irrigable, Acres.
Nakusp	125	56	...
Arrow Park	104	95	...
Burton City	320	218	...
Needles	279	219	...
Renata	65	8.5	260
Deer Park	90	87	...
Castlegar	1,056	1,000	2,000
Blueberry	49	14	1,450
Trail and Rossland	830	583	...
Waneta	125	51	...

NOTE.—I am greatly indebted to Mr. Tweedie, Assistant Statistician of the Agricultural Department, for many of the areas in the above table.

UTILIZATION OF STREAM-WATERS.

Irrigation is not as general as it is in the Okanagan and other parts of the Dry Belt. Owing to a greater annual precipitation, it is only during an exceptionally dry season that irrigation is absolutely necessary. In many cases where water is within easy reach, sufficient works have been installed to form a safeguard against a dry period.

On page 115 will be found a tabulated list of miscellaneous stream-measurements.

I have, etc.,

CLIFFORD VARCOE,

Engineer, Water Rights Branch.

SLOCAN RIVER WATERSHED.

December 30th, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I beg to submit the following report of my investigations of the Slocan River Watershed:—

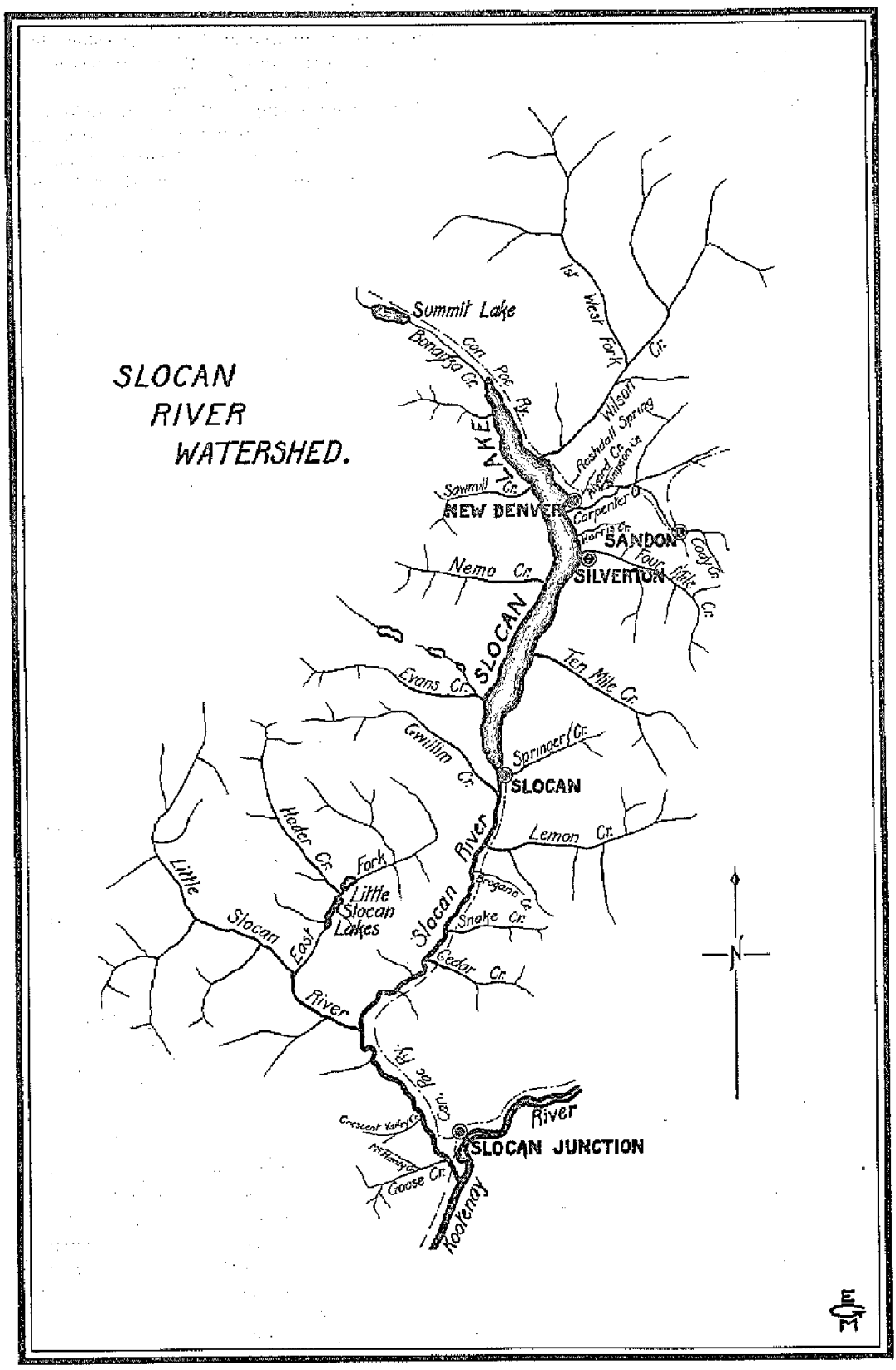
GENERAL PHYSICAL CHARACTERISTICS.

The Slocan River rises in Slocan Lake, this lake being fed by numerous streams and rivers which rise in the Valhalla and Lardeau ranges of mountains. The tributaries flow into the lake from all directions, but the river itself flows southerly until the point where it merges into the Kootenay River. From the Kootenay River to the Slocan Lake the river is thirty miles long. Slocan Lake is twenty-nine miles long by an average width of one mile. The bottom has not been found at some places, and on an average it is very deep.

Drainage-areas of several of the principal streams flowing into the Slocan Lake and the Slocan River are as follows:—

	Square Miles.
Slocan River	1,365
Carpenter Creek	60
Four-mile Creek	46
Wilson Creek	274
Lemon Creek	75
Goose Creek	19.8
Little Slocan River	325
Sawmill Creek	20

The widest part of the Slocan Valley is about two miles wide, the average being about one mile and a quarter.


SLOCAN
RIVER
WATERSHED.
Summit Lake
Bonanza Cr.
Can. Pac. Ry.
Ivy Wear Fork Cr.
Wilson Spring Cr.
Rosebell Cr.
Alvord Cr.
Simpson Cr.
LAKE
Sawmill Cr.
NEW DENVER
Carpenter Cr.
Harris Cr.
SANDON
Cody Cr.
Four Mile Cr.
Nemo Cr.
SILVERTON
SLOCAN
Evans Cr.
Ten Mile Cr.
Springer Cr.
Gwillim Cr.
SLOCAN
Lemon Cr.
Heater Cr.
Fork
Little Slocan River
Little Slocan Lakes
Slocan River
Slocan East
Bogans Cr.
Snake Cr.
Cedar Cr.
River
Can. Pac. Ry.
Crescent Valley Cr.
SLOCAN JUNCTION
River
Mt. Hennessy
Goose Cr.
Kootenay
N

For about fifteen miles down-stream from Slocan Lake the fall of the river is very slight, and for about a quarter mile on each side the land is very flat and subject to overflow during spring floods. The remaining stretch of the river until it merges into the Kootenay has a fairly good grade, and the land on each side is about 100 to 200 feet above the water.

The fluctuation of the flow of the river is fairly steady, owing to the Slocan Lake acting as a reservoir, but several of the tributaries are erratic. Of the creeks flowing into Slocan Lake, Carpenter Creek is about the worst in this respect, owing to the watershed having been burnt over in 1910. Lemon Creek, flowing into the Slocan River from the east, about six miles down-stream from Slocan Lake, is another erratic stream as regards run-off. The watersheds of the tributaries generally are covered with forest-growth, and there are numerous small glaciers which give off a fairly constant stream of water, both in the Valhalla and Lardeau ranges of mountains.

TIMBER.

The nature of the timber-growth generally is of a fairly heavy character. Both sides of the Slocan Valley proper are covered with timber, and there are some good timber limits up the Little Slocan River. The west side of Slocan Lake is very rocky and precipitous, with very little timber, but the east side is fairly heavily wooded.

IRRIGATED AND IRRIGABLE AREA.

The area of land irrigated from the creeks which were surveyed is 200 acres, while 2,100 acres additional could be irrigated under the rights which were investigated. The method used in arriving at these figures is described under the heading "Nature of Surveys."

Owing to the limited amount of arable land around the shores of Slocan Lake, there is not a great amount of irrigation, and what there is is chiefly done by spraying under pressure. However, between Slocan Lake and Slocan Junction irrigation by ditch is resorted to at various places on a small scale.

SOIL.

The soil in Slocan Valley is rich, but the subsoil generally is open. The bottom lands are fairly heavy where they occur, and are liable to flood in spring.

PRECIPITATION, ALTITUDE, AND TEMPERATURE.

The precipitation on an average amounts to 28.95 inches, being made up generally of 84 inches of snow and 20.55 inches of rain. The fairly heavy amount of snow protects the ground considerably from the frost, and consequently the moisture from the melted snow is allowed to seep into the ground and is available for plant-growth. Irrigation is not needed to a great extent, but during a dry summer a little is necessary for the crops.

The climate is good, and extremes of heat and cold are seldom known. The maximum temperature is 97 degrees, and the minimum is 7 degrees below zero, while the average is 46.3 degrees.

The altitude of Slocan Lake during high water in 1897 was 1,773 feet above sea-level, and during low water 1,761 feet. What lands are irrigated around the lake do not go above an elevation of 1,900 feet. The arable lands between Slocan Lake and the junction of the river with Kootenay River do not extend, on an average, more than half a mile back on each side of the river, and do not rise to a greater elevation than 200 to 300 feet above the level of the stream.

UTILIZATION OF STREAM-WATERS.

The waters of the creeks flowing from the east into Slocan Lake are chiefly used for the operation of concentrators in the milling of mineral ores. There are some notable examples here of the maximum use to which water may be put. A high head is utilized for driving the machinery of the mill, and after leaving the wheels the water is used for washing purposes.

Around Sandon and Silverton the water is chiefly used in connection with mining operations—viz., driving the machinery of the concentrating-mill and the washing of the concentrates. The mines of the district are silver, lead, and zinc, and they are now commencing an era of prosperity after having been from ten to twelve years in a state of quietude.

Around New Denver irrigation is done chiefly by spraying under pressure from the smaller streams. The water of Carpenter Creek is unsuitable for irrigation purposes when the concentrators are running, and, for other reasons, irrigation from this stream is impracticable.

At the north end of Slocan Lake there are approximately 600 to 800 acres of land which could be cultivated and irrigated, but no settlement has taken place up to the present owing to the land being tied up through litigation. Bonanza Creek and several small streams flowing from the east could be utilized for irrigation in this district.

There is no land along the west side of Slocan Lake which could be classed as arable land, the high rocky mountains rising direct from the lake.

From Slocan City to Slocan Junction hydrographic work was done at Slocan City, Lemon Creek, Perry's Siding, and Crescent Valley. At the first three places mentioned, irrigation is resorted to in a small way, as also several other isolated places down the valley, the precipitation not appearing to be quite sufficient to tide over during a dry summer.

Owing to the mountainous nature of the country generally, there are numerous instances where very small streams flowing down the mountain-side are utilized for irrigation purposes on a small scale. The waters of these streams are often sought after by two or more persons, and there are numerous instances of friction amongst the people. A notable instance is the case at New Denver, where several very small streams flowing down Goat Mountain are in dispute.

NATURE OF SURVEYS.

The nature of hydrographic work undertaken in 1911 consisted of a detailed survey of the creek between the highest and lowest intakes, traverse of the ditches and flumes, location of intakes, etc., where the water was used for mining purposes, and in addition the irrigated and irrigable lands where the water was used for irrigation purposes. Only those lands to which a water right was appurtenant were surveyed in respect to irrigable lands. Also the rights on only those streams which had two or more records were surveyed. The territory covered is shown on the map accompanying this report.

The hydrographic data relating to that part of the Province under review in the foregoing report may be found on page 115.

I have, etc.,

E. DAVIS,

Engineer, Water Rights Branch.

KOOTENAY RIVER WATERSHED WEST OF THE SELKIRKS.

December 30th, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I beg leave to submit the following report of my investigations of that portion of the Kootenay River which drains the western slope of the Selkirk range of mountains:—

GENERAL PHYSICAL CHARACTERISTICS.

The Kootenay River rises in the Rocky Mountains, and after flowing about 175 miles in a southerly direction it enters the United States at Gateway, through which country it flows for 125 miles, only to return into British Columbia again at Bedlington, whence it flows in a northerly direction for fifteen miles through the Kootenay flats to the Kootenay Lake. It leaves the Kootenay Lake at the "Outlet" at Balfour, which is situated thirty-three miles from the point where it enters, and from thence flows for forty miles in a south-westerly direction until its confluence with the Columbia River at Castlegar. The approximate length in British Columbia is 263 miles and 125 miles in the United States, making in all a length of about 388 miles.

The drainage-area of the main stream and the drainage-area of four of its tributaries in the West Kootenay are as follows:—

	Square Miles.
Kootenay River (14,838 square miles in Canada and 5,047 square miles in United States)	19,885.
Lardo River	745
Duncan River	711
Kaslo River	165
Slocan River	1,120

The flow of the river is fairly constant, owing to the Kootenay Lake acting as a storage reservoir. The water rises on an average 19 feet in the lake, and floods approximately 40,000 acres of land, known as the Kootenay flats, in the vicinity of Creston. The run-off of the majority of tributaries of the Kootenay is very rapid during spring floods, but the influence of these are modified considerably when merged into the main river.

The arable lands along the river and shores of the lake do not extend generally inland more than three-quarters of a mile, and the greater portion of the land is within half a mile of the water. The ground slopes very sharply towards the river, although at one or two points there are a few hundred acres of fairly level land.

TIMBER.

The nature of the timber-growth along the West Arm of Kootenay Lake and Kootenay River is varied in character, owing to the rocky nature of the hills; where the soil is plentiful there is a heavy growth, but otherwise it is very scattered.

IRRIGATED AND IRRIGABLE AREAS.

The area of land irrigated from the creeks enumerated under the heading of "Nature of Surveys" during 1911 was 786 acres, while 843 acres additional could be irrigated under those rights which were investigated.

SOIL.

The soil generally on the bench lands is of a light nature and the subsoil is open. The the hills in prehistoric times through the ravines of the creeks, similar to wash-outs caused by formation of these lands appears to have been caused by rocks and earth washed down from cloud-bursts.

PRECIPITATION, TEMPERATURE, AND ALTITUDE.

The precipitation on an average amounts to 28.95 inches, being generally made up of 84 inches of snow and 20.55 inches of rain.

The climate is good and extremes of heat and cold are seldom known. The maximum temperature is 97 degrees, and the minimum 7 degrees below zero, while the average mean is 46.3 degrees.

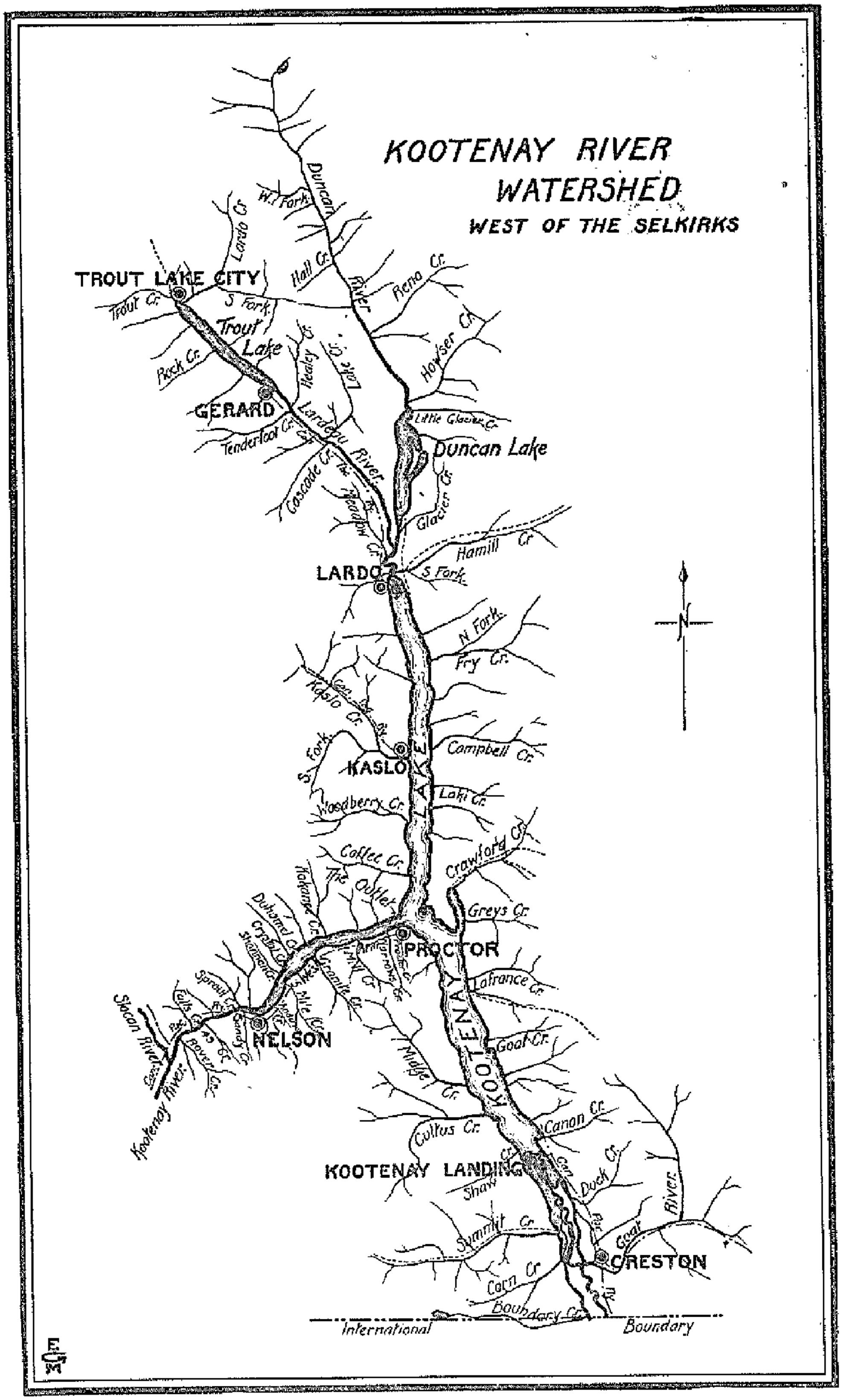
The normal altitude of the Kootenay Lake is 1,760 feet above sea-level, but during floods the waters rise considerably, and the average height to which the water rose during a number of years was 19 feet. During the flood of 1894 it rose 32 feet.

UTILIZATION OF STREAM-WATERS.

The waters of the main river are not used for irrigation purposes in this particular section of the valley, owing to the lands being situated a considerable height above the river-bed. The tributaries, however, are used for irrigation in a small way, the precipitation not being sufficient to supply all the moisture required during the dry summer months.

It is necessary to supply what irrigation is required at frequent intervals, as a great deal of water is lost by percolation into the soil beyond the reach of plant-roots. Also a great deal is lost in the beds of the creeks, where the latter reach the arable lands at the foot of the hills. In order to prevent this loss of water, it will be necessary to divert it generally in the canyons of the creeks above the arable land and convey it in concrete ditches or flumes.

There are no large systems of irrigation-works, although at one or two points works could be installed and more economical use made of the waters. These points are notably at Bonning-


KOOTENAY RIVER
WATERSHED
WEST OF THE SELKIRKS
TROUT LAKE CITY
GERARD
LARDO
KASLO
PROCTOR
NELSON
KOOTENAY LANDING
CRESTON
Duncan Lake
Duncan River
Lardeau River
KOOTENAY LAKE
Kootenay River
Slocan River
Trout Lake
International Boundary

ton Falls, Willow Point, and at the Narrows. Mining has been carried on extensively for a number of years, and consequently the waters of several streams have been utilized for power purposes and the washing of concentrates. The mining camps are somewhat scattered and are to be found all over the district. The waters of Coffee Creek near Ainsworth are used to operate a hydro-air compressor. This machine is of a novel character and there are not a great many in use. The head utilized is 107 feet and the horse-power developed 587.

Placer-mining was done in early days on Forty-nine Creek and several other small creeks, but very little of recent years.

