Canada Parliament

Sessional Papers

SESSIONAL PAPERS

VOLUME 19–PART 2

FIFTH SESSION OF THE TWELFTH PARLIAMENT

ERRATUM TO VOLUME I.

Owing to a transposition in make up of table on page xx of the Deputy Minister's Report, showing homestead entries reported each year since 1874, the figures are manifestly incorrect. The correct sequence of the figures will, however, be found on page 182, Part I. Dominion Lands, being Statement P. of Mr. N. O. Coté, Controller of the Land Patents Branch.

NOTE.—Please tear out this slip and insert it in same position in Volume 1.

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OF THE

DOMINION OF CANADA

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1. Report of the Auditor General for the year ended 31st March, 1914, Volume I, Parts A, B and A to L; Volume II, Parts M to U; Volume III, Parts V to Z. Presented by Hon. Mr. White, February 9, 1915.. .. .. ..*Printed for distribution and sessional papers.*

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2. The Public Accounts of Canada, for the fiscal year ended 31st March, 1914. Presented by Hon. Mr. White, February 9, 1915 .. .. ..*Printed for distribution and sessional papers.*

3. Estimates of sums required for the service of the Dominion for the year ending on 31st March, 1916. Presented by Hon. Mr. White, February 8, 1915.
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5. Further Supplementary Estimates of sums required for the service of the Dominion for the year ending on the 31st March, 1915. Presented by Hon. Mr. White, March 27, 1915.
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5*a*. Further Supplementary Estimates for year ending 31st March, 1916. Presented by Hon. Mr. White, March 31, 1915.. .. ..*Printed for distribution and sessional papers.*

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6. List of Shareholders in the Chartered Banks of the Dominion of Canada as on 31st December, 1914. Presented by Hon. Mr. White, February 9, 1915.
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7. Report on certified cheques, dividends, unclaimed balances and drafts or bills of exchange remaining unpaid in Chartered Banks of the Dominion of Canada, for five years and upwards prior to 31st December, 1913. Presented by Hon. Mr. White, April 10, 1915.
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8. Report of Superintendent of Insurance for year 1914. Presented by Hon. Mr. White, 1915.
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9. Abstract of Statement of Insurance Companies in Canada for year ended 31st December, 1914. Presented by Hon. Mr. White, 1914.
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10. Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1914: Part I.—Canadian Trade. Presented by Sir George Foster, 8th February, 1915. *Printed for distribution and sessional papers.*

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10*a*. Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1914: Part II.—Canadian Trade with (1) France, (2) Germany, (3) United Kingdom, and (4) United States. Presented by Sir George Foster, 8th February, 1915. *Printed for distribution and sessional papers.*

10*b*. Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1914: Part III.—Canadian Trade with foreign countries (except France, Germany, the United Kingdom, and United States.) Presented by Sir George Foster, 8th February, 1915.. .. ..*Printed for distribution and sessional papers.*

10*c*. Report of the Department of Trade and Commerce, for the fiscal year ended 31st March, 1914, (Part IV, Miscellaneous Information.) Presented by Sir George Foster, March 27, 1915.. .. ..*Printed for distribution and sessional papers.*

10*d*. Report of the Board of Grain Commissioners for Canada. Presented by Sir George Foster, 1914.. .. ..*Printed for distribution and sessional papers.*

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10*e*. Report of the Department of Trade and Commerce for the fiscal year ending 31st March, 1914. Part VI.—Subsidized Steamship Services, with statistics showing steamship traffic to 31st December, 1914, and Estimates for the fiscal year 1915-16. Presented by Sir George Foster, 1915.. .. ..*Printed for distribution and sessional papers.*

10*f*. Report of Trade and Commerce for fiscal year ended 31st March, 1914. (Part VII.—Trade of Foreign Countries, Treaties and Conventions.) Presented by Sir George Foster, 1915.. .. ..*Printed for distribution and sessional papers.*

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15. Report of the Minister of Agriculture for the Dominion of Canada, for the year ended 31st March, 1914. Presented by Hon. Mr. Burrell, February 8, 1915. *Printed for distribution and sessional papers.*

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15*b*. Report of the Veterinary Director General for the year ending 31st March, 1915. Presented by Hon. Mr. Burrell, 1915.. .. ..*Printed for distribution and sessional papers.*

16. Report of the Director and Officers of the Experimental Farms for the years ending 31st March, 1914. Presented by Hon. Mr. Burrell, March 1, 1915. *Printed for distribution and sessional papers.*

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17. Criminal Statistics for the year ended 30th September, 1913. (Appendix to the Report of the Minister of Trade and Commerce for the year 1913.) Presented by Sir George Foster, 1915.. .. ..*Printed for distribution and sessional papers.*

18. Return of By-elections for the House of Commons of Canada, held during the year 1914. Presented by Hon. Mr. Speaker, March 12, 1915. *Printed for distribution and sessional papers.*

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19. Report of the Minister of Public Works on the works under his control for the fiscal year ended 31st March, 1914, Volume I. Presented by Hon. Mr. Rogers, February 8, 1915. *Printed for distribution and sessional papers.*

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20. Annual Report of the Department of Railways and Canals, for the fiscal period from 1st April, 1913, to 31st March, 1914. Presented by Hon. Mr. Cochrane, March 12. *Printed for distribution and sessional papers.*

20*a*. Canal Statistics for the season of navigation, 1914. Presented by Hon. Mr. Cochrane, 9th April, 1915.. .. ..*Printed for distribution and sessional papers.*

20*b*. Railway Statistics of the Dominion of Canada, for the year ended 30th June, 1914. Presented by Hon. Mr. Cochrane, March 12, 1915. *Printed for distribution and sessional papers.*

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20*d*. Telephone Statistics of the Dominion of Canada, for the year ended 30th June, 1914. Presented by Hon. Mr. Cochrane, March 17, 1915. *Printed for distribution and sessional papers.*

20*e*. Express Statistics of the Dominion of Canada for year ended 30th June, 1914. Presented by Hon. Mr. Cochrane, 1915... .. ..*Printed for distribution nad sessional papers.*

20*f*. Telegraph Statistics of the Dominion of Canada, for the year ended 30th June, 1914. Presented by Hon. Mr. Cochrane, March 17, 1915. *Printed for distribution and sessional papers.*

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23. Supplement to the Forty-seventh Annual Report of the Department of Marine and Fisheries for the fiscal year 1913-14—Steamboat Inspection Report. Presented by Hon. Mr. Hazen, March 3, 1915 .. ..*Printed for distribution and sessional papers.*

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25b. Annual Report of the Topographical Surveys Branch of the Department of the Interior, 1912-13. Presented by Hon. Mr. Roche, 1914.
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25c. Report of progress of stream measurements for calendar year of 1914. Presented by Hon. Mr. Roche, 1914.. .. ..*Printed for distribution and sessional papers.*

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25e. Report on Bow River Water Power and Storage Investigations. seasons 1911-1912-1913. Presented by Hon. Mr. Burrell, 1915.. ..*Printed for distribution and sessional papers.*

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28. Report of the Royal Northwest Mounted Police, 1914. Presented by Hon. Sir Robert Borden, 8th February, 1915 .. ..*Printed for distribution and sessional papers.*

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29b. Report of the work of the Public Archives for the year 1913. Presented, 1915.
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33. Report of the Secretary of State for External Affairs for the year ended 31st March, 1914. Presented by Sir Robert Borden, 18th February, 1915.
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34. Report of the Minister of Justice as to Penetentiaries of Canada, for the fiscal year ended 31st March, 1914. Presented, 1915.. .. ..*Printed for distribution and sessional papers.*

35. Report of the Militia Council for the Dominion of Canada, for the fiscal year ending 31st March, 1914. Presented by Hon. Mr. Hughes, 10th February, 1915.
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36. Report of the Department of Labour for the fiscal year ending 31st March, 1914. Presented by Hon. Mr. Crothers, 8th February, 1915.
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36a. Seventh Report of the Registrar of Boards of Conciliation and Investigation of the proceedings under "The Industrial Disputes Investigation Act, 1907," for the fiscal year ending 31st March, 1914. Presented by Hon. Mr. Crothers, 8th February. 1915.
Printed for distribution and sessional papers.

37. Tenth Annual Report of the Commissioners of the Transcontinental Railway, for the year ended 31st March, 1914. Presented by Hon. Mr. Cochrane, 8th February, 1915.
Printed for distribution and sessional papers.

37a. Interim Report of the Commissioners of the Transcontinental Railway, for the nine months ended 31st December, 1914. Presented by Hon. Mr. Cochrane, 15th February, 1915.. .. ..*Not printed.*

38. Report of the Department of the Naval Service, for the fiscal year ending 31st March, 1914 Presented by Hon. Mr. Hazen, 8th February, 1915.
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39. Forty-seventh Annual Report of the Department of Marine and Fisheries, 1913-14—Fisheries. Presented by Hon. Mr. Hazen, 8th February, 1915
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39a. Fisheries Investigations in Hudson's and James Bays. Presented by Hon. Mr. Hazen, 1915... .. ..*Printed for distribution and sessional papers.*

39b. Supplement to the 47th Annual Report of the Department of Marine and Fisheries (Fisheries Branch),—Contributions to Canadian Biology, 1911-14, Part I—Marine Biology Presented by Hon. Mr. Hazen, 16th February, 1915.
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40. The Report of the Joint Librarians of Parliament. Presented by Hon. Mr. Speaker, 4th February, 1914 .. ..*Not printed.*

41. Report of R. A. Pringle, K.C., Commissioner appointed to investigate into the payment of subsidies to the Southampton Railway Company, together with the evidence, etc., taken before the Commissioner. Presented by Hon. Mr. Cochrane, 8th February, 1915.
Not printed.

42. Radiotelegraph Regulation 106 concerning the wave length for use by Canadian licensed ship stations during the period of hostilities, and

Amendment to the Radiotelegraph Regulations, Nos. 103 (Ship Stations in Territorial Waters) and 104 (Ship Stations in Harbours). Presented by Hon. Mr. Hazen, 8th February, 1915.. .. ..*Not printed.*

43. No. P. C. 260, dated 3rd February, 1915, *re* Establishment of Rank of Mate in the Royal Canadian Navy. Presented by Hon. Mr Hazen, 8th February, 1915... ..*Not printed.*

43a. Copy of Order in Council No. P.C. 304, dated 18th February, 1915.—Establishment of ranks of Lieutenant-Commander, Engineer Lieutenant-Commander and Lieutenant-Commander R.C.N.V.R., in the Royal Canadian Navy. Presented by Hon. Mr. Hazen, 11th March, 1915.. .. ..*Not printed.*

43b. Copy of Order in Council No. P.C. 476, dated 6th March, 1915,—Regulations concerning the classification of engineer officers. Presented by Hon. Mr. Hazen, 15th March, 1915.
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44. Copies of Orders in Council *re* Naval Service.

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No. P.C. 2251, *re* Rates of Pay and Allowances for Petty Officers and Men Volunteering for War Service.

No. P.C. 2960, *re* Scheme of Separation Allowance for the Dependents of those serving in H.M.C. ships. Presented by Hon. Mr. Hazen. 8th February, 1915.
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45. Return to an Order of the House of the 20th April, 1914, for a copy of all letters, papers, tenders and other documents in regard to the purchase of any cars for the Intercolonial Railway during the years 1912 and 1913. Presented 9th February, 1915.—*Mr. Macdonald*. . . . .*Not printed.*

45a. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams, contracts, and other documents relating to the purchase of cars by the Intercolonial Railway since 1st July, 1914. Presented 9th April, 1915.—*Mr. Macdonald.* *Not printed.*

46. Return to an Order of the House of the 26th February, 1914, for a return showing:—1. The average cost per mile of construction of the Canadian Pacific Railway from its inception to date. 2. The average cost per mile in the last ten years. 3. The average rental per mile of lines leased by the Canadian Pacific Railway Company, and the names of such leased lines. 4. The rental paid by the Canadian Pacific Railway for the Toronto, Grey and Bruce Railway from Toronto to Owen Sound. Presented 9th February, 1915.—*Mr. Middlebro*. . . . .*Not printed.*

47. Return to an Order of the House of the 1st June, 1914, for a return showing the revenue derived from freight received at and forwarded from the following stations on the Intercolonial Railway during the fiscal years 1913 and 1914, giving separately the amount for each of said stations, viz.: Drummondville, Rimouski, Ste. Flavie, Matapedia, Campbellton and Bathurst. Presented 9th February, 1915.—*Mr. Boulay.* *Not printed.*

48. Return to an Order of the House of the 1st June, 1914, for a return showing the names of the staff employed in the several departments of the general offices of the Intercolonial Railway at Moncton, together with their salaries respectively as of 1st April, 1914. Presented 9th February, 1915.—*Mr. Emmerson*. . . . .*Not printed.*

49. Return to an Order of the House of the 18th May, 1914, for a return showing the names of the men who have been appointed to positions in the Prince Edward Railway Service from the 1st January, 1912, to the 1st May, 1914; the positions held by such appointees and the salary or wages attached to each position. Presented 9th February, 1915.—*Mr. Hughes (Kings, P.E.I.)*. . . . .*Not printed.*

49a. Return to an Order of the House of the 1st March, 1915, for a return giving the names and post office addresses of all persons appointed to positions on the Prince Edward Island Railway from the 1st of October, 1911, to the present time; with a description of the position to which each person was so appointed. Presented 22nd March, 1915.—*Mr. Hughes (Kings, P.E.I.)*. . . . .*Not printed.*

50. Return to an Order of the House of the 11th February, 1914, for a return showing the names, tonnage, port of registry and destination of all foreign vessels engaged in fishing, both sail and steam, that entered and cleared from the port of North Sydney during the year ending 31st December, 1913. Presented 9th February, 1915.—*Mr. Sinclair*. . . . .*Not printed.*

51. Return to an Order of the House of the 1st June, 1914, for a copy of all correspondence between the Department of Justice and the Attorney General of Quebec, with regard to the appointment of judges, since the 1st of February, 1913. Presented 9th February, 1915.—*Sir Wilfrid Laurier*. . . . .*Not printed.*

52. Return to an Order of the House of the 30th March, 1914, for a return showing:—1. Particulars of the inventories and value of the estate of the late George A. Montgomery, Registrar at Regina, whose estate escheated to the Crown. 2. The amount realized at Regina or elsewhere, on the conversion of said estate into money. 3. The costs paid or allowed with names and amounts paid or allowed before the residue was paid over to the Crown. 4. The amount paid over and actually received by the Crown. 5. The disposition of the fund and the names of the persons to whom any sum has been paid, and the respective amounts thereof so paid over or allowed since the Crown received the same. 6. A statement showing the difference between the reports of the present and the late Minister of Justice as to disposition of the fund, and a copy of such correspondence and representations as led up to any change. 7. The actual balance now on hand and the intended disposition thereof. Presented 9th February, 1915.—*Mr. Graham*. . . . .*Not printed.*

53. Return to an Order of the House of the 16th March, 1914, for a return showing all persons, male or female, who have been capitally convicted in Canada, and each province, for each year, from the 1st of July, 1867, to the 2nd of February, 1914, specifying the offences and whether and how the sentences were carried into effect by execution, or otherwise, with the name of convicts; dates of conviction; crime of which committed; sentences passed; judges by whom sentenced; and how dealt with. 2. For a return showing all convicts, male and female, who have been reprieved from the execution of capital sentences passed upon them during the above mentioned period, with the name

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of convicts; dates of conviction; crime of which convicted; sentences passed; by whom sentenced; sentences commuted, and if so, to what. 3. For a return showing all persons in Canada, and each province, convicted during the above mentioned period of murder whose sentences have been mitigated, or who have received a free pardon, together with a statement of the offences of which they were severally convicted, with the name of convicts; dates of conviction; nature of offence; sentences; and extent of mitigation of sentences and dates. 4. For a return of instances, during the above mentioned period, in which appeal has been made on behalf of the persons convicted of capital offences to His Excellency, the Governor in Council, for the exercise of the Royal Prerogative of pardon, or mitigation of sentences, with the name of convicts; dates of conviction and place; crime of which convicted; sentences; dates of appeal; and the result. Presented 9th February, 1915.—*Mr. Wilson (Laval)*.. ..*Not printed.*

54. General Rules and Orders of the Exchequer Court of Canada made, respectively, on the 23rd September, 1914, and the 18th June, 1914. Presented by Hon. Mr. Coderre, 9th February, 1915.. .. ..*Not printed.*

54*a*. General Rules and Orders of the Exchequer Court of Canada made on the 15th February, 1915. Presented by Hon. Mr. Coderre, 16th March, 1915... .. ..*Not printed.*

55. Ordinances of the Yukon Territory passed by the Yukon Council in the year 1914. Presented by Hon. Mr. Coderre, 9th February, 1915... .. ..*Not printed.*

56. Return to an Order of the House of the 18th May, 1914, for a return showing the details of moneys paid to J. F. Farrington, $248.25; B. H. Smith, $469.50, and H. C. Dash, $182.40, as set forth in *Hansard* of this session, page 3071. Presented 9th February, 1915.—*Mr. McLean (Halifax)*... .. ..*Not printed.*

57. Return to an Order of the House of the 16th March, 1914, for a copy of instruction sent to Mr. Wm. Flynn, advocate, to hold investigations into charges made against employees of the Department of Marine and Fisheries in Bonaventure County, and reports made by him in such investigations. Presented 9th February, 1915.—*Mr. Marcil (Bonaventure)*.. .. ..*Not printed.*

58. Return to an Order of the House of the 27th April, 1914, for a copy of all documents bearing upon the application made to the Department of Marine and Fisheries for the dismissal of Ulric Dion, lightkeeper at St. Charles de Caplan, Quebec, and the appointment of Omer Arsenault in his place, and on the action taken by the Department in that connection. Presented 9th February, 1915.—*Mr. Marcil (Bonaventure)*. *Not printed.*

59. Return to an Order of the House of the 9th February, 1914, for a copy of all agreements made and entered into between the Department of Marine and Fisheries or the Government and Railway and Express Companies, including the Intercolonial Railway, relating to the transportation of fresh fish by fast freight or express, since the year 1906; also a copy of all guarantees given to railway and express companies by the Government or any Department thereof, relating to such transportation, together with a statement of all disbursements made by the Department of Marine and Fisheries each year under the terms of such agreements or guarantees, distinguishing between disbursements made on account of fast freight and disbursements made on account of express shipments; also the number of refrigerator cars, subject to guarantee, by Department of Marine and Fisheries, forwarded by fast freight from Mulgrave or Halifax to Montreal, each calendar year since 1906, and the number of tons of freight carried by such cars each year. Also the number of refrigerator express cars forwarded from said points, Mulgrave and Halifax to Montreal, up to December 31, 1913, under the terms of an agreement made since 1911, between the Department of Marine and Fisheries and the railway or express companies or both. Also the number of tons of fresh fish carried by express companies, prior to December 31, 1913, under the last mentioned agreement; and the amount paid up to December 31, 1913, by the Department of Marine and Fisheries, under the last mentioned agreement. Also the number of tons of fresh fish carried by express companies from Mulgrave and Halifax to points west since 1906, on which the Government paid one-third, but not under the terms of the said agreement made as aforesaid, since 1911. Presented 9th February, 1915.—*Mr. Sinclair*.. .. ..*Not printed.*

60. Return to an Order of the House of the 20th April, 1914, for a return showing all the post offices in the several counties in the province of Nova Scotia for which a rent allowance, or a fuel fund, and light allowance is made, specifying the amount of such allowance in each case. Presented 9th February, 1914.—*Mr. Chisholm (Antigonish)*. *Not printed*

61. Return to an Order of the House of the 16th March, 1914, for a copy of all correspondence, letters, telegrams, etc., in the year 1913, relating to the carrying of the mails between Grand River Falls and Grand River, county of Richmond, and the awarding of the contract to Malcolm McCuspic. Presented 9th February, 1915.—*Mr. Kyte*. ....*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

62. Return to an Order of the House of the 11th May, 1914, for a copy of all letters, telegrams, correspondence and memorials since the 1st day of November, 1911, relating to the post office at Johnstown, Richmond County, N.S., and to complaints against the present postmaster and recommendations for his dismissal. Presented 9th February, 1915.—*Mr. Kyte*.. .. ..*Not printed.*

63. Return to an Order of the House of the 20th April, 1914, for a copy of all papers, petitions, letters and telegrams concerning the change of site of the post office at St. Lazare Village, county of Bellechasse, Quebec. Presented 9th February, 1915.—*Mr. Lemieux.* ....*Not printed.*

64. Statement of Governor General's Warrants issued since the last Session of Parliament on account of 1914-15. Presented by Hon. Mr. White, 9th February, 1915. *Not printed.*

65. Statement of expenditure on account of "Miscellaneous Unforeseen Expenses," from the 18th August, 1914, to the 4th February, 1915, in accordance with the Appropriation Act of 1914. Presented by Hon. Mr. White, 9th February, 1915.. .. ..*Not printed.*

66. Statement of Superannuation and Retiring Allowances in the Civil Service during the year ending 31st December, 1914, showing name, rank, salary, service, allowance and cause of retirement of each person superannuated or retired, also whether vacancy is filled by promotion or by appointment, and salary of any new appointee. Presented by Hon. Mr. White, 9th February, 1915.. .. ..*Not printed.*

67. Statement of receipts and expenditures of the Ottawa Improvement Commission to 31st March, 1914. Presented by Hon. Mr. White, 9th February, 1915.. .. ..*Not printed.*

68. Statement of the affairs of the Royal Society of Canada, for the year ended 30th April, 1914. Presented by Hon. Mr. White, 9th February, 1915.. .. ..*Not printed.*

69. Account of the average number of men employed on the Dominion Police Force during each month of the year 1914, and of their pay and travelling expenses, pursuant to Chapter 92, Section 6, Subsection 2, of the Revised Statutes of Canada. Presented by Hon. Mr. Doherty, 10th February, 1915.. .. ..*Not printed.*

70. Return to an Order of the Senate, dated the 16th January, 1913, calling for copy of the plans, reports, soundings, and other germane information respecting the ports of Churchill and Fort Nelson, so far as the Department of Railways and Canals is concerned.—(*Senate*).. .. ..*Not printed.*

71. Return to an Order of the Senate, dated the 29th April, 1914, showing:—1. Titles of all books, pamphlets and other printed papers issued by the King's Printer during the year ending on the 31st of March, 1914. 2. The number of each of such books, pamphlets and papers printed during such year, and the number distributed, with the dates of distribution. 3. The number of pages in each. 4. The cost of each. 5. The authority for the printing and issuing of each of such books, pamphlets and papers.—(*Senate*).. .. ..*Not printed.*

72. Return to an Order of the Senate dated the 30th April, 1914, for the production of all proposals submitted to the Government for the construction of the Montreal, Ottawa and Georgian Bay Canal and all the correspondence relating thereto.—(*Senate*). *Not printed.*

72*a*. Return to an Order of the House of the 11th February, 1915, for a copy of all petitions and memoranda from commercial bodies or other parties in relation to the immediate construction of the Georgian Bay Canal, and of all correspondence in connection with the same since 21st September, 1911. Presented 4th March, 1915.—*Sir Wilfrid Laurier.* *Not printed.*

73. Copies of general orders promulgated to the militia for the period between 25th November, 1913, and 24th December, 1914.—(*Senate*).. .. ..*Not printed.*

74. Copy of correspondence respecting the control of the exportation of nickel. Presented by Sir Robert Borden, 11th February, 1915.. .. ..*Not printed.*

75. Memorandum respecting work of the Department of Militia and Defence—European War, 1914-15. Presented by Hon. Mr. Hughes, 11th February, 1915.. .. ..*Not printed.*

76. Return to an Order of the House of the 6th April, 1914, for a copy of all correspondence, letters, telegrams, complaints and documents of all kinds received by the Department of Trade and Commerce during the years 1913-14, with respect to the Pictou-Mulgrave-Cheticamp steamship route. Presented 11th February, 1915.—*Mr. Chisholm (Inverness)*.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

77. Return to an Order of the House of the 8th June, 1914, for a copy of all documents bearing on an application or applications made to the Superintendent General of Indian Affairs or the Department, on an amendment to the Indian Act to facilitate the sale of the Indian Reserve of Restigouche, Que., or on the acquiring otherwise of any portion or the whole of the said reserve for industrial or other purposes, and any answers given thereto. Presented 11th February, 1915.—*Mr. Marcil (Bonaventure).* *Not printed.*

78. Return to an Order of the House of the 2nd February, 1914, for a return showing the names of the sailors who have been employed on the *Eureka* during the years 1910, 1911, 1912 and 1913. Presented 12th February, 1915.—*Mr. Boulay*.. .. .. *Not printed.*

79. Return to an Order of the House of the 15th April, 1914, for a return showing the total bond issue of the Canadian Northern Railway Company and its affiliated companies; and the total cost to date of the construction of the lines of railways comprising the Canadian Northern Railway system, including terminals, sidings, etc. Presented 12th February, 1915.—*Mr. Murphy*.. .. .. *Not printed.*

80. Return to an Order of the House of the 18th May, 1914, for a copy of all papers, documents, reports and evidence relative to the dismissal or proposed dismissal of W. A. Case of the Government Quarantine Service at Halifax, N.S. Presented 12th February, 1915.—*Mr. McLean (Halifax)* .. .. .. *Not printed.*

81. Return to an Order of the House of the 26th February, 1914, for a return showing:—1. The freight rates charged during the years 1912 and 1913, on wheat from Canadian ports to ports in the United Kingdom by the Canadian Pacific Railway Company's Steamship Lines, the Allan Steamship Line and the Canadian Northern Railway Company's Steamship Lines. 2. The profits made by the freight boats of the said several lines which carried wheat alone or with other freight. Presented 12th February, 1915. —*Sir James Aikins*.. .. .. *Not printed.*

82. Return to an Order of the House of the 16th February, 1914, for a copy of all reports, requests, petitions, memorials, letters, telegrams and other correspondence and documents relating to the removal, suspension or dismissal, by the management of the Intercolonial Railway, of Warren Carter and Frederick Avard, employees in the freight department of the Intercolonial Railway at Sackville, N.B.; and of all letters, telegrams and other correspondence in the Department of Railways and Canals, or in the railway offices at Moncton, or in any Department of Government, addressed to the Minister of Railways and Canals, or to any other member of the Government, or to any official of the Department of Railways and Canals, or of the Intercolonial Railway, by any person or persons in the county of Westmorland, N.B., in any manner relating to said employees and to the dispensing with their services, particularly of any letters sent to F. P. Brady, General Superintendent of the Intercolonial, by any party or parties in Sackville, N.B., or elsewhere, and of all replies to any such letters, correspondence or documents. Presented 12th February, 1915.—*Mr. Emmerson.* *Not printed.*

83. Return to an Order of the House of the 23rd March, 1914, for a return showing:—1. What investigations and other work have been entrusted by the Government, or any Department thereof, to G. Howard Ferguson, member for the electoral division of the county of Grenville in the Legislative Assembly of the province of Ontario. 2. How much the said G. Howard Ferguson has been paid by the Government, or any Department thereof, for fees and disbursements since the 21st of September, 1911, and how much is still due and owing to him. 3. How much has been paid to the said G. Howard Ferguson by the Government or any Department thereof, since the 21st September, 1911, in connection with any other matter whatever. Presented 12th February, 1915.—*Mr. Proulx*.. .. .. *Not printed.*

84. Further Supplementary Return to an Order of the House of the 28th April, 1913, for a return showing a list of all the newspapers in Canada in which advertisements have been inserted by the Government, or any minister, officer or department thereof, between 10th October, 1911, and the present date, together with a statement of the gross amount paid therefor between the above dates to each of said newspapers or to the proprietors of the same. Presented 12th February, 1915.—*Mr. Sinclair*.. .. .. *Not printed.*

84*a*. Further Supplementary Return to an Order of the House of the 30th April, 1913, for a return showing a list of all the newspapers in Canada in which advertisements have been inserted by the Government, or any minister, officer or department thereof, between the 10th day of October, 1906, and 10th October, 1907, and between said dates in each of the years following up to the 10th October, 1911, together with a statement of the gross amount paid therefor for the years mentioned, to each of the said newspapers or the proprietors of the same. Presented 12th February, 1915.—*Mr. Thornton.* *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

85. Partial Return to an Order of the House of the 4th March, 1914, for a return showing:—1. How many employees of the Federal Government of Canada, including all services and all departments, have been dismissed from 10th October, 1911, to the present date. 2. How many have resigned. 3. How many have deserted the service. 4. How many deserters have been punished. 5. How many new employees have been engaged or appointed by the present Government during the same period. Presented 12th February, 1915.—*Mr. Boivin*.. .. ..*Not printed.*

85*a*. Return to an Order of the House of the 4th March, 1914, for a return showing:—1. How many employees of the Federal Government of Canada, including all services and all departments, have been dismissed from 10th October, 1911, to the present date. 2. How many have resigned. 3. How many have deserted the service. 4. How many deserters have been punished. 5. How many new employees have been engaged or appointed by the present Government during the same period. Presented 4th March, 1915.—*Mr. Boivin*.. .. ..*Not printed.*

85*b*. Further Supplementary Return to an Order of the House of the 4th March, 1914, for a return showing:—1. How many employees of the Federal Government of Canada, including all services and all departments, have been dismissed from 10th October, 1911, to the present date. 2. How many have resigned. 3. How many have deserted the service. 4. How many deserters have been punished. 5. How many new employees have been engaged or appointed by the present Government during the same period. Presented 5th March, 1915.—*Mr. Boivin*.. .. ..*Not printed.*

85*c*. Further Supplementary Return to an Order of the House of the 4th March, 1914, for a return showing:—1. How many employees of the Federal Government of Canada, including all services and all departments, have been dismissed from 10th October, 1911, to the present date. 2. How many have resigned. 3. How many have deserted the service. 4. How many deserters have been punished. 5. How many new employees have been engaged or appointed by the present Government during the same period. Presented 12th March, 1915.—*Mr. Boivin*.. .. ..*Not printed.*

85*d*. Further Supplementary Return to an Order of the House of the 4th March, 1914, for a return showing:—1. How many employees of the Federal Government of Canada, including all services and all departments, have been dismissed from 10th October, 1911, to the present date. 2. How many have resigned. 3. How many have deserted the service. 4. How many deserters have been punished. 5. How many new employees have been engaged or appointed by the present Government during the same period. Presented 7th April, 1915.—*Mr. Boivin*.. .. ..*Not printed.*

86. Further Supplementary Return to an Order of the House of the 18th February, 1914, for a copy of all charges, complaints, memorials, correspondence and telegrams, not already produced, relating to officials in any department of the Government since 10th October, 1911, the number of officials dismissed, reports of investigations held in respect of such charges, items of expenditure and costs of each investigation, the names of persons appointed to office in the place of dismissed officials, and of all recommendations received in behalf of persons so appointed in the province of Prince Edward Island. Presented 12th February, 1915.—*Mr. Hughes (Kings, P.E.I.)* *Not printed.*

87. Partial Return to an Order of the House of the 18th May, 1914, for a return showing in all cases in which Charles Seager, of Goderich, acted as Government Commissioner in the investigation of officials charged with partizanship, or other offences, from and including the year 1896 to the year 1900; and the names of all officials dismissed by reason of the reports of the said Charles Seager, the positions held by such officials, and when such dismissals took place; with a copy of the evidence taken in all such cases, together with the commissioners reports thereon, and also showing what fees were paid to the said Charles Seager for conducting such investigations. Presented 12th February, 1915.—*Mr. Clark (Bruce)*.. .. ..*Not printed.*

88. Return to an Order of the House of the 16th March, 1914, for a copy of all correspondence, letters, telegrams, complaints and of all other documents in any way referring to the operation of the salmon hatchery at North East Margaree, and the fish pond at Margaree Harbour from 1911 to date. Presented 15th February, 1915.—*Mr. Chisholm (Inverness)*.. .. ..*Not printed.*

89. Return to an Address to His Royal Highness the Governor General of the 11th May, 1914, for a copy of all letters, telegrams, Orders in Council, contracts, tenders, papers and other documents in possession of the Department of Public Works, and of the Department of Militia and Defence, relating to the construction of an armoury at Amherst, N.S. Presented 15th February, 1915.—*Mr. Sinclair*.. .. ..*Not printed.*

90. Letters of the Honourable Louis P. Pelletier, M.P., and the Honourable Wilfrid B. Nantel, M.P., resigning their positions as Postmaster General and Minister of Inland Revenue, respectively, and letters of the Prime Minister in acknowledgment thereof. Presented by Sir Robert Borden, 15th February, 1915.. .. ..*Not printd.*

CONTENTS OF VOLUME 28—*Continued.*

91. Report of Board of Officers on boots supplied to the Canadian Expeditionary Force. Presented by Hon. Mr. Hughes, 15th February, 1915.. .. ..*Not printed.*

92. Regulations under "The Destructive Insect and Pest Act." Presented by Hon. Mr. Burrell, 16th February, 1915... .. ..*Not printed.*

93. Report on "The Agricultural Instruction Act," 1913-14, pursuant to Section 8 of the above named Act. Presented by Hon. Mr. Burrell, 16th February, 1915.
Printed for sessional papers only.

93*a*. Supplementary Return to an Address to His Royal Highness the Governor General of the 9th February, 1914, for a copy of all arrangements made between the Government and the various provinces under the Agricultural Instruction Act. Presented 19th February, 1915.—*Sir Wilfrid Laurier*.. .. ..*Not printed.*

93*b*. Return to an Order of the House of the 20th April, 1914, for a copy of all documents, correspondence, letters, petitions, reports, etc., exchanged between Dr. C. C. James, Mr. J. C. Chapais and each of the Provincial Ministers of Agriculture, in connection with the distribution and the administration of the federal subsidy granted to the provinces for agricultural purposes since the granting of same. Presented 23rd February, 1915. —*Mr. Lapointe (Kamouraska)*.. .. ..*Not printed.*

94. Return to an Order of the House of the 11th February, 1914, for a copy of all telegrams, correspondence, instructions, recommendations, and other documents that passed between the Shellfish Fishery Commission of 1913, and the Department of Marine and Fisheries, from the date of the appointment of said Commission to 31st December, 1913, excluding such documents as have been printed in the published report of said Commission. Presented 16th February, 1915.—*Mr. Sinclair*.. .. ..*Not printed.*

95. Return to an Order of the House of the 16th March, 1914, for a copy of all correspondence, tenders, telegrams, complaints and of all other documents in any way referring to the collecting of spawn for the Margaree Lobster Hatchery during the years 1911-12, 1912-13 and 1913-14. Presented 16th February, 1915.—*Mr. Chisholm (Inverness)*.
Not printed.

96. Return to an Order of the House of the 10th February, 1915, for a return showing the amount of coal imported into Alberta, Saskatchewan and Manitoba, respectively, from the United States during the year 1914; also the amount of duty collected in each of the said provinces during the same year. Presented 16th February, 1915.—*Mr. Buchanan*... .. ..*Not printed.*

97. Copy of the Eighth Joint Report of the Commissioners for the Demarcation of the Meridian of the 141st Degree of West Lngitude. Presented by Hon. Mr. Roche, 18th February, 1915.. .. ..*Not printed.*

98. Return to an Order of the House of the 20th April, 1914, for a copy of the agreement between the Government of Canada and the Canadian Pacific Railway Company at the time the special land grant was made whereby the Canadian Pacific Railway Company were enabled to get their land grant in one block for the purpose of establishing their present irrigation system east of Calgary, province of Alberta. Presented 18th February, 1915.—*Mr. Burnham*.. .. ..*Not printed.*

99. Return to an Order of the House of the 23rd March, 1914, for a copy of all letters, telegrams and other documents in connection with the sale of any timber on Parry Island, Parry Sound District, and of advertisements, agreements for purchase and any other documents connected with such sale or grant of timber to any person or persons. Presented 18th February, 1915.—*Mr. Arthurs*.. .. ..*Not rpinted.*

100. Return to an Order of the House of the 11th February, 1914, for a return showing reasons for the dismissal of Mr. Larivière, Dominion Lands Agent at Girouard; the date of his appointment and of dismissal and salary at time of dismissal; also the name of agent appointed in his place, with date of appointment and salary. Presented 18th February, 1915.—*Mr. Oliver*.. .. ..*Not printed.*

101. Annual Return respecting Trade Unions under Chapter 125, R.S.C., 1906. Presented by Hon. Mr. Coderre, 18th February, 1915.. .. ..*Not printed.*

102. A detailed statement of all bonds or securities registered in the Department of the Secretary of State of Canada, since last return (21st January, 1914) submitted to the Parliament of Canada under Section 32 of Chapter 19, of the Revised Statutes of Canada, 1906. Presented by Hon. Mr. Coderre, 18th February, 1915.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

103. Return to an Order of the House of the 9th February, 1914, for a copy of all petitions, memorials, letters, telegrams, papers, and documents received by any department of the Government of Canada, or any Minister of the Crown from any company, corporation, person or persons, requesting the removal of any customs duties upon wheat or wheat products entering Canada, or protesting against any diminution or removal of such custom's duties, and any replies thereto. Presented 18th February, 1915.—*Mr. Maclean (Halifax)*.. .. ..*Not printed.*

104. Return to an Order of the House of the 20th April, 1914, for a copy of all correspondence, letters, documents or other papers relating to the cancellation of the entry of R. Bannatyne for the northwest ¼ of section 24, township 35, range 18, west of the 2nd meridian. Presented 19th February, 1915.—*Mr. Neely*.. .. ..*Not printed.*

105. Return to an Order of the House of the 16th February, 1914, for a return showing the name of the postmaster of the Parish of St. Romuald, county of Lévis, who, it is said, was dismissed from office since September, 1911, the reasons for such dismissal, the nature of the complaints made against him, the names of the parties who made those complaints, together with a copy of all correspondence and telegrams relating thereto, the name of the inquiring commissioner, and report of investigation, if any, and of all evidence taken at the investigation, the names of those who recommended the successor, names of the parties by whom the Government was represented at such investigation, with a detailed statement of all the accounts paid or to be paid by any department in connection with the aforesaid dismissal and investigation, the names of the parties who received any money or filed their accounts in connection with said investigation, and the amount awarded to or claimed by each of them. Presented 19th February, 1915.—*Mr. Bourassa*.. .. ..*Not printed.*

106. Return showing lands sold by the Canadian Pacific Railway Company during the year which ended on the 30th September, 1914. Presented by Hon. Mr. Roche, 19th February, 1915.. .. ..*Not printed.*

107. Return to an Order of the House of the 10th June, 1914, for a return showing:—1. The amount of money sent through the post offices in the past five years outside Canada from the following Cape Breton post offices: Glace Bay, Caledonia Mines, Dominion No. 4, New Aberdeen, Bridgeford, Old Bridgeford, Reserve Mines, Sydney, Whitney Pier, Ashby, North Sydney, Sydney Mines, Florence, Dominion No. 6, and Port Marrien. 2. What countries was such money transmitted to. Presented 22nd February, 1915.—*Mr. Carroll*.. .. ..*Not printed.*

108. Return to an Order of the House of the 15th February, 1915, for a copy of all correspondence, telegrams and other documents in connection with the removal from the customs service at Lethbridge, Alberta, of Brown Pipes and A. R. Gibbons. Presented 23rd February, 1915.—*Mr. Buchanan*.. .. ..*Not printed.*

109. Return to an Order of the House of the 15th February, 1915, for a return giving the names of all the transports hired since 1st August, 1914, for the conveyance of troops, horses, stores and material to England, the name of each vessel owner, broker or other person through whom the vessel was chartered, the tonnage of each vessel, speed, rate paid per ton per week or month, minimum time for which engaged, date of agreement, date at which pay commenced, date at which pay ceased, and the total sum paid by the Government for hire and other charges. Presented 23rd February, 1915.—*Mr. Murphy*.. .. ..*Not printed.*

110. Return to an Order of the House of the 15th February, 1915, for a return showing:—1. How many transport wagons were purchased for the Second and Third Contingents? 2. From whom they were purchased, and the name of each person or firm? 3. How many were purchased from each? 4. What was the price paid per wagon? 5. If any tenders were asked? 6. If any tenders were received that were not accepted? 7. If so, what was the price tendered at? Presented 23rd February, 1915.—*Mr. Nesbitt.* *Not printed.*

111. Return to an Order of the House of the 11th February, 1915, for a return showing:—1. How many persons have been made prisoners of war since the declaration of war between the Allies, Germany and Austria? 2. Where they have been kept captive? 3. What is the name of each place of detention, and the name of the officer in charge of such place of detention? Presented 23rd February, 1915.—*Mr. Wilson (Laval).* *Not printed.*

111*a*. Return to an Order of the House of the 19th February, 1915, for a statement in detail of: The number of prisoners of war in this country: the number under parole; the number held in detention camps: the number of detention camps, where situated, how accessible, and the number of prisoners in each. The amount of cost to Canada in each of these camps, respectively, for subsistence, pay, clothing, transportation and supervision; the nature of work done by prisoners, and the total value of same to date. Presented 1st April, 1915.—*Mr. Clark (Red Deer)*.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

112. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams, minutes of investigation and other documents relating to the dismissal of James Brennan, fireman Intercolonial Railway at Stellarton. Presented 25th February, 1915.—*Mr. Macdonald*. . . . .*Not printed.*

113. Return to an Order of the House of the 11th February, 1915, for return showing if any official statement was given on behalf of the management of the Intercolonial Railway to the effect that wages would be paid in their absence to the employees of the railway who volunteered for active service. If so, when and by whom? If any order has been made by the Railway Department providing for such payment, and if so, when the said order was made. Presented 23rd February, 1915.—*Mr. Macdonald*. . . . . .*Not printed.*

114. Return to an order of the House of the 9th February, 1915, for a copy of all papers, petitions, letters and telegrams exchanged between the Quebec Board of Trade and the Department of Railways and Canals concerning the circulation of trains on that section of the National Transcontinental Railway between Cochrane and Quebec City. Presented 23rd February, 1915.—*Mr. Lemieux*. . . . .*Not printed.*

115. Return (in so far as the Department of the Interior is concerned) of copies of all Orders in Council, plans, papers and correspondence relating to the Canadian Pacific Railway, which are required to be presented to the House of Commons, under a resolution passed on 20th February, 1882, since the date of the last return, under such resolution. Presented by Hon. Mr. Roche, 24th February, 1915. . . . .*Not printed.*

116. Return showing:—1. Who the Remount Commissioners are for Western and Eastern Canada respectively? 2. When and by whom they were appointed, and what their general instructions were? 3. Why were the mobilization orders 1913, which provide for the purchase of remounts, ignored and civilians put in charge of the purchase of remounts? 4. The names of the purchasers and inspecting veterinary officers appointed by the Remount Commissioner for Eastern Canada, in the various remount divisions? 5. If any of the purchasers and inspecting veterinary officers have been stopped buying. If so, what their names are, and the reasons given by the Remount Commissioner for his action? 6. How many horses have been purchased between 1st December and 31st January, in each remount division in Eastern Canada, and the average price paid per horse? 7. What the average cost per horse is in each remount division to cover the expenses, including pay or allowances and all travelling and other expenses, between the said dates. Presented 24th February, 1915.—*Mr. Lemieux*. .*Not printed.*

117. Return showing:—1. From how many firms the Government have ordered ankle boots for the various contingents now being equipped for service? 2. The names of these firms? 3. How many ankle boots have been ordered from each firm? 4. How many ankle boots each firm have delivered up to date? 5. How many ankle boots each firm have yet to deliver? 6. The price that each firm is receiving for these ankle boots. Presented 24th February, 1915.—*Mr. Lemieux*. . . . .*Not printed.*

118. Return to an Order of the House of the 22nd February, 1915, for a copy of all correspondence, recommendations, tenders and other papers on file in the office of the Department of Railways and Canals relating to supplying ice for the Intercolonial Railway at Mulgrave for the year 1915. Presented 25th February, 1915.—*Mr. Sinclair.*
Not printed.

119. Return to an Order of the House of the 18th February, 1915, for a return showing:—1. How many motor trucks were sent with the first contingent to England? 2. From whom they were purchased, and by whom they were manufactured? 3. What their capacity was? 4. What price was paid for them? 5. If any expert was employed by the Government in connection with their purchase. If so, who? 6. If any commission was paid by the Government to any one in connection with their purchase? 7. If the trucks have given satisfaction in service. If not, what defects were exhibited? 8. If a committee was appointed by the Militia Department or the Government in regard to the purchase of motor trucks for the second and further contingents. If so, who comprised it, and what were their special qualifications? 9. If one, Mr. McQuarrie, was a member of this committee. If so, is it true he was, and is still, an employee of the Russell Motor Car Company of Toronto? 10. If one, Owens Thomas, was employed as expert on the said Committee? If so, what he was paid, or what he is to be paid for his services, and how long his services were utilized? 11. If Mr. Thomas received any commission in connection with the purchases of motor trucks either from the Government or the manufacturers? 12. What recommendations were made by the said committee to the Militia Department or the Government in connection with purchases of motor trucks? 13. If the trucks have been purchased. If so, how many, from whom, and at what price? 14. If it is true that these trucks were purchased from the Kelly Company, Springfield, Ohio. If so, could not efficient and suitable trucks have been procured from Canadian manufacturers? 15. If it is true that the Government has decided to go into the motor truck business by placing orders with Canadian manufacturers for parts, and supplying such parts to assemblers in Canada. If so, is it true that orders have been, or are being placed with the Russell Motor Car Company, to manufacture engines? 16. Who recommended Mr. Thomas to the Minister of the Militia or the Government? Presented 25th February, 1915.—*Mr. Copp.*
Not printed.

CONTENTS OF VOLUME 28—*Continued.*

120. Return to an Order of the House of the 15th February, 1915, for a return showing whether any exportations of food-stuffs have been made since 1st August last, to European countries, other than the United Kingdom, France and Belgium, and if so, their nature and what countries. Presented 25th February, 1915.—*Mr. Cockshutt.* *Not printed.*

121. Return to an Order of the House of the 11th February, 1915, for a copy of the petition, papers, documents and letters in connection with the incorporation of the Dominion Trust Company, incorporated by Special Act of the Parliament of Canada in 1912, being Chapter 89 of 2 George V. Presented 25th February, 1915.—*Mr. Proulx.* *Not printed.*

121*a*. Return to an Order of the House of the 11th February, 1915, for a copy of all the correspondence exchanged between the Department of Justice and the Government of the province of British Columbia, or any of its members, with regard to a certain Act passed by the Legislature of the said province in 1913, being Chapter 89 of 2 George V., entitled: "An Act respecting the Dominion Trust Company." Presented 4th March, 1915.—*Mr. Proulx* . . . . *Not printed.*

122. Return to an Order of the House of the 11th February, 1915, for a copy of all correspondence which has passed between the Auditor General and the Militia Department or any other department of the Government service in regard to the expenditure under the War Appropriation Act. Presented 25th February, 1915.—*Mr. Maclean (Halifax).* *Printed for distribution and sessional papers.*

122*a*. Memorandum of the Accountant and Paymaster-General and the Director of Contracts of the Department of Militia and Defence, in respect to correspondence between the Auditor General and Militia Department, relating to expenditure under the War Appropriation Act. Presented by Hon. Mr. Hughes, 11th March, 1915. . . . . *Not printed.*

123. Copy of all correspondence between the Minister of Finance and the Auditor General from 18th August to date, respecting purchases for overseas contingents, army contracts, or other purchases for military purposes, or under the operation of the Naval Service Act of 1910, or under Orders in Council relating to military matters. Presented by Hon. Mr. White, 25th February, 1915 . . . . *Not rpinted.*

124. Certified copy of a report of the Committee of the Privy Council approved by His Royal Highness the Governor General on the 23rd January, 1915, on the subject of separation allowance to dependents of soldiers of the First Overseas Contingent. Presented by Hon. Mr. Rogers, 26th February, 1915 . . . . *Not printed*

124*a*. Certified copy of a report of the Committee of the Privy Council approved by His Royal Highness the Governor General on the 28th January, 1915, in respect to applications from men who have enlisted in the corps raised for overseas service, to be allowed to marry and to have their wives placed on the separation allowance list. Presented by Hon. Mr. Rogers, 26th February, 1915 . . . . *Not printed.*

125. Return to an Order of the House of the 16th February, 1914, for a copy of all telegrams, correspondence, petitions and documents of all kinds in any way referring to a drill shed or armoury to be built at the town of Inverness, Inverness county, Nova Scotia. Presented 26th February, 1915.—*Mr. Chisholm (Inverness)* . . . . . *Not printed.*

126. Detailed statement of revenue of custom duties and refund thereof under Section 92 Consolidated Revenue and Audit Act, through the Department of Commerce for the fiscal year ended 31st March, 1914.—(*Senate*) . . . . *Not printed.*

127. Orders in Council which have been published in the *Canada Gazette* betewen the 1st December, 1913, and 11th January, 1915, in accordance with the provisions of Section 19, Chapter 10, 1-2 George V. "The Forest Reserves and Park Act."—(*Senate*). *Not printed.*

127*a*. Return of Orders in Council which have been published in the *Canada Gazette*, between the 16th May, 1914, and 25th July, 1914, in accordance with the provisions of "The Forest Reserves and Park Act," Section 19, of Chapter 10, 1-2 George V. Presented by Hon. Mr. Roche, 12th March, 1915 . . . . *Not printed.*

128. Orders in Council which have been published in the *Canada Gazette* between 1st December, 1913, and 15th January, 1915, in accordance with the provisions of Section 5, of Chapter 21, 7-8 Edward VII, "The Dominion Lands Survey Act."—(*Senate*). *Not printed.*

128*a*. Return of Orders in Council which have been published in the *Canada Gazette*, between 24th January, 1914, and 6th February, 1915, in accordance with the provisions of Section 77 of "The Dominion Lands Act," Chapter 20 of the Statutes of Canada, 1908. Presented by Hon. Mr. Roche, 12th March, 1915 . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

128b. Return of Orders in Council which have been published in the *Canada Gazette* and in the British Columbia *Gazette*, between 11th April, 1914, and 10th December, 1914, in accordance with provisions of Subsection (*d*) of Section 38 of the regulations for the survey, administration, disposal and management of Dominion Lands within the 40-mile railway belt in the province of British Columbia. Presented by Hon. Mr. Roche, 12th March, 1915. . . . . *Not printed.*

128c. Orders in Council which have been published in the *Canada Gazette* and in the *British Columbia Gazette*, between 1st December, 1913, and the 15th January, 1915, in accordance with the provisions of Subsection (*d*) of Section 38 of the Regulations for the survey, administration, disposal and management of Dominion Lands within the 40-mile railway belt in the province of British Columbia.—(*Senate*) . . . . *Not printed.*

129. Orders in Council passed between 1st December, 1913 and 15th January, 1915, approving of regulations and forms prescribed in accordance with the provisions of Section 57 of the Irrigation Act, Chapter 61, Revised Statutes of Canada, 1906, as amended by Chapter 38, 7-8 Edward VII.—(*Senate*) . . . . *Not printed.*

130. Return to an Order of the House of the 25th February, 1915, for a return showing whether the Government purchased from the Canada Cycle and Motor Company tires for motor trucks for the first Canadian Contingent and, if so, the price paid per set and the number purchased; also whether the Government have obtained prices for tires for motor trucks for the second contingent and, if so, the prices per set so obtained. Presented 3rd March, 1915.—*Mr. Gauvreau* . . . . *Not printed.*

131. Return to an Order of the House of the 15th February, 1915, for a copy of all correspondence, telegrams and other documents in connection with the appointment of A. H. McKeown to the immigration service at Lethbridge, Alberta. Presented 3rd March, 1915.—*Mr. Buchanan* . . . . *Not printed.*

132. Return to an Order of the House of the 15th February, 1915, for a copy of all correspondence, telegrams and other documents in connection with the removal from office of A. E. Humphries, Inspector of Immigration at Lethbridge, Alberta. Presented 3rd March, 1915.—*Mr. Buchanan* . . . . *Not printed.*

133. Return to an Order of the House of the 3rd June, 1914, for a return showing:—1. Who secured the mail contract between Armagh Station and Mailloux, county of Bellechasse, Que.? 2. How many tenders were received? 3. The names of the tenderers, and the amount of each tender? Presented 3rd March, 1915.—*Mr. Lemieux* . . . . *Not printed.*

134. Return to an Order of the House of the 6th April, 1914, for a copy of all letters, telegrams, correspondence, complaints, and documents of all kinds in any way connected with the asking for tenders for the mail route between Low Point and Creignish Station during the years 1913-14. Presented 3rd March, 1915.—*Mr. Chisholm (Inverness).* *Not printed.*

135. Return to an Order of the House of the 6th April, 1914, for a copy of all letters, telegrams and other documents relative to the mail contract between New Ross and Vaughans post office, Waterville, province of Nova Scotia. Presented 3rd March, 1915. —*Mr. Macdonald* . . . . *Not printed.*

136. Return to an Order of the House of the 18th May, 1914, for a copy of all correspondence, telegrams, letters and documents of all kinds in possession of the Post Office Department received since 1913, up to the present date in any way referring to the mail contract from Mabou to Wycocomagh. Presented 3rd March, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed*

137. Return to an Order of the House of the 25th February, 1915, for a return showing:—1. The amount of money collected by sub-collectors of customs at Edmundston, N.B., at Clair, N.B., at St. Leonards, N.B., and at Green River, N.B., each and every year for the last five fiscal years. 2. The salaries paid in connection with each of said ports each year. Presented 3rd March, 1915.—*Mr. Michaud* . . . . *Not printed.*

138. Return to an Order of the House of the 10th February, 1915, for a return showing how much money has been spent amongst the merchants of the city of Medicine Hat for Government relief, to whom the payments were made and the total amount in each case. Presented 4th March, 1915.—*Mr. Buchanan* . . . . *Not printed.*

139. Return to an Order of the House of the 2nd February, 1914, for a copy of all letters, correspondence, papers and documents relating to the dismissal of the following persons from the below mentioned offices in Shelburne County, N.S.:—J. V. Smith, sub-collector of customs at Lower Woods Harbour; John H. Lyons, keeper of lightship, Barrington Passage; William L. Smith, lightkeeper, Baccaro; E. D. Smith, fishery overseer, Shag Harbour; J. A. Orechia, harbour master, Woods Harbour; J. C. Morrison, harbour master, Shelburne; and Albert Mahaney, postmaster at Churchover. Presented 4th March, 1915.—*Mr. Maclean (Halifax)* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

139*a*. Return to an Order of the House of the 24th February, 1915, for a copy of all letters, papers and documents relating to the dismissal of the following officers in Shelburne County, N.S.: Wm. L. Smith, lightkeeper, Baccaro, N.S.; J. A. Arechia, harbour master, Lower Wood Harbour, and J. C. Morrison, harbour master, Shelburne, N.S. Presented 16th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

140. Return to an Order of the House of the 9th March, 1914, for a return showing:—1. The amounts of money expended by this Government in the county of Portneuf from the 1st of July, 1896, to the 21st September, 1911. 2. The nature of the work done in each parish. 3. In what year such work was executed, and what amount was expended in each case. Presented 4th March, 1915.—*Mr. Sevigny*.. .. ..*Not printed.*

141. Return to an Order of the House of the 22nd February, 1915, for a copy of all papers, petitions, declarations, affidavits, sworn statements, requests, certificates and all other documents in connection with the naturalization of F. P. Gutelius, General Manager of the Intercolonial Railway. Presented 4th March, 1915.—*Mr. Gauvreau*.. ..*Not printed.*

142. Report of the delegates appointed to represent the Government of Canada at the Eighth International Purity Congress, held under the auspices of the World's Purity League, at Kansas City, Mo., November 5th-9th, 1914. Presented by Sir Robert Borden, 4th March, 1915. *Not printed.*

143. Return to an Address to His Royal Highness the Governor General of the 22nd February, 1915, for a copy of all complaints to the Government of the killing of one American citizen and the shooting of another by militia men, in the waters of Lake Erie, and of all correspondence with regard to the same with the British Embassy and American authorities. Presented 5th March, 1915.—*Sir Wilfrid Laurier*.. .. ..*Not printed.*

144. Return to an Order of the House of the 24th February, 1915, for a return showing the amounts in detail paid to Ward Fisher, of Shelburne, N.S., fishery inspector, for the years 1912 and 1913, for salary, office expenses, travelling expenses, and all other expenses. Presented 5th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

145. Return to an Order of the House of the 15th February, 1915, for a return showing the names and addresses of all persons in Yarmouth County to whom the bounty under the Fenian Raid Volunteer Bounty Act has been paid; the names and addresses of all persons from said county whose applications have been rejected, and a list giving names and addresses of all applicants from said county whose applications have not yet been disposed of. Presented 5th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

146. Return to an Order of the House of the 19th February, 1915, for a return showing the names and post office addresses of all persons in Guysborough County, N.S., to whom the bounty under the Fenian Raid Volunteer Bounty Act has been paid; the names and post office addresses of all persons whose applications have been rejected, and the reason for such rejections; also the names and post office addresses of all persons whose applications have been received but have not yet been paid, distinguishing between those who have been dealt with and allowed, and such applications as have been received but not yet considered, if any. Presented 5th March, 1915.—*Mr. Sinclair.* *Not printed.*

147. Return to an Order of the House, of the 12th February, 1915, for a return showing:—1. How many applications for seed grain have been received from residents of the three prairie provinces since June, 1914? 2. How many bushels of grain were included in the applications? 3. How many acres of land were to be seeded by the grain applied for? 4. How many bushels of wheat, oats and barley, respectively, the Government has on hand with which to meet the applications? 5. If arrangements have been made under which the several Provincial Governments will assist in meeting the needs of the settlers for seed grain? Presented 8th March, 1915.—*Mr. McCraney*.. ..*Not printed.*

148. Return to an Order of the House, of the 2nd February, 1914, for a return showing the number of ships chartered by the Government or any department thereof since October, 1911, to go to Hudson's Bay or James Bay; the name of each and the tonnage; the name and residence of each commanding officer; what cargo each carried, and what portion was landed, and where, what was lost and where, and what returned; with the values in each case. Presented 8th March, 1915.—*Mr. Graham*.. .. .. ..*Not printed.*

148*a*. Return to an Order of the House of the 3rd March, 1915, for a return showing the number of ships employed by the Railway Department, the number of men hired on vessels and on shore, and the amount expended for supplies, men and transportation from 31st March, 1914, to 31st December, 1914, in connection with the Hudson Bay Railway expenditures. Presented 22nd March, 1915.—*Mr. Macdonald*..*Not printed.*

149. Return to an Address to His Royal Highness the Governor General, of the 9th February, 1914, for a copy of all correspondence since the 1st January last with regard to the calling of an Imperial Conference on the subject of naval defence. Presented 8th March, 1915.—*Sir Wilfrid Laurier*.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

150. Return to an Order of the House, of the 11th February, 1915, for a return showing the names and addresses of all persons in Antigonish County to whom the bounty under the Fenian Raid Volunteer Bounty Act has been paid; the names and addresses of all persons from said county whose applications have been rejected, and a list giving names and addresses of all applications from said county whose applications have not yet been disposed of. Presented 8th March, 1915.—*Mr. Chisholm (Antigonish).* *Not printed.*

151. Return to an Order of the House, of the 3rd March, 1915, for a return showing:—1. Who were the different officers commissioned to the 17th Nova Scotia Regiment at Valcartier before they sailed for England? 2. Who are now the commissioned officers of said regiment. Presented 8th March, 1915.—*Mr. Macdonald*. . . . .*Not printed.*

152. Return to an Order of the House, of the 9th February, 1915, for a copy of all accounts of the transfer of the storm signal at Shippigan, N.B., from its former position on land to the public wharf, showing the total cost of said transfer during the months of October and November in 1911. Presented 8th March, 1915.—*Mr. Turgeon.* *Not printed.*

153. Return to an Order of the House, of the 4th May, 1914, for a copy of all correspondence, telegrams, petitions, including the signatures of such petitions, and all other documents and papers in the possession of the Department of Trade and Commerce, or the minister of said department, or in the possession of the Prime Minister, relating to any application made between 1st November, 1913, and date hereof by parties in Nova Scotia asking for Government assistance towards the transportation of fresh fish between ports in Nova Scotia and the United States. Presented 9th March, 1915.—*Mr. Sinclair.* *Not printed.*

154. Statement of Mr. H. C. Crowell, staff correspondent of the Halifax *Chronicle*, and correspondence in connection with statements appearing in the press referring to alleged ill-treatment of the 17th Regiment of Nova Scotia, at Salisbury Plains. Presented by Sir Robert Borden, 9th March, 1915. . . . .*Not printed.*

155. Return to an Order of the House, of the 3rd March, 1915, for a return showing:—1. The estimated cost of fitting up the works of the Canadian Car and Foundry Company, Limited, at Amherst, N.S., for military purposes. 2. The rent or other remuneration being paid, or will be paid, this company for the use of its buildings. 3. Who are to supply the military provisions, including food for men, coal for heating and cooking, and food and other supplies for horses quartered on these premises, and at what prices. 4. Whether it is true that forms for tendering for such military supplies could only be obtained from the office of the sitting member for Cumberland County, and in several cases forms of tender were refused to applicants. 5. Whether the Government is aware that in the case of the supplying of hay, as alleged, not only Liberals were not allowed to tender for same, but supporters of the Government were informed they would not secure any part of the contract, if any of the hay to be supplied was to be purchased from a Liberal. Presented 11th March, 1915.—*Mr. Copp*. . . . . .*Not printed.*

156. Return to an Address to His Royal Highness the Governor General, of the 1st March, 1915, for a copy of all correspondence of the Imperial authorities on the subject of loans from the Imperial Treasury to the Canadian Government. Presented 11th March, 1915.—*Mr. Maclean (Halifax)*. . . . .*Not printed.*

157. Return to an Order of the House of the 3rd March, 1915, for a copy of all correspondence, recommendations, letters and telegrams relating to the appointment of H. W. Ingraham as Assistant Registrar of Alien Enemies at Sdyney, N.S., and to his dismissal from the said office. Presented 12th March, 1915.—*Mr. Kyte*. . . . .*Not printed.*

158. Return to an Address to His Royal Highness the Governor General of the 11th February, 1915, for a copy of all correspondence relating to the purchase of, and payment by the Government for two submarines authorized by Order in Council dated the 7th August, 1914, and of any other Order or Orders in Council relating thereto; and also of all reports received by the Government or any department thereof referring to said submarines. Presented 12th March, 1915.—*Mr. Pugsley* . . . .*Printed for distribution only.*

158*a*. Supplementary Return to an Address to His Royal Highness the Governor General, of the 11th February, 1915, for a copy of all correspondence relating to the purchase of, and payment by the Government for two submarines authorized by Order in Council dated the 7th August, 1914, and of any other Order or Orders in Council relating thereto; and also of all reports received by the Government or any department thereof referring to said submarines. Presented 15th March, 1915.—*Mr. Pugsley.* *Printed for distribution only.*

CONTENTS OF VOLUME 28—*Continued.*

158*b*. Further Supplementary Return to an Address to His Royal Highness the Governor General, of the 11th February, 1915, for a copy of all correspondence relating to the purchase of, and payment by the Government for two submarines authorized by Order in Council dated the 7th August, 1914, and of any other Order or Orders in Council relating thereto; and also of all reports received by the Government, or any department thereof, referring to said submarines. Presented 24th March, 1915.—*Mr. Pugsley.* *Printed for distribution only.*

159. Return to an Order of the House of the 19th February, 1915, for a copy of all correspondence, telegrams, petitions, letters and all other documents in any way referring to the dismissal of Mr. Mallet, captain of the life-boat in the life-saving station at Cheticamp, and the appointment of his successor. Presented 12th March, 1915.—*Mr. Chisholm (Antigonish)* . . . . *Not printed.*

160. Return to an Order of the House of the 3rd March, 1915, for a copy of all letters, papers and other documents relating to the discharge of Dr. John McKenzie as medical doctor to the Indians of Pictou County, and to the appointment of Dr. Keith as his successor. Presented 12th March, 1915.—*Mr. Macdonald* . . . . *Not printed.*

161. Return to an Order of the House of the 15th February, 1915, for a copy of all correspondence, letters, telegrams, instructions, reports and other documents relating to an application by Udo F. Schrader for a grazing lease in townships 40 and 41, range 7, west of the 3rd meridian, province of Saskatchewan. Presented 12th March, 1915.—*Mr. McCraney* . . . . *Not printed.*

162. Return to an Order of the House of the 3rd March, 1915, for a return showing the names of all applicants for Fenian Raid Bounty in the county of Pictou who have not yet been paid their bounty. Presented 15th March, 1915.—*Mr. Macdonald* . . . *Not printed.*

162*a*. Return to an Order of the House of the 19th February, 1915, for a return showing the names and addresses of all persons in the county of Pictou who have been paid the Fenian Raid Bounty, and of all persons in said county who have made application for said bounty, and who have not yet received it. Presented 15th March, 1915.—*Mr. Macdonald* . . . . *Not printed.*

163. Return to an Order of the House of the 4th March, 1915, for a return showing:—1. From whom food for men and horses, and all other supplies and equipment for the Field Battery now being trained at Lethbridge, is bought? 2. If by tender, the date tenders were called for? 3. When tenders were opened and contracts awarded? 4. The names and post office addresses of all parties who submitted tenders? 5. The successful tenderers, and the price in each case. Presented 15th March, 1915.—*Mr. Buchanan* . . . . *Not printed.*

164. Return to an Order of the House, of the 1st March, 1915, for a copy of all petitions, reports, recommendations, letters, telegrams and correspondence relating to the dredging of Antigonish Harbour and the opening or improving of the entrance thereto, received by the Government, or any department thereof, since the 1st January, 1912, and not already included in the return presented the 30th of April, 1914, in obedience to the Order of the House passed the 16th March, previously. Presented 15th March, 1915.—*Mr. Chisholm (Antigonish)* . . . . *Not printed.*

165. Copy of Order in Council dated 9th March, 1915, restricting the transfer of British ships. Presented by Hon. Mr. Hazen, 16th March, 1915 . . . . *Not printed.*

166. Report of the Commissioners appointed to investigate and report upon the water levels of the River St. Lawrence at and below Montreal, together with a brief summary prepared by the Chief Hydrographer of the Survey. Presented by Hon. Mr. Hazen, 16th March, 1915 . . . . *Not printed.*

167. Return to an Order of the House of the 3rd March, 1915, for a copy of all letters, telegrams, papers and other documents relating to the mail contract between Chance Harbour and Trenton, Pictou County, in regard to the existing contract. Presented 18th March, 1915.—*Mr. Macdonald* . . . . *Not printed.*

168. Return to an Order of the House of the 19th February, 1915, for a copy of all correspondence and other documents relating to the awarding of the mail contract at Maria Capes, Bonaventure County, in 1914. Presented 18th March, 1915.—*Mr. Marcil.* *Not printed.*

169. Return to an Order of the House of the 15th February, 1915, for a copy of all tenders letters and telegrams, including first and second call for tenders, for rural mail delivery in the township of Dundee, county of Huntingdon. Presented 18th March, 1915.—*Mr. Robb* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

170. Return to an Order of the House of the 11th February, 1915, for a copy of all petitions, letters, telegrams and correspondence regarding a proposed daily mail service between Lower South River and South Side Harbour, Antigonish County, and improved postal accommodation for the residents of the last-named district. Presented 17th March, 1915.—*Mr. Chisholm (Antigonish)* . . . . *Not printed.*

171. Return to an Order of the House of the 1st March, 1915, for a copy of all letters, documents, telegrams, recommendations, petitions and other papers received by the Post Office Department since 1st January, 1914, relating to the contract for carrying the mails between Guysborough and Canso, N.S. Presented 18th March, 1915.—*Mr. Sinclair* . . . . *Not printed.*

172. Return to an Order of the House of the 22nd February, 1915, for a return showing:1. The total number of employees, both permanent and temporary, at the following post offices: Montreal, Toronto, Winnipeg, Halifax, Quebec, St. John, N.B., and Vancouver. 2. The total amount of salaries paid in each case. 3. The total number of employees, and the amount of salaries paid in the above offices on the 1st of October, 1911. Presented 18th March, 1915.—*Mr. Lemieux* . . . . *Not printed.*

173. Return to an Order of the House of the 19th February, 1915, for a copy of all correspondence, telegrams, letters, petitions and documents of all kinds in any way referring to a proposed change in the mail route from Inverness railway station to Margaree Harbour. Presented 18th March, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed.*

174. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or individuals the Government, or any department thereof, has ordered soldiers uniforms since the 1st of July, 1914. 2. The names of these firms. 3. How many Oliver equipments have been ordered from each firm. 4. How many of these uniforms each firm has delivered up to date. 5. How many each firm has yet to deliver. 6. The price each firm is receiving for these uniforms. Presented 18th March, 1915.—*Mr. Murphy* . . . . *Not printed.*

175. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or individuals the Government, or any department thereof, has ordered Oliver equipments since the 1st of July, 1914? 2. The names of these firms? 3. How many Oliver equipments have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these Oliver equipments? Presented 18th March, 1915.—*Mr. Murphy* . . . . *Not printed.*

176. Return to an Order of the House of the 11th March, 1915, for a copy of all letters, correspondence, etc., relating to the appointment of William Gore Foster, of Dartmouth, N.S., to the position of Inspector of Indian Reserves. Presented 18th March, 1915.—*Mr. Carroll* . . . . *Not printed.*

177. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams, correspondence, leases, and other documents relating to the cutting of lumber by Mr. B. F. Smith, and others, from the so-called Tobique Indian Reserve in the province of New Brunswick since the twelfth day of March, A.D. 1914, and also of all agreements, offers and promises made either by the said B. F. Smith or the Department of Indian Affairs, with reference to the sale or disposal of any of the said Tobique Indian Reserve since the said date, or any logs or lumber cut thereon. 2. Also a statement of all lumber cut by the said B. F. Smith from the said reserve, the rates of stumpage charged, and the amounts actually paid thereon from the first day of January, 1912, down to the date hereof. Presented 18th March, 1915.—*Mr. Carvell.* *Not printed.*

178. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. The number of customs officers employed at the customs port of Masonville, Quebec, on 20th September, 1911. 2. The names of these officers. 3. The salary each one received. 4. The total amount of salaries paid the officers at this port. 5. The number of customs officers employed at the port of Masonville at the present time. 6. The names of these officers. 7. The salary each one receives. 8. The total amount of salaries paid to the officers at this port. Presented 18th March, 1915.—*Mr. Kay* . . . . *Not printed.*

179. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. The number of customs officers employed at the customs port of Highwater, Quebec, on 20th September, 1911. 2. The names of these officers. 3. The salary each one received. 4. The total amount of salaries paid the officers at this port. 5. The number of customs officers employed at the port of Highwater at the present time. 6. The names of these officers. 7. The salary each one receives. 8. The total amount of salaries paid to the officers at this port. Presented 18th March, 1915.—*Mr. Kay* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

180. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. The number of customs officers employed at the customs port of Abercorn, Quebec, on 20th September, 1911. 2. The names of these officers. 3. The salary each one received. 4. The total amount of salaries paid the officers at this port. 5. The number of customs officers employed at the port of Abercorn at the present time. 6. The names of these officers. 7. The salary each one receives. 8. The total amount of salaries paid to the officers at this port. Presented 18th March, 1915.—*Mr. Kay*... ..*Not printed.*

181. Return to an Order of the House, of the 1st March, 1915, for a copy of all petitions, letters, communications and other documents relating to or bearing upon the dismissal of Leonard Hutchinson, chief keeper at Dorchester penintentiary. Presented 18th March, 1915.—*Mr. Copp*.. .. ..*Not printed.*

182. Return to an Order of the House of the 22nd February, 1915, for a copy of all letters, telegrams and papers generally concerning the proposed construction of a bridge to connect Isle Perrot with the mainland at Vaudreuil. Presented 18th March, 1915.—*Mr. Boyer*.. .. ..*Not printed.*

182*a*. Return to an Order of the House of the 22nd February, 1915, for a copy of all letters, telegrams and papers generally concerning the proposed construction of a bridge between the Island of Montreal and the Mainland at Vaudreuil. Presented 18th March, 1915.—*Mr. Boyer* .. ..*Not printed.*

183. Return to an Order of the House of the 22nd February, 1915, for a return showing:—1. What properties have been acquired by the Government in the City of Regina since 21st September, 1911? 2. The descriptions of such properties by metes and bounds? 3. For what purposes such properties were acquired? 4. From whom such properties were purchased? 5. The total price and the price per foot paid for each property? 6. If any such property was acquired by expropriation, what tribunal determined the price to be paid for any property so expropriated? 7. The dates on which any such properties were acquired? Presented 18th March, 1915.—*Mr. Martin (Regina).*

184. Return to an Order of the House of the 19th February, 1915, for a copy of all letters, telegrams, memoranda, pay-lists, recommendations and any other documents whatsoever in any wise appertaining to the construction of a wharf at Lower Burlington, in the County of Hants. Presented 18th March, 1915.—*Mr. Chisholm (Inverness).* *Not printed.*

185. Return to an Order of the House of the 24th February, 1915, for a copy of pay-rolls and all correspondence and vouchers in connection with the repairs to Jordan breakwater, Shelburne county, for which Leander McKenzie was contractor of works or foreman. Presented 18th March, 1915.—*Mr. Law* .. ..*Not printed.*

186. Return to an Order of the House of the 24th February, 1915, for a copy of all letters, telegrams, correspondence and pay-rolls in connection with repairs and extension of breakwater at Bluff Head, Yarmouth county, N.S., during year 1914. Presented 18th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

187. Return to an Order of the House of the 22nd February, 1915, for a return showing the amounts expended by the Public Works Department in the County of Inverness each year from 1896 down to 1915. Presented 18th March, 1915.—*Mr. Chisholm (Inverness)*.. .. ..*Not printed.*

188. Return to an Order of the House of the 24th February, 1915, for a copy of all letters, telegrams, correspondence and pay-sheets in connection with the repairs and other work on the breakwater at Sandford, Yarmouth County, N.S., during the year 1914. Presented 18th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

189. Return to an Order of the House of the 1st March, 1915, for a copy of all papers, letters, petitions and other documents relating to a mail contract with David D. Heard & Sons, between Whitby and Grand Trunk Railway station, or with one John Gimblet, Whitby. Presented 19th March, 1915.—*Mr. Pardee*.. .. ..*Not printed.*

190. Copies of Reports of the Committee of the Privy Council, approved by His Royal Highness the Governor General, relating to certain advances made to the Canadian Northern Railway Company and the Grand Trunk Pacific Railway Company, respectively, together with copies of agreements made between the said companies and His Majesty. Presented by Hon. Mr. White, 19th March, 1915.. .. ..*Not printed.*

191. Return to an Order of the House of the 11th February, 1915, for a copy of all tenders received by the Post Office Department for the mail service between Caraquet and Tracadie, Gloucester County, N.B., on the 15th day of January last, with the names of the tenderers, the respective amounts of the tenders, and the name of the new contractor. Presented 19th March, 1915.—*Mr. Turgeon*.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

192. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. The fractional areas of homestead lands or otherwise in the province of Saskatchewan sold in the year 1914. 2. The name of the purchaser, and the price paid in each case. Presented 22nd March, 1915.—*Mr. Martin (Regina)* . . . . *Not printed.*

193. Return to an Order of the House of the 25th February, 1915, for a return showing, in reference to the answer to question No. 6 of 9th February, and answered 15th February as per page 161 unrevised *Hansard*, the cost of furnishing the Government offices in each of the said buildings. Presented 22nd March, 1915.—*Mr. Turriff.* *Not printed.*

194. Return to an Order of the House of the 1st March, 1915, for a return showing the amount of railway subsidies paid in the county of Inverness since 1896, to date, and the dates on which such subsidies were paid. Presented 22nd March, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed.*

195. Return to an Order of the House of the 1st March, 1915, for a copy of all letters, papers, telegrams and other documents relating to the purchase or lease of the railway from New Glasgow to Thorburn, in the county of Pictou, known as the Vale Railway, from the Acadia Coal Company, since January, 1911, to date. Presented 22nd March, 1915. —*Mr. Macdonald* . . . . *Not printed.*

196. Return to an Order of the House of the 1st March, 1915, for a copy of all papers, letters, telegrams, correspondence, contracts, etc., in connection with the sale of the hay grown or the lease of certain tracts of land belonging to the Intercolonial Railway, upon which hay is grown, and which are contiguous to the properties of Charles Lavoie, Cléophas Leclerc and Joseph Parent of the Parish of Bic, county of Rimouski. Presented 22nd March, 1915.—*Mr. Lapointe (Kamouraska)* . . . . *Not printed.*

197. Return to an Order of the House of the 3rd March, 1915, for a copy of all letters, papers, telegrams, evidence taken at investigations, reports and all other documents relating to the suspension or other action in regard to the charge of drunkeness against Newton Hopper, conductor on the Intercolonial Railway, and to his subsequent reinstatement. Presented 22nd March, 1915.—*Mr. Macdonald* . . . . *Not printed.*

198. Return to an Order of the House of the 1st March, 1915, for a copy of all letters, telegrams and other papers relating to the dismissal of Bruce Wiswell, as sectionman on the Intercolonial Railway at Stellarton, Nova Scotia. Presented 22nd March, 1915.—*Mr. Macdonald* . . . . *Not printed.*

199. Return to an Order of the House of the 22nd February, 1915, for a return showing:— 1. The inward tonnage freight, and also the outward tonnage freight respectively, at Loggieville station of the Intercolonial Railway for each month of 1914, and also for the month of January, 1915. 2. The inward tonnage freight, and the outward tonnage freight at Chatham station, on the Intercolonial Railway for each month of 1914, and also for the month of January, 1915. 3. The inward tonnage freight, and the outward tonnage freight at Newcastle station on the Intercolonial Railway for each month of 1914, and also for the month of January, 1915. 4. The local and through passenger traffic to and through each of the above stations, respectively, during each of the months above mentioned. Presented 22nd March, 1915.—*Mr. Loggie.* *Not printed.*

200. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams and correspondence had by Margaret Lynch, or any person representing her, with reference to the expropriation of certain land beolnging to the said Margaret Lynch in the city of Fredericton, province of New Brunswick, by the Intercolonial Railway, and also of all letters, telegrams and correspondence had with F. P. Gutelius or any other official of the Intercolonial Railway with reference thereto. Presented 22nd March, 1915.—*Mr. Carvell* . . . . *Not printed.*

201. Return to an Order of the House of the 3rd March, 1915, for a copy of all documents bearing on the payment made to C. R. Scoles, New Carlisle, Quebec, in July, 1914, of balance of subsidy voted to the Atlantic and Lake Superior Railway on the recommendation of the Financial Comptroller. Presented 22nd March, 1915.—*Mr. Marcil.* *Not printed.*

202. Return to an Order of the House of the 1st March, 1915, for a copy of all letters, telegrams, correspondence and reports relating to the purchase of the New Brunswick and Prince Edward Island Railway, extending from Sackville to Cape Tormentine, county of Westmorland. Presented 22nd March, 1915.—*Mr. Copp* . . . . *Not printed.*

203. Return to an Order of the House of the 1st March, 1915, for a copy of the tariff on flour shipments now in force on the Quebec, Oriental Railway and the Atlantic, Quebec and Western Railway. Presented 22nd March, 1915.—*Mr. Marcil* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

204. Return to an Order of the House of the 22nd February, 1915, for a copy of all petitions, correspondence, complaints, reports and other documents relating to the dismissal of Alfred H. Bonnyman, postmaster of Mattatall Lake, in the county of Colchester, N.S. Presented 24th March, 1915.—*Mr. Sinclair*.. .. ..*Not printed.*

205. Return to an Address to His Royal Highness the Governor General, of the 1st March, 1915, for a copy of all correspondence, documents, charges, evidence, findings and Orders in Council in reference to the dismissal of John Thomas, postmaster at Hammond's Plain, Halifax County, N.S. Presented 24th March, 1915.—*Mr. Maclean (Halifax)*.. .. ..*Not printed.*

205*a*. Supplementary Return to an Address to His Royal Highness the Governor General, of the 1st March, 1915, for a copy of all correspondence, documents, charges, evidence, findings and Orders in Council in reference to the dismissal of John Thomas, postmaster at Hammond's Plain, Halifax County, N.S. Presented 8th April, 1915.—*Mr. Maclean (Halifax)*.. .. ..*Not printed.*

206. Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General, with reference to the question of providing adequate pensionary assistance for officers and men disabled or partially disabled on active service or for the dependents of such officers and men should they be killed on active service. Presented by Sir Robert Borden, 24th March, 1915.. .. .. *Not printed.*

207. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government has ordered saddles since the 1st of July, 1914? 2. The names of these firms? 3. How many saddles have been ordered from each firm? 4. How many saddles each firm has delivered up to date? 5. How many saddles each firm has yet to deliver? 6. The price each firm is receiving for these saddles? Presented 26th March, 1915.—*Mr. Murphy*.. .. ..*Not printed.*

208. Return to an Order of the House of the 8th March, 1915, for a copy of all correspondence, letters, telegrams and other documents relating to the dismissal of Mr. P. B. Hurlbert, postmaster at Springdale, Yarmouth County, N.S., and the removal of the office. Presented 30th March, 1915.—*Mr. Law*.. .. ..*Not printed.*

209 Return to an Order of the House of the 8th March, 1915, for a copy of all letters, petitions, telegrams and correspondence between the Hon. L. P. Pelletier, ex-Postmaster General and any person or persons of the county of Lévis, which during the month of April, 1912, had any connection with the appointment of G. A. Marois to a position in the customs office at Quebec, and the appointment of J. E. Gingras as postmaster of St. Romuald and Etchemin. Presented 30th March, 1915.—*Mr. Bourassa.* *Not printed.*

210. Return to an Order of the House of the 22nd February, 1915, for a copy of all letters, telegrams, petitions and documents of all kinds in possession of the Post Office Department, referring in any way to the conduct of the postmaster at Grand Etang since his appointment until the present date. Presented 30th March, 1915.—*Mr. Chisholm (Inverness)*.. .. ..*Not printed.*

211. Return to an Order of the House of the 1st March, 1915, for a copy of all telegrams, letters, papers, documents, evidence and reports, in connection with the dismissal of Charles H. Marshall as postmaster at Nanton, Alberta. Presented 30th March, 1915.—*Mr. Warwick*.. .. ..*Not printed.*

212. Return to an Order of the House of the 1st March, 1915, for a copy of the report of the officer in charge of the lobster hatchery at Port Daniel West, and of the report of the inspection thereof for the season 1914. Presented 31st March, 1915.—*Mr. Marcil.* *Not printed.*

213. Return to an Order of the House of the 24th February, 1915, for a copy of all correspondence, petitions, documents, etc., in connection with a petition of Donald Williams and others in respect to the regulation of fish traps in Green Harbour and vicinity. Presented 31st March, 1915.—*Mr. Law*.. .. ..*Not printed.*

214. Return to an Order of the House of the 9th February, 1915, for a copy of all correspondence, petitions, departmental recommendations and other papers and documents in the Department of Marine and Fisheries relating to the definition of a "coasting voyage," as defined in the Canada Shipping Act since the revision of the statutes in 1886. Presented 1st April, 1915.—*Mr. Sinclair*.. .. ..*Not printed.*

215. Return to an Order of the House of the 1st March, 1915, for a copy of all advertisements, tenders, contracts, vouchers, letters, documents, etc., relating to the establishment of the ferry service between the City of Halifax and Dartmouth, N.S., for the employees of the Marine and Fisheries Department at Halifax, N.S. Presented 1st April, 1915.—*Mr. Maclean (Halifax)*.. .. ..*Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

216. Return to an Order of the House of the 24th February, 1915, for a copy of all pay-rolls, vouchers in detail, correspondence and all other documents in connection with the following public wharves in Shelburne; breakwater or wharf at East Green Harbour; shed on public wharf at Shelburne, and repairs to Gunning Cove wharf. Presented 1st April, 1915.—*Mr. Law* . . . . *Not printed.*

217. Return to an Order of the House of the 22nd February, 1915, for a return showing:—1. What properties have been acquired by the Government in the city of Regina since 21st September, 1911? 2. The descriptions of such properties by metes and bounds? 3. For what purposes such properties were acquired? 4. From whom such properties were purchased? 5. The total price and the price per foot paid for each property. 6. If any such property was acquired by expropriation, what tribunal determined the price to be paid for any property so expropriated. 7. The dates on which any such properties were acquired. Presented 1st April, 1915.—*Mr. Martin (Regina)* . . *Not printed.*

218. Return to an Order of the House of the 11th February, 1915, for a copy of all papers, letters, telegrams, etc., concerning the purchase of the property known as the Carslake Hotel, in Montreal, for post office purposes. Presented 1st April, 1915.—*Mr. Lemieux. Not printed.*

219. Return to an Address to His Royal Highness the Governor General, of the 1st March, 1915, for a copy of all letters, telegrams, reports, recommendations, Orders in Council, pay-rolls, list of expenditures, names of foremen and superintendents, and all other documents whatsoever relating to or in anywise appertaining to the erection and maintaining of breakwaters at Phinney's Cove and Young's Cove, county of Annapolis. Presented 1st April, 1915.—*Mr. Macdonald* . . . . *Not printed.*

220. Return to an Order of the House of the 24th February, 1915, for a copy of all correspondence, petitions and documents since the 31st of October, 1912, relating in any way whatever to the proposed public wharf at Lower Wood Harbour. Presented 1st April, 1915.—*Mr. Law* . . . . *Not printed.*

221. Return to an Order of the House of the 1st March, 1915, for a copy of all advertisements, tenders, accounts, vouchers, letters, documents and correspondence relating to the construction of an extension to the breakwater at Prospect, Halifax County, N.S. Presented 1st April, 1915.—*Mr. Maclean (Halifax)* . . . . *Not printed.*

222. Return to an Order of the House of the 1st March, 1915, for a copy of all telegrams, letters, petitions, reports, recommendations and documents of all kinds in any way referring to the purchase of a site for a public building at Port Hawkesbury, and also referring in any way to the erection of a public building thereon. Presented 1st April, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed.*

223. Return to an Order of the House of the 8th March, 1915, for a return showing all amounts of money expended upon public works in the counties of Wright, Pontiac and Labelle from October, 1911, to date. Presented 1st April, 1915.—*Mr. Devlin. Not printed.*

224. Return to an Order of the House of the 17th March, 1915, for a copy of the pay-sheet for the month of October, 1914, in connection with repairs to the breakwater at Shippigan Gully, Gloucester County, N.B. Presented 1st April, 1915.—*Mr. Turgeon. Not printed.*

225. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered bicycles since the 1st of July, 1914? 2. The names of these firms? 3. How many bicycles have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these bicycles. Presented 1st April, 1915.—*Mr. Kyte* . . . . *Not printed.*

226. Return to an Order of the House of the 22nd February, 1915, for a return showing the names and addresses of all Fenian Raid Veterans in the county of Inverness who have been paid the Fenian Raid Bounty, the names and addresses of those who have not been paid, and the names and addresses of those whose applications have been refused. Presented 1st April, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed.*

227. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered motor cycles since the 1st of July, 1914? 2. The names of these firms? 3. How many motor cycles have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these motor cycles? Presented 1st April, 1915. *Mr. Chisholm (Antigonish)* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

228. Return to an Address to His Royal Highness the Governor General of the 19th February, 1915, for a copy of all Orders in Council, letters and telegrams exchanged between the Dominion Government and the several provinces, concerning the proposed transfer of fisheries in tidal waters from the Provincial to the Federal control. Presented 1st April, 1915.—*Mr. Lemieux* . . . . *Not printed.*

229. Return to an Order of the House of the 4th March, 1915, for a copy of all correspondence exchanged between the Government of Canada, or any minister or official thereof, in regard to the control of fisheries in Quebec province, as well as of all documents bearing on that question, together with a list of licenses granted by either Governments for the present year. Presented 1st April, 1915.—*Mr. Marcil* . . . . . . *Not printed.*

230. Return to an Order of the House of the 24th February, 1915, for a copy of all correspondence, letters, telegrams and petitions relating to the appointment of Alfred Bishop as farm foreman, or in any other capacity at the experimental station at Kentville, Nova Scotia. Presented 1st April, 1915.—*Mr. Kyte* . . . . *Not printed.*

231. Return to an Address of the 10th March, 1915, showing copies of all correspondence, telegrams and documents exchanged between the Department of Marine and Fisheries and the Minister of the Naval Service and the Department of Colonization, Mines and Fisheries of the province of Quebec, relating to the rescinding of the prohibition of net fishing in the waters of the Lakes of Two Mountains, St. Francis and St. Louis, as per Order in Council (197) passed in Ottawa, Thursday, 28th day of January, 1915.—*Senate*) . . . . *Not printed.*

232. Return to an Order of the House of the 1st March, 1915, for a copy of all papers, letters, petitions and other documents relating to the establishment of a rural mail route from River John to Hedgeville, county of Pictou. Presented 3rd April, 1915.—*Mr. Macdonald.* *Not printed.*

233. A communication from the Consul General of Belgium in Canada, respecting the protest of the Belgium Government against the contention of the German Chancery that as far back as in 1906, Belgium had broken her own neutrality by the conclusion of an agreement with Great Britain. Presented by Sir Robert Borden, 5th April, 1915. *Printed for sessional papers.*

234. Return to an Address of the Senate dated 11th March, 1915, showing:—1. How much wheat, oats and barley has the Dominion Government purchased in 1914 for seed to be distributed in the West, giving the amount of each kind? 2. Where is said grain stored, and what rate of storage is the Government paying on same? 3. How much did the Government pay per bushel for oats, barley and wheat, purchased for said provinces, and when was said grain purchased? 4. Have they given a contract for cleaning said grain, and to whom, and at what price?—(*Senate*) . . . . . . *Not printed.*

235. Return to an Order of the Senate dated the 18th March, 1915, that an Order of the Senate do issue for:—1. A return showing the results per grade of all grain in each of the terminal elevators at Fort William and Port Arthur at the annual weigh-up for each of the years 1912, 1913 and 1914. 2. A return showing the balances whether overages or shortages in each grade in each elevator for each of the said years. 3. A return showing the net result of the three years operations of each of said elevators in overages or shortages in each grade.—(*Senate*) . . . . *Not printed.*

236. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. The quantity of spirituous liquors, proof gallons, including ale, wines and beers, taken out of bond between 6th August and 21st August, 1914, at each port of the Dominion. 2. The quantity of cigars, cigarettes and tobacco taken out of bond between the above mentioned dates at each port of the Dominion. Presented 7th April, 1915.—*Mr. Hughes (Kings, P.E.I.)* . . . . *Not printed.*

237. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered forage caps since the 1st of July, 1914? 2. The names of these firms? 3. How many forage caps have been ordered from each firm? 4. How many each firm has delivered to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these forage caps? Presented 7th April, 1915.—*Mr. Murphy* . . . . *Not printed.*

238. Return to an Order of the House of the 11th March, 1915, for a copy of the report of Dr. Wm. Wakeham, on the extent of the losses sustained in the Baie des Chaleurs and Gulf of St. Lawrence in the storm of 5th June, 1914, together with a statement showing the number of claims received and those entertained, with names of claimants and their residence, and the amounts paid to each, together with a copy of other documents bearing on this question. Presented 7th April, 1915.—*Mr. Marcil* . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

239. Return to an Address to His Royal Highness the Governor General, of the 23rd February, 1915, for a copy of all letters, telegrams, reports, recommendations, Orders in Council and all other documents and papers in connection with rewards to the officers and crews of steamers *John L. Cann* and *Westport III*, for their heroic efforts in saving the passengers and crews of ss. *Cobequid,* wrecked on Trinity Lodge, 13th January, 1914. Presented 7th April, 1915.—*Mr. Law* . . . . *Not printed.*

240. Return to an Order of the House of the 29th March, 1915, for a copy of all documents, letters, telegrams, reports, etc., relating to the dismissal of Alexandre Blais, of the city of Lévis, from the position of customs officer at Bradore Bay, and the appointment of his successor or successors. Presented 7th April, 1915.—*Mr. Bourassa* . . . *Not printed.*

241. A Return to an Address of the Senate dated 18th March, 1915, for:—1. A return showing all appointments to the Civil Service, Department of the Interior, in that área contained in the present constituencies of Medicine Hat and Macleod, giving names, date of appointment, how appointed, and salaries from the year 1896 to the present date. 2. Also, all vacancies by death, resignation or dismissal, giving name, date, length of service and cause of dismissal in the same area and during the same period.—(*Senate*). *Not printed.*

242. Return to an Order of the House of the 1st March, 1915, for a copy of charges made against J. Herbert Sweetman, customs officer at Port Daniel Centre, Quebec, which brought about his dismissal; and also of charges against Velson Horie, lighthouse keeper at Port Daniel West, Quebec, which brought about his dismissal. Presented 8th April, 1915.—*Mr. Marcil (Bonaventure)* . . . . *Not printed.*

243. Return to an Order of the House of the 22nd February, 1915, for a copy of all correspondence, recommendations, petitions, contracts, tenders and other papers and documents in any way connected with the letting of the contract for carrying the mails between Guysborough and Erinville, N.S. Presented 8th April, 1915.—*Mr. Sinclair.* *Not printed.*

244. Return to an Order of the House of the 10th March, 1915, for a copy of all reports, petitions, letters, telegrams and other documents in connection with the dismissal of W. M. Thomson from the postmastership at Fort Qu'Appelle, and of any petition or petitions for his reinstatement, and of all correspondence in connection therewith. Presented 8th April, 1915.—*Mr. Thomson (Qu'Appelle)* . . . . *Not printed.*

245. Return to an Order of the House of the 22nd March, 1915, for a copy of all letters, telegrams, correspondence and petitions received in the Post Office Department, in any way referring to the calling of tenders for the Antigonish-Sherbrooke mail service, which tenders were opened or due at the Post Office Department on the 11th December last; and of all representations or requests, recommending or suggesting that new tenders should be invited as was done early in February last. Presented 8th April, 1915. —*Mr. Chisholm (Inverness)* . . . . *Not printed.*

246. Return to an Order of the House of the 3rd March, 1915, for a copy of all letters, telegrams, papers and other documents in regard to a proposed rural mail delivery service between Pictou and Saltsprings, Pictou county, and as to the arrangements for the existing service between those points. Presented 8th April, 1915.—*Mr. Macdonald.* *Not printed.*

247. Return to an Address of His Royal Highness the Governor General, of the 1st March, 1915, for a copy of all letters, telegrams, reports, recommendations, Orders in Council, and all other documents and papers whatsoever relating to or in any wise connected with the establishment of rural mail routes and deliveries from Bridgetown to Granville Ferry, county of Annapolis, and especially of all letters, telegrams, reports, recommendations and documents relating to the closing of the post offices at Belleisle, Upper Granville, and the establishment of the post office at Granville Centre, all in the county of Annapolis. Presented 8th April, 1915.—*Mr. Macdonald* . . . . *Not printed.*

248. Return to an Order of the House of the 22nd February, 1915, for a copy of all telegrams, letters, reports, petitions and all other documents in any way referring to the proposed line of railway from Orangedale to Cheticamp. Presented 9th April, 1915.—*Mr. Chisholm (Inverness)* . . . . *Not printed.*

249. Return to an Order of the House of the 11th March, 1915, for a copy of all documents, investigations, reports, correspondence, etc., relating to the burning of certain buildings belonging to the Trois Pistoles Pulp and Lumber Company and to André Leblond, near Tobin station, on the Intercolonial Railway. Presented 9th April, 1915.—*Mr. Lapointe (Kamouraska)* . . . . *Not printed.*

250. Return to an Order of the House of the 18th March, 1915, for a return showing the names of all officials, assistants and clerks, employed in the railway offices at Moncton, N.B., and the salary paid to each; also the names of officials formerly employed in said offices who have been retired on superannuation allowance, and the amount of retiring allowance being paid to each. Presented 9th April, 1915.—*Mr. Copp* . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

251. Return to an Order of the House of the 24th March, 1915, for a return showing the names of all persons from whom lands have been purchased, the quantity of land so acquired, and the amount paid therefor, in connection with the Dartmouth and Dean's Post Office Branch of the Intercolonial Railway since the date of return numbered 128 made to Parliament at the last regular session thereof. Presented 9th April, 1915.—*Mr. Maclean (Halifax)* . . . . *Not printed.*

252. Return to an Address to His Royal Highness the Governor General of the 17th March, 1915, for a copy of all correspondence, letters, Orders in Council, agreements, etc., in reference to the leasing or transfer of the Windsor Branch of the Intercolonial Railway to the Canadian Pacific Railway. Presented 9th April, 1915.—*Mr. Maclean (Halifax). Not printed.*

253. Return to an Order of the House of the 22nd February, 1915, for a copy of all petitions, correspondence, reports of engineers or other persons in the possession of the Department of Railways and Canals relating to the construction of a railway in the county of Guysborough, N.S. Presented 9th April, 1915.—*Mr. Sinclair* . . . . . . *Not printed.*

254. Return to an Order of the House of the 10th March, 1915, for a copy of all letters and correspondence, between D. McDonald, superintendent of the Intercolonial, at Lévis, P. Brady, general superintendent at Moncton, or any other official of the said Intercolonial Railway and Théophile Bélanger, commercial traveller of the city of Montreal, concerning certain claims made by the said Théophile Bélanger for delay of baggage in transportation between Drummondville and Matapedia, in May, 1913, also all reports made bearing upon such claims against the said Intercolonial Railway. Presented 9th April, 1915.—*Mr. Ethier* . . . . *Not printed.*

255. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams, minutes of investigation and other documents relating to the dismissal of Isaac Arbuckle, foreman carpenter Intercolonial Railway at Pictou, and of appointment of Alex. Talbot to the vacancy. Presented 9th April, 1915.—*Mr. Macdonald. Not printed.*

256. Return to an Order of the House of the 15th February, 1915, for a copy of all correspondence letters, telegrams, by any and all persons whomsoever, had with the Department of Railways and Canals, or F. P. Gutelius, general manager of the Intrcolonial Railway, or any other official thereof, with reference to freight rates over that portion of the Transcontinental Railway, province of New Brunswick, and also with reference to the removal of the Y connection at Wapski, county of Victoria, between the said Transcontinental Railway and the Canadian Pacific Railway at that point. Presented 9th April, 1915.—*Mr. Carvell* . . . . *Not printed.*

257. Return to an Order of the House of the 15th February, 1915, for a copy of all letters, telegrams, correspondence, contracts, and other documents relating to the operation of the St. John Valley Railway, so called, by the Intercolonial Railway, since the first day of July last past, and of all letters, correspondence, etc., had either with the Department of Railways and Canals, or with F. P. Gutelius, or any other official of the Intercolonial Railway. Presented 9th April, 1915.—*Mr. Carvell* . . . . *Not printed.*

258. Return to an Order of the House of the 1st March, 1915, for a copy of all petitions, memorials, letters, telegrams, communications and reports regarding the construction of a roadway to the new public wharf at Sackville, N.B., and also in regard to the building of a spur line or siding from the Intercolonial Railway at Sackville to said wharf. Presented 9th April, 1915.—*Mr. Copp* . . . . *Not printed.*

259. Return to an Order of the House of the 15th March, 1915, for a copy of all correspondence passing between any department of the Government and any official of the Government, or any other person, with respect to the placing of settlers on homesteads in the Duck Mountains Timber Reserve, and also of the evidence taken by Inspector Cuttle, of the Department of the Interior, in an investigation held by the said inspector with respect to the granting of entries for homesteads on the said timber reserve. Presented 9th April, 1915.—*Mr. Martin (Regina)* . . . . *Not printed.*

260. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered flannel shirts since the 1st of July, 1914? 2. The names of these firms? 3. How many flannel shirts have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these flannel shirts? Presented 9th April, 1915.—*Mr. Carroll* . . . . *Not printed.*

260a. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered cotton shirts since the 1st of July, 1914? 2. The names of these firms? 3. How many cotton shirts have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these cotton shirts? Presented 9th April, 1915. —*Mr. Chisholm (Antigonish)* . . . . *Not printed.*

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260*b*. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government or any department of the Government, has ordered service shirts since the 1st of July, 1914? 2 The names of these firms? 3. How many service shirts have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these service shirts? Presented 10th April, 1915.—*Mr. Carroll*. . . . .*Not printed.*

260*c*. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government or any department of the Government, has ordered winter shirts since the 1st of July, 1914? 2. The names of these firms? 3. How many winter shirts have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these winter shirts? Presented 12th April, 1915. *Mr. McKenzie*. . . . .*Not printed.*

261. Return to an Order of the House of the 11th March, 1915, for a return showing:—1. What medical supplies or other materials have been purchased since 1st August, 1914, by the Government, or any department of the Government, from Mr. T. A. Brownlee, of Ottawa? 2. The quantities of goods purchased from him and the prices paid? 3. Whether the Government, or any? department of the Government, prepared a schedule of rates tos how what constitutes a fair and reasonable price for such goods purchased? 4. If so, if a careful check was made to see that a fair and reasonable price was charged? 5. The total value of the goods delivered up to date? 6. The total value of the goods which have been ordered from Mr. T. A. Brownlee, but which to this date have not been delivered? Presented 9th April, 1915.—*Mr. Kyte*. . . . .*Not printed.*

262. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered kit bags since the 31st of July, 1914? 2. The names of these firms? 3. How many kit bags have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these kit bags? Presented 9th April, 1915.—*Mr. Kyte.* *Not printed.*

263. Return to an Order of the House of the 11th March, 1915, for a return showing:—1. What medical supplies or other materials have been purchased since 1st August, 1914, by the Government, or any department of the Government, from Mr. S. J. Stevenson, or the Waverley Pharmacy? 2. The quantities of goods purchased from him and the prices paid? 3. Whether the Government, or any department of the Government, prepared a schedule of rates to show what constitutes a fair and reasonable price for such goods purchased? 4. If so, if a careful check was made to see that a fair and reasonable price was charged? 5. The total value of the goods delivered by Mr Stevenson, or Waverley Pharmacy, up to date? 6. The total value of the goods which have been ordered from Mr. S. J. Stevenson, or Waverley Pharmacy, but which to this date have not been delivered? Presented 9th April, 1915.—*Mr. Chisholm (Antigonish).* *Not printed.*

264. Return to an Order of the House of the 8th March, 1915, for a return showing:—1. From how many firms or private individuals the Government, or any department of the Government, has ordered suits of underwear since the 1st July, 1914? 2. The names of these firms? 3. How many suits of underwear have been ordered from each firm? 4. How many each firm has delivered up to date? 5. How many each firm has yet to deliver? 6. The price each firm is receiving for these suits of underwear? Presented 9th April, 1915.—*Mr. Law*. . . . .*Not printed.*

265. Return to an Order of the House of the 11th March, 1915, for a return showing:—1. What medical supplies or other materials have been purchased since 1st August, 1914, by the Government, or any department of the Government, from Mr. W. B. McDonald, of Ottawa? 2. The quantities of goods purchased from him and the prices paid? 3. Whether the Government, or any department of the Government, prepared a schedule of rates to show what constitutes a fair and reasonable price for such goods purchased? 4. If so, if a careful check was made to see that a fair and reasonable price was charged? 5. The total value of the goods delivered by Mr. McDonald up to date? 6. The total value of the goods which have been ordered from Mr. McDonald, but which to this date have not been delivered? Presented 9th April, 1915.—*Mr. Carroll.* *Not printed.*

266. Report of Thomas R. Ferguson, commissioner appointed to investigate matters pertaining to the Blood Indian Reserve and the acquisition of certain Indian lands by Messrs. James A. Smart, Frank Pedley and William J. White, together with the evidence taken in the said investigation. Presented by Hon. Mr. Coderre, 10th April, 1915. *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

267. Return to an Order of the House of the 17th March, 1915, for a copy of all petitions, letters, documents, etc., between persons in the province of Nova Scotia and the Department of Trade and Commerce since 1st August last, with regard to Atlantic ocean freight rates on subsidized steamers or otherwise. Presented 10th April, 1915.—*Mr. Maclean (Halifax)*. . . . . *Not printed.*

268. Return to an Order of the House of the 22nd February, 1915, for a copy of the report of investigation held about 1st June, 1914, by T. R. Ferguson, as special commissioner, into the allotment of homesteads on the area cut out of the Riding Mountain Forest Reserve in the year 1908 or about that time. Presented 10th April, 1915.—*Mr. Cruise. Not printed.*

269. Copy of Order in Council dated 6th April, 1915.—Regulations in respect to steam trawlers clearing from ports on the Atlantic seaboard of Canada. Presented by Hon. Mr. Hazen, 10th April, 1915. . . . . *Not printed.*

270. Return to an Order of the House of the 15th February, 1915, for a copy of all tenders in connection with the supply of lumber to the Department of Militia for the training camps at Medicine Hat and Calgary, and of the invoices for the material supplied. Presented 12th April, 1915.—*Mr. Buchanan*. . . . . *Not printed.*

271. Return to an Order of the House of the 17th March, 1915, for a copy of all correspondence and reports relating to the purchase of 25,000 shovels of special pattern, mentioned in Order in Council P.C. 2302, dated 4th September, 1914, on page 38 of memoranda respecting work of the Department of Militia and Defence, and also relating to any further purchases of such shovels. Presented 12th April, 1915.—*Mr. Hughes (Kings, P.E.I.)*. . . . . *Not printed.*

272. Return to an Order of the House of the 15th March, 1915, for a return showing the names of the persons who bought the horses which were sold by auction at Valcartier camp, giving the price paid for each horse. Presented 12th April, 1915.—*Mr. Kay. Not printed.*

273. Return to an Order of the House of the 24th February, 1915, for a return showing:—1. If the Government ever leased any land at or near Shelburne, Nova Scotia, known as the Barracks property, to the town of Shelburne? 2. If, so, at what rental, and for how long? 3. If said lease is now in force? 4. If the Government has sold any of the standing timber on this property? 5. If so, when, to whom, and at what price? 6. How long the purchaser has to remove it? 7. What is the minimum size at the stump sold? 8. If the Government has ever had the property cruised by competent timber cruiser? 9. If so, by whom, and when? 10. If the timber on said property was advertised for sale, and if tenders were asked for, or any opportunity afforded to other prospective buyers to bid for this timber? 11. If any other offers were received? 12. If the town of Shelburne was notified before the sale took place. If so, on what date? 13. How much timber the Government estimates to be on this property? 14. What steps the Government intends to take to compute the quantity of timber cut from this property? 15. If the Government is aware that timber is now being cut from this property by a person or firm who are cutting timber from private property adjoining said Barracks property? 16. What steps are being taken by the Government to be sure that in this case the logs are kept separate from those coming from the adjoining lot, for the purpose of having accurate count and scale? 17. If the Government will bring down a copy of all correspondence, cruisers reports and contracts in relation to the sale of this timber? Presented 12th April, 1915.—*Mr. Law*. . . . . . . *Not printed.*

274. Return to an Address to His Royal Highness the Governor General, of the 11th February, 1915, for a copy of all correspondence, telegrams, Orders in Council, petitions and any other documents in connection with the removal of Edward N. Higinbotham from the position of postmaster at Lethbridge, Alberta. Presented 13th April, 1915.—*Mr. Buchanan*. . . . . *Not printed.*

275. Return to an Order of the House of the 10th March, 1915, for a copy of all petitions, correspondence and other documents in connection with the dismissal of Emile Cyr, postmaster at St. Hermas, county of Two Mountains. Presented 13th April, 1915.—*Mr. Ethier*. . . . . *Not printed.*

276. Return to an Order of the House of the 7th April, 1915, for a return showing:—1. Who the mail carriers are for the rural mail in the counties of Chicoutimi and Saguenay? 2. The salary of each such mail carrier, and the trip that each has to make? 3. Who the mail carriers are for the rural mails in the parishes of St. Prime and St. Louis de Metabetchouan, and their respective salaries? Presented 13th April, 1915.—*Mr. Lapointe (Kamouraska)*. . . . . *Not printed.*

277. Return to an Order of the House of the 29th March, 1915, for a copy of all documents, letters, telegrams, testimonials, reports, etc., relating to the claim of Télesphore Paradis, of the city of Lévis, arising from the burning of his wharf and mills which were set on fire by a locomotive of the Intercolonial Railway. Presented 13th April, 1915.—*Mr. Bourassa*. . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

278. Return to an Order of the House of the 8th April, 1915, for a return showing:—1. The number of employees connected with the administration of the Three Rivers post office on the 21st September, 1911, and the annual amount paid in salaries at that date for such service. 2. The number of employees connected with the administration of the Three Rivers post office at the present date, and the amount of the annual salaries paid for such service. 3. The number of employees in the Customs Department for Three Rivers on the 21st September, 1911, and the amount of the annual salaries paid for such service. 4. The number of employees in the Customs Department for Three Rivers at the present date, and the annual amount of the salaries paid for such service. 5. The number of employees in the Inland Revenue Department for the district of Three Rivers on the 21st September, 1911, and the annual amount of salaries paid for such service. 6. The number of employees at the present date in the Inland Revenue Department for the district of Three Rivers, and the amount of the annual salaries paid for such service. 7. The number of employees, and the amount paid in salaries for the works on the St. Maurice, in the county of Champlain, during the year 1911-12. 8. The number of employees, and the amount of salaries paid per year for the works on the St. Maurice, in the county of Champlain, since 1911-12. 9. If the employees whose names follow, were dismissed on the 26th and 27th November, 1914, and the 4th and 5th January, 1915; Wildé Lavalée, Pierre Thicierge, Joseph Paquin, sr., Joseph Paquin, jr., Athanase Gélinas, clerks. 10. If so, at whose request, and for what reasons. 11. If those days were taken off the salaries of such employees. Presented 13th April, 1915.—*Mr. Bureau*. . . . . *Not printed.*

279. Return to an Order of the House of the 4th March, 1915, for a copy of all documents bearing on the removal of the salmon retaining pond from Flat Lands to New Mills, N.B., and of all reports on the operations thereof, with a detailed statement of outlay and cost of removal, installation and operation. Presented 13th April, 1915.—*Mr. Marcil*. . . . . *Not printed.*

280. Return to an Address to His Royal Highness the Governor General of the 3rd February, 1913, for a copy of all Orders in Council, letters, telegrams, reports, petitions and other papers and documents in the possession of the Department of Marine and Fisheries, or any department of the Government, relating to the granting of licenses to pack lobsters, and bearing date between 1st January, 1912, and 25th January, 1913. Presented 13th April, 1915.—*Mr. Sinclair*. . . . . *Not printed.*

281. Report of Thomas R. Ferguson, K.C., commissioner appointed to investigate into all matters relating to, or connected with, the application for (although such application may not have been granted, or may still be pending) the sale, lease, grant, exchange, or other disposition by any means whatsoever, since the first day of July, 1896, of:—(a) Dominion Lands; (b) Timber and mineral lands and mining rights and privileges, including coal, petroleum, and gas lands and rights and irrigation tracts or lands, and the cutting of timber upon Government lands; (c) Water-power and rights; (d) Indian Lands and Indian Reserves: under authority or purporting to be under the authority of the Dominion Lands Acts, and Irrigation Act, or other statutes of the Parliament of Canada, and the acts or proceedings of any person or corporation in relation to the matters foresaid. Presented by Hon. Mr. Coderre, 13th April, 1915. *Not printed.*

282. Report and evidence upon the matter known as: "Timber Berths 550½ and 528, Howard Douglas, R. E. A. Leech, D. J. McDonald, and others." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

283. Report and evidence upon the matter known as: "The Kananaskis Coal Company, Limited, Howard Douglas, George E. Hunter, Walter Garrett, and others." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

284. Report and evidence upon the matter known as: "Blood Indian Reserve and Frank Pedley." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

285. Report and evidence upon the matter known as: "Southern Alberta Land Company, Limited, and Grand Forks Cattle Company, J. D. McGregor, Arthur Hitchcock, and others." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

286. Report and evidence upon the matter known as: "The Bulletin Company, Limited, the Honourable Frank Oliver, and the Grand Trunk Pacific Railway Company." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

287. Report and evidence upon the matter known as: "Aylwin Irrigation Tract, E. A. Robert and J. D. McGregor." Presented by Hon. Mr. Coderre, 13th April, 1915. . . *Not printed.*

288. Report and evidence upon the matter known as: "Timber Berths 1107 and 1108, W. H. Nolan, A. W. Fraser, and J. G. Turiff." Presented by Hon. Mr. Coderre, 13th April, 1915. . . . . *Not printed.*

CONTENTS OF VOLUME 28—*Continued.*

289. Report and evidence upon the matter known as: "Grazing Ranch No. 2422, J. G. Turriff, A. J. Adamson, and J. D. McGregor." Presented by Hon. Mr. Coderre, 13th April, 1915.. .. ..*Not printed.*

290. Report and evidence upon the matter known as: "Craven Dam, Walter Scott, Lieutenant-Governor Brown, and J. G. Turriff." Presented by Hon. Mr. Coderre, 13th April, 1915. *Not printed.*

291. Certified copies of Reports of the Committee of the Privy Council No. P.C. 1109 and No. P.C. 1589, approved by His Excellency the Administrator on the 10th May, 1913, and 27th June, 1913, respectively, in respect to the appointment of Thomas R. Ferguson, K.C., as commissioner to investigate and report upon all matters connected with the disposition by any means whatsoever, since the first day of July, 1896, of:—(a) Dominion Lands; (b) Timber and mineral lands and mining rights and privileges, including coal, petroleum, and gas lands and rights and irrigation tracts or lands, and the cutting of timber upon Government lands; (c) Water-power and rights. (d) Indian Lands and Indian Reserves. Presented by Sir Robert Borden, 13th April, 1915. *Not printed.*

292. Return to an Order of the House of the 11th March, 1915, for a copy of all charges, correspondence, letters, telegrams and other documents relative to the dismissal of Joseph Day, at Little Bras D'Or, in the riding of North Cape Breton and Victoria, and of the evidence taken and reports of the investigation held by H. B. Duchemin, in regard to same, with a detailed statement of expenses of such investigation. Presented 14th April, 1915.—*Mr. McKenzie*.. .. ..*Not printed.*

293. A Return to an Order of the Senate, dated 30th March, 1915, for a return giving the names of the trust companies up to the present date who have complied with the requirements of Clause 69 of the Trust Companies Act, 1914, and any correspondence connected therewith.—(*Senate*).. .. ..*Not printed.*

294. Report of R. A. Pringle, K.C., commissioner appointed to investigate into charges of corruption and fraud in relation to contracts for the building of certain drill halls in the province of Ontario, together with the evidence taken at the said inquiry. Presented by Sir Robert Borden, 14th April, 1915... .. ..*Not printed.*

295. Return to an Order of the House of the 1st March, 1915:—1. For a full statement and description of all lands taken possession of by the Government for the camp at Valcartier. 2. For copies of all titles of the Government to the same, whether by expropriation, purchase or otherwise. 3. For a specified statement of all amounts claimed and still unpaid whether for land or damages. 4. For a specified account of all amounts paid up to date either for land or damages. Presented 15th April, 1915.—*Sir Wilfrid Laurier*.. .. ..*Not printed.*

296. A return to an Address to His Royal Highness the Governor General:—1. A return showing all appointments to the customs in that area contained in the present constituencies of Medicine Hat and Macleod, giving names, date of appointment, how appointed and salaries, from the year 1896 to the present date. 2. Also, all vacancies by death, resignation or dismissal, giving name, date, length of service and cause of dismissal in the same area and during the same period.—(*Senate*).. .. ..*Not printed.*

297. Return to an Address to His Royal Highness the Governor General; praying that His Royal Highness will cause to be laid before the Senate copies of all letters between the Minister of Marine and Fisheries or his department and the fishery overseer at Baker Lake, in the province of New Brunswick; and also copies of all claims made by the said fishery overseer and the payments made thereon.—(*Senate*).. .. *Not printed.*

ANNUAL REPORT

OF THE

DEPARTMENT OF THE INTERIOR

FOR THE

Fiscal Year ending March 31, 1914

VOLUME II.

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
PRINTED BY J. DE L. TACHÉ, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY.
1915

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PART VI

FORESTRY

FORESTRY.

REPORT OF THE DIRECTOR OF FORESTRY.

OTTAWA, May 23, 1914.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the report of the work of the Forestry Branch for the year 1913-14, to which are attached the reports of the officers in charge of the various subdivisions.

As far as control of the fire situation is concerned, the past year has been a very satisfactory one. The proportion of the area of the forest reserves burned over was only two one-hundredths of one per cent, and of the area outside of forest reserves nine one-hundredths of one per cent. While this is largely due to the favourable season, the good result is also due to a considerable extent to the increase in numbers and efficiency of the staff of rangers, to the increased facilities for preventing fire in the forest reserves, due to the improvements such as roads, trails, telephone lines, and lookout stations (which make access to the reserve easier and enable the rangers to reach fires quickly), to the education of the public as to the danger of fire, and to the enforcement of the special provisions of the Railway Act relating to railways. The organization of the work has been more thorough and on the whole, with some exceptions, the personnel of the ranger staff has advanced both in qualification and efficiency. If it were arranged that appointments were made on special qualifications for the work required and that appointments were to be permanent during good behaviour and efficiency, a decided forward step would be taken which should ensure the placing of the staff on a permanent basis of efficiency.

A decided advance has been made in the question of brush disposal after lumbering operations, and it is to be regretted that this branch has not been authorized to take up the matter as it relates to the timber berths held under license in the forest reserves. The photographs which accompany this report will show some of the methods of brush disposal.

The argument has sometimes been made that the holding of land for forest purposes is an obstacle to settlement and a check to the development of the country. That a country, especially a northern country, can reach its best development in population by the assistance of the forests is well illustrated by the following extract from a statement made by Mr. G. P. Gordon, B.Sc., Professor of Forestry, Glasgow Agricultural College, as a member of a deputation to theBritish Government:—

> "The contrast between one of our highland glens and a glen in the highlands of Europe is very marked indeed. We have in our typical highland glen a stretch, generally of indifferent pasture, with perhaps a dozen shepherds' cottages scattered along it. A similar continental glen supports a vigorous population of small holders. We find that it is the forest which maintains this population. It is thus not due to any greater advantage, either of soil or of climate. I make that statement with detailed agricultural knowledge of the conditions in both countries—Germany and Scotland. The forest effects this by the employment which it affords. The nature of forest employment is specially well adapted to keep people on the land. First of all, it is permanent

both in time and in place. The people, then, within its sphere of influence have security of employment and do not require to migrate. Secondly, the nature of the employment is very varied. You have people employed as wood-cutters, as saw-millers, as road-makers. You have them also employed in various forest industries. You see, then, that this gives great scope for the people of a district. Thirdly, in winter, when other employment on the land is scarce, the forest demands a larger supply of labour, and this labour is highly paid. For example, a typical wood-cutter in Germany earns 4 shillings a day during five or six months of the winter. The following is a concrete example: a forest of 10,000 acres, with 3,000 acres occupied by small holders attached. Such an area in the highlands of Scotland would support at the most about 300. This area in question actually supports a population of 1,500 in Germany. In 1907, 81 per cent of the persons employed in forestry were small holders. We see, then, that forestry forms the backbone of an economic system of small holdings.

"In this connection one should not lose sight of the fact that in forestry it is large areas which are truly economic, and this, I may say, is clearly demonstrated upon the continent of Europe. The objection to small areas is that they do not give the same amount of employment, nor give the same permanency. They do not provide the same amount of timber, and the management of small areas is much more difficult and more costly.

"These few observations would seem to show that in any economic system of land holdings, especially when dealing with poor land, the forest is of prime importance."

While in some of the tracts recommended to be set apart as forest reserves there may be lands that will eventually be suitable for agricultural purposes, such lands are isolated and of poor quality, and it is certainly good public policy to direct settlement to more favourable districts until the development of lumbering operations and the facilities for communication which will be provided as means of protection and handling the products of the forest will make successful settlement a greater certainty and will provide for it under conditions that will not endanger the forest.

The forest products laboratories established at Montreal in connection with McGill University have charge of all experimental work in the use of forest products, the finding of new uses for Canadian timbers, the improvement of methods of use and the lengthening of the time of use. The laboratories were established with Mr. A. G. McIntyre, B.A., B.Sc., as superintendent. Mr. McIntyre was editor of the "Pulp and Paper Magazine" and secretary of the Canadian Pulp and Paper Association, and from this and his engineering training and experience was specially qualified for starting the work. Owing to Mr. McIntyre having received an offer of a much more remunerative position from a commercial firm, he has resigned, and the position has been accepted by Mr. J. S. Bates, Chem. E., Ph. D., a graduate of Columbia University, who has been engaged specially in staff investigations relating to pulp and paper.

STAFF.

During the year, nine foresters having technical training were added to the staff and there were four resignations. At the present time there are on the staff twenty-four graduates of forest schools, and the total permanent staff is as follows:—

Head office at Ottawa	35
Inspectors	5
Forest supervisors	8
Forest assistants	13
Forest rangers	56
Inspectors of tree planting	10
Outside clerical staff	24
Forest products laboratories (technical staff)	8
Total	159

This staff is assisted during the summer by a considerable additional number of temporary rangers.

In January the head office of the Forestry Branch was moved into the Journal building, and the increased accommodation provided makes efficient work more possible.

APPROPRIATION.

The appropriation for the year 1913-14 was $556,713.30, and the refunds by timber-limit holders of their proportion of the fire-fighting expenditure brought the total amount available for expenditure to $571,798.28. The expenditure was divided as follows among the various services:—

Salaries at Ottawa	$12,183 81
Travelling expenses	1,545 40
Printing and stationery	24,047 86
Head office—Miscellaneous expenses	5,549 04
Forest surveys	22,149 89
Forest reserves	265,984 47
Fire ranging	178,134 25
Tree planting	47,181 70
Statistics	5,829 78
Forest products laboratories	9,192 08
Total	$571,798 28

The field expenditure, exclusive of tree planting on the farms, is divided as follows among the provinces:—

Manitoba	$ 94,285 86
Saskatchewan	82,260 64
Alberta	175,425 95
British Columbia (railway belt)	108,305 86
	$460,278 31

ACCOUNTS.

The accounting methods have been more thoroughly systematized and have been developed to meet the present needs of the organization.

The ordinary departmental requirements in regard to accounts are sufficient to check whether expenditures have actually been made, but they do not furnish sufficient information to check or make comparison of costs. Special attention has been given to this matter, and a system of accounts and reports has been worked out which, when thoroughly understood and put into practice, will, it is hoped, ensure that expenditure is made so as to accomplish the work required efficiently and economically.

The accounting for revenues is not in as satisfactory a position. The necessity for reporting revenue through the Dominion Land offices makes a roundabout system which causes delay and confusion at times, as the agents do not always have the time to give the same consideration to this business as to the land-office business, and have little opportunity to get into the field and familiarize themselves with the outside work. While a careful and thorough system of accounting for revenue is necessary, the fact should not be lost sight of that the forests should be administered not only with a view to revenue, but with a view to the upbuilding of the districts in which they are situated and the convenience of the public, and that for that purpose the more directly and speedily the resources of the forest which should be used can be made available for this purpose the better. The system of accounting for revenue should be framed with this object in view as well as the other, and should be as simple and direct as possible. Any unnecessary number of offices through which the revenues have to pass will tend to hinder such a desirable result.

CORRESPONDENCE.

The letters received and sent out gy this Branch were as follows:—Number of letters received, 28,951. Mail sent out: letters, circulars, etc, 67,887; bulletins and reports, 28,123; parcels, 2,315. Total, 98,325.

THE LIBRARY,

The rapid and substantial development of the special library idea throughout Canada and the United States has abundantly justified the establishment and enlargement of the library of the branch. Not only are similar libraries found in various Government offices, but many large private firms and associations occupying leading positions in the financial, insurance, and industrial world are instituting collections of the literature specially pertaining to their fields of activity.

In the field of forestry, on account of its rapid development on this continent and the fact that there are in the country so few large private or academic collections of the literature of the subject, it is particularly important for future students that the literature of the subject, much of which has appeared and is appearing in pamphlet and magazine form and must be promptly secured, should be collected in some central place and fully classified and indexed, and so made readily accessible. Not only will the administrative and investigative work of the branch be benefited thereby, but a work of much importance to students and workers in forestry in general will be done.

During the past year 108 volumes were added to the library by purchase, and about the usual number of volumes of magazines and pamphlets were bound.

This year seventy-one magazines are being received in the library. The list of magazines received on subscription is somewhat smaller than last year, several magazines having been dropped from the list as they did not seem to contain sufficient material of value to our work to warrant their continuance. A few new subscriptions were entered in place of those dropped. Twenty magazines are received either free or in exchange for the publications of the branch.

The greatest step forward in connection with the library during the year has been the institution of two branch libraries. One of these is connected with the office of the District Inspector of Forest Reserves at Calgary, and the other is connected with the Forest Products Laboratories at Montreal. The library at Calgary is specially strong in books and pamphlets dealing with the actual work of reserve administration, while the work of the laboratories, being of a very technical character, requires a fairly extensive library to meet its needs. Both these libraries are in some respects under the supervision of the head-office library, but latitude is allowed for the development necessary for the particular requirements of each.

The photographic collection of the branch contained on March 31 last, 5,065 good negatives. During the past year, 1,252 new negatives have been received, but as, on the separation of the Irrigation Branch from the Forestry Branch, 1,225 negatives which pertained properly to the irrigation work were transferred to the Irrigation Branch, the actual number of photographs in the collection remains about the same as at this time last year. During the coming year it is hoped to develop this collection so as to make it considerably more useful in the work of the branch.

PUBLICATIONS.

During the year the following publications were issued:—

Bulletin 1 (Reprint).—Tree Planting on the Prairies of Manitoba, Saskatchewan, and Alberta.

Bulletin 38.—Forest Products of Canada, 1912; Pulpwood.

Bulletin 39.—Forest Products of Canada, 1912; Poles and Cross-ties.

Bulletin 40.—Forest Products of Canada, 1912; Lumber, Square Timber, Lath, and Shingles.

Bulletin 42.—Co-operative Forest Fire Protection.

Bulletin 43.—Forest Products of Canada, 1913 (a combination of Bulletins 38, 39, and 40).

Circular 6.—Preservative Treatment of Fence-posts.

Circular 7.—Manitoba a Forest Province.

Circular 8.—The Forest Products Laboratories.

Circular 9.—Chemical Methods of Utilizing Wood Wastes.

There are also in press at the time of writing the following:—

Bulletin 41.—Timber Conditions in the Little Smoky River Valley, Alberta.

Bulletin 44.—Wood-using Industries of the Maritime Provinces.

STATISTICS.

In order to make authoritative statements as to the need of forest conservation, it is necessary to have some definite information concerning the rate at which the forest products are being produced and utilized. The Forestry Branch in the last year has collected statistics on the production of lumber, lath, and shingles, the consumption of wood for pulp, railway ties, poles and mining timbers, and the consumption of bark for tanning. These are all annual statistics that will be published each year in the form of bulletins for the use of manufacturers of lumber and the consumers of the products mentioned, as well as for the education of the public at large.

In addition to these annual bulletins, a series of studies of wood-using industries is being undertaken which will eventually cover the whole of Canada. Bulletins have been completed describing the industries that use wood as a raw material in Ontario and the Maritime provinces. A similar bulletin describing conditions in the three prairie provinces is to be completed during the coming summer. These bulletins are valuable for the purpose of showing the importance of wood as a raw material in manufacturing. They show which woods are used in greatest quantity and which cost the most to the manufacturer, and also show the sources from which these woods are obtained. Detailed descriptions of the uses to which different woods can be put are valuable as suggestions to manufacturers for new uses for their waste material. The Forestry Branch has been instrumental in many cases in putting manufacturers into communication with each other when one firm was actually burning up wood which formed the raw material of another industry.

During the year 1912 the Forestry Branch compiled statistics based on reports received from 2,558 saw-mill operators, 48 pulp-mill operators, 389 companies purchasing wooden poles (including telephone, telegraph, electric light and power concerns, and electric and steam railway companies), and over 600 firms using wood as a raw material. In obtaining these 3,595 satisfactory replies, at least 7,000 firms and individuals were corresponded with during the year, and a number of them were visited in person. The statistics compiled from this mass of correspondence are handled by a more or less temporary staff and much time is wasted in training new clerks. An adequate permanent head-office staff is needed for this work, augmented by a field staff of men familiar with the lumber business and the industries using lumber.

The statistics collected up to the present time for the calendar year 1913 are as follows:—

Canada produced in 1913 a total of 3,816,642,000 board feet of sawn lumber, valued at $65,976,438; 739,678,000 lath, valued at $1,783,283; and 1,485,279,000 shingles, valued at $3,064,641.

The total quantity of pulpwood produced was 2,144,064 cords, valued at $14,313,-939. Of this over half was exported in the unmanufactured state to the United States, and the remainder, 1,109,034 cords, was manufactured in Canada into wood-pulp, producing approximately 854,624 tons of "air-dry" fibre.

The railways of Canada in 1913 purchased a total of 19,881,714 cross-ties, valued at $8,740,849; of these ties over sixteen per cent were reported as having been imported from the United States. Over ten per cent of the ties purchased were treated with preservatives before being laid in the road-bed.

Pole-line companies purchased 534,592 wooden poles in 1913, valued at $1,188,331, eighty per cent of which were the product of Canadian forests.

Mining companies used 34,802,000 lineal feet of round mining timbers at a value of $509,602.

The following is an estimate of the total value of forest products in Canada for the calendar year 1913:—

Lumber, lath and shingles	$71,000,000
Firewood	55,000,000
Pulpwood	15,000,000
Fence-posts and rails	10,000,000
Cross-ties	9,000,000
Square timber exported	500,000
Cooperage	1,900,000
Poles	1,800,000
Logs exported	900,000
Tanning materials	20,000
Round mining timbers	600,000
Miscellaneous exports	400,000
Miscellaneous products	11,000,000
Total	$177,120,000

These figures have been rounded off to even thousands, allowance having been made for discrepancies in data gathered, although the total figure is still a conservative one.

FIELD ORGANIZATION.

The Tree Planting Division, which manages the work of tree planting on farms in Manitoba, Saskatchewan, and Alberta, is under charge of Mr. Norman M. Ross, with head-quarters at Indian Head Sask.

The forest management division of the field work of the Forestry Branch has been organized on a provincial basis with a district inspector in charge of the work in each province. The districts and inspectors are as follows:—

Province.	Headquarters.	Inspector.
Manitoba	Winnipeg	F. K. Herchmer.
Saskatchewan	Prince Albert	G. A. Gutches.
Alberta	Calgary	W. N. Millar.
British Columbia (Railway Belt)	Kamloops	D. R. Cameron.

The fire ranging outside of the forest reserves in the provinces of Manitoba, Saskatchewan, and Alberta, has been organized under charge of an inspector, Mr. E. H. Finlayson, with a chief fire ranger in each of twelve districts into which these provinces have been divided.

It is considered that in the final organization of the forestry work of the department it will be advisable to leave the detail and administrative work largely in the hands of the field staff, under regulations established under the authority of the Forest Reserves Act, and to have the head office staff mainly composed of experts in special lines, such as accounts, forest management, silviculture, forest investigations, who will visit the outside offices regularly, check the work and records of these offices, and assist in the development of their organizations and methods.

TREE PLANTING ON FARMS.

The interest in tree planting on the farms is sustained and increasing. The number of applications for trees received last year was 7,350, the number of applicants receiving trees, 3,585, and the number of trees distributed, 3,729,765. The average number of trees supplied to each applicant was 1,008. Owing to dry weather in the spring and early summer there were more partial failures of new plantations in some localities than usual.

The distribution of conifers was continued, 74,000 trees being sent out. The success of this class of stock has been good where proper care was taken in selecting the location and preparing the ground. Coniferous trees furnish such good shelter, particularly in winter when it is most needed, that their general planting on the prairies is most desirable, and only the necessity for holding them in the nursery for a longer period than the deciduous species, thus greatly restricting the output and increasing the cost, makes it impossible to provide for a more general distribution.

I would call particular attention to the example, cited by the superintendent of the Tree Planting Division, of the results in the production of fuel obtained from a plot of three eighths of an acre of a plantation of Russian poplar set out in the spring of 1906, which was cut this year, producing 6¾ cords of wood, which, at the average, price of $4.50 per cord, would show a yield per acre of $81 after eight years' growth. This plantation was not the most favourable, either as to species or condition, but it shows a return of over 5 per cent on the outlay, reckoning full charges for all items of expenditure.

A very interesting development in connection with the tree-planting work is the active interest taken by many farmers, as evidenced by their applications to the office at Indian Head, in the proper laying out and beautification of their home grounds. While the department will assist in this matter as far as possible, it is of course rather outside of its work. It shows, however, that the object of the department, that is to assist in increasing the interest in the beauty and comfort of the homes on the prairie farms, is meeting with success.

The development of the new nursery station at Sutherland is being carried on, most of the new buildings required have been erected, and it is expected during the coming year to have the ground in condition for starting the growth of nursery stock, so that by the spring of 1916 at latest there should be a large additional stock for distribution.

FOREST RESERVES.

By an amendment of the Dominion Forest Reserves and Parks Act passed at last session, additions were made to the forest reserves amounting to 10,762 square miles. These additions were recommended after careful examination of the lands had been made by forest survey parties sent out by the department. The additions are as follows:—

	Square Miles.	
Province of British Columbia—		
Long Lake	74.21	
Monte Hills	76.75	
Martin Mountain	16.25	
Miskonlith	193.50	
Tranqui le	141.60	
Hat Creek	135.25	
Fly Hills	223.75	
Nicola	505.75	
Mount Ida	45.25	
Arrowstone	255.00	
Total		1,667.31
Province of Alberta—		
Rocky Mountains	2,683.65	
Lesser Slave	5,023.00	
Total		7,706.65
Province of Saskatchewan—		
Fort à la Corne	513.00	
Pines	12.15	
Porcupine No. 2	204.75	
Nisbet	134.55	
Total		864.45
Province of Manitoba—		
Duck Mountain No. 1	58.25	
Porcupine No. 1	465.50	
Total		523.75
Grand total		10,762.16

The organization of the forest reserves already established has been steadily developing. The permanent forest-reserve organizations consists of the following officers:—

District inspectors	5
Forest supervisors	8
Forest assistants	13
Forest rangers	56
Total	82

On the whole the staff are taking a more earnest and active interest in the work on the forests, and have a better realization of the public service they are rendering, but this spirit and the efficiency of the work could be developed to a much higher degree if the special qualifications necessary were made the basis of appointment, and if efficiency and good conduct assured permanency of tenure of office.

IMPROVEMENTS.

Work has gone on steadily during the year in the improvements necessary for the protection and utilization of the reserves. The better knowledge of the reserves gained through the year has enabled a more intelligent planning of the system of improvements, and their construction is now being pushed forward as rapidly as funds will permit.

The construction of houses on the reserves for the forest rangers has resulted in keeping them close to their work, and eliminating a great loss of time previously occasioned.

Particular attention has been given to developing a system of trails throughout the reserves, and the standard of the trails constructed has been materially improved without an increase of cost, through a better knowledge of the character of the trails required and greater experience by the rangers in their construction.

While considerable work has been done in constructing telephone lines, this part of the work has been delayed until a fuller knowledge of the reserves would enable a better and more permanent location of the lines.

The following is a tabulated statement of the improvements and their cost:—

Improvement.	No.	Total Cost.	Average.
		$ cts.	$ cts.
Rangers' houses	12	15,096 88	1,258 73
" cabins	27	7,471 81	276 73
" stables	23	4,131 38	183 99
Tool caches	5	550 07	110 01
Lookout towers	3	304 91	101 63
	Miles.		
Telephone line	99	6,644 26	67 11
Bridges	8	1,175 28	146 90
Fire-guards—			
Cleared	118	6,714 77	56 92
Ploughed	119	1,934 20	14 24
Roads—			
New construction	245	13,452 17	56 00
Maintenance	44	442 52	10 04
Trails—			
New	467	21,850 78	46 74
Maintenance	321	1,719 44	5 35
Corrals	4	170 90	43 09
Pasture fencing	15	1,567 42	103 83
Boundary demarcation	125	484 10	3 87

REGULATIONS.

New regulations for the administration of the Forest reserves were established by Orders in Council of the 8th August and the 24th September, 1913. These regulations improved the provisions for the protection of the reserves, and provided much more effective measures for dealing with the products. It is provided that any railway not under the jurisdiction of the Board of Railway Commissioners for Canada which operates within a forest reserve shall be required to provide a patrol and take necessary precautions to prevent fire, similar to those required by the regulations of the board. By this means control of the fire situation along the railway lines will be maintained.

TIMBER.

The regulations of the Forest reserves relating to timber had been framed when the main requirement was a supply of timber to settlers, and were framed with that requirement in view. The establishment of the reserves on the Rocky mountains and in British Columbia made it necessary to furnish further provisions for timber disposal. Provision was therefore made in the regulations for the granting of annual permits, not only to settlers, but to miners and prospectors, for municipal or public works, for the erection of schools and churches in rural districts, for irrigation works, for timber on rights of way, and for railway construction. This will supply, with the least possible delay, the main requirements for timber in smaller quantities which will be needed.

Provision is also made for sales by tender of timber in quantities not exceeding five million feet, board measure, being about the average quantity on one section of land with a time limit for removal not to exceed five years. Advertisement of such a sale must be made for a period of not less than thirty days in a newspaper circulating in the district where the timber is situated. This provision was intended to meet cases where the annual permit would not provide sufficient timber or where the timber is not sufficiently accessible to be handled on a permit basis. Thirty-three sales have been held under this section of the regulations, and operations have been carried on by small mills in connection therewith, which have supplied various demands for lumber.

Owing to the development of large coal-mining operations in the Rocky mountains, which require a supply of timber larger than the five million feet, board measure, authorized for sale by the regulations and for a longer period than three years, it has been necessary to arrange for the special authority of Council for the sale of a large area.

The Brazeau Collieries, Limited, applied to purchase the timber on an area of 7,360 acres in the valley of the Clearwater river, convenient to their operations. A careful examination of this tract was made by a forester, and it was found that a large proportion of the timber which was of a size suitable for cutting into lumber was over 200 years old and consequently overmature, and that it was advisable that the sale should be made. The tract was estimated to have a stand of 4,500,000 feet, board measure, of timber, and 9,700,000 lineal feet of mining props. This tract was therefore put up for sale by auction, at an upset price of $2 per thousand feet, board measure, for a period of eight years, and the price realized was $2.60 per thousand feet, which bid was submitted by the Brazeau Collieries. The sale was made subject to the following conditions:—

(1) That no trees shall be cut which are designated by the forest officer as being required to ensure the reproduction of the timber, the protection of the watershed, or any other beneficial public service;

(2) That the purchaser shall take out all material that is merchantable from the timber cut and shall not cause any unnecessary waste of timber;

(3) That no unnecessary damage shall be caused to the young growth or to any trees that are designated as not to be cut;

(4) That the débris of logging operations shall be piled and burned or otherwise disposed of in accordance with the instructions of the forest officer;

(5) That the purchaser shall take all necessary precautions to prevent the starting or spread of fire from his operations;

(6) That for fighting fire in the vicinity of, or threatening, the tract, the purchaser shall give, free of charge, the assistance of the men employed by him.

Sales were also made to the Mountain Park Coal Company and the Yellowhead Pass Coal and Coke Company.

The arrangement for allowing small mills on the Riding and Duck Mountain Forest reserves to cut on settlers' permits has been continued, but cannot yet be considered as having established itself as a successful method of management. The difficulties have been due; first, to the fact that there has not been as active a demand by settlers for timber permits during the past two winters; and, secondly, to the fact that some of the operators appear to consider the privilege granted as merely a basis and opportunity for irregular operations. The experiment will, however, be continued further.

It will be noted that the policy adopted in regard to the timber is to provide for its disposal as required by the people or the industries in the district. It is not the policy to withhold timber from sale, but to dispose of what is mature and suitable for use, and to protect the timber that is still immature and adding to its value by growth. Such disposal is made, however, so as to encourage the industries, such as coal mining, which are dependent on the forest, and to furnish a convenient and reasonablepriced supply to the shelter for the present and the future, when the timber will be still more in demand, and to furnish it as directly as possible to the persons or companies requiring it for use so as to eliminate merely speculative holding of timber as far as possible.

Considerable advance has been made in the disposal of the débris of the lumbering operations on reserves which are in charge of this branch. In all such operations the brush has been piled or scattered so as to lie flat on the ground, thus materially decreasing the fire hazard. This is particularly the case in connection with operations on the Riding and Duck Mountain reserves in Manitoba, on the Pines and Nisbet reserves in Saskatchewan, and on the Crowsnest forest in the Rocky mountains. The disposal of lumbering slash in the Railway Belt in the province of British Columbia has also been taken up with the lumbermen, and there is fair prospect of a more general movement to dispose of such débris, although there is still considerable difference of opinion among lumbermen as to the desirability or advisability of using fire for the purpose. Some of the lumbermen are, however, now regularly burning the slash after operations and, through the efforts of the officers of the branch, some of the most dangerous places have been cleared up.

GRAZING.

In defining the boundaries of the reserves, the endeavour was made to exclude as far as possible any land that is not absolute forest land. Lands that are better fitted for grazing than for forest purposes were excluded where it was possible to do so, but there are still left within the reserves some grazing areas, particularly the long narrow valleys stretching into the mountains and the grassy areas above timber-line.

It is important also at the present time that the development of the live-stock industry should be encouraged, as the scarcity of the supply of live stock has become a matter of serious moment.

Regulations have, therefore, been established providing for the use of such areas for grazing stock. In framing the regulations the following points were kept in view:—

(1) Flexibility so as to provide for meeting changing conditions. Consequently, annual permits were provided for, with a fixed charge for each head of stock covered by the permit, instead of leases for terms of years.

(2) The encouragement of the small holder. This is provided for by fixing a grazing unit, which is the number of stock which it is estimated can be carried during the winter on a homestead or small ranche and enacting that all grazing permits may be gradually reduced to this unit.

(3) Protection from overgrazing by fixing the maximum number of stock which may be grazed in any district.

As these regulations did not come into force in time to be effective during the year 1913-14, no report can be made as to how they are working out, but the principle of management is based on tried experience in the forest reserves of the United States, so that, while changes in detail may be necessary, it is expected that the main basis will be found of permanent application. Owing to objection and misunderstanding of the grazing regulations in the Railway Belt of the province of British Columbia, their application in that district has been suspended for the present.

An important section of the regulations relating to grazing is that which provides for the establishment of local stock associations which may be considered as advisory committees in the management of the grazing in their districts. Several such associations have already been formed with good prospects of usefulness.

GENERAL USES.

Provision was also made for the granting of leases or permits for other necessary uses of the reserves not previously provided for, such as surface rights for mining claims, hunters' cabins, mill-sites, logging railways, flumes, and other similar purposes.

GAME.

The regulations provide that in any part of a forest reserve set apart as a game preserve, no game shall be hunted, taken, or killed, but forest officers shall have authority at any time to destroy predatory, noxious, or dangerous animals. Any further necessary regulations are made when the game preserves are established by Order in Council.

The forest reserves in the province of Saskatchewan have all been made game refuges both by Dominion and provincial legislation, and in the province of Manitoba several game preserves have been set apart within forest reserves. On the Rocky Mountains Forest reserve in the Province of Alberta, the district inspector has been making a thorough inspection of the reserve, and is preparing a report as to conditions, which, among other things, will deal with the protection of the game and make recommendations as to further areas which should be established as preserves. A recommendation has already been submitted for a game preserve north of the international boundary within this reserve.

FISH.

The regulations established at the instance of the Department of Fisheries on February 12, 1912, for the protection of fish in the provinces of Alberta and Saskatchewan were not made applicable to the forest reserves. As it was decided, too, that the fishing regulations for the Province of Manitoba probably had no effect within the reserves, and that there was authority to establish regulations in regard to fishing in the forest reserves under the Forest Reserves Act, steps were taken to establish such regulations. The Department of Fisheries was consulted in the matter, and the regulations were approved by that department before being established. These regulations do not prohibit the taking of fish but require the taking out of a permit for fishing, fix close seasons similar to those in the regulations of the Fisheries Department, fix the size limit and the number of fish that may be taken in a day, and prohibit the taking of fish in any other way than by angling or trolling.

In the administration of these regulations, arrangements are being made to cooperate with the Department of Fisheries as fully as possible.

FIRES.

The number of fires reported on the forest reserves and their causes were as follows:—

Lightning	3
Railway locomotives	18
Settlers clearing land	8
Campers or trappers	7
Miscellaneous	8
Unknown	11
Total	55

These fires were all checked before they caused any serious damage, and the total area burned on the reserves was not two one-hundredths of 1 per cent.

SURVEYS.

In order properly to locate and map the timber and improvements on the Brazeau and Clearwater divisions of the Rocky Mountains Forest reserve, it was found necessary to have traverses made of several rivers in the Brazeau, Clearwater, and Bow River forests. This was done by two survey parties, with the result that it was necessary to materially change the location of these rivers on the map. Further traverses will be made during the coming year, and will complete the work necessary on these divisions so as to make it possible to have a reconnaissance survey to locate and map the timber types and bodies of timber accurately. The eastern boundary of the Crowsnest and Bow river forests was also marked on the ground.

A reconnaissance survey was begun on the Duck Mountain Forest reserve in the Province of Manitoba, and one-half of the work was completed. The survey will be completed during the coming season.

Reconnaissance surveys were also carried on on some of the forest reserves in the Province of British Columbia.

REFORESTATION.

Reforestation has not as yet been taken up actively on the reserves in general, as the work of protection has been given first consideration. The only work on any noticeable scale which has been done in this respect is on the Spruce Woods Forest reserve in the province of Manitoba, which is a sandy tract largely denuded of trees. On this reserve a forest nursery has been established for the purpose of providing stock for the reforestation of the reserve. In this nursery there is now the following stock:—

Lodgepole pine	25,000
Bull pine	8,000
Scotch pine	18,000
European larch	7,500
Silver fir (Nordmann's)	8,500
Norway spruce	13,000
Jack pine	24,500
White spruce	108,000
Douglas fir	2,000
Tamarack	1,000
Total	215,500

Much of this stock has now reached a stage when it may be set out, and the work of reforestation will be begun immediately.

The advisability of establishing a nursery in this vicinity for the supply of stock for the reforestation of all the reserves in Manitoba was considered, but no action in that direction has yet been taken.

Several of the smaller reserves which are recommended to be established in the province of Saskatchewan are of a similar nature, sandy and denuded of trees, and if these reserves are established it will be necessary to take steps at an early date to provide for their reforestation.

FOREST SURVEYS.

The exploratory surveys to determine the lands that are suited best for forest production, and should be included in forest reserves, were continued during the season by eight parties. The districts examined are in Manitoba between lakes Winnipeg and Manitoba, the territory in Saskatchewan forming the watershed between the Assiniboine and Saskatchewan river-systems, and between the Saskatchewan and Churchill river systems, southern part of the Peace river drainage basin in the Rocky

Mountains and several mountainous tracts in the coast district and in the vicinity of Shuswap lake in the Railway Belt in the province of British Columbia. An inspection was also made of a number of sandy tracts of non-agricultural land in the prairie districts of the province of Saskatchewan and recommendations were made that a number of tracts be set aside for reforestation.

The parties were distributed in the four western provinces as follows:—

Manitoba Inspection District	1 party.
Saskatchewan Inspection District	4 parties.
Alberta Inspection District	1 party.
British Columbia Inspection District	2 parties.

The party in Manitoba was in charge of Mr. D. Greig, who covered the country lying north of township 25, between lakes Winnipeg and Manitoba, and bounded on the north by Dauphin river and Sturgeon bay of lake Winnipeg. Altogether, 3,130 square miles were examined by this party. This tract is very flat, with poor drainage, and the greater part of it is covered with swamps and muskegs. In the muskegs there are narrow ridges running north and south covered with jack pine or poplar. About 60 per cent of the muskegs are covered with black spruce and tamarack. The southern and the southwestern portions of the area examined are slightly higher land, covered principally with young poplar and jack pine. Here the soil in general is a silty loam, too light for the growing of heavy crops, but good for mixed farming. When the jack pine occurs, however, the soil is very sandy. On a recommendation made in Mr. Greig's report, a temporary reservation has been made of about eleven townships of sandy land, which were found to be unsuitable for agriculture. A more intensive examination will be made of certain portions of this land in the near future.

In eastern Saskatchewan, Mr. A. B. Connell examined the district known as the Pasquia hills. This survey comprised an area of 3,000 square miles, and covered a tract bounded on the south by the main line of the Canadian Northern railway, on the east by the Pas branch of the same railway, and on the north and west by the Carrot river. The Pasquia hills reach an elevation of approximately 2,000 feet above sea-level, and 1,000 feet above the large marsh which lies around its base on the north and northeast. The whole tract has the appearance of a flat, rough-topped plateau, with a long and gentle southward slope and a sharp and steep northern face. Many creeks of fair size rise on the northern, eastern, and southern slopes of the hills. Many of these streams have eroded deep valleys, and their beds are strewn with boulders.

The characteristic soil of the plateau is boulder clay, which precludes any possibility of profitable settlement at present. The soil of the large stretch of hay marsh and swamp land on the north side of the plateau is fairly good, but this land would, of course, have to be drained to be of agricultural use. A drainage proposition here would have to be on a large scale and comprise the entire plain of the Lower Saskatchewan and Carrot river valleys.

The plateau is covered with white and black spruce balsam, poplar, aspen, and some jack pine, mostly of small dimensions. Numerically, the two poplars are the most important trees of the region. The white and black spruce are, however, the most important from a commercial standpoint. The white spruce seems to be well adapted to the boulder-clay soil and the climate of the region, and this plateau will develop into a spruce forest if fire does not interfere.

In the better situations and on the muskegs, stunted black spruce, with occasional larch intermixed, forms the stand.

As the inspection made clear that the Pasquia hills are absolute forest land, and as the timber thereon will be of great value to the settled prairie country to the west and south, it has been recommended that this area should be set aside as a forest reserve.

Another party under charge of Mr. E. H. Roberts examined the district northwest of Prince Albert in the vicinity of Big river, Birch lake, and Green lake. This tract is quite an important watershed covering the head-waters of Big river and other tributaries of the Beaver river which finally reach the Churchill. The elevation of this tract is from 1,500 to 1,900 feet above sea-level. The country is a rolling plain to the east and southeast, while to the west and southwest it is quite hilly. The general slope of the country is to the north and northwest. In the northern and eastern portions of the district examined there are numerous undrained flat areas making hay sloughs and muskegs. Of the 1,800 square miles examined only about three per cent is covered with merchantable timber, consisting principally of spruce, aspen, and jack pine. About forty years ago a very extensive fire burnt over most of the district examined, leaving a few strips of timber here and there, which are now included in timber limits. Reproduction is very good, however, covering about eighty per cent of the area inspected. The reproducing species are spruce, jack pine, and aspen. Muskeg covers about fifteen per cent of the area. The greater part of this muskeg carries no timber of any value, but the edges of the muskegs are fringed with a thick growth of black spruce and tamarack. About two per cent of the country examined is grazing land. This is chiefly found along Witcheken lake and south of Chitek lake.

The soil over the greater part of the area is sandy, specially so in the jack pine belt in the central portion of the district. The inspections made resulted in recommendation for the inclusion of the greater part of the area in a forest reserve.

A third party, under Mr. G. P. Melrose, explored the country lying north of Battleford in Townships 55, 56 and 57, Ranges 16 to 27 west of the third meridian inclusive. This examination covered an area of about 1,800 square miles, of which approximately 1,000 square miles are covered with poplar, spruce, and jack pine. Poplar is by far the most common species. About 250 square miles are muskeg or under water, and about 290 square miles were found to be grassland. The remaining 250 square miles are either brulé or cut-over lands. The tract examined, which consists of a series of low hills, is the watershed between the creeks running north to the Beaver river and south to the Saskatchewan. The soil is, as a rule, sandy and unsuitable for permanent agriculture. It is probable that a more complete survey will be made before a decision in regard to setting apart any of these lands will be reached.

In addition to these three surveys, Mr. L. Stevenson, who is an expert on soils, made examination of several small areas of sandy land in Saskatchewan. Representations have been made to the department that certain sandy areas in the southern or central portions of Saskatchewan are unsuitable for agriculture, and that it would be in the interest of the surrounding prairie country to have them reserved and reforested when necessary. All these areas are surrounded by settlements. As a result of Mr. Stevenson's examinations, recommendations have been made that certain areas, generally covered with a drifting sand where the tree-growth is scattered or altogether absent, should be set apart as forest reserves with a view of being later reforested or afforested for the use of the neighbouring settlers. The proposed forest reserves, seven in number, are situated as follows: One at Manito lake, one in the vicinity of Eagle hills, one just west of Dundurn, one at the Elbow of the South Saskatchewan river, one at Steep creek near Prince Albert, one at Seward east of Swift Current, one just east of Cypress Hills Forest Reserve No. 2.

In Alberta, Mr. J. A. Doucet continued the examination of the northern portion of the Rocky mountains as far as the Peace River block, covering the territory from the divide between the Little Smoky and Simonette rivers, to which point the examination had been carried the previous year, to the British Columbia boundary. This includes the valleys of the Simonette, Smoky, and Wapiti rivers and their tributaries, and comprises an area of 8,000 square miles in the mountains and foot-hills, and an area of 1,500 square miles of prairie and brush land. The examination was made at a cost of $5,310, or an average of 57 cents per square mile.

The western portion of the district is the main portion of the Rocky mountains, consisting of ridges and peaks from 4,000 to 9,000 feet elevation above sea-level with intervening valleys at elevations from 3,500 to 5,500 feet. Easterly as one descends into the valleys of the Smoky, Porcupine, and Simonette rivers, the elevation decreases to 2,000 to 5,000 feet. All of this territory below 5,000 feet in elevation was at one time or other covered with forests of spruce, lodgepole pine, and poplar, with some tamarack, fir, and white birch, but the fire loss has been enormous. Of the forest area of 8,000 square miles, only 648 square miles, or about 8 per cent, has been found bearing a forest cover of 100 years old or over, that is, of a diameter between 12 and 24 inches, and the forest between 50 and 100 years of age does not cover more than 8·5 per cent more. In the last fifty years more than 65 per cent of the area has beeen swept by fire. In the last thirty years probably more than 16,000,000,000 feet, board measure, of merchantable pine and spruce lumber have been destroyed by fire which, at the current selling price at the mill of $16 per thousand, would make a loss to the industries of the country of $196,000,000, and a direct loss to the Government in dues at the rate of 50 cents per thousand feet, board measure, of $8,000,000. Over a large part of the territory, reproduction is taking place naturally and satisfactorily, but in some places the soil-cover has been removed entirely, and it will be a long time before the forest can be re-established.

On the whole it is estimated that the present stand is 3,776,440,000 feet, board measure, of saw-timber and 10,417,600 cords of wood. Some of the stands in the river-valleys are remarkably good, running as high as 15,000 feet, board measure, to the acre in places, and there is no reason why a forest of immense value should not be developed in this district. The all-important question is the prevention of fire, and the value of the property involved would justify a sufficiently large expenditure to make this as near a certainty as can possibly be done.

This is the main source of timber supply for the Grande Prairie and Sturgeon Lake districts, both splendid farming districts filling up with a good population, which will be largely increased on the advent of railway communication.

A tract of land of an area of about 170 square miles, situated at the junction of the Wapiti and Smoky rivers, was also examined. It is largely sand, with muskegs between the ridges of sand, and has a variable stand of pine, spruce, poplar, and tamarack. It is particularly valuable as a source of building timber for the prairie country in the immediate vicinity, and therefore requires special protection.

Partial examination was also made of a tract of about 1,200 square miles south of the Peace river, which forms a plateau 3,000 to 3,600 feet in elevation, in which the Pouce Coupé and Burnt rivers take their rise. At this elevation the land can hardly be of agricultural value, and as the precipitation in the Peace river valley is light, it is important that watersheds should be carefully looked after. Moreover, on the part examined the soil was found to be sandy and very coarse on the ridges. This plateau was at one time well wooded with heavy spruce, pine, and poplar in the low valleys. The merchantable timber still existing on this tract is estimated at one thousand million feet, board measure. It is proposed to complete the examination of this tract on the earliest possible occasion.

In the Railway Belt of British Columbia two parties were at work under Mr. C. R. Mills and Mr. Bruce Robertson. They examined an area covering approximately 4,650 square miles. The country explored is all mountainous and chiefly of high elevations. Practically all land in the Railway Belt west of Revelstoke has now been examined by the Forestry Branch. Messrs, Robertson and Mills recommended that several tracts which were of high altitude, generally well timbered with Douglas fir, cedar, hemlock, white fir (balsam), and jack pine, and of no agricultural value on account of poor soil and the rough character of the country, should be set apart as forest reserves. No action has as yet been taken to that effect, however.

FIRE RANGING.

The fire patrol outside of the forest reserves covers the large extent of more or less forested land from the southeastern boundary of Manitoba through the northern part of Manitoba, Saskatchewan and Alberta, an extent of 205,344 square miles. It also covers most of the Railway Belt in the province of British Columbia. The patrol is carried out as fully as the appropriation will permit, but the large extent of territory involved makes the patrol for each fire ranger very large and the educative work done by the ranger is more effective than the actual work of extinguishing fires.

There were twelve fire-ranging districts, each under charge of a chief fire ranger. The districts and number of fire rangers employed were as follows:—

District.	Headquatters.	No. of Rangers.
Southern Manitoba	Winnipeg	8
Northern Manitoba	Norway House	16
The Pas	The Pas	12
Prince Albert East or Hudson Bay Junction	Hudson Bay Junction	12
Prince Albert	Prince Albert	18
Battleford	Emmaville	7
Edmonton	Edmonton	40
McMurray	McMurray	8
Great Slave	Fort Smith	2
Mackenzie	Fort Simpson	—
Revelstoke	Revelstoke	15
Salmon Arm	Salmon Arm	17
Coast	New Westminster	31
	Total	186

The number of fires reported was 511, and the total area burned over was 149,456 acres, of which over one-half was grass-land, so that the proportion of the forested area which was burned over was about nine one-hundredths of 1 per cent. The small extent of the area burned is due to the fact that the season was a favourable one in most districts, but it is evident also that the rangers have been doing more thorough work from the number of fires reported extinguished.

Campers, surveyors, and prospectors were the greatest individual causes of fires, and as these are ever changing and therefore the educative work of the rangers has little opportunity for effect, it is evident that a more intensive patrol will be necessary in dry years. Locomotives were the second greatest individual cause of fires, but with a more thorough organization of the patrol on railways which is being perfected each year, this source of danger should in time be controlled, and this would cover the several other causes of fires that occur along the railways.

Clearing of land by settlers is a third great cause of fire, and it is desirable that some change in the provincial Fire Act of the provinces of Manitoba, Saskatchewan, and Alberta should be made which would give a better control of this cause of fire, such as is given by the permit system for setting out fire under the British Columbia Fire Act.

I would call particular attention to the statement of the inspector of fire ranging that by far the greater proportion of fires started which are extinguished by our rangers result from the surrounding conditions of the woods as regards slash and débris. This emphasizes the fact that one of the most necessary preventive measures in regard to fire is to get rid of the débris and slash from lumbering operations, road-cutting or other work.

The patrol of the Peace river and Mackenzie river can best be carried on at the present time by steamboat, as the routes of travel and, therefore, the places of danger are along these waterways. They are both difficult of travel upstream by canoe, especially with the great distances to be patrolled, and it is advisable, if the timber, so important in these northern districts, is to be protected, that provision should be made for placing a steamboat on each of these rivers as soon as possible.

WOOD BISON.

The patrol for the protection of the herds of wood bison in the vicinity of the Great Slave river has been continued throughout the year, and a fair idea of the number in the herds has been obtained, although in a partially wooded country it is difficult to get any definite estimate of the herds, as they are easily stampeded and cannot be seen for any great distance. It is estimated that the number in the different herds may reach 500, and there is no indication that they are decreasing. The bison that were seen were in good condition, and food and shelter are plentiful, so that they may be expected to increase if protected from their enemies.

It was thought at one time that the Indians were killing off the herd, but no evidence can be found to substantiate the opinion, and the conclusion from several years' observation of the situation is that there is little, if any, trouble from this source. The penalty for killing the bison is severe, and moose and, in winter, caribou are plentiful, so that the temptation to follow the bison, which usually keep well away from the settlement, is not great.

Evidence was found that wolves were following the herds in some cases, but in only one case were there any signs seen of destruction by wolves. This was a case of a young bull who had evidently been separated from the herd. Wolves will not attack a herd, and as the young are usually kept in the middle of the herd and well protected it is not likely that there is great destruction from this source.

In such a large district with poor communications close protection cannot be given, but it seems safe to conclude that the herds are sufficiently protected so that they are increasing rather than decreasing and, if no serious accident occurs, there is no reason to expect that the herds will disappear. The most serious possibility of danger might be a general conflagration in the district, and the patrol of fire rangers, made as effective as the appropriation will permit, is designed to prevent the occurrence of such a catastrophe, as well as to assist otherwise in the protection of the bison herds.

REINDEER.

In accordance with instructions, Mr. E. H. Finlayson, Inspector of Fire Ranging, visited Fort Smith during last summer and looked into matters in connection with the reindeer herd at that place. As reported last year, after the stampede of the herd in the summer of 1911, only twelve of them were gathered together, and afterwards another was lost, which left the number at eleven.

This herd were brought down to Fort Smith in the spring and were kept there with the intention of taking them down to Hardisty island in Great Slave lake, which had been set apart, after inspection, as a suitable place for keeping the reindeer. Unfortunately, however, the department had no steamer of its own below the rapids at Fort Smith and none of the other steamers plying below could be secured to take the deer down. As a consequence, they were held at Fort Smith until the season when the flies became troublesome and on the 9th May this plague became so bad that the deer broke out of the place where they were confined by a fence and swam across the rapids of the Athabaska river. The rapids at this place are among the worst on the river and it was thought absolutely impossible that the deer could swim across. Eight of the deer swam across the river and scattered through the bush on the eastern side of the river. These were, however, all recovered later, and the herders gathered a large quantity of reindeer moss to supply the deer through the winter season.

Owing to the trouble that had been caused by the deer breaking away, they were put in a comparatively small enclosure for the winter with a good supply of reindeer moss. Before very long some of the deer became quite ill, and although the doctor at Fort Smith did all he could for them, seven died, leaving only four. It was decided then that possibly the close confinement was causing the difficulty, and the deer were allowed to run more openly with the result that the reindeer have continued in good health. It is the intention this spring to take these few remaining deer down to Hardisty island.

The time for which the two herders and the apprentice were hired on arrangement through Dr. W. T. Grenfell expired on the 1st September last, and as the herd was so largely reduced it was not considered necessary to retain all of these men. It was expected when the inspector went down to Fort Smith that this would be the case and he was given authority to make the best arrangements possible in the matter. After consultation with Mr. A. J. Bell, the Dominion Government Agent at Fort Smith, it was decided that it would be well to allow Mr. N. Geer, the chief herder, who had his wife with him, and who was anxious to return to Newfoundland, to do so, and that Mr. Wm. McNeill, the other herder, and Mr. John Broomfield, the apprentice, should be retained. An arrangement was therefore made with them to remain for a year further.

The result of the experiment in placing reindeer in this district is not satisfactory so far, as all that has been demonstrated is the difficulty of handling a herd in that district, though a better knowledge has been obtained of just what the difficulties are.

In the first place, it is quite clear that it is impossible to hold the reindeer in the summer in a place where the bull-dog flies are numerous, as they are in the bush country in the vicinity of Fort Smith. The caribou migrate south to that vicinity during the winter, but they all return to the north of Great Slave lake and the barren grounds in the summer, so that everything combines to lead to the conclusion that the reindeer cannot be held in that district for the summer. Of course the first endeavour was to demonstrate whether a herd could be kept by the ordinary method of herding which is followed in Lapland and Newfoundland without close confinement, as this is the only way in which a herd could be made a success in a general way anywhere. The experience shows that this is not possible the year round under the conditions existing south of Great Slave lake, and there is nothing to be gained by making any further effort in that direction.

As stated, during last winter the experiment was made of holding the herd in rather close confinement, and this has not turned out well, as close confinement and an exclusive diet of reindeer moss does not seem to be wholesome.

As to the future of the herd, it is proposed, as stated, that the reindeer should be taken down to Hardisty island in Great Slave lake during the coming season. This island is in an exposed situation in the lake and is fairly open, and it is expected, therefore, that the fly pest will not be so serious as on the mainland, while the deer are not so likely to leave the island as they are to break away from enclosures on the mainland, even if the flies should become troublesome.

Unless some addition is made to the herd, however, the experiment cannot be considered other than a failure, and three courses are open to be taken in connection with the matter.

1. The experiment might be abandoned altogether. Since so much expense has already been incurred in connection with the herd, and it is demonstrated that during winter they would be of great value for travelling purposes in the district, I think it is desirable the experiment should be carried out to a further extent. The Government of the United States lost heavily on the first shipments of reindeer to Alaska, and much more heavily than the Canadian Government has suffered with this shipment. If the reindeer can be held satisfactorily on Hardisty island in Great Slave lake during the present season it will demonstrate that we have overcome the main and only difficulty so far experienced, and will give very good hope that the keeping of reindeer may be made a success in that district.

2. An effort might be made to obtain some young caribou and cross them with the reindeer. There seems to be no reason why this might not be carried out satisfactorily, and an effort will be made to obtain some of the caribou. The Indians have

promised to assist in this, although owing to certain superstitutions in regard to the caribou it is a question how far they will be prepared to go. It is possible, however, that some of the caribou may be obtained by the reindeer herders after the deer are taken down to Hardisty island.

3. Another shipment of reindeer might be obtained from Dr. Grenfell, and if no success is obtained in capturing the caribou and crossing them with the reindeer I would consider it advisable to do so, as I am sure that the use of the reindeer can be finally made a success in that district. It would not be advisable, however, to consider undertaking another shipment until we have the result of this year's experience with the deer on Hardisty island. As the flies are the worst during early summer, we should have full information in regard to the matter before the season is over.

FOREST PRODUCTS LABORATORIES.

A small appropriation was provided for beginning the work of the Forest Products Laboratories, and arrangements were therefore undertaken for organizing the work.

The location of the laboratories was the first question considered, and at this time McGill University offered to place its timber-testing laboratory at the service of the department and to furnish office accommodation for the staff. It was decided that it would be advisable to accept this offer and to locate the laboratories in Montreal in connection with McGill University for the following reasons:—

(1) That the complete and costly equipment of McGill University for timber-testing would be available without cost, thus saving largely in the expenditure for equipment.

(2) That the advice and assistance of the staff of McGill University would be available for the development of the work.

(3) That Montreal is the main business centre for pulp and paper, the railways and other industries, investigations in connection with which will form some of the most important that will be undertaken.

The arrangement with the authorities of McGill University does not involve any grant to the university, and the only obligation assumed by the department is to permit of the staff of the laboratories delivering occasional courses of lectures and to allow the students doing special investigations at the university the use of the laboratories and the assistance of the staff. On the other hand, the university has undertaken to allow the use of its apparatus to the department and is at present providing accommodation for the laboratories and the staff. It also gives the advice and assistance of the professors in charge of the departments that relate to the work of the laboratories without charge. The university, therefore, is making a most generous contribution to the establishment of the laboratories.

The second consideration was to obtain a superintendent for the laboratories, and, after consultation with the authorities of McGill University and others, the position was offered to Mr. A. G. McIntyre, B.A., B.Sc. Mr. McIntyre graduated in arts from Acadia College, Wolfville, N.S., and in chemical engineering from McGill University. He has given special attention to research work in pulp and paper when at the university, and had some practical experience in such work in connection with pulp-and paper-mills. He was editor of the Canadian Pulp and Paper Magazine and had also organized the Canadian Pulp and Paper Association, of which he was secretary. In order to ensure that the laboratories would be organized on a proper basis and that the plans for the research work would not merely duplicate work already done elsewhere, it was arranged that Mr. McIntyre should visit the Forest Products Laboratory of the Forest Service of the United States at Madison, Wisconsin, and study the methods followed there and the investigations which had been undertaken. As a result of this study it will be arranged that:

(1) The Canadian laboratories will not duplicate work done by the Forest Products Laboratory of the United States, the results of which are applicable to Canadian conditions.

(2) The methods followed in general by the United States Forest Service will be followed here, and a similar system of record will be established, so that results obtained in Canada may be directly comparable.

(3) The initial mistakes necessarily occurring in the establishment of any new enterprise may be largely avoided by profiting by the experience of the United States.

In this connection I wish to express my appreciation of the courtesy shown at all times by the officials of the Forest Service of the United States and the readiness with which they were prepared to furnish information at any time.

After a careful study of the organization of the Forest Products Laboratory of the United States the following scheme of organization for the Canadian Laboratories was recommended, and, as it has been approved, is now being carried into effect. The divisions of the organization proposed are as follows:—

1. General staff, including clerical work, records, library, and maintenance.

It is of the utmost importance in work of this kind that the records should be complete and kept well up to date. Unless this is the case, the results of work done and the expenditure in connection with it may be wholly lost. The value of experimental work lies largely in its comparability with other experiments or with practical conditions, and comparison can be made only when all the conditions of an experiment are recorded so as to be available in definite form.

A good library, well indexed, dealing with the special subjects taken up in the laboratories, is a necessary part of the equipment. Through the kindness of the authorities of McGill University the library of the university will be available for the staff of the laboratories, but the special nature of the work of the laboratories is not covered fully enough by any general library and must be supplemented by a special library.

Maintenance, which here includes construction, design, and computation, requires special consideration. The equipment, being for the purpose of developing experiments, must be in many cases specially designed by the staff. The computation of results will also require a trained staff and careful and accurate calculations.

2. *Timber Physics.*—This division will investigate the physical properties of woods so as to know the intimate structure, the fibre, the specific gravity. A knowledge of the fundamental characteristics is necessary to all other investigations that may be made as to the usefulness of wood for various purposes, so that the work of this division is primary, and as it involves comparatively little equipment it has been organized at once under charge of Mr. W. B. Campbell, B.Sc.

3. *Timber Tests.*—This covers the testing of the mechanical properties of wood. such as strength, bending, elasticity, etc., and is particularly needful in connection with timbers required for structural purposes. The equipment at McGill University makes it possible to begin this work immediately, and shipments of Douglas fir timber from British Columbia and Alberta have been obtained for the purpose of conducting a series of tests of this timber. Tests will be made on small, clear specimens of the timber so as to get as nearly as possible an absolute factor, and will also be made on timbers in the form in which they will be in actual use in construction. This division is in charge of Mr. R. W. Sterns, B.Sc.

4. *Pulp and Paper.*—The pulp and paper industry is one of the largest and most rapidly developing industries of Canada, in spite of the fact that over one-half of our pulpwood product is exported to the United States unmanufactured. It may be confidently expected that Canada will become the greatest paper-manufacturing country in the world with the stores of raw material available. Anything that will tend to eliminate waste or improve the methods of manufacture will assist towards that end. A number of important problems will be taken up and investigated as soon as the necessary equipment can be secured.

The Superintendent of the Forest Products Laboratories has made exhaustive inquiries to determine the best equipment in pulp and paper machinery. The following men of expert knowledge of pulp and paper machinery were consulted by him: Mr. Arthur Hastings, President American Paper and Pulp Association; Mr. John H. Thickens, expert for the Beaver Companies of Buffalo, and director of the Beaver Laboratories, and formerly in charge of the United States Government Experimental Station at Wausau, Wisconsin; Mr. I. H. Weldon, President St. Lawrence Paper Mills, Company, Toronto; Mr. Carl Riordon, President of the Canadian Pulp and Paper Company of Montreal; Mr. J. A. De Cew, Consulting and Mechanical Engineer in pulp and paper, Montreal; Mr. R. O. Sweezy, Manager, Montreal Engineering Company; Mr. Howard F. Weiss, Director Forest Products Laboratory, Madison, Wisconsin; Mr. McGarvey Cline, past Director and Organizer, Forest Products Laboratory, Madison, Wisconsin, now manager of a seven million dollar mill being erected at Jacksonville, Florida. All other possible information was obtained both as to machines in Europe and the United States, and a recommendation which has now been submitted as to the proper machine which should be purchased is the result of the recommendations and suggestions of all these authorities combined and should furnish a machine that will be as fully capable of the work required as it is possible to obtain at the present time.

In charge of this branch of investigations will be Mr. John S. Bates, Chem. E., Ph.D., who has had considerable experience in pulp and paper investigations, having just concluded a special study of the southern pine of the United States in this relation.

While no other divisions of the work will be developed at the present time it is hoped later on to take up other lines of investigation. These would include studies of the fungi and other agencies destructive to wood and of preservatives and methods of preservation. The necessity for reducing waste by prolonging the life of ties, paving blocks and structural timber makes such investigations of great value. The chemical contents of the woods should also be investigated and the methods and results of wood distillation.

Respectfully submitted,

R. H. CAMPBELL,
Director of Forestry.

APPENDIX No. 1.

REPORT OF THE CHIEF OF THE TREE PLANTING DIVISION.

Indian Head, Sask., March 31, 1914

R. H. Campbell,
Director of Forestry,
Ottawa, Ont.

Sir,—I have the honour to submit herewith my thirteenth annual report, dating from March 31, 1913.

General conditions affecting tree-growth throughout the west for the past season were on the whole favourable for established plantations, but in the case of new plantings, the spring and early summer months were too dry in most localities. This resulted in a percentage of loss rather larger than the usual average in the case of seedlings, and a very considerable loss in the case of cuttings. In the latter, failures to the extent of 50 per cent were found in several localities where the lack of precipitation during spring was most marked. Rainfall during late summer was rather above the average and resulted in a good growth where plants and cuttings survived the preceding dry weather.

General interest in tree planting is still maintained; especially are farmers now paying more attention to ornamental planting of shrubs and establishing lawns, etc., in connection with the shelter-belts set out under our co-operative system. We have received numerous requests during the past season for plans suggesting the arrangement and laying out of ornamental grounds around farm houses. Although the furnishing of such landscape plans cannot be looked upon as exactly coming within the scope of our work, we have still endeavoured to furnish such plans when time has permitted. This office cannot however, hope to do much work of this nature unless there is added to the staff someone familiar with landscape gardening and horticultural conditions in the west, and also capable of draughting suitable planting-plans. There is no doubt that much general good to the country would be derived if the beautifying of the farm home could be more widely encouraged; but whether that can be looked upon as a legitimate branch of the work of the Tree Planting Division, and developed as such, is a matter worthy of consideration.

Data in connection with the general distribution work of this Division are shown in the tables given hereunder. It will be noted that there is a slight reduction in the number of new applications received this winter. I do not consider, however, that this is any indication of a lack of appreciation of the work of this division, but may be attributed to three causes. The first is a lack of sufficient advertising. The date up to which applications will be received has been set as March 1 in each year. The usual advertisements calling attention to this fact appeared in the farm papers only five or six weeks prior to this date. Then, too, the advertisements are not conspicuous enough to attract general attention. I think that far better results would be obtained if quarter or half-page advertisements could be used for a short time, suitably illustrated and accompanied with well-worded texts calling attention to the advantages of planting, the benefit to the farmers, etc. The small advertisement at present used is more than likely to be overlooked by the average subscriber.

Secondly it is now becoming more generally known that the branch will not furnish trees unless ground has been put in the best state of cultivation, and the tendency is for farmers not to send in applications if they cannot see the way to getting their land sufficiently worked to meet the requirements. In this connection it may be noted that 10 per cent more of the new applicants last year had their ground ready for planting than was found to be the case with new applicants of the previous season.

The third reason accounting for a reduction in this spring's applications is the general scarcity of money during the past season and at the present time. Several communications have been received stating that lack of funds is the main cause in certain cases for applications being withheld.

On reference to table No. 1 it will be noted that the total number of trees to be shipped out this spring is about 235,000 in excess of last season's figures. This does not include shipments of evergreen stock, which will total about 100,000 more, to be sent to some 375 applicants not included in the figures in table No. 1.

Table No. 1 gives a comparative statement showing the numbers of trees distributed annually since 1910, also the number of applicants on the lists, etc.

TABLE I.—Table of Comparative Data for distribution of Deciduous Stock.

Class.	1910.	1911.	1912.	1913.	1914.
Number of applicants on inspection list	8,318	8,036	7,375	6,987	7,350[1]
Number of applicants receiving trees	3,173	3,285	3,618	3,536	3,585[1]
Number of trees and cuttings distributed (not including conifers)	2,533,600	2,636,100	2,729,135	3,495,375	3,729,765[2]
Average number of trees per applicant	798	721	626	988	1,008[1]
Number of new applications received	3,832	2,656	1,649	1,899	1,559[1]

[1]Compiled March 31, 1914. The figures will be slightly altered when the 1914 lists are completed.

[2]The difference between this figure and the total number of trees allotted on Table III is accounted for by the addition of 113,500 trees which are to be shipped to the nursery station at Saskatoon, Sask.

INSPECTION WORK.

The following inspectors were employed during the past season: Messrs. A. P. Stevenson, Angus Mackintosh, James Cowie, Wm. Macdonald, Geo. Kennedy, Wm. Kynoch, Donald Macdonald and James Craig. The last two were engaged for the first time this summer; both had previously been employed on the nursery at Indian Head, and were thoroughly familiar with the species and methods of cultivation suitable for prairie conditions. Prior to their engagement on the nursery station, both men had spent several years in practical forestry work on large estates in Scotland.

Tables Nos. II. and III. show in detail the districts covered by each inspector, the number of applicants on each man's list, the number of trees allotted, etc.

TABLE II.—Table of Classification for 1914 Distribution.

Class.	A. P. Stevenson.	Angus Mackintosh.	W. Macdonald.	James Cowie.	Geo. Kennedy.	Wm. Kynoch.	James Craig.	Don. Macdonald.	Totals.
Number of applicants on inspection list	498	534	717	1,085	1,019	849	911	1,374	6,987
Number of applicants who had received trees	331	350	475	642	675	515	427	717	4,132
Number of applicants who had not received trees	167	184	242	443	344	334	484	657	2,855
Number of applicants receiving trees in 1914	247	165	444	514	477	423	474	841	3,585
Old applicants receiving trees in 1914	147	61	256	239	245	210	174	522	1,854
New applicants receiving trees in 1914	100	104	188	275	232	213	300	319	1,731
Number of applicants not receiving trees in 1914	251	369	273	571	542	426	437	533	3,402
Old applicants not receiving trees in 1914	67	80	54	168	112	121	184	338	1,124
New applicants not receiving trees in 1914	184	289	219	403	430	305	253	195	2,278
Number of plans drawn up to Feb. 20th	177	143	389	490	359	345	473	733	3,109

NOTE.—There will be a slight alteration of the above figures before the 1914 shipping list is completed on account of cancellations and additions to be received after the date of the compilation of this table Feb. 20, 1914.

TABLE III.—Table showing Distribution of Trees in relation to Districts, 1914.

Inspector.	District.	No. of Men on List.	No. to Receive Trees.	No. of Trees Allotted.	Average. No. of Trees per Applicant.
A. P. Stevenson	Central and Southern Manitoba	498	247	191,840	817
A. Mackintosh	Central Saskatchewan, G. T. P., Yorkton Branch and Pheasant Hills Branch, C. P. R. east of Saskatoon	534	165	167,425	1,014
Wm. Macdonald	Southern Saskatchewan West to Assiniboia	717	444	462,700	1,042
G. Kennedy	Northern Manitoba and Saskatchewan	1,019	477	581,625	1,220
J. Cowie	Southern Alberta	1,085	514	522,025	1,015
Wm. Kynoch	West Central Saskatchewan	849	423	395,000	934
J. Craig	Northern Alberta	911	474	481,725	1,016
D. Macdonald	Main Line, C. P. R., in Saskatchewan	1,374	841	813,925	968
*Distribution for 1914: Totals		6,987	3,585	3,616,265	1,008 average.
" " 1913: Totals		7,617	3,519	3,449,952	980 average.

[1]NOTE.—Above figures will be slightly altered on account of supplementary shipments and cancellations, subsequent to date of above table (March 1, 1914).

Following is a summarized report of the conditions in the various inspection districts:—

District covered by A. P. Stevenson.—Plantations visited during 1913 would compare favourably with other years. On account of the extreme dry weather in early spring in the eastern portion of Manitoba the young plantations did not do as well as those in the western part. The older plantations were all looking fine with the exception of a few into which brome grass had got a foothold. These were in rather poor shape. This pest of trees is much on the increase, especially in the older plantations, and its evil effects are soon noticed. The trees show an unhealthy, decrepit appearance, the leaves fall early and little or no growth is made. The seed blows in among the trees usually from the adjoining fields, but is often introduced in manure that is spread among the trees, and it appears to be a difficult matter to convince planters of the danger of this practice. They mulch to keep down weeds and often introduce the worst of all weeds. One or two hailstorms did some damage among the one-year trees, but this was only locally, and the damage was not much more than in other years from this cause.

District covered by Angus Macintosh.—Manitoba boundary to Saskatoon, Yorkton branch, Canadian Pacific railway, Qu'Appelle valley on the south to the Big Quill lake and Yorkton districts on the north—mileage covered during summer, 3,880 by team and 1,790 by train. The season was favourable to tree-growth, failures being only 7 per cent. The greatest loss was among the willow cuttings. In the new plantations the average growth ran as follows: Maple, 6 to 15 inches, ash, 4 to 9 inches, Russian poplar, 9 to 24 inches, willow, 12 to 24 inches. Evergreens were doing splendidly; 6 per cent would cover all losses. Annual growth ran as follows: Spruce, 3 to 5 inches, jack, lodgepole, and Scotch pines, 4 to 8 inches. Winter-killing was not as conspicuous as in past seasons. The old plantations, as a rule, have made a good growth and have been properly cared for.

District covered by William Macdonald.—Southern Saskatchewan, south of the main line of the Canadian Pacific railway from the Manitoba boundary, west to Assiniboia and Moosejaw. Among the 1913 plantations, maple and ash showed 2 per cent failures. The cuttings were not as good as in the season of 1912. Losses ranged from 50 to 30 per cent, due to the dry weather in the spring and early summer. Considerable winter-killing of maple and willow occurred from range 20, west of the second meridian, to range 2, west of the third meridian. Small branches and tips were affected, but the new growth was good, and the trees recovered from the above-mentioned injury. Some neglected plantations were seen along the Arcola-Moose Mountain section of the Canadian Pacific railway; these were due to the large number of farms in this section which have changed hands during the past year. The snowfall for the winter of 1912-13 was slight, and the spring of 1913 dry—conditions not favourable for tree-growth. Considerable hail-damage was found in the Willow Bunch country. Evergreens were doing very well, with 5 per cent loss on the average. They came through the winter with slight or no injury. Spruce is more in favour than pine, on account of its dense, compact appearance.

District covered by George Kennedy.—Saskatchewan, north of the main line of the Canadian Pacific railway except Yorkton and Pheasant Hills branches and part of Northern Manitoba. The 1913 plantations were made under favourable conditions, but dry weather followed, giving an average of 25 per cent failures with cuttings. The 1912 plantations were extra good and healthy, showing large annual growth, with 25 per cent failures. The older plantations, as a rule, require no further cultivation, and are making good headway. Drought was not as injurious in this district as in other parts of the west. There was little or no winter-killing. The largest and best plantations were found in the district west of Saskatoon. All species distributed are adaptable to this district. Maple shows the largest annual growth when young. Evergreens make excellent growth; the failures would average 5 per cent. The instructions supplied by the Forestry branch have been followed.

District covered by James Cowie.—Southern Alberta, including the main line of the Canadian Pacific railway from Dunmore Junction to Cochrane. The 1913 plantations showed 5 to 10 per cent loss in seedlings, and 35 per cent loss in cuttings, very little rain having fallen during the spring and early summer. The failures were much less in irrigated districts. Among the 1912 plantations the best showing was made by ash, Russian poplar, and caragana. Winter-killing of maple, cottonwood, and willow was conspicuous; these species have not made successful headway. The winter killing was most evident along the foot-hills country and in dry belts. In the Monarch district a species of blister beetle had done considerable damage to the young wood and leaves of the caragana, and in several other districts the willows had been attacked by a caterpillar. In the fall the plantations seemed to have ripened their new wood and were in a healthy, hardy condition to withstand the winter. Evergreens on the whole have been very successful, showing 3 to 5 per cent of loss. All species planted are apparently suitable to Alberta conditions.

District covered by William Kynoch.—Central Saskatchewan west of Saskatoon: The 1913 plantations were rather backward in starting growth. The spring was cool and dry, and the average loss among cuttings was 15 per cent. The 1912 plantations averaged 10 per cent failures. Freezing back was noticed in the cottonwood, maples, and willow. The older plantations were healthy and well established. On every variety of soil, encountered in the district, thoroughly successful plantations were seen, and in practically every case where the instructions of the branch as to the planting and subsequent treatment were carried out satisfactory and encouraging results followed.

District covered by James Craig: Northern Alberta.—The 1913 plantations as a whole made a good start, the greatest loss being among cuttings. The loss among the maple and ash was 5 per cent, among cuttings 25 per cent. The older plantations are well established. Few plantations in this district were planted prior to 1911. There were a few instances where maple and willow were frozen back, and a few plantations suffered from hail-storms. The evergreens were doing very well. The varieties which have been supplied are suitable to soil and climatic conditions. As a rule, proper cultivation and attention have been given to plantations.

District covered by Donald Macdonald: Main line Canadian Pacific railway in Saskatchewan.—The 1913 plantations have made good growth, showing 5 per cent loss in maple and ash, and 25 to 30 per cent in cuttings. Among the 1912 plantations some winter-killing was found in districts south of Moosejaw, but was not so conspicuous farther west. There was a good annual growth in 1913. The older plantations close to the main line give evidence of successful tree-planting on the prairies. Some damage was done in the south country through hail-storms. On the whole, plantations were well cared for and farmers showed a great deal of interest in tree-planting.

OFFICE WORK.

The work of preparing planting plans and compiling the distribution lists and the inspectors' lists for the coming summer is taken up in the office during the winter months. This work is carried on under the immediate supervision of Mr. S. S. Sadler, with the assistance of five of the inspectors.

The following tabulated statement of plans prepared and correspondence handled shows a small increase for 1913 over the previous season:—

	April 1, 1912, to March 31, 1913.	April 1, 1913, to March 31, 1914.
No. planting plans prepared	3,000	3,109
No. pieces mail received	14,161	14,387
No. pieces mail sent out	21,466 (inc 3,000 plans "franked").	21,122 (inc. 3,109 plans "franked").[1]
No. new files added	2,943	2,598

[1]This does not include bulletins, these being sent out from the office at Ottawa.

EXHIBITS.

An exhibit was prepared for the Dominion Fair held at Brandon during early August. This exhibit was prepared by Mr. Sadler, and consisted of an inside collection of native woods, tree-seeds, photographs, etc., and also an outside demonstration plot, part of which is planted permanently to certain varieties of the hardy conifers and a few ornamental shrubs, the other part being laid out to illustrate a small nursery plot such as would meet the requirements of an individual farmer. On this plot are small seeed-beds of the best conifers, showing seedlings one and two years old, and also transplants of three and four years old. There were also nursery rows showing propagation of maple and ash from seed, as well as poplar and willow from cuttings.

NURSERY WORK.

Results on the nursery during the past summer have been very satisfactory. Although the spring was somewhat dry, no bad effects were apparent in the germination of seed or growth of stock. The late summer was rather exceptionally wet, and this resulted in more than the average amount of lost time, and considerable difficulty in keeping down weeds. All stock matured well. Owing to an exceptionally early freeze-up we were prevented from digging some 5 acres of maple seedlings and a large plot of tamarack. The maples will have to be carried over for another season. The tamarack, however, will be lifted in the spring, as they would be too large to handle if left for another season's growth.

Areas devoted to the different varieties of stock were as follows:—

	Acres.
Broadleaf—	
Maple seedlings, 1 year old	28½
Ash seedlings, 1 year old	25
Ash seed'ings, 2 years old	20
Caragana seedlings, 1 year old	5
Willow-cutting stock	5
Russian poplar-cutting stock	2
Conifers—	
Transplants	9
Seed-beds	¾
Total	95¼
Seed sown in fall of 1913—	
Maple	10¼
Ash	21
Caragana	5½
Total	36¾

The following stock is available for distribution this spring (1914):—

Deciduous Stock—		
Maple (1-year seedlings)	1,445,000	
Ash (2-year seedlings)	1,240,950	
Caragana (seedlings)	233,425	
Russian poplar (cuttings)	203,000	
Willow (cuttings)	690,225	
Tamarack (4-year transplants)	38,690	
Siberian larch (4-year transplants)	8,800	
		3,860,090
Evergreen (not actually dug, but a close estimate)—		
Scotch pine (4-year transplants)	17,556	
Jack pine (4-year transplants)	15,982	
Lodgepole pine (4-year transplants)	48,775	
White spruce (5-year transplants)	37,955	
Colorado spruce (6-and 8-year transplants)	1,963	
Norway spruce (5-year transplants)	5,688	
Bull pine (4-year transplants)	3,457	
Flexilis pine (5-year transplants)	294	
Concolor fir (5-year transplants)	1,261	
		132,931
Grand total		3,993,021

This total is about 100,000 less than that available last season, but had we been able to lift the 5 acres of maple referred to above it would have increased the present total by some 400,000.

A considerable proportion of the above stock will be needed this spring for planting on the new nursery station at Sutherland, Sask.

COLLECTION OF SEED.

The past season was a poor one for seed collection. No seed of ash and maple could be secured in quantity in Saskatchewan. Search for maple and ash seed was made in many districts in Manitoba, but Brandon seemed to be the only place where large supplies could be collected.

The following seeds were collected:—

	Weight in Pounds.
227 bags maple seed at Brandon	3,446
9 " " near Indian Head	198
10 " ash seed " "	200

Cones were also collected as follows:—

36 bushels jackpine.
47 " lodgepole pine.

CONIFERS.

Seed-beds.—Three thousand six hundred square feet of new seed-beds were sown, principally of white spruce and Scotch, lodgepole and jackpines. Including two and there-year-old seedlings there were altogether 10,000 square feet of seed-bed of all ages. The stands of seedlings throughout are uniformly good, and the stock shows good growth.

Transplants.—The following seedlings were moved to the transplant plots:—

Scotch pine	77,924
Lodgepole pine	49,872
Jack pine	54,524
White spruce	240,797
Black spruce	3,504
Douglas fir	3,175
Magnus pine	500
Juniperus sabina	200
Total	430,496

Altogether, 9 acres were devoted to transplants of all ages up to 5 years.

EVERGREEN DISTRIBUTION.

Seventy-four thousand four and five-year transplants were dug in the spring of 1913 and the greater part of these were shipped out. A small number was used in the plantations at the Nursery Station and for lining out to be grown on with a view to having some larger stock to plant on the Saskatoon nursery in 1914. Forty-two shipments were made to Manitoba, 188 to Saskatchewan and 40 to Alberta,—a total of 270 lots made up of from 100 to 500 plants each.

Reports regarding the success of these evergreens are particularly encouraging, not more than 6 or 8 per cent of the trees having been lost. In some cases the planters report no deaths at all, and in others only one or two out of 500. Only one or two odd reports were received showing a much larger loss, and undoubtedly in such cases failures may be attributed to bad handling or planting on unfit soil. The pines will not stand planting on soil that has the least trace of alkali. Spruce is not so easily affected. Unfortunately, the unsuitability of the soil may not be apparent until some months after planting, when the needles of the pines commence to turn a greenish yellow or light-yellow colour. If this is noticed in time the plants may be saved by moving them to soil free from alkali.

The distribution of evergreens was commenced in 1912. The trees sent out stood the winter well, and favourable reports have been received as to their second season's growth. Undoubtedly the hardy coniferous evergreens when once established, are better suited in every way to prairie conditions than are the ordinary deciduous varieties, the only drawback being that the expense in connection with their propagation makes it practically impossible to turn them out in anything like the large numbers of the deciduous stock that are handled.

PERMANENT PLANTATIONS.

The permanent plantations, now aggregating nearly 100 acres, showed excellent growth during the past season. The plantations of Scotch pine set out in 1906 are a particularly valuable demonstration as to the possibilities of this variety for shelter-belts on the prairies. The tamarack, too, continues to make splendid growth. The first plantation of this variety set out in 1903 on backsetting now stands 20 feet high. In connection with some ornamental planting it was necessary last fall to cut out a dozen or more of these tamaracks which were encroaching too much on some white spruce. Several of these trees cut up into quite serviceable 7-foot posts, running from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in diameter at the tops.

The possibility of growing fuel has been practically demonstrated in connection with plantation No. X, a three-quarter-acre plot of Russian poplar. This plot was set out in the spring of 1906 on backsetting, broken in the spring of 1905, and extra well worked. The stock used was one-year rooted cuttings of *Populus certinensis* and *Populus Petrovski* in about equal proportion, spaced 4 feet apart each way. The growth of this plantation was rapid from the very start. Cultivation was continued during 1906 and 1907, but no work was needed after that as the trees then covered the ground, making further cultivation unnecessary.

In 1909 and 1910 some heavy pruning was done to get stock for cuttings which we were short of in those seasons. This seemed to be rather injurious to the trees, as in 1911 and 1912 the usual canker made its appearance. I think that the cutting of the limbs induced this canker to develop earlier than it otherwise might have done by providing wounds where spores could readily enter the tissues, for although the Russian poplar always shows this disease sooner or later, it does not as a rule develop until the tree is at least ten years old.

Last summer this canker seemed so general in the plantation (in many cases weakening the trees to such an extent that the main trunk would break off at the diseased point), that it was decided to cut half of the plot. The other half was left in order to see just how much injury the canker would cause later on, and the cut-over portion was allowed to sprout again and form a second growth which may or may not show evidences of the disease.

The results of the cut portion show without any possibility of question the feasibility of the prairie farmer growing his own fuel. From three-eighths of an acre were cut and piled 6¾ cords of very fair fuel, the sticks averaging from 6 to 8 inches in diameter. This, on an acreage basis, means a yield of 18 cords per acre. Poplar cordwood sells locally at from $4.50 to $8 per cord delivered, the price depending upon quality. The wood cut in this plantation is at least equal to the poorest quality sold. and would therefore show a gross acreage yield of $81 after eight seasons' growth.

The figures in connection with the labour cost of establishing this plantation, and, later, cutting and cording, calculated on an acreage basis, are as follows:—

1906, planting and cultivating, $15.20 at 5 per cent, 7 years. .	=$21.35
1907, cultivating, $9.05 at 5 per cent, 6 years	= 12.13
Fall 1913, cutting and cording, ...	= 46.93
Total	$80.41

In this particular case then the yield of this plantation would show a return of slightly more than 5 per cent on the actual labour expended. As against rent of land, cost of stock, etc., can be placed the value of the plantation in the meantime as a shelter and as an ornamental feature: also the value of cuttings taken off during this period at various times to extend the plantations. In this case several thousands of cuttings were taken off in 1909 and 1910,—about 30,000 in 1909, and 20,000 in 1910. These are worth at least $1 per thousand, being quoted commercially at from $2 to $4. This would mean $50 which should properly be credited to three-quarters of an acre (the actual size of the entire plantation).

To give an idea of the growth in this plantation, the following measurements taken in the fall of 1912 are submitted:—

Average height 21 feet 2 inches, maximum height, 25 feet 11 inches.
Average new growth, 2 feet 1 inch, maximum new growth 2 feet 7 inches.

Considering these figures as applied to an average farm plantation we believe that the establishing of an acre of trees would not necessarily add a single dollar of actual cash paid out in wages, as the planting and cultivating would be done at convenient times with the ordinary labour of the farm. Figures submitted above for cutting and cording are very high; first, because great care was taken to cut the wood the exact length and cord it accurately so that there might be no mistake as to the actual yield; and second, because the cost of clearing up and carting off all brush and tops is included.

I do not, on the strength of this result, recommend the Russian poplar as the variety to be used in every case for fuel production. Neither does the fact that this particular lot was cut after eight seasons mean that this is the most profitable time to cut, though in this particular instance it may have been. Had the plantation been in a good thrifty condition and not affected by canker there would have been no cutting till the trees had attained larger size. The figures, however, show the possibilities in connection with the growing of fuel in a very short time.

There are at the nursery station several other plantations of other varieties, such as maple, cottonwood, birch, tamarack and willow, all of which indicate that a good return from fuel may be expected in a comparatively short time.

I am, however, personally of the opinion that the Russian poplar under average conditions will give quicker results in the shortest time for the least expenditure.

New Plantations.—The following new plantations were set out in the spring of 1913:—

Norway poplar and Manitoba maple in equal mixture, 2¼ acres.
Russian poplar and Manitoba maple in equal mixture, 6¾ acres.
Red or Russian laurel willow and maple in equal mixture, 3 acres.

The Norway poplar is a variety of comparatively recent introduction. It is evidently a horticultural variety of the common cottonwood (*Populus deltoides*). It, however, grows very rapidly, resembling very much the Carolina poplar in habit and leaf. We have only had this variety a few years, having got our first stock of cuttings four years ago. The growth has been so far extraordinarily vigorous, and though there are signs of slight winter-killing, this variety appears hardier than the Carolina poplar. The growth, however, is so rapid that this variety may prove quite valuable as a fuel-producer in districts where it will not winter-kill too severely.

Of the red or Russian willow mentioned I do not know the exact botanical designation. Cuttings were obtained from John Caldwell, of Virden, Manitoba, about six years ago. This willow is sold by him as the red willow. This is quite distinct from the golden willow, acute-leafed willow, or common laurel willow. The growth is extremely vigorous, much more so than the other varieties mentioned, and the tree seems quite hardy.

The cottonwood (*Populus deltoides*) has shown itself quite unsuited to planting in pure stands on the soil here. The soil on the nursery might be classed as a medium light clay loam with clay subsoil. The soil on the Experimental Farm is a heavy clay, and here the cottonwood seems to thrive very much better. However, even on the heavier soils I think it would always be advisable to plant cottonwood in equal mixture with Manitoba maple. A 3-acre plantation of cottonwood set out in 1908 had to be rooted out last season, as a very large proportion of the trees failed to live, and those that did survive did not appear to be in a thrifty condition. In some seasons the cottonwood is badly affected by a leaf rust, which evidently weakens the tree to a very marked extent. Apparently this rust is more prevalent on the lighter soils, or so it would appear from our observations. There is on the nursery a very thrifty plantation of cottonwood and maple set out in 1906, mixed in equal proportions, while immediately adjoining, and planted on the same day under exactly similar conditions, is another plot of pure cottonwood in a most unthrifty condition. In the former case there is a fine ground-cover and no possibility of any weeds or grass coming up under the trees, while the belt itself is a dense wind-break. In the second plot there is now a heavy growth of grass and weeds, and although about 50 yards wide, the belt is practically useless as a shelter from the wind.

ORNAMENTAL GROUNDS.

The lawns, shrubs, and border plantings surrounding the buildings made a fine appearance during the growing season. A small addition to the ornamental planting was constructed last spring in connection with the new boarding-house recently erected.

GENERAL FARM WORK.

The usual grain and hay crops were grown to supply feed for the horses. An additional 33 acres of new land was broken and backset on the southern quarter and about 35 acres of summer-fallow ploughed and kept in cultivation. There are still about 80 acres unbroken, but this is so rough, scrubby, and cut up with bluffs and sloughs that clearing and breaking will be a slow and comparatively expensive work.

We have now approximately 400 acres under cultivation, made up about as follows:—

	Acres.
Permanent plantation and shelter-belts	100
For propagation of nursery stock	117
Crop land, hay, summer-fallow and pasture	100
Ornamental grounds, variety plots, roads and waste land in coulee and dam	83
	400

SUTHERLAND NURSERY.

Work was commenced on the land at Sutherland to put it into shape as soon as possible for the production of nursery stock. This nursery contains 320 acres, which at time of purchase in the spring of 1912 was all in stubble. As no buildings could be erected that season it was decided to have the land summer-fallowed by contract. Unfortunately, this was not done until very late in the season, and as a consequence the land got in a very dirty condition, being very badly overgrown with couch grass and wild roses, beside the usual annual seeds. The couch grass, however, was the worst feature, and the late summer-fallowing was not at all effective in getting rid of it.

In the spring of 1913 the necessary horses and equipment were purchased, and, as no buildings had yet been erected, the teams and men had to be housed in the village of Sutherland, some three-quarters of a mile from the south boundary of the nursery.

The work has so far been carried on under the direct supervision of Mr. W. B. Guiton as Acting Superintendent. Some 14 acres of ash seed were sown on what appeared to be the cleanest portion of the land in the spring and about 5 acres of cutting stock of Russian poplar and willow were also planted. The dry spring and the rapid growth of the couch grass resulted in practical failure of these first attempts, and later in the season it was thought advisable to thoroughly plough the land to eradicate the grass and give up any hope of growing stock under such adverse conditions.

Some 22 acres were seeded down to grass for hay in 1913, and 22 acres sown to oats for feed; about 10 acres adjoining the stables were also sown to permanent pasture.

During the summer all the remaining ground on the south quarter was thoroughly summer-fallowed and constantly worked, so I trust that all grass and roses will have been eradicated.

The main drives and cross-roads were marked out and roughly graded.

In the fall, about 20 acres more of ash seed was put in. The construction of the buildings was commenced by the Department of Public Works, but much delay was occasioned owing to no tenders being received, so that later it was decided to go ahead with the work by day labour. The buildings erected comprise: a brick residence for the Superintendent, 41 feet by 40 feet; a frame house for the men, 26 feet by 28 feet; a stable, 32 feet by 76 feet; a packing shed, 50 feet by 24 feet, with workshop 24 feet by 16 feet attached; an implement shed, 54 feet by 24 feet; pumping plant, 32 feet by 24 feet, containing pump, engine, and two compression tanks of a capacity of 1,000 gallons each, and the water and sewerage system.

The frame house mentioned will later be used as a foreman's house as soon as a larger boarding-house for the men can be erected. The equipment is very complete throughout, the buildings being conveniently arranged both as to their interiors and to their relation to one another. The work on these buildings has only just been completed.

The north quarter of the nursery was rented for cropping, as it would have been impossible for this branch to handle the land without doubling its equipment of horses and implements; besides as there was no accommodation for labour on the place itself the latter course would have been a very expensive undertaking.

This spring (1914) it is hoped to complete all the permanent planting in the way of shelter-belts and ornamental planting. The stock necessary for this purpose will be shipped from the Indian Head Nursery Station. In connection with the ornamental planting, detail plans have been prepared for all the different varieties of shrubs and specimen trees. There will be a considerable amount of work to accomplish in the way of levelling, grading, and cleaning up around the buildings preparatory to seeding down lawns, etc.

Blocks of willow and Russian poplar will be set out to supply future cutting stock. Land will be further worked up for seed sowing in the fall of 1914, and spring of 1915 so that in the spring of 1916 we should be able to put out between two and three million cuttings and seedlings from this station.

Respectfully submitted,

NORMAN M. ROSS.
Chief of the Tree-planting Division.

APPENDIX No. 2.

REPORT OF THE DISTRICT INSPECTOR OF FOREST RESERVES FOR MANITOBA.

WINNIPEG, May 16, 1914.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa.

SIR,—I have the honour to report on the Manitoba Inspection district for the year 1913-14 as follows:—

BOUNDARIES.

No changes are suggested in the boundaries of any of the reserves in this district, other than on the Spruce Woods, where an addition to the reserve might well be made by taking in those parts of the south half and northwest quarters of sections 1, 2, and 3 in township 10, range 15, west of the first meridian, being south of the Canadian Northern Railway line, and which, while of practically no value for agricultural purposes, would be of use for grazing if included in the pasture now being enclosed. If these were obtained it would obviate the necessity of building a fence along the north side of the pasture, as the present railway fence could be used.

An alteration was made in the Duck Mountain reserve by adding that portion of townships 29 and 30 in range 28 west of the principal meridian, which is east of the Shell river, excepting section 1 and the east half of section 2 in township 29, range 28, west of the first meridian.

MARKING OF BOUNDARIES.

Where not already clearly marked, all boundaries should be cut out, blazed, and posted, even if it is not found possible or advantageous to construct fire-lines along them. Some splendid work along these lines was done on the Riding Mountain reserve during the year, and it is expected that a considerable portion of this work will be accomplished on all the reserves in this district during the present year.

PERSONNEL.

There has been a marked improvement in the general work of the staff and, with the exception of some three or four rangers, all have worked well and shown interest in their duties, but one suspension having been called for; the ranger in this case was exchanged to another reserve, where it is hoped he will render better service.

FIRES.

There have been practically no fires in the district during the year. Weather conditions in the spring were most favourable, and, though grave cause for alarm existed in the fall, owing to the excessive rank growth of vegetation and the absence of rain, which caused nearly all of the sloughs and streams either to become completely dry or be greatly reduced in volume, we were fortunate in having no serious outbreaks. Close and constant supervision was urged on all officers.

The fires that occurred are as follows:—

1. *Spruce Woods.*—Covering one and a half sections, supposed to have been set by a Canadian Pacific engine; cost, $11; ran over 160 acres of young growth (poplar); occurred in April. 2. Covering seven sections, thought to be incendiary, but guilty party not known; cost, $40; ran over two sections of young poplar; occurred in April.

Riding Mountain.—1. Covered some four sections; no damage to timber, other than quarter section young growth; balance, dead spruce and poplar; supposed to have been set by Indians. Cost to extinguish, $44. 2. A small grass fire, no damage; put out by ranger; no charges; cause not known. 3. Small grass fire as above.

Turtle Mountain.—1. Covered one-half acre grass; set by some one not known; put out by ranger; no extra help; no damage; occurred in May. 2. Covered one-quarter acre grass, set by some person not known; put out by ranger; no extra help; no damage done; occurred in May.

Duck Mountain.—1. Covering 560 acres; supposed to have been set by trappers in April; some 60 acres timber destroyed; put out by ranger; no extra cost. 2. Covering some 1,300 acres; supposed to have been set by trappers; destroyed some forty 15-to-20-year-old spruce; cost to extinguish, $22.50; occurred in May. 3. Small fire discovered and at once put out by a temporary ranger, no damage done; occurred in October. 4. Covering some 400 acres; thought to have been caused by trappers; burned about 150 acres young growth; cost to extinguish, $7.50, occurred in November. 5. Covered 200 acres; set by settlers; no damage done; only scrub burned; cost to extinguish, $10.70; occurred in November.

IMPROVEMENTS.

The improvements on the different reserves have been carried out to the best possible advantage and good value received for all outlay. They have consisted of buildings (such as ranger houses and cabins, stables, store-houses and look-out towers), roads, trails, bridges, telephone lines, fire-guards, boundary lines, fencing, pastures and the opening of summer resorts, particulars of which are furnished in the reports of the several supervisors.

GRAZING.

As yet grazing has been established only on the Turtle Mountain reserve, where some 29,000 acres, including numerous lakes, have been enclosed with a woven-wire fence. The use of these lands by settlers in the surrounding country is increasing yearly, and it is expected that a considerably greater number of stock will be pastured during the coming season than formerly.

It is the intention to divide this pasture so as to prevent stock from approaching too close to the international boundary line, as in the past some trouble was caused by stock getting out and trespassing on the farms of settlers over the line.

This is an ideal pasture, and is of marked benefit to the settlement.

A similar proposition is under way on the Spruce Woods reserve, south of Carberry, where some 8,500 acres will be enclosed, the material being now on the ground and some of the posts set. This tract is also a good grazing area, though not quite as advantageous as Turtle Mountain owing to the absence of natural water supply. This lack, however, will be overcome by the use of pumps operated either by wind mill or a gasoline engine. The settlers in the vicinity are looking forward to the opening of this pasture, and it is expected that ere long it will be fully stocked. The rates charged on these enclosed pastures are $1 per head for the season, a charge which appeals to the public. A herder is kept on the Turtle Mountain during the grazing, which practice will be carried out on the Spruce Woods reserve, and the duties demand a close supervision of all stock taken in.

Open grazing has been instituted on the Riding Mountain reserve this season, and it is expected that many settlers will take advantage of the good grazing land which is available on both this and the Duck Mountain reserve, several applications having been received. On these last two reserves the tracts where it is proposed to graze are ideal for the purpose, being well watered and carrying heavy crops of grass and pea-vine. Stock should do well and the project prove of great value to the country tributary, as for some time past, owing to the private lands being so largely enclosed and brought under crops, settlers have not been in a position to provide summer feed for any considerable amount of stock, the result being a marked depreciation in the stock industry.

USES OF LANDS.

It is to be hoped that the public will make use of the reserves in every way possible by taking advantage of the summer resorts, one of which, at Arbor island on lake Max in the Turtle Mountain reserve, some 16 miles south of Boissevain, has been in operation for some years; here a number of cottages are occupied throughout the season and more are to be erected this season.

A number of lots have recently been surveyed on the main land on the shore of lake Max, close to the supervisor's headquarters, where parties who do not care to locate on the island will erect cottages. A dock has been built for the convenience of the people at this point, and the resort is largely used by the residents of the neighbouring towns and the farmers.

A summer resort has been laid out at Madge (or Island) lake in the Duck Mountain reserve, some sixteen miles northeast from Kamsack, Sask., an ideal spot, where it is expected a number of cottages will be built as soon as the plan is in the hands of the supervisor so that lots may be selected. A road is under construction from the edge of the reserve to the resort, and it is said the municipal authorities will improve the portion out of the reserve so that automobiles as well as horse-drawn vehicles may travel without difficulty. This should prove a most attractive resort and will without doubt be appreciated by the public. Many inquiries have for some time been made as to when lots will be available.

Another summer resort is to be established on the south shore of Clear lake in the Riding mountains, some 35 miles north of Minnedosa, where there is a beautiful sheet of water some seven by three miles. A most desirable spot has been selected, and this will attract the residents of Minnedosa, Neepawa, and other towns adjacent. A good road has been built to the lake, and all classes of vehicles can travel it with ease. Some further improvements will be made to this before the lots are placed on the market. and it is to be hoped that every effort will be made to hasten this survey and the preparation of the plans.

As yet no further demands have been made for such resorts, but in event of this occurring steps should be taken to open them up as a means of securing the good-will and interest of the public in the policy of conserving the reserves generally.

TRESPASS.

Trespassing has been confined to cutting timber without permit or in excess, and but one instance where large quantities are involved has occurred. This is now being investigated, so that exact figures are not to hand, but it is thought that these will reach some 400,000 feet board measure. The general public are appreciating the fact that regulations are enacted for their benefit and consequently are paying more attention to them from year to year.

There are some seven settlers located in that tract, enclosed by the Shell river. which was added to the Duck Mountain reserve. Instructions have been issued to the supervisor to inspect and report on their improvements with a view to arranging for their removal.

From time to time squatters attempt to gain a foothold in the reserves, but these parties are at once notified to move out as soon as their presence is discovered.

SURVEYS.

A survey was made of the southerly lines of the Spruce Woods reserve last summer, carried out by the forest assistant at that time attached to the reserve, and the boundaries marked out. Such further surveys as may be required can, I think, be done by the staff of the several reserves, and would be mainly in the way of establishing the location of timber areas, though some work along these lines may be required in cases where roads, trails and telephone lines are required.

I must draw attention to the need of a survey to be made at the earliest possible date of the summer resort at Clear lake in the Riding mountains and Madge (or Island) lake in the Duck Mountains.

FISH.

It is proposed to stock Clear lake and Madge (or Island) lake, in the Riding and Duck Mountains respectively, with pickerel, which are good game and edible fish. When in Ottawa I called on Professor Prince, and learned from him that the best plan was to take mature fish from some convenient point just before spawning, and have arranged to secure these at Winnipegosis, the most accessible place where they can be secured, and the Canadian Northern Railway Company kindly promised to furnish transportation over their lines free of charge. This will be taken up as soon as the fish run up the Mossy River, and nets can be set, the services of a competent fisherman having already been secured.

Should this venture prove successful, I would recommend that some other suitable lakes be stocked, as at present they contain only jack or pike, suckers and small perch. Steps should be taken to eradicate, or at least reduce, the number of suckers, which are of no value and are most destructive to the propagation of other and better fish.

Lake Max in the Turtle mountains might well be stocked, as I learn there are not as many or as large fish caught there now as in former years. Suckers and jack are the only varieties found there; I have been told there were some fry of black bass introduced some years ago, but I have never heard of any being taken.

GAME.

The game is under the management of the provincial authorities, and considerable criticism is indulged in, owing to the entire prohibition of shooting in either the Turtle Mountain or the Spruce Woods reserves. From my own point of view I think that small game might well be killed during the open Manitoba season on all the reserves, but the authorities have ruled otherwise.

Prairie chickens were very numerous last season in the Turtle mountains, and it is claimed by the settlers living adjacent that considerable damage was done to their crops; and from my own personal knowledge I can say that these birds, when disturbed on the fields, at once sought safety in the reserve.

I do not think there is any danger of the supply being seriously reduced, provided the regulations are enforced in the close season.

As far as duck and geese are concerned, they are simply preserved on this side of the line for the benefit of our American neighbours who, I understand, shoot them indiscriminately as soon as they cross the border—this especially south of the Turtle Mountain reserve.

As to big game, the number of elk is seriously reduced in the Riding Mountain reserve, which is practically their last home and refuge in Manitoba. Should much further reduction be made in their numbers, I fear speedy extermination will be the sure result, and a close season for some few years would be most beneficial. There are elk to be found in other localities not on our reserves, and a few frequent the Duck Mountains. Moose are numerous in the Riding and Duck Mountain reserves, and when in the Spruce Woods recently I found evidences of there being a few in this locality. Jumping deer are found in all of the reserves, and are not killed to any great extent, as hunters, being limited to one deer of any variety in a season, kill the moose or elk in preference.

Beaver are getting quite numerous in the Riding and Duck mountains, where many new dams are to be found, and a colony has established itself on the Spruce Woods reserve. These, however, are closely protected all through the province, and have been for a number of years.

Black and brown bears are found in both the Riding and Duck mountains, a number being taken each year, but I have not heard of any being seen in either the Turtle Mountain or Spruce Woods reserves.

EQUIPMENT.

The several reserves are now fairly well equipped, three of them being supplied with horses, the Duck Mountain being the only one not yet furnished, as the supervisor considers it more advisable, so far, to hire when required. The oxen which were in use on the Riding and Duck Mountain reserves, though proving useful at the time, were found unsatisfactory on account of slowness and the difficulty in hiring men to work them, and, in consequence, they were sold.

EDUCATION AND PUBLICITY.

Efforts are being made to interest the public in the protection of the reserves, and to impress them with the value they will be in the future. Most of the officers are doing all they can along these lines, and it is gratifying to know that a much better feeling exists among the settlers as to the reserves than in the past, this doubtless owing to the interest taken by the officers, and the work accomplished, as well as the benefits derived from grazing, timber, and summer resorts.

Respectfully submitted,

F. K. HERCHMER,
Inspector of Forest Reserves for Manitoba.

APPENDIX No. 3.

REPORT OF THE DISTRICT INSPECTOR OF FOREST RESERVES FOR SASKATCHEWAN.

Prince Albert, Sask., May 18, 1914.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa.

Sir,—I beg to submit the following report on the Saskatchewan Inspection District for the fiscal year 1913-14.

ORGANIZATION.

The Saskatchewan Inspection District was started April 10, 1913, by the opening of an inspection office at Prince Albert, Sask. At the time the organization of the district was undertaken, it comprised five forest reserves with an area of 1,248·19 square miles. Additions were made by Act of Parliament on June 21, 1913, and in May, 1914. Table No. 1 shows the names of the forest reserves and their areas in 1912, 1913 and 1914.

Table No. 1.—Areas of Forest Reserves in Saskatchewan Inspectorate.

Name.	Area, 1912.	Area, 1913.	Area, 1914.
	Sq. Miles.	Sq. Miles.	Sq. Miles.
Beaver Hills	99·00	99·00	99·00
Moose Mountain	156·00	156·00	156·00
Nisbet	14·94	149·49	149.49
Pines	152·75	166·15	166·15
Porcupine No. 2	360 00	564.75	3,246·75
Porcupine No. 1 (Manitoba)	312·00	777·50	777·50
Fort à la Corne	0·00	513·00	513·00
Big River	0·00	0·00	1,342.00
Dundurn	0·00	0·00	63·25
Elbow	0·00	0·00	119·00
Keppel	0·00	0·00	86·25
Manito	0·00	0·00	179·65
Pasquia	0·00	0·00	2,615·00
Sturgeon	0·00	0·00	729·00
Seward	0·00	0·00	30·75
Steep Creek	0·00	0·00	7·00
Total	1,094·69	2,425·89	10,279·79

The Dundurn, Elbow, Keppel, Manito and Seward reserves are located on the prairie, and have practically no tree-growth at the present time. The soil is wholly sandy and unsuitable for agricultural purposes. These small prairie areas were set aside with the idea that reforestation would be started as soon as conditions permitted. A careful examination of these reserves will be made during the coming summer for the purpose of ascertaining the best method to use in restocking. The remainder of the reserves are more or less timbered, and will gradually restock by natural methods (except certain areas on the Beaver Hills, Pines, and Nisbet reserves) provided adequate fire-protection can be secured.

BOUNDARIES.

The boundaries of the present reserves are well located, except in a few instances. The east boundary of The Pines, certain portions of Nisbet, and Fort à la Corne, and that part of the Porcupine from Hudson Bay Junction to Bowsman, south of the Canadian Northern Railway tracks, should be carefully examined, and all non-agricultural lands included in the reserve which at present separate the reserve from agricultural or railway lands. The boundaries of forest reserves in this district should be so located that all land suitable for agriculture should be excluded, but the reserve should include all non-agricultural land, so that there will be no land between the reserve and agricultural areas over which there is no supervision. Any areas of this nature are a source of trouble both to the settlers and reserve officials, as well as a source of danger to the reserve. Where there is no supervision, the areas along the boundary of the reserve are always fire-traps, and lead to trespass on reserve lands.

Practically all of the sandy, mountainous, and other non-agricultural areas of any size, south of township 54 have been examined, and that part suitable only for growing timber has been set aside as Dominion Forest Reserve lands. Only a small proportion of the land north of township 54 is suitable for agricultural purposes, and it should be examined as soon as possible. The Forestry Branch has three reconnaissance parties in the north country this season. It is the aim of the branch to examine the land before settlement commences, so that areas suitable only for forest reserves will have an organization on the ground, at least for fire-protection, when settlement begins. The timber on the areas north of the present settlement needs constant care, as homesteaders are rapidly occupying all lands in the north suitable for agriculture or stock. The timber in the north will be valuable, as well as a necessity to the homesteaders, and forest reserves, with a field force sufficient for fire-protection, should be set aside as soon as possible so that the forest administration will grow gradually up with the settlement.

As soon as the boundary of a forest reserve has been determined with any degree of permanency, it should be plainly marked. In a settled country where the danger from fire is great and there are a large number of grazing and timber permits, the boundary should be cut clean, at least 25 feet in width, should have at least three ploughed furrows on each side, and be burned between the furrows. This will give the forest officers a chance to get around the boundary, prevent trespass—except that of a wilful nature—and it will stop any ordinary fire from crossing into the reserve. Where there is heavy timber and less danger from fire, a line 12 or 16 feet in width with two ploughed furrows on each side and the intermediate space burned will be sufficient until the timber is valuable enough to warrant a better line. In the unsettled areas where there are very few permits issued, and where a fire is as liable to start within the line as on the outside, a blazed boundary, well posted with boundary notices, will be sufficient for the present time, as the money needed for a better line could be expended more advantageously on other improvements, such as a good system of trails, lookout stations, equipment, etc. A distinct boundary of some sort is an absolute necessity for the proper administration of the reserve, as well as for the benefit of the public.

PERSONNEL.

The Saskatchewan Inspection District comprises the province of Saskatchewan, and all the work of the Forestry branch is handled from the inspection office, except the Tree Planting Division and a small portion of the Duck Mountain and Cypress Hills reserves, which are under the supervision of the Manitoba and Alberta Inspection Offices, respectively. A part of the Porcupine reserve and of The Pas Fire-ranging District are in Manitoba, but the work is supervised from the Saskatchewan Inspection Office.

The work of the Saskatchewan Inspection Office is divided into three main divisions: (1) Forest reserves; (2) railway fire inspection; (3) fire ranging.

The fire ranging is divided into three districts: (1) Battleford; (2) Prince Albert, and (3) The Pas, with a chief ranger for each district. The chief rangers are permanent employees, but the rangers are employed only for the fire season.

The following outline gives the different branches of the service in the Saskatchewan Inspection District, the class and number of employees in each branch:—

Saskatchewan Inspection Office—
- 1 district inspector of forest reserves.
- 1 assistant inspector of forest reserves.
- 1 accountant.
- 1 stenographer.

A—Forest Reserves—
- Beaver Hills—
  - 1 ranger in charge.
  - 1 labourer.
- Fort à la Corne—
  - 1 ranger in charge.
  - 1 ranger.
- Moose Mountain—
  - 1 ranger in charge.
  - 1 ranger.
  - 1 labourer.
- Nisbet—
  - 1 ranger in charge.
- Pines—
  - 1 ranger in charge.
  - 1 ranger.
  - 1 temporary ranger (6 months).
- Porcupine—
  - 1 ranger in charge.
  - 11 rangers (for 6 months).

B—Railway Fire Inspection—
- 1 divisional fire inspector.
- 3 railway fire guardians.

C—Fire Ranging.
- Battleford District—
  - 1 chief ranger.
  - 9 rangers.
- Prince Albert District—
  - 1 chief ranger.
  - 18 rangers.
- The Pas District—
  - 1 chief ranger.
  - 16 rangers.

The fire-protection work on the forest reserves, created in May, 1914. is handled by the fire ranging branch of the service, but the forest reserve administration will be gradually established during the present season. The Pasquia reserve is under the jurisdiction of the ranger in charge of the Porcupine reserve, and the eleven rangers mentioned as being on the Porcupine reserve are also protecting the Pasquia reserve.

The prairie reserves will be simply a fire-protection and grazing proposition until such time as reforestation is started.

The forest reserves staff will require a few additions on the old reserves, and a new organization for all the new reserves. The Porcupine and Pasquia reserves will be administered as one reserve until conditions are more favourable for handling as separate units. The eleven fire rangers are all temporary men, and are not included in the forest reserve staff. The increase in staff urgently needed is shown by following outlines:—

Saskatchewan Inspection—
- 1 stenographer.

Fort à la Corne—
- 1 ranger.

Nisbet—
- 1 ranger.

Porcupine—
- 1 supervisor.
- 1 forest assistant.
- 6 rangers.
- 6 temporary rangers for 6 months.

Big River—
- 1 supervisor.
- 1 forest assistant.
- 3 rangers.

Manito—
- 1 ranger.

Keppel—
- 1 ranger.

Dundurn—
- 1 ranger.

Elbow—
- 1 ranger.

Sturgeon—
- 1 supervisor.
- 3 rangers.

The Seward, Steep Creek, and Stench Lake reserves comprise only a few sections each and will be administered by the nearest ranger.

The main responsibility for the results of the outside work of the branch lies with the rangers. The duties of a ranger are many and varied, such as office work, supervision of the timber, grazing, and fire protection; construction of cabins, houses, trails, telephones, bridges, and other classes of improvements, as well as the enforcement of the Reserve Regulations, fire, and game laws. Each ranger has a definite district and is responsible for the proper management of all the work within his district. The districts are usually some distance from settlement, and vary in size from 50,000 to 200,000 acres, according to location, danger from fire, and quantity of permit work. Districts of this size require a large amount of travel. In a grazing country, this travel should be done on horseback, and on most of the reserves this is the only mode of travel that will give results. On some of the northern reserves it is necessary to use a canoe or go on foot. A wagon cannot be used to advantage in any reserve work except to bring provisions and equipment to headquarters. It is also often necessary for rangers to be away from headquarters for days at a time, which necessitates a large amount of camp life. A man qualified to fill the position of forest ranger should be able-bodied, honest, have at least a common school education, and some executive ability. He should also be familiar with all branches of the field work such as grazing, woods-work, camp life and ordinary compass surveying, and be able to ride a horse. In connection with the above qualifications, he should be sober, energetic, and interested in his work.

FIRES.

The Pines, Moose Mountain and Beaver Hills were the only reserves directly under the supervision of this office during the fire season of 1913. The remainder of the reserves were patrolled by the fire-ranging staff. The season was very wet, and the danger from fire was at a minimum during the entire danger season.

Table No. 2 gives the number of fires, classes, expenditure, etc.

Table No. 2.—Fires on Saskatchewan Forest Reserves during 1913.

Class.	No.	Expenditure.	Damage.	Causes.	Season.
1	3	$110	$500	Settlers	May.
2	13	50	330	" ....5 Railway.........8	4 May. 4 June. 5 Oct.

The causes of fires in this district are: settlers, railways, carelessness, campers, incendiarism and lightning, enumerated in order of importance.

In the northern and mountainous section of the provinces where the settlements are new, fires are very numerous, due to the fact that the settler cares nothing for the damage done by a fire, so long as it burns over his quarter-section. He usually starts the fire when there is a high wind and everything is very dry, without any pretense at fire guarding or otherwise confining the fire. If the settler would take ordinary precautions in burning, 75 per cent of the fires and loss therefrom would be eliminated. It is a very simple matter in this country to either plough a furrow and back-fire, or simply back-fire when conditions are favourable around the area to be burned, and then start the fire against the wind. This method will give a far better burn than starting the fire with the wind, and there is practically no danger of its getting away if a small amount of precaution is used. The result more than counterbalances the extra time it takes to make the guard.

In the spruce belt from Green lake to Hudson Bay Junction, approximately four hundred million feet of merchantable timber has been destroyed by forest fires in the past six or eight years. There was far more than this amount destroyed, as the more northern and western areas are not included, on account of the lack of definite information and the distance of timber from market; but reports show that there has been a large quantity destroyed in the north and west during the past few years. The four hundred million feet include only areas that are accessible to market, and using a minimum estimate of $15 per thousand feet, board measure, for the lumber on the cars at the mill, it means a loss of six million dollars to the people in northern Saskatchewan and to the country at large. Nearly all of the money expended for labour, provisions, etc., is spent in the locality where the timber is manufactured, and practically all classes of trade in the vicinity of the timber belt are more or less affected by the destruction of each foot of merchantable timber.

There is also another factor that should be considered by the lumber-users of Saskatchewan. The province is situated about half way between the Atlantic and Pacific timber belts. The timber areas to the southeast and southwest are not close nor large, and most of the timber is south of the international line. Considering the timbered area of Saskatchewan, there is only a small quantity of merchantable timber, but it is located nearly in the centre and acts as a regulator on the price of lumber throughout the province. So long as the timber in the province is protected and the cut maintained, the lumber consumers will be able to purchase lumber at a reasonable figure, but when the timber in the province is exhausted, prices will rapidly increase, as the outside dealers will have no competition. The prices must also increase as the cutting advances into the unsettled areas to the north, or the lumbering industry in the province will gradually decline.

It is to the interest of each and every lumber consumer and manufacturer in the province that the small quantity of merchantable timber, together with all young growth not on agricultural soil, or on agricultural soil that will not be taken up for some years, be protected from fire. The only way that the timber can be protected is by securing a good class of fire-rangers. Approximately 90 per cent of the loss from forest fires in the past few years has been due to the poor class of rangers. The rangers are not universally in the above class, but in certain localities it is almost impossible to get a good, reliable man appointed as ranger. The rangers who are doing their duty deserve a large amount of credit, for it is very discouraging to a good man to have another ranger, perhaps in an adjoining district, doing nothing and drawing the same salary. It is to the interest of every citizen in the province to demand that a fire-ranger be a man capable of fulfilling his duties, and that he be dismissed for gross neglect of duty.

IMPROVEMENTS.

At the beginning of the fiscal year, 1913, the improvements in this district consisted of two ranger-houses, two small stables and about thirteen miles of neglected boundary line. During the year the following improvements have been made on the various reserves:—

Beaver Hills.—Thirty-eight miles boundary line, 28 feet wide; 13 miles of old line disked three times; one house; one stable; one wagon shed; one well; 1½ mile road.

Fort à la Corne.—One ranger-house, completed; one ranger-house nearly completed; two stables nearly completed; one well, 4 miles road 10 feet wide.

Moose Mountain.—Twelve miles boundary line 12 feet wide; 8 miles road 25 feet wide; one ranger-house; one bridge; 14 miles telephone line (material only purchased); one stable (material purchased).

Nisbet.—Thirty-four miles boundary line, 25 feet wide; 2 miles road allowance cleaned up, 66 feet wide; one ranger-house; one stable; one wagon shed; one 80-foot lookout tower; 140 acres brush piled and burned by the branch; one ranger-cabin (material purchased).

Pines.—Twenty-seven miles boundary line 25 feet wide; three corduroy bridges; one 80-foot steel look-out tower; one 30-foot wooden tower; one ranger-house; two stables; one wagon-shed; one tool-house; one kitchen added to head-quarters range-house (shingles purchased for house and the inside ceiled up); one pasture fence, quarter-section at head-quarters; 200 posts for pasture at Roddick; 7 miles road 10 feet wide; 75 acres brush cleaned up by branch; 5 miles of telephone (material purchased); 113 tamarack telephone poles cut and placed at headquarters; one nursery; seventeen seed-beds; some 12 acres broadcasted; 1 acre seed spots.

Porcupine.—One ranger-cabin; one stable; one cabin nearly completed; one stable (material purchased); 10 miles trail 6 feet wide; 4 miles road 10 feet wide.

The dimensions of the buildings are approximately as follows: Houses, 24 feet by 24 feet, six rooms; cabin, 18 feet by 24 feet, three rooms; stable, 18 feet by 24 feet, with loft; wagon-shed, 16 feet by 24 feet; tool-house, 12 feet by 16 feet.

The boundary lines were cut 25 feet in width on reserve land and adjoining the road allowance. All wood was saved and piled in the centre of the line, and the brush was burned on most of the tract as cutting proceeded. All stumps were cut close to the ground so that three furrows can be ploughed on each side of the line, and the intermediate area burned.

It will be necessary to expend a small sum on improvements on the old reserves this season, but as there are no improvements of any kind on the new reserves, it will be necessary at least to construct cabins for the permanent rangers before the season closes.

SILVICULTURE.

The following tree species indigenous to this district have a commercial value: White spruce, tamarack, jack pine, birch, white poplar, black poplar, black spruce. ash, and willow. The black spruce seldom grows to log size, but trees that will make a log are cut and sold the same as white spruce. Black spruce can be used as pulp, but there are no pulp-mills in this district, consequently very little black spruce is cut. White spruce, tamarack, and jack pine are the chief lumber trees, and are used to a great extent for ties. Jack pine and the poplars are largely used for cordwood, but only a small quantity of lumber is sawn from these species. Birch is used by farmers for general repair work, such as double-trees, etc., and for cordwood. Tamarack, ash, and willow are used for fence posts.

There is a large quantity of poplar throughout northern Saskatchewan that has very little commercial value at the present time, principally on account of prejudice. Poplar makes good lumber if properly seasoned, and makes cross-ties as good as, if not better than, those of white spruce. The sectionmen all agree that it lasts as long and holds the spikes better than green spruce. They secured the information from actual tests and under the most unfavourable conditions, as only the smaller poplar were cut and put on the track green and without peeling. If the poplar was even peeled and seasoned for a few months, the results would be far more favourable. I would suggest that the Forestry Branch take up the question of the utilization of the immense quantity of poplar now going to waste in all sections of the north country. I feel that treated poplar ties would give more satisfactory results, at the same cost, than any of the untreated native species now in use, and experiments should be made along these lines by the department. There is also a large amount of waste in white spruce, black spruce, and poplar that could be utilized for pulp and other purposes, and experiments should be undertaken for the purpose of determining a commercial method for the utilization of this waste.

There has been no attempt in the past to cut along silvicultural lines, but, on the contrary, all cutting is done in the most wasteful manner as regards the welfare of the forest. A few companies are utilizing the trees, cut well into the tops and cut fairly low stumps, but as a general rule the stumps are high, even to 3 or 4 feet, and the diameter of the tops left in the woods runs as high as 14 inches. Usually one and sometimes two logs are left in the tops. This is especially true in hewn-tie operations. All companies and individuals make no attempt to dispose of the brush, cut below the diameter limit, do not utilize the tops, leave merchantable timber in skidways, and pay no attention to the destruction of young growth. The operators pay very little attention to the limit-line and cut all timber in sight. The above manner of cutting leaves the woods in the worst possible condition for a future crop, and the Government loses a large amount of revenue, owing to the large amount of timber wasted. The blame for the wasteful cutting does not rest entirely on the operators, as a large percentage of them would be willing to cut along conservative lines and make proper brush-disposal, provided they were so instructed by the department under whose jurisdiction the cutting took place, and provided each operator in the district would be required to follow the same method. It is simply lack of proper supervision and enforcement of the regulations on the part of the Government that permits such wasteful cutting. The proper handling of this work lies with the field men, and when men are appointed to look after this work who do not know what should be done, and who do not visit many of the operations, the Government cannot expect to get results. The increase in revenue would more than pay for an efficient force of men to handle the cutting operations on a conservative basis.

The cutting on forest reserves in this district under the jurisdiction of the Forestry Branch was given close supervision last season, and good results were secured on all the reserves except Moose Mountain. The poor result on this reserve was due to the inefficiency of the ranger in charge, but he resigned, and better results are expected on this reserve next season.

Taking the reserves as a whole, the results were as follows:—

Brush piled for burning on 2,340 acres.

Brush piled and burned on 315 acres.

The disposal of the brush was something new, and many protests were made at the beginning of the season, but after it had been working for a few weeks the operators began to see the benefits, and by the end of the season there were practically no complaints. The operators were also required to cut only dead, down, and infected wood under cordwood permits, and only mature timber for lumber, piling, etc. The majority of the cuttings took place on the Nisbet reserve, and the good results obtained were due to the diligence of the ranger in charge. The cost of the work was not excessive, as shown by the data secured on the Nisbet reserve, which is a fair average for the work in the district. On this reserve instructions were issued about the first of October to all rangers of forest reserves in this district that the brush was to be piled on all timber operations within the reserves.

The work was inspected early in February, and it was found that permittees were not making suitable piles for burning, and new instructions were issued to all rangers on the reserves that the brush from all cuttings was to be piled and burned, and results show that it is easier and cheaper to pile and burn the brush in connection with the cutting than it is to make piles suitable for burning and then burn them at a later date.

This branch also undertook to dispose of the brush on old and new cuttings on the reserves, and the following figures show the results:—

Area 1.—This was a fair stand of jack pine, a cordwood operation. The cutting was done last year and the brush left scattered according to the old method. The brush and all refuse on an area of 20 acres of this old cut was piled and burned. The men were paid at the rate of 25 cents per hour. The average cut was twenty-two cords per acre. Total cut, 440 cords. Total cost, \$20.50. Cost per acre, \$1·025. Cost per cord, \$0·047.

Area 2.—This area was covered by a fair stand of jack pine, and was also a cordwood operation. The timber was cut this winter, and the brush was piled and burned as soon as cut. On an area of 18 acres the average cut was twenty cords per acre. Total cut, 360 cords. The men were paid at the rate of 25 cents per hour. Total cost, \$19.75. Cost per acre, \$1·097. Cost per cord, \$0·054.

Area 3.—This area was covered by a fair stand of jack pine, and was also a cordwood operation. Approximately 50 per cent of the area was cut over last year and the remainder was cut this season. All brush was piled and burned. The men were paid at the rate of 25 cents per hour. The area comprised 210 acres, with an average cut of 20 cords per acre. Total, 4,200 cords. Total cost, \$208. Cost per acre, \$0·99. Cost per cord, \$0·049.

Average cost for the above areas per acre.	\$1·00
" " " " " " cord	0·049

The brush was disposed of in the above areas under practically the most difficult conditions, as the brush was as heavy as any in this locality, and I feel that the above figures are a fair average for the cost of the work in this district.

The areas cut over under permit on the Nisbet reserve have been well cleaned up and the brush and refuse have been piled and burned by permittees on 58 acres, and piled on 1,350 acres.

The permittees at first felt that brush-piling would be a hardship, but after they had tried it for a short time they found it was far easier to get at the wood than under the old system, and this was especially true on areas where low stumps were cut. In former cuttings, the stumps were cut from 2 to 4 feet in height, and it was very difficult to get to the piles with sleighs without getting hung up on stumps. After a little experience, the permittees found that the brush-disposal and low-cut stumps did not entail any extra cost on the wood delivered, as any extra expense caused by cutting low stumps, piling and burning brush was saved by making the wood more accessible for hauling.

The cutting operations take place during the winter months in this district, and there is no danger from burning. Burning is not permitted during the fire season.

Cost-data were also obtained for an area, cut over for ties, where the tops were lopped. This was a heavy stand of spruce; all the trees were cut and the ties removed before the parties were notified that the tops were to be lopped, making the cost of the operation a maximum for this district. I visited the area when the operation was about half completed, and the tops were completely lopped, even to the smallest twigs. Approximately 300 acres were cut over, and 16,178 ties were removed. The top-lopping cost $161.75, or approximately 1 cent per tie, or 53⁹⁄₁₀ cents per acre. The cost per acre is not very satisfactory, as the entire 300 acres were not cut over as the timber was in various-sized bunches on the area, and consequently the cost per acre would be much increased if the figures had been determined from the actual area. These ties were much above the railway standard in so far as size is concerned, and the operator estimates that the timber removed would have sawed 521,000 feet, board measure, and the top-lopping on this estimate would have cost 31 cents per thousand feet board measure.

The operator reports in part as follows:—

> "I am of the opinion that, had I had information of the intention of the department enforcing the top-lopping last fall before starting in the work, I could have arranged with the tie-makers to do this lopping and could have had it done for less money per tie. I am also confident that the cost per M would have been less for sawlogs than for ties, as generally the tops will run out smaller."

The regulations covering the cutting of all timber on Dominion lands require that the brush be disposed of in proper manner, and if the work is not done it is due to neglect on the part of field officers, except in a few cases of trespass where it is impossible to locate the offender.

PLANTING.

There are approximately 500 square miles of open, sandy land within the reserves that need restocking by artificial methods. Ninety per cent of this area is included within the prairie reserves; and, considering the fact that these reserves are located in the midst of a settled country where there is practically no timber, the restocking of these areas should take place as soon as possible. It may seem foolish to talk of planting in a new country like Saskatchewan, but what will be the opinion twenty-five or fifty years hence? On the prairie to-day the farmers and towns people are travelling miles for a load of wood, and in the cities cordwood is selling as high as $8 per cord. A quantity of timber of any kind on the small prairie reserves would be of immense value to the surrounding country and the province at large. Even to-day, there is practically no saw-timber of any kind on the forest reserves south of the Saskatchewan river, and all the merchantable spruce north of the river is within timber limits, and will soon be cut off. There is very little natural reproduction of spruce on account of fire and other causes, and if many of the cut-over areas are to be restocked with spruce, it will have to be done artificially.

The artificial restocking of any of the reserve areas would be a waste of money until an experienced field force and an efficient fire-protection system is secured, but these can be easily acquired provided the department is given a free hand in the matter.

In forest-planting operations in this district, only species native to the region should be used extensively. Exotics should be experimented with, but not planted on a large scale until proved to be satisfactory. The most valuable native trees are the white spruce, tamarack, jack pine, and green ash. The latter is especially valuable for post material on the prairie.

Before starting any reforestation work, the branch expects to make a careful survey of the areas to be planted, for the purpose of outlining the planting plans and location and size of nursery needed. The nursery is an important factor and it should be under the supervision of an experienced man. I would advise one large nursery under a competent man in preference to small nurseries on each reserve with inexperienced men.

GRAZING.

The grazing regulations did not go into effect on the reserves until the beginning of the present year, consequently no permits were issued last season. Many applications have been received this spring, and the grazing will become an important factor of the forest reserve administration in the near future. Most of the stockmen have been more or less restricted on account of the grazing areas being taken up by homesteaders, but now that permanent range can be secured in the reserves, all classes of stock-raisers feel that the number of cattle in the district will be increased. Although settlers have first chance for grazing privileges on the reserves, they will use only a small portion of the range areas, and there will be room for all applicants.

Several of the small reserves are located in settled country where the herd law is in force. On such reserves it will be necessary to allow fencing, but such fencing should be restricted to the boundary of the reserve, or simply to small breeding pastures along the boundary. This will leave the reserve open to general grazing, or at the most only drift-fences will be needed.

Over-grazing should not be allowed, but regulated grazing would be a benefit on practically all of the reserves, until planting or young growth starts naturally, as grazing will reduce the fire-danger by removing the large quantities of grass which at present dies and becomes the worst sort of fire-trap. The cattle will also clean out a great deal of the brush and open up the country. It will also be to the interest of the stock-owners to prevent fire.

The regulations of the department for grazing on Forest Reserves place the stock industry in this section on a permanent basis, and I feel that as soon as the stockmen become familiar with the regulations, the range on the reserves will be well stocked.

GAME.

An Act of the Provincial Parliament creates game preserves out of all the Dominion Forest Reserves within the province, and the Dominion Forest Reserve Act confirms the provincial Act. This places the responsibility for the protection of the game upon the Dominion as well as on the province. The forest reserve rangers have protected the game on the reserves as far as possible.

but the province has taken no active interest in protection in the past, though plans for co-operation on forest reserves are now being worked out between the Dominion and the province. There is no use in setting aside game preserves unless the respective Governments intend to enforce the regulations.

Game preserves with adequate protection are urgently needed, as much game is being slaughtered out of season, and in some instances elk and moose are being killed, the carcases poisoned and used for wolf bait. Unless better protection is given the big game will rapidly decrease.

POLICY.

In the organization of the work on forest reserves the aim has been to secure, first, an efficient personnel. This has been a difficult task, as the work is new and there are few suitable men in the locality who are familiar with the work or can grasp the fundamental ideas of conservative forestry work. The men are rapidly improving, and have done well, but conditions would be greatly improved if a ranger school was established or a forestry course provided in the west, so that the local people would become more generally interested in the work.

The second object has been to secure comfortable quarters for the men. The head-quarters have been located as near the centre of the various districts as possible, so that the rangers would be centrally located. Lookout points, pasturage, water, and a small area of tillable land were considered, but one or more of the desirable points were usually lacking in the final selection of head-quarters, as the central location, lookout points, and water were the chief factors.

The third aim has been to require all rangers to familiarize themselves with their districts so that in cases of emergency they would know where to go and what to do. A ranger is of little use unless he knows his district and travels over it as often as conditions require.

The fourth requirement kept in mind has been to furnish the rangers with sufficient equipment and tools so that the reserve work can be done in proper shape. A ranger must have sufficient equipment to get results, as he is usually located where it is difficult to borrow in case of need, and a man with a good outfit has no excuse for not keeping his district in good shape.

The fifth aim kept in view has been to dispose of the brush in proper manner, and to cut, as far as possible, along silvicultural lines. It has been the aim in all cutting to get rid of all merchantable dead, down, and infected material. All brush should be piled and burned, as there is so much refuse on the ground throughout the wooded areas, that it is absolutely necessary to have a few clean areas, even though some young trees are destroyed in the process.

The work on the reserves has progressed very favourably during the year, and credit is due the rangers for all results obtained.

Respectfully submitted,

G. A. GUTCHES,

Inspector of Forest Reserves for Saskatchewan.

APPENDIX No. 4.

REPORT OF THE DISTRICT INSPECTOR OF FOREST RESERVES FOR ALBERTA.

CALGARY, ALTA., March 31, 1914.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa, Ont.

SIR,—I have the honour to submit herewith my second annual report as District Inspector of Dominion Forest Reserves for the province of Alberta.

BOUNDARIES.

The boundary work in the Alberta district during the year ending March 31, 1914, was comprised largely under three heads as follows:—

1. Creation of new reserves as a result of previous explorations.
2. Examination of lands proposed for inclusion in the forest reserve.
3. Survey and marking of boundaries of existing reserves.

As a result of previous examinations made by the Forestry Branch, one new reserve was created in the Alberta district during the past year, and three additions were made to existing reserves. I mentioned in my annual report for 1912 that certain additions were proposed to the Crowsnest, Clearwater, Brazeau, and Athabaska forests. These additions were all made by Act of Parliament, assented to on June 6, 1913, and comprise three separate areas lying (1) in the Porcupine hills in southern Alberta, (2) in the Rocky Mountain foothills between the North Saskatchewan and the Athabaska river, and (3) in the foothills between the Athabaska river and the 15th Base Line. The total area of these additions is, approximately, 2,683 square miles, or, in round numbers, 1,720,000 acres.

The new reserve created is known as the Lesser Slave Lake forest reserve and was established by Act of Parliament assented to on June 6, 1913. It comprises two separate areas, one located in the Swan hills immediately south of Lesser Slave lake, and the other in the Martin mountains north of the east end of Lesser Slave lake. These blocks are separated from each other by Lesser Slave lake and its outlet into the Athabaska river, and total, approximately, 5,023 square miles, or 3,215,000 acres.

The additions made to the Rocky Mountains forest reserve had all previously been under administration in connection with those divisions of the reserve of which they form a part, so that there was no material change in the organization as a result of these extensions. On the Lesser Slave Lake forest reserve no work has as yet been undertaken, as the reserve was created too late in the year to undertake an organization last season and there was no apparent necessity for administration during the winter. Plans have, however, been made for placing this reserve under formal administration during the season of 1914.

The examination of lands which it is proposed to include in forest reserves divides itself into two parts. The first is the preliminary inspection preceding the temporary withdrawal of the land for a more detailed reconnaissance. Work of this sort is handled mostly by the inspector in so far as it is done under the direction of the Alberta District Office, and last year involved a cursory inspection of about two townships adjacent to the east boundary of the Clearwater forest on the south side of the Saskatchewan river. On the recommendation of the inspector these lands were temporarily withdrawn from entry and these, together with about twenty-five townships withheld from entry in the vicinity of the east boundary of the Brazeau, will be examined in detail during the summer of 1914.

Detailed examinations under the direction of the Alberta District Office were made only in the coal-lands reserves in the Crowsnest region of British Columbia. This coal-lands reserve consists of two blocks, one of 45,000 acres and the other of 5,000 acres located east of Fernie on the head-waters of Michel creek and the Flathead river. The examination of this land was made under instructions prepared by the inspector in August, 1913, the crew consisting of Forest Assistant McVickar, with Forest Student J. M. Sloan as assistant. This examination involved a mapping of the entire area, showing types, and a report upon all phases of the problem, such as the climate, the timber, local industries, settlement, improvements, grazing, etc. This report, with map, was prepared by Mr. McVickar and submitted under date of September 10, and recommends the creation of both blocks of coal land into forest reserves and their attachment to the Crowsnest forest for the purpose of administration.

As was suggested in my annual report for 1912, there was urgent necessity of delineating and marking on the ground a considerable portion of the east boundary of the Rocky Mountains forest reserve. The most urgent work of this sort lay south of the main line of the Canadian Pacific railway, extending from there to the international boundary and comprised a total of 230 miles of boundary line. The purpose of this survey was twofold. The first was to mark on the ground by means of blazed or cleared lines and by posts and boundary notices the actual location of the forest reserve boundary, so that trespass through ignorance of the location of the reserve might be avoided. The second was to show on the map the types of land and cover, distinguishing particularly grazing lands from timber lands immediately adjacent to the boundary both inside the reserve and outside. In order to accomplish these purposes, detailed instructions were prepared in the inspector's office under date of April 17, in which the method of survey was explained and an outline prepared for a report on the examination, together with instructions covering the mapping. Two crews were organized, one under the supervisor of the Bow River and the other under the supervisor of the Crowsnest forest. Several changes in personnel occurred in these crews during the season, but the work as far as planned for 1913 was practically completed. The final report on the work on the Bow River was prepared by Forest Assistant McVickar, who was last in charge of the field work on that reserve. The final report on the Crowsnest was prepared by Forest Assistants Alexander and Clark. The work on the Bow River extended over approximately 85 miles of boundary line, while that on the Crowsnest extended over approximately 150 miles of boundary line. Both maps and reports were prepared in sufficient time to be of very material assistance in the handling of the grazing business during the present year.

The boundary marking consisted of blazing or cutting out the boundary line and establishing permanent wooden posts suitably inscribed and witnessed at half-mile intervals along the line. At these same intervals, and also at the points where all trails and roads enter the Reserve, boundary posters and fire warnings were placed for the information of the public.

There still remains urgent necessity for continuing this work so as to cover all of the boundary in the Porcupine hills addition to the Crowsnest, which involves the survey of about 150 miles of boundary line, and the marking of the boundary line in the north division of the Bow River forest, which involves about 100 miles of line. This work will be done under the same instructions and in the same manner as was the work last season and will be covered during the summer of 1914.

As a result of field examinations made by the inspector during the past year, it was thought desirable to make a change in the interior boundary between the Brazeau and Clearwater forests, so as to include in the Clearwater all of the drainage of the South Brazeau river. The most important reason for making this change was that this portion of the Brazeau had become very much more readily accessible from the south than from the north owing to the completion of the Canadian Northern railway to the town of Nordegg. It was therefore much easier to carry on improvement and protection work from Nordegg than it was from the nearest railway point to the north, and, as the business of the reserve naturally follows the lines of most ready communication, that portion of the Brazeau which lies in the South Brazeau drainage is, as a result of railway construction, being approached via Nordegg from Rocky Mountain House instead of via Pacific pass from Mile 37. It was therefore much more desirable to change the boundary line so as to include this valley in the Clearwater forest than to retain the old boundary line in opposition to the trend of local development.

The work for the next field season in the Alberta district which is of most pressing importance is the continuance of the boundary-marking on the Crowsnest and Bow River reserves as above stated and the examination of lands adjacent to the Brazeau and Clearwater reserves which have been temporarily withdrawn from entry so that it may be decided whether or not they should be included within permanent forest reserves. Plans for this work have already been completed so that the projects will be undertaken during the season of 1914. It is also very desirable to extend the boundary delineation work to the Cypress Hills reserve, and this will be done during the summer season if the work on the Rocky Mountains progresses as present plans would indicate.

PERSONNEL.

The staff in the inspector's office during the past year consisted of the same employees as in the year previous; that is, the inspector, an accountant, and one stenographer. On the forest reserves and in the district office there was employed, in addition to the inspector, a total of 275 employees. The grades and total salaries paid these employees are shown in the following table:—

Table 1.—Employees on Rocky Mountains Forest Reserve.

Grade.	Number.	Salary.
		$ cts.
Supervisors	5	6,347 27
Forest assistants	7	5,062 91
Surveyors	2	713 71
Clerks	5	4,369 40
Rangers	59	42,464 37
Surveyor's assistants	11	3,266 60
Temporary laborers	186	16,675 85
Total	275	78,900 11

It will be noted that during the year there were considerably fewer changes in the permanent employees than during the year previous. All of the supervisors employed, with the exception of one, remained in the district the entire year. The supervisor of the Bow River forest, Mr. F. C. Edgar, resigned from the service in August, and was not replaced during the year, his work being taken over by the district inspector. Of the forest assistants employed, one was employed only temporarily during the summer, one resigned in November, and one was promoted to a supervisory position and is included under the list of supervisors as well as among the forests assistants. There were no changes in the clerical staff during the year except that Mr. G. C. Blyth, forest clerk on the Brazeau forest, resigned during the last month and his place had not been filled at the end of the fiscal year.

In connection with the forest rangers, of whom fifty-nine were employed during the season, it should be noted that the greatest number employed at any one time was forty-nine. Of the total number employed, thirty-nine were employed for a period of less than nine months, and twenty for a period of nine months or more, of whom fifteen were employed for the entire year. The temporary labourers were employed exclusively on trail and other construction, this total not including any men employed on fire-fighting. Most of the temporary labourers were employed for a period of less than three months.

Although there were not as many changes in the permanent staff during the past year as took place the year previous, it was unfortunately necessary to carry on the work as originally planned with a wholly inadequate force. Many of the original plans for the administration having been crystallized into the form of regulations, it was essential that the administration be continued along practically the same lines as was originally planned, although the force available for this work was very inadequate. This applied particularly to the technical staff, which was seriously depleted as a result of the organization of the forest service of the province of British Columbia, which employed a considerable number of the men who were originally assigned to this district.

The practice of forestry under conditions very similar to those existing in the Dominion Forest reserve is not by any means unknown on this continent. It is true that there has been no extensive practice in conditions of timber growth exactly comparable with all conditions involved in the Dominion forests, but so close are the relationships between the types and species existing within the Dominion forests and those existing within other forest reserves and timbered lands upon which forestry is being practiced, that no difficulty need be experienced by a trained forester in applying the results of experience in corresponding regions to the forests of the Dominion reserves. This applies not only to silvicultural problems, but also to problems of protection, utilization, and the administration of grazing. But, while the technical aspects of the situation present comparatively few difficulties, yet the really fundamental problem which must be solved before any real progress can be made is that of the organization of a trained and efficient personnel. I pointed out in my last annual report what were the necessary qualifications for a forest ranger, and urged at that time the necessity for establishing some organization by means of which rangers could be instructed in their duties and trained to that degree of efficiency which is essential for the continuance of the work. This need has become very pressing, and the situation is daily becoming more acute as the demands upon the forest reserve continue to grow and the field force is confronted with the necessity of either meeting these demands and handling the reserve timber according to forestry principles, or else abandoning any attempt at the practice of forestry or the employment of conservative methods of utilization. As was pointed out in my annual report for 1912, it is impossible to expect that we can secure men having the requisite qualifications unless we can offer inducements which will attract to our organization and hold in it men who are willing to devote a great deal of time and effort to securing a training along the lines which are necessary for the proper administration of the reserves. Such men we cannot hope to secure unless appointment is placed upon a basis of efficiency and tenure of office, and promotion is determined by merit alone. In other words, we must practically create a new type of employment, that of minor forest employee or forest ranger, and the fact that, as pointed out in my previous report, it will probably be necessary for us to provide our own means of instruction is not by any means an unprecedented course either for the Government or for private enterprises. To show that this course is not without precedent in the Dominion Government it is only necessary to cite the report of the Militia Department for the fiscal year ending March, 1911, which shows that a total of more than $87,000 was expended during that year by this one department for schools of instruction. Assuming that the rate of increase in the expenditure for instruction in this department has been on the same basis as the increase in the total appropriation for the department, the expenditure next year would be approximately $250,000. If so vast a sum as this can be expended annually for the purpose of training to greater efficiency a force whose purpose it might not be impossible to demonstrate to be largely destructive in character, how much greater would be the justification for the expenditure of a comparatively insignificant sum of $8,000 or $10,000 that would suffice for the establishing of a service school for the training of a forest ranger staff which is a force that is not only essentially constructive in character but whose constructive efforts are confined not alone to the needs of the present but also take into full consideration the needs of future generations. Next to placing the administrative staff upon a basis of permanency, there is no more important step that could be taken in the Forestry branch than the creation of an organized scheme of training and instruction for the forest ranger staff.

There are in the Dominion adequate facilities for the training of men for the more highly technical positions. Two universities offer complete courses in forestry, while there is a special forest school maintained by the province of Quebec, and one is promised by the province of British Columbia in connection with its provincial university. There are absolutely no facilities whatever in the Dominion for the training of men for the lower grades of employment in the forestry service although such men outnumber the officers in the higher grades more than twenty to one. Naturally it can scarcely be expected that facilities for obtaining such training will be provided until there is a recognized demand for men having these qualifications, or at least reasonable grounds for assuming that there will be such a demand. This is in strict contrast with conditions in the United States, where almost every Western State university has its forest school for forest rangers, and several very large schools of this character are also maintained in connection with the more important universities in the East. It should not be expected that men whose field of work will lie in the forestry service of the Dominion Government or of the various Provincial Governments should be compelled to secure their forestry training in foreign schools as has been done in a few cases in the past. On the other hand, as none of the western provinces except British Columbia have any timber lands under their administration it will no doubt be out of the question to look for the establishment of ranger schools in connection with the provincial universities. At the same time it is highly desirable that this training be provided, if possible, in the general region in which the men's field of work lies, so that for work on the Dominion Forest reserves it would seem necessary for the Government to arrange for this course of training within its own establishment.

FIRE PROTECTION.

The fire situation during the past season was again remarkably favourable. Although it is a general impression that less rain fell during 1913 than 1912, nevertheless the precipitation in 1913 was very generally distributed at frequent intervals throughout the season, so that there was never any time during which the fire danger became at all acute. On the other hand, during 1912 rain was so frequent and so long-continued at certain periods that it not only removed the fire danger, but caused much loss owing to the impossibility of carrying on any kind of constructive work. This condition was not apparent during 1913, although the fire danger was on the whole little, if any, greater during that year than during the year previous. The general situation as regards fire within the reserves is shown in the following tables which give the number of fires that occurred on each reserve, the causes, the cost of control and damage caused by these fires:—

Table 2.—Number of all Fires Reported by Classes on Each Reserve.

Forest.	Large.	Small.	Total.
Crowsnest		2	2
Bow River		1	1
Clearwater	5	1	6
Brazeau	2	8	10
Athabaska	1	1	2
Cooking Lake			
Cypress Hills			
Total	8	13	21

Table 3.—Fires reported by each Forest, showing Month of Occurrence.

Forest.	April.	May.	June.	July.	Aug.	Sept..	Oct.	Nov.	Dec.	Feb.	Total.
Crowsnest					1	1					2
Bow River				1							1
Clearwater		1					2	1	1		6
Brazeau	3	2	1		3					1	10
Athabaska	1				1						2
Total	4	3	1	1	5	1	2	1	1	1	21

Table 4.—Causes of all Fires reported.

Forest.	Ry. Construction.	Locomotives.	Clearing.	Lightning.	Match dropping.	Sawmill Waste burning.	Unknown.	Total.
Crowsnest		1		1				2
Bow River							1	1
Clearwater	5						1	6
Brazeau		6	1	1		1	1	10
Athabaska					1		1	2
Total	5	7	1	2	1	1	4	21
Percent of Total	23·9	33·3	4·7	9·5	4·7	4·7	19·1	100

TABLE 5.—Damage caused by Fire on each Forest.

Forest.	Area of Reserved Land.	Damage to Timber or Reproduction on Reserved Land.			
		Timber Destroyed or Damaged.		Value[1] of Reproduction Destroyed.	Total.
		[1]Ft. B.M.	Value.		
			$ cts.	$	$
Clearwater	1,300	....	....	4,650	4,650
Brazeau	3,000	75,000	150 00	5,250	5,400
Athabaska	3,800	Not Known.		....	....
Total	8,100	75,000	150 00	9,900	10,050

[1]Value figured at flat rate of $5 per acre.

TABLE 6.—Expenditure for Fire-fighting by Forests, exclusive of Ranger Labour.

Forest.	Temporary Labour.	Supplies Transportation.	Total Cost.	Value of Voluntary Assistance.
	$ cts.	$ cts.	$ cts.	$ cts.
Clearwater	415 90	41 66	457 56	301 60
Brazeau	538 86	392 09	930 95	....
Total	954 76	433 75	1,388 51	301 60

It will be noted, on comparison with the previous year, that there were only about two-thirds as many fires placed under control by the forest rangers during 1913 as was the case during 1912. It will also be noted that the number of fires occurring inside the reserve during these years is practically the same, there being only one more in 1912 than in 1913. The difference in number of fires occurs entirely in fires fought outside the reserve, which is accounted for by the fact that during 1912 all fires that occurred along railways adjacent to the forest reserve boundary were handled by the forest reserve force, while during 1913 these fires were handled by the railway fire patrol employed by the railway companies. Also during 1912 there was more or less construction work on railways adjacent to the forest reserve boundary which gave rise to fires, most of which had progressed so that the work was largely within the reserves during 1913.

A comparison of the results for the two years, however, does not lead to altogether optimistic conclusions. It will be noted, for instance, that while there was one less fire during 1913 than during 1912, the number of large fires inside the reserve was 60 per cent greater than the year previous and that the area burnt over is ten times as large, with the cost of control increased from $58.95 to $1,388.54, and the damage from $1,221 to $10,050.

It takes but a brief examination into the history of the various large fires which occurred to fix very conclusively the responsibility for this condition. The bulk of the damage, and by far the greater part of the cost, occurred on the Athabaska and the Brazeau forest, and resulted from two fires. The only other very large fire which occurred was on the Clearwater forest in the mouth of December, when no fire danger was anticipated and conditions were thought to be such that the danger for the year was over. The two fires on the Brazeau and Athabaska, one of which covered about 2,500 acres and the other of which is set at 3,800 acres, but may be much larger, resulted solely from the incompetence of the rangers in whose district the fires occurred. In both cases, although the fires were sighted almost immediately after being set, the rangers were unable to get to the fires, although in one case the distance of the fire from the ranger's headquarters was only 8 miles, through comparatively open foothill timber.

I stated in my last annual report that it was impossible from the consideration of one season's work—particularly a season as favourable as was 1912—to arrive at any conclusions as regards the efficiency of the force. I indicated in the body of my report, however, that unless fundamental conditions as regards employment were radically changed it could scarcely be anticipated that any improvement in the protection can be secured. On the contrary, with the opening up of the reserve by railways and other means of communication, and the establishment of coal-mining towns and other settlements within its boundaries, it was to be fully anticipated that the number of fires occurring inside the reserve would constantly increase and without a corresponding increase in the efficiency of the protection the final result can not help but be disastrous. The basis of efficient fire-protection is an efficient personnel far more than an elaborate equipment of permanent improvements or carefully-worked-out plans. It is true that good men are not the only requirements, but that under modern conditions of fire protection the best results are secured by an efficient staff, assisted in every possible way by mechanical aids and permanent improvements and by careful organization, but to show that improvements alone are not sufficient it is only necessary for me to point out that in the case of the large fire which occurred on the Brazeau Forest reserve we not only had a newly constructed trail and headquarters for the ranger in the district, but also had the ranger headquarters connected with the supervisor by means of a Forestry Branch telephone, and that the fire was discovered from a lookout within a few hours after it was set. In fact, we had practically all of the necessary ingredients of first-class modern fire protection except an efficient ranger and this fire attained the size it did and caused so much damage simply because we had a ranger who was not able to find his way around the woods.

PERMANENT IMPROVEMENTS.

Although the amount expended on improvements during the past fiscal year constitutes only 3 per cent more of the total allotment than during the preceding year, the results obtained have been very much superior to those the year previous. This has been due to better organization of the work, to the establishment of standard specifications for the trail work and to better supervision of all work done. A considerable part of the work reported last season was found on inspection to be of rather low grade and not to come up to the specifications which it was reported to follow. This condition does not obtain for the work constructed last year, practically all of which conforms very closely to the specifications established for the improvement work on the reserves.

It is unnecessary to go into details of the necessity for the construction of permanent improvements, as I dealt with this matter at some length in my last annual report, and a very little consideration of the subject and of the conditions within the Dominion Forest reserves will convince any one of the impossibility of administering or protecting these reserves until they are equipped with trails and other improvements that make them readily accessible for our rangers. In so large a country as the Rocky Mountains forest reserve the mileage of trails required to make it accessible is, of course, very great, and a number of years will be required for the construction of all the needed improvements. The work has, however, progressed very satisfactorily during the past two years, considering the handicaps of lack of preparation and inadequate knowledge of the country which we have faced, and it is to be hoped that as the organization for the extension of improvement work is each year made more perfect, the funds for carrying out this work will be available so that the improvement equipment may be completed at as early a date as possible. It will, of course, be realized that the construction of permanent improvements on the forest reserves is a matter of temporary importance only as there is a limit beyond which it is not necessary to go, and as soon as this limit is reached the only charge for improvements will be the cost of maintenance, which will be larger or smaller according to the character of the original construction. It has been the aim of the administration in this district to make the original construction first-class in every respect so that subsequent maintenance charges may be reduced to the minimum. In order to accomplish this it has been found desirable to establish uniform specifications for trail construction throughout the district. This is greatly facilitated by the fact that natural conditions affecting the construction of trails and similar improvements do not vary greatly anywhere in the Rocky Mountains forest reserve.

I suggested in my last annual report the requirements for two classes of trails known as "standard" and "secondary." Shortly after submitting this report I prepared a circular letter in which the subject of trail construction was discussed in detail, and standard specifications for three classes of trails were laid down. These trails are known as "primary," "secondary," and "auxiliary." The primary and secondary trails correspond very closely with the standard and secondary trails as explained in my last annual report. The auxiliary trails are described as follows: "Auxiliary trails may consist only of a blazed line where there is no down timber or heavy brush. The purpose of these trails should be to indicate those passes, valleys, or other natural routes of travel which it is possible to take horses through. No clearing other than that which is absolutely necessary to get packs through will be required, nor should any grading be done unless it is essential in getting around an exceedingly steep side-hill. The grade on auxiliary trails should not exceed forty per cent. Where a trail with a grade of less than forty per cent cannot be secured without grading, then a tread about twelve inches wide should be cut to secure the proper slope. No bridges or corduroy need be built on auxiliary trails except across bog-holes that would be likely to mire horses at unfavourable seasons of the year. Wherever corduroy or bridges are constructed, however, they should be built according to specifications for secondary trails, since nothing is ever gained in constructing temporary corduroy or bridges."

The work of telephone construction has not advanced much over the previous year. One line 26 miles in length was built during last year, at an average cost of $46.82 per mile. This line is very satisfactory, and, if we could do similar work throughout the reserve and be as successful in the maintenance of the line as has been the case with the telephone on the Brazeau, we could do much more effective work both from an administrative and protective point of view. Certain personnel difficulties, however, particularly in those reserves which are most in need of telephone communication, have made it impossible, to date, to undertake extensive work of this character.

Further study of the situation on the reserves as regards rangers' cabins reveals the fact that three rather uniform types of log cabins might be adopted as standard on the reserves without being subject to any very great variation to meet special requirements. This fact was indicated in my last annual report, but has been elaborated during the past year, and plans and specifications for three standard types of log buildings have practically been completed and will be shortly distributed to the field officers and established as standard buildings for reserve work. In those districts where rangers are employed all year round, log buildings of from five to seven rooms, with log barns, will be used except where it is readily possible to secure lumber for construction purposes. It has been found, however, that the construction of frame buildings is not feasible except in a very few easily accessible localities, and the greater number of the large ranger stations which will hereafter be constructed will have to be built of logs.

In those localities where men are not stationed all year round, but are stationed for more than half the year, and where it may be anticipated that the growth of business and the increase of settlement near the reserve will shortly require year-long establishments, we are building houses 18 by 24 feet (inside dimensions), using them now for dwelling purposes, but having in view their future utilization for barns whenever it becomes necessary to provide a more elaborate equipment for year-long use. It will be noted from the tables of improvements accompanying this report that during the past year one Class A, three Class B, and twelve Class C buildings have been constructed. The Class A buildings are the large ranger-stations, Class B intermediate type, and the Class C. the small 12-by-14-foot or 14-by-16-foot cabins which are built only for tool-caches and temporary stopping-places. It will be noted, in addition, that three Class A cabins, fourteen Class B cabins, and one Class C cabin which were unfinished at the beginning of the year have been carried to completion during the present year. Several cabin projects which were reported last year as having been completed were found to require additional work, so that about $2,000 altogether was required to carry to completion eighteen buildings that were left unfinished last year. In addition to this, a little over $800 was required to fit out five buildings purchased during the year, which required some repairs in order to make them available for immediate use.

In the tables attached hereto the average costs have a much more distinct value than similar averages would have had last year. The reason for this is that the work during the past year has been on a more systematically organized basis, and, as most of the trails and buildings are built according to uniform standards, it is much easier to compare them and secure average costs that have a real value than was the case during the previous year. In considering averages, however, from year to year, certain points in regard to the improvements constructed must be kept in mind. For instance, during the past year the average road cost has been only $52.01 per mile. This cannot be assumed to be a figure that will hold good throughout the reserve, as a very large part of the road construction was included in one project on the Clearwater forest which involved a large amount of open country where the cost of construction was very slight and the average cost was, therefore, very low.

The cost of primary trails is shown to have averaged $48.71 per mile. This, I believe, may be taken to be a very fair average figure for primary trail construction throughout the reserves, as such trails were, during the past year, distributed in all types of country and timber in all of the reserves except the Crowsnest, and may be assumed to represent a fairly average figure for the cost of these improvements.

The secondary trail cost appears at $39.74 per mile. This is considerably higher than trails of this character should average, but the high cost is explained by the fact that on the Crowsnest Forest and on several trails in other reserves, trail work which corresponds to primary specifications except for minor points has been classified as secondary work. The cost of converting such trails into primary trails will be comparatively small, so that the final result will be a primary trail with the cost but little more than the average figure for such trails. The intention of these various projects was to construct them as primary trails, but there seems to have been some misunderstanding of instructions which resulted in a type of construction that is much more elaborate than necessary for secondary trails but does not quite comply with primary standards. Another factor which accounts for the high average cost of secondary trails is the fact that quite a number of these trails during the past year have been constructed in heavy timber and windfall, where the cost of construction is considerably greater than the average that may be reasonably anticipated for trails of this character throughout the reserve. I would point out that during the previous year the average cost of secondary trail construction was only about $15 per mile, which represents more nearly an average figure for the entire district than the results of the present year do.

The average cost on all classes of buildings as shown in the table of completed projects during the past year is aproximately what may be anticipated as the cost of such buildings throughout the district. Better organization and more experience in construction will undoubtedly cause some reduction in these averages, but I do not think that a greater reduction than 10 per cent below the average for the past year can be anticipated.

The purchase of buildings during the past year has enabled us to secure five new houses at a very reasonable cost. Most of these buildings were engineer's or contractor's camps in the vicinity of the new railway lines, which were very well constructed and happened to be located at the places where we needed buildings, and were secured much below their actual value owing to the fact that the cost of removal would in most cases have been prohibitive. In order to adapt these buildings to our requirements, it was necessary in all cases to make some repairs and alterations, but the final result is that we have secured three buildings that correspond practically to Class A specifications, and two that correspond to Class B specifications at an average cost, including alterations, of $561.05 per building, which is about $200 less than the average cost of newly constructed buildings of both types during the past year. The purchase of such buildings, however, has about ceased to be possible, as there are no more roads under construction in the forest reserve at the present time.

The four tables given below show the total work carried out in the district during the past year. These tables show not only the work that was done, but also the condition of the project at the end of the year. As was previously pointed out, a number of projects reported as completed last year were found to require some additional work during the present year. These are shown under Table 10. The greater part of the work was, of course, done by the permanent force.

TABLE 7.—Summary of Complete Projects.

Project.	Length.	No.	Average Cost.	Cost, Rangers' Salary.	Cost, exclusive Rangers' Salary.	Total.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.
Roads	40·25		52 01	291 52	1,801 81	2,093 33
Primary Trails	287·00		48 71	2,532 19	11,447 25	13,979 44
Secondary Trails	142·5		39 74	1,130 87	4,532 84	5,663 71
Auxiliary Trails	128·00		6 30	781 38	25 00	806 38
Corrals		1	25 00		25 00	25 00
Cabins, Class A		1	1,131 09	31 09	1,100 00	1,131 09
Cabins, Class B		14	359 12	745 89	690 60	1,436 49
Cabins, Class C		12	188 49	755 69	1,241 89	1,997 58
Barns		4	156 04	312 51	311 66	624 17
Bridges		4	84 23	122 27	214 63	336 90
Fences		10	79 08	334 10	456 74	790 84
Fire-guards (Timber)	1·00		148 40	148 40		148 40
Fire-guards (Ploughed)	671·00		1 00		670 95	670 95
Buildings (Purchased)		5	394 00		1,970 00	1,970 00
Telephones	26·00		46 82	239 46	977 81	1,217 27
Total				7,425 37	25,466 18	32,923 55

TABLE 8.—Summary of Incomplete Projects.

Project.	Length.	No.	Average Cost.	Cost, Rangers' Salary.	Cost, exclusive Rangers' Salary.	Total.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.
Roads	13		91 21	113 89	1,071 86	1,185 75
Primary Trails	22		39 76	329 40	545 20	874 60
Cabins, Class A		3	818 72	908 70	1,547 47	2,456 17
Cabins, Class B		3	157 25	231 77	240 00	471 77
Cabins, Class C		8	86 23	226 23	463 64	689 87
Barns		1	222 17	32 50	189 67	222 17
Bridges				54 30	230 00	284 30
Fences		4	70 78	46 67	236 45	283 12
Total				1,943 46	4,524 29	6,467 75

TABLE 9.—Maintenance and Alteration of Completed Projects.

Project.	No.	Cost, Rangers' Salary.	Cost, exclusive Rangers' Salary.	Total.
		$ cts.	$ cts.	$ cts.
Roads		16 70	159 90	176 60
Secondary Trails		231 84	121 25	353 09
Telephones		91 60	35 25	126 85
Houses, purchased	5	167 05	473 88	835 23
Total		507 19	790 28	1,491 77

TABLE 10.—Completion of Projects unfinished previous year.

Project.	No.	Average Cost.	Cost, Rangers' Salary.	Cost, exclusive Rangers' Salary.	Total.
		$ cts.	$ cts.	$ cts.	$ cts.
Cabins, Class A	3	379 81	603 50	535 94	1,139 44
Cabins, Class B	14	62 32	737 07	135 33	872 40
Cabins, Class C	1	3 40	3 40		3 40
Barns	2	22 76	45 52		45 52
Total			1,389 49	671 27	2,060 76

SILVICULTURE.

The most striking development in the timber-sale business during the past year was the very large demand for mining timbers on the Brazeau Forest reserve. The completion of railway lines into the Brazeau forest, and the opening up of new mines, has given rise to a demand for mining timbers which will undoubtedly continue and very likely increase to a considerable extent. This is also true of the northern por- within the Rocky Mountains forest reserve will be highly advantageous, not only to mines are already in operation. The building up of a market for mining timbers tion of the Clearwater forest to which a railway was completed and in which the mining interests and the general interests of the community, but also to the silvicultural interests of the forest reserve itself. The great advantage of having coal mines as a market for forest products lies in the close utilization which is secured in cutting timber for such purposes, and in the possibility of disposing of classes of timber which are not ordinarily suitable for manufacture into lumber. This close utilization naturally makes possible the application of many technical forestry operations which cannot be considered where the market is more stringent in its requirements as to size and quality.

The development of mining interests within the reserve, and the consequent demand upon the reserve for mine timbers, has given rise to a necessity for taking definite action in regard to limiting the use of forest reserve timber to those purposes for which it is best adapted, as was suggested in my last annual report. In certain portions of the Brazeau Forest reserve, and a relatively small portion of the Clearwater reserve also, it seems very desirable to designate portions of the reserve timber which will be put on the market only for use by mining operators. In designating these areas consideration must, of course, be given to legitimate demands for timber for local requirements other than mining, but, as a general rule, it will be found that the amount of timber adjacent to operating coal mines in this portion of the reserve is so limited that it cannot reasonably be expected that the available supply will suffice both for the needs of the coal mines and for saw-milling and export purposes. Under these circumstances, I feel that the coal mines, because of their close proximity to the timber, their absolute dependence upon timber for continuance of operations, and the superior utilization which they are prepared to make, should have the first opportunity to secure the timber that they need in their own vicinity. This should be accomplished by designating certain tracts of sufficient size within which competition on sales is limited to coal-mine operators alone. The preliminary work of locating these areas has already been done, and detailed recommendations will be prepared and forwarded during the next season.

The subject of brush disposal on timber sale areas has been referred to at various times, and all of the sales that have been made under the Forest Reserve regulations in this district have provisions providing for the disposal of the brush either by burning or in accordance with such other methods as might be specified by the forest officer in charge. It must, of course, be realized that while the methods of disposing of brush are not so very numerous, yet there are quite a number of small variations in these methods needed to make them applicable to local conditions, and that unless the best method with the proper variation is arrived at in each particular case the cost is likely to be excessive or the disposal unsatisfactory. The best way in which to arrive at a final decision in regard to the most satisfactory method of brush-disposal to be followed in any individual case is to carry out a series of experiments to ascertain what is the cheapest and most satisfactory procedure under the various conditions which exist within the reserve. A start has been made on a line of experiments of this sort, although, owing to lack of assistants, especially experienced assistants, the work has not been undertaken upon as clear-cut and scientific a basis as is desirable for the securing of reliable statistics and results within the shortest reasonable time. We have now in operation, however, timber sales in practically all of the more important types and situations which occur in the mountains, so that there is an opportunity afforded for carrying out experiments in brush-disposal which can be made conclusive and fully comprehensive, provided the work is organized upon the proper basis and handled with an adequate staff. This would involve the employment of an assistant in the inspector's office to take charge of silvicultural work alone, as the administrative work of the inspector is entirely too great to permit him to devote to silvicultural work the time both in the field and in the office that would be necessary to make this work a success.

Another line of work taken up during the past year and conducted with much success was the preparation of volume tables for the important species on the East Slope. The only tables available were those prepared by Mr. Dwight, and included within Bulletin No. 33. These tables, of course, were not based upon any large number of trees, and were taken in only one type, which happened to be perhaps the best type of timber on the reserve, and a type of which not very much remains in the hands of the Government. There was urgent necessity for volume tables applicable to the more unfavourable sites, and especially to the stands which occur in the northern portion of the reserve and at rather considerable elevations. In order to provide these tables, a small crew under the charge of Forest Assistant McVickar was kept employed practically throughout the winter making measurements and plotting results, so that we now have figures upon which we can base volume tables for practically all conditions from the Saskatchewan river south, and for most of the conditions encountered between the Saskatchewan and the Athabaska. There are still one or two tables needed in the Brazeau and Athabaska Forest reserves for which adequate data are not yet available, and which should be secured during the next season. We also secured figures upon which to reconstruct, if necessary, the tables prepared by Mr. Dwight and published in Bulletin No. 33. The work of computing the results of the measurements is not yet completed, but I attach hereto volume tables for lodgepole pine and Engelmann spruce, prepared as a result of measurements taken on the Highwood river, and based upon diameter and total height in 10-foot height classes in one table and diameter and merchantable height in 16-foot log lengths in the other table. Three tables will be prepared for both spruce and pine showing board-foot contents on the basis of total height and diameter, merchantable hight in log lengths and diameter, and cubical contents on diameter, merchantable length. These tables will be applicable in three different regions of the forest reserve. Work of this character should, of course, be under the direction of the assistant in the inspector's office above suggested.

The timber-permit business in the district, although it is rather large as regards totals, is yet distributed over so extensive an area that it is not possible to give to it the same close attention as in other districts. It is impossible in the Alberta district, with forest reserves of three or four million acres in extent, for the forest supervisor to have the intimate personal acquaintance with the timber-permit business on his reserve that can be readily secured in much smaller and more concentrated reserves such as those in Manitoba and Saskatchewan. A system of administration, therefore, which gives good results in small compact reserves of a few hundred thousand acres does not give equally satisfactory results on reserves the size of those in the Alberta district. There is evident necessity for some form of report by forest rangers on the timber permits handled under their supervision, so that inspection by the supervisor may not involve a knowledge of each separate permit, but may be confined simply to an inspection of a small portion of the work upon which the rest can be judged as shown by the rangers' reports. This procedure is particularly necessary in the Rocky Mountains, although it would perhaps not be so important on the Cypress Hills, provided there were a supervisor for that reserve who would live on the reserve and keep in direct touch with all lines of work, of which the most important is the timber-permit business.

In connection with the administration of fire protection on the timber berths within the forest reserve and the prevention of trespass on these berths or on lands adjacent to the berths, a great deal of difficulty has been experienced, owing to the fact that the lines in many cases, through lapse of time, or through fire, or other causes, have become obliterated. It has become urgently necessary in a number of cases, that these boundary lines be delineated, and for this purpose plans have been made for an examination of the more urgent cases by a qualified surveyor in co-operation with the district ranger, so that the lines which need retracement and re-establishment may be accurately determined. The resurvey of these lines would seem to be properly chargeable to the berth-owners and in order to maintain the lines in proper condition berth-owners should be required to re-blaze them and clear them out at least once every ten years. The work of examining these lines will be completed during the next season and the plans for this work contemplate the establishment of these lines only in the most urgent cases and the recommendation that the berth-owners be required to re-establish the lines wherever it appears that such re-establishment has become necessary. It would seem fully justifiable to assess a maximum rate of damages against timber-berth owners who, through neglect to mark up their lines, trespass on the forest reserve, as it is impossible in many cases to determine the location of these boundaries except by a transit survey, which none of our forest rangers are qualified to make.

A line of work which is of very considerable importance for the proper organization of the silvicultural work on the reserve is the preparation of a type map of the entire reserve, particularly those portions which are adjacent to areas where timber is in demand either under sale or permit. Such a map is also essential for the proper organization for fire protection as it will be obvious that without accurate knowledge of the location of valuable bodies of timber a proper distribution of the fire-protective force and line-up of fire-protective improvements is scarcely feasible. I will refer to this at greater length under the subject of Surveys, as a start has already been made on this work and much preliminary work has been done during the past season.

GRAZING.

The work of organizing the administration of grazing in the forest reserve in conformity with the Forest Reserve regulations governing this subject had progressed very satisfactorily at the end of the present year. The intentions of the Forestry Branch in regard to the administration of grazing within the reserve had been rather extensively advertised, and has been a matter of discussion between forest reserve officers and stock-owners in the vicinity of the reserve for the past two years, so that a fair proportion of the persons affected were already familiar with the system and prepared to conform to its requirements, although it is a rather new proposition and something which has never before been attempted in grazing administration in the Dominion. Nevertheless, it was found that the scheme appealed very strongly to the great majority of the stock-owners near the forest reserve, once it was adequately and carefully explained to them. Practically all of the land which has been utilized for grazing purposes and has a value for this purpose in the forest reserve south of township 19 has been applied for under the Forest Reserve regulations, and for the most part conflicting applications have been adjusted, and the range apportioned in accordance with the principles underlying the Forest Reserve regulations.

The fundamental principles underlying these regulations might be briefly stated as follows:—

1. The conservative use of the entire available range each year with restrictions that will not involve damage to the forest crop.

2. The distribution of this range among a large number of small nearby resident farmers and ranchers, under restrictions which will not compel any one privileged to use the range to run less stock than is commensurate with the maintenance of a home in accordance with recognized Canadian standards.

3. The encouragement of mixed farming by devoting the forest reserve range to summer use and carrying the stock thus ranged during the summer on the by-products of the farm lands outside the reserve boundary.

The desirability of the fundamental principles is almost universally recognized. The only difficulties which have arisen have been in connection with a misunderstanding of the administrative procedure by which the business would be handled so as to accomplish these objects. Almost without exception where the details of this procedure have been explained opposition to the scheme has disappeared. It is highly desirable—in fact, essential—for the continued operation of a system of grazing administration such as this established by the Forest Reserve regulations that there be some one officer, preferably an assistant to the inspector, charged exclusively with the supervision and inspection of the grazing and administrative work. There will be ranged under this system under permit south of the main line of the Canadian Pacific Railway somewhere betwen 15,000 and 20,000 head of horses and cattle, and perhaps 10,000 head of sheep. North of the Canadian Pacific Railway there will also be several thousand head of horses and cattle scattered over a large area of country as far up as Saskatchewan river. The total number of permittees will probably be in excess of 200, although exact figures are not available. All of these permits must be renewed during the following year, and all are subject to such readjustments as is provided for by the regulations. The amount of detail involved in the administration of such a large number of permits over such an extensive area is very great, and it is impossible that the inspector can continue to handle this work in addition to the numerous other lines of administration with which he is charged.

The scheme of grazing administration is decidedly co-operative in character and it will be found that a great deal more can be accomplished through the action of co-operative associations in the various grazing districts than through direct action with the numerous individuals concerned. This was recognized in the drafting of the regulations which make provision for consultation between Forest Reserve officers and recognized live-stock associations. Several such associations have been consulted, and one has been formed solely for the purpose of securing the benefits conferred by this regulation. A great deal more might be accomplished along this line if there were an officer charged specifically with the administration of the grazing business who could give his time exclusively to grazing work and furnish the advice and assistance which is always found to be necessary in the organization of such associations.

The problem of providing range for sheep within the forest reserve, about which there has been more or less agitation and which was referred to in my last annual report, seems to be well on the way to a satisfactory solution. Two areas of ranges in the Crowsnest forest have been considered for this purpose. The one range occupies a large part of the northern half of the forest lying in the valley of the Livingstone river and its branches west of the Livingstone range. This range was, after conference with the Southern Alberta Wool Growers Association, reserved for sheep-grazing purposes, and tentative applications for about 10,000 head were submitted by members of this association, subject to the results of a personal examination of the range which they undertook to make, and also depending upon the securing of a sheep driveway from the Livingstone Gap to the Crowsnest branch of the Canadian Pacific railway. This range will be available for use about three months of the year, and the plans of the sheep-owners who have applied for the privilege of running sheep in the district contemplate using it only for dry stock after shearing early in June. A very material impetus could be given to this business were it possible to secure from the railways special rate from Lethbridge to the summer range and back again such as is given by the American roads for similar service in Montana.

The second area of range which was more extensively in demand is that lying in the mountains east of the Waterton lakes. It was, unfortunately, not possible to meet all the wishes of the wool-growers in connection with this range, as much of it was previously occupied by cattle that could not be displaced without working a hardship upon those persons who were dependent upon this range for their stock. It was, however, claimed that there was additional range in the vicinity that could be used only for sheep and which had not been taken into consideration by the Forestry Branch. For the purpose of settling this question arrangements were made for a special examination of the range in this vicinity by a Forestry Branch officer in co-operation with sheep owners who are familiar with the district, and if it is found, as is claimed, that range valuable only for sheep occurs in this portion of the forest it may be possible to arrange for its utilization by the sheep interests.

SUPPLIES AND EQUIPMENT.

In my last annual report I suggested that a very material improvement in procedure and administration could be secured if the supplies for the department both for field and office use were standardized. Very little progress has been made in this direction during the past year, and I would again repeat my recommendation that the matter be taken up and standard lists of supplies be prepared as a result of a special investigation of the entire subject to be conducted by the head office and approved by the inspectors' conference. The use of standard lists of supplies would not only very greatly facilitate the preparation of requisitions and avoid much unnecessary correspondence, but would also insure a uniformity of equipment throughout the service and undoubtedly save a large sum of money. At the present time, for various reasons, more or less unsatisfactory equipment has accumulated because of the personal whims of officers who under the present procedure feel free to indulge their own individual ideas as to what kind of equipment is necessary, rather than conform to the requirements which the combined experience of the branch has found to be most desirable. Although this is not a matter of first importance, nevertheless it is a problem that could readily be solved and I am convinced that the results would amply justify the trouble and expenditure that might be necessary in the preparation of such standard lists.

SURVEYS.

The survey of the boundary, the necessity for which was pointed out in my last annual report, has already been described in a previous section of this report. Two other lines of surveys were indicated in my report as being necessary on the Rocky Mountains Forest reserve. These were the establishment of permanent traverse lines along the main rivers, particularly in the northern part of the reserve, and the location of administrative sites by definite surveys.

The work of establishing permanent traverses was undertaken by two parties under the charge of Mr. B. C. Pierce, an experienced surveyor, and Mr. T. H. G. Clunn, D.L.S., who was assigned to the branch from the Surveyor-General's office. Two parties were organized under the charge of these men, and the work was carried out in accordance with instructions prepared by the inspector under date of May 15, and June 7. These instructions provided for the running of accurate traverse lines by means of the transit along which permanent monuments were established at about half-mile intervals. These traverses are tied to the public land survey and in all cases close on a point on this survey. The monuments are numbered consecutively and elevations were carried along by trigonometric methods, so that the elevation of each monument is known. In addition to the primary traverse, secondary traverse lines were run up most of the important side-streams by means of compass or traverse board. These secondary lines are tied to the primary traverse and serve to enlarge the scope of country mapped in from the primary line. The purpose of this work was not only to afford a reasonably accurate map of those large areas of the reserve which had not heretofore been mapped, but also to afford permanent monuments from which subsequent surveys of any kind whatever can be started and properly located on the map.

Such surveys include the survey of administrative sites, of areas of land occupied under permit, of timber-sale applications and of permanent improvements, the location of which cannot otherwise be ascertained.

The work was started on the McLeod river by the northern crew under Mr. Pierce and on the Red Deer under Mr. Clunn, and the crews worked toward each other throughout the summer. The northern crew completed its work as far south as the South Brazeau river and the southern crew completed work north to the Clearwater river. The interval between the two crews, comprising the drainage of the Little Brazeau, the North Saskatchewan and the Sheep river, can readily be handled during the next season, largely by one crew, so that by the end of the season of 1914 this work will be practically completed as far as the reserve south of the Athabaska river is concerned.

In the southern portion of the Crowsnest forest the co-operation of the Topographic Surveys Branch was secured for the purpose of preparing a photo-topographic map of the reserve. The crew, operating under instructions from this branch, worked in the north half of the Crowsnest forest throughout the season and now have the map of this portion well along towards completion. It is understood that this work will be continued in the south half of the reserve during the next season and it would be very desirable to have the same work carried out for the south half of the Bow River forest as soon as the Crowsnest is completed.

The new addition to the Crowsnest forest lying in the Porcupine hills is very inadequately mapped, but it would seem possible, after consideration of the conditions in this portion of the reserve, to handle the mapping most economically in connection with a grazing reconnaissance of this portion of the reserve. I have already referred to this in connection with the subject of grazing.

The third line of surveys, the location of administrative sites, was well forwarded by most of the supervisors last year, so that a fair part of this work has now been completed, but there still remains a considerable number of sites to be surveyed, especially on the Bow river and the Brazeau forests. Little work of this kind can be undertaken on the Athabaska, for the reason that there are no permanent monuments to which surveys can be referred, and there is, therefore, almost no chance to determine with even reasonable accuracy the location of any body of land except at an unjustifiable expense. The following table shows the number of adminstrative sites surveyed and approved on the different reserves during the past season:—

TABLE 11.—Administrative Sites Surveyed and Approved.

Forest—	Number of Sites.
Bow River	5
Brazeau	1
Crowsnest	3
Clearwater	11
Total	20

So little was known of the topography of the mountain divisions of the Brazeau and Athabaska forest, and so conflicting was the information furnished by the persons who claimed to be acquainted with this country, that it was thought desirable last year to have this section explored and secure a sketch map and report upon the conditions in this portion of the reserve upon which further action could be based. The total area is something over three million acres, so that it was important that some plans for its protection and administration based upon adequate knowledge of conditions be made. To accomplish this work, Mr. C. H. Morse was employed and furnished with an outfit and one assistant, spent the entire summer exploring the mountain portion of the two reserves from the head-waters of the Athabaska to the head-waters of the Smoky. As a result of this work, Mr. Morse submitted corrected maps showing the courses of the streams and the location of ranges, passes and other natural features of importance. He also prepared plans for improvements and fire protection for the reserve, and made sketch maps of the timber resources, mapping in types in a broad way as was rendered necessary by the character of the exploration. This is the only portion of the reserve where exploration work of this kind is necessary, but it would be extremely useful to have a map of the entire reserve showing the timber types in accordance with the Forest Atlas legend so that more definite plans could be made in regard to both fire protection and the administration of the timber. At the present time there is no information of any kind available which shows the location of the merchantable timber or the location of areas requiring special protection inside the reserve. It would be out of the question and unnecessary under present conditions to undertake a detailed reconnaissance, but it would not be especially difficult to make a map of the timber resources of the entire reserve, using as a base the traverses and other survey work that is being done, and sketching in types in a general way from traverses along the main rivers and other elevated peaks. An experienced man on this work could probably cover the entire forest reserve south of the Athabaska river in two working seasons. In connection with this work the photographs taken in the preparation of the photo-topographic map of the Crowsnest would probably be of very material assistance. Such a map is indispensable for the systematic handling of the timber resources of the reserve, and considering its comparatively small cost it is a work that should certainly be undertaken as soon as a competent man can be secured and the permanent traverse lines upon which the map will have to be based are established.

EDUCATION AND PUBLICITY.

Owing to lack of assistance in the inspector's office, it was not possible during the past year to carry out as fully as was desired the plans for educational work in the district. Most of the work was continued along very much the same lines as the previous year, although, with the exception of the organization of the library, none of this work could be handled as effectively as it was during the year 1912. The work of organizing the library, however, was pushed forward with fair rapidity, and by the end of the year the great majority of the volumes had been listed and ordered, many of them were on hand and had already been bound and classified and a preliminary draft of the plans for operating the library had already been prepared. As the plans for the library contemplated the establishment of a circulating system and also the utilization of the library as a school of instruction for the Forestry Branch officers through the preparation of reading lists, etc., it is necessary that the library be much more intensively classified and indexed than would be the case were it to be used only for reference purposes. For the forestry literature in the library the classification prepared by the faculty of the Yale Forest School has been adopted. For other subjects such as stock-raising and grazing, engineering, fish and game and various auxiliary subjects it has been found necessary to prepare our own classifications as there are apparently none in existence which take up these subjects with that detail which was believed to be desirable in a library of the character established in this district. The work has now progressed so that it seems certain that the organization will be completed by the end of the field season of 1914.

The demand for popular lectures on forestry subjects which was referred to in my last annual report still continues and offers an opportunity for educational work which should certainly not be neglected. It was unfortunately not possible, owing to the inadequate staff in the district, to undertake any work of this character during the past season. Such work, however, is, I believe, of much importance, as by this means the aims and purposes of the forest administration can be most directly placed before the public and many misconceptions and much opposition due wholly to ignorance can thereby be dispelled.

Respectfully submitted,

W. N. MILLAR,

District Inspector of Forest Reserves for Alberta.

VOLUME TABLE FOR LODGEPOLE PINE (HIGHWOOD RIVER).—Based on measurements of 437 trees from Timber Berth No. 1,429, Bow River Forest, taken December, 1913. Trees taken from a stump-height of 1·5 feet to a 6-inch top. No allowance made for rot or abnormal defects. Board feet by Scribner Log Rule.

Diameter at Breast-Height.	Total Height.			Basis Number of Trees.	Average Diameter at Breast-Height.
	50 Ft.	60 Ft.	70 Ft.		
Inches.	Ft. B.M.	Ft. B.M.	Ft. B.M.		Inches.
9	40	47	54	15	9·2
10	50	60	70	59	10·1
11	60	73	86	84	11·0
12	72	86	100	100	12·0
13	84	104	122	73	12·9
14	96	122	144	62	14·0
15	110	141	172	36	15·0
16	124	168	212	8	16·0
Basis.......	104	236	97	437	

VOLUME TABLE FOR LODGEPOLE PINE (HIGHWOOD RIVER).—Based on measurements of 441 trees from Timber Berth No. 1,429, Bow River Forest, taken December, 1913. Trees taken from a stump-height of 1·5 feet to a 6-inch top. No allowance for rot or abnormal defects. Board feet by Scribner Log Rule.

Diameter at Breast-Height.	Number of 16·3-Foot Logs.				Basis, No. of Trees.	Average Diameter at Breast-Height.
	2	2·5	3	3·5		
Inches.	Ft. B.M.	Ft. B.M.	Ft. B.M.	Ft. B.M.		Inches.
9	42	50	58	66	9	9·1
10	51	62	72	83	57	10·1
11	60	74	86	100	80	11·0
12	70	87	102	119	102	12·0
13	80	100	120	140	73	12·9
14	91	115	139	161	63	13·9
15	103	132	160	188	37	14·9
16	116	150	185	220	20	16·1
Basis....	101	203	116	21	441	

VOLUME TABLE FOR ENGELMANN SPRUCE (HIGHWOOD RIVER).—Based on measurements of 553 trees from Timber Berth No. 1,429, Bow River Forest, taken December, 1913. Trees taken from a stump-height of 1·5 feet to a 6-inch top. No allowance for rot or abnormal defect. Board feet by Scribner Log Rule.

D.B.H.	Number of 16·3-Foot Logs.							Basis, No. of Trees.	Average Diameter Breast-Height.
	2	2·5	3	3·5	4	4·5	5		
Inches.	Ft.B.M.	Ft. B.M.	Ft. B.M.	Ft. B.M.	Ft. B.M.	Ft. B.M.	Ft. B.M.		Inches.
9	45	58	71	89	110	....	....	5	9·3
10	52	67	82	102	126	163	....	15	10·9
11	58	75	93	116	142	179	....	42	11·0
12	65	85	105	130	159	196	230	43	12·0
13	73	95	115	145	175	214	252	60	13·0
14	81	105	129	161	193	234	276	61	14·1
15	90	116	143	177	214	255	302	55	15·1
16	100	128	157	196	236	278	331	61	16·1
17	110	141	174	216	258	304	362	49	17·1
18	121	155	192	236	285	333	397	49	18·0
19	133	170	212	259	314	367	435	39	19·0
20	145	186	232	283	347	406	477	33	20·0
21	159	203	254	309	382	450	527	13	21·0
22	172	220	277	336	420	500	581	11	22·0
23	186	238	300	362	460	547	638	8	23·2
24	200	256	324	390	500	597	700	4	24·0
25	....	....	....	....	....	650	765	1	25·0
26	....	....	....	....	....	708	835	1	26·0
27	....	....	....	....	....	765	905	1	27·4
28	....	....	....	....	....	828	977	....	....
29	....	....	....	....	....	890	1,050	2	29·0
30	....	....	....	....	....	950	1,113	....	....
Basis...	60	102	162	130	65	25	9	553	

APPENDIX No. 5.

REPORT OF THE DISTRICT INSPECTOR OF FOREST RESERVES FOR BRITISH COLUMBIA.

KAMLOOPS, B.C., May 2, 1914.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa.

SIR,—I have the honour to submit hereunder my second annual report as District Inspector of Dominion Forest Reserves for British Columbia.

LIMITS OF DISTRICT.

The British Columbia Inspection District was enlarged this year to include inspection work of the fire ranging in the Coast district. Now, therefore, the fire protection work of the entire Railway Belt is under the general supervision of this office.

Four classes of work were carried out by the Forestry Branch this year, viz:—

1. Forest reserve administration.
2. Surveys.
3. Fire-ranging on Dominion lands.
4. Co-operation with the Board of Railway Commissioners in railway patrol.

These activities will be reported on separately.

FOREST RESERVE ADMINISTRATION.

By an amendment to the Dominion Forest Reserves and Parks Act, assented to June 6, 1913, some 1,100,000 acres were added to the forest reserve areas in the Railway Belt of British Columbia by extending the boundaries of existing reserves and creating new ones as per the following table:—

Reserve.	Original Area, 1911.	Additions.	Totals.
	Acres.	Acres.	Acres.
Long Lake	121,600	47,494	169,094
Monte Hills	67,840	49,120	116,960
Martin Mt	11,360	10,400	21,760
Niskonlith	80,000	123,840	203,840
Tranquille	95,360	90,624	185,984
Hat Creek	131,200	86,560	217,760
Larch Hills	16,000	....	16,000
Nicola	....	323,680	323,680
Fly Hills	....	143,200	143,200
Arrowstone	....	163,200	163,200
Mount Ida	....	28,960	28,960
	522,840	1,067,598	1,590,438

These additions comprise now practically the entire body of forest land within the Dry Belt, and, if administered rationally, should be of material benefit to the neighbouring population, as well as ensuring a permanent and continuous flow of water for irrigation purposes.

Forest Reserves.—Within the last year considerable criticism has arisen as to the advisability of the increase in forest-reserve area, based principally upon the opinion which is unfortunately prevalent among a good many people that large areas of agricultural land are included within these reserves.

I am convinced that this opinion is wrong. It is based on the complaints of a few settlers, which, originally directed against a few quarter-sections, have grown, through repetition and through misunderstandings fostered by ignorant or prejudiced persons, to include all reserves.

All lands within forest reserves challenged by settlers as agricultural amount to less than 1 per cent of the area of reserves in this district. Practically all of these areas challenged are at very high elevations, where frost occurs every month of the year, and are desired only for possibilities of hay production, which is admitted to be all they are good for.

It must be recognized that the opinion as to what constitutes agricultural land has changed greatly within the last few years. At the same time, however, there are many signs which go to show that the limit has about been reached.

It is the opinion of a great many thinking men in this district that no settler should be allowed to enter on lands which will not support him and his family in a decent way. It is considered to be the duty of the Government to take upon itself the guardianship of the future of these people, instead of encouraging them to waste years of their life in unprofitable pursuits. This can best be done by excluding poor lands from settlement.

By "poor lands" I mean areas such as I mentioned before, which are at high elevations, generally over 4,000 feet, where frost occurs every month of the year, and on which only hay can be raised, and that successfully only in limited quantities in small sloughs and meadows.

There has been in many cases a succession of entries and abandonments of lands of this class. Encouragement of settlement on such areas is surely a mistaken policy, which must inevitably retard the permanent prosperity of the country through the bad name given to the whole district by dissatisfied settlers who have moved elsewhere. Placing lands of this class in forest reserves will exclude this unprofitable settlement, and at the same time leave the way open for the fullest use of any resources they may contain. In this way the value of bona fide agricultural lands in the vicinity is increased without any injustice to anybody, and in the long run the country is benefited thereby.

There is the possibility, however, that lands which are bona fide agricultural lands may have in some cases been included in forest reserves.

It should be the policy of the forest administration to have such lands excluded, and thrown open for entry as soon as possible. Inspections will be made at as early a date as possible this summer of all areas about which complaint is made.

Such areas are, however, in my opinion very small and scattered. When it is considered that the lines of these reserves were run several years ago, when there was no hunger for agricultural lands, and when the possibilities of agriculture were presumed to be much lower than now, I think the Forestry Branch have reason to be proud of the scientific and conservative way in which these boundaries were delineated.

Personnel.—The administration of the forest reserves was placed under the direction of a forest supervisor during 1913. Under this officer there were two forest assistants and five forest rangers.

The average area per ranger was increased by the additions to the forest reserves. It amounted this year to over 183,000 acres per man. No appointments were made on the new reserves, the fire protection being handled by the regular fire rangers on Dominion lands as in former years.

The necessity of having the appointment of forest rangers based on their suitability for the position was emphasized during the year. Several rangers were put in charge of the construction of head-quarters, trails, etc., at the beginning of the season, but with one exception they had to be taken off this work, as they failed to show the requisite ability for handling work of this kind.

Improvements.—The splendid fire season rendered possible the construction of many improvements during the year, as practically the whole staff was available for this work.

A preliminary examination of the reserves showed that they were for the most part inaccessible and consequently very little known. In planning the improvements for the different units, a site for the head-quarters was first selected, and from this the trails for which the most pressing needs were felt were located. A main ranger station was planned for each of the five old reserves, and considerable work was done on all. Four good stables were built and four houses begun; a considerable amount of fencing and land-clearing was also done. The houses are of logs, with lumber roofs and partitions, and contain from six to seven rooms. Two were inhabited during the past winter and were found most satisfactory. The responsibility for the work on these houses was originally placed on the rangers, but as this scheme did not work out very satisfactorily it was found necessary to have one of the technical staff almost constantly on the ground during construction.

In addition to the houses at the administrative headquarters of the reserve, two shelter-cabins and a tool-cache were built.

For the purpose of opening up the reserves for patrol and administration, over 6 miles of wagon road and 48 miles of trail were built. About 45 miles of disused trail were opened up, and three lookouts made accessible to the patrolmen. In addition, about a mile of fencing was done for the purpose of inclosing pastures and corrals.

In planning the trail system for the forest reserves in this province, the splendid topographical maps prepared in 1898 and 1899 by G. M. Dawson were of considerable assistance. While, of course, these maps were not accurate in the smallest detail, they gave the general trend of the country and showed where we could best hope to succeed in locating a trail.

The actual selection of the routes was made in nearly every case by one of the forest assistants, either alone or in company with someone who was considered familiar with the country. After carefully examining all the possible locations, a final line was decided upon and blazed. The trail-locator then met the foreman of the trail gang, and, if possible, took him over the whole length of the trail, explaining the way in which different problems should be met. Where possible, the supervisor also went over the route before construction was begun. The trails were all cleared 6 feet wide, and all stumps, boulders, etc., removed from a strip about 18 inches in width down the centre of the right of way. On all hillsides where in the judgment of the foreman it was deemed necessary, a grade was made, the rule being to keep short grades down to 15 per cent and, in cases where a long climb was necessary, to below 10 per cent.

Only two roads of very great importance were begun, and of these one was located with the co-operation of the provincial roads superintendent, and the other by the supervisor and a forest assistant.

All the trail and road work was done under the supervision of temporary men of experience, and the results obtained were most satisfactory.

Summer Resorts.—The summer resort at Trout lake in the Long Lake forest reserve was improved by the construction of a road parallelling the lake just behind the lots. This makes all lots readily accessible to town by motor. Several fine summer-houses were constructed on lots during 1913, and the whole project is well on the way to becoming a very successful summer resort.

Camping at Trout lake has been restricted to certain localities under permit. In this connection, twenty camping lots were surveyed by forest officers for the use of persons desiring a private place all summer. In addition to this, a general camping area was laid out.

Fires.—The past summer in British Columbia was an unusually wet one. With the exception of a short period in the early spring, and another similar period shortly before the snow came, the timber never got an opportunity of getting dried out enough to cause worry over the fire situation. On forest reserves during the season there were only four fires, two of which occurred in the early spring. In all about 30 acres were burned over. Fire fighting on the forest reserves cost $121.97, and the total damage to the forest was negligible. These favourable weather conditions were most fortunate, as they enable the newly appointed men to get acquainted with their districts, learn the points of greatest danger, and plan means of approach to each.

The principal sources of danger in this country are campers and lightning. The former are rather confined in their operations, but the latter is likely to strike anywhere.

By close supervision of the camping places, posting notices, clearing away inflammable débris and appealing to the reason of the campers, it is hoped that this source of danger will soon be practically eliminated.

The lightning danger will always be with us and the only way of coping with it is by keeping well placed and vigilant lookouts, and having a sufficiently intensive trail-system to allow of reaching fires easily.

Disbursements.—During the past year disbursements amounting to $35,127.24 were handled from this office. Owing to the absence of clerical assistance, combined with the introduction of an entirely new system of account-keeping, some difficulty was at first experienced in making proper returns to head office. A clerk whose entire time is devoted to the accounts was added to the staff during the summer. In future there should be no difficulty in keeping records and accounts correct and up-to-date. The system of accounting which has been in use during the past year has been found very satisfactory and has simplified to a great extent the problem of keeping accurate account of costs. In connection with the latter much information of value for purposes of comparison has already been obtained and efforts will be made to summarize this and make it as useful as possible in working out plans for the reduction of expense.

Silviculture.—During the past field season the technically trained members of the staff endeavoured to obtain what information they could in connection with the silvicultural conditions upon the reserves, although no special efforts in this direction were made. During the winter, however, the reconnaissance survey carried out under Messrs. Wallensteen and Parlow in the Long Lake and Tranquille reserves obtained a great deal of information. In general, it may be said that the whole of the Dry Belt region between the altitudes of 3,500 and 5,500 feet is covered with lodgepole pine forest which has all been repeatedly swept by fire, and is, as a result, of many different ages. The burns are from five to one hundred and twenty-five years old, and from a few acres to somewhat over half a township in area. In a few cases areas were examined, which had been burned over repeatedly with the result that reproduction had been greatly reduced. One tract in particular is now entirely devoid of any trace of reproduction, and in the absence of seed trees there is very little hope of a stand being re-established for many years to come. This state of affairs is very significant and indicates the great importance of adequate protection in a country which, as in the present case, is so absolutely dependent on forest cover for regulation of its water-supply.

The lodgepole pine here seems rarely to reach merchantable size and most of it would never even do for ties. The small size of the timber seems to be primarily due to site conditions, although the density of the stand on poor soils may be another factor. It is probable that rational thinning would stimulate growth.

The appearance of great quantities of spruce reproduction under the lodgepole would indicate that here, as in the United States, the lodgepole type is temporary, and that if fire could be kept out a valuable spruce forest would replace it.

The Douglas fir and yellow pine are the only other trees of importance in the region. Both appear in open and park-like stands below 3,500 feet. The fir is, as a rule, limby and crooked, although the pine is of fairly good quality.

There is at present in the Dry Belt no demand whatever for timber on the forest reserves, and it is unlikely that timber-sale business on them will develop for some years to come.

Trespass.—Very little difficulty has so far been experienced with timber trespass upon the forest reserves in British Columbia. The principal reason for this is that in most places there are considerable areas of timber-covered Dominion lands which are much closer to the settled districts than are the forest reserve boundaries. It is due to this fact that while a thriving trade is carried on each winter in cordwood and lumber sawn by portable mills there is practically no demand for forest reserve timber and consequently little incentive to steal.

The permit business during the past year was practically negligible, on account of the reasons mentioned in the remarks on trespass.

Survey.—After the close of the improvement work a considerable portion of the reserves staff became available for investigatory work and a survey party was organized to work under Mr. Wallensteen in the Long Lake and Tranquille forest reserves. The general instructions of the party were to locate the boundaries of all important timber types, to map all areas which would be suitable for cattle and sheep grazing, to survey existing trails, and to make recommendations regarding the fire-plan for the reserves. The party consisted of a chief, three assistants, and a cook. The intention was to have two working units of two men each. The results were quite satisfactory, the information sought was obtained, and practically the whole of the two reserves covered.

During the period of operations the whole region was covered with a heavy mantle of snow, but this, although it made moving-camp difficult at times, was in other ways of considerable assistance, as areas which in summer are practically inaccessible on account of the windfall, were reached with ease on skis. The party moved from time to time by means of a Yukon sled and a toboggan pulled by hand. All the members were equipped with snowshoes and skis. The former were necessary when pulling on the toboggan or climbing mountains, but the latter were found much more satisfactory wherever the upgrades were not heavy. Considerable personal skill is needed in handling skis, but almost any healthy man can use them to advantage after two or three weeks practice.

A detailed report of the work is in process of preparation by Mr. Wallensteen. This will include accurate maps of the topography of the regions covered, and will give the location of all improvements, both existent and projected. It is hoped to continue this work until a thorough knowledge of all the reserves has been obtained.

The winter survey seems to be a very suitable way of utilizing the services of permanent employees during the winter. In this way not only is there obtained adequate return in labour at an otherwise slack season, but the work itself is of great benefit in educating the ranger staff in forestry work of numerous kinds.

Fish and Game.—The areas in which the forest reserves in British Columbia are situated are famous for the fish and game which is found within their limits. Trout lake (Fish lake) in the Long Lake forest reserve is one of the most noted fishing resorts in British Columbia. The game is all under the control of the Provincial Government and up to the present the Forestry Branch here has made no effort to take any part in the administration of the game laws. Here, as in the Rocky mountains there are those who consider that the forest reserve should be closed for hunting, but I believe that such an action is quite unnecessary and would only serve to increase the troubles of the forest officers and to decrease their popularity. The inhabitants as a whole respect the game laws and the provincial officers do their best to keep the number of offenders as small as possible.

The fishing within the forest reserves is handled by the Dominion authorities, and it has lately been apparent that some regulation of the use of the lakes is necessary. Owing to the elevation of the lakes in forest reserves and the consequent lateness of the break-up, spawning does not begin in the streams which feed these lakes until the middle of May or the beginning of June. If fishing is allowed in these creeks while spawning is in progress, tremendous quantities of fish can be shovelled out of the streams with ease, and the available stock for lakes will soon be exhausted. To prevent the possibility of this it has been deemed wise to continue the close season within the reserves until June 16, and this year fishing will not be allowed until that date.

Having made this restriction, and one pertaining to the per diem catch, it will be necessary for the Forestry Branch to enforce them. Little difficulty is to be expected in this regard, however, as the fishing is confined to a very limited area.

Supplies and Equipment.—The remarks made on this subject by the District Inspector for Alberta in Appendix 3 of your report for 1912-13 are applicable to this district during the past year. The principal difficulty in requisitioning supplies from Ottawa has been the lack of a check-list to enable us to state clearly just exactly what we needed.

The property-card record system by articles has proved satisfactory.

It should be possible, however, in addition, to work out a cross-reference system whereby the total accountability of any subordinate forest officer who is charged with property from this office can be obtained without the necessity of going through the cards.

The establishment of a system of this kind is being gone into at the present time by this office.

Education and Publicity.—No organized campaign of publicity has been made in connection with the forest reserves administration in British Columbia, but the members of the staff have been instructed at all times to explain to people the aims of the Forestry Branch and the means which it is adopting to secure the ends in view. It has been found that some misconceptions prevailed which resulted in a feeling of antagonism in some instances. It has been the practice of all forest officers to correct erroneous impressions wherever they are found and thus gradually the view-point towards the reserve policy is being changed from indifference or antipathy to interest and support.

Grazing.—During the past year I have paid considerable attention to the questions arising out of grazing of live stock on the forest reserves in this district. The amendment to the Forest Reserves and Parks Act of June, 1913, increased the forest reserve area by about 200 per cent, to a total of some 1,600,000 acres. At the present time practically all the non-agricultural land in the Dry Belt is in the forest reserves. Of this country I have estimated that approximately 660,000 acres are available for cattle and horse range. In addition to this there are over 250,000 acres of lodgepole pine, timber-grass country in which horses and cattle will not graze but which may be suitable in considerable part at least, for sheep range. There are also some 80,000 acres of highland range situated above timber-line at an elevation of from 6,000 to 7,500 feet, which contain a very luxuriant growth of grass, vetches, pea vine, etc. This will make good horse or cattle range, but requires herding, on account of flies and lack of salt, so that for some time to came, it can be utilized for sheep only.

Estimates have been prepared showing the approximate carrying capacity of forest range in this district. This has been compiled on the basis of allowing 40 acres as sufficient to provide feed for four months for each head of cattle or horses and 13 acres for each head of sheep. The table shows a minimum carrying capacity of 16,462 head of horses or cattle and 26,625 head of sheep.

Most of the forest range in this district is available for summer use only. In most places grazing should not be allowed much before June 1, in order to allow the young grass to obtain a start and the range to dry off, so that damage by trampling will be avoided. By early October the cattle come out of the forests of themselves, so that approximately four months can be considered an average grazing season.

Stock-growing at the present time is practically confined to horses and cattle; this has been a long established industry in this district. Misuse by overstocking of accessible range in the past, and the steady influx of settlers, who secured the best areas and the watering places on leased lands, caused a decrease in the number of stock some few years ago. Within the last year or two, however, the continued high price of beef has given a new impetus to the industry. More remote forest ranges are being opened up, and the number of stock in the country is increasing again. Besides this increase of stock by the ranchers we have another one, which year by year is increasing in importance, making itself manifest, namely, the gathering together of small herds by the numerous homesteaders and small settlers.

Stock held in this way will in the future by far outnumber that held by the present large owners. Indications, indeed, point to the fact that eventually all the industry will be devolved into these small holdings.

This state of affairs, namely, the necessity for using forest range, and the advent of the small owner into the question, makes it specially important at this time for the government to take steps to see that all the range possible is conserved and administered so that depreciation will not again occur. Inasmuch as this range is within forest reserves this work devolves on the Forestry Branch.

Proper range administration will mean the careful managing of allotments so that the fullest use can be obtained by both small and large owners, while at the same time forage conditions are improved from year to year.

The regulations drawn up by the Forestry Branch last year and passed by Orders in Council, dated August 8 and September 24, 1913, are suited, with some minor alterations, to accomplish this result very satisfactorily. These regulations provide for administration of grazing on forest reserve range under a permit system similar to that which has been so successfully carried out on national forests in the United States. Unfortunately, however, they were not well received by the stock-growers in this district, and their enforcement has, therefore, been delayed one year until the matter can be worked out to mutual satisfaction. A brief account of conditions and the proceedings leading up to the taking of this action by the department will probably be the best way to explain matters.

To begin with, no action had been taken by the department to enforce the provision of section 17 of the Regulations for Dominion Forest Reserves of 1910 which prohibited the grazing of live stock on forest reserves. All such regulations have been a dead letter in this district, and stock have ranged free on forest range since the inception of the industry here many years ago.

This neglect on the part of the Government for so many years led the leaseholders to understand that a lease of grazing land carried with it the right of free use of forest range lying in the mountains behind. Consequently, the proposal of administering this resource came as a disagreeable surprise to the members of the ranching industry.

Owing to the lateness of the season no attempt was made to enforce these regulations in 1913. It was considered advisable, however, to have the proposals thoroughly understood by the stock growers in plenty of time to come to an understanding before the grazing season opened in the spring of 1914. Therefore, on the 29th November, the district inspector issued an invitation to the members of the ranching industry to meet at the Forestry Branch office at Kamloops to discuss the questions which would arise out of the enforcement of these regulations.

As was anticipated, the stockmen present at this meeting voiced disapproval of the policy which would compel them to pay for forest range which had been used by them free of charge in connection with their leases, from the earliest settlement of the country.

Outside of the general objection to further taxation, the stock-owners' principal objection to the grazing regulations were directed against sections 40 and 43. Section 40 requires a minimum fee of 25 cents; which means payment for five months pasturage at the minimum fee of 5 cents per head per month. This they considered unfair in a country where stock did not spend all their time on the forest range.

Section 43, which requires notice for the movement of stock on and off the reserve, was also declared impracticable.

After considering these matters thoroughly, in accordance with instructions from the director, I suggested amendments to these sections designed to obviate these difficulties. These amendments, which were also submitted to the public through the Kamloops Farmers' Institute, recommended a separate classification of range in British Columbia as "on-and-off" range, and provided a procedure for the taxation of grazing only for such times as the forest range was actually used by the stock of the permittee, although the permit would run throughout the entire grnzing season.

I also recommended that the provisions of section 43 do not apply to the case of "on-and-off" range, and that, in place of notice of movement of stock, the permittee should make an affidavit within ten days of the time the stock was moved on or off the reserve, giving the particulars thereof.

The Farmers' Institute, after discussing these points, passed a resolution asking the Government to fence forest reserves before attempting administration.

A general meeting was called on February 18 at the Council Chamber, Kamloops, by the Farmers' Institute to discuss the whole question further. I hurried back from Ottawa to attend this meeting. In my address before it, I first announced the intention of the department not to enforce these regulations in British Columbia during 1914. I then pointed out the impracticability of the Government fencing forest reserves with a total length of boundary of not less than 900 miles. After reviewing briefly the proposed amendments to the regulations, I made the suggestion that those present at the meeting form themselves into a co-operative association as laid down in section 54 of the regulations, and that they should appoint an executive with authority to act for the whole association.

I also suggested the advisability of the Dominion Forestry Branch requesting the United States Forest Service to lend us a grazing expert who would go into the whole question thoroughly and report.

The reason for doing this was that the whole question of the administration of forest range on a permit basis has been very satisfactorily worked out in District 1 of the United States Forest Service under natural conditions practically identical with those in the Kamloops district. They have also developed an expert personnel for this administration, thoroughly acquainted with the stock-growers' side of the question as well as the objects of the Forest Service. Therefore, if we could borrow a competent man temporarily from the United States Forest Service, we could get a thoroughly reliable and unbiassed investigation of the whole question here, which would take into consideration the necessities of the situation from the stock-growers' point of view, as well as the requirements which good forestry practice would dictate. Recommendations from a man of this character would be very valuable to the ranching industry as well as the Forestry Branch.

Neither of these suggestions met with a favourable reception. The first was refused because the majority opinion was that no regulations were wanted on any basis, and that the stock-owners should do nothing whatever in this matter.

The second was objected to mainly on the ground that no outside interference was necessary. It would, however, be more consistent with true patriotism to try and benefit by the experience of others than to force upon ourselves the necessity of obtaining the same results by the roundabout and expensive method of making all the same mistakes which were made on the other side and finally reaching the same result which we might have obtained more quickly and economically by heeding the lessons their experience can teach us.

The suggestion for the formation of a Stock-growers' Association, however, bore good fruit for at a meeting of the members of the industry held at Kamloops subsequently the British Columbia Stock-growers' Association was formed.

In this condition the matter rests at the present time. It is to be hoped that your attendance at the meeting of the association at Ashcroft on June 2 next will clear up the situation. There is no doubt at all that economic conditions demand administration of the forest range, and this will have to come eventually. The department has treated the stock-growers in a fair way in inviting their co-operation in formulating the basis of such administration. It is to be hoped, therefore, that they will conclude that it is to their interest, as well as to that of the community at large, to meet the department in attempting a solution of this question.

SURVEYS.

In accordance with the policy of the Forestry Branch to define the boundaries of all tracts of non-agricultural lands in the Railway Belt, two forest survey parties were placed in the field in May, 1913, for the purpose of making such examinations.

Each of these parties was equipped with a democrat and light team which could also be ridden and packed, and two saddle-horses. A cook and packer were attached to each party. Tents were of silk, and all equipment supplied was as light as possible for ease in packing.

Of these, Survey No. 1 was in charge of Student Assistant F. Bruce Robertson, of the Faculty of Forestry, University of Toronto, who had spent the summer of 1912 in this district. He was assisted by E. B. Prowd, of the same forestry school.

This party examined the proposed southerly extension to the Hat Creek forest reserve and the country lying on both sides of the Fraser and Thompson rivers between North Bend and Spences Bridge. This work was completed on August 15. From here a move was made to the country lying east of the Okanagan valley and Mara lake, including the west slopes and interior valleys of the Gold range in the south half of the Railway Belt.

Survey No. 2, in charge of Student Assistant C. R. Mills, assisted by H. A. Parker, both of the Faculty of Forestry of the University of Toronto, spent the first half of the summer examining the country lying south and east of the Fraser river in the Coast district of British Columbia, comprising the Hope mountains. About the middle of July this work was finished and the party with its equipment, was brought through the Hope mountains via Coquihalla pass to Kamloops. From here the party examined lands lying north of Shuswap lake and Eagle river. On September 14 Mr. Mills combined his party with that of Mr. Robertson and together they finished examination of the east side of the Gold range in the Columbia River valley near Revelstoke.

Altogether the boundaries of 4,748 square miles of proposed new forest reserves were examined by these parties as follows:—

Survey No. 1	1,880
Survey No. 2	2,069
Combined parties	799
	4,748

The agricultural lands question in forest reserves in the district has led some people to criticize the nature of the boundary examinations for forest reserves. It might, therefore, be apropos to quote from my letter of instructions to Survey Party No. 2, that part relating to this question, which is as follows:—

> "Lands to be included in the reserve should be, as far as possible, only such as are absolute forest lands.
>
> "In a country such as British Columbia, where farm lands are relatively very scarce, the settler should be given the benefit of the doubt in a case of any land of uncertain value for agricultural purposes. In this connection I would advise you to keep your eyes open and try to ascertain just what kinds of lands will be homesteaded in the district in which you are working. This will help you to form your judgment as to the status of the lands examined.
>
> "Land is to be considered to be non-agricultural if the soil is pure sand or gravel, but a better criterion for your purposes is the nature of the slope and the elevation. Except in very exceptional cases it is not advisable to include any river or creek valley or bench-lands in the reserve. The inclusion of such lands always gives rise sooner or later to conflict with squatters. All reserve lands can be kept well on the hill or mountain slopes without doing any harm. In this connection it will be necessary to make flying trips with a pack outfit up the

various creeks flowing into the Fraser from the south to see if there are any lands within their valleys which could possibly be used for agricultural purposes. It will also be advisable, if possible, to penetrate right through to the south side of the Railway Belt in one or two places in order to ascertain whether the southern limit of the Railway Belt could be followed altogether as a southern boundary of the proposed forest reserve."

These instructions were carried out very thoroughly, as far as I can ascertain, and I feel we can be fairly confident that the lines delineated will stand the test of time satisfactorily.

FIRE RANGING ON DOMINION LANDS.

The fire season of 1913 in the railway belt of British Columbia was probably the most successful from the protective point of view in the history of the country. While a large part of the credit for this must be given to adequate and well distributed rainfall throughout the entire season, still the increased efficiency in the patrol force was also an important factor, as evidenced by the large number of fires which were extinguished in incipient stages compared with those which got away.

The fire-ranging work was organized in three districts, namely, Revelstoke, Salmon Arm and the Coast, under the general supervision of this office. These districts will be taken up separately.

Revelstoke District.—The boundaries of this district are the same as outlined in my report of last year.

Two additional rangers were appointed, making a total of fourteen in all. These men were under the direction of Mr. T. Wadman, chief fire ranger at Revelstoke. Of Mr. Wadman's work both in field and office, I cannot speak too highly.

Of the fires occurring in this district during the season only one caused any trouble or expense. This was extinguished at a total cost of $116.50. Inasmuch as it burnt over mostly logged-off land, it was a benefit in that it cleared up a large amount of inflammable debris without doing any great injury to surrounding timber. The following table shows the number of fires in this district and their causes:—

Railways	7
Campers	4
Tramps	11
Lightning	15
Unknown	23

The co-operative agreement with the Provincial Government with regard to the issuing of permits for burning was carried out during 1913. This agreement was a very great help in forest protection, as it gives to the organization responsible for the prevention of fires control of the fire situation. Under it the ranger knows that he is the only man in his own district who is authorized to grant permits for fires, and he can therefore tell at any time whether any fire which is occurring is legal or otherwise.

A co-operative agreement was also made with the Provincial Government for the construction of a telephone line up the Big Bend of the Columbia river from Revelstoke. This line was built by the provincial Forest Branch, and that part within the Railway Belt was taken over by the Dominion branch, which paid the cost thereof. The Big Bend country is a very heavily timbered country in which the fire hazard is abnormally high. Transportation facilities are very poor. It was, therefore, very important for fire-protection purposes, that a means of communication should be established between Revelstoke and this country, both from the standpoint of the government and from that of the lumbermen who had large interests at stake in that district. This telephone line, therefore, should pay for itself many times over in the increased protection which is afforded to this district.

The excellent season of 1913 enabled us to inaugurate the construction of permanent improvements for better fire protection in the Revelstoke district. The first start of this kind of work was commenced last fall, when 15 miles of trail were built. These trails were mostly to lookout points and will give much better control of the fire situation in the future.

Three boats were also bought for crossing the Columbia river at different points.

The construction of these improvements is a very great step in advance, not only on account of opening up the country, but because they have shown the fire rangers that the government is in earnest in its efforts to secure adequate fire protection. The rangers have in every case been very anxious to be allowed to undertake work in their districts, and have shown much more enthusiasm and interest in their work as a result of being allowed to construct a few improvements. It is planned to carry on this work from year to year until the whole country is easily accessible, so that the fire hazard is reduced to a minimum.

A meeting of the fire rangers in the Revelstoke district was held in Revelstoke at the close of the fire season, on October 10, 1913. At this meeting, resolutions were passed commending the Government's action in inaugurating improvement work. Discussion also occurred on the question of slash disposal, which has always been the greatest source of fires in the Revelstoke district. In this connection the district inspector reported to the meeting that an appropriation had been authorized by the director for some experimental burnings by the Government for the purpose of obtaining data which could be shown to the lumbermen, to prove to them that slash-burning was an economical business proposition from their own point of view. Experience in the United States has shown that it is not the cost of slash-burning operations which primarily prevents the lumbermen from doing this work, but rather an unwillingness on their part to take responsibility for setting out fires which might get beyond control, and do damage to property belonging to themselves or other people. Where the Government or a fire-protective organization has been willing to assume this responsibility, the lumbermen have, in practically every case, been found willing and anxious to have the slash burnt up, and to pay the cost thereof.

It was expected that some experimental work of this kind would be undertaken in October, 1913, but unfortunately weather conditions were so bad that this could not be done. At the time of writing, however, arrangements are under way for the carrying out of this work in the near future. For this purpose one of the oldest and most experienced of fire rangers in the employ of the Dominion Government in British Columbia, Mr. Frank Ashdown, of Golden, has been appointed slash-burner for the Railway Belt. Mr. Ashdown will make investigations and carry out slash-burning operations in co-operation with the lumbermen in the Railway Belt.

At this meeting also there was considerable discussion regarding the efficacy of the fire patrol along railway lines established by the Board of Railway Commissioners, and the following resolution was passed:—

> "Whereas we understand it is the intention of the Board of Railway Commissioners for Canada to compel the Canadian Pacific Railway Company to establish a fire patrol of sufficient intensity to allow the Dominion fire rangers to leave the fire protection of the lines of said railway to them,
>
> And whereas we are of the opinion that this state of efficiency cannot be obtained until special Canadian Pacific Railway patrolmen are appointed who shall give their whole attention to this matter,
>
> Resolved, that this meeting recommend to the Board of Railway Commissioners that such special patrolmen be required to be maintained by the Canadian Pacific Railway."

This matter will be discussed later in connection with the section of this Report dealing with the Board of Railway Commissioners and railway co-operation.

With regard to the resolution which was passed by the rangers' meeting in 1912, which was included in my annual report for that year, concerning the slash left along the rights of way of provincial roads, the fire rangers, at the meeting in October, 1913, reported that, in the cases of most new roads constructed by the Provincial Government, the slash and other debris from rights of way cleared had been properly disposed of at the time of construction. No action, however, has been taken by the Provincial Department of Public Works with regard to disposing of debris along roads already constructed.

Salmon Arm District.—The boundaries of this district are the same as outlined in my annual report of last year. Three additional rangers were taken on here also, making a total of sixteen. The addition of these men enabled us to give fairly satisfactory fire protection to all parts of this district. These men were under the direction of Mr. James Evans, of Salmon Arm, as chief fire ranger, whose efficient work in the field deserves commendation.

Burning permits were issued by our rangers alone in this district also, in accordance with the agreement entered into with the Provincial Government, and a considerable part of the rangers' time was occupied in supervising this work. Considerable satisfaction has been expressed by the public throughout the country at this arrangement, which enables them to get their permits at their own residence, instead of forcing them to come to town at inconvenient times to meet the forest officer, as was done under the provincial regime. At the same time we were enabled to make an inspection in every case of the locality to be burnt, which was never attempted in the old days.

A start was made in the construction of improvements in the fall of 1913 in this district also, which, though small, has had a good effect, both in increasing the esprit de corps of our rangers, and in showing to the public that the branch really means business in its efforts to secure fire protection.

Some 10 miles of trail were constructed in the most inaccessible portions of the district.

The fire boat on Shuswap lake was overhauled at the beginning of 1913 and a new engine installed. These repairs were badly needed, and put the boat in good shape for the work it had to do.

A supplementary appropriation was passed for the construction of a new launch for Shuswap lake, but this was delayed so long that the boat was not finished until after the close of the fire season. This new boat is better designed to meet the conditions on Shuswap lake, and will be put into commission at the beginning of the fire season of 1914. The old boat will be transferred to Adams lake, where it is expected it will render valuable service.

The creation of new forest reserves in the Salmon Arm district will make necessary re-arrangements of fire-rangers' districts. This was not effected last year, however, as there was no appropriation available for organization of administrative work on these new reserves. The fire protection was therefore handled on them by the fire-rangers as in the past.

The following table gives the number and causes of fires in the district:—

Railway	1
Settlers	1
Campers	2
Lightning	4
Unknown	4
Other causes	1
Not classified	13

Coast Fire-ranging District.—The Coast fire-ranging district extends from North Bend to the western limit of the Railway Belt. It falls into two natural divisions, viz.: (1) Mountain and (2) Valley.

The Mountain division includes all of the Belt on both sides of the Fraser, between North Bend and Hope, thence on the south side of the river southwest to Cultus lake and on the north side westerly to the north arm of Barnard inlet, keeping an average distance of about 6 miles back from the river.

The Valley division comprises the lower Fraser flats from Agassiz to the coast.

A description of the timber resources of this country, found in an appendix of your report for 1912-13, being the report of a reconnaissance survey by Mr. Wallin, need not be repeated here.

The fire hazard in this district is probably one of the highest in the world, especially in the timbered portions of the Valley district, and on the transition hill country along the borders thereof.

This hazard is largely human in origin, owing to the presence of a very dense population, settled in a country where timber growth is very dense and luxuriant. This results in numerous large accumulations of slash extending in some places, notably south of New Westminster, where subdivision has been carried out, for miles along the main highways. While the Coast is in the main a country of heavy precipitation, yet there appear periods of drought sometimes protracted for weeks at a time. Unfortunately, moreover, these are most liable to occur in the early spring and in fall, at times when the accumulation of dead matter from last season's growth is not covered up with green vegetation. A fire, therefore, occurring at such a time in the valley division could run for miles through a densely settled country, and, besides, destroying many million feet of tremendously valuable timber, would do incalculable damage to property, and probably result in a large loss of human life.

The great anxiety of settlers to clear wooded land and the absolute necessity of using fire as the only means of accomplishing this result make the danger of such a national calamity always imminent in dry seasons. Therefore, any system of fire protection in this country, to be adequate, must be designed to obviate this hazard.

I found, on taking up the question of organizing the fire ranging on the Coast district in the spring of 1913, that the needs of this country had not been thoroughly appreciated in the past. After going thoroughly into the question with the Crown Timber Agent at New Westminster, who handles the fire-ranging business for the Forestry Branch, I recommended the employment of four additional rangers, bringing the total number in the Coast district up to twenty-five, or one man for every 92,000 acres. This force, augmented in dry seasons by extra temporary short-time guards, and provided with the necessary trails, lookouts and other improvements to open up the country, should suffice to give adequate protection.

This force is directed by Mr. E. W. Beckett, Crown Timber agent at New Westminster, assisted by Mr. James Selkirk, Chief Fire Ranger. These men have the interests of the Forestry Branch and the protection of their district at heart, and, knowing local needs and conditions as they do, are making a record of which they may well be proud, as the fire-table below will show. Credit is also due to Mr. Walmsley, of the Crown Timber Office at New Westminster, who has handled all the records and accounts in connection with our work in a very satisfactory manner. The following is a list of fires, with their causes, for the season:—

Railways	50
Settlers	18
Campers	36
Tramps	5
Engines	5
Lightning	13
Unknown	6
Others	11

Out of the 114 fires which occurred in the Coast district during 1913 only two caused any expense in fighting. Of these the fire on timber berth "X" did much good by having cleaned up a large area of heavy slash, while the amount of timber destroyed was very slight.

The issuing of permits for burning was retained by the Provincial Government during 1913, and while the Dominion rangers were advised in nearly every case in which a permit was issued, yet it is thought that better control of the situation could be obtained were our own men to have charge of this work. In this way, not only would the organization responsible for the protection of timber handle the setting out of fires adjacent thereto, but much needless duplication of fire-wardens and consequent expense would be saved by the Provincial Government. I am glad to say that just a week prior to the time of writing an agreement was completed whereby this work will be handled by Dominion fire-rangers in the future.

The employment of extra rangers so depleted the appropriation available for the Coast district that improvement work was not possible until the fall, when it was found possible on account of the good fire season to devote a little money to this work.

The start made, while small, has encouraged the rangers greatly, and it is expected that further work will be done during 1914.

Some ten miles of trail were constructed and three cabins built back in the mountains to serve as headquarters for rangers in inaccessible districts.

A fine fire-boat was constructed for use on Harrison lake and the Fraser river, but owing to the late date at which the appropriation became available it was not completed until last winter. This boat is, however, in commission at the time of writing, and should give very valuable service.

The first ranger meeting ever held in the coast district was held at New Westminster at the close of the fire season on October 2. It was attended by all the rangers in the district. Discussion took place on many subjects of prime interest in forest protection, such as disposal of slash, issuing of permits, methods of fire-fighting, etc. Several rangers came prepared with improvement plans of their district which showed much care and thought in development.

This opportunity for the interchange of views was very much appreciated by the rangers, and aroused great enthusiasm. It is hoped to make the meeting a yearly affair in each district.

RAILWAY COMMISSION CO-OPERATION.

The co-operative agreement between the Fire Inspection department of the Board of Railway Commissioners and the Dominion Forestry Branch with regard to the handling of the railway patrol required by the Board under general order 107 was carried out during the fire season, 1913. Districts 1 and 2 of the British Columbia division of the Canadian Pacific railway were handled under my supervision as fire inspector for the Railway Belt.

Representations were made by the Canadian Pacific Railway to the Railway Board for a decrease in intensity of the patrol required by the board on the basis of the use of oil-burners through forested sections. In my annual report to the chief fire inspector for 1912, I pointed out, however, that this conversion had been only incompletely carried out, as coal-burners were operated quite frequently over the lines. For this reason, and because the condition of the right of way was very unsatisfactory, so that any sparks from coal engines, cigarette or cigar stubs from trains or careless use of fire by tramps along the right of way, would almost certainly get away in dry weather, I recommended to the chief fire inspector that the original special patrol measures specified be required for 1913. I also asked for a responsible man at the head of the railway patrol with whom I could deal authoritatively in all matters pertaining to this work.

Owing to objections by the Canadian Pacific Railway, neither of these recommendations was carried out by the board. All that was required of the railway company was a section patrol by regular employees in conjunction with their ordinary work.

When the co-operative work undertaken by the Dominion Forestry Branch with the Board of Railway Commissioners was inaugurated, it was the idea of the former that this work should be so organized as to make the railway company provide patrol along railway lines sufficient to make the said lines fire-proof. It was, accordingly, thought by the Forestry Branch that we should be enabled to dispense with patrol work by the Dominion fire rangers along railway lines altogether, and thus for the same money give much better protection to inaccessible regions lying back from the railway, which have hitherto been unprotected. Unfortunately, however, these patrols, as established under the order of the Board to date, were not of such a nature as to warrant the Forestry Branch in withdrawing its own patrol force from the region of the railway. This is manifested in the fact that the forty-two fires set by locomotive sparks were all extinguished by the Dominion fire rangers. It is evident from this that if the right of way of the railway company is to be protected by the company to such a degree that all fires started will be checked before they get away, increased patrol requirements will have to be ordered by the board.

Recommendations were made again to the board in my annual report for 1913 for the placing of this patrol work under a special organization. In this report I stated that, unless the action was taken, the whole co-operative scheme undertaken by the Forestry Branch with the Board of Railway Commissioners in connection with order 107 would be of little use to the Forestry Branch so far as it would relieve it of the patrol of railway lines.

Under the section-patrol system I do not believe that the Forestry Branch, which is, in the final analysis, responsible to the people of this country for the protection of timber from fire, will ever be able to entirely withdraw our fire-patrol organization from the vicinity of the railway.

With regard to the patrols specified by the board for 1913 I would say that every effort was made by the Canadian Pacific Railway officials to comply with the requirements of the chief fire inspector. My recommendations secured prompt attention, and, although some orders issued by higher officials seemed to lose force in the process of filtering down to the actual men who did the work, nevertheless, on the whole, credit is due to the company for the way they handled the whole business.

In my report for 1912 I stated that conversion to oil-burners between Kamloops and Revelstoke was completed during 1912. Increased traffic, however, rendered necessary the introduction of new motive power by the company on district 1. These engines were coal-burners, which, during the early part of the season, were operated at various times throughout the whole district. Representations made by me to the company resulted in action being taken by them limiting the use of coal-burners to the division between Kamloops and Revelstoke, so that after the 1st of July no coal burners were operated on regular trains between Revelstoke and Field. Several engines were, however, being used by contractors on double-tracking between Revelstoke and Field throughout the season. It is probably true that the use of oil as fuel will reduce the fire hazard along railway lines by at least 75 per cent. The intermittent use of coal-burners in an oil-burning section, however, prevents basing protection at this reduced hazard. To remedy this state of affairs as far as possible under my authority the patrol requirements in district 1 were increased at the end of July from a minimum section-patrol of one round trip per day to a minimum patrol of two round trips per day, one in the forenoon and one in the afternoon.

At the beginning of the fire-season of 1913 the right of way of the Canadian Pacific railway in districts 1 and 2 of the British Columbia division was in a deplorable state. Repeated urgings by the board resulted in considerable improvements being made during 1913 in the matter of right of way clearing, about half the mileage being well cleaned up. These improvements consisted of the following:

Clearing of the Okanagan and Arrowlakes Sub-Division rights of way by contract. This work was well done.

Clearing of the rights of way by extra gang between Craigellachie and Sicamous, and between Sicamous and Salmon Arm. This work was also well done.

Cutting and burning of brush in district 2 between Lytton and Yale. This work was, in general, well done, although certain danger points were not as completely cleared up as might be desired.

The inspection work done by the Forestry Branch in co-operation with the Board of Railway Commissioners was carried out on the same basis as last year, namely, two divisional fire inspectors, one for lines east of Sicamous and one for lines west of Sicamous, under my supervision.

The table below gives the number of fires, with their causes, occurring along the Canadian Pacific Railway that were discovered by Dominion fire rangers or divisional fire inspectors:—

Sparks from locomotives	42
Tramps' camp fires	12
Lightning	1
Sectionmen burning ties	1
	56

Respectfully submitted,

D. ROY CAMERON,

District Inspector of Forest Reserves.

APPENDIX No. 6.

REPORT OF THE INSPECTOR OF FIRE-RANGING.

OTTAWA, March 31, 1914.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa.

SIR,—I have the honour to submit my annual report covering the work of the fire-ranging organization in the provinces of Manitoba, Saskatchewan, and Alberta during the season 1913.

In the matter of fires we have again been rather fortunate, for, although the fire season as a whole was not as wet as that of the preceding year, there was considerable precipitation fairly well distributed over the season. Dry spells did occur, but these were not of sufficient duration or intensity to cause any very great danger. I think, too, we may claim a fair degree of improvement both in point of numbers and organization. Although there has been some improvement, the fact remains that the occurrence of the first dry season will put our organization to a very severe test; it is necessary, therefore, that such parts of the work as have been attempted should be improved upon, and details which have not as yet been worked out must receive attention.

For convenience I will give this report under two main headings, viz:—

1. Fire Protection along Railway Lines.

2. Fire Ranging on Crown Lands.

FIRE PROTECTION ALONG RAILWAY LINES.

The action taken by the Railway Commission in connection with railway fire protection has been the subject of several reports; there is, therefore, no necessity for detailing the requirements of the Board. They may be briefly enumerated as follows:—

1. Fire protection appliances.
2. Non-use of lignite coal.
3. Proper supervision of tie-burning.
4. Cleaning right of way.
5. Ploughing of fire-guards.
6. Establishment of a patrol force.

Appliances.—During the season ninety-eight engines were inspected by our men. Further, a large number, of which we have no record, were inspected by the various officers in the operation department of the board. In the great majority of cases the appliances were found to be in good order, while in a few instances defective screens were discovered, or the required connection between the overflow pipe and ash-pan had been neglected. In such cases the necessary repairs or alterations have been made without carrying the matter to head office. Generally, we may say that these appliances are now receiving attention that was almost or entirely lacking a few years ago. That locomotives still cause fires, even when spark-arresters are in repair, is evidenced by the number of fires still attributable to engines, but it is a certainty that with the greater care exercised in the repair of damaged screens the fires from this source are decidedly fewer in number, and when fires do occur with screens in good repair it is generally through the use of a low-grade or finely powdered coal. I think that it is now very seldom that an engineer or fireman will purposely destroy a screen in order to allow for greater draft, a practice that was quite common a few years ago.

Lignite coal.—This coal is prohibited by the board for use in railway engines, and, though it is sometimes used, such cases are comparatively rare. Coal samples were taken by our men at various points—Hudson Bay Junction, Prince Albert, and west of Edmonton on the Grand Trunk Pacific. In two or three cases such coal proved on analysis in the Department of Mines to be lignite. No action was taken, however, further than to issue warning against future use of such coal.

Tie-burning.—There is not the same great carelessness in the burning of old ties that was experienced some years ago; nevertheless, it still appears to be a difficult matter to get section employees to exercise the proper and necessary care in this work. On many occasions I have noticed burning tie-piles along the line without there being any guardian within such distance that he could control the fire, and although no serious damage resulted last season it is evident that greater care is necessary in the destruction of old ties.

Fire-guards.—Protection by means of fire-guards is designed primarily for the open farming and ranching country, and hence it has little significance to us from the standpoint of forest protection except where such land borders immediately on the timber land, and in such cases it is customary to have the patrol system overlap a little on the farming country rather than attempt the construction of fireguards through the heavy brush.[1]

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[1] The above remarks apply to all the companies concerned, namely, the Canadian Pacific, the Grand Trunk Pacific, the Canadian Northern, and the Edmonton, Dunvegan and British Columbia railways. In the succeeding paragraphs the work done by each company is referred to separately.

Right of Way Clearing and Patrol Service.

A. Canadian Pacific Railway.—The work done by this company in right of way clearing on lines over which I have jurisdiction was all handled by the regular section employees. All the lines concerned, namely, the main line from Winnipeg to the Ontario boundary, the Lac du Bonnet and Teulon-Arborg subdivisions, are in very fair condition. In the province of Alberta the Alberta Central railway, a subsidiary railway from Red Deer westward, comes under my inspection, but as only a few miles of steel have been laid, and as the line runs through an essentially farming country, it is as yet of little importance to us from the forest-protective standpoint. Shortly, however, the steel will be laid westward, penetrating the Rocky Mountains reserve, and it will then probably be necessary to establish special measures of protection.

On these subdivisions the patrol was carried on by the regular section employees, and, although this is not usually a satisfactory method of patrol, it has been effective for the past two years, these lines not being particularly dangerous ones.

B. Grand Trunk Pacific Railway.—(a) Superior Division, from Elma to Ontario boundary. In the spring of 1913 this line was in a rather unsatisfactory condition in regard to right of way, but during the summer considerable improvement was brought about, and by the end of the season the right-of-way conditions were fairly satisfactory.

The patrol service, however, was very poorly carried out, ostensibly on account of the motor speeder which was supplied the patrolman being frequently in disrepair. In such case it has been the practice of the company to have the patrolman ride freight trains, and this method of patrol is, of course not satisfactory. The one man that was ordered for this beat ceased work during the season, and for some time his beat was patrolled by the man to the east of him on the Ontario side.

Grand Trunk Pacific Railway: (*b*) Edmonton to Yellowhead.—This line has for the past few seasons been the source of considerable worry to us, as a result of the indifferent and dilatory attitude shown by the company to the requirements of the Railway Act as applied to right-of-way conditions. Vigorous action was taken in the fall of 1913, however, which resulted in the employment of a large extra gang to clear the line. Latest reports show that a very satisfactory clearing was made from Edson west, and east of that point the line was also to receive proper attention.

Here, too, the patrol service was very loosely carried on. Motor speeders were continually reported in disrepair, and the patrol men riding on freight trains. A patrol of five men on motor speeders from Wabamun to Yellowhead was prescribed for this line. Although a man can cover twice the distance by motor speeder that he can on an ordinary "jigger," it will be necessary for us to have the company resume the use of the hand machine unless they can provide a regular and satisfactory patrol with the motors. It is intended this year to have some spare cars and parts available, so that there will be no excuse for disruption of the organization on occurrence of a minor accident.

C. Canadian Northern Railway. (*a*) Rainy River and Ridgeville Subdivisions.—As a direct result of a hearing before the Railway Commissioners in the fall of 1912, these lines were splendidly cleared up in the spring of 1913, and considerable work of this kind was also done during the ensuing summer to maintain the right of way in satisfactory condition. Four men patrolled the lines on "jiggers," and as considerable care was exercised by the administrative officers of the company, the patrol service was very satisfactory indeed.

Canadian Northern Railway: (*b*) Gypsumville subdivision.—This line is not of great importance to us from our standpoint, as it traverses a fairly well settled country and there are also extensive bodies of water and sloughs along its course so that the fire hazard is not great. Although considerable work was done in right-of-way clearing, the line is not yet up to the desired standard. The patrol was carried on by the regular section employees.

Canadian Northern Railway: (*c*) Swan River, Erwood, Hudson Bay and Prince Albert Subdivisions.—These subdivisions have for a long time been the worst with which we have had to deal. Previous to 1912 repeated fires occurred as a result of railway operation and a great amount of damage was done to timber. The right-of-way was never properly cleared, and, as the country is a dangerous one in dry seasons, many fires resulted. In the spring of 1913, however, a considerable sum of money was expended by the company and the debris, accumulated through many years of neglect, was removed. Fourteen special men patrolled the line on velocipedes, and very satisfactory service was rendered.

Canadian Northern Railway: (*d*) Crooked Lake and Duck Lake subdivisions:—The same conditions as prevailed on the lines described in the immediately preceding section were also evident on the Crooked Lake subdivision, and similar action was also taken to clear the line. Good work was also done on Duck Lake subdivision which crosses the Pines forest reserve for some 8 miles. Both these roads are now in a fairly satisfactory condition. A special force of five men formed the patrol force, four of them patrolling from Prince Albert city to Big river, the fifth man patrolling that section of the Duck lake subdivision which traverses the Pines reserve.

Canadian Northern Railway: (*e*) Athabaska subdivision:—The right of way was well cleared and the patrol by regular section employees seemed to meet the demands.

Canadian Northern Railway: (*f*) Edmonton to Yellowhead (under construction): —A certain amount of work was done on this line, but there still remains a considerable amount before the line is up to the standard desired. Eight men patrolled the grade from the Pembina river westward, but the organization did not receive the same attention and care found on the other Canadian Northern lines. This was due, of course, to the fact that the line was under construction. The steel has now been laid, however, and hereafter it ought to be an easy matter to organize an efficient patrol service.

D. Edmonton, Dunvegan and British Columbia Railway:—This line is under construction from Edmonton north by west to the Athabaska river near Mirror Landing, and thence westerly along the south shore of Lesser Slave lake. On first inspection it was found that the usual conditions for lines under construction prevailed: since then, however, considerable clearing has been done and by the end of next season the line ought to be in very fair condition. Patrol was carried on by eight special men, patrolling for the most part on foot. Steel is now laid as far as Athabaska Crossing, so that it will be possible to patrol up to that point with velocipedes. West of the Athabaska the patrol will be on foot or horseback until steel is laid, after which the velocipede patrol will take its place.

E. Hudson Bay Railway:—This railway does not come within the jurisdiction of the Railway Commission, and the burden of fire-protection rests with our own fire-ranging organization, being part of the work of the Pas fire-ranging district. The line was well cleared up at the time of construction, so that conditions are now almost entirely satisfactory. The patrol service on the line was not what it ought to have been largely owing to the incompetency of the then chief ranger in carrying on the work of supervision. Under competent supervision there is no reason why we should not organize just as effectively as the railways, and the fact that we are more directly concerned but accentuates the necessity for efficient service. No great damage occurred on this railway with the exception of the loss of one construction camp and stores by fire.

Inspection.

The following men were appointed and acted under my direction in the inspection of railway fire-protective operations:—

Thomas McNaughton, Prince Albert, Saskatchewan., assisted in the general inspection of railway lines in the three provinces. Mr. McNaughton covered a great deal of ground during the season. All of the lines were inspected by him at least once, and most of them several times. As I also covered most of the lines frequently, it was possible for us to keep in constant touch with conditions all over the country. It is found that making quick jumps from one part of the country to another is productive of the best results.

Enoch Tennant, Hudson Bay Junction carried on a detailed inspection of the railway lines which traverse the district of which he is chief fire ranger. Mr. Tennant was provided with a motor speeder, and rendered very efficient service in the fire-inspection work.

Peter Lind, Sprague, Man., carried on a very efficient inspection of Canadian Northern lines in southeastern Manitoba.

A. C. Smith, Wabamun, Alta., inspected the lines of the Grand Trunk Pacific and Canadian Northern in northern Alberta.

Fires.

The record of fires which occurred along railway lines in 1913 is as follows:—

1. *Causes* (and numbers attributed to same) —	
Engines	109
Section-men and employees	37
Clearing right of way	6
Travellers, tramps, etc.	21
Unknown	47
Total	220
2. *Areas burned over*—	Acres.
Grasslands	1,100
Young growth	2,536
Timberland	330
Old slashing	140
Total area	4,106
3. *Damages*—	
Timber and young growth	$ 6,000
Railway property	10,800
Construction engineers' property	2,500
Total	$19,300

A bad fire which occurred on the Hudson Bay railway destroyed Construction Camp No. 8, belonging to MacMillan brothers, railway contractors, is said to have started from the right of way and resulted either from a clearing fire or from the camp-fire or smudge of some person travelling along the line. The damage to the camps and supplies is placed at $10,000, while an additional loss of supplies and equipment valued at $2,500 was sustained by the railway engineers. In addition to the actual loss, great inconvenience was caused owing to the difficulty of replacing the supplies destroyed. This fire accentuates the necessity for the exercising of greater care in the protection of camps by railway contractors. In all probability this camp could have been safely fire-guarded at time of building by the expenditure of a very few hundred dollars. Generally in the case of construction fires it is the country that suffers the loss as a result of carelessness; in this instance the contractor bears the loss.

Speaking generally for right of way conditions on all lines, a great deal of good work has been done. Lines that one or two years ago were dangerous fire-traps have now received attention, and the fire hazard has been greatly reduced. It only remains for the companies, by a comparatively small expenditure each year, to maintain the lines in the condition to which they have been brought. The large expenditures which in the last two years devolved upon the companies are due to neglect in previous years, and cannot be taken as yearly costs of maintenance of the right of way in safe condition.