The magnificent falls at Upper Bonnington are utilized in generating electricity for the surrounding country, and power is transmitted by the West Kootenay Power & Light Co. over eighty miles to the Boundary Country for use in the Granby Smelter and for general industrial purposes. The power plant of this company represents a first-class example of a hydro-electric station, and is up-to-date in every respect. The head utilized is 66 feet. The power generated at present is 10,000 horse-power. The transmission-line is operated at 60,000 volts.

The City of Nelson also generates electricity at these falls, the station being situated on the south side of the river.

The power-station at Lower Bonnington Falls is now held as a reserve to the plant of the West Kootenay Power & Light Co. at Upper Bonnington. The Lower Bonnington Falls were developed first and supplied the energy for a number of years. The head utilized is 40 feet.

There is a scheme on foot to enlarge the various points along the Kootenay River, which at present obstruct the flow from the "Outlet" at Balfour to Granite, which is about five miles below Nelson, in order to prevent the backing-up of the waters in the Kootenay Lake which flood the bottom lands known as the Kootenay flats. These bottom lands, should the reclamation scheme mature, will be eminently suitable for general farming purposes.

NATURE OF SURVEYS, ETC.

The hydrographic work in the Kootenay Valley from the Kootenay Lake to Slocan Junction was confined to streams on which there were more than two records. The streams investigated were as follows: Rover, Forty-nine, Sandy, Ward, Anderson, Dulhamel, Shannon, Mill, Narrows, Proctor, Ross, Aylmer, and Skunk Creeks; also Crawford Creek and its tributaries.

The course of the creeks investigated were traversed from the mouth to the highest intake, all intakes located, ditches traversed, and irrigable and irrigated areas surveyed. Owing to the time of the year when the investigation took place, no water was running in the ditches, and at scarcely any places were the ditches in such a shape that the capacity could be calculated by a well-known formula. These so-called ditches are usually made by a single plough-furrow, and then the water turned in them to find its way down as best it can. The waste of water by this method is enormous. Owing generally to the steep nature of the land, it would be far better for the record-holders to use the water under pressure—viz., pipe the water.

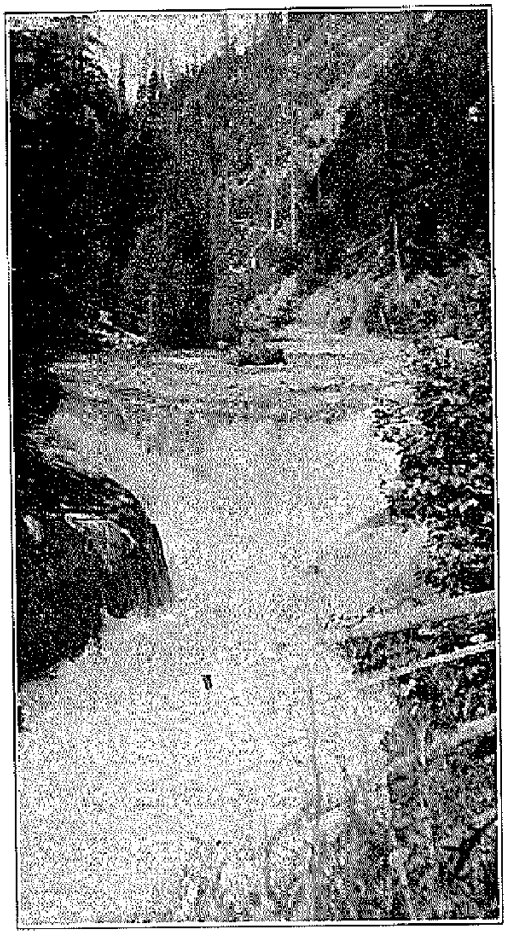
It may be noted that practically all the streams used for irrigation purposes in this district are small, and the gaugings appear very insignificant; however, as the disputes over water rights are generally on those streams where the water-supply is limited, the value of the figures will be plainly seen.

The hydrographic data relating to that part of the Province under review in the foregoing report may be found on page 116.

I have, etc.,

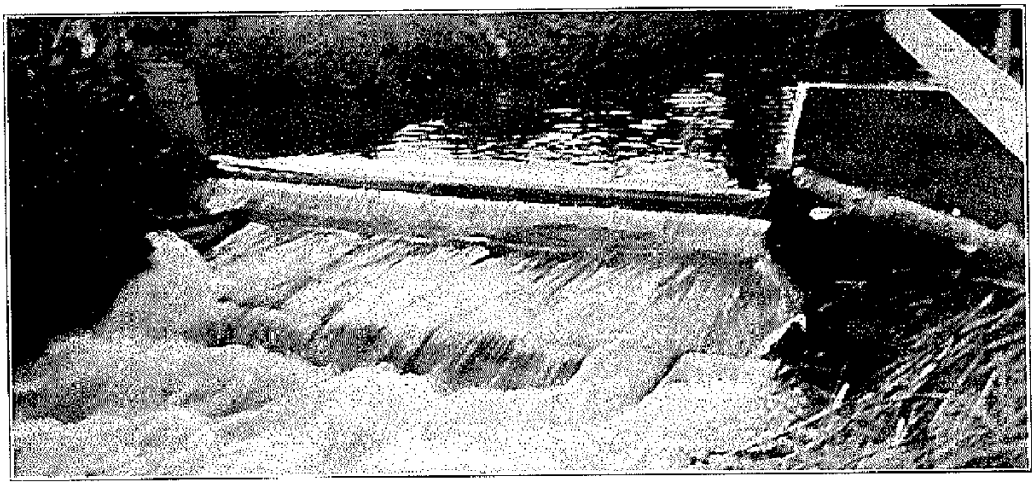
E. DAVIS,

Engineer, Water Rights Branch.



Carpenter Creek Falls, near New Denver.

Falls on Mark Creek, at Marysville.



Measuring Weir on Linklater Creek, with free fall of 12 inches on down-stream side.

UPPER COLUMBIA WATERSHED.

Comptroller of Water Rights,
Victoria, B.C.

December 31st, 1912.

SIR,—Pursuant to instructions received, I have the honour to report as follows upon that portion of the Columbia River Watershed commonly known as the Windermere District, and containing approximately 1,510 square miles:—

GENERAL PHYSICAL CHARACTERISTICS.

This area, within which are situated the sources of the Columbia River, is bounded on the east by the narrow ridge of mountains known as the Brisco Range, which divides the waters of the Kootenay River, taking a southerly course, from those of the Columbia flowing north; the western boundary is the Selkirk Range; and the part of the valley under review is included between Salmon River on the north and Findlay Creek on the south.

The eastern side of the drainage-basin being comparatively narrow, the creeks flowing therefrom are, generally speaking, short, and their discharge small, while on the western side, draining the long slope of the Selkirks, are several streams of considerable length and volume.

The width of the main valley varies from eight to twelve miles, while in the lateral valleys of the larger creeks are stretches of bottom land varying from a half to two miles in width.

In surface configuration the valley varies somewhat, but as a rule the ground rises steeply from the river or lakes for 200 to 300 feet, and then stretches back to the mountains in a series of gently sloping benches, broken here and there by knolls and ridges or by stream gulches.

TIMBER AND VEGETATION.

The valley is fairly well timbered, Douglas fir preponderating in this district, especially on the lower benches, while nearer the mountains jack-pine, spruce, and tamarac are found, with cottonwood and willow on the wetter parts. On the upper benches of the eastern side are stretches of sage-brush. Natural grasses grow somewhat sparsely on the lower benches owing to the dryness of the unirrigated soil.

On both sides excellent range feed is abundant on the higher lands, affording good pasturage for cattle and horses.

IRRIGATED AND IRRIGABLE LANDS.

The following table is given to show irrigated and irrigable lands so far as at present ascertained:—

Stream.	Total Area under Record.	Irrigated Area.	Irrigable Area.
Morigeau Creek	12,531	876	4,291*
Goldie Creek	3,070	38	2,625
Sunlight Creek	966	18	860
Salter Creek	Indefinite.	None.	Indefinite.
Brady Creek	Indefinite.	47	Indefinite.
Johnston Creek	363	62	308

* Total includes Indian reserve.

No records are in use from Salter Creek, and as the land in many cases is not clearly defined it is impossible to give all areas. This also applies in a certain degree to Goldie and Brady Creeks. In the case of Morigeau Creek, the total area under record includes the large Indian reserve, of which 500 acres has been allowed as irrigable from this stream.

In the entire district it is estimated that 148,000 acres are irrigable. This has been arrived at by taking the total area of settled land and allowing 40 per cent. as non-irrigable by ordinary methods.

SOIL.

The character of the soil is varied; that on the eastern side is, as a rule, lighter in composition, with more open and easily drained subsoil than is found on the western side. On both sides, as the mountains are approached, the soil appears to be heavier and more retentive of moisture, that along the foot of the Selkirks particularly being a fairly dense red-clay loam, apparently more or less sub-irrigated by mountain seepage. The soil on the lower benches is

mostly chocolate or brownish sandy loam of loose, almost ash-like, character, and is very easily cultivated, but its irrigation demands great care and constant attention to secure the maximum duty of water, to prevent the washing-away of surface soil and the scouring of deep channels.

Analyses made by Professor Shutt of soil samples from different parts of the valley show highly satisfactory nitrogen-content; a high percentage of lime; a satisfactory proportion of potash; and, although not rich in total phosphoric acid, a large proportion of the latter is present in a readily assimilable form.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

The mean summer temperature is about 60° Fahr. and the maximum 95 degrees. The mean maximum in winter is 53 degrees and the mean minimum 23 degrees, the range being from 68 degrees above zero to 36 degrees below. Extreme cold dips are rare and of short duration; winter climate is tempered by Chinook winds, and that of summer by winds blowing over glacial fields.

Precipitation for 1910 at Windermere Nurseries, Wilmer Station, amounted to 7.04 inches of rain and 1.9 inches of snow (melted), an equivalent of 8.94 rain-inches. This is probably below the average.

The altitude of the upper and lower lakes is 2,700 and 2,600 feet respectively. The maximum elevation of agricultural land is about 3,400 feet. At 3,350 feet, on the west side, is one of the most productive ranches in the valley, where small and tree fruits, vegetables, and hay are successfully cultivated.

UTILIZATION OF STREAM-WATERS.

The diversion of water from streams in this district has been almost exclusively for irrigation, the records usually including a right to domestic supplies. Some rights have been obtained for mining purposes, and several streams have been used for log driving. Owing to the normally low precipitation and the small quantity which falls during the growing season, irrigation is generally necessary, especially on the lower benches.

As has been previously stated, the ridge on the east side of the valley is narrow, affording a very limited drainage-area. The resulting streams, with one or two exceptions, are small, and, so far as information is at hand, there are no large lakes to act as natural regulators of flow. In some cases the demands on these streams are greatly in excess of the supply available; possibly in one or two instances storage-sites exist which may be turned to advantage. It is probable, however, that before full development can take place on these lands some means of augmenting the supply must be found, either by transmitting power from other parts of the valley and pumping water from the river and lakes, or otherwise.

On the western side the long eastern face of the Selkirks affords an extensive gathering-area; and there are several large streams on this side. These have, however, eroded deep valleys, and their use for irrigation, especially on the higher bench lands, involves the construction of long and costly ditches and flumes, such as are hardly likely to be undertaken by individual irrigators.

Most of the rights hitherto utilized on this side have been taken out of the smaller streams, which, flowing over relatively higher ground, can be used without costly supply-works.

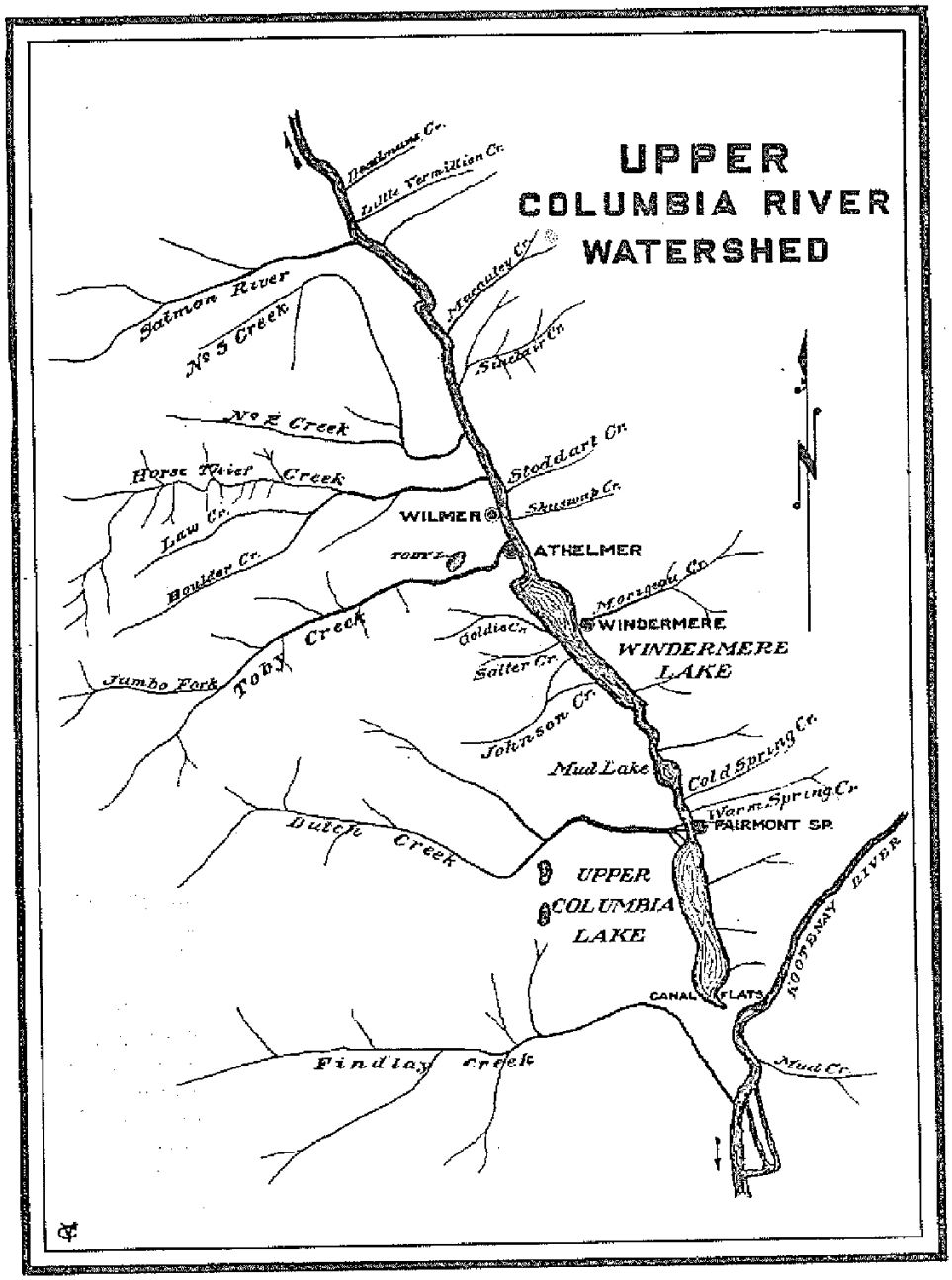
Several comprehensive projects are now under construction or in contemplation, including that of the Columbia Valley Irrigated Fruitlands, Limited, whose completed scheme will cover 45,000 acres west of the river and lakes, and the Columbia Valley Orchards, Ltd., who are laying out extensive areas at Sinclair on the east side.

All kinds of grain and vegetables, small fruits, and hardy tree-fruits seem to flourish in the district. Owing to absence of good transportation facilities, settlement has been somewhat retarded, but with the construction of the Kootenay Central Railway, now proceeding, rapid development will doubtless ensue.

NATURE OF SURVEYS.

Survey-work was commenced on May 20th, 1912, and the camp was closed on August 31st in order to take up power-investigation work under Mr. Gray Donald.

The streams dealt with were Morigeau, Goldie, Sunlight, Salter, Brady, Johnston, and Spring Creeks. Intakes of ditches and their courses were located and tied to any convenient lot corners. Stadia surveys of irrigated areas and contours were run to determine areas irrigable under existing intakes on appurtenant lands.



Gaugings of small creeks and ditches were made with a right-angled triangular notch, while for larger streams and ditches horizontal sharp-crested weirs or floats were used.

In some of the later work measurements of grades and ditches were taken to determine carrying-capacity.

Only a few gaugings were taken, the time spent in the district being insufficient to obtain observations for extreme variations in flow.

A table showing the results of such stream-gaugings as were obtained will be found on pages 116 and 117.

I have, etc.,

F. W. KNEWSTUBB, Assoc.M.Inst.C.E.,
Engineer, Water Rights Branch.

KOOTENAY RIVER WATERSHED EAST OF THE SELKIRKS AND NORTH OF WARDNER.

December 30th, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I beg to submit the following report upon a portion of the Kootenay River Watershed which lies in the district commonly known as the "East Kootenay," and which includes Bull River and Sheep Creek on the eastern side, and the St. Mary's and Moyie Rivers on the western side. The area embraced by the entire report is approximately 3,410 square miles.

PHYSICAL CHARACTERISTICS.

The Kootenay River rises about 125 miles north of Cranbrook, flowing southerly through British Columbia a distance of about 175 miles, crossing the International Boundary at Gateway, continuing in the United States for a distance of about 125 miles, and returning to British Columbia at Bedlington. The river is fed by numerous streams, large and small. These streams are fed by springs, and during the spring and summer months by the melting snow in the Rocky Mountains on the east and the Selkirk Range on the west. The more important tributaries will be briefly considered.

The Moyie River, which occupies a territory somewhat separated from the other tributaries of the Kootenay herein considered, rises in the Selkirk Range about twenty-five miles south-west of Cranbrook. Flowing first east and then south-west, it crosses the International Boundary at Kingsgate, joining the Kootenay River in the State of Washington. The length of the stream in British Columbia is about fifty miles and in the State of Washington about twenty miles.

The St. Mary's River rises in the Selkirk Range about forty miles west of Cranbrook, flowing east into the Kootenay River at Fort Steele, and having a total length of about fifty miles and a drainage-area of about 1,250 square miles. The stream winds its way among the mountains of the range for the first thirty-five miles of its course. Continuing to its confluence with the Kootenay, the adjacent country is a series of high rolling benches, excepting at its mouth, where there are several thousand acres of low land.

Sheep Creek rises in the heart of the Rocky Mountains, flowing first to the north-west and then to the south-west, and entering into the Kootenay River at a point about twenty miles above Fort Steele. It has a total length of about forty-five miles and a drainage-area of about 350 square miles. For the greater part of its length the stream winds through the mountains, the adjacent country for the lower twelve or fifteen miles being a series of flats or rolling benches. Some of this is cultivated and irrigated, and all of it could be.

The Skookum-chuck River rises in the Selkirk Mountains, flowing first north and then east into the Kootenay River, having a total length of about thirty miles and a drainage-area of about 100 square miles. For almost its entire length the river winds through the mountains.