A railway company is admirably adapted to the operation of an effective patrol service, for, with the large number of employees continuously on the ground and a good administrative officer, the roadmaster, always present, it is a simple matter to see that patrol is regularly performed; help is also always available within reasonable time in case of fire. This is exemplified in the case of the Canadian Northern, where thirty-four men patrolled a total mileage of 655.3 miles, the total cost amounting to $11,947.32. Although these figures indicate an average mileage per man of 19 miles, the normal average beat is between 20 and 23 miles in length, the reason for the 19-mile average being that on construction lines the patrols were only 15 miles in length. Taking the above figures, the average cost per mile for the whole season was $18.23, which figure will be reduced as steel is laid on lines under construction. On the Hudson Bay railway the cost was approximately $20 per mile, but the service secured was not so satisfactory. As steel is laid further northeast, however, it will be quite possible to increase the efficiency without increasing the average cost per mile. The Grand Trunk Pacific patrols were so erratic that it is difficult to arrive at approximate cost, and as the service was not by any means efficient, such figures would have little significance.

FIRE RANGING ON CROWN LANDS.

The fire-ranging organization is responsible for forest fire-protection on the Dominion lands of the three provinces which have not been included within forest reserves. The work is, therefore, confined to the northern parts of these provinces, with the exception that in Manitoba it also extends across the southeastern part of the province. The total area to which attention is given embraces some 125,000 square miles, although only a small part of this large tract is given really adequate protection. Each ranger district includes a great deal of country to which for several reasons it is not possible or advisable to give much attention. In the first place, the appropriation does not provide sufficient funds for the maintenance of a sufficient staff to secure absolute fire-prevention all over the country; in the second place, some parts are impossible or so difficult of travel that it would be a physical impossibility for the ranger to travel at the rate he must go in order to cover ground; third, the danger of fire in some places is so small that the expenditure of a large amount of money on fire protection would be out of proportion and, hence, an economic mistake; and fourth, the timber in some parts is of such little value and so widely scattered that it would not be wise to establish the intensive patrol that is required in heavily timbered districts. In spite of the above limitations in the degree to which forest protection should be applied, the fact remains that a considerable addition must be made to our staff in order to provide ample protection to those parts where intensive patrol is justified.

The whole territory coming under this inspection was divided into nine large districts as follows: 1, Southern Manitoba; 2, Northern Manitoba; 3, The Pas; 4, Hudson Bay Junction; 5, Prince Albert; 6, Battleford; 7, Edmonton; 8, McMurray; 9, Slave.

In the Slave district the supervision of the fire protection work devolves upon the Government agent located at Fort Smith. In each of the other districts there is a chief fire ranger whose sole duty in the fire season is the administration of the fire-ranging organization. Nearly all of the chief rangers are yearly men and in the winter time their time is devoted to land examinations, timber cruises, and work in connection with forest reserves. The total staff, exclusive of chief rangers, numbered about 130 men, most of whom were retained for the full season. While the staff as a whole was undoubtedly better than in previous years, there is still room for an immense amount of improvement, both in regard to the kind of men appointed to the work and in the attitude of the men to their work. The qualifications for a good fire ranger are not quite such technical ones as those for a forest ranger; nevertheless, there are certain fundamental qualifications which a man must have if he is to make a good fire ranger. He should be physically fit; he should not be too old; he should be an experienced woodsman and be able to get along under all sorts of trying conditions; he should be able to read and write sufficiently well to make record of his actions and observations; he should have stamina, foresight, and good judgment in the handling of men, so that when necessity arises for the hiring of help to fight fire he may properly control his force; and, finally, he should himself have had experience in fire-fighting. These qualifications are essential, and without them a man cannot be a first-class fire ranger. When we get a staff fully manned with rangers of this character, we shall be well on the road to efficient fire protection. That such men are available is evidenced by the fact that there are already many of them on the staff. Such men are found in different parts of the country, working for lumber companies, on survey parties, and in other industries and pursuits interested in and operating in the woods.

Southern Manitoba.

This district includes the northern half of the peninsula between lake Winnipeg and lake Manitoba, the area to the east of the southern half of lake Winnipeg and the belt of forest land stretching southeast to the international boundary (just west of lake of the Woods) and east to the Ontario boundary. The whole district comprises an area of some 8,000 square miles. The peninsula between the lakes abounds in swamps and muskegs, the country being generally low and flat. Merchantable timber of saw-log size does not occur in large quantities, the few good patches that exist being almost wholly confined to the shores of lakes and watercourses. Formerly there existed some good blocks of timber in the northern part of the peninsula bordering lake Winnipeg, but this timber has long since disappeared through logging operations. The chief value of the timber in the peninsula lies in its use as cordwood, for not only is it used locally by the settlers for fuel, but large amounts of cordwood are shipped to Winnipeg for consumption as fuel in that city. The chief species found are spruce (white and black) jack pine, poplar, and tamarack. The country to the east of lake Winnipeg is as yet but little explored, but for the past two seasons a large number of prospectors have penetrated the various water courses emptying into the lakes from the east. Here, too, the timber species are spruce, jack pine, poplar, and tamarack, but the quantity of timber which will be found there is as yet rather problematical, although several good blocks were observed by our ranger in this district. In the southeastern part of the province, extensive marshes and muskegs are found, the country being rather similar to that between the lakes. The main species are also the same, although towards the lake of the Woods red pine is found, also a little black ash and birch enters into the composition, though not in merchantable quantities. There is a certain amount of lumbering for saw-timber, but the main timber industry is the cutting of cordwood, both for local use and for shipping.

Although the above remarks would indicate that there is not a great amount of saw-timber in the district and that lumbering on a large scale is not carried on, this has resulted largely from extensive fires which have done great damage in past years In most places where these fires have occurred, however, there is a good reproduction coming up, and it is to the interest of the whole country that this reproduction should be protected. It is particularly desirable that the Winnipeg river water-shed should be protected in order that the stability of water-flow may be ensured.

Eight fire rangers were employed throughout the season, four in the peninsula, one east of the lake, one in the Winnipeg River district and two in the southeastern portion of the district. The method of patrol varied, of course, with the conditions, driving, walking and canoeing all being called into play.

The fire loss in southern Manitoba for the season of 1913 was very small, practically the only fires which occurred being confined to marsh and hay lands. A wet season prevailed, and to this the absence of destructive fires is in a large measure due. With the exception of the district to the east of lake Winnipeg it should not be necessary to make any considerable additions to the staff of the district. It must be remembered that in the appointment of permanent men for the season there is always a certain part of the wages spent in retaining the men through wet weather spells. With one additional man in the northern part of the peninsula we should have a sufficient staff of permanent men, while temporary additions might be made as occasion demands. East of the lake there should be several additions to the staff in order to provide adequate protection during the rush of prospectors to the country. Patrol there is almost entirely by canoe, and, as the rivers are for the most part rapid, travel is more or less difficult and slow. It is hoped that a fire-patrol boat will soon be put in operation on lake Winnipeg, and such a boat should be required to spend considerable time along the east shore of the lake. The mere presence of such a boat has a deterrent effect on those who might otherwise be careless with fire. The scattered nature of the timber would make it an impossibility to establish special telephone connection, and the construction of expensive lookout towers would not be justified; there are, however, some ridges in the district where inexpensive lookouts could be established by the use of materials close at hand.

Northern Manitoba.

The district embraces an immense tract of country from the foot of lake Winnipeg down the Nelson river and its affluents to Split lake; also, east to Island lake, God's lake and the Hayes river. This area of some 11,000 square miles is much broken up by the exceedingly numerous lakes and water courses, and and by the occurrence of numerous and extensive spruce and tamarack swamps and muskegs. Some parts are particularly rough with low irregular ridges and igneous outcrops. In some localities a fairly good soil is reported, on which it is claimed that hay and the coarser cereals could be grown, but it is altogether unlikely that agriculture will come into prominence in the near future, if ever. The country is for the most part wooded, but good blocks of merchantable timber are few and rather widely scattered. Practically the only lumbering carried on is for the supply of local demands, the logs being sawn at the small mills at the various posts and missions. Great damage has been done by fire, and it is estimated that fully 75 per cent of the country has been swept by fire within comparatively recent times. However, there is a good reproduction on such areas, an estimate being that from 40 to 50 per cent is growing up to spruce, jack pine, poplar, birch, and tamarack. This reproduction, in addition to the few remaining blocks of good timber, demands protection. The fires in past years have to a large extent been due to the thoughtlessness and ignorance of the Indian. An example of this may be cited from one of the chief fire ranger's reports, speaking of some country far over near the Ontario boundary: "The country was burnt over about five years ago, much good timber being destroyed. Four or five families of Indians live there, and when dry wood has disappeared from the immediate vicinity of their camps they simply move nearer to where there is dry wood. These few Indians must be responsible for the thousands of acres destroyed by fire, as they are the only people that make use of those waters and country." This carelessness on the part of the Indian has to a large extent been removed, as will be explained later on, but another danger has arisen in the progress of railway construction, and, though we may possibly be able to keep proper control of the fire situation along the railway line itself, vast quantities of supplies are being freighted in by the water route from Norway House to Split lake, so that there are hundreds of men engaged along this route, and, as a camp-fire is required by each party several times a day, there is great danger of fires being left to "burn out."

Patrolling the main water-routes by canoe, Mr. Blackford had a staff of sixteen men, only part of that number being retained for the full season. This staff of rangers is somewhat unique, in that most of the men are half-breeds and Indians, only three white men being employed. Although these half-breeds are not as good fire rangers as the best of white men, they are superior in this respect to the type of white man which we could get in that country for the funds available; and the chief ranger has so organized and controlled them that the patrols are very regularly made, and fires have been kept under control since the inception of the work in that district. Another feature of Mr. Blackford's work which continues to yield results is the "Indian Volunteer Fire Ranger" staff, consisting of the chief and important Indians in the various tribes of the district. These men have given Mr. Blackford great assistance in controlling the fire situation, for, by the example of careful attention to their own camp-fires they create an interest, generally, in the necessity for proper precaution. That he has been able to win the help and good-will of these men reflects very favourably on the foresight which he has exercised in supervising his work.

The improvements carried on consisted in making repairs and additions to the house of the chief ranger; the construction of a small dock and the building of a skiff to facilitate handling of supplies; taking out logs for use in construction of a small boat-house and workshop; making necessary repairs to the houses at Split lake and Oxford House; and getting out logs for the erection of a cache at Island lake.

No damage of any account resulted from the fires of the past season. Very few fires were discovered at all, and they were extinguished before any damage had been done. In the fore part of the season a short dry spell was experienced, but fires were kept in control. During the balance of the season the fire danger was retarded by the large amount of precipitation. The season, therefore, was a most successful one, and it is greatly hoped that the Indian populace can be prevailed upon to continue in the exercise of the proper precaution which has marked the work of the past two years.

The Pas.

This district embraces roughly the country within a radius of about 100 miles east, north and west of the town of The Pas, the larger part of it being in the province of Manitoba, and a small part extending into Saskatchewan, the approximate area of the whole being 10,500 square miles. The country is typically northern, being comparatively low, flat and much broken up by numerous lakes, water courses, spruce and tamarack swamps and muskegs. Along the Saskatchewan river, which is the main water course, and to which practically all the waters of the district are tributary, there are immense stretches of marsh and hay sloughs with but little timber. Down as far as Grand Rapids, east of Cedar lake, the river is alluvial, and, in addition to depositing bad sandbars in ever-changing positions, it is divided into almost innumerable channels and cut-offs, making navigation rather a trying proposition. Speaking generally for the whole district, the timber is of small size and consists of spruce, jack pine, poplar, tamarack, and a little birch. Spruce is practically the only species sawed into lumber and exists as merchantable timber in rather scattered blocks and the greater part of it is already under license or permit to timber operators and tie contractors. The good blocks are nearly all found along the route of the main rivers and lakes. The best of it is found up the Carrot river, which empties into the Saskatchewan a few miles above The Pas, and on the Sipanok channel. An immense amount of timber has been harvested for ties in the construction of the Hudson Bay railway. The one big saw-mill of the district constitutes the main industry of the town of The Pas. In this country, too, great damage has been done by fire, most of the country having been burnt over at one time or another. A very fair reproduction is found, however, which of course requires protection in addition to the remaining merchantable timber. The Saskatchewan river is very subject to floods, and it is therefore absolutely necessary for the welfare of the country that further fire depredations should be as far as possible prevented. Until the advent of the railway the fur trade was the one means of subsistence to the populace of the district, and for a long time to come it will continue to be the livelihood of the outlying people; this offers, therefore, a further incentive to fire-protective work.

The main danger lies, of course, in the large number of travellers along the route of the railway, and also by canoe along the navigable waters adjacent to the line. In the past few months, also, there has been a rush of goldseekers to the Beaver Lake region, and, as all such stampedes include a number who are not aware of the danger of fire, it will be necessary to keep close watch on this route.

A staff of twelve men was maintained for the entire season, of which (as previously indicated in this report) four men patrolled the railway line, the other six men being well distributed over the district, and patrolling by canoe the more dangerous water-courses and lakes. The patrol of the Saskatchewan river where, as a matter of fact,there is but little timber, but where on account of the large number of travellers it is necessary to have patrol of some kind, was carried on by the chief ranger in a motor boat. Much more careful supervision will be necessary before the work of the district will be by any means satisfactory. Next season, however, it is hoped that a new chief ranger will be installed and it will depend largely on the efforts of the new man whether the service reaches the desired efficiency or not. Normally the district should not be a hard one to protect, but with the added excitement of railway construction and gold rush the task becomes a much more difficult one.

The motor boat which was purchased for the use of the chief ranger has not on the whole been a success, for although they have managed to get about fairly well, serious difficulties were met with in the engine, mechanically, and also on account of excessive fuel consumption. I have already recommended, however, that the boat be kept in commission for the coming season, when a much better idea may be obtained as to exactly what improvements should be made.

During the season the fire loss was practically nil, with the exception of the fire in MacMillan Bros.' construction camps, previously mentioned. Altogether some 1,000 acres were run over by fire, but of this only 200 acres was open young growth, the balance grass land. The season was generally wet, and muskegs were filled with water, so that there was but little danger of fire spreading over extensive areas.

Hudson Bay Junction.

The district includes the Porcupine and Pasquia hills, and may be roughly defined as the country lying between the Thunderhill branch of the Canadian Northern railway and the Carrot River valley, east towards lake Winnipegosis, and west to the prairie country approximately south and north of Tisdale. About one-third of the district is in the province of Manitoba, the other two-thirds in Saskatchewan. This area of some 8,500 square miles is much broken up by the hills above mentioned. In these hills, and bordering them, are extensive spruce-tamarack swamps and muskegs. The lumber industry is quite highly developed, nearly all the villages and towns of the district being the seat of a lumbering industry. The principal species found and used for this purpose is spruce; jack pine, poplar and tamarack also exist in large quantities, while to a lesser extent white birch is found. Enormous damage has been done by fire, one hundred million feet of timber having been destroyed in the years 1908 and 1909 alone; also in 1910 and 1911 considerable loss was sustained, to say nothing of the years previous to 1908. In the neighbourhood of 50 per cent of these fire-swept areas have established a forest cover of poplar, both white and black, and although this species is not of very great value for lumber, it is of great importance as fuel-wood. Furthermore, in many places there is a reproduction of spruce beneath the poplar cover, which, if properly protected, will doubtless re-establish itself. This point has not been considered by various lumbermen, who have stated that the main type is poplar. Easily seen, therefore, is the necessity for fire protection. The country is well broken up with drivable streams, so that with protection and conservative lumbering there is no reason why the lumber industry should not continue on a permanent basis.

The district was patrolled by a staff of twelve men, who, with one exception, were retained for the entire season. The men were well distributed over the district, patrolling on foot, by saddle-horse, or driving, as occasion demanded. On the whole, the staff was an efficient one and good work was done. Altogether some 50 miles of trail were opened up, and a certain amount of cleaning up done on existing trails. The chief ranger of this district, Mr. E. Tennant, is a particularly efficient chief, having had many years' experience in timber operations and being thoroughly familiar with the district of which he has charge. As previously mentioned, he also carried on the inspection of railway work for the district.

The fire damage for the year was comparatively small, the loss of merchantable timber being confined to 150,000 feet, board measure, while some 1,650 acres of young growth were destroyed, and 3,400 acres of old slashing and 2,600 acres of grass lands burned over. Good fire protection can be provided in many places by the establishment and use of lookout towers on prominent hills, and already two trails have been opened up from the railway to the eastern summit of the Porcupine hills with this object in view. The most noticeable thing about the work of the district was the increase in efficiency over that of previous years, and if the same improvement can be made from year to year we will soon have a very effective organization indeed.

Prince Albert.

The district extends west of Prince Albert city some 80 miles, north to Isle à la Crosse lake and Lac la Ronge, and east down the Saskatchewan valley to the Sipanok channel, involving, roughly, an area of some 13,000 square miles. Just north of the Saskatchewan river for some 25 miles and extending westward along the line of the Canadian Northern the country is fairly well settled up; farther north, the country is but slightly settled, while in the vast lake country still farther to the north there are practically no settlers other than those at Hudson's Bay posts, missions, and Indian settlements. The general contour of the country is comparatively flat, although there are numerous sand ridges, especially in the valley of the Saskatchewan river. The country is much broken up by numerous lakes, muskegs, spruce-tamarack swamps, and sloughs. The timber is, generally speaking, of comparatively small size and more or less widely scattered. By far the greater part of the accessible merchantable saw-timber has already been cut or is under license to one of the two big lumber companies operating in the district, and large amounts are being cut yearly. In addition to the above companies, there are numerous smaller cordwood operators engaged in the district. The cordwood areas of the district are to a large extent the source of the fuel-wood supply for the country south as far as Regina. A large part of the district has been swept by fire, with the result that much land formerly covered with spruce has reproduced a dense growth of aspen. In places, however, these aspen areas have seeded to spruce, and if good fire protection is afforded, spruce forests of large extent can undoubtedly be established. The district is normally a dangerous one, for the average precipitation is comparatively low. The country, too, offers access by canoe to the Churchill and other northern waters, so that numerous prospectors, trappers and hunters are continually going into the north country, and, as many such men are very careless in the use of fire, great danger results. In the southern parts many settlers have filed on quarter-sections which can never be profitably farmed, their intention evidently being to cut all the cordwood and then abandon the homestead. It is unnecessary to say that settlers of this description leave the homestead a veritable fire-trap, with dry inflammable tops and brush scattered haphazard about the place.

Eighteen fire-rangers were retained for the entire season. In the more settled parts patrol was mainly carried on by horse and rig; farther north, where roads are few and water communication is not continuous, the men travelled mostly on foot; still farther north, in the lake and river country, patrol was entirely by canoe. The majority of the men were, of course, located in the southerly and more dangerous parts, while in the north the districts were large, altogether too large, in fact, for good protection. The service was decidedly better than in previous years, although much further improvement is required, both in personnel and the details of organization. The work was in charge of Mr. A. Williscraft, a man thoroughly familiar and experienced in such work and to his efforts the greater part of improvement is entirely due.

The fire damage was small, some 2,500 acres of young growth, 100 acres of cordwood timber and 1,800 acres of grass land having been burned over. The season was abnormal, the precipitation being above the average; at the same time there were several fairly dry periods, but fires were kept in control. No elaborate improvements were carried on, the trail work being for the most part confined to clearing up of existing trails.

Considerable areas of the districts have already been created forest reserves, and several large reservations are proposed at the present time. When these are all on an established basis of forest management, much will have been done to retard the fire danger. For the northern parts a combination sail-motor-boat is now under construction. Such a boat is undoubtedly an innovation, but will certainly greatly facilitate fire patrol on the big lakes, where with a canoe a ranger may often be stormbound for days at a time.

One great misfortune suffered in the district during the summer was the destruction by fire of the plant of the Big River Lumber Company at Big River. In June the sawmill was burned down, and later on, in August, the planer was also completely destroyed by fire. This plant was one of the finest in Western Canada, although perhaps a little too large for the locality in which it was situated. In addition to the loss of the mill hundreds of people were thrown out of employment, and it was necessary to dispose of large quantities of rough lumber which was in the yards; none of the latter, fortunately, was destroyed.

Battleford.

The character of the country in this district resembles very much that just described for the Prince Albert district, with the exception that settlement runs up in a more distinct line to the edge of the forest land. It may be defined as the area lying between the Prince Albert district and the boundary of the province of Alberta, altogether some 6,500 square miles. Topographical features are very similar, the same flat country with low ridges being in evidence. The lumbering industry has not been developed to the same extent, owing to the lack of railway facilities for marketing of the product; most of the sawing is done by small portable mills located here and there throughout the southern part of the district. North of the Beaver river, in the Waterhen Lake region, there is some of the best spruce, perhaps, found in northern Saskatchewan. This is still for the most part green, and all efforts should be made to keep it so. For the rest of the district the saw-timber is not so good, being more or less scattered in small blocks. There are large quantities of merchantable cordwood which at present has only local use. With the construction of a railway, however, it will be possible to harvest and market great quantities of fuel-wood. A large area has been fire-killed, as in the case of other districts, and there are enormous quantities of good, dry cordwood which, it is feared, will lose its value ere a railway reaches the district. In many places the reproduction of jack pine is very dense, while in others poplar has established the forest-cover with a light reproduction of spruce below.

Seven men were employed throughout the season, five working south of the Beaver river, patrolling on foot or driving as conditions permitted. The remaining two men patrolled by canoe the lake and river country in, and to the north of, the Beaver River valley. In this district the average calibre of ranger is perhaps better than in any of the other fire-ranging districts; all the men were comparatively young, sturdy, and good for any amount of hard work. South of the river the district was exceptionally well patrolled, and what is now most necessary to increase the efficiency of organization is improvement work. During the season some existing trails were cleaned up and some new ones cut. A good cabin and stable for one of the men were also built, the frame of a second one constructed, and a good lookout station erected all at very small cost of ranger labour, and with practically no additional expense. Improvements of this nature can easily be undertaken at the times when conditions do not necessitate active patrol duty, so that when the danger time comes, the ranger can be close at hand with his supplies, fire-fighting equipment and probably a fresh horse. In the country farther north the rangers had proportionately more ground to cover, and hence but little was undertaken in improvement work. Good work was done by all of the men in providing head office with detailed information and maps of their districts.

The fire damage for the year was comparatively small, no damage being done to merchantable timber, and the loss confined to 3,600 acres of young growth and some 36,000 acres of grassland. The season was a fairly wet one, but there were times when conditions created anxiety; at such times, however, the organization successfully withstood the fire danger.

Edmonton.

This is by far the largest district included in our present fire-ranging organization. It embraces all the timber country north of Red Deer and east of the Rocky Mountains forest reserve; it includes also the Peace River block and the Peace River valley down as far as Vermilion chutes, the Athabaska river down to Grand Rapids, and the vast area of country lying between the portions of the Peace and Athabaska rivers above defined; and, lastly, the Lac La Biche country east to the Saskatchewan boundary. Roughly speaking, an area of some 48,000 square miles indicates the extent of the district. A large part of this area has, of course, been opened up to settlement and settlers have for the past few years been pouring into the country. To describe the country topographically is impossible in this report; suffice it to say that practically the whole area is drained by large rivers which rise in the mountains—the Saskatchewan, the Athabaska, and the Peace. Between these rivers are high ranges of hills, which become lower as the rivers recede from the mountains. The intervening country is a network of rivers and streams, the largest of which also rise in the mountains. The country is much broken up with lakes, spruce-tamarack swamps, sloughs, and muskegs, making travel extremely difficult and confining it more or less to well-defined highways. The country has been repeatedly swept by fires, until at the present time but a small proportion of the timber retains its virgin state. To appreciate the awful destruction and loss one has but to travel through the foot-hills of the Rockies and witness the untold quantities of timber fire-killed and rotting on the ground, and not only in the foothills but almost generally throughout the district fire has at one time or another waged its dreadful toll on the timber resources. Fortunately, however, there are millions of acres of reproduction, pine, spruce, and poplar, which if carefully protected will one day restore the forest cover, thus ensuring a bountiful supply of forest products and increasing the stability of stream-flow.

A great deal of lumbering has for many years been carried on in the southern portion of the district, and saw-mills are to be found on all the main rivers; also, many hundreds of miles of railway have been laid with ties cut from the district, so that, in addition to the fire hazard under ordinary conditions, there are thousands of acres of old slashing, adding materially to the danger of fire. North of the Athabaska river there are practically no mills of large size and cutting has not been so general, being solely for the supply of a rather small local demand. On the Simonette, Smoky, and other northern rivers, many fine blocks of timber are found which will without doubt play an important part in timber supply to the northern part of the province.

Up to the present time the only highways into the northern country have been the Grande Prairie trail, the road from Athabaska and the Athabaska river. Travellers entering the country, therefore, have had to resort to camping out, and, of course, this has been the source of numerous fires. Now, however, a railway is penetrating the district, and even if in itself it constitutes a source of danger, it will materially decrease the number of campers and camp-fires. Formerly a railway penetrating a new country was a sure indication of wholesale destruction of timber by fire; now, however, with efficient legislation for railways under construction, it is hoped that the catastrophes of this nature may be prevented. In the southern part of the district, railway construction is also progressing rapidly, but the worst danger with which we have to contend is the prospector. This part is coming year by year under more efficient forest administration, however, and it is hoped that the apparently imminent danger may be largely offset.

Distributed over this enormous district was a staff of about forty men, practically all of whom were retained for the entire season. Patrol was more or less confined to the main avenues of travel, for it is along such roads that the main danger exists. The men were well distributed, so that all parts of the district received some measure of protection. On the Athabaska river, protection was afforded by a stern-wheel patrol boat equipped with fire-fighting apparatus. This boat patrolled between the Pembina river and Grand Rapids. The work of the whole protective organization of the district was under the direct supervision of one chief fire ranger, Mr. R. H. Palmer, of Edmonton. Splendid work has been accomplished by him in the organization of the district, but one has only to glance at the map to see that subdivision of the district is the first thing necessary in order to provide increase in efficiency of administration. Another problem that faces us is the protection of timber in the Peace valley and on the islands of that river. This can best be handled by the provision of a good patrol boat of the same type as that on the Athabaska river, but of larger size and greater power.

It is reported that 75,000 acres were burned over, of which by far the greater part was grassland and old slashing; of the balance, 7,000 acres was covered with young growth; and 100 acres consisted of merchantable timber on which 200,000 feet, board measure, was destroyed. The season was, therefore, a successful one as regards fire protection. This was largely due to wet conditions, but, as many fires were extinguished by the men, it is safe to say that there has been improvement over previous years. Under favourable conditions the staff seems to have been sufficient, but to hold our own in drier and more dangerous years would severely tax an organization of treble the number of men. It is necessary, therefore, that additions should be provided for in the future organization.

McMurray.

This district embraces the country along the Athabaska river and its tributaries, from Grand Rapids to the outlet of the river into lake Athabaska. The most important affluent is the Clearwater river, which joins the Athabaska at McMurray. Altogether the district may be said to include some 12,500 square miles. With the exception of isolated settlements at the various Hudson's Bay posts and missions, the country is entirely unsettled and in no part of the district do we find anything more than a mere trace of farming. The mainstay of the essentially Indian population has been the fur trade, and only lately have the mineral resources of the country attracted the general attention of prospectors. The best timber of the district is found in the valley of the Clearwater river, and although here the timber counts some good blocks of spruce it is almost wholly confined to the immediate valley of the river. Along the Athabaska some fair blocks of spruce are noted, but the most striking timber found there is the black poplar ("cottonwood," as it is called in that country, or balm of Gilead), which grows to a surprising size on the banks and alluvial islands of the river. As for the country back from the river, it is of the general northern description, large spruce-tamarack swamps and muskegs interspersed with low jack-pine and poplar ridges. Most of the country has been subjected to fire, with the result that a large proportion of the timber is of small size. Sufficient timber will be found in the valleys of the rivers, however, to supply the demands of the country for many years to come, but, as the development of mineral resources is likely to increase, and as they will enhance considerably the value of the timber, it is most necessary that fire should be kept out as much as possible.

Eight men were employed for the entire season, patrols being established on the Athabaska throughout the entire distance from Grand Rapids to the lake, the Clearwater river, the House River trail (which is an alternative route from McMurray to House River above Grand Rapids) and the Lac LaBiche trail. Patrol on the rivers is, of course, entirely by canoe, while the trails are covered either by pack-horse or on foot. For the first time since its inception the organization was placed under the exclusive direction of a chief fire ranger, Mr. J. M. Hill, of McMurray. Although there is room for much improvement in the district, the closer supervision over the work of the men has fully justified the appointment of the chief ranger.

The season was a most favourable one, and the fire loss exceedingly small, 1,000 acres having been burned over, of which about 400 acres consisted of young growth, the remainder being open and grass land. At the mouth of the Athabaska river there are extensive marshes and swamps covering hundreds of square miles; fires also occurred there, but owing to the wet nature of the area it is an impossibility to take any action other than preventing the spread of fire to higher and drier land. The area of such marsh land burnt is, of course, not taken into account. In the next few years the fire danger will be considerably greater on account of the influx of prospectors and travellers, but it is hoped that the ranger staff will be able to hold its own.

Slave.

The district embraces the valley of the Rocher and Slave rivers from lake Athabaska to Great Slave lake; also the Quatre Fourche river, and the Peace river up to Vermilion chutes. Generally speaking, the district is not well timbered but in many places extensive blocks of spruce are found. At the mouth of the Peace and Quatre Fourche rivers, and extending up the Peace river for some 20 miles there is very fine timber, indeed, in several blocks containing at least 100,000,000 feet of spruce. Good timber is also found on the Slave river between Fort Smith and Great Slave lake, large quantities of which are yearly cut by the Hudson's Bay Company to supply local demand. In other parts of the district the timber is smaller and does not exist in such large blocks as those just mentioned. The black poplar also reaches large size in this district and although very subject to heart-rot, it will undoubtedly be used to a considerable extent as development goes on. Although most of the timber along the rivers is green, a large part of the country has been burned over in previous years. As is the case in the McMurray district, however, with careful protection there will be sufficient timber to meet the demands of the country for many years to come.

Patrolling the district were two regularly appointed fire rangers, one working from Lake Athabaska to Smith Landing, the other below Fort Smith. A new patrol boat was sent down the river during the season, and will patrol from Fort Smith to Great Slave lake. As the boat did not arrive till mid-season, and as it was some time before it could be fitted up, it was not possible to make more than one trial trip. On this trip a full patrol was made from Fort Smith to Great Slave lake, and the boat proved satisfactory. Above Smith Landing is another small steamer which, when properly equipped with new machinery which is to be sent down, will be available for fire-protective work. The idea is that each boat will be in charge of a fire ranger and have a crew of engineer, fireman, and additional help as may be necessary. The operation of such boats will greatly increase the protection, as, after all, a man, even with an assistant, makes but slow progress in ascending the swift waters of those large rivers. During the past season continuous patrols were made from Fort Chipewyan to Smith Landing by the fire ranger, but each time the return upstream was very difficult and slow. The work of the district is under the direction of Mr. A. J. Bell, Government Agent at Fort Smith, Alberta. The fire situation seems to have been kept well in hand, no merchantable timber having been destroyed. Altogether, about 15,500 acres of young growth was burned over, of which a considerable amount was scrub poplar reproduction of but little value. The season was a fairly favourable one, though not so wet as that experienced in other districts.

A district to which we have as yet been able to give but scant attention is that below Great Slave lake, the Mackenzie river and its tributaries. On the Mackenzie river itself there is perhaps not much large timber, but up the Liard and some of the other large rivers it is reported that there is fine timber. Protection in such a remote district is, of course, a very difficult matter, the country in itself being of such enormous extent and communication very slow. It will, therefore, be difficult to work out an efficient organization for fire-patrol and the best thing that could be done would be to establish a good fire-patrol boat working from Great Slave lake northward.

GENERAL.

The fire record for the season in all of the above districts and along railway lines is as follows:—

Causes—	Number.
Campers, surveyors, prospectors, etc.	164
Locomotives	109
Careless clearing of land by settlers, etc.	66
Section-men on railways	32
Clearing right of way	11
Threshing engines	3
Logging engines and small mills	2
Deliberately set out	2
Lightning	1
Causes unknown	121
Total	511

Areas burned over—	Acres.
Merchantable timber	580
Young growth	34,136
Old slashing	28,540
Grasslands	86,200
Total	149,456

It is seen that 86,200 acres of the burned area was grass land, and the balance of 63,256 acres—a little under 100 square miles—was forest land. Estimating that 90 per cent of the area under patrol is forest land (namely, 112,500 square miles), it is seen that about 0·09 per cent (nine one-hundredths of one per cent) of the forested areas was burned by fire during the fire season of 1913. The amount of merchantable timber destroyed was comparatively small, being less than one million feet, board measure. The greatest loss, by far, is represented in the destruction of over 34,000 acres of young growth, which, given a nominal value of three dollars per acre, represents a loss of $102,000. Other losses to property as a result of forest fires would add to this loss by $25,000, making a very conservatively estimated total loss of $127,000—an amount greater than the total expenditure for fire protection over the total area concerned. This loss is very small as compared with other years; nevertheless it is clearly shown that even in a most favourable year the amount of loss to the timber resources of the country is such as would warrant the expenditure of more money for its protection. Although the expenditure of more money is urged, it is of great importance just how such funds should be spent. The present staff is not large enough, yet it would not suffice to merely add to the number of rangers employed. More emphasis must be laid on improvement work, for, no matter if the staff numbers into the thousands, in a dangerous year but little can be done unless the wherewithal to fight fire, namely, roads, trails, and equipment, is present. The most feasible policy to this end is at the present time being carried out in the establishment of forest reserves. It is a difficult matter to carry on extensive improvement work on open Crown lands, but by creation of reserves and the administration of them on a rational basis, establishment of organized patrol, construction and maintenance of roads and trails and the control of forest users, the problem is much simplified.

Reference to the area table shows that over 28,000 acres of slashing was burned over, again emphasizing that the present careless method of logging adds greatly to the fire hazard. Present legislation provides for the proper disposal of slash from lumbering operations, but legislation is not effective unless it is enforced; and the present method of inspection of cutting operations does not secure the desirable and necessary compliance with regulations. Stringent regulations have been provided in the case of railways, and these are being properly enforced at considerable expense to the railway companies concerned. Railway operation has for a long time been considered as a source of fire-danger, and action has been taken to offset, as far as practicable, this danger. The presence of slash in the bush has also been recognized as a factor in the source of fire, yet the compulsory action for the removal of such slash by timber operators has not been effected.

The fire table indicates that once again campers, prospectors, hunters, and others travelling the timbered country were the most prolific source of fires. Those people are always on the move, and the difficulty is that the quicker they move the more likely are they to leave a camp-fire unextinguished. On the other hand, the fires resulting from careless clearing of land have decreased over the previous year, and this feature is a most pleasing one to note; nevertheless, more effective legislation is required covering this phase of the question as well as the camp-fire problem, in order that we may compel more careful observance of the principles of conservation. Many of the fires caused by such agents occur along provincial roads either under construction or supposedly completed. Along nearly every such road piles of slash are left which become very dry and inflammable and all that is necessary to start a bad forest fire is that some careless person should throw a burning match or other ignited substance into this slash. By far the greater proportion of fires started which are extinguished by our rangers result from the surrounding conditions of the woods as regards slash and débris.

During the season I visited all of the districts with the exception of northern Manitoba. An extensive trip was made from Athabaska to Fort Smith and thence back to Prince Albert by way of the Clearwater river, Lac la Loche and the Beaver river waters. This trip will be dealt with in a separate report, as it was more or less distinct from the rest of my work. My general impressions of the organization are, I think, conveyed in the reports on the various districts. As far as can be seen there has been improvement, yet after all, no real test of efficiency will come about until we have a dangerous fire season.

Respectfully submitted,

E. H. FINLAYSON,

Inspector of Fire Ranging.

APPENDIX No. 7.

REPORT OF THE SUPERINTENDENT OF THE FOREST PRODUCTS LABORATORIES OF CANADA.

MONTREAL, QUE., March 27, 1914.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa.

SIR,—I have the honour to submit the report of the Forest Products Laboratories for the year ending March 31, 1914.

On being appointed Superintendent of the Forest Products Laboratories in June, 1913, I made a trip to the United States Forest Products Laboratory at Madison, Wis., where I spent five weeks in a study of their organization and work, with a view to utilizing their experience with various phases of the work as much as possible, so as to avoid, as far as could be, the difficulties with which they had to contend, particularly in the early days of the institution. Moreover, since up to the present time, this laboratory has been the only one in America whose field is forest products, a study of their work is extremely desirable in order that unnecessary duplication of research be avoided, and that, where the work on Canadian woods parallels similar work done by them on United States woods, the details should be exactly similar in the two laboratories, so that the results obtained in each may be combined or compared with the minimum of effort and possibility of error. This is particularly desirable in the case of tests of mechanical properties of timber, as the work, often very extensive, of various investigators in this line, has been rendered almost valueless from the non-observance of this principle, whereas, by conforming more closely with the researches of others the work of each would have supplemented that of the other, resulting in greatly increased value for both.

Since it was determined that the divisions of timber tests and timber physics should be instituted first, and that of pulp and paper follow immediately, the corresponding divisions at Madison received the most careful study. Through the courtesy and co-operation of the various officials of the laboratory, all available information was placed at my disposal and a great deal of valuable data, otherwise unobtainable, were secured and will be of immense service to our laboratories later on. Too much cannot be said in appreciation of the interest and support which the staff of the United States Forest Products Laboratory have displayed in our work, both during my visit there and later. The notes and data secured during this visit are now on our files here and are the basis of a very large part of our organization plans.

On returning from Madison, I first took up the matter of co-operation with McGill University. Many conferences were held with the various officers of the University, including Principal Peterson, Dean Adams, of the Faculty of Applied Science, Mr. Vaughan, bursar, Mr. Burrell, assistant bursar, Dr. Ruttan and Professor Mackay, of the Faculty of Applied Science, and also the Governors of the University. These gentlemen, and indeed all connected with the university, are very enthusiastic in their support and have done all in their power to aid us. As an outcome of these negotiations, memoranda have been prepared for the Governors and for Dean Adams, embodying the terms of our affiliation with the university. Copies of these memoranda are appended to this report.

The matter of accommodation was also considered in conjunction with the university authorities, as this is to be provided by the university. Temporary quarters were provided in the Old Medical building, consisting of two rooms for office and two rooms in the basement for the work of timber physics and the drafting in connection with timber tests and other work. The experimental work in timber tests will be done in the testing laboratory of the Macdonald Engineering building, which is one of the best equipped testing laboratories on the continent. In addition to the testing machines installed there at present, we are installing a Hatt "Impact machine" and an Olsen "Universal testing machine", which are particularly necessary for our purposes.

Regarding permanent accommodation, the building known as the "Joseph" property, now owned by the university, was first considered. This building is at present occupied by the Officers' Training corps, but will be vacated by them on the completion of their new armoury which is to be constructed this summer. During the negotiations for the use of this building, the university purchased a house on University street, known as the "Molson" house. As it was known that the university had no immediate use for this property, permission was applied for to investigate it with a view to taking this in lieu of the "Joseph" property.

The considerations involved as to which was most suitable to our needs were several. In the first place, it is a much larger building and is so laid out that we can install our paper machine without any addition to the building, which was not the case with the Joseph property. Then, too, this building is in close proximity to the Applied Science buildings of the university and to connect with the steam-supply line, from which we will draw our heat and power, will require only a very short conduit, whereas, in the case of the Joseph property, about 900 feet of conduit would have to be laid, and this would entail considerable cost. The foundations of the building are not at present in very good repair, but it is probable that they can be put into such shape as to suit our purposes without entailing too great an expense. The Board of Governors of the University have agreed to turn this building over to us for a period of four years. This will make no difference to our arrangements for the use of the testing laboratory.

Following the precedent of the United States Forest Products Laboratory, an Advisory Committee has been instituted to supervise the general policy of the laboratories. In selecting the men for this committee attention was paid to the following points:—

1. The interest manifested in work of this nature.

2. Experience with wood products.

3. Willingness to take the time and go thoroughly into the questions that may come up from time to time.

4. The confidence and esteem in which he is held by his associates and the public.

We have been extremely fortunate in finding men of the requisite qualities who are willing to act in this capacity, and enthusiastic in their support of the work and aims of the laboratories. Four of these may be considered as representing the university on the committee. These are Mr. F. H. Wilson, of the Board of Governors, and Dr. Frank D. Adams, Dr. R. F. Ruttan and Prof. H. M. Mackay, of the Faculty of Applied Science. The other members of the Advisory Committee are men prominent in commercial and technical work of a nature closely allied to that of the laboratories. These are Mr. Carl Riordon, of the Riordon Pulp and Paper Company, Montreal, Mr. Judson A. DeCew, Consulting Chemical Engineer, Montreal, and Mr. R. O. Sweezy, General Manager of the Montreal Engineering Company. All of these gentlemen have displayed very great interest and have shown themselves willing to make considerable sacrifice of their time to further the interests of the laboratories.

The appointments to the technical staff up to the present are as follows: W. B. Campbell, in charge timber physics; R. W. Sterns, in charge timber tests; W. G. Mitchell, N. W. Trapnell, L. L. Brown, S. D. McNab, assistants.

Several other appointments have been made to take effect at a later date. Notable among these is the appointment of Mr. John S. Bates to take charge of the division of pulp and paper. Mr. Bates is at present in the laboratories of A. D. Little, Inc., Boston, Mass., U.S.A., where he has already distinguished himself by his researches on pulp and paper—notably by his work on the utilization of the waste of Southern pines.

In addition to the appointments to these technical positions, a small clerical staff, consisting of two stenographers and an office boy, has been appointed.

No heavy apparatus has been installed up to this time, with the exception of the Impact testing machine and Universal testing machine previously mentioned as having been purchased for use in the testing laboratory. Both of these machines were purchased from the Tinius Olsen Company, of Philadelphia. They are at present being erected in the laboratory. Other equipment purchased includes one Bausch & Lomb-Zeiss microscope, one Sartorius chemical balance, one Freas electric oven, and a stock of glassware, etc., for the chemical laboratory. Draughting equipment, including two Universal draughting machines, three tables, and scales, squares, triangles, etc., has also been installed.

A considerable start has been made towards the establishment of a library and reference files to contain all available literature on forest products, and on all subjects related to this. Included in this will be a file of catalogues of manufacturers of all supplies and of various wood products, as well as accumulated clippings of all items of interest in this connection found in the current literature. We aim to include in the library all information published from now on. A classification system has been arranged to cover all this literature so as to make all information on any subject immediately available to the laboratory. The preparation of this system and the putting it into operation has been quite an undertaking in itself, but ready and complete reference to the contemporary literature is vital to the efficient working of the institution. The filing of the correspondence has also been arranged so that all correspondence relating to any one product is together, so that we will be able to accurately estimate the relative demands for information along the different lines and shape the investigations of the laboratory accordingly.

A system has been worked out, also, to keep records of the work as it goes through the laboratories. These records are to be kept in such a way as to make them independent of the personnel of the staff making the observations; that is to say, in the case of one man leaving or changing to some other part of the work, his successor will not find it necessary to duplicate any of the work previously done. This end can be attained only by means of an efficient system constantly and carefully managed.

Already the public are beginning to look to the Forest Products laboratories for information of all kinds in relation to various wood products. In the great majority of cases we are able to furnish this information from the knowledge at hand, but it frequently happens that this is impossible for the reason that no work has been done on the subject. The variety and extent of the inquiries already received indicate very clearly that the laboratories will fill a very real want of the users of wood in this country.

Although the laboratories have not yet been able to commence any original research work, both by reason of the time necessary to obtain proper equipment and proper personnel and also the delay which is necessarily incurred in collecting properly authenticated specimens, the laboratory has prepared some literature which should be of considerable interest and value to lumbermen and others concerned. The first of these publications deals with the organization and purposes of the laboratories and is for the purpose of acquainting the public with the ideas and scope of the work. This will pave the way for future publications and will make them proportionately more valuable by increasing the number of people who will become interested. Another circular is now in the hands of the printer and is on the subject of the "Chemical Utilization of Wood Waste." This circular is intended to give a brief outline of the various processes in use at the present time, for utilizing the various important forms of waste, without going into the technical details of any of them. This circular will cover a great many of the inquiries which we receive. A bulletin on the use of Wood-Paving Blocks has also been prepared and is now ready to be printed. This latter is a compilation of all previous literature on the subject and also includes something of the experience and opinions of various engineers and other authorities on the question. This bulletin will, it is expected, be of great value to the city and town engineers who are interested in good pavements and who wish to keep informed regarding the latest and best practice in this respect. The preparation of these two latter publications also serves another purpose, in that we require all the available information for our own reference and this makes a most convenient method of collecting it. For instance, in preparing the bulletin of Paving Blocks, it was necessary to get in touch with the engineers of all the more important Canadian cities, as well as with those interested in wood preservation in general. This has resulted in the accumulation of a mass of extremely valuable information which will be of very great use to us later on when we are in a position to do some original investigation and demonstration on this subject.

As previously stated, no laboratory research work has been done as yet owing to lack of material for test. The first work of this kind will be an investigation of Douglas fir, and the material for this has been cut and is now on the way to the laboratories. The shipments consist of portions of five typical trees from each of three localities and records are being made of each of these from the time of cutting so as to have at hand complete information as to these specimens

Respectfully submitted,

A. G. McINTYRE,

Superintendent of the Forest Products Laboratories.

APPENDIX No. 8.

REPORT ON WOOD BUFFALO.

Aurora, Ont., July 9, 1913.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa.

Sir,—I beg to submit a summary of my investigation of the conditions affecting the Wood Buffalo in the Slave River district, or rather a review of the information obtained during my two years travel in this country. I will also respectfully submit a few suggestions in regard to their future protection and welfare.

WOOD BISON.

The country in which the last wild herd of buffalo roam is situated west of the Slave river. The southern boundary of the district is formed by the broad expanse of the Peace river, from a point on it opposite the lower end of the Caribou mountains to its mouth, or rather its junction with the Slave river. The western boundary is the Caribou mountains, which run northwest and southeast some 150 to 200 miles west of the Slave river. The northern limit, of course, is Great Slave lake from the mouth of the Slave river to some point beyond the mouth of the Big Buffalo river.

The climate is not as severe as one would expect. In winter, although at times during January the temperature goes down very low, it remains about 10 or 20 degrees below zero Fahrenheit, and, as the air is very dry, it is not uncomfortably cold. Spring sets in near the middle of April, and all the snow is gone by the middle of May. All vegetation advances very rapidly owing to the long hours of sunshine. Summer, although very short, is luxurious in its production of new growth. Fall is usually very much prolonged, the sloughs and smaller rivers freezing solid long before the first snow falls. This country and climate seems to suit the wood buffalo to perfection. The snowfall is not so deep that it covers the feed in sloughs and small prairies beyond their reach. Added to that, the open places are not so large that the snow becomes packed by the wind, thus preventing them from tossing it aside with their huge heads. If the wind blows too hard, they can easily take shelter behind some thick bluff of timber or move on to some small slough where the grass is long and abundant and which is entirely surrounded by dense bush.

The chief difficulty in exploring this country and obtaining statistics of the wood buffalo is its lack of navigable rivers. The Little Buffalo river which drains this country is of little or no practical use for exploration purposes, as it is so very crooked; although I suppose it might be used as a supply base for parties rounding up the buffalo in the northern section, if that step is ever taken. Of course, added to this, are the usual difficulties of travel in the north; the prolonged spring when the country is boggy and flooded deep with water (see my report of our trip in June, in 1911, in regard to the great difficulty we had with pack-horse travel); the short summer when the flies worry to death both man and beast; the long cold winter when travel by dog-sled is the only practicable means, and when the very nature of the undertaking means a new soft trail through dense bush and deep, drifted, open places. But these are every one surmountable difficulties, that is, by men or animals of the requisite stamina. Another problem, and undoubtedly one of the greatest, is the difficulty of food supply. No wandering bands of Indians inhabit this country. They one and all stay at the different posts on the Slave river, only making short hunting excursions into the country for moose and fur, and then travelling light, far and fast. Therefore all supplies have to be taken with the party from the start. The party becomes self-supporting and self-dependent, as no succour from any outside source can be expected. As far as the buffalo themselves are concerned their investigation is more or less a matter of luck. Owing to the dense undergrowth one might pass within a few hundred feet of a band of them and never know of their existence. An experienced guide is absolutely necessary, one who knows the whole country thoroughly, who knows from experience where the different bands are likely to be found, as there are huge tracts of the country which the buffalo seldom, if ever, visit. Even then he is often disappointed and may travel for weeks without seeing them.

But I am wandering from my subject of facility of investigation. To put it in as few words as possible, the successful investigation into their condition and correct compilation of their numbers will have to be left until a sufficient number of supply depots placed at suitable points are established; or until they are confined in a certain part of the country. The only result which can be obtained from the kind of work we have been carrying on is a report on their favourite habitat and a rather inaccurate estimate of their numbers.

Investigation tends to show that they are scattered in small bands and individual animals up and down the whole country from the Peace river to Great Slave lake. Salt mountain, which runs parallel, or nearly so, to the Slave river, forms their eastern boundary in the central part of the country, that is, directly west of Fort Smith. In olden times the salt plains at the foot of this range of hills used to be a favourite stamping ground for them. In "Old King Bouillon's" time, when he and his band lived at the mouth of Salt river, the buffalo could be hunted by horses on the plains just as the great herds were on the western prairies. But no buffalo ever come as far east as that now. They seem to have learned by experience that they are safer in the dense woods.

There are two sections of the country which they prefer. One, the northern, is situated east and south of Big Buffalo lake. The other, the southern, 75 miles or so southwest of Smith's Landing. Between these two tracts there is a strip of country on the west side of Salt mountain which is higher and drier than the country farther west. Quite a few individual animals and small bands inhabit this part of the country, wandering north and south. Whether they are strays from the main herd or separate bands I was unable to determine.

Now to come to the question of numbers. I cannot claim to be as great an authority on this question as circumstances seem to indicate. The animals are too widely scattered and too roving in their movements from time to time to admit of any one giving an accurate estimate of their numbers. Indian information, unreliable at the best, seems to be uncertain and contradictory. Chief Squirrel, who has the reputation of knowing the country better than anyone else, is very vague in his ideas of their numbers. So at best my calculations must not be relied upon too implicitly. Owing to a multiplicity of circumstances too numerous to mention here, I never succeeded in getting in touch with the southern herd—that is, the main body. But as, owing to Mr. Radford's exertions and those of the Royal Northwest Mounted Police, more was known about them than the more northern ones, I was able to arrive at a fair estimate of their numbers.

The northern herd is divided into at least three separate bands. One of these occupies the country P. McCallum and I visited last fall. We managed to see only three of them, getting quite close to them, but from the signs left in wet sloughs, main trails and feeding grounds, there must have been from fifty to sixty of them in the immediate vicinity. Thirty-five or forty miles farther west is located the band which I visited in March last with the Indian guides. This band is about the same size. There is also a very much larger band farther north and west of this, in the vicinity of Buffalo lake. This information is so well authenticated and so generally known among the Indians that one cannot help but believe it true. To visit this last herd would almost necessitate starting in from a point on Buffalo lake and a basis of supplies at that point. Thus you see the number of animals in the northern section approximate from 180 to 200 head.

The herd inhabiting the central southern part of the country can be safely placed at from 200 to 250 head.

This leaves the individual animals and small bands in the central strip. I have encountered several of these, but only one at a time. Around Grassy lake, which is from 50 to 60 miles west of Fort Smith, many tracks were seen, and the Indians hunting in that country often encounter them. So we can safely place their numbers at the low estimate of one hundred head.

Recapitulating, then, my estimate would be from 500 to 550 head. There is much evidence to show that there may be very many more, but we have at least a minimum estimate to work upon.

Much has been said about their size relative to that of the plains buffalo. It may be a matter of surroundings or setting that makes them appear so large, but I think on an average they are very much bigger in every way than the plains buffalo. Some of the bulls we saw were very large, enormous in size and height. The size of the skulls of dead animals found in the bush also seemed to indicate a very much larger development. This may be due to their secluded condition and the abundance of rich feed to be found in their grazing grounds.

It is true that there are not the number of calves that one would expect; that is, judging by the tracks. The calves and their mothers stay with the larger bands as much as possible. They are never met with roaming around alone. When feeding about or moving slowly along the calves are always in the centre, so it is hard to see them or count them. Their tracks are thus pretty well covered up with the enormous imprints of the bulls' hoofs. With this large band seen by me last March were at least three "coming year-old" or young born last spring. That is all we could make out before the herd closed up in defensive formation, with the big bulls forming a ring outside and the cows and calves in the centre. At different times in other parts of the country we have noticed the tracks of young, both old and fresh; but not enough of them, as I have said, to account for the natural reproduction. However, there must be a fair reproduction as a great proportion of the band was composed of three and four-year-old animals. The two animals which McCallum and I saw feeding together last fall were from three to four years old, and were in splendid condition.

Although I have already spoken of the country in which they are generally to be found, a few further words about their natural habitat will not be "mal à propos." Their preference in the early summer is the rolling poplar and jack pine country. Through the jack pine, where the pine needles cover the ground, and grass is rather scarce, their trails are worn deep and well defined. Here they come in the hot summer days to get away from the flies, digging deep wallows where they can roll and throw fine sand over themselves. The trees all along the trails and near the wallows are used as rubbing posts and the lower branches broken off for 8 feet or more on the tree-trunks. In the open poplar coppices the grass and vetches or wild sweet-pea grow very abundantly. This makes splendid feed. Our horses prefer it very much to the rank slough grass and marsh hay.

Towards fall, when the sloughs in which this country abounds begin to dry up, they move out into the open. All winter long these small open places are their feeding-grounds. Of course, when the snow becomes deep, a herd of them can feed over each slough or meadowland only once, because the snow becomes trampled and packed as hard as pavement. Thus they have to keep moving from one open place to another all winter.

Contrary to my expectation, we did not find the timber wolves very numerous. As you see by my previous reports, we were singularly unsuccessful in trapping or poisoning any of these animals. They are not very numerous. Added to this, we found that they generally strike across country to the eastern side of the river about the time when the caribou are due in their yearly migration from the barren lands to the woods. This is the only time of year, that is, in winter, when the snow gets deep, that they are any menace to the buffalo. In fact, for a time I had come to the conclusion that the timber wolves had very little to do with lack of increase in the buffalo herds. But last March on my trip with the Indians I found that the wolf scare was not all "mere balderdash." In this case five or six timber wolves of enormous size were keeping pretty well in touch with this herd. We found, as stated, a two-year old bull (or at least a small part of him) which had been killed and eaten by this band of wolves. Of course the buffalo are not afraid of the wolves when in a band. They can easily protect themselves against such a few wolves as that. But the latter wait their opportunity, living between times on rabbits, I suppose, until one animal, relaxing his vigilance, strays too far from the main herd. Then they corner him. He puts up a gallant fight, but the odds are too great and he falls an easy victim. My regrets at finding this state of affairs and the futility of all our trapping and weary travelling for two years you may well imagine. The wolf question will have to be dealt with, I am afraid, in another manner, as two men, however well equipped, cannot cover the ground and do the work necessary for the complete destruction of the wolves at this season of the year. Our failure was due more to the lack of a competent guide than anything else.

In regard to the destruction of the buffalo by Indians one cannot but come to the conclusion, after living with them as I have done, that there is little or no fear in that direction. They are all too much afraid of the Northwest Mounted Police. The Chipewyans as a class are rather cowardly and superstitious. They have come to know that any transgression of the law is speedily followed by punishment. They are all inveterate gossips and know that any crime committed would reach the ears of the police very quickly. Moreover, moose are fairly plentiful, as well as other game, while in winter, caribou abound on the east side of the river. So I think there is no danger whatever of the Indians transgressing in this manner.

For years, in fact ever since the buffalo have been protected by law, it has been the custom of the Royal Northwest Mounted Police at Smith's Landing to make at least one yearly excursion in winter through the buffalo country. This was all right as far as it went. The information gathered on these trips was no doubt valuable, but as far as protecting them from their natural enemies, the wolves, went it was of little use. The appointing of two buffalo guardians in the year 1911 was a further step in the right direction, but is there not a very much simpler and cheaper way of ensuring a very sufficient protection? It costs considerable to keep two men on salary and to send in supplies for them. Moreover, two men can never adequately look after the protection of these animals, spread, as they are, over such an immense extent of country, that is, all the way from the Peace river to Great Slave lake.

The only feasible plan is to raise the bounty for wolves killed in this district. I understand that it has been raised this year. That is the only method by which the Indians can be persuaded to get right after them and eradicate them. As it is now, an Indian won't set a trap for a wolf unless the latter bothers his line of fur traps or steals from a fish cache or bothers him in some such manner. He won't waste a trap on a wolf because when he does catch him his hide is not very valuable and he may have some difficulty in getting the small bounty. With that same trap—and every trap is valuable—he could very much more easily catch a lynx, marten, beaver, or even fox, and be much more highly rewarded for his pains. Raise the bounty for this section and keep it there until all the wolves are exterminated. Make every Indian an involuntary buffalo protector and you will simplify this question to a few hundred dollars instead of incurring an expenditure, insufficient in its efficacy, of perhaps thousands of dollars.

Furthermore, I would suggest that Mr. A. J. Bell, or at least the Indian Agent at Fort Smith, be commissioned to send an investigation or inspection party through the buffalo country once or twice a year. Being on the ground he would necessarily know best whom to send and at what time of year a party of this kind would accomplish the most.

Regarding the feasibility of confinement of the different herds inside some suitable enclosure, I have little to say, beyond that I think it would be rather a larger undertaking than Mr. Bell anticipates. Of course, once confined in a stretch of country like the peninsula between the Peace and Slave rivers they could be easily and cheaply watched and protected. This "round up" would have to be done in the summer and early fall. The season is short and the work would have to be rushed. The different herds in the northern part are spread over a big territory, so quite a number of men would be needed to sweep the country. Nevertheless, this step must finally be taken if the buffalo and their increase are to be protected properly.

Respectfully submitted,

GEO. A. MULLOY.

Photo by D. Greig.

Forest Growth on Montagao River, Manitoba.

Photo by G. P. Melrose.
Muskeg Brulé (Sec. 4, Tp. 56, Rge. 20, west of 2nd Meridian).

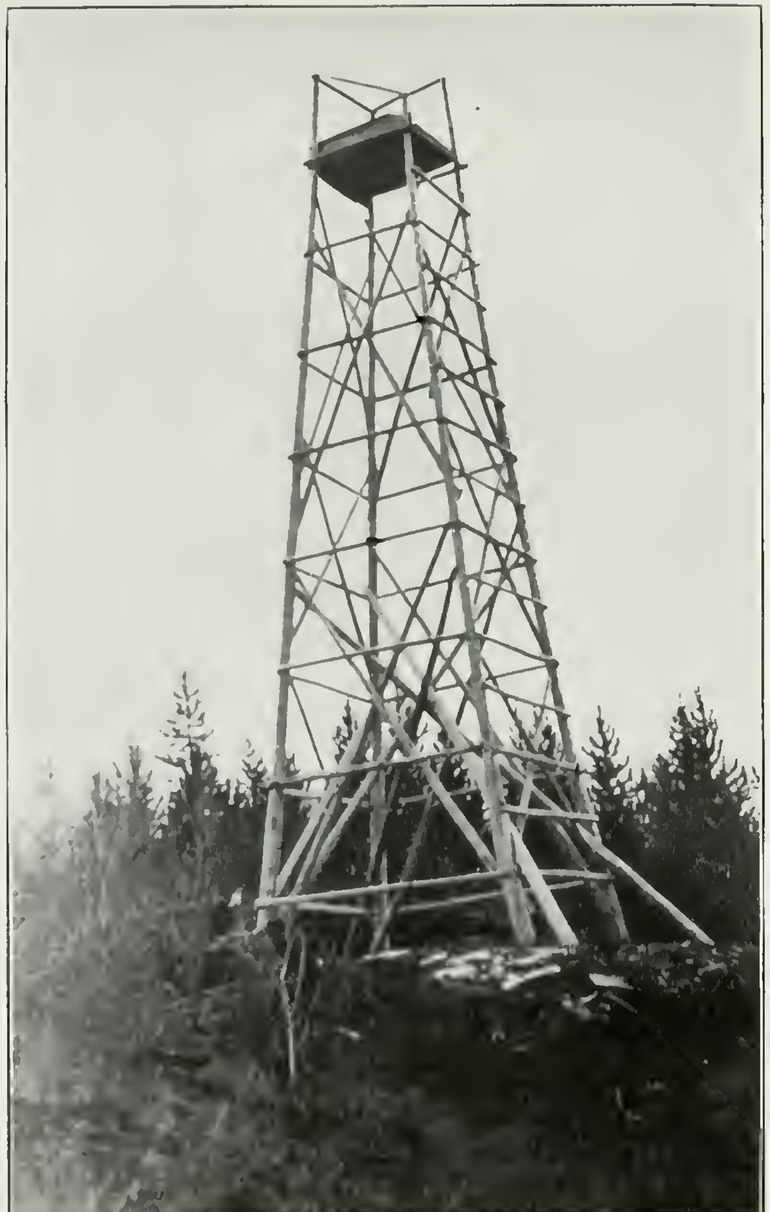
Photo by C. H. Morse.
Brulé in Maligne Valley, Brazeau Forest, Alberta.

Photo by H. I. Stevenson.

Roblin Steel Lookout Tower.

Photo by E. H. Roberts.

Lookout Tower on Pines Forest Reserve (NE. ¼ Sec. 6, Tp. 47, Rge. 1, W. 3rd mer.)



Leanchoil Lookout Tower, British Columbia.

Photo by C. W. Wellman.

Baldy Mountain Lookout Tower, Duck Mountain Forest Reserve, Manitoba.

Photo by G. A. Gutches.

Permittee Burning Slash, on Nisbet Forest Reserve.

Photo by G. A. Gutches.

Brush Piled. Permittee Starting to Burn it, Nisbet Forest Reserve, Saskatchewan.

Photo by G. A. Gutches.

Old Slashing on Nisbet Forest Reserve cleaned up by Forestry Branch in Spring.

Photo by W. N. Millar.

Cleared Right of Way, Canadian Northern Railway, Clearwater Forest, Alberta.

Photo by W. N. Millar.
Reserve Speeder on Canadian Northern Railway, Clearwater Forest, Alberta.

Ranger's Cabin and Boat Built at Lillooet Lake, British Columbia.

Photo by W. N. Millar.

Interior Wilson Ranger Station Cabin. Clearwater Forest. Alberta.

Photo by W. N. Millar.

Wilson Ranger Station Cabin.

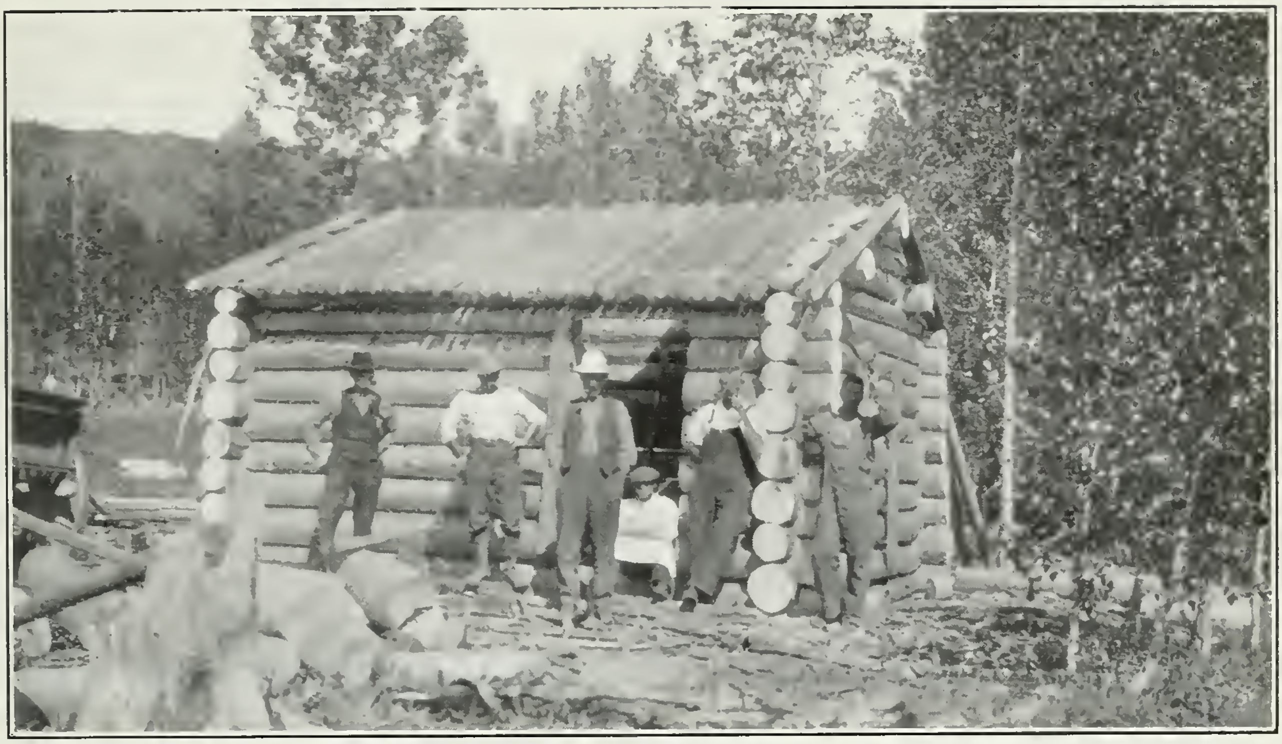


Photo by J. Y. Greenwood.

Boundary Cache, Red Deer River, Bow River Forest, Alberta.

Photo by R. M. Brown.

Bridge over Livingstone River, Crowsnest Forest, Alberta.

Photo by R. M. Brown.

Coleman Ranger Station, Bow River Forest, Alberta.

Photo by W. N. Millar.

Sheep-heads at Camp, Brazeau Forest, Alberta.

Photo by F. McVickar.

Horses and Cattle on Bow River Forest.

Photo by W. N. Millar.

Props and Lagging on the Brazeau Colleries Timber Sale, on the Brazeau Forest.

Photo by D. R. Cameron.

Langley Canyon, Oregon Jack Creek, Hat Creek Forest Reserve, British Columbia, showing Lowland Grazing.

Summit of Clear Mountains above Timber-line showing Highland Grazing. Hat Creek Forest Reserve.

Photo by N. M. Ross.

View from Intersection of Main Drive and Approach to Residence looking Northeast, at the Forest Nursery Station at Sutherland, Saskatchewan.

Photo by C. H. Morse.

Forks of the Chaba, Brazeau Forest, Alberta.

Photo by A. B. Connell.

Jack-pine Reproduction on a Burned Muskeg. Sand close beneath.
Tp. 47, Rge. 5, west of 2nd meridian.

Photo by A. B. Connell.

Poplar Slopes of the Fir Valley in Tp. 48, Rge. 5, west of the 2nd meridian, Saskatchewan. The muskeg type begins at the top of the slope on both sides of the river.

Photo by F. B. Robertson.
Western Cedar (*Thuja plicata*), Bear Creek, British Columbia.

Photo by F. B. Robertson.
Bull Pine and Grass-land type, Prospect Valley, British Columbia

PART VII

IRRIGATION

IRRIGATION

REPORT OF THE SUPERINTENDENT OF IRRIGATION.

OTTAWA, July 6, 1914.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa, Ont.

SIR,—I have the honour to submit the report of the Irrigation Branch for the year ended March 31, 1914, together with the report of the Commissioner and other officers in charge of the more important divisions of the work.

The rapid expansion of the work of this branch during the past two years, and the increasing importance of some of the work, have made it impossible to include in this report anything more than general reference to several phases of the work carried on. Full reports are, however, included respecting some of the more important works.

The reorganization of the staff at Ottawa, to which reference was made in my last report, has been satisfactorily carried out, and adequate office accommodation has at last been provided, thus facilitating the transaction of business and the proper care of the valuable records.

CANADIAN PACIFIC RAILWAY IRRIGATION PROJECT—WESTERN SECTION.

Dissatisfaction on the part of some of the settlers induced the Government to undertake the reclassification of irrigable land in the western section of the Canadian Pacific Railway Company's irrigation tract near Calgary, Alberta. The work was begun in June, 1913, and the field work was carried on as rapidly as possible until the approach of winter necessitated closing it down. During the winter the office work in connection with the reclassification was carried on, and arrangements were made for placing a larger staff of engineers in the field with a view to completing the field work by the end of the season of 1914.

Progress during 1913 was necessarily slow. The magnitude of the work and the degree of precision required in its performance necessitated the preparation and submission by the company of elaborate plans of the topography of a very large area. The accuracy of these plans was tested by resurvey of selected sections, and, where any material inaccuracies were found to exist, the company was required to submit new plans. In addition to this, each quarter section was examined by a departmental engineer who satisfied himself of the substantial accuracy of the plans before attempting to define the irrigable and non-irrigable areas.

As the capacity of the company's canal system and works had been questioned, an inspection of the entire system was made during 1912. Further investigations have since been made during the progress of the reclassification, and it is expected that, by the close of the present year, there will be sufficient information available to permit of an accurate definition of the irrigable and non-irrigable areas and the capacity of each canal and lateral throughout the western section.

In connection with this work, investigations have been made respecting the character of the soil and the climatic conditions within this tract. Samples of soil have been taken by the field engineers from portions of the tract which bore evidence of being strongly impregnated with alkali, and from other portions where either it was alleged that alkali existed in large quantities, or where, in the engineer's opinion, alkali might be expected to appear when water was applied for irrigation. Soil samples were taken from the surface and at varying depths down to 5 or 6 feet. These samples were forwarded to Ottawa and submitted to Dr. F. T. Shutt, Dominion Chemist, for analysis. This work is being continued during the present year, and will be supplemented by a personal investigation of the tract by Dr. Shutt during the summer. Any land found to be strongly impregnated with alkali, and not susceptible of reclamation by drainage at reasonable cost, will be classified as non-irrigable, regardless of its topographical suitability for irrigation.

Climatological data are being collected from numerous points within the western section, and from other points in the vicinity where irrigation has been successfully practised. The most important features of this investigation are:—

1. The amount and distribution of the annual precipitation.
2. The length of the growing season.
3. The incidence of killing frosts.
4. The character of crops best suited to the existing climatic and soil conditions.

It is anticipated that, within the next year, sufficient information will have been collected to permit of the expression of a reasonably definite opinion upon the climatic and soil conditions, as well as the topographical suitability of land in the western section for irrigated farming. The information so far collected does not warrant the assumption that any considerable portion of the tract is unsuitable for irrigation, notwithstanding statements that have been made to this effect.

CALGARY WEIR IN BOW RIVER.

With a view to raising the head of water at the intake of its main canal at Calgary, the Canadian Pacific Railway Company has under construction a concrete weir which it expects to complete during the present season. Work on this weir was begun in the autumn of 1913, and continued until the approach of high water in the spring of 1914. Work will be resumed when the high-water period has passed.

CANADIAN PACIFIC RAILWAY IRRIGATION PROJECT, EASTERN SECTION.

Water for the eastern section is taken from Bow river at what is known as the "Horseshoe Bend," near Bassano, where a huge concrete dam of the Ambursen type has been constructed.

During the process of construction, rumours were circulated by irresponsible persons to the effect that the foundation of the dam was unsafe, and that, when it was closed and the water level raised, it would probably give way. It is sufficient to say that the dam has been successfully closed, and that water is now being diverted from the river to the storage reservoir in lake Newell, and that no fault has yet appeared. The company has had the advice of the best obtainable consulting engineers at all stages of the work, and every known precaution has been taken to ensure the safety of the dam.

A very large tract of irrigable land—some 400,000 acres—is now being offered for sale in this section, and, in order to avoid all possible criticism of the correctness of the classification of irrigable and non-irrigable areas, the company's classification is being checked by departmental engineers before any land is offered for sale.

While the works in the western section were originally of a temporary character, the policy of the company has been to replace these with permanent works as opportunity offered. In the eastern section, however, practically all the works are of a permanent character, and will, in this respect, compare favourably with any heretofore constructed on this continent.

The company's expenditure on works in the western section up to December 31, 1913, has been $3,887,000, and in the eastern section $8,393,000, or a total expenditure to that date of $12,280,000.

SOUTH SASKATCHEWAN DIVERSION PROJECT.

Reference was made in my report for 1912 to preliminary survey work, undertaken by engineers of this branch, for the purpose of developing the most feasible method of diverting water from the South Saskatchewan river for the domestic supply of the cities of Moosejaw and Regina and the surrounding country.

Further surveys were carried on during the past year, and several routes were located and surveyed and preliminary estimates of cost prepared. It is believed that the work now completed is all that is required until the cities chiefly interested, or the Provincial Government, are prepared to seriously consider the development of a water supply from this stream. All the data collected by our engineers have been placed at the disposal of the provincial authorities.

OLDMAN RIVER DIVERSION PROJECT.

Some three years ago the attention of the department was drawn to the desirability of ascertaining whether water could be provided for the irrigation of a tract of land between the Belly and Little Bow rivers, north of Lethbridge. Surveys made during 1913 indicate that water can be diverted from Oldman river, a tributary of the Belly, and that a tract roughly estimated at 100,000 acres can be irrigated within reasonable cost limits.

Further surveys will be made during the present year to definitely locate the canal system, define the tract susceptible of irrigation, and estimate the cost of the works. Soil analyses will be made and climatological data collected, so that by the end of the year sufficient information will be available to permit of the preparation of a full report on the project.

As the lands comprised in this project are practically all in private ownership, the final decision as to whether or not the works will be constructed will rest with the land-owners, and will probably resolve itself into a question of opinion as to the increased productiveness of land under irrigation as compared with the cost of the works per acre of land irrigated, *plus* the annual maintenance cost.

STREAM MEASUREMENT.

The work of stream measurement, which was begun on a systematic basis in 1909, has been continued and extended steadily. Owing to the limited funds available, the work was at first confined to the districts in which accurate knowledge of stream flow was most urgently required in connection with irrigation development. With more liberal appropriations it has been found possible to greatly extend the scope of the work, and plans are now being perfected to obtain systematic records of stream flow throughout the provinces of Alberta and Saskatchewan.

The records so far obtained have been published annually under the title "*Report of Progress of Stream Measurements*," but it has been the practice heretofore to include in the annual departmental report the reports of all the district hydrographers. The increasing bulk of the departmental report has made a change desirable, and this year, for the first time, all such reports are omitted; they may, however, be found in the report on stream measurements, which is published separately.

INSPECTIONS.

Regular inspections have been made of all irrigation and water supply projects, both licensed and under construction. Inspections have also been made for the purpose of determining the feasibility of proposed projects, and to settle disputes between water users. Three regular inspection parties and three special inspectors have been continuously employed at this work.

SOUTHERN ALBERTA LAND COMPANY.

Brief reference was made in my last report to difficulties encountered by the Southern Alberta Land Company in completing its canal system, and to the complete reorganization of its engineering staff. Since the date of that report the company has encountered further and more serious difficulties. The crisis in the company's affairs occurred after the close of the fiscal year 1913-14, but, as some misleading reports have gained currency, it is considered advisable to give a brief *résumé* of the facts for the information of any who may be interested in this project.

In June, 1906, an agreement was made between the Robins Irrigation Company and the Government, by which the company purchased a tract of 380,573 acres of land at the rate of $3 per acre, payable $1 in cash and $2 in works capable of irrigating one-fourth of the area purchased.

With the consent of the Government, the Robins Irrigation Company transferred its interest in this concession to the Southern Alberta Land Company, an English syndicate with its head offices in London.

The original company did no actual development work, but made a few preliminary surveys for canal location. The present company found, as a result of further surveys, that a considerable proportion of the tract originally sold could not be irrigated within reasonable limits of cost. It therefore applied for permission to exchange a portion of the tract for an equal area more favourably situated for irrigation, and for permission to amend its plans so as to take water from Bow river at a point more suitable than the one originally selected. Both of these requests were granted by the Government of that day.

The work of canal location and construction was seriously undertaken in 1909 and has been continuously carried on ever since. The works consist of a diversion dam and intake on Bow river at a point about 35 miles southeast of Calgary, a main canal some 44 miles in length to a storage reservoir known as Lake McGregor, which has a capacity of 335,000 acre-feet of water; a canal 40 miles in length from the reservoir to the tract to be irrigated, and main and secondary canals, laterals and distributing ditches throughout the irrigated tract.

Engineering difficulties developed from time to time during the work of construction, and these culminated in the summer of 1912 when the main diversion dam in Bow river broke, destroying also the intake and the upper portion of the canal. This roused the company to a realization of the magnitude of its undertaking and to the necessity for procuring the best obtainable engineering advice before undertaking the work of reconstruction. One result was a complete reorganization of the company's engineering staff, and the retirement of the resident general manager.

The plans of the works were revised in several material respects, and work under the new plans was actively begun during the season of 1913 and has been steadily continued to the present time.

The Robins Company had originally estimated the cost of the complete system of irrigation works at $1,000,000. The present company has already expended over $5,000,000 in works alone, and estimates the cost of the further works required to complete the system at $2,500,000. In addition to this the company has expended some

$2,500,000 for the purchase of the concession from the Robins Company, payment to the Government of principal and interest on the 380,573 acres of land purchased, and the purchase of School and Hudson's Bay Company's land within and adjoining the main tract purchased from the Government. Interest charges on debentures, management expenses, etc., amount to a goodly sum in addition to the items enumerated.

These figures are given for the purpose of conveying some idea of the size of the undertaking, and to explain the financial difficulties which the company finally encountered. The original amount of stock issue was $3,500,000 and has been fully paid up. The first issue of debentures produced an additional $3,500,000, and a further issue of debentures realized $1,200,000. Thus the company has raised over $8,000,000 by sale of stock and debentures, and all of this has been expended.

Early in the present year, when the revised plans of the works were finally completed and approved, the company was confronted with the necessity of raising a further sum of about $2,500,000 for construction work, in addition to interest charges, management expenses, etc., during the period required to complete the works and earn title to the land purchased from the Government. In the state of the money market at that time it was found impossible to raise any such sum, and the company therefore applied to the Government for assistance.

The company asked the Government to lend $380,573, or, in effect, to return to the company the amount paid by it for the purchase of the tract to be irrigated, and to cancel the clause in the agreement for sale requiring, as a condition precedent to the patenting of the land, that one-fourth of the area sold should be irrigated, and to place the land at the company's disposal so that it might be able to raise thereon a sum sufficient to complete the works.

Before taking this request into serious consideration, the Government required the company to submit a complete statement of its financial standing, together with an estimate of the sum required to complete the works. Government engineers were also required to thoroughly examine the existing works and to carefully check the company's estimate of the cost of completing them. With this information in its possession the Government finally decided to assist the company by lending it a sum of $380,000, at 5 per cent interest, and taking adequate security on the land and other assets of the company, provided the company raised a further sum sufficient to complete the works; the whole of this fund to be expended under Government supervision.

Before this arrangement could be completed it was necessary for the company to secure the consent of its security holders to some form of reorganization, whereby interest charges would be waived for a term of years and the Government be given a first charge on the company's assets. This was likely to prove a somewhat tedious undertaking and the company finally decided, upon the advice of its solicitors, to appoint a receiver, not with a view to liquidation, but to facilitate the scheme of reorganization.

Unfortunately, within a few days of the appointment of the receiver the company's London bankers, Messrs. Chaplin, Milne, Grenfell & Company, suspended payment. This suspension wiped out the company's entire cash reserve, and left it without the means to continue construction work until the scheme of reorganization was completed and the Government loan made available.

Under these circumstances the company asked the Government to somewhat modify the terms of the promised loan so that it might be made immediately available for construction work. It was finally agreed that the Government should lend to the company a sum equal to $1 for each acre of land pledged to the Government as security, but not in excess of $380,573, the Government to be secured by a first charge against such land. This loan is to be made in instalments from time to time upon estimates submitted by the company's chief engineer and approved by the Government.

The Government also agreed to convey to the company absolute title to the 380,573 acres of land comprised in the original sale upon repayment of the loan above referred to and interest thereon, provided, however, that the company may take title to any portion of the tract by repayment to the Government at the rate of $1.25 per acre, such payments to be credited on account of the loan.

The company was pledged to raise a sum not less than $800,000 and to deposit this in a chartered bank in Canada, and this sum, together with the amount of the Government loan, is to be expended for construction and other necessary works under Government supervision.

The arrangement between the Government and the company has not yet been worked out in detail, but will be substantially as stated here. The expectation is that the company will thus be possessed of funds sufficient to complete the first unit of its irrigation system, and to place the lands comprised therein on the market, and that the funds realized from the sale of lands will thereafter be sufficient for the completion of the remaining works.

These difficulties, engineering and financial, have made the company's problem exceedingly difficult, and there has been considerable scepticism as to its ability to carry its project to successful completion. The project is, however, entirely feasible from an engineering point of view, and the works as now planned will, when finally completed, provide for the irrigation of some 200,000 acres of fertile land well adapted to irrigated farming. Excellent transportation facilities are provided by two lines of railway directly through the tract. The climate, aside from scanty rainfall, leaves little to be desired, and the soil is of excellent quality. If, therefore, the company satisfactorily adjusts its present financial difficulties in the manner contemplated, and carries out its present plan of construction, there is good reason to believe that it will eventually succeed in complying with the terms upon which the land was originally sold, thus transforming a district heretofore devoted entirely to cattle-ranching into a thickly settled and prosperous mixed-farming community. Strict economy will be required and good business management, and even with these it is probable that the investment of the original shareholders will not be profitable.

DRAINAGE.

Reference has been made in previous reports to numerous applications that have been made to the Government for the sale of land for reclamation by drainage. Some of these projects have been investigated by engineers of this branch and found to be feasible within reasonable limits of cost, and decidedly in the public interest, as they would reclaim and make productive large areas of now valueless marsh land which seriously retards the development of the surrounding country. Others of these projects are, while feasible from an engineering point of view, too costly to warrant their construction at present.

Somewhat informal negotiations are now being carried on between the Dominion Government and the Governments of the Prairie Provinces with a view to the enactment of such laws, or the amendment of existing laws, as will permit of dealing with the reclamation of submerged and marsh lands in a satisfactory manner. Some progress has been made, and there is reason to expect that a satisfactory agreement may be reached between the respective Governments during the present year. Up to the present it has been considered undesirable to authorize work on more than a few of the many drainage projects now under construction.

REVENUE.

Appended hereto is a statement of the revenue received and accounted for by this branch during the year ended March 31, 1914. The revenue received from the several land agencies consists entirely of payments on account of land purchased or leased under the irrigation system; that from the irrigation office at Calgary covers fees paid for the issue of water licenses, survey permits, etc., and for the recording of documents.

STATEMENT OF REVENUE FOR 1913.

Calgary	$ 873 33
Lethbridge	10,287 98
Medicine Hat	2,438 83
Moosejaw	228 10
Maple Creek	10,295 84
Swift Current	272 90
Irrigation Office	754 00
	$25,150 98

Your obedient servant,

E. F. DRAKE,
Superintendent of Irrigation.

CALGARY, May 5, 1914.

E. F. DRAKE, Esq.,
Superintendent of Irrigation,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit herewith my annual report of the work done under my charge during the year 1913, on irrigation administration and surveys.

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

F. H. PETERS,
Commissioner of Irrigation and Chief Engineer.

REPORT ON IRRIGATION AND IRRIGATION SURVEYS.

BY

F. H. Peters, Mem. Can. Soc. C. E.; Ass. Mem. Am. Soc. C. E., D.L.S., A.L.S.,
Commissioner of Irrigation.

This report contains full reports from all the engineers employed in charge of work on the staff of this office, on irrigation administration and surveys. All of the data gathered in connection with the hydrographic surveys branch are being submitted in a separate report on the "Progress of Stream Measurements," and those interested in this should refer to the separate report.

Those who are interested in any particular phase of the work of this office should consult the index, and then read the full report on those projects which have been prepared by the engineer actually in charge of the work in the field, where it will be found that the question is fully explained and discussed. Many readers, however, will be interested only in a general way in the work, and for these persons perusal of this brief report written by the commissioner will explain in general the work which has been carried on, and will bring out the main features in connection with the various surveys developed.

This report in commencement will make mention of some interesting details with reference to the office organization and work not touched upon in the reports submitted by the engineers. Following this, an attempt will be made to give a brief review of the work which has been done during the fiscal year 1913-14, bringing out the main features of the different units of work done, and in conclusion a short reference will be made to the work which it is proposed to carry out during the fiscal year 1914-15.

OFFICE WORK AND ORGANIZATION.

The office organization has reached such proportions that it is difficult to give any description of it in words; therefore a diagram has been prepared with the idea of giving graphically a clear idea of how the office staff is organized.

A schedule has also been inserted, which enumerates the details of the office work at Calgary. These details are set forth in a similar manner to the preceding years, so that by reference to the reports submitted for previous years a comparative idea can be gained of the amount of work done in the office.

Letters received	10,965
Letters sent	16,909
Applications for water rights recorded	59
Plans examined and filed	297
Agreements (right of way, etc.) recorded	57
Right of way plans recorded, in quadruplicate	191
Water agreements filed in quadruplicate	64
Water agreements cancelled	87
Water agreements transferred	92
Notices for publication prepared	55
Plans prepared	585
Blue prints made	19,457
Certificates issued under section 20, Irrigation Act	39
Certificates issued under section 33, Irrigation Act	52
Licenses recorded, in triplicate	95
Weekly reports received from engineers	1,552
Reports of discharge measurements (H4) received	2,524
Reports of gauge heights (H2) received	5,651
Descriptions of regular gauging stations (H1)	52
Reports of changes at river stations (H22)	89

DEVELOPMENT OF WATER RIGHTS SINCE 1895.

Water rights are granted in Alberta and Saskatchewan under the classifications of domestic, industrial, irrigation and others, and a map has been prepared for publication with this report showing all the water rights on record in this office, and an endeavour has also been made, by using different shaped red characters, to indicate the class of water right. In studying this map, reference should be made to the schedule of water rights which is being published with this report. The schedule is arranged showing all the water rights on record by township and range west of the several meridians, so that if the map is consulted and it is desired to ascertain the details about any water right as indicated on the map, it is possible to do this easily by referring to the schedule and locating the water right by its geographical index. It has been attempted, in preparing this schedule, to give briefly the essential details of every scheme.

Questions are frequently asked as to how the development of water rights in Alberta and Saskatchewan is progressing, and in order to bring out this matter and show the development in as true a manner as possible, the following schedule has been prepared. The two critical periods in the development of any scheme for the diversion of water are when the scheme is authorized for construction, and when it is finally licensed to divert water, and the following schedule shows for each year the number of schemes which have been authorized for construction and the number of schemes which have been finally licensed to divert water:—

Year.	Authorized.	Licensed.	Year.	Authorized.	Licensed.
1895	85	13	1905	62	34
1896	88	19	1906	60	46
1897	67	79	1907	98	40
1898	16	15	1908	52	26
1899	42	31	1909	58	53
1900	22	20	1910	83	49
1901	15	24	1911	62	39
1902	12	9	1912	47	61
1903	39	5	1913	39	52
1904	62	18			

PERMANENT IRON BENCH-MARKS.

A schedule has been inserted at the end of this report showing the location and elevation of the seventy-four permanent iron bench-marks which were set during 1913 in various parts of the provinces. The endeavour has been in every case to refer all of these bench-marks to mean sea-level datum, so that, as the network is extended to cover larger areas of territory, the data which have been gained in this way will prove of great value in the future in working out various undertakings for the development of the resources of the provinces. None of this work has been done merely with the idea of establishing permanent bench-marks over the country, but rather it has been necessary for the development of certain projects which this office has undertaken, to gain information regarding the general contour of large areas of territory, and in order to perpetuate the information so gained, the policy has been adopted of setting these permanent bench-marks usually at every township corner.

CYPRESS HILLS IRRIGATION DISTRICT.

Attention was drawn in the report submitted for 1912 to the development which is at present being actively carried on in the Cypress Hills irrigation district.

Reference is made, in the reports submitted by the two engineers who have operated in this district, to the great necessity for some comprehensive scheme for conserving the flood discharge of the streams in this district by the construction of reservoirs. This question is one of great importance to the settlers in this district. A special party was placed in the southerly drainage basin of the Cypress hills during the past season, and a full report has been submitted upon the surveys made of the Cypress Lake reservoir and another reservoir on Middle creek. In addition to this, several smaller reservoir sites have been surveyed during the past year, and the report submitted herewith by Mr. Russell, Chief Field Inspector, includes a schedule which gives an idea of the capacity and cost of these smaller reservoirs, all situated in the northerly drainage basin.

Most of the schemes in the Eastern Cypress Hills district are now ready for license, while in the Western Cypress Hills district very considerable activity is noticeable in carrying to completion the many small projects which are under construction, and it is pleasing to note the increasing interest in, and realization of the value of, irrigation in this district.

Crop reports have been submitted showing the conditions in the two Cypress Hills districts. These reports will no doubt be very interesting to the residents in these districts, but no general statement can be made in this matter excepting to say that progress, while slow, is steady.

CALGARY IRRIGATION DISTRICT.

Reports have also been submitted by the engineer in charge of the Calgary irrigation districts, indicating the work done by him in the field and the condition of the district as regards the growth of crops. This district, which lies mainly in the foot-hills fringing the eastern slope of the Rocky mountains, has been visited during recent years with heavy natural precipitation, so that under these conditions it is only natural to expect, what is indeed true, that the activity in developing or maintaining irrigation schemes is not great.

The crop report submitted for this district, while indicating that alfalfa and grass crops can be greatly benefited by irrigation, shows that most of the ditch owners do not put water to the beneficial use that they might if more interest and realization of the value of the water were displayed by them.

SPECIAL INSPECTIONS.

The work of special inspections has been carried on actively during 1913 in much the same manner as in previous years. The progress of this work was somewhat retarded during the early part of the season owing to the fact that some difficulty was experienced in providing suitable engineers to carry out the work. As the result of the whole year's work, however, it may be said that a large amount of work has been accomplished, and the few schemes requiring inspection that could not be taken up before the winter set in were visited and inspected at an early date in the spring. The schedule submitted with the reports of the special inspecting engineers indicates clearly the amount of work that has been accomplished.

INSPECTION OF WORKS OF IRRIGATION COMPANIES.

Prior to the year 1913, the appropriations for irrigation administration and surveys had not been sufficient to permit of as close inspection as was desirable of the work being carried on by the companies which are developing large tracts of irrigable land in the province of Alberta. This has now been changed, and since early in 1913 a thoroughly competent engineer has been assigned to this work, who has from time to time been given such assistance as he required, in order to keep thoroughly in touch with the work which is being carried on by these companies. The importance of this branch of the work may be better realized by a consideration of the cost of the works constructed, or under construction, by these companies, which is approximately $20,000,000.

This work is carried on by Mr. S. G. Porter, who has submitted a brief report of his work. Very thorough inspection was made of all works under construction, and a great deal of time was spent in studying the many problems that will affect the operation and maintenance of these irrigation systems.

The Irrigation Act anticipates that the actual work of construction will not be begun, in any case, until complete plans of all ditches and structures have been filed with the Commissioner of Irrigation, and approved by him. It has, however, been found in practice that, in connection with any of the larger irrigation schemes, so many plans are necessary that it has not been practicable to carry out this idea fully. Apparently this was realized a good many years ago and some of the larger companies were permitted to begin construction after having filed only what may be termed "general, preliminary location plans." It was doubtless the intention of those then charged with the administration of the Irrigation Act that these preliminary plans should be replaced, as rapidly as possible, by plans showing the actual location of the canals and ditches and by detail plans of the structures. Unfortunately this was not done, and the result is that all of the large irrigation companies are greatly in default in so far as the filing of plans is concerned.

Definite and effective steps are now being taken to require the submission of all necessary plans by these companies and, in addition to this, Mr. Porter, by keeping in close touch with all of the work under construction, will be able to advise the department promptly of any unauthorized or ill-advised action that may be taken or contemplated by any of these companies.

CHIEF FIELD INSPECTOR.

Owing to the fact that three large field parties were employed during the season, and widely separated in different parts of the provinces, it was found necessary to place an engineer in the field in special charge of the work being done by these parties, in order that it might be economically and properly conducted.

Mr. B. Russell, Chief Field Inspector, has submitted a report covering in general all of the work under his charge, and this report may be read with interest by any person who desires to gain a general idea of this particular portion of the work.

SOUTH SASKATCHEWAN WATER SUPPLY DIVERSION PROJECT.

Surveys of the development of this project, of such great importance to the residents of Regina and Moosejaw and the territory which surrounds them, and tributary to them, have been carried on by this office during the past three years, and have now been completed to a point where it will not be advisable or necessary to make any further surveys on the field, until such time as the scheme is actually under consideration with a view to construction, when, no doubt, some further details and final location surveys will be required.

This project has been very fully taken up in the reports submitted by the engineer in charge of the field party, and by the chief field inspector, so that it is not desired in this report to go any further into the matter than to again draw attention to the great importance of the project, and indicate the prominent features in connection with the surveys which have been carried on.

The application for the right to divert water in connection with this scheme, which was made by the Government of the province of Saskatchewan, asks for a quantity of water equal to 100,000,000 gallons per diem, or roughly, 200 second-feet; but the estimates for the cost of the project made by this office have all anticipated the diversion of only 60 second-feet, or 32,000,000 gallons per diem, which has been estimated as sufficient to fulfil the requirements of the reasonably near future.

The report submitted by the engineer in charge of this party includes, for the purpose of comparison, the estimates of schemes Nos. 1, 2, and 3, all based upon the same unit costs, so that if the total amounts of these estimates are not exact, the comparison between the financial consideration of each scheme will at least be approximately correct. Schemes Nos. 1 and 2 were developed on the basis that the water diverted from the South Saskatchewan river would always be free from serious bacterial contamination, and that it would therefore be desirable to conduct it from the river to the various points of use through entirely enclosed pipes, so that no contamination of the water could take place between the point of diversion and the points of use. These schemes, including very long pipe lines, are both necessarily very expensive. Scheme No. 3 has been developed with the idea of utilizing to the fullest degree the natural features of the territory, which lend themselves to conducting the water to its place of use at the least possible cost, and this scheme differs from Nos. 1 and 2 in that, by taking advantage of a natural water course and a natural reservoir, the water diverted from the river must necessarily be liable to more or less serious contamination, by the natural drainage of the surrounding country into the natural watercourse and reservoir which it is proposed to utilize.

Estimates Nos. 1 and 2 include the cost of a very expensive dam in the South Saskatchewan river, which would serve the double purpose of raising the water surface in the river, and of developing electric energy to pump the water out of the river to the intake of a gravity system, while scheme No. 3 does not anticipate the construction of this expensive dam, but estimates the cost of pumping the water by using a coal and steam pumping plant. It should be remembered therefore that with schemes Nos. 1 and 2, a coal and steam pumping plant might be substituted for the hydro-electric power dam estimated on, which would make a difference of about one and a half million dollars in the estimate for first cost.

It is considered that estimate No. 3, which has the lowest cost and very easy possibilities of future enlargement, is possibly the most economic and feasible scheme; but it should be remembered that the main idea of the work undertaken by this office has been to develop all the possibilities that exist of creating this general scheme, and that the time and facilities have not been available to make the close and detailed studies of the question, which will be necessary before a final decision as to the best scheme can be made. It should be noted that for scheme No. 3, which anticipates the diversion of about 32,000,000 gallons per diem at a cost of $8,850,000, figures out at a construction cost of 27 cents per imperial gallon, including of course only the main pipe lines.

While this department has been developing the physical possibilities, the Government of the province of Saskatchewan has been investigating the financial possibilities, of this undertaking, and, by an arrangement made with the provincial authorities, their report in this connection is being published with this volume, so that those who are interested in the matter can have both reports readily available.

For the information of those interested in this question, it is further desired to call attention to the reports on this project published by this branch for the years 1911 and 1912, and also to the report submitted by Mr. H. E. M. Kensit, to the Superintendent of Water-powers, Department of the Interior, during 1912.

This department has now completed all of the surveys which it is proposed to make in connection with this project, and it is believed that sufficient information has been gained and put on record to allow of a thorough and final determination of the relative value of the various schemes suggested.

In concluding these remarks on this project, it is hoped that the great necessity and importance of this undertaking will not be overlooked in the future, and that the undertaking will be kept under advisement until such time as it may be proper to consider the actual construction of works.

CYPRESS HILLS RESERVOIR SURVEYS.

That district lying south of the Cypress hills is one well suited to irrigation, and there is probably no other district in Alberta or Saskatchewan where such a great number of small private irrigation projects have been developed. These irrigation schemes have all suffered from the fact that the greater part of the run-off from this district takes place in the early spring, so that most of the irrigators are only able to get a good supply of running water in the spring, as later on there is not a sufficient supply available. Most of the streams of this district are tributaries of Milk river, and therefore subject to the "Waterways Treaty" between Canada and the United States. It is therefore possible that, in the final division of the waters of St. Mary and Milk rivers and their tributaries between the respective countries, the supply available for diversion in Canada may be somewhat restricted. This emphasizes the desirability of conserving, to the fullest extent possible, all the water supply of this region.

As the conservation of the water supply in this district can only be accomplished by some comprehensive undertaking, which is beyond the means of any one of the private interests which are affected, it was decided that this department should make such surveys as were necessary to gain a complete idea of the reservoiring possibilities in this district, together with the cost thereof.

A very fine reservoir site exists at Cypress lake, which may be utilized to conserve the waters of both Battle creek and Frenchman river. All the details in connection with this site were fully developed, and a complete estimate of the cost of the project prepared.

There is also great necessity for a reservoir on Lodge creek, and in order to develop the possibilities in this connection, levels were taken over a large block of land containing twelve townships, in order to develop the controlling elevation, which would allow a study of these conditions being made. This work resulted in the locating of only one good reservoir site, which lies due west of Cypress lake on Middle creek, one of the two main branches of Lodge creek. This reservoir site was fully developed and an estimate of the cost of construction made.

The Cypress Hills district may be divided into two sub-districts having their drainage respectively south and north from the Cypress hills. The work already referred to is confined entirely to the streams flowing south from the Cypress hills. It was further decided that while this party was in the vicinity the whole question of reservoir possibilities should be looked into, so instructions were issued to get the necessary data to cover the reservoir possibilities on the streams flowing north from the Cypress hills.

These latter streams are all small, and no opportunity exists for any large centralized reservoir. It was known that practically all of the available sites in this watershed had been surveyed some years ago by Mr. Ellicott, acting under instructions of the Government of the Northwest Territories. The plans of these surveys were examined, and also the note-books, which led us to believe that the information had been accurately gained and the plans accurately plotted, so that no necessity appeared to exist for making any re-surveys.

In order, however, to complete this work, and that the engineers of this department might have sufficient knowledge of the local conditions to prepare an estimate of the cost of the construction of these reservoirs, a reconnaissance of all the sites was made.

This whole subject has been fully taken up in the reports submitted, which are included herewith, by the chief field inspectors and the engineer in charge of the field party.

OLDMAN RIVER DIVERSION PROJECT.

In the year 1910, certain settlers in the vicinity of Iron Springs, which lies almost directly north of Lethbridge, and also north of the Belly river, petitioned the Department of the Interior for the construction of an irrigation scheme, by pumping out of the Belly river, to irrigate their farm lands in this very dry section of the country. The scheme as advocated by these settlers was found to be impracticable, but the petition had the result of calling attention to the necessity for irrigation in this district. This matter having been brought to the attention of the Commissioner of Irrigation, it was kept under consideration, and during 1911, when employed on making a report on storage possibilities on the Oldman river, the possibilities were noted of diverting water from that stream, and carrying it in a canal to serve the district above referred to, and this was reported to the department at that time. The project was not taken up actively, however, until the spring of 1913, when it was decided to develop all the possibilities in this connection.

A small reconnaissance party was first sent into the field to run rapid level lines, and determine, in a general way, whether the scheme, as it had been outlined, was feasible, and, as soon as this had been determined, a larger party was placed in the field for the purpose of locating the canal and defining the areas susceptible of irrigation from it.

The surveys carried on developed the fact that there are about 100,000 acres which can be irrigated under this project, and such approximate estimate of cost as is possible at this time indicates that water can be supplied to the land for a first cost of about $18 per acre, which again indicates that the project is entirely feasible. This whole subject has been fully taken up in the reports submitted herewith.

INTERNATIONAL WATERWAYS TREATY.

The International Waterways Treaty, which was entered into between Canada and the United States in the year 1909, and ratified in 1910, is of very great importance to the western part of the province of Alberta, insofar as it regulates the division of the waters of the Milk and St. Mary rivers between these countries. At the present time, neither country has fully developed the irrigation schemes which will be tributary to these sources of supply, so that at present no shortage of water exists; but in the future, when all the land susceptible of irrigation in both countries has been developed, the question of the division of these waters will be one of great importance.

With a view to securing and compiling in convenient form all available data respecting the available water supply in the several streams subject to the treaty, for the full protection of Canadian interests, an engineer was specially assigned to this work. In a brief report, included herewith, Mr. R. J. Burley, the engineer in charge, has outlined the work carried on by him during the year.

A map has also been prepared of the watershed of the streams covered by the treaty, comprising the areas in Canada and the United States.

DUTY OF WATER EXPERIMENTS.

The Minister of the Interior has prescribed a certain "duty of water," which must be observed throughout the provinces of Alberta and Saskatchewan on all irrigation projects. While the determination of this very important question was given careful consideration some years ago, yet the prescribed duty was based entirely on such information as could be gained, regarding the use of water in other districts to the south of the international boundary, and it has since been realized that, in order to determine the proper "duty of water," it is necessary to determine this quantity under the varying conditions which exist in our own country.

The district wherein irrigation is most extensively carried on lies under the Canadian Pacific Railway Company's Lethbridge system, and is commonly known as the "Coaldale district," lying just to the east of the city of Lethbridge. One field engineer was placed in this district with instructions to undertake experimental work. As one of the main elements in this work is to procure the co-operation of the farmers who practice irrigation, it was not possible to do a great deal of this work during the first season, but the interest taken by the farmers in the district where the operations were carried on was most encouraging, and it is intended to carry on the work on a considerably larger scale during the year 1914.

The report on "duty of water" investigations, which has been submitted by Mr. G. D. Walters, engineer in charge of the work, is included in this report. It contains a good deal of explanatory matter dealing very largely with the proper methods of irrigation, etc., most of which information can be found in other publications, but as this information has never been published before in Canada in a form readily available to those interested in the subject, it is thought that its publication in this report will serve a useful purpose.

PRINCIPLES GOVERNING THE DESIGN AND OPERATION OF IRRIGATION SYSTEMS.

While the requirements of the Irrigation Act are quite full and complete as governing construction and operation of an irrigation system, the provisions of the Act do not fully analyse the question, nor indicate why certain requirements are necessary, so that the question of the quantity of water, for the delivery of which provision must be made, has become somewhat obscured and does not seem to be generally well understood.

Particular attention is drawn to the annexed report under this heading. This does not in any way undertake to criticize the provisions of the Irrigation Act, but rather to expound in a clear manner the correct ideas which should be borne in mind in designing any system of irrigation works.

CANADIAN PACIFIC RAILWAY IRRIGATION PROJECT.

If reference is made to the report of the Superintendent of Irrigation for 1912, there will be found, under this heading, a short description indicating the conditions which have made it necessary for this department to carry out a reclassification of all the irrigable lands in the western section of this company's irrigation block. It was indicated, in the report above referred to, that arrangements were being made for a thorough inquiry that should finally settle the differences then existing (1912) between the company, the water users, and the department.

During the year 1913, provision was made for an additional staff to undertake this work, and the whole question of the reclassification of the irrigable lands was definitely taken up, and commencement made on a programme which anticipates the final completion of this work, in a thorough and careful manner, at the earliest possible date.

Owing to the fact that there were a great many details to be worked out, and also to the fact that we were not able to commence the work in the field until late in the summer, the progress made during 1913 was not as great as was desirable, but the work is being actively continued in 1914, and it is anticipated that all of the sold lands in the tract above mentioned will be finally reclassified before the completion of the field season of 1914.

This question, insofar as the irrigation office at Calgary is concerned, is one of carrying out a routine of work under the decisions which have been made by the Minister of the Interior, and, as the work is not of general interest to the public in Alberta and Saskatchewan, no further description will be given otherwise than to draw attention to it.

DRAINAGE.

During the year 1913, a very large number of applications have been received by the Department of the Interior for the draining and reclaiming of swamp lands situated in the northerly portions of Alberta and Saskatchewan, and, while no definite policy has as yet been decided upon by the department for dealing with these applications, the question is one with such great possibilities for development in the future, that attention should be directed towards it at this time.

The northerly portions of Alberta and Saskatchewan, as is well known to any of the residents in these districts, contain a very large number of shallow lakes or marshes, sometimes of considerable extent, which, while constituting only a drawback to the development of the country at the present time, have great possibilities, in many cases, of easy drainage, and reclamation thereby into lands which in a few years' time will have very high agricultural values.

In the districts where these drainage applications have been made, there is, as a rule, no shortage of water for domestic or other requirements, so that the value of these shallow lakes or marshes for the purpose of water supply is not great. On the other hand, these large marshy areas are a drawback to the settlement of the districts, as they generally make the construction of roads very difficult and expensive, and, it is thought in some cases, exert a considerable influence on the lands closely surrounding them by attracting frosts, and thereby shortening the average period for the maturing of crops in the district. The lands underlying these shallow marshes have no value at the present time, so that any successful drainage reclamation can be looked upon as a development that will create useful agricultural lands where none existed before.

It should be realized, however, in dealing with these drainage applications, that all of these marshy areas, to a greater or lesser degree, constitute natural reservoirs which conserve the water, which naturally flows away through the streams; and therefore, in dealing wholesale with this question, the possibility of spoiling too many of these natural reservoirs on the head-waters of any one stream must be guarded against, or else, hand-in-hand with the development of the drainage schemes, must go some policy of improving other natural reservoirs, so that the natural flow of the streams during the low periods may not be seriously interfered with.

THIS YEAR'S WORK (1914).

A very large proportion of the work done annually by the irrigation office at Calgary is routine work, which must be carried on from year to year with very little change, except to provide for certain expansion or contraction in order to comply with the varying necessities. The ordinary routine work of irrigation inspections will therefore be carried on during the year 1914, but, in addition to this, several important projects will be especially developed.

The surveys in connection with the Oldman River Diversion project, which were carried on during 1913, will be completed, so that a close estimate can be made of the area and character of the land which can be irrigated, together with the cost per acre of doing so. In addition to this, three field parties are to be employed in the districts south and east of Lethbridge, in order to determine the area of land in Canada which is irrigable from the Milk and St. Mary rivers. These surveys will be quite comprehensive, and will cover an area of about 5,000 square miles.

The work of "duty of water" investigations, which really includes a considerable amount of instruction in the best methods of irrigation, will be carried on in a much more extensive manner than was the case during 1913, and it is hoped that, through the kind co-operation of the large irrigation companies which has been promised, and with the co-operation and assistance of many farmers who are practical irrigators, this work will be very satisfactory in its results.

The reclassification work in the western section of the Canadian Pacific Railway Company's irrigation block, is to be carried on during 1914, with a large staff both in the field and in the office, and, in addition to this, a party will be operated in the eastern section of the same company's irrigation block, with the idea of approving the classification of the irrigable land therein, prior to the time that the water license is finally granted by the department or the land sold by the company.

In concluding this report, the commissioner wishes to express his thanks and appreciation to every member of his staff for their hearty and conscientious co-operation, which alone has made it possible to carry on the successful season's work during the year 1913.

Respectfully submitted,

F. H. PETERS,

Commissioner of Irrigation and Chief Engineer.

SCHEDULE of Bench-marks Established, 1913.

Location.	Elevation.	Remarks.
NE. corner Tp. 13, R. 26, W. of 4th Mer.....	3182·60	Permanent iron D.G.B.M.
" NE. " Tp. 12, R. 26, W. of 4th "	3220·66	" " "
" NE. " Tp. 11, R. 26, W. of 4th "	3229·67	" " "
" SE. " Tp. 11, R. 26. W. of 4th "	3214·80	" " "
" NE. " Tp. 12, R. 25, W. of 4th "	3179·84	" " "
" NE. " Tp. 11, R. 25, W. of 4th "	3169·19	" " "
" SE. " Tp. 11, R. 25, W, of 4th "	3142·95	" " "
" NE. " Tp. 12, R. 24, W. of 4th "	3121·78	" " "
" NE " Tp. 11, R. 24, W. of 4th " . ..	3134·22	" " "
" SE. " Tp. 11, R. 24, W. of 4th "	3129·36	" " "
" NE. " Tp. 12, R. 23, W. of 4th "	3261·45	" " "
" NE. " Tp. 11, R. 23, W. of 4th "	3131·01	" " "
" SE. " Tp. 11, R. 23, W. of 4th "	3203·92	" " "
" NE. " Tp. 9, R. 23, W. of 4th "	3055·16	" " "
" SE. " Tp. 11, R. 22, W. of 4th "	3012·61	" " "
" NE. " Tp. 11, R. 21, W. of 4th "	2869·60	" " "
" SE. " Tp. 11, R. 21, W. of 4th "	2907·01	" " "
" NE. " Tp. 11, R. 20, W. of 4th "	2784 15	" " "
" SE. " Tp. 11, R. 20, W. of 4th "	2779·88	" " "
On Old Man river, 1500 feet below the mouth of Beaver creek..........................	3284·56	" " "
" Willow creek, 2418.0 feet N. 61°, 57 feet W. from NE. corner of sec. 24, Tp. 10, R. 27, W. of 4th Mer................	3249·36	" " "
" Old Man river, 1 mile below Indian Mission...	3300·55	" " "
" NE. corner Tp 5, R. 3, W. of 4th Mer.....	3524·68	" " "
" NE. " Tp. 5, R. 2, W. of 4th "	3581·07	" " "
" NE. " Tp. 5, R. 1, W. of 4th "	3581·01	" " "
" NE. " Tp. 5, R. 30, W. of 3rd "	3472·36	" " "
" NE. " Tp. 5, R. 29, W. of 3rd "	3415·12	" " "
At NE. " Tp. 4, R. 29, W. of 3rd "	3249·49	" " "
" NE. " Tp. 4, R. 30, W. of 3rd "	3270·11	" " "
" NE. " Tp. 4, R. 1, W. of 4th "	3311·65	" " "
" NE. " Tp. 4, R. 2, W. of 4th "	3339·98	" " "
" NE. " Tp. 4, R. 3, W. of 4th "	3538·09	" " "
" NE. " Tp. 3, R. 3, W. of 4th "	3164·23	" " "
" NE. " Tp. 3, R. 2, W. of 4th "	3203·97	" " "
" NE. " Tp. 3, R. 1, W. of 4th "	3038·55	" " "
" NE. " Tp. 3, R. 30, W. of 3rd "	3235·78	" " "
" NE. " Tp. 3, R. 29, W. of 3rd "	3136·03	" " "
" NE. " Tp. 2, R. 29, W. of 3rd "	2967·88	" " "
" NE. " Tp. 2, R. 30, W. of 3rd "	2926·05	" " "
" NE. " Tp. 2, R. 1, W. of 3rd "	2977·91	" " "
" NE. " Tp. 2, R. 2, W. of 3rd "	3006·03	" " "
" NE. " Tp. 2, R. 3, W. of 3rd " . ..	2955·59	" " "
In SW. ¼ Sec. 30, Tp. 5, R. 29, W. of 3rd Mer..	3297·37	Hydrographic P.I. D.G.B.M.
" NW. ¼ " 36, Tp. 3, R. 1, W. of 4th " ..	3008·38	" " "
" SE. ¼ " 12, Tp. 1, R. 29, W. of 3rd " ..	2718·83	" Wooden B.M.
" SE. ¼ " 12, Tp. 1, R. 29, W. of 3rd " ..	2752·33	" Concrete B.M.
" NE. ¼ " 33, Tp. 5, R. 29, W of 3rd " ..	3313·27	" P.I D.G.B.M.
" NE. ¼ " 34, Tp. 5, R. 29, W. of 3rd " ..	3209·16	" " "
" SW. ¼ " 2, Tp. 6, R. 28, W. of 3rd " ..	3187·94	" B.M. on spike in wooden post.
" NW. ¼ " 20, Tp. 6, R. 27, W. of 3rd " ..	3203·75	" P.I. D.G.B.M.
" NE. ¼ " 16, Tp. 6, R. 27, W. of 3rd " ..	3165·09	" B.M.
" SE. ¼ " 12, Tp. 6, R. 27, W. of 3rd " ..	3199·63	" P I. D.G.B.M.
" NE. ¼ " 20, Tp. 6, R. 26, W. of 3rd " ..	3184·37	" " "
" NW. ¼ " 24, Tp. 6, R 26, W. of 3rd " ..	3196·25	" " "
" SW. ¼ " 30, Tp. 6, R. 25, W. of 3rd " ..	3168·57	" " "
" NE. ¼ " 29, Tp. 6, R. 25, W. of 3rd " ..	3183·06	" " "
At NE. cor. Sec. 24, Tp. 20, R. 3, W. of 2nd Mer.	1959·19	Permanent iron D.G.B.M.
" NE. " 36, Tp. 19, R. 2, W. of 3rd " .	1959·34	" " "
" NE. " 21, Tp. 18, R. 2, W. of 3rd " .	1966·30	" " "
" NE. " 1, Tp. 19, R. 1, W. of 3rd " .	1954·49	" " "

SCHEDULE of Bench-marks Established, 1913—*Continued.*

Location.	Elevation.	Remarks.
At NE. cor. Sec. 20, Tp. 18, R. 27, W. of 2nd Mer	1941·15	Permanent iron D.G.B.M.
" NE. " 24, Tp. 18, R. 27, W. of 2nd " .	1940·52	" " "
" NE. " 31, Tp. 17, R. 24, W. of 2nd " .	1895·65	" " "
" NE. " 35, Tp. 17, R. 23, W. of 2nd " .	1888·23	" " "
" NE. " 31, Tp. 17, R. 20, W. of 2nd " .	1876·49	" " "
" NE. " 34, Tp. 18, R. 25, W. of 2nd " .	1679·22	" " "
" NE. " 36, Tp. 17, R. 27, W. of 2nd " .	1921·95	" " "
" NE. " 24, Tp. 21, R. 29, W. of 2nd " .	1728·69	" " "
" NE. " 16, Tp. 23, R. 2, W. of 3rd " .	1806·70	" " "
" NE. " 13, Tp. 24, R. 6, W. of 3rd " .	1733·99	" " "
" E ¼ Md. Sec. 4, Tp. 19, R. 3, W. of 3rd " .	1973·60	" " "
" E ¼ " 20, Tp. 18, R. 28, W. of 2nd " .	1954·29	" " "
" E ¼ " 7, Tp. 18, R. 25, W. of 2nd " .	1924·29	" " "
" E ¼ " 25, Tp. 23, R. 4, W. of 3rd " .	1740·99	" " "

DOMESTIC SUPPLIES.—West of the Second Meridian.

T=Township; **R**=Range; **H. & F**=High and Flood Stages; **L**=Licensed; **A**=Authorized for Construction; **AS**=Application Submitted.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Quantity.	Stage.	Method.	Standing and Remarks.
T. 12, R. 15.						
Wellington Rural Mun. No. 97	Spring	NE. 11	Total available flow	All		**L.** Domestic use for municipality.
T. 12, R. 17.						
Govt. Prov. of Saskatchewan	Creek	Rd. Allce. E. of NE. 12.	Sufficient to fill reservoir	**H. & F.**	Impounding	**L.** 9·5 ft. dam and spillway.
T. 15, R. 24.						
Govt. Prov. of Saskatchewan	Moosejaw creek	SW. 19, Rd. Allce, SW. 19, SE 24, T. 15, R. 25	Sufficient to fill reservoir	**H. & F.**	Impounding	**L.** Earth dam.
T. 16, R. 18.						
Clancy, Wm	Wascana creek	SW. 16	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam.
T. 16. R. 22.						
Spring—Rice, G. & B.	Cottonwood creek	NE. 17	Sufficient to fill reservoir	**H. & F.**	4 reservoirs	**L.** Earth dam 5 ft. high. " " 5 ft. " " " 6 ft. " " " 4 ft. "
Spring—Rice, G. & B	Cottonwood creek	NE. 16	Sufficient to fill reservoir	**H. & F.**	4 reservoirs	**L.** Earth dam 4 ft. " " 12 ft. " " 6 ft. " " 6 ft.
T. 17, R. 7						
Govt. Prov. of Saskatchewan	Coulee	NE. 8	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam.
T. 17, R. 20.						
Govt. Prov. of Saskatchewan	Wascana creek	Rd. Allce. E. of NE. 13	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Reinforced concrete dam.

T. 17. R. 28.						
Govt. Prov. of Saskatchewan......	Branch of Thunder creek.	NW. 23..... ..	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam 14 ft. high.
T. 18, R. 13.						
Francis, J. H.....................	Watercourse..... ..	NE. 35	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Rock and timber dam.
T. 18, R. 19.						
Seibel, H	Coulee.............	E. ½ 23.........	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Timber, earth and stone dam.
T. 18, R. 23.						
Killough, J. A......	Coulee	N.W. 4........	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** 8 ft. earth dam.
T. 22, R. 2.						
Govt. Prov. of Saskatchewan.......	Coulee.............	NW. 28	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam 12.5 ft. high.
T. 25, R. 6.						
Garry & Co........................	Insinger creek	NW. 32.	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam.
T. 29, R. 15.						
Govt. Prov. of Saskatchewan.... .	Coulee......... ..	NW. 12	Sufficient to fill reservoir	**H. & F.**	Reservoir	**L.** Earth dam.
T. 32, R. 11.						
Foam Lake Rural Mun.....	Spring.........	SW. 1..........	Total available flow.	All	.. ..	**A.** Domestic use for municipality.

West of the Third Meridian.

T. 10, R. 25.						
Peecock & Peecock	Springs	NE. 31..	362 acre-feet, 269,136 imp. gals. per 24 hours......	All	Gravity..	**L.** 6 in. pipeline.
T. 11, R. 11.						
Simpson, Williamson & Ryan .. .	Russell creek.......	SW. 3..........	Sufficient to fill reservoir	All	Reservoir	**AS.** Not constructed.
T. 19, R. 5.						
Rural Mun. of Enfield No. 194......	Spring	SW. 33.........	Available flow	All	....	**A.S.**

DOMESTIC SUPPLIES.—West of the Fourth Meridian.

T=Township; **R**=Range; **H. & F**=High and Flood Stages; **L**=Licensed; **A**=Authorized for Construction; **AS**=Application submitted.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Quantity.	Stage.	Method.	Standing and Remarks.
T. 5, R. 1.						
Link, H. C.	Spring	NW. 32	1 acre-foot 1,076 imp. gals. per 24 hrs.	All	Gravity	**L.** ½-inch pipeline and concrete well.
T. 5, R. 11.						
Burlington Rural Mun. No. 34	"	SE. 21, SW. 21	Total available flow	All		**A.S.**
T. 9, R. 28.						
Adair, P. F.	"	Rd. Allce. bet SE. 8 & SW. 9	Available flow 362 acre-feet	All	Gravity	**L.S.** 1-inch pipe.
Gardiner, C. W. E.	"	NE. 16	270,000 imp. gals. per 24 hrs.	All	"	**L.** 1½-inch pipe.
T. 19, R. 29.						
Alberta, Govt. of Prov.	Highwood river	NE. 1	36,200 acre-ft. 27,000,000 imp. gals. per 24 hrs.	All	"	**L.** Water diverted to feed Little Bow.
T. 22, R. 8.						
Vee Bar Vee Brand Ranching Company	Blood Indian creek	NE. 33	Sufficient to fill reservoir.	**H. & F.**	Impounding	**L.** For fire protection.
T. 26, R. 12.						
Purves, G.	Berry creek	SE. 17	To fill reservoir	**H. & F.**	"	**A.** 4 feet concrete dam.

West of the Fifth Meridian.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Quantity.	Stage.	Method.	Standing and Remarks.
T. 7, R. 1.						
Fortier, P.	Spring	SE. 17	5·792 acre-feet, 4,320 imp. gals. per 24 hrs.	All	Gravity	**L.** Pipeline.

T. 7, R. 3.						
Sinclair & Fairfield	Spring creek	SW. 21	18·1 acre-feet, 13,456 imp. gals, per 24 hrs.	All	"	**A.** Reservoir and pipeline.
T. 7, R. 4.						
Canadian Coal Consolidated	Sulphur spring	SE. 36	97 acre-feet, 72,128 imp. gals. per 24 hrs.	All	Pumping	**L.** Electrically driven centrifugal pump 50 gals. per min. Reservoir 5,000 gals.
T. 8, R. 6.						
Miller & McCool	Summit creek	SW. 12	422 acre-feet, 313,802 imp. gals. per 24 hrs.	All	Gravity	**A.** Pipeline, water turbine and dam.
T. 23, R. 1.						
Shaw, Helen	Fish creek	NE. 4	12·308 acre-feet, 9,180 imp. gals. per 24 hrs.	All	"	**L.**

IRRIGATION.—West of the Second Meridian.

T=Township; **R**=Range; **H. & F**=High and Flood stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted.

Note—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acres.	
T. 3, R. 30.								
Knox, J. M.	Spring creek	NW. 29	99	All	4 ac.-ft.	·59	49	**A.** 10 ft. earth dam.
T. 10, R. 2.								
Weatherald, C. E.	Creek	SE. 21	....	....	....	....	....	**AS.**
T. 18, R. 18.								
Anticknap, H	Coulee	SE. 18	10	All	Unknown	Nil	5	**L.** Earth dam 10 ft. high.

West of the Third Meridian.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
T. 2, R. 24.								
Brown, J. A. G	Coulee	SW. 34	500	All	....	....	247	**AS.**
T. 2, R. 26.								
Badger, H. J.	Battle Creek	NW. 16	225	**H. & F.**	Nil	2·03	111	**L.** Earth dam, 8 ft. high.
T. 2, R. 30.								
Hammond, D. A.	Lodge Creek	SW. 35.	516	"	"	2·95	255	**A.** Brush dam, 8·5 ft. high.
Lynch, M	"	SE. 25	514	"	"	3·26	254	**L.** Boulder dam, 4 ft.
Spangler, M. M. M. & D.	"	SW. 35	2,483	"	80 ac.	9·65	1,227·2	**A.** Small boulder dam.

T. 3, R. 27.								
Stirling & Nash	Battle Creek	SE. 28	2,539	"	442 ac.-ft.	17·19	1,255	**A.**
T. 3, R. 29.								
Peachey, E. J	Middle Creek	NE. 4	463	"	Nil	2·76	229	**A.** 7 ft. 6 in. rock and brush dam, 4 ft. rock and brush dam.
T. 4, R, 24.								
Bull, H. M. & V. J.	Spring	NW. 19	107	All	13 ac	·74	53	**A.** 6 ft. earth dam.
T. 4, R. 26.								
McKinnon, J	Battle Creek	Rd. Allce. bet. SE. 36-4-27 and SW. 31	2,304	**H. & F.**	Nil	4·20	1,139	**A.** Dam and headgate.
Wood, D	"	Rd. Allce. bet. SE. 36-4-27 and SW. 31	1,228	"	62 ac	5·50	640	**A.** Ditches only.
T. 4, R. 29.								
Gregg, W. B	Middle Creek	NE. 4	511	"	Nil	2·53	252	**L.** 2 ft. boulder dams.
Jahn, B. A	"	SE. 8	182	"	"	0·35	90	**L.** Rock crib dam.
Jahn, B. A	"	NE. 4	162	**F.** only	"	3·75	80	**A.** Through other works.
T. 5, R. 1.								
Weeres, B	Creek	NE. 36	32	All		·27	16	**AS.** 11 ft. dam and headgates.
T. 5, R. 21.								
McIver, A	Coulee	NW. 36	409	**F.** only	Nil	Dykes	202	**L.** 2 ft. earth dam.
T. 5, R. 24.								
Nelson, N. C	Coulee	NE. 20	740	All	1,176 ac.-ft.	3·11	366	**L.** Dam and reservoir.
T. 5, R. 26.								
Richardson, L. E.	Coulee	SW. 4	850	All.				
	Battle Creek	(Through other works).		**H. & F.**	Nil	3·07	420	**A.** 4 ft. earth dam.
T. 5, R. 27.								
Gilchrist, R. P. & W. F.	Battle Creek	SW. 11	354	"	"	2·05	175	**A.** 5 ft. 10 in. crib dam.
Richardson, Mrs. L. E	"	SW. 11	2,448	"	"	7·38	1,210	**A.** Headgates.
T. 5, R. 28.								
Henry, F. W.	Battle creek	SW. 29	524	**H. & F.**	Nil	2·65	259	**A.** Boulder dam 3 ft.
Wilson, W. S	"	NE. 28.	917	"	"	4·97	453	**L.** Earth dam, 12 ft. high.

IRRIGATION.—West of the Third Meridian.

T=Township; **R**=Range; **H & F**=High and Flood stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted.

Note—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-foot.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acre.	
T. 5, R. 29.								
Gaff, J. A.	Battle creek	NW. 34	1,487	All	Nil	6·59	735	**L.** Dam and headgate.
Marshall, Mrs. L. A.	"	NW. 34	309	"	"	1·50	153	**L.** Headgate only.
T. 5, R. 30.								
Wright, W. X	Middle creek	SE. 23. NE. 23. NW. 24. SW. 25.	1,140	**H. & F.**	"	Dykes only.	563	**L.** Earth dam 11·6 ft. high.
Wright & Alexander	Middle creek	SE. 22. SW. 22. NE. 23.	739	"	"	Dykes	365	**L.** Dyking system.
Wright, W. X.	Coulee	SE. 26.	75	"	"	·66	37	**L.** Dyke.
T. 6, R. 16.								
Bate, A. E.	Spring creeks	SW. NW. 7.	36	All	·073 ac.-ft.	·52	18	**L.** 5 ft. rock crib dam.
T. 6, R. 21.								
Duncan, A. S	Frenchman river	SE. 27.	647	**H. & F.**	Nil	1·29	320	**L.** Ditches only.
Enright & Strong.	Gallien and Outlet Coulees	S½. 20. S½. 22.	423	All	2 reservoirs	2·35	209	**A.** 2 timber dams.
Morrison, D. & A. A.	Frenchman river	S½. 27.	2,235	"	Nil	5·30	1,105	**L.** Rock crib dam.
Morrison, G. N.	"	SE. 27	991	**H. & F.**	"	5·98	490	**L.** Ditch only.
Watson, G. F. & E. A	"	SE. 27.	1,103	"	"	2·27	545	**L.** Ditches only.

T. 6, R. 22.								
Enright & Strong..........	Frenchman river	NW. 25........	5,123	"	"	23·48	2,532	**L.** Timber dam.
		NW. 25........	516	"	"	2·65	255	**AS.**
Lock, C. W	Spring creek ...	SE. 34........	101	"	"	·63	50	**A.** 16 ft. earth dam.
T. 6, R. 23.								
Barroby, F..............	N. F. Frenchman river........	NE. 33........	405	All........	"	1·75	200	**L.** Earth dam.
Freel, W. B..............	Frenchman river	NW. 24........	164	**H. & F.**....	"	·85	81	**L.** Rock crib dam 2 ft. high.
Garissere, J.............	Blacktail coulee.	NW. 30........	202	All.	"	2·82	100	**L.** Headgate only.
T. 6, R. 25.								
Bettington, J. H. G........	Belanger creek..	SW. 30........	243	"	"	·75	120	**L.** Headgate only.
Bewlay, R. L	Frenchman river and a creek...	SE. 15. SW. 13........	698	**H. & F.**....	"	3·24	345	**A.** Timber dam.
Drury, T. A...............	Belanger creek..	SW. 30........	142	"	"	1·48	70	**L.** Log and boulder dam, 2·5 ft. high.
T. 6, R. 27.								
Maple Creek Cattle Co....	(Oxarart creek) Spring.	NE. 20	819	All.	"	1·00	405	**L.** Headgate only.
Wilkes, R. W. & W. L......	Battle creek.....	NE. 8	455	**H. & F.**....	"	3·24	225	**A.** Timber crib dam, 9 ft.
T. 6, R. 29.								
Linder Bros	Battle creek	NE. 9..........	405	All.	"	1·52	200	**L.** Headgate.
Patterson, W. G..........	"	SE. 4..........	525	**H. & F.**....	"	2·85	259	**A.** 4 ft. log crib dam.
T. 7, R. 21.								
Axton, J. W. E.	S. F. Swift Currant creek.....	NE. 23. NE. 26.........	420	All..........	"	2·11	208	**L.** Boulder dam and headgate.
Clark & Thompson..........	Spring creek....	NW. 5.........	162	"	"	1·85	80	**L.** 5 ft. earth and boulder dams
Jones, H. S..............	Chimney coulee. Spring creeks...	NW. 16. SW. 21. SW. 16.........	192	"	"	1·59	95	**L.** Earth dam 4 ft.
Pollock, D. H............	S. F. Swift Current creek.....	NW. 22. SW. 27.........	761	"	Unknown	2·07	376	**L.** Small reservoir dam and headgate.

IRRIGATION.—West of the Third Meridian.

T-Township; **R**=Range; **H. & F**=High and Flood Stages; **L**=Licensed **A**=Authorized; **AS**=Application Submitted.

Note:—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-Feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
T. 7, R. 22.							Acres.	
Barrett, W. H	Doyle's creek	NW. 17	106	"	Nil	·77	52	**L.** 3 ft. earth dam.
Bolingbroke, J. E.	Spring creek	SW. 18	67	"	"	·66	33	**L.** 4 ft. earth dam.
Cross, F.	N.B. Frenchman	NW. 15	274	**H. & F.**	"	1·30	135	**L.** Rock crib dam 6 ft.
McNicol, W. F.	"	SW. 27	121	"	"	1·80	59	**A.** Rock crib dam 3 ft.
T. 7, R. 23.								
Pearse, S.	Concrete coulee.	NW. 2. SW. 2.	231	All	"	1·15	114	**L.** Headgate only.
T. 7, R. 25.								
Nicholson, J.	Coulee	SW. 26	384	**H. & F.**	"	2·27	190	**A.** 5 ft. earth dam.
T. 7, R. 26.								
Hewitt, S.W.	Lone Pine creek	NE. 28	253	**H. & F.**	Nil	1·15	125	**L.** Headgate only.
Hewitt, S.W.	Lone Pine creek	SE. 27	182	**H. & F.**	"	1·12	90	**L.** Crib dam, 8 ft. high.
McDonald, A.P.	Lone Pine creek	NE. 28	152	All	"	·74	75	**L.** Earth dam, 4 ft. high.
T. 7, R. 27.								
Fordice, E.S	War Lodge creek	NW. 14	465	"	10·3 ac.	1·81	230	**A.** 3 ft. earth dam.
T. 7, R. 28.								
Spangler, J. M.	Coulees	NE. 3 SW. 12	303	**H. & F.**	580 ac. ft.	·37	150	10 ft. Earth dam. **L.** 5 ft. earth dam.
Spangler, J. M	Six Mile coulee.	NE. 6	587	All	Nil	2·54	290	**L.** Earth and boulder dam, 16 ft. high.
T. 7, R. 29.								
Mull, F. L.	Spring creek. Coulee	NW 24 SW. 24	324	"	"	1·50	160	**L.** Headgate only.
Parsonage, J. E	Spring creek	SW. 3	91	"	"	·77	45	**A.** 4·5 ft. earth dam.

Wood & Anderson	Coulee	NW. 23 NE. 22	486	"	3 ac.	3·65	240	**L.** Earth and rock-fill dam, 8 ft.
Wood & Anderson	Spring creek	NE. 21	101	"	Nil	1·12	50	**L.** Earth dam, 10 ft.
Wood & Anderson	Mink creek	NE. 31	162	"	"	·72	80	**L.** 6 ft. earth dam.
T. 8, R. 20.								
Stearns, C.	Spring creek	SE. 19 SE. 19 SE. 18	276	"	"	1·76	136	**L.** Headgate only.
T. 8, R. 21.								
Smith, S. A.	S. F. Swift Current creek	NW. 10	91	"	10 ac.	·68	45	**L.** 2 earth dams, 6 ft. high.
T. 8, R. 22.								
Cross, A. M.	Calf creek	SE. 5	202	"	Nil	1·06	100	**L.** Timber and earth-fill dam.
Lewis, C. L.	Spring	NW. 34	32	"	"	·67	16	**L.** Rock crib dam 5 ft.
Rose, B. E.	Lake	SE. 12	47	"	"	2·09	23	**L.** Headgate only.
Tenaille, D.	N. Br. Frenchman	SW. 21	202	**H. & F.**	"	3·02	100	**L.** Regulating gate only.
T. 8, R. 23.								
Armstrong & Sons.	W. Br. Fairwell creek Spring creek	NW. 9 SW. 8	2,063	All	2 reservoirs	6·90	1,020	**L.** 2 earth dams, 10 ft.
Ingram, J. E.	W. Br. Fairwell creek Spring creeks	NE. 21 SE. 28 SE. 20	398	**H. & F.**	Nil	2·48	196	**A.** Headgates only.
Kearney Bros	S. Br. Fairwell creek	SW. 29	688	All	"	5.30	340	**L.** 6 ft. rock crib dam
T. 8, R. 25.								
Halsten, J.	Dip creek spring	SE. 7 NW. 6.	172	"	"	1·67	85	**A.** Headgate only.
Wright, B. C.	Davis creek	SW. 27	320	"	"	1·74	158	**L.** Earth-fill and log dam
T. 8, R. 26.								
Dixon & Stewart	Belanger creek	NW. 21	769	"	"	2·87	380	**L.** Headgate only.
Williamson, R. G.	Belanger creek Jackpot creek.	SE. 14 SW. 12 SW. 13. SE. 24	2,072	**H. & F.**	167 ac.	9·22	1,024	**A.** 6 ft. earth and brush dam.

IRRIGATION.—WEST OF THE THIRD MERIDIAN.

T = Township ; **R** = Range ; **H & F** = High and Flood stages ; **L** = Licensed ; **A** = Authorized ; **AS** = Application Submitted.

NOTE—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-foot.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acre.	
T. 8, R. 27.								
McGrath & Morgan	Spring creek	NE. 17	142	All	Nil	·34	70	**L.** Headgate only.
Pollock, G.	Rocky creek	SW. 6	242	**H. & F.**	"	3·02	119	**A.**
White, D.	McShane creek	NW. 36	222	"	"	·45	110	**L.** 5 ft. earth dam.
T. 8, R. 28.								
Bettes, H.	Rocky creek	SE. 1	253	"	"	1·61	125	**A.** Headgate only.
T. 8, R. 29.								
Cheeseman, B.	Six mile Coulee	SW. 12 SE. 11	597	All	"	2·35	295	**L.** Dam and headgate.
T. 9, R. 20.								
Dunlap, R.J.	Spring creeks	SE. 14 SE. 23 NE.14 NE.11	485	"	"	3·03	240	**L.** Ditches only.
Hawken, C.E.	Spring creek	SE. 26	225	"	·5 ac. ft.	·94	111	**L.** 6 ft. earth dam.
Parker, H.	Spring creeks	SW. 4 SE. 5	182	"	Nil	·74	90	**L.** Headgate only.
Stearns, J. S. & J. W.	Spring creeks	SW. 9 SE. 9 NW. 9	212	"	"	1 12	105	**L.** Headgate only.
T. 9, R. 22.								
Waite, F. T.	Spring creek	NW. 1	59	**H. & F.**	"	1·05	29	**L.** Earth dam, 3 ft.

T. 9, R. 26.								
Harris, J. E.	W. Br. Maple creek.	SE. 32.	20	"	"	·38	10	**L.** Headgate only.
T. 9, R. 27.								
Adams, G. A	Spring creek	NW. 10.	283	"	"	1·05	140	**L.** 5 ft. earth dam.
McGarry, J.	Gap creek.	NW. 29.	421	All.	"	1·10	208	**A.** 3 ft. earth dam.
Pollock, G.	Cypress creek.	SW. 17.	769	"	"	2·45	380	**A.** 4 ft. earth dam.
Small, W. A.	McShane creek.	SE. 22.	303	"	"	1·25	150	**L.** Headgate only.
T. 9, R. 28.								
Small, W. A	Downie creek	SW. 26.	388	**H. & F.**	Nil.	1·42	191	**L.** 4 ft. earth dam, ditches, and dykes.
T. 10, R. 14.								
Pearce, T. B	Pearce creek	NW. 27. NW. 22. E½ 13.	1,649	**H. & F.**	3 reservoirs.	6·07	815	**L.** 3 ft. earth dams.
T. 10, R. 19.								
Sinclair, K	Spring creeks.	NW. 18. SE. 18.	175	All.	·25 ac.	·55	86	**L.** 8 ft. 6 in. earth dam. **L.** 12 ft. earth dam.
T. 10, R. 22.								
Mann, J.	Dry Fork coulee.	NW. 32.	336	**H. & F.**	Nil.	·96	166	**L.** 5 ft. earth dam.
T. 10, R. 24.								
Beveridge, D.	Piapot creek.	NE. 7.	81	All.	"	1·20	40	**L.** Headgate only.
		NE. 7. NW. 18.	554	**H. & F.**	"	3·39	274	**L.** 6 ft. log crib dam with spillway.
McCarthy, A.	Glennie creek.	SE. 25.	698	All.	"	1·38	345	**L.** Headgate only.
Tranter, G.	Piapot creek.	NW. 5 NE. 7.	445	**H. & F.**	"	2·09	220	**L.** 3 ft. timber crib dam.
T. 10, R. 25.								
Fauquier, H. H.	Hay creek.	SW. 29.	142	"	"	1·59	70	**A.** Headgate only.
Fearon, E.	Piapot creek. Spring creek.	SE. 25. NW. 36.	647	"	"	2·23	320	**L.** Headgate only.
Hammond, G. R.	Hay creek, SE. fork.	SW. 16.	51	All.	Reservoir (cap 3 ac. ft.)	1·01	25	**L.** Headgate only.
Moorhead & Fearon.	Piapot creek	SE. 25.	607	"		3·00	300	**L.**
Moorhead, H.	"	SE. 25.	405	**H. & F.**	Nil.		200	**L.** Headgate only.
Udal, G.	Spring coulee.	SW. 34. SE 34.	172	All.	"	2·77	85	**A.** 8 ft rock fill dam.

IRRIGATION.—West of the Second Meridian.

T=Township; **R**=Range; **H & F**=High and Flood stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted.

Note—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-foot.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acre.	
T. 10, R. 26.								
Drury, T. A.	Spring.	NW. 1.	162	All.	Nil.	1·10	80	**L.** 4 ft. earth dam.
Greely, H. A.	Maple creek	SE. 28.	223	"	"	·90	110	**L.** concrete headgate.
Peecock, F. W.	Coulee.	SW. 36.	366	**H. & F.**	"	1·51	181	**L.** 6 ft. earth dam.
T. 11, R. 20.								
Gordon, Ironsides & Fares Co.	Bone creek.	SE. 12.	1,961	"	....	....	969	**AS.**
T. 11, R. 21.								
Dimmock Bros.	Bridge creek.	SW. 33.						
	"	NW. 33.						
	"	NE. 33.						
	"	NE. 29.	445	"	Nil.	·67	220	**A.** Headgate only.
	Coulees.	SE. 16.						
	"	NE. 17.						
	Spring creek.	NW. 17.						
	"	SW. 17.	772	"	Unknown.	3·75	381·4	**L.** 3 ft. earth dam. 3 ft. 5 in., 4 ft., and 4 ft.
T. 11, R. 23.								
Braniff, D.	Bear creek.	SE. 30.	445	All	Nil.	1·05	220	**L.** Earth dam, 5 ft. high.
McCarthy, et al.	"	NW. 29.	1,600	"	"	5·21	790	**L.** Dam and 2 headgates.
Needham, R. & H.	"	SW. 30.	1,861	"	"	1·24	920	**L.** Headgate only.
T. 11, R. 24.								
Cumberland, A.	Piapot creek	SW. 17.	334	**H. & F**	"	1·00	165	**L.** Headgate only.
Unsworth, S.	Spring creek.	NW. 5.						
	Coulee.	SE. 13.	506	"	7 acs.	4·42	250	**A.** 20 ft. earth dam.

T. 11, R. 25.								
Peecock, F. W. & R. E.	Hay creek	NW. 4	2,500	"	Reservoir cap. 192 ac. ft.		1,235	**L.** Dam, dykes and headgate.
T. 11, R. 28.								
Martin Bros.	E. Br. Box Elder creek.	NE. 5	146	All	6 ac.	·44	72	**L.** Earth dam, 7 ft high.
T. 12, R. 16.								
Thomsen, T. F.	Spring creek	SW. 15	64	"	·6 ac. ft.	·42	31	**L.** 6 ft. earth dam.
T. 12, R. 20.								
Holding, W. R	Coulee.. Spring creek	SE. 5. SW. 4	1,232	**H. & F.**	Nil	1·19	609	**L.** 12 ft. earth dam.
Moore, W.	"	SW. 9	718	"	6 ac.	2·25	355	**L.** 13 ft. earth dam.
Murdock, T. W	Bridge creek	NE. 25	688	"	Nil	1·25	340	**L.** 4·5 ft. earth dam and headgate.
T. 12, R. 22.								
Gordon, Ironside & Fares Co. (Limited).	Skull creek	NW. 7. NE. 30	1,882	All	"	5·88	930	**L.**
T. 12, R. 26.								
Dixon, J.	Maple creek	SE. 20	1,015	**H. & F.**	65·5 ac.	9·42	502	**A.** Rock crib dam, 6 ft. high.
		SE. 17	1,711	"	"	9·42	846	**A.**
Williams, I. H.	"	SE. 20	870	"	Nil	4·1	430	**A.** 6 ft. earth dam.
		SE. 17	522	"			258	**A.**
T. 12, R. 30.								
Hargrave Bros.	McKay creek	SW. 36. NE. 26	2,417	"	Nil	1·40	1,195	**L.** 12 ft. crib dam.
T. 13, R. 7.								
Vogel, L. A	Wiwa creek	SE. 19	182	"	"	·68	90	**A.** 9 ft. earth dam.

IRRIGATION.—WEST OF THE THIRD MERIDIAN.

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NOTE—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
T. 13, R. 21.							Acres.	
Nicol & Heffer	Sidewood creek	SW. 7	920	**H. & F**	94·5 ac.-ft.	1·66	455	**A.** 20 ft. earth and boulder dam.
T. 13, R. 22.								
Nicol, F. G	Skull creek	NW. 5. SE. 6	283	"	Nil	Nil	140	**L.** Earth fill, 6 ft. " " 4 ft.
T. 13, R. 26.								
Blair, C	Maple creek	SE. 33	1,295	"	"	2·33	640	**L.** 7 ft. timber crib dam with waste gate.
Tenaille, J.	"	SE. 19	1,032	"	...	·18	510	**A.** Dykes, 4 ft. dam and headgates.
T. 14, R. 14,								
Green, J. S	Spring creek	SE. 17	79	All	..	...	39	**AS.** Not constructed.
T. 14, R. 26.								
Conrad-Price Cattle Co.	Maple creek	NW. 23	2,144	**H. & E.**	Nil	4·40	1,060	**L.**
Wilson, I. T.	"	SW. 4 (R. allce. 4 & 5)	1,879	"	"	2·21	929	**L.** Dam and headgate.
		SW. 15	465	"	"	1·10	230	**A.** 12 ft. rock crib dam.
T. 16, R. 11.								
Cruickshank, R.	Rush Lake creek	SE. 28	354	"	Unknown	3·64	175	**L.** Earth dam, 14 ft.
T. 17, R. 11.								
Fares, W. H.	"	SW. 3	1,572	All	Nil	3·02	777	**L.** " " 16 ft.

T. 19, R. 15.								
Jones & Smart	Springs	NW. 26. NE. 27	405	"	"	1.51	200	**L.** 2 small earth dams.
T. 20, R. 8.								
Richardson, H.	Creek	SW. 33	536	"	"	1·73	265	**L.** Earth dam, 3 ft.
"	Spring creek	NE. 29	20	**H. & F.**			10	**A.**
T. 20, R. 13.								
Smith, G. G.	"	SW. 5	281	All	Nil	·95	139	**L.** 18 ft. earth and brush dam.
T. 20, R. 15.								
Smart, J. L	Spring creeks	Sec. 5	514	"	"	2·50	254	**L.** Earth dams 5 and 6 ft. high.
T. 21, R. 18.								
Smith, G. F.	Miry creek	SE. 20	253	**H. & F**	"	1 09	125	**A.** 4 in. centrifugal pump and gasoline engine pumping method.
T. 21, R. 19.								
Jones & Webster	"	SW. 25	789	All	"	2·35	390	**L.** Earth dam, 12 ft.
T. 21, R. 20.								
Wayne, R. H.	Coulees	SE. 21 NW. 20	566	**H. & F.**	"	1·08	280	**A.** 2 earth dams, 13 ft. and 10 ft.
T. 22, R. 8.								
Belhumeur	Coulee	NE. 12	425	All	12 ac	1·00	210	**L.** Timber dams, 13 ft.
T. 23, R. 27.								
Gordon, Ironside & Fares Co.	Spring creek	NE. 27.						
Smith, W. T.	S. Saskatchewan river.	SW. 22	2,975	All	65 ac.-ft	5·55		**AS.** 30 ft. earth dam; centrifugal pump, 18 in. suction, 15 in. discharge, 5,833 Imp.gals., cap., 110 B.H.P., steam engine pumping method.
	Coulee	NE, 23		"			1,470·5	
T. 24, R. 23.								
Dudley, J. A.	S. Sask. river	SW. 4	81	All	Nil	·56	40	**A.** 4 in. centrifugal pump, 10 B.H.P.

IRRIGATION.—WEST OF THE FOURTH MERIDIAN.

T = Township; **R** = Range; **H. & F.** = High and Flood stages; **L** = Licensed; **A** = Authorized; **AS** = Application Submitted.
NOTE—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acre.	
T. 1, R. 1.								
Heydlauff, V. W.	Cut Bank coulee.	SE. 31, NE. 30, SW. 30, NW. 9, NW. 19, SW. 10.	1,548	**H. & F**	202 ac.	1·00	765	**A.** 5 ft. earth dam.
T. 1, R. 2.								
Lumley, J. W.	Sage creek	NW. 15, SW. 3.	627	"	Nil	1·58	310	**L.** 6 ft. earth dam.
Wiley, C. A.	"	NW. 3.	486	All	"	1·21	240	**L.** Concrete headgate.
T. 1, R. 11.								
Fornfeist, J.	Spring creek	NW. 30.	245	"	"	1·75	121	**L.** Dam.
T. 1, R. 12.								
Deer Creek Cattle Co.	Deer creek	SW. 36	718	"	79 ac.	2·12	355	**L.** Earth dam, 15 ft.
Dickinson Bros.	"	SW. 15.	405	"	Nil	2·14	202	**L.** 3 ft. boulder dam.
T. 1, R. 13.								
Sickler, B. E.	Coulee	NE. 1.	218	"	1·2 ac.	·68	108	**L.** 21 ft. 8 in. dam, earth, rock and brush.
T. 1, R. 26.								
Fidler Bros.	Boundary creek.	SE. 19.	221	"	Nil	1·07	109	**L.** Rock crib dam, 5 ft.
Smith, R. S.	Lake	SW. 34.	51	"	"	·88	25	**L.**
T. 2, R. 10.								
Hall, P. M.	Halfbreed creek.	NE. 21.	172	"	"	·80	85	**L.** Headgate only.
T. 2, R. 27.								
Duce, G.	Lees creek	SE. 13.	142	**H. & F.**	"	·95	70	**L.** " "

T. 2, R. 28.								
West, J. N.	Meadow creek	SE. 3	242	All	"	1·75	120	**L.** Earth dam.
"	Miami creek	NW. 2	127	**H. & F.**	"	·94	63	**L.** Headgate only.
T. 3, R. 6.								
McLean, D.	Coal creek	SW. 7						**AS.**
Nattrass, D. W.	"	NW. 30						**AS.**
T. 3, R. 28.								
Christiansen, E.	Belly river	SE. 12.	81	All	Nil	·98	40	**L.** Headgate.
T. 3, R. 30.								
Jones, J. E.	Jones creek	SE. 21	162	**H. & F.**	"	·79	80	**L.** Log crib dam, 5 ft.
T. 4, R. 2.								
Lerge, G. A.	Lodge creek	NE. 36	361	"	"	1·44	180	**A.** Earth and boulder dam.
T. 4, R. 6.								
Hooper & Huckvale	Manyberries ck.	NW. 22 NW. 27	4,289	All	"	6·45	2,120	**L.**
		NW. 22	1,072	"	"		530	**AS.**
T. 4, R. 7.								
Harms, E. F.	Manyberries ck.	NE. 36	3,085	**H. & F.**	"	Dyking.	1,525	**A.**
Kruger, J. F.	Ketchum creek	(Rd. allce, bet. SE. 34 & SW. 35.)	629	"	"	1·59	311	**A.** Headgate only.
McLean, D.	Canal creek	N ½ 1	506	"	"	Nil.	250	**L.** Earth dam, 2 ft
Roberts, E. L.	Ketchum creek	NW. 27. SW. 35. NE. 27	1,076	"	"	2·35	532	**A.** Headgate only.
T. 5, R. 1.								
Link, H. C.	Coulee	SW. 32	324	All	"	1·35	160	**A.** Timber crib dam, 6 ft. 3 in. high.
McCann, P. H.	Middle creek	NW. 29	344	**H. & F.**	"	2·26	170	**L.** Log dam, 8 ft. high.
McKinnon, A. H. & A. D.	"	NE. 24	1,6 0	All	"	3·70	815	**A.** Pile dam.
T. 5, R. 2.								
Mitchell, W.	Lodge creek Spring creek	SW. 29. SE. 15	1,366	**H. & F.**	"	5·10	675	**L.** 2-12 ft. earth dam.
Muir & Frantzon	Middle creek	NE. 35	554	"	"	1·90	274	**L.** 4ft. rock and brush dam

IRRIGATION.—WEST OF THE FOURTH MERIDIAN.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
T. 5, R. 7.							Acres.	
Haugan, H.	Irrigation creek.	SE. 36	235	"			116	**AS.**
Jaques, C.	"	SE. 36	202	"			100	**AS.**
T. 5, R. 29.								
Thibaudeau, J. B.	Indian Farm ck.	NE. 17. SW. 21.	405	All	Res. cap. 30 ac. ft.	1·14	200	**L.** Small dam and headgate.
T. 6, R. 1.								
Faulkner, W. C.	Spring creek	SE. 25	255	"	2 ac.	2·50	126	**L.** 6 ft. earth and brush dam.
T. 6, R. 2.								
Jenkinson, F. B	Spring creek	SE. 33.	747	**H. & F.**	Nil	2 10	370	**A.** 4-5 ft. rock and earth dam.
T. 6, R. 3.								
Anderson, J	E. Br. Lodge ck.	NW. 14	83	**H. & F.**	Nil	·60	41	**L.** 1·5 ft. earth dam.
Hartt, J. E	"	SE. 22	202	"	"	2·78	100	**L.** Headgate.
Read, J.	Michael coulee. Read creek	NE. 33. NW. 34	526	All	"	1·45	260	**A.** 4 ft. earth dam.
Sniste, A. J	Coulees	SE. 9. NE. 4	218	"	"	1·47	108	**A.** 5 ft. "
T. 6, R. 6.								
Mattson, Axel	Coulee	NW. 6	566	**H. & F.**	"	·72	280	**A.** 4 ft. "
T. 6, R. 29.								
Cyr & Cyr	Stead creek	NE. 2. SW. 7	708	All	"	·57	350	**L.** Earth dam and headgate.

T. 7, R. 2.								
English, J. A.	E. Br. Lodge ck.	NW. 19	981	**H. & F.**	"	4·00	485	**L.** Headgate only.
Mock, A. F.	Middle creek	SE. 29	384	"	"	1·57	190	**A.** "
T. 7, R. 3.								
Clarke, M. T.	Sexton creek	SE. 21	142	All	"	·68	70	**L.** Rock crib dam, 8 ft.
Mudie, H. A.	"	SW. 21	241	**H. & F.**				
	Coulee	NW. 21		"	6·2 ac	1·07	119	**L.** " " 3 ft. 6 in. high.
Taylor, H.	Lodge creek	NW. 29	243	"	Nil	1·15	120	**L.** 6 ft. dam (earth).
T. 7, R. 4.								
Denbigh, A. G.	Peigan creek	NW. 30	1,329	All	"	4·26	657	**A.** 14 ft. earth dam.
T. 8, R. 1.								
Hansen, H. A. & A. E.	Spring creek	NW. 13	160	"	"	1·05	79	**A.** Earth dam, 7 ft.
Reesor, W. D.	Coulee	SW. 36	182	"	Reservoir	1·45	90	**A.** 9 ft. 6 in. earth dam.
T. 8, R. 3.								
Brown, Miss A. H.	Gros Ventre ck.	NW. 31	223	"	Nil	·65	110	**A.** 10 ft. earth and boulder dam.
T. 8, R. 4.								
Dempster, W. B.	Bowler creek	SE. 14	202	"	"	1·38	100	**A.** 10 ft. earth dam.
Dempster, J.	Spring creek	NW. 1	83	"	"	·48	41	**A.** Headgate only.
T. 8, R. 8.								
Foster, Mrs. A. E.	Red Rock coulee	SE. 27	496	"	28·8 ac	1·02	245	**A.** 16 ft. earth dam with concrete spillway.
T. 8, R. 25.								
McNab, W. H. & J.	Coulee	SE. 26						
		NE	688	"	8 ac	·91	340	**L.** Dam 8 ft. high.
Patterson, Lachance *et al.*	Belly river	NE. 14	2,913	"	Unknown	4·72	1,440	**L.** Dam and headgate.
T. 9. R. 3.								
Robinson, J.	E. Fork Ross creek	SE. 1.	51	"	7 ac	1·38	25	**L.** 6 ft. earth dam. 16 ft. "
T. 9, R. 4.								
Putnam, W. M.	Coulee	NE. 29	122	"	16 ac	1·95	60	**A.** Headgate only.

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T. 9, R. 5.							Acres.	
Clarke, Mrs. M. A.	Bullshead creek.	NE. 10.	202	"	Nil	1·30	100	**L.** 4 ft. earth dam.
T. 9, R. 29.								
George Bros.	Beaver creek	SW. 20	809	"	"	1·89	400	**L.** Log dam 7 ft. 6 in. high.
T. 10, R. 18.								
Bountiful Canal & Irrigation Co.	Chin coulee	SW. 6	3,620	**H. & F**			750	**A.**
Cassidy, W. J.	"	SW. 6	344	"			170	**A.**
Crest, C. A	"	NE. 4	486	"			240	**A.**
Fuller, J. D. & Hill, W. S.	"	SE. 3	303	"			150	**A.**
Hill, W. S	"	NE. 4 SW. 6	607	"			300	**A.S.**
T. 11, R. 2.								
McLeish, J. G	Dry coulee	SW. 36	613	"	Nil	1·18	303	**A.** 8 ft. earth dam.
T. 11, R. 5.								
Stark & Burton	Bullshead creek.	SE. 17	486	All	"	1·78	240	**A.** Headgate only.
Wright, F.	"	NW. 34	121	"	"	1·06	60	**L.** Rock, crib and earth dams, 4 ft. high.
T. 11, R. 28.								
Quail, W. H	Muddypound ck.	SW. 26	1,349	Flood	Res. 32 " 38·3 " 32·6	4·38	667	**L.** Earth dam, 5 ft. high. " 5 ft. " " 3 ft. "
Stevenson, R. & J.	"	SE. 27	769	All	Nil	1·88	380	**L.** Earth dam, 6·6 ft. high.
Downs, F.	Spring creek	NW. 9						**A.S.**

T. 11, R. 29.								
Stewart, Mrs. W. R.	Spring creek	NW. 20	281	All	Nil	·57	139	**L.** Concrete headgate.
T. 11, R. 30.								
Patterson, A.	Springs	NW. 26 NE. 26	223	All	Nil	1·05	110	**L.** Headgate.
Jacobs, F.	Spring creek	SE. 35 NW. 23	34	All	Nil	·57	17	**A.** Headgate only.
T. 12, R. 2.								
Mackie, G.	Coulee	NE. 26	....	....	....	....	....	**A.S.**
T. 12, R. 3.								
Drinnan, J. K.	Ross creek	NE. 7	826	**H. & F**	Nil	1·58	408·6	**A.** 8 ft. earth and timber dam.
T. 12, R. 27.								
Stevenson, J. & W.	Trout creek	NW. 2	985	All	Nil	5·49	487	**L.** Headgate only.
T. 12, R. 28.								
Leeds and Elliott	Spring creek	NE. 35	518	All	Nil	1·58	256	**L.** Headgate only.
T. 12, R. 29.								
Glengarry Ranche Co.	N. Fork Trout creek	NW. 26	957	All	Nil	3·31	473	**L.** Dam and Headgate.
Lyndon, C. A. & W. A.	Trout creek	SW. 34	324	**H. & F**	Nil	1·70	160	**L.** Headgate only.
T. 12, R. 30.								
Burton, Mrs. F. M.	Spring creek	SE. 23	20	All	....	....	10	**A.S.**
Quail, W. H.	"	NE. 25	61	All	Nil	1·61	30	**L.** Dam and headgate.
T. 13, R. 1.								
Drinnan, D.	McKay creek	SE. 23	1,539	**H. & F.**	Nil	2·51	761	**A.** Dam.
Drinnan, J. K.	"	NE. 11	564	**H. & F**	Nil	1·13	279	**L.** earth and timber dam.
Hargrave Bros.	"	NW. 1	2,296	**H. & F.**	Nil	3·11	1,135	**L.** Rock crib dam 12 ft.
Many Island Lake Sheep Ranch Co.	"	NE. 11	1,199	All	Nil	2·50	593	**L.** Earth dam, 14 ft.

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							Acre.	
McLaren, Rev. (late)........	" ...	SE. 12	346	**H. & F.**... ..	Nil..	2·28	171	**L.** 10 ft. timber and earth dam.
T. 13, R. 5.								
Kelly, W. N........... ...	S. Saskatchewan river..........	NE. 18..........	362	All..	Nil...........	·95	179	**A.** 5 in. centrifugal pump, 20 B.H.P. engine, pumping method.
Mitchell, J.	Spring creek....	NW. 34...	30	All	Nil........ .	·50	15	**L.** 18 ft. earth dam.
T. 13, R. 6.								
Rae, J....	S. Saskatchewan river	NE. 24	348	All...	Nil...	1·11	172	**L.** No. 4 centrifugal pump, B.H.P. gasoline engine, pumping method.
T. 13, R. 29.								
Carmichael, J.....	Spring creeks...	SE. 34. NE. 27........	61	All...........	Nil......... ..	·65	30	**A.** 2 ft. earth dam.
Lyndon, W. A.......... ...	Reservoir......	NW. 2..........	20	"	4·08 ac........	·45	10	**A.** 12 ft. earth dam.
Stone, F. A....	Spring...	NE. 10...... ..	67	"	Nil..........	1·45	33	**L.** 6 ft. boulder dam.
T. 14, R. 3.								
Elson, R...................	Coulee..........	WS. 23	835	"	....	None.	413	**L.** Earth dam 5·5 ft. Dyking method.
Smith, Dr. A....	"	WS. 30.........	991	"	100 ac........	174	490	**L.** Earth dam, masonry spillway.

T. 14, R. 14.								
Hemsley, J. M.	"	SW. 29						**AS.**
T. 14, R. 22.								
Scott, D.	Little Bow R.	NW. 33	62	**H. & F**	Nil	·71	30	**A.** Portable Myers, sgl. cyl. pump. 2 B.H.P. gasoline engine. Pumping method.
T. 14, R. 28.								
Hull, W. R.	Oxley creek	SW. 7	51	All	"	1·58	25	**L.** 4 ft. rock dam.
T. 14, R. 29.								
Blake, G.	Spring creek	NE. 33	83	"	"	·70	41	**L.** Headgate only.
Connell, A.	"	NE. 24	417	"	"	1·54	206	**L.** " "
Hull, W. R.	Oxley creek	SE. 34	1,153	"	"	3·46	570	**L.** " "
T. 14, R. 30.								
Gordon, Ironside & Fares Co. & Geo. Lane	Kuntz creek	NE. 24	1,131	"	Unknown	4·30	648	**L.** Dam and headgate.
Gorden, Ironside & Fares Co. & Geo. Lane	Springs & coulee	NE. 13. SE. 13	162	"	Nil	1·59	80	**L.** 4 ft. brush and earth dam.
T. 15, R. 3.								
Will, J.	Creek	SW. 23. SW. 24	1,214	**H. & F.**	Reservoirs	2·52	600	**A.** 2 earth dams 7 ft. and 9 ft. high.
T. 15, R. 5.								
Drowning Ford Schg. Co.	S. Sask. river	SW. 21	570	All	Nil	3·68	282	**A.** 6 in. centrifugal pump, 30 B.H.P. engine.
T. 15, R. 26.								
Cooper & Hendrickson	Musquito creek	SE. 10	702	**H. & F.**	"	3·90	347	**L.** Headgate only.
T. 5, R. 28.								
Bartlett, R. W.	Oxley creek	NE. 31	223	All	"	1·12	110	**L.** " "
Cooper, J. T.	Spring creek	SE. 28	194	"	"	1·25	96	**L.** Earth dam 5 ft. high.
T. 15, R. 29.								
Alberta Estates Ltd.	Nanton creek	Rd. allce. W. of SW. ¼ sec 25	131	"	"	1·20	65	**L.** Dam and headgate.
Alberta Estates, Ltd.	"	SW. 25	131	"	"	·67	65	**L.** Headgate only.
Beeching, G.	Spring creek	SE. 10	30	"	5 ac.	2·11	15	**L.** Earth dam, 6·6 ft.
Coughlin, C.	Nanton creek	NE. 25	352	**H. & F.**	Nil	2·52	174	**L.** 2 timber dams, 4·5 ft. high.

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T. 16, R. 29.							Acres.	
Greig, G.	Springhill creek.	SE. 11	330	All	"	1·51	163	**L.** Headgate only.
T. 17, R. 5.								
Murphy & Lokier	S. Sask. river	SW. 25 NW. 24	1,093	"	"	3·55	540	**A.** Pump and ditches Pumping method.
Tinney, T. H.	" "	NE. 23	790	"			391	**AS.**
T. 17, R. 29.								
Drumheller & Coolidge	Mosquito and Little Musquito creek.	NE. 6. SW. 8	910	**H. & F.**	Nil	3·52	450	**L.** Rock crib dam.
T. 18, R. 29.								
Findlay & McDougall	Highwood river.	NW. 30	5,361	All	Nil	10·25	2,650	**L.** 6 ft. earth dam.
McLaughlin, J. W.	Subsid. channel. Highwood river.	NE. 34 SE. 33	1,376	"	Unknown	3·88	680	**L.** Rock crib dam.
T. 19, R. 22.								
Conrad Circle Cattle Co.	Spring Creek	NE. 32	152	All.	Nil	·34	75	**L.** Earth dam, 11·5 ft.
"	Spring Creek	SE. 33	5	"	Reservoir	·15	2·55	**L.** 5 ft. earth dam.
T. 19, R. 29.								
Robertson, Mrs. M. A. E.	Highwood river.	NE. 7	2,559	All	Nil	6·00	1,265	**L.** Headgate and 8 in. centrifugal pump.
Wallace, R. A.	" "	NW. 1	4,345	"	None	11·50	2,148	**L.** No dam. Headgate only.

T. 20, R. 22.								
Wallace, F. A	Spring	SE. 30	60	All	2.7 ac.	·59	30	**A.** 8 ft. earth dam.
T. 20, R. 23.								
Grace & Wal ace	Spring	SE. 32	61	All	4 ac. ft.	·80	30	**A.** 6 ft. earth dam.
T. 22, R. 6.								
Gordon, A. & J. R	Red Deer river	NW. 8	2,883	All	Nil	5·90	1,425	**A.** 8 in. centrifugal pump 60 H.P. steam engine. (Pumping method).
T. 22, R. 12.								
Berry Creek Ranching Co.	Berry Creek	NE. 32	4,958	**H. & F**	800 ac. ft.	12·81	2,571	**L.** Earth dam 21 ft.
T. 23, R. 2.								
Kennedy & Sons	Kennedy Creek	NW. 10	838	All	38 ac.	3·60	414	**A.** 19 ft. e rth dam.
T. 23, R. 8.								
Fewing, E. J	Red Deer river	SE. 3	850	All	Nil	3·58	420	**A.** 8 in. centrifugal pump, 32 B.H.P. gasoline engine. (Pumping method).
Hallam, J. R	Blood Indian Ck.	SW. 10	475	**H. & F**	33.6 ac.	1·52	235	**A.** Through works of Vee Bar Vee Brand Ranching Co. (Pumping method).
Vee Bar Vee Branch Ranching Co.	" "	NW. 3	609	All	33.6 ac.	3·00	301	**L.** 15 ft. earth dam.
T. 24, R. 13.								
Helmer, W J	Dead Fish Creek	SE. 7	506	All	Nil	2·76	250	**L.** 5 ft. earth dam.
Park, Hill & Forster	Berry Creek	NW. 11	1,813	"	7 ac	3·25	896	**L.** 8 in. centrifugal pump and steam engine. (Pumping method.)
T. 26, R. 17.								
Peake, A	Red Deer river	SW. 31	461	All	2.7 ac.-ft.	1·61	228	**L.** 4 in. centrifugal pump, 16 B.H.P. engine; 225 ft. windmills; 5 in. suction; 4 in. discharge. (Pumping method.)
T. 30, R. 25.								
Patterson, J. D	Creek	SE. 3	344	All	Nil	1·05	170	**L.** 6 ft. dam, earth and boulders.
T. 43, R. 5.								
Kelly, W. J	Ribstone Creek	SE. 33	647	**H. & F**	Nil	1·04	320	**A.** Pile and timber dam.

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T. 44. R. 13.							Acre.	
Peterson, G	Creek	SE. 11	91	All	Nil	1·23	45	**L.** Headgate only.
T. 7, R. 2.								
Burn, H. St. G.	Connelly creek	NW. 34	202	All	Nil	·25	100	**L.** Headgate only.
T. 8, R. 1.								
Elton, C. W. S.	Todd creek	SE. 19	101	"	"	·66	50	**L.** Rock and brush dam, 2 ft high.
Nelson, J	N. F. Oldman river	NW. 33	364	"	"	1·00	180	**L.** Headgate only.
T. 8, R. 2.								
Cardwell, C. A.	Todd creek	SE. 36	405	"	"	·75	200	**L.** Rock and brush dam.
Ross & McLean	Ross creek	NE. 34	1,171	"	"	3·50	580	**A.** Headgate only.
T. 9, R. 2.								
Offutt & Co.	Todd creek	SE. 11	182	"	"	·50	90	**L.** Headgate only.
Wilson, Mrs. M.	"	SE. 11	506	"	"	2·35	250	**A.** 5 ft. timber crib dam.
T. 10, R. 3.								
Dennis, W	Ernst creek	NE. 26	162	**H. & F.**	"	1·65	80	**A.** 3 ft. dam and headgate.
T. 11, R. 1.								
Burton, F. A.	Spring creeks	NW. 36	190	All	"		90	**L.** Headgate only.
	Spring	SE. 35						
Playle, A. H	Playle creek	SW. 32	334	"	"	1.54	165	**L.** Headgate only.

T. 12, R. 1.								
Burt, J. A	Spring creek	SW. 7	243	"	"	·86	120	**L.** Headgate only.
Burton, F. A	Burke creek	NE. 2	132	"	"	1·27	65	**L.** Headgate only.
	Burton creek	SE. 15	119	"	"	1·38	59	**L.** Headgate only.
	Trib. Callum creek	SE. 6	166	"	"	1.55	82	**L.** Headgate only.
T. 13, R. 1.								
Ford, Mrs. M	Spring creeks	NW. 36 N.E. 26	983	"	"	4·51	486	**L.**
T. 13, R. 2.								
Drumheller & Coolidge	Spring creek	SE. 23	32	"	"	·28	16	**A.** Headgate only.
Riley, D. E	Creek	Rd. allce. SW. 16 & SE. 17	324	**H. & F**	"	1.85	160	**A.** 10 ft. rock crib dam.
Meneice, Robt	Spring creek	SW. 30	363	All			165	**AS.**
Meneice, Lewis	Westropp creek	SW. 30	101				50	**AS.**
Riley, D. E	" "	NW. 28 NE. 28	364	**H. & F**	Nil	2 65	180	**L.** Rock crib dam and headgate.
Riley, D. E.	Dago creek	NW. 17						
	Irishman creek	SW. 17	172	All	"	·58	85	**L.** Timber dam, 4 ft. 2 in. high.
T. 14, R. 1.								
Gregory, A. J. & E. J	Spring creek	SE. 21	182	"	"	·62	90	**L.** Headgate only.
Riley, D. E	" "	SE. 16	131	"	"	·74	65	**L.** Headgate only.
T. 14, R. 2.								
Dick, A. S	Spring creeks	Pts. in secs. 28 and 29	202	"	"	1·94	100	**L.** Headgates only.
T. 15, R. 1.								
Carmichael & Boulton	Jim creek	NE. 6	32	"	"	·45	16	**A.** Through other works.
Cross, A. E	Ranch creek							
	Dry Timber creek	S½ 34	247	"	.	3·47	122	**L.** 2 dams and headgates.
Cross, A. E	W. Branch Dry	NE. 22						
	Timber coulee	SW. 22	405	"	"	1·67	200	**L.** Headgate.
McNab, D	Jim creek	NE. 6	51	"	"	·43	25	**A.** Timber dam 4 ft. 6 in.
T. 15, R. 2.								
Gardner, W. C	Creek	SE. 20	235	"	"	1·88	116	**L.** Rock crib dam 5 ft.
T. 16, R. 1.								
Ellis & Russell	Mosquito creek	SW. 8	52	"	"	·56	26	**L.** Log and earth-fill dam.
Skrine, W. C	Snake creek	NW. 17						
	Mosquito creek	NE. 8	162	**R. & F**	"	1.89	80	**L.** 7 ft. earth dam.

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							Acres.	
T. 16, R. 3.								
Bedingfeld, F. N.	Lake.	NE. 26.	346	All.	61 ac.	·91	171	**L.** earth dam 14 ft.
T. 16. R. 4.								
Cameron, D.	Millar creek. Spring creek.	NE. 23. SW. 25.	142	"	Nil.	1.51	70	**L.** 3.3 ft. earth dam.
T. 17, R. 3.								
Brown, J. H.	Pekisko creek & Spring creek.	SW. 2, SE. 14.	370	All.	Nil.	2·02	183	**L.** 2 timber crib dam, 3 ft. 4 in. and 4 ft. 4 in. high.
Gordon, Ironside & Fares Co.	Pekisko creek.	NE. 1.	5,027	"	"	7·50	2,485	**A.** 3 ft. earth and brush dam.
T. 17, R. 4.								
Beaudry, O.	Meinsinger creek	SE. 14.	716	"	"	1·09	354	**L.** Rock and earth dam, 5 ft. high.
Marston, E.	Spring creek.	NE. 5.	97	"	"	·77	48	**A.** 2 headgates.
T. 18, R. 4.								
Vine, W.	Sullivan creek.	SE. 9.	189	"	"	1·58	93	**L.** Dam and headgate.
T. 19, R. 2.								
Grant, J. A.	Creek.	NE. 29, NE. 16.	293	"	18·7 ac.	1·63	145	**L.** Earth dam, 13 ft.
T. 19, R. 3.								
Lincham, J. (late).	Macabee creek.	NW. 30.	293	"	Nil.	1·51	145	**L.** Timber and earth-fill dam, 6 ft. high.

T. 19, R. 4.								
Lineham, J. (late)	"	NE. 26	787	**H. & F**	20 ac.	1·62	389	**L.** Earth dam, 5 ft.
T. 20, R. 2.								
Fisher & Barnes	S.Br. Sheep river	NE. 6	4,048	All	Nil	14·85	2,001	**A.**
T. 20, R. 4.								
Basilici, R.	N.F. Sheep creek	SE. 27	216	"	"	·66	107	**L.** Earth dam.
Taylor, E. L. T.	"	NE. 23	162	"	"	1·12	80	**L.** Headgate only.
T. 21, R. 3.								
Fisher, Jos.	"	NW. 1	637	"	"	1·68	315	**L.** Rock crib dam.
Millar, Adams & King	Trib. of Sheep creek	NW. 2	334	"	"	1·69	165	**L.** " "
Wright, F.	Sheep creek	SE. 8	162	"	"	·19	80	**L.** " "
Wright, J. & B.	Creek	SW. 4	158	"	"	1·45	78	**L.** Log dam 3 ft. 6 in. high.
T. 21, R. 4.								
Burns, P.	N. F. Sheep	SW. 5	607	"	"	2·17	300	**L.** Timber and earth dam.
T. 22, R. 1.								
Sheepy, J.	Swamp	NW. 21	61	"	"	·80	30	**L.** Small dam.
T. 22, R. 2.								
Darling, A.	Carter's creek	NW. 30	81	"	"	1·00	40	**L.** 2 earth dams 6 ft.
T. 22, R. 3.								
Ockley, J. W.	S. F. Fish creek.	NE. 10	223	"	"	·85	110	**L.** Headgate only.
Stanton, R.	Spring creek	SE. 14	81	"	unknown.	·30	40	**L.** Dam 5·5 ft. high.
T. 23, R. 1.								
Shaw, Helen	Fish creek	NE. 4	36	**H. & F.**	Nil	·38	18	**L.** Earth dam and headgate.
T. 24, R. 2.								
Lott & Walker	Elbow & a creek	NW. 6	738	All	"	2·65	365	**L.** Timber and gravel-fill dam.
T. 24, R. 4.								
Gardner, M.	Trib. Elbow	NE. 12	728	"	"	2·26	360	**L.** Headgate only.

IRRIGATION.—West of the Second Meridian.

T=Township ; **R**=Range ; **H & F**=High and Flood stages ; **L**=Licenced ; **A**=Authorized ; **AS**=Application Submitted.

Note—All schemes are "Gravity" unless otherwise indicated.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-foot.	Stage.	Storage.	Miles of Ditch.	Irrigable Area.	Remarks.
							Acre.	
T. 27, R. 3.								
Hutchinson, W....... ...	Spring creek....	SW. 4	47	"	"	·47	23	**L.** Rock and earth dam, 4 ft. high.
T. 27, R. 5.								
Kerfoot & Meiklejon..	Coal creek ...	SW. 34, SE 22..	1,173	**H. & F.**.....	"	4·70	580	**L.** Rock and brush dam.
T. 28, R. 4.								
Cooke, H. E. G	Dogpound creek	SE. 21.........	162	All..........	"	1·12	80	**L.** Brush and timber dam.

INDUSTRIAL SUPPLIES.—West of the First Meridian.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet per Annum.	Imp. galls. per 24 hours.	Method.	Stage.	Standing and Remarks.
T. 7, R. 30.							
C.P.R.	N. Antler creek	NW., SW. 18	145	107,654	Pumping	All	**L.** Pipeline, tank, pumping plant.
T. 13, R. 30.							
C.P.R.	Spring creek	SE. 9	145	107,654	"	"	**L.** Timber dam, 10 ft. high. Pipeline and tank.
T. 18, R. 32.							
C.P.R.	Qu'Appelle river	NW. 9	290	215,308	"	"	**L.** Pipeline, tank, pumping plant.
T. 19, R. 32.							
G.T.P.	Big Cutarm creek	NW. 25	121	89,891	"	"	**L.** Pipeline, tank, pumping plant and dam.
T. 28, R. 30.							
C.N.R.	Creek	NE. 10	72	53,827	"	"	**L.** " "
T. 29, R. 32.							
C.N.R.	Assiniboine river	Gabriel Cote Indian reserve	181	134,568	"	"	**L.** Pipeline, tank, pumping plant.
West of the Second Meridian.							
T. 1, R. 2.							
G.T.P.	Coulee	N.½ 6	121	89,891	"	"	**A.** Pipeline, pumping plant, tank and dam.
T. 2, R. 5.							
C.P.R.	Creek	NW. 11	145	107,654	"	"	**A.** Pipeline, tank and pumping plant.

INDUSTRIAL—West of the second Meridian.

T=Township; **R**=Range H & F.=High and Flood stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted.

Township and Name of Applicant.	Source of Supply	Point of Diversion.	Acre feet per annum.	Imp. Gals. per 24 hrs.	Method.	Stage.	Standing and Remarks.
T. 1, R. 6.							
C.P.R	Souris river	NE. 30	145	107,653	"	"	**L.** 4 in. pipeline, dam, pumping plant and tank.
T. 2. R. 8.							
C.P.R	"	NE. 11	56	41,405	"	"	**L.** Pipeline, tank, pumping plant.
C.P.R	"	NE. 11	362	269,136	"	"	**L.** Pipeline, tank, pumping plant and dam.
T. 3, R. 10.							
C.P.R	"	SE. 30	724	538,272	"	"	**L.** " "
T. 8, R. 17.							
C.P.R	Brokenshell creek	NE. 8	145	107,654	"	"	**L.** " "
T. 8, R. 19.							
C.P.R	Dry lake	Rd. allce. NW. 15	145	107,654	"	"	**L.** Pipeline, tank and pumping plant.
T. 9, R. 9.							
C.P.R	Slough	SW. 22	290	215,308	"	"	**L.** 3 in. pipeline, tank and windmill.
T. 10 R. 8.							
C.P.R	Swan lake	NE. 6	217	161,481	"	"	**A.** Pipeline, tank and pumping plant.
T. 11, R. 26.							
C.N.R	Spring	SE. 21.	72	53,827			**AS.** No works constructed.
T. 12, R. 19.							
C.P.R	Moosejaw creek	SW. 9	145	107,654	Pumping	All	**L.** Tank, pump and pipeline.

T. 14, R. 11.							
C.N.R.	Spring	SW. 27	72	53,827	"	"	**L.** Pipeline, tank, pumping plant.
T. 14, R. 22.							
C.P.R.	Moosejaw creek	SE. 16	145	107,654	"	"	**A.** 6 in. pipeline, tank, pumping plant and dam.
T. 15, R. 17.							
C.P.R	Stream	SW. 26	145	107,654	"	"	**L.** Pipeline, tank, pumping plant and dam.
T. 15, R. 23.							
C.P.R.	Moosejaw creek	SE. 30	45	33,642	"	"	**L.** Dam, pumping plant, windmill and pipeline.
T. 16, R. 5.							
C.P.R.	Springs	NE. 23	72	53,827	Pumping	All	**L.** 8 in. pipeline, tank, and pumping plant.
T. 16, R. 26.							
C.P.R.	Moosejaw creek	SW. 33	724	538,272	"	"	**L.** Pipeline, tank, pumping plant, concrete dam, and purification plant.
International Milling Co	Thunder creek	NW. 32	36	26,913	"	"	**A.** Water for fire protection and boilers.
C.P.R.	Moosejaw creek	NW. 29	486	358,848	Impounding	**H. & F.**	**A.** Timber dam 9 ft. high.
T. 17, R. 10.							
C.P.R.	Wolf creek	NE. 11	434	322,963	Pumping	All	**L.** 3 in. pipeline, tank, pumping plant, and dam.
T. 17, R. 18.							
C.P.R	Dewdney creek	NW. 34	94	69,975	"	"	**L.** Well, pipeline, and pumping plant.
C.P.R.	" "	NW. 34	434	322,963	"	"	**L.** Dam, reservoir, pipeline, and tank.
T. 17, R. 21.							
C.P.R.	Cottonwood creek	NE. 7	145	107,654	"	**H. & F.**	**L.** Dam, pipeline, tank, pumping plant.
T. 17, R. 22.							
G.T.P.	" "	NE. 25	121	89,891			**AS.** No works constructed.
T. 17, R. 25.							
C.P.R.	Moosejaw creek	SE. 5	45	33,642	Pumping	All	**L.** 4 in. pipeline, dam, pumping plant, and tank.

INDUSTRIAL.—West of the second Meridian.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre feet per annum.	Imp. Gals. per 24 hrs.	Method.	Stage.	Standing and Remarks.
T. 17, R. 29.							
C.P.R.	Sandy creek	SW. 34	145	107,654	"	"	**L.** Ditch, reservoir, pipeline, and pumping plant.
T. 18, R. 15.							
C.P.R.	Spring	NE. 17.	91	67,284	"	"	**L.** Pipeline, tank, pumping plant.
T. 19, R. 1.							
C.P.R.	Kaposvar creek	SW. 34	145	107,654	"	"	**A.** Pipeline, tank, and pumping plant.
T. 19, R. 7.							
C.P.R.	Qu'Appelle river	SE. 21	290	215,308	"	"	**L.** 8 in. pipeline, tank, pumping plant.
T. 19, R. 21.							
C.N.R.	Creek	NW. 26	121	89,891	"	"	**L.** Well and pumping plant.
T. 20, R. 7.							
C.P.R.	Pearl creek.	SE. 36	145	107,654	"	"	**A.** Pipeline, tank, pumping plant and dam.
T. 20, R. 15.							
G.T.P.	Coulee	SE. 14	121	89,891	"	"	**A.** " "
T. 21, R. 12.							
C.P.R.	Creek	NW. 23	121	89,891	"	"	**L.** Pipeline, tank, and pumping plant.
T. 21, R. 23.							
C.P.R.	Last Mountain lake.	NE. 35	72	53,827	"	"	**L.** " "

T. 22, R. 1.							
C.P.R.	Big Cutarm creek	NW. 10	434	322,963	"	"	**L.** " "
T. 24, R. 2.							
C.P.R.	Anderson lake	SW. 1	145	107,654	"	"	**L.** " "
T. 24, R. 28.							
C.N.R.	Arm river	NE. 23.	45	33,642	"	"	**A.** 4 in. pipeline, dam, pumping plant, and tank.
T. 25, R. 24.							
G.T.P.	York lake	SW. 22	121	89,891	"	"	**L.** Pipeline, tank, and pumping plant.
T. 25, R. 11.							
G.T.P.	Crooked lake.	Rd. allce bet. SE. 20 & SW. 21	121	89,891	"	"	**L.** " "
T. 26, R. 25.							
C.P.R.	Creek	SW. 16	145	107,654	Pumping	All	**A.** Pipeline, tank, pumping plant, and dam.
T. 27, R. 2.							
C.N.R.	Slough.	SE. 23	72	53,827	"	"	**L.** Pipeline, tank, pumping plant.
T. 27, R. 14.							
G.T.P.	Lake.	Muskowekwun Indian reserve	121	89,891	"	"	**L.** "
T. 27, R. 15.							
G.T.P.	Pelican lake	SW. 19	121	89,891	"	"	**L.** "
T. 28, R. 7.							
C.P.R.	Slough.	SW. 15	161	120,034	"	"	**L.** " "
T. 29, R. 4.							
G.T.P.	Whitesend river	SE. 25	121	89,891	"	"	**L.** " "

INDUSTRIAL.—West of the Second Meridian.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet per annum.	Imp. Galls. per 24 hours.	Method.	Stage.	Standing and Remarks.
T. 30, R. 9.							
C.P.R.	Ebbels creek	NW. 9.	161	120,034	"	"	**L.** Pipeline, tank, pumping plant, and dam.
T. 32, R. 6.							
C.N.R.	Spirit creek	SW. 4	72	53,827	"	"	**L.** Pipeline, tank, pumping plant.
T. 32, R. 14.							
C.P.R.	Birch creek	NE. 13.	241	179,244	"	"	**L.** Pipeline, tank, pumping plant, and dam.
T. 32, R. 16.							
C.P.R.	Creek	NW. 15	362	269,136	"	"	**L.** Pipeline, tank, pumping plant.
T. 33. R. 10.							
C.N.R.	Lake	SW. 10	72	53,827	"	"	**L.** " "
T. 35, R. 28.							
C.P.R.	Slough	NW. 1.	145	107,654	"	"	**L.** 6 in. pipeline, tank, and pumping plant.
T. 37, R. 26.							
G.T.P.	Lake	SE. 19.	121	89,891	"	"	**AS.** Pipeline, tank, pumping plant.
T. 38, R. 22.							
C.N.R.	Dead Moose lake	Rd. allce. bet. sec. 17 & 18	181	134,568	"	"	**L.** " "
T. 48, R. 26.							
C.P.R.	Saskatchewan river	Within city Prince Albert.	72	53,827	"	"	**L.** 4 in. pipeline, tank, pumping plant.

West of the Third Meridian.

T. 12, R. 19.							
C.P.R.	Springs	Sec. 25	290	215,308	Pumping	All	**L.** Pipeline, tank, pumping plant.
T. 12, R. 22.							
C.P.R.	Reedy lake	SW. 33	241	179,244	"	"	**A.** " "
T. 12, R. 23.							
C.P.R.	Bear creek	NW. 8	145	107,654	"	**H. & F.**	**L.** Dam, tank, 4 in. pipeline, pumping plant
C.P.R.	"	"	217	161.418	"	All	**L.** This application licensed only from Oct. to April each year.
C.P.R.	"	"	34	25,357	"	"	**L.**
T. 13, R. 21.							
C.P.R.	Spring	SE. 17	45	33,642	"	"	**L.** Dam, tank, 4 in. pipeline, pumping plant.
C.P.R.	"	"	72	53,827	"	"	**L.** " "
T. 14, R. 16.							
C.P.R.	"	NW. 25	45	33,642	Gravity	"	**L.** 4 in. pipeline.
C.P.R.	"	"	72	53,827	"	"	**L.** Dam, 3 in. pipeline, tank and pumping plant.
T. 14, R. 18.							
C.P.R.	Bridge creek	SE. 11	45	33,642	Pumping	"	**L.** Dam, tank, 4 in. pipeline, pumping plant.
C.P.R.	"	"	72	53,827	"	"	**L.** " "
T. 15, R. 13.							
C.P.R.	Swift Current creek	NW. 19	167	124,340	"	"	**L.** Dam, 5 in. pipeline, tank, pumping plant and purification plant.
C.P.R.	" "	"	167	124,340	"	"	**L.** " "
T. 16, R. 12.							
C.P.R.	" "	SW. 25	145	107,654	"	"	**L.** 6 in. pipeline, tank, dam, pumping plant.
T. 17, R. 5.							
C.P.R.	Spring	SW. 32	45	33,642	"	"	**L.** Dam, tank, 4 in. pipeline, pumping plant.
C.P.R.	Slough	NE. 30	145	107,654	"	"	**L.** Pipeline, tank, pumping plant.

INDUSTRIAL.—West of the Third Meredian.

T=Township; **R**=Range; **H. & F**=High and Flood stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted,

Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre feet per Annum.	Imp. Gals. per 24 Hours.	Method.	Stage.	Standing and Remarks,
T. 17, R. 8.							
C.P.R.	Coulee	NE. 9	45	33,642	"	"	**L.** Dam. tank, 4 in. pipeline, pumping plant.
T. 25, R. 5.							
C.P.R.	S. Saskatchewan riv.	NE. 9	241	179,244	"	"	**L.** Pipeline, tank, pumping plant.
T. 29, R. 8.							
C.P.R.	S. Saskatchewan	SE. 21	362	269,136	Pumping	All	**L.** Pipeline, tank, pumping plant.
T. 34, R. 22.							
C.P.R.	Spring	NW. 18	72	53,827	"	"	**L.** " "
T. 35, R. 14.							
C.P.R.	Spring	SE. 35	145	107,654	"	"	**L.** 6 in. " "
G.T.P.	Slough	NE. 27	121	89,891	"	"	**L.** " "
T. 36, R. 5.							
G.T.P.	S. Sask. river	NW. 17	121	89,891	"	"	**L.** " "
City of Saskatoon	"	Within city limits	2,679	1,991,606	"	"	**L.** For Power-house use.
T. 39, R. 8.							
C.N.R.	N. Sask. river	NW. 29	72	53,827	"	"	**L.** Pipeline, tank, pumping plant.
T. 39, R. 19.							
C.P.R.	Slough	NE. 13	246	179,244	"	"	**L.** " "
T. 39, R. 28.							
C.P.R.	Macklin lake	SE. 3	290	134,568	"	"	**L.** " "

T. 42, R. 24.							
G.T.P.	Lake Clare	NE. 6	121	89,891	"	"	L. " "
T. 44, R. 16.							
C.N.R.	N. Sask. river	H.B. reserve	181	134,568	"	"	L. " "
T. 44. R. 17.							
C.N.R.	"	NE. 26.	72	53,827	"	"	L. " "
T. 46, R. 1.							
C.N.R.	McFarlane creek	NE. 13	145	107,654	"	"	L. Dam, tank, 4 in. pipeline, and pumping plant.
T 46, R. 18.							
C.N.R.	N. Sask. river	SE. 7	72	58,827	"	"	L. Pipeline, tank, pumping plant.
T. 47, R. 17.							
C.N.R	Jackfish creek	SE. 8	72	58,827	"	"	L. " "
			West of the Fourth Meridian.				
T. 7, R. 22.							
C.P.R	St. Mary's river	NE. 34	45	33,642	"	"	L. Two 4 in. pipelines, tank, and pumping plant.
C.P.R	"	NW. 34	100	....	"	"	L.
T. 7, R. 28.							
C.P.R	Oldman river	E. 8	145	107,654	"	"	L. 4 inch pipeline, tank, pumping plant.
T. 9, R 1.							
C.P.R	Spring creek	SE. 29	295	215,308	"	"	L. 6 in. pipeline, tank, earth dam, pumping plant.
T. 9, R. 26.							
C.P.R	Spring	SW. 2	72	53,827	"	"	L. Tank, 4 in. pipeline, pumping plant.
T 10, R. 16.							
C.P.R	Belly river	NW. 7	104	76,896	"	"	L. 4 in. pipeline, tank, pumping plant.

INDUSTRIAL SUPPLIES.—West of the Fourth Meridian.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet per Annum.	Imp. Gals. per 24 Hours.	Method.	Stage.	Standing and Remarks.
T. 10, R. 24.							
C.P.R.	Oldman river.	SE. 1	434	322,963	"	"	**L.** Pipeline, tank, pumping plant.
T. 10, R. 27.							
C.P.R.	Willow Creek.	SW. 36	145	107,654	"	"	**L.** 4 in. pipeline, tank, and pumping plant.
T. 11, R. 2.							
C.P.R	Ross creek	NW. 31	45	33,642	"	"	**L.** Dam, 3 in. pipeline, tank, pumping plant.
C.P.R.	"	NW. 31	45	33,642	"	"	**L.** Pipeline, tank, pumping plant and dam.
T. 11, R. 7.							
C.P.R.	Seven Persons creek.	SE. 4	145	107,654	"	"	**L.** Two dams, windmill, and 4 in. pipeline.
T. 11, R. 9.							
C.P.R.	Coulee	SW. 18	23	16,821	"	"	**L.** Dam, 4 in. pipeline, tank, pumping plant.
C.P.R	"	SE. 18	145	107,654	"	"	**L.** Dam, pipeline, tank, pumping plant.
T. 11, R. 11.							
C.P.R	S. Sask. river.	SW. 15	241	179,244	Pumping	All	**A.** 5 in. pipeline, well, pumping plant.
T. 12, R. 5.							
C.P.R.	Ross Creek	NE. 15	45	33,642	Pumping	"	**L.** tank, 4 in. pipeline, and pumping plant.
C.P.R.	" "	NE. 15	145	107,654	Pumping	"	**L.** " "
C.P.R.	S. Sask. river.	Sec. 31	145	107,654	Pumping	"	**L.** tank, 6 in. pipeline, pumping plant.
C.P.R.	S. Sask. river	Sec. 31	145	107,654	Pumping	"	**L.** 6 in. pipeline, well, and pumping plant.

T. 13, R. 9.							
C.P.R.	S. Sask. river	SE. 10	290	215,308	Pumping	"	**L.** 6 in. pipeline, tank, and pumping plant.
T. 13, R. 12.							
C.P.R.	Bow river	SE. 17	145	107,654	Pumping	**H. & F**	**A.** Pipeline, tank, pumping plant.
T. 13, R. 23.							
C.P.R.	Little Bow river	SW. 32	72	53,827	Pumping	All	**A.** Pipeline, tank, pumping plant.
T. 16, R. 28.							
C.P.R.	Mosquito creek	NW. 15	145	107,654	Pumping	**H. & F**	**L.** 5 in. pipeline, tank, pumping plant, and dam.
T. 17, R. 12.							
C.P.R.	Lake	NW. 20	45	33,642	Pumping	All	**L.** Pipeline, tank, pumping plant.
C.P.R.	Slough	NW. 20	145	107,654	Pumping	"	**L.** ditch, reservoir, pipeline, and pumping plant.
T. 18, R. 14.							
C.P.R.	Lake	Sec. 30	45	33,642	Pumping	"	**L.** 4 in. pipeline, tank, pumping plant, and pile dam.
C.P.R.	Lake	Sec. 30	104	76,972	Pumping	"	**L.** reservoir, 4 in. pipeline, timber dam. pumping plant.
T. 19, R. 28.							
C.P.R.	Highwood river	NE. 31	217	161,481	Pumping	"	**L.** Pipeline, tank, pumping plant.
T. 20, R. 12.							
C.P.R.	Little Sand Hill Cr.	NE. 18	145	107,654			**A.**
T. 20, R. 17.							
C.P.R.	Slough	NW. 15	145	107,654	Pumping	All	**L.** Windmill, pump, pipeline, tank.
T. 21, R. 15.							
C.P.R.	Matziwin creek	W½ 6	145	107,654	Pumping	"	**A.** Dam, spillway, pipeline, tank.
T. 21, R. 20.							
C.P.R.	Bow river	Blackfoot Indian Reserve	145	107,654	Pumping	"	**L.** 3 in. pipeline, tank, pumping plant.

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Township and Name of Applicant.	Source of Supply.	Point of Diversion.	Acre-feet. per annum.	Imp. Gals. per 24 hrs.	Method.	Stage.	Standing and Remarks.
T. 22, R. 23.							
C.P.R.	Bow river	Blackfoot Indian Reserve	72	53,827	Pumping	"	**L.** tank, pipeline, pumping plant.
C.P.R.	Bow river	Blackfoot Indian Reserve	72	53,827	Pumping	"	**L.** tank, pipeline, pumping plant.
T. 24, R. 26.							
C.P.R.	Spring	NW. 2	45	33,642	Pumping	"	**L.** 4 in. pipeline, tank, pumping plant.
C.P.R.	Spring	NW. 2	145	107,654	Pumping	"	**L.** 4 in. pipeline, tank, pumping plant.
T. 25, R. 22.							
C.P.R.	Chimney Hill creek	NW. 3	72	53,827	Pumping	"	**L.** pipeline, tanks, pumping plant, dam, and reservoir.
T. 25, R. 25.							
C.N.R.	Serviceberry creek	SE. 21	72	53,827			**AS.**
T. 29, R. 20.							
C.N.R.	Red Deer river	SW. 10	72	53,827	Pumping	All	**L.** pipeline, tank, pumping plant.
T. 31, R. 24.							
G.T.P.	Three Hills creek	NW. 12	121	89,891			**A.**
T. 35, R. 28.							
C.P.R.	Mud Lake	NE. 29	145	107,654	Pumping	All	**L.** pipeline, tank, pumping plant.
T. 37, R. 14.							
C. P. R.	Castor creek	NE. 26	72	53,827	Pumping	All	**L.** Pipeline, tank, pumping plant.

T. 37, R. 23.							
G. T. P.	Stinking Lake	Rd. allce. 27-28.	121	89,891	"	"	**L.** " "
T. 38, R. 17.							
C. P. R.	Little Knife creek	NE., NW. and SW. 28	72	53,827	"	"	**L.** " "
T. 38, R. 22.							
C. P. R.	Red Deer river	SE. 33	217	161,481	"	"	**A.** " "
T. 38, R. 27.							
C. P. R.	"	SE. 20	290	215,308	"	"	**L.** " "
T. 39, R. 21.							
C. P. R.	Lake	NE. 1	145	107,654	"	"	**L.** 6 in. pipeline, tank, pumping plant.
T. 39, R. 23.							
C. P. R.	"	NE. 35	145	107,654	"	"	**L.** 4 in. pipeline, tank, pumping plant.
T. 40, R. 22.							
G. T. P.	Buffalo lake	NE. 22	121	89,891			**AS.**
T. 40, R. 24.							
C. P. R.	Creek	NE. 30	362	269,136	"	"	**A.** Pipeline, tank, pumping plant.
T. 40, R. 26.							
C. P. R.	Barnett's Lake	SW. 31	290	215,308	"	"	**L.** 6 in. pipeline, tank, pumping plant.
T. 43, R. 3.							
G. T. P.	Lake	SE. 28	121	89,891	"	"	**L.** Pipeline, tank, pumping plant.
T. 43, R. 9.							
C. P. R.	Battle river	SE. 6	434	322,963	"	"	**L.** 6 in. pipeline, tank, pumping plant.
T. 43, R. 25.							
C. P. R.	"	SW. 4	45	33,642	"	"	**L.** Dam 2 in. pipeline, tank, pumping plant.
C. P. R.	"	SW. 4	72	53,827	"	"	**L.** Pipeline, tank, pumping plant and dam.

INDUSTRIAL—West of the Fourth Meridian.

T=Township ; **R**=Range ; **H & F**=High and Flood Stages ; **L**=Licensed : **A**=Authorized ; **AS**=Application Submitted.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-feet per Annum.	Imp. Gallons per 24 Hours.	Method.	Stage.	Township and Name of Applicant.
T. 44, R. 21.							
G. T. P.	Little Beaver lake	SW. 3	121	89,891	"	"	**L.** Pipeline, tank, pumping plant.
T. 46, R. 23.							
C. P. R.	Pipestone river	NE. 24	145	107,654	"	"	**L.** 4 in. pipeline, tank, pumping plant.
T. 47, R. 20.							
C. P. R.	Creek	SE. 3	290	215,308	"	"	**L.** Pipeline, tank, pumping plant.
T. 47, R. 24.							
C. P. R.	Bigstone creek	SW. 10	272	261,852	"	"	**L.** Pipeline, tank, pumping plant, and dam.
T. 49, R. 25.							
C. P. R.	Lake	NE. 26	145	107,654	"	"	**L.** Reservoir, pumping plant, and pipeline.
T. 50, R. 6.							
C. N. R.	Vermilion river	NE. 31	181	134,568	"	"	**L.** Pipeline, tank, pumping plant.
T. 50, R. 10.							
C. N. R.	Slough	NW. 14	72	53,827	"	"	**L.** " "
T. 50, R. 18.							
G. T. P.	Amisk creek	SE. 22	121	89,891	"	"	**L.** Pipeline, tanks, pumping plant and dam.
T. 51, R. 4.							
C. N. R.	Slough	NW. 9	72	53,827	"	"	**L.** Pipeline, tanks, pumping plant.

T. 52, R. 20.							
G. T. P.	Cooking lake	NW. 6	121	89,891	"	"	**L.** " "
T. 54, R. 18.							
C. N. R.	Beaver Hills creek	SW. 32	72	53,827	"	"	**A.** Pipeline, tank, pumping plant and dam.
West of the Fifth Meridian.							
T. 7, R. 2.							
C.P.R.	Crowsnest river	NE. 21	145	107,654	Pumping	All	**L.** Tank, 4 in. pipeline, pumping plant.
"	"	NE. 26	145	107,654	"	"	**L.** 6 in. Pipeline, tank, pumping plant.
T. 7, R. 3.							
C.P.R.	Creek	SE. 11	217	161,481	"	"	**A.** Pipeline, tank, pumping plant, and dam.
Frank Lime Co.	Spring	SW. 29	72	53,827	"	"	**A.** 2 in. Pipeline and hydraulic ram.
T. 7, R. 4.							
International Coal and Coke Co.	York creek	NE. 32	362	269,136	"	"	**L.** 2 in. Pipeline, hydraulic ram, and tank.
Rocky Mountain Cement Co., Limited.	Pond	NW. 36	72	53,827	"	"	**L.** Pipeline and pump.
T. 8, R. 4.							
McGillivray Creek Coal and Coke Co.	McGillivray creek.	NW. 8	724	538,272	"	"	**L.** Reservoir ⅝ ac., 8 in. pipeline.
T. 8, R. 6.							
C.P.R.	Summit creek	SW. 12	145	107,654	Gravity	"	**L.** 3 in. Pipeline and tank.
"	"	"	145	107,654	"	**H. & F**	**L.** " "
T. 24, R. 1.							
C.P.R.	Bow river	Within city of Calgary.	362	269,136	Pumping	All	**L.** Tank, pipeline, pumping plant.
T. 24, R. 2.							
Tregillus, W. J.	"	NW. 26	219	538,272	"	**H. & F**	**A.** Pipeline, pumping plant.

INDUSTRIAL.—West of the Fifth Meridian.

T=Township; **R**=Range; **H, & F**=High and Flood Stages; **L**=Licensed; **A**=Authorized; **AS**=Application Submitted.

Township and Name of Applicant.	Source of Supply.	Point of Division.	Acre-feet per Annum.	Imp. Gallons per 24 Hours.	Method.	Stage.	Standing and Remarks.
T. 24, R. 8.							
C.P.R.	Bow river	NW. 30	45	33,642	Pumping	All	**L.** 3 in. Pipeline, pumping plant.
"	"	"	72	53,827	"	"	**L.** 3 in. Pipeline, tank, pumping plant.
T. 24, R. 9.							
Western Canada Cement and Coal Co.	"	SW. 22	7,602	5,651,856	"	"	**L.** 12 in. pump, 18 in. intake pipe.
T. 24, R. 10.							
C.P.R.	Spring creek	Road allowance 32-33.	145	53,827	"	"	**L.** Tank, 4 in. pipeline, pumping plant.
T. 25, R. 4.							
C.P.R.	Bow river	NE. 35	45	33,642	"	"	**L.** " "
"	"	"	72	53,827	"	"	**L.** 4 in. Pipeline, tank, pumping plant.
T. 25, R. 7.							
C.P.R.	"	Stony Indian reserve.	217	161,481	"	**H. & F.**	**L.** Pipeline, tank, pumping plant.
T. 26, R. 12.							
C.P.R.	Forty-mile creek	SE. 2	45	33,642	"	All	**L.** Tank, 4 in. pipeline, pumping plant.
T. 26, R. 14.							
C.P.R	Castle Mountain creek.	NE. 32	145	107,654	"	"	**L.** 4 in Pipeline, dam, tank, pumping plant.
T. 27, R. 1.							
C.P.R.	Nose creek	SW. 12	45	33,642	"	"	**L.** Tank, 4 in. pipeline, pumping plant.

"	"	"	80	59,210	"	"	**L.** Reservoir, pipeline, pumping plant.
T. 28, R. 16.							
C.P.R.	Pipestone creek	SW. 34	434	322,963	"	"	**L.** Pipeline, tank, pumping plant, and dam.
T. 34, R. 1.							
C.P.R.	Lake	SW. 22	145	107,654	"	"	**L.** 4 in. Pipeline, tank, pumping plant.
T. 51, R. 19.							
G.T.P.	Embarres river	NW. 6	145	179,244	"	"	**L.** Pipeline, tank, pumping plant.
T. 52, R. 2.							
G.T.P.	Mink lake	SE. 33	121	89,891	"	"	**L.** " "
T. 53, R. 6.							
G.T.P.	Island lake	Road allowance bet. SE23-SW 23.	121	89,891	"	"	**L.** " "
T. 53, R. 7.							
Pembina Coal Co	Pembina river	NW. 20	112	83,432	"	"	**A.** 2 in. and 4 in. Pipeline, tank, and pump.
T. 53, R. 17.							
G.T.P.	Cabin creek	SE. 16	242	179,424	"	"	**L.** Pipeline, tank, pumping plant.
T. 53, R. 19.							
Edmonton Portl'd Cement Co	Whitemud creek	SE. 7	39	....	....	....	**AS.**
T. 54, R. 11.							
G.T.P	Lobstick river	Road allowance S. of SW. 2	121	89,891	Pumping	All	**L.** Pipeline, tank, pumping plant.
T. 54, R. 13.							
G.T.P.	Carrot creek	NE. 7	121	89,891	"	"	**L.** " "
T. 55, R. 3.							
C.N.R.	Lac Ste. Anne	NE. 3	72	....	....	....	**AS.** No works constructed.

MUNICIPAL SUPPLIES.—WEST OF THE SECOND MERIDIAN.

T = Township; **R** = Range; **H. & F** = High and Flood stages; **L** = Licensed; **A** = Authorized; **AS** = Application Submitted.

Township and Name of Applicant.	Population, 1911.	Source of Supply.	Point of Diversion.	Acre-feet Per Annum.	Imperial Gallons. Per 24 hrs.	Method.	Stage.	Standing and Remarks.
T. 2, R. 8.								
Estevan, Town of	4,325	Souris river	NE. 10	724	538,272	Pumping	All	**A.** 50 horse-power gasoline engine, 2 turbine pumps, 450 Imp. gals.
T. 8, R. 4.								
Arcola, Town of	794	Spring	SE. 26	555	412,854	"	"	**L.** Tank, pipeline, and pumping plant.
T. 8, R. 14.								
Weyburn, Town of	5,413	Souris river, Beaver Dam creek	SW. 29	796	592,099	"	"	**AS.** Not constructed.
T. 13, R. 14.								
Francis, Town of	263	Springs	SW. 26	111	82,893	"	"	**L.** Pipeline, basin, tank, and pumps.
T. 15, R. 23.								
Drinkwater, Village of	200	Coulee	NE. 29	Suff. to fill reservoir		Impounding	"	**A.** Earth fill and timber dam.
T. 16, R. 27.								
Moosejaw, City of	29,800	Snowdy's springs	SE. 9	Total flow		Gravity	"	**A.** 12 in. pipeline, reservoir.
T. 17, R. 13.								
Indian Head, Town of	1,284	Squirrel hills, Springs creek	NW. 20			"	"	**A.** Reservoirs and pipeline.
T. 17, R. 26.								
Moosejaw, City of	29,800	Moosejaw creek	Within city	To fill reservoir 1,653,600,000 gallons			**H. & F**	**A.** Reinforced concrete dam and pipeline.
T. 17, R. 29.								
Moosejaw, City of	29,800	Sandy creek	SE. 29. SW., NW. and NE. 28	Unknown		Gravity	All	**A.** For city of Moosejaw.

T. 18, R. 18.								
Regina, City of........	41,000	Boggy creek ...	NW. 7.	2,172	1,614,816	Gravity and Pumping. ..	**H. & F**	**A.** Reservoir, pipelines, and pumps.
T. 18, R. 19.								
Regina, City of	41,000	Boggy creek. Beaver creek....	Various points	1,448	1,076,544	Gravity	All, **H. & F.** ..	**A.** Collecting galleries, reservoirs, pipeline, and pumping plant.
T. 21, R. 22.								
Martin, Ritchie & Daniel. ..	....	Spring.	Indian reserve No. 80A	290	215,308	....	All	**AS.**
T. 33, R. 4.								
Canora, Town of...........	426	Assiniboia river.	SE. 12.......	721	538,272	Gravity for 25 miles pumping plant....	"	**AS.** Pipeline, reservoir, and pumping plant.
T. 37, R. 22.								
Humboldt, Town of	1,550	Humboldt lake..	Sec. 5	....	....	....	....	**AS.**
West of the Third Meridian.								
T. 10, R. 25,								
Maple Creek, Town of.	936	Springs.	SE. 20........	724	538,272	Gravity	All	**A.** Dam 6 in. woodpipe.
T. 15, R. 14.								
Swift Current, Town of......	5,765	Swift Current creek.........	NW. 18	2,896	2,153,088	Pumping......	"	**A.** Reinforced concrete dam, pumping plant, and pipeline.
T. 29, R. 8.								
Outlook, Town of..........	1,200	S. Saskatchewan river.	NE. 16.	724	538,272	"	"	**L.** 20 H.P. gasoline engine and centrifugal pump.
T. 29, R. 20.								
Scott, Town of......	420	Springs.........	SE. 16.. ...	269	199,698	"	"	**A.** 6 in. steel supply main, 2 storage tanks, 2·2 stage centrifugal pumps, 300 gals. per min. each; 100 B.H.P. oil engine.

* Municipal water supply schemes have heretofore been classified as diversions of water for "other purposes", i.e., other than domestic, industrial, or irrigation; by a recent amendment to the Irrigation Act they are now properly described as "Municipal".

MUNICIPAL SUPPLIES.—West of the third Meridian.

T=Township; **R**=Range; **H. & F**=High and Flood stages; **L**=Licensed; **A**=Authorized; **A S**=Application Submitted.

Township and Name of Applicant.	Population, 1911.	Source of Supply.	Point of Diversion.	Acre-feet Per annum.	Imperial Gallons Per 24 hrs.	Stage.	Method.	Standing and Remarks.
T. 29, R. 23.								
Kindersley, Town of	1,135	Coulee	NW. 2	362	269,136	Pumping	All	**A.** Comp. Duplex pump, 500 gals. min; reservoir, 65 million gals; 25 ft. earth dam, 10 in. steel supply main.
T. 36, R. 5.								
Saskatoon, City of	27,527	S. Saskatchewan river	SE. 29	1,267	941,976	"	"	**L.** Pumping plant, water tower, pipe line.
Saskatoon, City of	27,527	" "		41,174	3,061,152	"	"	**A.** Pumping plant, water tower.
Sutherland, Town of	1,200	" "				Through works of city of Saskatoon		**AS.**
T. 43, R. 16.								
Battleford, Town of	2,000	N. Saskatchewan river	SE. 31	724	538,272	Pumping	All	**A.**
T. 44, R. 16.								
North Battleford, City of	5,868	" "	Rd. Allce. W. of SW. 6	724	538,272	"	"	**AS.** Two triplex pumps, 300 gals. per min; 8 in. and 12 in. force main; 50 B.H.P. gasoline engine.
T. 48, R. 26.								
Prince Albert, City of	12,800	" "	River Lot 72	1,810	1,345,680	"	"	**L.** Sedimentation basin, pipeline and pumping plant.
T. 3, R. 25.								
Cardston, Town of	1,400	Lees creek	Within town limits	2,095	1,557,220	"	"	**A.** Pipeline, tank, pumping plant, and reservoir.

T. 6, R. 30.								
Municipal Water and Light Company (Pincher creek)..	1,027	Pincher creek...	S½ of SE. 21..	724	538,272	Gravity.....	"	**AS.** Water supply for Pincher creek, pipeline, and infiltration gallery.
T. 8, R. 22.								
Lethbridge, City of	10,072	Belly river......	SE. 36........	10,860	8,074,080	Pumping.	"	**L.** Two 6 in. vert. turbine pumps; two 6 in. hor. turbine pumps; one Worthington duplex steam pump, stand pipe, and distributing system.
T. 9, R. 21.								
Chinook Coal Co............	250	"	NW. 31.	181	134,568	"	"	**A.** 6 in. pipeline, electrically driven pumps.
T. 9, R. 22.								
Lethbridge Collieries Ltd....	500	"	NW. 7.......	724	538,272	"	"	**L.** 6 in. pipeline, tank, and pumping plant to supply mining camp.
T. 9, R. 26.								
Macleod, Town of..	2,510	Oldman river....	NE. 11......	724	538,272	"	"	**L.** Tank, pipeline, pumping plant.
T. 10, R. 16.								
Taber, Town of.......... ...	2,321	Belly river......	NW. 7........	145	107,654	Pumping through works of C.P.R. Co.	"	**L.** 4 in. pipeline.
T. 10, R. 17.								
Canada West Coal & Coke Co., Ltd.....	....	"	NE. 9...	362	269,136	Pumping. ...	"	**L.** 10 in. pipeline and pumping plant, to supply plant.
T. 12, R. 5.								
Medicine Hat, City of..... .	16,000	S. Saskatchewan river	SW. 31.......	1,354	1,006,568	"	"	**L.** 24 in. pipeline.
T. 12, R. 6.								
Medicine Hat, City of......	16,000	" "	NW. 35......	6,717	4,993,549	"	"	**A.** Filter beds, 20 in. steel main; reservoir, 2,320,000 gals; 3 high-pressure pumps; 3 low-pressure pumps.
T. 12, R. 28.								
Claresholm, Town of..	809	Willow creek....	NE. 23... ...	724	538,272	"	"	**A.** Electric turbine pump, 8 in. pipeline, and infiltration galleries

MUNICIPAL SUPPLIES.—West of the Fourth Meridian.

T=Township; **R**=Range; **H. & F**=High and Flood Stages; **L**=Licensed: **A**=Authorized; **AS**=Application Submitted.

Township and Name of Applicant.	Population, 1911.	Source of Supply.	Point of Diversion.	Acre-feet per Annum.	Imp. galls per 24 hours.	Method.	Stage.	Standing and Remarks.
T. 13, R. 6.								
Redcliffe, Town of	450	S. Sask. river	SE. 6	181	134,568			**A.** Stand-pipe, 200,000 imp. galls.
T. 13, R. 23.								
Carmangay, Town of	410	Little Bow river.	SW. 32	Not yet fixed.		Pumping	**H. & F**	**AS.**
T. 21, R. 18.								
Bassano, Town of	545	Bow river	Blackfoot Indian reserve.	581	431,955	″	**H. & F**	**L.** 10 in. pipeline, duplex pump, 300 imp. galls. per minute.
T. 38, R. 27.								
Red Deer, Town of	2,118	Red Deer river	SE. 20	1,448	1,076,544	″	All	**L.** 12 in. force main, pumping plant.
T. 53, R. 24.								
Edmonton, City of	67,243	N. Sask. river	Within city limits.	1,303	968,889	″	″	**L.** Water tower, pipeline, pumps.
T. 53, R. 25.								
Canadian Coal & Coke Co.	500	Sturgeon river	Riv. lot 54	181	134,568	″	″	**A.** 4 in. pipeline, steam boiler and pumping plant.
T. 6, R. 2.								
Western Coal & Coke Co.	500	Canyon creek	SE. 4	121	89,891	Gravity	″	**AS.** Dam, pipeline, pumping plant.
T. 7, R. 1.								
Municipal Water & Light Co	200	Springs	NW. 17	72	53,827	Pumping	″	**A.** For town of Cowley, 4 in. wooden pipe, 5,000 gal. tank.

T. 7, R. 3.								
Hillcrest Collieries, Ltd.....	1,000	Drum creek.....	NE. 18.......	470	349,876	"	"	**L.** Dam and pipeline.
West Canadian Collieries....	Unknown.	Creek	NE. 29.	181	134,568	"	"	**L.** Water supply for Bellevue dam, reservoir 4 in. pipeline.
T. 7, R. 4.								
Blairmore, Town of	1,666	York creek. ..	NW. 34	1,418	1,076,544	Gravity	"	**A.** 26 ft. concrete dam, 12 in. supply main.
T. 8, R. 3.								
West Canadian Collieries....	200	Bear creek	NE. 18. ..	14,480	10,765,440	"	"	**L.** Dam, reservoir, 8 in. pipeline for village of Lille.
T. 8, R. 4.								
International Coal & Coke Co.................. ...	1,557	Nez Percee creek	SE. 17..... .	3,620	2,691,360	Pumping......	"	**L.** Waterworks, Town of Coleman.
T. 22, R. 5.								
Calgary, City of......... ...	81,851	Elbow river.....	NW. 29	32,037	23,817,536	Gravity	"	**AS.** Supplementary supply.
T. 24, R. 1.								
Calgary, City of	81,851	"	NW. 16	14,480	10,765,440	Pumping......	"	**L.** Waterworks.
T. 24, R. 3.								
Calgary, City of	81,851	"	NW. 10	11,439	8,504,697	Gravity	"	**A.** Wood stave pipe, reservoir
T. 25, R. 12.								
Banff, Town of..............	500	Forty Mile creek	....	362	269,136	" ...	"	**L.** 10 in. pipeline, tank and water works distributing system.

REPORT OF M. H. FRENCH, INSPECTING ENGINEER.

PARTY No. 1.

CALGARY, January 23, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following report for the year 1913, describing briefly the work done under my supervision in the eastern division of the Cypress Hills Irrigation district.

After arriving in Maple Creek on April 25, I immediately commenced the assembling of the party and equipment at a temporary camp just west of the town. Camps were afterwards established successively at the following places: Bigstick lake, on May 12; Hay creek, at Peacock's ranch, on May 23; Bear creek, at Skibbereen, P.O., on June 10; Skull creek, at Skull Creek P.O., on June 20; Jones coulee, on July 7; North branch of Frenchman river, at Cross' ranch, on August 1; Fairwell creek, at Drury's ranch, on August 22; Battle creek, at Richardson's ranch, on September 13; Belanger creek, at Williamson's ranch, on October 10.

The outfit was moved into Maple Creek, October 21, equipment stored away and horses returned to Needham's ranch. From that date until November 22, I was engaged in making a few reinspection surveys, etc., to complete the season's work.

The personnel of the party this season, the equipment, the area of the country covered, the methods used in making the inspections and surveys, were in every respect very similar to those of the previous year, and to go more into detail would merely be a repetition of previous reports.

An attempt was made this year to complete the amendment of all detail and general plans of the irrigation schemes in the district. This will be of great service in the future in checking up the amount of water used, or required, by the different irrigators, and in arriving at a proper duty of water.

This year was a favourable one for construction work, and a fair amount of work was done upon the unlicensed schemes, most of which are practically ready for license. A little work was also done upon the licensed schemes in the way of new ditches, headgates, and diversion dams. Very few dykes or laterals were constructed. There is still plenty of room for improvement upon many of the older schemes in the way of repairing the structures, cleaning out the ditches and extending laterals over small areas not now irrigated. Many of the irrigators, through indifference or pressure of other work, are inclined to neglect their works unless encouraged and urged a little. While the successful attempts of one or more irrigators in any locality are an ample object lesson, and a sufficient incentive to most people to keep their works in serviceable condition, unfortunately there are a few cases where more encouragment is required, or failing that, where coercive measures may be necessary.

The fact that nearly all of the water which is available for irrigation purposes runs off early in the spring, when it is hardly needed, makes the subject of reservoirs one of paramount importance to the irrigators. There are quite a number of sites in the district, but whether the cost of storage per acre-foot would be such as could be borne jointly by those irrigators interested is yet to be determined. Before this can be done the duty of water must be determined and the cash value of the water per acre-foot to be applied to the land must be estimated as closely as possible. This last is something that will require years to decide.

The hydrographic work consisted in making stream measurements when time permitted, and in establishing gauging stations in the irrigation ditches.

The problem of obtaining accurate data relating to the quantity of water used upon every irrigated farm is a very difficult one. There are various reasons for this. In a great many cases the gauges must be placed in the ditches long distances from any farm house, and consequently will only be read occasionally. Some farmers do not see the use or necessity of knowing how much water is applied to the land, and therefore consider the demand to read the gauges as an imposition on the part of the department. There are others that consider it folly, or a waste of time, and will not make any effort whatever to submit reliable records. Furthermore, there are a few schemes where it is almost impossible to obtain the quantity of water used, such as hay meadows naturally flooded every year during high water. The inaccuracy of the results to be obtained from ordinary ditch stations on account of changing conditions will be considerable; this, however, can be remedied by the construction of weirs or rating flumes. Thus it is evident that it will require an almost endless amount of work on the part of the department and others interested to obtain reliable records from only the more important ditches.

The conditions in this district are altogether different from those of the larger irrigation schemes of the west, where water can be applied at any and all times of the year in a scientific manner. Here, nearly all the water available for irrigation purposes runs off early in the spring, and is turned upon the land in a flood, and then is gone for another year. Only upon a very small percentage of the irrigable area can water be applied at all according to the best irrigation practice of the west.

It would be well for the field engineers of the district to secure as many seepage and evaporation records as possible these data would be of great value in the construction of reservoirs.

The following data summarize briefly the season's work:—

Number of inspections	103
Number of re-inspections	11
Number of schemes recommended for license	15
Number of schemes recommended for cancellation	6
Number of new schemes	3
Number of licensed schemes	60
Number of miles travelled by democrat	2,683
Number of miles traversed	77.3
Amended detail plans submitted	10
Amended general plans submitted	29
Rainy days, exclusive of Sundays	14

Your obedient servant,

M. H. FRENCH,

Inspecting Engineer.

CROP REPORT FOR THE YEAR 1913, BY M. H. FRENCH, INSPECTING ENGINEER.

PARTY NO. 1.

CALGARY, February 12, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following crop report for the eastern part of the Cypress Hills Irrigation district for the year 1913.

The present state of irrigation in this district, that is the amount of time and money expended in the actual irrigation of the land, the areas irrigated, and returns therefrom, is practically the same as for the last three or four years. There has been no appreciable increase in the use of water or in the areas seeded to alfalfa or other cultivated grasses. The people have been too niggardly in the time and labour spent upon the land, and the results have therefore not been as good as they otherwise would have been. This lull is probably only temporary, and the next few years should witness a considerable increase in the quantity of water used. There is no reason to believe, however, that irrigation in this district will reach as high a state as is found in other districts more favoured by climatic conditions, and with a regular water supply, but no doubt the extra returns from the applications of water to the land will more than justify a reasonable expenditure in irrigation works.

This last season was not a very favourable one for growing crops of any kind. The spring was not only late and cold but was followed by severe drought in June. Those irrigators who were fortunate enough to be provided with ample reservoirs, or were able to divert a little water from the creeks for a second watering of the land, received good crops, while the others did not.

The irrigation of grass in early spring, which is not followed by a later irrigation, is of very little use upon slightly rolling lands or lands from which the water readily runs off. The soil bakes and dries up before the grass is high enough to shade the ground, with the result that the grass scarcely grows sufficiently high to be cut. This was seen upon nearly every hay meadow in the district. The higher lands merely irrigated from the ditches in the spring produced almost no crop, while the lower lands upon which the water naturally lay, or was held artificially by means of dykes, produced a fair yield. Water that lies upon hay meadows to a depth of 3 feet to 4 feet for an indefinite period seems to cause a heavy, rank growth of grass. This is very noticeable upon the lower parts of hay meadows and along the sides of very shallow sloughs. If, however, the water is deeper than a few inches, and is not drained off after a short period, it kills out the native blue-joint, or cultivated grasses, and encourages the growth of "water grasses."

Good judgment must be used in allowing water to lie upon the land, as this standing water dissolves and brings to the surface the soluble salts of the soil which are very injurious to plant life if deposited on the surface. In time this would ruin the hay meadows. It can be prevented by draining off the water after being upon the land for a short while, thereby carrying off injurious salts in solution. That this flooding of the land once or twice every season improves the quality and composition of the soil is proven upon the fields of Mr. F. W. Peacock. Several small areas that, previous to irrigation, were covered with white alkali and yellow alkali grass, are now producing a good growth of blue-joint grass, this being due to the alkali being dissolved and carried away by the water.

One system of irrigation that seems to have found favour with most irrigators is the dyking system. The reason for this is because of the intermittent flow of the streams. These dykes to some extent take the place of reservoirs, by impounding the flood waters for a certain period of time after the high-water stage in the creeks has past. A considerable amount of money has been spent by several irrigators in the construction of dykes, and it will be interesting to see what results are obtained from these lands.

A few exceptionally good crops were obtained by different persons this last season. Mr. J. C. Strong at East End had a field of about 60 acres of timothy and clover that would rank well with any seen in Eastern Canada. The timothy was 30 inches high, and was very thick and even over the whole field. Clover seed had been sown with the timothy, and there is now a good catch averaging about 20 inches high. This field was seeded down some years ago and has been irrigated well ever since. The soil is a fairly heavy clay loam provided with good drainage.

Earl Nash, at Nashlyn post office, has had fair success in growing alfalfa on an experimental scale. He believes that the same results could just as easily be obtained from three or four hundred acres of his land as from a few acres, but other work has prevented him from giving to this field any more than average attention and care.

In 1912, 800 pounds of alfalfa seed were threshed out and sold in Chinook, Mont., for $18 per hundred pounds. This year two fair crops were taken off, and the third growth in September stood about 8 inches high and was very thick and even all over the field. This field was sown with inoculated seed, using the usual amount. Water was applied whenever the soil appeared to be getting dry. The surface soil is a medium clay loam underlaid, very probably at a depth of six or eight feet, with a stratum of gravel and sand, as the observation of the strata along the creek banks tends to show.

Mr. T. Drury, at the head of Maple creek, and Mr. Pearce, on the Frenchman river, had very good results with alfalfa this last season upon small plots of ground. The land was covered with scrub timber at one time, and the soil is naturally very porous and easily worked up. It consists of a clay loam filled with a great deal of humus from decayed vegetation, underlaid at a depth of about three feet with a stratum of gravel. Perhaps less than 1 per cent of the irrigable land in the district is so well adapted to the growing of alfalfa. The second crop looked as good and thrifty as any seen in the vicinity of Lethbridge at the time of the convention on August 7. The ground had been cropped to potatoes and other vegetables for a few years. The alfalfa seed was sown with inoculation at the usual rate per acre. Very little water was applied on the surface, as it is thought that the alfalfa is sub-irrigated from the gravel strata below.

Heavy yields of bromus have been obtained for four or five years by Messrs. Stearns Bros. from a small field of about 20 acres. They did not have the trouble experienced by other growers of bromus by the land becoming "sod bound" or run out in the second or third years. Their land has been seeded down for five years and is just now beginning to get too soddy for a good crop.

Mr. A. M. Cross prevents the grass roots from getting too thick by ploughing his meadows very shallow every third spring after the grass has started to grow. By this system he gets two good crops and one light one every three years. Bromus is not considered nearly as good feed as timothy or Western Rye, but it seems to make up for that defect by bulk.

Mr. F. W. Peacock and Mr. Joseph Dixon, near Maple Creek, are now getting over 1 ton per acre of blue-joint hay from their irrigated meadows. By improving their irrigation systems, and seeding their land down with cultivated grasses, a yield of at least 1½ tons per acre on the average every year should be obtained. Their hay is all being disposed of in Maple Creek and Medicine Hat at from twelve to eighteen dollars per ton. This is much better than growing grain, and is furthermore practically unaffected by drought or hail.

Although the above results are better than the average for the district, it is not because of the superiority of the soil altogether or the location or lie of the land, but is due chiefly to the fact that a reasonable amount of money has been expended in irrigation works, and a reasonable amount of time and labour spent in applying the water to the land.

The following statistics give very closely the state and extent of irrigation in my district for the year 1913:—

1913.	Total Irr. area.	Irr. in 1913.	Per cent.
Licensed schemes	25,808	7,670	37·5
Unlicensed schemes	9,647	650	6·7
Totals	35,455	8,320	44·2

Of that area which was irrigated in 1913, a large part could be much more efficiently irrigated by applying a little more work to the land.

In conclusion it must be pointed out that although water is being applied by many irrigators with excellent results, there are still large areas upon which little or no water is being applied, and although the future looks more encouraging, still it will be some time before a large percentage of all the irrigable land of the licensed schemes will be efficiently irrigated.

Your obedient servant,

M. H. FRENCH,

Inspecting Engineer.

REPORT OF H. R. CARSCALLEN, INSPECTING ENGINEER.

PARTY No. 2.

CALGARY, March 3, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit herewith my report on the work done in the Western Maple Creek district under my supervision during the season of 1913.

In accordance with instructions of May 3, the outfit stored in Maple creek by Mr. H. J. Duffield the previous season was taken over by me. Camp was set up near town on May 7, and the ordinary routine work of getting horses into shape, outfitting the camp, etc., was proceeded with. While camped at Maple Creek an inspection trip was made to a scheme near Many Island lake. This trip lasted from May 12 to 17. On May 20 the first working camp was pitched about 16 miles southwest of Maple Creek. Exclusive of that at Maple Creek, twelve camps were made throughout the season, and the party returned to that place on December 2. The outfit was stored the following day and the party disbanded. Five of the seven horses were taken out to Mr. Needham's ranch on December 4, a team being kept up for a special trip southwest of Maple Creek. The field work for the season was finished on December 11.

The following is a list of the camps with the dates on which they were pitched: Near Geo. Pollock's ranch, May 20; near old Fort Walsh, May 29; W. S. Wilson's pasture, June 20; W. X. Wright's pasture, July 8; M., M. M. & D. Spanglers' pasture, July 23; V. W. Heydlauff's pasture, Aug. 4; B. A. Jahn's pasture, Aug. 12; Wm. Mitchell's pasture, Aug. 22; at Eagle Butte post office, Sept. 17; Hooper and Huckvale ranch, Oct. 11; On Bullshead creek near Medicine Hat, Oct. 30; Geo. Crichton's ranch, Nov. 18; Maple Creek, Dec. 2.

The work in the western district was particularly heavy this past season, due in a great measure to the fact that a large number of schemes were completed and required to be valued and traversed, amended plans prepared, etc. This entailed a considerable amount of office work. A number of schemes were not quite finished on first inspection, and particular pains were taken to hurry them along to completion during the season, necessitating in some cases a return to the scheme and another inspection. In all, thirty-four surveys were made during the season, including some of the largest schemes in the district. Mr. J. A. Tom, who was taken on as rodman and draughtsman, spent the greater part of his time in camp, plotting up these surveys and making the necessary plans, etc.

The following schedule gives in brief and concise form the work accomplished during the season of 1913, together with other information which may be of interest:—

Period of field work	May 13 to Dec. 11
Number of working days	183
Number of days unsuitable for field work	16
Number of days of actual work	167
Number of inspections made	97
Number of re-inspections	9
Number of licensed schemes in district	34
Number of new applications	5

Number of schemes recommended for cancellation..................	3
Number of schemes on which additional water right was applied for..	2
Number of schemes valued for license	13
Total number of schemes recommended for license	21
Number of gauges established	1
Number of gaugings made	36
Number of miles travelled by democrat	4,432
Number of miles traversed	133

The outfit used in carrying on the work was identical with that used by the previous inspector as provided by Mr. R. J. Burley. It was found to be very suitable and in every way adequate for all purposes. The camp equipment was made up of five tents with the accompanying requisites, and transportation was effected by eight horses, two democrats, and one heavy wagon. Six men in all were carried. Considerable survey work still remains to be done in this district, and this outfit should be maintained at least another season.

In carrying on the work, camp sites were so located as to be as nearly as possible in the centre, not necessarily of the district which it was intended to work, but of the schemes on which most work was to be done, having due regard, of course, to the availability of water and good feed for the horses. The work done from each camp was so accomplished that all surveys, valuations, etc., were made first, such work requiring the services of the entire camp. The schemes on which inspections only were to be made were left until the last, and these inspections were always made by myself with one man. This left the balance of the party free to do the office work in connection with the surveys and valuations.

The above schedule shows that during the season thirty-six gaugings were made and one gauging station established by the party. This work was done by my assistant, Mr. H. O. Brown. Practically all of this work was done in the early part of the season, before the middle of July. After that time the party was located in a very dry section of the country, where the streams for the most part have no flow during the greater portion of the year. A few more gaugings might have been made later on in the season, but, owing to the pressure of irrigation work, it was thought unwise to spend any time on hydrographic work, particularly as this work was being covered very well by the district hydrographer. For the same reason, little attention could be given to the establishing of gauging stations on irrigation ditches. More of this work can be done during the coming season. The proper type of station for all ditches which have sufficient fall is probably a permanent weir station with a gauge rod above the weir, from which the gauge height observations may be taken. This is the type of station advocated in Mr. M. H. French's report for 1912, and is the one established on Lindner Bros. ditch in 1910, and which has given good satisfaction. As Mr. French pointed out, for ditches with a grade too low for a weir to be established, good results may be obtained by the insertion of an artificial controlling section below the gauging station.

On some of the schemes in my district which are finished up and ready for operation, it will be a matter of extreme difficulty to secure reliable records of daily gauge heights, on account of the distance that the owners live from the head of their ditches, or from the lowest point on the ditches at which a gauging station can be established in order that the total amount of water diverted may be recorded. In such cases, it is hardly reasonable to expect the irrigators to make daily observations, entailing, as it would, a journey of one or two miles and return each day. During the period when water would be used in the ditches, the irrigators would probably find it necessary to visit their headgates, and consequently the vicinity of the gauges, twice a week, and at such times accurate observations of the gauge height could be obtained. It would seem that these few accurate readings would be of much more value than the "guess-work" records which would very probably result, were the owners of the schemes ordered to make readings every day.

The class of work being put into the construction and maintenance of irrigation schemes in the district is gradually improving. This is due in a great measure to the present high standard called for by the department. The great majority of plans sent in and accepted for the older schemes were very crude, and gave the man constructing the works very little to go upon. The consequence was that no attempt was made to follow the plans, but the works were put in according to the man's own ideas, which might or might not be of value. Now, the plans sent in for any scheme must be approved by a competent engineer, and it becomes the duty of the district inspector to see that the works are constructed according to the plans.

Another factor making for the uplifting of the general standard of irrigation works is the increased interest taken in irrigation by the owners of schemes as the advantages derived therefrom become more and more apparent. The majority of these men are stock raisers. The open range is almost a thing of the past, and they have to depend almost entirely on the small leases available for their summer grazing lands and on their hay meadows for their winter feed. Their irrigable land is devoted almost entirely to the growth of fodder. The beneficial results of the proper application of water, and the rapidly increasing value of the hay crops have combined to show the owners of irrigation schemes that their water rights are of value, and that, the higher the standard to which they can bring their works, the better will be the results obtained from their use. This is true mainly of the older irrigators, many of whom have had their works so far advanced for a number of seasons as to be able to use at least a portion of the water to which they are entitled, and to beneficially apply it towards the improvement of hay and other crops. Practically all of the men holding irrigation rights in this section of the country started with little or no knowledge of the proper methods to follow, and it may be said that those men whose works, although delayed in their completion, have been, in part at least, in working order for some seasons are the real experimenters. The knowledge gained by them has been of great benefit to the district in general, not only in proving the benefits of irrigation, but in teaching the proper methods to follow both as regards the application of water and the construction of works. These men are not only willing to adopt suggestions from the departmental officers towards the improving of their schemes, but are themselves substituting better structures whenever the old ones become unfit for use.

With but very few exceptions, all the schemes in the district are located on streams which flow only in the spring, or occasionally in the summer after periods of heavy rain. As a consequence, the irrigator is restricted to one good supply of water during the spring run-off, with the possibility of a small flow for a short time in the summer. As stated above, the greater portion of the irrigable land in the district is devoted to the growth of wild hay, and this particular kind of crop appears to do very well with the present system of irrigation. However, other crops such as grain, alfalfa, and cultivated grasses, will be grown more extensively as the country settles up and the value of land increases, and a more steady and permanent water supply would be very desirable. It is a recognized fact that by far the greater portion of the run-off from the Cypress hills goes entirely to waste as far as concerns the irrigation schemes in that district. Many good reservoir sites are available, some of which have been investigated by the department, but no effort has been made up to the present to construct the works necessary to conserve this wasted water. Such work cannot be undertaken by individuals, nor, even if their financial circumstances would permit, would it be fair to expect this, since the benefits accruing from such undertakings would be shared to a greater or less degree with every irrigator as well as every resident located lower down on that stream. It is therefore essentially a matter for the Government of the country to handle. The cost and maintenance of such works could be repaid within a certain period of time by charging each person concerned a sum commensurate with the benefits which he derives. As the district becomes more and more settled, the securing of suitable reservoir sites is becoming increasingly difficult and expensive, the land affected being now practically all taken up and increasing in value. In addition to conserving water which now goes entirely to waste, such reservoirs would practically eliminate the sudden floods now prevalent on all the streams and the resulting damage.

In spite of the large amount of traverse work done in 1913, there still remain a number of schemes which are sufficiently far advanced to be traversed. This work, together with the ordinary inspections and the increased amount of hydrographic work contemplated, combine to assure a full season's work to the party in this district the coming year.

Your obedient servant,

H. R. CARSCALLEN, B.A.Sc., D.L.S.,
Inspecting Engineer.

CROP REPORT FOR THE YEAR 1913, BY H. R. CARSCALLEN, INSPECTING ENGINEER.

PARTY NO 2.

CALGARY, March 3, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit herewith my crop report for the Western Maple Creek district for the season of 1913.

As may be expected, from the fact of its being a ranching country, practically all of the irrigable land in the district is used for the growing of feed for stock. The greater portion is uncultivated land growing natural grass, mainly blue-joint. The irrigable flats are for the most part located along the valleys of the streams from which the water supply is obtained, and these flats are as a general rule composed of a heavy gumbo soil, which, without the application of water, is barren and unproductive. A very marked degree of success has been reached on this class of soil by the beneficial use of water, a splendid growth of natural blue-joint grass resulting with from two to three years' irrigation. The yield generally varies from 1 to 2 tons per acre. This year's crop was somewhat below the average, due to lack of water. Very little snow fell in the Cypress hills during the winter of 1912-13, and the spring run-off was correspondingly small. An average natural hay crop for 1913 would be about 1 ton to the acre, with an occasional meadow yielding as high as 1½ tons to the acre.

It was found that many of the older meadows were becoming useless for the raising of natural hay on account of the increasing prevalence of foxtail grass. Some meadows, after producing natural hay crops under irrigation for several seasons, have become what is locally termed as "root-bound," that is the roots have become over-developed and retard the growth in the grass itself. A case of this kind was encountered at Tenmile, in the meadow of Lindner Bros. This meadow has produced hay for a number of seasons under irrigation, and up to a year or two ago was one of the finest blue-joint meadows in the district, but for the last two seasons has produced very little.

In all such cases where the meadows have become unfit for the raising of natural hay it is necessary to break up the land and sow cultivated grasses, grain, etc. The owners have seen this for themselves, and are starting to cultivate the older meadows. Timothy, Brome grass, and Western Rye grass have been grown under irrigation in different parts of the district with very good results.

Very good success has been attained in the growth of alfalfa, although the raising of this crop is merely in its experimental stage, only a few men in the district having attempted it. Several new meadows were sown in 1913, and a good stand was secured in all the cases investigated.

A considerable amount of grain, mostly oats, is grown in the district, but the greater part of it is sown and cut for green feed. However, some exceptionally heavy yields have been recorded as harvested from irrigated land in this section, thus proving that grain crops can be grown to advantage. With the settling up of the country and the resulting better market and shipping facilities, more grain will be grown to maturity in the future.

The lack of a convenient market has also prohibited the greater number of irrigators from the growing of garden produce for anything but their own use. Enough, however, has been done in this line to prove that practically anything of this nature can be raised with the best of results. Several men in the vicinity of Medicine Hat have gone into market-gardening, one quite extensively. This man, Mr. Francis Wright, has 60 acres under irrigation, and has had remarkable success in the growth of garden produce for several seasons. From half an acre planted to cucumbers and corn he realized $350 this season. He also grows successfully potatoes, turnips, mangels, sugar beets, table beets, onions, cabbage, tomatoes, parsnips, peas, lettuce, radishes, and beans. Such men have demonstrated the possibilities that may be attained by a thorough system of intensive farming with the aid of a little water, judiciously applied.

It has been found next to impossible to obtain reliable records from the water users in the district as to the crops grown on their irrigated land, amount of land sown to each kind of crop, the yield, quantity of water used, when used, etc. It is impossible for anyone who has not had the actual experience in the field to appreciate the difficulties which arise when trying to gain this information. The men, being for the most part ranchers, grow their crops for the purpose of feeding their own stock, and keep no account of the yield, except in a very haphazard manner. With regard to the quantity of water used for each particular crop, no record whatever is kept, generally speaking, the irrigators attaching no importance to this class of information.

Only a very small percentage of the irrigable land in the district has as yet been efficiently irrigated, although a large area of unbroken land is flooded each year, with beneficial results in the growth of wild hay. Enough has been done, however, in the irrigation of all grain crops, cultivated grasses, and vegetables to demonstrate that these can be grown successfully. The value of the yield per acre from land growing these crops is, of course, much greater than from wild hay land, and it is only a question of time when a large part of the irrigable land in the district will be cultivated and devoted to the growth of such crops.

Your obedient servant,

H. R. CARSCALLEN,

Inspecting Engineer.

REPORT OF R. H. GOODCHILD, INSPECTING ENGINEER.

PARTY NO. 3.

CALGARY, ALTA., March 5, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit herewith a report of the work done by me in the Calgary Irrigation district during the season of 1913.

This district, comprising the area lying west of the Calgary and Edmonton railway, and between townships 2 and 28, is the oldest settled district in Alberta, and the irrigation schemes are, for the most part, covered by licenses of long standing. They are nearly all in the ranching country, and, if used at all, are used for the purpose of promoting the growth of crops for feed.

During the past twelve years or so, except during 1910, which was exceptionally dry, the precipitation has been plentiful, and there has therefore been little need for irrigation, with the consequent result that many of the licensees have not felt inclined to maintain their irrigation works in good repair, and a certain amount of missionary work is necessary to get these license holders to realize the advisability of keeping the works always in serviceable condition.

My work during the past season consisted of the inspection of authorized schemes, consulting with advising owners as to methods of repairing and maintaining the works, investigating the feasibility of new schemes, and of laying out schemes found to be feasible, and also of obtaining information with regard to results obtained through irrigation. Although at first glance no reason appears why any trouble should arise in connection with the obtaining of this information, it is a most difficult thing to do. The water users for the most part use little or no system in irrigating, and as they do not grow crops for sale, but only for the use of their stock, they keep no records, and frequently do not know how much they cut, and figures which can be obtained are often of little or no value.

The weather conditions during the past season were, on the whole, very favourable for outside work, and comparatively few days were lost through inclement weather. The number of schemes to be inspected during the season was 126. Outside work began on May 2, and before returning to the Calgary office on December 4, all but one of these schemes had been inspected, and twenty-three re-inspections made, bringing the total number of inspections up to 148.

A brief summary of work is given below.

Inspections—	
Number of irrigation schemes inspected	116
" domestic schemes inspected	3
" municipal schemes inspected	3
" industrial schemes inspected	3
Total	125
Number of re-inspections	23
Total	148

Number of schemes licensed, and in good standing	102
" " recommended for license	2
" " " cancellation	23
" " " partial cancellation	2
New applications reported on	6
Distance travelled—	
Miles travelled by trail	2,080
" " rail	553
Total	2,633
Number of surveys made	10
" new schemes laid out	1
" extensions to old schemes laid out	2
" right of way surveys made	2
" miles of traverse run	7
" gaugings made	20
" general plans made	4
" sets of detail plans made	8
Time taken—	
May 2 to December 4, inclusive ... days	217
Number of days spent on inspection work	162
" " lost through rain or snow	17
" " " other causes	7
Sundays	31
Total	217

A large number of schemes in this district taking their supply from springs having small and in some cases almost no flow, are being maintained, not with a view to irrigating at any future time, but simply to ensure that no other person will be granted a right to use the water from such creeks. The flow from these creeks is of no value for irrigation purposes, but the present licensees fear that if they allow their rights to lapse, some other party will come in and obtain the right to divert water from these creeks, and cause them very serious inconvenience and loss. These license holders are therefore being put to an unnecessary expense to maintain works which are absolutely of no value. Their schemes should, in my opinion, be cancelled, but before any such action is taken the licensees should receive assurance that no other party will be able to come in and obtain a license for these waters, and that, in the event of the creeks resuming their normal flow, or a flow sufficient to be of value for irrigation purposes, they, or their assigns, should be given priority in the granting of future licenses for the use of water from these streams.

As would naturally be expected, unfamiliarity with the country, the different projects, and conditions generally, made progress slow and work difficult.

Your obedient servant,

R. H. GOODCHILD,

Inspecting Engineer.

CROP REPORT FOR THE YEAR 1913, BY R. H. GOODCHILD, INSPECTING ENGINEER.

Calgary, April 1, 1914.

F. H. Peters, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

Sir,—I have the honour to submit herewith, the annual crop report for the Calgary Irrigation district for the year 1913.

The crops grown in this district by the aid of irrigation were produced for fodder purposes entirely. The percentage of authorized schemes in actual use is small and, as intimated in my general report, the precipitation during 1913 was plentiful, and irrigation was little needed in most parts of the district.

The authorized schemes in this district comprise an irrigable area of about twenty-six thousand acres, but the total area irrigated in 1913 was only about one thousand acres.

CROPS.

Wild hay, alfalfa and timothy are the principal crops, while a few attempts are being made, with more or less success, to irrigate for oats, but for green feed only.

NATURAL OR WILD HAY.

As a general thing, in irrigating for wild hay, little system is used, and in some cases little care either. Frequently the headgates are opened and the water is allowed to run down the ditch, no attempt being made to turn the water out over the land, and any benefits derived are due to the process of sub-irrigation or seepage from the ditch.

In a few cases where wild hay is grown, rude attempts are made to flood the land, but through a useless extravagance of water over-irrigating it, sometimes resulting in serious damage being done to both land and crop.

The use of small portable dams to be placed in the laterals, which can be easily moved as the occasion requires, and the judicious location of plough furrows leading from the laterals, would largely prevent the above-mentioned trouble. With more careful work, though not necessarily expensive, a great increase in the hay crop may be obtained.

ALFALFA.

With alfalfa, however, more care is used, those growing it realizing to a certain extent the great value of this crop as a stock food.

The acreage under this crop is, however, very limited, many of the attempts made to grow it being experimental. The most successful grower of this grass in the whole district is Mr. George Lane, who cut last season about 175 acres at his Willow Creek ranch, township 14, range 29, west of the 4th meridian, and obtained with two cuttings a yield of about 3½ tons per acre from the irrigated portion.

Mr. Lane is putting in more and more alfalfa every year as he gets the land in shape for it, and it is his intention to spend a good deal of money in levelling the land under the ditches, in order to get the best possible results, and his work and the results therefrom should prove most valuable in showing what can be done with alfalfa in this district, if irrigation is carefully and systematically carried on.

Among the schemes where alfalfa is grown on a smaller scale, may be mentioned those of Mr. W. H. Quail and Mr. J. W. Stevenson, both of Claresholm, and Mr. C. W. S. Elton, on Todd creek, but the work being done by these gentlemen is more or less experimental, and the yield per acre obtained by them from their alfalfa patches, while encouraging, is not yet as great as has been obtained by Mr. Lane, who has irrigated for years.

TIMOTHY.

The cultivation of timothy with the aid of irrigation, has not been carried on to a great extent, the best crop in the district being that obtained by Mr. W. A. Lyndon, on the north fork of Trout creek, who cut about 40 acres, obtaining a yield of 2¼ tons to the acre.

OATS.

Only a few attempts are being made to irrigate for oats. Messrs. A. E. and E. J. Gregory, on Willow creek, obtained a yield of 4 tons per acre from 30 acres. Mr. Gregory's method is to soak the land well in the fall, and to wet it a little again in the spring.

Mr. W. A. Lyndon obtained a crop which ran 3 tons to the acre, and Mr. C. W. S. Elton, on Todd creek, irrigated a small patch, obtaining a yield of 1½ tons per acre.

For heavy crops it is, in my opinion, the best practice to soak the land well in the fall, and to use water very sparingly in the spring. By this means the ground will be quite moist when the plant growth is beginning, and the later rains will bring the crop to maturity; whereas, if a lot of cold water is applied in the spring, it will more likely injure than benefit the young growing plant, and will probably delay the ripening of the grain, even if no serious damage is done, and delay in ripening of grain is an important consideration in this district, where the growing season is, at the best, a short one.

With the elimination by means of cancellation of licenses of many of the old disused schemes, and with the completion of the present authorized schemes, which will really benefit the land, a great improvement will be evident throughout the district, and irrigation will be more highly thought of and appreciated by the people, as a whole.

Your obedient servant,

R. H. GOODCHILD,

Inspecting Engineer.

REPORT OF P. J. JENNINGS, OFFICE ENGINEER.

PARTY No. 4.

CALGARY, February 4, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following report upon the work done during the season of 1913 on "Special Inspections."

The work undertaken during the past year has been of such a diversified nature that it will be impossible in this report to more than outline the duties performed and the class of work embraced.

Prior to the opening of the season, from January until the end of April, the following duties were undertaken: (1) Inspecting and recording all applications for the removal of sand and gravel from the beds of the rivers within the limits of the city of Calgary. This work was discontinued altogether in May, in compliance with instructions received. (2) The examination for approval of all plans submitted for the construction of works for the diversion and use of water under the various sections of the Irrigation Act.

WINTER INSPECTIONS.

During the winter a special inspection, at Swift Current, was necessary. This comprised an investigation into the conditions leading up to a shortage of water at the Canadian Pacific Railway Company's reservoir on Swift Current creek, and below the intake works of the town of Swift Current. The railway company has priority on this stream. It was found upon investigation that the town authorities, who had no storage whatever, were diverting practically the total flow of the creek, and they were consequently required to cease pumping operations until the absolute needs of the prior applicants were first satisfied. Luckily the inconvenience was of very short duration, as a sudden thaw enabled both parties to obtain sufficient water for all their requirements.

In connection with this inspection, two important points were brought out: firstly, the benefit to a licensed water user of the protection afforded by the provisions of the Irrigation Act; and secondly, the demonstration of the absolute necessity for the town to protect its future winter supply by the immediate construction of storage works. This was readily seen by the town authorities, for within twelve months a substantial reinforced concrete dam was built and in operation, with a storage capacity of 80,255,000 imperial gallons.

There is one other point which might be mentioned, i.e., the desirability of giving matters of this kind immediate attention, for by this means only can a proper conception of the importance of such a dispute be realized and properly dealt with. Furthermore, it is essential in such cases, where enormous damages through delay would accrue, to be on the ground and take notes of actual conditions prevailing, and so fix the responsibility.

SPECIAL INSPECTION WORK.

At the opening of the 1913 season the staff engaged on this work comprised only Mr. C. C. Chambers and myself. The work was carried on until July 18, when Mr. L. Danielson was appointed to the staff as a special inspecting engineer. This officer remained upon the work until August 23, when he was transferred to the hydrographic staff. On September 19 Mr. F. R. Burfield was transferred from the hydrographic surveys to the special inspection staff, and is still engaged on this work. A report of his services from the above date has been submitted, and will be found under "Special Inspections."

In connection with the inspections made by myself, the first tour, a short one, was east to Moosejaw, leaving Calgary on May 4, and returning again on May 10, seven inspections having been made.

A special tour was made to the Lethbridge and Crowsnest district from June 10 to June 19, when the inspections were made.

From June 21 to 28 a short tour was made north to Athabaska; two drainage applications were investigated, and one industrial scheme inspected.

Between July 8 and 13 four inspections were made from Edmonton, one in connection with the illegal diversion of surface water, and three industrial schemes.

Routine office work was attended to between the above dates.

Mr. Danielson joined the staff on July 18, and, in order to familiarize him with the methods of procedure in making an inspection, it was considered advisable for me to accompany him on a portion of his first tour of inspection. Seven inspections were made on this tour, two in company with Mr. Danielson.

On August 6 official notification was received of my appointment as Office Engineer, with instructions to report for duty at Calgary. Routine office work was carried on until October 8, when instructions were received to proceed at once to southern Manitoba to make a survey and investigation in regard to the drainage and reclamation of a large area of lake-bed. This work occupied some twelve days, after which two inspections were made at Estevan and one at Melfort, and Calgary was reached on November 1.

Owing to a number of important inspections still to be made, it was decided to arrange another tour, and to include a number of drainage applications situated northeast of Athabaska and west of Edmonton. These inspections, together with one special visit to Viking in connection with surface water disposal, were completed by November 20.

At the close of the season there were only some three or four scattered inspections which remained unfinished and for which instructions had been issued. As these were widely separated and would necessitate a considerable expenditure, it was decided, as they were not urgent cases, to hold them over for the first tour in 1914.

During the past season, 171 inspections were made—74 by Mr. Chambers, 40 by Mr. Burfield, 14 by Mr. Danielson and 43 by myself.

Of the four engineers engaged on this work during the year, only Mr. Chambers and myself had any previous experience in this class of work. The introduction of new men to this work is admitted as being at times unavoidable; but it is desirable, if consistent with future organization arrangements, to retain the services of engineers already familiar with the work. A great deal of time and unnecessary work can thus be saved, and efficiency increased.

Detail of schemes inspected—

Inspections made	43
Domestic purposes	3
Irrigation	6
Municipal	5
Industrial	15
Drainage investigations	8

Special	5
Complete surveys made for two schemes. Amended plans prepared for three schemes. Number of days on outside service	81
Balance of time spent as office engineer.	

Mileage travelled—	Miles.
Total number of miles travelled	8,698
Travelled by team	766
Travelled by train	7,932

DRAINAGE APPLICATIONS.

During the past year, a great deal of time was spent on investigation work in connection with the reclamation of shallow lakes and swamp lands. The majority of these schemes are situated a good distance from the railways, and their investigation usually entails long drives and a considerable expenditure of time.

Those recently investigated embrace extensive areas of Crown lands, the disposal of which, for development purposes, at a nominal figure, requires a careful and accurate estimate of the relative value of the body of water it is proposed to remove, and the land which is to be reclaimed for cultivation.

As there are a considerable number of investigations of this nature to be undertaken during the coming season, it is suggested that it would greatly add to the value of the reports and estimates of these schemes, if a small party was engaged for this work in the early part of the year, and equipped with a light camping outfit and a collapsible boat. They would then be in a position to take soundings and soil samples, the former being necessary in order to gauge the extent of construction work required, and the latter for the value of the submerged land when reclaimed.

Much of the land in northern Alberta and northern Saskatchewan, which is at present swampy or submerged, is very excellent land, and after being properly reclaimed would soon become very valuable as hay or agricultural land.

The reclamation of these vast areas, although perhaps at present a little premature, will in a very short space of time become a necessity for the betterment of the conditions of the surrounding settlers. The existence of these bodies of water and swamp lands cannot in any way be construed as being a benefit to the country. On the contrary, it is claimed by the settlers living in proximity to such lands, that their presence is a decided detriment, and renders farming operations more precarious than they otherwise would be, by reason of the fact that they are conducive to early frosts.

Bona-fide applicants for the reclamation of these lands should be encouraged, for not only does a whole community benefit by virtue of increased settlement, the opening up of new roads and the betterment of conditions generally, but reclamation is a means of converting large areas of cold, sour, and unproductive soil into useful, productive land.

Although, as stated above, these undertakings should, speaking generally, be encouraged, yet it will be at all times necessary to carefully investigate the merits or otherwise of each application.

Your obedient servant,

P. J. JENNINGS,

Assoc. M. Can. Soc. C.E.,

Office Engineer.

REPORT OF CHARLES CHAMBERS, INSPECTING ENGINEER.

PARTY No. 5.

CALGARY, January 28, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I have the honour to submit herewith my annual report of the inspections and surveys made by me during the year 1913 in connection with "special inspections."

AREA COVERED.

The area within which my inspection work was carried on covered approximately 80,000 square miles in the central portion of the provinces of Alberta and Saskatchewan.

OUTLINE OF WORK.

The inspections may be divided into four general classes, viz.:—

(1) Diversion of water for irrigation.

(2) Diversion of water for domestic or industrial purposes.

(3) Diversions of water for purposes other than those enumerated above, such as waterworks systems for towns and cities or where companies desire to dispose of water and to charge a rate therefor, use of water in condensing plants, straightening the course of a stream, etc.

(4) Illegal diversions of water.

The methods by which water is utilized may be divided into three groups, viz., gravitation, pumping, and reservoiring.

SUMMARY OF INSPECTION TRIPS.

Beginning with a trip in connection with the water supply system for the village of Cowley on April 14, my time was fully occupied until December 22, when I completed my final trip and returned to Calgary for the winter. During this period, seventy-four inspections were made as shown by the following tabulated statement:—

Class.	Methods Employed.			
	Gravitation.	Pumping.	Impounding	Totals.
For irrigation purposes	22	3	2	27
For domestic purposes	3	1	13	17
For industrial purposes	2	14		16
For "other" (waterworks) purposes	2	5		7
(condensing plant) purposes		1		1
(reclamation) purposes	2			2
For wrongful diversion purposes	1		3	4
Totals	32	24	18	74

Surveys were made of	5 schemes.
Plans were prepared for	7 "
The works were measured and the cost of construction estimated of	2 "

MILEAGE TRAVELLED.

The total number of miles travelled by train was	6,615
The total number of miles travelled by trail was	1,852
Grand total miles	8,467

IRRIGATION SCHEMES.

Of the irrigation schemes inspected, five were in course of construction, five were in bad repair, one was reported feasible, and the remainder were completed. Of the completed schemes, two were used to irrigate oat crops, one for garden produce, one for alfalfa by means of pumping, and the remainder for growing wild hay.

It is often difficult to obtain reliable information respecting the crop returns from irrigated land. Many irrigators keep no records of these operations, and are unable to state definitely the dates of the several irrigations, the quantity of water used, the dates of sowing and harvesting the crops, the yield per acre, etc. Only general, and frequently unreliable, information can usually be obtained. In order to facilitate the collection of such information, it is suggested that a circular letter be sent to each irrigator early in each season, stating fully and clearly the kind of information required, and requesting that suitable records be kept, in which the following should be included:—

(1) The area in acres under each crop irrigated. *Note.*- All grasses and hays to be considered as crops.

(2) The method of preparation of the soil. If alfalfa is sown, whether the seed or the soil was inoculated, or both.

(3) The date or dates the seed was sown.

(4) The quantity of seed sown per acre.

(5) The date or dates when the crop was cut.

(6) The yield of the crop per acre.

(7) The price per unit (bushel or ton).

(8) The date or dates when the crop was irrigated.

(9) The quantity of water used during each irrigation period (as shown by his ditch gauge).

(10) The method of irrigation carried out.

DOMESTIC SCHEMES.

Seven of the domestic schemes inspected were constructed by the Government of the province of Saskatchewan, one by the Canadian Coal Consolidated Company for sulphur baths at their sanitorium at Frank, Alta., one by the town of Indian Head, one by the rural municipality of Enfield, and the remainder by private individuals.

INDUSTRIAL SCHEMES.

All but two of these were pumping schemes; three were constructed by the Canadian Northern Railway Company, four by the Canadian Pacific Railway Company, seven by the Grand Trunk Pacific Railway Company, and one for a brewery.

WATERWORKS SCHEMES.

Five of these were pumping schemes, viz., those for Moosejaw, Swift Current, Redcliff, Bassano, and Scott; two were gravitation schemes.

Your obedient servant,

CHARLES CHAMBERS,
Ass. Mem. Inst. C.E.,
Inspecting Engineer.

REPORT OF F. R. BURFIELD, INSPECTING ENGINEER.

PARTY NO. 6.

CALGARY, ALTA., January 13, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following report on the work done by me in connection with "special inspections" during 1913.

After transfer from hydrographic work on September 19, a few days were spent in the office, and on September 23 a trip of inspection of irrigation schemes was commenced along the Red Deer river between township 6 and 17 west of the 4th meridian.

This involved a round trip by trail of 168 miles from the town of Bassano through what is probably the driest district in Alberta, and one which would benefit as much as any by irrigation if such could be provided. Unfortunately the quantity of water available for irrigation by gravity is very limited. There are three creeks which traverse the district, namely, Bullpound, Blood Indian, and Berry creeks. Of these, Bullpound creek, except during the spring freshet, has a very small flow, and dries up during the summer. Blood Indian creek has a permanent flow of about half a second-foot, due to a spring and a fairly large run-off from its drainage area in the spring. Berry creek has normally a much larger flow than either of the others, but last summer there was only sufficient water to keep the water holes filled. The irrigation schemes from Berry and Blood Indian creeks are giving good results. There are three schemes for pumping water from Red Deer river to the adjacent flats, but these are not in a sufficiently advanced state to warrant any expression of opinion as to their success.

After my return from this trip, I was engaged under Mr. Jennings on an investigation into the possibilities of the drainage of a lake-bed in southwestern Manitoba, and then made a trip of inspection of various schemes in eastern Saskatchewan, returning to the office on December 15.

The following is a summary of the season's work:—

Number of inspections made	40
Number of reports submitted	38
Miles travelled by train	4,061
Miles travelled by trail	895

Your obedient servant,

F. R. BURFIELD,

Inspecting Engineer.

REPORT OF SAM. G. PORTER, INSPECTING ENGINEER.

PARTY NO. 7.

CALGARY, March 31, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following brief report on the inspection made of the large irrigation systems of Alberta during the past season.

My engagement with the Irrigation Branch of the Department of the Interior for the inspection of the large irrigation systems of Western Canada began June 20, 1913. The remainder of the month of June was spent in the Calgary office familiarizing myself with the history and general conditions affecting the work in which I was to be engaged. During the first ten days of July a general tour of the large irrigation systems of southern Alberta was made, in company with the commissioner of irrigation, in order to obtain a broad, general view of the field, and to meet the men who are actually in charge of the various projects.

Returning to Calgary July 10, active preparations were made for undertaking the inspection work in detail, a brief description of which is here given, under the titles of the projects inspected rather than in chronological order.

THE SOUTHERN ALBERTA LAND COMPANY.

During July and August, in addition to the brief trip in company with the commissioner, three weeks were spent making a thorough field inspection of the Southern Alberta Land Company's system, and another week studying plans and writing a report. In November another week was occupied in field inspection for the purpose of a progress report. In February, 1914, a special trip was made to the intake to inspect the progress of the work there which was continued during the winter.

The Southern Alberta Land Company is to take its water supply from the Bow river in section 31, township 21, range 25, west of the 4th meridian, and will irrigate about 200,000 acres located between the Bow and Belly rivers and north of the south

Saskatchewan in townships 11 to 15, ranges 6 to 16. At the point of intake the river is divided into two channels by an island, there being a concrete dam across each channel, known as the north dam and the south dam. An earth dike 1,700 feet long extends across the island, connecting the two concrete dams. The north dam is 525 feet long. It was completed in 1909. The south dam is 530 feet long, and was completed in 1911. The intake of the canal is connected to the south end of the south dam.

In July, 1912, the undermining of the wall connecting the intake and the south end of the dam in which sluice-gates were located, caused the failure of the intake structure of the south end of the dam. During 1913 these works were reconstructed in a substantial manner, which will amply provide against a recurrence of similar accidents.

Notwithstanding the fact that the main canal and many other structures had been built prior to 1913, a number of changes and revisions have been undertaken for the betterment of the system. The principal features of the system in addition to the dam and intake already described, are as follows:—

The Big Cut, 5 miles below the intake, where considerable trouble has been encountered on account of slides. It is more than 1½ miles long, with a maximum cut of 64 feet. A steam shovel and a drag-line bucket have been engaged all season widening the cut and flattening the side slopes. It will be ready to carry water in the summer of 1914.

The East Arrow-wood Syphon, consisting of two 7½-foot wood-stave pipes, 1,220 feet long. Some changes at the intake and outlet of the pipes have been made during the year.

Lake McGregor, a storage and regulating reservoir of about 300,000 acre-feet capacity. It is a long valley with an earth dam at each end. The dams are 40 to 50 feet high, and were completed prior to 1913. The outlet structure in the south dam settled and cracked, and is to be entirely reconstructed.

Side-hill Work along the Little Bow River.—Many changes are in progress along this difficult stretch. Puddling, lining, and fluming will be resorted to in order to make a safe carrying channel.

The Little Bow Reservoir.—A regulating reservoir of about 30,000 acre-feet capacity, not included in the original plans, is to be developed at the end of the Little Bow section. A diversion from the old canal line into it will avoid the worst part of the side-hill cutting, where serious slides have already occurred. This work will be undertaken in 1914.

Concrete Drops.—There are many concrete drops along the line of the main canal. Several had been built prior to 1913, six or eight were constructed during the year, and several more are yet to be built.

Flumes.—About half a dozen timber flumes on the main canal were built prior to 1913. The most notable is the one across Mile Wide valley, 4,840 feet long. Some changes at the ends of all these flumes are in progress.

Bow River Crossing.—The main canal is to cross the Bow river near the north line of township 12, range 12, by means of an eight-foot wood-stave pipe inverted syphon 6,500 feet long, under a maximum head of 190 feet. The pipe is to be supported on six steel trusses each with a 120-foot span. These trusses have been under construction during 1913. The construction of the pipe has not yet been undertaken.

The canal from the intake to lake McGregor is 44 miles long, with a capacity of about 800 second-feet, but is to be reconstructed to carry 1,500 second-feet. It is expected that it will be in condition to carry water into lake McGregor by June, 1914, and that the enlargements will be completed by dredge or otherwise, while the canal is in operation.

From lake McGregor the main canal is to have a capacity of 1,350 second-feet. Active construction on this canal, distributaries and structures will be carried on during 1914 with the purpose of supplying water for irrigation in the season of 1915.

The Lethbridge section of the Canadian Pacific Railway Company's Irrigation System.—This section is known as the Alberta Railway and Irrigation Company's system, which was the name of the company before it was taken over by the Canadian Pacific Railway in 1912. Water for the system is diverted from the St. Mary river, a few miles north of the international boundary, for the irrigation of about 100,000 acres south and east of Lethbridge. It is the oldest of the large systems in Alberta, having been in operation since 1900. Nevertheless, it has not yet had the final inspection and approval of the department, as the period allowed for construction has not yet expired, and extension of the systems are in contemplation.

In July, 1913, a hasty inspection was made in company with the commissioner of irrigation. In September, two weeks were spent in a field inspection for the purpose of reporting on the present condition of the system. In addition to this, some special features of the system have received attention from time to time. Some of the canals and several structures are to be improved or reconstructed, and these changes, as well as the system as a whole, will demand further consideration on the part of the inspecting engineer.

Western Section of the Canadian Pacific Railway Company's Irrigation Block.—The western section of the Canadian Pacific Railway Company's tract covers upwards of 200,000 acres north of Bow river, just east of Calgary. The system has been in operation several years, but has not yet been approved, pending a reclassification of the irrigable lands, and the construction of a dam in the Bow river at the intake at Calgary. The dam is under construction, and practically all the concrete portion will be completed before the summer floods of 1914.

It is a movable dam, partly operated by stoplogs, and partly by the semi-automatic hydraulic control of a steel radial gate or sector. The stoplog section consists of twenty-three openings of 20 feet. The sector section has one opening, 152 feet long. The entire dam, together with the new concrete headgates, will be completed in 1914.

Eastern Section of the Canadian Pacific Railway Company's Irrigation Block.—The water supply for the eastern section of the Canadian Pacific Railway Company's irrigation block is taken from Bow river at what is known as the "Horseshoe Bend," near Bassano. It will irrigate about 400,000 acres between Bow and Red Deer rivers from range 11 to range 18. The dam across Bow river is a reinforced concrete hollow dam of the Ambursen type. The concrete part of the dam is 720 feet long and 40 feet high; the earth part is about 7,000 feet long. Several inspection trips have been made to the dam since July, 1913. It is expected that it will be completed in April, 1914, and that water will be turned into the canal in May.

The entire system is nearing completion and will no doubt be finished in 1914. The main canal, as far as the storage reservoir, lake Newell, and the north branch canal will be put in operation in 1914. A detailed inspection of the system will be made during the season of 1914.

LAND CLASSIFICATION.

From August to December, 1913, about thirty days were spent in making field inspections of land classification in the eastern section of the Canadian Pacific Railway

Company's irrigation block. Six townships in the western part of the eastern section were inspected, together with several colonies and special tracts in other parts of the section. Much of the office work consisted of the inspection of maps, and checking and tabulating the lists of land classifications. The classification of about fifty townships in the eastern section alone has yet to be inspected. As much as possible of this work will be done during the season of 1914.

GENERAL.

A few special inspections of more or less importance have been made, various plans have been examined in the office, and sundry questions pertaining to the work of the department have been studied and reported to the commissioner.

Your obedient servant,

SAM. G. PORTER, B.A., B.S., M. Am. Soc. C.E.,
Inspecting Engineer.

REPORT OF B. RUSSELL, CHIEF FIELD INSPECTOR.

PARTY No. 8.

REPORT ON IRRIGATION SURVEYS.

CALGARY, ALTA., April 3, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit herewith my annual report of the field work carried out during the past season under my supervision.

More detailed reports and estimates of cost of construction in connection with the several projects investigated have been prepared by the various officers in charge of parties, and will be found elsewhere. It is probable, however, that many who receive this publication, although they have not the time nor yet perhaps the inclination to study a technical report on the projects investigated, may still be sufficiently interested to know briefly what this department is doing toward developing the natural resources of the country. It is therefore the intention in this report, only to deal generally with the various schemes of which preliminary surveys were completed during the past season.

The three schemes investigated are as follows:—

(1) The South Saskatchewan Water Supply Diversion project.

(2) The Cypress Hills Reservoir surveys.

(3) The Oldman River Diversion project.

These schemes will be discussed briefly here in the above order, but before taking up the main theme of this report a few remarks with respect to the work in general may be helpful in organizing parties in future, and carrying on the surveys in connection with the many schemes which will be investigated from time to time by this department.

The most efficient arrangement and size of party for the work depends, of course, almost entirely upon the nature of the surveys to be made. For parties of say ten or twelve men, however, such as were employed by this department during the past season, it would be very much more satisfactory if the officers in charge were free from the necessity of doing any instrument work whatever. Probably the responsibilities of these officers are not sufficiently appreciated, but particularly in this department, where it is necessary for them to attend personally to the purchasing of all supplies, and to the submitting of the necessary expense accounts, the officer in charge of one of these parties, if he also has to do his own instrument work, has more to attend to than he can expediently handle.

The department was fortunate during the past season in having exceptionally capable men in charge of parties, and considerably more than an average season's work was accomplished, and with very satisfactory results. Had these men been free from the necessity of doing any instrument work themselves, however, and had more time to direct operations and study the problems which from time to time come up in connection with the work, still more information could have been gathered by the parties, with even better results.

With all three of the parties in the field during the past season, some difficulty was found in moving camp, owing to the fact that one wagon is not sufficient to move a party of any size. Every effort was made to cut down the outfit as much as possible, but even then there was great difficulty in moving with only one wagon.

Two wagons are even more essential to one of these parties than two democrats, because, although the men can walk if necessary, it is not possible to handle the camp equipment as it should be handled if proper transport is not provided.

THE SOUTH SASKATCHEWAN WATER SUPPLY DIVERSION PROJECT.

During recent years, as the southern part of the province of Saskatchewan has become more thickly populated, with new country opened up by the construction of various railroads, and as a consequence many new towns springing into existence with mushroom-growth rapidity, the deplorable lack of suitable water supply facilities has become more and more realized. Although the possibilities of procuring an abundant supply of good water from the South Saskatchewan river were made known as early as the year 1894 by Mr. J. S. Dennis, who was then connected with this department, not until recent years has such a source been seriously considered. Even at the present time, although this river has been reported by engineering authorities to be the only source of an adequate water supply for this rapidly growing country, the general public scarcely appreciates how imminent has become the necessity for a water supply scheme from the South Saskatchewan river, prodigious though such a scheme may be.

When it is considered that the authorities of New York city are now installing a system to supply not less than 500,000,000 gallons of water to their population at an estimated cost of $161,857,000, and that other cities in the United States have completed schemes of like magnitude, the present project of supplying the whole of the southern part of the province of Saskatchewan with an adequate water supply at a cost between eight and fifteen million dollars (depending upon the scheme adopted), does not seem impracticable.

Various phases of the possibilities of diverting water from this river have been reported upon from time to time by eminent engineers who have been called upon to investigate this project.

Mr. R. J. Burley, C.E., of this department, in his annual report for the year 1912 has ably discussed all the previous work which has been done in connection with this project, and those interested may refer to his report with advantage.

Likewise, Mr. H. E. M. Kensit, Mem. Inst. E.E., Mem. Am. I.E.E., of the Water-power branch of this department, although dealing more particularly with the power possibilities of this project, ably discusses the many alternatives of furnishing the country under consideration with more adequate water supply.

It will not be necessary, therefore, in this report to refer to any previous work, further than to say that the writers all agree that this project is by no means a visionary one, and that the opinions expressed must necessarily expedite the construction of some scheme whereby this country, so wholly destitute of this prime necessity, can be supplied with water from the South Saskatchewan river.

The two routes for a pipeline surveyed during the past season, and shown on the key plan accompanying the report submitted by Mr. T. M. Montague, C.E., who had charge of the party in connection with these surveys, are as follows:—

(1) A short line route from the reservoir in township 20, range 6, west of the 3rd meridian, following a contour along the north slope of the Thunder Creek valley considerably beyond a crossing with the Outlook branch of the Canadian Pacific railway, and thence crossing the depression of the Moosejaw valley direct to Regina.

(2) A route starting from the South Saskatchewan river near the mouth of Aiktow creek, following the valley of this creek to the height of land between it and the Qu'Appelle river, and thence down the valley of this river to Buffalo Pound lake. In connection with this route, the possibilities of storing the diverted water in Buffalo Pound lake were investigated and a contour survey of this proposed reservoir site completed. Surveys were also made in this connection for a pressure pipeline from Buffalo Pound lake to a point on the hillside at such an elevation that the water pumped to a distributing reservoir there could be conveyed to Moosejaw, Regina, and the surrounding country, by gravity.

Upon completing the surveys of these two routes it is believed that every feasible location for a diversion from South Saskatchewan river has now been investigated by this department, the more circuitous route for a gravity pipeline to Regina by way of the head of Mosejaw creek having been surveyed during the previous season.

When Mr. Montague started his work last spring it was not expected that he could do very much more than complete the surveys necessary for a preliminary investigation of the short line route referred to previously. But as a considerable portion of the pipeline by this route would be under pressure and as it was not necessary to take extensive topography, it was possible to run line quickly, and all of the surveys in connection with this route were completed by the middle of August.

Upon completing the surveys in connection with the above route it was considered advisable to investigate the possibilities of pumping water over the summit of Akitow creek, thus delivering it by way of the Qu'Appelle river to Buffalo Pound lake.

Mr. Montague, in starting his surveys of this route was instructed to investigate the following possibilities:—

(1) A 40-foot dam across the south Saskatchewan river at some place near the mouth of Aitkow creek, and a 50-foot cut through the height of land, allowing the water to gravitate to Buffalo Pound lake; a 20-foot or 30-foot dam and storage reservoir at Buffalo Pound lake, and a pumping plant operated either by water power developed at the river and transmitted to Buffalo Pound lake electrically, or from a steam power plant at the lake using coal or other fuel; a pressure pipeline to a distributing centre at such an elevation as to enable the water after having been pumped to it to be distributed by gravity to Moosejaw, Regina, and the surrounding country.

(2) A 40-foot dam across the South Saskatchewan river, a 20-foot lift and 30-foot cut through the height of land, allowing the water to gravitate to Buffalo Pound lake and be distributed as in scheme No. 1.

(3) A 40-foot dam and a 50-foot lift over the height of land, allowing the water to gravitate to Buffalo Pound lake and be distributed as in previous cases.

(4) A 90-foot pump from the South Saskatchewan river over the height of land, allowing the water to gravitate to Buffalo Pound lake and be distributed as in the previous cases.

Having completed the necessary surveys in connection with the above four schemes, Mr. Montague, as well as making a complete estimate of a scheme by the short route to Regina referred to above, completed an estimate of the most feasible of the above four alternatives and since all these estimates accompany the report submitted by him reference is here made to this report.

It will be found that scheme No. 4 of the Qu'Appelle valley route is for the following reasons the most feasible for supplying the southern part of the province of Saskatchewan with water:—

(1) It eliminates the necessity of constructing a dam across the South Saskatchewan river. Such a dam, if constructed, must be so designed as to furnish the power necessary to pump a water supply for all time. Although various estimates have been made, the cost of any structure on the South Saskatchewan river remains very uncertain, and might greatly exceed the estimate which has been made.

(2) The proposed power plant at Buffalo Pound lake can be so designated as to enable it to be installed in the proper sized units to suit the present demand, while the necessary additions for any greater supply of water can be made from time to time at no great additional cost.

(3) The water can be conveyed from the river to Buffalo Pound lake for the most part through a natural channel, thus doing away with 88 miles of expensive pipe.

(4) A greater area of country can be supplied with water from this scheme than from any of the other schemes investigated.

(5) This scheme throughout, eliminating as it does the main supply pipe, lends itself to possibilities in regard to cheap construction not possible by the other schemes.

In choosing the most feasible water supply scheme for the country in question, not only were the possibilities of supplying the cities and towns of this district thoroughly investigated, but every consideration was given to the demands of the rural population as well, because, although both Moosejaw and Regina as well as many of the smaller towns have fairly good water for their present use, 90 per cent of the rural population has no good water whatever. It is thought that when any such water supply scheme as the present one is under consideration the demands of this population should not be overlooked.

Although this project has been thoroughly discussed in the report submitted by Mr. Montague, it should be stated here that the surveys which have thus far been made have necessarily been of a preliminary nature, and it is not possible from this information to make any very close estimates of the cost of a project of this magnitude.

The same unit prices have been used in estimating each scheme, however, so that the estimates submitted should be fair comparisons between schemes.

Since the city of Regina has recently completed a water supply system at a cost of $2,000,000, which it is claimed will provide 10,000,000 gallons of water daily to its population, it is not probable that they would consider a further expenditure in this connection for some time to come. Likewise the city of Moosejaw, although their present supply is by no means satisfactory, have already spent large sums of money upon this system, and would probably not consider any further expenditure until it is found absolutely necessary to do so.

It will therefore probably be some time before any such project as the one under discussion will be installed and, as many conditions will have changed in that time, the present estimates may be very considerably altered.

The accompanying key plan shows the system described under scheme No. 4, of the Qu'Appelle valley route, which is considered the most feasible for supplying water to the country under consideration.

TEST BORINGS.

In order to make any estimate of the cost of a structure on the South Saskatchewan river, or to even determine definitely upon the location of such a structure, it is absolutely necessary to determine by test borings the nature of the bottom for foundations.

During the past few years preliminary surveys have been carried on in connection with the South Saskatchewan water supply project by this department, and several estimates of the cost of such a scheme have been made. Since it was realized, however, that no reliable estimate of such a project could be made until the location and cost of the necessary dam were determined, it was decided to provide, in the appropriations for 1913, a sum of money to carry on the work of testing the bottom for suitable foundations.

In his report for the year 1912, the commissioner estimates the cost of a dam at $1,000,000, but says: "One fact alone which is liable to make the estimate of the cost of a dam seriously in error, is that the bottom of the South Saskatchewan river is known to be most treacherous for the foundations of any structure, and no definite information whatsoever has been gained on this point."

Mr. Burley in last year's report estimated the cost of such a dam at about $1,500,000, but since nothing whatever was known of the bottom, these estimates are of course little better than a guess.

Mainly with the end in view of determining the proper location for a dam, the necessary equipment, consisting principally of a McKiernan Terry drill, a gasoline engine, and pump were purchased, and upon the completion of last year's field work a party was outfitted to carry on this work during the winter.

Mr. L. J. Gleeson, who had charge of this party, has submitted a report of the work done by him in this connection and has also prepared a small plan showing the locations of the points where the borings were made, and cross sections of the various holes bored.

Since there were a great many difficulties in connection with this work, it may be interesting to note a few of them here.

The drill used was what is known as the Class Z-1 type of McKiernan Terry drill and, although a first-class drill for test borings, particularly in rock and clay, was rather too light for the work on the South Saskatchewan river.

The following quotation is from a letter written to the commissioner of irrigation on January 8, 1913:—

> "The drill, engine, and pump have all been working satisfactorily, and we have a power hammer for driving the casing. Although it will still be slow work to drive casing through sand after a depth of 30 feet, we should make good progress with the work.
>
> "As the outfit stood, without a power hoist, an engine was almost unnecessary for the work here. The engine was only necessary when drilling, while all the heavy work, such as hoisting tools, and driving casing, had to be done by hand. Even hand-power is necessary to bore through sand and clay, as the force of the water is sufficient to cut out a hole, and the drill drops down under its own weight. Except in the case of rock and gravel the engine (outside of driving the pump) was almost unnecessary to the work in the absence of a power hoist.
>
> "In boring through sand it is impossible to drill beyond the end of the casing, as the sand of course will not stand up, and washes in as fast as it is taken out. It is therefore necessary to drive the casing all the way through sand. The sand, of course, packs around the outside of the casing, and every length put down adds another coupling, which likewise adds greatly to the difficulty of driving."

Not only was there great difficulty found in driving casing, but also in taking it up. The drill frame was too light to take any very great strain, so that the power hoist would not be used in this connection. It was therefore necessary to pull the whole length of casing with screw-jacks, and this is a very slow process.

In order to decrease the frictional resistance and thereby facilitate the work of driving and pulling casing, the couplings were taken off and the lengths of casing rethreaded so as to go together flush. It was found that smooth casing drove and pulled much easier than casing with outside couplings, and therefore this casing was used entirely for the work.

Another difficulty, which was probably responsible for more delay than anything else, was that of procuring the necessary accessories, such as hose, valves, pipes, wrenches and other connections which were required to fit up the drill. For many of these accessories it was necessary to send all the way to Winnipeg, and this caused a great deal of delay on the work. The nearest foundry where repairs could be made was at Moosejaw, and consequently much time was lost. With an outfit of this kind, working at such a distance from the source of supplies, a small forge would be a very valuable asset. The foreman could then make a great many repairs himself and save many long trips to town.

Although the gasoline engine worked satisfactorily, and there was little trouble from this source, it would be safer and much more convenient to use steam when this work is carried on during the winter. Plenty of heat and hot water is necessary in order to avoid freezing about the drill, pump, and drill house generally, and had a steam engine been employed on this work, many of the difficulties in this connection would have been avoided.

Probably this work could have been done more cheaply and satisfactorily during the summer than in the winter months, but this is a matter of opinion. In order to do the work in the summer it would be necessary to build a large scow from which to work, and employ a motor boat to move it from place to place. Three or four large anchors would probably hold the scow in position while the borings were made, and each hole could be located from the shore by triangulation. By doing this work in the summer a great many difficulties could be avoided.

An attempt was made to investigate the stretch of the South Saskatchewan river between the Elbow and Shellstone creek. Owing to the danger of having the outfit stranded up the river, however, it was not found advisable to continue the work beyond Riverside. Upon arriving at Riverside Mr. Gleeson was accordingly instructed as follows:—

> "As soon as you have bored at Riverside you will immediately bring your whole outfit down to near the mouth of Aiktow creek, where you will endeavour to develop a good cross-section of the river somewhere between the mouth of Aiktow creek and your original cross-section 'A.'
>
> "The Grand Trunk Pacific Railway have a cross-section at the mouth of Aiktow creek showing clay right across the river, and your section 'A' in about section 29, township 24, range 5, west of the 3rd meridian, shows that at this point the clay bottom of the river dips from the north to the south so that the clay bottom is quite close to the surface on the north side but at a considerable depth on the south side of the river. You will therefore work along the south side of the river in the best manner possible in your judgment, until you find where the south dip of the clay bottom leaves it at a reasonable depth from the surface at the south side of the river and you will then develop a full cross-section at this point, so that as the result of the boring operations we can have at least one fully developed boring cross-section on the basis of which to estimate the cost of dam."

Unfortunately the river broke up earlier this season than usual, and Mr. Gleeson was not able to get all of the information anticipated. The results of his work, however, clearly show that the only solid foundation for a dam at a reasonable depth is at the Elbow, and it is believed that if such a dam is constructed this will be the proper location for it.

As stated previously, Mr. Gleeson, who had charge of this work, has submitted a report, and plans of the work done by him, which have been filed in the Calgary office.

It will be noted that although the idea in making these test borings was to determine the location of and estimate the cost of a dam in the South Saskatchewan river, no reliable estimate is included in this report. This is due to the fact that the results of Mr. Gleeson's work were not available in time to make this estimate of cost.

It is believed, however, that the most feasible water supply scheme considered by the department eliminates the dam on the South Saskatchewan river, and even if a more accurate estimate of such a dam does show that the amount previously allowed for this structure is very much in error it cannot materially affect the conclusions reached.

CYPRESS HILLS RESERVOIR SURVEYS.

A system of storage reservoirs in a district where the run-off takes place within a short period of time is most essential to the successful operation of irrigation projects.

In the Cypress Hills Irrigation district the conditions are such that, in the spring of the year, as the snow melts in the hills, large volumes of water, sometimes amounting to floods, pour down the various creeks, not only running to waste, as far as irrigation in the Cypress Hills district is concerned, but sometimes destroying the headworks of schemes now in operation.

It is estimated that, during the month of April, 1912, sufficient water ran to waste from the Cypress Hills watershed to irrigate 125,000 acres of land, if it had been possible to catch and store this run-off. At the present time it is doubtful if more than 15,000 acres in the Cypress Hills district are actually being irrigated, and without storage it will not be possible to irrigate properly any considerable proportion of the available land.

Up to the present time the principal crop grown under irrigation in this district has been hay, and since good results are obtained with this crop by flooding the land perhaps only once during the season, more of the flood water can be utilized and consequently greater benefits derived from irrigation than if other crops were grown. It will probably be found desirable, however, as the country becomes more thickly settled, to grow other crops than hay, and it will be then that the importance of storing this flood water will be more fully realized by the water users themselves.

Mr. R. J. Burley, who should be most familiar with conditions in the Cypress hills, says:—

> "When natural hay ceases to be the main object of irrigation the necessity for reservoiring will become very forcibly impressed upon the irrigators of this district, as while flood water irrigation is quite suitable for hay lands and is of great assistance in growing grain, when available at a suitable time, this method will not be of any great value when intensive farming is practised nor when alfalfa is grown. As but few of the schemes have water available at all times, reservoiring is the only solution."

The possibilities of utilizing Cypress lake to store the flood waters of Battle, Oxarart, and Sucker creeks have been known for some time and surveys were made by Mr. Thibadeau during the year 1909 to determine what quantity of water it would be possible to impound. It was found that the work done in this connection in 1909 was not satisfactory, and Mr. N. M. Sutherland last season was instructed to make a more detailed survey of this project, and prepare an estimate of the cost of construction.

Accordingly a party was placed in the field with instructions to make a contour survey of the shores of the lake to a sufficient elevation to enable the department, with the information of the amount of water available, to decide upon, and estimate the cost of, some feasible scheme whereby the flood waters of these creeks, for perhaps several wet years, could be stored and used on the land during a cycle of a corresponding number of dry years.

Mr. Sutherland completed a very accurate contour survey of this lake, developed the necessary dam sites, and made surveys for the necessary diversion canals. After completing the surveys, a system of levels was run over the block of townships shown on the plan accompanying the report submitted by Mr. Sutherland. The primary object in running these levels was to locate and develop any possible reservoir sites in the Lodge Creek watershed whereby the flood waters of this creek could be stored, and fairly complete notes of the topographical features of the country were kept, from which the watersheds of the various creeks can be more accurately defined.

In connection with these reservoir surveys in the Cypress hills an inspection was made of the sites surveyed by Mr. Ellicott in 1902 in order to determine approximately what the cost of constructing the necessary dams, canals, etc., would be.

In determining upon the feasibility of these sites for reservoirs it is necessary to know the quantity of water which is available for storage, and although an estimate of this quantity has been made from the watersheds tributary to these sites, it will be essential before constructing such reservoirs to actually determine, by gauging, the quantity of water available.

Since Mr. Sutherland has submitted a full report of the work carried out by him in connection with the Cypress lake storage scheme, a brief reference here will suffice. It may be interesting, however, to mention a few of the problems which had to be solved in the preparation of an estimate of the cost of this project.

(1) As already stated, the principal crop grown under irrigation in the Cypress hills at the present time is hay, and in order to supply the most suitable head of water which will be required for this crop provision for very large outlets from the reservoir both into Battle creek and the Frenchman river would have to be made. Probably for some time to come hay will continue to be the principal crop. On the other hand, since hay can be grown by flooding the land at such times as there is sufficient water in the various creeks, a reservoir will be most beneficial when other crops than hay are grown more extensively. It would therefore appear proper to figure on a head suitable for these crops, and to design the outlet canals accordingly. Since the outlet canals will be short, and since, if there is a discrepancy the error will be on the safe side, these canals have been designed for a head to irrigate the present crop, which is hay.

(2) It is not possible to determine with any accuracy the maximum area of irrigable land tributary to Battle creek and the Frenchman river, and it is the area of irrigable land which governs to a large extent the design of outlets from this reservoir.

In a memorial submitted in 1909 by Mr. Robert E. Kemerer, the applicant proposed to irrigate 200,000 acres of land tributary to Battle creek from a reservoir of Cypress lake, impounding the waters of Battle and Oxarart creeks. There is no question but that it would not be feasible, even although a sufficient quantity of water were available to irrigate anything like this area.

It has been actually determined from surveys that it is feasible to irrigate 6,265 acres of land tributary to Battle creek, and 5,542 acres tributary to the Frenchman river. The probability is, however, that considerable more land than this could be irrigated from these streams at a reasonable cost, and Mr. Sutherland has estimated and used in his calculations the following:—

Tributary to Battle creek, 7,000 acres.

Tributary to Frenchman river, 24,000 acres.

The area of land which will eventually be irrigated from these streams will of course depend upon the value of irrigation to the land. The areas here considered irrigable are all in the creek bottoms and are so situated that the water can be diverted to them at a low cost. It may be found, however, that it will be profitable in the future to build more expensive headworks and divert water to the higher lands, in which case it is not possible to even approximate the area of land which could thereby be watered.

(3) In determining the proportion of water which should be diverted from the reservoir into Battle creek and Frenchman river, it was at first considered advisable to provide for each of these streams in proportion to the run-off from their respective watersheds. Such a provision would be necessary if there was a limited supply of water. Since, however, it has been determined that this reservoir will hold sufficient water to more than tide over all the dry periods for the land under consideration, provision has been made to run off the water in proportion to the irrigable areas tributary to their respective streams.

There appears to be, from the estimates made, about three times as much irrigable land tributary to Frenchman river as there is to Battle creek, while the quantity of water stored in this reservoir from Battle creek will be at least three times the quantity stored from the watershed of Frenchman river. If, then, the stored waters were run off to these two streams in proportion to their watersheds few of the possible benefits of such a reservoir would be realized.

It will be readily seen from the estimates submitted that this scheme is a most feasible one, and before irrigated farming is practised to any great extent on the lands tributary to Battle creek and Frenchman river such a scheme will have to be put into operation.

As stated previously in connection with these surveys of reservoir sites in the Cypress hills, an investigation was made of the sites surveyed by Mr. C. H. Ellicott in 1902. These reservoirs sites are all on the north slopes of the Cypress hills and would provide storage for irrigation schemes on several of the creeks flowing north from the Cypress hills.

It has beeen stated that it is not possible to determine definitely whether or not the reservoir sites surveyed by Mr. Ellicott in the Cypress hills are feasible until more accurate measurements have been made of the discharge of the creeks which it is proposed to divert into them. An estimate of the cost of constructing dams, canals, etc., for the highest water possible, to suit the topography of the site has been made, and these estimates, as well as a small sketch plan showing the locations of these sites, are attached to this report.

With the completion of these surveys it is believed that the most feasible sites for storage reservoirs in the Cypress hills have now been investigated by this department. It is very probable, however, that there are still many small basins in which water can be stored and used to advantage on the contiguous lands. All that will be necessary to determine the feasibility of most of these schemes will be an inspection by an engineer who is familiar with the country and with the various irrigation schemes now in operation.

The several officers in charge of parties inspecting irrigation schemes in this district and the hydrographers in charge of these districts should be most familiar with the location of any possible reservoir sites in the Cypress hills, and without going very much out of their way should be able, from time to time, to look over any possible reservoir sites in their districts and report upon them to this office. If any of these proposed sites seemed to be feasible, and it were found desirable to develop them, a very small party could then get the necessary information to enable the department to determine whether such a scheme were practical.

Further, if the various water users in the Cypress hills, who should be most interested in these storage projects, would inform this office from time to time as to the location of any possible sites for storing water, instructions could then be given to an engineer on the ground to report upon such a scheme. If then it appeared that such a scheme were feasible, a small party could be placed in the field to procure the necessary information at the least cost to enable the department to decide definitely whether such a scheme were feasible or not.

Without any definite information with respect to the locations and feasibility of these reservoir sites, it is not possible to intelligently provide for carrying on any surveys in connection with them, and furthermore, if a party is put in the field with the general idea of looking for any feasible sites, the cost of carrying on such an investigation will necessarily be altogether out of proportion to the value of the information obtained. The only thorough method of investigation with respect to possible storage is, of course, a system of levels over the whole of the district, but this work is very expensive in comparison with the results obtained.

CYPRESS HILLS RESERVOIR SITES—SURVEYED BY C. H. ELLICOTT, C.E., 1902.

Location.	Drainage area.	Run-off, year 1912.	Maximum height of dam.	Maximum length of dam.	Total cost of construction.	Capacity of reservoir.	Cost construction in terms of capacity, per acre-foot.
	Sq. miles.	Ac.-feet.	Feet.	Feet.	$ cts.	Ac.-feet.	$ cts
Reservoir site, Tp. 10, R. 26, W. 3rd Mer........	24·5	2,412	32	1,100	24,667 30	1,954	12 62
Skull creek site, Tp. 11, R. 22, W. 3rd Mer.....	33	3,572	50	590	28,390 00	3,873	7 35
Parson lake site, Tp. 10, R. 25 and 26, W. 3rd M.	8	371	20	800	7,000 00	835	8 34
Hammonds lake site, Tp. 10, R. 25, W. 3rd Mer..	7	296	22	300	4,035 00	666	6 06
Sec. 8, Tp. 10, R. 25, W. 3rd Mer.	7	296	11·6	610	2,544 50	588	4 32

NOTE—Drainage areas shown here have been estimated from the drainage maps compiled by the hydrographic branch. The cost of construction of the various schemes has been estimated roughly from the plans made by C. H. Ellicott, C.E., in 1902.

The run-off shown in the preceding statement, or the amount of water available for storage during the year 1912, is considerably greater than for an average year, the year 1912 having been exceedingly wet. During the year 1910 there was very little run-off from the above drainage areas.

As stated previously in this report, it is not possible to determine accurately what quantity of water it will be possible to store in these reservoir sites until gauging stations have been established and records taken of the run-off at the points of diversion.

The costs of construction per acre-foot shown are figured from the heights of dams proposed and designed by Mr. Ellicott. These dams have all been figured at a height to provide the greatest possible capacity, evidently without any consideration of the quantities of water available for storage in these reservoirs. Before it can be determined definitely whether these sites are feasible for reservoirs, careful measurements of the run-off must be made and the most economical height of dam with respect to available storage determined. The feasibility of these storage schemes also depends to a large extent on the value of water in these districts.

From the estimates submitted it will be seen that the above sites, although feasible for the purpose of storing small quantities of water, are of very little benefit for irrigation purposes.

The following is a quotation from a letter of instructions written to Mr. C. H. Ellicott, C.E., upon starting his investigations in 1902:—

> "The object of the work is with a view of ascertaining what can be done towards improving the surface water supply for stock watering and domestic purposes by locating possible reservoir sites at or near the head waters of the several streams, which you will examine, by means of which a portion of the large spring run-off of water could be stored and utilized later in the season by turning it back again into the stream."

It is evident from this extract that the main idea of creating reservoirs at the head-waters of the creeks investigated was to provide a supply of water for stock-watering and domestic purposes. At the time these investigations were made this country was almost entirely used as an open range for stock and, since many of the streams go completely dry during a part of the season, it was probably found desirable to hold up pools of water at various points, where feasible to do so, principally for stock-watering purposes. It would appear that, if the object in making these surveys is to create reservoirs for irrigation purposes, the investigations should have covered the lower portions of the streams rather than the head-waters, where a very small portion of the run-off is available and where the likelihood of finding any large basins in which to store the run-off is small.

THE OLDMAN RIVER DIVERSION PROJECT.

For a number of years past a community of settlers in the vicinity of Iron Springs, Alta., have been petitioning the Government to install a pumping plant whereby the water pumped from Belly river could be used on the land about Iron Springs for irrigation purposes, and although the proposition suggested by these farmers has been found to be impracticable, yet the urgent demand for water could not be entirely disregarded, and led this department to investigate other sources for a supply of water for the land referred to.

At this stage of the country's development, when the slogan "Back to the land" is attracting more attention than ever before, and the Government has been called upon from time to time to encourage farming, the importance of irrigation in Western Canada cannot be overlooked. Every possible scheme to reclaim the land and make it more profitable for the farmer, who is the mainstay of any country, should be thoroughly investigated. In the United States the crop produced on lands irrigated from the Government projects alone has an estimated value of $14,000,000, and land values have increased not less than $105,000,000 as a result of the construction of these works.

Mr. C. J. Blanchard, statistician for the United States reclamation service, in a paper entitled *The Purpose and Progress of National Irrigation,* from which paper the above figures have been taken, says: "The creation of additional opportunities for our citizens to secure homes on the land is a national duty of obvious importance. Under our present system of cultivation the lands cropped to-day will not supply the food required by our population fifty years hence. Not only must these lands be required to produce larger yield per acre, but enormous additional acreage must be cultivated if this country is to hold its place as the world's granary."

In Canada, where it is said that the land has as yet hardly been scratched, and where there are not the large tracts of arable land with climatic conditions most suitable to irrigated farming, the demand for irrigation will never be so great as in the States, where more suitable conditions exist. It is no less important, however, if we would encourage farming and make it a more profitable pursuit, to thoroughly investigate the many possibilities which do exist of applying water to the land.

Realizing the value of irrigation to that dry stretch of country between Belly and Little Bow rivers and east of the Porcupine hills, this department endeavoured last season to find some means by which the whole or part of this country could be irrigated.

One which was thought might be feasible to provide for a small section of the country in the vicinity of Iron Springs was a scheme to tap the Southern Alberta Land Company's canal at a point where this canal, coming out of Snake valley, strikes the valley of Little Bow river, by carrying the water across this valley in a flume, or syphon, and thence to Iron Springs in a canal.

Upon investigating this proposition it was not found to be practicable, on account of the prohibitive cost of a flume to cross the valley, and of the very rough side-hill work necessary for the excavation of a canal. The area of land benefited by such a scheme would not warrant the expenditure of an amount sufficient to construct the works.

Another possibility suggested in connection with this project was to divert water from the north fork of Oldman river at some point near the Gap in section 33, township 10, range 3, west of the 5th meridian, to carry this water in a canal along the valley of Callum creek, over the summit and into the head-waters of Willow creek. The water thus delivered could be again diverted at any desirable point from this creek and used to irrigate the tract of land under consideration. It was thought that this scheme of delivering water, as it would be at a high elevation above the land to be irrigated, would be the most feasible one. Upon making a reconnaissance of this route, however, it was found that, although possible, a scheme to divert water from this source would not be practicable for the following reasons:—

(1) There would not be a sufficient quantity of water available from the north fork of Oldman river to irrigate any considerable area of land, and there would therefore be no advantage in taking water from the river at this high elevation, since there would not be a sufficient quantity to supply the land under the ditches.

(2) A canal constructed by this route would have to follow along the very steep and rough side-hills of Oldman river and Callum creek, making the cost of construction prohibitive. Such a scheme would not only involve the construction of a great number of long and high trestles, but the side-hills are of such a nature that the excavation would be most difficult.

The scheme which proved to be most feasible to irrigate the land under consideration, and of which the most extensive surveys were made, is to take water from Oldman river at a point on the Peigan Indian reserve above Macleod and to carry it to the land by a system of canals.

Mr. Meek, after outfitting his party at Macleod about June 15, started his surveys from the northeast corner of section 31, township 8, range 27, west of the 4th meridian, the elevation of the land at this point having been found to be the controlling elevation of this end of the line, in that it is necessary to get the canal away from the river at this point in order to avoid the cut-banks on the north side of Oldman river lower down. A traverse starting from this point was made of the south bank of the river as far as the mouth of Beaver creek, and several cross sections of possible dam sites were developed.

An alternative route from an intake on the south side of Oldman river considerably below this first line was also surveyed in connection with this end of the work, and then the party was moved back to continue these surveys along the west side of Willow creek, approximately following the contours at their respective elevations to the land to be served with water. Upon completing these surveys a level party was formed, and a system of levels run over the whole of the block of land under consideration.

In carrying on the surveys in connection with this project, the aim was to compile the necessary information to enable the following points to be determined as nearly as possible:—

(1) The most feasible point of diversion.

(2) The most feasible route for a canal from the intake to the land under consideration.

(3) The cost of constructing dams, flumes, drops, etc.

(4) The possibilities of storing the diverted water.

(5) The area of land which can be successfully irrigated.

It was realized early in the season that Mr. Meek would not be able to intelligently make any surveys for secondary canals or laterals until the whole block of land had been levelled over and contour maps completed. He was therefore instructed, upon completing his surveys for a canal from the intake to the land to be affected to form a level party and procure as much of the necessary data as possible, the idea being to gather as much information of a general nature as was possible in the time at his disposal.

These secondary canals and laterals in connection with this scheme have since been projected upon the contour maps prepared, and, by putting a party in the field during the coming season to actually run the lines and complete this system of levels, it should be possible from the information thus obtained to arrive at a fairly close estimate of the cost of such a project.

As previously stated, a more detailed report, including an approximate estimate of the cost of constructing this project, and a small plan showing the surveys completed during the past field season, will be found elsewhere.

It will be readily understood that these surveys were necessarily of a preliminary nature, and consequently it is not possible, with this information, to arrive at any accurate estimate of the cost of irrigating the land. In order to determine with any degree of accuracy what the cost of constructing such a scheme would be, more detailed surveys would have to be made. It is thought, however, that a complete estimate of the cost of this scheme, though probably very much in error, will approximate the actual cost to irrigate the land per acre and whether or not the project is feasible.

CONCLUSION.

In concluding this report it should be stated that the officers in charge of parties, who have submitted reports upon the various projects investigated by them, have worked hard and conscientiously to present the results of their work in such form as to be of the greatest possible value to anybody who should in the future see fit to study these projects further.

The schemes investigated during the year 1913 are all of the greatest importance, and although it is realized that only a preliminary study of these projects has as yet been made, and that before any of these schemes can be constructed a great deal more work will be necessary, it was only the intention to do preliminary work and to present the results of the work in such a manner as to be of the greatest public benefit.

The South Saskatchewan water supply project, which is probably the largest scheme ever investigated by this department has now been under consideration for several years, and an attempt has been made this year to finish up this work, in a general way, and present what is believed to be the most feasible scheme for a water supply system in south Saskatchewan.

It is not pretended, however, that this department has now so thoroughly investigated and disposed of this scheme that no more surveys will be necessary. On the contrary, the results so far attained simply show in a general way the most feasible schemes and the approximate cost of constructing them. Before any such scheme as this could be constructed, surveys in more detail would have to be made and the estimates gone into at much greater length than was possible by this department at present.

Although a scheme by way of Qu'Appelle river and Buffalo Pound lake route has been recommended in this report as the most feasible one to supply the southern part of the province of Saskatchewan with water, it should be remembered that the great objection to this route has always been that the bed of this river is of such material as to pollute any water turned into it, and it has not been possible to study this phase of the question at any great length. It is believed, however, that the large body of water which it is proposed by this scheme to turn down Qu'Appelle river will not be seriously affected, and even if it is necessary to provide filter beds to purify the water, this scheme will still cost much less than any of the other proposed schemes.

No estimates have been made of the cost of the filter beds, but it will be seen from the estimates submitted by Mr. Montague, that the difference between the estimated cost of this scheme and the next lowest is $5,650,000, and this amount will more than cover any system of filtration necessary.

It is believed that the most feasible sites for storing water in the Cypress hills have now been investigated by this department, but before any of these schemes could actually be constructed, a further investigation would be necessary.

Although the Oldman river diversion project has been discussed in a report submitted this year, and an approximate estimate of the cost of such a scheme prepared, it should be remembered that the surveys as yet completed have necessarily been of a most preliminary nature, and the estimates have been submitted merely to show the feasibility of such a scheme. This project will be further investigated during the present year, and a more detailed report submitted next year.

Your obedient servant,

B. RUSSELL,

Chief Field Inspector,

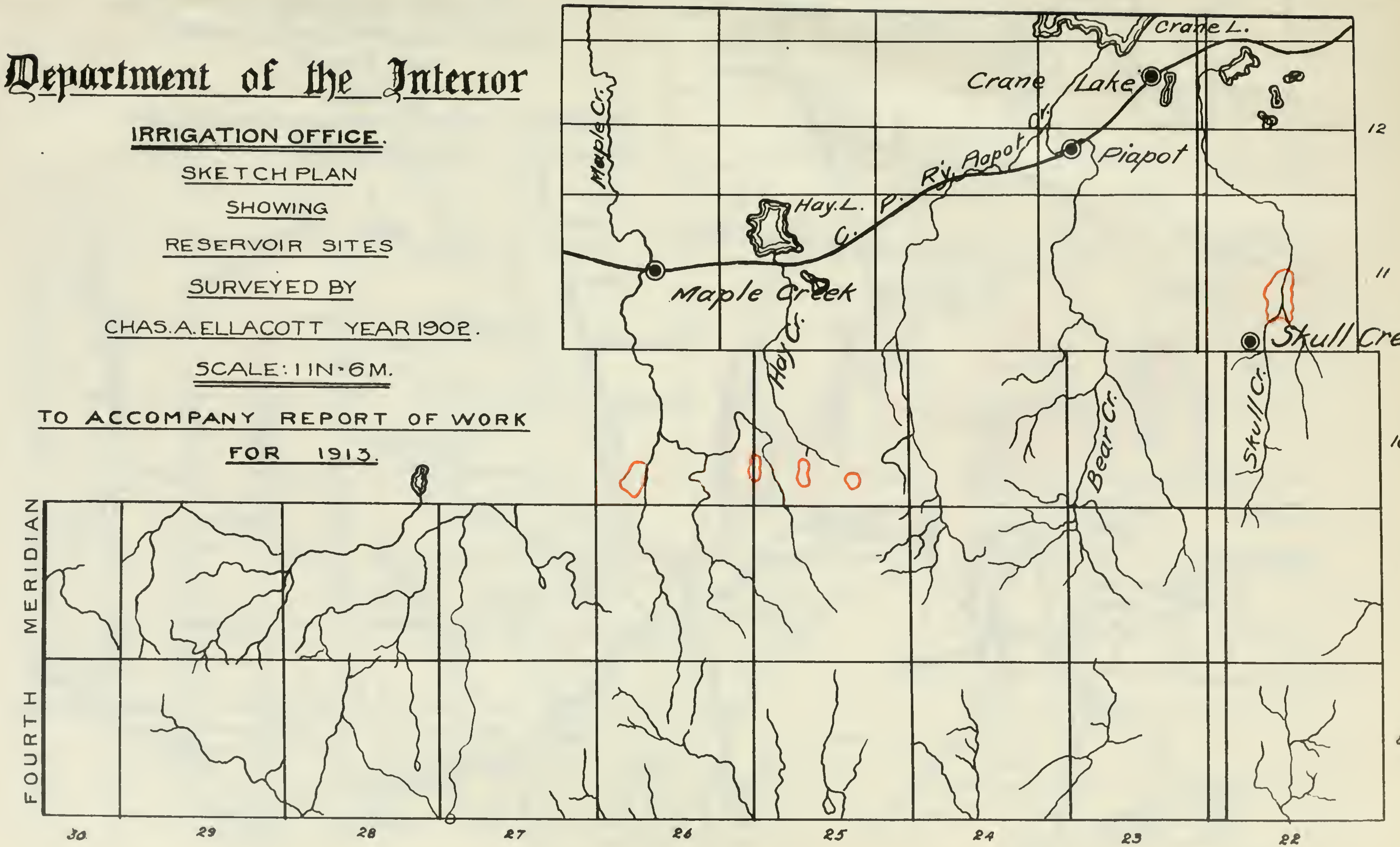
REPORT ON THE SOUTH SASKATCHEWAN WATER SUPPLY DIVERSION, PROJECT, BY T. M. MONTAGUE.

CALGARY, March 31, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I have the honour to submit herewith my report on the South Saskatchewan Water Supply Diversion project.

This project has been under the consideration of this department for several years, and, since reports have been published from time to time dealing at some length with the problems involved, it will be unnecessary to treat of these problems further. It is believed that all the feasible routes for a diversion of water from the South Saskatchewan river have now been investigated by this department.



Department of the Interior
IRRIGATION OFFICE.
SKETCH PLAN
SHOWING
RESERVOIR SITES
SURVEYED BY
CHAS. A. ELLACOTT YEAR 1902.
SCALE: 1 IN.-6 M.
TO ACCOMPANY REPORT OF WORK
FOR 1913.
Crane L.
Crane Lake
Piapot Cr.
Piapot
C. P. Ry.
Hay L.
Maple Creek
Maple Cr.
Hay Cr.
Bear Cr.
Skull Cr.
Skull Cree
FOURTH MERIDIAN
30
29
28
27
26
25
24
23
22
12
11
10
9
8

Department of the Interior.

IRRIGATION OFFICE

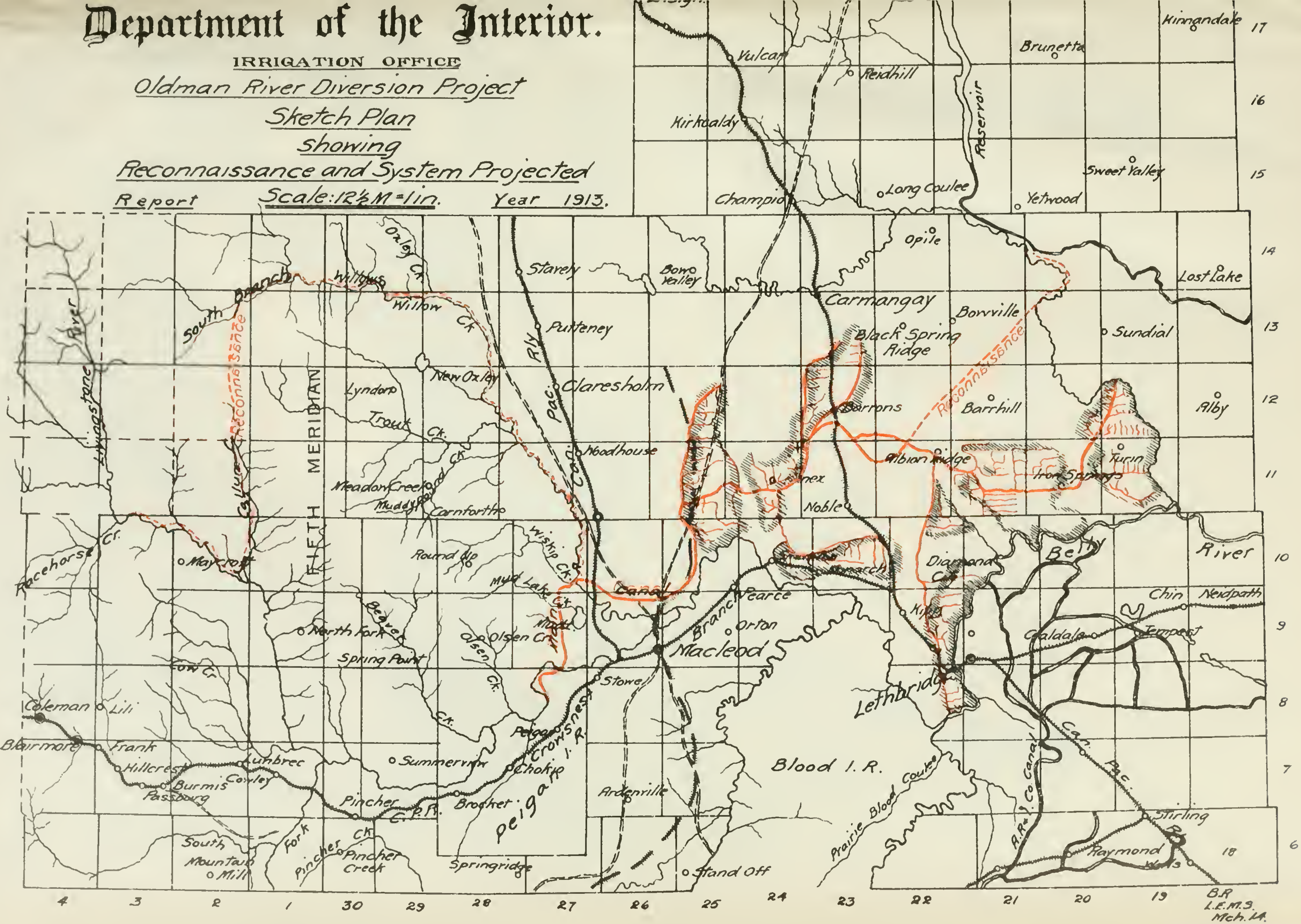
Oldman River Diversion Project

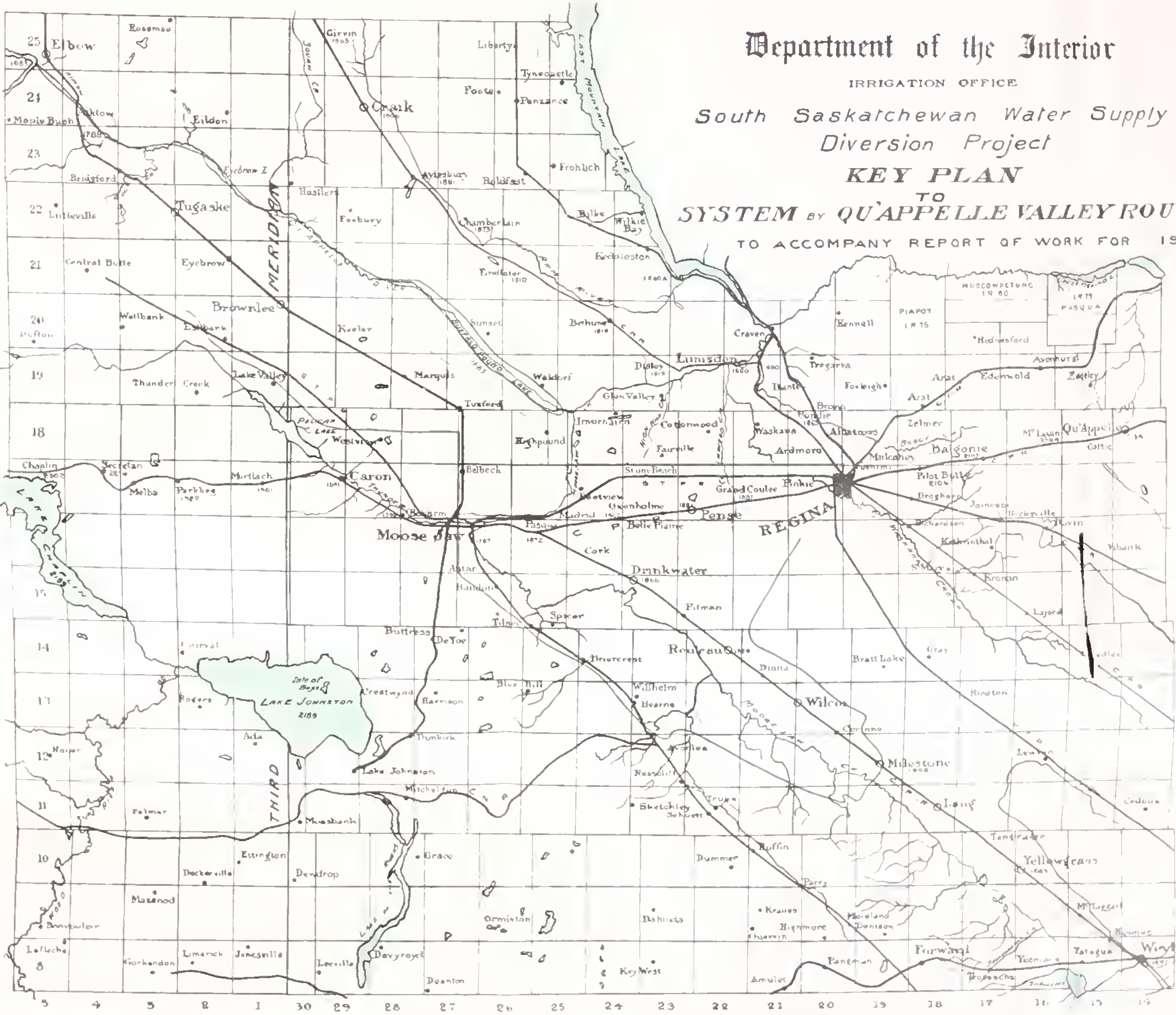
Sketch Plan

showing

Reconnaissance and System Projected

Report Scale: 12½ M = 1 in. Year 1913.




Department of the Interior
IRRIGATION OFFICE
South Saskatchewan Water Supply
Diversion Project
KEY PLAN
TO
SYSTEM BY QU'APPELLE VALLEY ROUTE
TO ACCOMPANY REPORT OF WORK FOR 1913.
Elbow
Craik
Tugaske
Brownlee
Eyebrow
Lumsden
Craven
Caron
Moose Jaw
Pense
REGINA
Balgonie
Qu'Appelle
Drinkwater
Rouleau
Wilcox
Milestone
Lang
Lake Johnston
Lake Johnston
Yellowgrass
Weyburn
Forward
THIRD MERIDIAN
Buffalo Pound Lake
Last Mountain Lake
Lake Chaplin
Pasqua
Piapot
Muscowpetung
Belle Plaine
Grand Coulee
Mortlach
Parkbeg
Secretan
Chaplin
Tuxford
Marquis
Keeler
Bethune
Chamberlain
Aylesbury
Girvin
Liberty
Foote
Penzance
Frohlich
Holdfast
Bulke
Disley
Ardmore
Boharm
Belbeck
Westview
Dummer
Parry
Ruffin
Truax
Avonlea
Spicer
Briercrest
Wilhelm
Hearne
Dunkirk
Crestwynd
Buttress
Key West
Davyroyd
Ormiston
Grace
Dewdrop
Mazenod
Limerick
Amulet
Pangman

The purpose of this report is to touch briefly upon the merits of the several proposed schemes and, by comparison, to determine which of them appears most suitable, having regard to all the circumstances of the case.

The instructions which were issued for carrying on the field work in connection with this project during 1913 were, in effect, to locate a short air-line for a pipe from the South Saskatchewan river to Regina, with a branch to Moosejaw which, continued, intersects the line as located in 1912, and then to investigate the possibilities of utilizing the natural watercourse and reservoir provided by Qu'Appelle river and Buffalo Pound lake.

The first part of this report deals with the actual field work done in carrying on these surveys.

In part two, those schemes that require a long pipe line are segregated, and comparisons are made as to their suitability to fulfill the various requirements. Since the route as located in 1912 comes under this class, it is indicated here.

Part three of the report deals entirely with a scheme which would utilize Qu'Appelle river and Buffalo Pound lake as part of the system. The river and lake would be connected up with what might be termed the supply pipes of the systems described in part two, to make a complete project.

Part four includes the complete estimates for all the routes that have been investigated up to the present time. In making these estimates the unit prices for all materials are the same throughout, and it is assumed that the same quantity of water would be required for each scheme, which makes the different routes surveyed readily comparable.

Part 1.

The party as organized in 1913 consisted of an engineer in charge, one transitman, one topographer, one field draughtsman, two rodmen, two chainmen, one picketman, two teamsters, and one cook.

Upon starting the field work the outfit and party were assembled in Chaplin, Sask., and on May 23 were moved back to Thunder valley, where active survey operations were started immediately. The line as located in 1912 from the river to a lake in township 20, range 6, west of the 3rd meridian, which lake it is proposed to use as a reservoir, was considered the best possible route between these two points, so that a line starting at the southern end of the lake in section 15, township 20, range 6, west of the 3rd meridian, and following the northern side of the valley was surveyed. The first part of this course is on grade following, for the first 18 miles, the steep and stony side-hill of the valley, which is broken in places by coulees and draws. The country then flattens out and, from section 32, township 19, range 3, west of the 3rd meridian, the slope is gentle, and a long loop to the north is required to keep the pipe on an even gradient. Several long, inverted syphons are also necessitated in this section of line on account of the country falling away to the north, where it would be impracticable to carry the pipe around on grade. The ground in the latter part of the country is for the most part a heavy clay loam practically all under cultivation. The end of this section is at a point in section 28, township 18, range 26, west of the 2nd meridian, from which point it is impossible to keep the pipe on a grade line as the country falls away to the east and south. A direct line was then run to Regina, which followed mainly along the township line between townships 17 and 18, and is subject at all points to considerable pressure, which at Moosejaw creek, Cottonwood creek, and Wascana creek becomes very high. The soil for the most part is a heavy clay loam and mostly cultivated.

A branch was run from the main line starting at a point in section 25, township 18, range 27, west of the 2nd meridian, following along the range line to Moosejaw, and was connected to the present high-level reservoir of that city; it was then continued south to intersect the line as located in 1912 in section 16, township 16, range 26, west of the 2nd meridian, as a means of supplying the country adjacent to and the towns along the Portal branch of the Canadian Pacific railway and the Moosejaw-Forward branch of the Canadian Northern. This branch is for the most part under considerable pressure and traverses a country in which water is very scarce.

Starting at a point in section 19, township 19, range 3, west of the 3rd meridian, a line was run by a more direct route to Mortlach in an endeavour to shorten the line, thus cutting out a large loop which was necessary to follow a grade line. This cut-off, although it will entail some very heavy work for the first 4 miles, will shorten the line appreciably, and since the route chosen between these points would be the one entailing the smaller expenditure, comparison of costs and a recommendation will be made further on this report.

In the line run in 1912 between Milestone and Regina a heavy cut (some 5 miles long) was found necessary. An endeavour was made to eliminate this by running a location around it. This, however, was found impracticable, and the new location was abandoned.

It has been previously suggested that a feasible scheme would be to divert water from the river at some point near the Elbow, take it up to the Aiktow Creek valley to the height of land, turn it into Qu'Appelle river, and allow it to gravitate to Buffalo Pound lake, where it could be impounded and pumped to a system of pipes which would deliver it to the districts requiring water. One natural feature which tends to make such a scheme most feasible is that the height of land between Aiktow creek and Qu'Appelle river is only 88 feet above the level of the water in the South Saskatchewan river. It was decided to investigate the possibilities of this route.

Starting at a point in section 18, township 24, range 5, west of the 3rd meridian, where a possible site for a dam had been located in 1911, a line was run following along the bank of the South Saskatchewan river to the confluence of Aiktow Creek valley, thence along the side slope of this valley over the height of land, and down the Qu'Appelle valley as far as Eyebrow lake in section 15, township 23, range 2, west of the 3rd meridian. Sufficient topography was developed on either side of this traverse to permit an investigation of several alternatives which presented themselves.

In order to utilize Buffalo Pound lake as a reservoir it would be necessary to construct a dam across the valley, at the foot of the lake, to impound water. There is no place near the southeasterly end of the lake that could be termed a natural dam site. The valley being of a fairly uniform width, with steep banks on either side, and the lake having sufficient capacity for the largest scheme, a point at the south end of the lake was chosen as a desirable place for the dam.

It was assumed that a dam 30 feet high would be built and the topography of the lake shores was developed to an elevation 15 feet higher. The survey was continued further up the valley from the northwest end of the lake to a point where the creek level was 30 feet above the level of the lake.

In order to get the water from Buffalo Pound lake to an elevation from which it would gravitate to the districts requiring it, a pumping station would have to be established, operated by steam produced by coal, or electricity developed at a plant at the river and transmitted to the pumping station at the lake. A site was chosen for this near the southeastern end of the lake in section 2, township 19, range 25, west of the 2nd meridian, and a pressure line located to the top of the bank. From this point a pipeline was located in a southerly direction connecting with the main line to Regina at a point in section 3, township 18, range 25, west of the 2nd meridian, and thence in a westerly direction to connect with the line run to Moosejaw. This line, joining up as it does at a point in section 6, township 18, range 26, west of the 2nd meridian, connects the reservoir with other lines previously run.

During the summer eighteen standard Dominion Government bench-marks were established at intervals along the lines, the elevations of which have been reduced to "Canadian Pacific Railway Winnipeg Sea-level Datum." A tie was also made on the Dominion Government geodetic bench-mark on the Canadian Pacific Railway station at Regina.

In the course of the summer the following work was done:—

Traverse run with topography and levels	279 miles.
Traverse without topography and levels	6 "
Dominion Government bench-marks established	18
Other bench-marks	7

In connection with this report the following large scale plans have been prepared from which the estimates have been made: they are, however, of too great bulk to submit with this report:—

PLANS.

Roll No. 1.—Main line, 0+00—911+70.
Mortlach, 943+00—1978+00.
Roll No. 2.—Main line, 911+70—3286+00.
Roll No. 3.—Moosejaw branch, 0+00—864+00.
Main line, 3284+00+3956+91·7.
Roll No. 4.—Main line, 3952+00—5620+83·3.
Roll No. 5.—Buffalo Pound lake, 0+00—1908+30.
Roll No. 6.—Moosejaw tie line, 0+00—823+35.
Roll No. 7.—Qu'Appelle Valley traverse, 0+00—1342+00.

PROFILES.

Roll No. 1.—Main line, 0+00—3309+00.
Roll No. 2.— " 3300+00—5260+00.
Roll No. 3.—Moosejaw branch, 0+00—864+00.
Roll No. 4.—Moosejaw tie line, 0+00—802+00.
Roll No. 5.—Qu'Appelle Valley traverse, 0+00—633+00.
Roll No. 6.—Mortlach cut-off, 910+00—1978+00.

Part 2.

The scheme as surveyed in 1912, and of which a report and estimate were published in 1913, was kept as near as possible to a grade line, and is shown in red on the accompanying map. The scheme as surveyed in 1913, shown in green on the map, and of which an estimate is submitted with this report, only follows a grade line where convenient to do so, portions of the pipe going in a direct line to the point of consumption, regardless of the pressure developed in the pipe by falling below the hydraulic grade line. In comparing the two routes, the former scheme will be referred to as scheme No. 1, and the estimate of it as estimate No. 1. The latter scheme will be referred to as scheme No. 2, and the estimate of it as estimate No. 2.

In order that a fair comparison can be made between the two schemes it is necessary to adopt a uniform scale of unit prices, therefore in estimate No. 2 the same unit prices are used as for estimate No. 1, with the exception that the estimate for scheme No. 1 in which concrete was figured at $12 per yard, had been dropped, as this is considered too low a unit price for the work under existing conditions. The comparison will be made with the cost of scheme No. 1, using $15 per cubic yard as a unit price for the concrete in the pipe. The unit prices of 40 cents per cubic yard for excavation and back-fill, 25 cents per cubic yard for borrow, and $25 per lineal foot for pressure pipe, remain unchanged.

Estimate No. 1 makes provision for a pipeline from the river to the reservoir in township 20, range 16, west of the 3rd meridian, and since this portion of the line was not surveyed in 1913, the estimated cost of this part as figured in estimate No. 1 will be added to estimate No. 2, this being necessary to complete the scheme. Estimate No. 1, as published, does not include a connection to supply the city of Moosejaw.

An estimate of cost of such a connection has been computed from information taken during 1913 and added to estimate No. 1.

The estimated cost for scheme No. 1, as already published, is increased in this report (1) by the additional cost of the branch for Moosejaw, (2) by the allowance of $334,293.37 for right-of-way and contingencies; figuring for a right of way 100 feet wide and land at $50 per acre, which is not high when the damage to a farm arising from cutting it in two is considered, with a fence on each side, would make an item of $160,000. Other items, such as ditching, culverts, and the interest on the lands during the time of construction, would also have to be provided for. It is evident that the $174,293.37 left after right-of-way and fencing have been accounted for is quite inadequate to offset these other expenditures and leave a fund for other contingencies.

In the estimate for scheme No. 1, as published in this report, a separate amount has been allowed for the cost of a right-of-way, fencing, and approximately 15 per cent of the total cost added for engineering and contingencies. Taking into account these additional amounts it is found that estimate No. 1 is increased from $13,500,000 to $15,000,000. On the same basis estimate No. 2 amounts to $14,500,000, so that from a standpoint of capital cost there is very little to choose between the two. Consequently, other features will control the choice of a route.

The cost of maintenance of scheme No. 2 will be somewhat higher than scheme No. 1, as the former requires 243 miles of pipe ranging from a 7-foot 6-inch to a 2-foot, and the latter 200 miles of pipe ranging from a 7-foot 6-inch to a 5-foot 0-inch, but whatever advantage scheme No. 1 has in this respect would probably be equalized by the advantage No. 2 has in the first cost.

Comparing the two schemes from a stand point of the service rendered, the area of country and number of people to which water could be supplied without the necessity of auxiliary pumping stations, all other things being nearly equal, is the chief factor in controlling the route followed by any scheme chosen. Referring to the map it will be seen that scheme No. 1 (the red line), from the reservoir in township 20, range 6, to section 6, township 16, range 26, west of the 2nd meridian, follows along the valley of Thunder creek, where there are but few towns accessible, and the farming district cannot be termed the best, and where water is not so scarce as elsewhere in this district. From section 6, township 16, range 26, west of the 2nd meridian, the line follows along the slope of Moosejaw Creek valley as far as Milestone, and is capable of supplying, by means of secondary pipes, the towns along the railroads and a rich farming country in which water is very scarce. From Milestone the line runs north to Regina, taking in a few towns and a rich farming district, but a heavy cutting some 5 miles in length, which cannot be avoided, renders that section of line useless as a gravity supply to the farming community.

Referring to scheme No. 2 on the map (the green line), it will be seen that it follows the north slope of Thunder valley from the reservoir to a point in section 28, township 18, range 26, west of the 2nd meridian. As far as Darmoody the country is very similar to that followed in the first part of scheme No. 1, but from Darmoody on, water could be supplied to the towns along the Grand Trunk Pacific railway, to some of the towns along the Outlook branch of the Canadian Pacific railway, and to the settlers west of Tuxford. The branch from Tuxford south to Moosejaw is continued to section 6, township 16, range 26, west of the 2nd meridian, from which point it parallels the route shown in red to Regina, supplying the same area. At a point north of Milestone it is intended to diverge from the red line to obviate the heavy cutting. By swinging to the west at this point it is possible to provide a gravity supply to more of the country and towns than by the route followed in 1912. The main line continued from south of Tuxford to Regina is capable of supplying the towns along the main line of the Canadian Pacific railway and the Regina-Moosejaw branch of the Grand Trunk Pacific; it will also supply a great many farms on the route.

From an engineering standpoint both routes are quite feasible, there being no very great obstacles in either one. Railway facilities for bringing in material would probably be somewhat in favour of scheme No. 2, as it is seen from the map that it parallels existing railways for probably three-quarters of its entire length, while scheme No. 1 in some parts is almost inaccessible from existing lines.

It is evident then, from a comparison of the areas just described, that scheme No. 2 is capable of supplying a much greater area of country than scheme No. 1. Moreover, the country traversed by the second scheme is nearly all good farming country, in need of water, which statement cannot be made for the first part of the former scheme. Consequently it would be quite safe to advocate the adoption of scheme No. 2 over No. 1 if it came to a choice between the two.

As has been previously mentioned in this report, an attempt was made to reduce estimate No. 1 by shortening the line, the location starting in section 19, township 19, range 3, west of the 3rd meridian, and running southeast to a point near Mortlach. On making a detailed estimate of each route, and comparing them, it was found that the shorter route entails a saving of approximately $70,000. This is a very small percentage of the entire cost, so that the route chosen would really be a matter of final location. The shorter route, however, has the advantage that inasmuch as it is nearly 4 miles shorter it saves approximately 2 feet in grade, which would enable the pipe to supply a greater territory by gravity. A summary of cost estimate will be found under the heading estimate No. 3.

Part 3.

In this part of the report, the scheme for diverting water from the South Saskatchewan river and delivering it to the country under consideration via Qu'Appelle valley and Buffalo Pound lake route is considered, and since it is proposed by this scheme to allow the water, after having been delivered to the height of land between Aiktow creek and Qu'Appelle river, to gravitate to Buffalo Pound lake to be stored, a brief description of both the Qu'Appelle valley and Buffalo Pound lake is necessary.

The Qu'Appelle river, which it is proposed to use as a channel for the water from the end of a cutting at the height of land to the reservoir, follows a very sinuous course, so that the total length between any two points would probably be double that of an air line. An average cross-section of the river would be 30 feet wide at the top, 15 feet wide at bottom, and from 10 to 15 feet in depth. The water in the river at the present time is in most places stagnant and quite unfit for consumption. It tastes strongly of alkali, and in many places deposits of this can be seen along the banks.

Buffalo Pound lake is approximately 15 miles long and one-half mile wide. The banks for the most part rise abruptly from the lake shore to an elevation of 200 to 300 feet above, and are composed principally of gravel and loam. The water along the shore of the lake is shallow, with a bottom of black muck grown up with reeds and gradually deepens towards the centre, where it has a maximum depth of 14 feet. The valley above the lake is flat, with a rise of about 2 feet to the mile. The land is alkali gumbo and of very little use for anything but pasture. Although some attempts have been made to cultivate it, the efforts so far have met with little success. Very few buildings and but little valuable land would be affected by raising the water 30 feet above the present elevation.

The four most feasible alternative schemes for diverting water from the South Saskatchewan river and delivering it to the land to be served are as follows:—

(1) A 40-foot dam across the South Saskatchewan river at a point near the mouth of Aiktow creek, a 50-foot cut through the height of land between this creek and Qu'Appelle river, allowing the water to gravitate from the river to Buffalo Pound lake where it would be impounded.

(2) A 40-foot dam across the South Saskatchewan river, a 20-foot lift and a 30-foot cutting through the height of land, allowing the water to gravitate to Buffalo Pound lake.

(3) A 40-foot dam across the South Saskatchewan river, a 50-foot lift over the height of land, allowing the water to gravitate to Buffalo Pound lake.

(4) A 90-foot lift from the South Saskatchewan river to a point in Aiktow Creek valley, and a canal to the height of land, allowing the water to gravitate to Buffalo Pound lake as before.

Since all four of these require the conversion of Buffalo Pound lake into a reservoir, it will be necessary, before treating them further, to describe this reservoir site.

BUFFALO POUND LAKE RESERVOIR.

Buffalo Pound lake, of which the physical features have been previously described in this report, has a water area at the present time of 4,696·7 acres. Consequently it will be seen that, by raising the water very little, an enormous storage capacity can be provided.

It is proposed for the purposes of this report to raise the water, by means of a dam, 15 feet above its present level, and a dam with a crest elevation of 23 feet above the present level of the lake has been designed for this purpose. It is thought that this 15 feet of water will be of sufficient depth to obviate any danger of the sediment at the bottom of the reservoir being stirred up and drawn into the intake pipe.

By raising the water level 15 feet a reservoir can be created which will have a superficial area of 7,577·16 acres and a capacity of 92,046·3 acre-feet, or 25,059,605,175 gallons. This quantity of water is not only abundant for the present installation, but will also be sufficient when future extensions are made to the scheme.

The dam proposed is an earthen one, and since the wave action on a body of water of this shape and dimensions would be considerable, a height of 8 feet was allowed for this.

The upper face of the dam is to be rip-rapped, and a control gate capable of discharging 200 c.f.s. under a full head provided at the lowest point.

Although the capacity of this gate is in all probability considerably greater than necessary, no reliable records were available from which the discharge of Qu'Appelle river at this point could be estimated, and the gate was designed of sufficient capacity to be safe in any event. The only measurements recorded on this stream were made further down, so that the discharge is a combined one of several creeks, including Moosejaw, Cottonwood, and Wascana creeks, the first-named being the only one of which gaugings were made.

Provision has been made in the estimate for clearing any obstructions in the channel of Qu'Aappelle river feeding into the lake, and also for deepening the channel at the outlet to lower the present water level in order that the vegetation along the edges may be killed. A detailed cost of this reservoir will be found in estimate No. 4.

The absorption losses from such a reservoir would consist of seepage and evaporation. The total loss for any year would probably be in the neighbourhood of 5 feet over the entire surface of the reservoir, giving a loss of about 36,000 acre-feet. The watershed above the reservoir has an area of at least 1,000 square miles. The run-off for 1911 on the whole of the Qu'Appelle watershed was ·054 inch. This gives a run-off above the reservoir of 34,560 acre-feet, which practically balances the absorption losses.

In order to make the reservoir as inaccessible as possible, to prevent trespassing, and to keep stock from getting into the river above the reservoir, thus polluting the inflowing water, it is proposed to build a fence the entire length of the river and around the lake. An amount covering the cost of this fence and also of a strip of land around the lake about half a mile wide has been provided for in the estimates.

In further discussing the four alternatives of delivering water to Buffalo Pound lake *via* the Aiktow creek and Qu'Appelle valley, it is proposed in the first three to develop hydro-electric power from the South Saskatchewan river. This could be accomplished by constructing a 40-foot dam across the river with an hydro-electric power-station in connection. This station would have sufficient capacity to pump the water from the river to the reservoir, and when transmitted to the pumping station at the reservoir, after deducting all losses, would furnish enough power to elevate the water to the plateau above. The construction of such a dam and pump-house, however, would be very costly, but as yet the information available is insufficient to make a close estimate of just what the cost of such an undertaking would be.

In the estimate for these three alternatives, a steam pumping plant, using coal as fuel, is included, to serve as stand-by power in order to assure a continuous service. Alternative No. 1 entails, in addition to the big dam, a 50-foot cutting through the height of land between Aiktow creek and Qu'Appelle river which would be very long and therefore costly; also a transmission line to transmit the power from the hydro-electric station at the river to the pumping station to be built at the reservoir. From the pumping station a pressure pipe would be constructed to the top of the hill. It is estimated that the capital cost of this scheme would be $6,388,000 and an annual cost of $400,180, which includes interest on the capital expenditure, labour, oil waste, and maintenance.

Alternative No. 2 also requires the construction of the dam in addition to a pressure pipe to the canal, an expensive canal 30 feet deep through the height of land, the transmission line, the pumping station on the lake, and the pressure pipe to the top of the hill. The capital cost of this is estimated to be $4,228,000, and the annual cost, $277,680.

Alternative No. 3 also entails the construction of a dam, together with a pressure pipe to the canal, a canal to the height of land, the transmission line, the pumping station at the reservoir and the pressure pipe to the top of the hill. The capital cost is estimated at $3,528,680.

Alternative No. 4 consists of a power-station at the river, operated by coal and steam, with steam turbines driving centrifugal pumps, a pressure pipe to a canal, a canal to the height of land, the conversion of Buffalo Pound lake into a reservoir, and a pumping station at the reservoir operated by coal and steam. A pressure pipe would convey the water to a surge basin on the plateau above the lake. It is estimated that the capital cost of this would be $893,000, and an annual cost of $233,280, which includes interest on expenditure, coal, oil, waste, labour, and maintenance.

Summing up the four alternative means of getting water from the South Saskatchewan river to the plateau above the reservoir inclusive:—

Alternative.	Capital Cost.	Annual Cost.
	$	$
(1)	6,388,000	400,180
(2)	4,228,000	277,680
(3)	3,528,000	255,680
(4)	893,000	233,280

The above figures show that alternative No. 4 is the cheapest one to install and maintain. In the above estimates used for the comparison a canal is proposed from the end of the pressure pipe to a point where the water would gravitate down the Qu'Appelle river. This open canal might be exceedingly difficult to operate in the winter months, and, even though the reservoir is of sufficient capacity to carry the consumption over this period, it is thought that a better scheme would be substitute a 7-foot 6-inch gravity pipe on an even gradient from the end of the pressure pipe at the South Saskatchewan river to a point where the water would be discharged into Qu'Appelle river. If concrete pipe were estimated for this purpose in all four alternatives it would not change their relative costs. It is proposed that this portion of the system be made up of alternative No. 4 with a 7-foot 6-inch inside diameter concrete pipe in place of the canal, and estimate No. 5 is figured on this basis.

Scheme No. 3.

(See diagrammatic sketch for complete layout.)

This scheme is made up of alternative No. 4 of Qu'Appelle river, Buffalo Pound lake route linked up with the service pipes already located and described in part two.

COUNTRY SERVED.

The main supply pipe runs from the surge basin above the pumping station at the reservoir in section 2, township 19, range 25, west of the 2nd meridian, to a point in section 3, township 18, range 25, west of the 2nd meridian. At this point a 5-foot diameter branch is taken off, which runs to Regina to supply that city and the towns and farms between. The main pipe is reduced to 6 feet diameter, and runs west as far as section 6, township 18, range 26, west of the 2nd meridian. Here a 2-foot diameter branch runs northwest, to supply the country west of Tuxford and the towns along the Grand Trunk Pacific railway. The 6-foot pipe is continued south as far as the Moosejaw high-level reservoir, where a short branch line is taken off to supply that city.

The pipe is now reduced to 4 feet diameter, and runs south and southeast as far as Milestone, supplying the farms, the towns along the Portal branch of the Canadian Pacific railway, and the Moosejaw-Forward branch of the Canadian Northern railway. At Milestone it is reduced to a 2-foot diameter pipe, running northeast to a point in the vicinity of Regina, supplying the farms in that district.

A general plan showing this system, and the country which can be served, accompanies the report submitted by the chief field inspector, and reference is made here to this report.

The capacity of this system is 60 second-feet, or 32,400,000 gallons per day, which is the same as that used in the report on this project published in 1913. For a full discussion of how this quantity was arrived at see 1913 report.

The quantity of water to be pumped from the river is:—

	60	second-feet required for consumption.
	15	" to bring reservoir up to normal level after a period of inaction.
Total	75	second-feet.

Power required for pumping plant at the South Saskatchewan river:—

	Feet.
Elevation of water in river	1,652·75
" canal	1,742·75
Height to pump	90·0
Add 10 per cent for friction	9
Total head to pump against	99·0

Quantity pumped = 75 cubic second-feet.

Water horse-power required — $\frac{99 \times 62 \cdot 5 \times 75}{550} = 843 \cdot 7$. Or say 845 W. H. P.

This power would be developed by boilers with coal as fuel, supplying steam to turbines which would in turn drive centrifugal pumps. The pumps deliver the water into a pressure pipe 5 feet 8 inches inside diameter. The pressure pipe discharges the water directly into the concrete pipe. In the estimates for this pumping station no reserve power has been included, as the storage provided by Buffalo Pound reservoir serves that purpose.

The concrete pipe from the end of the pressure pipe is on a grade of 1 in 10,000, and is 12 miles long. The water is discharged from it into the head-waters of Qu'Appelle river, which it follows to the reservoir. No allowance is made for seepage in this part of open channel, as the bottom of the river is almost impervious to water, and, as it is necessarily in the lowest part of the valley, any seepage there might be would ultimately find its way to the reservoir. Buffalo Pound lake has already been discussed.

The pumping station to Buffalo Pound reservoir is essentially the same as that at the river, only of larger capacity. The plant proposed is made up of three units of equal power, one being spare, which gives 50 per cent reserve power.

Power required at Buffalo Pound reservoir:—

		Feet.
Elevation of reservoir		1,667.75
" surge basin on plateau		1,952.75
Height to elevate water		285.00
Add 10 per cent for friction		28.50
Total head to pump against		313.5
Quantity to be pumped = 60 cubic second-feet.		
Water horse-power required—		
$\frac{60 \times 313.5 \times 62.5}{550} = 2,141.4$ W.H.P. say	2,140 W.H.P.	
Add 50 per cent for reserve	1,070	
Total capacity of plant	3,210 W.H.P.	

The pumps deliver the water into a pressure pipe 5 feet 8 inches in diameter, which conveys the water to the surge basin at the top of the hill from where it is distributed as already described.

The unit price of $77.40 per water horse-power that is used in the estimate of this scheme includes boilers, turbines, pumps, and any cribs and wells that may be necessary to pump from. It is based on the prices obtained by Mr. H. E. M. Kensit, in his report on the power possibilities for this undertaking.

It has been shown previously in this report that scheme No. 2 is more desirable than scheme No. 1. A comparison will now be made between Nos. 2 and 3. From a study of the areas which are capable of being supplied by these two schemes it is evident that they are almost identical, consequently, neither scheme has any advantage in this regard.

A comparison between the two schemes on a basis of capital and annual cost:—

Capital cost, Scheme No. 2	$14,500,000 00	See estimate No. 2.
" " No. 3	8,050,000 00	" No. 5.
Scheme 3 costs less by	$ 6,450,000 00	

ANNUAL COST.

Item.	Scheme No. 2.	Scheme No. 3.
	$	$
Interest on bonds at 6 per cent	870,000	531,000
Maintenance	....	....
Labour (pumping station)	9,150	26,250
Labour (pipeline)	10,000	8,000
Management	15,000	15,000
Operation	....	....
Coal	....	128,500
Oil waste and repairs	4,800	21,250
Total	908,950	730,000

Scheme No. 3 may be enlarged very easily at any time by the addition of extra units as required, and if at a future time the district becomes so densely populated that a sufficient quantity of water would be consumed to warrant the construction of a dam and power-house, the steam pumping plant could be used as stand-by power, and consequently no capital expenditure would be wasted.

If a coal-steam plant were substituted in scheme No. 2 for the hydro electric development as proposed, the capital and annual costs of the scheme would be somewhat changed. In making this estimate a plant similar to that adopted for scheme No. 3 is used.

Estimated capital and annual cost of scheme No. 2 with a coal-steam power development:—

Cost of scheme 2 less hydro-electric development	$12,750,000
Cost of steam power plant	250,000
Total cost	$13,000,000

ANNUAL COST.

Interest on bonds	$780,000
Maintenance—	
Labour, pump-house	17,500
Labour, pipeline	10,000
Management	15,000
Operation—	
Coal	97,850
Oil waste and repairs	12,000
Total annual cost	$932,350

By using coal steam plant in place of a hydro-electric one there is a saving of $1,500,000 in capital cost, but the annual cost is increased by $23,400, consequently a coal steam plant in connection with scheme No. 2 offers no advantage over scheme No. 3.

From these studies of the different routes and schemes made in connection with this project it is evident that scheme No. 3 would be the best one to adopt for the following reasons:—

(1) It has the least capital cost.

(2) It has the least annual cost, which means the cheapest water to the consumer.

(3) It serves as great an area of country as any.

(4) The main pumping plant is close to the centre of gravity of the system.

(5) It can easily be enlarged.

There is against it, however, the fact that there is a tendency for the water to become polluted in the open canal and river before it reaches the reservoir, and by the surface water running off the watershed.

As already stated in this report, it is now believed that all the feasible routes and schemes whereby water can be diverted from the South Saskatchewan river and supplied to the district requiring it have now been investigated. General comparisons have been made between the various schemes proposed as to their desirability to fulfil the various requirements, and one (scheme No. 3) has been recommended as the best one to adopt for the purpose.

It can readily be seen that a project of this magnitude cannot be undertaken by any of the communities. It must, therefore, be built under the supervision of one of the Governments, either Provincial or Dominion, and arrangements made by which each city, town, or individual, using water would bear their share of the total cost of construction and operation. The construction of such a scheme is by no means impracticable, as many cities both on this continent and in Europe have spent more than this project would cost to develop an adequate water supply.

ESTIMATE No. 1—Sheet (1) of 1. Summary of Cost Estimate. Concrete at $15 per cubic yard.

Division.	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
					$ cts.	$ cts.	$ cts.	
A.	Dam and pumping plant.				1,750,000 00			Assumed.
	Pressure pipe	5 ft. 8 in. inside diam.	3,700 lin. ft.	$25 00 per lin.ft.	92,500 00			
	Settling basin				62,500 00	1,905,000 00		"
1	Concrete pipe	7 ft. 6 in. inside diam.	68,001 lin. ft.	$10 42 per lin.ft.	708,570 42			Gravity pipe settling basin to reservoir.
	Concrete pipe	3 ft. inside diam.	17,600 lin. ft.	1 94 per lin.ft.	34,144 00			Pipe to dispose of surface run-off.
	Excavation		295,768 cu.yds.	0 40 per cu.yd	118,307 20			
	Borrow		3,360 cu. yds.	0 25 per cu.yd	840 00			
	Excavation		5,866·7 cu. yds.	0 30 per cu.yd	1,760 00			
	Reservoir dams	2—2,200 ft. long, 552 sq. ft. cross-sec.	90,000 cu. yds.	0 20 per cu.yd	18,000 00			Approximate dimensions.
	Cleaning reservoir	234 acres, 2·9 feet deep	1,110,000 c.yds	0 22 per cu.yd	244,200 00	1,125,821 62		
2	Concrete pipe	6 ft. inside diam	23,190 lin. ft.	8 38 per lin.ft.	194,332 20			By pass.
	Excavation		124,528 cu.yds.	0 40 per cu.yd	49,811 20			
	Overhaul		1,287 cu. yds.	0 02 per cu.yd	25 74			
	Borrow		9,009 cu. yds.	0 25 per cu.yd	2,252 25	246,421 39		
3	Concrete pipe	7 ft. inside diam	380,109 lin.ft.	9 72 per lin.ft.	3,694,659 48			Gravity line from reservoir to Moosejaw.
	Excavation		1,334,494 c.yds	0 40 per cu.yd	533,797 60			
	Overhaul		48,610 cu. yds.	0 02 per cu.yd	972 20			
	Borrow		334,907 cu.yds.	0 25 per cu.yd	83,726 75	4,313,156 03	7,590,399 04	
4	Concrete pipe	6 ft. inside diam	360,379·3 lin.ft.	8 38 per lin.ft.	3,019,978 53			Gravity line, Moosejaw to Milestone.
	Excavation		545,541 cu.yds.	0 40 per cu.yd	218,216 40			
	Overhaul		716 cu. yds.	0 02 per cu yd	14 32			
	Borrow		810,326 cu.yds.	0 25 per cu.yd	202,581 50	3,440,790 75		
5	Concrete pipe	5 ft inside diam	170,518·5 lin.ft.	7 08 per lin.ft.	1,207,270 98			Gravity line, Milestone to Regina.
	Excavation		476,058 cu.yds.	0 40 per cu.yd	190,423 20			
	Borrow		46,737 cu.yds.	0 25 per cu.yd	11,684 25	1,409,378 43		
6	Concrete pipe	5 ft. inside diam	31,980 lin. ft.	7 08 per lin.ft.	226,418 40			Branch line from main line to Moosejaw.
	Excavation		74,800 cu. yds.	0 40 per cu.yd	29,920 00			
	Borrow		37,600 cu. yds.	0 25 per cu.yd	9,400 00			
	Extra steel		31,980 lin. ft.	2 80 per lin.ft.	89,544 00	355,282 40	5,205,451 58	

			12,795,850 62	12,795,850 62	12,795,850 62
Trimming fill..........			101,400 00	101,400 00	101,400 00
Right-of-way and fencing			164,000 00	164,000 00	164,000 00
			13,061,250 62	13,061,250 62	13,061,250 62
Add for engineering and contingencies....			1,938,749 38	1,938,749 38	1,938,749 38
			15,000,000 00	15,000,000 00	15,000,000 00

ESTIMATE No. 2—Sheet (1) of 2. Summary of Cost Estimate. Concrete at $15 per cubic yard.

Division.	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
A.	Dam and pumping plant.				1,750,000 00			Assumed.
	Pressure pipe	5 ft. 8 in. inside diam.	3,706 lin. ft.	25 00 per lin. ft.	92,500 00			
	Settling basin				62,500 00	1,905,000 00		Assumed.
	Concrete pipe	7 ft. 6 in. inside diam.	68,001 lin. ft.	10 42 per lin. ft.	708,570 42			Gravity pipe settling basin to reservoir.
	Concrete pipe	3 ft. inside diam.	17,600 lin. ft.	1 94 per lin. ft.	34,144 00			Pipe to dispose of surface run-off.
	Excavation		295,768 cu. yds	0 40 per cu. yd.	118,307 20			
	Borrow		3,360 cu. yds.	0 25 per cu. yd.	840 00			
	Excavation		5,866·7 cu. yds.	0 30 per cu. yd.	1,760 00			For surface run-off pipe.
	Reservoirs	2 each 2,200 ft. long, 552 sq. ft. cross-sec.	90,000 cu. yds.	0 20 per cu. yd.	18,000 00			
	Cleaning reservoir	234 acres, 29 deep	1,110,000 cu. yds	0 22 per cu. yd.	244,200 00	1,125,821 62		
2	Concrete pipe	6 ft. inside diam.	23,190 lin. ft.	8 38 per lin. ft.	194,332 20			By pass around reservoir.
	Excavation		124,528 cu. yds	0 40 per cu. yd.	49,811 20			
	Overhaul		1,287 cu. yds.	0 02 per cu. yd.	25 74			
	Borrow		9,009 cu. yds.	0 25 per cu. yd.	2,252 25	246,421 39		
3	Concrete pipe	7 ft. inside diam.	330,900 lin. ft.	9 72 per lin. ft.	3,216,348 00			Gravity from south end of reservoir to Tuxford.
	Excavation		1,157,206 cu. yds	0 40 per cu. yd.	462,882 40			
	Borrow	Class (1)	437,491 cu. yds	0 25 per cu. yd.	109,372 75			New material.
	Borrow	Class (2)	76,017 cu. yds.	0 20 per cu. yd.	15,203 40	3,803,806 55	7,081,049 56	Excavated material.
4	Concrete pipe	5 ft. inside diam.	226,100 lin. ft.	7 08 per lin. ft.	1,600,788 00			Gravity line, Tuxford to Regina.
	Excavation		547,098 cu. yds	0 40 per cu. yd.	218,839 20			
	Borrow		223,420 cu. yds	0 25 per cu. yd.	55,855 00			
	Steel pressure pipe	5 ft. inside diam.	5,000 lin. ft.	23 00 per lin. ft.	115,000 00			To be used at Moosejaw, Cottonwood and Wascana creeks.
	Bridge across Moosejaw creek				5,000 00			Assumed.
	Extra steel		229,300 lin. ft.	0 61 per lin. ft.	139,873 00			
	Blow-offs				4,000 00	2,139,355 20		
5	Concrete pipe	6 ft. inside diam.	56,626 lin. ft.	8 38 per lin. ft.	474,525 88			From Tuxford to Moosejaw to supply Moosejaw and south country.