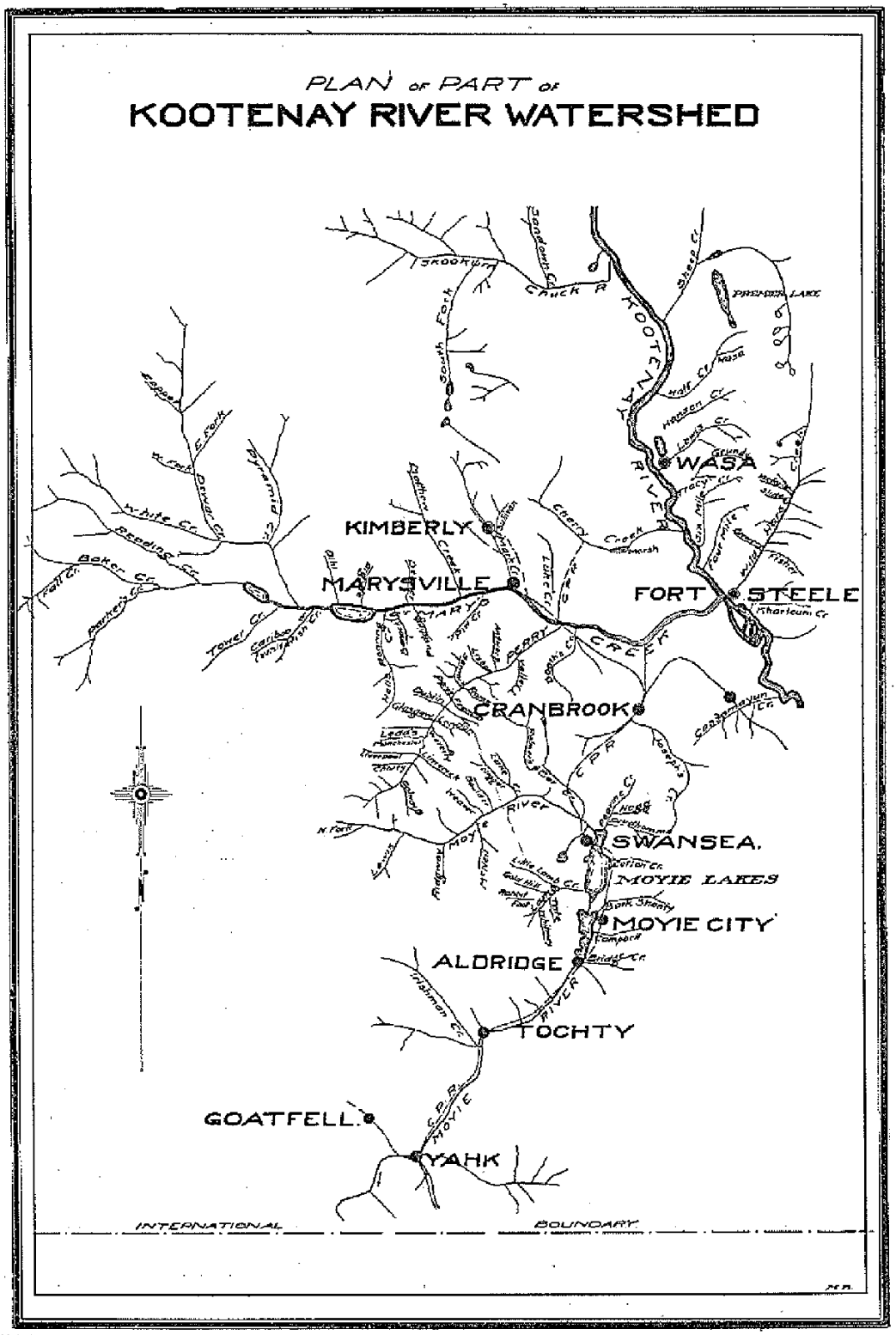
Bull River rises in the heart of the Rocky Mountains and flows west into the Kootenay River near Wardner, having a total length of about twenty-five miles and a drainage-area of about 360 square miles. The stream for almost its entire length winds through the mountain-range. The lower five or six miles of adjacent country are a series of benches.

Wild Horse Creek rises in the heart of the Rocky Mountains and takes its course to the west, flowing into the Kootenay River at Fort Steele. Its length is about twenty-five miles, and it has a drainage-area of about 360 square miles. Excepting the lower two miles, the stream flows through the mountain-range.

TIMBER AND VEGETATION.

All the streams and mountains in this district are timbered. Tamarac and pine predominate, with a small percentage of fir throughout the district. Occasionally small patches of good merchantable cedar are found.

In traversing the country, one frequently finds a considerable area where the trees are scattered, with a very little or no underbrush, some of the country being a natural prairie. Then, again, one will encounter strips quite densely covered with an underbrush which generally consists of small pine, willow, and birch. This brush is usually found along the stream-beds and at the base of the mountain-slopes. Bunch-grass and other grasses sufficient for good grazing are found over the entire country.


PLAN OF PART OF
KOOTENAY RIVER WATERSHED
KOOTENAY RIVER
WASA
KIMBERLY
MARYSVILLE
FORT STEELE
CRANBROOK
SWANSEA
MOYIE LAKES
MOYIE CITY
ALDRIDGE
TOCHTY
GOATFELL
YAHK
INTERNATIONAL BOUNDARY
C.P.R.
MOYIE RIVER

IRRIGATED AND IRRIGABLE AREAS.

The district known as the "East Kootenay," a part of which is embraced in this report, is quite distinct from other parts of British Columbia south of the main line of the Canadian Pacific Railway in respect to the extensive areas of evenly sloping lands lying between the rivers and the mountains. The figures given in the following table include not only such areas as may be readily irrigated from adjacent streams, but take into consideration the fact that, in the near future, systems of conserving the waste waters will be developed, making it possible to irrigate all the valley and bench lands:—

Locality.	Irrigated or cultivated, Acres.	Irrigable (estimated), Acres.
Bull River	750	25,000
Fort Steele	835	18,000
Wasa	360	29,000
Sheep Creek	260	18,000
Skookum-chuck	140	13,000
Cherry Creek	750	20,000
St. Mary's Prairie	1,150	33,000
Upper St. Mary's Prairie	50	10,000
Perry Creek	80	2,400
Cranbrook	830	30,000
Upper Moyie	200	5,000
Lower Moyie	50	12,000
Total	5,455	215,400

TEMPERATURE, PRICIPITATION, AND ALTITUDE.

The steady winter weather usually begins during December, continuing through January and February, the temperature ranging from freezing-point to zero, and occasionally, for a few days at a time, going as low as 20 or 25 degrees below zero. The snowfall is sufficient for sixty or seventy days' good sleighing. In a very exceptional year the temperature may go to 30 degrees below zero during November, with 12 or 15 inches of snow, this low temperature lasting only one or two days. In the month of March all snow and ice will disappear from the lower flats and valleys. Generally the rainfall is scattered through the months of April, May, June, September, and October; July and August are the dry and warm months. In exceptionally wet seasons it is necessary to irrigate but very little.

Below is a table compiled from the records taken at Cranbrook and kept by the Meteorological Service at Victoria, giving the total precipitation for all of the year 1911 and eleven months of the year 1912. It may be noted that 10 inches of snow is equal to 1 inch of rain. I believe the total precipitation for the year 1911 would represent an average year. The total precipitation is not necessarily the governing factor in determining whether a year shall be called a wet or dry year. Two consecutive years might have the same precipitation, but if the rainfall were so distributed that during one season it was necessary to irrigate, and the next season it was not, they would be called respectively a dry and wet season.

Precipitation Records, Cranbrook, 1911 and 1912.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
1911.													
Inches of rain	0.73	...	1.63	0.05	1.26	2.35	0.40	1.84	2.10	0.17	...	...	10.53
Inches of snow	37.20	4.60	7.00	3.00	...	...	...	...	...	...	14.00	11.00	76.80
Total precipitation	...	...	...	...	...	...	...	...	...	...	...	...	18.21
1912.													
Inches of rain	...	...	0.03	0.35	1.08	1.65	3.76	1.01	0.56	1.14	...	...	9.58
Inches of snow	11.00	2.00	...	...	...	...	...	...	...	...	11.60	...	24.60
Total precipitation	...	...	...	...	...	...	...	...	...	...	...	...	12.04

The elevation, together with the dryness of the atmosphere, make the climate most agreeable and invigorating. The altitude of the lower valleys and benches will vary from 2,450 to 3,100 feet. The adjacent mountain-ranges vary in height from 7,000 to 9,000 feet.

UTILIZATION OF STREAM-WATERS.

The principal uses made of the water in this district are irrigation, and in connection with the mining and logging industries. There is not, in my opinion, any country which has the combined natural advantages and resources confined to so small an area as this part of British Columbia, with its hundreds of thousands of acres of tillable soil, its millions of feet of standing merchantable timber, its rich deposits of precious metals, and its immense coalfields, with natural power lying dormant in the mountain-streams.

Josephs Creek, a small stream, supplies water to the Municipality of Cranbrook, and to numerous tracts of land for irrigating purposes. Cherry, Wolf, Lewis, Four-mile, Maus, and Cassamayook Creeks and Little Bull River are other small streams whose waters are used for irrigation.

Perry Creek, a tributary of the St. Mary's River, is one of the oldest and best-known placer creeks in British Columbia, having produced many millions of dollars in gold-dust. Recently flumes and pipe-lines have been constructed preparatory to working the old diggings at the falls; and on another part of the creek the most up-to-date and systematic methods of prospecting are being carried on with modern machinery under expert and experienced management.

Wild Horse Creek, at a point near Fort Steele, has produced more gold-dust than any stream in British Columbia. The mines are now being worked, and have been continuously worked for the past forty-five years. The old ditch built in early days has a capacity of about 50 cubic feet per second.

Bark, Shanty, Bridge, and Sunday Creeks are four small streams flowing into the Lower Moyie, whose waters are used by the Consolidated Mining and Smelting Co. of Canada for generating power and washing ore. Mark Creek, a tributary of the St. Mary's River, furnished water to this same company for power purposes. During the fall months the discharge of 14 cubic feet per second with a 186-foot head is just sufficient for the requirements of the company.

Bull River has a dam and flume built along its banks representing an expenditure of about $120,000. This flume has been used for floating logs and ties, but recently has been purchased by a hydro-electric company, who intend developing it. The minimum horse-power is about 9,000. Stream-measurements have not extended over such a period of time as to form a basis for a more exact estimate of horse-power at this site.

Lumbering is a big industry in this district, and with few exceptions the streams are used for floating logs and ties. Lamb Creek, which flows into the Moyie River, is used by the Porto Rico Lumber Company, $30,000 having been expended in improving the stream-channel. On other streams flumes have been built for this purpose.

NATURE OF SURVEYS.

I began the hydrographic work in this district in June, 1911. The work at this time consisted principally of surveys of irrigable and irrigated lands under rights held under old records. Stream-measurements were confined, with the exception of one stream, to miscellaneous discharge measurements.

In September, 1912, definite instructions were received to proceed with systematic and continuous work in stream-measurements. Suitable meters were also received, and ganging-stations established as follows: The St. Mary's River, near the wagon-bridge at Wycliffe; Cherry Creek, near the wagon-road bridge; Skookum-chuck, near the proposed C.P.R. crossing; Josephs Creek, about four miles above Cranbrook.

All available hydrographic data for the territory embraced in this report is given on pages 117 and 118.

I have, etc.,

H. B. HICKS,

Engineer, Water Rights Branch.

KOOTENAY RIVER WATERSHED EAST OF THE SELKIRKS AND SOUTH OF WARDNER.

December 31st, 1912.

Comptroller of Water Rights,
Victoria, B.C.

SIR,—I beg to submit, according to instructions, the following report on that portion of South-East Kootenay extending north from the United States Boundary to Bull River, and bounded on the east by Alberta, including the whole of the Elk River Watershed, an area of 3,050 square miles:—

For convenience I have considered the district in two portions; the first part known locally as the Roosville Valley or Tobacco Plains, and the second part as the Elk River Watershed. The major portion of the report has reference to the Tobacco Plains Precinct, but the Precincts of Linklater, Gold, and Rock Creeks are part of the same watershed and adjoin this precinct; therefore the general data may be taken as applicable.

GENERAL PHYSICAL CHARACTERISTICS.

The general character of the country in the Roosville Valley is mountainous, with a gradual slope west from the main range of the Rocky Mountains, ending in the Kootenay River.

The mountains, which are practically north and south, give rise to twelve streams or creeks, and all except one sink in the valley, eventually reaching the Kootenay River by subterranean channels. Those in the top portion of the valley seem to collect underground and form a stream of 25.389 cubic feet per second flowing into the Upper Edwards Lake, which has a stream of 25 cubic feet per second running into the lower lake, where it again disappears.

Transportation facilities are good. The Great Northern Railway between Spokane and Fernie parallels the Kootenay River and the valley for about twenty miles, and the Canadian Pacific is reached at Elko and Waldo. Two good Government roads traverse the valley, one at the foot of the mountains and one adjoining the river, with cross-country connections at Flagstone and Gateway. From the base of the mountains to the Kootenay River, a distance of about six miles, the land is rolling and nearly all good from an agricultural standpoint.

The drainage-area is 110 square miles. Fifty per cent. of the land must always remain uncultivated because of its elevation and mountainous character.

Agriculture, stock-raising, lumbering, and horticulture constitute the four leading industries of the valley. In a way it is regrettable that timber licences hold back from cultivation much good land.

TIMBER AND VEGETATION.

The valley is still mostly a natural forest, with the exception of the ranches, the chief standing timber being tamarac, bull-pine, fir, and patches of willow on the swamps where the streams sink. The merchantable timber in many places will cut as high as 10,000 feet per acre, but the average is not higher than 4,000 feet. The mountains to the east are sparsely timbered and should always remain as a timber reserve.

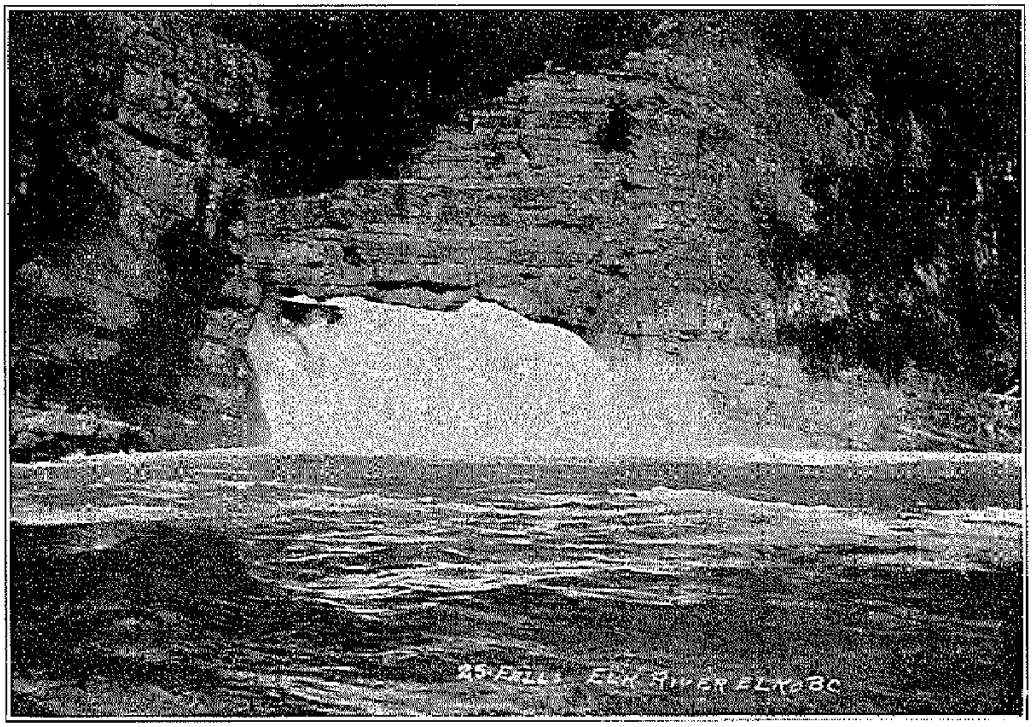
The cost of clearing and preparing land for cultivation varies with the amount to be cleared. There are from eighteen to twenty-two stumps per acre averaging 18 inches in diameter, and from twenty-eight to thirty-five small trees under 9 inches in diameter. In small lots varying in area from 5 to 10 acres, the cost of clearing is between $45 and $50 per acre, but the same land, if let in contracts covering several hundred acres, can be cleared for a price ranging between $35 and $40.

SOIL.

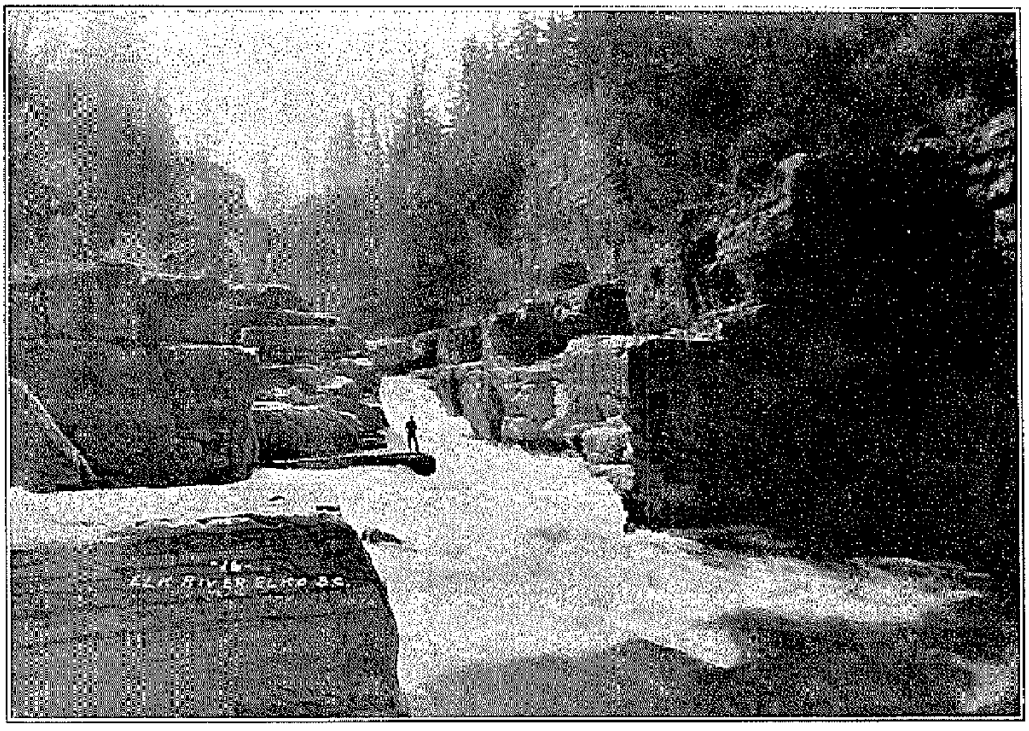
The best soil in the valley is a rich dark-brown coloured loam, composed of decayed vegetable matter, deposits of silt, and glacial till. That of the rolling bench land is lighter in colour, sandy in character, and not so rich, mixed in places with small gravel. The subsoil is a washed gravel and provides an excellent sub-drainage.

TEMPERATURE, PRECIPITATION, AND ALTITUDE.

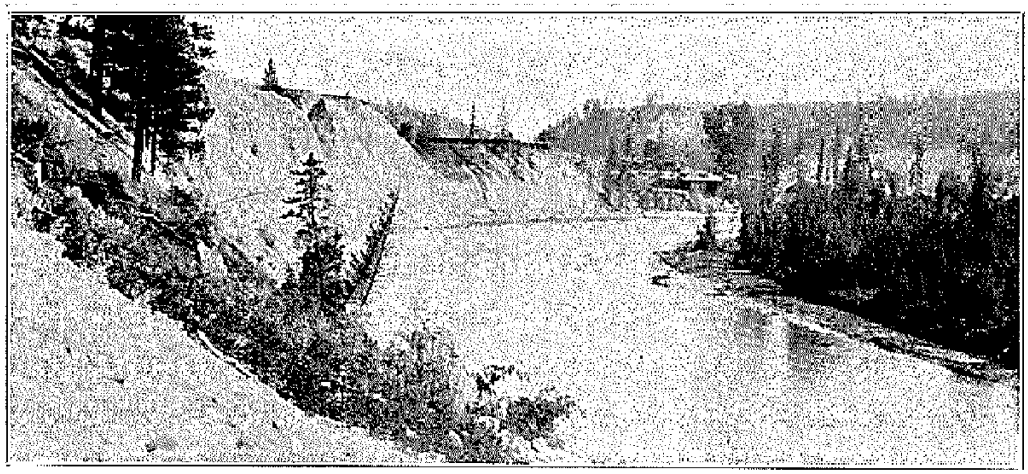
The valley is at an altitude of 2,670 feet above sea-level, and protected from the most severe weather by the high mountains to the east. Although the records show the lowest temperature



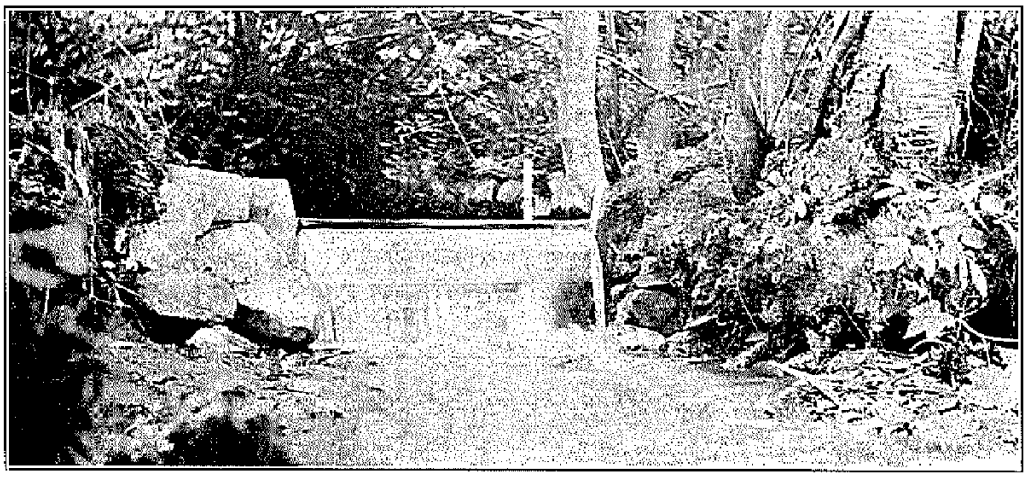
Falls of Elk River, Elko, B.C.