6	Excavation		146,190 cu. yds	0 40 per cu. yd.	58,476 00			
	Borrow		77,590 cu. yds.	0 25 per cu. yd.	19,397 50			
	Extra steel	1/3 in. sq. twisted	39,300 lin. ft.	1 79 per lin. ft.	70,347 00	622,746 38		
	Concrete pipe	4 ft. inside diam.	394,194·7 lin. ft.	4 23 per lin. ft	1,667,443 58			Line from Moosejaw to supply dry country to south as far as Milestone.
7	Excavation		1,048,972 cu. yds	0 40 per cu. yd.	419,588 80			
	Borrow		134,092 cu. yds	0 25 per cu. yd.	33,523 00			
	Extra steel	1/2 in. sq. twisted	31,000 lin. ft.	1 28 per lin. ft.	39,680 00	2,160,235 38	4,922,336 96	
	Concrete pipe	2 ft. inside diam.	162,210 lin. ft.	1 44 per lin. ft.	233,582 40			To supply district north of Milestone.
	Excavation		260,128 cu. yds	0 40 per cu. yd.	104,051 20			
	Borrow		44,568 cu. yds.	0 25 per cu. yd.	11,142 00	348,775 60	348,775 60	
					12,352,162 12	12,352,162 12	12,352,162 12	
	Trimming top of dump				146,492 00	146,492 00	146,492 00	
	Right-of-way and fencing				180,000 00	180,000 00	180,000 00	
					12,678,654 12	12,678,654 12	12,678,654 12	
	Contingencies and engineering				1,821,345 88	1,821,345 88	1,821,345 88	
					14,500,000 00	14,500,000 00	14,500,000 00	

COMPARISON of estimated cost of route as located in 1912 to route located in 1913 from a point in section 19, township 19, range 3, west of 3rd meridian, to a point near Mortlach.

Cost of Location, 1913.

104,000 lin. ft. of 7-foot pipe at $9.72 per lin.. ft.	$1,010,880 00
Excavation, 713,235 cubic yards at 40 cents per cubic yard	285,294 00
Borrow, 134,517 cubic yards at 25 cents per cubic yard	33,629 25
Total cost	$1,329,803 25

Cost of Location, 1912.

120,270·6 lin. ft. pipe at $9.72 per lin. ft.	$1,169,030 23
Excavation, 426,643 cubic yards at 40 cents per cubic yard	170,657 20
Borrow, 217,051 cubic yards at 25 cents per cubic yard	54,262 75
Total cost, 1912 route	$1,393,950 18
" 1913 "	1,329,803 25
1913 route costs less by	$64,146 93

ESTIMATED COST of converting Buffalo Pound lake into a reservoir.

Cost of dam, 149,094 cubic yards at 20 cents per cubic yard	$ 29,818 80
" riprapping upper face of dam, 16,888 square yards at $1.25	21,110 00
" straightening and cleaning channel of Qu'Appelle river	20,000 00
" gate valves and pipe under dam	1,495 00
" draining lake	12,000 00
" land flooded 3,752 acres at $12 per acre	45,024 00
" land around reservoir 128,000 acres at $10 per acre	128,000 00
" fencing, say 100 miles at $75 per mile	7,500 00
Total cost	$264,947 80

N.B.—No contingencies or engineering charges have been added as these are provided for in the tabulated estimate.

ESTIMATE No. 3.—Estimated Capital Cost of Scheme No. 3. Sheet (1) of 5.

Division.	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
A.	Power-house and pumping plant		845 W.H.P.	77 40 per W.H.P.	65,403 00			At Saskatchewan river.
	Pressure pipe	5 ft. 8 in. in dia	3,000 lin. ft.	25 00 per lin. ft.	75,000 00			
	Concrete pipe	7 ft. 6 in. in dia	63,360 lin. ft.	10 42 per lin. ft.	660,211 20			Pressure pipe to Qu'Appelle river.
	Excavation		249,600 cu. yds.	0 40 per cu. yd.	99,840 00			
	Reservoir	Dams, sluice-way, cleaning, &c			264,947 80			Buffalo Pound lake.
	Power-house and pumping plant		3,210 W.H.P.	77 40 per W.H.P.	248,454 00			At reservoir.
	Pressure pipe	5 ft. 8 in. in dia	2,600 lin. ft.	25 00 per lin. ft.	65,000 00			
	Surge basin	100 ft. x 100 ft. x 12 ft.			8,000 00	1,486,560 00		
1	Concrete pipe	7 ft. 0 in. in dia.	32,200 lin. ft.	9 72 per lin. ft.	312,984 00			Surge basin to reservoir.
	Excavation		122,045 cu. yds.	0 40 per cu. yd.	48,818 00			
	Borrow		23,770 cu. yds.	0 25 per cu. yd.	5,942 50	367,744 50		
2	Concrete pipe	5 ft. in dia	191,221 lin. ft.	7 08 per lin. ft.	1,353,844 68			Main line to Regina.
	Excavation		402,851 cu. yds.	0 40 per cu. yd.	161,140 40			
	Borrow		166,328 cu. yds.	0 25 per cu. yd.	41,582 00			
	Extra steel		191,221 lin. ft.	0 61 per lin. ft.	116,644 81			
	Pressure pipe	5 ft. in dia	5,000 lin. ft.	23 00 per lin. ft.	115,000 00			At Moosejaw, Wascana, and Cottonwood creeks.
	Bridge concrete				5,000 00			Across Moosejaw creek.
	Blow-off valves				3,750 00	1,796,961 89		At bottom of depressions.
3	Concrete pipe	6 ft. in dia	80,990 lin. ft.	8 38 per lin. ft.	678,696 20			Main line pipe for Moosejaw and south country.
	Excavation		236,756 cu. yds.	0 40 per cu. yd.	94,702 40			
	Borrow		56,267 cu. yds.	0 25 per cu. yd.	14,066 75			
	Extra steel	Reinforcing	32,190 lin. ft.	1 79 per lin. ft.	57,620 10	845,085 45		
4	Concrete pipe	4 ft. 0 in. in dia	394,194·7 lin. ft	4 23 per lin. ft.	1,667,443 58			Moosejaw to Milestone.
	Excavation		1,048,972 cu. yds	0 40 per cu. yd.	419,588 80			
	Borrow		134,092 cu. yds.	0 25 per cu. yd.	33,523 00			
	Extra steel	½ in. sq. twisted	31,000 lin. ft.	1 28 per lin. ft.	39,680 00	2,160,235 38		
5	Concrete pipe	2 ft. 0 in. in dia	162,210 lin. ft.	1 44 per lin. ft.	233,582 40			
	Excavation		260,128 cu. yds.	0 40 per cu. yd.	104,051 20			
	Borrow		44,568 cu. yds.	0 25 per cu. yd.	11,142 00	348,775 60		

ESTIMATE No. 3.—Estimated Capital Cost of Scheme No. 3, Sheet (1) of 5.—*Continued.*

Division.	Part.	Dimensions.	Quanities.	Unit Cost.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
	Concrete pipe	2 ft. in dia	236,000 lin. ft.	1 44 per lin. ft.	339,840 00			For country along G.T.P. N.W. of Tuxford.
	Excavation		200,000 cu. yds.	0 40 per cu. yd.	80,000 00	419,840 00		
					7,425,498 82	7,425,498 82	7,425,498 82	
	Trimming dump				109,000 (0	109,000 00	109,000 00	
	Right-of-way and fencing				160,000 00	160,000 00	160,000 00	
					7,694,498 82	7,694,498 82	7,694,498 82	
	For engineering and contingencies				1,155,501 18	1,155,501 18	1,155,501 18	
	Total				8,850,000 00	8,850,000 00	8,850,000 00	

Your obedient servant,

T. M. MONTAGUE.

REPORT ON BORING OPERATIONS, SOUTH SASKATCHEWAN WATER SUPPLY DIVERSION PROJECT.

Party No. 9a.

The boring operations for the purpose of testing the possibilities for dam foundations in the South Saskatchewan river were carried out during the winter of 1913-14, under the charge of Mr. L. J. Gleeson, who has submitted a full report indicating in detail the results which were gained by him.

This report is of a detailed nature, and therefore is not entirely suitable for inclusion in this report, so that it has been filed in the Calgary office, together with the plans submitted, for purposes of future reference.

The plans which have been placed on file in this connection are as follows:—

(1) Key plan showing location and cross-sections of test borings.
(2) Plan showing location of test borings A, G and H.
(3) Plan showing location of borings of B, C, and F.
(4) Plan showing location of boring, D.
(5) Plan showing location of boring, E.
(6) General plan showing location of test borings.

A reference to the work done by Mr. Gleeson is made in the general report submitted herewith by Mr. B. Russell, but the following short summary of the work has been prepared by the commissioner in order to give a general idea of why this work was undertaken, and the results accomplished.

As is explained elsewhere in the body of this report, there are two general schemes for diverting the water from the South Saskatchewan river, one of which anticipates the construction of a 40-foot power and diversion dam in the river. It was known that it was difficult to find good foundations in the river, and so no advised opinion could be formed as to the possibilities or otherwise of constructing a dam, and the cost thereof, until some general work had been carried out to actually test the conditions for dam foundations.

Information as regards the formation of the bed of the river had been very kindly given by the chief engineer of the Grand Trunk Pacific Railway Company, covering two locations at the Elbow, and one location in section 8, township 22, range 7, west of the 2nd meridian. The stretch of the river between these locations is where a dam would have to be located, to be of value in connection with the project under discussion, and by putting the test-boring party in the field it was desired to determine the condition of the river bottom, covering this part of the river.

The test-boring party began work on December 24, 1913, and carried on their work until March 15, 1914, at which time the ice had become so unsafe that, although some work still remained to be done, it was deemed desirable to take the outfit off the river rather than risk losing it in the spring break-up, which usually takes place in a very short period of time after the ice has become rotten.

Mr. Gleeson developed three cross-sections quite fully in that portion of river extending about 6 miles upstream from the Elbow, and then made reconnaissance borings at intervals of about four or five miles in the river-bed upstream, so that reconnaissance borings were gained covering the whole stretch of river between the points already indicated, where information had been supplied by the Grand Trunk Pacific Railway Company.

The general results of the borings have been to show that the conditions, as regards dam foundations, are very much more favourable in the vicinity of the Elbow than in any other location developed; but even at this point, the upper surface of the main body of clay underlying the river is very erratic, and while possibilities exist of gaining a solid clay foundation at a reasonable depth in the vicinity of the Elbow, it would require very close and careful test borings at close intervals to determine any location where a large dam could be safely constructed.

While the information as regards the possibilities of dam founations is still somewhat meagre, the results obtained do give definite information as to the general conditions, which make this phase of the investigations consistent with the development of the main land surveys.

As indicated elsewhere, the scheme to be adopted for the diversion of water from the South Saskatchewan river, which is now looked upon with favour by this department, is one which does not anticipate the creation of a large dam in the river; but in connection with the test borings, the desire was, and the results accomplished have been, to develop sufficient information along these lines to allow of the matter being advisedly considered at such time in the future as it is decided to carry out the scheme, and the many final considerations in connection with the location and design have yet to be taken up in detail and decided upon.

REPORT ON CYPRESS HILLS RESERVOIR SURVEYS, BY N. M. SUTHERLAND.

Party No. 10.

Calgary, Alta., April 30, 1914.

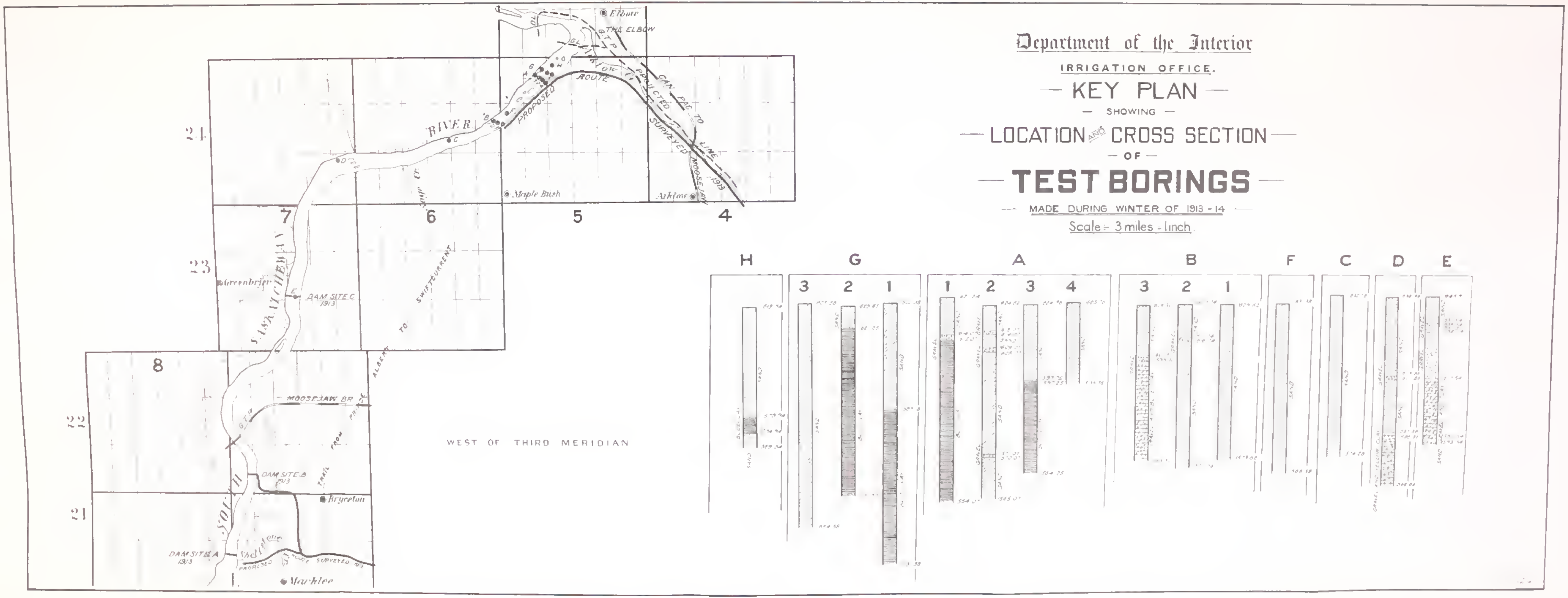
F. H. Peters, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

Sir,—I have the honour to submit my reports on the Cypress Lake reservoir, Middle Creek reservoir, and levels run in the Cypress Hills district during 1913.

Report on Cypress Lake Reservoir Scheme.

The object of this scheme is to create a reservoir in Cypress lake which shall impound all the waters of Oxarart creek and Sucker creek, the flood waters of Battle creek, Belanger creek, and Davis creek, in addition to all the natural drainage into Cypress lake. As conditions are at present, a very small portion of the flood water of Battle creek is used, and the remainder drains off and flows into Milk river at Chinook, Mont. Very little of Oxarart creek is utilized at present, and practically all the flood water drains into Cypress lake and cannot be of much further use for irrigation. None whatever of Sucker creek is utilized for irrigation, since this creek also runs into Cypress lake. Portions of both Belanger creek and Davis creek are used for irrigation, but practically all the flood waters drain into Frenchman river, which flows into Milk river at Saco, Mont.

If the waters of these creeks were diverted into Cypress lake by means of canals, and there impounded by dams, provision could be made to allow this stored water to be drawn off during periods of low flow in Battle creek and Frenchman river, in



Department of the Interior
IRRIGATION OFFICE.
— KEY PLAN —
— SHOWING —
— LOCATION AND CROSS SECTION —
— OF —
— TEST BORINGS —
— MADE DURING WINTER OF 1913 - 14 —
Scale = 3 miles = 1 inch.
H
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A
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SAND
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24
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8
Elbow
THE ELBOW
RIVER
PROPOSED ROUTE
SURVEYED
LINE
1913
Maple Bush
Arkfow
SASKATCHEWAN
Greenbrier
DAM SITE C 1913
SWIFTCURRENT
ALBERTA
MOOSEJAW BR.
DAM SITE B 1913
TRAIL FROM
Bryceton
SOUTH
DAM SITE A 1913
Shellstone
PROPOSED ROUTE SURVEYED 1913
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quantities proportionate to the quantities that are stored from the watersheds of these two creeks respectively, or to the quantities required for irrigation on the lands contiguous to these streams. As conditions are at present the flood water comes down in such volumes, as compared with the low-water stages, that it is a most difficult matter for irrigators to control the water, whereas if this flood water were impounded in a reservoir sufficiently large, water could be supplied in suitable quantities and at times when most required.

In order to determine the quantity of flood waters which can be stored in this reservoir from the above-mentioned sources, a study of the hydrographic records of these streams is necessary and, since irrigation rights have to be fulfilled during the period when the reservoir is being filled with water, the quantities of water which have already been granted have to be taken into account. As there may possibly be two or more wet years in succession, the reservoir should be of sufficient capacity to impound the total discharge for at least two wet years, which can again be used in the following cycle of two or more dry years.

DETAIL OF FIELD PARTY.

In order to carry out the surveys necessary in connection with the Cypress Lake reservoir it was decided to place a party in the field in May, 1913. This party consisted of: Engineer in charge, assistant engineer, topographer and draughtsman, two chainmen, two rodmen, two teamsters, one cook.

INSTRUCTIONS GOVERNING WORK.

The instructions issued to the engineer in charge, in connection with the proposed work, are summed up as follows:—

(1) After having determined on the proper capacity of the reservoir, based on such information as you have, you should run the contour line at the proposed full supply level and develop contours at other grades with 5-foot vertical intervals covering sufficient range above and below the proposed full supply level, so that the information will be sufficient to cover any scheme which may be worked out later in the office, with full supply level at a different elevation from that determined by you in the field.

(2) It is possible to dam the waters of Battle creek sufficiently high to flood into Cypress lake, but the best scheme will probably be to build a dam higher up on the stream and locate a diversion canal from Battle creek into the reservoir. It must be borne in mind that the capacity of this canal must be equal to the flood discharge of Battle creek.

(3) The datum of your levels shall be sea-level datum obtained from the bench-marks located by the irrigation surveys in a previous year.

(4) Sufficient iron bench-marks should be established by you to allow of the elevation of this survey being easily picked up at any time in the future.

(5) If in carrying out this work you are close to any stream gauging stations you should tie on to the bench-marks located at them.

(6) You should make careful note of any deposits of good sand, good gravel, good clay, or any other material that might be useful in the type of construction that will probably be used in connection with this project.

(7) Where any deep cutting is encountered you should determine the character of the soil by digging test pits.

Acting upon the above instructions, it was determined (from the hydrographic records), before going into the field, that during a wet year the available water supply would be about 50,000 acre-feet, and for a dry year about 6,000 acre-feet. From plans of a former survey of this reservoir site, it was determined that it would be necessary to take topography of the country around the lake to a height of at least 20 feet above the present water surface, in order to be able to store the run-off from two wet years in succession.

The party was organized in Maple Creek and moved from there on May 12 to a point near the west end of Cypress lake.

FIELD WORK.

The first step taken in connection with the field work was to carry a line of check levels from a permanent iron bench-mark located in northeast corner township 5, range 28, west of the 3rd meridian, to the point at east ¼ corner section 11, township 6, range 27, west of the 3rd meridian, from which the traverse of the lake was started, thus enabling sea-level datum to be kept throughout the survey. A traverse line of the lake, with topography taken to 30 feet above the elevation of the lake, was then run as far as it was possible from the camp at the west end of the lake. From this camp the following lines were also run:—

> A canal location from the reservoir to a point on Battle creek which would divert Battle creek without the necessity of a dam; that is, the line was run until the bottom of the creek and the proposed grade of the canal were the same.
>
> Another survey was made for a canal to allow the stored up water in the reservoir to be drawn off again into Battle creek.
>
> A traverse of Battle creek was made from the intake to a point below the proposed outlet from the reservoir to Battle creek.

Two dam sites for the west end of the reservoir were located, one in section 15, township 6, range 27, west of the 3rd meridian, and the second one in S.W. ¼ section 20, township 6, range 27, west of the 3rd meridian.

A dam in the S.W. ¼ section 20, township 6, range 27, west of the 3rd meridian, would provide a much greater superficial area to a reservoir than one located in section 15, township 6, range 27, west of the 3rd meridian, but the earth-fill required would be some 14 feet lower than the other site selected. If the dam were located at this point, however, some 900 acres of hay flat, valued here at $22,500 would be flooded, and it is estimated that the additional cost of buying this land would be as great as the cost of building the higher dam on the site selected in section 15, township 6, range 27, west of the 3rd meridian.

It should also be noted that if the dam were located in S.W. ¼ section 20, township 6, range 27, west of the 3rd meridian, a large area of shallow water would be impounded, the evaporation from which would be very great, making the effective storage probably less than if the dam were built at the other location. As a result of these studies, therefore, the calculations for this report are based on the assumption that the dam will be located at the site selected in section 15, township 6, range 27, west of the 3rd meridian.

After completing the above surveys, camp was moved to a point in section 19, township 6, range 25, west of the 3rd meridian, near the mouth of Belanger creek. From this camp, the traverse of Cypress lake was completed. A canal line was surveyed from the reservoir to a point on Belanger creek so that this creek might also be diverted without the use of a large dam. Likewise a canal from Belanger creek to Davis creek was located which would divert Davis creek into Belanger creek and thence into the reservoir. In the case of both Belanger and Davis creeks, upon completing the surveys to a sufficient distance upstream to allow of them being diverted at grade, it was found that on account of the creek-beds widening out into marshy flats, it would be advisable to locate dam sites lower down on these creeks where the natural cross-sections of the streams were narrow.

With regard to the dam required at the east end of the reservoir, it was first thought that the graded road along the range line between section 24, township 26, west of the 3rd meridian, and section 19, township 6, range 25, west of the 3rd meridian, could be utilized to advantage, as this road is about 5 feet higher than the flat which it crosses and is about 30 feet wide on top. Another site, however, near the mouth of Sucker creek, which appeared suitable for a dam, was investigated and a cross-section developed, in order that the cost of these two most probable locations for a dam could be thoroughly examined, estimates of each prepared, and a comparison made.

After completing the above surveys, traverses were made: (1) of the Frenchman river from Cypress lake to a point below the mouth of Davis creek, (2) of Belanger creek from proposed point of diversion to its mouth, (3) of Davis creek from proposed point of diversion to its mouth.

While the latter part of the work was being completed, the chief field inspector, accompanied by the engineer in charge of the field party, made a reconnaissance of Battle creek above the proposed point of diversion, and found that it would be possible to divert Middle creek into Battle creek so that its flood waters might also be stored in the Cypress Lake reservoir. Accordingly, on the completion of the above-mentioned surveys, the camp was moved to section 11, township 6, range 28, west of the 3rd meridian, near Battle creek. A traverse was then run following up Battle creek as far as Ten Mile, R.N.W.M.P. detachment, in section 33, township 5, range 29, west of the 3rd meridian. At this point there is a depression between Middle creek and Battle creek where it is said that extreme high-water stages considerable water from Battle creek runs into Middle creek. Accordingly a canal was located through this depression and thence up Middle creek to a point where this creek could be diverted at grade. On account of cut banks near the proposed point of diversion a dam site was surveyed in section 30, township 5, range 29, west of the 3rd meridian, and a survey was also made of the land which would be flooded by constructing a dam at this point.

STUDY OF STREAM FLOW AND STORAGE.

After completing the surveys in the field, a study was made of the creeks to be utilized in connection with this reservoir. In order to determine the sizes of the various canals required so that none of the flood waters would be lost, it was necessary to reduce the maximum discharge of each stream, as shown by the hydrographic records at some gauging station on that stream, to the discharge at the point of diversion.

In the case of Battle creek, the highest discharge at section 4, township 5, range 29, west of the 3rd meridian, was 771 second-feet, recorded during the month of April, 1912. As the point of diversion to the reservoir is about 10 miles downstream from the gauging station, bringing in an additional drainage area of about 60 square miles, the maximum flow for the Battle creek canal is estimated at 1,000 second-feet.

At a gauging station located on Oxarart creek at the point of diversion, the maximum discharge recorded is 537 second-feet. Since it will be necessary for the canal from Battle creek to take in Oxarart creek, this canal from the point of diversion of Oxarart creek to the reservoir is designed to carry 1,550 second-feet.

With the scheme under consideration it will not be necessary to provide for a canal from Sucker creek to the reservoir as this creek flows directly into Cypress lake and the waters of the reservoir will simply flood back into Sucker creek until the full supply level is reached. The maximum discharge is 270 second-feet, recorded during the spring of 1912.

The maximum discharge of Davis creek at the point of diversion is 529 second-feet, recorded during April, 1912. The canal from Davis creek to Belanger creek is designed to carry 530 second-feet.

A gauging station is located on Belanger creek at the point of diversion, but unfortunately the records taken at this station are incomplete. At a gauging station located above the point of diversion the maximum discharge is 270 second-feet. The discharge at the point of diversion is therefore estimated at 400 second-feet. Since the canal from Belanger creek to the reservoir will have to carry the waters of both Belanger and Davis creeks, the canal has been designed to carry 930 second-feet.

In determining the amount of water available for storage in the reservoir during a wet season, the computations were based on the hydrographic records for the year 1912. From the quantities thus obtained the following reductions have to be made: (1) The quantity of water granted above the point of diversion, all of which, up to the present, has never been used, less 40 per cent, which it is estimated will return to the streams; (2) the water granted below the point of diversion, less the additional flow to the stream below this point. In the case of Battle creek, an additional reduction for the extra land which can be irrigated by means of the reservoir has to be made.

Considering the case of Battle creek:—

	Acre-feet.
The quantity of water granted for irrigation above the point of diversion	8,128·9
Quantity of water available for storage, or 40 per cent of 8,128·9	3,251·6
Balance or amount consumed on land	4,877·3

During the season of 1912 the total discharge of Battle creek at the point of diversion was 36,836 acre-feet, but during this season it is estimated that 2,801·4 acre-feet were diverted and utilized for irrigation above the point of diversion, 40 per cent of which amount, or 1,120·6 acre-feet, are included in the discharge of 36,836 acre-feet. Had no irrigation taken place during the year 1912 the actual discharge of Battle creek at point of diversion would have been 36,836 *plus* (2,801·4 *minus* 1,120·6)=38,516·8 acre-feet.

When all the licenses above the point of diversion are made use of, in such a year as 1912, the available storage for the Cypress Lake reservoir will then be 38,516·8 acre-feet *minus* 4,877·3 acre-feet=33,639·5 acre-feet.

If there were no irrigation grants below the point of diversion the quantity, 33,639·5 acre-feet would all be available for storage, but it has been estimated that 14,000 acre-feet will be required to irrigate the land below this point. All of the 14,000 acre-feet will not, however, have to be allowed for from the discharge at the point of diversion, as there is additional flow to the creek below the point of diversion which assist in irrigating the land. This additional flow has been estimated at 1,800 acre-feet. The quantity then which would actually be available for storage in a season such as 1912 would be 33,107·4 acre-feet *minus* 14,000 acre-feet *plus* 1,800 acre-feet= 21,439·5 acre-feet.

During a dry year the quantity of water necessary for irrigation both above and below the point of diversion will be the same as for a wet year. The discharge of Battle creek at the point of diversion during the open water season of 1910, which year has been taken as the minimum of dry years, is 7,605 acre-feet. To this quantity must be added 375 acre-feet, the additional run-off below this point, thus making a total run-off of 7,980 acre-feet.

Since the quantity of reservoir water required for irrigation is 17,196 acre-feet, it will be seen that the quantity of water granted will in a dry year exceed the discharge of the creek by 9,216 acre-feet, and this quantity will have to be supplied from the reservoir.

A similar study of each creek to be diverted has been made and the results tabulated in tables (1) and (2) of this report. These tables show the quantity of water available for storage from each creek dealt with. An estimate of the run-off of the drainage area of Cypress lake has been made, and the quantity added to the available storage from creeks. From the totals, a reductions is made for absorption losses, which has been taken as 48 inches over the area of the reservoir of 5,525 acres.

Table (1) shows the available storage from all sources during the year 1912, which has been taken as standard for a wet season. The total available supply being 59,795 acre-feet, from which the absorption losses of 22,100 acre-feet have to be subtracted, leaving the total quantity stored at the end of one wet year of 37,695 acre-feet. In two wet years in succession the storage will be 75,390 acre-feet. Table (2) shows the available storage during the year 1910, which has been taken as standard for a dry season. The total supply being 6,800 acre-feet, and absorption losses 22,100 acre-feet. This means that there will be 15,300 acre-feet of the previous storage lost by absorption during a dry season.

IRRIGABLE AREAS.

It has been estimated that there are about 24,000 acres of land on Frenchman river which can be irrigated, and on Battle creek about 7,000 acres, making a total of 31,000 acres. In discussing whether this amount of land could be served from the reservoir, it is supposed that the waters of two wet years such as 1912, have been impounded, and that a cycle of two dry years such as 1910, is to follow. The discharge of Frenchman river at section 5, township 5, range 14, west of the 3rd meridian, during 1910 is estimated at 11,251 acre-feet and of Battle creek at section 3, township 3, range 27, west of the 3rd meridian, at 7,980 second-feet. As the waters of Frenchman river and Battle creek will irrigate a portion of the irrigable land along these streams, the total water available for irrigation during the dry season will be a total of the water in the reservoir (75,390 acre-feet), *plus* the available storage for a dry year (6,800 acre-feet), *plus* the discharge of Battle creek (7,980 acre-feet), *plus* the discharge of Frenchman river (11,251 acre-feet), *less* absorption of losses in the reservoir (22,100 acre-feet), making a total for the year of 79,321 acre-feet. The total quantity of water required to irrigate 31,000 acres is taken as 62,000 acre-feet, to which must be added 3,196 acre-feet which will be required on Battle creek above the point of diversion and has not been allowed for, making a total of 65,196 acre-feet required. At the end of the first dry year there will be 14,125 acre-feet in the reservoir. If there should be two dry years in succession, the quantity available to supply to the land would be 14,125 acre-feet, *plus* the discharge of Frenchman river (11,251 acre-feet), *plus* the discharge of Battle creek, (7,980 acre-feet), *plus* the available supply to the reservoir (6,800 acre-feet), *less* the absorption losses of 20,000 acre-feet (figured as 48 inches over an area of 5,000 acres), making a total of 20,156 acre-feet. The quantity required is the same as for the preceding year, 65,196 acre-feet, making a deficiency of 45,040 acre-feet. Such years as 1910 are, however, exceptional, and it is estimated that the supply of two wet years will be sufficient for two average dry years.

Of the total 31,000 acres of irrigable land along the Frenchman river and Battle creek, there are only about 12,000 acres at present under irrigation. It will therefore be seen that, although the reservoir may not be able to serve the total area of irrigable land, during exceptional years, it will be more than sufficient for the land at present irrigated.

DAMS AND RESERVOIR.

With regard to the dams necessary to impound the water in the reservoir, earth-fills have been selected as being the most economical. For the west end of the reservoir it was decided to utilize the site in section 15, township 6, range 27, west of the 3rd meridian, which had been surveyed in the field. This dam requires an earth-fill of 1,835 feet in length. For the east end of the reservoir three dam sites were considered:—

(1) The graded road on the range line between section 24, township 6, range 26, west of the 3rd meridian, and section 19, township 6, range 25, west of the 3rd meridian.

(2) Near the mouth of Sucker creek in west ½ section 24, township 6, range 26, west of the 3rd meridian.

(3) East of Sucker creek in east ½ section 24, township 6, range 26, west of the 3rd meridian.

Site (1) would require a fill of 3,700 feet in length, the construction of a road of 1½ miles in length around a coulee in section 24 and section 13, township 6, range 26, west of the 3rd meridian, which would be flooded and would require a crest width on the fill of 30 feet, as this would replace the graded road and would therefore require to be wide enough for traffic. Site (2) would require a fill of 2,900 feet in length, which is the shortest of the three, but would also require a canal from Sucker creek to the reservoir. Site (3) would require a fill 3,275 feet in length and about 3,000 feet more canal from Belanger creek than site (1); however, as it is 450 feet shorter and does not entail the construction of roads nor the construction of a canal from Sucker creek to the reservoir, it was decided to use this site.

Using the dam site in section 15, township 6, range 27, west of the 3rd meridian, and site (3) in the east ½ section 24, township 6, range 26, west of the 3rd meridian, the capacities of the reservoir are as follows:—

	Acre-feet.
Present elevation of lake raised 16 ft. capacity...............	89,727
" " " " 21 ft. "	106,926
" " " " 22 ft. "	126,625

The total quantity of water available for storage in two wet years in succession is 106,356 acre-feet. Since there is no assurance that two or even three years during which the run-off will exceed that of 1912 will not occur, and in order to provide sufficient capacity in any event, it was decided to base all calculations upon the assumption that the water level in the reservoir could be raised to an elevation of 22 feet above the present water level of the lake, thus providing a capacity of 126,625 acre-feet.

The present elevation of Cypress lake with reference to sea-level datum is 3,154 feet, the elevation of the reservoir when full after the construction of the dams will then be 3,176 feet, and the elevation of the crests of the dams 3,181 feet, allowing for a freeboard of 5 feet.

With the capacity of the reservoir sufficiently large to store the available water of at least two wet years in succession, it was decided that the outlets to Battle creek and Frenchman river should be sufficiently large to carry off any flood waters from Oxarart and Sucker creeks without the necessity of constructing a concrete spillway, the remaining creeks to be turned back into their natural channels by means of headgates.

OUTLETS.

In designing the outlet pipe to Frenchman river, it is assumed that the reservoir might at some time be called upon to supply a sufficient quantity of water to serve all the irrigable land at a critical period when a large quantity of water is required. The quantity of water required at such a period has been taken as that which would cover 50 per cent of the land 6 inches deep in a period of twelve days. Since it is estimated that there are about 24,000 acres of irrigable land along Frenchman river, it is necessary, in order to supply the required amount of water for this land, to design an outlet to this river of sufficient capacity to carry 252 c.f.s., or in other words, 6,000 acre-feet in a period of twelve days. Assuming that the reservoir will never be completely lowered to the present elevation of the lake, the lowest head of water on the outlet pipe is calculated at 2 feet. Using a 6·5-foot diameter pipe with a 2-foot head, the discharge is 253·6 second-feet. With the reservoir full, in case of a flood this pipe would have a discharge of 885·4 second-feet.

The area of land on Battle creek which can be irrigated, without taking into account extensive schemes which would necessitate the supplying of water to land lying on the benches above the creek, has been estimated. The maximum requirement upon the same basis as for Frenchman river, viz., quantity required to cover 50 per cent of the irrigable land with water 6 inches deep in a period of twelve days, an opening of 73·5 c.f.s. capacity is required into Battle creek. Under a 2-foot head (the minimum head allowed on the outlet pipes) a pipe 3 feet 9 inches in diameter would carry 76 c.f.s., and under a head of 22 feet, or with the reservoir full, would discharge 251·9 c.f.s.

Under a full head, with both the sluice-gates into Frenchman river and Battle creek open, the maximum discharge which could be taken care of would be 1,137 c.f.s., and since this quantity exceeds the combined flood discharge of Sucker and Oxarart creeks, no spillways have been considered necessary.

INTAKES.

As has been previously stated in this report, the lines of the different canals were, when surveyed, run far enough up the creeks to allow of these creeks being diverted without the necessity of dams. Later, when the locations of the canals were being projected, it was decided in each case to make use of a low dam with a concrete spillway.

The intake of the Battle Creek canal, which is located in SW. ¼ section 2, township 6, range 28, west of the 3rd meridian, consists of an earth-fill 1,298 feet in length at a maximum height of 12 feet and a concrete spillway 127 feet in length designed to carry 1,100 c.f.s. The headgates of this canal consist of three gates 4 feet by 9 feet, supported by concrete piers and curtain walls.

The intake of Belanger creek, located in SW.¼ section 30, township 5, range 25, west of the 3rd meridian, consists of an earth-fill 927 feet long at a maximum height of 22 feet, and a concrete spillway 58 feet long designed to carry 500 c.f.s., the headgates being the same as for the intake at Battle creek.

The diversion of Davis creek is at a point in NE.¼ section 29, township 6, range 25, west of the 3rd meridian. The intake consists of an earth-fill 717 feet in length at a maximum height of 6 feet and a concrete spillway 69 feet in length designed to carry 600 second-feet. The headgates of the canal consist of two 4-foot by 9-foot gates similar to those of the Battle creek canal intake.

The canal from Middle creek to Battle creek was not projected, as it was found that the reservoir which was later surveyed on Middle creek would have sufficient storage for the maximum discharge of that creek, the water stored being used for irrigation on lands contiguous to Middle creek.

ESTIMATES.

The tables of estimates accompanying this report show in detail the cost of constructing the canals, dams, and structures required for this scheme. It must be borne in mind, however, that with the dams of the reservoir located at other points than those prepared for this scheme, the cost of construction could probably be reduced. The surface area of the reservoir would, however, be greatly increased and consequently the losses due to evaporation and seepage would also be increased.

CONCLUSION.

In concluding this report, it may be said that although a close study was made of each stream to be utilized, the figures given for discharges cannot be said to be absolutely correct, as the hydrographic records are incomplete, and consequently the discharges for several periods had to be interpolated. For instance, during 1910 the daily discharges of Davis creek were not computed and had to be estimated from the discharge of Belanger creek. The discharges of Oxarart creek and Sucker creek are only obtainable for seven months, and as they are necessary for twelve months, those for the remaining five months had to be estimated.

If, at some time in the future, the total area of irrigable land lying in the valley of Frenchman river and Battle creek is placed under irrigation, it will be seen from this report that all the available water will be required to serve these lands. The scheme submitted has been prepared as the most feasible one, in that it provides for the greatest storage with the least loss from evaporation and seepage.

TABLE No. 1.—Water supply available for storage in Cypress Lake reservoir during a wet year, based on measurements and observations made during 1912.

Source of Supply.	Discharge in acre-feet at intake.	Duration of Flow.	No. of acre-feet granted above intake, less quantity estimated to return to creek.	Acre-feet granted below intake	Additional flow below intake.	Acre-feet available for storage.
Battle creek	36,836·0	8 months.	3,196	(1) 14,000	1,800	21,440
Oxarart creek	6,416·0	12 "	600	820		4,996
Sucker creek	8,513·0	12 "				8,513
Belanger creek	11,278·0	8 "	1,346	607	240	9,565
Davis creek	11,598·0	8 "	422			11,176
Natural drainage into Cypress lake						4,105
Total acre-feet available for storage						59,795
Absorption losses						22,100
Quantity stored in 1 wet year						37,695
Quantity stored in 2 wet years						75,390

(1) Includes quantity estimated for additional land to be irrigated on Battle creek.

Source of Supply.	Discharge in acre-feet at intake.	Duration of Flow.	No. of acre-feet granted above intake, less quantity estimated to return to creek.	Acre-feet granted below intake	Additional flow below intake.	Acre-feet available for storage.
Battle creek	7,605·0	8 months.	3,196	14,000	375	-9,216
Oxarart creek	1,966·0	12 "	600	820		546
Sucker creek	3,596·0	12 "				3,596
Belanger creek	2,078·0	8 "	1,346	607	60	185
Davis creek	1,637·0	8 "	422			1,215
Natural drainage into Cypress lake						1,258
Total acre-feet available for storage						-2,416
Absorption losses						-22,100
						-24,516

NOTE—The quantity -24,516 acre-feet, includes the excess quantity required for irrigation above the available supply and the losses due to absorption, which in a dry year must be provided for in reservoir.

Estimate of Battle Creek Diversion.

Description.	Quantity.	Unit Cost.	Cost.	Remarks.
		$ cts.	$ cts.	
Earth-fill	6,658·6 c. yds.	0 25	1,664 65	Intake Battle creek canal.
Riprap (for earth-fill)	840·7 "	2 50	2,101 75	" "
Stripping bed of earth-fill	503·0 "	0 10	50 30	" "
Concrete weir	1,811·0 "	10 00	18,110 00	" "
Concrete in headgates	65·6 "	12 00	787 20	" "
Lifting device for headgates			225 00	" "
Excavation	408,033 c. yds.	0 20	81,606 60	Battle creek canal.
Borrow	3,426 "	0 25	856 50	" "
Drop (concrete)	226 "	20 00	4,520 00	" "
Riprap				" "
Right-of-way	89·0 acres.	12 00	1,068 00	" "
Total cost			110,990 00	

Estimate of Davis Creek Diversion.

Earth-fill	930 c. yds.	0 25	232 50	Intake Davis creek.
Riprap (for earth-fill)	145·8 "	2 50	364 50	" "
Stripping bed of earth-fill	163·8 "	0 10	16 38	" "
Concrete weir	482·6 "	10 00	4,826 00	" "
Concrete in headgates	43 "	12 00	516 00	" "
Lifting devices for headgates			150 00	" "
Excavation	162,139 c. yds.	0 20	32,427 80	Davis creek canal.
Right-of way	36·8 acres.	12 00	441 60	" "
Total cost			38,974 78	

Estimate of Belanger Creek Diversion.

Earth-fill	35,342·8 c. yds.	0 25	8,835 70	Intake Belanger creek.
Riprap (for earth-fill)	2,227·8 "	2 50	5,569 50	" "
Stripping bed of earth-fill	1,088·7 "	0 10	108 87	" "
Concrete weir	1,587·5 "	10 00	15,875 00	" "
Concrete in headgates	65·6 "	12 00	787 20	" "
Lifting devices for headgates			225 00	" "
Excavation	71,950 c. yds.	0 20	14,390 00	Belanger creek canal.
Right-of-way	16·7 acres.	12 00	200 40	" "
Total cost			45,991 67	

Estimate of East Reservoir Dam.

Earth-fill	265,367 c. yds.	0 25	66,341 75	Dam in E. ½ Sec. 24-6-26-3.
Stripping bed of earth-fill	5,902 "	0 10	590 20	" "
Riprap for earth-fill	12,116 "	2 50	30,290 00	" "
Concrete for tower, wing walls and floor of outlet	102·2 "	12 00	1,226 40	" "
Timber for bridge of tower			115 00	" "
Concrete for outlet pipe	336 c. yds.	15 00	5,040 00	" "
Total cost			103,603 35	

West Reservoir Dam and Outlet Canal.

Earth-fill	136,770 c. yds.	0 25	34,192 50	Dam in Sec. 15-6-27-3.
Stripping bed of earth-fill	3,010 "	0 10	301 00	" "
Riprap for earth-fill	6,858 "	2 50	17,145 00	" "
Concrete for tower, wing walls and flooring of outlet	84·7 "	12 00	1,016 40	" "
Timber for bridge of tower			80 00	" "
Concrete for outlet pipe	176·5 c. yds.	15 00	2,647 50	" "
Parapet wall (top of dam)			1,882 80	" "
Excavation	128,904 c. yds.	0 25	32,226 00	Canal from reservoir to Battle creek.
Right-of-way	16·9 acres.	12 00	202 80	" " "
Total cost			89,694 00	

Estimate of Cost of Cypress Lake Reservoir.

Description.	Cost.	Total Cost.
	$	$
Battle creek canal and structures	110,990 00	
Davis " "	38,974 78	
Belanger " " "	45,991 67	
Dam in E½ Sec. 24, Tp. 6, R. 26, W. 3rd mer.	103,603 35	
Dam in Sec. 15, Tp. 6, R. 27, W. 3rd mer., and canal from reservoir to Battle creek	89,694 00	
Damages to land, 15 acres at $20 per acre	300 00	
		389,553 80
10 per cent. for engineering and contingencies		38,955 40
		428,509 20

Capacity of reservoir, 126,625 acre-feet.
Cost per acre-foot of storage, $3.38.

LAND CONTAINED IN CYPRESS LAKE RESERVOIR.

Part.	Sec.	Tp.	Rge.	Mer.	Remarks.
SW. ¼	15	6	27	3	Reserved for reservoir.
SE. ¼	15	6	27	3	" " "
NE. ¼.........	15	6	27	3	About 10 acres to be purchased.
NE. ¼.........	10	6	27	3	" 5 " " "
SW. ¼.....	14	6	27	3	Reserved for reservoir.
SE. ¼	14	6	27	3	" "
NW. ¼.....	11	6	27	3	" "
NE. ¼	11	6	27	3	" "
SW. ¼	13	6	27	3	" "
SE ¼..........	13	6	27	3	" "
NE. ¼..........	13	6	27	3	" "
NW. ¼....	12	6	27	3	" "
NE. ¼..........	12	6	27	3	" "
SW. ¼	12	6	27	3	" "
SE. ¼..	12	6	27	3	" "
SE. ¼	24	6	27	3	" "
SW. ¼..........	19	6	26	3	" "
SE. ¼..........	19	6	26	3	" "
NE. ¼..........	19	6	26	3	" "
	18	6	26	3	(All of section) reserved for reservoir.
	7	6	26	3	" " " "
NW. ¼....	20	6	26	3	Reserved for reservoir.
SW. ¼	20	6	26	3	" "
NE. ¼..... .. .	20	6	26	3	" "
SE. ¼..........	20	6	26	3	" "
	17	6	26	3	(All of section) reserved for reservoir.
	8	6	26	3	" " " "
NW. ¼..	9	6	26	3	Reserved for reservoir.
NE. ¼...... ...	9	6	26	3	" "
SW. ¼..........	9	6	26	3	" "
	16	6	26	3	(All of section) reserved for reservoir.
	21	6	26	3	" " " "
NW. ¼	22	6	26	3	Reserved for reservoir.
NE. ¼.........	22	6	26	3	" "
SW. ¼....	22	6	26	3	" "
NW. ¼	23	6	26	3	" "
SW. ¼..... ...	23	6	26	3	" "
SE. ¼..........	23	6	26	3	" "
NW. ¼..........	14	6	26	3	" "
NE. ¼....	14	6	26	3	" "
NW. ¼..........	24	6	26	3	" "
SW. ¼	24	6	26	3	" "
SE ¼..........	24	6	26	3	" "
NW. ¼..........	13	6	26	3	" "
NE. ¼..........	13	6	26	3	" "

REPORT ON MIDDLE CREEK RESERVOIR.

During September, 1913, a survey was made of a reservoir site on Middle creek in township 5, range 30, west of the 3rd meridian, and township 5, range 1, west of the 4th meridian. The object of creating a reservoir at this point is to impound the flood run-off of Middle creek, and allow the stored water to be drawn off when needed in quantities necessary to serve the land under irrigation below this proposed reservoir.

On Middle creek, like all other streams rising in the Cypress hills, practically all the run-off takes place either during the early spring when the snow is melting, or during periods of heavy rainfall. As an example of this, the total discharge of Middle creek, in section 30, township 5, range 29, west of the 3rd meridian, during the open water season of 1912, was 18,071 acre-feet, while the discharge for the month of April alone was 17,582 acre-feet. From this it is quite apparent that practically all the run-off during the season took place in the month of April, so that if the run-off during this month is not stored in such a manner that the water may be utilized during the dry periods of the year, irrigation cannot be carried on in this section of the country to any great extent, or with much success.

When making the survey of this site it was found that there were two alternative schemes by which the water could be impounded. The first of these, viz., reservoir "A," is to have a dam in NE.¼ section 21, township 5, range 30, west of the 3rd meridian, and will flood about 1,500 acres of land, including a large flat in which there are 800 acres at present under irrigation with an estimated value of $30 per acre.

The advantages of the above site are: (1) that the length of dam required would not be more than 1,000 feet, about 300 feet of which would only require a fill of 4 feet, and the maximum height of the remainder, 25 feet; (2) the length of spillway would be short, and accordingly the cost of expensive work such as riprap, small. On the other hand, this scheme necessitates purchasing 300 acres of land.

The alternative, reservoir "B," is to raise the present dam of Mackinnon Bros. in NE. ¼ section 24, township 5, range 1, west of the 4th meridian, and flood 800 acres of land, the greater part of which is at present held under grazing leases and may be reserved for reservoir purposes.

The advantages of this latter scheme are: (1) only 200 acres of land would require to be purchased, and as this land is at present used only for grazing the cost would be small; (2) the dam constructed on this site by Mackinnon Bros. could be made use of and would reduce the amount of fill required. In connection with this scheme, however, a dam 2,400 feet in length would be required with a maximum height of 36 feet, and a long and expensive spillway.

In order to determine the capacity that would be necessary for either of these reservoirs, it is essential to know the maximum discharge of Middle creek at the respective dam sites.

With a dam in NE. ¼ section 21, township 5, range 30, west of the 3rd meridian, the hydrographic records show that the available water for storage during a year such as 1912 would be about 15,840 acre-feet. The capacity of the reservoir with a dam at the above point at a maximum height of 25 feet, allowing a freeboard of 5 feet, would be 16,782 acre-feet.

With a dam in NE. ¼ section 24, township 5, range 1, west of the 5th meridian, the available water for storage during a year such as 1912 would be 13,000 acre-feet. The capacity of this reservoir with the present dam raised to a maximum height of 36 feet, allowing a freeboard of 5 feet, would be 13,372 acre-feet.

An estimate of the cost of each of these proposed reservoirs has been made and shows the cost of reservoir "A" as $83,338.35, or $4.96 per acre-foot of storage; and the cost of reservoir "B" as $133,343, or $9.98 per acre-foot of storage.

A comparison of these two schemes shows that the cost per acre-foot of storage in reservoir "A" is about half the cost for reservoir "B." Reservoir "A" has therefore been adopted as being the more feasible, and all calculations are based upon this scheme.

The above estimates include in each case the cost of spillways of sufficient capacity for a discharge of 1,500 c.f.s. The cost of such spillways are, however, out of proportion to the cost of the dams themselves, and in the case of reservoir "A" other means for taking care of flood water have been adopted.

The dam for reservoir "A," as stated above, is calculated with a freeboard of 5 feet. The capacity of the reservoir with this dam and a freeboard of 2 feet will be 21,826 acre-feet, and, as will be shown later, this is sufficient for the available storage of two very wet years in succession. This, however, as hydrographic records show, is a very unlikely case and it has been decided that in place of using an expensive spillway, it would be more economical to have two 3-foot diameter sluice-pipes in the dam. The discharge from one of these pipes, with the reservoir lowered to a height of 2 feet, is 47 c.f.s. This is a sufficient discharge for the land under irrigation below the proposed reservoir. The discharge from the two outlet pipes with the reservoir full, or a head of 23 feet, is 318 c.f.s., which is sufficient for all stages of the stream with the exception of the early spring run-off, which may be stored in the reservoir.

The estimate accompanying this report shows the cost of reservoir "A" with two sluice-pipes in place of a spillway. The cost of this scheme, estimating a storage of 21,826 acre-feet is $66,458, or $3.04 per acre-foot of storage.

As previously stated, the storage available during a year such as 1912 is 15,840 acre-feet. The absorption losses, estimated at 60 inches over an area of 1,325 acres, amount to 6,625 acre-feet. The water available for irrigation purposes will then be 9,215 acre-feet.

The area of land lying along Middle creek below the proposed reservoir, at present under irrigation, is 2,420 acres, requiring an annual amount of 4,840 acre-feet of water.

The additional flow to the stream, below the proposed reservoir, is estimated at 15,400 acre-feet. This quantity, if it were distributed throughout the irrigation season, would supply all the water necessary for irrigation, but as 13,000 acre-feet of the above amount runs off during the month of April, and the remainder during the months of May and June, it is estimated that only about 1,500 acre-feet of the additional flow would be used for irrigation. The remainder of the quantity required, or 3,340 acre-feet, would have to be supplied from the reservoir. The quantity of water in the reservoir at the end of a year such as 1912 would then be 5,875 acre-feet.

The hydrographic records of Middle creek show that a case of two such years as 1912 following in succession is very unlikely. If there were, however, the total quantity of water which the reservoir would be called upon to store would be the amount remaining in the reservoir from the preceding year, or 5,875 acre-feet, *plus* the run-off for the present year, or 15,840 acre-feet, making a total of 21,715 acre-feet. This quantity does not take into account the losses due to evaporation and seepage, but as the capacity of the reservoir is 21,826 acre-feet, it will be seen that the reservoir is of sufficient capacity to store all run-off which may possibly occur.

Considering the case of a very dry year following one wet year, the available storage during a very dry year such as 1910 is estimated at 1,700 acre-feet. The total quantity of water available for storage will be that remaining in the reservoir from the previous year (5,875 acre-feet), *plus* the available supply for the dry year (1,700 acre-feet), *less* the losses due to absorption (60 inches over an area of 1,000 acres, or 5,000 acre-feet), making a total of 2,575 acre-feet.

The additional flow to the stream during a dry year is 1,571 acre-feet, all of which could probably be used for irrigation. The quantity required for irrigation is 4,840 acre-feet. The quantity which the reservoir will be called upon to supply will be the total quantity required, less the additional flow, or 3,269 acre-feet.

The quantity available from the reservoir is, however, only 2,575 acre-feet, leaving a quantity of 694 acre-feet which, in a year such as 1910, cannot be supplied even with this reservoir.

From the above it will be seen that the area of land at present held under water rights is about all the land which can be irrigated from Middle creek. Without this reservoir, irrigation can only be carried on during the high water stages of the stream, and only such crops as can be grown with one or two floodings are successful.

ESTIMATE of cost of Middle Creek reservoir site "A," dam in NE. ¼ section 21, township 5, range 30, west 3rd meridian.

Description.	Quantity.	Unit Cost.	Cost.	Total Cost.	Remarks.
		$ cts.	$ cts.	$ cts.	
Earth-fill	25,026 cu. yds.	0 25	6,256 50		
Riprap	4,151 sq. "	1 25	5,188 75		
Sluice-pipes (2), concrete required	210 cu. "	15 00	3,150 00		Concrete in place.
Stop walls on sluice-pipes	70·1 cu. yds	15 00	1,051 50		" "
Gates, (2), etc			150 00		
Trestle and platform for operating gate	1,934 board ft.	60 00	116 00		Lumber in place.
Riprap at entrance to sluice pipes	32 sq. yds.	1 25	40 00		
				15,952 75	
10 per cent for engineering and contingencies				1,595 25	
				17,548 00	
Land to be purchased	1,257 acres	30 00		37,710 00	
" " "	560 "	20 00		11,200 00	
				66,458 00	

Capacity of reservoir=21,826 acre-feet. Cost of storage per acre-foot=$3.04.

LANDS flooded by reservoir "A," with dam in NE. ¼ section 21, township 5, range 30, west 3rd meridian.

Part.	Sec.	Tp.	Rge.	Mer.	Remarks.
SE. ¼	29	5	30	3	About 2 acres.
SW. ¼	28	5	30	3	" 10 "
NW. ¼	21	5	30	3	
NE. ¼	21	5	30	3	" 13 "
SE. ¼	21	5	30	3	" 15 "
SW. ¼	21	5	30	3	
NE. ¼	20	5	30	3	
SE. ¼	20	5	30	3	
NE. ¼	17	5	30	3	
SE. ¼	17	5	30	3	About 26 acres.
NW. ¼	16	5	39	3	
SE. ¼	16	5	30	3	" 40 "
SW. ¼	16	5	30	3	
NE. ¼	9	5	30	3	" 4 "
NW. ¼	9	5	30	3	" 27 "
NE. ¼	13	5	1	4	Reserved for reservoir.
NE. ¼	24	5	1	4	
SE. ¼	24	5	1	4	Legal subdivisions Nos. 1 and 8.
NW. ¼	24	5	1	4	About 1 acre.
SE. ¼	26	5	1	4	" 1 "
NE. ¼	26	5	1	4	
NW. ¼	26	5	1	4	Legal subdivisions Nos. 13 and 14.
	25	5	1	4	(All of section reserved for reservoir).
SE. ¼	35	5	1	4	Included in lease of ranch No. 4387.
SW. ¼	35	5	1	4	Legal subdivisions Nos. 3 and 4.
SE. ¼	34	5	1	4	Included in lease of ranch No. 3245.

Report on Levels Run by Cypress Lake Reservoir Party during 1913.

Upon the completion of the Cypress Lake Reservoir survey, instructions were received to run level lines over the country between townships 3 and 5 inclusive, in ranges 29 and 30, west of the 3rd meridian, and in ranges 1 and 2, west of the 4th meridian, the datum of these levels to be sea-level datum as used on the Cypress Lake survey. The object in running these levels was to ascertain if there were any feasible reservoir sites in this section of country.

The method employed in running these levels was to level along the boundaries of the townships, and also along a line from the centre of each boundary to the centre of the opposite boundary. The distances were obtained by pacing, checking in on each quarter-section mound, and line was obtained by means of a compass on the level. The general topography of the country was noted as far as possible on each side of the line being levelled. Permanent iron bench-marks were placed in the northeast corner of each township levelled over, and all hydrographic bench-marks in the district were tied in with these levels.

The levels were run from five different camps, one on Battle creek, two on Middle creek, one on Bear creek, and one on Lodge creek. From each camp lines of levels were run as far as could be conveniently reached by driving. Starting from a permanent iron bench-mark at the northeast corner of township 5, range 29, west of the 3rd meridian, levels were run both west and south. On the line running west checks were kept on the permanent iron bench-marks in the NE. corners of township 5, range 30, west of the 3rd meridian, and NE. corner township 5, range 1, west of the 4th meridian, which had been placed there during 1911. All levels were circuited and when the error of closure exceeded one-tenth foot $\sqrt{\text{distance in miles}}$, the levels were re-run.

On reaching Middle creek a reservoir was found in township 5, range 1, west of the 4th meridian, a separate report of which scheme is submitted.

A line of check levels was run from the southeast corner of township 3, range 29, west of the 3rd meridian, to a permanent bench-mark at Willow creek police detachment in section 11, township 1, range 29, west of the 3rd meridian.

All levels were plotted and a plan of the country levelled over was made, showing contours at 25-foot vertical intervals. During the winter of 1913-14 a separate plan of each township was made also showing contours at 25-foot vertical intervals.

As no further reservoirs were located, the completion of these levels finished the field work for the season, the party disbanding in Maple Creek on November 14.

After disbanding the field party, the chief field inspector, accompanied by the engineer in charge of the reservoir party, made inspections of five reservoir sites located on the north slope of the Cypress hills, which had been surveyed in 1902, but of which there had not been estimates submitted. Since these estimates accompany the report submitted by the chief field inspector, no further reference will be made to them here.

List of Plans prepared in connection with reservoirs in the Cypress hills.

1. General plan of Cypress Lake reservoir and diversion canals.
2. General plan of traverse of Battle creek.
3. General plan of Middle creek.

4.	Contour	plan	of township	3,	range	30,	west of	3rd meridian.
5.	"	"	"	3,	"	29,	"	3rd "
6.	"	"	"	3,	"	1,	"	4th "
7.	"	"	"	3,	"	2,	"	4th "
8.	"	"	"	4,	"	29,	"	3rd "
9.	"	"	"	4,	"	30,	"	3rd "
10.	"	"	"	4,	"	1,	"	4th "
11.	"	"	"	4,	"	2,	"	4th "
12.	"	"	"	5,	"	29,	"	3rd "
13.	"	"	"	5,	"	30,	"	3rd "
14.	"	"	"	5,	"	1,	"	4th "
15.	"	"	"	5,	"	2,	"	4th "

16. Tracing of general plan of reservoir in township 10, ranges 25 and 26, west of the 3rd meridian.
17. Tracing of general plan of reservoir in township 10, range 25, west of 3rd meridian.
18. Tracing of general plan of reservoir in section 8, township 10, range 25, west of the 3rd meridian.
19. Tracing of general plan of reservoir in township 10, range 26, west of the 3rd meridian.
20. Tracing of general plan of reservoir in township 11, range 22, west of the 3rd meridian.
21. Profile of Battle Creek diversion canal.
22. Profile of Belanger Creek diversion canal.
23. Profile of Davis creek diversion canal.

Your obedient servant,

N. M. SUTHERLAND.

Cost Data on Reservoir Water.

In considering the advisability or otherwise of constructing reservoirs in the Cypress Hills district, the first question which naturally presents itself is, "can these reservoirs be constructed at a reasonable cost?" In order to study this most important question, a considerable amount of data have been collected, which are published in the following tables for the general information of the interested public. By studying the reservoir capacities an idea of the size of the storage can be gained, together with the first cost per acre-foot of water, while notice of the location of the reservoirs, etc., will indicate where and for what purpose the water is being used, and this in turn indicates the economic value of the water, which, for irrigation, varies greatly from the southerly to the more northerly latitudes.

COST OF CONSTRUCTION of American Reservoirs. (Taken from *Irrigation Pocket Book*, by R. B. Buckley, C.S.I., 1911.)

Name.	Character of Dam.	Capacity of Reservoir.	Cost.	Cost per Acre-foot.	Cost per Million Cubic Feet.
		Acre-feet.	$	$	£
Sweetwater Dam, California.	Masonry	22,566	264,500	11 72	56 05
Bear Valley Dam, California	"	40,000	68,000	1 70	8 13
Hemet Dam, California	"	10,500	150,000	14 29	68 34
Escondido Dam, California	Rock-fill	3,500	110,059	31 44	150 37
La Mesa Dam, California	Hydraulic-fill	1,300	17,000	13 10	62 65
Cuyamaca Dam, California	Earth	11,410	54,400	4 76	22 76
Buena Vista Lake, California	"	170,000	150,000	0 88	4 21
English Dam, California	Rock-fill crib	14,900	155,000	10 40	49 74
Bowman Dam, California	"	21,070	151,521	7 19	34 38
San Leandro Dam, California	Earth	13,270	900,000	68 00	325 22
Eureka Lake Dam, California	Rock-fill	15,170	35,000	2 32	11 09
Fancherie Dam, California	"	1,350	8,000	5 92	28 31
Lake Avalon, Pecos River, N.M.	Rock-fill and earth	6,300	176,000	27 94	133 63
Lake McMillan, Pecos River, N.M.	Rock-fill and earth	89,000	180,000	2 02	9 66
Tyler, Texas	Hydraulic fill	1 770	1,140	0 64	3 06
Cache la Poudre, Colorado	Earth	5,654	110,266	19 50	93 26
Larimer and Weld, Colorado	"	11,550	89,782	7 77	37 16
Windsor, Colorodo	"	23,000	75,000	3 26	15 59
Monument, Colorado	"	885	33,121	38 69	185 04
Apishapa, Colorado	"	459	14,772	32 18	153 91
Hardscrabble, Colorado	"	102	9,997	97 78	467 65
Boss Lake, Colorado	"	205	14,654	71 39	341 43
Saguache, Colorado	"	954	30,000	31 45	150 41
Seligman, Arizona	Masonry	703	150,000	169 50	810 66
Ash Fork, Arizona	Steel	110	45,776	416 30	1,991 02
Williams, Arizona	Masonry	338	52,838	156 35	747 77
Walnut Canyon, Arizona	"	480	55,000	114 60	548 10
New Croton, New York	Masonry and earth	98,200	4,150,573	42 27	202 16
Titicus, New York	Masonry and earth	22,000	933,065	42 42	202 88
Sodom, New York	Masonry and earth	14,980	366,990	24 50	117 17
Bog Brook, New York	Earth	12,720	510,430	40 12	191 88
Indian River, New York	Masonry and earth	102,548	83,555	0 81	3 87
Wigwam, Connecticut	Masonry	1,028	150,000	145 90	697 79

UNITED STATES Reclamation Service Reservoirs.

Reservoir.	Project.	State.	Capacity in Acre-feet.	Cost per Acre-foot.
				$ cts.
Belle Fourche	Belle Fourche	South Dakota	203,770	5 67
Pathfinder	North Platte	Nebraska–Wyoming	1,025,000	1 86
Willow Creek	Sun River	Montana	16,700	12 17
Deer Flat	Boise	Idaho	177,600	5 14
Jackson Lake	Minidoka	"	380,000	1 23
Lake Walcott	"	"	150,000	3 80
Shoshone	Shoshone	Wyoming	456,000	2 62
Average			344,153	4 64

COLORADO Reservoirs, Irrigation.

Name of Reservoir.	Owners.	Capacity in Acre-feet.	Cost per Acre-foot.
			$ cts.
Rocky Ridge	Water Supply and Storage Co	4,726	
Long Pond	" "	3,922	
Nos, 2 and 3	" "	1,026	4·11
No. 4.	" "	996	
Lindemeier Lake	" "	716	
Curtis Lake	" "	778	
Chambers Lake	" "	1,259	47·70
No. 1	North Poudre Irrigation Co	674	4·45
" 2	" "	5,000	1·50
" 3	" "	2,550	1·96
" 4	" "	1,074	4·66
" 5	" "	5.740	·36
" 6	" "	11,478	1·13
Coal Creek	" "	4,477	1·34
Fossil Creek	" "	11,478	14·22
Douglas	Poudre Valley Reservoir Co	10,547	4·74
Warren Lake	Warren Lake Reservoir Co	689	*11·61
Claymore Lake	Pleasant Valley and Lake Canal Co.	896	*2·23
Windsor Lake		689	1·45
Wood	A. J. Eaton	2,755	·73
Lake Lee	Latimer and Weld Irrigation Co	321	*3·12
Average		3,419	6 00

*Estimated.

SMALL Reservoirs Irrigation.

Name of Reservoir.	State.	Owner.	Capacity in Acre-feet.	Cost per Acre-foot.
				$ cts.
Oliver	S. Dakota	C. Oliver	10	20 00
Brant	"	Mr. Brant	60	3 33
Harris No. 1	Montana	Mr. Harris	10	8 00
" No. 2	"	"	85	5 88
" No. 3	"	"	100	7 50
Gray (5)	"	A. F. Gray	60	15 00
Barbour (3)	S. Dakota	Mr. Barbour	25	10 00
Kidd	Wyoming	David Kidd	60	33 33
Warner	"	"	16	25 00
Ryan	"	Mr. McDonald	35	10 00
McDonald	"	"	75	9 33
Ballard	"	Mr. Ballard	10	50 00
Hemmingway	"	Mr. Hemmingway	65	15 00
Garvey No. 1	"	O. K. Garvey	435	4 30
" No. 2	"	"	1,000	4 30
Sedgwick	"		300	10 00
Whoop Up	"	N.W. Cattle Co.	1,300	2 69
		Average	214	13 74

SMALL Domestic Reservoirs.

Name of Reservoir.	State.	Owner.	Capacity in Acre-feet.	Cost per Acre-foot.
				$ cts.
Casper Creek	Through South Dakota and Wyoming.	Chicago and North Western Railway Company.	75·3	25 11
Powder River			11·5	68 60
East Woolton			14·6	37 70
Poison Creek			59·2	27 66
Forks			13·8	34 08
Tisdale			15·5	33 58
Cut Bank			18·7	57 85
Cloud Creek			18·0	68 41
Sage Creek			99·2	23 05
Lusk			6·6	13 03
Duck Creek			12·3	38 84
Badwater Creek			31·9	25 49
Soldier Creek			18·0	56 06
Crow Creek			25·8	18 46
Dry Creek			7·4	50 21
Round Out			46·9	12 12
Box Elder			52 7	10 42
Flying V			87·5	10 39
Cheese Factory			71·6	18 83
Short Creek			34·2	11 53
Battle Creek			85 0	8 40
East Cottonwood			187·4	7 68
Corral Creek			186·1	6 82
New Indian Spring			13 2	32 35
North Butte Creek			23 9	47 10
New Battle Creek			22·8	49 21
New Bull Creek			12·2	58 99
Brouse Creek			9·3	72 40
		Average	45·4	33 01

REPORT ON OLDMAN RIVER DIVERSION PROJECT, BY V. MEEK.

PARTY No. 11.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I have the honour to submit herewith my report on the Oldman River diversion project.

The primary object of this report is to demonstrate the feasibility of a scheme to divert water from Oldman river and to utilize it to irrigate certain tracts of land north of this river, and south and west of Little Bow river.

HISTORICAL.

In 1910 a number of homesteaders and others, residing in townships 10 and 11, range 20, and township 11, range 19, west of 4th meridian, petitioned the Government for the construction of an irrigation system to supply water to their lands. Their proposal was to take water from Belly river at NW. ¼ section 30, township 10, range 20, west of the 4th meridian, and, by means of a pumping plant, raise the water to the level of the bench (approximately a 300-foot vertical lift) and distribute it over their lands by means of ditches and flumes. The persons benefited were to pay an annual water rental of $1 per acre irrigated.

ESTIMATE FOR THIS PROPOSAL.

Area of land to be irrigated....acres	16,000
Quantity of water required....sec.-ft.	110
Vertical lift ....feet.	300
Pumping plant necessary ....horse-power	4,500
Annual cost, including interest on capital invested, at $30 per horse-power $135,000 00	
Annual cost per irrigated acre, for pumping plant	$7 60
Annual cost per irrigated acre, for distributing system	2 00
Total annual cost per irrigated acre....	$9 60

This proves the absurdity of this proposal. It is absolutely impracticable to pump water against a 300-foot head for irrigation purposes.

It has been suggested that it might be feasible to take water from the Southern Alberta Land Company's irrigation canal just south of Lake MacGregor, where the canal route runs into the valley of Little Bow river and turns east, and conduct it through a gravity canal to the land in townships 10, 11, and 12, ranges 19, 20, and 21, for irrigation purposes.

Another scheme proposed, to furnish a water supply for the land east of Willow creek and north of Oldman river, was to divert water from the north fork of Oldman river just below the "Gap" and carry it up the valley of Callum creek over the height of land and into the south branch of Willow creek. This would necessitate about 35 miles of main canal, and once the water was turned into Willow creek it could be taken out at any point thought desirable.

A fourth proposal was brought out in a report by the Commissioner of Irrigation, dated August 19, 1911, on the *Proposed Reservoir Site on Oldman River at the 'Gap.'* The following, with reference to irrigation, is quoted from page 6, paragraph 1 of that report: "It should, however, be noted here from a rough study of the surrounding country that a possibility exists of diverting water from Oldman river north of Peigan on the Canadian Pacific Railway, carrying it thence round the south end of the Porcupine hills just west of Mud lake, and thence northeasterly to serve that dry country lying south of Little Bow river and north of Belly river."

RECONNAISSANCE.

In the spring of 1913 it was decided to put a party in the field to investigate these schemes, particularly the last—to divert water from Oldman river probably somewhere on the Peigan Indian reserve.

As no definite information was available to show whether or not the last scheme was feasible from an engineering standpoint, it was thought best to first carry on the work as a reconnaissance survey. All the known Government elevations of the land to be irrigated were collected, together with the Canadian Pacific railway track elevations on the Crowsnest, Aldersyde, and Macleod branches. Starting from Chokio on the Crowsnest branch, a line of levels was run to Oldman river, crossing to the north side of the mouth of Beaver creek. The elevation of the river at this point is 3,290 feet. Following this contour, it leaves the river banks about 6 miles below Beaver creek. This seemed to be the only place on the north side of the river where a gravity canal could be run out of the river bottom within the elevations 3,100 to 3,300 feet above sea-level. The preliminary levels were continued to Granum, roughly following line "A" as shown on the key plan, and from there across to Noble on the Aldersyde branch of the Canadian Pacific railway.

The following conclusions were reached from a consideration of these levels:—

(1) That it is possible to bring water from Oldman river by a gravity canal (about 35 miles long) to serve the land under consideration, and further that this canal could be easily constructed with the exception of the first 5 miles along Oldman river.

(2) That the only feasible place to leave the river banks on the north side is near the NE. ¼ of section 32, township 8, range 27, west of the 4th meridian, at an elevation of approximately 3,285 feet.

(3) That the intake, to be as near grade as possible, will have to be located about the mouth of Beaver creek or, as an alternative, to dam the river and locate the intake at a point about 1 mile below the Indian mission, thus saving 3 miles of very costly canal construction.

(4) As there is a tract of low-lying country between Oldman and Little Bow rivers on the west side of range 24, the highest elevation at which a canal can be located across this depression will be approximately 3,160 feet.

(5) That a large tract of land can be served by a canal located at a lower elevation, such that it would cross this low-lying land approximately on grade.

In the month of July a reconnaissance was made to prove the possibilities of diverting water from Oldman river at the "Gap" into Willow creek.

The following is a quotation from Mr. Russell's report on this project, dated July 28, 1913:—

> "As an alternative to the present scheme of diverting water from Oldman river near Beaver creek for irrigation purposes it is out of the question.
>
> "Regardless of storage possibilities, it would only be possible to divert a comparatively small quantity of water from the north fork, and I am of the opinion that the quantity of water available will be of first importance in considering the scheme in question.
>
> "In comparing the two schemes from their intakes to some common point, say Granum, the length of constructed canal would be about the same for each scheme. The excavation for a canal from Beaver creek, with the exception of a few miles, would be fairly light, whereas the excavation for a canal up Callum creek would be very heavy and, in fact, almost impossible. There would be many rock cuts and trestles on this line and the side-hill is so steep all the way that it would not be practical to construct a canal along it."

In October a line of levels was run from the Southern Alberta Land Company's canal on the north side of Little Bow river, across this river and along the south bank to determine the feasibility of irrigating part of the land under consideration from this source. Mr. Russell's report of October 9, 1913, on this reconnaissance is in part as follows:—

> "From the reconnaissance made it was found that:
>
> "(1) The south side of the valley of Little Bow river is even rougher than the north side.
>
> "NOTE.—The Southern Alberta Land Company have decided that it is not practical to maintain a canal along the north side of the valley and abandoned a large portion of canal after having constructed it.

"(2) The land on the south side of the Little Bow river is from 80 to 100 feet higher than the grade of the Southern Alberta Land Company's canal.

"(3) The length and height of flume or syphon necessary to carry the water across the valley would be approximately 4,000 feet long, at a maximum height of 132 feet.

"(4) That even if the valley were crossed by a canal as far down as reservoir No. 2, where the Southern Alberta Land Company's canal leaves the river, it would be necessary for the canal to follow the south bank of the valley for a considerable distance before finally getting away on top.

"Note.—The Southern Alberta Land Company's canal gets away from the river through a depression, so that if a canal were located on down the north side of the valley to a 'grade crossing' there would still be the same costly side-hill construction, and the height of flume and trestle greatly increased.

"I would therefore report that the scheme is not feasible for the reason that there is not a sufficient area of land to benefit by this scheme to warrant the expenditure of the amount necessary to construct it."

A comparison of these three schemes to irrigate the land under consideration by a gravity system shows that the one to divert water from Oldman river at some point on the Peigan Indian reserve would be the most practical and economical of construction. This project would also provide the greatest quantity of water, which is of primary importance, since there is more land to be irrigated than there is water to serve.

ORGANIZATION OF PARTY.

As it was decided to proceed with the preliminary survey for a gravity canal from Oldman river, a party was outfitted in Lethbridge and Macleod, and actual fieldwork commenced on June 18, 1913.

The party was made up as follows:—Engineer in charge, assistant, field draughtsman and topographer, head chainman, rear chainman, rodman, stakeman, two teamsters, cook.

Later in the season an additional rodman was engaged. This was not the most efficient size of party for canal location.

SURVEYS FOR MAIN CANAL.

Since, as previously stated, the NE. ¼ of section 32, township 8, range 27, west of the 4th meridian, was a controlling elevation for a canal located on line "A," the surveys were commenced at this point and worked backwards to the river, using the north boundary of the Peigan Indian reserve as an east and west bearing.

In order to establish a bench-mark with a known elevation, a line of levels was run from a farm crossing 1 mile south of Nolan on the Canadian Pacific railway (Macleod branch). The datum was arrived at by reading the elevation of the base of rail at this point from the Canadian Pacific railway track profile, and adding 22·4 feet, to get the elevation above sea-level. This only gives an approximate elevation, since the track profile may not agree with the present base of rail, but the error should not exceed 1 foot as a maximum. All the levels for this survey were referred to this same datum.

The centre line was chained and staked every 100 feet in rough country and every 200 feet in smooth, and the angles were turned to tacks set in lath hubs driven flush with the ground. To avoid angular error, the magnetic bearing of each course was noted, and at each hub the transit was reversed and the angle doubled, to eliminate errors in the instrument.

The levelman took the elevation of each stake, and also intermediate breaks in the ground, to give sufficient information for an accurate profile of the centre line. Sufficient topography was also taken on either side of the line to project a location. Temporary bench-marks were established along the centre line at intervals not exceeding 1 mile, and three permanent iron bench-marks were set at convenient points, as shown on the key plan.

Since the preliminary levels proved that a canal at a lower elevation would serve a large tract of land, a second line was located so that this canal would cross the low-lying country east of Granum at an elevation of 3,160 feet without necessitating any drops. Allowing a canal grade of ·025 per cent, such a canal would have to leave Oldman river at an approximate elevation of 3,210 feet. Starting from the NE. ¼ of section 32, township 8, range 27, west of the 4th meridian, on line "A," levels were carried along the top of the river bank until an elevation of 3,200 feet was reached, at which point it was found that by crossing the river to the south side, a good canal location could be obtained to the water surface of the river as shown at the beginning of line "B" on the key plan. As it could not be proved which location would be the most feasible until a study was made of the land to be irrigated, the lines "A" and "B" were both continued as independent surveys. Ties were run between the two lines at intervals, not exceeding 10 miles, so that the work was absolutely checked as it proceeded. At the last check from the end of line "B," station 1694 + 00 to station 1170 + 00, line "A" making a closed traverse of approximately 70 miles, the angular error was 3 minutes of arc, and error in levels 0·25 foot. The centre lines were tied to the land lines at every road crossing and three observations on Polaris were made, at intervals, to connect the bearings with true north.

SURVEYS FOR DAM SITES.

For 10 miles below the mouth of Beaver creek, Oldman river runs in a valley from 4,000 to 5,000 feet wide, with banks from 100 to 200 feet high. The river has a fall of, roughly, 15 feet per mile. As it was not practical, owing to steep cut-banks, to locate a canal in the river bottom above the mouth of Beaver creek, and as the canal grade at this point was 10 feet above the river surface, a cross-section was made for a dam. As an alternative, a second cross-section of the river bottom was taken about 1 mile below the Indian mission, where a 40-foot dam would save 3 miles of costly side-hill canal construction. These cross-sections were chained and staked at every 100 feet, and sufficient levels taken to develop an accurate cross-section, with the exception of that part of the river where the water was too deep and swift to wade. The distance across the river was calculated by triangulation.

The grade for line "B" runs to the water level of the river, and a cross-section was taken at this point (*see key plan*) by wading as far as possible from both sides of the river, which is fairly straight above and below this section, with a sand and gravel bottom. To divert the water from this point would necessitate the construction of a weir 600 feet long at a 6-foot maximum height.

CONTOUR SURVEYS.

Lines "A" and "B" were continued, as shown on the key plan, for a sufficient distance to project a location for a main canal. Since the area of land which could be successfully irrigated was not known, and therefore no way of determining the quantity of water necessary to take off from time to time in laterals, it was decided, in continuing the surveys, to run levels over the land in order to obtain sufficient information with respect to the general topography of the country, and suitability of the soil for irrigation, to project the proper sized ditches on correct grades. This work was commenced on September 18, and as there was not time to run sufficient levels to make an accurate contour map of the district, comprising about twenty townships, levels were simply run over the road allowances and the distances read by stadia. These notes were plotted on township sheets to the scale of 40 chains to the inch, 10-foot contours being sketched in. The location of these contours is not by any means accurate, but should give a general idea of the topography of the land to be irrigated.

Permanent iron bench-marks were established at every township corner, and also temporary bench-marks were placed where two lines of levels crossed. In this way a complete check was obtained upon the work as it proceeded. The maximum error of closure was $\cdot 10\sqrt{\text{distance in miles}}$, but for the most part was never greater than $\cdot 05\sqrt{\text{distance in miles}}$.

The hatched areas on the key plan show roughly the best of the irrigable land. In addition to these areas there are numerous small tracts of land which could be irrigated, but this would necessitate the building of long and expensive laterals.

The soil of the irrigable tracts varies considerably. Starting from Little Bow river it is a light sandy loam and gradually changes to a heavy clay loam at Blackspring ridge, and farther west is for the most part a light clay loam.

RESERVOIR SURVEYS.

Contour surveys were made for two reservoir sites. The first on line "A," at NW. corner of township 13, range 25, west of the 4th meridian, has a capacity of roughly 10,000 acre-feet, but is at too great a distance from the irrigable lands to be of use, and is at too great an elevation to be used in connection with scheme "B." The second and most suitable reservoir for this project is at Keho lake, in the NW. corner of township 11, range 22, west of the 4th meridian. The elevation of this lake, which is almost dry, is 3,130 feet, and it could be raised to 3,145 feet, giving a storage of 43,000 acre-feet. The lake at present has no outlet, but at an elevation of 3,150 feet it would drain in Pyami coulee, and hence by cutting through this low ridge, this water could be used to irrigate the land east and south of the reservoir. The cost of appropriating the land flooded should not be very large, as the greater part of the area, although patented, is good for nothing but grazing.

Another reservoir site which could be used in connection with this scheme is on Oldman river at the "Gap" in SW. ¼ section 33, township 10, range 3, west of the 5th meridian. Mr. Peter's report of August 19, 1911, on this site, estimates the available storage to be 23,660 acre-feet, and the cost of providing for it approximately $200,000.

HYDROGRAPHS.

Since one of the first considerations in any irrigation scheme is necessarily the quantity of water available, a study was made of the discharge records of Oldman river. The nearest gauging station to the intake is near Macleod at NW. ¼ section 10, township 9, range 26, west of the 4th meridian. Since there are no streams of any size emptying into Oldman river between this station and the intake, the results should closely approximate the discharge at the intake on the Peigan reserve. Daily discharge records at this station date back to July 12, 1910. Hydrographs of the daily discharge were plotted for the irrigation season (May 1 to September 30) for the four years 1910, 1911, 1912, and 1913 (*see plates 1, 2, 3, and 4*). Judging from the discharge of Oldman river near Cowley, of which records date back to May 1, 1907, the year 1910 shows the lowest records for the past six years. Since it is in these dry years that water for irrigation is most necessary, all calculations were based on the available water in the year 1910 as shown in hydrograph plate 1.

ALTERNATIVE ROUTES.

Considering the two lines "A" and "B" as surveyed for the main canal from their intakes to a common point (say the crossing of Willow creek), line "A" is 27 miles, and line "B" 16 miles from intake to Willow creek. Canal "A" would require a diversion weir at Beaver creek 10 feet high and 3,600 feet long, and canal "B" a diversion weir 6 feet high and 600 feet long, and further, the first 5 miles of canal "A" would involve costly side-hill construction, including a flume 2,600 feet long by 30 feet high to avoid cut banks, and a 2,000-foot cut 35 feet deep, where the canal leaves the river banks. The only costly construction on canal "B" is a flume 4,100 feet long across Oldman river. Without making any detailed estimates, it is seen that the cost of construction of canal "A" would greatly exceed that of canal "B." The only advantage of canal "A" is the additional area of irrigable land, roughly, 10,000 acres, which it might serve, but since there is sufficient land under canal "B" for all the water available in Oldman river, and since the land served by canal "B" is more in need of water than the additional area which would be served by canal "A," this advantage is offset. Hence canal "A" was abandoned and all estimates were based on the surveys for canal "B."

DESIGN OF CANALS.

In designing the canals the first question to be considered was the area of irrigable land. This was estimated roughly from the contour sheets of the townships levelled over, and the side notes taken during the contour surveys. The results of this estimate are tabulated as follows:—

Land irrigable from scheme "B" above the reservoir at Keho lake—

	Acres.
Township 10, range 25, west of 4th meridian	4,210
" 11, " 25, " " "	9,430
" 10, " 24, " " "	3,700
" 11, " 24, " " "	4,200
" 12, " 23, " " "	7,100
" 10, " 23, " " "	8,760
	37,400

Land irrigable from scheme "B" below reservoir—

	Acres.
Township 10, range 22, west of 4th meridian	7,660
" 9, " 22, " " "	6,780
" 8, " 22, " " "	2,580
" 10, " 21, " " "	4,880
" 11, " 21, " " "	15,120
" 10, " 20, " " "	2,480
" 11, " 20, " " "	8,850
" 11, " 19, " " "	7,760
" 12, " 19, " " "	7,320
	63,430

Total land irrigable, 100,830 acres, say 100,000 acres. This is a very conservative, and rough estimate, only covering the best of the irrigable land. When a more detailed contour survey is made of the district, a larger acreage will probably be shown to be irrigable.

During a portion of the irrigation season (in June or July) there will always be some critical period during which time nearly all the farmers will require water, and if the canals are not large enough to supply it at this time the crops will be damaged.

Hence the canal must be designed of sufficient capacity to cover this period. This is analogous to the case of a power plant where this critical period corresponds to the peak load on the plant. In Alberta, with its short and intensive growing season, this critical period is assumed to be fifteen days.

In any irrigation season from 10 to 30 per cent of the irrigated land will be idle, and during this fifteen days another 30 to 40 per cent of the land will be in crops which can be irrigated at an earlier or later period without injury.

The depth of water required for irrigation varies in Alberta from 4 inches to 8 inches, depending on the character of the soil, the variety of crop, and other factors, but may be assumed at 6 inches for an average.

Summing up these assumptions, the maximum requirement governing the capacity of the canals will be 6 inches of water over 50 per cent of the land in fifteen days, or 6 inches of water over 100,000 acres in thirty days.

Evaporation and seepage losses in canals depend upon the character of the soil and climatic conditions, and thus can only be approximated. An average taken from the measured losses of several of the United States Reclamation Service irrigation projects, and used in this estimate, is 20 per cent total loss in distributaries, and 25 per cent to 5 per cent per mile loss in main canal.

The probable requirements in inches of water over 100,000 acres will be as follows:—

May. 4 inches.	June. 6 inches.	July. 6 inches.	August. 4 inches.	September, 2 inches.
33 days.	60 days.		31 days.	30 days.

Sketch of System.

Canal A.	Tract A. 37,000 acres.	Canal B.	Reservoir 43,000 acre-feet.	Canal C.	Tract C. 63,000 acres.

Note.—The letters A, B and C have been used in this sketch to designate canals advocated under route "B" and should not be confused with the previous use of the letters A and B referring to the two surveyed lines.

Tract A represents all the irrigable land above the reservoir at Keho Lake. Tract C represents all the land below the reservoir.

Study for maximum draft period, June 2 to August 1, 60 days:—

1 second-foot in 60 days = 120 acre-feet.

	Second-feet.
Tract C requires 63,000 acre-feet of water, net.	
Absorption loss 15,750 acre-feet or 131 second.	
78,750 acre-feet or	656
Loss in main canal C at 5 per cent per mile	54
Hence canal C must supply	710
Using 5,000 acre-feet storage during this period or	42
Canal B must supply to reservoir	668
Loss in main canal B	30
Hence canal B must supply	698

Tract A requires 37,000 acre-feet.
Absorption loss 9,250 " or 77 second-feet.

Second-feet.
46,250 " or. 385

Hence canal A must supply. 1,083
Loss in main canal A. 120

Hence canal A at intake must supply. 1,203

Total estimated absorption loss is 412 second-feet, or 34 per cent.

Study for period August 1 to August 31, 31 days, 4 inches water:

1 second-foot in 31 days=62 acre-feet.

Tract A requires 21,000 acre-feet.
Absorption loss 5,375 "

Second-feet.
26.375 " or. 425
Loss in main canal C. 35

Hence, canal C must supply. 460
Using 18,000 acre-feet storage in 31 days, or. 290

Canal B must supply to reservoir. 170
Loss in main canal B. 15

Hence canal B must supply. 185
Tract A requires 12,333 second-feet.
Absorption loss 3,087 "

15,420 " or. 250

Hence canal A must supply. 435
Loss in canal A. 45

Hence canal A at intake must supply. 480

Study for period September 1 to September 30, 30 days:—

Tract C requires 2 inches of water, or 10,500 acre-feet.
Absorption loss. . . . . 2,625 "

Second-feet.
Canal C must supply. . . . . 13,125 " or. 220
Loss in canal C. 20

Hence canal C must supply. 240
Loss in canal B. 10

Hence canal B must supply. 250

Tract A requires 6,160 acre-feet.
Absorption loss 1,540 "

7,700 " or. 128

Canal A supplies. 378
Loss in canal A. 30

Hence canal A at intake must supply. 408

Study for period May 1 to June 2, 33 days:—

Tract C requires 4 inches or 21,000 acre-feet.
Absorption loss . . . . 5,375 "

Second-feet.
26,375 " or. 400
Loss in canal C. 35

Hence canal C must supply. 435
Loss in canal B. 25

Hence canal B must supply. 460

Tract A requires 4 inches or	12,333 acre-feet.		
Absorption loss	2,967 "		
	15,300 "	or.	232
Canal A must supply.			692
Loss in canal A.			100
Hence canal A at intake must supply.			792

Hence required capacities of main canal are as follows:—

	Canal A. second-feet.	Canal B. second-feet.	Canal C. second-feet.
May 1 to June 2....................	792	460	435
June 2 to August 1..................	1,203	698	710
August 1 to August 31................	480	185	460
August 31 to September 30...........	408	250	240

Maximum capacities governing design are: canal A 1,203 second-feet, canal B 698 second-feet, canal C 710 second-feet, for the dry year 1910; referring to plate 1, the reservoir would be drawn from as follows:—

	Acre-feet.
June 2 to August 1..	5,000
July 7 to August 1..	17,000
August 12 to August 31..	18,000
Total	40,000

Since the reservoir capacity is 43,000 acre-feet, this allows an absorption loss of 3.000 acre-feet for the period June 2 to August 31.

Assuming an absorption loss in the reservoir of 60 inches for the year over an average reservoir area of 3,000 acres, it is probable that one-third of this loss, or 20 inches, will occur during June, July, and August, or a total of 5,000 acre-feet. Hence, for this period, June 2 to August 31, there would still be 2,000 acre-feet to make up, but it is reasonable to assume that there will be some few days of wet weather when irrigation is not required, and the canals can be used to run this additional 2,000 acre-feet of water into the reservoir from the river.

During the balance of the year the estimated loss in the reservoir is 40 inches over 3,000 acres, or 10,000 acre-feet. This reservoir drains an area of approximately 16,000 acres, and in 1910 the total rainfall from records at Lethbridge, Alta., was 7·34 inches. Assuming a run-off of 30 per cent, the reservoir would receive from natural drainage 3,000 acre-feet. Hence, the estimated loss from August 31 to June 2 is 7,000 acre-feet, and the total quantity of water which must be run from the river during this period in order to have the reservoir full on June 2 is 43,000 + 7,000 = 50,000 acre-feet.

In May and September, canal B can be run to its full capacity to refill the reservoir.

From Hydrograph, plate 1:—

	Acre-feet.
Storage water which can be taken from river in September..........	12,000
Storage water which can be taken from river in May..............	15,000
Total	27,000

Additional water required to fill reservoir = 50,000—27,000 = 23,000 acre feet.

Running canal B to its capacity, 668 second-feet, for eighteen days at the end of April would give this required 23,000 acre-feet.

For the other years, 1911, 1912, and 1913, plates 2, 3, and 4 indicate that required quantity of water could be taken directly from the river.

The main canal from the intake to the first secondary was projected on a large scale plan (400 feet to the inch) and designed with side slopes of 1½ to 1, top width of bank 12 feet, maximum depth of water 8 feet, and maximum bed width 40 feet. This design was not intended to suit all conditions, but was an average upon which the preliminary estimate of earthwork was based.

From the end of the surveyed portion, the main canals, secondaries, and laterals were projected on the contour sheets as shown roughly in the key plan, and the maximum capacities were estimated upon the same assumption as for the main canal.

DESIGN OF STRUCTURES.

No attempt was made to go into details, but the estimate for structures was based on standard designs wherever possible, and made sufficiently high to allow for concrete construction, with the exception of flumes, road crossings, and headgates on canals under 40 second-feet capacity, which were designed to be constructed of timber.

The weir at the intake, from surface indications, has a sand and gravel foundation, and was designed of concrete construction 600 feet long with a maximum height of 6 feet above the lowest point in the present river-bed, and the weir crest 1 foot above the high-water surface in the canal. The headgates consist of four 4- by 10-foot gates of the Stoney type, with concrete piers 3 feet thick and 18 feet high.

All other concrete structures, such as intakes to secondaries, drops, etc., were estimated on the basis of $15 per cubic yard for concrete in place, and 80 cents per cubic yard for excavation and back-fill.

Flumes were designed of the ordinary trestle type, and the cost was estimated on a basis of $50 per thousand feet b.m. for timber in place. Wood structures, such as bridges and headgates in canals of small capacity, were estimated at the same unit cost.

SUMMARY of Estimates.

Description.	Dimensions.	Quantities.	Unit Costs.	Cost.	Total Cost.	Remarks.
				$	$	
Excavation		4,585,421 cu. yds.	$ 0.20 per cu. yd.	917,084	....	75 miles of main canal.
Right of way	100 ft maximum width	830 acres.	35.00 " acre.	29,050		
Road and farm bridges	14 ft. wide	60	600.00 " bridge.	36,000		
		40	300.00 " "	12,000		
Concrete drops				67,000		
Wooden flume 16 x 8 ft	Av. trestle height, 25 ft.	1,770 M b.m.	50.00 per M b.m.	88,500		
" "	" " 12 ft.	1,023 "	50.00 " "	51,150		
" "	" " 13 ft.	2,224 "	50.00 " "	112,000		
Concrete weir at intake				18,416		
" headgates at intake				3,705		
" " at reservoir				3,000		
Land flooded by reservoir		4,000 acres.	10.00 per acre.	40,000		
				1,377,905	1,377,905	Cost of main canal.
Excavation		889,000 cu. yds.	0 20 " cu. yd.	177,800	....	Secondaries and laterals.
Structures and right of way				83,051		
				260,851	260,851	Total cost of secondaries and laterals.
Engineering and contingencies at 15 per cent					1,638,756	
Total cost per irrigated acre, $18.84					245,813	
					1,884,569	

CONCLUSION.

It is highly probable that upon a more detailed survey, which will be made during the season of 1914, more than 100,000 acres will be found to be irrigable, which will certainly lessen the cost per acre. Although the above estimate is necessarily approximate, owing to the lack of detailed field information, it will require a large error in the total cost to materially affect the cost per irrigated acre, and hence it is practically safe to assume that, under efficient management, the scheme can be constructed at a cost of between $15 and $20 per irrigated acre.

The greater number of farmers in the district have not sufficient water on their land for domestic purposes, being compelled to haul it in tanks from 1 to 10 miles. Hence, not having water for more than a few head of stock, they have to depend entirely upon the growing of grain, and suffer from crop failures in dry years. With an adequate irrigation system for the farmer would be insured against crop failure, and be able to undertake mixed farming, which is not only more remunerative but less apt to impoverish the soil. Hence, the continued success of farming in this district depends upon some system of water supply being provided.

The present selling value of the proposed irrigated area averages $30 per acre. With water rights it is estimated that the selling value of this land would be $60 per acre, or an increase of $30 per irrigated acre, and since from the above estimates it will cost $18.84 per irrigated acre to construct the irrigation system, it is thought that the scheme is quite feasible.

Your obedient servant,

V. MEEK.

REPORT OF R. J. BURLEY, DIVISION ENGINEER.

PARTY No. 12.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following brief report upon the work done by myself during the past year.

Last spring I was transferred from the irrigation surveys work to work in connection with the International Waterways treaty, and the field operations were entirely in the nature of a reconnaissance, in order that a better idea might be obtained of the conditions along the St. Mary and Milk river watersheds.

Three of the most important tributaries of Milk river were carefully inspected, as were most of the important diversions from them, in order to obtain an idea of the most satisfactory methods for an equal division of water between Canada and the United States in accordance with the provisions of the Waterways treaty.

With this in mind for the reconnaissance, the Frenchman river was closely followed from its source in Cypress lake to its mouth north of Saco, Montana, and the more important tributaries were noted in passing, as well as the nature of the country forming the watershed and the easily irrigable areas along it. Inspections were also made of many of the irrigation schemes within the watersheds to obtain an idea of the quantity of water being utilized beneficially.

After leaving the Frenchman River valley, an inspection was made of the irrigated hay flats surrounding Saco above Beaver creek, and then the Milk river valley was followed closely around the big bend to the north of the Great Northern railway until Malta was reached. From this point the ditches and works, including the Nelson reservoir being constructed by the United States Reclamation Service, were carefully inspected, and the canals were then followed for their whole length up to the Dodson diversion dam.

Along this portion of the valley there are several small and unimportant tributaries which contain some small private irrigation schemes, but time did not permit of any detailed examination of them. They are in most instances constructed under the Carey Act, and it is believed that there is considerable doubt as to the validity of their filings for water, owing to prior filings by the Reclamation Service.

Above the Dodson dam there are numerous diversions, and some comparatively extensive schemes have been constructed, although in most cases the works are, at present, in poor repair owing probably to the agreements entered into by the owners with the Reclamation Service, by virtue of which this service contracts to irrigate the lands at present served by these schemes.

From Chinook a short trip was made into the country to the south, and then the north fork of Milk river (Battle creek) was followed as far as Kelvinhurst on this side of the international boundary, the return trip being made down the west fork (Lodge creek), thence along Milk river to the western crossings of the north and south branches, where the proposed St. Mary's canal will empty into the north branch.

After completing this work a trip was made over the route of the St. Mary's canal along the lower St. Mary drainage basin, and through the country affected by the Belly river—St. Mary diversion project on the Canadian side.

The Alberta Railway and Irrigation Company's canal was then followed to Stirling, and a reconnaissance was made of the district lying between that point and the western end of the Cypress hills, completing the field work for the season.

After the outfit was stored I returned to Calgary for a few days, and then made a trip by rail to Glasgow, Montana, in order to inspect the last diversion on the Milk river project at Vandalia.

During the winter detailed studies are being made of the stream flow conditions along the two watersheds, and maps are being prepared showing drainage areas, gauging stations, precipitation, and run-off curves, irrigation schemes, reservoir sites, both developed and feasible, and alternative schemes for the division of the water to obtain the most beneficial use of the stream flow to both countries.

Schedules are also in course of preparation showing all the available information regarding stream flow, precipitation, diversion through canals, etc., and after this information has all been tabulated, summaries will be prepared and several alternatives for the division worked out.

There still remains several months' field work to be done, especially in the eastern part of the Milk river basin, before the case will be ready for final submission and a special memorandum will be prepared regarding next season's work.

Your obedient servant,

RALPH J. BURLEY,

Division Engineer.

REPORT ON DUTY OF WATER INVESTIGATIONS, BY G. D. WALTERS

PARTY No. 13.

CALGARY, ALTA., March 30, 1914.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to herewith submit my report on the Duty of Water experiments for 1913.

In addition to this I have touched upon some of the more important phases of irrigation, which I believe will be of benefit to the irrigation farmer and others interested in this subject.

Irrigation was practised in prehistoric times in that portion of Asia Minor lying between the Tigris and Euphrates rivers. Water was distributed to the cultivated area by large canals, the ruins of some of which can be traced to-day, the principal canals having been supplied from the Euphrates. From the ruins of ancient towns and cities it is evident that this now practically desert region once supported a numerous and prosperous people.

In India, also, irrigation was practised in remote ages, and many of the earlier canal systems, enlarged and improved, are still in use. More than 53,000,000 acres are irrigated in India at present.

In China, enormous canals are used for navigation, irrigation, and drainage combined, and steps are now being taken to devise some adequate means of stream control for the prevention of the disastrous floods from which the country has suffered so greatly. Two-thirds of the cultivated land in Japan is under irrigation and supports a population of more than 41,000,000.

Large areas are irrigated in Italy, Spain, France, and Russia, and even in humid England meadow-irrigation, probably introduced by the Romans, is still practised.

On this continent, irrigation was practised on an extensive scale by a people whose very name and history are unknown. The ruins of their villages and canal systems are found throughout the southwestern portion of the United States, in Mexico, Central America, Peru, and Argentina.

Modern irrigation in the United States was first practised by the Mormon pioneers of Utah in 1847, and has since extended over portions of all the Western States, converting barren wastes into productive agricultural land. The census of the United States for 1910 gives the total crop area under cultivation as 13,739,499 acres.

CONDITIONS UNDER WHICH IRRIGATION IS PRACTISED.

Whether irrigation is practised in an arid, semi-arid, or humid region, the object is to establish those conditions of soil moisture essential to plant growth or to increased crop production.

In arid regions the soil is often surprisingly rich in the constituents necessary for plant growth. This, with the abundant sunshine, gives an ideal condition if only water can be supplied. Many attempts have been made to reclaim such land by the application of the principles of dry, or scientific, farming, but these have not proven successful in truly arid regions, and only partially successful in the semi-arid.

Any region in which the annual rainfall is between 12 and 20 inches is usually considered semi-arid, but within any such region the distribution of the rainfall may be very unequal and uncertain. Years of moderately plentiful rainfall are followed by years of extreme drought, and profitable farming can only be assured where a supply of water for irrigation is always available.

If dry farming methods are followed, summer-fallowing must be resorted to, if not every alternate year at least every third year, thus materially reducing the area available for crop production in any one year. But when water can be supplied for irrigation there is no necessity for these "off years." It is in semi-arid districts that the advantages of irrigation are most frequently questioned, and where crop failures due to drought are most frequent. There are seasons when the quantity and distribution of the rainfall are such that irrigation may not be absolutely necessary, but there is seldom a year in which there is not at least one period of drought during the growing season, when serious injury to crops might be averted by irrigation at the proper time.

The years of sufficient rainfall and resultant good crops are incentives to greater activities in the following season, which often brings drought, crop failure, and bitter disappointment and loss. It is now generally admitted that irrigation in semi-arid regions is not only necessary as an insurance against crop failure, but that it is also desirable as a means of increasing crop production, even during years when the rainfall seems ample.

The advantages of irrigation are now being more and more recognized in the humid regions. The practice is at present limited to crops which grow rapidly and require a great deal of water at all stages of growth.

Even here, however, the distribution of the rainfall is such that short periods of drought often occur which may seriously affect plant growth, so that while irrigation may not be a necessity it is often desirable. Mr. Elwood Mead, in Bulletin No. 148, United States Department of Agriculture, says:—

> "The great success of irrigation of market-gardens, and the increased demands for agricultural products, are leading to the adoption of irrigation for field crops in the humid sections of our country. In this the farmers of America are repeating the experience of farmers of Europe, who have found that there are few sections where irrigation will not pay simply as an insurance against drought. The irrigated portions of France, Switzerland, and Italy have a greater rainfall than the Mississippi valley. The average rainfall for eighty years of the largest irrigated district in Europe is 40 inches, and is better distributed than the rainfall of Ohio, Illinois, or Iowa."

PREPARATION OF LAND FOR THE APPLICATION OF IRRIGATION WATER.

Irrigation usually requires special preparation of the surface of the land so that the water may be applied easily, cheaply, and properly. This seldom appreciated until some permanent crop has been planted; then any necessary changes must be made at an additional expense. The distribution of the water so that all portions of the land may be easily and properly watered can be attained only when the surface of the land is properly levelled. The little irregularities in a field cause the irrigator considerable trouble, and often make it impossible to water all portions of the land uniformly. Smoothing or levelling these inequalities may be readily accomplished by following a ploughing or harrowing with a leveller or drag. The drag cuts away the high spots and deposits the soil in the hollows.

Department of the Interior Irrigation Office Calgary.

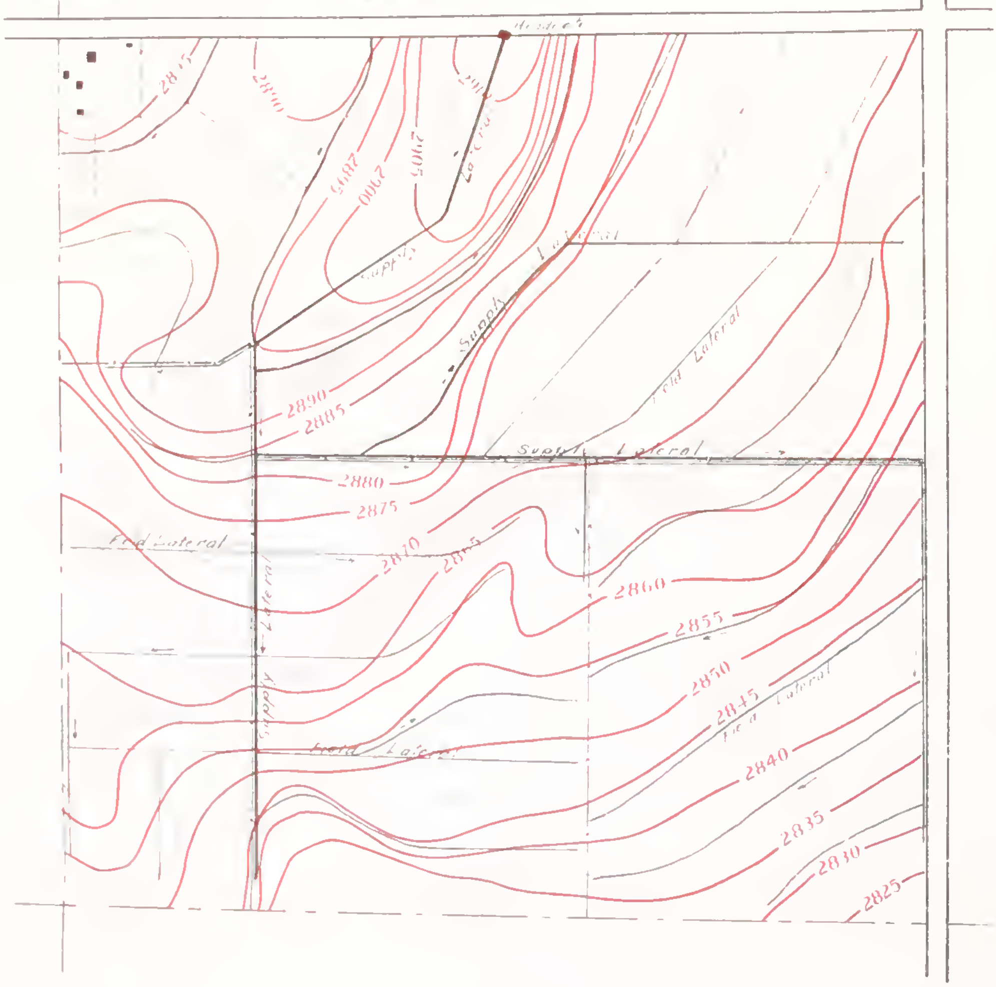


Fig. 1 Map showing location of field Laterals and the contour lines for a field of 160 acres.

Thorough preparation of the land is a big factor in the reduction of the time and labour required for its irrigation; the most important result, however, is the ease with which a uniform irrigation may be accomplished. It is not always advisable to attempt to do all the preparation of the surface before planting the first crop. It may be but roughly prepared, then cropped and irrigated. Then the irrigator, having had one year's experience in the application of the water to the land, is better able to determine how much levelling is necessary. The preparation of the surface of the soil should be completed before sowing a permanent crop like alfalfa, as any irregularities remaining after this crop has been sown will be a continual source of annoyance at each irrigation. The method and care to be used in the preparation of the land will depend to a large extent upon the method which the waters is to be applied.

METHODS OF APPLYING WATER.

The methods of applying water to the soil differ greatly, being dependent upon the character of the climate, the crop, the soil and its slope, the water supply, the experience of the irrigator, and the amount of money available. A general knowledge of the different methods is necessary to determine which is best suited to the conditions at hand. The most common methods may be grouped under the following heads: Flooding from field laterals, furrow irrigation, flooding within borders, and the check method. Other methods used are usually a modification of these.

FLOODING FROM FIELD LATERALS.

Flooding from field laterals is the most common method of applying water to the soil where grain and forage crops are raised, and where the returns from the crop produced do not justify the necessary expenditure incurred in the preparation of the land for the order or check methods. It requires the least preparation of the land, the general contour of which need not be changed. When the surface is practically uniform, deep ploughing followed by the harrow and dragging over with a leveller or drag for smoothing the surface are often very sufficient. This method is applicable to steep slopes, and recommends itself to the farmer of limited means, as raw land may be levelled and ditched for from \$2 to \$5 per acre; this cost may be distributed over one or two years. It, however, requires more labour to distribute the water than by any one of the other methods, an irrigator being required in continuous attendance, as the water has the tendency, especially on steep sloping ground, to follow one course, cutting the soil and often causing considerable damage. The method of distributing consists of a series of field laterals so located that the water may be spread to all parts of the land. The location of these laterals depends upon the contour of the land; when this is rolling, it is often necessary to run them along the top of a ridge, irrigating the land on each side by running the water down the slopes, or by running the laterals along the general line of the contours. When the slope is very uniform the laterals may be run in straight lines either down the slope, at an angle to the slope, or along the line of the gentlest slope that will permit water to flow. A combination of these methods is usually advisable. *See fig. 1.*

The supply lateral is usually made permanent and, whenever the slope permits, is run along a high side of the field, and from this the field laterals are extended at regular intervals of from 75 to 250 feet in such direction that all the land may be readily watered. The field laterals are generally opened and closed each year, so that they may not interfere with the movement of farming implements. They are not opened in the spring until after seeding, and are closed before harvesting by turning in the banks with plough or ditcher. The location of the laterals can be readily seen when it is desired to open them the following year.

The farm laterals are made by turning three or four furrows over with a plough, then removing the loose earth with a ditch-plough, ditcher, or V-scraper.

The grade of the laterals may vary from 1 to 12 inches, preferably 3 to 5 inches per 100 feet, depending upon the soil; where the slope is excessive, causing the water to cut, checks or drops should be used. It must be kept in mind that the slope should be as small as possible, so that when the water is checked up it may be turned out at several places. The water is made to rise in the lateral by checking it with an earth, metal, or canvas dam, then turning it out over the field by cutting the lower bank in several places, directing the water by the aid of a shovel. When this section is irrigated the dam is moved to a lower point and the work continued.

The canvas dam (see fig. 3) consists of a piece of canvas 6 to 8 feet long and 6 feet wide, tacked to a pole or a 2 by 4-inch scantling, 7 to 9 feet long. When in use the 2 by 4 is placed across the ditch bank, and the canvas is laid against the bottom and sides of the ditch, the free end being loaded with earth to hold it down in position.

The advantages of the flood method of irrigation are: the cheapness of first cost, the ease with which the field may be prepared, and its adaptability to rough land. Its disadvantages are: the hard labour required to handle the water, the small area that one man can irrigate in one day, and the difficulty in spreading the water over the field uniformly. With a large irrigation head one man can irrigate from 10 to 20 acres in a day of twenty-four hours.

FURROW IRRIGATION.

Furrow irrigation is most commonly used in the irrigation of orchards, garden, and root crops. For example: potatoes are planted in rows, and as the water must be applied below the tubers it is necessary to make small ditches between the rows through which the water is applied. The making of these ditches, which is termed "furrowing," is done by running a shovel plough between the rows. The water is supplied at the head of each furrow, and as it passes down through the rows it percolates into the soil. It is often advisable to apply this method to the irrigation of grain and alfalfa, especially on soils that have a tendency to bake, as baking makes the surface of the soil quite hard, increases the evaporation, and injures the crop. With grain, alfalfa, and crops similar to beets, the furrows used are but small, shallow corrugations. This method of irrigation is adapted to land of considerable slope, as the furrows may be run across the slope at an angle and of a grade which will give the desired velocity. With a small water supply this method is advisable, as the water may be confined to but a few furrows and the waste due to evaporation is decreased. Whenever possible, cultivation should follow each irrigation as soon as the ground is dry enough to work.

The field laterals are run very similar to the method used for flood irrigation, but the intervals between them may be increased. When the field is small the furrows may be run across its entire length, and field laterals are not necessary; as a rule, however, the furrows are made too long, permitting the upper portion of the field to become over-saturated while the lower portions may not receive sufficient water. In light soils the percolation may be so rapid that the water may not even reach the lower portion of the furrows. In heavy soil the furrows may vary from six to seven hundred feet long. In light, sandy soil, having a porous subsoil, it may be necessary to reduce the length to even less than 250 feet. The furrows or corrugations may be easily made by the use of the shovel plough for the larger furrows, and the furrowing sled or corrugated roller for the smaller furrows. The corrugated roller not only makes the furrow but also crushes the clods and produces a better seed-bed.

The furrowing sled consists of an open framework of timber placed upon two or more runners of logs or 4 by 6-inch timbers bevelled to almost a V-shape. This will,

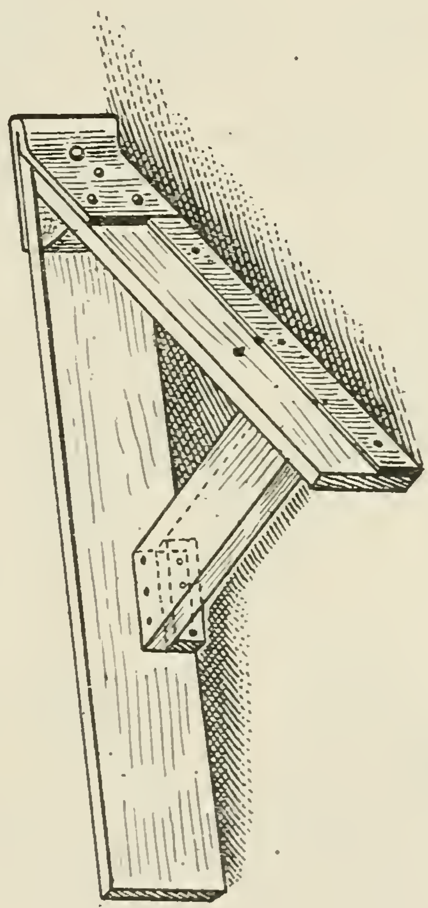


Fig. 2. Y Scraper.

when properly loaded, make furrows about 4 inches deep. The spacing of the furrows may vary from the close ones of the corrugated roller to from 16 to 24 inches for the furrowing sled, depending upon the character of the soil. On the more retentive soils it may be necessary to place them closer than 16 inches, while on the more open soils they may be placed much farther apart.

The water is in some cases diverted directly from the supply lateral to the furrows, by making a small break in the lower bank of the lateral and connecting it to the head of the furrow; it is, however, difficult to control the water under these conditions, as it frequently washes the soil very easily. The better method is to construct a secondary lateral along the side of the supply lateral and then divert the water to the furrows. The features of this method of irrigation are extremely simple; it is difficult, however, to divide the water equally to the furrows, the common practice being to divert all the water by the use of a shovel and dam. This method is crude and requires the constant attention of the irrigator. A more uniform distribution of the water may be obtained by the use of lath boxes placed in the bank of the supply or secondary lateral at the head of each furrow. The water is checked up by either a canvas dam or check gate, so that it will back up to the check above. The lath boxes are then placed in the bank of the lateral at an equal depth below the surface of the water, so that it may be distributed equally to all furrows. The distribution of the water by the use of lath boxes slightly increases the cost of preparation, but reduces materially the labour required for a uniform distribution, and as the irrigator need not be in constant attendance at one place he can attend to water at several places, making it possible for one man to often irrigate more than twice as much land.

The boxes used are most frequently made of lath or other strips of wood, and vary from 12 to 24 inches long.

The preparation of the field for the furrow method of irrigation is more expensive than that for the flood method, but the distribution of the water requires less labour and a more uniform irrigation can be secured. It also requires less attention from the irrigator, and the loss due to evaporation is materially decreased.

BORDER AND CHECK METHODS OF IRRIGATION.

The border and check methods of irrigation are confined to very high-priced land where the returns from the crops raised are large. Both methods require special care in the preparation of the surface of the soil, in addition to which is added a large amount of dyking or ridging.

In the border method of irrigation the land is flooded somewhat similar to the ordinary flooding method: the water, however, is confined between ridges or borders which are run generally in the direction of the steepest slope. Whenever this is so steep that erosion results, the borders are placed at an angle to the slope. These borders form "lands," which are levelled from border to border, so that when the water is turned out of the lateral at the head of the strip it flows down the slope in a uniform sheet extending from one side to the other. When the land is properly prepared the water requires very little attention from the time it is turned on until shut off. The supply lateral is run across the head of the strips. If the strips are excessively long, field ditches are placed at intervals across the "lands;" these supply the lower "lands," and also collect the waste from those above.

In the check method the land is also flooded, but the water is confined within small areas where it is sometimes retained until it is all absorbed by the soil. The field is divided by low ridges or dykes into a series of small plots, which may be either rectangular or irregular. The rectangular checks are used whenever the land is very uniform, and the irregular checks, sometimes called contour checks, for rolling land. The dykes are usually built broad and flat so that they need not interfere with the

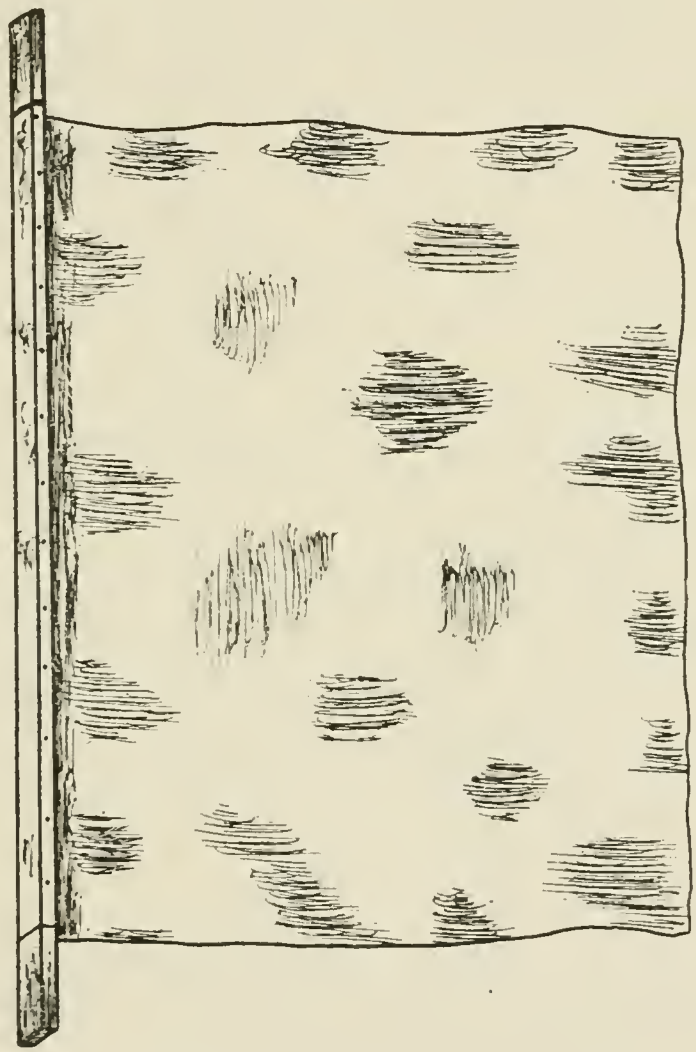


Fig. 3. Canvas Dam.

operation of farm implements. The water may be either admitted directly from a field lateral to each check and retained there until it is all absorbed by the soil, or it may be supplied to an upper check, and when this has received sufficient water the remainder may be drawn off and passed on to the next lower check.

MEASUREMENT OF WATER.

The measurement of the water used to irrigate land is a most important factor in the development of any irrigated country, as upon the economic use of this water will depend the extent of the irrigable area. The value of an irrigated farm is often two, three, or more times that of adjacent non-irrigable land, yet the water that has increased the value of this land is used and wasted in a most extravagant manner. The necessity for the measurement of water is not always apparent, especially in a new district where water may for the time be very plentiful; however, even with an abundant water supply, the use of unnecessary water is wasteful, and it may result in considerable damage not only to the land and crops of the irrigator, but usually to a far greater extent to the land and crops of his neighbour below him. It frequently brings the ground water so close to the surface that the salts in the soil, which are commonly termed alkali, are rapidly deposited at the surface by the increased evaporation, or it may cause the water-logging of the soil. In either case the land may be made useless until it is reclaimed by a drainage system, the cost of which will be a high price to pay for carelessness.

Where water is not abundant, the necessity for its measurement is more apparent, as it is impossible to distribute and satisfy the water users without the use of some kind of a measuring device. The problem of just distribution causes constant friction between the management of canals and the water users, much of which might be eliminated by the use of proper measuring devices.

The success of the irrigation farmer depends largely upon his ability to determine the quantity of water necessary to maintain the proper condition of soil moisture. Applying too little water retards plant growth, while too much may damage both land and crop, and the water thus wasted might have been used to advantage upon other land. The irrigation farmer should be able to say to what depth he applies water to the soil. For the above reasons some of the methods of the measurement and division of water adapted to the distribution of irrigation water are here described.

UNITS OF MEASUREMENT.

There are several units for the measurement of water in general use; however only those used in connection with water for irrigation will be discussed here, viz., the cubic foot per second, or second-foot, the acre-foot, and acre-inch.

The cubic foot per second has come into general use as the unit of measurement of flowing water, and is the legal unit in Western Canada. It may be defined as a cubic foot of water flowing at a rate of 1 foot per second.

The discharge of a stream or canal may be determined by measuring the mean velocity or mean rate of flow per second and multiplying it by the area in square feet of the water cross-section. The result obtained will be the discharge in cubic feet per second. From the engineer's viewpoint there is no other unit which adjusts itself so readily to his purpose.

The acre-foot, however, is the best unit of measurement for water at rest, when that water is used to cover land for irrigation, as it expresses a quantity of water and its relation to an acre of land. One acre-foot is the quantity of water required to cover 1 acre of land to a depth of 1 foot, or, as there are 43,560 square feet in one acre, an acre-foot of water will be equal to 43,560 cubic feet of water. The acre-inch is another convenient term and is equal to a quantity of water to a depth of 1 inch over an area of 1 acre.

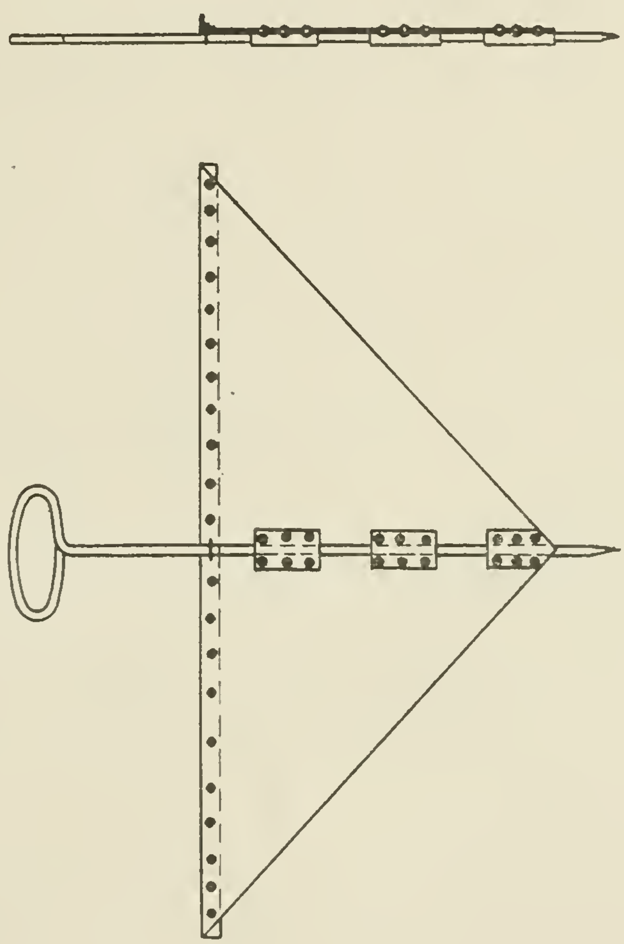


Fig. 4 Galvanized Iron Dam.

The measurement of water expressed by one of the above units may be readily converted into the other when it is remembered that there are 43,200 seconds in twelve hours, so water flowing at the rate of 1 cubic foot per second is equal to 43,200 cubic feet, or approximately 1 acre-foot (43,560 cubic feet), in which case the error is less than 1 per cent. One cubic foot per second flowing for one day of twenty-four hours is approximately equal to 2 acre-feet, or 24 acre-inches. To convert second feet, flowing for one day, into acre-feet, multiply the discharge in second-feet by two, and to convert acre-feet to second-feet divide by two. If it is desired to obtain a more accurate conversion use the number 1·983 instead of 2.

A second-foot flowing for one hour is equal to approximately 1 acre-inch.

DIVISORS.

It is often necessary to divide the water flowing in a lateral between two or more consumers. For this purpose the division box, or divisor, is often used. As the rate of flow is not constant throughout the cross-section of a stream, an accurate division is seldom possible, but the convenience of this method often counter-balances any inaccuracy that may exist. No unit of measurement is used, as the purpose is but to divide the water in proportion to the rights of the water users. In its most common form the divisor consists of a partition board set lengthwise in a flume so as to divide the channel into two, making their widths proportional to the respective claims of the users. For the best results the flume should be placed in a portion of the lateral where the channel above the divisor has a straight, uniform course or has been widened sufficiently to secure a uniform velocity of approach. It is also necessary that the channels of the divisor be in identically the same relation to the main channel. One branch should not have a straight course directly below the point of division, while the other has an abrupt turn. It is preferable to have a short, straight course, with an abrupt turn for each branch.

If the water is to be divided into two equal parts the division is not difficult, as the partition may be placed along the centre line of the flume. Whenever the water is to be divided into unequal parts the difficulty increases because the velocity of the stream increases from a minimum at the sides to a maximum at the centre, so that when a partition is set at a distance from the side in proportion to the claim of a water user, the actual division of the water is to the disadvantage of the smaller user, as he takes the water from the side of the flume, the mean velocity of which is less than the mean velocity of the other channel.

By making the velocity of the water uniform, this difficulty may be overcome. It may be accomplished by widening the channel above the box enough so as to form a pool which will bring the water approximately to rest, or accuracy may be obtained by the use of weir boards or by adjusting the division board. The last method is very convenient when it is necessary to vary the division of water from day to day.

When it is desired to make more than two divisions the difficulties increase. However, the most satisfactory method is to use more divisors.

The divisor is adapted to the division of water when the users, under a small lateral, use some definite proportion of the water in the lateral. In the distribution of the water by the canal rider, it is only necessary for him to turn into the lateral the total amount of water required by the users, the division boxes making the necessary further divisions.

DIVISION BY TIME.

Whenever the water is low and the available supply to the individual user is too small for him to use to advantage, it is customary for two or more users to combine their supply and to divide it upon the basis of time, each user using the water for a period proportional to the quantity of water that he is entitled to. This practice, founded on necessity, has grown, and the principle is now used in many irrigation districts where the water is supplied in rotation not only to the individual farmer but to the distributing laterals. The method admits of the use of large irrigation heads, and is a big factor in the economical use of water.

WEIRS.

The most popular device used in the measurement of water in small, open channels, and especially of water flowing in the field supply laterals of an irrigation system, is the sharp-crested weir with complete end contractions. It is a measuring device that can be easily constructed, and when properly located will give accurate results. The weir proper consists of a notch cut out of a board and bevelled on the downstream side, and set so that the water passing through falls free upon the lower side, permitting air to freely circulate underneath the falling water. To secure the most accurate measurements, weir plates are used to form the edges of the sides and crest so that the water passes over a knife edge.

This weir board may be placed across the channel or set in a short flume or weir box. Whichever method is used, care must be taken to see that all the water passes over the weir and that no water is permitted to leak underneath or around its sides Wherever the weir board is placed, further care must be taken to see that the area directly above it is such that the depth below the weir crest, and also the distance from the sides of the weir to the waters' edge, be at least twice the depth of the water flowing over the weir. If the weir is placed below the upstream end of the flume the flume must of such dimensions that the above requirements are satisfied. The expense may be somewhat reduced by the use of a short flume, and by placing the weir board at the upstream end, then widening the channel directly above the weir to the necessary requirements. The discharge of water over a weir may be very readily determined when the length of the crest and depth of the water flowing through the weir is known. The depth is measured from a reference point which is set level with the weir crest. It must be far enough upstream from the weir crest so that the water surface is not affected by the curvature of the water flowing over the weir. This point should be from 3 to 6 feet, preferably 6 feet, upstream. Whenever the weir board is placed at the upstream end of the weir box, a stake may be driven into the ditch and a nail driven into the top of this stake, to be used as the reference point. The depth of the water is then obtained by determining the depth of the water over the reference point by the use of a rule and reading to the nearest one-eighth of an inch, or, if an engineer's rod is used, a hundredth of a foot. When the depth is known, the discharge in cubic feet per second, or acre-feet per day, may be obtained by reference to weir tables or by computation from weir formulæ.

KIND OF WEIRS.

The Cippoletti or trapezoidal weir is probably used more than any other type. This is no doubt partly due to the simplicity of its formula, in which the discharge varies directly as the length of the weir crest, for example: if one weir is twice as long as another, the discharge, if the head is the same, will be twice as great. Recent experiments conducted by Mr. W. S. Steward and Mr. J. S. Longwell, of the United States Reclamation Service at Boise, Idaho, show that when compared with the rectangular weir the Cippoletti weir gives the more accurate results. This weir consists of a board having a trapezoidal opening: the crest, or lower edge, is set horizontal, and the side slopes incline from the vertical, 1 inch horizontal to every 4 inches vertical. (*See fig. 5.*)

The rectangular weir has a horizontal crest with vertical sides, for which reason it is considered more easily constructed. The triangular or V weir is not as common as either the Cippoletti or rectangular weir; however, it has an advantage in that a very small volume of water can be accurately measured by its use and that the shape of the weir tends to reduce the velocity of approach, a factor which is difficult to control in either of the above weirs. Its usual construction is a right-angled notch with the corner downward. (*See Rectangular Weir, fig. 6.*)

To obtain accurate results the following conditions must be observed for both the Cippoletti and the rectangular weirs, most of which are also applicable to the triangular weir:—

(1) The upstream edge of the notch should be sharp, forming what is commonly termed a knife edge, and the downstream side should have a bevel of about 30 degrees with the vertical.

(2) The water must fall free from the downstream side of the weir board and sides of the weir box, so that air may freely circulate underneath the falling water, and the water on the lower side of the weir must not rise to the height of the weir crest.

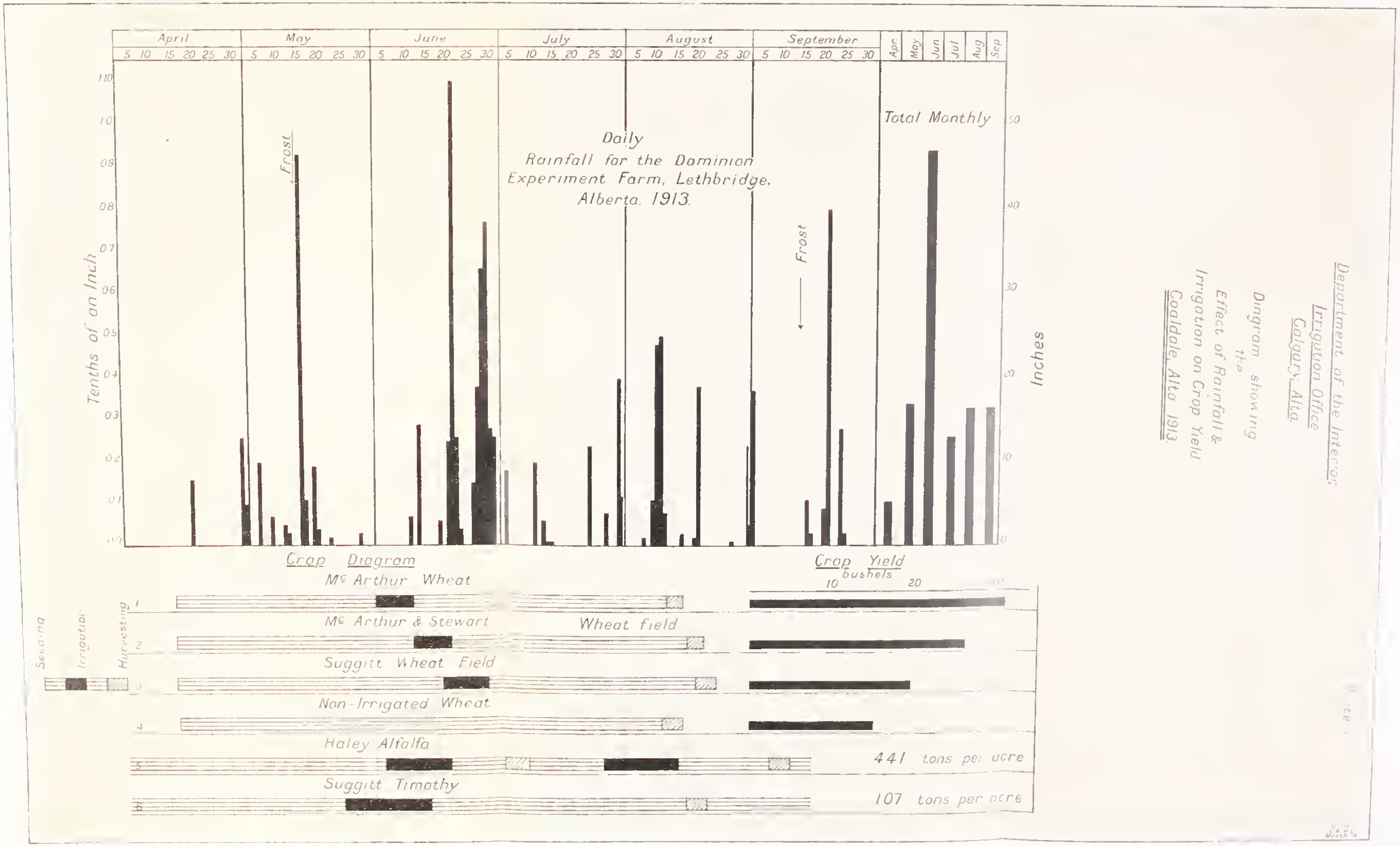
(3) The depth of water flowing over the weir should be less than one-third the length of the crest. With a 3-foot weir the depth of the water flowing over should be less than 1 foot.

(4) The channel for some distance above the weir should be uniform, with its centre line perpendicular to the weir board and passing through its centre. The cross-section of the channel should be enlarged to such a size that the velocity of approach may be reduced to a minimum, producing a condition similar to that of a pond or reservoir. Baffle boards are sometimes used to aid in settling the water; however, in field practice it is usually better to control the water by some other means.

(5) The depth of water below the crest and the distance from the side of the weir to the water's edge should be at least twice the greatest depth of the water over the weir. In other words, the area of the cross-section directly above the weir should be at least seven times the area of the water flowing over the weir. The depth of the water below the crest should not be less than 1 foot.

(6) The depth of the water should be measured far enough upstream so that it is not affected by the curvature of the water flowing over the weir. This may be measured from a nail head driven in the top of a stake and set level with the crest of the weir, so that the depth of the water above the nail head is the depth required. For convenience the stake should be set to the side of the channel. For very accurate results a hook-gauge is usually used for reading the depth.

(7) The weir crest must be set horizontal, and the sides for the Cippoletti must incline outward at a slope of one horizontal to four vertical. In the rectangular weir the sides must be vertical.


Department of the Interior,
Irrigation Office
Calgary, Alta.
Diagram showing the Effect of Rainfall & Irrigation on Crop Yield
Coaldale, Alta. 1913.
Daily
Rainfall for the Dominion Experiment Farm, Lethbridge, Alberta. 1913.
Total Monthly
April
May
June
July
August
September
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May
Jun
Jul
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Sep
Tenths of an Inch
Inches
Frost
Frost
Crop Diagram
Crop Yield
bushels
10
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Seeding
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Mc Arthur & Stewart Wheat field
Suggitt Wheat Field
Non-Irrigated Wheat
Haley Alfalfa
441 tons per acre
Suggitt Timothy
107 tons per acre

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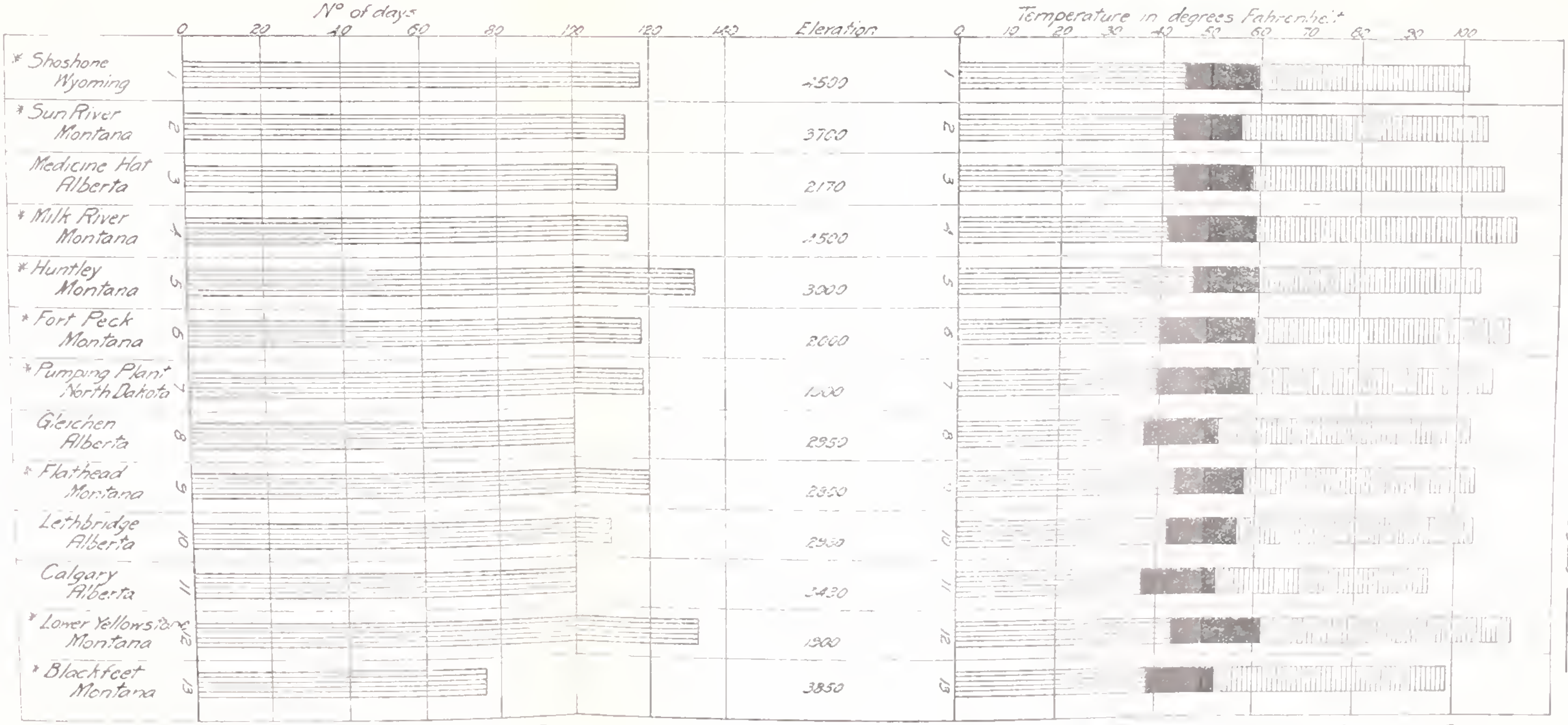

Diagram showing the average Period in days between the last Spring and the first Fall Frost.

* Irrigation Projects of the United States Reclamation Service, Northern Division

Temperature Diagram Showing the Maximum, Average Yearly, and Average for April to September inclusive

Maximum

Average, April to September inclusive

Average Yearly.

Department of the Interior, Irrigation Office, Calgary, Alberta

Plate 2

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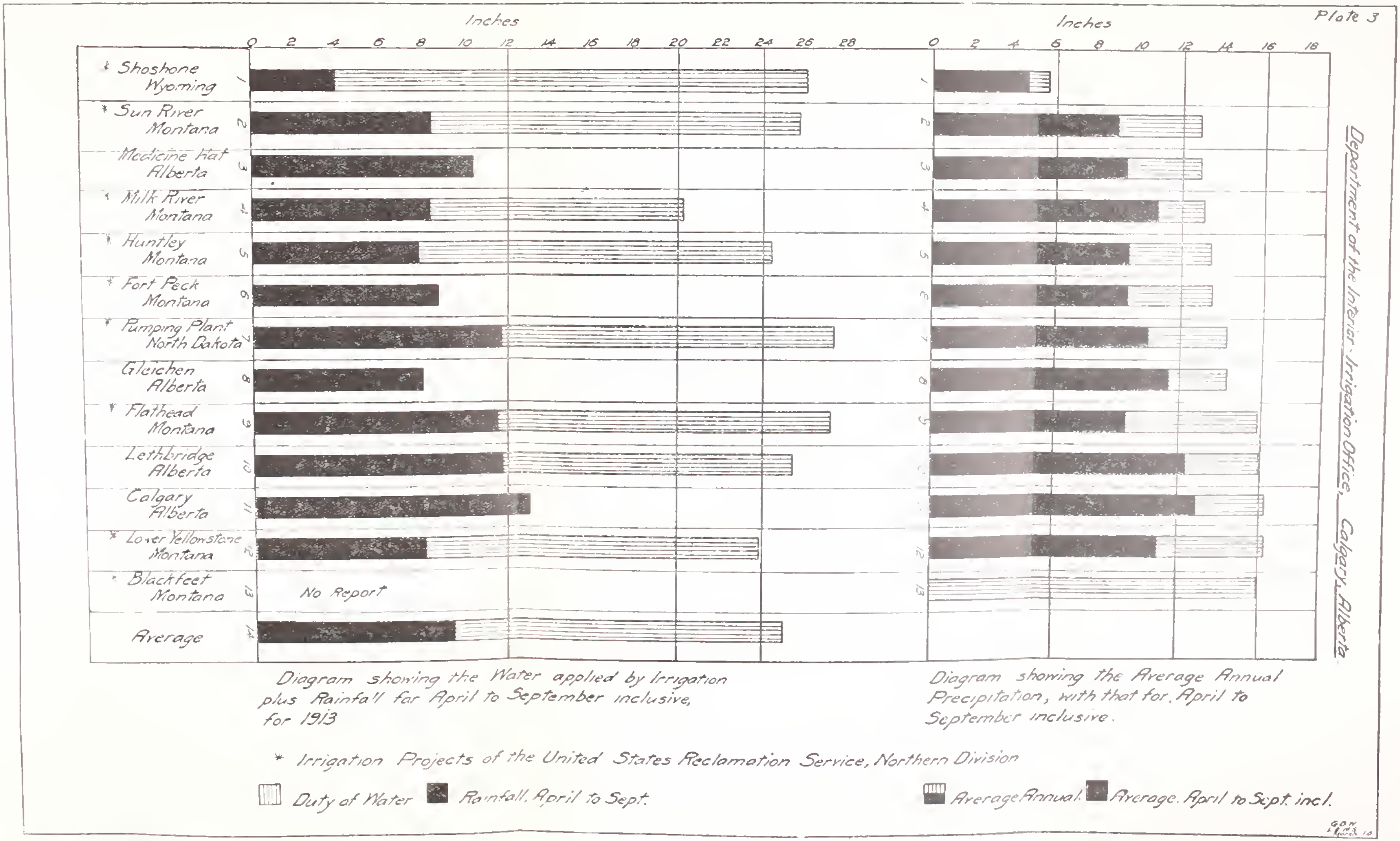

Plate 3
Department of the Interior · Irrigation Office, Calgary, Alberta.
Inches
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Inches
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* Shoshone Wyoming 1
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Medicine Hat Alberta 3
* Milk River Montana 4
* Huntley Montana 5
* Fort Peck Montana 6
* Pumping Plant North Dakota 7
Gleichen Alberta 8
* Flathead Montana 9
Lethbridge Alberta 10
Calgary Alberta 11
* Lower Yellowstone Montana 12
* Blackfeet Montana 13
No Report
Average 14
Diagram showing the Water applied by Irrigation plus Rainfall for April to September inclusive, for 1913
Diagram showing the Average Annual Precipitation, with that for April to September inclusive.
* Irrigation Projects of the United States Reclamation Service, Northern Division
Duty of Water
Rainfall, April to Sept.
Average Annual.
Average. April to Sept. incl.

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Department of the Interior. Irrigation Office,
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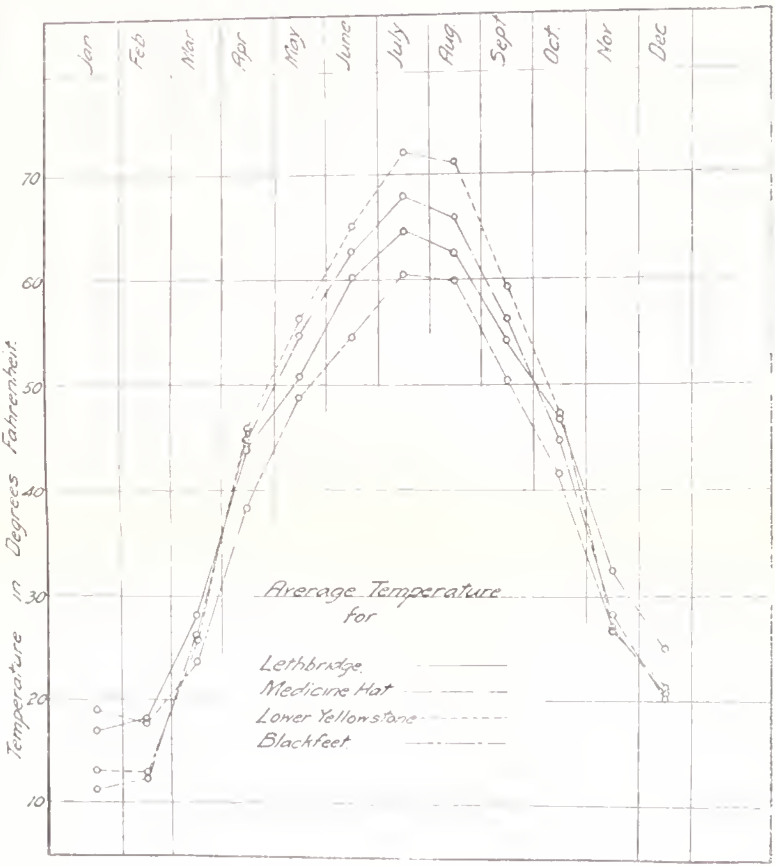

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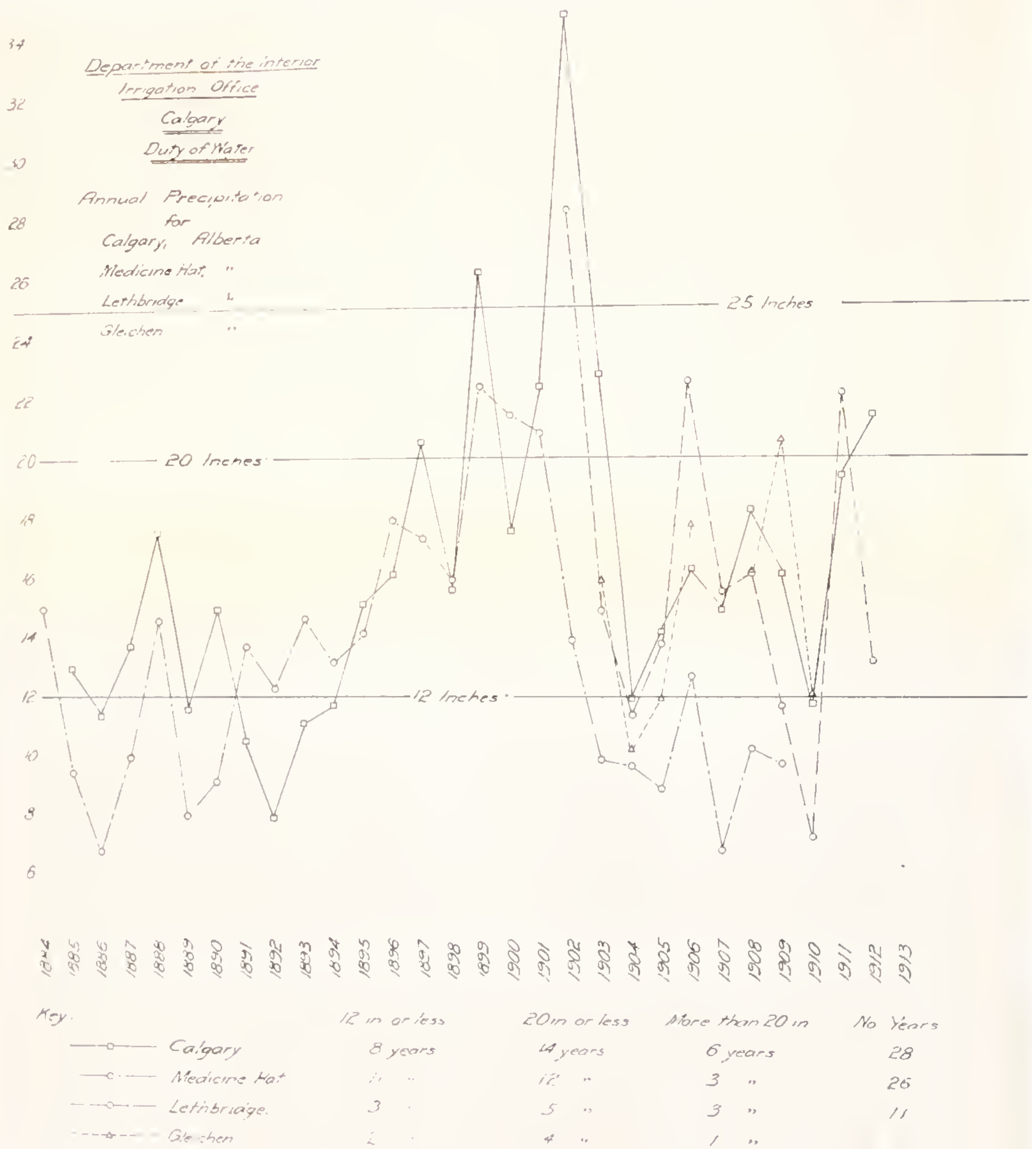

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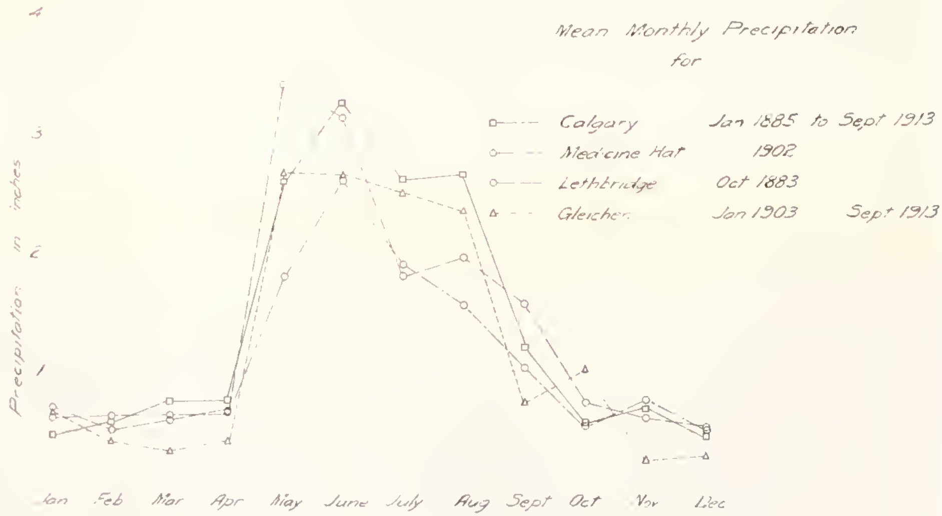
Department of the Interior Irrigation Office Calgary



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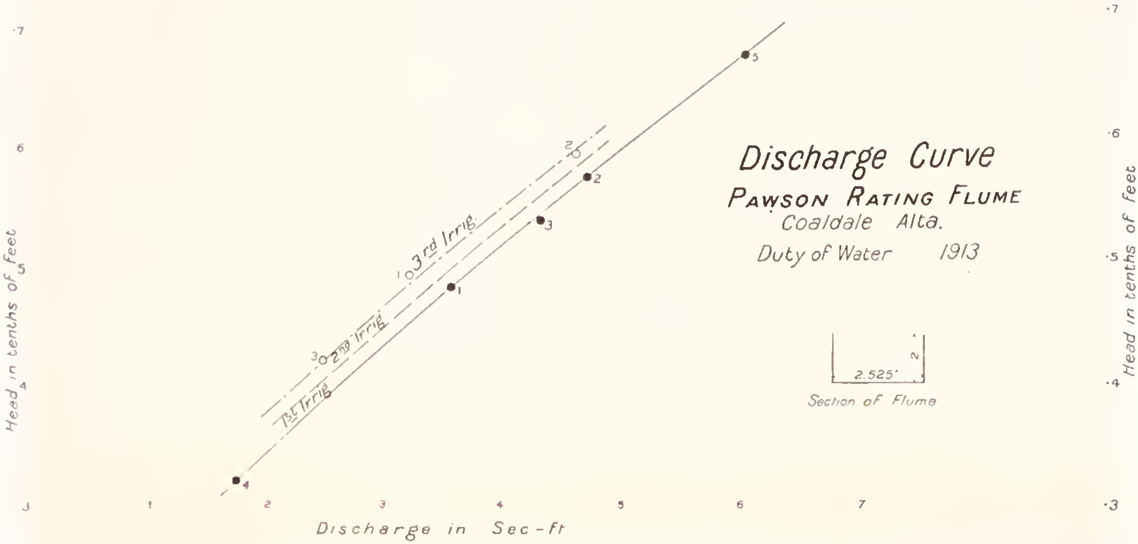


Rating Tables

1st Irrigation

Gauge Height	Discharge	Gauge Height	Discharge
32	1.73	52	4.10
.33	1.84	53	4.23
.34	1.95	54	4.36
.35	2.06	55	4.49
36	2.17	56	4.62
37	2.28	.57	4.75
.38	2.40	.58	4.88
39	2.52	.59	5.01
40	2.64	60	5.14
41	2.76	61	5.27
42	2.88	62	5.40
43	3.00	63	5.53
44	3.12	64	5.66
45	3.24	65	5.79
46	3.36	66	5.92
47	3.48	67	6.05
48	3.60	68	8.18
.49	3.72	.69	6.31
50	3.84	.70	6.44
51	3.97		

3rd Irrigation

Gauge Height	Discharge
.32	1.47
33	1.56
34	1.65
.35	1.74
.36	1.84
.37	1.94
.38	2.04
.39	2.15
40	2.26
.41	2.37
.42	2.49
43	2.60
.44	2.72
.45	2.84
.46	2.95
47	3.07
48	3.19
49	3.31
.50	3.43
.51	3.56
.52	3.68
.53	3.81
.54	3.94
.55	4.07
.56	4.20
.57	4.33
.58	4.46
.59	4.59
.60	4.73

Discharge Table 1st Irrigation

Date	Head	Discharge
June 10	48	3.60
12	57	4.73
12	535	4.35
12	32	1.73
12	67	6.03

Discharge Table 3rd Irrigation

Date	Head	Discharge
Sept. 19	.49	3.25
19	59	4.64
19	42	2.49

G.D.W.
J.C.
Nov 1913

TABLE No. 1.—Discharge in cubic feet per second, and in acre-feet per day over Cippoletti weirs of various lengths and with the depths given in inches and in feet. Discharge = $3{\cdot}3\frac{3}{8}\ L.H.^{3/2}$

Head.		1 foot.		1½ foot.		2 feet.		3 feet.		4 feet.		5 feet.	
Inches.	Feet.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.
½	·042	·029	·058	·044	·087	·058	·115	·087	·173	·117	·232	·146	·289
¾	·062	·052	·103	·078	·155	·104	·206	156	·309	·208	413	·260	·516
1	·083	·080	·158	·121	·240	·161	·319	·241	·478	·322	·638	·402	·787
1¼	·104	·113	·224	·170	·335	·226	·448	·339	·672	·452	·897	·564	1·118
1½	·125	·148	·293	·223	·442	·297	·589	·446	·885	·595	1·180	·743	1·474
1¾	·146	·188	·372	·282	·559	·376	·746	·562	1·122	·751	1·489	·939	1·862
2	·167	·230	·456	·345	·685	·460	·912	·689	1·366	·918	1·823	1·149	2·279
2¼	·187	·272	·539	·408	·809	·544	1·079	·817	1·620	1·089	2·160	1·862	2·701
2½	·208	·319	·633	·479	·950	·639	1·267	·958	1·900	1·277	2·533	1·597	3·168
2¾	·229	·369	·732	·554	1·097	·738	1·464	1·107	2·196	1·475	2·926	1·844	3·657
3	·250	·421	·835	·631	1·252	·842	1·670	1·263	2·505	1·684	3·340	2·105	4·175
3¼	·271	·475	·942	·712	1·412	·950	1·884	1·425	2·826	1·900	3·768	2·375	4·711
3½	·292	·531	1·053	·797	1·581	1·063	2·108	1·594	3·160	2·126	4·217	2·656	5·268
3¾	·312	·587	1·164	·880	1·745	1·174	2·329	1·761	3·493	2·347	4·655	2·934	5·819
4	·333	·647	1·283	·970	1·924	1·294	2·567	1·941	3·850	2·588	5·133	3·235	6·416
4¼	·354	·709	1·406	1·064	2·110	1·418	2·812	2·127	4·219	2·836	5·625	3·546	7·033
4½	·375	·773	1·533	1·160	2·300	1·546	3·067	2·320	4·602	3·093	6·134	3·866	7·668
4¾	·396	·839	1·664	1·258	2·495	1·680	3·332	2·519	4·996	3·359	6·662	4·199	8·328
5	·417	·906	1·797	1·360	2·698	1·813	3·596	2·720	5·395	3·626	7·192	4·533	8·992
5¼	·437	·973	1·930	1·459	2·894	1·945	3·858	2·918	5·788	3·891	7·717	4·864	9·645
5½	·458	1·044	2·070	1·566	3·105	2·088	4·141	3·132	6·212	4·176	8·283	5·220	10·35
5¾	·479	1·116	2·213	1·674	3·320	2·232	4·426	3·348	6·638	4·464	8·854	5·580	11·07
6	·500	1·190	2·360	1·765	3·540	2·380	4·720	3·570	7·081	4·760	9·441	5·950	11·80
6½	·54	...	...	2·016	3·999	2·688	5·331	4·032	7·997	5·376	10·66	6·720	13·32
7	·583	....	.....	2·248	4·459	2·988	5·946	4·497	8·919	5·976	11·89	7·495	14·83
8	·667	......	....	2·751	5·457	3·668	7·276	5·502	10·91	7·336	14·55	9·170	18·19
9	·750	......	....	3·280	6·505	4·374	8·675	6·561	13·01	8·746	17·35	10·93	21·68
10	·833	......	....	3·839	7·614	5·120	10·15	7·680	15·23	10·24	20·31	12·80	25·39
12	1·00	.....	......	5·05	10·02	6·734	13·36	10·10	20·03	13·47	26·72	16·84	33·40

The above table is computed for Cippoletti, or trapezoidal, weirs of several widths. The discharge is given in cubic feet per second of flow, and in acre-feet per day of twenty-four hours. The depths are given in inches and fractions of an inch with their equivalents in decimals of a foot. An acre-foot of water is equal to water to the depth of 1 foot over 1 acre of land. The depth in acre-inches per day may be found by multiplying the depth in acre-feet by twelve. Since the discharge varies directly as the length of the weir crest, the discharge for larger weirs than those contained in the table may be found by multiplying the discharge of a 1-foot weir by its length. For conditions outside the limits of the table the discharge may be computed by the use of the above given formula.

TABLE NO. 2.—Discharge in cubic feet per second, and in acre-feet per day over Rectangular weirs of various lengths and with the depths given in inches and in feet. Discharge = 3·33 (L-2 H) H ½.

Head.		1 foot.		1½ foot.		2 feet.		3 feet.		4 feet.		5 feet.	
Inches.	Feet.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.	sec-ft.	acre-ft.
½	·042	·028	·056	·042	·084	·056	·112	·085	·167	·113	·224	·141	·280
¾	·082	·051	·101	·977	·153	·103	·204	·155	·308	·207	·411	·260	·517
1	·083	·079	·157	·119	·236	·159	·315	·239	·474	·319	·633	·399	·791
1¼	·104	·110	·218	·156	·329	·222	·450	·334	·663	·445	·883	·557	1·104
1½	·125	·144	·286	·217	·430	·291	·577	·438	·86	·585	1·160	·732	1·453
1¾	·146	·180	·357	·273	·542	·365	·725	·551	1·093	·736	1·490	·922	1·829
2	·167	·219	·434	·332	·658	·446	·887	·672	1·333	·899	1·783	·125	2·231
2¼	·187	·260	·515	·395	·783	·531	1·053	·801	1·588	1·071	5·124	1·342	2·662
2½	·208	·303	·601	·465	·916	·620	1·230	·937	1·858	1·253	2·485	1·570	3·114
2¾	·229	·349	·692	·531	1·053	·714	1 416	1·079	2 140	1·444	2·864	1·810	3·590
3	250	·395	·782	·604	1·198	812	1·610	1·228	2·436	1·644	3·261	2 060	4·086
3¼	·271	·444	·881	·679	1·347	·913	1·811	1·383	2·743	1·852	3·673	2·321	4·603
3½	·292	·494	·980	·756	1·500	1·018	2·019	1·543	3 060	2·007	4·101	2 592	5·141
3¾	·312	·545	1·081	·836	1·658	1·127	2·235	1·709	3·390	2·291	4·544	2 872	5 696
4	·333	·598	1·183	·919	1 823	1·239	2·451	1·880	3·739	2 621	5·000	3 172	6·272
4¼	·354	·652	1·293	1·003	1 989	1·354	2·685	2·056	4·078	2 758	5·469	3·460	6·862
4½	·375	·707	1·402	1 090	2·162	1·475	2·926	2·237	4·437	3·001	5·952	3·766	7·469
4¾	·396	·764	1·515	1·178	2·336	1·593	3 160	2·422	4·804	3·252	6·450	4·081	8·094
5	·417	·821	1·628	1·269	2·517	1·717	3·305	2 612	5·181	3·508	6 958	4·404	8 735
5¼	·437	·879	1·743	1 361	2·701	1·843	3·655	2·806	5·566	5·770	7 478	4 733	9 385
5½	·458	·938	1·860	1·455	2·886	1·971	3 909	3·005	5·960	4·033	8·009	5·071	10·06
5¾	·479	·998	1·079	1·555	3·084	2·103	4·171	3·207	6·361	4 312	8·588	5·416	10·74
6	500	1·060	2·102	1·649	3·271	2·237	4·437	3·415	6·773	4·592	9·108	5·769	11·44
6½	·542	......	.....	1·849	3·655	2·511	4 980	3·839	7·614	5·166	10·25	6 494	12·88
7	·583	......	....	2·056	4·078	2·795	5 543	4 278	8 485	5·762	11·43	7 245	14·37
8	·667	.....	..	2·477	4·913	3·384	6·712	5·196	10 31	7·009	13·90	8·821	17·50
9	·750	....	....	2·919	5·790	4·001	7·935	6·164	12·24	8·327	16·52	10·49	20·81
10	·833	....	......	.....	....	4·644	9·211	7 177	14·24	9·711	18·26	12·25	24·28
12	1·00	...	.....	.....	......	......	......	9·324	18·50	12·65	25·08	15·98	31·69

The above table is computed for rectangular weirs of several widths, giving the discharge in cubic feet per second and acre-feet per day. The discharge for this weir does not vary as the length of the weir crest, so that for larger weirs the discharge must be computed from the formula given, or interpreted from other tables which can usually be easily secured.

RATING FLUMES.

Whenever the sediment carried by the water is so great that the deposit at the weir interferes with accurate measurement by the use of a weir, or if the fall is not sufficient to secure the necessary free fall at the downstream side of the weir, the measurements may be made by the use of the rating flume. The chief objection to the use of the flume is the necessity for using a current-meter, which requires the service of an engineer and the time which is then required in preparing a rating table.

The flume for even the smaller laterals should be at least 10 feet long, while in the ordinary supply lateral to a farm it should be from 12 to 16 feet. Its width should be somewhat greater than that of the bottom of the lateral. The channel of the ditch should be straight and of uniform grade and cross-section for some distance above the flume, so that the water may pass through it at a uniform velocity.

Measurements are made with the current-meter to determine the quantity of water flowing through the flume. This flow, termed the discharge, is found for several depths and the results plotted on co-ordinate paper. The points usually form a well-defined curve, and from the drawn curve the discharge may be found for any of the intermediate depths. A rating table is then prepared, giving the discharge for the various probable depths. The depth of the water is usually read from a graduated scale nailed to the inside of the flume, or better in a stilling box placed outside of the flume and connected so that the water may pass freely from the flume to the box.

Should the water in the flume surge, making it impossible to make accurate measurements, baffle boards may be placed at the downstream end of the flume, and the discharge determined from the enlarged water area. The mean depth of the water read before the baffle boards are set in the flume and after they are taken out should be used with the discharge in plotting the discharge curve. (*See fig. 7.*)

A simple method of determining the approximate discharge of a stream is by the use of a chip float thrown into the centre of the stream and noting the time it requires to travel a given distance, expressed in feet. The quotient found by dividing the distance travelled by the time will give the surface velocity in feet per second. This velocity multiplied by 0·7 will give the approximate mean velocity per second for the portion of the stream tested.

The area of cross-section in square feet may be found by multiplying the average depth by the width in feet. The product of the mean velocity and this area will give the discharge in cubic feet per second.

In determining the discharge of a stream by the float method care must be taken to see that the portion of the stream used is straight, that the current is uniform throughout the whole section and that the banks are free from rubbish or weeds. This method should be used only in a case of necessity, as the results cannot be depended upon.

DUTY OF WATER AT THE FIELD.

Wherever irrigation is practiced there inevitably arises the question: what is the duty of the water, or how much water is required to irrigate a given area of land?

Without a knowledge of this question and the conditions which affect it, it is not possible to utilize to the best advantage the water supply available for irrigation, and this water supply in an arid or semi-arid district is usually not sufficient to properly irrigate all the available land.

Until more is known concerning the water requirement of crops under irrigation, and the seepage losses of water in carriage through the supply canals, it will not be possible to intelligently estimate the area that may be properly irrigated by a given supply of water.

The irrigation farmer at the very beginning of his experience with the application of water to the soil is confronted with the problem of the proper distribution of the water to his crop. He should know how much soil moisture is necessary to the best plant growth, and the degree of his success will depend upon his ability to judge the proper time to apply the necessary water. The application of water regardless of the requirements of the crops is no doubt the cause of many failures which are attributed to irrigation. The failure to apply sufficient water at the proper time results in a decreased yield, while the application of too much water is a waste of both water and labour. Every irrigator should have a working knowledge of the effect of water on different crops and an understanding of the conditions which affect the duty of water.

The duty of water may be defined as a ratio between the quantity of water and the area of land that it will serve. It may be expressed either as the number of acres irrigated by a given quantity of water flowing for a certain number of days (as a cubic foot per second for 150 days to 150 acres), or in terms of the depth of water applied, as in acre-feet or acre-inches, an acre-foot being equivalent to water applied to 1 acre to a depth of 1 foot, and an acre-inch being one-twelfth of this. The acre-foot and the acre-inch are the most convenient units of measurement when used in connection with the application of water for irrigation, as they are expressions that may readily be understood. If the irrigator wants to apply a 6-inch irrigation or 0·5 acre-feet to 30 acres, the total water required is 15 acre-feet.

CONDITIONS WHICH AFFECT THE DUTY OF WATER.

Climatic Conditions.—The climatic conditions, which include precipitation and its distribution, temperature, wind movement, and the humidity of the atmosphere, all have a marked effect upon the quantity of water that must be applied to land by irrigation. When considering the rainfall and its distribution it will be found that the quantity of water that must be applied by irrigation may vary from nothing in the more humid areas where the rainfall is large and well distributed, to a maximum required in the arid belt where there is practically no rainfall.

Kind of Crops.—The quantity of water and the frequency with which it should be applied depends upon the kind of crop grown. Some of the garden crops can often utilize a continuous flow of water; alfalfa will require about twice as much as the grains, and when alfalfa and other forage crops are raised for seed the quantity of water applied must be reduced. When grains are grown for green feed they can utilize more water than when raised for grain.

Soil and Subsoil.—The character of the soil and subsoil is an important factor in determining the duty of water. As water is supplied to the soil it moves downward, saturating first the upper portions of the soil, then the free water is drawn down by gravity and a portion of it is retained by capillary action. Capillary water moves about in the soil, passing from a wet area to a dry area in the same manner that oil is drawn up to the dry portion of a wick. The water thus retained is the principal source of supply of soil moisture available for plant growth. Since the soil is capable of holding but a limited quantity of capillary water, that applied in excess of this percolates deeper and deeper into the soil until it reaches the ground water or passes off in some drainage channel.

The quantity of water lost by percolation depends largely upon the texture of the soil and subsoil. A porous soil retains less water than a close or heavy soil, and the loss due to deep percolation is greater for sandy than for loamy soils, and least for heavy clay soils.

The loss due to percolation in porous soil is difficult to control, but it may be somewhat reduced by the use of large irrigation heads and by passing the water over the soil as quickly as possible, or by locating the distributing system so that it is not necessary to force the water over long distances.

With close, clay soils the water is absorbed slowly and it is often necessary to to retain it for a time on the soil to secure a proper irrigation.

Years land has been irrigated.—It has been the experience of all irrigators that the land requires considerable water during the first years that it is irrigated, and only requires about one-half as much after the land has been watered several years. This is due to a great extent to the rise of the ground water and the decrease of loss due to deep percolation. If the ground water rises to a depth from which it may be drawn by capillarity to the roots of the plants, the water that need be applied by irrigation is practically that needed by the crop and evaporation and any loss of the ground water due to lateral or deep percolation. If the water rises to such a height that it interferes with plant growth it may be necessary to lower it by a drainage system.

Preparation of the land and method of irrigation.—The duty of water also depends upon the preparation of the land and the method used in the distribution of water. If the field laterals are properly distributed and the land levelled, it is not only easier to control the water, but a more uniform wetting may be secured.

If the land is poorly prepared and uneven, the water first fills up the lower places, which must be over-irrigated that the water may be raised to the higher spots, resulting in the application of more water than the land actually needs. Whenever the distance between the field laterals is too great, the land under and adjacent to the lateral must be over-irrigated, in order that the water may be given sufficient time to reach to the next lateral below. The flood method of irrigation requires more water than the furrow method, because in the latter water is confined to the furrow, from which it percolates into the soil. With the flood method the land is flooded, and if it were possible to irrigate as uniformly as with furrows, the losses from evaporation would still be greater, due to the greater exposed water surface.

Skill of the irrigator.—To all these conditions, which affect the duty of water, must be added the skill of the irrigator in the distribution of the water, and in his ability to judge the time of applying the proper quantity to the soil. The waste due to careless application of water to the soil should not be tolerated. Too often the irrigator is inclined to the belief that water does not need very much attention, and it is permitted to run for hours in one place. Under such conditions a uniform irrigation is impossible, as some portions of the land are bound to receive more water than others, and this unnecessary water is wasted. Unattended water may often cause considerable damage by soil erosion or by flowing out into the adjoining roads or field.

The application of water, at a time when the crop needs it, will make crop, but if water is applied at times when the crop cannot utilize more than there is in the soil, in the belief that the more water used the better will be the crop, it may be detrimental to the best crop production

DUTY OF WATER INVESTIGATIONS.

Investigations to determine the proper duty of water were commenced in 1913 in the irrigated district near Coaldale, east of Lethbridge, Alta. It was decided that the results secured should be applicable to ordinary field conditons, and the work for the first year be confined to the measurement of water actually being applied by the irrigation farmer to his various crops. It was apparent also that the tracts should be as large as possible in order to eliminate any errors that would inadvertently creep in. Care was taken to secure tracts of land which would not be interfered with by any flow from adjacent fields, and to secure land upon which the water supplied to and wasted from the field might be readily and accurately measured. It is obvious that to determine the proper duty of water, it is necessary to apply varying qualities of water to the same crop and to compare the results in crop yild; however, under the prevailing conditions it was not possible to apply this phase of the question to the work of 1913.

The measurements of water were made over standard Cippoletti weirs or carefully gauged rating flumes, continuous records being kept of the depth of water by the use of Simplex water stage registers.

The Cippoletti weirs (*fig. 5*) were made of 2-inch plank, and consisted of a box 3 feet long, with the weir board placed at the upstream end. The weir plates used were strips of 18-gauge galvanized iron, 4 inches wide, nailed to the weir board. To reduce the velocity of approach to a minimum, the cress-section of the channel directly above the weir was deepened and widened to an area at least seven times the area of the maximum discharge measured in the plane of the weir.

The waste water in each case was collected by a waste ditch and measured over a 1-foot Cippoletti weir, and this amount was deducted from the amount supplied to the land.

Measurements of the water flowing through the rating flumes were made by a small Price current-meter. These were then plotted and, from the curve produced, rating tables were derived.

Simplex water stage registers, manufactured by the W. and L. E. Gurley Company, Troy, N. Y., were used to record the depth of water. This register consists of a clock, recording drum, and float. (*Fig. No. 8.*)

Two screws parallel to each other, about 2 inches apart, and geared to the clock, are so placed that a pencil set in a carriage is moved across the recording drum.

This drum is of a width sufficient to receive the record made in a period of forty-eight hours. The recording paper, instead of being in one continuous strip, is of four smaller strips, the ends of which are passed through slots in the drum and are drawn and held taut by clips and springs arranged in the interior of the drum; thus the paper presents a smooth surface to receive the records. The float and counterweight are suspended from a sprocket wheel by a perforated bronze band, and this wheel is connected by gears with the drum. Two sets of gears are supplied so that either a natural or a quarter scale may be used. As the float actuates the drum, the range of depth that can be recorded is only limited by the length of the suspending band. With weirs, a stilling box for the float was placed at the side of the channel of approach at a distance of 3½ feet upstream from the weir crest.

The measurements of water applied to various crops were made by co-operating with water users on representative farms under the Canadian Pacific Railway Company's canal system near Coaldale.

In these measurements no attempt was made to control or vary the quantity of water applied to the land. The work was commenced so late that it was possible to secure but a small number of fields, and this was later cut down for various reasons. The results obtained, however, when added to the rainfall for April and September inclusive, compare so favourably with data obtained from irrigation systems in the northern division of the United States Reclamation Service, where climatic conditions are somewhat similar to those of southern Alberta, that they are thought to at least indicate that the quantity applied was desirable.

On the farms of Mr. D. J. McArthur and Mr. A. F. Stewart, both of which were farmed by Mr. McArthur, preparations were made to measure the water supplied to about 75 acres of land, growing alfalfa, barley, and wheat. Complete measurements, however, were made on but 45 acres of land cropped to wheat. This field has been in grain for five consecutive years, and the yield of 26.4 bushels per acre was considered small. The soil is a chocolate loam underlaid with a friable clay subsoil which absorbs water rapidly. The water applied was measured over a 3-foot Cippoletti weir, and the waste was gathered by a ditch and measured at the lowest point of the field, by a 1 foot weir. The following table shows the results for this field:—

Irrigation.			Duration of Run.		Acre Feet.			
No.	Date. Began.	Date. End.	Days.	Hrs.	Supplied.	Wasted.	Used.	Per Acre Used.
1.	June 10....	June 18....	8	6	37·07	2·93	34·14	·759
Rainfall from April to September inclusive.... feet..								·982
Total....								1·741
Average irrigation head cubic feet per second								2·26

Measurements were made to determine the quantity of water applied to 80 acres of wheat owned by Mr. H. A. Suggitt, of Coaldale. This field was in potatoes in 1912. Water was not applied until June 17, at a time when the crop was showing signs of injury due to the dry period of May and June. The land was then hurriedly irrigated, but the crop failed to recover and the yield was less than 20 bushels to the acre. This land is at a lower level than the McArthur field of wheat, and the soil somewhat heavier. In the application of water to this field there was practically no waste.