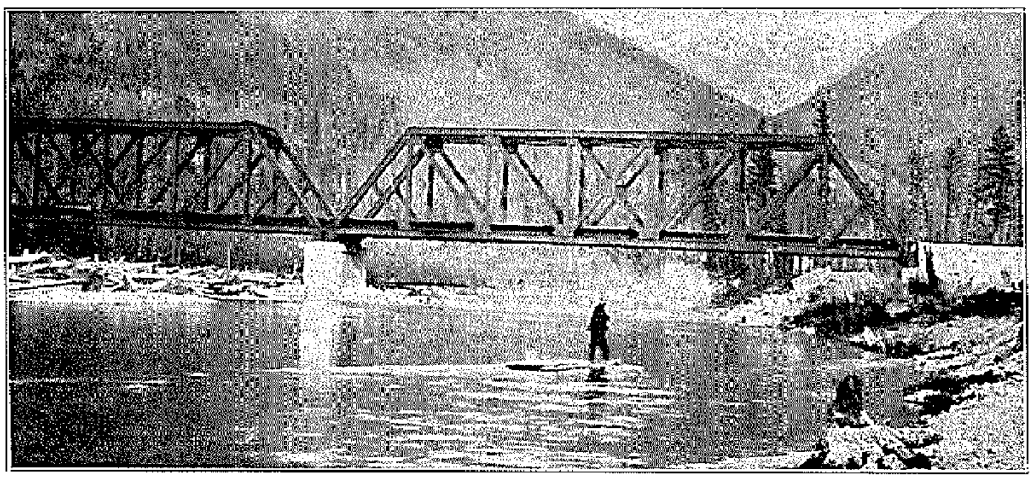
Elk River Canyon, showing Rapids.



St. Mary's River, East Kootenay.

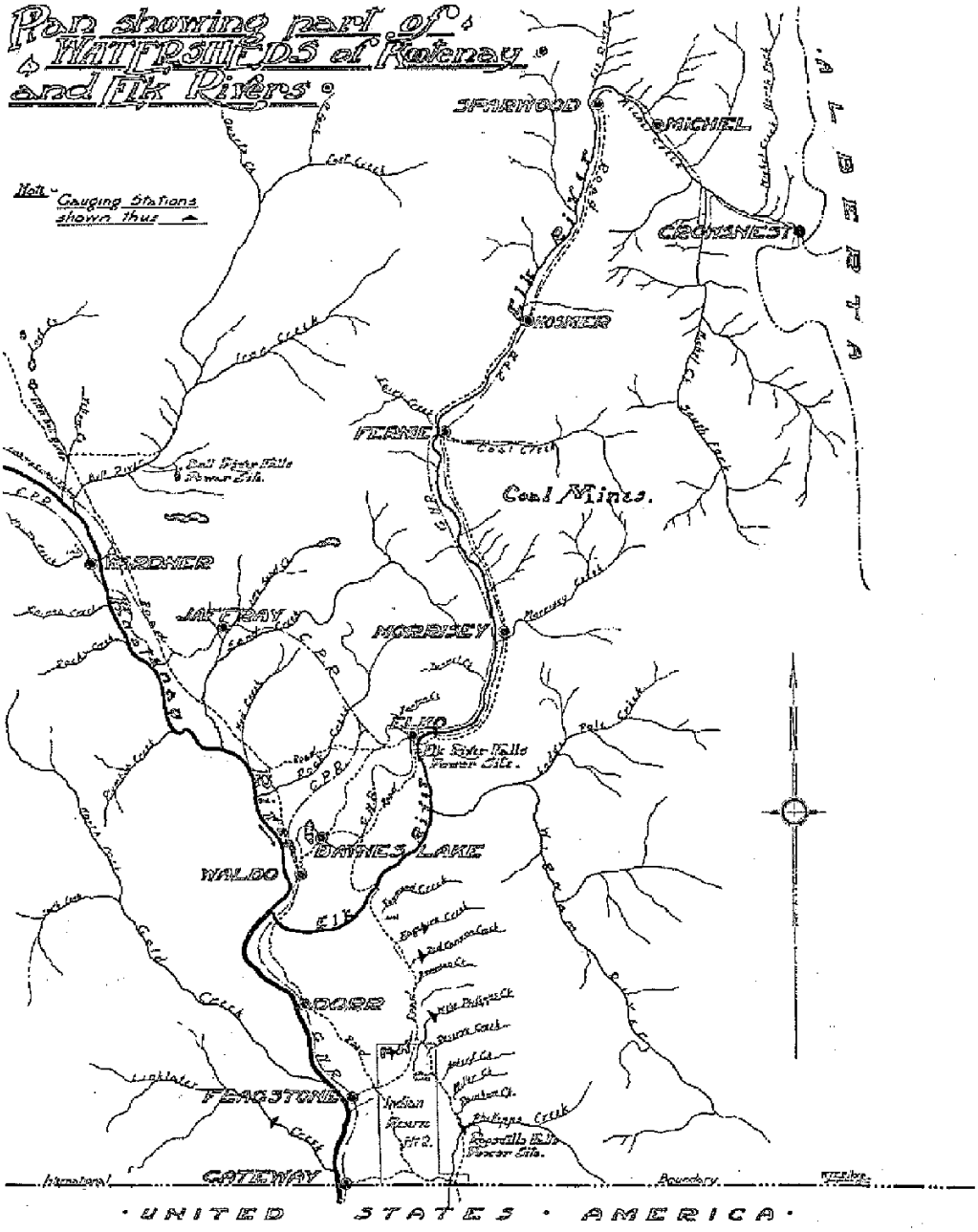


Measuring Weir on Morrissey Creek, near Grand Forks.



Gauging Elk River from a Raft.

to have been 32 degrees below zero, this only obtains very occasionally, and is of short duration. Precipitation records are given below, and show a total mean annual precipitation of 18.23 inches. To analyse the rainfall figures, they show that no months are absolutely without rain, and that the heaviest rain falls in the months of May and June, in which irrigation is most needed. In fact, no irrigation is required at all in such seasons as 1912.



The seasons are fairly well defined, and conditions are about ideal for horticultural products. Extremes of heat and cold do exist, but are confined to periods when nature is dormant; therefore no damage is done.

Average Monthly Rainfall and Snowfall, 1897 to 1912.

Precipitation in Inches per Month.												Average Annual Precipitation.
Jan.	Feb.	March.	April.	May*	June*	July*	Aug.*	Sept.	Oct.	Nov.	Dec.	
1.51	1.34	1.15	0.94	2.12	2.59	1.85	1.36	1.27	1.01	1.89	1.20	18.23

* Irrigation months.

NOTE.—The above figures are compiled from data obtained from E. Baynes Reed, Esq., Government Meteorologist, Victoria, the Observer being Michael Phillips, Esq., J.P., Elko, B.C.

IRRIGATED AND IRRIGABLE AREAS.

Owing to the fact that a comparatively small part of the territory embraced in this report has been surveyed and investigated in respect of the rights of record-holders, it will not be possible to give exact figures or even estimates of the irrigated and irrigable areas for the whole district; however, such figures and estimates as can be given are presented in the following table. It will be noted that Fernie Precinct is omitted, as that is one of the districts in which very little investigation of water rights has been carried on:—

District.	Amount of Land under Record, Acres.	Land cultivated or irrigated, Acres.	Estimated Additional Irrigable Area, Acres.
Tobacco Plains Precinct	17,480	941	20,000
Rock Creek	35,880	2,400	37,735
Linklater Creek	1,620	170	6,500
Gold Creek	4,700	300	17,408

The acreage of land for which water is held under record for the Tobacco Plains Precinct is 17,480 acres; and 5,505 acres, or a little under one-third of this total, is possible and worthy of irrigation. At the present time only 941 acres of the above lands are cultivated and irrigated.

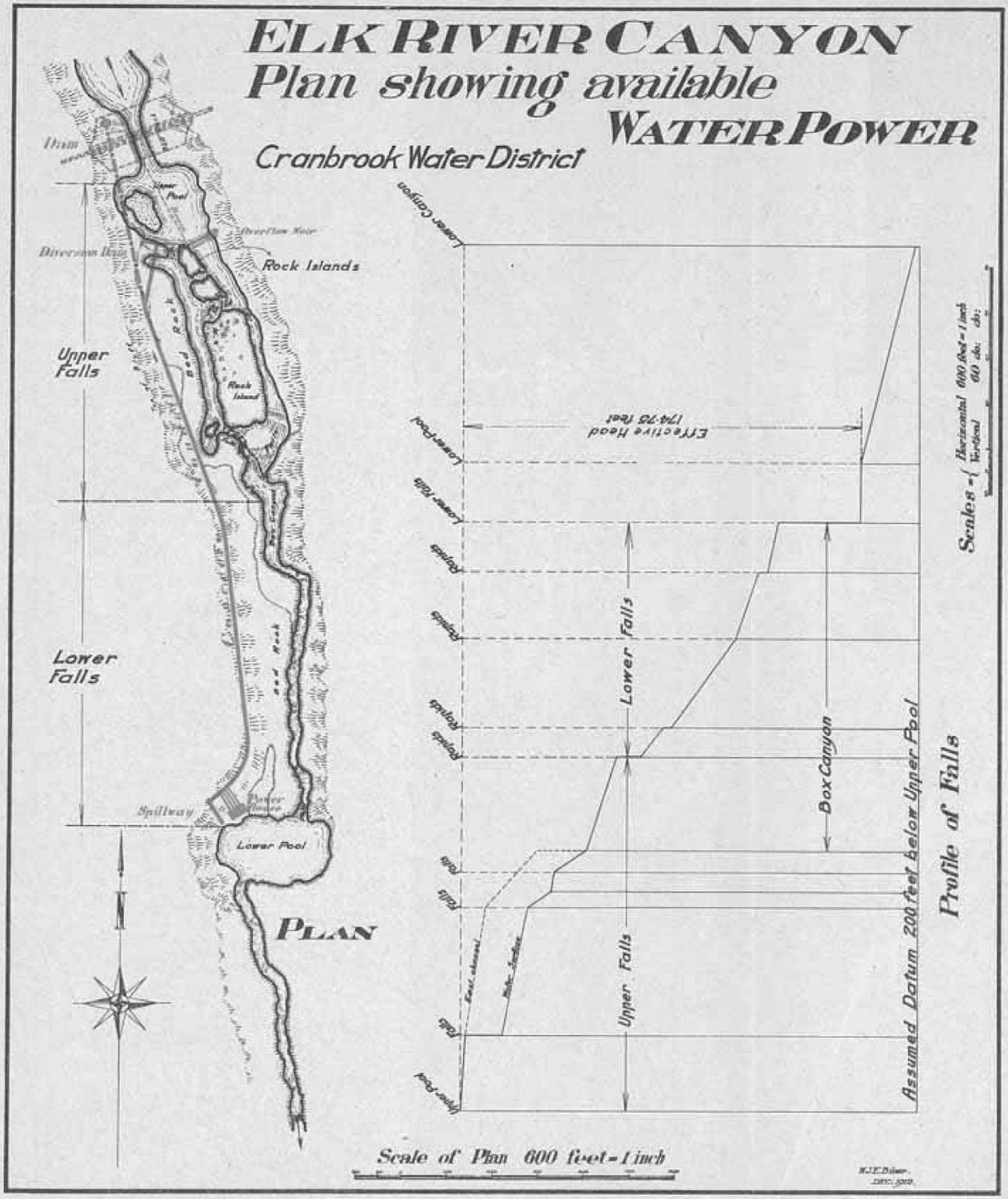
From gaugings taken at the low-water period of the irrigation season, there is shown to be sufficient water to submerge the present cultivated land to a depth of 20 feet in an irrigation period of 100 days. At the same time many of the ranchers declare a shortage of water. This is due, however, to the very crude and ineffectual method in use regarding the design and construction of irrigation schemes. The position, therefore, is that some of the present ranchers are wasting and holding the water to the exclusion of intending settlers. There is sufficient water continuously flowing (without the storage of flood-water) to irrigate approximately 20,000 acres, and yet more land is susceptible to irrigation than there is water to supply, but little development is in progress regarding the increase in the irrigated area.

The calculation given above is based on a water duty of 1 acre-foot per acre, which, when considered in conjunction with the precipitation, makes a total depth of water on the land of 2.5 acre-feet per acre. I hold the opinion (if it were possible to legally form water districts) that the Roosville Valley could be developed to make most excellent returns on capital expenditure. This would at the same time open up the district for agriculture. Much money has been expended on projects unsuitable to the existing conditions, and, in consequence of the failure of such, a few hard-working settlers have abandoned all hope and left the land.

UTILIZATION OF STREAM-WATERS.

It is too early to arrive at any final conclusions from the data at hand, but it is safe to say that quite four-fifths of the water in this drainage-area is lost through waste, seepage, and bad ditches, and will continue without improvement. This condition is very regrettable, since the storage, conservation, and beneficial use of water is one of the most important of public utilities.

From an examination of stream systems and appropriations, it appears that in many cases the creeks are over-appropriated; or, in other words, the prior record-holder is diverting the



Report of the Water Rights Branch, 1912

water to the absolute exclusion of later rights. The holders of these later records have not up to the present time felt justified in constructing irrigation-works, but it must be remembered that in the near future, when the administration exercises a closer supervision over the use of water, many of these records will be in good standing. Therefore it would be unjust to question these rights from a non-use standpoint until such adjudications are arrived at as will establish the respective rights.

The Tobacco Plains Indians have a reserve of 10,400 acres extending northwards from the International Boundary for a distance of six miles and a half. Approximately 75 per cent. of this land is worthy of cultivation, and at the present time only 190.5 acres are cultivated and irrigated. The water held under record by the Indians is 506 miners' inches, or 14.17 cubic feet per second, and not more than one-seventh of this amount is beneficially used. First-class raw land in the district can be bought from $15 per acre upwards; improved land, with fences, and partially cultivated, from $50 to $75 per acre; irrigated and cultivated land from $120 to $150, according to quality and situation. The cost of irrigation-works in this locality ranges, according to location, from $15 to $25 per acre.

In reference to power and reservoir sites, there is a good small power-site on Phillipps Creek on Sub-lot 45, Lot 4589. The creek has a fall of 410 feet in a length of 1,500 feet, and would produce 745 horse-power at low water. This power could be produced without jeopardizing the existing irrigation rights, since the water could be returned at an elevation which would command all the available land. On the easterly portion of Sub-lot 45 there are surface indications of a good reservoir-site, very valuable from an irrigation standpoint, because of its elevation, also as a means of augmenting the power-site at the falls.

NATURE OF SURVEYS.

Prior to 1912 no hydrographic work had been done in this district. Therefore I have spent considerable time on stream and ditch gaugings, and have established permanent Cippoletti weirs on six of the most important creeks. The ranchers and record-holders appreciate the importance of this work, and I have to acknowledge with thanks the assistance rendered to the Department, in the way of weekly readings of the weirs, by the following: J. Desrosiers, near Elko; G. Peterson and Colin Sinclair, near Flagstone; Fred Roo, Jr., Roosville; and A. Murphy, near Gateway.

ELK RIVER CANYON.

According to instructions, I investigated the Elk River Canyon from a power standpoint, and give below the salient features drawn from the report thereon. The power-site is about one mile south-east of the Town of Elko.

The Elk River rises in the Rocky Mountains near the summit of the Kananaskis Pass and the eastern boundary of British Columbia with Alberta, from which point it runs in a southerly direction for a distance of 110 miles to its confluence with the Kootenay River, which is thirteen miles north of the International Boundary. This river is subject to great variation in flow, and the high- or flood-water period (by reason of the active lumbering operations and forest fires within the watershed) is getting gradually shorter and more violent in character, although I think the limit in this regard has now been reached. To compensate for this condition there are many admirable economical reservoir-sites which could be developed to control these flood-waters, and be made capable of contributing towards the uniformity of stream-flow. H. B. Hicks, Field Engineer, gauged the river on October 22nd, 1911, and found 817 cubic feet per second. I gauged it about the same point on October 16th, 1912, and found 846.226 cubic feet per second, which may be said to be almost low-water flow. In regard to high water, from indications of driftwood and flood-wash, I estimate the flow to be twenty times the above, or 16,924 cubic feet per second. The watershed of the river above the power-site is 1,700 square miles in area and very mountainous in character, resulting in a very rapid run-off. The canyon and falls are very fine from a scenic point, and much frequented by travellers and residents of the district. The water in the river is now held under records for power purposes, but applications are pending for irrigation rights, and very careful consideration will be required in giving one right a preference over the other.

The plans and photographs accompanying this report show the character of the canyon. The profile shows the available effective head to be 174.75 feet. Power possibilities at low water with an efficiency of 80 per cent. at the turbines is 13,443 horse-power.

The chief features of the plant are shown on the plan in red, and are as follows: The site selected for the diversion has the advantage of being partially formed. A rock island standing 15 feet above the water and dividing the river can be utilized, since the foundation is solid rock at this point. The headgates and entrance to the main conduit can be taken out on the west side, and a submerged weir constructed on the east side, which will be long enough on the crest to take care of the flood-water. A wing-boom as shown will be required to divert all floating debris from the headrace. The conduit would be 2,600 feet in length, and may be constructed at a very moderate cost, contouring the west side of the canyon as far as the lower pool, where a waste spillway and pipes leading to the turbines could be placed. The power-house may be located on solid rock in the north-west corner of this pool, the site admitting of easy construction.

It is surprising that this power-site has been allowed to remain undeveloped so long, for the district within a radius of twenty miles can easily be proved to have a "power market" to justify the initial expenditure. The main feature in regard to this power-site is its exceptionally low initial cost per horse-power developed. I hold the opinion that the works at the power-site alone, without distributing systems, could be installed for $25 per horse-power.

Another advantage is the ease and low cost of increasing the power produced by the construction of a reservoir immediately above the diversion-works, as shown by a red dotted line on the plan, which could be made to develop 30,000 horse-power on day load at low-water flow.

The plan shows the available power possibilities, and the scheme taking advantage of the full head would develop 13,443 horse-power. This could be augmented by storage to double the above horse-power.

All stream gaugings and measurements accompanying this report will be found on pages 118 and 119.

I have, etc.,

W. J. E. BIKER, M.Inst.M.Cy.E., Qual.P.A.S.Inst.,
Engineer, Water Rights Branch.

FORMS USED UNDER THE "WATER ACT."

Water Notice.

FOR A LICENCE TO STORE OR PEN BACK WATER.

NOTICE is hereby given that *The Confederation Power Co.*, of *Vancouver*, will apply for a licence to store or pen back *10,000* acre-feet of water from *Douglas* Creek, a stream flowing in a *southerly* direction and emptying into *Causupscal Lake*, near *Lot 4567, Cariboo*. The water will be stored in a reservoir of *10,000 acre-feet* capacity, to be built *above the falls*, and will be used for *power* purposes, as authorized by Water Licence No. *706*, on the land described as *Crown land north of Lot 4567, Cariboo District.*

This notice was posted on the ground on the *9th* day of *December, 1912*. The application will be filed in the office of the Water Recorder at *Barkerville*.

Objections may be filed with the said Water Recorder or with the Comptroller of Water Rights, Parliament Buildings, Victoria, B.C.

THE CONFEDERATION POWER CO. (Applicant).
By *PETER ROBINSON* (Agent).