The following table shows the results for this field:—

Irrigation.			Duration of Run.		Acre-Feet.			
No.	Date.				Supplied.	Wasted.	Used.	Per Acre Used.
	Began.	End.	Days.	Hrs.				
1.	June 17.....	June 27.....	9	23.5	57·49	....	57·49	·719
Rainfall from April to September inclusive...feet...								0·982
Total....								1·701
Average irrigation head cubic feet per second								2·91

The Suggitt timothy field consists of 160 acres, and is located 7 miles east of Lethbridge. The water applied to this land was measured at a rating flume and the waste over a 1-foot Cippoletti weir, the average irrigation head being 3·9 second-feet, with a maximum of 7·4. The time required to irrigate this tract (twenty-one days) was so long that although the growth at the upper portion of the field was very good, the lower portion received the first water so late that the stand was poor. Had it been possible to have irrigated this land by the middle of June the yield, 1·07 tons per acre, would no doubt have been materially increased. The soil of this field is a dark chocolate loam representative of that for the low land of the Coaldale district. The following table gives the results obtained:—

Irrigation.			Duration of Run.		Acre-Feet.			
No.	Date.				Supplied.	Wasted.	Used.	Per Acre Used.
	Began.	End.	Days.	Hrs.				
1.	June 2.....	June 23. ..	19	13.5	151.15	16.23	134.92	.853
Rainfall from April to September inclusive....feet.								.982
Total								1.835
Average irrigation head cubic feet per second.								3.90

*Water off one day June 5.

Measurements were made to determine the quantity of water applied to 35 acres of alfalfa owned by Mr. A. Haley, of Coaldale. A portion of this field had been in alfalfa for five years, and the remainder three. A small irrigation head was used in irrigating this field and the first watering was not completed nutil June 18; this was followed immediately by heavy rains, making it impossible to commence cutting the crop until July 2.

The land received its second irrigation commencing July 25 and was again cut the last of August. The total yield for the two cuttings was 4·4 tons per acre. The crop made about 8 inches of growth after this time, but it was not cut. This land is adjacent to the McArthur wheat field, and the soil is similar. The table following gives the results of the measurements of water made:—

Irrigation.			Duration of Run.		Acre-Feet.			
No.	Date.				Supplied.	Wasted.	Used.	Per Acre Used.
	Began.	End.	Days.	Hrs.				
1.	June 3......	June 18. ..	15	1	38.03	5.43	32.60	.931
2.	July 25.....	Aug. 7.....	13	3	31.31	4.47	26.84	767
	Total.		28	4	69.34	9.90	59.44	1.698
Rainfall from April to September inclusive ... feet.								982
Total....								2 680
Average irrigation head cubic feet per second.								1.24

Measurements were made of the water applied to 30 acres of alfalfa owned by Mr. W. H. Pawson, jr., of Coaldale. This field was broken in 1906, seeded to oats in the spring of 1907, and yielded 95 bushels per acre. It was then backset and again seeded to oats in 1908, and ploughed and seeded to alfalfa in 1909. It was irrigated with a large irrigation head, and so required much less time to cover than the Haley field. Three irrigations were made, but the quantity of water applied was practically equal to that applied to the Haley alfalfa field, which received only two irrigations. Three cuttings were taken off this field, with a total yield of 4·7 tons per acre.

The data concerning this field are given in the following table:—

Irrigation.			Duration of Run.		Acre-feet.			
No.	Date. Began.	End.	Days.	Hrs.	Supplied.	Wasted.	Used.	Per Acre Used.
1	June 10	June 12.	2	6·5	19·17	0·00	19 17	·639
2	July 18	July 22..........	3	17	24·94	3·53	21·41	·714
3	Aug. 30.	Aug. 31..........	1	11	13·26	2·60	10·66	·355
	Total		7	10·5	57·37	6·13	51·24	1·708
	Rainfall from April to September, inclusive.........feet.							·982
	Total							2·690
	Average irrigation head cubic feet per second.							3·88

As no attempt was made to control the quantity of water that was applied to the land, it was expected that the results obtained would vary greatly. The quantity of water, however, that was applied to like crops are practically equal. The least was applied to grain and the greatest to alfalfa, alfalfa requiring more than twice the quantity required by the grain. Complete duty of water data were obtained upon five fields; two were in grain, one in timothy and two in alfalfa, or 60 per cent of the number of fields used were forage crops. The average quantity of water applied by irrigation was 1·147 acre-feet, or water applied to a depth of 13·76 inches over the irrigated area.

The irrigation head used varied from 1·20 second-feet for the Norton wheat field to 3·90 second-feet for the Suggitt timothy field of 160 acres, and the average head used on seven fields was 2·39 second-feet.

The results in duty of water and the irrigation head used are given in the following table:—

Duty of Water and Irrigation Head, 1913.

—	Acre-Feet per Acre.	Head. Sec.-Feet.
McArthur and Stewart wheat field	·759	2·26
Suggitt wheat field	·719	2·90
Suggitt timothy field..........	·853	3·90
Haley alfalfa..........	1·698	1·24
Pawson alfalfa..........	1·708	3·88
Norton wheat stubble..........	....	1·20
McArthur alfalfa and barley	....	1·34
Average..........	1·147	2·39

The diagrams, *Plate 1*, show the daily rainfall for April to September, inclusive, for the Dominion Experiment Station, a crop diagram giving the time of seeding, irrigating, and cutting for three kind of crops, and a yield diagram for the four fields of wheat sown in the crop diagram.

The four fields of wheat had received very similar preparation and had been cropped to grain for several years, except for field No. 3, which was in potatoes in 1912, and the difference in the yield is without doubt due to the time or lack of application of water by irrigation. The three diagrams are so placed that the relation between the rainfall, irrigation, and yield may be seen at a glance.

From April 29 to May 17 about 2 inches of rain fell; this, *plus* the moisture that was already in the soil, was sufficient to bring up the crop. However, this was followed by a very dry period extending from May 17 to June 17, during which time the total rainfall was less than one-half inch, and grain crops which were not irrigated suffered in some cases to such an extent that the yield was reduced to 5 bushels per acre. As the rainfall for 1913 is very similar to the average rainfall for this district, the advantage of irrigation is very apparent. The field that was irrigated first, or before the crop was permitted to suffer by the drought, produced more than twice the yield upon the non-irrigated land.

It is apparent that delay in irrigation means reduced yields. The first field was irrigated before any injury to crop was noticed, the second was slightly affected, while in the third considerable injury had been done even before the irrigation was commenced. Although the drought of late May and June did considerable damage, further injury was done by the dry period during the middle of July, which was very noticeable on fields that were not heavily irrigated in the early part of the season.

The effect of this drought was not so noticeable upon the forage crops other than to retard the plant growth. This may be explained by the fact that there is a great difference in the power of different crops to withstand drought. The shallow rooting crops, such as the grains, may perish during a drought that will have little or no effect upon the more hardy or deeper rooted crops, such as the grasses, clovers, and alfalfa. A drought that will kill the first-mentioned class of crops may not affect the second further than to check plant growth until such time as the necessary moisture is supplied. This power to resist drought also depends upon the period of plant growth, as the older the plant is the better is its root system. From the above, and a study of the rainfall, it is evident that grain crops will require practically all the irrigation water necessary for good plant growth during the early part of the growing season, and as forage crops require considerable water during the period of plant growth, it is evident that the maximum quantity of water will be required at the time when the grain crops must be irrigated. The necessity for the use of so much water at one time may probably be modified to some extent by the practice of fall irrigation.

The diagrams, *plates 2 and 3*, show the climatic conditions and water requirements of crops for southern Alberta, as compared with those for nine irrigation projects of the United States Reclamation Service. *See map for location of these projects.*

On the right, *plate 2*, is given a temperature diagram which shows the maximum, the average for April to September, inclusive, and the average yearly temperature for the irrigated districts given in the column at the left. The diagram to the left shows the period in days between the last spring and the first fall frost. It will be noticed that the average temperature is lower, and the period between frosts shorter, for southern Alberta than the average for the irrigation projects in the United States, with one notable exception, that of the Blackfeet project in the United States, which has a very short period between frosts.

These diagrams, however, are not a true criterion of the duration of the growing season, as this small difference may be more than counterbalanced by the greater amount of possible sunshine, for the long, summer days of southern Alberta. Diagram, *plate 4*, shows a comparison of the average monthly temperature for Medicine Hat and Lethbridge, which is a fair average for the possible irrigable area of southern Alberta, compared with that for two irrigation projects of the United States.

In the diagram to the right of *plate 3* is shown the average annual rainfall, and that falling during April to September, inclusive. To the left is shown the duty of water, or the quantity of water applied to crop by irrigation, *plus* the rainfall from April to September, inclusive, for the year 1913.

It will be noticed that the total quantity of water used, assuming that the precipitation during the remainder of the year is not available for plant growth, varies less than 2½ inches from the average, except in the case of the Milk River project, where the total is but 20¼ inches. This, however, is no doubt due to a large percentage of the land being in grain. The quantity of water used by crops in the Lethbridge district, which is 25½ inches, agrees very closely with the average for all the irrigated districts used.

The work for the Lethbridge district is based upon but one year's data obtained upon 350 acres of land; however, as it agrees so closely with the average obtained for nine large irrigated districts in the United States which have climatic conditions and soil somewhat similar to that of southern Alberta, it indicates that 25 inches of moisture during the period from April to September, inclusive, is very desirable for good plant growth. A study of the rainfall diagram, *plate 5,* shows that the annual precipitation for Calgary has exceeded 25 inches only twice during the last twenty-eight years, and that the average precipitation for four stations in southern Alberta is only 15 inches.

Your obedient servant,

G. D. WALTERS.

SOME PRINCIPLES GOVERNING THE DESIGN AND THE OPERATION OF IRRIGATION SYSTEMS, BY SAM G. PORTER, B.A., B.S., M. AM. SOC. C.E.

An irrigation system, like any other machine, must be designed to meet the requirements of efficient operation. A machine may be perfect mechanically, and built of the best material to be had, yet be worthless as a working unit because it does not fulfil the practical requirements of operation. This analogy is not sufficiently recognized by many who are responsible for the design and the operation of irrigation plants. It is not the purpose of this paper to present a complete discussion of the principles of design and construction of irrigation systems, but to emphasize one or two important features which do not usually receive sufficient consideration.

The design of many irrigation canals is based on the theory that the required carrying capacity of the canal depends solely on:—

(1) The area to be irrigated;

(2) the duty of water, or the quantity to be supplied per acre each season;

(3) the length of the irrigation season, or length of period required to mature the crop irrigated.

These three factors, together with a proper allowance for losses, determine the total quantity of water required per season, but they do not, by any means, determine the necessary rate of delivery or carrying capacity of the canal. As a matter of fact, this latter requirement is practically independent of the second and third factors, as stated above. In other words, it may easily happen that a canal serving a certain area which requires 1·5 acre-feet per acre per season may need to be fully as large as another canal serving an equal area, which requires 3·0 acre-feet per acre per season. The reason for this will, I trust, be made clear by the discussion which follows.

It is the practice in India and Egypt to express the second factor, on duty of water, in the number of acres which a flow of 1 cubic foot per second will serve, while the third factor, or length of period of flow, is called the "base" of the duty. Usually the "base" is the period required to mature the crop. It is sometimes used, however, in a more restricted sense to apply to the period of maximum demand, called by Buckley the "period of pressure."[1] Likewise Parker uses the term in both ways, to express the length of the irrigation season, and also as "the interval between successive waterings."[2] In American practice, duty was formerly expressed in acres served per second-foot, often without defining the length of period of flow. This, of course, was very indefinite. Now it is usually expressed in depth of water applied, or in acre-feet per acre per season, and the maximum demand as a certain depth applied in one month, or a certain percentage of the full season's duty in one month.

As already pointed out, the total quantity required for the season does not determine the required rate of delivery, for it does not take into consideration the fluctuating character of the water requirements. The demands through the season are never, under any circumstances, uniform. To state the quantity required per month, rather than per season, is better, but even the arbitrary division into months many not always meet the conditions imposed. The base should be that period, of whatever length, within which important crops under the system must receive an irrigation, or, this being delayed, will suffer in consequences. The length of the period will be influenced by the climatic conditions and the nature of the crops. In Egypt, for instance, the principal crop is cotton, and it has been determined that it requires an irrigation once in eighteen days. The base in that case should be eighteen days and the capacity of the system determined on that requirement.

The question arises, will this principle apply to conditions in southern Alberta? The climatic conditions of a short season, but long days of bright sunshine, produce a short, intense growing season which necessitates the crop being urged through the growing stage without opportunity for a set-back, otherwise either the yield will be materially reduced or the date of maturity will be too far prolonged, or both. Hence the maximum demands are concentrated within a very short period.

Not to be provided with a reasonable irrigation within that period will mean practical failure, or at least dry-land returns to most crops. It may be called the critical period, and its length should be the 'base' used in computing the required rate of delivery. Probably a fair statement of its length as applied to average conditions in southern Alberta is fifteen days.

A chart appearing elsewhere in this report entitled "*Diagram showing the effect of rainfall and irrigation on crop yield*" under the report of the Duty of Water investigations presents a very striking illustration of the above argument. It will be noted that the McArthur wheat, irrigated at the proper time, produced 31 bushels per acre, the McArthur and Stewart wheat irrigated nine days later fell off 15 per cent in yield, and the Suggitt wheat irrigated sixteen days later fell off 37 per cent. It is also worthy of note that a delay in applying the irrigation likewise delayed the date of maturity of the crop.

In arriving at the conclusion that fifteen days, or thereabouts, is the length of the critical period and is to be used as the base in our computation, it does not necessarily follow that all the land under the system must be provided with an irrigation within that time. Two important factors need to be considered in that connection: first, what is termed the "irrigation factor," or the percentage of the entire irrigable area which is likely to be irrigated during any one season; and second, the percentage of the area which is in crops whose water requirements are of an exacting, non-drought-resisting nature. It is essential that crops of this class, in which may be included grains, garden produce, sugar beets, etc., be provided with water promptly when needed. On the other hand, such crops as alfalfa, while requiring a greater total amount of water during the season, are less exacting in their demands, and

[1] "The Irrigation Works of India," page 275 et seq.

[2] "The Control of Water," page 632.

can suffer a delay with less permanent injury. It will then serve his own interest, no less than the efficiency of the system as a whole, for the irrigator to plan to water his forage crops as much as possible before and after the critical period during which all the water supply, and perhaps more, is required to save the more perishable crops. It is evident that the greater the proportional area in one crop of an exacting nature, the greater the allowance necessary for increased capacity during periods of pressure.

Ordinarily the irrigation factor will not exceed 80 per cent. For illustration let it be assumed that 75 per cent is a fair figure. Then with 25 per cent of the land idle, and say 25 per cent in crops whose requirements are of the less urgent nature, 50 per cent must be watered during the critical period.

The depth which will be required for one irrigation will, under ordinary practice, vary from 0·3 feet to 0·8 feet, and will average 0·5 feet.

On the above assumed basis, the system should be designed to deliver 0·5 feet depth to 50 per cent of the irrigable area in a period of fifteen days. This is equivalent to 0·25 acre-feet per acre in fifteen days, or 0·0167 acre-feet per acre per day, equal to 0·0083 second-feet per acre, or a net capacity of one second-foot for each 120 acres. Frequently only one irrigation will be applied in this climate on certain crops; but just as great a capacity, if not greater, is required to deliver that one irrigation at the proper time as for three or four irrigations, extended over the entire season, because the major part of the land will want it at one and the same time.

The above serves to emphasize the importance of a proper diversification of crops, in order that the water requirements may be more evenly distributed. It also emphasizes the importance of reservoirs for storing water during periods of low demands for use during periods of pressure.

The old system of constant flow delivery has given place almost universally to the more practical rotation system. But in adopting the rotation method of delivery instead of the constant flow, the extreme should be avoided. That is, the rotation period must not be made too long. This point has been brought out in discussing the capacity to be provided for in designing the system. It may be presented from a partially different point of view. What is meant by going to the extreme in rotation is giving each farmer enough water to thoroughly irrigate his entire irrigable area in one short run. It is better to divide it into two or three runs, so that he will always have at least a small quantity at his disposal within a short period rather than the whole quantity at once, and being compelled to wait correspondingly longer between runs. In other words he can come nearer meeting the agricultural requirements with a flow two days out of each ten, or three out of each fifteen, than if he has one run of six days in each thirty. It is in every way fairer to the water user, for if he receives a run only once in thirty days, and must take it in his turn, it may come either before or after the time he most needs it. On the other hand, his neighbour's turn comes just at the period of greatest need and produces much greater benefit. Such an arrangement works an injustice.

It is much easier to plan a system of distribution where the rainfall is negligible. Rainfall introduces complications. Where the irrigator is of an optimistic disposition, and likewise strongly disposed to avoid unnecessary labour, he is likely to postpone his irrigation to the last possible moment, on the prospect of a providential rain making it unnecessary. The hoped-for rain does not come, the farmer is thrown behind in his work, the water demands become congested, the irrigation system is overtaxed, and the crops suffer by the consequent delay.

Engineering design and operation management are of primary importance, but for ultimate success they must be supplemented by the co-operation of the water users themselves, who must exercise foresight and skill in their own methods. Results are the measure of success. A loss of five dollars an acre more or less, in crop returns, either by not being able to deliver the water at the time it will do the most good, or by not properly handling it when it is delivered, is sufficient evidence that the machine is not properly doing its work.

Photo by R. H. Goodchild.

View of Crowsnest River near Blairmore, Alberta, where the channel is being enlarged and straightened.

Irrigated Wheat. D. J. McArthur's Farm, Coaldale, Alberta, 1913.

25—1915—vii—13½

First cutting 3 feet high.

Second Cutting

Third Cutting Alfalfa on the A. L. Brown Farm, Coaldale, Alberta, 1913.

Alfalfa on the A. Haley Farm, Coaldale, Alberta. Duty of Water. 1913.

Ditching. D. J. McArthur Farm, Coaldale, Alberta.

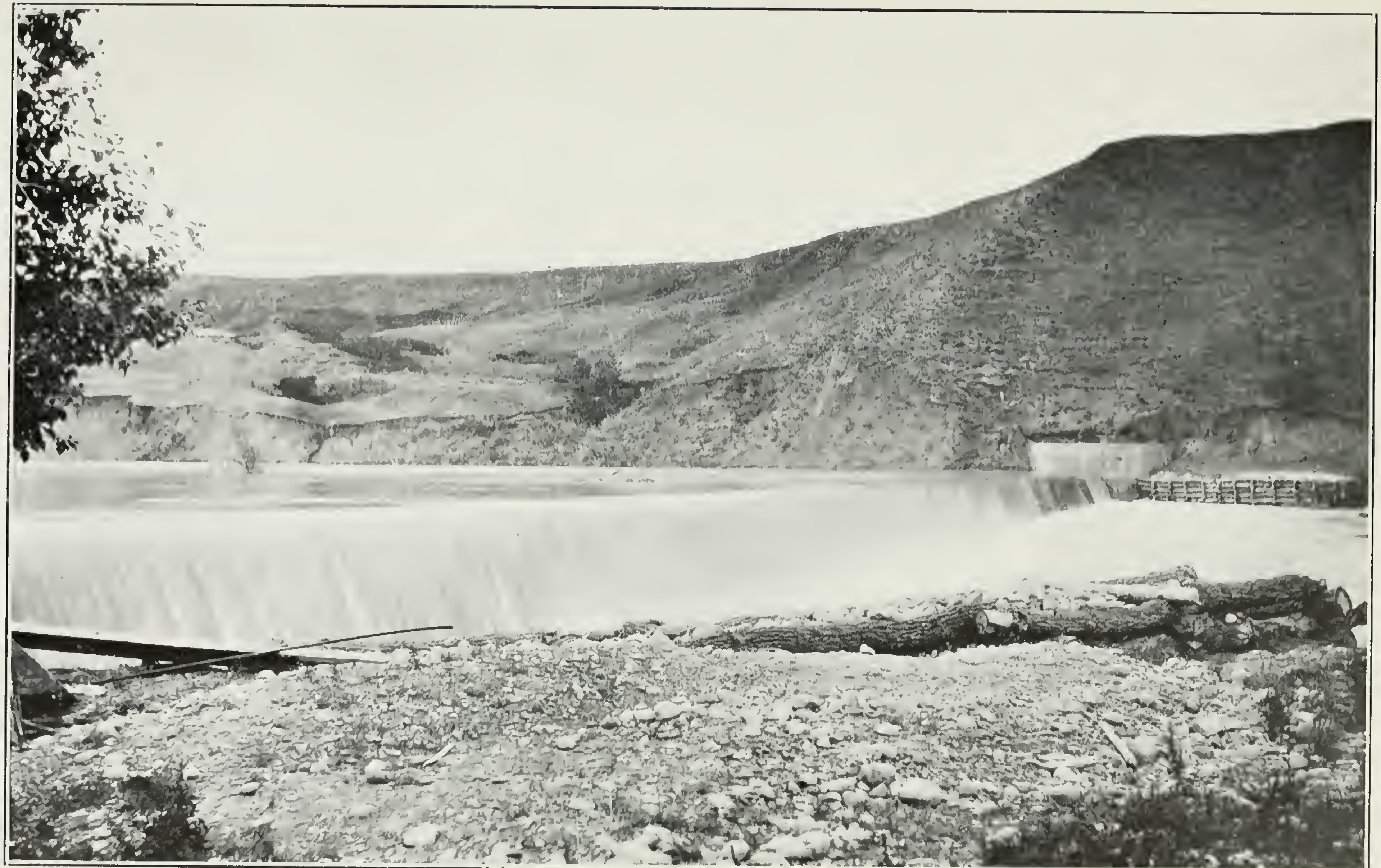


Photo. by S. G. Porter, Aug., 1913.

Southern Alberta Land Company, North Dam on Bow River.

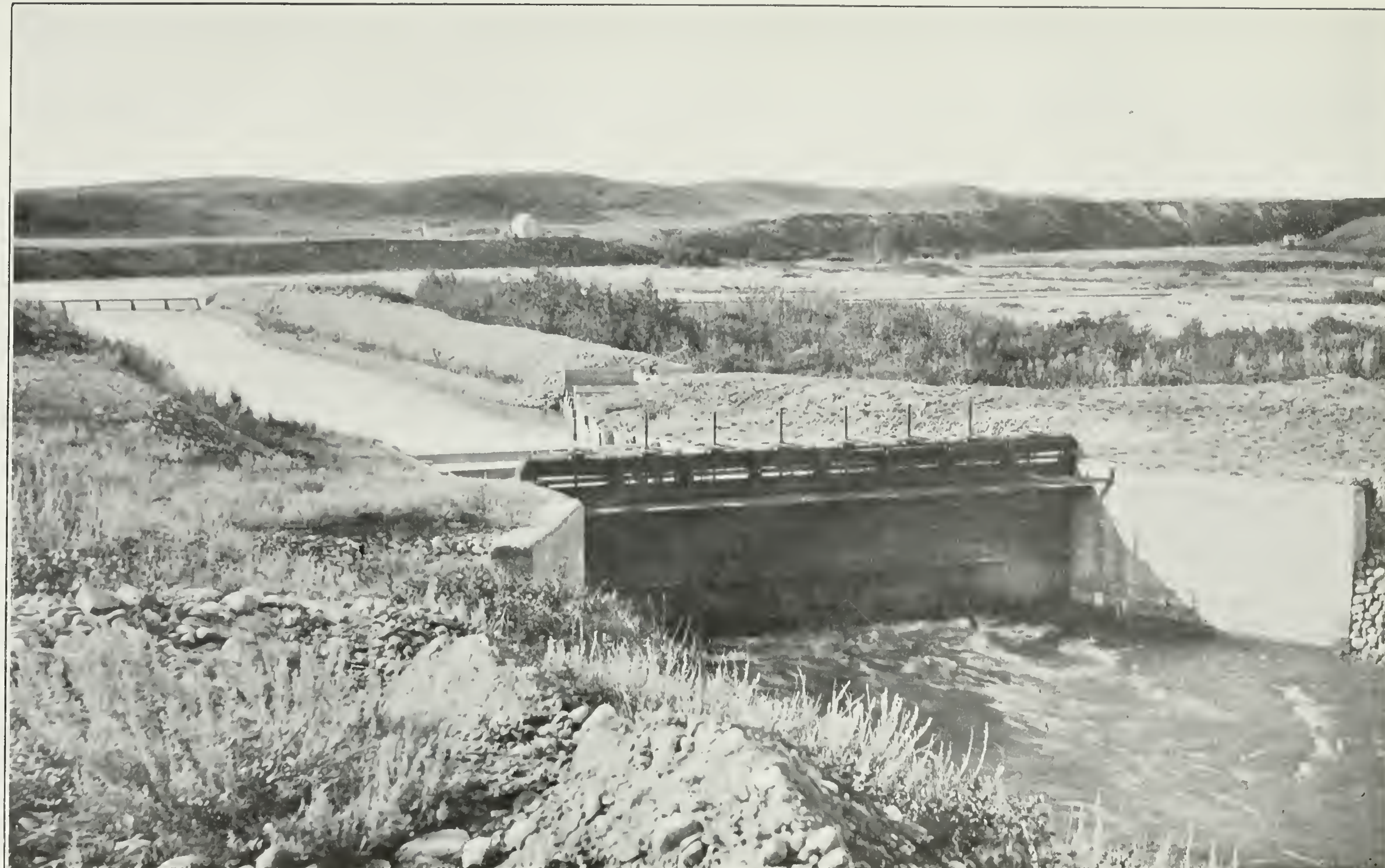


Photo. by S. G. Porter, Sept., 1913.

Intake of Alberta Railway and Irrigation Company's Canal. (Lethbridge Section of the Canadian Pacific Railway Company's Irrigation System.) Headgates and wastegates in the foreground. Intake protected with grid of railroad iron on the left and timber weir across St. Mary River in line with it to the right.

Photo. by S. G. Porter, Nov., 1913.

Eastern Section Canadian Pacific Railway Company's Irrigation Block. Intake of main canal and dam across Bow River near Bassano.

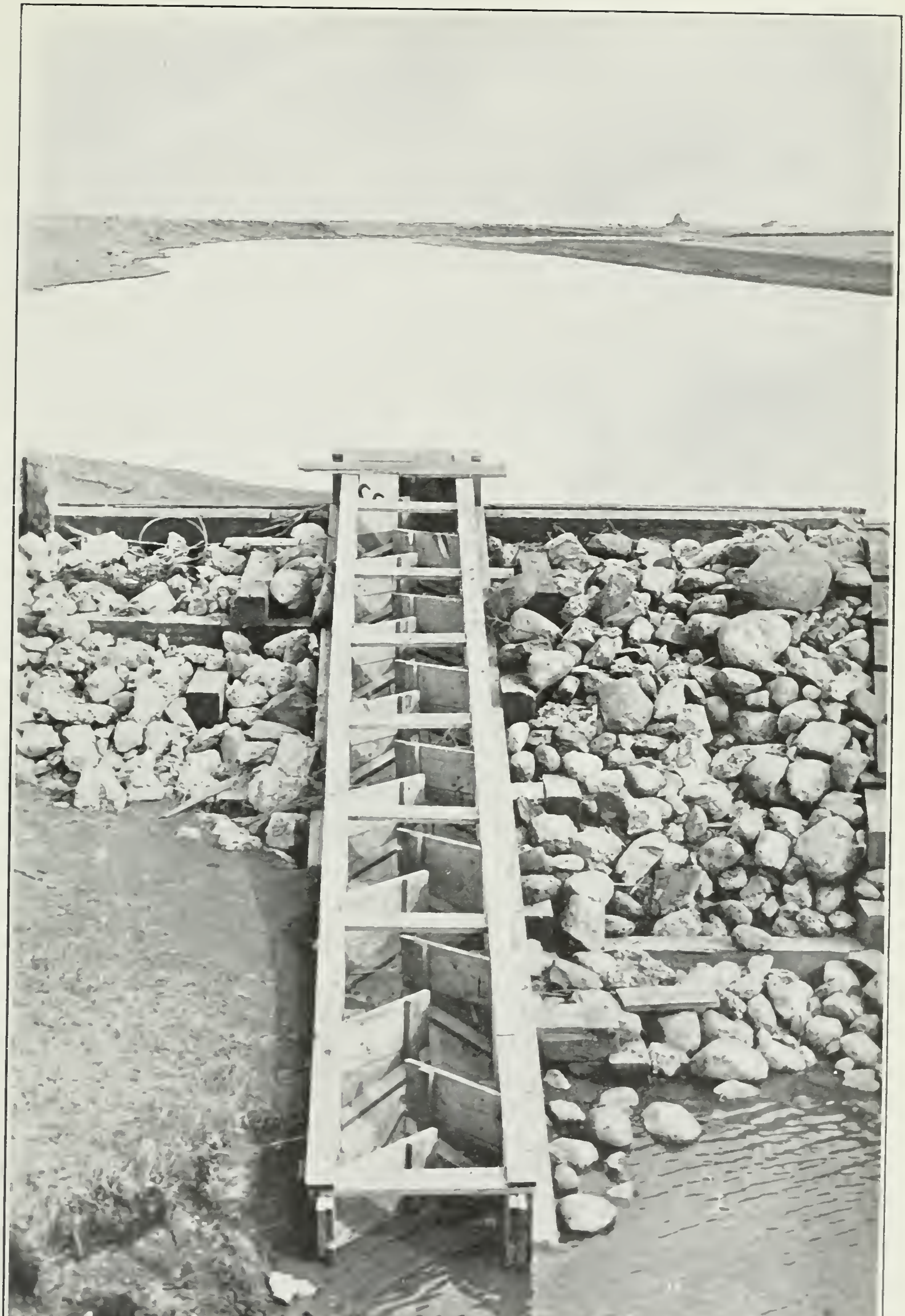
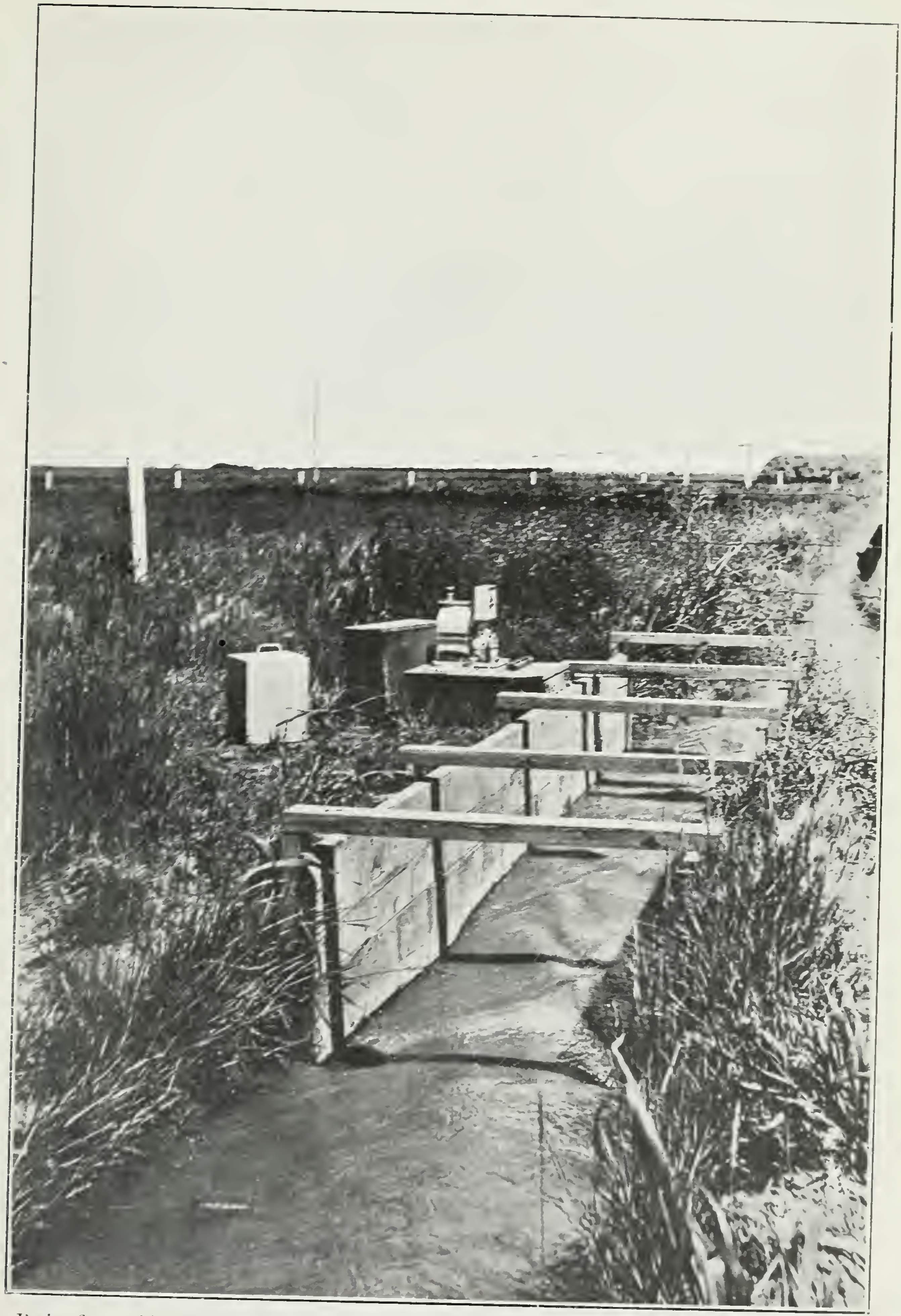


Photo. by P. J. Jennings.
Fish ladder in Canadian Pacific Railway Company's dam near Rouleau, Saskatchewan.

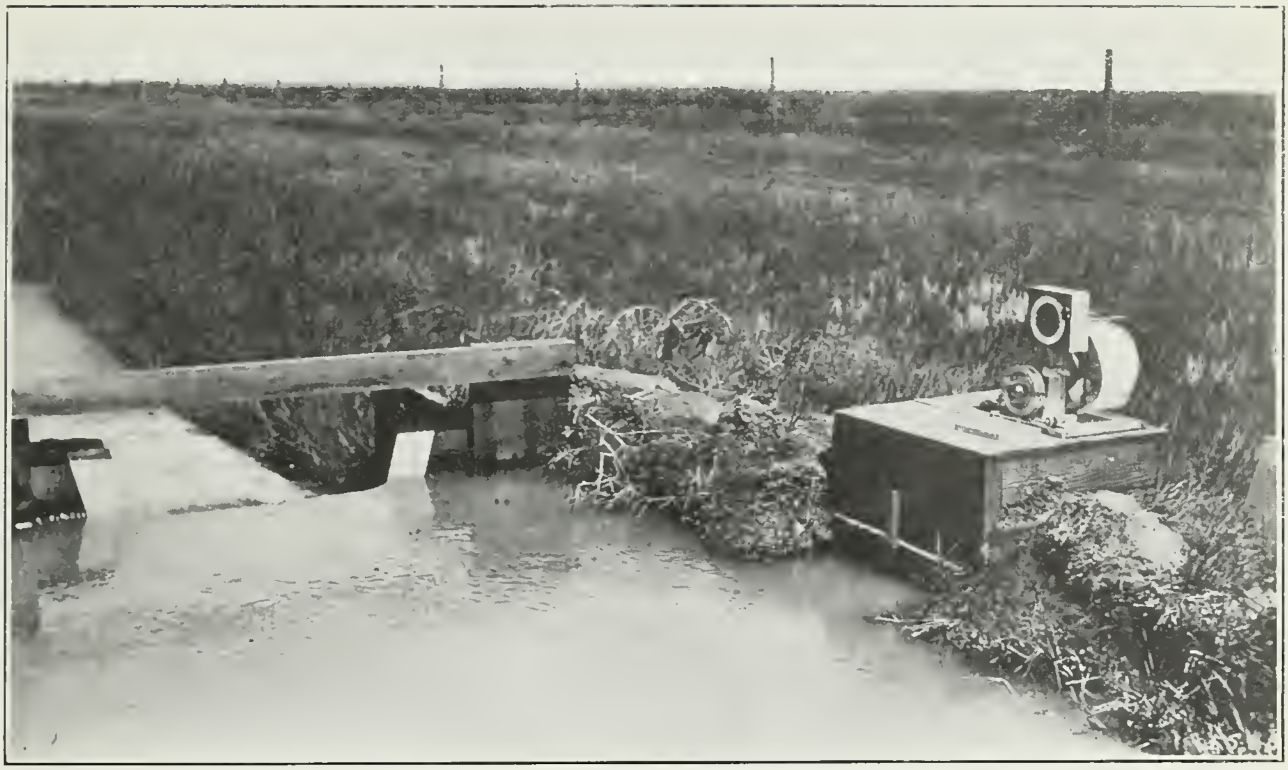
Supply Lateral, D. J. McArthur Farm, Coaldale, Alberta.

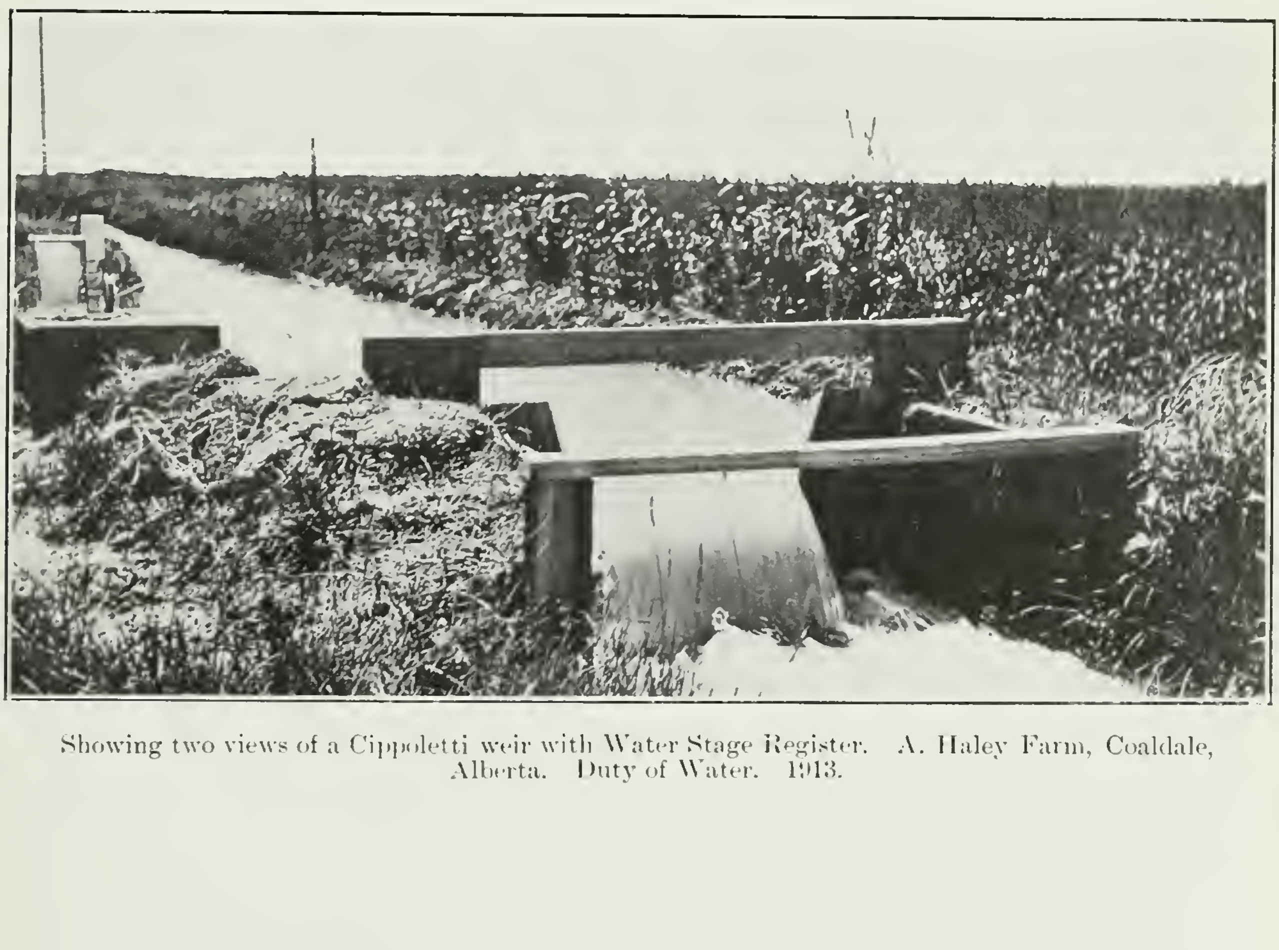


Rating flume with Water Stage Register. W. H. Pawson Farm, Coaldale, Alberta. Duty of Water 1913.

Diverting Water from a Field Lateral B. S. Pawson Farm. Coaldale, Alberta.

Canvas dam in position. B. S. Pawson Farm, Coaldale, Alberta.





Showing two views of a Cippoletti weir with Water Stage Register. A. Haley Farm, Coaldale, Alberta. Duty of Water. 1913.

Photo. by S. G. Porter, Sept., 1913.

Lethbridge Section of Canadian Pacific Railway Company's Irrigation System. Alberta Railroad and Irrigation Company's Canal.

Fall Irrigation on the B. S. Pawson Farm, Coaldale, Alberta.

25—1915—vii—15

Photo. by S. G. Porter, Sept., 1913.

Lethbridge, Section of Canadian Pacific Railway Company's Irrigation System. North Chin Storage Reservoir. Constructed 1912.

25—1915—vii—15½

Photo. by E. W. W. Hughes.

Delegates at the meeting of the Cypress Hills Water Users' Association at Maple Creek, on May 23, 1913.

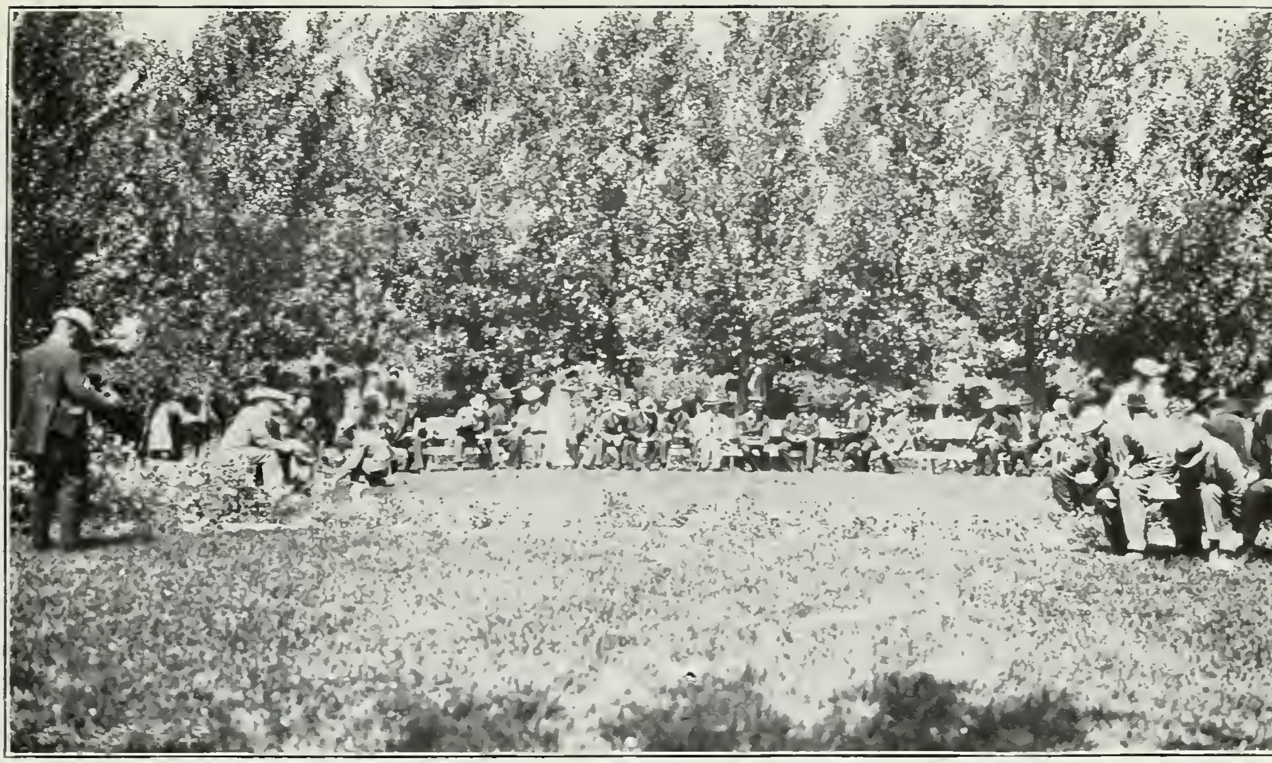


Photo. by F. H. Peters.
Delegates of Seventh Annual Convention of Western Canada Irrigation Association, having luncheon at Whitney's farm near Lethbridge, Alberta, on August 7, 1913.

Photo. by F. H. Peters.
Delegates of Seventh Annual Convention of Western Canada Irrigation Association on motor trip at Lethbridge, Alberta, on August 7, 1913.

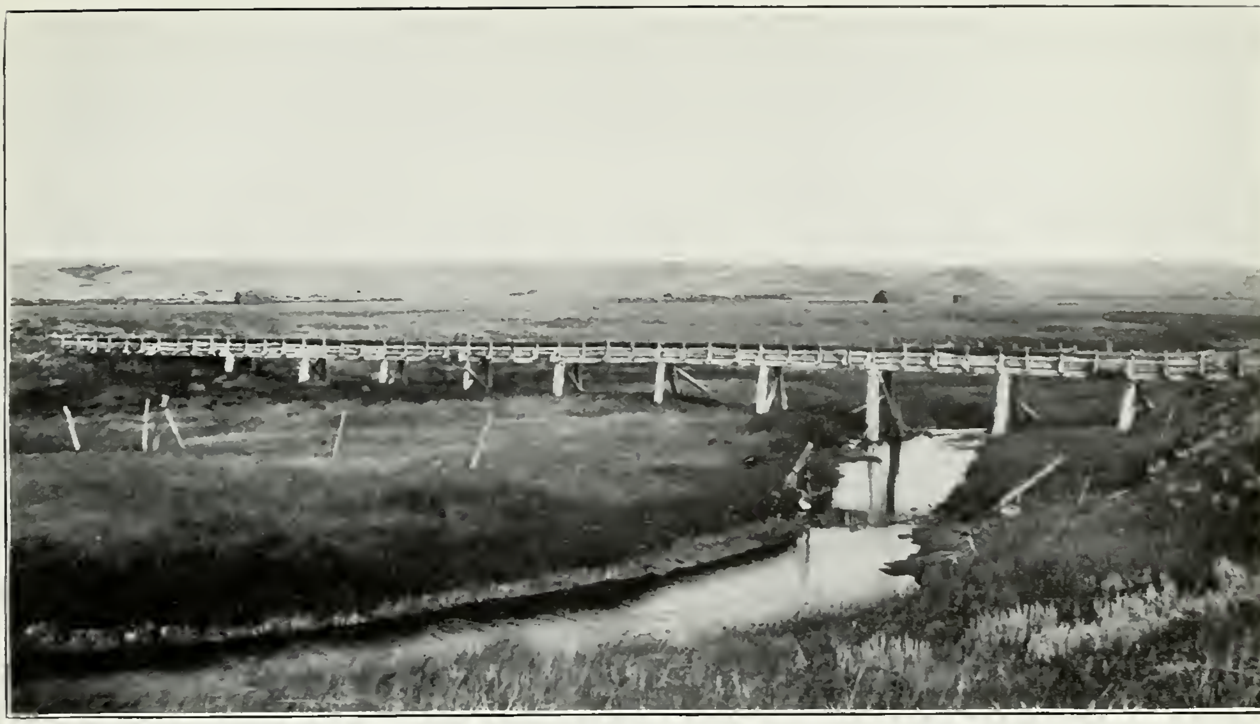


Photo. by M. H. French.
Wooden flume over Galienne coulee on Strong and Day's ditch near East End, Saskatchewan.

Photo. by M. H. French.
Kenneth Sinclair's reservoir near Gull Lake, Saskatchewan.

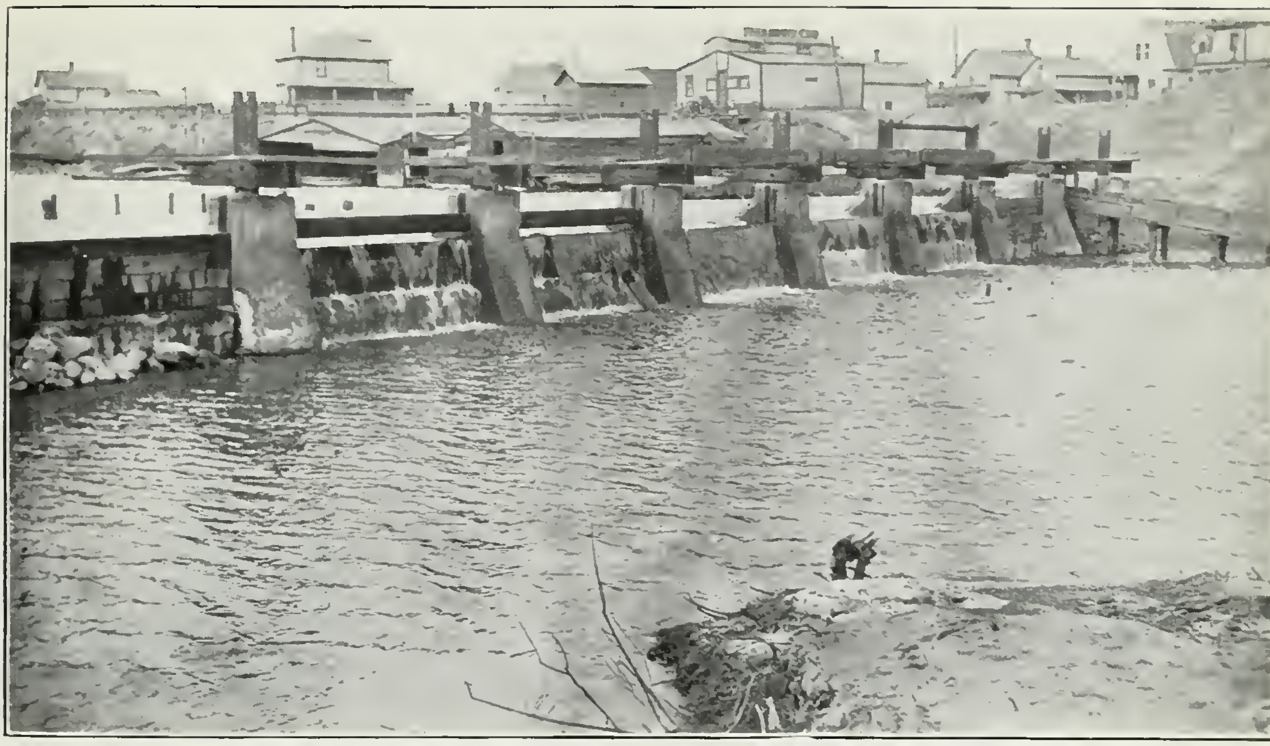


Photo. by P. J. Jennings.
Concrete weir built by the Canadian Pacific Railway Company in Moosejaw creek at Moose Jaw, Saskatchewan, to store water for industrial purposes.

Photo. by P. J. Jennings.
Rock-fill crib dam built by the Canadian Pacific Railway Company in Moosejaw creek near Rouleau, Saskatchewan, to store water for industrial purposes.

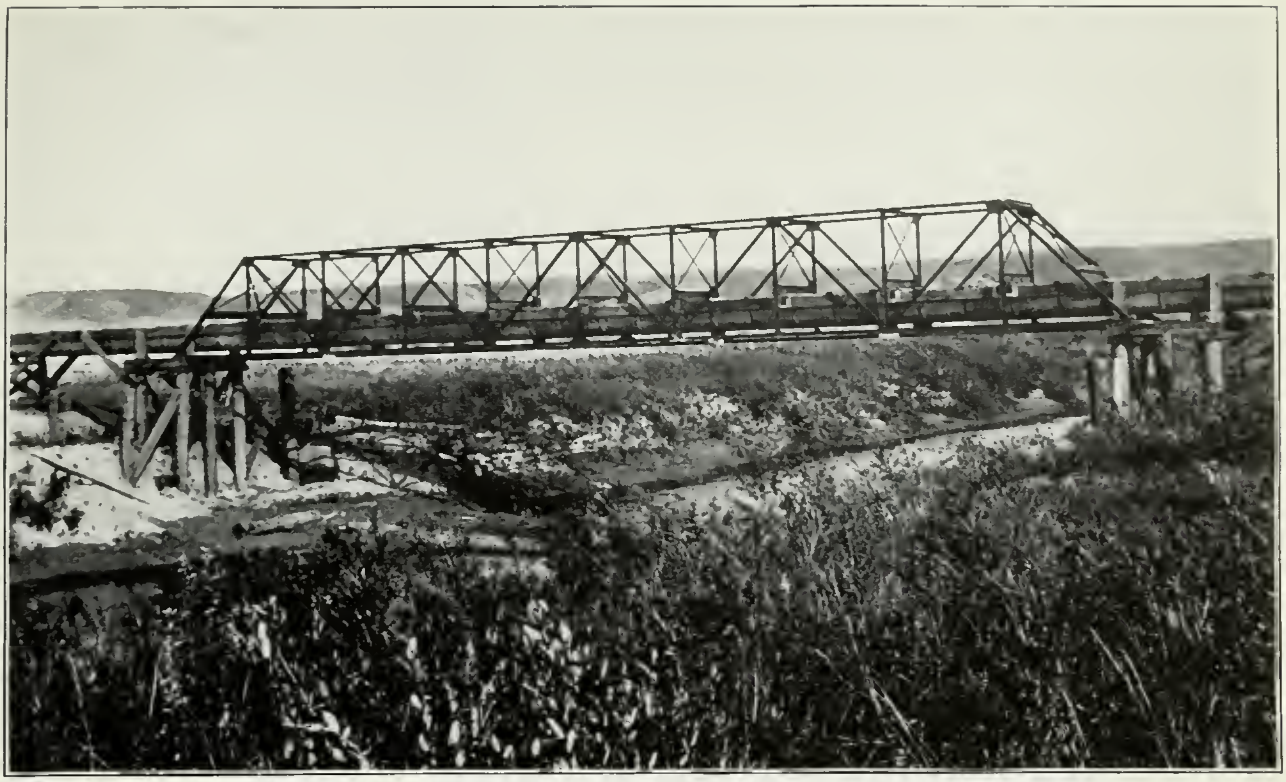
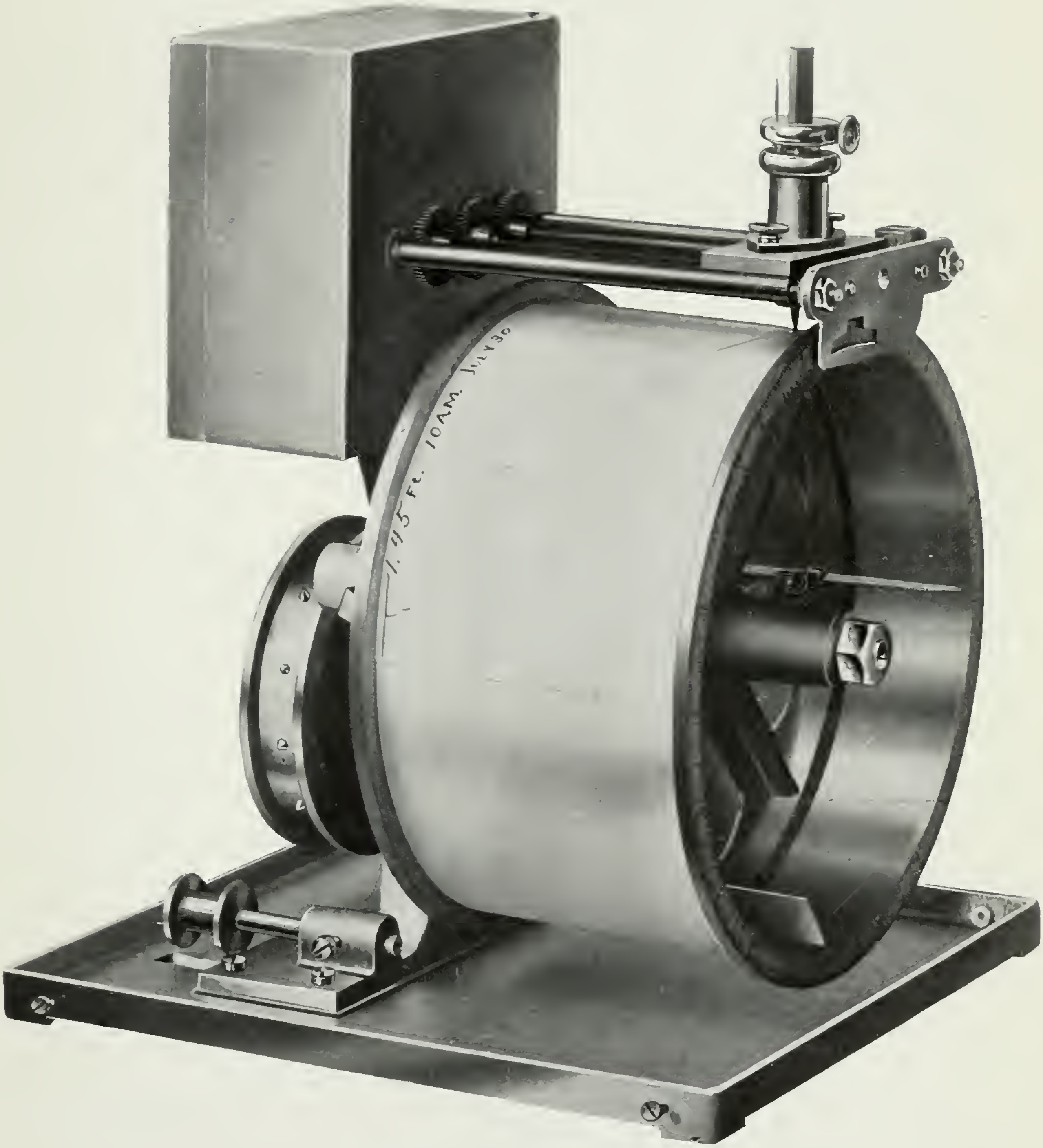
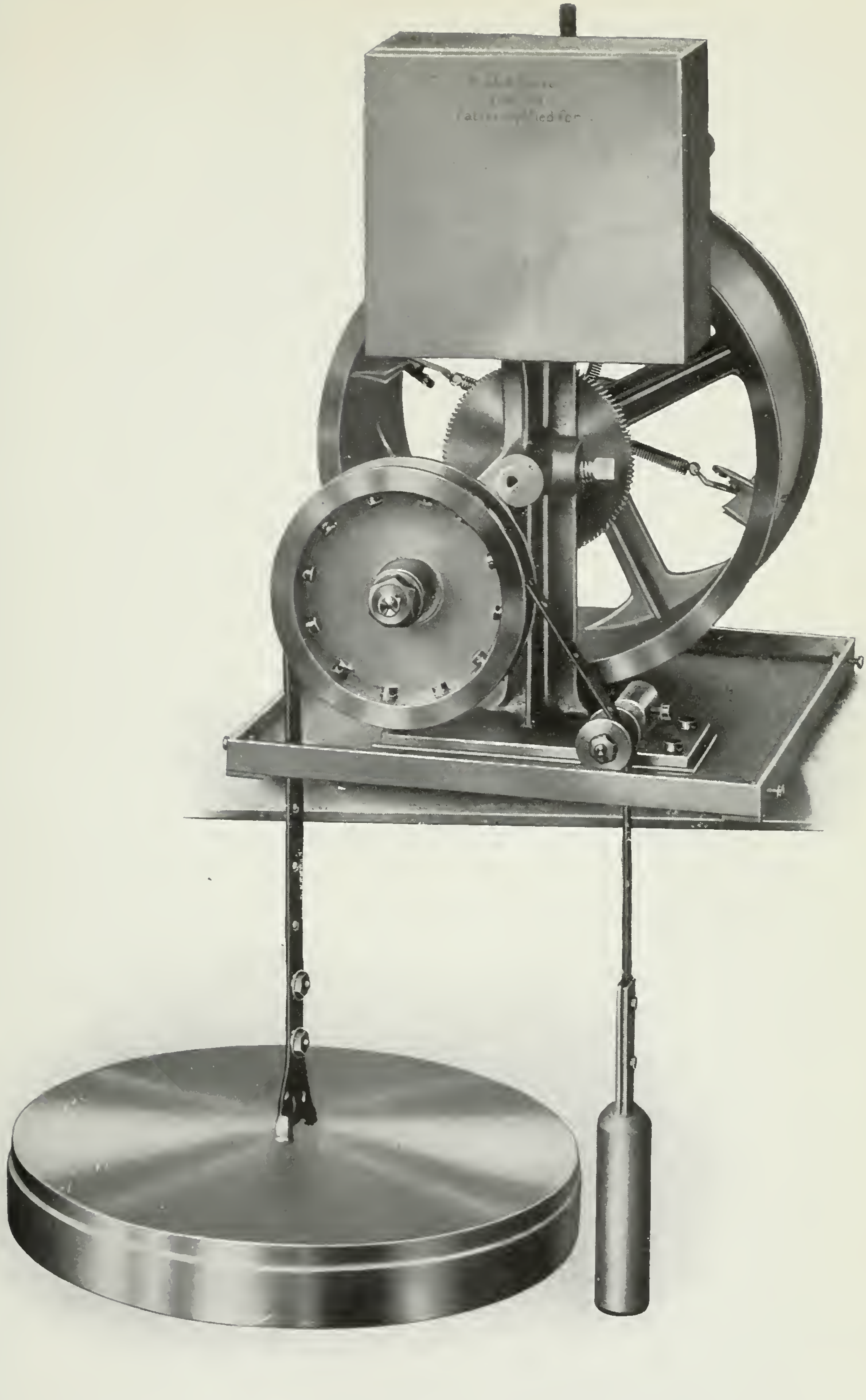


Photo by M. H. French.
Steel flume over Frenchman River on Morrison Brothers' ditch near East End, Saskatchewan.

Photo. by M. H. French.
Morrison Brothers' ditch near East End, Saskatchewan.

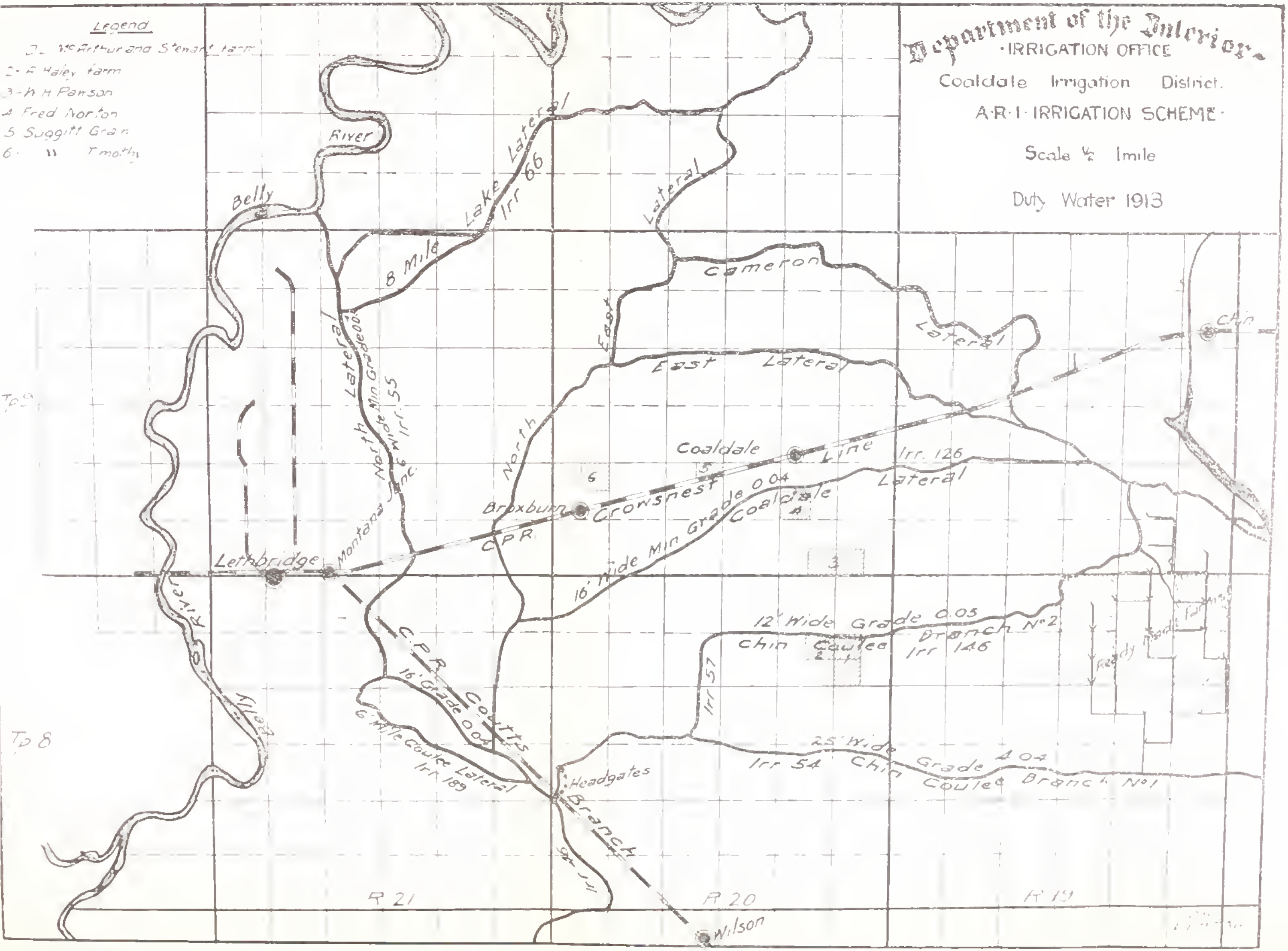


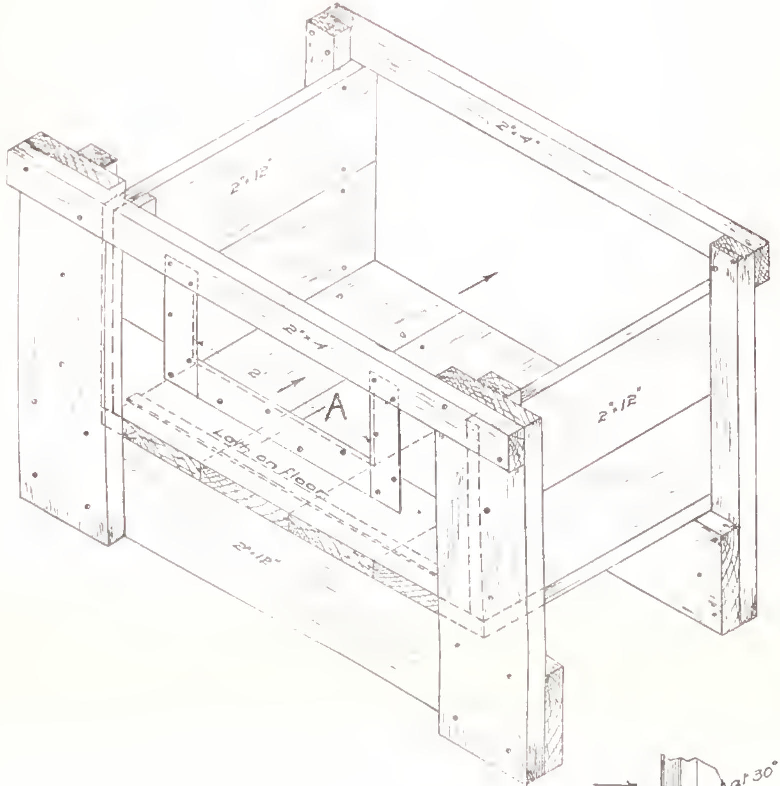
Simplex Meter Register.



W. and L. E. Gurley Simplex Water Stage Register. Used in Duty of Water. 1913.

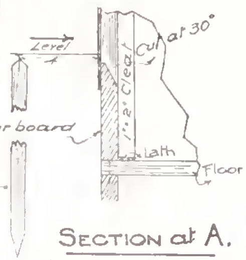
25—1915—vii—16


Department of the Interior
IRRIGATION OFFICE
Coaldale Irrigation District.
A·R·I· IRRIGATION SCHEME
Scale ½ 1mile
Duty Water 1913
Legend
2- F Haley farm
3- H H Parson
4- Fred Norton
5 Suggitt Grain
6- " Timothy
Belly River
Lake Lateral Irr 66
8 Mile
Lateral
Cameron
Lateral
East
East Lateral
North
North Lateral
Coaldale
Crowsnest Line
Broxburn
Irr. 126
Lateral
16' Wide Min Grade 0.04 Coaldale
CPR
Lethbridge
Montana Junc.
River
12' Wide Grade 0.05
Chin Coulee Branch No 2
Irr 146
Irr 57
C.P.R.
Coutts
16' Grade 0.04
6 Mile Coulee Lateral
Irr 189
Headgates
Branch
25' Wide Grade .04
Irr 54 Chin Coulee Branch No 1
Chin
Tp 8
R 21
R 20
R 19
Wilson



Description	No. Pieces	Size	T.&G.	F.B.M.
Top ties front & back	1	2"×4"×12'0"		8
Bottom do do	1	2"×12"×18'0"		36
Floor & walls both sides	2	2"×12"×12'0"	T.&G.	48
Weir boards	1	2"×12"×8'0"		16
Cleats to groove for holding weir board in place	1	1"×2"×4'0"		
Lath on floor below entrance	1	4'0" long		
1 Strip No. 18 Galvd Iron for weir	1	4"×5'0" to cut		
Tinned 1" Cloutheaded nails for weir plates.	1 lb.			
3½ Cut iron nails	10 lbs			

Bill of Material.



SECTION at A.

Department of the Interior

IRRIGATION OFFICE

RECTANGULAR WEIR

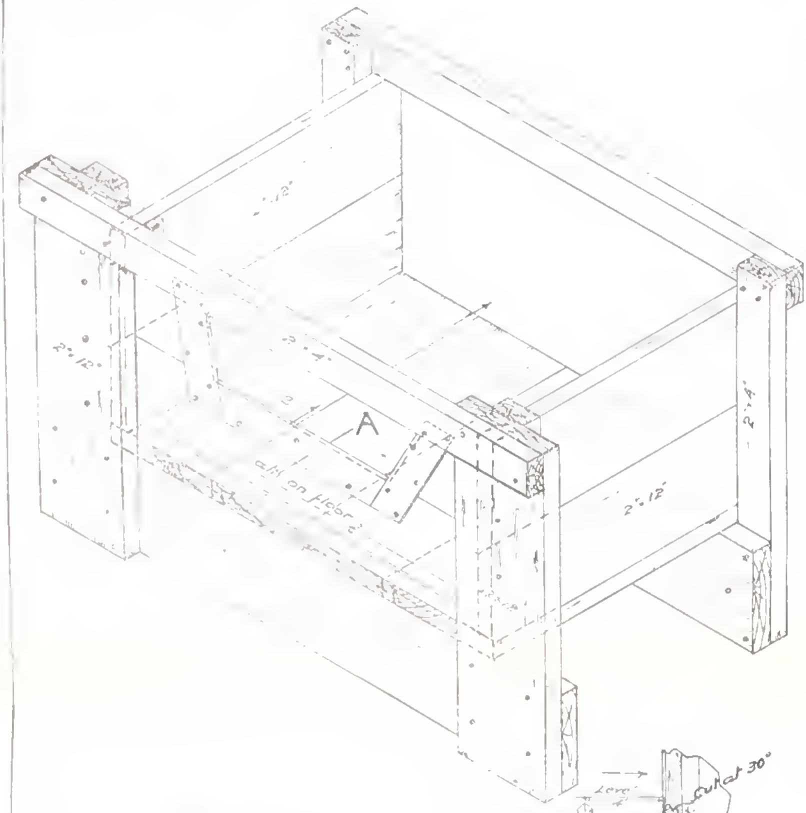
ISOMETRIC PROJECTION

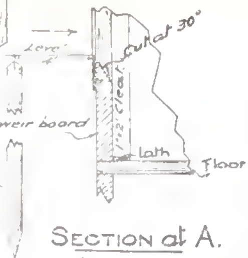
Scale $\frac{3}{4}$" = 1 ft.

Duty of Water Investigation

G. D. W.
Nov. 3rd 1913
E. S. M. M.

Fig 6





Section at A.

B[illegible]l of Material

Description	No. Pieces	Size	T.&G.	T.B.M.
Top ties (to cut)	1	2"×4"×12'0"		8
Bottom [illegible]	[illegible]	[illegible]×12"×12'0"		24
Front & side boards	[illegible]	2"×12"×20'0"	T.&G.	44
Floor boards	[illegible]	2"×12"×12'0"	"	24
Weir board	[illegible]	2"×12"×10'0"	"	20
Cleats & groove for holding weir board in place	[illegible]	[illegible] 2"×4'0"		
Lath on floor below entrance	[illegible]	4'0" long		
3 ½ cut iron [illegible]	[illegible] lbs			
strip of #18 gauge galv. iron for we[illegible]	[illegible]	4"×5'0" to cut		
Tinned 1" cut headed nails for [illegible]	[illegible] lb			

Department of the Interior.

Irrigation Office.

Cippoletti Weir

Isometric Projection

Scale 3/4" - 1 ft.

Duty of Water Investigations G. D. W. Nov 3rd 1913 [illegible]

o 5

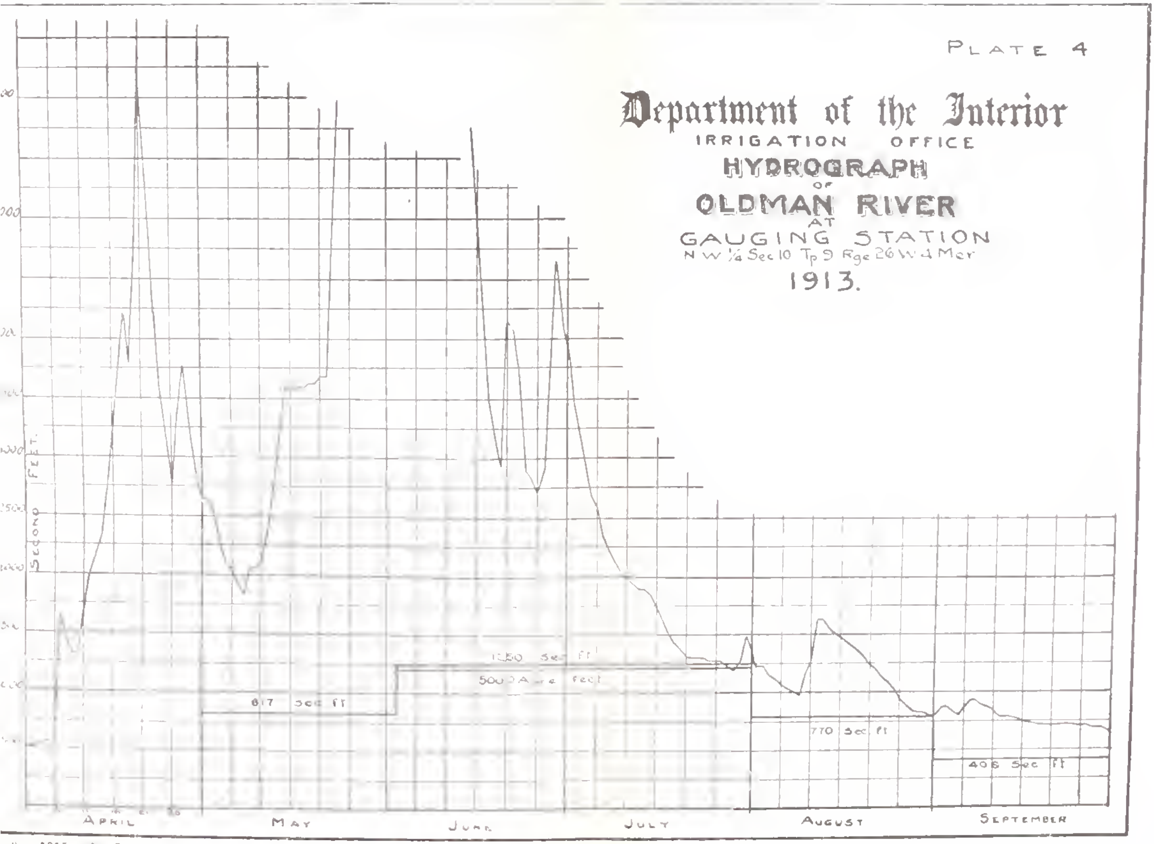


PLATE 4
Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
OLDMAN RIVER
AT
GAUGING STATION
N W ¼ Sec 10 Tp 9 Rge 26 W 4 Mer
1913.
SECOND FEET.
1250 Sec ft
5000 Acre feet
617 Sec ft
770 Sec ft
406 Sec ft
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER

2 1915 vii—21

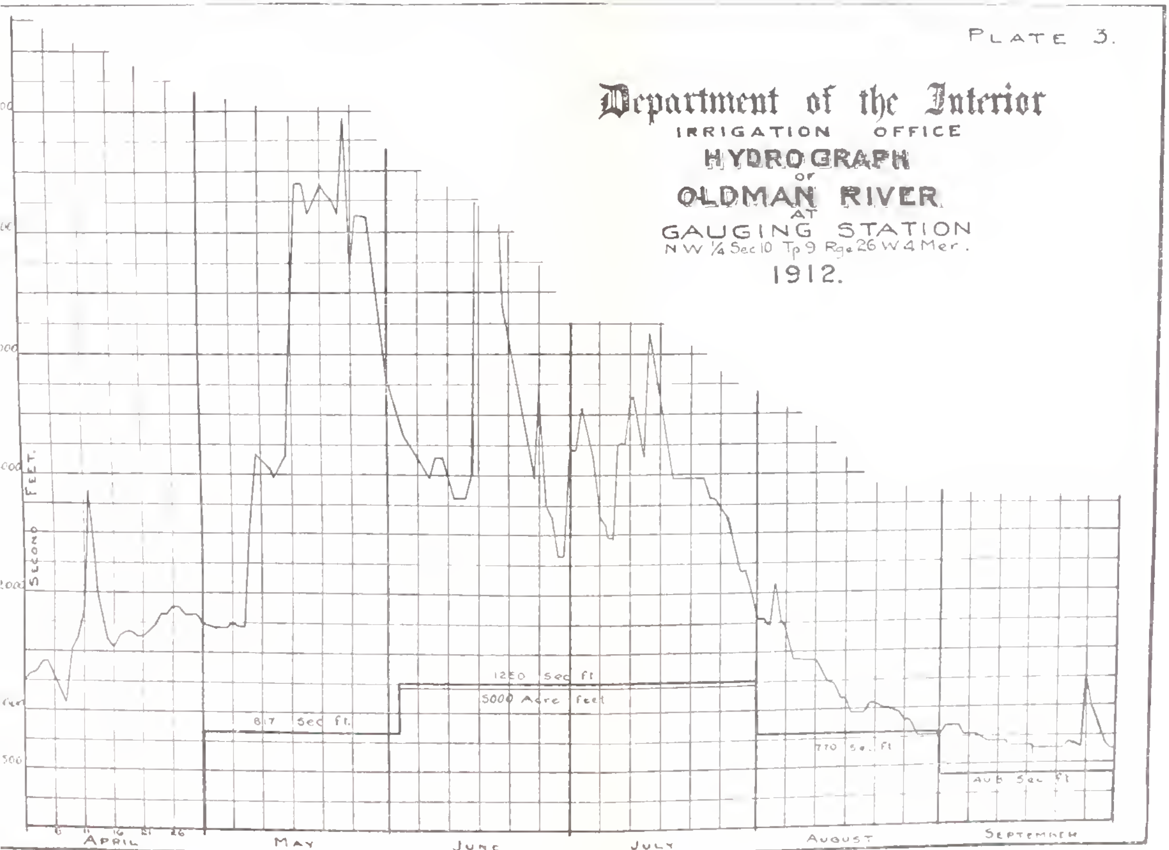
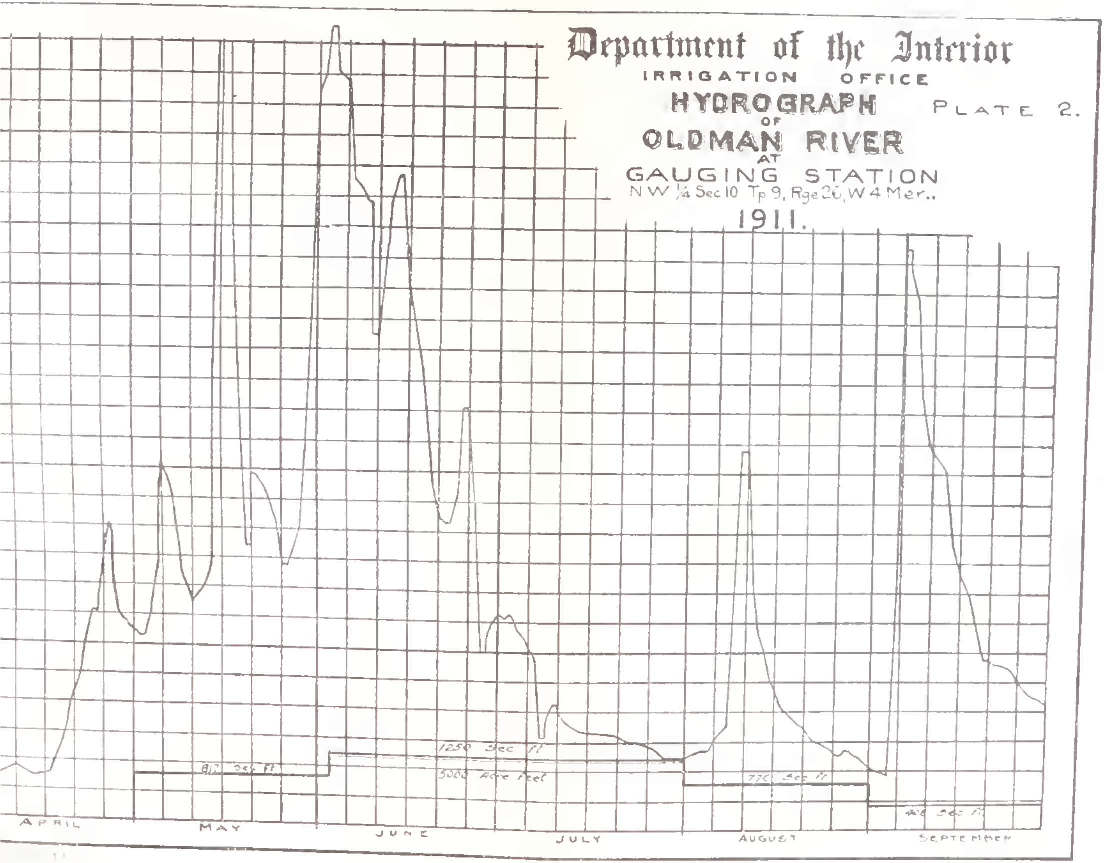
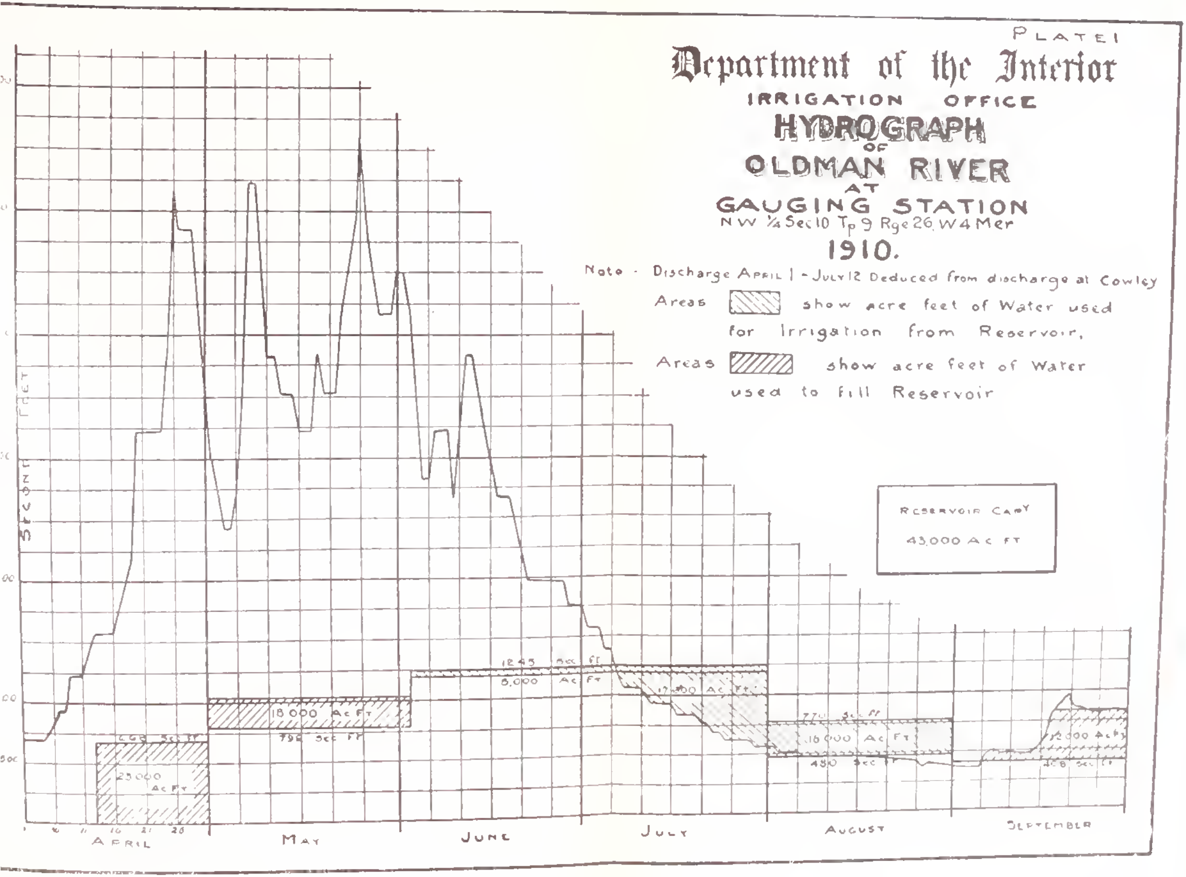


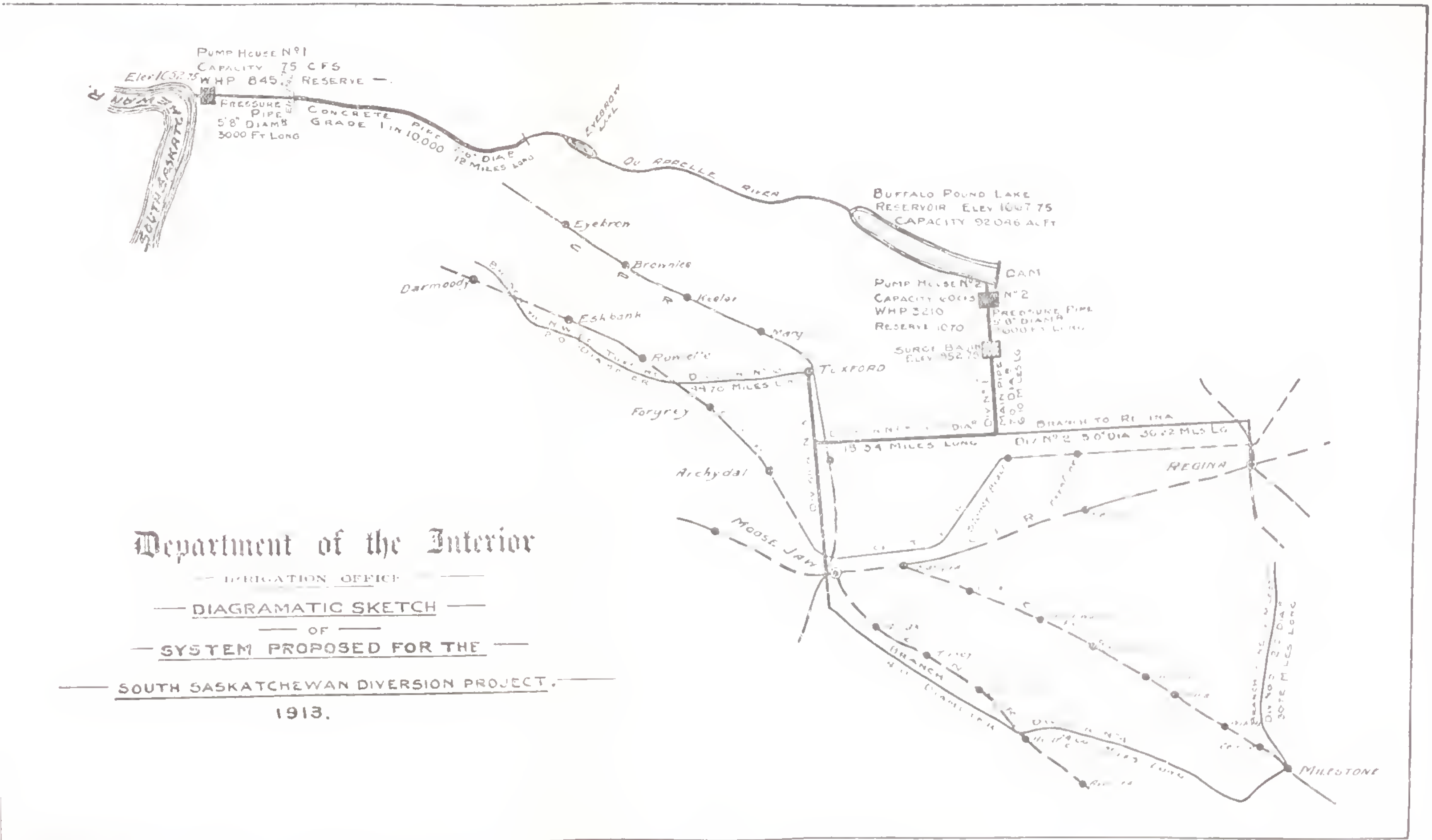
PLATE 3.
Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
OLDMAN RIVER
AT
GAUGING STATION
NW 1/4 Sec 10 Tp 9 Rge 26 W 4 Mer.
1912.
SECOND FEET.
1250 Sec ft
5000 Acre feet
817 Sec ft.
770 Sec ft
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER

1913—vii


Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
OLDMAN RIVER
AT
GAUGING STATION
NW ¼ Sec 10 Tp 9, Rge 26, W 4 Mer..
1911.
PLATE 2.
1250 Sec Ft
5000 Acre Feet
770 Sec Ft
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER



25—1916—vii—18



Pump House No 1
Capacity 75 CFS
WHP 845 Reserve
Pressure Pipe
5'8" Diam
3000 Ft Long
Concrete Pipe
Grade 1 in 10,000
12 Miles Long
South Saskatchewan R.
Eyebrow Lake
Qu Appelle River
Buffalo Pound Lake
Reservoir Elev 1667.75
Capacity 92 046 Ac Ft
Dam
No 2
Pump House No 2
WHP 3210
Surge Basin
Eyebrow
Brownlee
Keeler
Mary
Tuxford
Darmoody
Eshbank
Rowletta
Forgrey
Archydal
Moose Jaw
Branch to Regina
Div No 2 5'0" Dia 30.2 Miles Lg
18.54 Miles Long
Regina
Milestone
Department of the Interior
Irrigation Office
Diagramatic Sketch
of
System Proposed for the
South Saskatchewan Diversion Project.
1913.

PART VIII.

WATER POWER

No. 1.

REPORT OF THE SUPERINTENDENT OF WATER POWER.

OTTAWA, March 31, 1914.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report concerning the Water Power Branch for the fiscal year ending March 31, 1914, together with the attached reports of the engineers in charge of divisions.

In the early part of the year, the head office of the branch moved into more commodious quarters in the Union Bank building, where every reasonable facility is afforded for the work. Several urgent additions have been made to the staff, partly by transfers from other branches of the department, but mainly by competitive examination through the Civil Service Commission of Canada. The most important transfer is that of Mr. Percy Wilkinson, from the Accounts Branch of the Interior to act as accounts clerk. Mr. Wilkinson has, by his long experience in the department, and his knowledge of accounting, proved a most efficient and effective member of the staff. Accountants have also been attached to the permanent offices in the west, and have, under Mr. Wilkinson's direction, worked out a simple and complete system of accounting and costing, which is of great benefit to the work generally, and, at the same time, has relieved the engineering executive officers of a great deal of difficult and tedious administration.

The work of draughting at head office under the direction of Mr. B. E. Norrish, M. Sc., Chief Draughtsman, has assumed very considerable proportions. At present, there are five draughtsmen engaged in the plotting of field notes and the preparation of final plans to accompany the various reports of the field engineers.

Very satisfactory progress has been made in all field work carried on under the direction of the hydraulic engineer, Mr. J. T. Johnston, whose report attached hereto covers this work in detail. The Hydraulic and Hydrographic Surveys in the provinces of Manitoba and British Columbia have been gradually extended and developed in a highly satisfactory manner. Full reports of this work are in the press and will be available for general distribution shortly.

The report on the extensive power and storage investigation of the Bow river above Calgary will be issued very soon. Realizing the importance of the Bow River waters to every phase of the development of the district through which it flows, and of the urgent necessity of having a practicable conservation scheme worked out, and put into practice without delay, the investigations covered by this report have been carried to completion with all reasonable thoroughness and every possible despatch. They have been exceedingly gratifying, showing that it is economically feasible to so regulate the flow of the Bow river by means of storage works in its upper waters as to warrant the development at six power sites of over 45,000 continuous 24-hour W.H.P., all within 50 miles of the city of Calgary. At the same time, it has been shown that the use of these waters for power purposes above Calgary need not conflict with the consumption of the same water below Calgary for irrigation purposes; rather would the regulation proposed for power purposes be a decided advantage to the extension of existing irrigation systems to their ultimate capacity, and would also ensure future encouragement for additional irrigation projects.

All the present power and storage projects within the Bow River basin have been authorized under the Dominion Water Power regulations, which provides for all that is essential in present-day conservation principles regarding water-power development in the way of limited grants, reasonable return to the Crown for the privileges, continuous control and periodic regulation of rates to consumers, the best possible physical use and continuous beneficial operation. Care has also been taken to make all the present power developments on this river conform to any future comprehensive scheme which may be put into practice.

All the field work in connection with the report of similar investigations of the Winnipeg river in the province of Manitoba have not yet been completed; but it is expected that a full report covering this work by Mr. Johnston will be ready for distribution during the coming fiscal year.

In connection with these surveys, it is very encouraging to know that a large power development proposed by the Winnipeg Power Company at Great Falls has been made certain, so far as its physical features are concerned, and commencement of construction work facilitated greatly by the complete surveys that have been carried on under Mr. Johnston's direction. Eminent engineering and financial authorities, connected with this proposed development, have spoken in the highest terms of the work done and the results accomplished.

During the year the Calgary Power Company has completed the construction of a 12,000 horse-power project at Kananaskis falls on the Bow river, which will be operated in conjunction with its other plant on the same river at Horseshoe falls. These two developments will be in a position to supply the local power market for several years to come.

Owing to financial stringency, the city of Prince Albert has been compelled to temporarily suspend construction operations on its hydro-electric development at La Colle falls, North Saskatchewan river. It is hoped that more favourable conditions will prevail in the near future, and that this very important and desirable project may be carried to successful completion.

Several important power development propositions have been before the department during the year to supply the Edmonton power market, but so far actual construction operations have not been commenced. The department has been called upon to make a very careful and complete investigation of the power and storage possibilities within economic radius of Edmonton. This has involved a great deal of difficult work in new and extensive territory which has been carried out in a quick and satisfactory way. A full report covering this work is appended. There is an enormous amount of very important and, in some cases, essential work which should be undertaken by engineers of this branch in connection with the hydraulic investigations of the three prairie provinces, but it has been found impossible to do so with the limited staff and funds available. A preliminary effort has already been made to cover the essential features of this new work, and it is confidently expected that it will be properly looked after within reasonable time. An effort has been made to begin a systematic study of evaporation, but this work cannot be properly organized until technical officers can be exclusively assigned for this work. Very satisfactory co-operation has been realized with the director of the Meteorological Service of Canada in connection with the extension of meteorological stations at strategic points for waterpower investigations. Effective co-operation of immediate benefit has been arranged with the director of the Geological Surveys of Canada in connection with the investigation of the branch, particularly with regard to Mr. Hendry's power and storage investigations on the Bow river. A full report by Mr. C. Camsell, B. Sc., Ph.D., of the Geological Survey, on the geology of the Bow River basin has been furnished for publication along with Mr. Hendry's report. A similar report is being arranged for the Winnipeg river investigations and will probably be published along with Mr. Johnston's report.

In connection with the Panama Pacific Exhibition at San Francisco, the four National American engineering societies have organized an International Engineering Congress. It has been deemed wise to take advantage of this occasion to have the water-power developments, and the latent power resources of Canada, made known in the best possible manner to the engineers who will attend. Arrangements have been made for Mr. C. H. Mitchell, of the firm of C. H. and P. H. Mitchell, Consulting Engineers, Toronto, to prepare and read two papers on the Water-powers of Canada. It is expected that engineers of the Dominion Water Power Branch will attend, and that some of the Provincial Government water-power engineers will also make a special effort to be present, with the express object of securing as much active interest as possible in the tremendous water-power resources of this country.

After a conference with Mr. William Hutchison, Canadian Exhibition Commissioner, arrangements were made to have an exhibit of the Dominion Water-Powers in the Canadian building at the exposition. This exhibit will take the form of a large panoramic landscape bird's-eye view painting of the whole Dominion from coast to coast, showing the main waterways of the country, the cities, railways, and general topographical and political features. On this map will be indicated in some manner the location of all the developed water-powers, and of as many of the undeveloped as possible, distinction being made between them. In front of this painting, which will be of a semi-circular form as is employed in cycloramas, there will be arranged a series of models of typical developed power plants from coast to coast. These models will be as accurate representations as possible of the originals, and will be chosen with the object of showing that practically every Canadian city to-day is furnished with hydro-electric power from contiguous plants of considerable magnitude. Probably this feature of the power situation in Canada is little appreciated, nevertheless it is a fact that, except a few cities in the middle prairies, there are power developments to-day distributing power to every city in Canada. Furthermore, these cities can be furnished with sufficient additional power for any growth that may arise during the next fifty years. For instance, Winnipeg has available dependable power within economic distance, from the Winnipeg river, sufficient to furnish all the energy required by a city larger than Chicago.

It is hoped that the money spent in connection with this water-power exhibit will cause many of the consulting engineers, who attend the Engineering Congress, to return home through Canada and visit some of the power developments and thereby realize the tremendous economic advantages that obtain for industrial and commercial growth in Canada to-day, and also of what is possible in the way of future development. If some of these eminent engineers who are often called into consultation in connection with investment of foreign capital in Canada, be made to understand the power situation in Canada and the possibilities of future development, it can be confidently expected that much foreign capital will be made available for the development of water-power and of allied commercial industries.

I have been credibly informed that as a direct result of the visit to Canada a few months ago of eminent geologists from all parts of the world. thousands of dollars of foreign capital have been invested in mining industries in Canada. The money spent by the Government in the entertainment of these geologists was therefore a very direct and profitable investment. It is hoped that as much will be realized from the money expended in connection with the engineering congress and the water-power exhibit at the Panama Pacific Exhibition.

Following a resolution passed at the last session of the Manitoba Legislature calling for a report by His Honour Judge Robson, the Public Utilities Commissioner of the province, on the water-power situation of Manitoba, this branch was called upon to furnish Judge Robson, by December 15, 1913, with a report on the power possibilities of the province. This entailed the organization of an elaborate, quick reconnaissance investigation of the less-known rivers of the province and the collation of all the available data of the better-known rivers. This was carried out in a very acceptable fashion by the Manitoba Hydrographic Survey engineers under the immediate direction of Mr. S. S. Scovil, the assistant chief engineer. A full report in the matter was presented to Judge Robson on December 15, and received his very flattering commendation. This report was in due course presented to the Provincial Legislature, along with Judge Robson's full report. Much of the material in the report has been specially requested by the Conservation Commission of Canada for inclusion in their forthcoming report on the water-powers of Western Canada.

The Conservation Commission also requested the undersigned to prepare a chapter for this same report on the water-powers of the Bow river: this has been done. In connection with the report of the same commission on the water-powers of British Columbia, a great deal of pertinent technical material has been furnished by the chief engineer of the British Columbia Hydrographic Survey, Mr. Swan, and will no doubt form a very important part of this report.

I regret to report the resignations of Messrs. P. A. Carson, B.A., D.L.S., Chief Engineer, Railway Belt Hydrographic Survey, Mr. D. L. McLean, B. Sc., Chief Engineer, Manitoba Hydrographic Survey, and Mr. H. E. M. Kensit, M.E., Electro-Mechanical Engineer of the branch.

Mr. Carson's connection with the various surveys of the department has been a particularly creditable one. He has occupied many technical positions of great executive and professional importance to the lasting benefit of the service. He has resigned to go into private practice in Calgary, Alta.

Mr. McLean has carried out some very difficult engineering investigations in a manner that has been very favourably commented upon by the eminent consulting engineers connected with the department, and in a way that has proven satisfactory to the department. He has left the service to accept an important professional appointment with the Greater Winnipeg Water Supply Commission.

Mr. Kensit's connection with the department, although brief, has been an unusually satisfactory one, and it will be very difficult, if not impossible, to secure another professional officer with similar capacity for careful and cautious detail investigation of economic engineering questions. Mr. Kensit has resigned his position to accept the office of City Commissioner of the corporation of Prince Albert.

I regret to report the death by drowning of G. H. Burnham and A. E. W. Hannington, engineers of the field staff, who lost their lives while actively engaged in the field.

Mr. William Ogilvy, D.L.S., who was connected with the Water Power Branch for the last two years, died in Winnipeg after a brief illness resulting from exposure in connection with survey work he was carrying on along the Winnipeg river. Mr. Ogilvy has occupied some of the most important executive positions in the gift of the Canadian Government with great credit to himself and to the Dominion of Canada. His association with the Water Power Branch has been an exceedingly pleasant and profitable one to all its officers, and it is with great personal regret that his loss has to be recorded.

In conclusion, I would state, that the fiscal year just ended has witnessed a steady and permanent increase in the efficiency and effectiveness of all branches of the work of the Dominion Water Power Branch. While the desired extensions of the scope of the work have not yet been reached, it is certain that they will be realized in due time.

I have the honour to be, sir,

Your obedient servant,

J. B. CHALLIES,

Superintendent.

No. 2.

REPORT OF B. E. NORRISH.

Office of Chief Draughtsman, March 31, 1914.

J. B. Challies, Esq., C.E.,
Superintendent, Water Power Branch,
Ottawa.

Sir,—I beg to submit the following statement of the work of this office for the fiscal year 1913-14:—

The work assigned to this office may be classified under three heads, viz:—

(1) The general draughting work; the compilation and drawing of original plans, maps, and diagrams to illustrate the reports of the branch; the preparation of these for reproduction by various processes, and their revision for publication.

(2) The filing of all the official plans in connection with the branch.

(3) The publication and distribution of reports.

In May, 1913, the Union Bank building having been completed, new quarters were secured therein for the draughting office which has, up to the present, provided the necessary space for draughting tables, filing cabinets, etc. At the same time, to meet the increasing demands of the work, a filing clerk and two draughtsmen were added to the staff. The accommodation for the winter months of the engineers engaged in the field during the summer, is somewhat difficult, entailing as it does the placing of six additional men in an office already well filled.

The draughting work in connection with the compilation of original plans, maps and diagrams, and general routine work, has continued to increase to such an extent that two additional draughtsmen are required to successfully cope with the work.

A small press is used giving great satisfaction, and saving much time in printing numbers and titles on plans for which purpose it is used whenever possible.

The installation of the photostat has done much to save time in the work of the branch by the rapidity with which the constantly increasing amount of copying is done. This demand for copies of plans, documents and printed matter of all descriptions, will necessitate many minor improvements and changes in the photographic room. It is not intended to discuss this work here, but the various features will be fully dealt with in a future report when all the improvements conducing to efficiency are completed.

A list of plans and maps prepared for publication during the past year is appended herewith.

A new filing system has been introduced and all original plans are filed flat in a large steel filing cabinet. This cabinet is made in sections, each section containing eighteen trays, each of which holds twenty-five plans. The plans are numbered consecutively in the order in which they are received. Two cards are made out for each plan, one for the numerical, and the other for the alphabetical index. The plans are also noted on group cards. The blue prints and vandykes are rolled on round sticks and kept in a pigeon-hole cabinet. This system of filing is very simple and efficient, not only preserving the original plans, but rendering the checking of the files at intervals a simple matter.

The publication and distribution of reports represents a very large amount of work in this office. In the last year in addition to the annual report, there have been published reports on the Railway Belt Hydrographic Survey, the Bow River Power and Storage Investigations west of Calgary, the Pasquia Reclamation Project, the South Saskatchewan Water Diversion Project, and the Manitoba Water-powers.

The above reports are published as Water Resources Papers, Nos. 1, 2, 5, 6, and 7, respectively. These reports contain on an average two hundred pages of printed matter, including many pages of tabulated stream measurement data.

Besides the printed matter of the above reports, one hundred and forty-four photo-lith. plans and maps required personal supervision.

A distribution list has been prepared and arrangements made for the sending out of these reports.

I have the honour to be, sir,

Your obedient servant,

B. E. NORRISH,

Chief Draughtsman.

LIST OF MAPS AND PLANS PREPARED FOR PUBLICATION DURING THE PAST YEAR.

Title.	Accompanying.
British Columbia Railway Belt, showing Hydrographic Survey District and Gauging Stations. Scale, 35 miles to 1 inch.	Annual Report, 1913.
Manitoba Hydrographic Survey, showing locations of Gauging Stations. Scale, 35 miles to 1 inch.	Annual Report. 1913.
Profile of Power Section of Bow River, showing Proposed and Existing Developments. Scales, Horizontal, 2¼ miles to 1 inch. Vertical, 85 feet to 1 inch.	Annual Report, 1913.
Plan of Winnipeg River basin. Scale, 50 miles to 1 inch..................	Annual Report, 1913.
City of Winnipeg Municipal Plant. General Layout. Scale, 950 feet to 1 inch.	Annual Report, 1913.
Winnipeg river. Profile showing Proposed and Existing Developments. Scales, Horizontal, 11½ miles to 1 inch. Vertical, 60 feet to 1 inch.	Annual Report, 1913.
Winnipeg river. Existing and Possible powers below Kenora. Scale, 17 miles to 1 inch.	Annual Report, 1913.
City of Prince Albert. La Colle Falls Development. General layout. Scale, 46 feet to 1 inch.	Annual Report, 1913.
City of Prince Albert. La Colle Falls Development. Typical section of Dam. Scale, 16 feet to 1 inch.	Annual Report, 1913.
Pitt Meadows Reclamation. Scale, 1 mile to 1 inch......................	Annual Report, 1913.
Sumas Dyking Project. Scale, 6 miles to 1 inch.........................	Annual Report, 1913.
Winnipeg Electric Railway. Pinawa Channel. General layout. Scale, 400 feet to 1 inch.	Annual Report, 1913.
Winnipeg Electric Railway. Pinawa Channel Sectional Plan of Power House. Scale, 16 feet to 1 inch.	Annual Report, 1913.
Winnipeg Electric Railway. Pinawa Channel. Section of Power House. Scale, 16 feet to 1 inch.	Annual Report, 1913.
Western Canada Power Company. Stave River Development Key Map. Scale, 2 miles to 1 inch. General layout. Scale, 400 feet to 1 inch	Annual Report, 1913.

LIST OF MAPS AND PLANS PREPARED FOR PUBLICATION DURING THE PAST YEAR—*Concluded.*

Title.	Accompanying.
Western Canada Power Company, Stave River Development General Plan. Scale, 40 feet to 1 inch.	Annual Report, 1913.
Western Canada Power Company. Stave River Development. General Section. Scale, 40 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Horseshoe Falls Development. General Layout. Scale, 400 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Horseshoe Falls Development. Plan of Power House. Scale, 20 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Horseshoe Falls Development. General Section. Scale, 16 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Horseshoe Falls Development. Plan of Intake. Scale, 20 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Kananaskis Falls Development. General Layout. Scale, 400 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Kananaskis Falls Development. Plan of Power House. Scale, 16 feet to 1 inch.	Annual Report, 1913.
Calgary Power Company. Kananaskis Falls Development. General Section. Scale, 16 feet to 1 inch.	Annual Report, 1913.
City of Prince Albert, La Colle Falls Development. General Section of Power House. Scale, 8 feet to 1 inch.	Annual Report, 1913.
Pasquia Reclamation Project. Plan of Cedar and Cross Lakes. Scale, 1,500 feet to 1 inch.	Annual Report, and Water Resources Paper No. 5.
Pasquia Reclamation Project, showing area flooded. Scale 6 miles to 1 inch.	Annual Report, and Water Resources Paper No. 5.
Pasquia Reclamation Project, Twenty-two Topographical Sheets showing detail Surveys. Scale, 400 feet to 1 inch.	Annual Report, 1914.
South Saskatchewan Water Diversion Project, Routes for Proposed City Water Supply. Scale, 11½ miles to 1 inch.	Annual Report, and Water Resources Paper No. 6.
South Saskatchewan Water Diversion . Sources of Fuel Power and Indications thereof. Scale, 35 miles to 1 inch.	Annual Report, and Water Resources Paper No. 6.
Index Map, Railway Belt Hydrographic Survey. Scale, 35 miles to 1 inch.	Water Resources Paper No. 1.
Port Moody Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch..	Water Resources Paper No. 1.
Yale Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch..........	Water Resources Paper No. 1.
Lytton Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch........	Water Resources Paper No. 1.
Kamloops Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch....	Water Resources Paper No. 1.
Sicamous Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch.....	Water Resources Paper No. 1.
Seymour Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch......	Water Resources Paper No. 1.
Donald Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch.......	Water Resources Paper No. 1.
Spillimacheen Sheet, showing Gauging Stations. Scale, 6 miles to 1 inch.	Water Resources Paper No. 1.
Manitoba Power Survey, showing water-powers of southern Manitoba. Scale, 19 miles to 1 inch.	Water Resources Paper No. 7.
Key Map of Bow River Basin (West of Calgary). Scale 4 miles to 1 inch..	Water Resources Paper No. 2.
Contour Map of Bow River Basin (West of Calgary). Scale, 4 miles to 1 inch.	Annual Report and Water Resources Paper No. 2.

No. 3.

REPORT OF PERCY WILKINSON.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I beg to submit the following report for the fiscal year 1913-1914.

SYSTEM OF ACCOUNTING.

For the better administration of the Water Power appropriation, the fiscal year is divided into four periods, each of three months. Advances are made to each of the chief engineers in charge of field parties, upon their furnishing the office at Ottawa with a statement, on a prescribed form, showing in detail for what purposes the advance is required. At the end of each period of three months, the accounts covering the period are prepared, and submitted to the Ottawa office, together with the requisition for a further advance to cover the succeeding period. Upon the receipt of these accounts at Ottawa, they are carefully checked and when considered to be in order are submitted to the superintending accountant for final examination.

GENERAL.

As a result of the increase in the technical operations, and the consequent increase in the accounting work in Manitoba and British Columbia, it was found necessary to appoint qualified accountants at Winnipeg and Vancouver. Mr. C. Greenwood was appointed to the Winnipeg office on September 30, 1913, and Mr. F. MacLachlan to the Vancouver office on January 1, 1914. Previous to these appointments being made, the chief engineer at each of the above mentioned places was considerably handicapped in his technical work as the accounts took up so much of his time.

During the month of March, 1914, a conference of the accountants of the branch was held at Winnipeg, at which matters relating to accounts, records of instruments and a system of costing were discussed. The advantages accruing from this conference are already making themselves felt; as a result the accounts reach the Ottawa office promptly, and in such condition that they are easily examined, and passed on to the office of the superintending accountant, without unnecessary correspondence and delay.

Number of accounts dealt with	425
Amount of accounts	$138,763
Number of cheques forwarded	716

STAFF.

The following statement shows the personnel of the staff employed on the inside and outside services, together with any changes that have taken place during the year:

STAFF REPORT FOR ANNUAL REPORT 1913.

LIST OF EMPLOYEES, Water Power Branch, giving the name, classification, and duties of office of each.

INSIDE SERVICE.

Name.	Classification. Division.	Sub-Division.	Duties of Office.	Remarks.
J. B. Challies, C.E.	I	B	Superintendent	
Correspondence.				
Miss C. J. McIlmoyle	3	A	Stenographer	
Mrs. I. G. Elwell	3	B	"	Resigned Oct. 18, 1913.
Miss E. A. McKenzie	3	B	"	
Miss M. M. Spence	3	B	"	From July 7, 1913.
Miss M. C. King	3	B	"	From Oct. 6, 1913.
Miss L. J. Barber	3	B	"	Transferred from the B.C. Lands Branch, Jan. 23, 1914.
Miss M. E. Murphy	Temporary.		"	Transferred from Immigration Br., July 25, 1913.
E. B. Boselly			Messenger	
Accounts, Supplies, etc.				
Percy Wilkinson	3	A	Accountant	Transferred from Accounts Br., July 28, 1913.
Drafting Room.				
B. E. Norrish, M.Sc	2	A	Engineer in charge	
A. M. Beale, B.Sc	2	A	Engineer	
F. W. Brander	2	B	Draughtsman	
G. E. Jones	2	B	"	
W. L. Brown	2	B	"	From Aug. 12, 1913.
S. Witten	2	B	Clerk	Transferred from Forestry Br., July 28, 1913.
Inspection of Construction.				
R. S. Stronach	2	B	Engineer	Transferred to Dom. Parks Br., Nov. 1, 1913.

STAFF REPORT FOR ANNUAL REPORT, 1913—*Continued.*

LIST OF EMPLOYEES, Water Power Branch, giving the name, classification, and duties of office of each—*Continued.*

OUTSIDE SERVICE.

Name.	Duties of Office.	Remarks.
Head Office.		
J. T. Johnston, B.A.Sc.	Hydraulic Engineer	
J. R. Bissett, B.A.Sc.	Engineer	Appointed May 13, 1913.
H. Edmondson	Engineer	" July 4, 1913. Resigned Jan. 1, 1914.
W. Cook	Clerk	Appointed Nov. 17, 1913.
Manitoba Hydrographic and Power Surveys.		
D. L. McLean, B.Sc.	Chief Engineer	Resigned Nov. 1, 1913.
S. S. Scovil, B.Sc.	Asst. Chief Engineer	
G. H. Burnham, B.A.Sc.	" Engineer	Drowned July 15, 1913.
S. C. O'Grady, B.Sc.	" "	
A. E. W. Hanington, B.Sc.	" "	Drowned Aug. 22 1913.
A. Pirie	" "	
D. B. Gow, B.Sc.	" "	
G. J. Lamb	" "	To October 13, 1913.
E. E. Bankson	" "	From Apr. 15, 1913. Resigned June 12, 1913.
M. S. Madden, B.Sc.	" "	Appointed Apr. 27, 1913.
T. J. Moore, B.Sc.	" "	" May 7, 1913.
W. J. Ireland, B.Sc.	" "	" July 28, 1913.
H. M. Nelson	Junior Asst. Engineer	Resigned June 21, 1913.
Frank Allan	" " "	Appointed May 12, 1913.
Claud Allen	" " "	" June 1, 1913.
P. J. Barry	Draughtsman	
E. B. Chalmers	"	
A. P. Smith	"	
F. S. Smith	"	Appointed Apr. 14, 1913.
C. Greenwood	Accountant	" Sept. 30, 1913.
W. H. Bartlett	Clerk	" June 5, 1913.
J. Jarrett	Stenographer	" June 1, 1913.
Temporary Clerks.		
W. H. Wallace	Asst. Engineer	Appointed Sept. 1, 1913. Made permanent Mar. 1, 1914.
C. V. Cameron	" "	Appointed Sept. 9, 1913. Made permanent Mar. 9, 1914.
E. J. Budge	" "	From Sept. 26, 1913, to Jan. 3, 1914.
G. Ebner	" "	From May 15, 1913, to Sept. 13, 1913.
A. E. Sidford	Draughtsman	From Sept. 9, 1913 to Feb. 28, 1914.
C. Hayes	Stenographer	June 7, 1913.
S. W. A. Mackey	Stenographer	From Sept. 24, 1913.

STAFF REPORT FOR ANNUAL REPORT, 1913—*Continued.*

LIST OF EMPLOYEES, Water Power Branch, giving the name, classification, and duties of office of each—*Continued.*

OUTSIDE SERVICE.

B.C. Hydrographic Surveys.

Name.	Duties of Office.	Remarks.
P. A. Carson, B.A., D.L.S.	Chief Engineer	Resigned Sept. 1, 1913.
R. G. Swan, B.A.Sc.	Asst. Chief Engineer	Appointed June 1, 1913.
C. G. Cline, B.A.Sc., D.L.S.	Asst. Engineer	
C. E. Richardson, B.A.Sc.	" "	
E. M. Dann, D.L.S., Grad.S.P.S.	" "	
C. E. Webb	" "	Appointed Oct. 29, 1913.
H. J. Keys, B.A.	" "	
K. G. Chisholm	" "	Appointed Apr. 7, 1913.
H. C. Hughes	Junior Asst. Engineer	" May 13, 1913 to Aug. 23, 1913.
J. A. Elliott	" " "	Appointed May 4, 1913 to Sept. 17, 1913.
F. MacLachlan	Accountant	Appointed Jan. 1, 1914.
Miss B. B. Allan	Stenographer	
Miss W. M. Robinson	"	" Nov. 15, 1913.
Bow River power and storage surveys.		
M. C. Hendry, B.A.Sc.	Chief Engineer	
C. H. Attwood, O.L.S.	Asst. Engineer	
B. Hogarth, B.A.Sc.	" "	May 1 to Oct. 10, 1913.
Construction.		
(*a*) Coquitlam Dam,— R. S. Stronach	Inspecting Engineer	Transferred to Dom. Parks Br., Nov. 1, 1913.
A. T. Milner	Clerical Asst.	Transferred to B.C. Hydrographic Survey, Nov. 1, 1913.
(*b*) La Colle Falls Power Plant,— E. B. Patterson	Inspecting Engineer	Transferred to Man. Hydro. Survey, Aug. 31, 1913.
(c) Kananaskis Falls Power Plant,—		
K. H. Smith, B.A.	Inspecting Engineer	To Dec. 31, 1913, employed Jan. 1 to Mar. 31 on Panama Pac. & Wpg. Indust. Exhibit.

STAFF REPORT FOR ANNUAL REPORT, 1913—*Continued.*

LIST OF EMPLOYEES, Water Power Branch, giving the name, classification, and duties of office of each—*Continued.*

Reclamation.

Name.	Duties of Office.	Remarks.
T. H. Dunn, C.E., O.L.S.	Chief Engineer	
O. W. N. Charlton, B.A.Sc.	Assistant Engineer	
J. D. Gardner, B.Sc.	" "	From May 14 to Oct. 10, 1913.
L. B. Lytle	Jr. Asst. Engineer	" May 22 to Sept. 30, 1913.
J. L. Alton	" "	" " "
J. C. Wilson	" "	" " "
J. A. Owens	" "	" " "
Philip Earnshaw	" "	" June 4 to Sept. 30, 1913.
South Saskatchewan Water Supply Diversion Project.		
H.E.M.Kensit,Mem.Inst.E.E. Mem. Am. I.E.E.		Resigned June 20, 1913.
International Waters Investigations		
G. G. McEwen	Engineer	From June 1. 1913.

Board of Consulting Engineers.

J. R. Freeman, C.E., Providence, R.I.
C. H. Mitchell, C.E., Toronto.
J. B. McRae, C.E., Ottawa.

I have the honour to be, Sir,
Your obedient servant,
PERCY WILKINSON,
Accountant.

No. 4.

REPORT OF A. M. BEALE.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—In my report on small water-powers (See No. 3, Part VIII, Annual Report, 1913) I had the honour to recommend that a technical officer of this branch should inspect every site for which an application is received, that a careful study be commenced of the whole question of small powers, and that, until a fixed policy is formulated, no small water power privileges be given without an inspection by a technical officer of this department. In August, 1913, an Order in Council was passed amending the water-power regulations, so that powers of less capacity than 200 horsepower can be readily dealt with. Consequent on this legislation, the recommendations mentioned above were approved, and, acting upon your instructions, I left for the west on October 8, 1913.

I was instructed to inspect some twelve sites, for which application had been made to the department, with a view to making definite recommendations thereon and to inspect certain small water-powers that had actually been developed in the Dominion parks and in British Columbia; facilities were also given for interviewing any authorities who were reasonably accessible from my line of travel. Since returning to Ottawa in December, 1913, I have made a study of small powers,—water, oil, steam, &c.— with special reference to the needs of farmers, and have already submitted a full report of my investigations (See Part 13, hereunder); it will be sufficient here to summarize the results.

The study of small water-powers was instituted in the hope that at many places a cheap and convenient source of power for the farm might be found. It was particularly desired to investigate the conditions in the settled portions of Manitoba, Saskatchewan, and Alberta, where power facilities would be a decided boon to the farmers. A careful study of physical conditions of stream flow in the prairies soon made it plain that suitable sites for the development of a small amount of water-power would be few. The conditions may be briefly set forth as follows:—

1. *Flow.*—The stream-flow in prairie streams varies between wide limits and a ratio of 100 or more to 1 between maximum and minimum flow in any season is quite a regular occurrence. In April or May a stream will frequently overflow its banks, whereas in February the flow may be completely checked, or at most be a mere "trickle."

2. *Fall.*—The gradient of the stream bed is generally slight, no abrupt fall is found, and rapids are inconsiderable, those that are found being as a rule produced by gravel or sand-bars.

3. *Banks.*—These are frequently of easily eroded material, and cannot be regarded as permanent, even under natural conditions. The obstruction of flow by a dam would, in many cases, make it necessary to ensure the stability of the banks by protective work of some kind; this would entail almost prohibitive expense.

4. *Dam.*—The foundations of the dam would, at the best, consist of impervious clay underlying a layer of sand and gravel of from 2 to 8 feet thick; in some cases this clay will be 2 or 3 feet thick, only, with gravel or sand beneath. If it were desired to secure a head of 10 feet, the absence of actual fall and the depth to impervious foundations would require a structure 12 feet or more in height. The structure would require to be strong and the downstream toe amply protected against scour. The discharging capacity provided would have to be very large, to provide passage for the spring floods which would otherwise not only endanger the stability of the dam, but might overflow the banks above the dam and cut a channel completely around it. The cost of such a structure would be excessive.

It will be seen, therefore, that the power available is very variable, being almost negligible during the middle of winter; that the development is liable to meet with disaster unless particular precautions be taken, and that the cost will probably be out of all proportion to the value of the power which will be continuously available. There are, of course, a few exceptions where one or all of the above conditions are modified, to such an extent that the development of a small water-power may be feasible. It has been noticed that the average settler is liable to overestimate the power and underestimate the cost; it is therefore respectfully urged that no development be authorized except after inspection and recommendation by a technical officer of this branch. This officer should base his recommendations upon (1) the engineering feasibility; (2) the financial expediency; (3) the possibilities of other sources of power in the locality; (4) the personal skill and resources of the applicant. It is thought that approval should be withheld, unless the inspector is satisfied that the development will prove cheap, reliable, and of real service to the applicant.

In the region north of the prairies, the conditions of stream-flow set forth above are considerably modified. I have seen many places in Northern Alberta and Saskatchewan, where a small amount of power could be easily and cheaply developed; but, at the present time, the region is unsettled and there is little demand for power. For the present therefore the question of small powers in Northern Manitoba, Saskatchewan, and Alberta is not pressing. Conditions alter largely in passing to the mountainous portions of Alberta and to British Columbia. High head, permanent banks, and rock foundations are everywhere to be found. The precipitation is high, but the intense cold at the higher altitudes frequently seriously checks the winter discharge.

The eastern slope of the Rockies is mainly included in Dominion parks, so that there are no small individual interests to be considered. The existing hydrographic organization of British Columbia is probably best fitted to supervise small water-powers in that province. It is suggested that some unbiassed engineering advice might be made available there, for the man who contemplates developing a small water-power. I came across a development which, although excellent from an engineering standpoint, and not unduly costly, was nevertheless a financial burden to the owner, who had developed an amount of power out of all proportion to the requirements of the locality. I was much impressed by the possibilities for small powers along the British Columbia coast, where many have already been developed in connection with the salmon canning industry. The conditions seem almost ideal, excessive precipitation, high heads, mild winters, rocky gorges forming ideal dam sites, and frequent storage facilities.

With regard to the power prospects for the western farmer it is considered that, under present circumstances, the best source is the gasoline or oil engine. It is not thought that electric power will have a widespread application until central station service at reasonable cost becomes available. In some cases, where cost is not a prime consideration, it is possible that a gasoline electric set with storage batteries, switchboard, lighting fixtures, motors, and other electric accessories, may be installed, entailing a capital cost of anything up to $3,000 and an annual cost of (including fixed and running costs) up to $1,000, depending on the completeness of the installation, and the demands placed upon it. It is thought that the average demand for power will be met by the cheap gasoline engine mounted on a skid; this engine could be easily moved about and will furnish power for wood-cutting, feed-grinding, etc. A gasoline engine can now be purchased at a cost which most settlers can well afford; the very cheap make of engine may not perhaps be particularly reliable or efficient, while a thoroughly reliable engine is by no means expensive. An automatic gasoline-electric lighting set is now on the Canadian market, and is proving successful for lighting hotels and small settlements in the West. In the East it has been installed at some summer homes, and, where purchased power is not available, has proved of value for dairy-farms, both for lighting the barns, and providing power for the milking machines, separators, churns, pumps, etc.

I would draw your attention to the fact that while the above recommendations and statements in general are based on present conditions, these conditions are constantly changing. I beg to recommend, therefore, that the technical officer who has charge of the small water-power work be instructed to keep abreast of development, and keep the figures contained in my full report up-to-date. If this be done, it will be possible, when inspecting a site for which application has been made, to furnish valuable advice as to the various methods of developing farm power and their cost.

I have the honour to be, sir,

Your obedient servant,

A. M. BEALE,

Engineer.

No. 5a.

REPORT OF J. T. JOHNSTON.

General Report on Outside Field Work.

Ottawa, March 31, 1914.

J. B. Challies, Esq.,
Superintendent, Water Power Branch,
Ottawa.

Sir,—I have the honour to submit herewith the following report regarding the field organization and the general work carried on under the jurisdiction of the Water Power Branch during the past year.

HYDROGRAPHIC SURVEYS.

British Columbia Hydrographic Survey.

During the first half of the past fiscal year, the Railway Belt Hydrographic Survey was continued much along the lines of the preceding year. Full and careful measurements were continued on all rivers and streams calling for consideration in the interests of water supply, irrigation, or power, and new stations were established wherever requirements demanded.

At the end of September, 1912, Mr. P. A. Carson resigned from the position of chief engineer of the Railway Belt Hydrographic Survey, in order to enter private practice, and was succeeded by the assistant chief engineer, Mr. R. G. Swan. During August, an agreement had been reached between the province of British Columbia and the Dominion Government, whereby the Railway Belt stream-measurement work should be enlarged to cover the entire province. The principal clauses of this agreement were, that the Water Power Branch should assume responsibility for all hydrographic survey work in the province, and should gradually extend the Railway Belt work to cover the enlarged field. In order to be in closer touch with the provincial authorities, the headquarters of the survey were moved from Kamloops to Vancouver, and, for the purpose of economy and convenience of field organization, the territory was divided into three divisions, each under charge of a divisional engineer, all under the direct supervision of the chief engineer at Vancouver. The name of the survey was to be changed to the British Columbia Hydrographic Survey, and the field organization was given responsible charge of all general hydrographic work, both for the Dominion and the province, the work for the province to be carried on, in extent and nature, to the satisfaction of the provincial authorities.

The provincial district engineers and assistants were, so far as possible, consistent with their duties under the Provincial Water Act, to co-operate with the hydrographic field engineers, and the Provincial Government was to financially co-operate with the Dominion for the carrying on of the work during the succeeding fiscal year, upon a basis to be later determined.

During the months following, this agreement was put into active operation in so far as the vote available would permit. The office of the chief engineer was removed to Vancouver, and the division offices were established. Considering the handicap caused by lack of funds, very satisfactory progress was made in laying the foundation for the new work, as will be seen by reference to Mr. Swan's full report (No. 6), and the accompanying key plan hereunder.

The first stream measurement report for the Railway Belt, covering the measurements up to the end of the year 1912, is now being printed as Water Resources Paper No. 1, and should shortly be ready for distribution. Rapid progress is also being made in preparing the second report to the end of 1913. The text of this report which will be issued as Water Resources Paper No. 8, is now practically prepared, and will be submitted to the printers very shortly.

Manitoba Hydrographic Survey.

The stream measurement work in Manitoba has been carried on vigorously and continuously during the past year. Up to November 1, the work was under charge of Mr. D. L. McLean as chief engineer, and, after his resignation on that date, was carried on by Mr. S. S. Scovil, the assistant chief engineer. The entire work has progressed in an entirely satisfactory manner, and continuous records of the run-off of all the rivers of any importance within the settled portion of Manitoba are now being secured. In addition to these rivers, miscellaneous measurements have been made on the rivers along the eastern and northern shores of lake Winnipeg. These rivers are difficult of access, and lack of settlement and transportation facilities has, up to the present, rendered the securing of continuous measurements impracticable. Readings have, however, been obtained under both summer and winter conditions, and an approximate estimate of the discharge available for power is now possible. The Nelson river is also receiving attention, and during the coming season, a regular metering station will be installed thereon to secure a continuous record of its flow. The first stream measurement report for the province of Manitoba is now in course of preparation, and will be issued as Water Resources Paper No. 4.

General Notes.

One of the interesting features, in connection with the hydrographic survey work, is the evaporation station which has been established on the Lake of the Woods near the entrance to Portage bay. This station has been very fully equipped, and a complete record is being secured not only of the evaporation, but also of rainfall, temperature, humidity, and meteorological conditions generally.

The evaporation data were especially desirable in connection with the Winnipeg river power studies, and the location selected is well representative of the conditions throughout the entire central portion of the basin. The partially submerged tank is located on a raft suitably constructed to protect it from wave action. Careful daily readings of all the instruments, and of the evaporation losses, are kept by the field officers of the branch, and the results being gathered will form an exceedingly valuable addition to the general meteorological information, now available in the district.

The enamelled staff gauges, which were commented on in the last annual report, have been adopted throughout all stream measurement work carried on by this branch, with most satisfactory results. The gauges are cheap, light, and durable, and steps are being taken to secure additional units to record in all a twelve foot variation.

It is proposed to install four automatic water stage registers during the coming season, at points requiring especially accurate records. These gauges will be placed on the Adams river in British Columbia, on the Winnipeg river at the Slave falls metering station, on the Lake of the Woods at Kenora and on Lac Seul. At all these locations, especial conditions exist which call for more accurate water level records than can be secured by ordinary gauge reading methods.

Recommendations as to Future Work.

In British Columbia, it is highly important that aggressive steps be taken towards establishing stations on the principal rivers in the northern portion of the province. Due to lack of transportation facilities, this will, in places, be difficult to inaugurate and to maintain. At the same time, it is possible to commence a systematic campaign on the more important rivers and streams, and the gradual expansion of the work, as the country becomes more settled, will naturally follow. These rivers in the north form the basis of the future industrial life of that section of the province, and too early steps cannot be taken towards securing an accurate knowledge of their discharge.

Similar conditions exist in northern Manitoba, and a similar policy of expansion is contemplated, as access to the rivers becomes available through the construction of the Hudson Bay railway. The Nelson river is particularly important with its almost unequalled power resources. The establishment of a permanent gauging station on this river during the coming season is particularly recommended, although some difficulty will probably be experienced in locating a suitable and accessible station.

POWER AND STORAGE SURVEYS.

Manitoba.

The field surveys in connection with the power and storage investigations of the Winnipeg river have been practically completed during the past year. One small gap in the bank contours, just above the diversion weirs of the Winnipeg Electric Railway Company, still remains to be closed. When this is done, the plans will embody a complete contour survey of the Winnipeg river, from the mouth to the municipal plant of the city of Winnipeg at Point du Bois. In addition, there are sufficient data now in the department to compile topographic sheets showing the flooded lands above the city plant. Further detail work may be required along the Pinawa channel, in order to finally deal with the lands flooded by, and required for, the Winnipeg Electric Railway Company in connection with their Pinawa plant, but the essential portion of the field survey may now be considered complete.

A continuous study has been under way in this office based on these plans, looking to the insuring of a broad scheme of hydro-electric development covering the entire river in Manitoba. Work on this is now rapidly approaching completion, and the results to date are covered in detail in Section 5b of my report. The final report will be published at an early date as Water Resources Paper No. 3.

Throughout the past season,. an active field compaign of power investigation has been carried on, in connection with the smaller rivers throughout the southern portion of the province of Manitoba. The rivers surveyed in this work are the Assiniboine in the vicinity of Brandon, the Little Saskatchewan, Mossy, Valley, Dauphin, Fairford, Manigotagan, Whitemouth, and Brokenhead. These surveys are fully covered in Mr. Scovil's report, No. 7. The work was entirely of a reconnaissance nature carried on by light field parties. The object in view in all cases was not the mapping out of a definite hydro-electric scheme of development for each of the rivers in question, such as was being undertaken on the Winnipeg, but rather the determination of the existing power opportunities, and the securing of sufficient information to estimate, with fair accuracy, what would be involved in the way of cost and of construction, in connection with their development. The low discharges, which have been recorded during the past year, have tended to discourage the hope of extensive power resources on a large number of the rivers in the southern part of the province; but considerable possibilities exist in the way of development in conjunction with auxiliary power, or from the discharge alone during the open season. Other rivers due to storage possibilities show much better prospects. Persons interested in hydro-electric development on these smaller rivers of the province should communicate with the Water Power Branch, and secure definite information as to their possibilities before undertaking extensive expenditures.

Alberta and Saskatchewan.

During the past season, extensive field investigations of the various power and storage prospects in Alberta and Saskatchewan have been carried on by a light field party under Mr. M. C. Hendry as chief engineer. These investigations have been of two natures: first, the inspection of projects for which application had been made to the department; and second, the investigation of power and storage prospects which were of immediate importance to the general power situation.

The work did not involve any prolonged or detailed field work at the sites investigated, such as was necessary in the Bow river work, and hence called for an entirely different mode of attack. The field work was more of a reconnaissance nature, and was carried on by a small mobile party, thus cutting down transportation charges to a minimum. As a result, the extensive campaign marked out at the commencement of the season has been satisfactorily completed in a most economic manner. The data collected are first hand, and form a reliable basis upon which the policy of the department can be administered in the district in question. Full details of Mr. Hendry's work are supplied in his report, see No. 8.

Bow River Power and Storage Investigations.

The report on the Bow river power and storage investigations, under final revision during the past season by Mr. M. C. Hendry, chief engineer in charge of the work, deals with the Bow river basin above Calgary, and is exceedingly comprehensive in scope, covering in detail the entire ground, from the events leading to the inauguration of the work to the final conclusions and recommendations with respect to the departmental policy for the proper administration of the power situation covered. The principal features of the report are the new power sites discussed, and storage basins proposed. These have been summarized in the following tables.

STORAGE DEVELOPMENT.—*Table No. 1.*

Site.	Capacity Acre-feet.	Estimated Cost.	Cost per Acre-foot.
		$	$ cts.
Bow lake	27,400	105,000	3 83
Spray lake	171,000	514,000	2 98
Minnewanka	44,700	145,000	3 24
" with auxiliary	58,900	145,000	2 96
Elbow river	23.000	200,000	8 70

POWER DEVELOPMENTS.—*Table No. 2.*

Bow river.

Site.	Head in feet.	Continuous output wheel horse-power.	Estimated cost of plant including cost of storage.	Estimated cost of power per K.W. hr. delivered in Calgary on 50 p.c. load factor basis including storage transmission lines, etc.
			$	$ cts.
Bow fort	66	9,000	924,970	0 49
Mission	47	6.410	851,100	0 60
Ghost	50	7,275	892,500	0 57
Radnor	44	6,400	807,460	0 59
Cascade river.				
Minnewanka dam	54	1,165		
Elbow river.				
Canyon site	215	3,900		

Full estimates of the cost of both the respective sites and the proposed storage reservoirs, together with the proposed layouts of dams and power stations, form the most interesting feature of the report. The text is illustrated by some fifty plates and diagrams, and the whole forms a most thorough study and analysis of the power situation in the district.

This Bow river report will be published in the near future as Water Resources Paper No. 2.

Recommendations for Future Work.

During the coming season the following investigations into power and storage possibilities in the West are recommended, in order to supplement the data now on hand in this office necessary for the proper administration of the water-power resources of Manitoba, Alberta, and Saskatchewan:—

(1) A reconnaissance survey of the north branch of the North Saskatchewan river from Prince Albert to the mouth of the Sipanok channel. The data required here could be based upon plans now in the possession of the department and could be secured by a small party involving but little expenditure.

(2) An investigation into the storage possibilities of the lakes to the north of Prince Albert with a view to ascertaining the possibilities of diverting their flow to the North Saskatchewan river in order to increase the low water discharge of the same. This matter has been particularly pressed by the municipal authorities of Prince Albert in connection with their hydro-electric undertaking at La Colle falls.

(3) An inspection of the possibilities of Jackfish and Beaver Hill lakes, and also of what is known as the Kootenay plains reservoir in further connection with storage investigations along the North Saskatchewan river.

(4) A reconnaissance investigation of the new power site now under consideration at the Rocky rapids on the North Saskatchewan river.

(5) A further investigation into the power and storage possibilities of the Red Deer river, giving particular attention to storage possibilities in Gull lake and power possibilities at the Canyon site.

(6) An investigation of the possibilities of power along the Brazeau river in connection with applications now before this branch.

(7) A further investigation of the possibilities of power development along the Bow river in the immediate vicinity of Calgary, in connection with applications now before this branch.

(8) An inspection of small power applications along the Shining Bank creek.

(9) A reconnaissance power and storage survey of the possibilities of the Bloodvein, Berens and Pigeon rivers flowing into the eastern side of lake Winnipeg.

(10) A reconnaissance of the English river and basin, mainly with a view to ascertaining its storage possibilities in the interests of the powers on the Winnipeg river in Manitoba.

CONSTRUCTION WORK.

Coquitlam Dam.

The hydraulic-fill Coquitlam dam, which has been under construction at the south end of Coquitlam lake by the Vancouver Power Company, is now completed. The purpose of the dam is to raise the level of Coquitlam lake some 60 feet and thereby store the surplus run-off for power purposes, in connection with the company's plant at Burrard Inlet. A tunnel from Coquitlam lake through the mountains to Buntzen lake, the direct balancing reservoir, supplies this stored water as required.

The preliminary work in connection with the construction was laborious and long drawn out, due to the difficulty of transportation, and to the protective measures which were enforced by the department for the safeguarding of the dwellers in the valley below the dam, and of the water supply of the city of New Westminster. The work of actually sluicing the material into the dam was begun on October 7, 1912, and was continued without interruption until July 8 of the following year, at which date the dam was completed. A total volume of 427,000 cubic yards of material was placed in the dam during these nine months. This shows a most satisfactory rate of progress, once the initial preparations had been completed. Mr. R. S. Stronach continued in his duties as resident inspecting engineer until the completion of the dam, and forwarded to this office, and to Mr. Freeman, consulting engineer to the department in this connection, his weekly progress reports, covering thoroughly all features and conditions involved in and covered by the construction of the dam. The services of Mr. Freeman were retained until the completion of the dam, and he paid his final inspection visit in company with the undersigned on April 11 and 12 last. Mr. G. R. G. Conway, chief engineer of the Vancouver Power Company, Mayor Gray, Alderman Bryson, and City Engineer Blackman of New Westminster were also present during this inspection. The dam was, at this time, at elevation 491, i.e., 12 feet below regulated level. The result of the inspection was entirely satisfactory to all concerned. A full history of the construction of the dam is given in Mr. Beale's digest of Mr. Stronach's final report, No. 9*b* hereunder. The final report of Mr. Freeman is also attached herewith, and is worthy of careful consideration by all who are interested in the dam and the water supply of New Westminster.

Kananaskis Power Plant.

At the time of writing the last annual report, the initial work on the construction of the hydro-electric plant at Kananaskis falls on the Bow river by the Calgary Power Company had been started. This plant is designed to operate in conjunction with the company's first plant built at the Horseshoe falls. Mr. K. H. Smith, of the field engineering staff of the Water Power Branch, was appointed to the position of resident inspecting engineer during construction, to properly safeguard the interests of the department. He proceeded to the ground towards the end of April, and forwarded to this office full and satisfactory weekly progress reports up to the date of the completion of the dam.

The plans submitted by the company called for the development of a head of 70 feet. The general scheme of layout required a dam across the crest of the falls raising the pond to regulated level, a power canal 700 feet in length on the right bank, and a power station in partial excavation, with tunnels leading to and from the turbines, the discharge taking place below the falls. In view of the uncertainty as to the foundation conditions, it was deemed advisable that the department should secure an expert opinion regarding the safety measures to be required for the proper protection of all interests concerned. To this end, the services of Mr. Freeman, as consulting engineer, were secured, since he was already acquainted with the locality and general conditions, having revised the plans of the Horseshoe falls plant about three miles below, and since his inspection could be timed to coincide with his visit to the Coquitlam dam. Mr. Freeman's visit to the site was made on April 7, 8 and 9, in company with the undersigned. As a result of his visit, he submitted definite recommendations, looking to the safeguarding of the structures. These recommendations dealt principally with the drilling and grouting of the foundations, the thickening of the spillway section, and the proper regulation of the pond level, looking to the protection of the Canadian Pacific Railway bridge across the Kananaskis river, a short distance above the site. All these recommendations were subsequently carried out by the company. An alternative site for the dam about 550 feet below the one adopted was also recommended by Mr. Freeman, as offering cheaper construction and more direct regulation. In view, however, of the headway which had been made at the upper site, the latter recommendation was not adopted by the company, and was not pressed by Mr. Freeman.

The general course of construction was rapid and most satisfactory. It was essential that the plant should be completed for the heavy winter load, and every means was adopted to achieve this end. As a result, the plant was finally completed in December and the power first placed on the transmission lines on December 27.

Mr. Smith's final report on the construction of the plant is attached as No. 11.

City of Prince Albert Power Plant.

The Prince Albert municipal power undertaking is located at the La Colle falls. on the North Saskatchewan river, about 26 miles east of the city. Preliminary work on this plant was started in the spring of 1912, although it was well on towards the following winter before active construction operations of any magnitude were undertaken. The general layout consists of a lock adjacent to the right bank of the river. a hollow reinforced dam spanning the channel, a stoplog controlled intake on the left bank, a power canal 2,000 feet in length leading to the power station and an excavated tailrace to the river below the falls.

Mr. E. B. Patterson, who acted as resident inspecting engineer for the department throughout the construction operations, forwarded to this office his weekly progress reports covering, in a satisfactory manner, the entire work. Very good progress was made throughout the winter and during the following season of 1913. The writer visited the site on April 23 and 24. Unfortunately, a break in the coffer dam, on the previous day, had flooded the site of operations on the dam itself. Apart from this temporary mishap, the work was being prosecuted vigorously and satisfactorily, with every prospect of a successful termination.

Unfortunately, due to the financial depression, which became increasingly manifest throughout the latter part of the summer, the city was compelled to shut down construction on the entire project. Instructions to this effect were issued to the city authorities towards the end of July, and steps were taken to protect the uncompleted works until such time as operations could be recommended. The dam at this stage was completed from the right bank to a point about half way across the channel. The protection of this section, from the possibility of damage in flood season, called for careful consideration on the part of both the city and the Ambursen Company. who held the contract for the building of the dam. Efficient steps were taken in this direction and no ill effects have resulted to date. Careful oversight on the part of the city should however be maintained, in order to ensure that the protective structures built are not allowed to deteriorate, or that the sluice openings left in the dam for the passage of flood waters do not become choked or fall into disuse.

Mr. Patterson's report, up to the shutting down of the work, is attached as No. 10.

Du Bonnet Falls Development.

Numerous applications of conflicting character have been before the department from time to time, looking to the development of the Du Bonnet falls on the Winnipeg river. It was largely to establish a definite basis of development along this reach in conjunction with the other rapids and falls of the Winnipeg river, that the extensive field surveys along the river were undertaken. The various proposals along the river from Lac du Bonnet to lake Winnipeg involving a total drop of one hundred and ten feet, have been thoroughly examined and a final scheme of comprehensive development decided upon.

This result had just been satisfactorily achieved, when the department was called upon to deal with an application looking to immediate construction. This application was that of the Winnipeg River Power Company, to whom all rights for the development of the Du Bonnet falls had been assigned in July, 1913, by the parties previously in control. Fortunately the department, as a result of the surveys of the Water Power Branch, was in a position to immediately deal with the situation. The company was ready to organize its final engineering investigation into the project toward the end of August, and the writer proceeded to Winnipeg with detailed reports and plans covering a scheme of development, which the department was prepared to authorize. A full discussion was held on November 3 with the directors of the company, and the departmental proposals were fully explained. These proposals, it may be said, conflicted very materially with those previously considered, which were based on private investigation, and had in view the development of a particular site, without regard to the power properties and capacities of the balance of the river. The conference was entirely satisfactory, and the departmental plans and reports were left with the directors, for submission to their engineers.

The engineers of the company proceeded to carry on very extensive field investigations throughout the winter season, with a view to gathering such additional detail as was necessary, and which was not already incorporated on departmental plans, and also with a view to checking up and tying in, without a possibility of mistake, the entire field data in the vicinity of the proposed development. These field investigations are still under way, and are not likely to be completed for some little time. In the meantime, it is satisfactory to note that the company's engineers have advised that the previous plans and schemes of development be abandoned, and that the company accept the principles of development laid down by the department.

The successful issue which has been reached in securing the proper development of this site, as a component unit of the broad scheme of hydro-electric development, which has been mapped out for the Winnipeg river, already more than justifies the power survey of the river which has just been completed, the full report of which is now being prepared for publication as Water Resources Paper No. 3.

Proposed Cascade Power Plant.

Advantage was taken by the department of the construction, by the Calgary Power Company, of the Minnewanka dam at the outlet of lake Minnewanka, to provide for the creation of a small hydro-electric power, available for utilization in the Rocky Mountains park in and around Banff. Rights were retained by the Crown to withdraw 150 second-feet from the lake at all seasons for this purpose. In addition to this, an auxiliary storage of some 14,000 acre-feet was also available to the department. A normal head of 64 feet can be economically developed at this site. The preparation of final plans and specifications for the power plant was placed in the hands of Mr. C. H. Mitchell, of the engineering firm of C. H. and P. H. Mitchell of Toronto, and a member of the board of consulting engineers retained by the Water Power Branch. Mr. Mitchell's initial report was published in the last annual departmental report. Mr. Mitchell's report has since been revised to include a larger installation than was first considered feasible, and the revised plans and specifications are now finally prepared. Tenders for the construction of the plant could be called for at any time.

In view of the fact that the site of this station is centrally located in the Rocky Mountains park, and that the station when built will be constantly inspected by the tourists who visit lake Minnewanka during the summer season, an aesthetic treatment of the power station was desirable. In order to secure the benefit of different ideas in this regard, a competition was arranged among the architectural students of the Faculty of Applied Science of Toronto University. The competitors were furnished with a set of the specifications covering the features to be kept in view, and also with the engineering plans of the power station. Fifteen students competed, and the designs submitted showed an excellent variety of architectural types. The great majority of the plans showed splendid work, both as regards detail, general execution, and originality. Several of the more pretentious designs are published herewith.

RECLAMATION.

Pasquia Reclamation Project.

In the last year's annual departmental report, the report of Mr. T. H. Dunn, reclamation engineer, covering the possibility of reclaiming the lands in the vicinity of Cedar lake, and along the Saskatchewan river below The Pas, was published in full. The land in question consists of flat alluvial country, and is constantly in a partial or wholly saturated condition, while at times extensive portions are wholly submerged. The area affected varies from 400,000 acres, in the initial stages of reclamation, to 2,000,000 acres, when the undertaking is finally completed. The sole apparent possibility of reclamation exists in the lowering of Cedar lake from 11 to 12 feet, and thereby giving proper drainage to the lands adjacent to the lake, and to the river immediately above. The soil in the affected district is exceptionally rich, and its successful reclamation would be of untold benefit to the entire West, and more especially to the province of Manitoba.

The preliminary work carried on by Mr. Dunn during the season of 1912, and covered in last year's report, has been supplemented by additional detailed surveys, covering the route and work involved in the construction of the necessary drainage canal. Mr. Dunn's work has been very thoroughly carried to completion, and his full report is attached as No. 12B.

Columbia Valley Reclamation Project.

The Columbia valley project has in view the reclaiming of the bottom lands of the Columbia River valley south of the town of Golden in British Columbia. This proposal has been persistent during the past year, and in May, 1913, Mr. T. H. Dunn was asked to report on the general feasibility of the same. His report is appended as No. 12A.

Recommendations as to future work.

At the time of writing, the more important reclamation work before the department, involving Dominion land, and calling for further inspection and field investigation on the part of the field engineers during the present season, is as follows:—

(1) A field investigation into the possibilities of reclaiming the land bordering the south bank of the Saskatchewan river above The Pas.

(2) A field inspection into the possibilities of draining large areas of land near lake Winnipeg to the south of the Winnipeg river.

(3) A field investigation into the benefits which would accrue from, and what would be involved in, the lowering of lakes Winnipegosis and Manitoba, in order to better drain the adjoining lands.

(4) A careful field inspection and report on the present status of the Sumas reclamation project.

(5) A further progress inspection of the Columbia valley reclamation project.

(6) A field inspection of the Silver creek reclamation project.

GENERAL.

Panama Pacific Exhibit.

The Panama Pacific Exposition was considered as offering an unexcelled opportunity for advertising the water-power resources of the Dominion of Canada, and, at the instigation of the Water Power Branch, active steps were undertaken to ensure that a water-power exhibit would be placed on view, which would, in a striking manner, emphasize the power activities and opportunities of the northern half of the continent. To this end, active steps were taken, towards the latter part of 1913, to place the project on a definite footing.

The scope and details of the proposed exhibit were determined upon, and, in January, 1914, Mr. K. H. Smith, who had just completed his duties as inspecting engineer on the construction of the Kananaskis Falls plant, was placed in charge of its preparation. A full description and history of the project to date will be found in Mr. Smith's report.

Winnipeg Industrial Exhibit.

Upon the completion of the power studies of the Winnipeg river in Manitoba, and the final design of the various concentrations proposed, it was considered that, in view of the important results to the province at large, it would be advisable to bring these results to the attention of the public in a striking manner. The method finally selected, as best meeting the requirements, was the preparation of an actual model of the entire reach of the river within the scope of the survey, accompanying the same with a relief map of the basin, and suitable diagrams and tables setting out the actual results secured.

The preparation of this exhibit was placed under charge of Mr. K. H. Smith to be worked out in company with the Panama Pacific models. Work on the details is being prosecuted vigorously, and the history and progress of the undertaking is set out in full in Mr. Smith's report. When completed, the exhibit will be set up in the Industrial Bureau in Winnipeg, where free access to the public is assured.

International Joint Commission.

The work of securing and compiling data, in connection with the reference before the International Joint Commission respecting the regulation of the Lake of the Woods, has been continued throughout the year. The enormous importance of the proper regulation of this lake, to the power situation of the Winnipeg river in Manitoba, renders it most essential that nothing be overlooked, which will have an effective bearing on the final settlement of this question. The major part of the work, carried on by the Water Power Branch in this connection during the past year, has been the maintenance of continuous and careful meterings recording the run-off from the various outlets of the lake, both collectively and individually. Also the research into, and collation of, old records covering the conditions of lake level and run-off, which have existed in past years, has formed a most important phase of the investigations. When the reference in question comes before the International Joint Commission for final settlement, it is hoped that the results of the extensive work which has been carried on by the Water Power Branch will convincingly demonstrate the reasonableness of, and necessity for, regulation in the lake within fixed limits.

Red and Assiniboine Rivers' Survey.

The final compilation and plotting of the field notes of the Red and Assiniboine rivers' survey was somewhat delayed, owing to the lack of drafting assistance in the Winnipeg office. It was, however, continued as steadily as the circumstances would permit, and the plans are now rapidly approaching completion. As soon as the plans are in final state, and a covering report prepared, the whole will be submitted to the Department of Public Works for further study, in connection with the navigation possibilities of the Red river. The plans (62 in number on standard-sized sheets, 37 by 40 inches) cover the entire reach of the river, from the international boundary to the northern limits of the city of Winnipeg, and are complete with soundings and bank contours.

Publications of the Water Power Branch.

The following list of Water Resources Papers covers the publications which have been issued, or which are in course of preparation by the Water Power Branch:—

Water Resources Paper No. 1.—Report of the Railway Belt Hydrographic Survey for 1911-1912 by P. A. Carson, B.A., D.L.S., Chief Engineer. Published 1914.

Water Resources Paper No. 2.—Report of Bow River power and storage investigations. (Bow river, west of Calgary) by M. C. Hendry, B.A.Sc., Chief Engineer in charge of Surveys. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg river, by J. T. Johnston, B.A.Sc., Hydraulic Engineer of Water Power Branch. In course of preparation.

Water Resources Paper No. 4.—Report of the Manitoba Hydrographic Survey to the year ending 1914, by M. C. Hendry, B.A.Sc., Chief Engineer. In course of preparation.

Water Resources Paper No. 5.—Preliminary report on the Pasquia Reclamation Project, by T. H. Dunn, C.E., O.L.S., Chief Engineer in charge of Reclamation Survey. Published 1914.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping, in connection with the South Saskatchewan Water Supply diversion project, by H. E. M. Kensit, M.I.E.E. Published 1914.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. Published 1914.

Water Resources Paper No. 8.—Report of the British Columbia Hydrographic Survey for 1913, by R. G. Swan, B.A.Sc., Chief Engineer. In press.

Water Resources Paper No. 9.—Report on Red river navigation surveys, by S. S. Scovil, B.Sc., Assistant Chief Engineer of Manitoba Hydrographic Survey. In course of preparation.

Water Resources Paper No. 10.—General Guide for compilation of Water Power Reports of Dominion Water Power Branch, prepared by J. T. Johnston, B.A.Sc., Hydraulic Engineer of Water Power Branch. In press (limited edition).

Water Resources Paper No. 11.—Final Report on the Pasquia Reclamation Project by T. H. Dunn, C.E., O.L.S., Chief Engineer in charge of Reclamation Survey. In press.

Water Resources Paper No. 12.—Report on small Water Powers and power for farm, by A. M. Beale, B.Sc., Engineer in charge. In press.

That the entire season's field work has been carried on to a successful conclusion, is due to the wholehearted and conscientious co-operation of the field engineers and their staffs with the head office organization. The survey work necessary, in the interests of a proper administration of the water-power regulations, involved a more extensive programme than the field organization of the branch warranted, and its successful completion has only been secured by the continuous and efficient efforts of the field officers.

I have the honour to be, sir,

Your obedient servant,

J. T. JOHNSTON,

Hydraulic Engineer.

No. 5b.

PRELIMINARY REPORT ON WINNIPEG POWER AND STORAGE INVESTIGATIONS.

OTTAWA, March 31, 1914.

J. B. CHALLIES, ESQ.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following preliminary report, covering the power studies which have been made to date on the Winnipeg river.

The extensive power studies which were inaugurated in 1911 by the Dominion Water Power Branch along the Winnipeg river in Manitoba are now practically completed, and a comprehensive report is now in preparation, covering in detail the entire course of the field work and the results of the same, together with the conclusions drawn, and general policy to be adopted by the department in consequence. The progress of the field work and office studies has been briefly reviewed in the two preceding annual reports, and it is intended to present here a general synopsis of the same to date.

Scope of the Investigation.

In the preliminary mapping out of the scope of the investigation, the broadest lines were laid down. The aim of the department was to dictate a definite and comprehensive scheme of water-power development along the river in Manitoba, which would utilize to a maximum extent the full power resources of the river; this necessitated the securing of complete and reliable data covering all features and aspects of hydro-electric investigation.

The scope of the work involved the following phases:—

(1) A preliminary reconnaissance of the power reach of the river by engineers of recognized standing with a view to mapping out a systematic method of attack by the field parties.

(2) A continuous profile of the power reach of the river, on which could be based all the detail surveys.

(3) Detailed contour surveys with soundings of all falls or rapids at which power concentration was determined upon.

(4) Contour survey of the river banks throughout the entire power reach of the river.

(5) Determination of the locations at which the drop of the river could best be centralized and developed.

(6) Design of layouts for such locations, in sufficient detail to permit of fairly accurate estimating.

(7) Estimates of the capital cost of constructing the various plants proposed, in order to compare the economic feasibility of the different sites.

(8) Estimates of the annual cost of operation of the various plants proposed.

(9) Estimates of the cost of transmission from a typical site to Winnipeg.

(10) Establishment of metering and gauging stations, for the purpose of obtaining accurate records of the river flow, and a thorough study of the same, together with all existing records.

(11) Establishment of evaporation stations.

(12) Study of existing rainfall and temperature records, with effect of same on run-off.

(13) Close investigation into the question of storage in the upper waters of the basin in all its aspects.

(14) Investigation into, and study, of prior water rights, and the relative value and effect of the same.

(15) Adequate provision for future navigation.

(16) Close study of existing power plants, and of all existing interests on the river.

(17) Study of present and future power market conditions and prospects.

(18) Recommendations for the carrying out of an aggressive policy of hydro-electric development, also for insuring Government supervision of regulation, both in connection with individual power plants and of the storage conditions as a whole.

Inauguration and Course of the Survey.

In instituting an investigation with such far-reaching ends in view, it was essential that the department should be guided by expert engineering advice and opinion. This was particularly the case, in consideration of the fact that the powers of the Winnipeg are of such magnitude that they would call for the services of engineers and engineering firms of outstanding reputation, in the actual design and layout of the various independent plants. If the conclusions of the department were to be made the basis of the hydro-electric development of the river, it was necessary that such conclusions should be backed by recognized and reliable authorities in the engineering world. To this end the services of Mr. J. R. Freeman, C.E., of Providence, R.I., U.S.A., were secured in a consulting capacity to assist in the inauguration and organization of the field investigations. The services of Mr. J. B. McRae, C.E., of Ottawa, were likewise secured in connection with the inauguration and organization of the work, and he was further retained to act as consulting engineer throughout the full period of field and office investigations.

The power survey was inaugurated in the spring of 1911 under charge, in the field, of Mr. D. L. McLean, B.Sc., of Ottawa, as chief engineer. The first field work undertaken was the securing of a continuous profile of the river from lake Winnipeg to the Lake of the Woods. These levels were referred to sea level datum, and were based on the Canadian Pacific Railway levels at Lac du Bonnet. While the profile was being run, a reconnaissance trip down the river was arranged, for the purpose of securing a comprehensive point upon which to base the detailed surveys afterwards undertaken. The reconnaissance party consisted of Messrs. Freeman, McRae, McLean, and the writer; and the trip was made by canoe from Kenora to the mouth of the Winnipeg river during the last week in August. The only section of the river not covered was the reach including the Seven Sisters falls. The party was pressed for time and considered that the Pinawa channel situation required the more urgent attention. As a result of this inspection, detailed field work was at once commenced in the vicinity of the Du Bonnet falls, and prosecuted vigorously, being completed in August, 1913. It involved a contour survey of the entire power portion of the river, extending from its mouth to the municipal plant of the city of Winnipeg at Point du Bois, augmented by detailed cross-section work, with soundings at all falls and rapids and possible power sites.

While the field work was being carried on, the plotting of the notes was proceeded with in the Winnipeg office, and the final sheets forwarded to Ottawa as completed. The field work covering the lower section from Lac du Bonnet to lake Winnipeg was first carried to completion, after which the reach of the river below the municipal plant of the city of Winnipeg was covered, and finally the reach of the Seven Sisters, together with Lac du Bonnet and the Pinawa channel. As the finished sheets were compiled and plotted, a careful study of the various power possibilities and systems of concentration was carried on in this office by the undersigned, in collaboration with Mr. McRae. A preliminary study indicated the sites at which concentration of the various heads would apparently make best use of the power resources of the river, and provisional layouts were designed. Before making final decision and proceeding with detailed layouts and estimates, the writer made a second visit to the Winnipeg river in September, 1913, in order to make a further inspection of the sites proposed, with a view to ascertaining their general adaptability to the layouts proposed. Consideration of the foundation conditions was given particular attention in this connection. As a result of this inspection, some alterations were necessary in the provisional layouts, after which the detailed designs and estimates were proceeded with.

General Aim of the Power Study.

The main purpose in view in the inauguration of the power survey, and in the subsequent working out of an hydro-electric system for the Winnipeg river in Manitoba, was the maximum utilization of its resources. This involved provision for the utilization of every foot of fall in the river, of which the development was economically feasible. A study of this report, noting the head and tailwater elevations which have been determined upon, will indicate that this aim has been attained, and that the available power in the river has been conserved to the utmost. A reference to the tabulated estimates will also serve to show that the concentrations, which have been decided upon, are all commercially sound propositions, and that the development of any one of the six sites will prove financially attractive, as soon as there is a market for the output.

A full investigation of the power possibilities of the river necessitated a careful study of the facilities for storage and regulation, in the upper portion of the basin. While this section of the work is still uncompleted, sufficient information has been secured, and investigation made, to establish the fact that a very complete regulation can be attained, providing full use is made of the great natural storage reservoirs in the basin. It is the intention to continue the investigations, covering this portion of the work, until a complete system of regulation can be developed.

The Winnipeg river is classed as a navigable stream, and hence any hydro-electric installation along its course must provide for the possible future utilization of the river channel for water traffic. This feature has been carefully kept in view throughout all the investigations which have been carried on, and full provision has been made at each of the proposed plants for the incorporation of a lock 300 feet by 40 feet, with 15 feet of water on the sills. These dimensions can be increased if desirable. The locks, with approaches, can, in all cases, be constructed in the future, without in any way interfering with the operation of the power plants, nor will the provision for lockage facilities incur any extra expense in the present construction or operation of the developments. Particular attention has been given, at all sites, to the protection of both the upper and lower lock entrances from the effects of cross currents, or draws, in the direction of the power-house intake. It is not proposed that future locks must necessarily occupy the sites now proposed, but it is necessary to show that provision can be made for navigation at any time in the future.

In addition to providing for the incorporation of locks at the various sites, the head and tailwater elevations have been so fixed, that the inclusion of these locks is practically all that is required, in order to render available a continuous deep channel. The power plants proposed practically, of themselves, canalize the river.

No portion of the cost of the locks with approaches is included in the estimates for the various power developments.

Departmental Control of Regulation.

The necessity for an independent supervision of the regulation of the river, as a whole, was recognized at the outset of the investigations, and the detailed work in connection with the layout and design of the individual developments emphasizes how essential is the retention, by the Government, of the control, not only of the main regulation in head waters, but also of a measure of direct supervision over the regulation at the individual sites.

That this independent control is essential to the maximum advantageous use of the river for power purposes, can be briefly depicted by the following instances:—

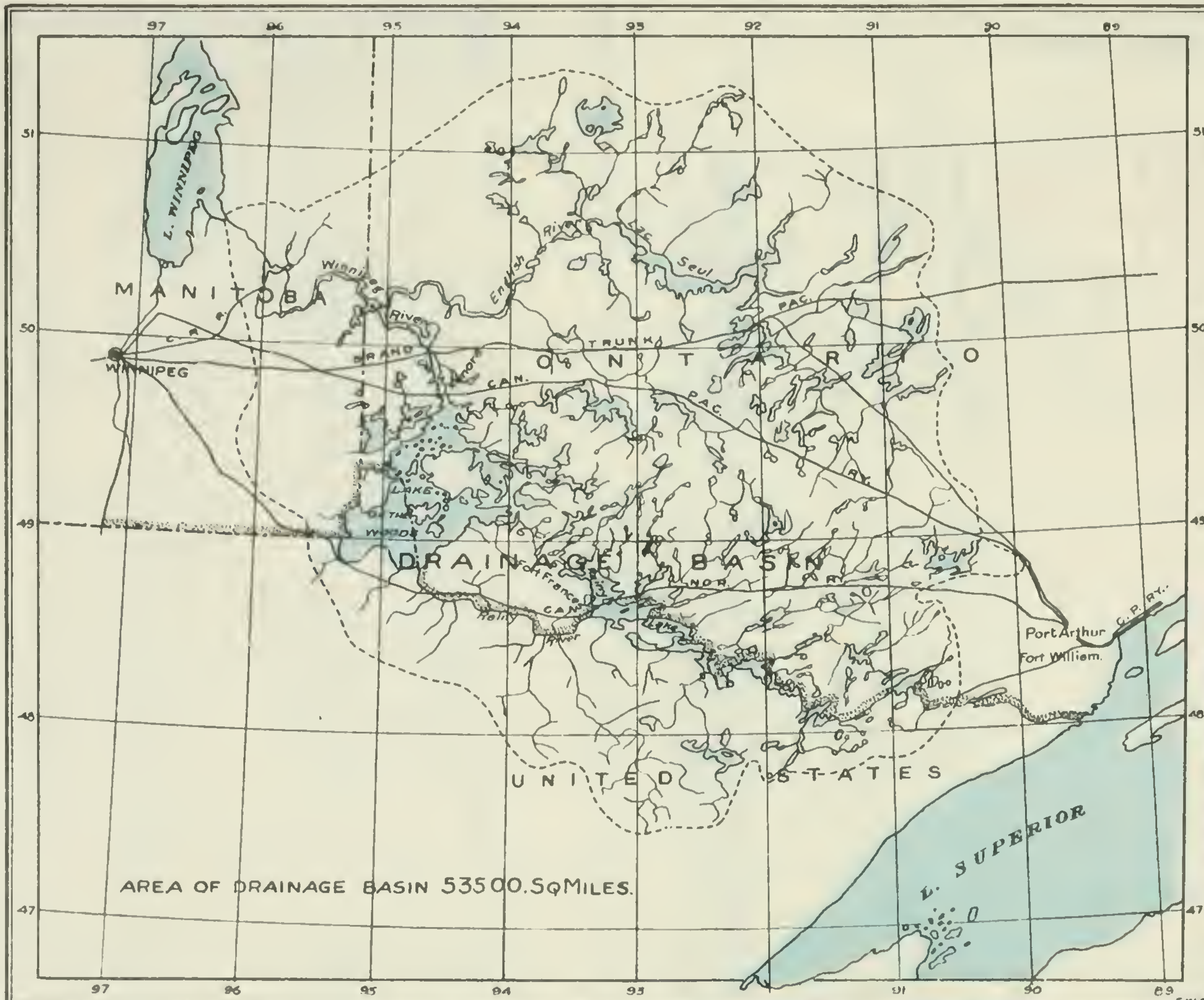
1. A private control of the outlet of the lake of the Woods could completely shut off the discharge therefrom for a period of several days, if it were of advantage to the interests controlling outlets, to suddenly store water in the lake. The lake, with its area of 1,500 square miles, would require an inflow of 12,000 second-feet (mean of six years' discharge), for 161 days in order to raise its level four feet. It is conceivable that circumstances might arise, whereby the above conditions might become partially operative under private management, with the result that the Winnipeg river might be deprived of one-half its flow (this being practically the proportion which the run-off received from above Kenora bears to the total flow), for a considerable period, and hence the entire system of plants in Manitoba, with all the interests dependent thereon, would be deprived of a large proportion of the normal power available. In a time of low water, the adverse consequences of such a condition can hardly be exaggerated.

2. Considering the question of regulation at the individual sites, the necessity of a supervised control is best illustrated at the McArthur plant. The pond of this plant is formed by Lac du Bonnet, the area of which, when raised to elevation 827, will be 38 square miles. This provides unexcelled storage facilities for the McArthur plant with its 18 foot head. These facilities may be made equally available to the 56 foot Du Bonnet plant immediately below the McArthur. On the other hand, a selfish control of the McArthur station could so manipulate the flow, as to entirely cut off the water from all the plants below for a period of several hours at a time. Such a contingency is not to be anticipated in its entirety, but in a modified form it is to be expected, since private interests at McArthur will not be concerned with private, and possibly competing, interests on the lower river.

Other outstanding points along the finally regulated and developed river, requiring a supervised control in order to harmonize conflicting interests, might be mentioned, i.e., the headwater regulation of the Upper Seven Sisters plant, with its effect on the diversion of a portion of the flow down the Pinawa channel, and on the tailwaters of the proposed plant at Slave falls, also the regulation of the headwater elevation of the Slave Falls plant, with a view to protecting the tailwaters of the municipal plant of the city of Winnipeg.

The fact also that the head and tailwaters of the various proposed and existing plants are, in practically all cases, mutually governed each by the other, and that the occasions for future conflict are practically unlimited under an individual control of each plant, renders an independent regulation in the interests of all, absolutely necessary.

PLATE Nº 1



DEPARTMENT OF THE INTERIOR, CANADA.

WATER POWER BRANCH.

J.B. CHALLIES. SUPT.

MANITOBA POWER SURVEY.

WINNIPEG RIVER

PLAN SHOWING

ENTIRE RIVER BASIN

Scale. of Miles

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Winnipeg, March 31st 1914.

S.S. Scovil, Asst. Chief Eng.