[*Note.—This note does not form part of the notice.*]

A notice is to be posted at conspicuous points in the neighbourhood of the point of diversion and of the proposed place of user. Forthwith after posting the notice a copy is to be filed in the office of the Water Recorder and to be published once a week for four weeks in a local newspaper. If the application is for more than ten thousand gallons per day for domestic purposes, or for more than five cubic feet per second (178 miners' inches) or 250 acre-feet per annum for irrigation, or for more than two cubic feet per second for industrial purposes, or for more than ten cubic feet per second for mining purposes; it must also be published in two issues of the British Columbia Gazette.

A sketch showing the course of the stream and of the lands affected and an application on Form 62 shall be filed in the office of the Water Recorder within ten days after the first appearance in a local newspaper.

Form 60—Water Rights Branch.

Water Notice.

FOR A LICENCE TO TAKE AND USE WATER.

NOTICE is hereby given that *John P. Ramsay*, of *Brooklyn*, *farmer*, will apply for a licence to take and use *100 acre-feet* of water out of *Campbell* Creek, which flows in a *northerly* direction through *Lot 7568*, *Yale*, and empties into *the Fraser River*, near *York*. The water will be diverted at *100 feet below the south line of the said Lot 7568*, and will be used for *irrigation* purposes on the land described as *Pre-emption No. 453*.

This notice was posted on the ground on the *15th* day of *January, 1914*. The application will be filed in the office of the Water Recorder at *Ashcroft*.

Objections may be filed with the said Water Recorder or with the Comptroller of Water Rights, Parliament Buildings, Victoria, B.C.

JOHN P. RAMSEY (Applicant).
By *HARRY WHITE* (Agent).

[*Note.—This note does not form part of the notice.*]

A notice is to be posted at conspicuous points in the neighbourhood of the point of diversion and of the proposed place of user. Forthwith after posting the notice a copy is to be filed in the office of the Water Recorder and to be published once a week for four weeks in a local newspaper. If the application is for more than ten thousand gallons per day for domestic purposes, or for more than five cubic feet per second (178 miners' inches) or 250 acre-feet per annum for irrigation, or for more than two cubic feet per second for industrial purposes, or for more than ten cubic feet per second for mining purposes; it must also be published in two issues of the British Columbia Gazette.

A sketch showing the course of the stream and of the lands affected and an application on Form 62 shall be filed in the office of the Water Recorder within ten days after the first appearance in a local newspaper.

Form 61—Water Rights Branch.

"Water Act" and Amendments.

APPLICATION to be filed with the Water Recorder within ten days after the first publication of the Water Notice in a local newspaper. (*See* Section 60 as re-enacted by the Amendment Act of 1912.)

1. The name and residence of the applicant. Please give full name, initials are not sufficient.	*Herven James Wendover, Revelstoke, B.C.*
2. A clear description of the stream, with its name (if any); state the direction in which it flows and where it sinks or empties.	*Hopkorth Creek, flowing westward into the Columbia River about thirty miles north of Revelstoke.*
3. The quantity of water applied for expressed in acre-feet per annum, cubic feet per second, gallons per day, or miners' inches, as you prefer.	*One cubic foot per second.*
4. The point of diversion, stating the distance from some surveyed line or some known point. For example: About 500 feet up-stream from the south line of Section 25, Township 19.	Attach a sketch of the stream and the lands affected. *About 50 feet from the west line of Lot 1234, Group 1, Kootenay District.*
5. The dams, ditches, flumes, pipes, or other works for diverting, carrying, or storing the water.	*A dam, ditches, and flumes.*
6. The purpose for which the water will be used—Domestic, municipal, irrigation, industrial, power (which includes the sale of power), mining, or as the case may be.	*Irrigation for mixed farming.*
7A. If the purpose is domestic, irrigation, industrial, mining, or the lowering of a body of water, and accurate description of the land or mine where it is intended to use or lower the water.	*Pre-emption Record No. 546, surveyed as Lot 4216.*
7B. If it is intended to sell the water or the power to be generated from the water, a description of the territory within which the water or the power will be sold.	*Water will not be sold.*
8. A general description of the land which will be affected by the construction of the works, giving the lot numbers or the owners' names, if known.	*Lot 1234, owned by Thomas Braun.*

9. The area of Provincial Crown lands which will be affected by the said works, so far as known.	*5 acres.*
10. The area of private lands which will be affected by the said works, so far as known.	*A right-of-way 50 feet long.*
11. The date of the posting of the notices on the ground.	*14th December, 1912.*
12. The date of the first publication of the notice in a local newspaper, and the name of the newspaper and the place where it is published.	*In the Revelstoke Herald, 17th December, 1912.*
13. The address to which notices to the applicant may be mailed.	*H. J. Wendover, Box 756, Revelstoke.*

If the application includes an application for a licence to store or pen back water, add:—
14. A description of each reservoir site. *On Crown land close to east line of Lot 1234.*
15. An estimate of the area of each reservoir when full. *Four acres.*
16. The probable length and height of each dam. *40 feet long, 6 feet high.*

(Signature.) *H. J. WENDOVER.*

Form 62—Water Rights Branch.

LICENCE FORM.

(The form printed below is proposed by Dr. S. Fortier and H. W. Grunsky as answering the requirements of Part III. of the British Columbia "Water Act." It is for irrigation where works have been completed. The principle underlying this form is that the licence, or water patent, should not be issued until certain preliminary things have been done by the applicant, just as the pre-emptor is required to make certain improvements upon his pre-emption before receiving his Crown grant. This is discussed more particularly on page 18.)

WATER RIGHTS BRANCH, DEPARTMENT OF LANDS.

PROVINCE OF BRITISH COLUMBIA.

LICENCE FOR IRRIGATION PURPOSES.

(After Order of Board—Works completed.)

Whereas the Board of Investigation created under the "Water Act" of British Columbia, and acting in conformity with its requirements, duly made an investigation of certain claims and records relating to the waters of the stream hereinafter described, and caused to be entered in the order-book of the Board an order relating to the said claims and records, and directing that a licence be issued embodying the terms and conditions hereinafter set forth:

Now, therefore, I, Comptroller of Water Rights of the Province of British Columbia, in pursuance of the said order, and in conformity with the "Water Act," issue this licence establishing the right to take and use water from the said stream under the said Act, and declare the said right and the terms and conditions respecting the same to be as follows:—

(*a.*) The source from which the said water shall be diverted is , a tributary of :

(*b.*) The point of diversion for the water to be used under this licence is located as shown on the plat hereto attached, which is hereby incorporated herein and made a part hereof, and the original of which is attached to the counterfoil of this licence on file in the office of the Comptroller of Water Rights in Victoria, British Columbia:

(*c.*) The date from which this right shall take precedence is :

(*d.*) The purpose for which the water is to be used is irrigation:

(*e.*) The maximum total quantity of water per annum which may be used under this licence, until lawfully altered, is acre-feet; and the maximum quantity of water which may be used per annum on each acre actually irrigated is acre-feet:

(*f.*) The period of the year during which water may be used under this licence is :

(*g.*) The area and description of the lands on which water may be used under this licence are as follows: acres, comprising part of the hereditaments described in hereof:

The extent and location of the said lands are further shown by cross-hatching on the hereinbefore-mentioned plat:

(*h.*) A concise description of the works is given on the said plat:

(*i.*) The owner or lawful occupant of the lands for which a right is herein established is the licensee hereunder, and as such is entitled to all the rights, powers, and privileges, and is subject to all the obligations and limitations conferred and imposed by the "Water Act," amending Acts, and the rules and regulations made thereunder upon holders of licences of this class, particular attention being drawn to the following:—

(*j.*) The water is to be used without waste, the use being restricted to the particular purpose herein specified and to the particular lands to which the right herein determined is declared to be appurtenant:

(*k.*) The total quantity of water used under this licence in any season shall be based upon the number of acres of the above-described lands which are actually and beneficially irrigated; and the quantity of water used per acre shall be limited to such quantity as experience may hereafter indicate to be necessary for the production of crops in the exercise of good husbandry:

(*l.*) Having due regard to the priority of this right, the said owner or occupant shall take and use the said quantity of water, on being so directed by a proper officer of the Water Branch, at intervals of time, under such system of rotation with other water-users on the same stream, or otherwise, as may best meet the requirements of growing crops and at the same time secure an economical use of water:

(*m.*) The annual fee, until lawfully altered, shall be $, and shall be payable on or before the first day of June in advance.

In testimony whereof, I have hereunto set my hand and seal this day of , 19 .

.....

Comptroller of Water Rights, Victoria, B.C.

ORDER FORM.

(The following is a proposed form for an order to be given by the Board of Investigation in determining a right held under an old record for irrigation purposes where no works have been constructed, and where, consequently, certain things remain to be done before a licence, or water patent, can be issued.)

WATER RIGHTS BRANCH, DEPARTMENT OF LANDS.

PROVINCE OF BRITISH COLUMBIA.

ABSTRACT OF AN ORDER OF THE BOARD OF INVESTIGATION.

(Defining Irrigation Right—No Works constructed.)

1. Whereas the Board of Investigation created under Part III. of the "Water Act" of the Province of British Columbia, acting in conformity with the requirements of the said Act, duly made an investigation of all known claims and records on file relating to the waters of the stream now officially known as , a tributary of , and caused to be entered in the order-book of the Board an order determining and establishing the several rights to the use of the said waters; and

2. Whereas, at said investigation, the Board determined that a valid record, among others, had been made under the authority of a former Act of the said Province, granting a right to take and use water from the said stream for the irrigation of lands within the hereditaments described as , and

3. Whereas , of , duly presented at said investigation a statement of claim under the above-mentioned record, wherein he affirmed himself to be the owner or lawful occupant of a part or all of the said hereditaments:

4. Now, therefore, in conformity with the requirements of the said "Water Act," the said Board determines and defines that particular right to the use of the waters of the said stream held under the said record and appurtenant to the lands claimed to be owned or occupied by the said claimant, and orders with respect to the same as follows:—

(*a.*) The point of diversion for the water to be used under this order is located as shown on the plat hereto attached, which is hereby incorporated herein and made a part hereof, and the original of which is attached to the counterfoil of this abstract of order on file in the office of the Comptroller of Water Rights in Victoria, British Columbia:

(*b.*) The date from which this right shall take precedence is :

(*c.*) The purpose for which the water is to be used is irrigation:

(*d.*) The maximum total quantity of water per annum which may be used under this order, until lawfully altered, is acre-feet; and the maximum quantity of water which may be used per annum on each acre actually irrigated is acre-feet:

(*e.*) The period of the year during which water may be used under this licence is :

(*f.*) The area and description of irrigable lands to which the use of water under this order may extend on completion of works and beneficial use of the water in the way of the irrigation of the said lands are as follows: acres, comprising part of the hereditaments mentioned in paragraph 2 hereof. The extent and location of the said irrigable lands are further shown by single hatching on the hereinbefore-mentioned plat:

(*g.*) The terms under which a new licence will be issued to take and use water pursuant to the present "Water Act," replacing the said record, are as follows:—

(1.) Works shall be constructed for the diversion and carriage of the said water and shall consist of :

(2.) Surveys necessary for the construction of the said works shall be made and a statement in writing and plan of the said works shall be submitted to the Comptroller of Water Rights on or before , 19 , and his approval thereto shall be obtained before construction is commenced:

Permission to make said surveys is hereby granted, and the record-holder herein considered is entitled to the right of entry and generally to all the other rights, and is subject to all the obligation of a permit-holder under Part V. of the "Water Act": Provided that nothing in this order shall be construed as conferring any interest in or authority over any lands belonging to the Crown in the right of Canada:

(3.) The said statement in writing and the said plan taken together shall show the route by which the water is carried, the position of the works, the particular lands upon which the water is to be used, each parcel of land crossed or touched by the works, the name of the registered owner of said parcels of land crossed, the area of the said owners' lands to be occupied, and the position of all public works, highways, and private roads along or across which the works are to be constructed:

(4.) The construction of the said works, according to plans approved as aforesaid, shall be begun on or before the day of , 19 :

(5.) The said construction shall be prosecuted with due diligence and to the satisfaction of the Comptroller of Water Rights, and shall be completed on or before the day of , 19 , and proof thereof shall be filed within sixty days thereafter:

(6.) Proof that the whole of the said lands described in clause (*f*) hereof have been properly prepared for irrigation and have been irrigated beneficially from the said works shall be filed in the office of the Comptroller of Water Rights on or before the day of , 19 : Provided that if within the time allotted proof is filed that a part only of the said lands have been so prepared anad irrigated, a licence shall be issued in respect of the said part of the said lands:

(7.) Where no proof of construction of the said works is presented as required in subdivisions (5) and (6) above, the said record and entry or such part thereof as applies to the lands of the said owner or occupant will be treated as directed in sections 45 and 46 of the Act, which are as follows:—

"Sec. 45. If proof is not filed as required by the last preceding section, the Comptroller of Water Rights shall, without further notice, demand, or proceeding, declare the said record forfeited and the entry of such record cancelled, and the works constructed under such record, if upon Crown lands, shall become forfeited to the Crown, and if not upon Crown lands shall become forfeited to and become the property of the owner of the land upon which the works are situate.

"Sec. 46. Before the time fixed for the completion of the works and the putting of the water to beneficial use as aforesaid, an application to extend the time may be made to the Board, but the Board shall not entertain the application nor have any power to extend the time, unless the applicant shall satisfy the Board, upon oath, that the applicant has begun and diligently continued the work in perfect good faith, and has been prevented by causes beyond his control from completing the works so ordered to be constructed as aforesaid."

(8.) Upon the filing of proof as required in either subdivision (5) or (6) above, and upon it appearing to the Comptroller of Water Rights that the record-holder herein considered has made full and satisfactory compliance with the terms of the "Water Act," amending Acts, the rules and regulations adopted thereunder, and the orders of the Board and of the Comptroller relating to the said right, the said Comptroller shall issue a licence, in conformity with the terms of this order, replacing and cancelling the record, or such part of the same as applies to any of the lands claimed to be owned or occupied by the said claimant:

(*h.*) The owner or lawful occupant of the lands in respect whereof the privileges herein named are granted is entitled, in respect of the said privileges, to all the rights, powers, and privileges, and is subject to all the obligations and limitations, conferred and imposed by the said "Water Act," amending Acts, and rules and regulations made thereunder; and this order is particularly conditioned in the following respects:

(*i.*) The water is to be used without waste, the use being restricted to the purpose herein specified, and to the particular lands to which the right herein determined is declared to be appurtenant:

(*j.*) The total quantity of water used under this order in any season shall be based upon the number of acres of the above-described lands which are actually and beneficially irrigated; and the quantity of water used per acre shall be limited to such quantity as experience may hereafter indicate to be necessary for the production of crops in the exercise of good husbandry:

(*k.*) Having due regard to the priority of this right, the said owner or occupant shall take and use the said quantity of water, on being so directed by a proper officer of the Water Branch, at intervals of time, under such system of rotation with other water-users on the same stream, or otherwise, as may best meet the requirements of growing crops and at the same time secure an economical use of water:

(*l.*) The annual fee, until lawfully altered, shall be $, and shall be payable on or before the first day of June in advance.

By order made and entered this day of , 19 .

BOARD OF INVESTIGATION OF THE PROVINCE OF BRITISH COLUMBIA.

By ..... *Chairman.*

..... *Member of the Board.*

STREAM MEASUREMENTS.

Late in the season of 1912 an effort was made to begin the systematic and continuous gauging of some of the more important streams. These were selected with special reference to the utilization of their waters for irrigation, mining, power, and other purposes. Such results of this work as are available, together with miscellaneous discharge measurements previously made, are given in the following pages.

While information upon many of the streams is rather meagre, it is felt that a satisfactory start has been made. It is well known that miscellaneous measurements, or even continuous measurements through one season, do not afford a safe guide for judging the flow of a stream. It is only the record for a series of years which becomes valuable. The figures are printed primarily with this latter end in view. Nevertheless, though incomplete, they will give the Board and the public a better idea, in most cases, of stream-flow than could be gathered from mere verbal evidence.

In the Railway Belt the engineers of the Water Rights Branch conducted investigations in some of the valleys in 1912, collecting only such data, exclusive of stream-measurements, as were necessary to determine rights under old records. This was due to the fact that since the date of the Privy Council's decision declaring the administration of the waters to lie with the Dominion Government, an efficient hydrographic survey has proceeded in that territory under the direction of P. A. Carson, Chief Engineer, Kamloops. It is understood that the results of this work are in course of preparation for early publication, and may, no doubt, be procured upon application to the Department of the Interior in Ottawa. A few of the figures from the Dominion survey on some streams are included herewith by courtesy of Mr. Carson.

The arrangement of the tables follows the same order as the descriptions of the respective drainage-basins which are to be found in the foregoing pages.

STREAM MEASUREMENTS.

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
			Feet.	Sq. Ft.	Ft per S	Feet.	Cu. Ft. perS.	
VANCOUVER ISLAND (WEST COAST).								
Gordon River (drainage-area, 165 square miles)	March 10th, 1911	G. Gray Donald (Hyd.)	120	827	2.25	.....	1,863	Metered at Newton's No. 1 Camp.
Ditto	Oct. 17th, "	C. W. Roberts (Hyd.)	113	634	2.78	.....	1,760	" "
Stamp River (drainage-area, 177 square miles)	March 11th, 1912	"	135	480	0.97	.....	465	Metered 300 feet down-stream from Great Central Lake.
Ash River (drainage-area, 120 square miles)	" "	"	.....	.....	.....	.....	150	Estimated. Drains Ash, Dixon, Elsie, & Deep Lakes. Tributary of Stamp River.
Sproat River (drainage-area, 125 square miles)	"	"	.....	.....	.....	.....	300	Estimated. Drains Sproat Lake, tributary to Stamp River.
VANCOUVER ISLAND (EAST COAST).								
Koksilah River (drainage-area, 96 square miles)	Dec. 14th, 1911	H. B. Hicks (Hyd.)	88	157	2.02	1.50	318	Metered 500 feet up-stream from E. & N. Railway Bridge.
Cowichan River (drainage-area, 300 square miles)	" 13th, "	"	160	627	4.64	5.20	2,910	Metered 175 feet down-stream from Government Bridge.
Chemainus River (drainage-area, 146 square miles)	" 19th, "	"	105	303	1.90	0.95	575	Metered from E. & N. Railway Bridge.
Nanaimo River drainage-area, 249 square miles)	" 29th, "	"	135	372	2.87	1.75	1,070	Metered 300 feet up-stream from Canadian Collieries Railway Bridge, five miles from Ladysmith.
Puntledge River (drainage-area, 214 square miles)	Jan. 3rd, 1912	"	161	364	2.49	2.22	900	Metered 300 feet up-stream from Logging Railway Bridge.
Tsolum River (drainage-area, 99 square miles)	" 8th, "	"	75	86	1.04	2.05	90	Metered 150 feet up-stream from foot-bridge, one and one-half miles from Courtenay.
FRASER RIVER BASIN.								
Fraser River (drainage-area, 80,550 square miles)	Jan., 31st, 1912	E. Davis (Hyd.)	1015	7780	3.75	.....	28,725	Metered near Agassiz.
Chehalis River (drainage-area, 200 square miles)	Feb., 2nd, "	W. S. Wilson (Hyd.)	89	242	5.15	2.80	1,247	Metered three miles north of West Fork.
West Fork Chehalis River (drainage-area, 99 square miles)	" "	"	20	168	2.40	1.10	404	Metered one mile from junction with main stream.
Silver Creek (drainage-area, 10 square miles)	" "	"	12	5.5	3.20	.....	17.6	Tributary of Chehalis River. Metered at trail crossing half a mile below falls.
FRASER AND THOMPSON RIVER WATERSHEDS.								
Jones Creek	Nov. 3rd, 1911		.....	.....	.....	.....	51.80	Gauge-station at Jones Lake.
"	Sept. 18th, 1912		.....	.....	.....	.....	87.10	" "
Coquihalla River	Nov. 16th, 1911		.....	.....	.....	.....	333.00	Gauge-station at road-bridge near mouth.
"	Dec. 12th, "		.....	.....	.....	.....	1,220.00	" " "
"	Feb. 29th, 1912		.....	.....	.....	.....	422.00	" " "
"	June 8th, "		.....	.....	.....	.....	2,890.00	" " "
"	" 29th, "		.....	.....	.....	.....	891.00	" " "
"	Sept. 13th, "		.....	.....	.....	.....	334.00	" " "
	Nov. 15th, "		.....	.....	.....	.....	762.00	" " "

Coquihalla River	Nov.	18th,	1912						1,210.00	Gauge-station at road-bridge near mouth.
"	"	20th,	"						1,510.00	" " "
Nahatlatch River (Salmon River)	Feb.	25th,	1912						417.00	Gauge-station at lakes.
"	July	18th,	"						1,930.00	" "
"	Nov.	28th,	"						818.00	" "
Silver Creek	Dec.	11th,	1911						373.00	Gauge-station between road-bridge and mouth.
"	March	1st,	1912						201.00	" " "
"	June	7th,	"						1,100.00	" " "
"	Sept.	17th,	"						133.00	" " "
"	Nov.	19th,	"						868.00	" " "
"	Dec.	7th,	"						242.00	" " "
Stein River	Sept.	22nd,	1911						685.00	Gauge-station at road-bridge near mouth.
"	March	27th,	1912						152.00	" " "
"	May	30th,	"						1,360.00	" " "
"	July	26th,	"						1,190.00	" " "
Nikaia Creek	Sept.	23rd,	1911						4.50	Gauge-station at road-bridge.
"	June	1st,	1912						8.10	" "
Botanie Creek	Sept.	21st,	1911						4.20	Gauge-station four and one-half miles from mouth.
"	May	28th,	1912						14.30	" " "
Fraser River	March	7th,	1912						18,300.00	Gauge-station at Hope.
"	June	6th,	"						135,000.00	" "
"	"	25th,	"						295,000.00	" "
"	Feb.	26th,	"						12,300.00	Gauge-station one mile above Lytton at ferry.
"	March	26th,	"						11,500.00	" " "
"	May	31st,	"						141,000.00	" " "
"	June	26th,	"						102,000.00	" " "
"	July	25th,	"						91,400.00	" " "
"	Sept.	29th,	"						34,000.00	" " "

NOTE.—The above table of hydrographic data has been made available through the courtesy of P. A. Carson, D.L.S., Chief Engineer of the Dominion Hydrographic Survey of the Railway Belt of British Columbia. These measurements constitute only a small part of the data obtained on the flow of the streams mentioned. Full information will be found in the report of the Dominion Survey when published.

THOMPSON AND BONAPARTE RIVER WATERSHEDS.

Bonaparte River	May	9th,	1912	W. R. Pilsworth (Hyd.)					757.00	Velocity obtained by floats.
"	June	15th,	"	"					297.00	" "
"	July	17th,	"	"					228.00	" "
Cornwall Creek	May	8th,	"	"					3.80	" "
"	"	14th,	"	"					6.70	" "
"	June	20th,	"	"					2.00	" "
"	July	10th,	"	"					6.50	" "
Scotty Creek	May	11th,	"	"					33.00	" "
"	"	14th,	"	"					25.00	" "
"	June	22nd,	"	"					5.50	" "
"	July	12th,	"	"					7.50	" "

NOTE.—All these streams are subject to even greater fluctuations than those noted in the above table, especially the smaller streams, which in the spring often become torrents, during which time enormous quantities of water run to waste.

NICOLA DRAINAGE-BASIN.

Nicola River	Sept.	2nd,	1911	P. de Lautour (Hyd.)					54.00	Taken near Nicola, below Clapperton Creek. It may be possible to refer those readings to Dominion Government gauges.
"	"	18th,	"	"					53.00	" "
"	Oct.	9th,	"	"					48.00	" "
"	May	22nd,	1912	Dom. Govt. Engineer (H.)					4,500.00	Maximum discharge at Spence's Bridge.
"	Oct.	14th,	"	"					150.00	Minimum discharge at Spence's Bridge.
Coldwater River	Sept.	11th,	1911	P. de Lautour (Hyd.)					104.00	It may be possible to refer those readings to Dominion Government gauges.
"	Oct.	3rd,	"	"					93.00	" " "
"	May	21st,	1912	Dom. Govt. Engineer (H.)					1,800.00	Maximum discharge.
"	Sept.	30th,	"	"					25.00	Minimum discharge.
Clapperton Creek	Oct.	4th,	1912	J. F. Rowlands (Hyd.)	0.5	5.62	0.56	1.48	3.85	
"	Nov.	16th,	"	C. W. Munslow (Obs.)	....	6.80	0.61	1.60	4.15	Interpolated.
Quilchena Creek	Sept.	2nd,	1912	J. F. Rowlands (Hyd.)				0.73	8.00	
"	"	8th,	"	"				0.59	6.90	Interpolated.

STREAM MEASUREMENTS.—*Continued.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
NICOLA DRAINAGE-BASIN.—*Concluded.*								
			Feet.	Sq. Ft.	Ft per S	Feet.	Cu. Ft. per S.	
Quilchena Creek	Sept. 15th, 1912	J. F. Rowlands (Hyd.)				0.45	5.20	Interpolated.
"	" 25th, "	"				0.57	6.80	"
"	Oct. 2nd, "	"	22.0	20.92	0.304	0.63	7.20	"
Moore Creek	May 6th, 1908	H. B. Hicks (Hyd.)		51.92			327.00	Velocity by floats. Taken about one mile and a half from mouth, under the direction of H. W. E. Canavan, Consulting Engineer, Victoria.
"	" 13th, "	"		33.21			253.00	Ditto.
"	" 20th, "	"		25.72			176.00	"
"	" 27th, "	"		18.55			95.00	"
"	June 3rd, "	"		12.13			47.42	"
"	" 10th, "	"		9.29			25.26	"
"	" 17th, "	"		6.96			14.54	6-foot Cippoletti weir. Taken about one mile and a half from mouth, under the direction of H. W. E. Canavan, Consulting Engineer, Victoria.
"	" 24th, "	"					15.20	Ditto.
"	July 1st, "	"					13.20	"
"	" 8th, "	"					8.10	"
"	" 15th, "	"					10.00	"
"	" 22nd, "	"					8.00	"
"	" 29th, "	"					9.40	"
	Aug. 5th, "	"					7.90	"
	" 12th, "	"					4.50	"
	" 19th, "	"					3.10	"
"	" 26th, "	"					7.60	"
"	Sept. 2nd, "	"					5.40	"
"	" 9th, "	"					4.90	"
"	" 16th, "	"					3.90	"
"	" 23rd, "	"					3.40	"
"	" 28th, "	"					5.20	"
"	Oct. 3rd, "	"					3.60	"
OKANAGAN WATERSHED NEAR VERNON.								
						Inches.		
Long Lake Creek	Aug. 24th, 1910	W. R. C. Morris (Hyd.)	3.00	0.60	1.00		0.60	Near Long Lake.
Coldstream Creek	Sept. 6th, "	"				4	6.31	One mile above ranch; 10-foot Cippoletti weir.
"	" 14th, "	"				6	11.77	At ranch; 10-foot Cippoletti weir.
Deer Creek	" 14th, "	"				1⅜	0.70	4-foot Cippoletti weir.
Deer Creek, trib. of B.X. Creek	Aug. 12th, "	"					Dry.	
Larch Creek	Sept. 7th, "						"	
Bissette Creek	Sept. 29th, "	"	1.00	0.25	3.00		0.75	
Brewer Creek	Sept. 19th, "	"					Dry.	
Swan Lake Creek	June 28th, "	"	2.50	1.25	2.50		3.12	
B.X. Creek	July 4th, "	"					Dry.	At Swan Lake.
"	Aug. 19th, "	"				2¾	0.61	At city intake; 1.66-foot rectangular weir.
Brookside Creek	July 28th, "	"					Dry.	At B.X. Creek.
"	Aug. 5th, "	"	1.00	0.08	1.00		0.08	Two miles from B.X. Creek.
Meakins Creek, trib. of B.X. Creek	" 16th, "	"					Dry.	
Hog Gulch	June 10th, "	"					"	

Nelson Creek	Sept.	23rd,	1910	W. R. C. Morris (Hyd.)				1½	0.414	3-foot Cippoletti weir.
Spider Creek	"	22nd,	"	"	0.25	0.01	1.00		0.01	
Jones Creek	Oct.	7th,	"	"					Dry.	Below intake of Grey Canal.
"	"	12th,	"	"				1	13.32	4-foot rough temporary weir above Grey Canal intake.
Harris Creek	"	11th,	"	"	20.00	20.00	3.00		60.00	Above Lumby.
"	July	31st,	1911	"	40.00	23.20	2.00		46.40	Below Lumby.
Blue Springs Creek	June	17th,	"	"	0.75	0.09	0.50		0.045	
Creighton Creek	"	20th,	"	"	11.50	8.625	1.66		14.32	
"	"	23rd,	"	"	12.00	12.00	3.00		46.80	After wet weather.
"	"	27th,	"	"	12.00	7.92	4.00		31.68	Six miles above Lumby.
Vance Creek	July	31st,	"	"				1½	1.40	At rough weir (8 feet wide).
Deafy Creek	"	22nd,	"	"				2	0.32	At rough temporary weir (1.50 feet).
Big Creek	Aug.	10th,	"	"	2.00	0.66	3.18		2.10	
Branch of Shuswap River	"	9th,	"	"	40.00	50.00	3.00		150.00	
Copper Creek	"	5th,	"	"	0.33	0.053	1.59		0.08	
Dutchman's Creek	"	21st,	"	"	2.00	0.20	1.00		0.20	
Fall Creek	"	29th,	"	"	11.50	1.84	3.12		5.74	
Cherry Creek	"	15th,	"	"	40.00	56.80	7.00		397.60	
Eight Mile Creek	"	26th,	"	"	12.00	7.02	2.00		15.84	
Norris Creek	Oct.	5th,	"	"	1.16	0.464	3.50		0.16	
Morden's Creek	"	3rd,	"	"					Dry.	
Hope Creek	"	5th,	"	"	0.16	0.0128	3.66		0.046	
Porteous Creek	"	24th,	"	"					Dry.	
Brown's Creek	"	24th,	"	"	0.50	0.04	0.50		0.02	
Siwash Creek	"	31st,	"	"	8.00	3.30	1.60		5.56	
Six Mile Creek	Nov.	4th,	"	"	9.00	3.78	2.00		7.56	

SHUSWAP LAKE WATERSHED NEAR NOTCH HILL.

								Feet.		
Scotch Creek	Aug.	26th,	1912	W. R. C. Morris (Hyd.)					243.99	
Broderick Creek	"	21st,	"	"					0.42	
Gulch Creek	"	27th,	"	"					0.14	
Bonds Creek	Sept.	2nd,	"	"					0.48	
Cedar Creek	"	2nd,	"	"					Dry.	
Spring Creek	"	3rd,	"	"					0.92	

OKANAGAN WATERSHED NEAR KELOWNA.

Mission Creek	June	10th,	1910	G. Gray Donald (Hyd.)					450.00	At K.L.O. Bridge.
"	Aug.	2nd,	"	"					14.00	At Rutland headgate, weir gauging.
"	April	25th,	1911	E. Davis (Hyd.)	78	118.00	3.04	1.80	361.00	At K.L.O. Bridge.
"	"	28th,	"	"	60	132.00	2.44	2.45	322.00	At Mission Bridge.
"	May	11th,	"	"	60	153.00	3.20	2.80	491.00	"
"	"	17th,	"	"	71	284.00	5.20	4.10	1,345.00	"
"	"	10th,	"	"	71	266.25	4.47	3.70	1,189.00	"
"	"	25th,	"	"	71	216.50	3.10	3.00	690.00	"
"	"	22nd,	"	"	69	246.00	3.76	3.25	925.00	"
"	"	27th,	"	"	70	204.00	2.84	2.90	579.00	"
"	January,		1912	Belgo-Can. F.L. Co. (Obs.)					17.30	Weir 10 feet wide. Mean for month.
"	February,		"	"					15.80	" "
"	March,		"	"					15.70	" "
"	April,		"	"					48.60	For first three days of month.
Hydraulic Creek	March,		1910	South Kelowna Land Co. (O)					3.90	Mean for month at S.K.L. intake.
"	April,		"	"					23.20	" "
"	May,		"	"					24.00	" "
"	June,		"	"					12.10	" "
"	May	12th,	1911	E. Davis (Hyd.)					17.50	Half a mile up from mouth of creek.
"	"	22nd,	"	"					36.20	" "
Canyon Creek	"	1st,	"	"					17.40	At K.L.O. domestic-supply intake.
"	"	12th,	"	"					21.00	" "
"	"	22nd,	"	"					63.00	" "
Sawmill Creek	"	3rd,	"	"					15.00	One mile above Crawfords Falls.

STREAM MEASUREMENTS.—*Continued.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
			Feet.	Sq. Ft.	Ft per S.	Inches.	Cu. Ft. per S.	
OKANAGAN WATERSHED NEAR KELOWNA.—*Concluded.*								
Sawmill Creek	May 26th, 1911	E. Davis (Hyd.)					20.70	One mile above Crawford's Falls.
Willow Creek	" 1st, 1912	South Kelowna Land Co. (O.)				5½	3.10	Cippoletti weir 3 ft. wide. At crossing main S. K. L. Co.'s ditch.
"	" 16th, "	"				3¾	1.49	" " "
"	" 23rd, "	"				2¾	0.90	" " "
"	" 30th, "	"				1 13/16	0.59	" " "
Mill Creek	January, 1911	Kelowna Irrigation Co. (O.)					Parl'y frozen	At weir about half a mile above Kelowna Irrigation Co.'s intake.
"	February "	"					"	Ditto.
"	March, "	"					"	"
"	April, "	"					15.80	Mean for month above Kelowna Irrigation Co.'s intake.
"	May "	"					65.00	" "
"	June, "	"					22.40	" "
"	July, "	"					20.00	" "
"	August, "	"					10.40	" "
"	January, 1912	"					Parl'y frozen	
"	February, "	"					"	
"	March, "	"					"	
"	April, "	"					18.60	Mean for month above Kelowna Irrigation Co.'s intake.
"	May, "	"					109.30	" "
"	June, "	"					23.20	" "
"	July, "	"					20.00	" "
"	August, "	"					11.20	" "
Scotty Creek	April 27th, 1911	E. Davis (Hyd.)					14.00	At road-crossing near the N.E. corner of Sec. 6, Tp. 24.
"	May 9th, "	"					13.30	" "
"	" 18th, "	"					27.40	" "
"	" 23rd, "	"					21.80	" "
"	March 28-31st, 1912	Belgo-Can. F. L. Co. (Obs.)					0.67	Mean at road-crossing near the N.E. corner of Sec. 6, Tp. 24.
"	April 1-30th, "	"					4.07	Mean for month " "
"	May 1st, "	"					20.90	At road-crossing near the N.E. corner of Sec. 6, Tp. 24.
"	" 2nd, "	"					20.10	" "

NOTE.—The figures under Mill Creek include storage-water.

OKANAGAN WATERSHED WEST SIDE OF OKANAGAN LAKE.								
Powers Creek	August 15th, 1912	O. J. Bergoust (Hyd.)					3.40	300 feet below intake, Westbank Co.'s ditch.
Bear Creek	June 7th, 1910	F. R. Johnson (Hyd.)					119.40	500 feet from mouth.
"	" 8th, "	"					103.70	"
"	" 30th, "	"					24.70	"
"	August 12th, "	"					5.25	Above junction with Bald Range Creek.
Shorts Creek	Sept. 28th, 1911	W. C. R. Morris (Hyd.)					2.48	Below irrigation ditches.
"	Oct. 2nd, "	"					5.39	Above irrigation ditches.
Whiteman's Creek	" 18th, "	"					21.00	Above Indian ditches and below C. Woods ditch.
OKANAGAN WATERSHED, NARAMATA TO BOUNDARY.								
Pine Creek	July, 1910	J. C. Dufresne (Hyd.)					Dry.	
"	" 23rd, "	"					2.80	On South Fork.
Shoot Creek	Aug. 16th, "	"					0.90	On North Fork.

Maple Creek	July,		1910	J. C. Dufresne (Hyd.)						Dry.
Robinson Creek	"	21st,	"	"					1.70	
"	"	27th,	"	"					1.40	
Naramata Creek	"	19th,	"	"					1.00	At Okanagan Trust Co.'s headgate.
Arawana Creek	"		"	"						Dry.
Four-mile Creek	"	4th,	"	"					0.27	At Southern Okanagan Co.'s intake.
"	Aug.	11th,	"	"						Dry.
Johnson Spring	July	7th,	"	"						"
Three-Mile Creek	"		"	"						"
One-mile Creek	"		"	"						"
Penticton Creek	June	9th,	"	"					108.00	At Southern Okanagan Co.'s dam.
Ellis Creek	Aug.	25th,	"	"					3.00	" "
Gillie's Creek	Sept.	12th,	"	"					0.22	At creek-mouth.
Matheson Creek	"		"	"						Dry.
McLean Creek	"	24th,	"	"					1.10	At Smithe's intake.
Keogan Creek	Nov.	4th,	"	"					1.70	At Shuttleworth's intake.
"	Sept.,		1912	M. C. Brotherton (Hyd)					0.12	Measured by weir south of Okanagan Falls Townsite.
"	"		"	"					6.30	Measured by floats three miles up from mouth,
"	"		"	"					4.00	Measured by floats three and one-half miles up from mouth
Okanagan River	Sept.	29th,	1910	J. C. Dufresne (Hyd.)	46				176.00	Taken between Okanagan and Dog Lakes.
"	"	29th,	"	"	102				204.00	Below Okanagan Falls.
McIntyre Creek	April	29th,	1911	"					39.60	Creek just beginning to flood.
Hester Creek	May	18th,	"	"					1.85	At Hody's intake.
Testalinda Creek	"	18th,	"	"	3	1.2	4.45		5.35	100 feet east of road, near S.O.L. Co.'s intake.
Tinhorn Creek	"	18th,	"	"					0.14	At foot-hill. Dry 500 feet farther down.
Reed Creek	"	31st,	"	"					1.45	At Stemwinder Dam.
Meyers Creek (Park Rill)	June		"	"					0.04	At Park Ranch.
Kearns Creek	"		"	"					0.23	
Orofino Creek	"		"	"					0.23	
Spring Creek	"		"	"					0.03	
Wolf Creek	Nov.,		"	O. J. Bergoust (Hyd.)					0.56	Estimated flow. Creek partly frozen over.
Inkameep Creek	"	3rd,	"	"					5.00	Above dam.
A-tsi-klak Creek	"	19th,	"	"					0.06	At mouth of canyon.
Haynes Creek	May	13th,	1912	"					0.84	At Hill's intake.
Strawberry Creek	"	13th,	"	"					0.05	Estimated flow at road.
Sheep Creek	Sept.	22nd,	1911	W. C. Ricardo (Hyd.)					11.30	Above Kaleden Co.'s intake.
				SIMILKAMEEN WATERSHED.				Feet.		
Similkameen River	Oct.	14th,	1911	O. J. Bergoust (Hyd.)	170.00	312.55	1.67		520.00	At Indian Ford ten miles south of Keremeos.
"	Sept.	24th,	1912	"	140.00	312.42	1.12	1.02	*351.00	South channel, at wagon-bridge.
"	"	24th,	"	"	80.00	96.31	1.31	1.23	*126.50	North channel, at wagon-bridge.
Keremeos Creek	"	23rd,	1911	"	4.80	7.30	1.62		11.90	In Surprise Meadow above Olalla, measured with floats.
"	"	23rd,	"	"	7.50	17.40	0.48		8.35	400 feet above Richter's intake.
"	Aug.	22nd,	1912	"	13.60			0.85	13.85	About quarter of a mile south of Olalla.
"	"	26th,	"	"				0.80	12.30	" "
"	Sept.	2nd,	"	"				0.87	14.50	Discharge calculated from gauge heights.
"	"	8th,	"	"				0.80	12.30	" "
"	"	15th,	"	"				0.78	11.70	" "
"	"	22nd,	"	"				0.75	10.75	" "
"	"	27th,	"	"	12.00	6.50	1.66	0.75	10.75	Measured with Gurley current-meter.
"	"	29th,	"	I. Jones (Obs.)				0.80	12.30	Discharge calculated from gauge heights.
"	Oct.	3rd,	"	"				0.87	14.50	" "
"	"	6th,	"	"				0.89	15.30	" "
"	"	13th,	"	"				0.89	15.30	" "
"	"	20th,	"	"	14.00			0.90	15.70	" "
"	"	27th,	"	"				0.91	16.00	" "
"	Nov.	3rd,	"	"				0.90	15.70	" "
"	"	10th,	"	"				0.90	15.70	" "
"	"	17th,	"	"				0.82	13.00	" "
"	"	24th,	"	"				0.80	12.30	" "
"	"	30th,	"	"				0.78	11.70	" "
"	Dec.	7th,	"					0.76	11.00	" "

*Note.—Total discharge, 481.40 cubic feet per second near Keremeos.