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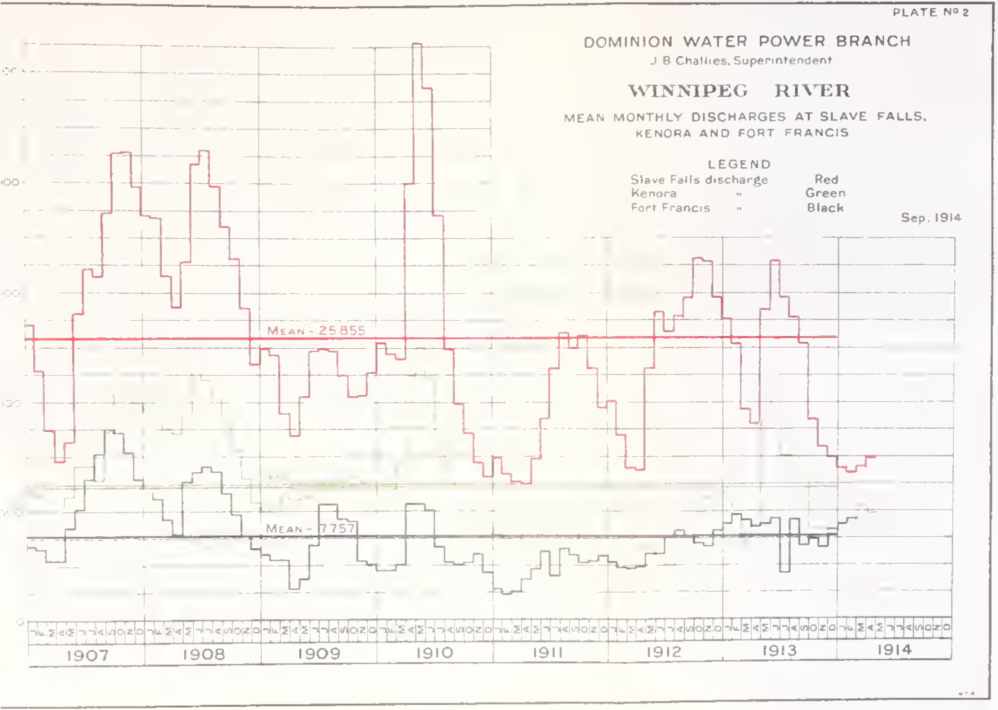
PLATE No 2
DOMINION WATER POWER BRANCH
J B Challies, Superintendent
WINNIPEG RIVER
MEAN MONTHLY DISCHARGES AT SLAVE FALLS, KENORA AND FORT FRANCIS
LEGEND
Slave Falls discharge Red
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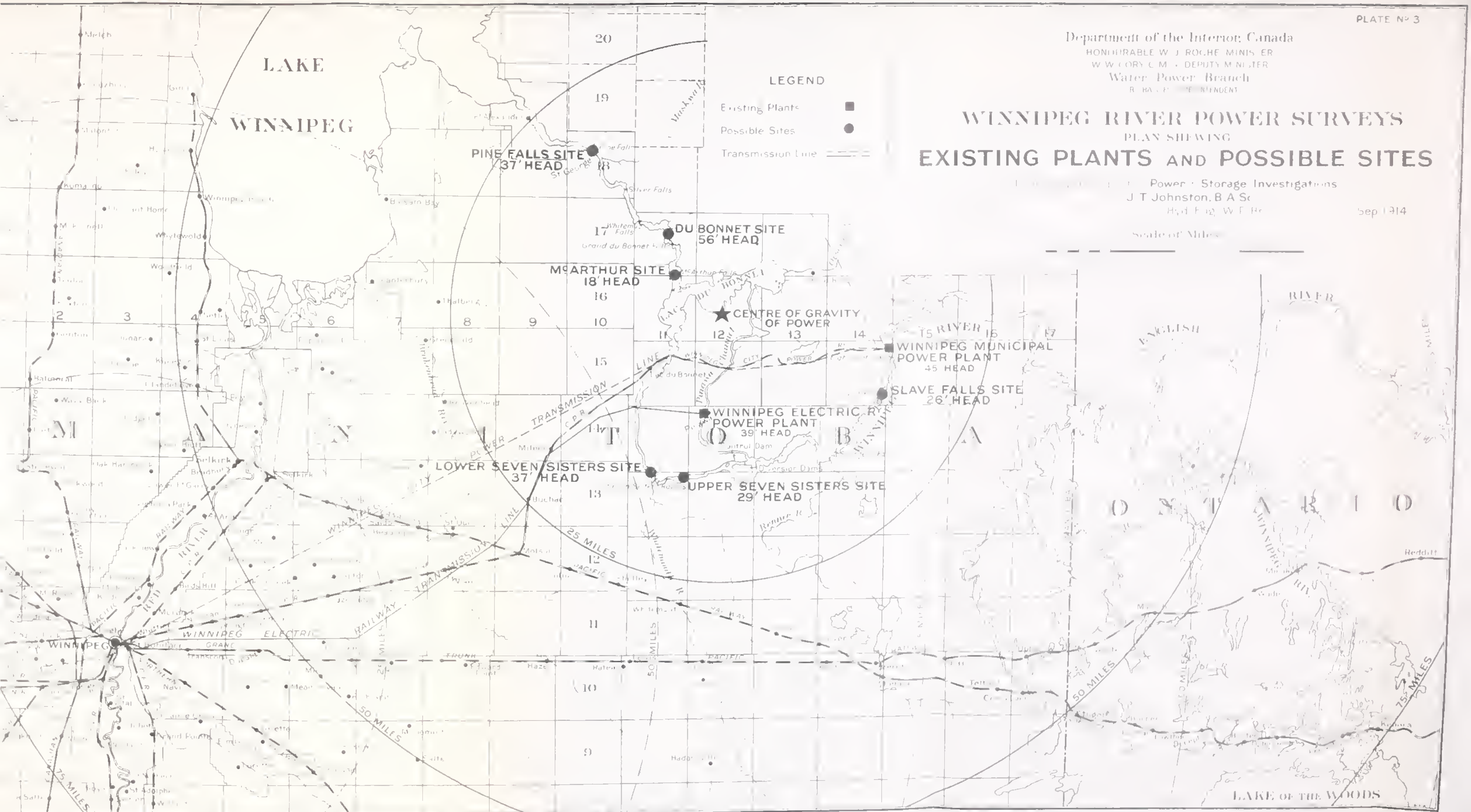

PLATE Nº 3
Department of the Interior Canada
Water Power Branch
WINNIPEG RIVER POWER SURVEYS
PLAN SHEWING
EXISTING PLANTS AND POSSIBLE SITES
Power Storage Investigations
J T Johnston, B A Sc
Sep 1914
LEGEND
Existing Plants
Possible Sites
Transmission Line
LAKE WINNIPEG
PINE FALLS SITE 37' HEAD
DU BONNET SITE 56' HEAD
McARTHUR SITE 18' HEAD
CENTRE OF GRAVITY OF POWER
WINNIPEG MUNICIPAL POWER PLANT 45' HEAD
SLAVE FALLS SITE 26' HEAD
WINNIPEG ELECTRIC RY POWER PLANT 39' HEAD
LOWER SEVEN SISTERS SITE 37' HEAD
UPPER SEVEN SISTERS SITE 29' HEAD
WINNIPEG
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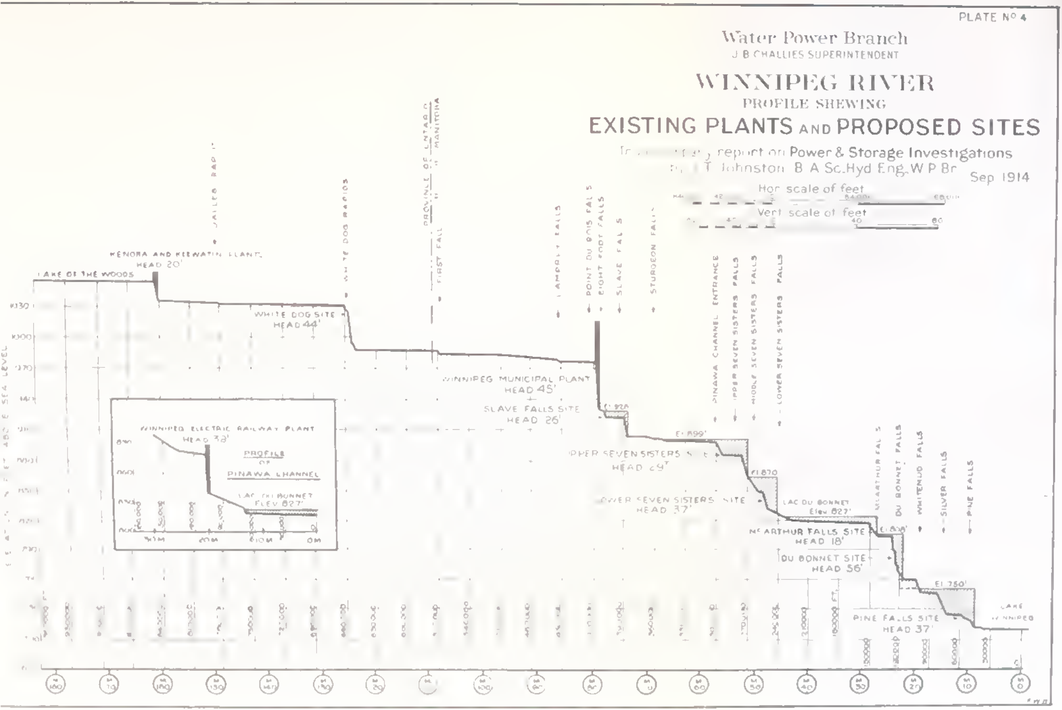
PLATE Nº 4
Water Power Branch
J. B. CHALLIES SUPERINTENDENT
WINNIPEG RIVER
PROFILE SHEWING
EXISTING PLANTS AND PROPOSED SITES
report on Power & Storage Investigations
Johnston B. A. Sc. Hyd. Eng. W. P. Br.
Sep 1914
Hor. scale of feet
Vert. scale of feet
LAKE OF THE WOODS
KENORA AND KEEWATIN PLANTS
HEAD 20'
WHITE DOG SITE
HEAD 44'
WHITE DOG RAPIDS
PROVINCE OF ONTARIO
MANITOBA
FIRST FALL
POINT DU BOIS FALLS
EIGHT FOOT FALLS
SLAVE FALLS
STURGEON FALLS
WINNIPEG MUNICIPAL PLANT
HEAD 45'
SLAVE FALLS SITE
HEAD 26'
El. 899'
HEAD 29'
El. 870
LOWER SEVEN SISTERS SITE
HEAD 37'
PINAWA CHANNEL ENTRANCE
UPPER SEVEN SISTERS FALLS
MIDDLE SEVEN SISTERS FALLS
LOWER SEVEN SISTERS FALLS
LAC DU BONNET
Elev. 827'
McARTHUR FALLS SITE
HEAD 18'
DU BONNET SITE
HEAD 56'
DU BONNET FALLS
WHITEMUD FALLS
SILVER FALLS
PINE FALLS
El. 750'
PINE FALLS SITE
HEAD 37'
LAKE WINNIPEG
WINNIPEG ELECTRIC RAILWAY PLANT
HEAD 32'
PROFILE
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PINAWA CHANNEL
LAC DU BONNET
ELEV. 827'

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PLATE No

DOMINION WATER POWER BRANCH

J. B. CHALLIES SUPERINTENDENT

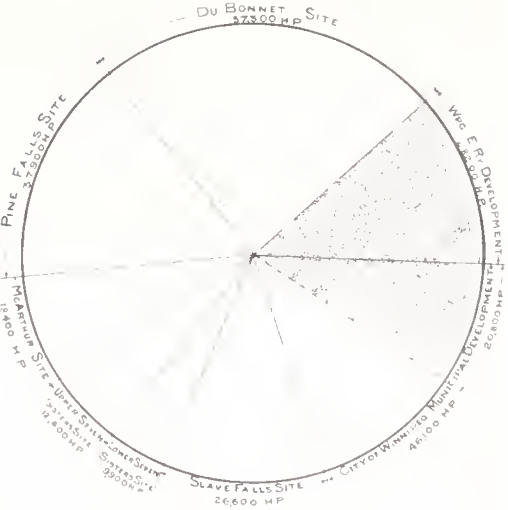

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DIAGRAM

THE DEVELOPED AND UNDEVELOPED POWERS AT THE VARIOUS SITES

... THE

WINNIPEG RIVER

Power ... Storage Investigation

J. T. Johnston, B.A.Sc.

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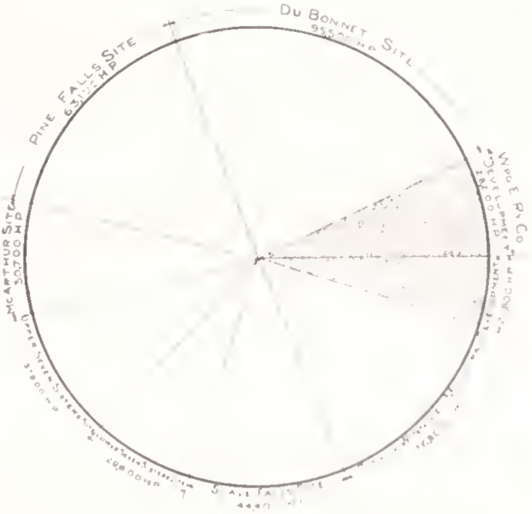
Dominion Water Power Branch



Legend: Developed Power
Undeveloped Power

TO DATE

Regulated

DIAGRAM
SHOWING
THE DEVELOPED AND UNDEVELOPED POWER
AT THE VARIOUS SITES
ON THE
WINNIPEG RIVER

Discharge of the River.

The attached hydrograph (Plate 2), gives the latest information with respect to the run-off of the Winnipeg river. The discharges are plotted for three points, *i.e.*, Slave falls, Kenora, and Fort Frances. The drainage basin above Slave falls is approximately 52,000 square miles in area, and is exceptionally well supplied with lakes, which form natural reservoirs, regulating the river to such an extent that its maximum yearly discharge seldom exceeds four times its minimum.

Actual meterings on the river have shown a minimum record of 11,700 second-feet, and a maximum of 52,700 second-feet, the latter occurring on May 19, 1910. These readings are based on a cable metering station established by the Water Power Branch just above Slave falls. Well-defined high water marks along the shores would indicate that a flood of possibly 100,000 second-feet has taken place in the past.

The Winnipeg river offers excellent storage facilities in the upper reaches (Plate 1), and by making full use of the same the flow can be very completely controlled. A complete regulation of the river would produce a uniform flow of about 25,000 second-feet. By properly controlled use of the natural storage basins, Lake of the Woods, Rainy lake, lake Namakin, Lac Seul, etc., etc., some of which are at present being so utilized, the minimum flow can readily be raised from 12,000 to 20,000 second-feet.

It is on the above basis that the layouts along the river have been designed, and the estimates worked out. At points where the whole flow of the river is available for development, a preliminary installation, capable of utilizing 12,000 second-feet, with provision for the subsequent addition of sufficient units to take care of a regulated flow of 20,000 second-feet, has been developed, and is accompanied by corresponding and final estimates.

Existing Plants.

It is not intended here to make more than passing reference to the existing developments on the Winnipeg river. Two plants are now in operation, namely, the plant of the Winnipeg Electric Railway Company, and the municipal plant of the city of Winnipeg (Plate 3). Both plants transmit power to the city of Winnipeg for general distribution for lighting and power purposes.

A.—The Winnipeg Electric Railway Company's Plant.

The Winnipeg Electric Railway Company's plant is located on the Pinawa channel about 59 miles from Winnipeg. The project was investigated by the Winnipeg General Power Company in the year 1901, and the following winter was devoted to transporting the material necessary to begin operation at the site. The plant was practically completed by June, 1906. The Pinawa channel does not carry the main flow of the Winnipeg river, but the natural capacity has been greatly increased by extensive deepening and straightening. Three diversion weirs across the main and secondary channels, divert into the Pinawa the water necessary to properly operate the plant. A head of 39 feet is normally developed, there being installed (at present five 2,000 k.w. and four 1,000 k.w. generators, making a total of 14,000 k.w. These machines can be and frequently are run at 50 per cent overload making in all an output of 21,000 k.w. or 28,200 water-wheel h.p. The entire output is transmitted to the city of Winnipeg over a 65-mile transmission line at 60,000 volts, and there used for the operation of the street railway system, and for general lighting and industrial purposes.

B.—City of Winnipeg Municipal Plant.

The municipal plant of the city of Winnipeg is located at Point du Bois about 76 miles from the city. The project was first investigated in 1905, and in the following year money was voted for the construction of the plant. Actual work was commenced on the spur railway in the spring of 1908, and, in the following January, contracts were let for the construction of the hydro-electric works and transmission line, together with other necessary equipment. The plant was completed and placed in operation in October, 1911. There are at present installed five units, each of 5,200 h.p. turbine capacity at full gate. In the building, as at present completed, there is room for an additional three units, which will be shortly installed, while the necessary headworks have been constructed for the future inclusion of eight further units. The normal head developed is forty-five feet. The present normal output of the plant is 20,800 h.p. With the river regulated to 20,000 second-feet, there will be available at this site 76,800 twenty-four-hour power. The entire output is transmitted to Winnipeg over a seventy-seven mile transmission line, and there used for general lighting and domestic and industrial purposes.

Reach of the River Developed.

The reach of the river covered in the power studies, extends from the mouth to the headwaters of the municipal plant of the city of Winnipeg at Point du Bois, and comprises practically the entire drop of the river in Manitoba (Plates 3 and 4). The channel of the Winnipeg river follows the general trend of rivers flowing through this district where the Laurentian granite lies practically on the surface. The river is, to a large extent, composed of deep broad basins with but little current, broken by abrupt changes in level at the various falls and rapids. These pitches take place at, and are occasioned by, granite outcrops which are invariably in evidence on both river banks, and in the stream bed. At such points, the bed rock, as a rule, forms a distinct ridge at a higher elevation than the bed of the river in the pond above, and is in fact the controlling feature governing the level of the lake-like expanses. As a result of these conditions the falls are, as a rule, well concentrated, and the hydraulic gradient between the various falls and rapids is usually negligible, a combination of circumstances which renders possible the utilization of practically the entire drop in the river. The reaches below the Lower Seven Sisters and the Pinawa channel are the only sections of the river where it has been necessary to sacrifice any considerable portion of the drop.

The following tabulation illustrates concisely the natural conditions on the river prior to development, and the altered conditions which will result from the development of the available sites.

Table No. 1.—Table outlining the Proposed Development of the Winnipeg river in Manitoba.

Site.	Proposed Conditions.			Natural Conditions.			
	Tail water.	Head water.	Head.	Falls.	Tail water.	Head water.	Head.
Pine	713	750	37	Pine	713	722	9
				Masqua	722	727	5
				Silver	728	749	21
DuBonnet	752	808	56	Whitemud	750	762	12
				Little du Bonnet	762	770	8
				Grand du Bonnet	770	805	35
McArthur	809	827	18	2nd McArthur	806	812	6
				1st McArthur	812	818	6
Lower Seven Sisters	833	870	37	Lower Seven Sisters	834	850	16
				4th Seven Sisters	851	859	8
				3rd Seven Sisters	859	867	8
Upper Seven Sisters	870	899	29	2nd Seven Sisters	867	876	9
				1st Seven Sisters	876	886	10
				Div. Weir	888	899	11
Slave falls	902	928	26	Slave	902	921	19
				Eight Ft.	921	928	7
Winnipeg Power plant	931	976	45	Point du Bois	931	962	31
				Lamprey	962	978	16

Note.—The plant of the Winnipeg Electric Railway Company on the Pinawa channel is not included in the above table, since it is not a link in the main river channel. Its head and tailwater elevations are 880 and 841 respectively.

Flooding and Pondage.

The flooding involved along the river by the construction of the plants will, except at a few points, be wholly confined within the natural river banks. As the banks, at practically all points, rise fairly abruptly from the water's edge, the flooding involved is inconsiderable. A large portion of the river banks is still Dominion land, and a reservation is being made of all lands which will be affected by the power projects.

The pondage which will be available at each of the sites varies from 1,175 acres at the Lower Seven Sisters to 38 square miles at the McArthur site. The latter forms an unexcelled pondage basin, and one which can be utilized to the benefit of the three plants on the lower reach of the river. The ponds available at the head of the Pinawa channel, and above the plant of the city of Winnipeg may also, through sympathetic regulation, be utilized to the advantage of the plants farther down the river with smaller pondage facilities.

The tabulation hereunder illustrates concisely the flooding involved by the construction of each plant, and the pondage available at the same. The areas are not exact, having been scaled off by planimeter from the topographic sheets, but represent the actual conditions with fair accuracy.

TABLE No. 2.—Table of Pondage and Flooding in connection with Proposed Plants.

Sites.	Pondage in acres.	Flooding in acres.
Pine	3,642	375
Du Bonnet	1,700	360
McArthur	24,320	2,443
Lower Seven Sisters	1,175	70
Upper Seven Sisters	8,470	404
Slave falls	1,300	100

Ice Conditions.

The northerly latitude, in which the Winnipeg river is located, necessitates a most careful consideration of ice conditions in the design of all hydro-electric plants along the river. This necessity is exceptionally emphasized in the plant of the Winnipeg Electric Railway Company on the Pinawa channel. The approach to this plant is through a long tortuous channel with rapid current, and, in places, turbulent water, forming a combination of conditions favourable to the formation of frazil ice and the accumulation of anchor ice. The narrow winding tailrace presents similar conditions to those in the headrace, and, during the winter season, considerable difficulty is experienced, both from the fact that the accumulations of ice above prevents the required flow of water reaching the plant, and at the same time, the accumulations in the tailwater frequently partially choke the channel and cut down the head available.

The question of preventing conditions of this nature has been given full consideration in all the layouts which are submitted, and it is not anticipated that any troubles from anchor ice need be anticipated. In all cases, the plants will draw undisturbed water into the turbines from deep quiet ponds extending, in most cases, for several miles up the river. The falls and rapids which, in a natural state favour the formation of frazil ice, will, in the general scheme, be flooded out, and the entire drop in the river will practically take place from one pond to another, over and through the dams at the points of concentration.

Ample provision has also been made at each site for the drawing off of all floating ice and drift. Wherever possible, these ice sluices have been placed in such a position that their discharge will produce a cross current along the face of the power station, in such a manner as to draw off floating material. The racks and entrance to the water passages of the turbines are protected by a sloping concrete curtain across the face of the entrance piers, the bottom elevation of which is placed from two to three feet below regulated pond level.

Foundation Conditions.

Unexcelled foundations can be secured for all the proposed plants. The granite formation which underlies the entire country is exposed at all locations selected for hydro-electric development. This formation is in evidence on both river banks and at various points in the river bed.

General Basis of Design and Layout.

The designs and layouts have been worked out in this office on the general basis set out in the following, and have, on this basis, been approved by Mr. J. B. McRae, C.E. The designs of the power houses, dams, and contingent structures, and the proposed hydraulic and electrical equipment, have been developed only in sufficient detail to permit a fairly accurate estimate of the quantities and costs involved being made. It is not intended that the designs and layouts proposed, and the equipment suggested, should be adhered to absolutely by any parties developing the power at these sites. It is intended, however, that the basic elements of the design shall be maintained as proposed, in the interests of the complete river development scheme. These basic elements are: head and tailwater elevations, discharging capacity, and stability and tightness of dam, power house, and contingent structures. The details of the design, such as sections and plans of the power house, dam, ice sluices and embankments, etc., have been standardized throughout all the plants, varying of course according to the head and to the equipment at each site. In all cases, single runner vertical turbines have been adopted. The reason for this standardization of design was the convenience of having the cost of development at each site reduced to the same basis, in order that the comparative merits of the different projects could be ascertained. For this purpose of comparison also, the cost of the power is given in terms of the power available at the low tension switchboard in the power house, considering 75 per cent efficiency on a 24-hour basis. This is considered conservative, as an efficiency of 90 per cent has been claimed by the manufacturers for the turbines. No estimate has been made of transmission costs, since it is impossible to anticipate the future purposes for which the power at the various sites may be developed.

In view of the complete system of river development which is contemplated, as well as of future navigation requirements, ample discharging capacity at the various plants is provided.

It is recognized that the Winnipeg river is particularly favoured naturally by its extensive lake area in the upper waters, and that rapid rises, such as are experienced in basins not so supplied, and in mountainous districts, do not take place. In the future, however, when the river is fully regulated, it is reasonable to anticipate a combination of circumstances which will result in more sudden rises, and perhaps larger floods than have been experienced. Such a combination of circumstances might be a prolonged and widespread period of heavy rain, at a time when the reservoirs in the upper lakes were all filled to high level. The surplus waters would then be discharged at once. For this reason, discharging capacity has been provided at the various plants along the river, to a larger degree than past floods in the river would apparently require.

PROPOSED SITES.

Pine Falls Site.

The pine Falls site is established at the Pine falls, about 8½ miles above the settlement of Fort Alexander and about 64 miles from Winnipeg. The tailwater of this plant is governed by the elevation of lake Winnipeg, there being but little drop between the foot of Pine falls and the lake itself. The headwater elevation, which has been fixed with a view to fitting in with the general scheme of power development for the entire river, has been placed at elevation 750 (Water Power Survey datum). This elevation will flood out the Masqua rapids and Silver falls, and will slightly raise the normal tailwater elevation of the Whitemud falls. In determining whether Whitemud falls could be more profitably attached to the Pine or to the Du Bonnet concentration, the governing feature was the elevation of the banks between Pine falls and Silver falls. Flooding above the proposed regulated level requires extensive embankments, and the drainage of land now settled and cultivated. The Whitemud falls has been incorporated with the Du Bonnet falls, as is set out in full hereunder. The head available at Pine Falls site under normal conditions is 37 feet.

The flooding involved will be about 375 acres, and consists entirely of land directly bordering on the river front. The land in all places rises rather abruptly from the water's edge, and embankment will only be required on the left bank for a short distance above the power site. About 2,600 acres of pondage will be created by the construction of the dam, and this will be increased by an additional 1,044 acres, after the Whitemud falls has been added to the Du Bonnet site.

Granite formation is in evidence on both river banks, and in the bed of the channel, throughout the entire length covered by the layout. Such assumptions as are made, concerning the elevation of the rock in the rapids, are considered to be amply conservative. The layout proposed will draw water directly into the power station from a deep pond, and it is not anticipated that any trouble will be experienced from frazil and anchor ice. Ice sluices below the power house will amply protect the racks from all floating ice and drift.

The general layout of ice sluices, power house, and dam, forms a straight line running diagonally across the river, the power house being located on an island close to the left bank and below the lowest pitch of the Pine falls, so that the tailwater is not affected by the same. Advantage has been taken of a natural gully on the right bank to lengthen the free spillway.

The estimates for the power house have been calculated for two stages of development. The initial development consists of six 10,000 h.p. units with electrical installation in proportion. These six units will utilize the minimum flow of 12,000 second-feet at 37-foot head with turbines operating at 8-10 gate, and provide a spare unit for emergencies. The output available on the low tension switchboard on a 75 per cent over-all efficiency, and a 24-hour basis is 37,900 h.p. The final development will consist of ten 10,000 h.p. units, providing machine capacity for the utilization of 20,000 second-feet, together with a spare unit for emergencies. The output of the final plant will be 63,100 24-hour h.p.

At regulated pond level, the sluiceways will discharge 92,000 second-feet, in addition to which the completed power station will provide for 20,000 second-feet. While this latter is not considered to be a source of discharge available at all times, it, nevertheless, forms an additional factor of safety. A 775-foot spillway with crest at 750 provides the necessary automatic check of the pond level, should the sluice control for any reason be neglected. With pond level at 753, a total discharging capacity of 135,000 second-feet is available. The headworks of the plant will withstand a pond level of elevation 757.

Provision for a lock with approaches has been made on the left bank of the river.

The Du Bonnet Falls site.

The Du Bonnet Falls site is located about 10 miles above the proposed Pine Falls concentration, and about 64 miles from Winnipeg. As was referred to above, the tailwater of this site will, upon the completion of the development as is finally proposed, be controlled by the headwaters of the Pine Falls plant. The method of development suggested at this site contemplates concentration at the foot of the Little du Bonnet falls. In the initial development, the tailwater will be governed by the natural conditions now existing at Whitemud falls and will normally be about elevation 762, giving a head of 46 feet. In the final development, it is proposed to add to this head an additional 10 feet, to be obtained by blasting a channel through the rock ridge over which the Whitemud fall pitches. The final tailwater elevation will be 752, that is, 2 feet higher than the regulated high-water level of the Pine Falls site.

The removal of the Whitemud falls by blasting will result in a rapid current in the vicinity of Island No. 2, a short distance below the Little du Bonnet falls. Under present conditions in the river, this point becomes choked with accumulations of ice during the winter season, and lowering the reach 10 feet will accentuate the conditions favourable to the disposition of ice at this point. On the other hand, the flooding out of the Du Bonnet falls, and the replacing of the same by a deep and extensive pond, will largely reduce the present tendency to produce frazil ice, and tend to better the conditions at Island No. 2. Before a final determination can be made as to the effects of lowering the reach 10 feet, and the best means of remedying the same, further investigation should be made in the vicinity of the island with a view of determining the nature of the river-bed. Should conditions warrant it, the question of concentrating the head at this point rather than at the Little du Bonnet falls might be advisable, although the capital cost of such a location would be considerably higher than that of the layout discussed herein. The further field investigations into this alternative site should consist of soundings and borings, in the river bed, and are of a character such as can best be undertaken by whatever company or interest undertakes this development.

The regulated headwater has been placed at elevation 808. In the layout proposed, the dam spans the river along the crest of the Little du Bonnet falls and drowns out the entire Grand du Bonnet drop, raising the normal headwaters of these falls by about two feet. The resulting flooding consists only of some 360 acres, and necessitates about one mile of embankment on the left bank of the river. The embankment will not, at any point, withstand a head greater than 8 feet and can be cheaply constructed. A pondage of about 1,700 acres will be created. Solid granite formation is in evidence throughout the entire site covered by the layout. Assumptions were made as to the elevation of this granite along the crest of the falls, after a careful inspection on the ground, and it is considered that the assumptions are fully warranted. No ice troubles need be anticipated in connection with drawing the water into the turbines from the pond. The undisturbed area above the plant, combined with the favourable location of the ice sluices, will fully protect the plant from troubles either from frazil or floating ice.

In the general layout, the power house has been located on the right bank along the shore line below the Little du Bonnet falls, and is connected to the high land by means of three decked ice sluices and a corewall embankment. A curved concrete dam from the outer end of the power station, spans the river, following what is considered to be highest rock in the river-bed. The spillway portion of the dam is connected to the high land on the left bank by means of a concrete corewall embankment.

The estimates for the power station and for the whole development have been calculated for initial, intermediate and final installations. The initial development will consist of the seven 10,000 h.p. units adjacent to the dam, and will provide for the utilization of 12,000 second-feet at 46-foot head. This installation practically leaves one unit as a spare for emergencies, with the turbines operating at 8-10 gate, and renders available at the switchboard 47,000 24-hour power. The headworks of the remaining units will be sufficiently constructed to support the stoplogs and racks, leaving the balance of the station to be added when required. The intermediate development consists of twelve 10,000 h.p. units, the additional five being adjacent to the initial installation, and will provide for the utilization of 20,000 second-feet regulated flow at 46-foot head, the output available being 78,500 24-hour power. The final development will consist of fourteen units providing for the utilization of 20,000 second-feet at 56-foot head, the additional 10 feet being obtained as referred to above, by the removal of Whitemud falls, and will render available 95,500 twenty-four-hour power.

At regulated level, the sluiceways will discharge 72,000 second-feet at full opening. The free spillway, 400 feet in length with crest at elevation 808, will automatically control sudden rises in the river. The total discharging capacity, with pond at 811, considering the power station also available, is 118,000 second-feet. The headworks are designed to withstand a pond level of 815.

Lockage facilities can be installed upon the right bank whenever required.

McArthur Falls site.

The McArthur Falls site is located about 4 miles above the Du Bonnet site, and 62 miles from Winnipeg. The tailwater will be directly governed by the regulated pond level of the Du Bonnet project. During times of low water, there should be but little loss due to hydraulic gradient, between the crest of the Du Bonnet dam and the tailwater at the McArthur site. During times of high water, however, there will undoubtedly be some such loss. In consideration of this, the tailwater of the McArthur site has been placed at 809 under normal conditions, and this elevation is used throughout the calculations and estimates. The headwater elevation proposed is 827. This elevation will drown out the first McArthur falls, and will raise Lac du Bonnet to practically high water level, thus making it directly available for local pondage. A head of 18 feet will be created.

As the high water marks along the shore indicate an elevation of 827 in extreme floods under natural conditions, the question of flooding cannot be considered as introducing entirely new conditions. Some 2,500 acres will be flooded, the greater part of this land being located at the western end of the lake. An item covering the flooded land involved has been included in the estimated cost of the development. The pondage facilities which Lac du Bonnet will render available are unexcelled, there being 38 square miles of surface area included within the 827 contour. This extensive area possesses a double advantage in that the necessary local storage can be obtained without any appreciable loss of head, a matter of considerable importance in a low-head plant. The storage facilities here available are out of proportion to the requirements of the McArthur development above, and in order that the maximum benefits may be derived therefrom, the storage should also be made available to the Du Bonnet project. As the headwater of the Du Bonnet layout forms the tailwater of the McArthur, the Lac du Bonnet pondage can be made instantly available to the two plants, providing some independent supervising control is exercised. It is only by some such single control that maximum utilization can be made of the power resources of this reach of the river. A selfish regulation of the lake could completely shut off the water for considerable periods from plants below.

In the general layout, upon which the estimates have been based, the power station spans the western channel, the river being at this point divided by a large central island. The power house is connected with the left bank by means of ice sluices and a corewall embankment. The eastern end of the power station, resting on the island, is connected to a long section of alternative embankment, sluiceway and spillway forming a dam, which runs longitudinally with the island. This dam, while of considerable length, is for the most part low, and the cost of its construction is not excessive. The eastern or main channel of the river is spanned by a 975-foot concrete spillway with crest at 827. Although the layout described has been adopted for purposes of securing an estimate as to the cost of work at this site, it is recognized that the contours and general formation at the second McArthur falls permit of various layouts, no one of which apparently offers any great outstanding advantages. Several alternative schemes were considered and investigated. To finally determine the most economic of the various possible designs, would require a very careful detailed estimate of each, assisted by further boring and sounding operations in the field. It is considered that the layout discussed herein will form as economic a development as is possible at this site under the conditions which must be met. In view of the regulated level being placed at 827, and of the fact that it is not desired to exceed this elevation to any extent if possible, ample free spillway has been provided, the main section being 925 feet in length, referred to above, and a second section 750 feet in length forming a portion of the dam across the island.

An initial installation of eleven 2,500 h.p. units at full gate with corresponding electrical equipment and with normal operating load corresponding to 8-10 gate opening on the turbines, has been provided, giving sufficient capacity to utilize 12,000 second-feet at 18-foot head with one spare unit for emergencies. The available output of 24-hour power at 75 per cent efficiency is 18,400 h.p. The final development will consist of seventeen 2,500 h.p. units, supplying machine capacity for the utilization of the regulated flow of 20,000 second-feet. The final output available under the same conditions as above will be 30,700 h.p.

Twenty-one 20-foot sluices, with sills, at 812, provide for the discharge of 81,000 second-feet at regulated level without considering any discharge through the power station. The 1,725 feet of free spillway will take care of 16,000 second-feet with 2 feet over the crest, and should, within this limit, cope with the most sudden rises which may be anticipated. The total discharging capacity with pond level at 829, all sluices open and the power station in full operation, is 134,000 second-feet. The headworks of the plant will withstand a headwater elevation of 832.

Provision has been made on the central island for the installation of lockage facilities when required.

The Seven Sisters reach.

The two proposed Seven Sisters developments are located on the main channel of the Winnipeg river, which is here divided, a portion of the flow taking place through the back or Pinawa channel, upon which is located the power plant of the Winnipeg Electric Railway Company, and finding its way into the eastern end of Lac du Bonnet. The discharge in the river, over and above that necessary to properly operate the Winnipeg Electric Railway Company's plant, is available for development throughout the reach of the Seven Sisters falls. As a result of this division of the river, it will not be profitable to undertake the development of the Seven Sisters reach until such time as the river has been regulated. For the purposes of present discussion, it has been assumed that a mean flow of 8,000 second-feet takes place down the Pinawa channel. With a 20,000 second-feet regulated flow, this will leave 12,000 second-feet available for the two Seven Sisters plants. Estimates covering a development capable of utilizing this flow have been deemed sufficient for the purpose of demonstrating the capabilities of the two sites.

In working out the power possibilities of this reach, with the utilization of every available foot in view, two governing levels were already fixed. The regulation of Lac du Bonnet to elevation 827 forms the governing feature at the lower end of the reach, while the diversion weirs of the Winnipeg Electric Railway Company across the main channel at the upper end, present conditions which must be fully considered in any scheme of development contemplated.

Lower Seven Sisters site.

The lower Seven Sisters site is located about 19 miles above the McArthur, or 8½ miles above the town of Lac du Bonnet and 52 miles from Winnipeg. This site contemplates the development of the lower five drops of the Seven Sisters falls. Other feasible locations than the one herein discussed are available. A thorough exploration of the foundation conditions would necessarily precede any active construction operations, and would definitely locate the most favourable site. The assumptions which are made for the purpose of estimating on the layout under consideration are thought however, to be in every way conservative, and as favourable conditions as those assumed, are undoubtedly available.

The tailwater elevation has been assumed at 833, six feet being allowed for the hydraulic gradient in the river between the site and the regulated Lac du Bonnet. The headwater is placed at 870, the river banks permitting this raising of the water without necessitating embankments. A head of 37 feet will be available under normal conditions. Raising the water to 870 will flood some 70 acres of land, consisting entirely of the steeply sloping banks in the immediate vicinity of the river. A pond of 1,175 acres will be created.

The whole site, so far as could be determined from inspection and sounding through ice cover, is underlaid with granite formation. Should borings fail to substantiate these preliminary soundings along the line of the dam as now laid out, further exploration above and below will undoubtedly reveal conditions as favourable as those assumed. Provision for the protection of the plant from frazil, anchor and floating ice is similar to that already discussed in previous layouts. The water will be drawn directly into the turbines from a deep, still pond, and the racks protected from floating material by a sloping curtain wall and ice sluices.

In the general layout considered, the power house has been placed adjacent to the right bank, and is connected thereto by the ice sluices and a short embankment. Leaving the outer end of the power station, the dam curves 67 degrees through the arc of a circle, and is extended as a tangent to the left bank. The power station is designed to contain six single runner vertical turbines of 10,000 h.p. capacity at full gate. This will supply machine capacity for the utilization of 12,000 second-feet at 37-foot head, with the turbines operating at 8—10 gate opening. At 75 per cent efficiency, 37,900 24-hour power is available at the switchboard. One spare unit is provided for emergencies.

At regulated level, 870, the sluiceways at full opening will discharge 81,000 second-feet. The power station itself is designed to utilize 12,000 second-feet, while the Pinawa channel in times of high water will pass at least 11,000 second-feet. This gives a total of 104,000 second-feet which can be passed down the river without exceeding regulated level. A 700-foot spillway, with crest at 870, is provided for automatic regulation should the same become necessary. Three feet over the crest will discharge 12,000 second-feet. In all, 130,000 second-feet can be cared for with the pond at elevation 873; to this must be added the Pinawa discharge. The headworks are constructed to withstand a pond level of 877.

Lockage facilities can be provided on the right bank.

Upper Seven Sisters site.

The upper Seven Sisters site is located about 4 miles above the lower site, and 55 miles from Winnipeg. The tailwater under normal conditions in the river will be at 870, *i.e.*, the proposed regulated headwater level of the plant below. The regulation of the headwater of the upper plant involves several questions which require careful investigation before a final decision, as to its elevation, can be reached. The discharge down the Pinawa channel varies with the elevation of the water above the weirs, but can be regulated completely by the control dam now in position across the head of the channel. The elevation of the water level above the diversion weirs directly affects the tailwater level of the proposed development at Slave falls, and the interests of this latter plant will be best served by maintaining the water level above the weirs as low as possible. It is necessary then to maintain the water level above the weirs at such an elevation as will discharge down the Pinawa channel a sufficient flow to properly operate the Winnipeg Electric Railway Company's plant. At the same time, since the weirs are non-regulated, the water level above will rise with the stage of the river. The net result is that the headwaters of the upper Seven Sisters plant must be maintained during times of low water at such an elevation as will divert 8,000 second feet down the Pinawa channel, and in times of high water at such an elevation as will permit the discharge of the flood over the weirs with least interference to the operation of the Slave Falls plant. At present the data on hand with reference to the various vital features outlined above is not sufficiently complete to permit detailed studies being made as to the effects and results of the diverse conditions which must be considered. For the purpose of the present discussion, the head-water elevation of the upper Seven Sisters has been assumed at 899, this being a fair basis upon which the site can be investigated, and representing a fair mean of the working conditions which will be met with in actual operation. A head of 29 feet will be available, under the conditions assumed, and the development will drown out the first and second drops of the Seven Sisters falls.

The banks in the vicinity of the site rise abruptly to elevation 898. At this elevation, the ground elevation becomes approximately level, rising slowly as one goes upstream. Regulation to elevation 899 will result in considerable flooding and saturation of the ground in the vicinity, unless embanking is resorted to. Provision has been made for this in the estimates. A pondage of 2,600 acres will be created between the site and the Electric Railway Company's weirs, and an additional 5,870 acres will be indirectly available above the same. Upon the completion of the upper Seven Sisters plant, it will be to the general advantage of all concerned, that the main weir or a section of it should be removed, and thus place the regulation of the reach directly with the upper plant. This regulation can only be satisfactorily attained through an independent control.

Granite formation underlies the entire site and is exposed on the surface on both river banks. It also projects above the water in the form of islands at different points along the line of the dam. Protecting the plant from the formation of anchor and frazil ice has been attained in a manner similar to that adopted at the plants lower down the river.

In the general layout, the power station is placed adjacent to the right bank and forms, with the iceways and sluiceways, a straight line running approximately north and south. At the south end of the sluices, the line of the dam turns to the south-east through an angle of approximately 40 degrees following the high rock, and forming the spillway section. The spillway section has been extended out over the river bank giving the total length of 600 feet, with crest at elevation 899. The power station is designed to contain eight 6,000 h.p. units supplying machine capacity for the utilization of 12,000 second-feet at a 29-foot head, the turbines operating at 8—10 gate opening. This will provide a spare unit for emergencies. The output at the low tension switchboard is 29,600 24-hour power.

The layout suggested will discharge 77,000 second-feet at regulated level through the ice and sluiceway sections. This, together with the power station and the Pinawa channel, will provide for the passage of 100,000 second-feet, without exceeding the proposed regulated level. A three-foot rise from this level, which all the headworks will permit, will bring the 600-foot spillway into play, and raise the total discharging capacity to 126,000 second-feet plus the Pinawa discharge. The headworks will withstand a pond level of 903.

Lockage facilities can be provided on the right bank.

Slave Falls site.

The Slave Falls site is located at the Slave falls, about 20 miles above the upper Seven Sisters plant, and 74 miles from Winnipeg. The development will drown out the Eight Foot falls $3\frac{1}{2}$ miles above and will raise the headwater level to elevation 928. The contours of the river banks would here permit holding the headwater elevation at 950, and would render available a head of about 50 feet. A development of this head would have been very attractive. The elevation of the pond level of the Slave Falls plant must, however, be determined with reference to its effect on the city plant, and the necessity of protecting the normal head of the latter. With this end in view, the level had been placed at 928 under normal conditions. The diversion weirs of the Winnipeg Electric Railway Company previously referred to, cause a backing up of the tailwater at the Slave falls during times of high water. To counterbalance this loss of head to the Slave Falls plant, the headwaters of the same can be controlled and raised, to correspond with the rising tailwater, except during years of excessive flood. This will not impair the head at the city plant, since the headwater of the latter varies with the stage of the river. A 26-foot head will be available at the Slave falls.

A local pondage of 1,300 acres will be created which, with sympathetic supervising regulation, could be augmented from the 8,000 acres of the city plant. One hundred acres of land will be flooded immediately adjacent to the river, no embankment being required. Granite is exposed on both river banks, and rises above the surface along the line of the dam at the brink of the falls. The headrace has been laid out with easy curves and, where necessary, has been excavated to a practically level bottom. It is designed to carry 12,000 second-feet to the initial development, and 20,000 second-feet to the final development at a rate of about 2.7 feet per second. This will secure an undisturbed approach to the plant leading from the pond above, and will prevent all frazil and anchor ice troubles. Floating ice and drift will be automatically discharged through the ice sluices at the lower end of the power house.

The power station is placed on the right bank of the river below the falls, and is connected with the high land by means of three ice sluices and an embankment, at right angles to the line of the power station. The dam extends upstream from the power house and, curving through an angle of 88 degrees, crosses the river along the crest of the falls.

The initial development consists of eight 5,000 h.p. units, with electrical installation to match. The output available on the low tension switchboard on a 75 per cent efficiency and a 24-hour basis is 26,600 h.p. The final development will consist of thirteen 5,000 h.p. units, the five additional being added to the south of the first installation, and giving a total output of 44,400 24-hour power.

Twenty sluices are provided for the control of the river in addition to the automatic spillway crest. In all, a discharging capacity of 82,000 second-feet is available, with the headwater at elevation 928, not including the power station. The headworks will withstand a pond level of 936, ample provision being made for the careful regulation, which is here necessary. An intelligent control of the discharging sluices of the dam can be utilized in protecting the discharge from the draft tubes, by forcing the major portion of the current against the left bank of the river.

Provision for a lock, with approaches, has been made on the left bank of the river.

Summary of Available Power.

To briefly summarize the power situation on the Winnipeg river in Manitoba, there is 49,000 h.p. developed to date, 188,000 undeveloped h.p. available in times of extreme low water on the river, and 357,000 undeveloped h.p. available when the river is regulated to a uniform flow of 20,000 second-feet (Plates 5 and 6). As these totals are given in terms of twenty-four hour power, the commercial power, which is available from the development of the river, could be stated in considerably higher figures.

Estimates of Cost.

The estimates of the capital cost of the various sites have been standardized, the same unit prices being used throughout. It is considered that these estimates are amply conservative. Wherever assumptions were necessary, liberal provision for eventualities has been made, in order that the development might not be made to appear more favourable than circumstances warrant. In all cases, provision has been made for access to the site by rail, or in the case of the Pine Falls plant, by boat. In each case, 10 per cent has been allowed for contingencies, 5 per cent of this for engineering and inspection, and 6 per cent on the whole for one year for interest during construction.

As pointed out above, in view of the fact that it is not possible to foretell at this stage for what purpose the various plants along the Winnipeg river will be utilized, whether for the purpose of transmitting power to the industrial centres of Manitoba or for local uses at a particular site, the estimates of capital cost of development in all cases have placed power on the low tension switchboard in the power station. The object of the estimates has been primarily to arrive at the capital cost of the actual development of the independent sites, and by means of standardization, both as to design and as to unit prices, to compare the sites with each other from the point of view of economic feasibility. Since the basis is standardized throughout, a study of the results submitted herewith will be found most interesting.

For the purpose of ready comparison, the vital features as to output, installation and estimated capital cost of development of the various undeveloped power sites have been tabulated as follows:—

TABLE NO. 3.—UNDEVELOPED POWER ON THE WINNIPEG RIVER IN MANITOBA.

I.—Sites at which the full flow of the River is available.

Site.	Distance from Winnipeg.	Head.	Power Available. H. P. at 75% Eff. on a 24 hr. basis. 12,000 Sec.-ft.	Power Available. H. P. at 75% Eff. on a 24 hr. basis. 20,000 Sec.-ft.	Power Available. Turbine Installations Units considered. 12,000 Sec.-ft.	Power Available. Turbine Installations Units considered. 20,000 Sec.-ft.	Estimated Capital Cost on Low Tension Switchboards in Power Stations. Total Cost. 12,000 Sec.-ft.	Estimated Capital Cost. Total Cost. 20,000 Sec.-ft.	Per H.P. on basis of 75% Eff. 24 Hr. Power. 12,000 Sec.-ft.	Per H.P. on basis of 75% Eff. 24 Hr. Power. 20,000 Sec.-ft.	Per H.P. on basis of Installation. 12,000 Sec.-ft.	Per H.P. on basis of Installation. 20,000 Sec.-ft.
	Miles.	Feet.										
Pine falls	64	37	37,900	63,100	6—10,000	10—10,000	$3,217,416	$4,671,991	$84.90	$74.25	$53.62	$46.72
Du Bonnet falls (Initial)	64	46	47,000	....	7—10,000	....	3,730,426	....	79.40	....	53.29	....
Du Bonnet falls (Final)	64	56	....	95,500	....	14—10,000	....	6,749,470	....	70.70	....	48.21
McArthur falls	62	18	18,400	30,700	11— 2,500	17— 2,500	2,106,610	2,830,993	114.48	92.21	76.60	66.61
Slave falls	74	26	26,600	44,400	8— 5,000	13— 5,000	2,436,673	3,612,232	91.60	81.45	60.92	55 57
Total I	....	....	129,900	233,700	197,500	347,500	11,491,125	17,864,686	88.46	76.44	58.18	51.41

II.—Sites on Seven Sisters reach, considering 8,000 sec.-ft. down Pinawa channel and 12,000 sec.-ft. available.

Site.	Distance from Winnipeg.	Head.	Power Available. H.P. at 75% Eff. on a 24 hr. basis.	Power Available. Turbine Installations Units considered.	Estimated Capital Cost on Low Tension Switchboard in Power House. Total Cost.	Per H.P. on basis of 75% Eff. 24 Hr. Power.	Per H.P. on basis of Installation.
	Miles.	Feet.					
Lower Seven Sisters	52	37	37,900	6—10,000	$3,570,976	$94.20	$59.50
Upper Seven Sisters	55	29	29,600	8— 6,000	2,854,785	96.44	59.47
Total II			67,500	108,000	6,425,761	95.19	59.50

1. Undeveloped power on the unregulated river (12,000 second-feet):—

Main river (including 56 feet head at Du Bonnet).. ..	140,200
Seven Sisters reach..	22,500
Undeveloped as yet at municipal plant of city of Winnipeg..	25,300
Total undeveloped..	188,000

2. Undeveloped power on the regulated river (20,000 second-feet):—

Main river..	233,700
Seven Sisters reach..	67,500
Undeveloped as yet at municipal plant of city of Winnipeg..	56,000
Total undeveloped..	357,200

3. Total power on Winnipeg river in Manitoba in terms of twenty-four hour power at 75 per cent efficiency:—

	Unregulated flow.	Regulated flow.
Undeveloped..	188,000	357,200
Developed..	49,000	49,000
Total..	237,000	406,200

4. Total capital cost of developing above plants:—

To placing power on low tension switch in power station..	$24,290,447.00
Mean cost per h.p. on a 75 per cent eff. 24-hour basis	80.61
Mean cost per h.p. on basis of machinery installed..	53.35

The complete report covering in detail the entire power and storage investigations on the Winnipeg river, is now nearing completion, and will be published as Water Resources Paper No. 3 at as early a date as possible. This report will include all field and layout plans, together with full estimates and conclusions as to departmental policy.

I have the honour to be, sir,

Your obedient servant,

J. T. JOHNSTON,

Hydraulic Engineer.

No. 5c.

GENERAL GUIDE FOR THE COMPILATION OF WATER-POWER REPORTS.

(Water Resources Paper No. 10.)

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following general guide for the compilation of water-power reports.

The increasing number of inspections and field investigations, on the part of the engineers of the Water Power Branch, has rendered it desirable that some uniform guide be prepared upon which the various reports forwarded to head office may be based, so that they may, as far as possible, be standardized. At the same time it has been noted that field reports are frequently forwarded lacking in essential features which can only be supplied by the Engineer on the ground. In order to remedy this, and at the same time provide a standard basis upon which reports can be submitted, the undersigned has prepared the following general guide for the compilation of water-power reports. In addition to this guide being utilized as the framework of the report, it is also intended for use by the engineers in the field. A careful study while on the ground, of the points outlined, will tend to secure more complete field data than would otherwise be the case.

The investigations, in connection with which reports are required, vary in character and are usually required to cover the following cases: (1) Applications for water-power privileges, such applications being unaccompanied by detailed data as to the site or stream. (2) Applications for water-power privileges accompanied by fairly well developed plans, setting out the general scheme of development. (3) A first-hand investigation of an entirely new site or series of sites, for the purpose of studying power, storage and conservation features.

In preparing the following instructions, the above has been kept in view, and the outline hereunder is intended to serve as a general guide for all such reports, only such portions being utilized as are directly applicable to the class of report under preparation. It is not intended that these instructions should limit a report solely to the ground covered herein; much must be left to the discretion of the engineer who compiles the report. The points briefly dealt with represent, however, the general important features which require investigation and discussion, in order that the ground may be completely covered.

The engineer should make a careful study of the instructions while in the field. All reports should be addressed to the Superintendent of the Water Power Branch.

A brief summary of the sections and sub-headings follows. Further details of the ground to be covered under each section are given later.

I. *Sources of data used in report.*—

(1) Why investigated and scope of investigation.
(2) Personal examination—route followed and time consumed.
(3) Run-off records from departmental stream measurement offices.
(4) Maps.
(5) Existing reports.
(6) Miscellaneous.

II. *Summary of report.*

III. *General introductory.*—

Description, including location as to province, river, cities, township, range and section.

IV. *Water Supply.*—

(1) General description of drainage area.

(2) Actual records if available showing maximum, minimum, and mean discharge for each month, also absolute minimum for year. Measurements on ground if foregoing are not available.

(3) Rainfall, temperature, evaporation.

(4) Storage already developed and effect of same.

(5) Storage possibilities,—

(*a*) Location of reservoir site or sites.

(*b*) Height of dam and class of dam suitable.

(*c*) Capacity of reservoirs and extent of adjacent drainage basin.

(6) Prior water rights above and below power site,—water supply, irrigation or power.

(7) Ice conditions, during winter months and in spring flood (frazil, anchor and floating ice).

(*a*) Under present conditions on river.

(*b*) After construction of plant.

(*c*) Without storage.

(*d*) With storage.

V. *Description of existing Power Developments on the River.*—

VI. *Detailed Work at Site investigated.*—

(1) Scope of the inspection at the site.

(2) Accessibility of site and transportation problems.

(3) Detailed information and plans at site,—

(*a*) Contour plan of site.

(*b*) Cross sections.

(*c*) Profiles.

(4) Foundation conditions.

(5) Flooding and pondage.

(6) Existing interests.

VII. *Possible Power Developed.*—

(1) Horse-power at wheel shaft without storage,—

(*a*) At minimum flow.

(*b*) For the 9 high months.

(2) Horse-power at wheel shaft with storage. Discuss utilization of local pondage at site for peak loads.

VIII. *Estimates.*—

Cost of power developed.

Cost of storage.

IX. *Market for Power.*—

(1) Present.

(2) Future.

(3) Length of transmission lines, etc.

X. *Suggestions and Recommendations.*

XI. *Appendices.*—
(1) Plans pertinent to the actual sites investigated.
(2) Photographs.
(3) Run-off records.
(4) Gauge records.
(5) Reports.
(6) Maps and plans of exising power plants and structures, etc.

DETAILS AS TO THE FOREGOING SECTIONS.

I. *Sources of Data used in Report.*

This section should set out the basis and authority on which the investigation was instituted, outline the scope of the same, and the organization by means of which the field data were obtained.

It is also intended to summarize the sources of information upon which the subject matter of the report is founded, and to set out in full the degree of thoroughness with which the investigation has been carried on.

II.—*Summary of Report.*

All the essential features of the report should be brought together here, in a brief statement forming a concise summary of the whole, tabulation of results being made where possible.

III.—*General Introductory.*

This section should cover the general features of the situation being investigated. This involves a general description of the river and its characteristics, and of the basin as a whole, touching on drainage area, source, direction, drop, falls, rapids, banks, river bed, tributaries, lakes, muskegs, swamps, forest, cultivation along banks, settlements, glaciers, general topographical and geological features, etc., and giving the definite location of the site under study.

IV.—*Water Supply.*

(1). Under general description of the drainage area those features should be dealt with which are of direct importance to the question of the water supply, such as probability of sudden floods, influence of the seasons, etc.

(2). If the site inspected is situated on one of the rivers covered by any of the systematic stream measurement work carried on by the Department, the existing records should be utilized as a basis upon which the run-off may be discussed. A summary of the essential features of the discharge covering high, low and mean flow, etc., should be inserted, while the records in their complete form should be attached as appendices in Section XI of the report. Where no records have been taken on the river, estimates or measurements of the flow at the time of the inspection should be made, either by meter or by whatever method of stream measurement is most applicable or convenient. From this, in conjunction with high water marks in evidence and from the testimony of local inhabitants as to extreme low and high water conditions, as careful an estimate as is possible should be made of the extreme low and high water conditions on the river, also of the average low and high flows which may be expected. With this data, the months and seasons in which the above conditions are usually in evidence must be given.

(3). The maximum, minimum and mean annual rainfall as recorded at the nearest stations maintained by the Meteorological Service, should be discussed, being utilized in estimating the run-off if stream flow records are not to hand. Temperature and evaporation records, if available, should also be fully considered.

(4). If storage is already in operation in the river basin above the site, a full discussion of the same is required under the heads of location; owners and operators; date of installation; area and volume of reservoir and of tributary drainage basin; description and condition of dam and structures; effect on natural run-off conditions; actual experience since being placed in operation covering date, time of filling and emptying reservoir; gauge records if available (to be attached in full in appendix); method of control; photographs, comments, etc., etc. Copies of plans of structures are to be secured if possible.

(5). The question of storage possibilities and locations on the upper waters should be covered as thoroughly as the conditions of the inspection, and the detailed instructions issued therewith, may require. If a visit is made to any lakes in the upper basins, the general elevation of the banks of the same relative to the water surface should be recorded, with notes as to what flooding would result if the lakes were raised to various definite limits. When the reservoir is in a surveyed district the approximate land flooded should be given in sections and quarter sections.

At the outlets all the conditions affecting the construction of a dam, and the type of structure advisable, are required. This will include, foundation conditions; height and character of banks; a section across the river at the point selected for the dam carried sufficiently far up the banks to cover all possible limits to which it may be advisable to hold the lake surface.

A profile should be secured of the water surface from the lake outlet to the damsite. Should there be a possibility of securing storage by means of dredging or otherwise clearing the outlet, a profile should be obtained of the water surface, and, if possible of the river bed from the lake to a sufficient distance below the damsite; any other field information necessary to determine what is involved in the construction of a dam and in the operation of a storage is also required.

When circumstances render it inadvisable to visit the upper waters of the basin for the purpose of personal inspection, a review of the storage situation, as far as it can be gathered from existing maps and from local information, should be included.

The surface area and capacity of all storage reservoirs considered, together with the area of the drainage basins adjacent to the same and their sufficiency to fill the reservoirs, should be fully covered; the beneficial effect of such storage on the flow of the river should be discussed.

(6). Any existing or projected schemes of municipal water supply, irrigation or water-power, which have or may in the future permanently divert a portion of that river flow, thus reducing the water available at the site, should be investigated and reported on.

(7). The general conditions in winter along the river as a whole, covering time of freeze up, conditions in mid-winter, and time and manner of break up in the spring, should be secured from whatever local sources may be available or, if possible, from personal observation. The question of anchor and frazil ice under present conditions should be considered carefully, also that of ice jams in the spring, both above and below the site. The possible formation of ice jams below the site and the consequent effect on the tailwater and floor elevation of the power house, should be particularly noted.

The frazil and anchor ice conditions, to be anticipated at the site after the construction of the plant, should be discussed. In this connection a careful study covering the winter conditions and troubles experienced in the operation of any existing plants on the river, together with methods of remedying the same, is advisable.

The probable effect on ice conditions of the development of storage for the purpose of increasing the winter flow, should also be covered.

V.—*Description of existing Power Plants.*

Existing power developments along the river should be dealt with under the following general heads: Ownership of plant and when constructed; description of layout and structures (dam, intake, penstocks, tunnels, canal, forebay, power house, foundations, transmission, substations, etc.) and present conditions of the same; head at different seasons; installation (electrical and hydraulic machinery in detail); auxiliary power, power load and power factor, daily load curves if possible, use of power, market for power, present and future; special features, etc., etc.; comments and photographs. Plans of plant to be secured if possible and attached to appendix.

VI.—*Detailed Work at Site Investigated.*

(*1*) *Scope of the inspection at the site.*—If a definite and well defined project be investigated, the engineer making the inspection should study the general scheme carefully in the light of his personal inspection of the ground, and should record his opinion as to the engineering and economic feasibility of the same, pointing out whatever weaknesses may be apparent, and recommending whatever changes in design, layout, or scheme of development he may consider advisable.

When no definite scheme of development has been proposed, the inspecting engineer is expected to outline the most feasible scheme which his study on the ground may suggest, setting out the head available and method of securing the same. He should also gather all information and field data which may be essential to its proper consideration and to getting out the estimates. A layout of his scheme, together with all pertinent data, should be plotted on the contour plan of the site.

Arrangements should be made on the ground for the installation and continued reading of gauges at all points where the record of the same is advisable.

Numerous photographs illustrating the site are required.

(*2*) *Accessibility of site.*—Secure all data with reference to accessibility of the site. This includes the distance to the nearest railway line; the ease or difficulty of building a spur line to the site should the size of the development warrant it; the condition of any roads in the vicinity and their suitability for heavy transport; the length of new road that may be required; the use which can be made of water transportation as a means of access. In brief, the best means of connecting the site with existing lines of traffic should be covered.

(3) Detailed informaation and plans at site—(a) Contour plan.—Enough rough instrument work must be done to permit of plotting a fairly accurate contour plan of the whole vicinity covered by the proposed layout. These contours should extend above the highest elevation to which there is any possibility of raising the headwaters of the proposed plant. Sufficient notes should be taken to plot on the said plan, with the elevations, any rock outcrops which may be in evidence. Should the rock outcrop along both banks of the river, the continuous line of demarcation between the rock and the overlying material should be plotted, *with the elevations,* along both shore lines. The plan should also indicate all other classes of material, such as: clay, gravel, sand, loam, etc., which may be in evidence, together with notes as to whether the site is wooded, cleared or cultivated, etc.

Water levels (together with date of taking, and river flow if possible) should be recorded and plotted on this plan at all important points, such as the brink and foot of falls and rapids, marking the limits of the still water above and below. All eddies and back waters should be marked and the elevation and date recorded. The general line of the brink and foot of any falls which will be involved in a proposed scheme of development should be secured and tied in to the plan. The high and low water levels to be expected in the tail water of the projected power station are of particular importance. Maximum high water marks along the shore should be carefully noted.

All natural features of which advantage might be taken in laying out a power plant should be fully shown on the plans and discussed in the report.

(b) *Cross Section.*—A cross section of the river bed and both banks along the line of the proposed dam, and sections of any alternative sites which may present themselves to the engineer on the ground, should be secured and plotted. Sections when plotted should indicate the character of the ground surface and river bed and of foundation conditions, either in evidence or assumed, throughout.

(c) *Profiles.*—A profile of the river surface from the upstream limit of the new pond created by the plant is desirable, but is not essential should the circumstances of the inspection render the securing of the same inadvisable. In all cases, however, a profile of the river surface and if possible of the river bed, from a point up stream from the dam, to below the tailrace of the power plant is required. A profile section through the dam, intake, headrace (or pipeline as the case may be), power plant, and tailrace, showing such governing elevations as, head water, crest of dam, floor of generator room, tail water, etc., should also be obtained in the best manner which circumstances may dictate.

Profiles of any pipe or canal lines are also required.

(4) *Foundation Conditions.*—Full note should be made of the natural conditions of the ground and river bed at the proposed dam and power house site. If there is rock in sight a full statement of its character, weathering qualities, etc., is required. If no rock is in evidence, as careful an investigation of the existing conditions as circumstances permit is required.

(5) *Flooding and Pondage.*—The direct flooding which will be caused by the construction of the proposed or any feasible plant, at the site, should be determined approximately either by inspection or, if necessary, by rough instrument work. If the land has been surveyed, the flooded portion can be listed by sections and quarter sections.

The utilization of this local pondage in connection with peak loads at the projected plant should receive general consideration.

(6) *Existing Interests.*—All existing interests, such as bridges, trails, roads, railways, buildings, etc., that may be affected by the construction of the plant and by the consequent flooding, should be fully reported on. The question of the logging and fishing interests on the river should be discussed in considerable detail.

VII.—*Possible Power Developed.*

The question of power possible of development should be discussed from the standpoints of, first,—no storage available, and second,—storage available. Under the first head, the power available at minimum flow, and the power which might be developed during the eight or nine months not included in the extreme low water season, should be covered.

Under both headings the beneficial utilization of the local pondage for peak loads and the consequent increased power output should be dealt with.

VIII.—*Estimates.*

Approximate estimates of the cost of the proposed scheme of development and the basis on which these are made should accompany the report, together with similar estimates of the cost of any proposed storage reservoirs.

IX.—*Market for Power.*

This will involve as thorough an investigation as the circumstances warrant, of the present and future power market in the surrounding municipalities and district. Possibilities for the local use of power at the site and in the immediate vicinity are also to be covered. With the question of power market, the question of distance of transmission necessary to reach the same requires careful consideration.

X.—*Suggestions and Recommendations.*

Suggestions, comments or recommendations with reference to the foregoing and the writer's opinion as to the questions at issue should be set out in full. The location of suitable metering stations for the continuous record of the river flow at vital points should be covered in these recommendations. The question of sources of power in the vicinity other than water, and their possible more economic development is, at times, most important. All recommendations should be set out definitely and concisely.

XI.—*Appendices.*

(1) *Plans.*—(*a*) A general plan (a section of published map is desirable) showing the location of the power and storage sites with reference to centres of population. (*b*) A general plan (a section of published map) showing the whole drainage basin above the power site, together with storage reservoirs. (*c*) Contour plans of the sites of power plants and storage dams. (*d*) Cross sections along dam sites. (*e*) Profiles of reach of river affected and of pipe and canal lines. (*f*) Any other plans warranted by the nature of the investigation.

These plans should, if at all feasible, be plotted on standard sheets, *i.e.*, outside measurement 40 inches by 32 inches, and inside or border measurement 37 inches by 30 inches. This allows 1-inch border on the top, bottom and right edge, and a 2-inch border on the left edge for binding, if necessary. Lettering on these plans should permit of reduction to at least one-quarter size. Brief reports may, with advantage, be illustrated by plans of suitable size for inclusion (with folding if necessary) by binding in the report cover. All plans, sections, and profiles, etc., should be suitably numbered, and should be referred to in the text by these numbers whenever necessary. A complete list of the above plans, giving numbers and description should be included in the table of contents of the report.

(2) *Photographs.*—A set of all the views taken to illustrate the different features of the report should be mounted and included. Where these views deal with power plant and storage dam layouts, they should be accompanied by a sketch plan showing the point from which each is taken, and the direction the camera faced. The films should be numbered, dated and titled, in order that all prints may be immediately recognized. A complete list of the photographs, giving numbers, date and subject should be included in the table of contents of the report.

(3) *Run off records.*—All tabulated and plotted curves which may have been secured.

(4) *Gauge records.*—Copies of all gauge records which are of interest in connection with the power or storage features of the report.

(5) *Reports.*—Copies of any existing reports which may have been made with reference to power development on the river.

(6) *Maps.*—Any maps which may usefully illustrate the report, and any plans which may have been obtained covering existing power plants, storage works, bridges, etc., etc.

BINDING REPORT FOR SUBMISSION.

All reports submitted to head office should be typed on the standard 8 by 13-inch paper, and should be suitably bound in the regular covers of the Water Power Branch. A table of contents listing the headings and the pages upon which each subject is dealt with should preface the text. The plans pertinent to the actual sites investigated (*i.e.* under No. 1 of the appendices) should, if not too bulky, be bound in with the report. If the plans are too numerous to be inserted in the bound report, they should be properly listed and forwarded in a roll or package.

The photographs should be listed and suitably mounted on 8 by 13-inch paper and bound with the report together with the sketch plans locating the same.

The run-off and gauge records together with copies of existing reports should be included in the bound report if not too bulky, otherwise they should be bound separately.

Maps and plans of existing structures should be suitably listed and forwarded.

INVESTIGATION AND INSPECTION OF A SERIES OF SITES.

Frequently the investigation of a river involves the consideration and detailed inspection of a series of power sites. In such cases, the report covering the work should follow the foregoing guide, with the following slight changes.

It will be noted in the foregoing, that Sections I to V can be applied as they stand, to the compilation of a report on a series of sites. Sections VI to VIII are directly applicable to each individual site; section IX is applicable to individual sites or to groups as conditions may warrant, and Sections X and XI are applicable as they stand to the ending up of the report. In preparing a report on a series of sites, the only alteration advised in the foregoing guide is that under section VI, each site be treated as a unit and completely covered according to the outline in Sections VI to IX. The new Sections VII and VIII will correspond to X and XI in the foregoing.

Following is the outline for a report covering a series of investigated sites, with the necessary alterations:—

I.—*Sources of Data used in Report*—

(1) Why investigated and scope of investigation.
(2) Personal examination, route followed and time consumed.
(3) Run-off records from Departmental stream measurement offices.
(4) Maps.
(5) Existing reports.
(6) Miscellaneous.

II.—*Summary of Report*—

Concise statement of results of investigations covering all essential features of the report. Tabulation of results as to power and storage.

III.—*General Introductory*—

Description, including location as to province, river, cities, township, range and section.

IV.—*Water Supply*—

(1) General description of drainage area.

(2) Actual record if available showing maximum, minimum and mean discharge for each month, also absolute minimum for year. Measurements on ground if foregoing are not available.

(3) Rainfall, temperature, evaporation.

(4) Storage already developed and effect of same.

(5) Storage possibilities.

(*a*) Location of reservoir site or sites.

(*b*) Height of dam and class of dam suitable.

(*c*) Capacity of reservoirs and extent of adjacent drainage basin.

(6) Prior water rights above and below power site; water supply, irrigation or power.

(7) Ice conditions during winter months and in spring flood (frazil, anchor, and floating ice).

(*a*) Under present conditions on river.

(*b*) After construction of plant.

(*c*) Without storage.

(*d*) With storage.

V.—*Description of existing Power Developments on the River.*

VI.—*Sites Investigated.*

(a) *Detailed work at each site investigated.*

(1) Scope of the inspection at the site.

(2) Accessibility of site and transportation problems.

(3) Detailed information and plans at site,—

(*a*) Contour plan of site.

(*b*) Cross sections.

(*c*) Profiles.

(4) Foundation conditions.

(5) Flooding and pondage.

(6) Existing interests.

(b) *Possible Power Developed.*

(1) Horse-power at wheel shaft without storage,—

(*a*) At minimum flow.

(*b*) For the 9 high months.

(2) Horse-power at wheel shaft with storage. Discuss utilization of local pondage at site for peak loads.

(c) *Estimates.*

Cost of power developed.

Cost of storage.

(d) *Market for Power.*

(1) Present.

(2) Future.

(3) Length of transmission lines, etc.

(e) *Recapitulation.*

Comprehensive discussion of the foregoing data as to the individual sites, and a consideration of the same as a whole or in groups, as local conditions may warrant.

VII.—*Suggestions and Recommendations.*

VIII.—*Appendices.*

(1) Plans pertinent to the actual sites investigated.
(2) Photographs.
(3) Run-off records.
(4) Gauge records.
(5) Reports.
(6) Maps and plans of existing power plants and structures, etc.

The details of the data to be covered in each section are in the main as previously outlined in connection with the report on an individual site. A careful study of these details is desirable.

In section VI each site investigated should be completely covered under the headings,—a, b, c, d and e before discussion on a second site is commenced. Plans and photographs should be suitably numbered in order that they can be referred to when necessary, in the text.

BINDING REPORT FOR SUBMISSION.

The general instructions as to binding will correspond to those given above in connection with reports on individual sites. Should the full data be too bulky for inclusion in one cover, it should be bound in sections as may be convenient.

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

J. T. JOHNSTON,
Hydraulic Engineer.

No. 6.

REPORT OF R. G. SWAN.

VANCOUVER, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following report covering the work of the British Columbia Hydrographic Survey for the year ending March 31, 1914.

ORGANIZATION AND SCOPE OF WORK.

For the first half of the year Hydrographic investigations were confined to the rivers inside the Railway Belt. Most of the stations established in 1911 and 1912 were maintained, and a number of new stations established.

With the organization of the British Columbia Hydrographic Survey in October, 1913, stream measurement work was extended to cover the entire province. The territory of the province to be covered during the year was divided into three main divisions with headquarters at Vancouver, Kamloops, and Nelson, where permanent office quarters were provided for the division engineers and the office of the chief engineer was moved from Kamloops to Vancouver. (*See* Plate No. 7.)

STAFF.

My office staff consists of Mr. F. MacLachlan, accountant, Mr. A. T. Milner, clerical assistant, and Miss W. M. Robinson, stenographer.

Mr. C. G. Cline, who was placed in charge of the Coast division, should be provided with three assistant engineers. At present Mr. H. G. E. Keys is his only assistant.

Mr. E. M. Dann is in charge of the Kamloops division. His staff consists of Mr. R. G. Chisholm, assistant engineer, and Miss B. B. Allan, stenographer. It is hoped that two assistant engineers will be appointed to Mr. Dann's staff shortly.

Mr. C. E. Richardson is in charge of the Nelson division. His required staff of two assistant engineers and a clerical assistant is likewise incomplete, and Mr. Richardson has at present the assistance of but one engineer, Mr. C. E. Webb.

FIELD WORK.

In the past the most expensive feature of field work in British Columbia has been transportation. During the time of the Railway Belt Hydrographic Survey, the hydrographers all returned to Kamloops at least once a month to bring their work up to date; while this was of advantage in keeping a close check on the field work, it made the cost of transportation exceedingly high. In the extension of the work throughout the province, the district system has been used, and the territory to be covered divided into nine districts. An engineer is placed in charge of each district, and the field work, after being compiled in the field, is sent into the division office. In this way it is not necessary for the engineers in the field to come into the office unless instructed to do so.

During the coming winter, it is hoped that it will not be necessary to maintain so many engineers in the field, as the only stations maintained will be in connection with water power possibilities and municipal water supply.

COAST DIVISION.

As briefly outlined above the divisions were divided into districts for carrying on the field work. The Coast division comprises three districts, viz., Southern, Vancouver Island and Lillooet.

The Southern district takes in the stations on the Fraser river and its tributaries as far east as North Bend, that portion of the Skagit river and its tributaries lying within the province of British Columbia, and, the stations on the Mesliloet river and its tributaries.

The territory covered to date in the Island district reaches as far north as Campbell river on the east side of the island, and Great Central lake on the west coast.

The stations along the route of the Pacific Great Eastern railway together with a number of others in the vicinity of Lillooet belong to the Lillooet district.

In the Southern and Vancouver Island districts no irrigation is practised, as the precipitation is very large, the investigation in these districts being carried on in connection with water power possibilities and municipal water supply. In the eastern portion of the Lillooet district climatic conditions are very different, being very similar to those around Kamloops and investigations are carried on mainly in the interests of irrigation.

Gauging Stations.—Coast Division, March 31, 1914. (*See Plate No.* 7).

Number.	Stream.	Location.
1000	Belknap creek	Tp. 6, R. 7, W. 7 M.
1001	Boulder creek	Tp. 3, R. 27, W. 6 M.
1002	Brandt creek	Tp. 7, R. 7, W. 7 M.
1003	Chehalis river	Tp. 4, R. 30, W. 6 M.
1004	Chilliwack river	Tp. 23, E.C.M.
1005	Coquihalla river	Tp. 5, R. 26, W. 6 M.
1006	Coquitlam river	Tp. 5, R. 6, W. 7 M.
1007	Fraser river	Tp. 5, R. 26, W. 6 M.
1008	Gold creek	Tp. 39, E.C.M.
1009	Hixon creek	Tp. 6, R. 7, W. 7 M.
1010	Jones creek	Tp. 3, R. 27, W. 6 M.
1011	Mesliloet river	Tp. 7, R. 7, W. 7 M.
1012	North Lillooet river	Tp. 12, E.C.M.
1013	Norton creek	Tp. 7, R. 7, W. 7 M.
1014	Rainbow creek	Tp. 6, R. 4, W. 7 M.
1015	Rushton creek	Tp. 5, R. 4, W. 7 M.
1016	Silver-Hope creek	Tp. 5, R. 26, W. 6 M.
1017	Silver-Pitt creek	Tp. 4, R. 5, W. 7 M.
1018	South Lillooet river	Tp. 12, E.C.M.
1019	Stave river	Tp. 4, R. 3, W. 7 M.
1020	Young creek	Tp. 7, R. 7, W. 7 M.
1021	Brandt creek	Tp. 7, R. 7, W. 7 M.
1022	Seymour creek	Near North Vancouver water district No. 1, Vancouver division.
1023	Capilano creek	Near North Vancouver water district No. 1, Vancouver division.
1024	Lynn creek	Near North Vancouver water district No. 1, Vancouver division.
1034	Cheakamus river	Near Squamish water district No. 1.
1035	Green river	At Green lake water district No. 1.
1038	Lillooet river	Above Lillooet lake water district No. 1.
1041	Green river	Two miles from mouth water district No. 1.
1045	Bridge river	Thirty miles from mouth water district No. 1, Lillooet division.
1063	Belknap creek	Tp. 7, R. 7, W. 7 M.
1064	Hixon creek	Tp. 6, R. 7, W. 7 M.

KAMLOOPS DIVISION.

The territory included in the Kamloops division covers an area of about twenty-nine thousand square miles and is divided into three districts, viz., Kamloops, Ashcroft, and Okanagan.

The Kamloops district may be described as that area drained by the North and South Thompson rivers. While most of the stations in this district were established in connection with irrigation investigations, some have been required for the purpose of water-power studies as for instance on the Adams river, where the largest and most valuable water-power in central British Columbia is to be found.

The country around Adams lake is very heavily timbered and at present extensive lumbering operations are being carried on. A reconnoissance of the Clearwater river, a tributary of the North Thompson, shows good power possibilities, the information at hand is however too meagre to make an approximation of the amount of power that can be developed.

The Ashcroft district takes in the main Thompson river drainage area and station on the Fraser river at Lytton. The streams in this district are important for irrigation only, there being no power possibilities of any extent.

The Okanagan district includes the stations on the rivers in the Nicola, Okanagan, and Similkameen valleys.

Throughout the whole of the Kamloops division agriculture is the chief industry, a large portion of each district being in the "Dry Belt." The judicious application of water has made the Okanagan and Similkameen valleys the best known fruit growing districts in Canada, while in the Kamloops and Ashcroft districts mixed farming has proved a great success.

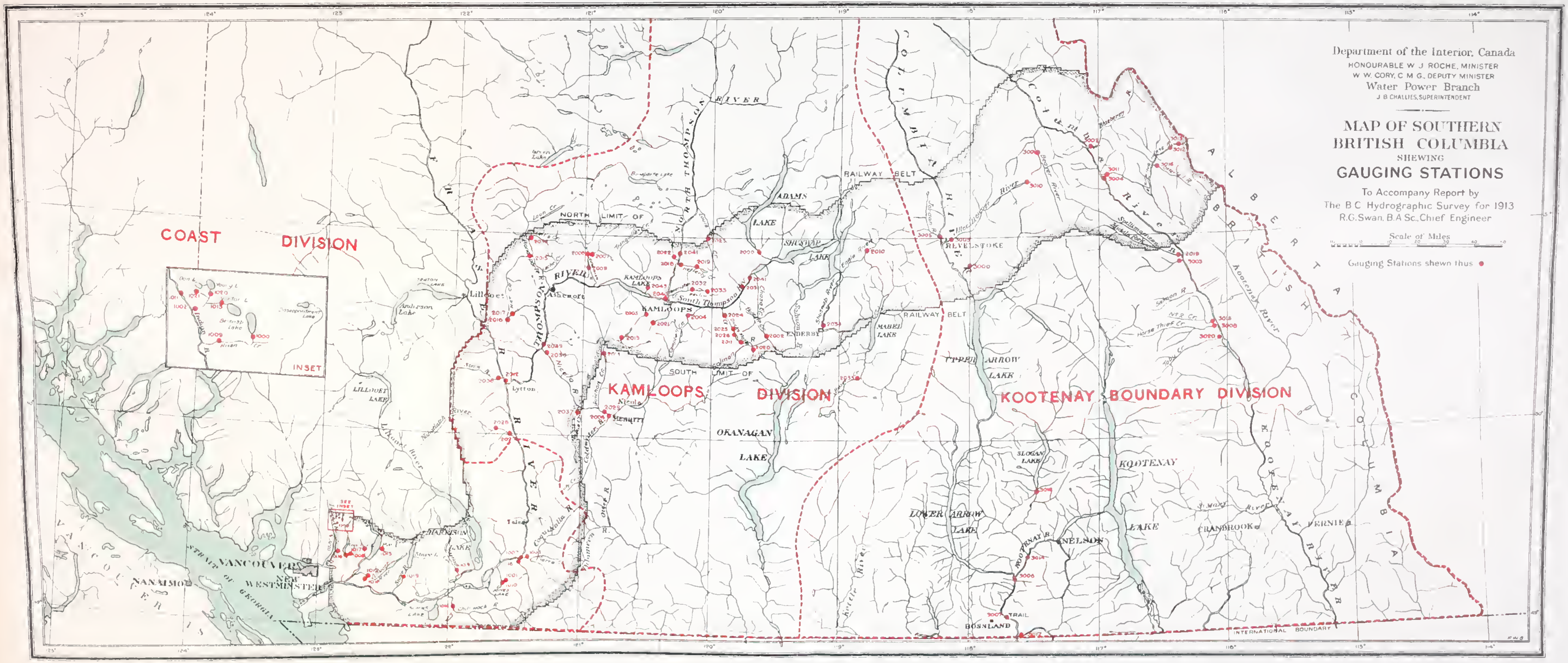
GAUGING STATIONS.—Kamloops Division, March 31, 1914.—(See Plate No. 7.)

Number.	Stream.	Location.
2000	Adams river	Tp. 23, R. 12, W. 6 M.
2001	Barnes creek	Tp. 20, R. 24, W. 6 M.
2002	Bolean creek	Tp. 18, R. 12, W. 6 M.
2003	Bonaparte river	Tp. 21, R. 24, W. 6 M.
2004	Campbell river	Tp. 19, R. 16, W. 6 M.
2005	Cherry creek	Tp. 19, R. 19, W. 6 M.
2006	Coldwater river, Merritt	Water district No. 3.
2007	Criss creek	Tp. 22, R. 22, W. 6 M.
2008	Deadman river (Walhachin Flume)	Tp. 21, R. 22, W. 6 M.
2009	Deadman river	Tp. 22, R. 22, W. 6 M.
2010	Eagle river	Tp. 23, R. 6, W. 6 M.
2011	Essell creek	Tp. 17, R. 14, W. 6 M.
2012	Fraser river	Tp. 15, R. 27, W. 6 M.
2013	Greenstone creek	Tp. 17, R. 20, W. 6 M.
2014	Guichon creek, Mamit lake	Water district No. 3.
2015	Hat creek, H. C. Ranch	Tp. 22, R. 25, W. 6 M.
2016	Hat creek, Hammonds ditch diversion	Tp. 19, R. 26, W. 6 M.
2017	Hat creek, upper	Tp. 19, R. 26, W. 6 M.
2018	Hefferly creek	Tp. 22, R. 17, W. 6 M.
2019	Hefferly creek	Tp. 22, R. 16, W. 6 M.
2020	Ingram creek	Tp. 17, R. 13, W. 6 M.
2021	Jacko creek	Tp. 19, R. 18, W. 6 M.
2022	Jamieson creek	Tp. 22, R. 17, W. 6 M.
2023	Louis creek	Tp. 23, R. 15, W. 6 M.
2024	Monte creek, above Bostock's diversion	Tp. 19, R. 15, W. 6 M.
2025	Monte creek, Summit lake diversion	Tp. 18, R. 14, W. 6 M.
2026	Monte creek, below Summit lake diversion	Tp. 18, R. 14. W. 6 M.
2027	Nahatlatch river, Lower station	Tp. 2, R. 26, W. 6 M.
2028	Nahatlatch river, Upper Station	Tp. 12, R. 27, W. 6 M.
2029	Nicola river, Merritt	Water district No. 3.
2030	Nicola river, mouth	Tp. 17, R. 25, W. 6 M.
2031	Niskonlith creek	Tp. 21, R. 13, W. 6 M.
2032	Paul creek, below Paul lake	Tp. 20, R. 15 W. 6 M.
2033	Paul creek, below Pinantan lake	Tp. 20 R. 15, W. 6 M.
2034	Shuswap river, Enderby	Tp. 18, R. 9, W. 6 M.
2035	Shuswap river, Lumby	Water district No. 4.
2036	Scottie creek	Tp. 23, R. 25, W. 6 M.
2037	Spius creek	Tp. 13, R. 23, W. 6 M.
2038	Stein creek	Tp. 15, R. 27, W. 6 M.
2039	Thompson river, Spence's bridge	Tp. 17, R. 25, W. 6 M.
2040	Thompson river, Kamloops	Tp. 17, R. 20, W. 6 M.
2041	North Thompson river	Tp. 22, R. 17, W. 6 M.
2042	South Thompson river	Tp. 21, R. 13, W. 6 M.
2043	Tranquille river	Tp. 23, R. 19, W. 6 M.

NELSON DIVISION.

The Nelson division is comprised of East and West Kootenay districts of British Columbia, and of the area drained by the Kettle river. The total area of the division is approximately 32,000 square miles and is divided into the Golden, Cranbrook, and Nelson districts.

PLATE No 7


Department of the Interior, Canada
HONOURABLE W. J. ROCHE, MINISTER
W. W. CORY, C. M. G., DEPUTY MINISTER
Water Power Branch
J. B. CHALLIES, SUPERINTENDENT
MAP OF SOUTHERN BRITISH COLUMBIA
SHEWING
GAUGING STATIONS
To Accompany Report by
The B.C. Hydrographic Survey for 1913
R.G. Swan, B.A.Sc., Chief Engineer
Scale of Miles
Gauging Stations shewn thus ●
COAST DIVISION
KAMLOOPS DIVISION
KOOTENAY BOUNDARY DIVISION
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SEE INSET
NORTH LIMIT OF RAILWAY BELT
SOUTH LIMIT OF RAILWAY BELT
RAILWAY BELT
INTERNATIONAL BOUNDARY
ALBERTA
BRITISH COLUMBIA
FRASER RIVER
NORTH THOMPSON RIVER
South Thompson
COLUMBIA RIVER
KOOTENAY RIVER
KAMLOOPS
KAMLOOPS LAKE
ADAMS LAKE
SHUSWAP LAKE
MABEL LAKE
ENDERBY
REVELSTOKE
UPPER ARROW LAKE
LOWER ARROW LAKE
SLOCAN LAKE
KOOTENAY LAKE
NELSON
TRAIL
ROSSLAND
CRANBROOK
FERNIE
OKANAGAN LAKE
Nicola
Merritt
Lytton
Lillooet
Ashcroft
LILLOOET LAKE
HARRISON LAKE
Anderson Lake
Seaton Lake
VANCOUVER
NEW WESTMINSTER
NANAIMO
STRAIT OF GEORGIA
VANCOUVER IS.
Kettle River
Coquihalla R.
Nicola R.
Similkameen R.
Bonaparte Lake
Eagle River
Illecillewaet River
Spillimacheen R.
Kootenay River
Horse Thief Cr.
Toby Cr.
St. Mary River

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The Golden district includes the stations on the Columbia river and tributaries, from Windermere lake to upper Arrow lake.

The Cranbrook district includes the stations on the branch of the Kootenay river and its tributaries.

Nelson district includes the stations on the Columbia, Kootenay, and Slocan rivers and their tributaries in the vicinity of Nelson, and the stations on the rivers in the Kettle valley.

The climate varies greatly in different sections of the Nelson division, around Revelstoke the climate is humid, while the upper Columbia and Kootenay valleys are arid and irrigation is necessary.

In the southern part of the division the most important natural resources are minerals and mining is the chief industry, and there are a number of small power developments now in operation in connection with the mining development.

GAUGING STATIONS.—Nelson division—March 31, 1914. (*See* plate No. 7).

Number.	Stream.	Location.
3000	Akolkolex	Tp. 25, R. 1, W. 6 M.
3001	Beaver river	Tp. 29, R. 25, W. 5 M.
3002	Blaeberry river	Tp. 28, R. 22, W. 5 M.
3003	Bugaboo creek, Spillimacheen	Water district No. 8.
3004	Columbia river at Golden	Tp. 27, R. 22, W. 5 M.
3005	Columbia river at Revelstoke	Tp. 23, R. 2, W. 6 M.
3006	Columbia river at Castlegar	Water district No. 6.
3007	Columbia river trail	Water district No. 6.
3008	Horsethief creek, Wilmer	Water district No. 8.
3009	Illecillewaet river at Revelstoke	Tp. 23, R. 2, W. 6 M.
3010	Illecillewaet river at Glacier	Tp. 26, R. 26, W. 5 M.
3011	Kicking Horse river at Golden	Tp. 27, R. 22, W. 5 M.
3012	Kicking Horse river at Field	Tp. 28, R. 18, W. 5 M.
3013	Kicking Horse river, No. 2 Tunnel	Tp. 28, R. 18, W. 5 M.
3014	Kootenay river, Glade	Water district, No. 6.
3015	No. 2 creek, Wilmer	Water district No. 8.
3016	Ottertail river	Tp. 27, R. 19, W. 5 M.
3017	Pend d'Oreille river, Waneta	Water district No. 6.
3018	Slocan river, Slocan	Water district No. 6.
3019	Spillimacheen river, Spillimacheen	Water District No. 8.
3020	Toby creek, Athalmere	Water district No. 8.
3021	Boundary, Greenwood	Water district No. 5.
3022	Christina, Christina lake	Water district No. 5.
3023	Elk river, Elko	Water district No. 7.
3024	Kettle river, Grand Forks	Water district No. 5.
3025	Kettle river, Kettle valley	Water district No. 5.
3026	Kettle river, Midway	Water district No. 5.
3027	Kettle river, Westbridge	Water district No. 5.
3028	Kooskanax, Nakusp	Water district No. 6.
3029	Nakusp, Nakusp	Water district No. 6.

FUTURE WORK.

At the time of the organization of the British Columbia Hydrographic Survey, the season was far advanced, and sufficient funds were not available for extending the work as rapidly as was desired.

It is hoped that, during the coming season, a new division will be started in the northern part of the province with headquarters at either Fort George or Fort Fraser. The Grand Trunk Pacific has opened up an immense territory and already the demand for water for domestic and industrial purposes is very large.

I have the honour to be, Sir.

Your obedient servant,

R. G. SWAN,

Chief Engineer.

No. 7.

REPORT OF S. S. SCOVIL.

WINNIPEG, MANITOBA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa, Ont.

SIR,—I have the honour to submit herewith a report of the work of the Manitoba Hydrographic and Power Surveys for the year ending March 31, 1914.

SCOPE OF WORK.

The Hydrographic Survey of Manitoba was only commenced in the spring of 1912, and while the work has covered but a period of two years, in this short time much has been accomplished, and a great mass of valuable information obtained. The extent and scope of the work has increased so rapidly, that it has been necessary to make both numerous appointments to the staff, and also to secure greater office space.

During the past year, practically all rivers in central and southern Manitoba were embraced in the study of stream flow; this entailed the establishment of numerous gauging stations and the securing of continuous records at each station. At the same time, surveys were made, by special field parties, as to the power possibilities of all the more important rivers in the southern portion of the Province. Briefly the investigations of this nature have included the following rivers; the Assiniboine in the vicinity of Brandon, the Little Saskatchewan from the junction with the Assiniboine upstream to Minnedosa, the Valley river from Gilbert Plains to some four miles below the village of Valley River, the Mossy river from Lake Dauphin to lake Winnipegosis, the Waterhen river in conjunction with Meadow Portage between lake Winnipegosis and lake Manitoba, the Fairford and Dauphin rivers between the latter lake and lake Winnipeg, the Manigotagan river from its headwaters to lake Winnipeg, and the Whitemouth river from Whitemouth Settlement to the Winnipeg river. In each case the investigation involved the securing of a profile of the river, a detailed survey of possible power concentrations, and the possibilities of storage and regulation of river flow. While a brief summary is given in this report as to the results of the work, detailed plans and reports of the same have been in course of preparation, during the past winter, in this office.

The detailed power survey of the Winnipeg river was also continued throughout the year, and the work is now rapidly nearing completion.

Field work comprising stream gauging and special surveys has also been carried on continuously at the outlets of the Lake of the Woods. This work has been necessitated by the reference before the International Joint Commission as to the regulation of the Lake of the Woods, by which the powers on the Winnipeg river are vitally affected.

The compilation and preparation of the vast amount of data gathered in the field throughout the year, and more particularly in the open season, has required strenuous labour on the part of the office staff, but as a result of the special effort made during the past winter, this phase of the work is now well in hand.

The importance of such work as is being carried on by this survey is evidenced, by the widespread interest of the public in questions relating to water supply, drainage, navigation and hydro-electric development. Particularly does this apply to the possibilities of hydro-electric development, as, on account of the physical and geological features of the province, it is to this source that Manitoba must look for its power. While the question of hydro-electric power has been agitated for years in the many towns and cities of the province, it has recently been brought more greatly to the fore. This is evidenced by the request of the city of Brandon for the power surveys on the Assiniboine and Little Saskatchewan, and of the town of Dauphin for the surveys in its vicinity. In the 1913 session of the Provincial Legislature of Manitoba, a resolution was passed calling for an immediate investigation of the possibilities of hydro-electric development within the province. This matter was referred for action to the Manitoba Public Utilities Commissioner, the Honourable H. A. Robson, and it was then arranged that the reporting upon the water powers of the province be done by this branch. This survey's report, while preliminary in nature, gave the first definite and reliable information as to Manitoba's power resources, and, following its presentation to the commissioner evoked much favourable comment from all sources. On the tabling of the report in the Legislature in February, 1914, conferences were held of the cities and municipalities lying between Winnipeg and Brandon, with the object of jointly securing long distance transmission of electric power from the Winnipeg river. Negotiations are said to be still under progress in this connection. Not only has this agitation been peculiar to the southern portion of the province, but also has it been apparent in the central north.

With such widespread interest, and interest of such importance, it is imperative that the study of the hydrology of the province be carried on as expeditiously as possible. As yet, funds have not permitted a detailed investigation of the more northerly rivers flowing into Hudson Bay, but, from information so far gathered, it is evident that the power potentialities of these rivers are of enormous extent. The rapid construction of the Hudson Bay railway, and the consequent opening up of this northern territory, necessitates that work should be commenced upon these rivers at the earliest possible date.

STAFF AND ORGANIZATION.

The survey was, as in the previous year, supervised from the Winnipeg office. Early in the year, the office space was found entirely inadequate, and steps were then taken to secure more commodious quarters. A new office of suitable size was finally secured at 231 Chambers of Commerce, the same building in which the survey was then located. The transfer to the new quarters was made during the first week of December.

Several new appointments to the staff were made, in order to cope with the ever-increasing extent of the work. This more particularly applied during the summer season at which time the various power surveys were in progress, and for which several temporary appointments were made.

Two deplorable accidents occurred during the past year. On July 15, Mr. G. H. Burnham, who was in charge of the Power Survey of the Valley river was drowned while attempting to cross the river in a canoe with three of his field party. Mr. Burnham was one of the Survey's most efficient and reliable engineers, and had been with the Survey since its inception.

On August 22, a second fatality occurred on the Winnipeg River Survey when Mr. A. E. W. Hanington lost his life, while attempting to run a rapid on the Pinawa channel. Mr. Hanington had been employed as assistant to Mr. O'Grady, engineer in charge of the above work, and, at the time of the accident was temporarily in charge of the party. While the period of Mr. Hanington's services with the Survey had only been of short duration, he had already been found to be an extremely capable and efficient officer.

It is also with regret that reference is made to the resignation of the chief engineer, Mr. D. L. McLean, as it was under his most efficient direction that the Survey was organized and developed to its present standing. Mr. McLean's resignation took effect on October 28, 1913, and from that date to the end of the fiscal year, the work was carried on by myself.

STREAM GAUGING.

The extent of the investigation of stream flow was greatly enlarged during the year; not only was a greater territory covered, but also it was possible to make a more detailed study of the more important rivers. Measurements of flow were made regularly throughout the summer and winter at thirty-eight gauging stations, and records of river and lake stage were maintained continuously at thirty-four other points. The following table gives a list of the regular metering stations, gauging stations at which stage only has been secured and of stations at which reconnaisance meterings have been made (*See Plate No. 8*).

REGULAR METERING STATIONS.

No.	River.	Locality.
A.1.a	Assiniboine	Brandon.
A.1.c	Assiniboine	Headingly.
A.1.d	Assiniboine	Millwood.
A.1.e	Assiniboine	St. James.
B.3.a	Brokenhead	Sinnot.
F.1.a	Fairford	Fairford.
K.1.a	Kettle falls	Canadian channel, outlet. Namakan lake.
K.1.b	Kettle falls	International channel, Outlet Namakan lake.
L.1.a	Lake of the Woods outlets	Kenora Power-house.
L.1.b	Lake of the Woods outlets	Western outlet, North Tunnel island.
L.1.c	Lake of the Woods outlets	Western outlet, Norman Traffic bridge.
L.1.e	Lake of the Woods outlets	Keewatin Lumber Company, Millrace.
L.1.f	Lake of the Woods outlets	Mill "A", Keewatin.
L.1.g	Lake of the Woods outlets	Mill "C", Keewatin.
L.1.j	Lake of the Woods outlets	Old headrace, C.P.R. culvert.
L.1.k	War Eagle lake	Outlet, Keewatin.
L.3.a	Little Saskatchewan	Riverdale.
L.3.f	Little Saskatchewan	Bilbey's bridge
M.1.a	Manigotagan	Wood falls.
M.4.c	Mossy	Lacey's farm.
O.1.a	Ochre	Ochre river.
P.2.b	Pinawa	Control dam.
P.2.c	Pinawa	W.E.S.R. Co. Power-house.
P.3.a	Pipestone	Cromer.
R.1.a	Rat	Otterbourne.
R.4.a	Red	Emerson.
R.5.b	Roseau	Baskerville's farm.
R.6.a	Red Deer	Hudson's Bay junction.
R.6.c	Red Deer	Erwood.
S.1.a	Saskatchewan	Grand Rapids.
S.1.d	Saskatchewan	Le Pas.
S.3.a	Shell	Assissippi.
S.4.a	Souris	Wawanesa.
S.5.a	Squirrel	Austin.
S.6.a	Swan	Swan river.
V.1.a	Valley	Valley river.
W.1.a	Whitemouth	Whitemouth.
W.6.d	Winnipeg	Slave falls.

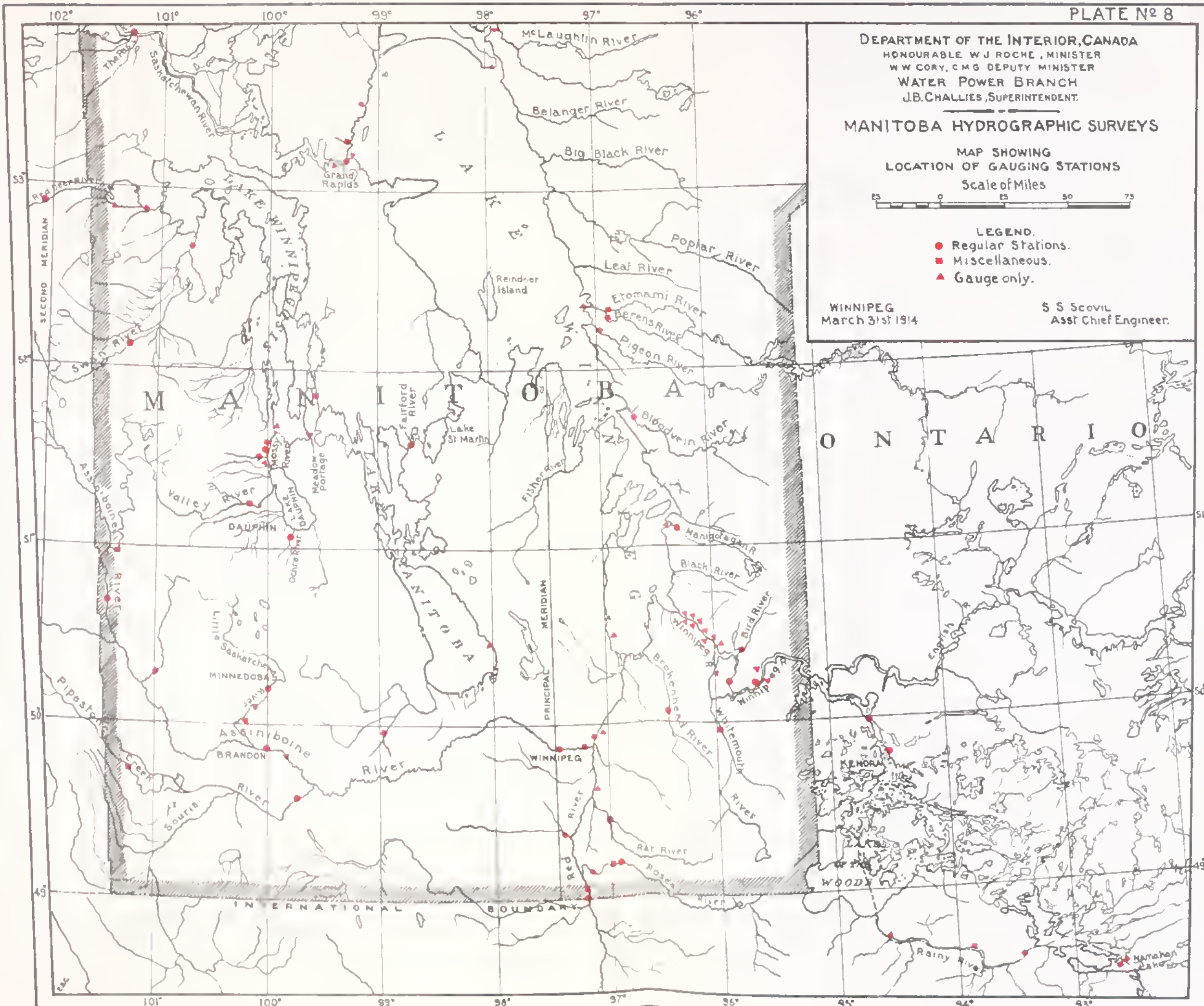


PLATE No 8
DEPARTMENT OF THE INTERIOR, CANADA
HONOURABLE W J ROCHE, MINISTER
W W CORY, C M G DEPUTY MINISTER
WATER POWER BRANCH
J.B. CHALLIES, SUPERINTENDENT.
MANITOBA HYDROGRAPHIC SURVEYS
MAP SHOWING
LOCATION OF GAUGING STATIONS
Scale of Miles
25 0 25 50 75
LEGEND.
Regular Stations.
Miscellaneous.
Gauge only.
WINNIPEG
March 31st 1914
S S Scovil
Asst Chief Engineer.
102° 101° 100° 99° 98° 97° 96° 95° 94° 93°
53° 52° 51° 50° 49°
MANITOBA
ONTARIO
LAKE WINNIPEG
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE DAUPHIN
LAKE OF THE WOODS
Lake St Martin
Reindeer Island
McLaughlin River
Belanger River
Big Black River
Poplar River
Leaf River
Eromami River
Berens River
Pigeon River
Bloodvein River
Fisher River
Fairford River
Manigotagan R
Black River
Bird River
Winnipeg R
Brokenhead River
Whitemouth River
Rat River
Roseau River
Red River
Assiniboine River
Little Saskatchewan River
Souris River
Pipestone Creek
Valley River
Mossy River
Meadow Portage
Ochre River
Swan River
Red Deer River
Saskatchewan River
English River
Rainy River
Namakan Lake
The Pas
Grand Rapids
DAUPHIN
MINNEDOSA
BRANDON
WINNIPEG
KENORA
SECOND MERIDIAN
PRINCIPAL MERIDIAN
INTERNATIONAL BOUNDARY

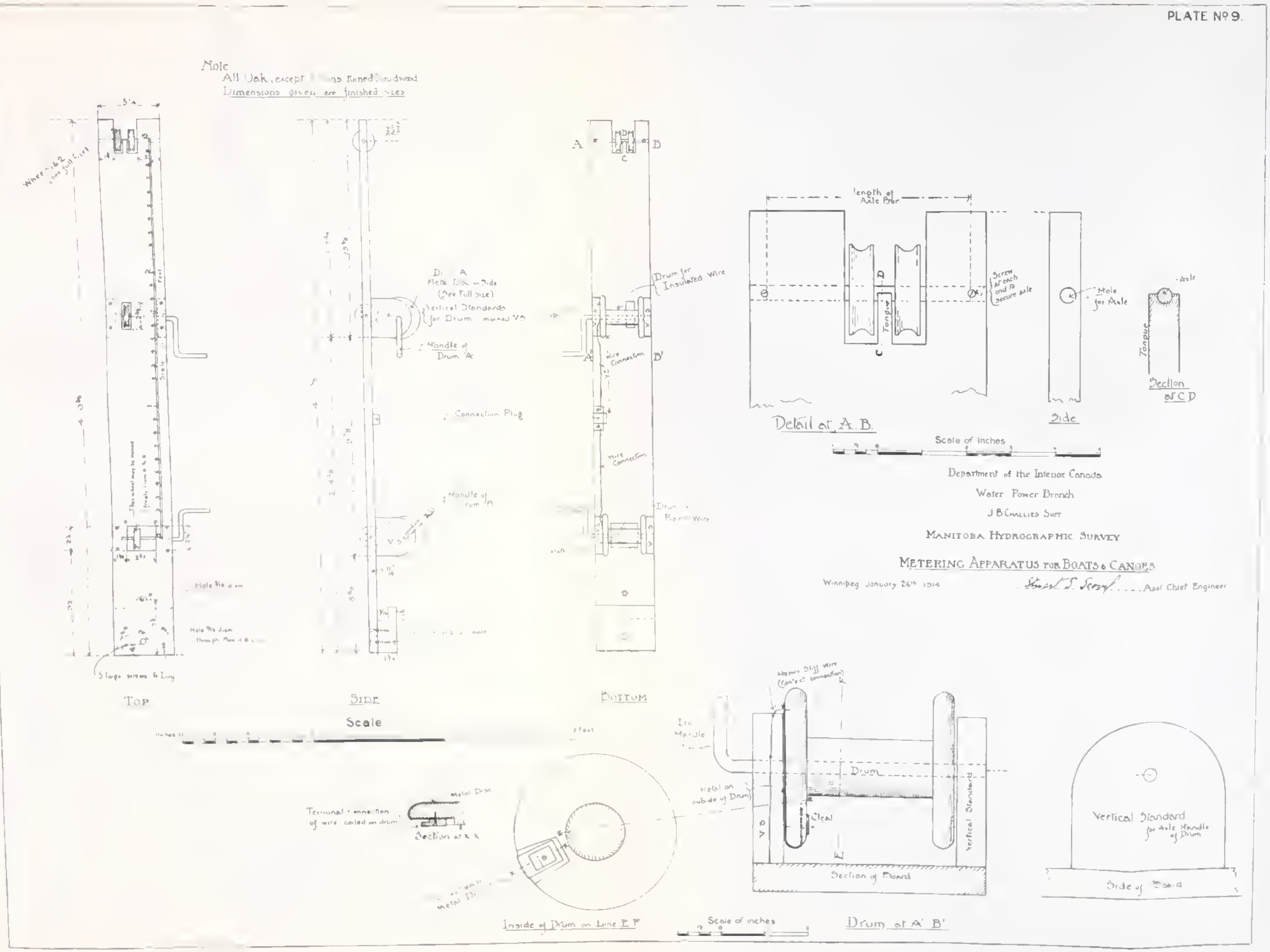
of the party. Wh
been of short dur
efficient officer.

It is also w
engineer, Mr. D. I
vey was organized
took effect on Oct
work was carried

The extent o
year; not only was
detailed study of
larly throughout t
of river and lake s
following table gi
stage only has be
been made (*See F*

No.
A.1.a
A.1.c
A.1.d
A.1.e
B.3.a
F.1.a
K.1.a
K.1.b
L.1.a
L.1.b
L.1.c
L.1.e
L.1.f
L.1.g
L.1.j
L.1.k
L.3.a
L.3.f
M.1.a
M.4.c
O.1.a
P.2.b
P.2.c
P.3.a
R.1.a
R.4.a
R.5.b
R.6.a
R.6.c
S.1.a
S.1.d
S.3.a
S.4.a
S.5.a
S.6.a
V.1.a
W.1.a
W.6.d

PLATE No 9.

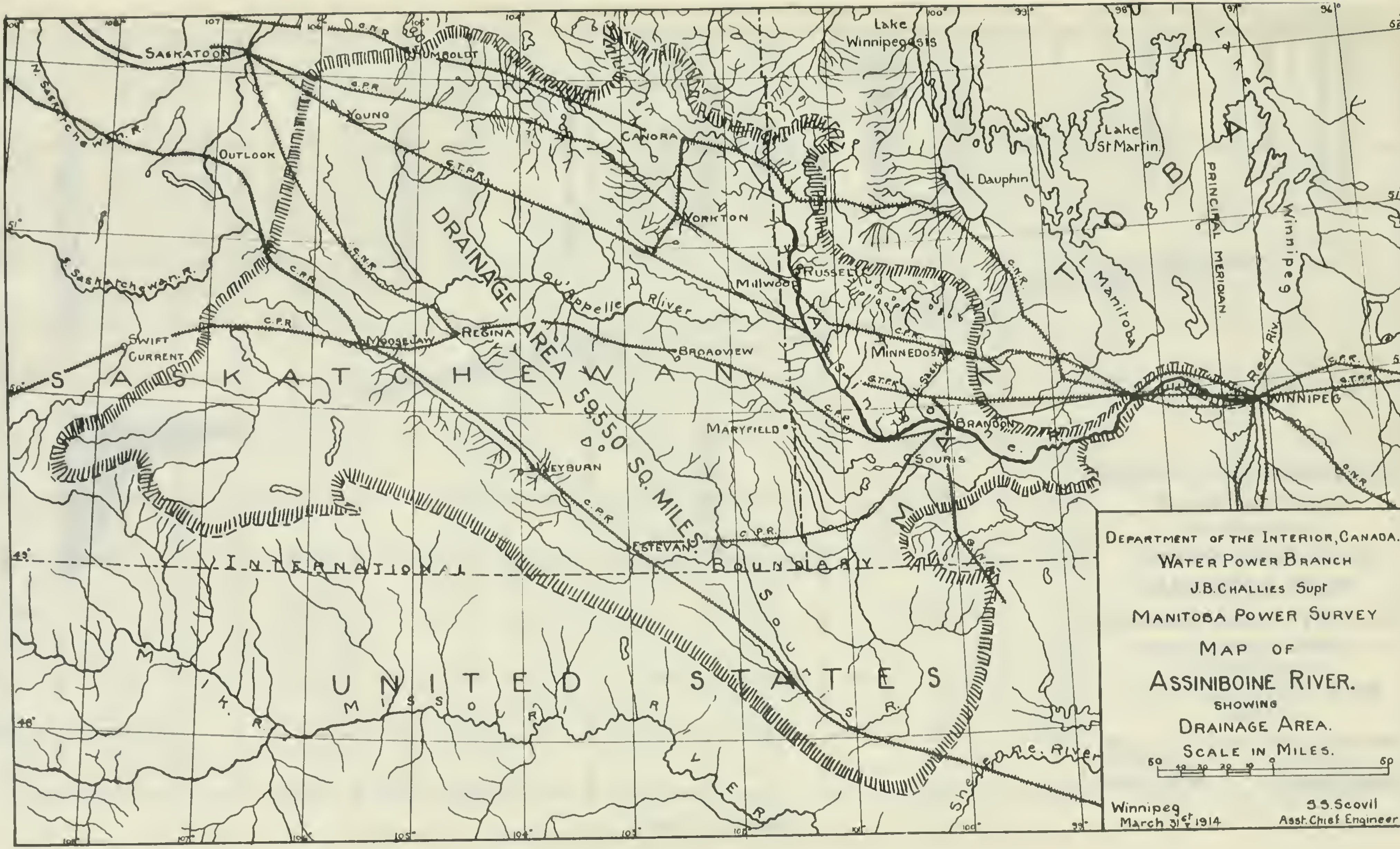

Note
All Oak, except
Dimensions given are finished sizes
Length of Axle Bar
Detail at A.B.
Side
Section at C D
Tongue
Hole for Axle
Scale of Inches
Department of the Interior Canada
Water Power Branch
J B Challies Supt
MANITOBA HYDROGRAPHIC SURVEY
METERING APPARATUS FOR BOATS & CANOES
Winnipeg January 26th 1914
Asst Chief Engineer
Drum for Insulated Wire
Vertical Standards for Drum marked VS
Handle of Drum A
Connection Plug
Wire Connection
TOP
SIDE
BOTTOM
Scale
Terminal connection of wire coiled on drum
Section at X X
Metal Disc
Drum
Cleat
Vertical Standard
Section of Board
Vertical Standard for Axle Handle of Drum
Side of Board
Inside of Drum on Line E F
Scale of inches
Drum at A' B'

of the party. Whi
been of short dur
efficient officer.

It is also wi
engineer, Mr. D. I
vey was organized
took effect on Oct
work was carried

The extent oi
year; not only was
detailed study of
larly throughout t
of river and lake s
following table gi
stage only has be
been made (*See P*

No.
A.1.a.. ....
A.1.c...............
A.1.d...............
A.1.e...............
B.3.a...............
F.1.a...............
K.1.a...............
K.1.b...............
L.1.a...............
L.1.b....... ....
L.1.c...............
L.1.e...............
L.1.f...............
L.1.g...............
L.1.j...............
L.1.k...............
L.3.a...............
L.3.f...............
M.1.a...............
M.4.c...............
O.1.a...............
P.2.b...............
P.2.c...............
P.3.a...............
R.1.a...............
R.4.a...............
R.5.b...............
R.6.a...............
R.6.c...............
S.1.a...............
S.1.d...............
S.3.a...............
S.4.a...............
S.5.a...............
S.6.a...............
V.1.a...............
W.1.a.... ....
W.6.d...............



Department of the Interior, Canada.
Water Power Branch
J.B. Challies Supt
Manitoba Power Survey
Map of
Assiniboine River.
showing
Drainage Area.
Scale in Miles.
Winnipeg
March 31st 1914
S.S. Scovil
Asst. Chief Engineer
Drainage Area 59550 Sq. Miles
Saskatchewan
Manitoba
United States
International Boundary
Principal Meridian
Lake Winnipegosis
Lake St Martin
L. Dauphin
L. Manitoba
Lake Winnipeg
Saskatoon
Outlook
Young
Canora
Yorkton
Russell
Millwood
Minnedosa
Brandon
Souris
Maryfield
Broadview
Regina
Moose Jaw
Swift Current
Weyburn
Estevan
Winnipeg
Qu'Appelle River
N. Saskatchewan R.
S. Saskatchewan R.
Souris R.
Missouri R.
Milk R.
Red Riv.
Sheyenne River
C.P.R.
C.N.R.
G.T.P.R.

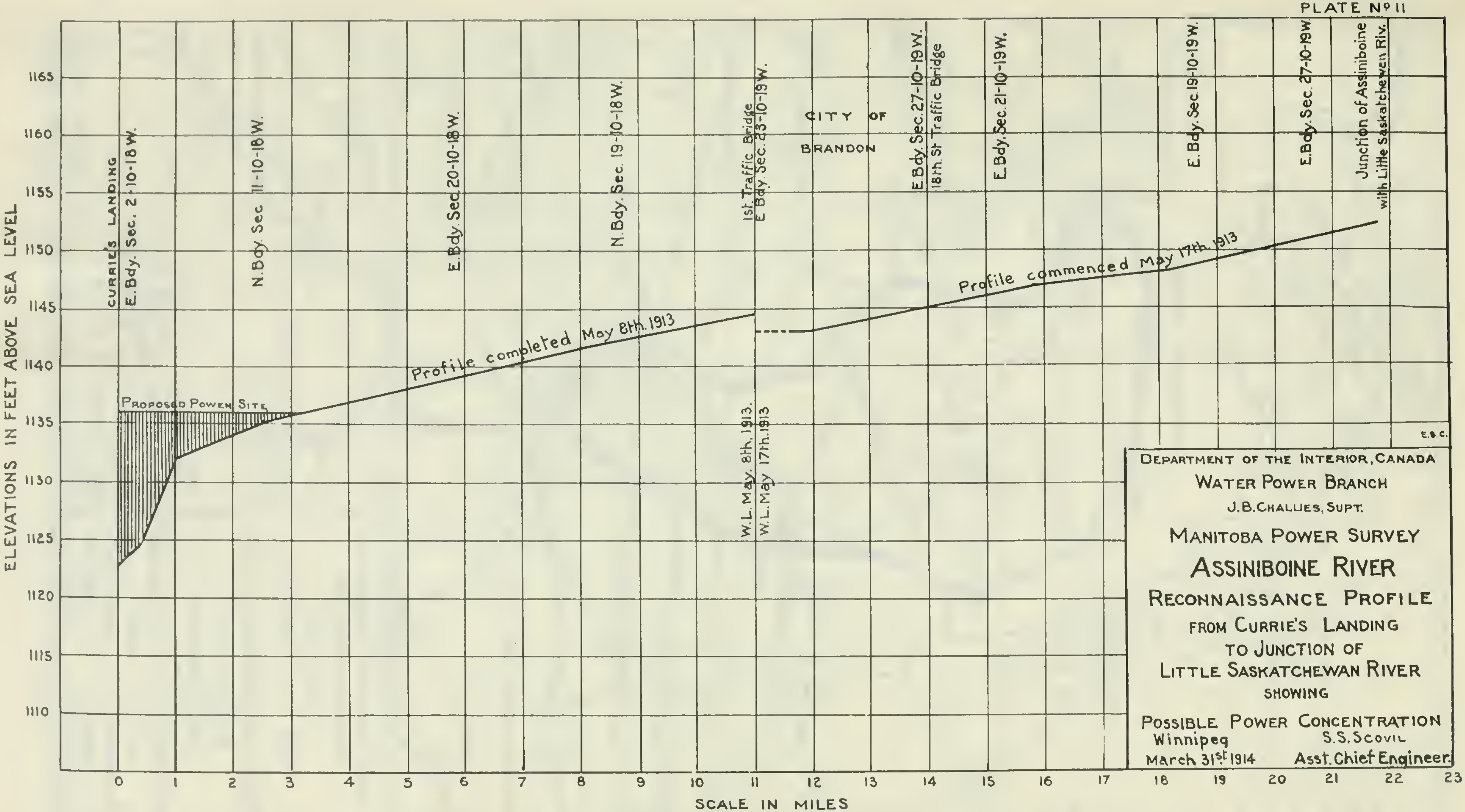
of the party. Wh
been of short du
efficient officer.

It is also w
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent o
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a
A.1.c
A.1.d
A.1.e
B.3.a
F.1.a
K.1.a
K.1.b
L.1.a
L.1.b
L.1.c
L.1.e
L.1.f
L.1.g
L.1.j
L.1.k
L.3.a
L.3.f
M.1.a
M.4.c
O.1.a
P.2.b
P.2.c
P.3.a
R.1.a
R.4.a
R.5.b
R.6.a
R.6.c
S.1.a
S.1.d
S.3.a
S.4.a
S.5.a
S.6.a
V.1.a
W.1.a
W.6.d

PLATE Nº 11



ELEVATIONS IN FEET ABOVE SEA LEVEL
1165
1160
1155
1150
1145
1140
1135
1130
1125
1120
1115
1110
SCALE IN MILES
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
CURRIE'S LANDING
E. Bdy. Sec. 2-10-18 W.
N. Bdy. Sec 11-10-18 W.
E. Bdy. Sec. 20-10-18 W.
N. Bdy. Sec. 19-10-18 W.
1st. Traffic Bridge
E. Bdy. Sec. 23-10-19 W.
CITY OF
BRANDON
E. Bdy. Sec. 27-10-19 W.
18th. St Traffic Bridge
E. Bdy. Sec. 21-10-19 W.
E. Bdy. Sec 19-10-19 W.
E. Bdy. Sec. 27-10-19 W.
Junction of Assiniboine
with Little Saskatchewan Riv.
Proposed Power Site
Profile completed May 8th. 1913
Profile commenced May 17th. 1913
W. L. May. 8th. 1913.
W. L. May 17th. 1913
E.S.C.
Department of the Interior, Canada
Water Power Branch
J.B. Challies, Supt.
Manitoba Power Survey
Assiniboine River
Reconnaissance Profile
from Currie's Landing
to Junction of
Little Saskatchewan River
showing
Possible Power Concentration
Winnipeg
March 31st 1914
S.S. Scovil
Asst. Chief Engineer.

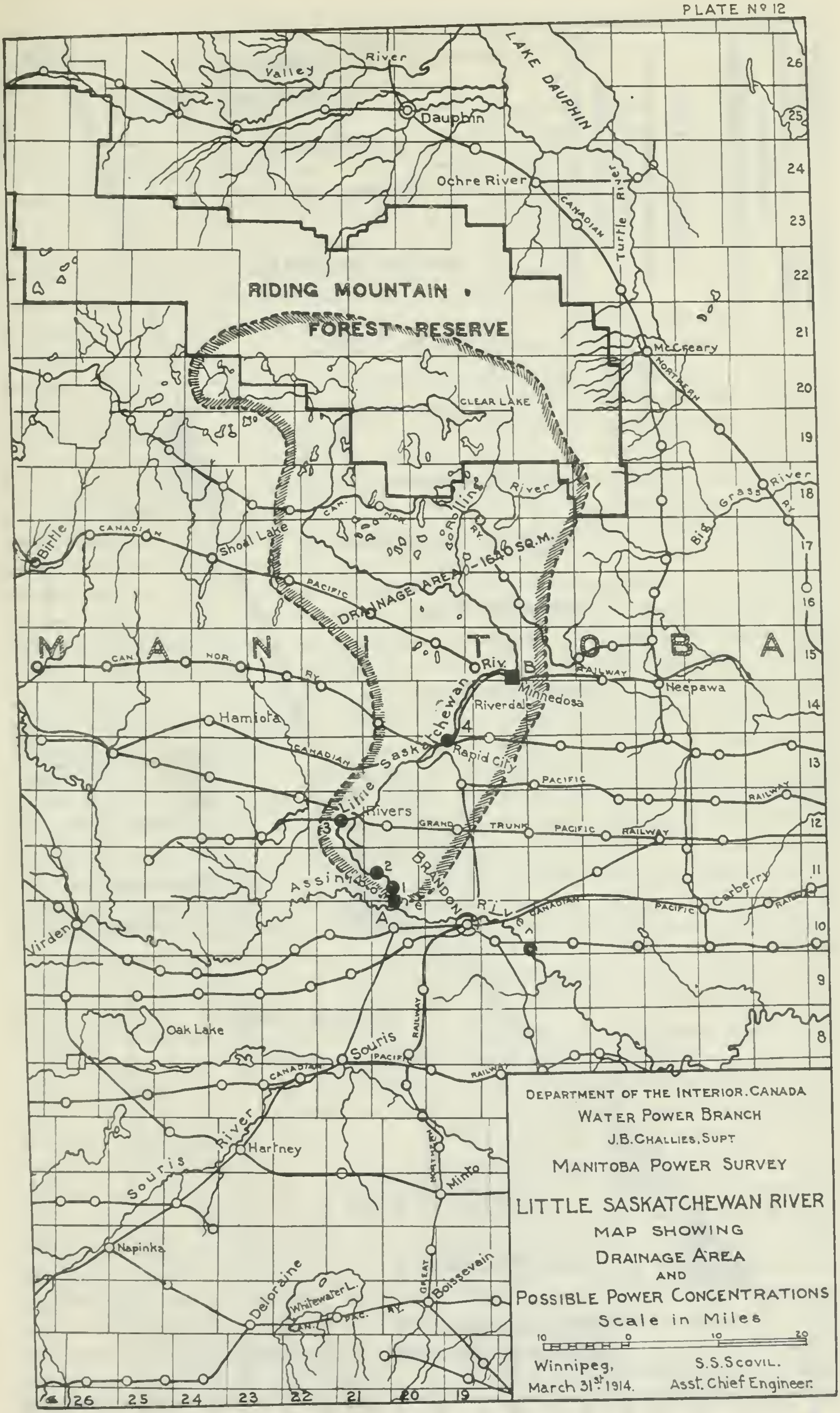
of the party. Wl
been of short du
efficient offieer.

It is also w
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent o
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a
A.1.c
A.1.d
A.1.e
B.3.a
F.1.a
K.1.a
K.1.b
L.1.a
L.1.b
L.1.c
L.1.e
L.1.f
L.1.g
L.1.j
L.1.k
L.3.a
L.3.f
M.1.a
M.4.c
O.1.a
P.2.b
P.2.c
P.3.a
R.1.a
R.4.a
R.5.b
R.6.a
R.6.c
S.1.a
S.1.d
S.3.a
S.4.a
S.5.a
S.6.a
V.1.a
W.1.a
W.6.d

PLATE No 12

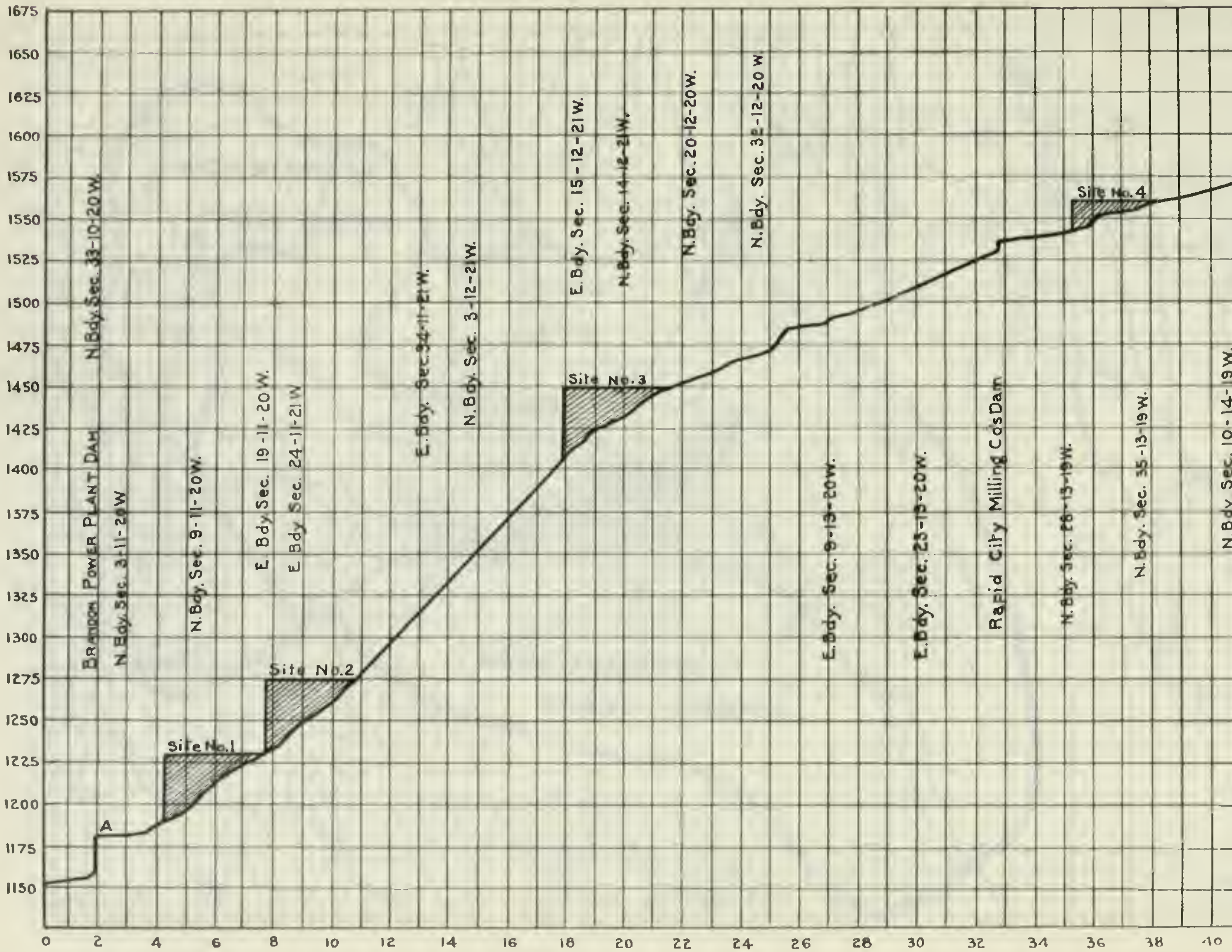

DEPARTMENT OF THE INTERIOR. CANADA
WATER POWER BRANCH
J.B. CHALLIES, SUPT
MANITOBA POWER SURVEY
LITTLE SASKATCHEWAN RIVER
MAP SHOWING
DRAINAGE AREA
AND
POSSIBLE POWER CONCENTRATIONS
Scale in Miles
10 0 10 20
Winnipeg,
March 31st 1914.
S.S. SCOVIL.
Asst. Chief Engineer.
RIDING MOUNTAIN
FOREST RESERVE
DRAINAGE AREA - 1640 SQ.M.
MANITOBA
LAKE DAUPHIN
Valley River
Dauphin
Ochre River
Turtle River
McCreary
CLEAR LAKE
Rolling River
Big Grass River
Birtle
Shoal Lake
Minnedosa
Riverdale
Neepawa
Hamiota
Rapid City
Little Saskatchewan
Rivers
Assiniboine
BRANDON
River
Carberry
Virden
Oak Lake
Souris
Souris River
Hartney
Minto
Napinka
Deloraine
Whitewater L.
Boissevain
CANADIAN NORTHERN
CANADIAN PACIFIC
GRAND TRUNK PACIFIC RAILWAY
26 25 24 23 22 21 20 19

of the party. Wh
been of short du
efficient officer.

It is also w
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent o
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a..............
A.1.c..............
A.1.d..............
A.1.e..............
B.3.a..............
F.1.a..............
K.1.a..............
K.1.b..............
L.1.a..............
L.1.b..............
L.1.c..............
L.1.e..............
L.1.f..............
L.1.g..............
L.1.j..............
L.1.k..............
L.3.a..............
L.3.f..............
M.1.a..............
M.4.c..............
O.1.a..............
P.2.b..............
P.2.c..............
P.3.a..............
R.1.a..............
R.4.a..............
R.5.b..............
R.6.a..............
R.6.c..............
S.1.a..............
S.1.d..............
S.3.a..............
S.4.a..............
S.5.a..............
S.6.a..............
V.1.a..............
W.1.a..............
W.6.d..............



DEPARTMENT OF THE INTERIOR, CANADA
WATER POWER BRANCH
J.B. CHALLIES, SUPT
MANITOBA POWER SURVEY
RECONNAISSANCE PROFILE
OF THE
LITTLE SASKATCHEWAN RIVER
SHOWING
POSSIBLE POWER CONCENTRATIONS

Winnipeg
March 31st 1914.

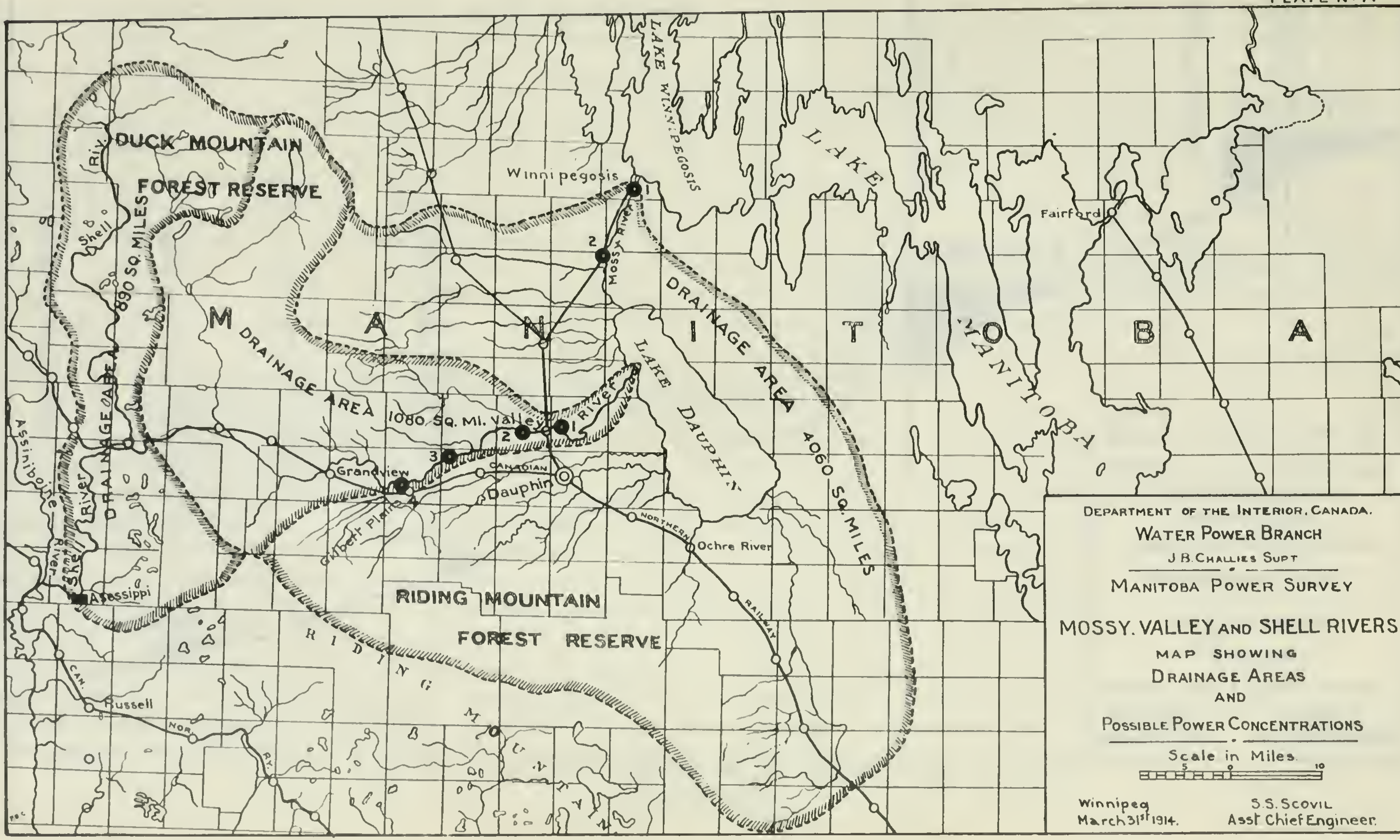
S.S. Scovil
Asst Chief Engineer

of the party. Wh
been of short du
efficient officer.

It is also w
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent o
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See F*

No.
A.1.a...............
A.1.c ....
A.1.d..............
A.1.e...............
B.3.a...............
F.1.a...............
K.1.a...............
K.1.b...............
L.1.a...............
L.1.b...............
L.1.c...............
L.1.e...............
L.1.f...............
L.1.g...............
L.1.j...............
L.1.k...............
L.3.a...............
L.3.f...............
M.1.a...............
M.4.c...............
O.1.a...............
P.2.b...............
P.2.c...............
P.3.a...............
R.1.a...............
R.4.a...............
R.5.b...............
R.6.a...............
R.6.c...............
S.1.a...............
S.1.d...............
S.3.a...............
S.4.a...............
S.5.a...............
S.6.a...............
V.1.a...............
W.1.a...............
W.6.d.............


DEPARTMENT OF THE INTERIOR, CANADA.
WATER POWER BRANCH
J.B. CHALLIES SUPT
MANITOBA POWER SURVEY
MOSSY. VALLEY AND SHELL RIVERS
MAP SHOWING
DRAINAGE AREAS
AND
POSSIBLE POWER CONCENTRATIONS
Scale in Miles.
5
0
10
Winnipeg
March 31st 1914.
S.S. SCOVIL
Asst Chief Engineer.
M A N I T O B A
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE DAUPHIN
DUCK MOUNTAIN
FOREST RESERVE
RIDING MOUNTAIN
FOREST RESERVE
RIDING MOUNTAIN
DRAINAGE AREA 890 SQ. MILES
DRAINAGE AREA 1080 Sq. MI. valley River
DRAINAGE AREA 4060 SQ. MILES
Winnipegosis
Fairford
Grandview
Dauphin
Ochre River
Russell
Assessippi
Gilbert Plains
Mossy River
Shell River
Shell
Assiniboine River
CANADIAN NORTHERN RAILWAY
CAN. NOR. RY.

of the party. Wl
been of short du
efficient officer.

It is also w
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent c
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a. . . . .
A.1.c. . . . .
A.1.d. . . . .
A.1.e. . . . .
B.3.a. . . . .
F.1.a. . . . .
K.1.a. . . . .
K.1.b. . . . .
L.1.a. . . . .
L.1.b. . . . .
L.1.c. . . . .
L.1.e. . . . .
L.1.f. . . . .
L.1.g. . . . .
L.1.j. . . . .
L.1.k. . . . .
L.3.a. . . . .
L.3.f. . . . .
M.1.a. . . . .
M.4.c. . . . .
O.1.a. . . . .
P.2.b. . . . .
P.2.c. . . . .
P.3.a. . . . .
R.1.a. . . . .
R.4.a. . . . .
R.5.b. . . . .
R.6.a. . . . .
R.6.c. . . . .
S.1.a. . . . .
S.1.d. . . . .
S.3.a. . . . .
S.4.a. . . . .
S.5.a. . . . .
S.6.a. . . . .
V.1.a. . . . .
W.1.a. . . . .
W.6.d. . . . .

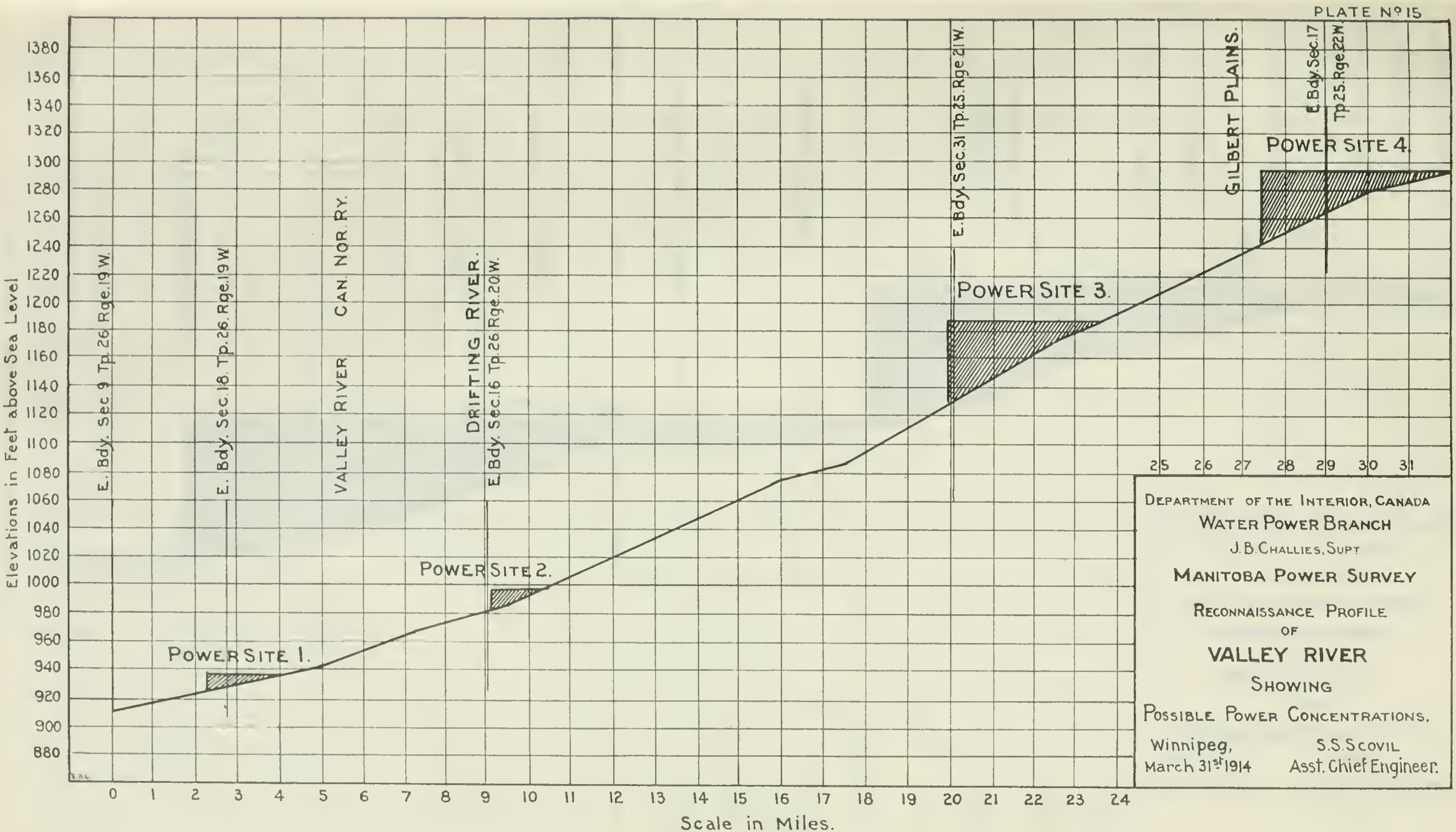


PLATE Nº 15
Elevations in Feet above Sea Level
Scale in Miles.
E. Bdy. Sec 9 Tp.26 Rge.19 W.
E. Bdy. Sec.18. Tp.26. Rge.19 W.
VALLEY RIVER
CAN. NOR. RY.
DRIFTING RIVER.
E.Bdy. Sec.16 Tp.26 Rge.20 W.
E.Bdy. Sec.31 Tp.25. Rge 21 W.
GILBERT PLAINS.
E.Bdy. Sec.17
Tp.25. Rge.22 W.
POWER SITE 1.
POWER SITE 2.
POWER SITE 3.
POWER SITE 4.
DEPARTMENT OF THE INTERIOR, CANADA
WATER POWER BRANCH
J.B.CHALLIES, SUPT
MANITOBA POWER SURVEY
RECONNAISSANCE PROFILE
OF
VALLEY RIVER
SHOWING
POSSIBLE POWER CONCENTRATIONS.
Winnipeg,
March 31st 1914
S.S.SCOVIL
Asst. Chief Engineer.

of the party. Wl
been of short du
efficient officer.

It is also v
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent c
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a
A.1.c
A.1.d
A.1.e
B.3.a
F.1.a
K.1.a
K.1.b
L.1.a
L.1.b
L.1.c
L.1.e
L.1.f
L.1.g
L.1.j
L.1.k
L.3.a
L.3.f
M.1.a
M.4.c
O.1.a
P.2.b
P.2.c
P.3.a
R.1.a
R.4.a
R.5.b
R.6.a
R.6.c
S.1.a
S.1.d
S.3.a
S.4.a
S.5.a
S.6.a
V.1.a
W.1.a
W.6.d

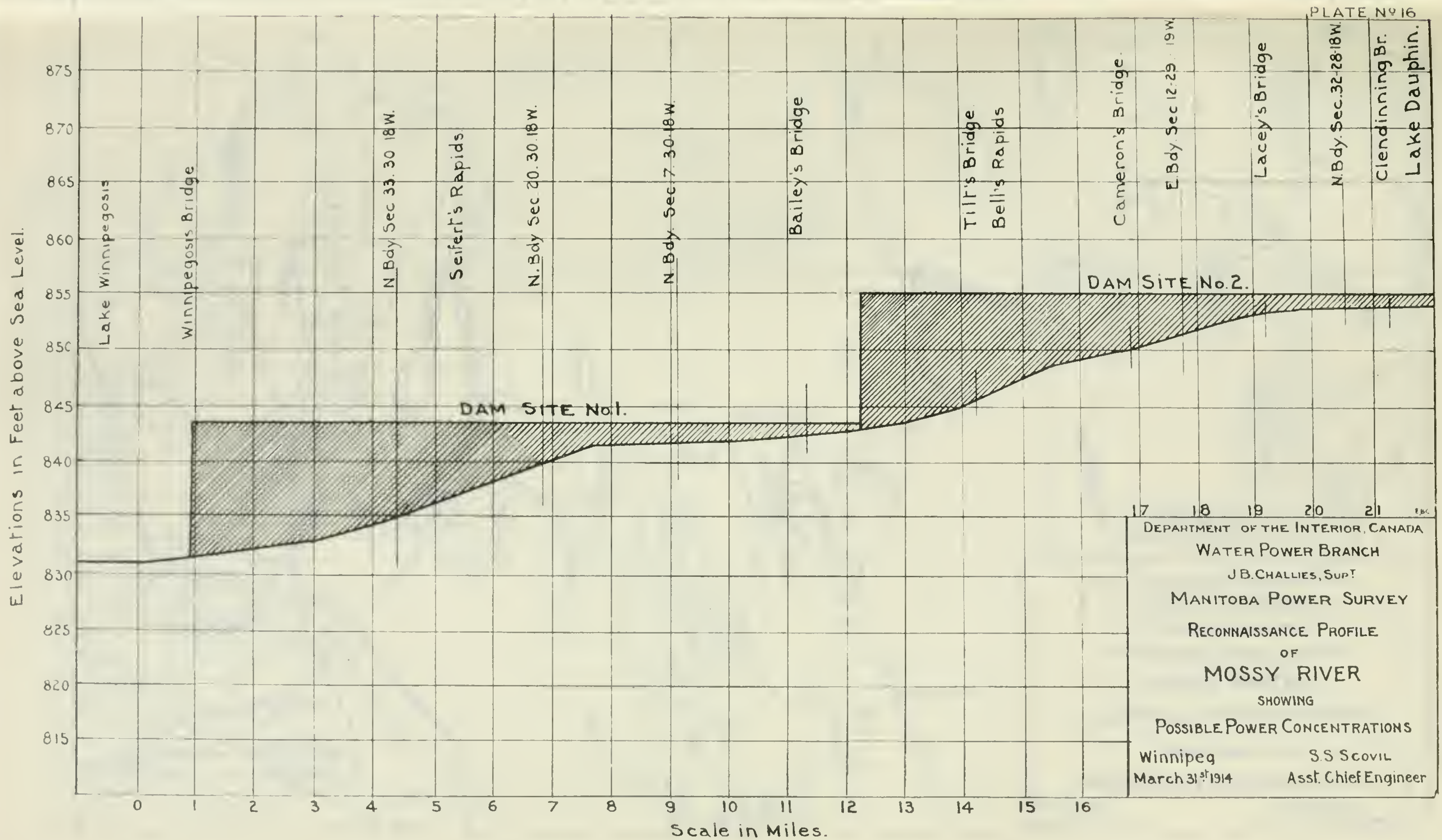


PLATE Nº 16
Lake Winnipegosis
Winnipegosis Bridge
N. Bdy. Sec 33. 30 18W.
Seifert's Rapids
N. Bdy Sec 20. 30. 18W.
N. Bdy. Sec 7. 30. 18W.
Bailey's Bridge
Till's Bridge
Bell's Rapids
Cameron's Bridge
E. Bdy Sec 12-29 19W.
Lacey's Bridge
N. Bdy. Sec. 32-28-18W.
Clendinning Br.
Lake Dauphin.
DAM SITE No. 1.
DAM SITE No. 2.
875
870
865
860
855
850
845
840
835
830
825
820
815
Elevations in Feet above Sea Level.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Scale in Miles.
DEPARTMENT OF THE INTERIOR, CANADA
WATER POWER BRANCH
J.B. CHALLIES, SUPT.
MANITOBA POWER SURVEY
RECONNAISSANCE PROFILE
OF
MOSSY RIVER
SHOWING
POSSIBLE POWER CONCENTRATIONS
Winnipeg
March 31st 1914
S.S. SCOVIL
Asst. Chief Engineer

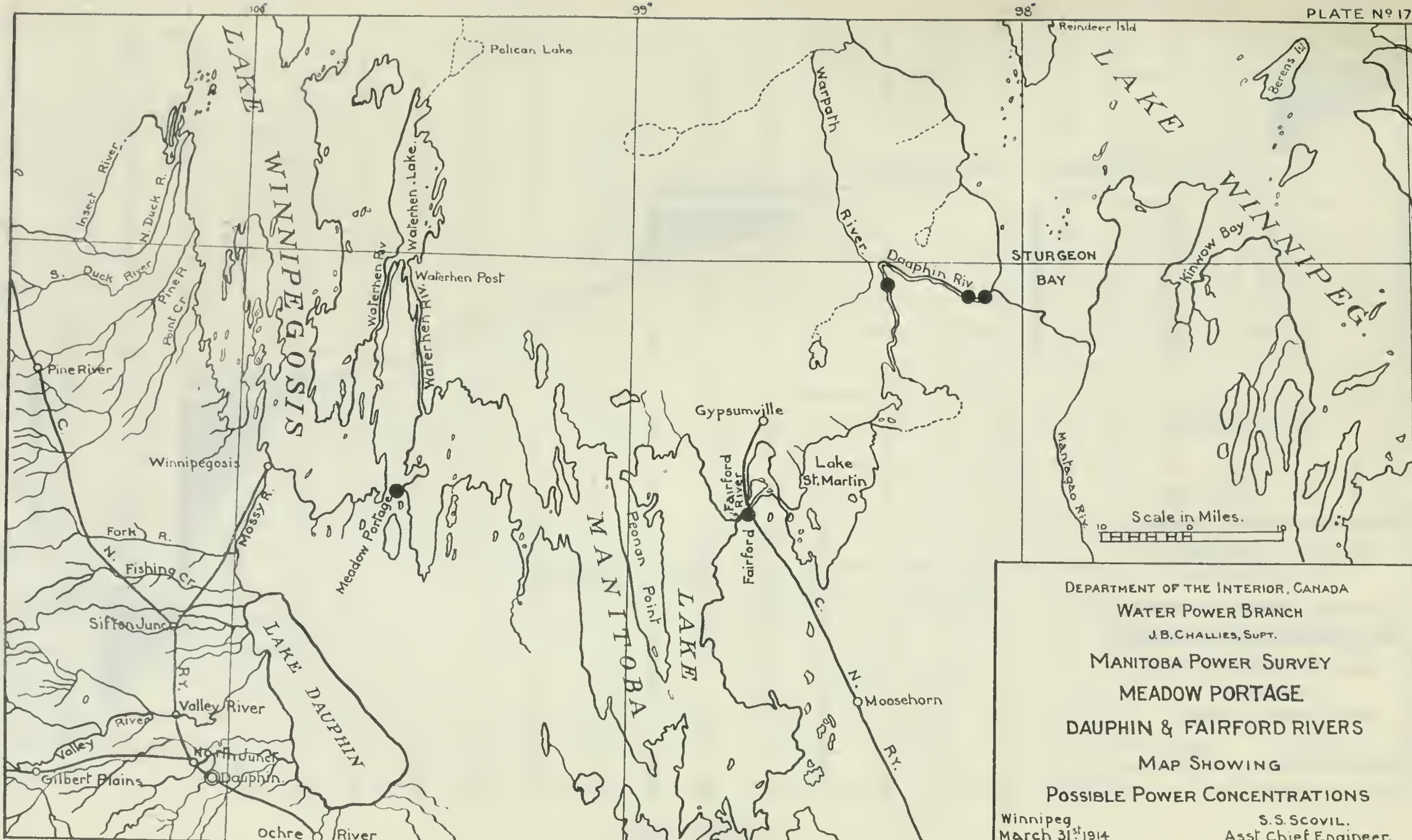
of the party. W
been of short du
efficient officer.

It is also v
engineer, Mr. D.
vey was organize
took effect on Oc
work was carried

The extent c
year; not only wa
detailed study of
larly throughout
of river and lake
following table gi
stage only has be
been made (*See I*

No.
A.1.a
A.1.c
A.1.d
A.1.e
B.3.a
F.1.a
K.1.a
K.1.b
L.1.a
L.1.b
L.1.c
L.1.e
L.1.f
L.1.g
L.1.j
L.1.k
L.3.a
L.3.f
M.1.a
M.4.c
O.1.a
P.2.b
P.2.c
P.3.a
R.1.a
R.4.a
R.5.b
R.6.a
R.6.c
S.1.a
S.1.d
S.3.a
S.4.a
S.5.a
S.6.a
V.1.a
W.1.a
W.6.d

PLATE Nº 17



Department of the Interior, Canada
Water Power Branch
J. B. Challies, Supt.
Manitoba Power Survey
Meadow Portage
Dauphin & Fairford Rivers
Map Showing
Possible Power Concentrations
Winnipeg
March 31st 1914
S. S. Scovil.
Asst. Chief Engineer.
Scale in Miles.
10 0 10
100°
99°
98°
52°
Lake Winnipeg
Lake Winnipegosis
Lake Manitoba
Lake Dauphin
Lake St. Martin
Waterhen Lake
Pelican Lake
Reindeer Isld
Berens Isl
Kinwow Bay
Sturgeon Bay
Peonan Point
Dauphin Riv
Warpath River
Mantagao Riv
Waterhen Riv
Waterhen Post
Meadow Portage
Fairford River
Fairford
Gypsumville
Moosehorn
C. N. Ry.
Winnipegosis
Mossy R.
Fork R.
N. Fishing Cr.
Sifton Junc
Valley River
North Junc
Dauphin
Gilbert Plains
Ochre River
Pine River
Insect River
N. Duck R.
S. Duck River
Pine R
Point Cr

of the party. W
been of short d
efficient officer.

It is also
engineer, Mr. D.
vey was organiz
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R.6.a.
R.6.c.
S.1.a.
S.1.d.
S.3.a.
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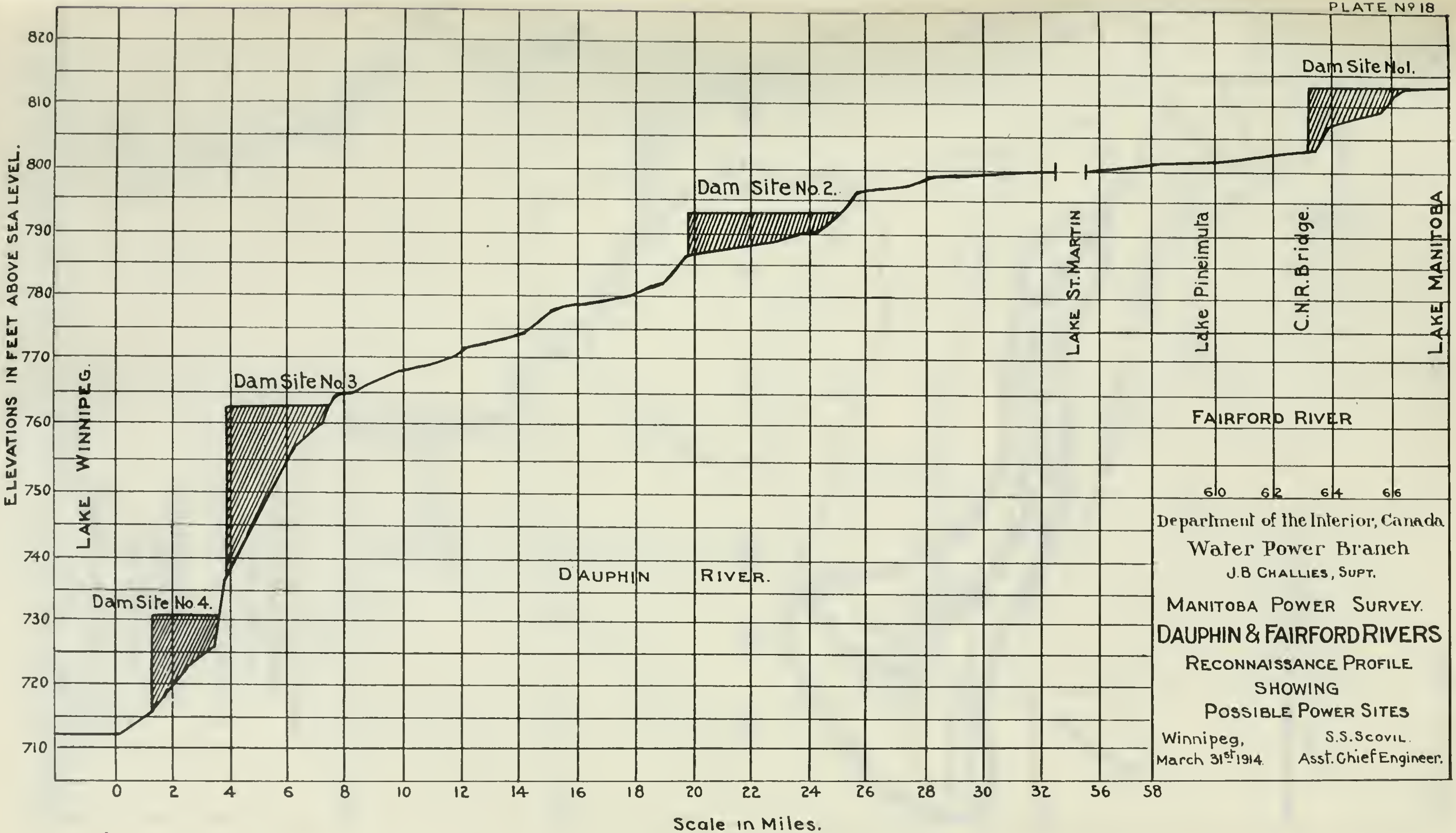
S.6.a.
V.1.a.
W.1.a.
W.6.d.

PLATE Nº 18



Dam Site No.1.
Dam Site No.2.
Dam Site No.3
Dam Site No.4.
LAKE WINNIPEG.
DAUPHIN RIVER.
LAKE ST. MARTIN
Lake Pineimuta
C.N.R. Bridge.
LAKE MANITOBA
FAIRFORD RIVER
ELEVATIONS IN FEET ABOVE SEA LEVEL.
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790
780
770
760
750
740
730
720
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60
62
64
66
Scale in Miles.
Department of the Interior, Canada
Water Power Branch
J.B Challies, Supt.
Manitoba Power Survey.
DAUPHIN & FAIRFORD RIVERS
Reconnaissance Profile
Showing
Possible Power Sites
Winnipeg,
March 31st 1914.
S.S. Scovil.
Asst. Chief Engineer.

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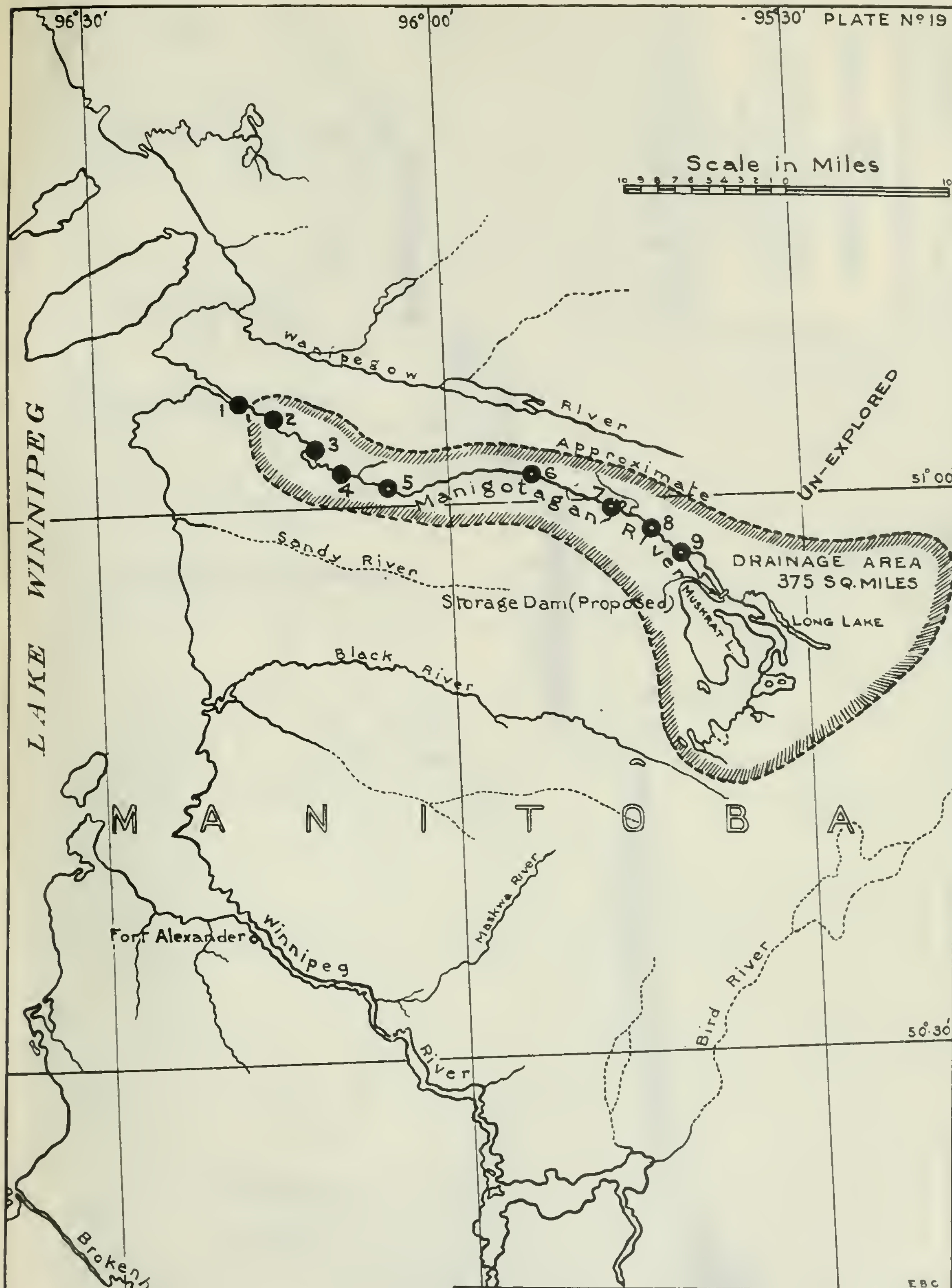

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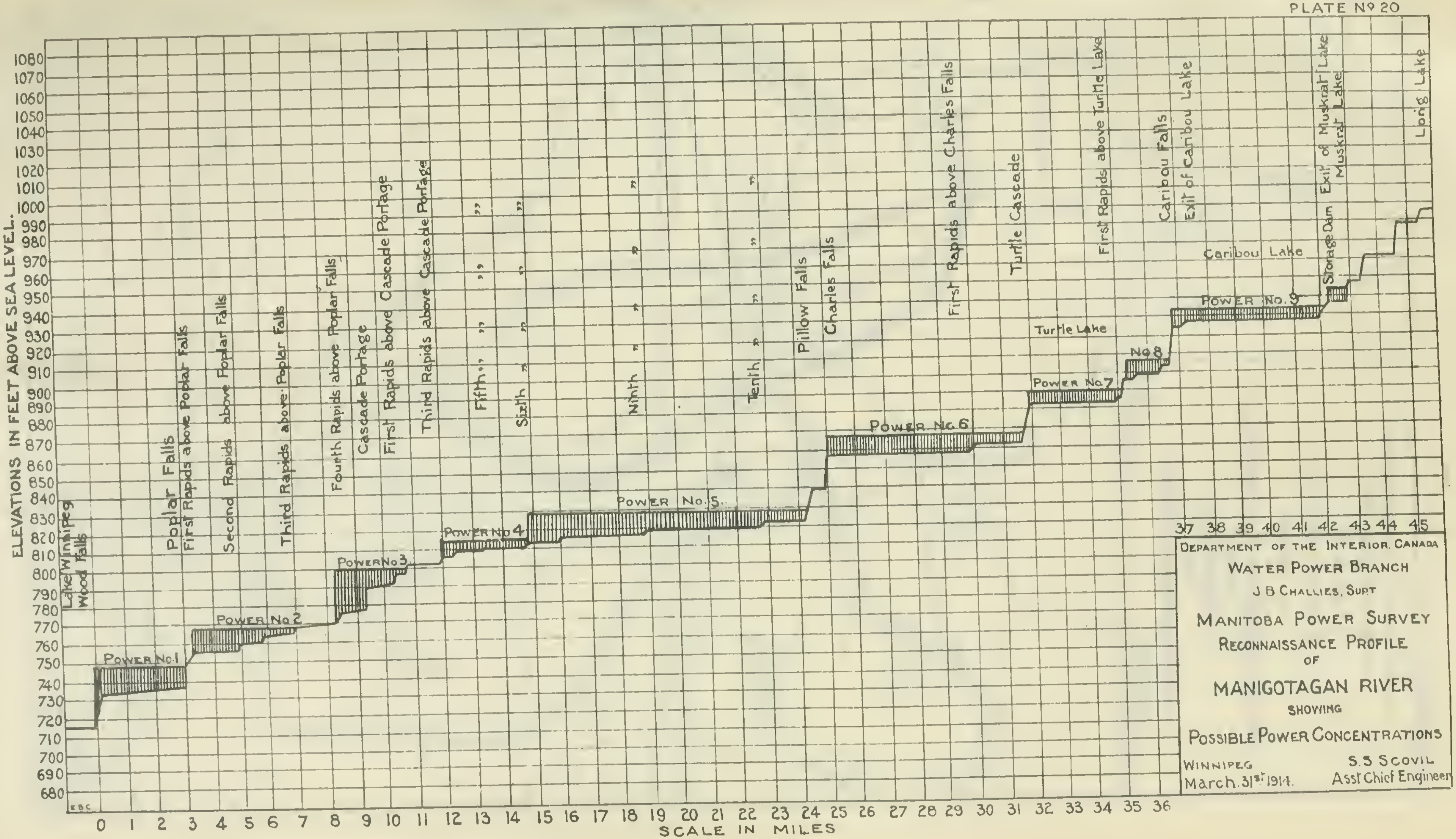
PLATE No 20



ELEVATIONS IN FEET ABOVE SEA LEVEL.
SCALE IN MILES
Lake Winnipeg
Wood Falls
Poplar Falls
First Rapids above Poplar Falls
Second Rapids above Poplar Falls
Third Rapids above Poplar Falls
Fourth Rapids above Poplar Falls
Cascade Portage
First Rapids above Cascade Portage
Third Rapids above Cascade Portage
Fifth " " "
Sixth " " "
Ninth " " "
Tenth " " "
Pillow Falls
Charles Falls
First Rapids above Charles Falls
Turtle Cascade
Turtle Lake
First Rapids above Turtle Lake
Caribou Falls
Exit of Caribou Lake
Caribou Lake
Storage Dam
Exit of Muskrat Lake
Muskrat Lake
Long Lake
Power No.1
Power No 2
Power No 3
Power No 4
Power No. 5
Power No 6
Power No 7
No 8
Power No. 9
Department of the Interior. Canada
Water Power Branch
J B Challies, Supt
Manitoba Power Survey
Reconnaissance Profile
of
Manigotagan River
showing
Possible Power Concentrations
Winnipeg
March. 31st 1914.
S. S. Scovil
Asst Chief Engineer

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F.1.a.....
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P.3.a......
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R.5.b......
R.6.a......
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S.3.a.......
S.4.a.......
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V.1.a......
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PLATE Nº 21

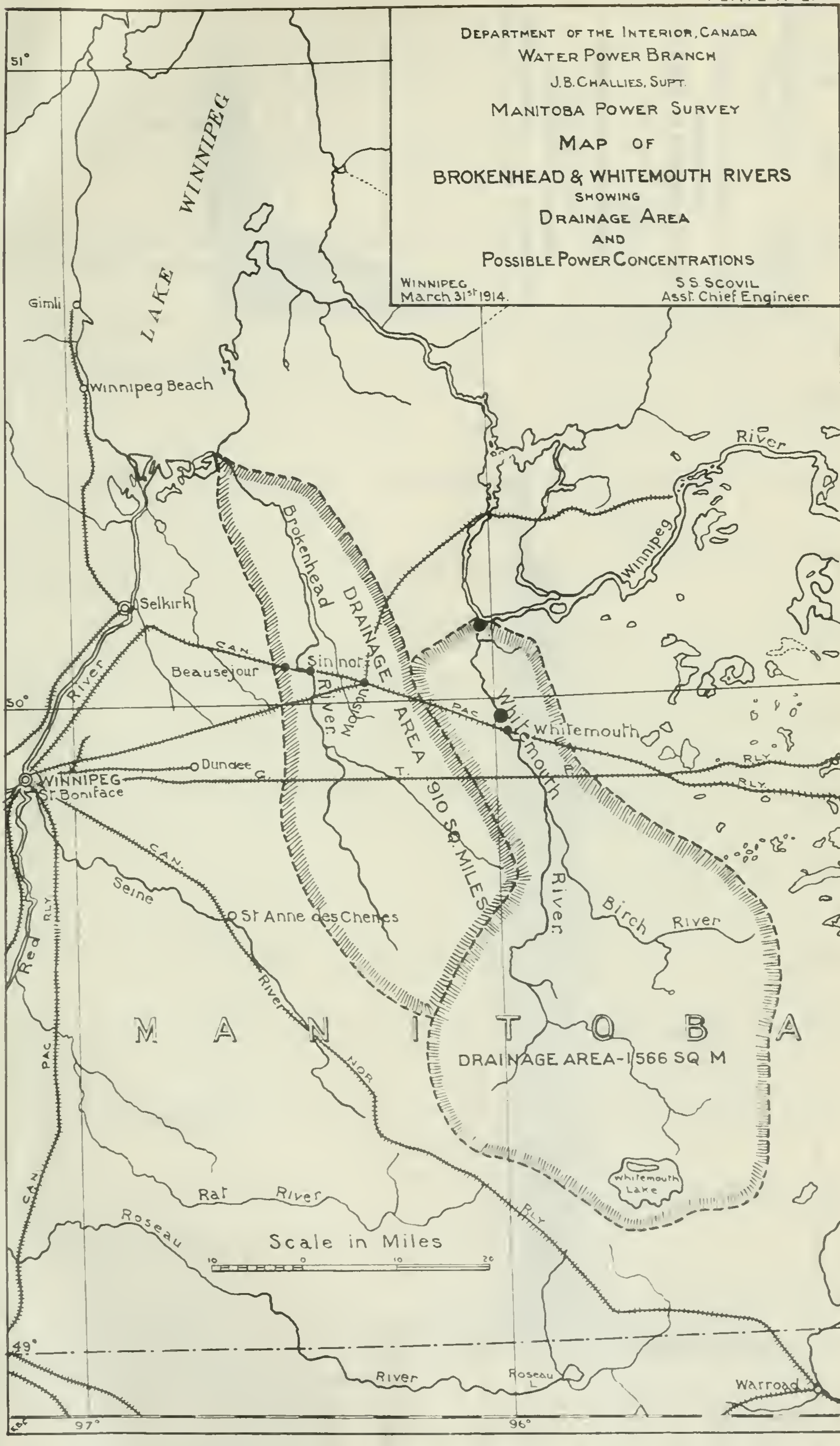
DEPARTMENT OF THE INTERIOR, CANADA
WATER POWER BRANCH
J.B. CHALLIES, SUPT.
MANITOBA POWER SURVEY
MAP OF
BROKENHEAD & WHITEMOUTH RIVERS
SHOWING
DRAINAGE AREA
AND
POSSIBLE POWER CONCENTRATIONS
WINNIPEG
March 31st 1914.
S.S. SCOVIL
Asst. Chief Engineer
51°
50°
49°
97°
96°
LAKE WINNIPEG
Gimli
Winnipeg Beach
Selkirk
Beausejour
Sinnot
Whitemouth
Dundee
WINNIPEG
St. Boniface
St Anne des Chenes
Warroad
Brokenhead
River
Red River
Winnipeg River
Whitemouth River
Birch River
Seine
Rat River
Roseau River
Roseau L
Whitemouth Lake
DRAINAGE AREA 910 SQ. MILES
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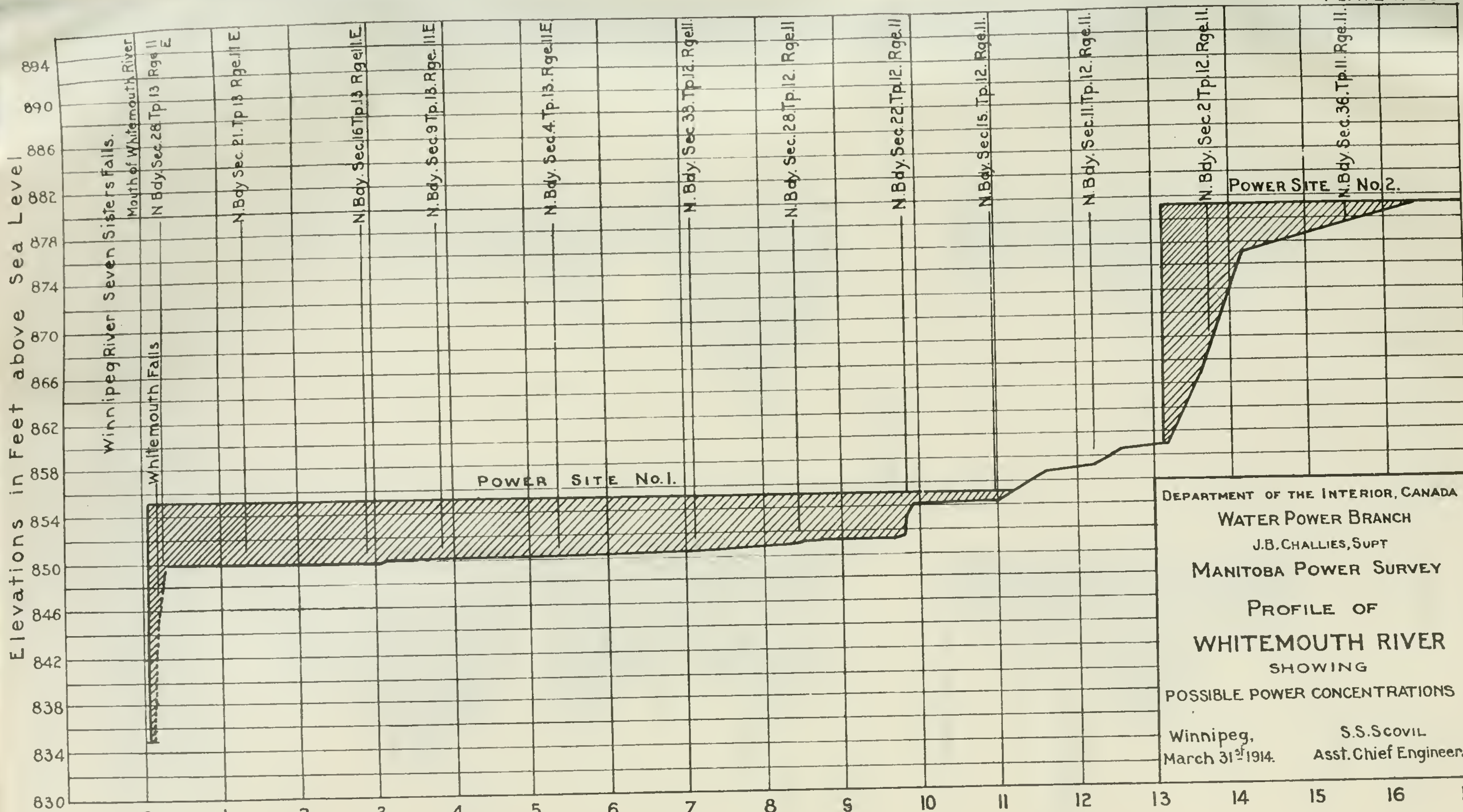
PLATE Nº 22



DEPARTMENT OF THE INTERIOR, CANADA
WATER POWER BRANCH
J.B. CHALLIES, SUPT
MANITOBA POWER SURVEY

PROFILE OF
WHITEMOUTH RIVER
SHOWING
POSSIBLE POWER CONCENTRATIONS

Winnipeg, March 31st 1914.

S.S. SCOVIL
Asst. Chief Engineer.

MISCELLANEOUS METERING STATIONS.

No.	River.	Locality.
B.1.a	Berens	First falls.
B.4.a	Birdtail	Birtle.
B.5.a	Bloodvein	Eagle falls.
E.2.a	Etomami	First falls.
F.2.a	Fork	Fork river.
M.1.a	Manigotagan	Cascade portage.
M.1.a	Manigotagan	Outlet, Turtle lake.
M.1.a	Manigotagan	Outlet, Muskrat lake.
M.1.a	Manigotagan	Outlet, Moose lake.
M.1.a	Manigotagan	Inlet to Muskrat lake.
M.1.a	Manigotagan	Caribou rapids.
N.1.b	Nelson	East branch, Sea River falls.
N.1.c	Nelson	West branch, vicinity of Whiskey Jack.
P.4.a	Pigeon	Sturgeon falls.
R.4.d	Red	Winnipeg.
R.6.b	Red Deer	Outlet, Red Deer lake.
S.7.a	Shoal	Pelican rapids.
W.2.b	Whitemud	Gladstone.
W.6.a	Winnipeg	Minaki.
W.7.a	Waterhen	Outlet, lake Winnipegosis.

GAUGE ONLY.

A.1.b	Assiniboine	Currie's Landing.
B.1.a	Lake Winnipeg	Berens River post.
L.1.d	Lake of the Woods	Forebay, Norman Dam, Kenora.
L.1.m	Lake of the Woods	Keewatin, Ontario.
L.1.n	Lake of the Woods outlets	Tailrace, Norman dam.
L.1.n	Lake of the Woods outlets	Tailrace, Mill "A" Keewatin.
L.3.a	Little Saskatchewan	Kirkham bridge.
L.3.a	Little Saskatchewan	McKellar bridge.
M.1.a	Lake Winnipeg	Manigotagan Post.
M.2.a	Lake Manitoba	Oak Point.
M.4.a	Mossy	Clendenning bridge.
N.1.a	Nelson	Norway House.
N.1.d	Nelson	Warren's Landing.
R.2.c	Rainy	International falls.
S.1.c	Saskatchewan	Foot of Grand Rapids.
S.1.e	Lake Winnipeg	Mouth of Saskatchewan.
W.1.b	Whitemouth	Head of First falls.
W.6.a	Winnipeg	Minaki.
W.6.b	Winnipeg	Point du Bois.
W.6.c	Winnipeg	Hunt club Landing.
W.6.e	Winnipeg	Head of Fourth falls, Seven Sisters.
W.6.f	Winnipeg	Foot of Seven Sisters.
W.6.g	Winnipeg	City Tramway bridge.
W.6.h	Winnipeg	Foot of First McArthur falls.
W.6.j	Winnipeg	Head of Grand Du Bonnet.
W.6.k	Winnipeg	Head of Little Du Bonnet.
W.6.l	Winnipeg	Head of Whitemud.
W.6.m	Winnipeg	Head of Silver falls.
W.6.n	Winnipeg	Foot of Silver falls.
W.6.o	Winnipeg	Head of Pine falls.
W.6.p	Winnipeg	Foot of Pine falls.
W.6.q	Winnipeg	Fort Alexander.
W.6.r	Winnipeg	Head of Seven Sisters.
W.4.a	Lake Winnipegosis	Winnipegosis.

The method employed in gauging the flow of the rivers and streams, and in computing daily discharges, run-off, etc., has been similar to that of the previous year. Meterings were made at each station, monthly or oftener, dependent upon the rate in change of stage. For obvious reasons, more detailed study was given to the more important rivers such as the Winnipeg, Saskatchewan, Red, etc.

Two valuable improvements, applying more particularly to boat and cable car stations, were made in the method of meter suspension and operation. First among these was the adoption of a single wire suspension of the meter, and the use of a water return in the circuit of the telephonic recorder of the instrument. Experiments were first made as to the use of a ground return, and later of a water return. The latter method was found to be much the more satisfactory. Briefly, the method employed was as follows:—The meter was suspended by a single small-gauge piano-wire, in which was inserted, immediately above the meter suspension bar, a small-sized standard insulated joint. A connection was made directly above the joint to the meterhead. On the wire of the return circuit to the battery or dry cell, a small piece of scrap iron was attached, and lowered just below river surface. Not only has the method practically eliminated short circuits, and the consequent loss of time, but also it has greatly lessened the surface of wire or cable exposed to the flow of the water, and the consequent carriage of the meter off section.

Following the adoption of single wire suspension, an apparatus for sounding and metering from boat or canoe was devised by assistant engineer G. J. Lamb. The apparatus, which is shown in detail in Plate 9, consists essentially of a board, which is placed across the top of the boat at right angles to the boat's length, and held in place by a lug which grips the gunwale, and is prevented from slipping by the weight of the meter and lead weights. Dependent upon whether or not it is desired to use an insulated return wire from the meter, either one or two drums, on which the wire is reeled, are attached to the lower side of the board by vertical supports. Should a single-wire suspension of the meter be contemplated, the drum at that end ot the board over which the meter is lowered is eliminated. A constant connection from each drum, to a plug in the centre of the board, is made by means of brass springs pressing on plates on the ends of the drums. The suspension wire is led from the drum upwards through the board, and passes over a three-foot scale to that end of the board at which the meter is suspended. The suspension wire is marked with solder at 3-foot intervals, and intermediate distances are therefore given directly by the underlying scale on the board.

Through a fortunate circumstance, totally diverse conditions of run-off have been encountered during the two year's work. A period of high discharge prevailed during the first year, but the opposite was encountered during the past fall and winter. This has enabled the survey to secure well-defined ratings of the majority of the gauging stations, and has given invaluable information regarding the run-off of the various rivers.

Of special interest are the results of flow measurements on the Pigeon, Berens, and Bloodvein rivers, three rivers which drain into lake Winnipeg from the east. Gaugings made during the month of February, a time at which most western rivers are at an extreme low stage, indicate that a low flow of appreciable extent may be anticipated. Considering this in conjunction with other physical features, the rivers present very favourable power possibilities.

POWER SURVEYS.