STREAM MEASUREMENTS.—*Continued.*

SIMILKAMEEN WATERSHED.—*Concluded.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
			Feet.	Sq. Ft.	Ft per S	Inches.	Cu. Ft. per S.	
Shuttleworth Creek	Oct. 5th, 1912	O. J. Bergoust (Hyd.)				1¼	0.062	8-inch Cippoletti weir above Richter's intake.
Olalla Creek	Aug. 26th, "	"				2⅞	1.975	5-foot Cippoletti weir near mouth of canyon, quarter of a mile from Olalla.
"	" 30th, "	"				3¼	3.090	Ditto.
"	Sept. 2nd, "	"				3⅜	2.795	"
"	" 9th, "	"				3¼	2.650	"
"	" 11th, "	"				3¼	2.370	"
"	" 15th, "	"				3	2.105	"
"	" 17th, "	"				2⅞	1.975	"
"	" 23nd, "	I. Jones (Obs.)				2⅞	1.975	"
"	" 27th, "	"				2⅞	1.975	"
"	" 29th, "	"				2⅝	1.845	"
"	Oct. 1st, "	"				2⅝	1.845	"
"	" 3rd, "	"				2¼	1.280	"
"	" 6th, "	"				2⅝	1.845	"
"	" 13th, "	"				2⅝	1.845	"
"	" 20th, "	"				2½	1.600	"
"	" 27th, "	"				2⅝	1.722	"
"	Nov. 3rd, "	"				2⅝	1.722	"
"	" 10th, "	"				2⅝	1.722	"
"	" 17th, "	"				2½	1.600	"
"	" 21th, "	"				2 7/16	1.541	"
"	" 30th, "	"				2⅜	1.482	5-foot Cippoletti. Frozen over December 7th.
Cedar Creek	Sept. 9th, "	O. J. Bergoust (Hyd.)				3¾	2.370	5-foot Cippoletti weir, located about one mile west of Keremeos Creek.
"	Oct. 6th, "	I. Jones (Obs.)				2⅞	1.975	Ditto.
"	" 13th, "	"				2⅞	1.975	"
"	" 20th, "	"				2¾	1.722	"
"	" 27th, "	"				2⅝	1.722	"
"	Nov. 3rd, "	"				2⅞	1.975	"
"	" 10th, "	"				2⅞	1.975	"
"	" 17th, "	"				2½	1.845	"
"	" 24th, "	"				2 9/16	1.661	5-foot Cippoletti. Frozen over November 30th.
Sheep Creek	Sept. 14th, "	O. J. Bergoust (Hyd.)				2⅝	1.975	5-foot Cippoletti weir, about three-quarter of a mile above mouth of creek.
"	Oct. 13th, "	C. D. Campbell (Obs.)				2⅜	1.482	Ditto.
"	" 20th, "	"				2⅜	1.845	"
"	" 27th, "	"				2¼	1.255	"
"	Nov. 3rd, "	"				2⅜	1.482	"
"	" 10th, "	"				1¼	0.978	"
"	" 17th, "	"				2⅜	1.482	"
"	" 24th, "	"				1 3/16	0.531	"
"	Dec. 1st, "	"				1¼	0.978	"
Goat Creek	Sept. 21st, "	O. J. Bergoust (Hyd.)				2¼	1.186	4-foot Cippoletti weir, about half-mile from creek-mouth.
"	Oct. 13th, "	C. D. Campbell (Obs.)				2¼	1.186	" " "
"	" 20th, "	"				2½	1.280	" " "
"	" 27th, "	"				2¼	1.004	" " "
"	Nov. 3rd, "	"				1¾	0.752	" " "
"	" 10th, "	"				1¾	0.752	" " "

Goat Creek	Nov.	17th,	1912	C. D. Campbell (Obs.)				2¼	1.255	4-foot Cippoletti weir, about half mile from creek-mouth.
"	"	24th,	"	"				1½	0.595	" " " "
"	Dec.	1st,	"	"				1 3/16	0.426	" " " "
Tom Creek	Oct.	5th,	"	O. J. Bergoust (Hyd.)				2⅜	0.890	3-foot Cippoletti weir at mouth of canyon.
"	"	20th,	"	C. D. Campbell (Obs.)				2⅜	0.890	" "
"	Nov.	3rd,	"	"				1½	0.564	" "
"	"	10th,	"	"				1½	0.446	" "
"	"	17th,	"	"				1 3/16	0.319	" "
"	"	24th,	"	"				1½	0.446	" "
"	Dec.	1st,	"	"				1⅛	0.207	" "
								Feet.		
Nahumsheen Creek	Oct.	18th,	1911	O. J. Bergoust (Hyd.)	4.00	7.20	3.44		24.75	Measured with floats at mouth of canyon.
Susap Creek	Oct.	9th,	"	"					9.50	Measured about one mile above mouth.
Ashnola River	Sept.	27th,	1912	"	29.00	86.30	1.02		88.40	At south line, I.R. No. 10.
Cold Creek	May	17th,	"	"					0.56	Measured in flume.
Schunmaker Creek	"	31st,	"	"					1.12	Measured by floats at mouth of canyon.
Fifteen-mile Creek	June	1st,	"	"					15.00	Measured with floats at road-crossing.
Sixteen-mile Creek	"	4th,	"	"					35.00	Measured with floats at head of Indian ditch.
Twenty-mile Creek	Oct.	8th,	"	"	20.00	27.07	0.67	0.70	18.14	Measured with Gurley meter 100 feet above third bridge above D. R. Co.'s dam.
"	"	15th,	"	"	20.00	26.00	0.66	0.65	17.10	Calculated from gauge height.
"	"	22nd,	"	"	20.00	26.00	0.66	0.65	17.10	" "
Stirling Creek	June	25th,	"	"					7.50	Measured by floats in creek and flume.
Areat or Thirty-two-mile Creek	"	29th,	"	"					2.50	Measured by floats in ditches.
Nine-mile Creek	July	8th,	"	"					1.12	" " "
Wolf Creek	"	9th,	"	"	24.50	24.25	1.22		30.00	" " at mouth.
"	"	29th,	"	"		0.18	1.21		0.22	" " at Voight's Camp.
Five-mile Creek	"	10th,	"	"	18.00	20.10	2.22		65.60	" " one-quarter mile from mouth.
One-mile Creek	"	20th,	"	"	12.50	10.00	1.84		18.40	Measured 100 feet above junction with Summers Creek.
Summers Creek	"	20th,	"	"	13.00	7.80	1.68		13.10	Measured by floats near bridge near junction with One-mile Creek.
China Creek	"	15th,	"	"					1.36	Measured by floats in ditches.
Cedar Creek, trib. of Tulameen River	Aug.	9th,	"	M. C. Brotherton (Hyd.)					0.80	Measured by floats.
Welldo Creek	"	12th,	"	"					0.30	" "
Otter Creek	"	5th,	"	"					10.00	Measured by floats in Frembd Lot, about one mile north of Otter Lake.
West Branch of Otter Creek	"	18th,	"	"					5.00	Measured by floats in ditch.
Elliott Creek	"	5th,	"	"					0.50	" " "
Boulder Creek	"	6th,	"	"					0.30	" " "
Thynne's Creek	"	20th,	"	"					3.80	" " "
Stevenson Creek	July	24th,	"	"					0.28	" " "
Bromley Creek	"	23rd,	"	"					0.34	" " "

KETTLE RIVER WATERSHED.

								Inches.		
Kettle River	Oct.	19th,	1911	Clifford Varcoe (Hyd.)	170	303.80	1.00		303.80	Measured at Grand Forks, 400 feet below V. V. & E. Railway bridge. Water low.
"	Sept.	3rd,	1912	"	209	443.00	0.976		432.00	Measured at Midway.
North Fork of Kettle River	Nov.	4th,	1911	"	47	161.00	0 90		145.00	Measured at Granby Smelter. Low water.
Boundary Creek	July	30th,	1912	"	33	46.75	2.77		130.00	Measured at Greenwood.
"	"	30th,	"	"	31	32.50	1.63		53.00	Measured four miles north of Greenwood.
"	Aug.	29th,	"	"	31	23.62	2.16		51.00	Measured one-half mile north of International Boundary.
Eholt Creek	July	25th,	"	"	4	5.00	1.70		8.50	Measured one-half mile from confluence with Boundary Creek.
Deep Creek	May	25th,	"	"	11	13.75	4.00		55.00	Measured at Carroll's Ranch. High water.
McRae Creek	"	17th,	"	"	30	90.00	6.00		540.00	Measured at English Point. High water.
Sutherland Creek	"	29th,	"	"	24	80.00	3.00		240.00	Measured at Maida's Ranch, Fife. High water.
Moody Creek	"	14th,	"	"	4	4.00	3.15		12.50	Measured at Wolverton's Ranch. High water.
4th July Creek	Oct.	6th,	1911	"				1 9/16	0.476	2-foot rectangular weir on Doukhobor Ranch.
"	Aug.	19th,	1912	John Zihoroff (Obs.)				3½	1.360	3-foot Cippoletti weir on Doukhobor Ranch.
"	Sept.	1st,	"	J. D. Honsberger (Obs.)				3½	1.860	" " " "

STREAM MEASUREMENTS.—*Continued.*

KETTLE RIVER WATERSHED.—*Concluded.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
			Feet.	Sq. Ft.	Ft per S	Inches.	Cu. Ft. per S.	
4th July Creek	Sept. 4th, 1912	J. Ziboroff (Obs.)				3¼	1.401	3-foot Cippoletti weir on Doukhobor Ranch.
"	" 8th, "	J. D. Honsberger (Obs.)				4	1.950	" " " "
"	" 16th, "	J. Ziboroff (Obs.)				3¼	1.350	" " " "
"	Oct. 13th, "	J. D. Honsberger (Obs.)				2⅜	0.900	" " " "
"	Nov. 28th, "	J. Ziboroff (Obs.)				2¾	1.020	" " " "
"	Dec. 6th, "	J. D. Honsberger (Obs.)				2¼	0.81	" " " "
May Creek	Oct. 9th, 1911	C. Varcoe (Hyd.)				1⅝	0.290	2-foot rectangular weir on Doukhobor Ranch.
"	Aug. 17th, 1912	John Ziboroff (Obs.)				2 9/16	0.670	2-foot Cippoletti weir " "
"	Sept. 1st, "	J. D. Honsberger (Obs.)				2½	0.640	" " " "
"	" 4th, "	J. Ziboroff (Obs.)				2⅜	0.600	" " " "
"	" 8th, "	J. D. Honsberger (Obs.)				2½	0.640	" " " "
"	Oct. 13th, "	"				2¼	0.59	" " " "
"	Nov. 28th, "	J. Ziboroff (Obs.)				2¼	0.54	" " " "
"	Dec. 6th, "	J. D. Honsberger (Obs.)				2¼	0.54	" " " "
Gibbs Creek	Oct. 9th, 1911	C. Varcoe (Hyd.)				15/16	0.132	2-foot rectangular weir on Doukhobor Ranch.
"	Aug. 17th, 1912	J. Ziboroff (Obs.)				2 3/16	0.510	2-foot Cippoletti weir " "
"	Sept. 1st, "	J. D. Honsberger (Obs.)				3½	0.900	" " " "
"	" 4th, "	J. Ziboroff (Obs.)				2½	0.600	" " " "
"	" 8th, "	J. D. Honsberger (Obs.)				3	0.840	" " " "
"	" 16th, "	J. Ziboroff (Obs.)				2	0.440	" " " "
"	Oct. 13th, "	J. D. Honsberger (Obs.)				1½	0.260	" " " "
"	Nov. 28th, "	J. Ziboroff (Obs.)				1⅝	0.340	" " " "
"	Dec. 6th, "	J. D. Honsberger (Obs.)				1¼	0.220	" " " "
Morrisey Creek	Aug. 20th, "	C. A. S. Atwood (Obs.)				1 11/16	0.520	" " mouth of canyon.
"	Sept. 9th, "	"				2 3/16	0.780	" " " "
"	" 23rd, "	"				1 11/16	0.529	" " " "
McConnell Creek	Aug. 20th, "	H. W. Collins (Obs.)				1⅜	0.230	" " N.E. corner Lot 351.
"	Sept. 1st, "	"				1¼	0.210	" " " "
"	" 10th, "	"				2⅛	0.600	" " " "
"	Oct. 15th, "	"				1⅜	0.260	" " " "
"	Nov. 11th, "	"				1¼	0.200	" " " "
"	Dec. 11th, "	"				13/16	0.131	" " " "
McCarron Creek	Sept. 10th, "	Mark Christenson (Obs.)				3⅛	0.90	" " Mark Christenson's Ranch.
"	" 17th, "	"				2⅛	0.50	" " " "
"	" 24th, "	"				1⅝	0.42	" " " "
"	Oct. 2nd, "	"				1⅝	0.38	" " " "
"	" 7th, "	"				1⅜	0.31	" " " "
"	" 18th, "	"				1⅝	0.38	" " " "
"	" 22nd, "	"				1⅝	0.42	" " " "
"	" 29th, "	"				1⅝	0.42	" " " "
"	Nov. 6th, "	"				1⅝	0.42	" " " "
"	" 14th, "	"				2⅛	0.74	" " " "
"	" 20th, "	"				2⅜	0.60	" " " "
Kerr or Jolly Jacks Creek	Sept. 11th, "	Robert Williamson (Obs.)				3	0.42	" " Kerr's Ranch.
" "	Oct. 5th, "	"				3	0.42	" " " "
" "	Nov. 25th, "	"				2⅝	0.40	" " " "
Ingram Creek	Sept. 24th, "	C. Varcoe (Hyd.)				3⅜	1.00	" " Richter's Ranch.
Meyers Creek	" 27th, "	Frank Roberts (Obs.)				3⅞	3.72	6-foot Cippoletti weir, Roberts' Ranch.
"	Oct. 15th, "	"				3⅞	3.72	" " " "

Meyers Creek	Oct.	27th,	1912	Frank Roberts (Obs.)				4¾	5.04	6-foot Cippoletti weir, Roberts' Ranch.
"	Nov.	5th,	"	"				5	5.46	" " " "
"	"	27th,	"	"				3⅛	3.36	" " " "

ARROW LAKES AND PART OF COLUMBIA RIVER WATERSHED.

								Feet.		
Dog Creek	May	8th,	1912	C. Varcoe (Hyd.)	20	70	8		560.00	Measured at Renata. High water.
West Fork of Dog Creek	"	8th,	"	"	14	42	8		336.00	" " " "
Blueberry Creek	Aug.	18th,	1911	"				0.346	5.42	Rectangular weir, measured one mile from mouth.
"	"	20th,	"	"				0.246	3.25	" " "
China Creek	"	20th,	"	"				0.198	1.19	" " one-half mile from mouth.
"	"	30th,	"	"				0.180	1.016	" " " "
Iron Creek	"	30th,	"	"				0.150	0.126	8-inch rectangular weir, measured at Doukhobor intake.
Trail Creek	Sept.	9th,	"	"				0.312	2.327	Rectangular weir, measured above smelter dam.
Ryan Creek	"	9th,	"	"				0.091	0.183	Rectangular weir, measured one-quarter mile from mouth.

SLOCAN RIVER WATERSHED.

								Inches.		
Slocan River	Oct.	11th,	1911	E. Davis (Hyd.)	103	217.0	2.10		457.00	Metered at Slocan City.
Sawmill Creek	July	15th,	"	"	16	32.0	4.16		133.00	
Carpenter Creek	"	15th,	"	"	35	73.5	7.00		514.00	At New Denver.
" South Fork	"	20th,	"	"	12	0.3	14.50		52.20	At Sandon (in flume).
Wilson Creek	"	3rd,	"	"	90	135.0	7.00		945.00	Estimated velocity of water.
Goose Creek	"	10th,	"	C. Varcoe (Hyd.)	26	46.1	1.40		64.60	
"	"	13th,	"	"	26	38.8	1.25		48.60	
Lemon Creek	Aug.	1st,	"	"	43	63.6	2.85		181.00	
"	"	12th,	"	"	43	58.3	2.48		145.00	
Cropps Creek	June	24th,	"	E. Davis (Hyd.)				1	0.08	1-foot Cippoletti weir.
"	July	3rd,	"	"				1 5/16	0.122	" "
"	"	8th,	"	"				1⅜	0.13	" "
Mollie Hughes Creek	June	24th,	"	"				15/16	0.0864	14-inch Cippoletti weir.
"	July	3rd,	"	"				1 1/16	0.1025	" "
"	"	8th,	"	"				1¼	0.11	" "
Rashdall Spring	June	24th,	"	"				½	0.042	15¾ " "
"	"	28th,	"	"				½	0.042	Rashdall Spring measured alone; other sources of supply to waterworks diverted.
"	July	5th,	"	"				½	0.042	
Alyard Creek	June	20th,	"	"				1¼	0.112	14-inch Cippoletti weir.
"	"	28th,	"	"				15/16	0.0864	" "
"	July	8th,	"	"				⅞	0.077	" "
Turris Creek	June	17th,	"	"				1 5/16	0.12	12-inch "
"	"	28th,	"	"				1 5/16	0.12	" "
"	July	7th,	"	"				1¼	0.11	" "
East Fork Simpson Creek	June	21st,	"	"					0.77	Weir measurements plus capacity of 4-inch pipe.
" " "	July	8th,	"	"					0.583	" " " "
West Fork "	June	21st,	"	"				1¼	0.047	6-inch Cippoletti weir.
" "	July	8th,	"	"				1¼	0.055	" "
Florence Creek	June	27th,	"	"				2 3/16	0.63	30-inch "
"	July	8th,	"	"				1 13/16	0.485	" "
Harris Creek	June	29th,	"	"				3¾	1.45	" "
Brogans Creek	Aug.	4th,	"	C. Varcoe (Hyd.)				2¼	0.526	2-foot rectangular weir.
Orange Creek	"	3rd,	"	"				2	0.224	1-foot "
Snake Creek	"	7th,	"	"				3 3/16	0.024	2-foot "
Crescent Valley Creek	July	19th,	"	"				1¾	0.255	" "
McHardy Creek	June	29th,	"	"				5½	6.155	6-foot "
"	July	13th,	"	"				2⅛	2.321	" "

STREAM MEASUREMENTS.—*Continued.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
KOOTENAY RIVER WATERSHED WEST SIDE OF SELKIRK MOUNTAINS.								
			Feet.	Sq. Ft.	Ft per S	Inches.		
* Kootenay River.								
Sandy Creek	Aug. 23rd, 1911	E. Davis (Hyd.)	2	0.852	2.7	.....	2.30	Metered in Poorman mine-flume.
Duhamel Creek	Sept. 23rd, "	"	11	5.42	2.4	.....	13.00	
Crawford Creek	" 24th, "	C. Varcoe (Hyd.)	24	30.60	2.7	.....	82.63	Velocity by surface floats.
Mill Creek	" 28th, "	E. Davis (Hyd.)	8	4.32	1.9	.....	8.20	
Preacher Creek	" 28th, "	C. Varcoe (Hyd.)	.....	.....	.....	3	2.51	6-foot rectangular weir.
Zimmer Creek	" 28th, "	"	.....	.....	.....	3	0.83	2-foot "
McGregor Creek	" 29th, "	"	.....	.....	.....	1⅜	0.208	" "
Skunk Creek	" 29th, "	"	.....	.....	.....	2½	1.28	4-foot "
Election Creek	" 29th, "	"	.....	.....	.....	2⅛	0.50	2-foot "
Aylmer Creek	" 21st, "	"	.....	.....	.....	1⅛	0.156	1-foot "
Ross Creek	" 21st, "	"	.....	.....	.....	1	0.0867	" "
Procter Creek	Oct. 6th, "	E. Davis (Hyd.)	.....	.....	.....	3½	1.07	2-foot Cippoletti weir.
Narrows Creek	" 5th, "	"	.....	.....	.....	6	3.50	3-foot " "
Crystal Creek	Sept. 19th, "	"	.....	.....	.....	3	0.82	2-foot " "
Shannon Creek	" 19th, "	"	.....	.....	.....	3½	1.57	3-foot " "
Anderson Creek	" 6th, "	"	.....	.....	.....	3¼	0.936	2-foot " "
Forty-nine Creek	Aug. 30th, "	"	.....	.....	.....	3½	3.10	6-foot rectangular weir.
Rover Creek	" 29th, "	"	.....	.....	.....	3¾	2.38	4-foot "
Wasson Creek	May 20th, 1912	W. J. Biker (Hyd.)	.....	.....	.....	.....	0.0859	Volumetrically.
Johnstone's Creek	" 20th, "	"	.....	.....	.....	.....	0.0197	"
Frazer's Creek	" 21st, "	"	.....	.....	.....	.....	0.0151	"
Kay's Creek	" 21st, "	"	.....	.....	.....	.....	0.0142	"
Sutherland Creek	" 22nd, "	"	.....	.....	.....	.....	0.1858	"
Isaac's Creek	" 24th, "	"	.....	.....	.....	.....	0.1523	"
Va Wagner Creek	" 27th, "	"	.....	.....	.....	.....	0.1923	"
UPPER COLUMBIA WATERSHED.								
Morigeau Creek	June 19th, 1912	F. W. Knewstubb (Hyd.)	.....	.....	.....	5	12.40	Weir discharge includes flow in ditches having intakes above gauging-station.
Sophy Creek	" 19th, "	"	.....	.....	.....	.....	.....	Dry.
Sunlight Creek	July 20th, "	A. C. Whitehouse (Obs.)	.....	.....	.....	6⅜	0.52	Right-angled V notch.
Goldie Creek	Aug. 23rd, "	F. W. Knewstubb (Hyd.)	.....	.....	.....	4⅝	11.8	Weir discharge includes flow in ditches having intakes above gauging-station.
Salter Creek	" 23rd, "	"	.....	.....	.....	.....	2.00	Approx. flow.
Brady Creek	" 30th, "	"	.....	.....	.....	.....	3.00	"
Johnston Creek	" 30th, "	"	.....	.....	.....	.....	1.50	"
Spring Creek	" 30th, "	"	.....	.....	.....	Feet.	0.50	"
Big Vermilion Creek	April 8th, 1911	Henry B. Hicks (Hyd.)	.....	.....	.....	0.68	17.1	Discharge from Big and Little Vermilion and Sinclair Creek measured with K. & E. Meter No. 6018, by H. B. Hicks, April 8th, 10th and 14th, respectively.
"	" 11th, "	"	.....	.....	.....	0.67	17.0	Discharges furnished by Canavan & Mitchell, calculated from gauge heights.
"	" 23rd, "	"	.....	.....	.....	0.83	22.2	Ditto.
"	" 27th, "	"	.....	.....	.....	1.00	29.6	"
"	" 30th, "	"	.....	.....	.....	0.98	28.5	"
"	May 1st, "	"	.....	.....	.....	1.03	33.5	"
	" 3rd, "	"	.....	.....	.....	1.04	31.5	"

* For discharge curve *see* page 137.

Big Vermilion Creek	May	5th,	1911	Henry B. Hicks (Hyd.)				1.12	25.2	Ditto.
"	"	6th,	"	"				1.33	45.5	"
"	"	7th,	"	"				1.24	43.3	"
"	June	13th,	"	"	21.5			2.90	143.5	"
Little Vermilion Creek	April	10th,	"	"	14.0			1.18	8.0	"
"	"	23rd,	"	"				1.23	9.5	"
"	"	30th,	"	"				1.31	11.4	"
"	May	1st,	"	"				1.42	15.0	"
"	"	2nd,	"	"				1.33	11.6	"
"	"	5th,	"	"				1.33	11.6	"
"	"	6th,	"	"				1.43	15.6	"
"	June	13th,	"	"	16.7			2.60	64.5	"
Sinclair Creek	April	14th,	"	"	13.0			1.55	15.7	"
"	"	18th,	"	"				1.57	16.1	"
"	"	30th,	"	"				1.88	28.0	"
"	May	1st,	"	"				1.96	28.6	"
"	"	5th,	"	"				2.13	34.0	"
"	"	6th,	"	"				2.30	41.0	"
"	June	13th,	"	"					95.0	"

EAST KOOTENAY WATERSHED.

Joseph's Creek	June	15th,	1911	Henry B. Hicks (Hyd.)	13	12.30	3.27	1.75	40.21	Metered. Gauge about 400 feet up-stream from the Cranbrook reservoir.
"	"	20th,	"	"	13	12.30	3.27	1.53		Record of gauge height kept by M. B. Heath.
"	"	25th,	"	"	13	12.30	3.27	1.75		" " "
Smith Creek	Sept.	7th,	"	"	5	1.78	1.35		2.41	Metered below the mouth of Dickson Creek.
Rock Creek	Oct.	15th,	"	"	19		2.30		78.00	Metered four miles from mouth of creek.
Big Sand Creek	"	17th,	"	"	12	13.30	2.50		33.23	Metered 3,000 feet above the C.P. Railway.
Little Sand Creek	"	23rd,	"	"	22	13.63	1.76		24.05	Metered one and one-half miles above Big Sand Creek.
Wild Horse Creek	May	10th,	1912	"					87.00	Ten miles from Fort Steele, measured by floats.
"	June	1st,	"	"					470.00	Two miles from Fort Steele, measured by floats.
Maus Creek	May		"	"					33.00	" " " "
Four-mile Creek	"		"	"					3.30	On Lot 332 with floats.
Khartoum Creek	"		"	"					1.25	" 781 "
Boulder Creek	"		"	"					40.00	" "
Tracy Creek	"	24th,	"	"					5.00	" 5802 "
Lewis Creek	"	25th,	"	"					15.00	" 7656 "
Wolf Creek	July	9th,	"	"					12.00	" 7033 "
Sheep Creek	"	16th,	"	"					350.00	" 8757 "
Skookum-chuck Creek	"	24th,	"	"					623.00	At Shaw Parker's, metered with floats.
"	Dec.	11th,	"	"	95	110.00	0.68	1.05	97.00	" " "
Cherry Creek	July	29th,	"	"					52.00	At wagon-bridge, metered with floats.
"	Aug.	26th,	"	"	19.50	17.63	1.09	1.00	19.16	" " "
Matthew Creek	"	10th,	"	"					37.00	" " "
Bull River	Sept.	22nd,	"	"	27	339.00	1.36		460.60	Metered two and one-half miles above pack-bridge.
"	Dec.	7th,	"	"	16	80.00	4.18		334.00	2,000 feet above pack-bridge, metered in flume and stream.
Little Bull River	Sept.	9th,	"	"	15	17.00	0.77		13.50	Metered on Lot 313.
St. Mary's River	Aug.	21st,	"	"	150	477.00	1.81	2.05	863.00	Metered at wagon-bridge near Wycliffe. Record of gauge height taken by Otis Staples Mill Company.
"	Sept.	1st,	"	"				1.80		Ditto.
"	"	8th,	"	"				2.10		"
"	"	15th,	"	"				2.20		"
"	"	29th,	"	"				1.80		"
"	Oct.	6th,	"	"				1.50		"
"	"	13th,	"	"				1.30		"
"	"	20th,	"	"				1.50		"
"	"	27th,	"	"				1.40		"
"	Nov.	3rd,	"	"				1.30		"
"	"	10th,	"	"				1.40		"
"	"	17th,	"	"				1.30		"
"	"	24th,	"	"				1.30		"
"	Dec.	2nd,	"	"	135	345.00	1.36	1.10	468.00	Metered

STREAM MEASUREMENTS.—*Concluded.*

Stream.	Date.	Hydrographer or Observer.	Width.	Area of Section.	Mean Velocity	Gauge Height.	Discharge.	Remarks.
			Feet.	Sq. Ft.	Ft per S	Feet.	Cu. Ft. per S.	
EAST KOOTENAY WATERSHED.—*Concluded.*								
Lamb Creek	Nov. 10th, 1912	Henry B. Hicks (Hyd.)	9	5.00	3.3	.....	19.40	Metered near wagon-bridge.
Palmers Bar Creek	" 16th, "	"	8	3.40	0.91	.....	3.10	Metered at Wattsburg.
Moyie River	" 16th, "	"	20	15.70	2.51	.....	39.40	Metered at C.P.R. Bridge.
"	" 13th, "	"	125	266.00	1.5	.....	399.00	At Kingsgate with floats.
Perry Creek	Oct. 10th, "	"	16	10.90	1.43	.....	15.53	Metered at old shaft.
Joseph's Creek	Dec. 5th, "	"	8.65	6.50	0.92	0.75	6.00	Metered in flume near M. B. Heath's home.
						Inches.		
Mark Creek	Aug. 25th, "	"	.....	.....	.....	7	13.35	Cippoletti weir on top of concrete dam two miles above Kimberley.
"	Oct. 14th, "	"	.....	.....	.....	6⅝	12.31	Ditto.
Bridge Creek	Nov. 2nd, "	"	.....	.....	.....	6⅜	1.00	Cippoletti weir.
Sunday Creek	" 2nd, "	"	.....	.....	.....	2⅝	0.73	"
KOOTENAY RIVER WATERSHED EAST OF THE SELKIRK MOUNTAINS AND SOUTH OF WARDNER.								
Maguire Creek	June 28th, 1912	W. J. E. Biker (Hyd.)	.....	.....	.....	.....	7.844	3-foot rectangular weir.
"	Sept. 6th, "	J. Desrosiers (Obs.)	.....	.....	.....	7¼	5.310	" Cippoletti weir.
"	" 18th, "	"	.....	.....	.....	7⅛	4.930	" "
"	Nov. 11th, "	"	.....	.....	.....	8	5.437	" "
"	" 29th, "	"	.....	.....	.....	7¼	4.691	" "
"	Dec. 12th, "	"	.....	.....	.....	6	3.532	" "
Red Canyon Creek	July 27th, "	W. J. E. Biker (Hyd.)	.....	.....	.....	12	11.250	" rectangular weir.
"	Sept. 5th, "	G. Peterson (Obs.)	.....	.....	.....	9	6.488	Cippoletti weir.
"	" 10th, "	"	.....	.....	.....	10	7.599	"
"	" 14th, "	"	.....	.....	.....	8⅜	6.220	"
"	" 21st, "	"	.....	.....	.....	8⅛	5.955	"
"	" 28th, "	"	.....	.....	.....	8	5.437	"
"	Oct. 5th, "	"	.....	.....	.....	7½	4.936	"
"	" 12th, "	"	.....	.....	.....	7	4.450	"
"	" 19th, "	"	.....	.....	.....	7⅛	4.936	"
"	Nov. 2nd, "	"	.....	.....	.....	8	5.427	"
"	" 9th, "	"	.....	.....	.....	9	6.488	"
"	" 16th, "	"	.....	.....	.....	8⅛	5.955	"
"	" 23rd, "	"	.....	.....	.....	8	5.437	"
Willie Phillips Creek	July 10th, "	W. J. E. Biker (Hyd.)	.....	.....	.....	.....	11.739	4-foot rectangular weir.
"	Sept. 3rd, "	C. Sinclair (Obs.)	.....	.....	.....	6⅞	4.857	" Cippolettie weir.
"	" 8th, "	"	.....	.....	.....	6¼	5.006	" "
"	" 15th, "	"	.....	.....	.....	6	4.709	" "
"	" 22nd, "	"	.....	.....	.....	6	4.709	" "
"	" 29th, "	"	.....	.....	.....	6	4.709	" "
"	Oct. 6th, "	"	.....	.....	.....	6	4.709	" "
"	" 13th, "	"	.....	.....	.....	5⅝	4.732	" "
"	" 20th, "	"	.....	.....	.....	5⅜	4.133	" "
"	" 29th, "	"	.....	.....	.....	5⅝	4.372	" "
"	Nov. 3rd, "	"	.....	.....	.....	5⅜	4.133	" "
"	" 10th, "	"	.....	.....	.....	5⅝	3.903	" "
"	" 17th, "	"	.....	.....	.....	5⅝	3.993	" "
"	" 24th, "	"	.....	.....	.....	5¼	3.754	" "
Phillips Creek	Aug. 20th, "	W. J. E. Biker (Hyd.)	.....	.....	.....	12¾	20.772	6-foot "

Phillips Creek	Aug.	25th,	1912	Fred Roo, Jr. (Obs.)				12	20.140	6-foot Cippoletti weir
"	Sept.	1st,	"	"				14¼	27.510	" "
"	"	7th,	"	"				18½	40.579	" "
"	"	15th,	"	"				16¾	34.860	" "
"	"	21st,	"	"				15	29.748	" "
"	"	28th,	"	"				14¼	28.237	" "
"	Oct.	6th,	"	"				13¼	24.804	" "
"	"	13th,	"	"				13	24.218	" "
"	"	20th,	"	"				13¼	24.804	" "
"	"	27th,	"	"				12¾	23.567	" "
"	Nov.	2nd,	"	"				12¾	23.567	" "
"	"	9th,	"	"				12½	22.941	" "
"	"	17th,	"	"				12¼	20.772	" "
"	"	24th,	"	"				12	20.140	" "
"	Dec.	1st,	"	"				12	20.140	" "
Linklater Creek	"	11th,	"	H. B. Hicks (Hyd.)	18.00	8.02	2.86		22.92	Metered one mile from its mouth.
"	Sept.	25th,	"	W. J. E. Biker (Hyd.)				5¾	10.687	10-foot Cippoletti weir.
"	"	29th,	"	A. Murphy (Obs.)				5½	10.333	" "
"	Oct.	6th,	"	"				5¼	10.333	" "
"	"	13th,	"	"				5¼	10.333	" "
"	"	21st.	"	"				5¾	10.687	" "
"	"	28th,	"	"				6½	10.687	" "
"	Nov.	3rd,	"	"				5¾	11.045	" "
"	"	10th,	"	"				7¾	15.638	" "
"	"	17th,	"	"				7½	16.454	" "
"	"	24th,	"	"				6¼	13.275	" "
"	"	26th,	"	"				5½	10.333	" "
Unnamed stream between Edwards Lakes on Indian Reserve No. 2, South East Kootenay	July	18th,	"	W. J. E. Biker (Hyd.)					20.522	8-foot rectangular weir.
Rock Creek	Oct.	24th,	"	"	37.62	46.18	1.11		69.96	Metered about four miles from mouth.
Elk River	"	10th,	"	"	125.00	276.35	2.78		824.577	Metered one and one-half miles above Elko.
Gold Creek	Sept.	19th,	"	"				9 5/16	22.97	10-foot Cippoletti weir.
Scherf Creek	"	2nd,	"	"				6 11/16	3.463	2.6-foot "
Unnamed creek on S.L. 10, Lot 354, S.E. Kootenay	"	18th,	"	"				5 7/16	4.326	3-foot "
Conners Springs, rising in S.L. 21, Lot 4689—No. 1	"	19th,	"	"					0.0078	Volumetrically.
Ditto No. 2	"	19th,	"	"					0.06	"
" No. 3	"	19th,	"	"					0.0864	"
Unnamed stream rising on Lot 9491	Aug.	1st,	"	"				7/16	0.51	1-foot Cippoletti weir.
Miller Creek	July	30th,	"	"				7	3.707	2.5-foot "
Rainbow Creek	"	30th,	"	"				5¼	2.409	" "
Reserve Creek	"	22nd,	"	"				8¼	6.802	3.6-foot "
Edwards Lake Creek	"	18th,	"	"				12 5/16	25.389	7.3-foot "
Bowman Creek	"	9th,	"	"				5 11/16	2.176	2-foot "
Redmond Creek	June	16th,	"	"				6¾	2.160	1.5-foot "
Unnamed stream sinking in S.L. 16, Lot 357	"	25th,	"	"				3	1.22	3-foot "

KOOTENAY RIVER DISCHARGE—OBSERVATIONS AT GAUGING STATION, RAPIDS NEAR NELSON (JULY 31ST, 1912).

By HARRY F. MEURLING, ENGINEER.

Distance from Instrument Station.	Distance between Sections.	Depth of Sections.	Area of Sections.	Time in Seconds for 70 Revs. of Meter.	Corresponding Velocity.	Increase in Velocity per Ft. Dist. from Bank. Vel. at North Bank = 1.56.	Mean Velocity of Sections.	Discharge in Cubic Ft. per Sec.	Remarks.
Feet.	Feet.	Feet.	Sq. Ft.		Feet per Sec.		Feet per Sec.		
*31	.....	*0.00	.....	.....	.....	.....	1.56	.....	
39	8	3.09	12.4	.....	.....	0.009	1.59	19.72	
*40	1	*3.59	3.3	.....	.....	.....	1.62	6.38	
43	3	4.49	12.1	.....	.....	.....	1.65	19.96	Gauge ..... = 6.50
*60	17	*9.09	115.4	.....	.....	.....	1.74	200.78	Difference ..... = 0.59
65	5	9.09	45.4	.....	.....	.....	1.84	83.51	
*80	15	*9.29	137.8	.....	.....	.....	1.93	265.95	Gauge at cross-section .... = 7.09
94	14	10.09	135.7	.....	.....	.....	2.06	279.54	Elevation of zero ..... = 1,755.91
*100	6	*10.39	61.4	.....	.....	.....	2.15	132.01	
120	20	11.09	214.8	.....	.....	.....	2.27	487.60	Elevation of water surface .. 1,763.00
*140	20	*12.29	233.8	.....	.....	.....	2.45	572.81	
*160	20	*14.09	263.8	53.0	2.58	0.012	2.70	712.26	All distances taken from Instrument Station on North Bank.
172	12	16.09	181.1	.....	.....	.....	2.89	523.38	
180	8	16.09	128.7	.....	.....	.....	2.01	387.89	
200	20	25.09	411.8	.....	.....	.....	3.18	1,309.52	Distance of Instrument Station from edge of water = 31 feet.
220	20	25.09	501.8	.....	.....	.....	3.42	1,716.16	
240	20	30.09	551.8	46.2	3.51	0.004	3.55	1,958.89	
*260	20	*37.09	671.8	.....	.....	.....	3.63	2,438.63	Elevation of Instrument Station = 1,767.88.
280	20	40.09	771.8	.....	.....	.....	3.71	2,863.33	
300	20	42.09	821.8	.....	.....	.....	3.79	3,115.12	
320	20	45.09	871.8	.....	.....	.....	3.87	3,373.87	Number of Sounding Range = 2.
324	4	43.09	176.4	.....	.....	.....	3.91	689.72	
340	16	38.09	649.9	.....	.....	.....	3.95	2,567.11	Bearing of Sounding Range = S. 27° 10' W. Ast.
*360	20	*33.59	716.8	48.2	4.03	0.002	4.03	2,888.70	
370	10	31.09	323.4	.....	.....	.....	4.02	1,300.07	
375	5	30.09	152.9	.....	.....	.....	4.00	611.60	Current meter used: W. & L. E. Gurley No. 621.
380	5	28.09	145.4	.....	.....	.....	3.98	578.69	
390	10	27.09	275.9	.....	.....	.....	3.96	1,092.56	
*400	10	*26.09	265.9	.....	.....	.....	3.93	1,044.99	Field Notes: Book No. 3.
420	20	26.09	521.8	.....	.....	.....	3.88	2,024.58	
430	10	27.09	265.9	.....	.....	.....	3.84	1,020.06	
*440	10	*26.59	268.4	.....	.....	.....	3.81	1,022.60	
*460	20	*26.09	526.8	.....	.....	.....	3.76	1,980.77	
480	20	24.09	501.8	44.8	3.64	0.003	3.70	1,856.66	
490	10	21.09	225.9	.....	.....	.....	3.62	817.76	
500	10	26.09	235.9	.....	.....	.....	3.59	846.88	
510	10	23.09	245.9	.....	.....	.....	3.56	875.40	
520	10	20.09	216.9	.....	.....	.....	3.53	762.13	
*540	20	*11.59	316.8	.....	.....	.....	3.49	1,105.63	
550	10	7.09	93.4	48.0	3.39	.....	3.44	321.30	
.....	.....	.....	12,273.4	.....	.....	.....	.....	43,873.10	

Mean velocity of cross-section = 3.6.

* NOTE.—Starred figures denote interpolated distances and depths.

VICTORIA, B.C.:
Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.
1913.