With the exception of the Winnipeg river, on which detailed surveys as described in the last annual report were being carried to completion, the surveys on the other rivers of the province were more in the nature of a reconnaisance. The information secured on each river comprised the following: A profile of river surface, a detailed survey of all possible power sites, the securing of data with respect to foundation conditions, height of banks, nature of soil and vegetation, and an investigation of the possibilities of storage and regulation of flow. Field work was commenced early in the spring of 1913, by a small party, of which Mr. G. H. Burnham was in charge.

Mr. Burnham had completed the surveys of the Assiniboine and Little Saskatchewan rivers, and was engaged upon that of the Valley river when his death occurred. Mr. D. B. Gow was then placed in charge of the party and continued in this capacity until the completion of the season's work.

Assiniboine River at Curries Landing.

A possible power site on the Assiniboine river at Curries Landing, situated some twelve miles downstream from the city of Brandon, was investigated in May, 1913. A detailed topographic survey was made of the site, and a profile of river surface (Plate No. 11) secured from Curries Landing to the city of Brandon.

The Assiniboine river rises in the southeasterly slopes of the Nut mountains in the province of Saskatchewan, and flows, first in a southerly, and then in an easterly direction, emptying into the Red river at Winnipeg. The drainage basin of the river (Plate 10), comprising an area of 59,550 square miles is, in the main, level prairie on which there is no appreciable timber growth. In the upper and mid-reaches the river flows in a well-defined, wide valley, with banks varying from one hundred and fifty to two hundred and fifty feet in height; the channel of the river itself being sharply cut down in the valley to a depth varying up to twenty-five feet. The bed and banks of the river are composed of a sandy clay interspersed with boulders, and in that section investigated there is an underlying stratum of blue clay.

As a result of the investigation, it is evident that a normal head of 15 feet could be concentrated at Curries Landing. Flow records obtained on the Assiniboine river at Brandon in the past winter indicate, however, that a much lower flow is encountered than was at first anticipated. Measurements in the previous winter showed a low flow of 400 second-feet, but during January of this year there was an extreme low stage of 200 second-feet. This, on a basis of 80 per cent turbine efficiency and for a 15-foot head would only show an available output of 270 continuous-hour horse-power. If, however, hydro-electric development were considered in conjunction with an auxiliary steam plant as is the present plant of the Brandon Electric Company on the Little Saskatchewan river, then for operation during the eight months of highest flow in the year, existing records indicate an available flow of 1,000 second-feet. The possible power output for this flow during eight months of the year would then be 1,360 horse-power.

The Little Saskatchewan River.

On the Little Saskatchewan river, the investigations extended from the junction with the Assiniboine river, upstream to a point on the river four miles above the town of Minnedosa, a distance in all of 55 miles. Detail surveys were made of four possible power sites, and a profile of river surface secured throughout the entire distance. Following the river survey, a reconnaisance was made of the storage possibilities of the lakes lying in the headwaters of the drainage basin.

As shown (Plate 12), the Little Saskatchewan river rises in the southeasterly part of the Riding Mountain Forest Reserve, and flows with a winding course in a general southerly direction, emptying into the Assiniboine river some eight miles above the city of Brandon. The drainage basin of the river has an extent of 1,640 square miles, and is, in the upper reaches, hilly and undulating with a considerable timber growth. In the central and lower reaches, the country is entirely agricultural, and is well settled. The valley in which the river flows is well defined ranging in width from 1,000 feet to a mile and a quarter and with banks varying in height from 100 to 300 feet. The nature of the soil is mostly a sandy clay overlying beds of gravel with, usually, an underlying stratum of blue clay.

The Saskatchewan has a drop of 490 feet between Minnedosa and the Assiniboine river, a distance of 55 miles, or approximately a slope of 9 feet per mile. The possibility of concentrating a portion of this at six different locations (Plate 13), was investigated. Development work has already been done at two of these points; one immediately above the junction with the Assiniboine, known as the Brandon Electric Light Company's plant; and the other the Minnedosa Power Company's plant at the town of Minnedosa.

The Brandon Electric Light Company's development comprises an earth dam 25 feet high and 450 feet long with a wooden spillway 68 feet wide. The power house is a frame building, erected immediately below the dam, and there is an installation for the development of from 400 to 600 k.w. under a head of 33 feet. The plant is used throughout the summer months, and is shut down, and held as a possible auxiliary to the company's steam plant, during the winter. This reversal of the ordinary custom is accounted for, by the fact that the company sells exhaust steam for general heating purposes through the winter months, and has a source of revenue above the cost of fuel used.

The development of the Minnedosa Power Company, which is located within a half-mile of the town of Minnedosa, consists of an earthen dam 1,800 feet long concentrating, at present, a head of 17 feet, which under completed conditions will be increased to 24 feet. A frame generator and turbine house is situated some 400 feet below the western end of the dam, and the water is carried from the intake to a 450 h.p. turbine in a 6-foot wood stave pipe line. At the eastern end of the dam, there is a concrete spillway 60 feet in width.

The extremely low flow, encountered during the winter months, apparently limits the operation of any present or future power plants to the open season. In the past winter, the flow during the extreme cold weather was practically negligible, though it was claimed that this was partially due to the construction of beaver dams, and the flooding of the upper country. There are numerous lakes lying in the headwaters, where a certain amount of storage might be obtained; but it is not yet known whether this storage could be utilized in winter months, for the water would have to be brought a distance of eighty or ninety miles down a winding river channel. Investigations, as to the feasibility of regulation by storage on one of the upper lakes, are to be made by this office during the ensuing year.

Valley River.

The reconnaissance survey of the Valley river, which was made at the request of the town of Dauphin, included that portion of the river lying between Gilbert Plains and a point four miles below the village of Valley River. A profile of river surface was secured, and a detailed survey made of four possible power sites.

The Valley river, so called since it flows in the valley between Riding and Duck mountains, rises in the Duck mountains and discharges into lake Dauphin. The drainage basin of the river, (Plate 14), comprises 1,080 square miles, and, while confined in the lower reaches, widens out in the upper reaches, and is in that section covered with a considerable timber growth. The valley in which the river flows has a width varying from 700 to 2,000 feet, and banks from 15 to 85 feet in height. The banks of the river are composed of yellow clay overlying a bed of gravel and boulders, which is from 6 to 30 feet deep.

Records of run-off for the past year indicate that the winter flow is practically negligible. Further, the possibilities for storage and regulation of stream flow are of very doubtful value; and, therefore, development can only be contemplated for open season operation. From flow records for 1913, it is anticipated that there would be a dependable flow of 100 second-feet for the six months of the year from April to September. On this basis, the four sites investigated, the locations of which are shown on profile (Plate 15), would show an available power output with 80 per cent turbine efficiency, as follows:—

Site No.	Head.	Horse Power.
1	19	172
2	19	172
*3	25	227
*4	25	227

*Sites 3 and 4 would permit a concentration of fifty-six and fifty-two feet respectively, were the river discharge sufficient, and the foundation, on more detailed investigation, found to be suitable to warrant same.

The Mossy River.

Following the investigations on the Valley river, a similar reconnaissance was made on the Mossy river, throughout its entire course. A profile of river surface was secured, and detailed surveys made of a possible storage dam site at the outlet of lake Dauphin, and of two possible power sites.

The Mossy river rises in lake Dauphin, and is approximately 21 miles in length, discharging into the southerly end of lake Winnipegosis. At its outlet, the river has a drainage basin of 4,060 square miles (Plate 14); but, of this drainage, the major portion is collected by lake Dauphin, into which flow the Valley, Turtle, Ochre, and Vermilion rivers. This feature is of especial importance, since the lake, with an area of 196 square miles, exerts a great natural regulation of the flow of the river.

The banks of the Mossy river vary in height from 4 to 14 feet, and are, for the most part, composed of a layer of blue or yellow clay overlying a bed of fine gravel. Approximately one and a half miles above lake Winnipegosis, an outcrop of limestone crosses the bed of the river, and extends along the left bank a distance of 100 feet. The river channel was, during the years 1908 and 1912, improved by dredging; this work being done in order to lower lake Dauphin, and reclaim certain low lying lands on its borders.

The results of the survey show that it would be possible to obtain 3 feet storage on the lake, which would be of extreme value to any power development on the river. This may be briefly exemplified, when it is stated that 1 foot storage on an area of 196 square miles is equivalent to a run-off of 346 second-feet for a period of six months. Damage to the reclaimed lands above mentioned would have to be taken into consideration, in dealing with any scheme of storage.

In connection with the two possible power sites, the locations of which are shown on profile, (Plate 16), both are for concentration of a low head of 10 feet. Gauging station records for the past winter indicate a low flow of 300 second-feet. Considering this flow alone, without an addition through storage regulation, the available power on an 80 per cent turbine efficiency basis would be as follows:—

Power Site.	Head.	Horse-Power.
1	10	272
2	10	272

Waterhen River and Meadow Portage.

Differing from other power investigations of the season, the above survey dealt with the damming of the Waterhen river, and the diversion of its water across the narrow neck of land, known as Meadow Portage, separating lake Winnipegosis from lake Manitoba. (*See* Plate 17).

The Waterhen river forms the connecting link between the two above lakes, and drains an area of 21,200 square miles. This watershed comprises that area lying between the highlands of the Porcupine, Riding and Duck mountains and lake Winnipegosis, the latter, with an area of 2,000 square miles, acting as a collecting basin for practically the whole drainage. On leaving lake Winnipegosis, the Waterhen flows in two distinct channels, with an intervening space varying from a half mile to a mile. At a distance of a mile from the source of the larger stream, there is a cross channel between the two rivers, but below this to Waterhen lake there is no connection. From the latter lake to lake Manitoba the river flows in one channel. In both the upper channels the river flows between low marshy banks which extend some 1,200 feet back, before the timber line is reached; there the banks reach an average elevation of from 3 to 4 feet above the ordinary river stage. The soil, to a depth of 1 foot, is light and sandy, but, underlying this, is a stratum of light blue clay mixed with gravel, while the bed of the river is composed of gravel strewn, in some places, with large boulders.

In order to divert the waters of the Waterhen river, it has been found that three dams would be necessary, one on each of the two upper channels, and a third on the cross-channel between them.

With regard to the narrow neck of land separating lake Winnipegosis from lake Manitoba, the minimum width is in the vicinity of Meadow Portage, and is in all a distance of 9,400 feet. The summit elevation is approximately 6 feet above lake Winnipegosis. Investigations made at the summit show that, at a depth of 4 feet, hard-pan, is encountered, underlying the surface soil of light gray calcareous clay. Adjacent to the lakes, clay constitutes the underlying soil.

The difference in elevation between the two lakes was found to be 18·6 feet, at a time at which both lakes were stated to be at a high stage. This difference is naturally subject to a variation, dependent upon atmospheric and other conditions, but, until further records are obtained, it is assumed that a normal head of 15 feet would be available for power purposes.

Owing to its inaccessibility, no continuous flow records have been made on the Waterhen river, but records at the outlet of lake Manitoba give approximately the flow to be anticipated, and from these it is estimated the low flow is 5,000 second-feet, which with an 80 per cent turbine efficiency and a 15-foot head would give 6,800 continuous horse-power.

Special reference should also be made to the storage possibilities of lake Winnipegosis. The equivalent of one foot storage on an area of 2,000 square miles would be a flow for six months of 3,536 second-feet or for one year of 1,768 second-feet. The magnitude and extreme value of such storage is self-evident. Another feature worthy of note is that, at various times, the construction of a canal between the two lakes has been advocated for navigation purposes, and, therefore, development of power in conjunction with the building of the canal would be an important factor.

Fairford and Dauphin Rivers.

The scope of the survey on these two rivers included the securing of a profile of river surface from source to outlet, and the investigation of four possible power sites.

Discharging from lake Manitoba, the Fairford river flows in a northeasterly direction emptying into lake St. Martin. From the latter lake to lake Winnipeg, the river is known as the Dauphin. In general terms, the drainage basin includes the territory to the east of the Manitoba escarpment, together with those portions of the plains tributary to the Swan and Red Deer rivers. Through a fortunate natural occurrence, a series of lakes act as the collecting basins for the entire drainage, and in the lower reaches of the watershed are situated the two larger lakes, Winnipegosis and Manitoba; the major portion of the run-off being first collected in the former lake, and discharged from it into lake Manitoba. The relative situation and magnitude of these two lakes have exerted a vast equalizing effect upon the flow of the Fairford and Dauphin rivers.

The banks of the Fairford river, for the first three miles, are well defined, varying from 3 to 10 feet in height, and reaching a maximum in the immediate vicinity of the Canadian Northern Railway bridge at Fairford station. Below this point, the banks become gradually lower, opening out into a wide expanse of low marshy land, which merges into a stretch of water known as lake Pinemuta. After leaving this lake, the banks range from 2 to 3 feet in height, but again merge into swampy shores as lake St. Martin is approached. Throughout, the banks are composed of light gray clay, in which a few boulders are imbedded. Where the Dauphin river leaves lake St. Martin, the banks are poorly defined; low lying meadows, subject to overflow in periods of high water, merge into timber line about one-half-mile from either side of the channel. The banks, which are composed of sandy clay, and which vary in height from one-half-foot to two feet, present this same general appearance for the first 11 miles of the river. At this distance from the lake, the river cuts through a sandy ridge, running in an east and west direction, and of a maximum height of some 8 feet. For the following 12 miles to a point on the river where rapids occur, the banks become higher ranging from 1 to 6 feet in height, though in many places giving way to swampy indentations. From the rapids to Sturgeon Bay there is a range of from 5 to 32 feet. At numerous places in this lower reach limestone ridges cross the bed of the river, and rock outcrops are visible in the sandy soil of the banks. The Fairford river varies in width from 500 to 900 feet, while the Dauphin, with an average width of 450 feet, is in places slightly narrower than the Fairford.

Practically a complete regulation of river flow should be possible, by use of storage on the immense lake areas in the drainage. Reference has previously been made to the possibilities of lake Winnipegosis, while lake Manitoba with an area of 1,711 square miles offers storage facilities almost as great. It is interesting to note that the latter lake is stated to have a range in level of 2 feet, and only 1 foot storage would give a flow of 3,024 second-feet for a period of six months.

Discharge measurements made at Fairford settlement since June, 1912 show during that period a low flow of 5,000 second-feet; but when the records are carried over a more extended period, this amount may be subject to some revision. Based on this flow and with a turbine efficiency of 80 per cent the sites investigated, shown on (Profile plate 18), show the following power possibilities:—

Site No.	Head.	Horse-Power.
1	8	3,630
2	6·5	2,950
3	28	12,706
4	16	7,260

Manigotagan River.

The survey of the Manigotagan river, made by Mr. Gow in June, 1913, comprised a reconnaissance of the river from lake Winnipeg to Long lake. All points at which power concentrations were possible were investigated, and sufficient data were secured to define the limiting features of the river banks. Storage investigations included the determination of the area of certain of the headwater lakes, and the elevations at which these lakes might be maintained.

The Manigotagan river discharges into lake Winnipeg from the east, 50 miles north of the mouth of the Winnipeg river. The drainage basin of the Manigotagan as shown, (Plate 19), is approximately 375 square miles in extent. In the lower reaches, the water-shed is confined between those of parallel river systems; while, in the upper reaches, it is stated that the drainage widens out to the north and south, though no definite information is as yet available with regard to this. Some 32 miles above lake Winnipeg the river broadens out into Turtle lake, followed upstream by Caribou, Muskrat, Long, and Moose lakes.

At the mouth of the river the banks are composed of good agricultural clay with occasional rock outcrops. Above Wood falls, the first drop on the river, the banks are very irregular, and, in most cases rocky, ranging in some places up to 60 or 70 feet in height, while in others they are broken by valleys leading back to muskegs and swamps. In the first 25 miles the river has an average width of 75 feet, narrowing down at the many rapids and falls. In the vicinity of Turtle lake the channel widens, and from there to Muskrat lake the width at places reaches from 700 to 900 feet. A noticeable feature of the river is that, below each rapid, there is a large circular pool of from 500 to 800 feet in diameter. The bed of the river is covered with a black muck, except at the various falls and rapids where boulders or rock outcrops occur.

From a study of existing flow records, in conjunction with the results of the surveys of the headwater lakes, it is apparent that Muskrat lake, with an area of 8·3 square miles, and a storage range of 10 feet, would have ample capacity to ensure a complete regulation of river flow. Gauging station records for the period from January, 1913, show a low flow of 35 second-feet during the past winter, while mass-curve studies indicate that a regulated flow of 150 second-feet could be maintained. The estimated available power, therefore, on this river at nine possible concentrations, (Plate 20), are given in the following table. The power has been computed on a basis of 80 per cent turbine efficiency for a minimum flow of 35 second-feet, and for a regulated flow of 150 second-feet.

Power Site.	Distance from Wood Falls.	Available Head.	Power Output with Min. flow at 35 sec.-ft.	Power. Output with regulated flow at 150 sec.-ft.
	Miles.	Feet.	H.P.	H.P.
Wood Falls		29·5	94	401
First Rapids above Poplar	3·4	16·0	51	218
Fourth Rapids above Poplar	8·6	30·0	95	409
Third Rapids above Cascade	12·2	12·0	38	164
Sixth Rapids above Cascade	15	15·0	47	204
Charles Falls	25·5	29·0	92	395
Turtle Cascade	30·6	23·0	73	313
Second Rapids above Turtle	34·1	14·5	46	198
Caribou Cascade	35·9	27·0	86	368
		Totals....	622	2,670

Whitemouth River.

In connection with the detailed power survey of the Winnipeg river, a reconnaissance was made of the Whitemouth river by S. C. O'Grady, engineer in charge of the above survey. The examination of the river was of a decidedly preliminary nature, but sufficient data were secured to make an approximate estimate as to the river's power potentialities, in the section between the Winnipeg river and the village of Whitemouth.

The Whitemouth river rises in the Whitemouth lake, (Plate 21), in the south-easterly corner of the province of Manitoba, and flows in a northerly direction discharging into the Winnipeg river at the foot of the Seven Sisters rapids. The watershed has an area of 1,566 square miles, and in the upper portion comprises part of what is known as the Julius muskeg.

The bed of the river consists almost entirely of boulder clay, with occasional outcrops of rock in the lower reaches. In the vicinity of Whitemouth falls at the mouth of the river, these rock outcrops extend well above bed elevation. With the above exception, the banks throughout are composed of a sandy clay, and rise to a height of 50 feet, varying in some places from a very gradual to a steep slope.

As shown on profile (Plate 22) there is a difference in elevation of 44 feet between the mouth of the river and the village of Whitemouth. Of this, there are two possible concentrations of 20 feet each, one at the falls at the mouth of the river, and the other about three miles below Whitemouth village.

Based on estimates of flow for the past two years, the following table gives the power available with 80 per cent efficiency for a minimum flow of 25 second-feet, and also for the lowest monthly mean flow (100 second-feet) for the period of six months, from May to October.

Site No.	Head.	Estimated H.P. at 80% Efficiency. Min. Flow 25 Second-feet.	Flow 100 sec.-ft. Period May to October.
1	20	46	180
2	20	46	180

The Winnipeg River Power Survey.

The power survey of the Winnipeg river was continued along similar lines to those described in the last annual report. The field party under the charge of Mr. S. C. O'Grady was, at the beginning of the year, engaged upon the Seven Sisters reach of the river. While in this locality a reconnaissance of the Whitemouth river was made, and a line of levels carried up the latter river were tied into the Canadian Pacific railway datum at Whitemouth, thus giving a check upon the levels run upstream to Kenora and downstream to Lac du Bonnet. On the completion of detail surveys of possible power sites on the above portion of the river, the survey was continued upstream embracing Twin falls and the diversion dams of the Winnipeg Electric Street Railway. The survey was then carried down the Pinawa channel to the city bridge, connecting in this manner with the work of the previous year. Following this, the party was detailed to secure certain additional information regarding that portion of the river between the Seven Sisters and Pine falls. The information desired was of such a nature that it had previously been impossible to secure it due to ice conditions, or had not been deemed necessary until studies of possible concentrations had been carried out. On October 8, the party was disbanded, and the work discontinued for the season.

THE LEVELS OF THE LAKE OF THE WOODS.

In the progress report for the year ending March 31, 1913, reference was made to the questions respecting the levels of the Lake of the Woods, now before the International Joint Commission for examination and report. The questions referred to the Commission are as follows:—

> (1) In order to secure the most advantageous use of the waters of the Lake of the Woods, and of the waters flowing into, and from that lake on each side of the boundary for domestic and sanitation purposes, for navigation and transportation purposes, and for fishing purposes, and for power and irrigation purposes, and also in order to secure the most advantageous use of the shores and harbours of the lake and of the waters flowing into and from the lake, is it practicable and desirable to maintain the surface of the lake during the different seasons of the year at a certain stated level; and if so at what level?
>
> (2) If a certain level is recommended in answer to question No. 1, and if such level is higher than the normal or natural level of the lake, to what extent, if at all, would the lake, when maintained at such level, overflow the low lands upon its southern border, or elsewhere on its border, and what is the value of the lands which would be submerged?
>
> (3) In what way or manner, including the construction and operation of dams or other works at the outlets and inlets of the lake, or in the waters which are directly or indirectly tributary to the lake or otherwise, is it possible and advisable to regulate the volume, use and outflow of the waters of the lake, so as to maintain the level recommended in answer to question No. 1, and by what means of arrangement can the proper construction and operation of regulating works, or a system or method of regulation, be best secured and maintained in order to insure adequate protection and development of all the interests involved on both sides of the boundary, with the least possible damage to all rights and interests, both public and private which may be effected by maintaining the proposed level?

It is unnecessary here to deal with any of the various aspects of the regulation of the lake, other than the far reaching effects upon the powers of the Winnipeg River in which this branch is vitally interested. The Lake of the Woods with an area of 1,500 square miles is the largest and most important reservoir within the Winnipeg River drainage basin. The importance of the lake as a possible storage is not only due to its magnitude, but also to its strategical position immediately above the powers on the Winnipeg river. The watershed tributary to the lake comprises an area of 25,000 square miles, and from a study of existing flow records it would be possible to regulate the entire run-off of this basin through the use of the lake. Such a regulation would increase the available powers on the Winnipeg River from 276,000 horse-power to 464,400 horse-power, or an amount of 68 per cent. The utilization of the Lake of the Woods alone as a regulating medium would require a permissible range of 9 feet in lake level; this would not be practicable, for it would be injurious to the powers at the lake outlets and to various other important interests, such as fishing, navigation, etc. Fortunately, this extreme range is unnecessary as numerous lakes in the basin above, including Rainy, Namakan, Kapitogaman, Sand Point, etc., can be utilized to carry a portion of the desired storage.

During the past two years, field and office studies of the Lake of the Woods and its drainage basin in its entirety have therefore been carried on, in order that a full and comprehensive statement may be made on the part of the Water Power Branch before the commission. At the same time, a vast amount of work, comprising stream-gaugings, special surveys, and the gathering of all records relative to lake level, has been done by this survey at the joint request of the Consulting Engineers to the Commission.

In the upper watershed, gaugings were made at the outlet of Namakan and Rainy lakes and on the Rainy river at Emo. This territory was taken over during the year by the Dominion Department of Public Works, and the work of this survey was concentrated upon the Lake of the Woods, and more particularly at the outlets of the latter.

The peculiar physical features of the Lake of the Woods outlets rendered the work of securing continuous records of run-off, and of estimating past run-off from available gaugings, extremely difficult. Practically continuous discharge measurements have been made at the lake outlets. At the eastern outlet, a discharge rating of the Kenora power-house was based on power output. This rating, together with the power house daily loads, has been used to estimate the mean daily discharge through this outlet since 1907, the year of the power house construction.

At the western outlet on which the Norman dam is located, flow measurements were made at a station above the dam. These records were used, in conjunction with gaugings of the flow through the three mill races at Keewatin, to check the gaugings at a station downstream at which the combined flow of the above four outlets was obtained. Through the use of daily gauge records of the Ontario Department of Public Works, in conjunction with the above discharge measurements, estimates of the daily discharge have been made for the above outlets for a period of the past seven years.

Detail surveys have been made during the year of the eastern outlet, western outlet, and Norman dam and of the three Keewatin outlets.

On May 1, 1913, an evaporation station was established on the lake at Portage Bay, Keewatin. The equipment consists of the following: A galvanized iron tank with a suitable raft for supporting same, a rain gauge, recording and standard barometers, recording and standard thermometers, an anemometer and a sling psychrometer. Records were obtained twice daily at the station by the resident engineer.

The work at the outlets was carried on by assistant engineer G. J. Lamb until the month of October, when Mr. Lamb secured an extended leave of absence. Mr. S. C. O'Grady was then appointed in charge of the work, and, during the period at which the numerous surveys were in progress, Mr. M. S. Madden acted as Mr. O'Grady's assistant.

OFFICE WORK.

Due to the rapid manner in which the field investigations expanded, the office staff was at first unable to cope with the work devolving upon it. The situation was howewer, relieved by the appointment of further office assistance. The plotting and drafting of the plans of the numerous surveys, carried on during both the previous and present year, necessitated the concentration of a great porton of the staff on this phase of the work. The detail topographic plans of the Red River Survey comprising in all sixty-one sheets were completed during the month of February. The plans of the Winnipeg river power survey were brought up to date and at the same time the plans of the numerous power surveys of the present year were in most cases completed while the remainder are now rapidly nearing completion. Considerable time was involved in connection with plans of the surveys of the lake of the Woods outlets and in the preparation of diagrams and the copying of miscellaneous plans and records bearing upon the level of the lake.

During the month of November the office staff was concentrated upon the compilation of all field data necessary for a preliminary report on the water powers of the province for the Manitoba Public Utilities Commissioner: While the gauging station records covered with few exceptions only a period of a year, yet in most cases a well defined discharge rating had been obtained and it was possible to give a complete record of discharges since the establishment of the stations. For this same report, brief descriptions were prepared from field investigations of this survey, or from other reliable sources, respecting the power possibilities of the various rivers. It might here be noted, that this is the first report on which the hydrology of the entire province is dealt with, and on which authentic information is given with regard to stream-flow.

In September a much needed addition was made to the office staff. Mr. C. H. Greenwood, who has the necessary qualifications, being appointed accountant. This not only relieved the engineer in charge of certain routine work, but also made it possible to have a detailed study made of the costs of hydrographic and power surveys.

RECOMMENDATIONS.

(1) *Investigation of Nelson and Churchill Rivers.*

Reference has previously been made in this report to the advisability of an immediate investigation, even if preliminary in nature, of the more northerly rivers. It is definitely known that there are vast power possibilities on both the Nelson and Churchill rivers, on the Nelson alone the power is estimated at over 2,500,000 horsepower. The early completion of the Hudson's Bay Railway, and the certain influx of settlers, will rapidly open up the north country and bring about the development of its resources. It is, therefore, necessary that a comprehensive study be made of the power possibilities of both these rivers, with a view to the conservation of the resources; or, in other words, that maximum possible development may be secured, such study to include the rivers in their entirety. With respect to stream gauging, it is essential that records, if to be at all valuable, should commence at the earliest possible date.

(2) *Winnipeg River Storage.*

The extreme value and present necessity of regulation of the flow of the Winnipeg has previously been pointed out, both in this and other reports. Special attention is now being given to that portion of the drainage entering the river through the Lake of the Woods, and the question of regulation of the latter lake is under consideration by the International Joint Commission. No field study has however been made of the English river and the storage facilities on the numerous lakes in its head-waters. The English river at its point of junction with the Winnipeg is almost of as great magnitude as the latter, draining a basin of 22,000 square miles. Of the numerous larger lakes lying in its upper reaches, Lac Seul with an area of 340 square miles, offers particularly good storage possibilities. The need of investigation of such storage is self-evident when it is considered that practically half the Winnipeg river drainage is derived from this source. As an instance of the present necessity of regulation of the river flow, a minimum stage was experienced on the river during the past winter and the plant of the Winnipeg Electric Railway was only able to operate at much below its capacity.

(3) *Ground Flow.*

Among the recommendations of the previous year, is one dealing with the requisites necessary for the study of ground-flow in the province. This recommendation is again brought forward, for this phase of the hydrology of Manitoba is so far unknown. In the near future knowledge of ground flow will be a necessity, for the southern portion of the province must look to this source for its water supply.

(4) *Standard Bench-Marks.*

The adoption of a standard type of metal bench-mark, similar to that used by the United States Geological Survey, is strongly recommended. In connection with the numerous power surveys in the province, extensive lines of levels have been traced, and, in order to make these of general benefit, distinctive permanent bench-marks should be established.

(5) *Conferences of Hydrographers.*

During the past winter there has been an interchange of information relative to stream-gauging methods between the British Columbia staff and this office. The benefits derived here, and, it is hoped in British Columbia, from this source, would indicate that a conference between members of the two staffs would be of inestimable value in the general furtherance of the work. This system has been adopted by the United States Water-resources Branch, and a conference is held annually at Washington.

(6) *Surveys of small Water Resources.*

Certain rivers such as the Shell, Swan, Red Deer, etc., present power possibilities of small magnitude, but on some of these rivers development is already contemplated. It would appear advisable that surveys of these rivers be made, but that the surveys should be entirely in keeping with the nature of the rivers. These surveys could be carried out by a topographer, instrument man, and two rodmen, and would include the securing of the following data: Determination of levels by transit, a magnetic traverse, and sketches of shore topography. While the information obtained would be in the nature of a reconnaissance, it would nevertheless be of great value in dealing with any possible power sites.

Appreciation of the Work of the Staff.

In conclusion, I wish to take the opportunity of acknowledging the loyal support and hearty co-operation of the staff, and the excellence of work done by them.

I have the honour to be, Sir,
Your obedient servant,
S. S. SCOVIL,
Assistant Chief Engineer.

No. 8.

REPORT OF M. C. HENDRY

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following as a report of the work carried on under my supervision during the year ending March 31, 1914.

The work carried on consisted of inspections of power sites for which applications had been filed, the observations for other possible sites in the vicinity of those inspected, the examination into possible storage basins, and the collection of some additional information on the Bow river. To carry out this work I had two assistants, Messrs. Attwood and Hogarth. Owing to the nature of the work and the extent of territory to be covered during the season, it was not felt that a larger organization was warranted.

The work accomplished during the season was as follows (see plate No. 23):—

1. Inspection of Sturgeon river and tributary lakes.

2. Investigation into power possibilities of Athabaska river between Athabaska and mouth of Lesser Slave river.

3. Investigation into power possibilities of Lesser Slave river.

4. Investigation into storage possibilities of Lesser Slave lake.

5. Investigation of storage possibilities of Lac La Biche.

6. Investigation of storage possibilities of Jasper lake.

7. Investigation of storage possibilities of Brulé lake.

8. Inspection of power site, Stony river.

9. Inspection of two power sites, Athabaska river.

10. Investigation of Red Deer river near Red Deer for power.

Two trips were also made into the Spray lakes, to gather additional information for the Bow river report, also to look into the possibilities of power on the Spray river. Separate reports covering each of the above have been submitted and are now on file.

In carrying out these investigations, the lack of sufficient run-off data upon which definite conclusions could be based, was keenly felt. Much has been accomplished along this line but further extension of the work is greatly needed.

STURGEON RIVER.

The first investigation made during the season was that on the Sturgeon river. The river below the outlet of Big lake was examined, with a view to ascertaining the existence of any possible power sites. The lakes of the system were also examined, to determine the possibility of securing storage to augment the low water flow.

From information gathered in connection with the plant of Fort Saskatchewan, situated on the river near its mouth, it was known that the winter discharge was very low so that storage would be almost imperative if power development on the river was to be rendered feasible.

An examination of the river showed that, at a point in section 10, township 56, range 23, west 4th meridian, there existed a site where it was considered possible to develop power. As there are no direct falls in the river, the head to be developed would have to be created by a dam, the banks being of sufficient height to secure a head of approximately 60 feet; the length of the structure would be approximately 500 feet on the crest.

The lakes mentioned above were examined for their storage possibilities. Isle lake was the first investigated, it has an area of approximately 5,250 acres, the shores are for the most part low, and a great deal of the surrounding country would be flooded were the lake level raised to any considerable height. With a storage of 5 feet on this lake the capacity available is estimated to be 27,000 acre-feet, though it is questionable whether the banks would allow this, or whether the run-off would be sufficient to fill the basin.

Lac Ste. Anne, Sandy lake, and Big lake were next examined. Of these, Big lake appeared to be the most attractive for storage, the area is 2,420 acres with a tributary drainage area of 404,000 acres. With 20-foot storage—which the shores are capable of sustaining, though considerable flooding of very desirable farm land would be involved—the capacity would be approximately 100,000 acre-feet. The structure involved in securing this amount of storage would be very long, about 1,800 feet on the crest.

The discharge data for this stream cover a very short period, and consist for the most part of isolated gaugings. The conclusions drawn, therefore, regarding the power and storage possibilities of the river may be subject to a very considerable revision; but from the data available the possibility of obtaining 100,000 acre-feet of storage seems very remote. The records justify the assumption that for at least nine months of the year the flow is below 200 c.f.s.; under such discharge conditions, the power output of the river is very limited and the economic phase of the question does not appear very attractive.

ATHABASKA RIVER.

The Athabaska river between Athabaska and the mouth of Lesser Slave river was examined for possible power sites. On account of the numerous applications for power, it was felt that information regarding this stretch of the river should be obtained. A trip of inspection was therefore made, which was more in the nature of a reconnaissance. A launch was secured, and the banks were examined for a suitable site for development.

In the stretch indicated, about 75 miles in length, there are no falls or rapids; but, at a number of points, swifts or long flat rapids occur. The banks are generally clay, and rise in a series of benches to the level of the main valley. Steep-cut banks are generally opposed to low flats, the river bank at these points varying from 8 to 10 feet high. After a careful examination, the conclusion was reached that no suitable sites occur in this stretch of the river.

It was contemplated that on the return from Lesser Slave lake, a trip would be made down the river from the Landing to Grand Rapids; but, owing to the low water, it was impossible to secure transportation to that point, and the amount of work to be done during the season precluded the use of canoes and the consequent length of time required to track back up the river. The trip was therefore abandoned.

During the season a reconnaissance was made of different parts of the Athabaska drainage basin, in order to obtain information regarding the possibility of securing storage to augment the low-water flow of the river. The winter discharge of the river is low, reaching approximately 2,000 c.f.s. at Athabaska. This low flow renders questionable the development for power purposes of several points on the river. Could storage of any magnitude be secured, these several sites would be placed upon a more attractive basis.

The points looked into were Lesser Slave lake, Lac La Biche, Jasper and Brulé lakes. These form the principal lakes of the drainage basin, the first two being upon tributaries, and the last two, situated near the headwaters, being expansions of the river. Data relating to discharge from the first two lakes can now be obtained; but, for the last two, all figures are sporadic and indirect.

The results of these investigations were disappointing, the outlets of the lakes being wide and offering no favourable opportunity to the creation of storage.

LESSER SLAVE LAKE.

Lesser Slave lake forms what is practically the source of the river of the same name, one of the largest tributaries of the Athabaska after the latter leaves the mountains. Owing to its relation to the Athabaska river, the lake was looked upon as a possible storage basin for increasing the low-water flow of that river. The area of the lake is approximately 500 square miles, being about 60 miles long and averaging 8 miles in width.

The lake is navigable, two or three shallow draught stern-wheel steamers being operated upon it by the Northern Transportation Company and the Hudson's Bay Company. The lake is for the most part very shallow, and in consequence gets very rough.

The shores of the lake vary considerably, on the north side they are high and, present the appearance of cut banks, while at the west end, on the south and at the east end, the banks are very low, being but a few feet above lake level.

The information relating to the discharge from the lake is confined to one metering, made at the time of inspection which, from local information, was supposed to be practically high water. This metering gave a discharge of approximately 2,300 c.f.s. While no conclusions can be drawn from a single measurement, one fact should nevertheless be borne in mind, namely, that this metering was taken at what was considered high water, so the withdrawal of any considerable amount of water for storage would have a marked effect upon the river below which is used for navigation. The possibility of creating storage on Lesser Slave lake is controlled by the discharge and the topographical features, especially those at the lower or outlet end of the lake.

As has already been stated, the shores of the lake on the west, south, and east (the last the outlet end), are low. At the upper and west ends, considerable areas of hay land lie at an elevation of between 2 and 3 feet above lake level. On the south, the shores are wooded and are low lying, as at the west end. To the east, with the exception of some sand dunes at the northeast corner of the lake, the whole of the country is not over 3 or 4 feet above lake level. The mouth of the river is wide, and presents no favourable opportunity for raising and holding the lake at a higher elevation. After a study of the situation, the combination of the topographical features, and the requirements of flow in the river during the navigation season, lead to the reluctant conclusion that the creation of storage on Lesser Slave lake seems remote.

LAC LA BICHE.

Lac La Biche forms the head-waters of the river of the same name, which joins the Athabaska about 50 miles below Athabaska, and is the only stream of importance between that point and Fort McMurray.

The lake is reached by wagon trail from Athabaska, a distance of about 60 miles; this trail is very bad during wet weather, being nearly impassable in places, near the lake it improves and for the last eight miles is fairly good.

The area of the lake is approximately 90 square miles. The surrounding country is hilly, and fairly well covered with forest growth, most of which, however, is small. The streams entering the lake are all small, those noted being but 20 to 30 feet wide, and flowing bank-full when first seen, though a few days later the water had subsided considerably. The banks of the lake are generally high, rising 20 to 40 feet, and are skirted with sand and gravel reaches. At the outlet end these features change, giving place to low marshy banks behind which lie spruce swamps and muskegs.

There are no records available regarding the run-off from the lake, and the stream where examined was so sluggish and full of weeds, that no attempt was made to gauge it, also no estimate could be formed of the discharge.

The general surroundings of the lake, high banks, etc., gave at first a very favourable impression, but when the outlet was reached, this impression was removed; as the outlet was approached, the banks gradually got lower, until they were practically at water level, a low sand ridge intervening between the lake and the country behind. This back country was nearly all spruce swamp and muskeg, except for a narrow fringe of hay land on the east side of the mouth. This kind of country extends for some miles on either side of the river from the lake, and is so low that the stream cannot be approached for the reeds and grasses in the water.

These conditions obtaining, the idea of storage on Lac La Biche had to be abandoned.

JASPER AND BRULÉ LAKES.

On account of the close similarity of the governing features, and their proximity to one another, these lakes are dealt with together.

These two lakes are situated within Jasper park, the outlet of the latter being just on the boundary of that reserve. They lie in the main valley of the Athabaska, which is, at this section, very wide: they are in fact simply expansions of that river. Jasper lake is nearer the source, and lies just above the mouths of the Stony and Rocky rivers which, the one from the north and the other from the south, add their waters to the Athabaska. The lake is about 6 miles long and 1 mile wide. At the upper end the valley is narrow, and the hills which form the valley approach the shores of the lake. At the lower end, however, the valley is much wider and the lake banks are composed of sand. The outlet is wide and the banks on the south side are low.

Brulé lake is about 8 miles below the outlet of Jasper lake. It is approximately 7½ miles long and averages 1 mile in width. The banks are low and sandy, being composed for the most part of sand dunes which are continually shifting with the wind. The outlet end of the lake is wide and the banks low.

The Grand Trunk Pacific line follows the south bank of the lake, and the Canadian Northern the north bank. On account of the trouble experienced from the drifting sands, it was proposed by the Grand Trunk Pacific to place a dam at the outlet of the lake, and raise the water surface so flooding the sands. The idea was a good one but the proposed level interfered with the Canadian Northern Railway grade, so had to be abandoned.

The outlet of each of these lakes is wide, the foundation conditions poor, and the limit to which the water could be raised low. The lakes are also shallow with shelving shores, so that a great proportion of the water would be formed into ice. The river below these lakes, too, is shallow and contains many rapids, the troubles from ice would be serious and the proportion of water wasted this way, great. Unless the water could be utilized at some point comparatively close to these lakes, the creation of storage at this point should not be considered.

STONY RIVER.

Stony river was next examined to ascertain its power possibilities. It joins the Athabaska between Jasper and Brulé lakes, and within Jasper park. As practically the whole river lies within unsurveyed teritory, which is more or less unexplored, there are no maps of the district upon which an estimate of the area of the drainage basin can be based. Measurements of the discharge of the river have been made by officers of the Irrigation Branch and a measurement was also made by Mr. Attwood at the time of this inspection.

About 15 miles of the river, extending upstream from the mouth, was examined in greater or less detail, particular attention being given to that portion in the vicinity of the falls which occur at the upper end of this section. Here a survey was made in sufficient detail to permit of the contours being plotted approximately, and a general plan of the river and falls made.

The river flows through a narrow steep valley; at very few points in its course, however, is the river channel canyon-like; generally where rock cut banks occur, they are opposed to wide flats, near the mouth, and in the vicinity of the falls, these conditions are reversed and canyons are to be found. The river averages about 100 feet in width, the bottom is full of boulders and hence the stream is very turbulent.

The data relating to the discharge of the Stony river are, as was stated, confined to individual measurements, and these have all been made within the last year so that no very definite conclusions can be drawn regarding run-off. Fortunately, the greater number of measurements were made during the low water period of streams in the district, so that a fair idea of the behaviour of the stream during that period may be obtained.

The results of only two measurements of the stream during normal period are available, one made by Mr. G. W. McLeod on August 1, 1913; the other was made on September 10, 1913. The first, made above the falls, gives a discharge of 1,200 c.f.s.; the second, at the crossing of the Canadian Northern railway near the mouth, gives a discharge of 1,000 c.f.s. Comparing it with somewhat similar streams, it seems probable that a discharge, under flood conditions, of from 5,000 to 6,000 c.f.s. might be expected with an extreme flood of probably twice that amount.

The following are the available records as to discharge:—

Date.	Made by	Discharge.
		c.f.s.
Feb. 15, 1913	Officer Irrigation Branch	170
Mar. 10, 1913	" " "	180
April 9, 1913	" " "	175
" 30, 1913	" " "	186
May 19, 1913	" " "	380
Aug. 1, 1913	G. W. McLeod	1,200
Sept. 10, 1913	C. H. Attwood	1,000

The possibility of creating storage on the upper waters of the Stony river appears remote. Mr. Moore, of Jasper, who has spent a number of years in the district, and has been over the whole length of the river, describes the upper valley as being wide, and for the most part with muskeg bottoms; the wide stretches are not confined at the lower ends by narrow gorges, so that the country does not lend itself to the creation of storage basins.

The falls are formed by the river flowing over a limestone ledge into a narrow box canyon; the fall is a direct one, and is approximately 60 feet. The fall at the time of investigations was about 70 feet wide on the crest, the river above being slightly wider. Below the fall, the river flows through a narrow box canyon with sheer walls on the west side, those on the east being less precipitous and affording room for a power house. The canyon extends approximately 700 feet, before opening out into a wider valley. Above the falls, the banks are less abrupt, the immediate river banks varying from 5 to 20 feet high; but immediately adjacent to the main valley, the banks rise to considerable heights above the river. The river slopes rapidly immediately above the falls, falling some 15 feet in about 2,000 and having in this stretch several small cascades and rapids. Below the fall the slope is also considerable, a fall of nearly 10 feet occurring between the foot of the fall and the mouth of the canyon.

The head of approximately 60 feet at the falls could be increased to at least 75 feet, by placing a dam across the river about 500 feet upstream from the crest of the falls; this would also serve as an intake to a penstock which would lead to the power station, placed in the canyon below the falls. The water from a dam 15 feet high would be backed up for a distance of about one-third of a mile, and the pond so created would be confined to the river channel, except for a small flat about 2 acres in extent lying immediately above the dam. Such pond would only be of use as a partial protection against ice troubles being too small for any regulation purposes.

From a study of the available run-off data, it appears that the amount of power that may be developed is very limited, for nearly eight months of the year a flow of under 200 c.f.s. may be expected which, with the head developed, would give (using say 180 c.f.s.) approximately 1,230 w.h.p.; for the remainder of the year, a flow of probably 1,200 to 1,500 c.f.s. might be secured, this no doubt would be considerably exceeded for short periods, but assuming a flow of 1,200 c.f.s., the power that could be developed would be approximately 8,100 w.h.p.

From these figures, it would appear that the development is one which could not support any large expenditure on capital cost.

ATHABASKA RIVER.

Two possible sites were examined on the Athabaska river in townships 58 and 56, range 21, west 5th. The former is referred to as "Site No. 1," and the latter as "Site No. 2"; they are so designated on account of their proximity to one another, and the lack of other means of distinguishing them.

The stretch of the river upon which they are situated lies above the crossing of the Edson-Grande Prairie trail. Site No. 1 lies just above the crossing.

Site No. 1

From an inspection of this site and a rough survey, it was ascertained that a head of eighty feet could be obtained by the erection of a dam of that height, no rapids or falls existing at this point. The length on the crest would be approximately 550 feet, and the materials to be found at the site would appear to warrant a structure of these dimensions.

The drainage area of the Athabaska, down to the power site is, for the most part, virgin forest and the greater part of the headwaters are in Jasper Park Forest reserve on the east slope of the Rocky mountains. Above Jasper the Maligne, Miette, and Whirlpool rivers are all tributary to the Athabaska, and all are mountain streams which fluctuate with the varying temperature. Below Jasper the Stony and Solomon rivers are tributaries of some importance.

From a study of the very few meterings, taken on the Athabaska at Hinton between September, 1912, and April, 1913, and compared with the gaugings taken at Jasper commencing February 4, 1913, it is seen that at Hinton in March the flow increases, whereas at Jasper the flow is gradually decreasing until about the middle of April. These records tend to show that the Stony and Solomon rivers receive their spring floods earlier than the tributaries on the higher altitudes, and thereby increase the flow during March.

The data relating to stream flow are confined to individual meterings, most of which have been made during the past year, so that no definite conclusions can be drawn regarding run-off. The greater number of the readings have, however, been taken during low water and were recorded at Athabaska falls, Jasper and Hinton. Of these meterings, those taken at Hinton more truly represent the flow of the river at the power site; Hinton is a station on the Grand Trunk Pacific railway, and is approximately 50 miles above the power site.

DISCHARGE figures at Hinton.

Date.	Made by	Discharge.
		sec.-ft.
Sept. 18, 1912	Officer, Irrigation Branch	7,334
Feb. 14, 1913	" " "	1,017
Mar. 11, 1913	" " "	1,099
Apr. 10, 1913	" " "	1,396

On October 3, 1913, a rough estimate was made at the crossing of the Grande Prairie trail 1·5 miles below site, and the flow was estimated to be 4,600 c.f.s. Comparing these figures of discharge with high water mark on river banks, it seems probable that a flood discharge of from 30,000 to 50,000 c.f.s. might be expected at the site.

From information gathered relative to the upper part of the drainage basin, the possibility of obtaining storage appears remote. Any basins that exist are comparatively small, and are so remote from the points at which the water might be utilized that the benefit derived would be somewhat problematical.

The site apparently offers all that is required from an engineering standpoint. Two rock cliffs form the main valley of the river at this point, they are nearly parallel, being nearest to one another at the west end, and rise approximately to a height of 150 to 200 feet. On the north side, the cliff is nearly perpendicular, and is from 700 to 1,000 feet long. On the south side, the cliff is not perpendicular, but rises at both ends at approximately a 45 degree slope for about 75 feet; then the rock appears as a perpendicular cliff rising above. Between the two ends, the slope is more gradual, ending in a flat 200 or 300 feet wide at the middle point, the flat forming a bend in the river. West of the upper point the cliff bends away to the southwest. The rock on each side of the river is a hard sandstone, somewhat weathered, and lies in horizontal strata.

The whole head of any development would have to be created by a structure placed in the river, as no direct falls occur in the river. The average fall of the river is approximately 3 feet per mile. In the application a dam 80 feet high has been proposed: it would be approximately 525 feet long on the crest with the power house on the flat below.

The only available records of stream flow to hand at present are a few miscellaneous meterings, taken above the site during the winter of 1913. These records show 1,017 c.f.s. as the minimum flow recorded on February 14, 1913. Comparing this river with other mountain rivers of known flow, it seems reasonable to assume that the minimum flow might easily go as low as 700 c.f.s. Also from the study of these same records, 2,500 c.f.s continuous flow for 7 months seems to be all that can be expected at the site, without storage.

The power from 2,500 c.f.s and 80-foot head with 80 per cent efficiency would be 18,000 h.p. for 7 months; and assuming 700 c.f.s as the minimum flow, 5,000 h.p. would be the minimum amount available. Again, if 1,000 c.f.s. proved to be the minimum, 7,200 h.p. would be minimum power developed.

Site No. 2.

Access is had to this site, which lies in the SW. ¼ section 31, township 56, range 21, west of the 5th meridian, by way of the Medicine Lodge trail from the crossing of the Athabaska river. The trail is very little used, so that a whole day was occupied in covering the 15 miles between the two points.

The remarks regarding discharge, made in connection with Site No. 1, apply also to Site No. 2, about 12 miles upstream, as no streams of sufficient magnitude enter between them to make any difference in the low water discharge.

The site seems worthy of consideration, and from the examination made it would seem possible to develop a head of approximately 50 feet, and there should be no difficulty in finding a sufficiently good solid rock foundation for the structure. The east bank is a sandstone cliff 50 or 60 feet high, and the bench from here to the bottom of the main valley is from 50 to 100 yards wide. The river is 500 feet wide, and on the west shore the banks are shelving with occasional rock outcrops. The length of structure involved could only be known after a detailed survey had been made, but 1,000 feet is about the minimum length. One thing to be determined is whether the water from the proposed site in township 58, range 21, west 5th meridian will be backed up as far as this site or not, a distance of approximately 12 miles by the river.

The site is rather a hard one to reach by a land route, it being approximately 30 miles via Medicine Lodge: Grand Prairie trail, from Medicine Lodge, a station on the Grand Trunk Pacific railway, 156 miles west of Edmonton.

The trail would have to be cleared out and put in shape for teaming. No personal inspection was made of the trail, but, from reports given by settlers, it is very wet in places and very little used. The site could be reached more easily, and heavy loads easily handled, by making Hinton (station on the Grand Trunk Pacific railway, 185 miles west of Edmonton) the base, and freighting machinery and supplies down the river from there, either by scows in summer or by making an ice road on the river in winter, and thereby avoiding hills and bad roads.

The only available records as to discharge are those given above. These records show 1,017 c.f.s as the minimum flow recorded on February 14, 1913. Comparing this river with other mountain streams of known flow, it seems feasible to assume that the minimum flow might easily go as low as 700 c.f.s. Also from the study of these same records, 2,500 c.f.s. continuous flow for seven months seems to be all that can be expected at the site without storage. The power from 2,500 c.f.s. and 50-foot head with 80 per cent efficiency would be 11,300 h.p. for seven months, and assuming 700 c.f.s. as the minimum flow and 80 per cent efficiency, 3,200 h.p. would be the minimum amount of power available.

These two sites while feasible from an engineering standpoint, do not on the surface appear attractive from an economic point of view. Their remoteness from a possible market of any magnitude (Edmonton), the length of transmission line involved, the difficulty of securing access to the sites for construction purposes, and the apparent low discharge of the river during a considerable period, places them in the position where careful consideration should be given them, and an increased number of run-off records secured before any great sum is expended upon them.

EMBARRAS RIVER.

The Embarras river forms one of the tributaries of the McLeod river, joining the latter in section 5, township 52, range 18, west 5th meridian. The river has a drainage area of approximately 650 square miles, and lies in the country to the east of the east fork of the McLeod river, the upper waters being for the most part in the foothills. The greater part of drainage area is wooded, though some of the tributaries, entering from the east, head in muskegs to be found in the district. An examination of a section of the river near the mouth was made by myself, accompanied by Mr. Attwood, about October 1, 1913. In the section examined, the stream averages between 100 and 150 feet in width, and has a fall of approximately 5 feet per mile. The banks vary in height from 10 to 50 feet in height, they are very steep in many places, being perpendicular and formed entirely of sandstone which lies in horizontal strata. The bed of the stream is composed of sand and gravel, and in many places the bed-rock appears.

The data relating to stream-flow are confined entirely to miscellaneous meterings, no gauging station having been established, and these readings have only been taken during two seasons, 1912 and 1913; an estimate, based upon a gauging made in the McLeod river below the mouth of the Embarras, was made in 1912, by myself; although considered conservative, it appears from recent meterings to have been high. The meterings of the river in 1912 were made near the head waters above most of the tributaries, and therefore do not indicate accurately the flow to be expected at the site in question, and are therefore omitted. When the site was examined, an attempt was made to meter the stream, but no suitable section giving sufficient depth was found in the vicinity; an estimate, however, was made, the discharge being placed at 200 c.f.s. A metering made near the mouth on October 9, or nine days later, gave a discharge of 168 c.f.s.

A list of the gaugings is given below, and it will be seen that the maximum recorded was 551 c.f.s., on August 12, 1913. From the nature of the drainage basin, the flow should be fairly uniform, though evidence goes to show that very extreme floods occur. No definite conclusions can be drawn, but it appears from the data to hand that a minimum flow of 25 c.f.s. may be expected, while the extreme flood discharge of 3,000 c.f.s. is possible.

The following are the available records as to discharge:—

Date.	Made by.	Discharge.
		c. f. s.
July 23, 1913	Officer of Irrigation Branch	283
Aug. 12, 1913	" " "	551
" 29, 1913	" " "	235
Sept. 11, 1913	" " "	148
Oct. 9, 1913	" " "	168
" 1, 1913	Estimated, M. C. Hendry	200

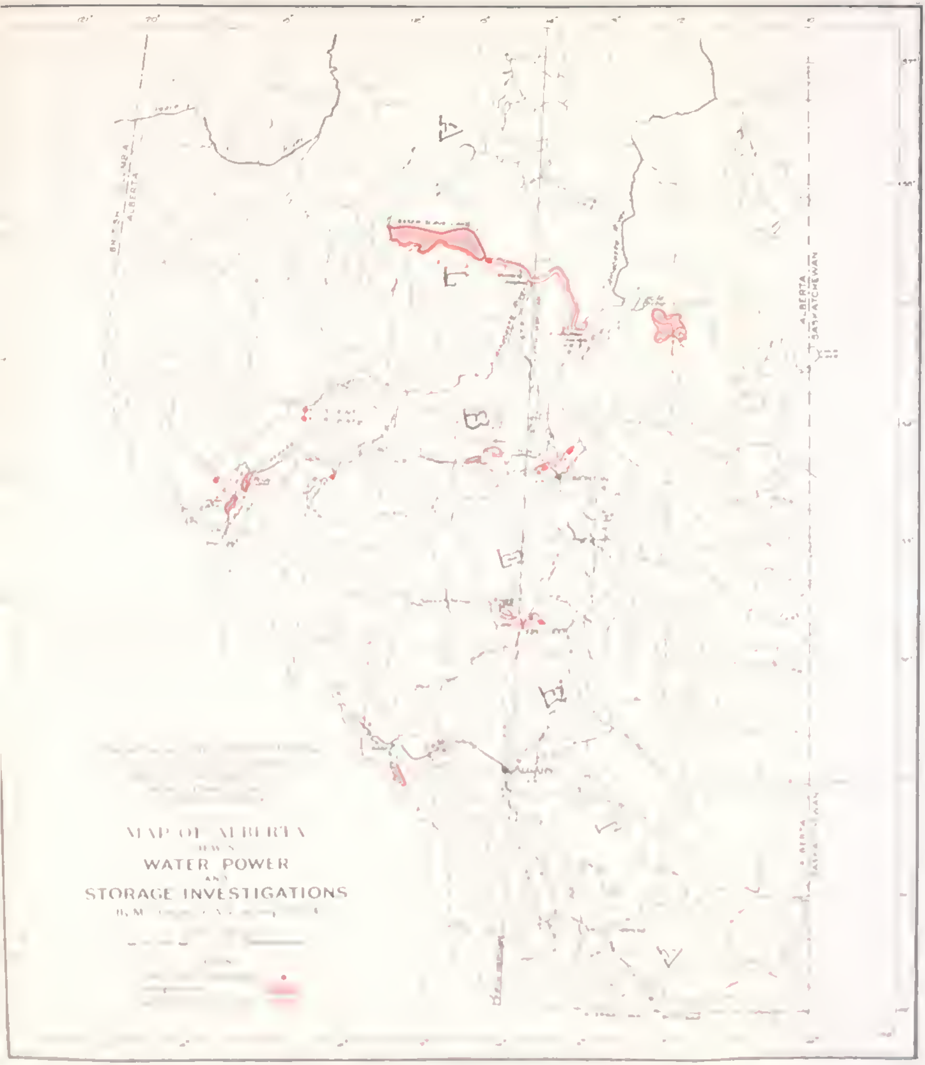
The possibility of creating storage on the upper waters of the Embarras river appears to be remote; the information in respect to this is not definite, but, from a study of the general features of the drainage area, and also from what could be gathered on the subject, there does not appear to be any feasible basin where storage could be created; added to this, the evident limited discharge of the river puts the creation of any valuable storage out of the question.

During the last summer, the discovery of placer gold on the bars of this stream was reported, and a large number of placer-mining claims were staked and recorded upon the river in the vicinity of the proposed site, and both up and down stream from it. When the stream was examined, with one or two exceptions, the claims staked were not being worked, and had apparently been abandoned. The exceptions are located upstream from the site. In one case, that of the West Lands Mining Syndicate, protest has been entered against the granting of a water-power license on the river, on account of the consequent flooding of their holdings. It is claimed that considerable sums of money have been, and will be spent upon these claims showing their bona fide nature.

The whole head of any development at this point would have to be created by a structure placed in the river, as no direct falls occur, the natural slope averages approximately 5 feet per mile. The greatest head that could be secured, by building a structure in the river, would be approximately 50 feet. In view of the figures regarding the stream flow presented earlier in the report, it seems possible that a low discharge of from 25 to 30 c.f.s. can be expected, and this condition may obtain for a considerable period. Further discussion of the development is therefore not waranted. the conclusion reached being that any development on the Embarras river, at the point indicated is out of the question, from an economic or any other standpoint.

RED DEER RIVER.

The Red Deer river has its source near the summit of the Rocky mountains in what is known as the Sawback range. The mountainous district tributary to it lies between the drainage basins of the Bow and the North Saskatchewan rivers. The main branch in the mountains is the Panther and the greater number of its tributaries, as the Burnt and Fallen Timber creeks, the Little Red Deer, and the James, have their source in the foot-hills. The Red Deer does not draw its waters from as great altitudes as does the Bow river, but from the lower ranges and foot-hills; in consequence of this, the high water season is liable to occur somewhat earlier than


MAP OF ALBERTA
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on the Bow river. The first flood water, due to the melting of the snow in the foothills, comes down in April, and the flow so derived is later augumented by the melting of snow in the higher altitudes.

The stream resembles all others in the district, having a very rapid flow, while no actual falls occur in the section examined, the current is swift; flat rapids succeed one another almost continuously and are especially noticeable during the low water period; the current is not so great as to prevent the formation of an ice sheet over the greater part of the river. The fall in the river in the vicinity of Red Deer averages about 8 feet per mile, the banks of the valley are generally high, but the valley is wide, the river changing from side to side of the valley, high banks alternating with low wide flats.

The data concerning the flow of the Red Deer are very meagre, so that it is impossible to draw definite conclusions. The first measurements were made in 1910, beginning in June: no continuous readings were taken, but one gauging was made in each of the following months, June, July, August, September, and November. In 1911, some gaugings were made, but no continuous readings were taken, of which the most important are the two made in December, as they are the first taken during the low water period. In December of that year, a gauging station was established at Red Deer, and since that time continuous readings have been available, although, at present, those for the year 1912 are all that are to hand. A study of these records seems to indicate that there are four low water months, and that January, February, and March, are the extreme months. In April, the flood water from the foothills comes down raising the flow in that month. Extreme low discharge may be expected to reach 200 c.f.s., 222 c.f.s. being the lowest recorded. The lowest mean monthly flow is 238 c.f.s., so that it would not appear safe to count on a mean monthly flow of more than 250 c.f.s. during the extreme low water period. For November, December, and March, a mean flow of between 350 and 400 c.f.s. may be expected.

There are three lakes tributary to the Red Deer near the section in question. These are Cygnet lake, Sylvan lake and Gull lake. The water discharged from Sylvan lake flows to Cygnet lake and then to the Red Deer entering that river in section 11, township 38, range 28, west 4th meridian. The water from Gull lake flows into the Blindman river, which joins the Red Deer in section 8, township 39, range 26, west 4th meridian.

Cygnet lake, which is the smallest of the three, has an area of 4,700 acres, the area of Sylvan lake is 10,800 acres and that of Gull lake 25,700 acres. Cygnet lake is a shallow basin, the shores being low and marshy, and large areas of low hay land are adjacent to it. The level of this lake has been lowered in connection with the construction of the Alberta Central railway. The line passes through the centre of the lake, on account of this, storage there is out of the question.

Sylvan lake drains into Cygnet lake through a small stream which meanders across the flats lying between the two lakes. The nature of the shores of the lake vary; on the west and north sides they are high-cut banks composed for the most part of clay; on the south and east side the shores are low and sandy, especially at the outlet where the water is shallow and somewhat reedy.

Storage might be created here by raising the lake level 1 foot, and so securing approximately 10,800 acre-feet, which is equivalent to a flow of 60 c.f.s. for three months. Any storage undertaking would have to be in conjunction with a reclamation project involving the land lying between Sylvan and Cygnet lakes. Such a scheme would necessitate the digging of a drainage ditch through the flats, as at present the greater part of the land is under water part of the year. A method of drainage would make some hundreds of acres of land available for agricultural purposes.

Gull lake is tributary to the Blindman river. This lake was not visited, but from information gathered it appears that some attempt has been made to utilize it as a regulating basin for the plant at the mouth of the Blindman river. It was not learned what success has attended this undertaking, but judging from the other two lakes visited, the volume of water secured from that source cannot be very great.

The possibility of developing power near Red Deer on the river of that name is confined to two sites. Three were investigated, the upper site being discarded as not feasible, while the lower one was not considered in detail, owing to the difficulty of access at present and the distance from the town. Particular attention was given to the middle site, that lying within the boundaries of the town.

The amount of power that may be developed is limited, the mean monthly flow for the river reaching the low figure of approximately 230 c.f.s., and a minimum discharge of 200 c.f.s. may be expected. The head for any development must be created by structures and river diversion, no direct falls occurring in that stretch of the river.

The present power load is limited, the electric plant in the town having a capacity of 320 kilowatts is a steam driven plant. What this load may amount to is hard to determine, owing to the lack of figures upon which to base an estimate.

There is a possibility of developing approximately 1,000 h.p. within the town for eight months in the year and for the remaining four months about 400 h.p. as a maximum. At present to dispose of this power, direct competition with the company, which handles the entire power load would be necessary. While the development is feasible, it does not appear on this account attractive from a commercial standpoint.

The question of storage to augment the low water flow was also taken up, and two or three possible storage basins investigated. Owing to lack of run-off data from these lakes, no conclusions could be reached; but the possibility of storage appears to be remote, and would then have to be undertaken in conjunction with a scheme for draining the land lying between the Red river and these lakes, otherwise no benefit would be derived from any storage that might be placed upon them.

JORDAN RIVER.

At the end of the season it was necessary to go to Vancouver to obtain advice on the construction of hydraulic fill dams, Mr. G. R. G. Conway, Chief Engineer of the British Columbia Electric Company, and Mr. G. L. Albert, late Superintendent of the Coquitlam Dam, being interviewed. At the same time advantage was taken of an invitation extended by the British Columbia Electric Co., through Mr. Conway, to examine their Jordan river plant and control works on Vancouver island.

The plant operates under a static head of 1,200 feet, the highest head in Canada. The station is situated on tide water, and the forebay upon the high land behind, steel pen-stocks laid to the contour of the ground connect the two. The water is carried to the forebay in a wooden flume about 5 miles in length, which follows along the shoulder of the Jordan river valley, the steep slope of the river being taken advantage of to secure the head. At the point where the water of the river is diverted into the flume, the two are at the same elevation, but a large dam has been built to secure storage at this point. Above this dam, on a branch of the river known as Bear creek, another dam, hydraulic fill, has been placed.

The dam of most interest is that at the point of diversion. This dam is of the hollow reinforced-concrete type, and is one of the highest of its kind on the continent, being 126 feet high. It is 891 feet long over all, which includes 450 feet of bulkhead section, 306 feet of spillway and 135 feet of earth embankment. The spillway has a freeboard of 8 feet and provides for a flood discharge of 25,000 c.f.s.

The dam provides for 612,000,000 cubic feet of storage, and together with that of the Bear Creek dam, 327,900,000 cubic feet, will provide sufficient water to run the enlarged plant of 25,000 h.p. capacity continuously on a 50 per cent load factor over the dry weather season.

This plant is interesting from the standpoint that it evidences the power possibilities of the small rivers of the British Columbia coast, where the annual rainfall is heavy, and the heads that may be obtained high.

The foregoing examination was made at the end of the season and completed the year's work.

I have the honour to be, sir,

Your obedient servant,

M. C. HENDRY

No. 9.

REPORTS ON COQUITLAM DAM, B.C.

Final Report of Mr. J. R. Freeman, C.E., on the Construction of the Coquitlam Dam.

Providence, R.I., U.S.A., November 4, 1913.

J. B. Challies, Esq.,
Superintendent Water Power Branch,
Department of the Interior,
Ottawa, Canada.

Sir,—As requested by you, I have reviewed the agreement between the Crown and the Vancouver Power Company, bearing date of March 24, 1910, and have reviewed the records made by myself, and those made by my assistants in the capacity of inspecting engineers on behalf of the Dominion Government, during the construction of the Coquitlam lake dam, and respectfully report as follows upon the matters wherein the city of New Westminster is chiefly interested, by reason of the domestic water supply which it obtains from the said lake.

SUFFICIENCY OF WATER SUPPLY AND INTAKE.

First.—As to a supply of water for domestic purposes, I find that the present and prospective needs of the city of New Westminster are amply provided for by means of the new intake tower and the conduit leading from said tower to a point safely downstream from the limits of the dam.

At its smallest section this conduit is a steel pipe, 4 feet in diameter, and it terminates in a steel pressure regulating chamber, provided with valves, to which the city's present conduits are connected, and to which future connections can be attached.

I find that the intake tower is well located on solid rock, about 700 feet upstream from the city's former intake, and can take water from any desired level, from highest down to the original lake level, and that it is an exceptionally massive and durable structure, of ample capacity and of much architectural beauty, and that its screens, gates and details, are well adapted to their purpose and embody the principles of the very best contemporary engineering practice.

I find that the tunnel leading from this intake tower through the dam, was mainly through the solid rock and is of ample size, and that all of the works, for taking water from the lake and delivering it into the existing conduits leading to the city of New Westminster, appear to have been built by the Power Company of first-class materials in an efficient and satisfactory form, and in accordance with the best engineering practice.

PURITY OF WATER SUPPLIED FROM LAKE.

Second.—As to the purity of water, I find that the works of the company have been so carried out, and of such scope, as to tend to improve the quality of the water delivered from Coquitlam lake to the city of New Westminster. This improvement in quality results from the removal of stumps and decaying logs from the swampy margins at the lower end of Coquitlam lake, and also results from the very thorough work of felling, removing, and burning the timber and brush within the range of the increased height of flowage by the new dam.

I find from studying many bacterial and other analyses, and from personal inspection of the lake and the surroundings, that this water is of remarkable purity and freedom from colour and turbidity. The coldness of the water which enters the lake, the great depth of the lake, the long period of sedimentation and exposure to light, the character of the vegetation in the drainage area, and, above all, the almost complete absence of human kind (except those connected with building the dam and clearing the lake margins from live and dead timber), all contribute toward a water of exceptionally good quality, and now that the dead timber in the swamps at the foot of the lake, mentioned above, has been removed, the conditions are better than before this dam was begun.

The flooded lands have been completely cleared of all timber and underbrush, well above the new top-water-level of the lake, for a distance of about 3 miles above the city intake tower, while the remainder of the lake shore at the head of the lake, including the swamp land, has been cleared to an average level of 30 feet above the old lake level, or at about the average level of the lake when the company are using their full water supply for power purposes. This clearing has, I believe, cost the Power Company upwards of $600,000, a sum which has been expended solely in the interests of the purity of the water supply of the city.

For camp sewerage at the camp buildings near the water power tunnel outlet to lake Buntzen, an iron drain pipe was laid into the discharge tunnel, through which all sewage was diverted from entering the lake, and I understand that similar provision will be made relative to any future drainage at this locality from the gate keeper's residence, or from any future occupancy of this camp.

Infrequently, when the lake is drawn down near its natural level, there may be sometimes in future, as heretofore, be some temporary turbidity, caused by the scour of the brooks near the intake during very heavy rains, but this is not a serious matter, and as a whole there will be less of this turbidity in future than before the dam was raised. The lake is so sheltered between mountains that the wave wash on the shores is not large, and the digging out of stumps by wave-wash at the varying levels will be negligible.

I know of no natural surface supply of water that is superior to Coquitlam lake as a source for domestic supply, and I find that the company's works in dam building have been so carried out as to conserve and improve this excellent quality.

STABILITY OF THE DAM.

Third.—I believe the site selected for the dam was the very best that could be found here. Prior to the performance of any extensive work on this dam, I visited the site and made a careful study of the construction plans, and I recommended various changes in the designs, for increasing the safety, all of which were accepted by the Power Company. During the entire period of construction a resident engineer, acting under my instructions, has exercised constant supervision, and inspection of the character and extent of the work performed, making weekly reports to me concerning it, and I have regularly received copies of the weekly reports of the company's superintendent of construction.

Also, I have personally visited the dam once or twice each year during the entire period of construction, and have endeavoured in every way to keep well informed as to all conditions that could affect its stability.

On the easterly side of the middle of the valley, there is granite ledge, and a trench was cut down to this through the overlying sand and clay, so as to give the dam an impervious contact with this ledge. On the westerly side of the valley, the glacial clay slopes down to indefinite depths and on this side the less impervious earth overlying the clay was sluiced off very carefully, so as to make a broad, impervious joint on this side also. A stratum of cemented gravel, revealed by test pits beneath the clay, was so dense and lay so deeply buried by the clay that it was not considered that any possible percolation through it could do harm.

I am pleased to report that I consider this one of the very best earth dams that has ever been built. Its thickness and breadth of base are uncommonly large. The site was cleared off to a broad base of excellent impervious material, which I carefully inspected personally before consenting to the depositing of the earth for the dam. The structure has been built up by the best known methods for securing imperviability and the rock footings at the up-stream and down stream edges of the dam have been built of exceptionally large size, as a safeguard against the sloughing or disturbance of the thick, impervious core of the dam. The earth sluiced was of excellent quality, possessing sufficient clay for imperviability and sufficient grit for firmness. Under the constant inspection and tests of the resident engineer, the work of sluicing earth was only permitted to go on in cold weather after it had been found possible to do this without including ice or clods of frozen earth in the dam. The slopes of the dam are uncommonly flat, and have been further protected by thick layers of "riprap," well placed, and the super-elevation or "freeboard" of the top of the dam above the wasteway crest is uncommonly high. The structure is, in my opinion a thoroughly safe dam.

THE SPILLWAY.

Fourth.—The overflow spillway for safety against exceptionally heavy floods is over a granite ledge, of ample width and of a character not likely to become clogged by floating logs, and its discharge is carried in an open channel to a safe distance below the dam.

SLUICE-GATES.

Fifth.—The sluice-gate structures are of a durable and substantial character, and the sluice-way consists of a tunnel through the solid granite ledge. This sluice is ample for the discharge of any water that the company might be called upon to release under articles 7 and 8 of the agreement of March 24, 1910.

No special log sluices have been built, but there appears to be no present need for them, and if ever needed, the wasteway and the channels leading to and from the sluices can be readily adapted to receive additional structures needed for this purpose.

INCREASED AREA OF RESERVATION.

Sixth.—The Dominion Government, by an Order in Council dated March 4, 1910, has set aside as a reservation a tract of land comprising some 56,000 acres, and embracing substantially the entire watershed of Coquitlam lake, and has thus safeguarded the lake against pollution that might come from future human habitation or from promiscuous lumbering operations. The area now within the Coquitlam reserve is about four times the area contained in the tract that was at one time proposed to be sold to the city of New Westminster, and which was confined to the immediate surroundings of the lake. The action of the Dominion Government, in extending this reserve to cover valuable land and timber in close proximity to the cities of New Westminster and Vancouver, should be indeed appreciated by the city authorities.

To make this reserve more permanent and to serve the purpose of general public interest and at the same time preserve the purity of the city of New Westminster's water supply, I would also strongly endorse a former suggestion that the Dominion Government be requested to consider the advisability of extending it to include all the available Dominion land and timber between the Burrard inlet, the North Arm, Pitt river and Pitt lake, and establish in this new reserve a park, under the Dominion Forest Reserves and Parks Act. Such action by the Dominion Government would not only result in the preservation, for all time to come, of the existing natural advantages of the Coquitlam lake watershed and surrounding district, for the preservation of the water supply of the city of New Westminster, but also in the establishment of a natural park, within easy access of the present cities of Vancouver and New Westminster and the surrounding municipalities. Such a purpose would not necessarily conflict in any way with the original purpose of the present reserve, the preservation of the purity of the city of New Westminster's water supply.

CONCLUSION.

In conclusion I consider that the rights of the city of New Westminster have been very efficiently safeguarded and that, as a whole, the city is now in a better position than when the dam building was begun, about three years ago, for the reasons already stated: namely, first, the removal of decaying timber from certain swampy margins of the lake; second, the broader channel at the outlet; third, the superior quality of the present intake works for the municipal works of the water supply; and, fourth, by reason of the greater extent of the reserved lands around the lake, which now appear to comprise almost the entire watershed.

Furthermore, the dam and structures appurtenant thereto have been constructed, not only with the view of securing maximum stability in accordance with the best engineering practice, but unusual attention has been given to the aesthetic features of the design, at considerable extra expenditure on the part of the company, with the result that all concrete structures, including the intake and gate towers, present an unusually pleasing appearance, well in keeping with any natural park which may be established here, as referred to above.

Respectfully submitted

JOHN R. FREEMAN,
Consulting Engineer.

No. 9b.

FINAL REPORT ON THE CONSTRUCTION OF THE COQUITLAM DAM, COMPILED BY A. M. BEALE FROM DATA SUPPLIED BY R. S. STRONACH.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following final report on the construction of the Coquitlam dam, British Columbia.

The magnitude and many interesting features combined with the close connection of the Dominion Water Power Branch with this undertaking since 1911, has made it desirable that a full account be published in the annual report. Mr. R. S. Stronach, the resident inspecting engineer for this department having, on the completion of his duties at Coquitlam, been transferred to the Dominion Parks Branch, the preparation of the following report has devolved on the undersigned. The matter presented is compiled from the official files and from Mr. Stronach's final report, of which large portions have been incorporated bodily.

HISTORICAL.

Early in 1898, the Vancouver Power Company—a subsidiary of the British Columbia Electric Company—was incorporated in accordance with Part IV of the "Water Clauses Consolidation Act, 1897," of the statutes of British Columbia. One of the objects for which the company was established was for the acquisition of water for hydro-electric development; the generation of electricity for light, heat and power; and the construction and operation of electric railways.

It was not until 1901, however, that sufficient capital was forthcoming for the actual work of development, which involved, amongst other things, the boring of a 9-foot tunnel for 2½ miles through the mountain separating Buntzen and Coquitlam lakes. Water was to be brought from the Coquitlam watershed to Buntzen lake and, in conjunction with its waters, be used to supply the flow to the power-house at Burrard Inlet, where an initial installation of 6,000 h.p. was planned.

In 1886, the Provincial Legislature granted the right to take water from Coquitlam lake and river to the Coquitlam Waterworks Company; this water to be used for the domestic supply of Vancouver and New Westminster. The right to dam the waters of the lake was contained in this grant.

In 1889, the city of New Westminster acquired by purchase such rights of the Waterworks Company as were necessary to enable the corporation to construct, maintain, and in the future, enlarge, a water supply system for the city. The charter, stock, and all other property of the Coquitlam Waterworks Company was subsequently acquired by the Vancouver Power Company.

It is hardly necessary here to go fully into all the issues involved, however, it may be stated that a basis of agreement between the Corporation of New Westminster and the Vancouver Power Company was reached, and a timber crib dam was constructed at the outlet of Coquitlam lake.

In 1908, the city, as a result of a report from an engineer engaged to study their water supply, requested that the Vancouver Power Company replace their existing dam by a first-class reinforced-concrete dam, of such type and size as to secure for the city a permanent and satisfactory water supply. The Power Company was inclined to accede to this request, because it would supply additional storage, and enable it to obtain all the water to which it was entitled, and thus be able to supply the rapidly expanding market.

Preliminary plans and rough estimates for the new dam were sent to London, England, in order to obtain the authority of the directors for necessary exploration work; the engineer to whom these plans were submitted there advised the employment of Mr. J. D. Schuyler of Los Angeles, California, U.S.A. Mr. Schuyler's services were therefore retained and, after full investigation, he decided that a hydraulic earth fill dam would be the safest and best structure to erect.

In June, 1909, plans for a dam of this type on a site immediately downstream from the existing dam were prepared. These plans showed a hydraulic fill dam with a maximum height of 98 feet; width 466 feet; upstream slope 2½ to 1 and downstream slope 2 to 1. the crest was to be 25 feet wide, 650 feet long and 15 feet above the spillway, which was located where the rock outcropped to the east of the dam. These works were designed to give 60 feet additional storage or 163,000 acre-feet.

For the New Westminster water supply, an intake tower of concrete was to be built on a rock outcrop at the east side of the lake 900 yards upstream from the dam site, and 36-inch diameter steel pipe was to be laid from this tower to the upstream toe of the dam, where connection was to be made to a 48-inch diameter riveted steel pipe surrounded by concrete which was to pass through the dam, suitable connections being made to the city's mains on the downstream side.

To liberate water into the Coquitlam river for logging or domestic purposes, if need should arise, two 9-foot diameter steel pipes surrounded by concrete were also shown passing through the dam, the discharge being controlled by two cylindrical balanced valves in a concrete tower on the upstream side of the dam. Since the dam site was traversed by the Coquitlam river a large flume was proposed to divert the water during the construction.

The proposal to build a hydraulic fill earth dam caused a great deal of apprehension to the inhabitants of the district immediately below the proposed dam, and also to some of the citizens of New Westminster. The principal objections being that such a dam would be unsafe, and that the flooding of so much timbered land would have a deleterious effect upon the water supply of New Westminster.

Strong representations along these lines were made to the Dominion Government which, in order to allay public alarm and ensure that a safe structure would be built, and that the water supply would be unimpaired, decided to retain the services of a consulting engineer of acknowledged reputation and eminence in his profession.

The department was fortunate in obtaining the services of Mr. John R. Freeman, of Providence, R.I., U.S.A., an engineer of international reputation, recognized as one of the greatest authorities on large-scale hydraulic enterprises. When it is mentioned that Mr. Freeman has been retained on works of such magnitude as the Panama canal, the New York water supply, and the Hetch-Hetchy project for the Greater San Francisco water supply, it can readily be appreciated that the best possible advice was being obtained.

In order that the department might keep in close touch with the work, and that Mr. Freeman might have a representative on the ground who should report to him and see that his instructions were carried out, it was decided to appoint a resident engineer. The engineer selected was Mr. R. S. Stronach, who was already on the staff of the department. Mr. Stronach had already upward of ten years' practical experience, including three years as resident engineer on various important works for R. McAlpine & Sons, of Glasgow, Scotland.

It will be seen therefore, that the department assured itself that the design of all works would be sound, and that they would be carried out under capable independent supervision. The resident engineer furnished weekly reports of the progress of the work, collected samples of material deposited in the dam; provided samples of the lake water for analysis, and saw that the sanitary regulations within the Coquitlam reserve were strictly enforced, thus safeguarding the purity of the New Westminster water supply.

Exploration work had been commenced by the company early in 1909, and the data gathered indicated that the foundation conditions of the site consisted of a granite ledge for the eastern third, this ledge then dipped rapidly downward and the remainder was rock-flour. Mr. Freeman was anxious that some further exploration of the strata below the rock-flour portion should be made, and after a consultation with Mr. Schuyler it was decided to sink two additional shafts, "G" and "H." Work on these two shafts was begun on April 28, 1910, but on May 20, in shaft "G," and June 8 in shaft "H," work had to be suspended, owing to the leakage through a cemented gravel stratum which exceeded the capacity of the sinking pumps, the elevation of the bottoms being 404·0 feet and 402·4 feet or 51·0 feet and 39·0 feet respectively below the surface.

A new pump rated at 100 gallons per minute was ordered, but did not arrive until July 14, and when the two shafts were unwatered the timbering was found to be in bad condition, and, as further sinking operations would prove dangerous, a new shaft "I" was commenced on August 6 and a new vertical centrifugal pump of 400 gallons per minute capacity was ordered. On August 28, owing to the non-arrival of the new pump, operations had to be suspended, the pump arriving on October 6, and mining being resumed on the 11th. Mr. Freeman paid his second visit of inspection on the 14th and, after both he and Mr. Schuyler had personally inspected the shaft, it was decided that further sinking operations were not necessary, as sufficient data had been secured.

The following is a record of materials encountered:—

Shaft	Surface Elevation	Depth	Bottom Elevation	Class of Material
I	442·4	48·7	393·7	Loam 3·7 feet, rock-flour 31·3 and cemented gravel 13·7.

The cemented gravel stratum in shaft "I" was carefully examined by both Mr. Freeman and Mr. Schuyler. Water was percolating uniformly through the gravel surface at a rate of 141 gallons per minute, or 0·033 cubic feet per minute per square foot of gravel stratum; the water was perfectly clear, there being no sign of erosion, and it was also observed that as soon as the gravel stratum was penetrated no timbering was required, as the gravel was so well cemented that a pick or bar was required to loosen it.

A cut was also sluiced along the centre line of the dam at the east side of the river channel, and showed that the granite ledge was overlaid by a stratum of pervious gravel averaging 2 feet in thickness.

Holes were drilled at other places on the site, and all the data collected clearly indicated that there was a cemented gravel stratum of a decidedly leaky character below the rock-flour portion of the site and also overlying the ledge at the east side of the river channel; in view of this, Mr. Freeman suggested the advisability of either building a concrete corewall in the dam to extend through the leaky stratum, or else to flatten the slopes of the dam and increase the impervious section, in order to insure that any leakage from the reservoir would have to travel such a distance that its hydraulic gradient would be lessened and its velocity reduced so low, that there could be no possibility of scour. Mr. Freeman also suggested that the idea of constructing a large flume to carry the river during the first stages of construction be abandoned, and a large sluice tunnel through the granite ledge at the east side of the damsite be substituted with suitable approach and outlet canals, and with a concrete tower at the upstream end of the tunnel. Mr. Freeman also held a consultation with the city officials and company's engineers, when it was agreed that the site for the city's intake tower should be moved to a point on the east shore of the lake, where there is a rock outcrop about 1,000 feet upstream from the damsite; the pipe through the dam to be replaced by a tunnel through the granite mountain to the east of the damsite located entirely outside the damsite.

Further exploration work was done and continued until January 24, 1911, when a conference was held in Mr. Freeman's office at Providence, R.I., U.S.A., with Mr. Blundell-Brown, one of the London directors, and Mr. G. R. G. Conway, who had been appointed chief engineer to the company. Mr. Conway took complete charge of the work from this date, as the consulting engineer to the company, Mr. Schuyler, resigned, owing to ill health.

At this conference the location of the water supply tunnel, sluice tunnel, approach and outlet canals was agreed upon, and the sites for the control towers for the water supply and sluice tunnels decided.

Final plans were prepared under Mr. Conway's supervision, and these were signed by Mr. Freeman on January 10, 1912, and approved by the Government. They were also approved by the city officials of New Westminster, as far as they affected their interests.

The scheme, as finally carried out, is illustrated by Plate No. 26, which shows a substantial hydraulic fill earth dam sealing the gap between the banks of the Coquitlam river; while on the eastern side, and quite clear of the dam, are located the spillway, sluice tunnel, and New Westminster water supply tunnel. The land along the shores of the lake flooded by the raising of the water was carefully cleared of all timber and the debris burnt.

The operations may here be outlined with more detail:—

NEW WESTMINSTER WATER SUPPLY TUNNEL.

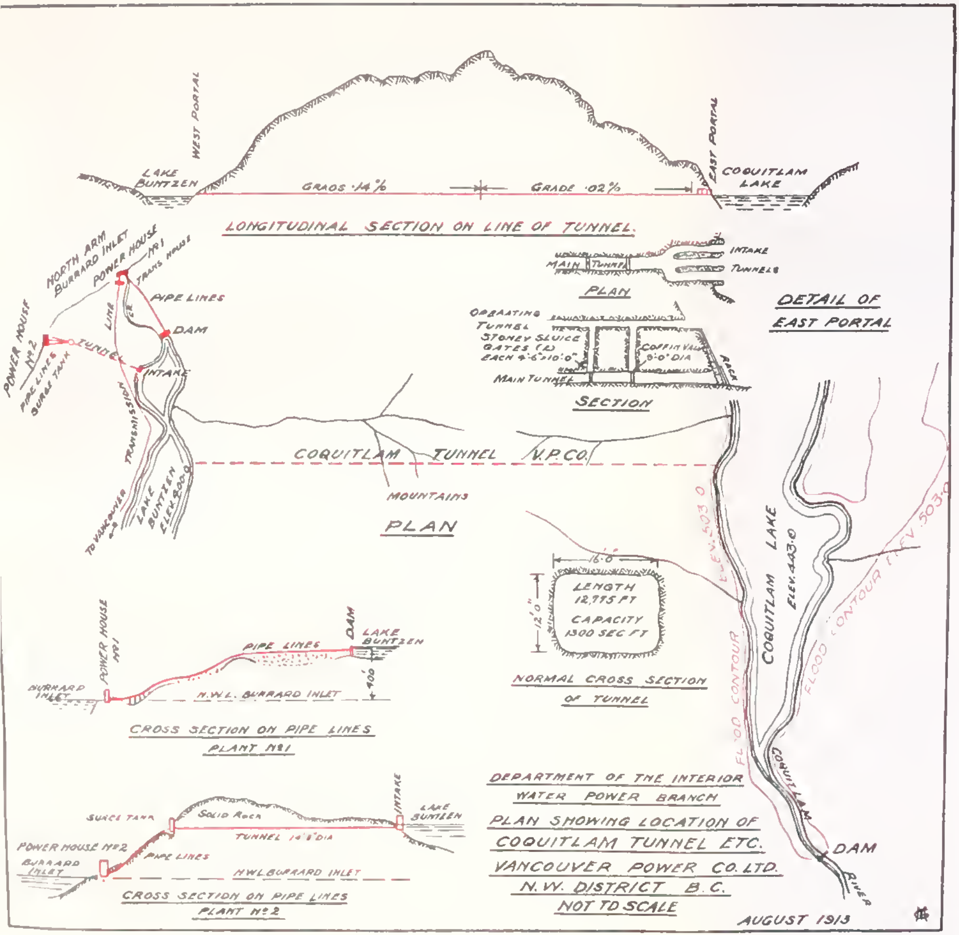
As the agreement between the Government and the company required that the domestic water supply of the city of New Westminster be neither interfered with nor impaired, the first actual construction work to be commenced was the driving of the water supply tunnel, the location of which is shown on Plate No. 25, this work was commenced on December 31, 1910, and completed on April 16, 1912.

The work of driving this tunnel was done under contract by Messrs. Ironside, Rannie & Campbell, of Vancouver, and was completed by January 21, 1912, with the exception of 10 feet at the upstream end, which was left until the control tower site had been excavated.

In order to expedite the work, two shafts were sunk and four additional headings thus secured, air-hoists were installed at each of these shafts, and buckets with a capacity of half a cubic yard used, a flat topped car being used to convey these buckets to the working face, rails being laid on the tunnel floor. To save a length of 115 feet, the downstream end was located in an exploration drift, the floor of which being $3\frac{1}{2}$ feet above the tunnel grade was first excavated to grade.

The tunnel is located through solid rock except for 190 feet at the downstream end and for a distance of 301 feet in the line between the two shafts, where there was no ledge, and where further exploration revealed none within a distance of 75 feet. These sections through cemented gravel was constructed of 48-inch diameter rivetted slip-jointed steel pipe thoroughly packed round with concrete. The pipes were to extend well into the ledge, and the concrete filling at the points where ledge was met (at each end of the 301-foot section and the upstream end of the 190-foot section) being well tightened by grouting under pressure. At the downstream end

PLATE N°24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DETAIL OF EAST PORTAL
OPERATING TUNNEL
STONEY SLUICE GATES (2) EACH 9'6"x10'0"
COFFIN VALVE 5'0" DIA
MAIN TUNNEL
SECTION
NORTH ARM BURRARD INLET
POWER HOUSE NO 1
TRANS HOUSE
PIPE LINES
DAM
POWER HOUSE No 2
PIPE LINES
SURGE TANK
TUNNEL
INTAKE
TRANSMISSION LINE
TO VANCOUVER
LAKE BUNTZEN ELEV. 400.0
COQUITLAM TUNNEL V.P.CO.
MOUNTAINS
PLAN
16'0"
12'0"
LENGTH 12,775 FT
CAPACITY 1300 SEC FT
NORMAL CROSS SECTION OF TUNNEL
FLOOD CONTOUR ELEV. 503.0
COQUITLAM LAKE ELEV. 443.0
COQUITLAM RIVER
DAM
BURRARD INLET
POWER HOUSE No 1
PIPE LINES
DAM
LAKE BUNTZEN
400'
N.W.L. BURRARD INLET
CROSS SECTION ON PIPE LINES PLANT No 1
SURGE TANK
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TUNNEL 14'0" DIA
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CROSS SECTION ON PIPE LINES PLANT No 2
DEPARTMENT OF THE INTERIOR
WATER POWER BRANCH
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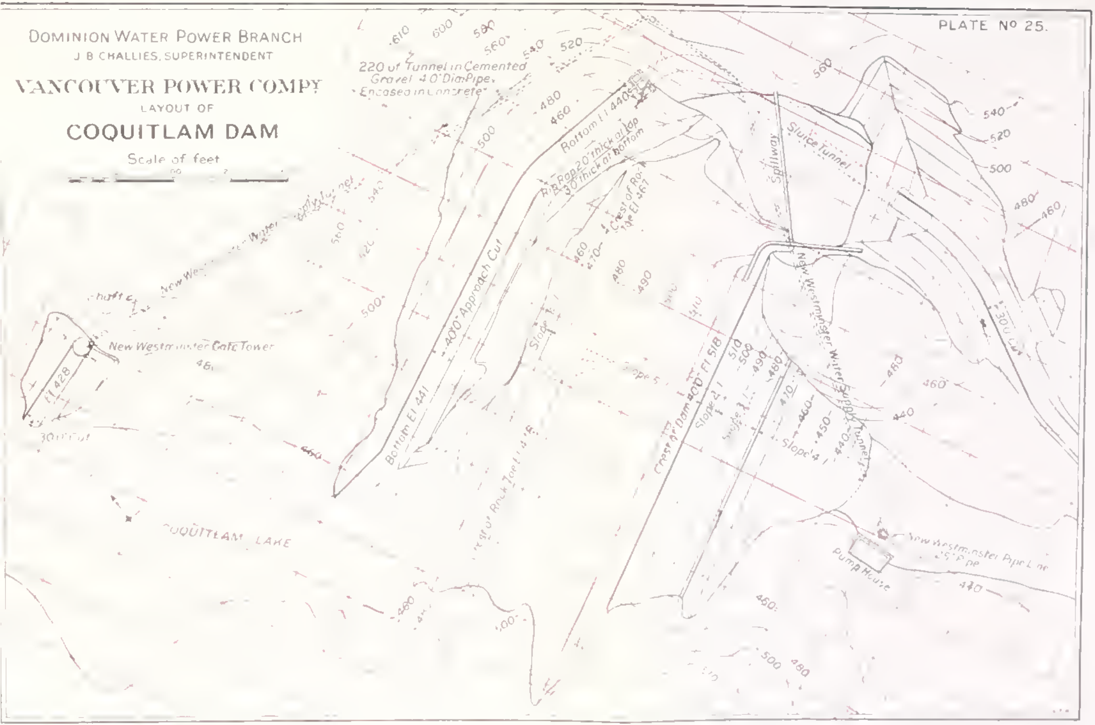
PLATE No 25.
DOMINION WATER POWER BRANCH
J B CHALLIES, SUPERINTENDENT
VANCOUVER POWER COMPY
LAYOUT OF
COQUITLAM DAM
Scale of feet
220 of Tunnel in Cemented Gravel 4 0' Dia Pipe Encased in Concrete
Bottom El 440
Rip Rap 2 0' thick at top 3 0' thick at bottom
Spillway
Sluice Tunnel
400' Approach Cut
Bottom El 441
New Westminster Gate Tower
El 428
Crest of Dam 400' El 518
New Westminster Water Supply Tunnel
300' Cut
Pump House
New Westminster Pipe Line
COQUITLAM LAKE

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PLATE Nº 26

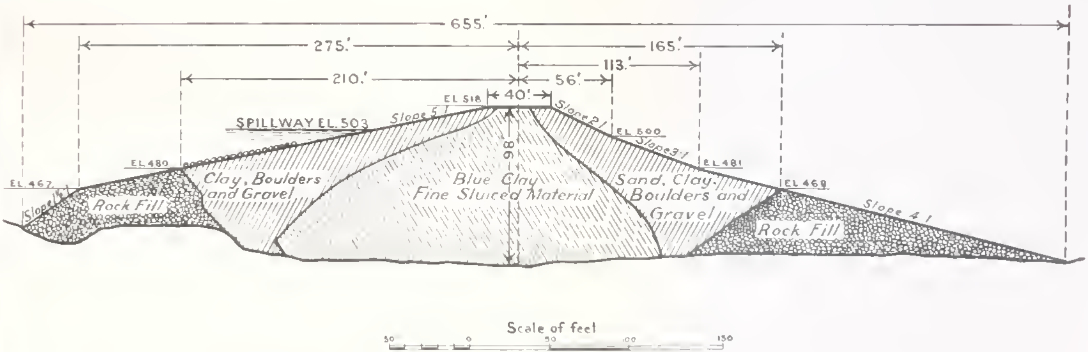
DOMINION WATER POWER BRANCH

J. B. CHALLIES, SUPERINTENDENT

VANCOUVER POWER COMPY

MAXIMUM CROSS SECTION

COQUITLAM DAM



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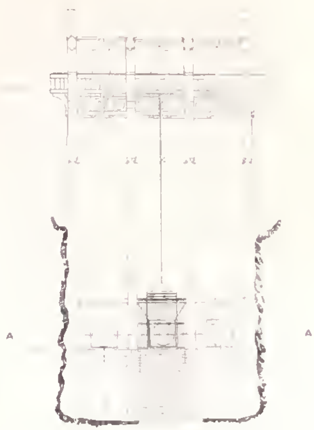
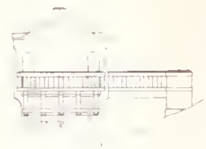
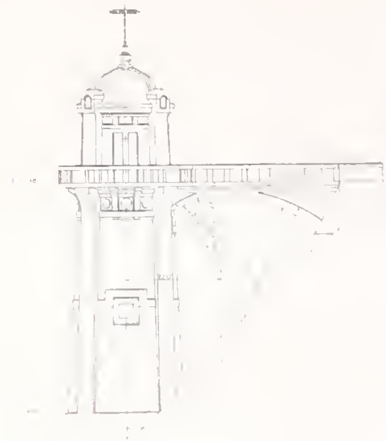


FRONT ELEVATION OF HEADWORKS TOWER



END ELEVATION OF TOWER HOUSE

SECTION ON A A



ELEVATION OF TOWER AND BRIDGE

SECTION ON CENTRE LINE OF SLUICE TUNNEL

SECTION IN ROCK

SECTION WHERE TIMBERING IS REQUIRED

CROSS SECTION OF SLUICE TUNNEL

SECTION ON CENTRE LINE OF NEW WESTMINSTER WATER SUPPLY TUNNEL

VANCOUVER POWER COMPANY

COQUITLAM DAM

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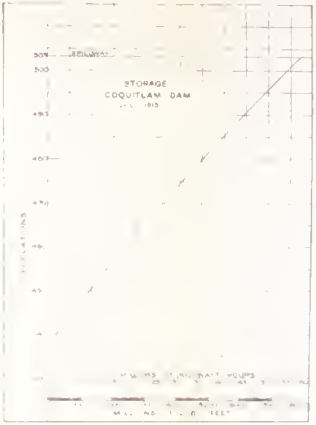


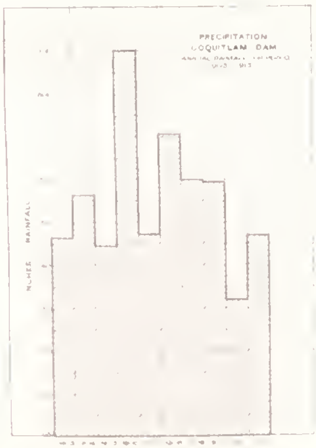


DIAGRAM re CONSTRUCTION
OF
COQUITLAM DAM

the 48-inch pipe surrounded by concrete was extended to the distrbuting chamber, where suitable connections were made with the city mains, consisting of a 14-inch and a 25-inch diameter rivetted steel pipe lines.

A concrete floor was laid for the entire length of the rock tunnel, the sides of the two shafts were also concreted and were supplied with suitable covers, ladders and landing stages so that they might always be available for inspection purposes, this part of the work was done by the company and not by the contractors. The rock encountered was granite with a few short lengths of diorite, no trouble was experienced from springs.

NEW WESTMINSTER CONTROL TOWER.

This is the finest and most handsome intake and control tower on the Pacific Coast, in Canada; it is artistic and massive, and is some 90 feet in height from the base to the floor level of the operating chamber. As the lake is frozen over in winter, the walls were made very thick to withstand ice thrust, being 4½ feet thick from the base to elevation 465 feet,—38 feet below spillway level—from which point there is a batter which reduces them to 1·5 foot at the floor level which is 15 feet above the spillway.

The control tower is built on solid rock; the channel thereto from the lake has a bottom elevation 428 feet, a width 30 feet and suitable side slopes, the excavation under water was done by a Weeks drag bucket, after the coffer dam, constructed in connection with the foundation excavation and the building of the control tower, had been removed.

The intake gates consists of four 40-inch square valves set at different elevations ranging from 430 to 487 feet and operated by hand. These gates have iron grills on the outside and a fine mesh screen on the inside, there is a secondary control inside the tower consisting of a 42-inch diameter stand pipe in four lengths resting on a cast-iron elbow in the floor of the tunnel, this elbow is connected to the water supply by a steel pipe surrounded by concrete.

A total of 2,251 cubic yards of concrete was placed in this tower, which was built under contract by Mr. H. P. Peterson, the work commenced on the completion of excavation for foundations in February, 1912, and the work was completed and the water turned on by July 2.

SLUICE TUNNEL TO CARRY RIVER DURING CONSTRUCTION OF DAM.

As has been already stated, it was proposed to drive a tunnel through the rock bluff to the east of the damsite, in order to carry the river during the construction of the dam; it was also necessary to excavate approach and outlet canals, this was done by hydraulic sluicing, the material moved being washed into the river, and completely swept away by the spring and fall floods. The approach canal was excavated to 441 elevation at the intake end and 440 at the tunnel end, being 40 feet wide at the bottom; work commenced on February 5, 1911, and continued intermittently until completion on April 7, 1912, when it was completed, 153,800 cubic yards of material having been removed.

For the outlet canal, it was originally intended to drive an 8 feet by 6·5 tunnel, beginning at elevation 433·8 and rising to 434 at the downstream portal of the sluice tunnel. This tunnel was intended to follow the line of the canal as at present constructed; work was commenced on March 15, 1911, and continued until August 27 of the same year, when 111 feet of tunnel had been driven. Trouble from quicksands and water then caused the abandonment of the tunnel, and the construction of an open canal by sluicing was immediately commenced, being completed on March 21, 1912, when 96,000 cubic yards of material had been removed.

The contract for driving the sluice tunnel itself was let to the same firm that drove the New Westminster water supply tunnel. Work was commenced on June 27, 1911, by breaking up from the water supply tunnel which crosses below the sluice tunnel; two working headings were thus secured. Excavation for the foundations of the control tower at the upstream portal of the sluice tunnel was commenced on June 15, and a third heading obtained here on August 27; a heading was not obtained at the downstream portal, as this face was not exposed by the sluicing for the outlet canal until after the tunnel was completed.

The rock penetrated was of good solid granite, no timbering was required, nor was any trouble from springs experienced; all the rock from the break-up from the water supply tunnel was carried through that tunnel and dumped at its downstream portal, that from the heading from the upstream portal being deposited in the upstream toe wall of the dam, care being taken to leave the river channel open.

The length of the sluice tunnel from portal to portal was 501 feet with a fall of 10 feet, the section was 26·0 feet by 18·5 feet with an arched roof of 13·0 feet radius to increase the discharging capacity the tunnel was completely lined from the upstream portal to the point where the straight portion was reached, a distance of 161 feet, the remainder was lined only on the floor and on the sides to the spring of the arch; this work of lining was done by the Power Company, 1,100 cubic yards of concrete being used.

CONTROL TOWER AT SLUICE TUNNEL.

Rock excavation for the foundations commenced on June 15, 1911, but, owing to delay caused by the operations in the sluice tunnel, was not completed until January 28, 1912.

Concreting was commenced immediately the excavation was completed, and a total of 2,465 cubic yards of concrete was used in the construction of the tower.

Three 10-feet by 15½ feet openings were left below the tower, in order to convey into the sluice tunnel any floods which might occur during the construction of the dam; the intake level of these openings was 440·0 feet or 4 feet below the level of the crest of the timber crib dam. Each opening was controlled by two roller gates operated by an 18 h.p. Fairbanks-Morse gasoline engine; after the completion of the dam, the space behind these gates was filled in with concrete.

In order to liberate water into the Coquitlam river, for logging or domestic purposes should need arise, permanent gates were installed in the tower at elevation 455·25, or 47·25 feet below the spillway level of the new dam; these permanent gates consist of three 60-inch diameter sluice gates inside the tower and on the outside of the upstream wall three 83-inch by 78½-inch auxiliary stop-log gates in front of which are iron racks; two concrete division walls inside the tower, extending from the floor to the level of the operating platform divide the gates into three separate sets, all of which can be operated by hand, or by the 18 h.p. gasoline engine which had been used on the temporary roller gates, and which was installed in the tower after the completion of the dam.

DAM CONSTRUCTION.

Work on the dam was not commenced until March 21, 1912, although a certain amount of rock had been deposited in the toe walls from the sluice tunnel excavation and such stripping of the dam site as had already been done.

In order to locate accurately on the plans the various operations, Mr. Freeman adopted the co-ordinate system, the centre line of the dam being taken as the main axis, lines were located parallel to it on both sides at intervals of 100 feet; another system of lines at right angles to the axis were located also at intervals of 100 feet, and stakes marked with the co-ordinate were placed at the intersections thus enabling any point to be accurately located on the plans. (See Plate No. 25.)

The pumping plan used for hydraulic work during the construction of the dam consisted of two centrifugal Dayton pumps, one a three-stage volute, delivering 4 cubic feet per second at 150 pounds pressure, and the other a single-stage delivering the same quantity at 50 pounds pressure; these were driven by 250 h.p. and 75 h.p. Westinghouse motors respectively; a Worthington three-stage centrifugal pump delivering 4 cubic feet per second at 135 pounds pressure, and driven by a 200 h.p. Allis-Chalmers-Bullock motor; a three-stage Byron-Jackson volute pump of 7 cubic feet capacity at 150 pounds pressure, belt-driven by a 300 h.p. C. G. E. motor; a three-stage Byron-Jackson turbine pump, direct coupled to a 300 h.p. Fairbanks-Morse motor, and delivering 7·8 cubic feet at 150 pounds pressure.

These pumps were installed in a new pump-house in February, 1912, the old pump-house being on the dam site, had to be removed. The new pump-house was located close to the distributing chamber of the New Westminster water supply, whence water was obtained through a 24-inch pipe connection.

On March 21, 1912, hydraulic sluicing, in order to strip the overburden from the ledge at the spillway site, was commenced, and for the first two weeks the material moved was boulders and cobble stones; these were deposited at the east end of the upstream toe wall by means of a flume. After two weeks' work the material was about 50 per cent rock-flour and sand, and, as the toe wall had been brought up to the required height from co-ordinate 1,500, 275 northeastwards, a levee was built from this point to co-ordinates 1,450, 150 north and the material removed from the ledge was used to fill in the space east of this levee. On April 28, the overburden had been stripped from the spillway site, and 4,050 cubic yards deposited in the hydraulic fill, which was built up to elevation 475·0.

The next stage was the resumption of the exploration cut along the centre line of the dam at the east side of the river channel; this was widened to an average width of 25 feet and the ledge thoroughly cleaned off from elevation 432·0 at co-ordinates 1,400·0 to elevation 518·0 (dam crest level) at co-ordinates 1,620·0. A low concrete key-wall was then built on this ledge, following the centre line of the dam from co-ordinate 1,392·0 and elevation 426, where the rock-flour section of the dam site met the ledge, to co-ordinate 1,600·0 and elevation 508.

The hydraulic sluicing in this cut was finished on May 15, 1912, and the monitor moved across the river channel to commence stripping the overburden from the portion of the damsite between the two toe-walls down to rock-flour stratum.

This work was done by setting the monitor at the top of the slope at the west side, the material was bucked down toward the river channel, the monitor being moved forward as required; the boulders, cobble-stones and gravel collected in the river channel, the lighter material being carried away down the river. The monitor was then set in the river channel, and the boulders, etc., bucked into the two toe-walls of the dam.

Upon the completion of the sluice tunnel in May, 1912, the upstream toe-wall was extended across the river channel, rock excavated from the spillway being used to make the fill. A pit was then opened at the west end of the dam, upstream from the toe-wall end, a blanket of rock-flour sluiced in front of the toe-wall effectually sealing it; this enabled the damsite to be cleared without water leaking in from the lake, and also gave the Power Company some additional, badly needed, storage. While this blanket was being deposited, the gates at the sluice tower were kept open, so that the turbid water might be drawn off through the sluice tunnel, and the city water kept clear.

Stripping the damsite between the two toe-walls was in progress when Mr. Freeman paid his visit of inspection on the 6th September, 1912, and in view of the excellent class of material disclosed by this work, he and Mr. Conway decided to reduce the width of the impervious portion at the base of the dam, as shown on Plate No. 26, to an area bounded on the north by a line between co-ordinates 950, 155 north, and 1300, 153 north, and on the south by a line between co-ordinates 1170, 120 south, and 1360, 115 south, giving a maximum width of 268 feet, the area between those lines was to be thoroughly stripped, the rock-flour stratum being thoroughly cleared of all pervious material by means of hydraulic sluicing, this work was pushed ahead vigorously and was completed on the 5th October, 1912, when an excellent base had been prepared for the impervious portion of the dam, the rock flour being exposed, and thoroughly cleaned off, between the points above mentioned from the west end of the dam, to where it met the ledge; during the process of stripping above mentioned a seam of pervious gravel was exposed in the west bank at co-ordinates 900, 0 and elevation 490·0, a cut-off trench, having an average width of 10 feet at the bottom, was sluiced into the bank for a distance of 150 feet or to co-ordinates 750, 0 where the pervious seam rose to elevation 504·0 or 1 foot above the level of the spillway crest; this trench was refilled with rock-flour during the hydraulic filling in the dam, thus effectually sealing the pervious seam.

Hydraulic filling was commenced on the 7th October, 1912, and was completed on the 8th July, 1913, the total quantity of the fill was 427,000 cubic yards, the total quantity of rock in the two toe-walls was 117,710 cubic yards, thus giving a total yardage of 544,710 cubic yards for the dam. The material for the hydraulic fill was all secured from two pits, the first of these pits to be opened up was situated downstream from the dam and to the west of it, the second was upstream and to the east.

The material in pit No. 1 consisted of about 50 per cent of rock-flour and 50 per cent sand, gravel, and boulders, while that in pit No. 2 was about 75 per cent rock-flour and 25 per cent sand, gravel, and boulders, the boulders which were too large to pass through the flumes were bulldozed until they were sufficiently small to do so, the timber and stumps having previously been removed from the site of both pits by means of donkey engines, this work being done while the damsite was being prepared and the toe-walls built up.

There were two flume lines at first for conveying the material from the pits and delivering it in the dam, one commenced at the east end of the downstream toe-wall at elevation 468·0 and co-ordinates 1400, 80 south, from this point it rose on a 4 per cent grade to the west end of the toe-wall, following co-ordinate line 80 south, from where it curved round to pit No. 1, the second commenced at the west end of the upstream toe-wall at co-ordinate 860, 155 north, and elevation 468·0, from which point it rose on a 4 per cent grade to the east end of the toe-wall, following co-ordinate line 155 north from where it curved round to pit No. 2, the fill was completed to elevation 468·0 by means of these two flumes, after which they were too low to be of further use, another flume on the upstream slope being 18·0 feet higher, or commencing at elevation 486, and the one on the downstream slope 16 feet higher, or commencing at elevation 484·0; the fill being brought up to the latter elevation by means of these two flumes, when the fill reached elevation 484, a third flume line was built, consisting of a main flume commencing at co-ordinates 1170, 80 north and elvation 522 0, from which point it rose on an average grade of 4 per cent to co-ordinates 1350, 80 north, this portion being built on the fill; from co-ordinates 1350, 80 north, the flume line curved round to pit No. 2, lateral flumes were built across the fill to each slope of the dam from co-ordinates 1170, 80 north, and depositing flumes built from each of these laterals along the slopes of the dam to each end, a second flume line or deck being built above this flume when it became too low to be of further use, this flume line was 20 feet higher and completed the fill in the dam.

The flumes were all of a uniform pattern, being built of two 1-inch by 12-inch planks on the bottom and two 1-inch by 12-inch and one 1-inch by 6-inch planks on each side, they were lined on the bottom with 6-inch hemlock blocks placed on end, and there was also a 1-inch by 6-inch plank nailed along each side of the flume above the blocks to protect the sides; the bents were built of 6-inch by 6-inch posts, caps and stringers for the first deck, for the second deck 4-inch by 4-inch posts and caps and 6-inch by 6-inch stringers were used, the bents were an average distance of 16 feet apart, the lumber used being hemlock sawn in the company's mill; the block lining in the flumes from pit No. 2 had to be entirely renewed once, but the lining in the flumes from pit No. 1 only required occasional patching, due to there being a higher percentage of sand in this pit, which protected the bottom from wear.

The material was deposited in the dam through 24-inch by 24-inch openings, in the sides of the flumes along the slopes, having each an adjustable timber gate, which was lifted and placed across the flume, just below the opening, thus diverting the stream through the opening and depositing the material at any required point; as the slope was built up, lateral flumes were built from these openings towards the centre of the dam.

The pipe lines used from the pump-house to the monitors in the pits were 16-inch flanged riveted steel pipes in 17-foot lengths; at first 11-inch slip-jointed pipe was used, but proved unsatisfactory due to leakage and loss from friction.

Plate No. 26 shows a maximum section of the dam, and the class of material deposited during the hydraulic filling process. Mr. Stronach took numerous samples of this material from the fill, and found that they would, after drying, in all cases pass through a 200-mesh screen. The rock for the two toe-walls was all secured from the excavation necessary for the tunnels and spillway.

The natural result of the high percentage of rock-flour in the material sluiced from the pits was, that the settling pond was shallow, and the percentage of solids high, in the overflow from the settling pond, due to the water being drained off before the finer particles in suspension had been given time to deposit. Daily samples were taken of the water in the overflow channel between February 15, 1913, and the completion of the fill on July 8, 1913, the following being a record of these measurements:—

	Average maximum depth of settling pond from October 7, 1912, until July 8, 1913 (start and finish of fill).	Average percentage of solids in overflow channel from settling pond, from February 15, 1913, until July 8, 1913.
1912.	ft.	per cent.
October	14·3	—
November	14·5	—
December	11·7	—
1913.		
January	7.3	—
February	2·6	1·6
March	0.6	1.6
April	0 4	1·1
May	0·5	3·7
June	0·3	3·9
July	0·25	3·9

NOTE.—Samples allowed to stand six days, percentages given being volume of sediment in bottom of measure.

The average maximum depth of the settling pond from the start to the finish of the fill was 5·24 feet and the average percentage of solids in the overflow channel from February 15, 1913, until the completion of the fill on July 8, 1913, was 2·6. It is interesting to note the rapid decrease in the depth of the settling pond after the fill had reached the top of the toe-walls in January, 1913, also the increase in the percentage of solids in the overflow as the area and depth of the settling pond became less.

The water was drawn off from the settling pond by means of an overflow channel on the downstream slope. This channel, which followed co-ordinate line 1,300, was built of 1-inch by 12-inch planks for the sides, these planks were in 17-foot lengths and were nailed to 2-inch by 4-inch posts, the bottom of the channel being filled by boulders and cobble-stones; the top of the sides was kept level with the slope of the dam, each side being an average depth of 7 feet below the slope, the first 4 feet in the bottom being refilled with the boulders and cobble-stones, thus preventing scour. The sides of the channel were always kept well in advance of the fill, the boulders and cobble stones being placed in the bottom as the slope rose, adjustable planks across the intake end of the channel being used to control the level of the settling pond, the width of the channel was 4 feet.

In January, 1913, when the fill had reached elevation 468·0, or maximum height of 42·8 feet, the resident inspecting engineer, acting upon instructions received from Mr. Freeman, put down a bore at co-ordinates 1200, 0, in order to ascertain the solidifying which was taking place in the rock-flour or impervious portion of the fill; the following is a record of the specific gravity and percentage of moisture found in the samples secured, the testing being done by Mr. F. T. Shutt, Dominion Chemist:—

Sample collected from elevation.	Percentage of water.	Specific gravity.
468·0	28·98	1·798
462·0	27·39	1·842
458·0	24·94	1·871
454·0	28·78	1·762
450·0	25·67	1·853
446·0	24·17	1·844
442·0	25·13	1·859
438·0	27.58	1·821
434·0	28·24	1·814
430·0	31·43	1·740
426·0	24·80	1·841

Elevation 468.0 was the top of the fill when the samples were taken, and elevation 426.0 was 0.8 feet above the rock-flour stratum. The low percentage of water, and the high and uniform specific gravity of the fill, was a source of considerable satisfaction and shewed that the hydraulic fill was excellent.

Although cold weather was experienced during the hydraulic filling, the temperature falling as low as 11° F. one night in January, 1913, no trouble was experienced from freezing of the pond or any material; this was probably due to the fact that cold weather was not continuous, and also that the water used was drawn through the New Westminster water supply tunnel of which the intake is considerably below the surface of the lake.

The following quantities are of interest:—

Total sluiced from Pits No. 1 and 2	489,130 cubic yards.
Volume of water delivered by giants	7,909,232 " "
Percentage of solids carried by water	6·17 per cent.
Total hydraulic fill in dam	427,000 cubic yards.
Total wastage	62,130 " "
Percentage of wastage	12·7 per cent.
Rock toe-walls	117,710 cubic yards.
The total yardage in dam	544,710 " "

SPILLWAY.

As wil be seen on Plate No. 25, the spillway was located on the shoulder of granite to the east of the dam, the level of the crest is elevation 503 0, or 15 feet below the dam crest; it is 250 feet wide on the crest, and is calculated to have a capacity of 12,000 cubic feet per second when the level of the lake is 510 , or

7 feet above the crest. As the greatest recorded flood in the Coquitlam river was 10,000 cubic feet per second it will be seen that an ample margin for safety has been allowed.

Stripping the overburden from the ledge by means of the monitors was commenced on the March 21, 1912, a working face being exposed on April 4, when rock excavation was commenced; this was done by Mr. H. P. Peterson, under contract. The rock excavated was deposited in the two toe-walls by means of a gravity car line along each toe-wall, and two Ledgerwood aerial cableways, one being used on each toe; these cableways were operated by an 112 h.p. motor for each, the cable being 2¼ inches diameter, and were also very useful for moving aggregate for the sluice tower, also lumber, pipes, etc., required in the construction of the dam.

Rock excavation was continued until December 23, 1912, when it was suspended on account of a heavy snow fall, and also owing to the toe-walls being practically completed; work was not resumed until July 14, 1913, and was completed in September, 1913, the rock excavated being used for 'riprap' on the slopes of the dam, the hydraulic fill being completed on July 8, 1913.

A total of 82,395 cubic yards was excavated; of this about 20,000 cubic yards was rock, the remainder being overburden.

CLEARING.

After careful investigation, and personally inspecting the land to be flooded around the marign of the lake by the construction of the dam, Mr. Freeman recommended that all timber and underbrush be removed from the land to be submerged, in view of the effect that the flooding of this timber would have upon the water supply of the city of New Westminster. In accordance with this recommendation clearing operations were commenced by the company in March 1911, Mr. A. Barclay being appointed their superintendent for this work, which was continued until November, when it was suspended for the season owing to inclement weather.

A camp (camp No. 1) was built on the west shore of the lake, close to the intake of the tunnel to lake Buntzen, and was capable of accommodating 300 men. Special care was observed regarding the sanitation, a drainage system being installed throughout it, and a pipe-sewer connection made to the lake Buntzen tunnel at a point behind the control gates, so that no sewage could possibly find its way into lake Coquitlam: An incinerator was also built and all camp and cookhouse wastes carefully burned in it. For the men working on the land to be cleared, portable canvas houses, with zinc buckets, were supplied, the foremen of each crew being held responsible for the good conduct of his men; these houses were moved forward as the work advanced, the buckets being changed twice each week and their contents burned in the incinerator. Great credit is due to the company for the efficient manner in which they attended to the sanitary control of their camps and employees.

Where the timber was small, all the clearing was done by hand; but for the heavily timbered areas donkey-engines were used, nine donkey-engines being used in the work. The underbrush and scrub timber was piled and burned, the merchantable timber left on the ground, being floated off at a later date, when the lake level was raised.

The following is a record of the progress made during the first season:—

	Acres.	Percentage of total.
Completed..	23	2·7
Donkey clearing done..	19	2·2
Ready for burning..	132	15·3
Falling partly done..	61	7·1
Total area to be cleared.	860	—

Clearing operations were resumed in March, 1912, and continued until October, when this work was suspended for the season; two additional camps were built, one at the north end of the lake (camp No. 2) being capable of accommodating 230 men, and the second, on the east shore (camp No. 3) half-way between camps Nos. 1 and 2, was capable of accommodating 145 men, an incinerator was built at camp No. 2 and all refuse burnt in it, the refuse in camp No. 3 being placed in zinc buckets and burned at camp No. 1; no sewage system was used in camps Nos. 2 and 3, tin buckets being used, the kitchen and wash-house drainage being led into sumps excavated in a gravel bed, chloride of lime being frequently sprinkled in these sumps.

The following is a record of the progress made during the second season:—

	Acres.	Percentage of total.
Completed (including previous season).....	582	67·7
Burning partly done....	11	1·3
Donkey clearing done....	30	3·5
Falling done....	16	1·9
Brushing done....	16	1·9

Clearing was only done on a small scale during the season of 1913, Mr. Barclay having resigned. Mr. E. Campbell was placed in charge of this work, which principally consisted of piling and burning drift-wood and booming the logs. In order to take out the logs, the company built a logging railway from the south end of the lake to Port Moody; this railway was completed in September, 1913, and is 8½ miles long.

During the season of 1911, a 50-foot steam tug was built, and used in taking the men to and from their work, also for towing purposes; when the logs were being collected for shipping, this tug was used to tow them to the south end of the lake, where they were loaded on the railroad cars.

No stumping was done on the areas cleared, the trees being cut close to the level of the ground south of camp No. 1, and cut to within two feet of the ground north of that camp.

INCREASE IN POWER PLANT.

In view of the increased storage at lake Coquitlam, the company increased their plant on the North Arm of Burrard Inlet, and built a second power-house there, the following being the details of the complete plant:—

Power-house No. 1.

Four 3,000 h.-p. Pelton units installed, 1903-6.
Two 10,500 h.-p. Pelton units installed 1908.
One 10,500 h.p. Doble units installed 1910-11.

Power-house No. 2.

Three 13,500 h.p. Pelton Doble units installed 1913.
Total plant being thus 84,000 h.p.

The tunnel between lake Coquitlam and lake Buntzen was also enlarged from 81 square feet to 178 square feet, this work being commenced in 1909, and completed in 1912.

During the construction of the dam, Mr. Fleming Ramsaur was the resident engineer for the company from August, 1911, succeeding Mr. C. A. Lee, who had accepted an important head office appointment. Mr. G. L. Albert was the superintendent of construction and his brother, Mr. D. W. Albert, assistant superintendent; these two gentlemen being the eminent hydraulic experts who have built a large proportion of hydraulic-fill dams already constructed. Mr. G. R. G. Conway, chief engineer of the company, exercised direct supervision over the whole work.

As has already been stated, Mr. R. S. Stronach was resident engineer for the department until the completion of the work. Mr. Freeman, in his capacity of consulting engineer, visited the site on five separate occasions; namely, April and

October, 1910, July, 1911, September, 1912 and April, 1913. Mr. J. B. Challies, Superintendent of the Water Power Branch, who was in administrative control of the situation in so far as the Department of the Interior was involved, inspected the work on July 20, 1911, August 30, 1912, and August 15, 1913. Mr. J. T. Johnston, Hydraulic Engineer to the Water Power branch, paid visits of inspection on September 22, 1911, and April 11 and 12, 1913.

The whole undertaking was completed in the autumn of 1913 and, being in many ways unique, it was considered worthy of a somewhat elaborate description here. The particulars of the earliest stages as well as the historical notes have been taken from the official files, the remainder has been compiled from the final report of Mr. R. S. Stronach, the resident departmental engineer; and, where desirable, large sections have been incorporated bodily, I being merely the compiler.

I have the honour to be, sir,

Your obedient servant,

A. M. BEALE.

No. 10.

REPORT OF E. B. PATTERSON.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent Water Power Branch,
Ottawa.

SIR,—I have the honour to submit a report on the progress of construction at La Colle falls hydro-electric development during the year ending March 31, 1914.

This development, as was outlined in my last annual report, is being undertaken by the city of Prince Albert. The work was shut down on August 26, 1913, owing to the inability of the city to float the necessary bonds to finance the work to completion.

I was appointed resident inspecting engineer in December, 1912, and remained at the site until the suspension of operations.

On April 23, 1913, Mr. J. T. Johnston, hydraulic engineer of the Water Power Branch, Department of the Interior, made his official visit to the works, he was accompanied by Mr. F. A. Creighton.

OUTLINE OF DEVELOPMENT.

The plans call for the construction of a lock, dam, headworks, canal power-house, and tailrace. (See Plates 29, 30, 31).

LOCK.

The lock is of the same general design as those of the Trent canal. The principal dimensions are: Length for boats 150 feet; width for boats 40 feet; lift wall 24 feet; depth of water on sills 6 feet. The lock is a component part of the dam, and the cut-off trenches of the dam extend underneath the lock into the south bank of the river.

DAM.

The dam is of the Ambursen variety, reinforced concrete hollow construction. The general dimensions are as follows:—

		Feet.
Length of spillway		755
Width of base (to toe of bucket)		67
Width of tumbling hearth		56
Buttresses, centre to centre		15
Thickness of buttresses	18 inches to 15 inches.	
" deck	24 " 18 "	
" apron deck	18 "	
Elevation of spillway		1,420·0
" bottom of floor		1,390·67

There are three cut-off trenches, one at the upstream edge, one under the bucket or at the toe of the dam, and the third at the downstream edge of the tumbling hearth. These walls extend five feet into the clay.

The floor of the dam, which is a series of spread footings for the buttresses, is level across the river, and is provided with weepholes, and strongly reinforced.

The buttresses, the general dimensions of which are given above, are 3 feet long at the top, and extend into the crest 2 inches.

The deck, which is at a slope of 45 degrees, is built in 30 foot sections with the reinforcement continuous over one buttress.

The plans call for openings in 25 bays, through which to run the river, while the rest of the section of the river bed is coffer-dammed. Six Stoney sluices are provided, in alternate bays near the north end of the dam, for discharging flood water. At the north end of the dam one sluice way, 22 feet wide and controlled by stop logs, is provided. A two foot flashboard is provided on the crest of the dam. A passageway, four feet wide extends through the dam. In the lower part of each buttress an opening is left to equalize the water level inside the dam.

HEADWORKS.

The headworks are situated at the north end of the dam, and the structures are tied together. The upper cut-off wall of the dam is to be carried along the east side of the intake.

The intake floor is 2 feet thick reinforced, provided with two cut-off trenches and weep holes.

The piers are 5 feet thick and the openings between piers are 18 feet in width. Stop-log seats are provided in each pier.

An ice curtain of reinforced concrete extends across the face from the top of the piers to 4 feet below the crest of the dam.

From the west end of the intake an embankment is to be built to high ground to the north.

CANAL.

The canal is 2,000 feet long, 58 feet wide at bottom and side slope of 1½ to 1. The excavated material consists of sandy clay and loam. The canal, as being excavated, is to deliver water for the initial installation. When the final installation is undertaken, the canal will be widened on the west side. The material from the excavation of the canal is deposited between the canal and the river to form a levee. The junction between the levee and the power house is made with steel and wooden sheet piling.

Power-House.

The selection of the site of the power-house was controlled by the material for a foundation. Future extensions to the power-house will be on the west side. The orders for the equipment of the power house have not been placed.

Tailrace.

The tailrace is 1,800 feet long, 46 feet wide at bottom, side slope of 2 to 1 below water and 1½ to 1 above water. The material consists of gravel and sand with a surface covering of from 6 feet to 14 feet of sandy clay.

CONSTRUCTION PLANT.

Two cableways, each having a span of 1,000 feet, and supported on heavy squared timber towers, were stretched across the river over the site of the dam. These cableways handled gravel, concrete, sectional forms, plant and a portion of the excavation. They were operated by engines located on the south bank, south of the towers.

A concrete mixing plant with gravel bin above was erected on each side of the river in front of the towers. The concrete was handled in bottom-dump steel cars, 1 yard capacity.

Gravel was delivered to the bin on the south side of the river by the cableways, and on the north side a derrick with a clam shell bucket lifted the gravel from the storage pile to the bin.

For unwatering the coffer dam four centrifugal pumps 10-inch to 6-inch diameter were used, operated by steam from a 50 h.p. boiler.

Steam for all purposes on the south side of the river except pumping was supplied by three 50 h.p. boilers. On the north side of the river one 50 h.p. boiler provided the steam for the mixing plant.

For handling gravel, a tramway was laid from the tailrace to the north end of the dam, where the gravel was dumped into a bin, and from which it was transported by the cableways across the river.

The excavation for the headworks was done with wheel scrapers. In the excavation for the canal, the plant used was an elevating grader drawn by a gasoline traction engine, and an outfit of dump wagons.

At the power-house site, excavation was carried on by an orange-peel excavator, and a horse-drawn elevating grader with an outfit of dump wagons. The excavation for the tailrace was done by orange-peel excavators, and some of the stripping with wheel scrapers and a horse-drawn elevating grader. At the power-house a mixing plant was in the course of erection when operations were suspended.

All the plant necessary to complete the work is on the ground.

PROGRESS OF CONSTRUCTION.

General.

The principal points affecting construction were: firstly, that the scene of operations lay at a distance of 26 miles from Prince Albert, the nearest point on a railway; and secondly, that the summer floods had to be reckoned with, and the sequence of the work so arranged that it would not be interfered with.

In the spring of 1912, the contracting firm for the lock, dam and headworks began preliminary operations; building camps, cutting cordwood and erecting plant.

In November, 1912, the first coffer-dam which enclosed the site of the lock, and 300 feet of the south end of the dam site was completed. Excessive leakage, however, required an extra row of sheet piling on the outer end, and it was not till January, 1913, that the enclosed portion of the site was unwatered.

As spring approached, the situation, as affecting construction operations, was: firstly, the construction of the south wall of the lock to such an elevation that it would prevent sliding of the river bank when the frost left the ground: and, secondly, the construction of floor and buttresses of the dam on the portion of the bed unwatered by the coffer-dam before the arrival of the summer floods.

The world-wide financial depression and the consequent difficulty in raising money for development work in the West was beginning to be keenly felt in the early part of 1913. The city of Prince Albert was unable to float the necessary bonds to complete the work and the authorities were reluctantly forced to suspend operations. On July 30, 1913, instructions were issued to shut down all the works, taking the necessary steps to protect the work already completed so that everything should remain in perfect order until such time as the development could be proceeded with.

The canal and tailrace excavation was continued during the month of September but all other work was discontinued on August 26 and has not yet been renewed.

Lock.

The first step in the construction of the lock, as previously stated, was to build the south wall to elevation 1,419·0 before the frost came out of the ground. On April 1, 35 per cent of this had been placed, and was completed during the first week in May. It is probable that if this work had not been accomplished in time the bank would have slid, burying the entire excavation.

On April 22, a week after the ice moved out, the river rose to elevation 1404.0, causing a breach in the coffer-dam, and about one foot of silt was deposited over the excavation enclosed by the coffer-dam, which acted as a settling basin to the swiftly running water; after the necessary repairs work was resumed. The next step was to build a portion of the north wall to elevation 1410.0, so as to act as a coffer-dam for the rest of the lock during high water. After the flooding in April, construction proceeded without incident until 95 per cent of the lock was completed in August, 1913, when operations were suspended.

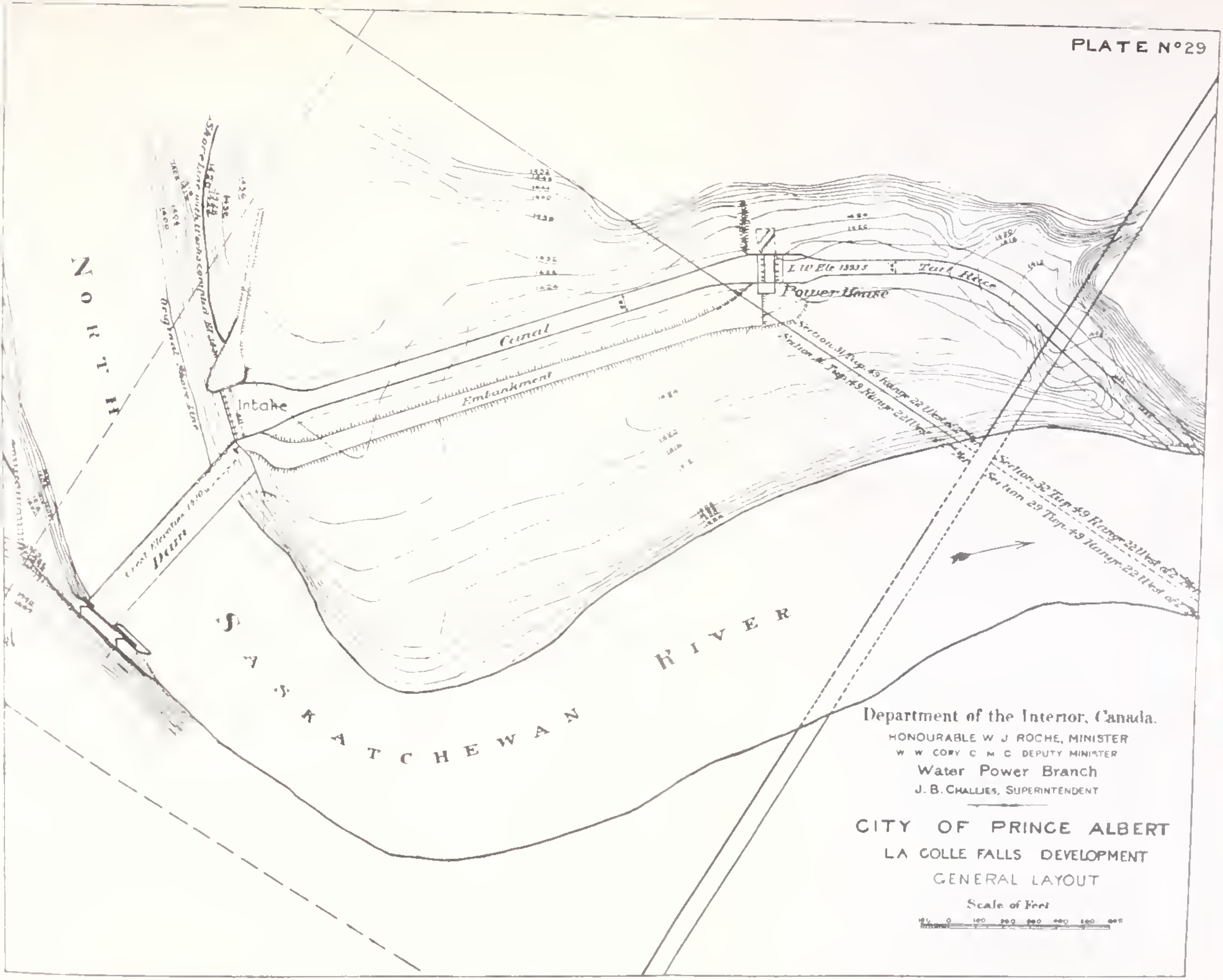
At this date, the excavation for the upper and lower entrances of the lock was not completed, and a coffer-dam extends across the lower entrance. Concrete work is completed with the exception of a few hundred yards in the upper left of the North and South walls.

Dam.

The excavation for the dam, as completed to the middle of the river, showed the foundation to be a hard impervious clay, carrying a certain amount of sand and scattered, small pebbles; boulders being rarely found. Pockets of dry sand, varying in size from a few cubic inches to a few cubic yards, were disclosed; but these evidently had no connection with the water of the river, as the sand was dry, which set at rest any fears of under-flow from that cause. This strata of clay is over 50 feet thick, according to borings carried to that depth. When these sand pockets were encountered in excavating for the cut-off walls, the excavation was carried below them into the clay. By April 1, 35 per cent of the excavation for the built portion of the dam was completed.

The construction of the dam was commenced in the middle of April at the outer end of the coffer-dam. The method of construction in building the dam was as follows: In placing the floor, each 15-foot section with the buttress at the centre was considered a unit, each unit being concreted at one operation. The buttresses, which are supported by the floor, were built in two lifts; sectional forms were built and each side

PLATE N°29



NORTH
SASKATCHEWAN RIVER
Intake
Canal
Embankment
Dam
Crest Elevation 1430
Power House
Tail Race
Original Shore Line
Section 31 Tup 49 Range 22 West of 2
Section 32 Tup 49 Range 22 West of 2
Section 29 Tup 49 Range 22 West of 2
Department of the Interior, Canada.
HONOURABLE W J ROCHE, MINISTER
W W CORY C M G DEPUTY MINISTER
Water Power Branch
J. B. CHALLIES, SUPERINTENDENT
CITY OF PRINCE ALBERT
LA COLLE FALLS DEVELOPMENT
GENERAL LAYOUT
Scale of Feet

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PLATE Nº30

Department of the Interior, Canada

HONOURABLE W. J. ROCHE MINISTER

W. W. CORY C. M. G. DEPUTY MINISTER

Water Power Branch

J. B. CHALLIES SUPERINTENDENT

CITY OF PRINCE ALBERT

LA COLLE FALLS DEVELOPMENT

TYPICAL SECTION OF DAM

Scale of feet

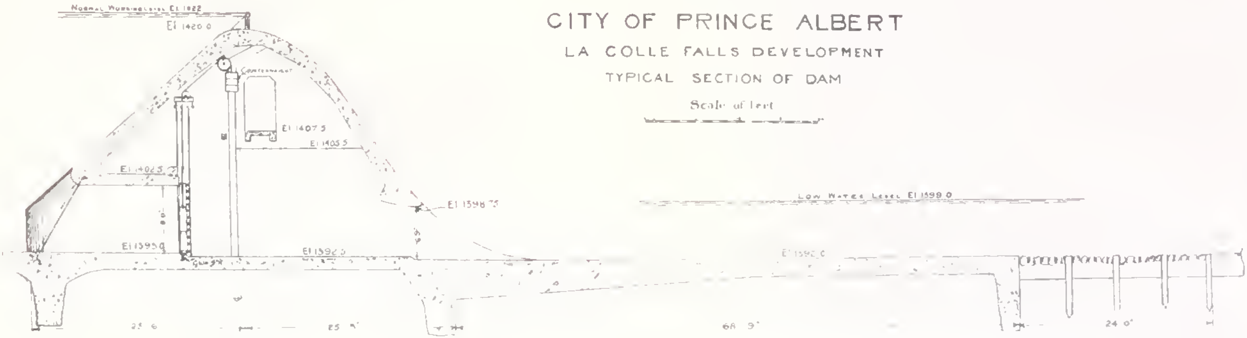

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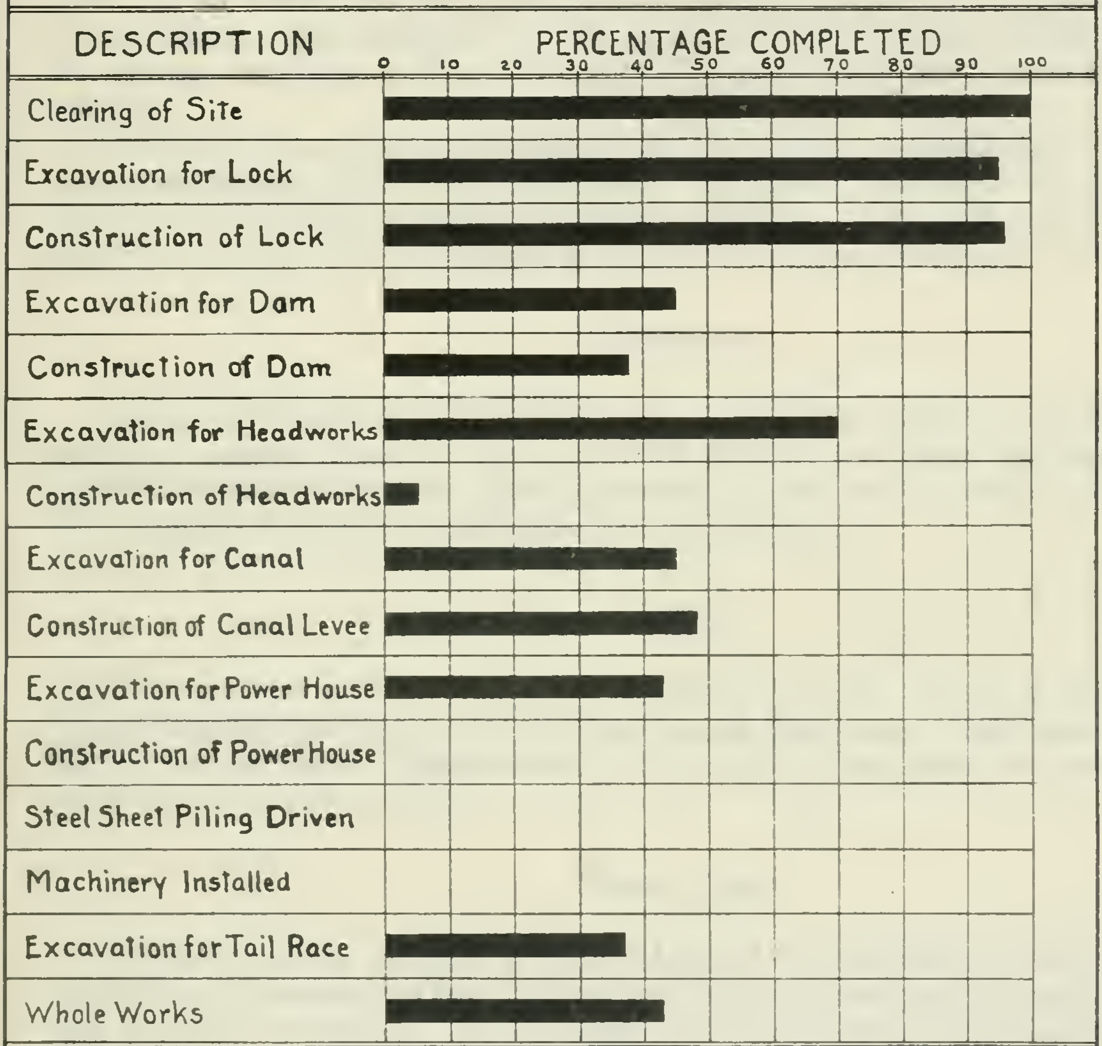
PLATE N° 31.

LA COLLE FALLS POWER DEVELOPMENT

SASKATCHEWAN

PERCENTAGE OF WORK COMPLETED

TO AUGUST 31 1913



E. B. Patterson

RESIDENT INSPECTING ENGINEER

was kept intact, being moved bodily by means of the cableways as occasion required. Upon the completion of first lift of adjacent buttresses, the deck spanning the closure openings was built. The buttresses were then completed, after which the deck, crest and apron deck, above the closure openings, were concreted in 30-foot sections at each operation.

At the time of the flood in April, referred to above, the construction of the dam amounted to the floor for two buttresses and the first lift of one buttress (elevation 1405.5). It was feared at this time that it would be impossible to complete the work to a sufficient height to clear the summer floods. These floods occur any time after the middle of June, and are of such size as would destroy the coffer-dam beyond repair until the end of the season. The work was pushed with all possible speed, and by June 18, the coffer dam was allowed to fill. This was done without skimping the work in any detail. The remainder of this portion of the dam was completed, except for the closure openings, without incident in August, 1913, when operations were suspended.

Of the excavation yet to be taken out for the dam, approximately 15 per cent has been done on the north bank of the river. Three hundred feet of the dam adjacent to the lock is completed except for the closure openings. The outer face of the coffer-dam has been reinforced with rock filling to protect the unfinished end of the dam.

Headworks.

The excavation for the headworks was commenced at the end of May, and 70 per cent was completed and 80 per cent of the floor of the intake was constructed when operations were suspended. The excavated material was deposited to the northwest of the intake to form an embankment to high ground.

Canal.

The excavation of the canal was commenced in the beginning of July, and continued through the months of July, August and September. The material was a light sandy clay and loam. Approximately 45 per cent of the work was completed; of the levee 48 per cent is completed.

Power House.

Throughout the months of July, August, and September, the sub-contractors worked on the excavation from the limit of the canal contract through the power-house to a point in the tailrace. On the north side of the power house, excavation was carried on during July with an orange-peel excavator. Approximately 43 per cent of the excavation for the power-house is completed. No other construction work has been done at this point.

Tailrace.

The excavation of the tailrace was commenced in January with one orange-peel excavator, for the purpose of obtaining gravel for concrete. When the frost came out of the ground, the removal of the earth super-imposing the gravel was carried on with wheel scrapers, and later with a horse-drawn elevating grader and dump carts. Three orange-peel excavators were put on this work, one digging gravel, and the others removing the earth. Approximately 37 per cent of this excavation was completed in August, 1913.

Material.

All the reinforcing steel required to complete the work and the steel sheet piling is on the ground. A storage pile of gravel of some 4,000 cubic yards lies on the north side of the river. The material for the construction of the coffer dam on the north side of the river is also on the ground.

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

E. B. PATTERSON,
Resident Inspecting Engineer.

No. 11.

REPORT OF K. H. SMITH.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent Water Power Branch,
Ottawa.

SIR,—I have the honour to submit the following report of the Kananaskis Power Development, which work was completed in December last. During the last three months of the fiscal year, I was engaged upon investigations in connection with the Canadian Water-power exhibit for the Panama Pacific Exhibition, and also in preparing an exhibit in connection with the power possibilities of the Winnipeg river for the Winnipeg Industrial Exhibition, brief notes on which are appended to the Kananaskis report.

KANANASKIS POWER DEVELOPMENT.

Preliminary Historical Sketch.

The earliest investigations of the Bow river for power purposes were made by Mr. Prince and his associates of the Eau Clair Lumber Company, of Calgary, about 1891. The Eau Claire Company had extensive timber limits at the head-waters of some of the tributaries of the Bow river, over much of which the timber was small and apparently well adapted for pulp purposes. Accordingly, their idea was to utilize the water-powers on the Bow river for pulp making purposes, and the Kananaskis site along with the Horseshoe falls site was particularly considered. I believe no detailed investigation was made, but the proposition was given up because of the obvious low winter flow.

The first serious study of the Kananaskis site seems to have been made in the winter of 1905-06, by the Canadian Pacific Railway Company, who investigated this site in connection with a general study of the power possibilities of the Bow river in this district, and made surveys for that purpose. I believe too, that in the early part of 1906, application was made by officials of the Canadian Pacific Railway Company for the power rights at Kananaskis falls. The rights asked for were never granted, and in any case the whole scheme was dropped when a current meter measurement revealed an entirely unsuspected low winter flow.

The location of the Horseshoe falls site, only about 1½ miles below the Kananaskis site, made it imperative that any scheme of development at Horseshoe falls should be considered in conjunction with the Kananaskis site, so that the power possibilities of the Bow river in this section might be developed to the fullest extent. The study given to existing conditions by the Department of the Interior, has resulted, now that both sites are developed, in the above ideal being realized.

In the latter part of 1906, the first officially recorded application for power rights at Horseshoe falls was placed on file, although this development was not finally completed until early in the year 1911. All rights at Horseshoe falls were given with a view to preventing any interference with a possible future development at Kananaskis falls, and at least one survey made in connection with the Horseshoe falls development, included the Kananaskis falls site and several miles of the Bow river above it. In the meantime, during January, 1910, the same interests, who were behind the Horseshoe falls development, applied for rights at Kananaskis falls.

In connection with the application referred to above, surveys at the Kananaskis site were made in February, 1910, by H. S. Johnston, then in the employ of Messrs. Smith, Kerry and Chace at Horseshoe falls, and preliminary plans were submitted.

In June, 1911, Mr. H. S. Johnston, made a detailed survey of the Kananaskis site for the Montreal Engineering Company acting for the Calgary Power Company, while in the meantime a party had also been put in the field by the Water-resources division of the Railway Lands Branch, to make extensive surveys in connection with a study of the power possibilities of the Bow river, and a detailed survey of the Kananaskis site was made by this party under Mr. M. C. Hendry in August, 1911.

On November 25, 1912, permission was given by the Department of the Interior to begin and to proceed with, preliminary construction operations at Kananaskis falls, provided that such work was undertaken without prejudice to the future action of this Department respecting approval of plans, and terms and conditions of agreement under the Water-power regulations, and provided further that such work was undertaken without prejudice to the future action of the Department of Indian Affairs with regard to the terms and conditions covering the taking and use of "Indian lands." With this understanding, preparations for construction by the company's own forces were begun immediately with Mr. H. A. Moore, as General Manager and Chief Engineer of the Calgary Power Company, C. W. Allen, superintendent of construction and H. S. Johnston, resident engineer. An agreement between the Government and the Calgary Power Company was executed shortly after.

(2). *Introduction.*

Under date January 16, 1913, I received notification of my appointment as resident engineer on the proposed Kananaskis power development of the Calgary Power Company, Limited, on the Bow river. My services were required, however, at head office for some little time after that, and, as the inspection of the Kananaskis falls development was being provided for in other ways, I did not finally take up residence on the work until April 23, 1913. The following report is based on my experience there, as well as on some previous knowledge and study of the power situation on the Bow river at this point.

(3). *Location.*

The Kananaskis falls development is located at the junction of the Bow and Kananaskis rivers, in such a manner that the Kananaskis river flows directly into the headwater above the dam. It is on the main line of the Canadian Pacific railway, at mileage 52 from Calgary, and is, therefore, about 30 miles from Banff. The dam and other works are situated on the extreme westerly edge of the Stoney Indian reserve, while the headwater from the dam backs into the adjoining Rocky Mountains park. This location corresponds to township 25, range 8, west of the 5th Meridian.

(4). *Water Supply.*

The question of water supply at this point is thoroughly discussed in a report by Mr. M. C. Hendry, B.A.Sc., giving the results of an investigation of the power and storage possibilities of the Bow river, and only the general conclusions are here given.

It is found that the mean low-water flow is in the neighbourhood of 800 second-feet, with a minimum flow as low as 550 second-feet, the latter small flow being due to ice jams in the river. With storage basins at present in operation or proposed, it is expected that a mean regulated flow of about 1,500 second-feet can be obtained. This storage is made up as follows:—Minnewanka at present in use, 44,000 acre-feet; Spray Lakes, proposed, 171,000 acre-feet; Bow Lakes, proposed, 27,400 acre-feet.

These basins are all at such great distances from the Kananaskis plant, the nearest being about 35 miles distant, that local regulation by them is out of the question. For this purpose, besides a pond above the dam of about 122 superficial acres, there is at present under consideration a storage basin on the Kananaskis river near the head of the pond from the Kananaskis falls dam. This would give a storage capacity of about 8,300 acre-feet, and would be used entirely for regulation purposes. The present idea is to take one of the small units from the Horseshoe falls plant of the Calgary Power Company, and place it at this storage dam. This small unit could well be spared from the Horseshoe falls plant, and such an arrangement would not only give double use of water from the Kananaskis storage but would give immediate relief to the main power plants, depending only on the time required to synchronize the smaller machine. Under normal conditions, it is thought that the auxiliary plant need be used only for short periods at a time, so that there would be no great variation in head at the Kananaskis storage dam. The advantage of this whole scheme, from the standpoint of taking care of peak loads and tiding over periods of extreme low water is obvious.

The question of a regulating pond at Exshaw, about 5 miles above the Kananaskis plant, was also given some consideration. An enlargement of the Bow river occurs at this point, but storage was found impracticable, due to the extremely flat and wide valley at this point.

General Scheme of Development.

The first ground in connection with the Kananaskis construction was broken on November 27, 1912, when some work was done on a road leading to the site of the development from the already existing development at Horseshoe falls. Work was carried on continuously from that date to December 27, 1913, when power from the new plant was first delivered to the Calgary Transmission lines, though even at that time there was much work to be done in connection with various fittings in and about the power house and dam, and the installation of the second generator unit.

While the final plans for the development were not approved until early in the year 1913, still they were sufficiently matured in their more important essentials to allow of organization proceeding during December 1912. This organization was carried out with the idea of meeting the requirements of a development consisting of the following main features:—

1. A gravity section concrete dam part free spillway and part stop-log sluiceway, extending across the Bow river immediately below its junction with the Kananaskis river.

2. An open canal extending from the forebay along the south bank of the river for about 650 feet to a concrete intake structure.

3. A power-house situated in an excavated site about 20 feet from the intake structure, the excavation to the bottom of the draft tubes being almost 100 feet from the surface of the ground, and connected with the intake by pressure tunnels through rock leading to the scroll case of each turbine.

4. Two tailrace tunnels leading from the power house some 120 feet to the river below the falls. A more complete description of each part of the development is given in the following, and Plates 32 and 33 show the general layout and section through the power-house.

PRELIMINARY OPERATIONS AND ORGANIZATION.

This general scheme, apart from the large amount of excavation and tunnel work involved, also necessitated one main coffer-dam and a smaller coffer-dam at the outlet of the tailrace tunnels. The overflow section of the dam, which rests on a long rock projection, could be built at the low-water period without any unwatering being necessary. The control of the water was then as follows:—

1. The overflow section was begun at low-water, an opening being left at a natural low spot in the rock foundation large enough to take care of the low-water flow of the river.

2. A coffer-dam was built embracing about one-half of the sluice section of the dam.

3. After the high-water period, the coffer-dam was extended across the remaining portion of the dam.

The result of this plan was that the medium and high water was taken care of by the small opening in the overflow section, and that portion of the river beyond the first cofferdam; low water was entirely taken care of by the opening in the overflow section. This small opening was finally closed by stop logs, for which provision had previously been made, behind which concrete was placed, the water in the meantime rising and passing through the main sluiceway openings.

Apart from the building of the necessary camp buildings, machine shops, etc., the first necessary step was the building of a spur line of railway some three-quarters of a mile from Seebe siding on the main line of the Canadian Pacific railway across the Kananaskis river, which involved a trestle some 40 feet maximum height and about 300 feet long. This spur line was finally connected up on December 31, 1912. With the various branches, which were shifted from time to time, it was used not only for bringing in supplies, but also for handling gravel for concrete and spoil from excavation. Coal cars were brought into the works intact as well as car loads of machinery.

A well-equipped machine-shop was set up, also a central heating, lighting and pumping plant.

A large concrete-mixing plant was built near the south end of the dam site, equipped with two Milwaukee mixers of one yard capacity each. This plant was equipped with a gravel hopper of about 120 yards capacity, feeding to the mixer by gravity. Cement was loaded directly from the cars into storehouses adjacent to the mixing plant, and was delivered to the mixer hoppers by timber chutes. Suitable gravel was found on the ground some one thousand feet from the mixing plant. It was loaded in dump cars by a steam shovel, and taken directly to the mixing plant hopper. Frequent physical tests were made of this gravel, to insure its being properly graded and free from too large a quantity of loam. Regular physical tests were also made of the cement, which was supplied mostly by the local plant of the Canada Cement Company at Exshaw some 5 miles away. This cement was often found to be too green for immediate use, and the work was on account of this held up for short periods on several occasions.

By December 24, 1912, the Kananaskis commissariat was in complete running order. Previous to this, meals had been supplied from a camp already existing at Horseshoe falls. Throughout January, work proceeded on the tailrace cofferdam which was completed on February 6, as far as the cribbing went. These rock-filled cribs were afterwards sheeted, and a wall of concrete was placed around the bottom edge of the sheeting. This concrete was placed under a slight head of water, which tended to force it under the edges of the sheeting, and the result was a coffer-dam which was practically tight.

During January and February, investigations were made of possible storage near Exshaw, with the result that any idea of storage at this point was abandoned.

On February 1, 1913, the first concrete was placed in the main dam, in a large hole at the site of the temporary unwatering sluiceway; this was mixed by hand. Due to precautions necessary against frost, the placing of concrete proceeded slowly.

On February 13, excavation of rock at the upper end of the canal was begun, in order to get rock for the main cofferdam which was begun two days later. This cofferdam consisted of rock filled cribs made of material 2-inch by 8-inch. Rock from the canal excavation was transported in push cars to the cribs. This cofferdam was placed on the brink of the upper pitch of the falls, so that only three slides were necessary for it. An opening was left during its construction to pass the Kananaskis flow, which opening was later closed by a wedge-shaped crib partly swung, and partly floated, into place. The first attempt to close this opening was unsuccessful as the crib buckled due to the force of the current and was carried through the opening. The next attempt was more successful, though unfortunately even in this latter case the crib jammed before it was entirely in place, and much patching had to be done to make the opening tight. There was always considerable leakage through this cofferdam, so much so that a temporary opening was left through the bottom of the dam which was afterwards filled from the inspection tunnel of the dam and another opening on its downstream side.

During January and February, the temperature ranged mostly from zero to 35 degrees below and very little concrete was placed during this time. By March 21, the main mixing plant was ready for operation, but due to cold weather no concrete was placed.

For the lower parts of the dam, concrete was taken directly from the mixers in Hudson 1 yard dump cars. For the upper lifts Insley hoists were arranged and the push cars used as before. The capacity of the mixing plants was about 700 yards per ten-hour day, the longest haul was about 800 feet, the average haul about 250 feet, and the highest days yardage, 312 with one mixer running.

Recommendation by Mr. J. R. Freeman.

During the week of April 7, Mr. J. R. Freeman, consulting engineer, was on the ground for several days at the joint instigation of the Calgary Power Company and the Water Power Branch, Department of the Interior.

He vigorously opposed the plan of the Calgary Power Company then being carried out, and advocated, rather, an arched dam further down stream, having the power-house immediately contiguous to it. His reasons were in brief as follows:—

(1.) Greater factor of safety due to arched structure.

(2.) Better operating conditions due to sluices being closer to Power House, thereby allowing higher maximum water level.

(3.) Economy of initial cost and operation.

The company, however, saw fit to adhere to its original plans because:—

(1.) It believed there would be no saving in first cost, because considerable work had already been done on the upper site, and the reorganization of the construction layout would also involve considerable expense.

(2.) They were anxious to have the work completed as quickly as possible. A general change of plant at this time would mean delay, not only in the reorganization of plant, but also in a slackening of the enthusiasm of the construction staff until such time as they became thoroughly familiar with the new scheme.

(3.) Mr. Freeman was willing to approve their present plan with certain modifications.

The question of maximum head water level was a serious one, and was governed entirely by the elevation of the bottom chord of the Canadian Pacific bridge across the Kananaskis river. The bridge across the Bow river upstream from the dam was also considered, but was so far away as to need little consideration. The Canadian Pacific Railway raised the Kananaskis bridge some three feet at the cost of the Calgary Power Company, and the spillway elevation was fixed at 6 feet below this bottom chord, with the bottom of the deck across the dam 2 feet above contemplated high-water level. These absolute elevations were: spillway 4155, bottom of deck 4162. The maximum high water level contemplated was 4158, which gave a total discharge with all sluices open of 64,250 feet. The normal headwater was then 4155, normal tail-water 4085, giving a static head of 70 feet.

Apart from dealing with the question of head-water levels and the general discharging capacity of the dam, Mr. Freeman recommended thorough drilling and grouting of the dam foundations, a complete system of drainage and inspection tunnels with weep drains, and the thickening of the dam above the cliff in the spillway section, since he feared the part of the dam below the cliff might break away from the upper part. His idea was to make the upper part of the section stable in itself.

Dam Construction and Description.

The construction of the dam presented no unusual difficulties, and the placing of concrete proceeded steadily with the plant described above: Insley hoists and hand push-cars on narrow-gauge track. The unwatering operations have already been described, and the only other difficulty encountered was in the final closing of the small temporary sluiceway. This was complicated by the fact that the water could not be entirely shut off, but enough must be allowed to pass to supply the existing Horseshoe falls plant downstream. With this idea in view, an attempt was made to raise the water slowly by placing a few stop-logs at a time. Unfortunately, however, cold weather conditions set in, ice formed under and between the few bottom stop-logs, thereby raising them and rendering it impossible to make the opening tight. These logs were finally abandoned, and a new set placed in a second gain which fortunately had been provided. A low level sluicegate intended to be placed in this opening was also abandoned. The main mixing plant was by this time dismantled due to the raising of the water, and a small mixer was placed on the deck of the dam, from which concrete was deposited behind the stop-logs in the temporary sluiceway, the water in the meantime passing through the permanent sluiceway of the dam. The last concrete was placed in the dam on December 22, 1913.

A particularly interesting feature of the construction of the dam, was the drilling and the grouting operations. Holes were drilled to an average depth of 40 feet along the upstream face of the dam, about 2 feet from it, and 10 feet apart. The drilling was done by a Calyx core-drill electrically driven, using a soft bit and chilled shot. Two shifts a day were employed most of the time, and the average amount of drilling was about 170 lineal feet per two weeks period. These holes were afterwards grouted to refusal under a pressure of about 70 pounds per square inch, running as high in one case as 100 pounds per square inch. A single tank designed on the ground was used for this purpose.

The complete apparatus consisted of a simple boiler plate tank, with connections to the air line and to the hole to be grouted; a gauge was also attached. The grouting materials were dumped in through a door in the top opening inward, and therefore requiring no fastening. Mixing was done in the tank itself by turning on the air slightly.

Reference has already briefly been made to the general layout of the dam, which is shown on *Plate No. 32*. It will be seen that the whole dam is surmounted by a deck with its underside at elevation 4,162, and may be divided into the following main sections:—

(1). A stop log sluice section consisting of eleven openings each 18 feet wide with rollway at elevation 4,138.

(2). A central spillway section with spillway at elevation 4,155, comprising 8 openings each 17 feet wide, and one log chute opening 24 feet wide. This section was intended originally to have a low level sluice tunnel with centre line at elevation 4,121·5, but this was later abandoned.

(3). A spillway section with spillway at elevation 4,155 comprising 9 openings each 17 feet wide. In all, there are 313 feet free spillway at elevation 4,155, and 198 feet stop log sluiceway with rollway at elevation 4,138, giving an automatic discharging capacity of about 5,400 second-feet, and a total capacity, exclusive of the discharge through the turbines, of 65,000 second-feet below elevation 4,158. The Department of the Interior required that a total discharging capacity of 40,000 second-feet be provided below elevation 4,158. An electrically operated winch has been installed to handle the stop-logs in the large sluiceway.

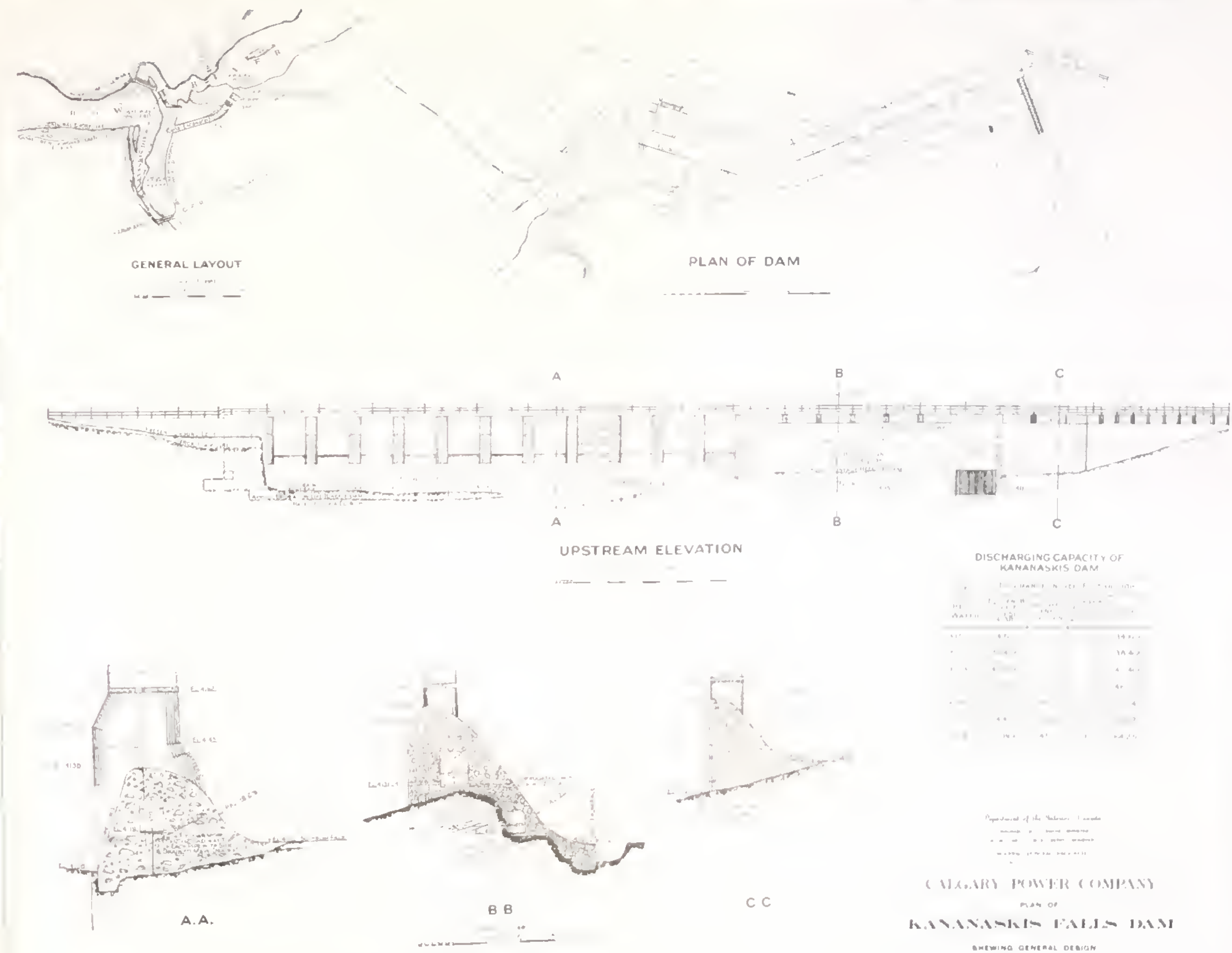
As mentioned before, the dam is provided with a thorough system of drainage and inspection tunnels, while the foundations were thoroughly grouted both from the up-stream face of the dam and from within the tunnels; a number of weep holes extend some 40 feet into the foundations, opening into the drainage tunnels. In the central spillway section, two tunnels are provided, one at the foot of the cliff on which this portion of the dam stands, and the other on top of the cliff. From the lower tunnel, open drains extend to the face of this cliff to take care of any leakage through it, while from the upper tunnel, openings extend well up into the concrete. It was also originally intended to extend a drift into the north bank of the river through the abutment, but this was abandoned and the vicinity of this abutment was thoroughly grouted. The need for this thorough system of grouting and drainage was conclusively shown, not only by the amount of material used in grouting, but also by the appearance of the grout under pressure at various places remote from the hole to which pressure was being applied; notably at the down-stream side of the cliff under the central spillway section of the dam. The efficiency and thoroughness of this grouting is apparent from the fact that on December 31, 1913, it was estimated that the total leakage through the dam from all sources was about 50 gallons per minute, with some grouting from within the tunnel still to be done. This also included one considerable spring encountered near the angle between the two spillway sections of the dam, and deliberately piped out to the down-stream side, the flow from which itself amounted to about 20 gallons per minute. In fact it is expected that when all grouting operations are completed, the leakage from the foundations and abutments of the dam will be practically negligible.

The dam has a maximum height of about 60 feet, and contains about 22,000 cubic yards of concrete.

Canal.

The open canal leading from the forebay to the intake has its bottom elevation at 4,140, averages 18 feet deep and 80 feet wide at the top, and is about 650 feet in

PLATE No 32


GENERAL LAYOUT
PLAN OF DAM
A
B
C
UPSTREAM ELEVATION
DISCHARGING CAPACITY OF
KANANASKIS DAM
A.A.
B B
C C
CALGARY POWER COMPANY
PLAN OF
KANANASKIS FALLS DAM
SHEWING GENERAL DESIGN

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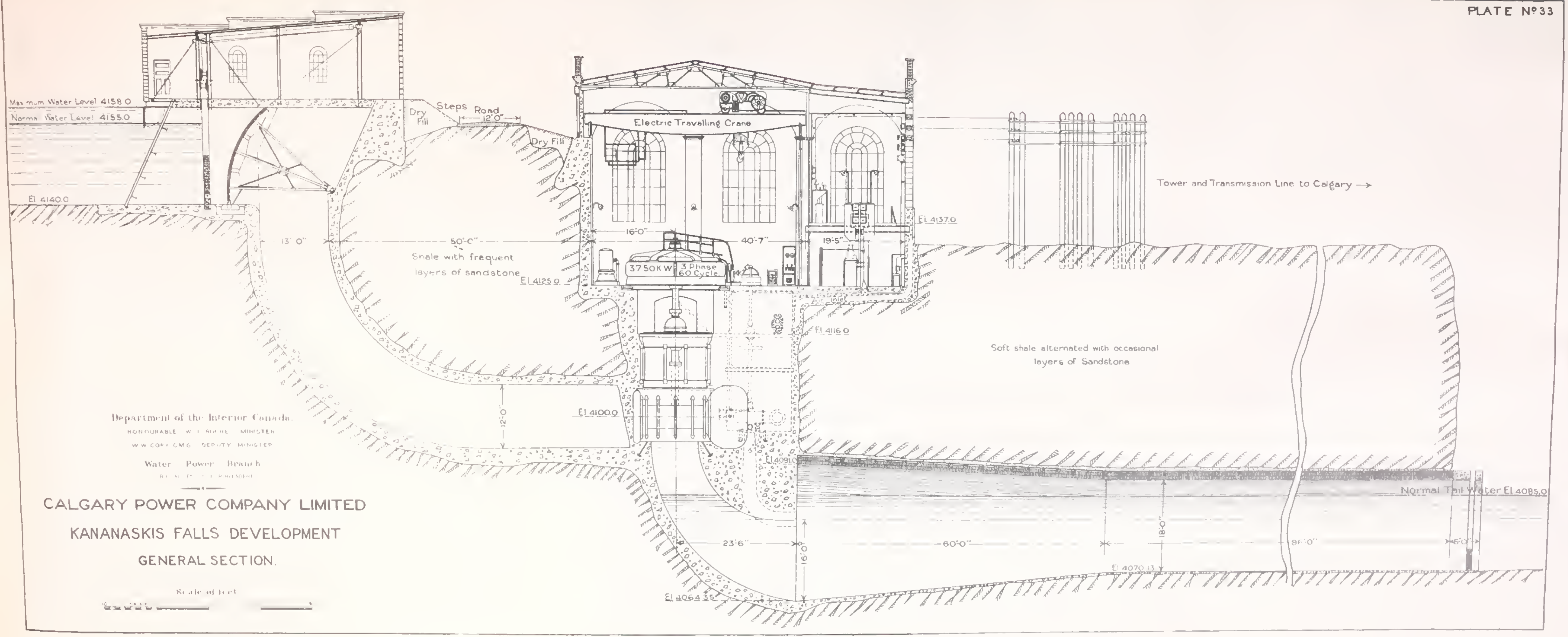

Department of the Interior Canada.
HONOURABLE W. J. ROCHE MINISTER
W. W. CORY C.M.G. DEPUTY MINISTER

Water Power Branch

CALGARY POWER COMPANY LIMITED
KANANASKIS FALLS DEVELOPMENT
GENERAL SECTION.

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length. Its construction involved the removal of 13,865 cubic yards of earth, 17,685 cubic yards of rock, total, 31,550 cubic yards; 2,300 cubic yards of back-fill, and 2,340 square yards of 'rip-rap' plastered with concrete. Excavation was opened up in the early stages of construction at the entrance to the canal, in order to obtain rock for the main coffer-dam, this was all handled in hand dump-cars, later on, however, excavation was carried on night and day. A travelling derrick with clam-shell bucket was used for a time, and horses with wheel scrapers were used to clean off the surface earth in places. The best progress however was made with a small tractor steam-shovel loading into standard-gauge 6 and 12 yard dump-cars, which were handled over the service tracks and dumped in the vicinity of the Kananaskis trestle. Much of the rock was so soft as to be handled by the steam shovel without blasting, while in other places comparatively little drilling and blasting was necessary. The rock in the upper end of the canal was, however, extremely hard. During one period of 8 hours, 45 minutes, seventy-one 12 yard cars were loaded by the steam shovel; most of this was rock which had been loosened by blasting.

Several methods were tried in protecting the earth banks of this canal; placing concrete in forms, 'rip-rapping' and plastering by means of the grouting tank used for grouting the dam foundation, 'rip-rapping' and hand plastering. The last method was finally adopted for most of the work. The banks were trimmed to a slope of of 1 to 1 up to elevation 4,152, while above that the slope to elevation 4,158 was 2 to 1, the water level being 4,155. This flat slope at the top was intended to minimize disintegration of the concrete by ice action. Wet concrete 1 to 5 mix was dumped from barrows down over the 'rip-rapped' slope, penetrating and filling most of the spaces. The surface was afterwards finished by hand trowelling. This method was found to be cheap and fast, and so far seems to be quite satisfactory.

Intake and Pressure Tubes.

The general arrangement of the intake and power house is shown in one of the accompanying plates.

Pressure tubes excavated in rock, and lined with concrete, lead from the canal to the scroll case of each of the two units. The entrance to each pressure tube is through two bays formed by concrete walls. At the entrance to the bays are the usual screens, except that in this case, to aid in overcoming winter conditions, wooden screens are used at and above the water line. There are also stop-log gains for emergency use, though the main control is by large Tainter gates, four in all. These gates consist of steel trusses with wooden lagging. On the bottom is a wooden foot block which comes into contact with two steel knife edges placed in the sill of the intake, thus making a tight joint at the bottom, while leather strips attached to the edges of the gates and projecting into the grooves in which the gates run, make the gates completely water-tight. They are operated by hand winches attached to the gates by tackle and so far have given complete satisfaction.

The whole intake structure is enclosed by a structure built of hollow brick, and plastered with concrete.

The pressure tubes are 12 feet by 12 feet at the scroll cases enlarging to 13 feet by 35 feet at the intake. There was considerable overbreak in excavating for them, and to support the heavy mass of concrete on their upper surfaces, a heavily reinforced pillar of elliptical section was placed in the throats of each. Openings were left in the concrete lining too, through which the surrounding rock was grouted under pressure.

The main quantities in the headworks structure are:—

Excavation	2,400	cubic yards	earth.
"	550	"	" rock.
Backfill	250	"	"
Concrete	1,887	"	"
Brickwork	4,117 hollow tile, 5,000 brick.		

Power-house.

Work on the various phases of the power-house construction was carried on throughout the whole period of construction. The main quantities involved, including wheel pits and draft tubes are as follows:—

Excavation	8,226 cubic yards rock.
"	2,335 " " earth.
"	5,000 " " earth adjacent to power-house.
Concrete	4,000 " "
Brickwork	8,000 hollow tile, 72,000 brick.

The power-house is placed in a site almost wholly excavated, so that the maximum depth of excavation from the surface was about 100 feet. All the spoil was handled by derricks and skips loading into standard-gauge dump-cars. At the proper level, headings were begun for the pressure tubes. There were no special features connected with this work. Its proximity to the river bank gave natural drainage so that no pumping whatever was required.

The draft tube forms were each built in two pieces to facilitate handling them, and were placed by the derick used for handling spoil without any special trouble. The forms for the scroll cases were also built on the surface and lowered into place intact, these scroll cases were very strongly re-inforced. All material, including turbine foundation rings and some concrete was handled by the derrick. Most of the concrete in the substructure was placed by chutes from a hopper supplied by dump cars from the main mixing plant, a small portable mixer was also used in connection with the concrete for the power-house and intake structure. Above the power-house floor elevation 4125, a spur line of track was run right into the power-house, so that all the turbine and generator machinery was brought in on this track in car lots as it was shipped, and unloaded by the power-house crane. The crane rails were so nearly at the same level as the adjoining ground, that the crane itself was set up on the ground, and run into place before the end of the power-house closed. Power for the crane was supplied from the local service, which by this time was augmented by a supply from the existing Horseshoe falls plant.

The substructure and back wall of the power-house is of concrete, plain and reinforced, while the other walls are of hollow tile and brick with a steel framework. The hollow tile is plastered with cement plaster, while the walls are relieved by plain brick pilasters. The roof is supported by steel trusses, covered with material 2 inches by 4 inches, sized and dressed, placed edgewise. This is covered with an asbestos felt roofing.

The general scheme of development has already been outlined, and there follows herewith a more detailed description of the hydraulic and electrical machinery installed in the power-house.

There are two main turbines set vertically in concrete scroll cases moulded in place and direct connected to the two main generators. The turbines were supplied by the Allis-Chalmers Company, and are of the single runner type, designed to deliver 5,800 h.p. at 164 r.p.m., under a normal effective head of 68 feet. They were guaranteed to give 85 per cent efficiency at $\frac{3}{4}$ gate, to maintain their normal speed and capacity under heads varying from 65 to 72 feet, and to have a runaway speed not exceeding 270 r.p.m., when operating under 68 feet head. There is also a small single runner turbine operating under the same conditions as the main units, in a cast-iron scroll case with vertical shaft direct connected to an exciter. This is designed to give 150 b.h.p., at 600 r.p.m., with a runaway speed not exceeding 1,000 r.p.m.; water is supplied to this unit by intakes from each main scroll case.

Governing of both the main units is accomplished by automatic oil-pressure governors with the actuating flyball mechanism driven by shafting geared to the main shaft. The motor-driven oil pumps are interconnected, and each pump is large enough to operate both units at the same time. The governing mechanism is guaranteed to maintain constant speed within one-half of 1 per cent at all times at constant load, and to allow a variation in speed of not more than 15 per cent on a change of load amounting to the full rated capacity of the turbine. The small exciter unit is governed by a self-contained oil-pressure type governor.

The two main generators, the turbine driven exciter, and the motor driven exciter, were supplied by Messrs. Kilmer, Pullen and Burnham, of Toronto, agents for the General Electric Company of Sweden. The two main generators are 4,250 kva., 3-phase, 60-cycle, 12,000 volt, 164 r.p.m., vertical shaft machines. They are designed to carry a momentary overload of 100 per cent, and a dead short circuit for two minutes without injury, or straining any of their parts. The turbine driven exciter generator is a 75 k.w., 600 r.p.m., 230 volt direct current machine, while the motor generator set consists of one 75 k.w., 860 r.p.m., 230 volt shunt-wound, interpole direct current generator, direct connected to one 110 h.p., 860 r.p.m., 2,200-volt, 3-phase, 60-cycle, squirrel cage induction motor.

The switch board and all appurtances for the control of the whole electrical output was supplied and erected by the Canadian Westinghouse Company of Hamilton. The main switchboard consists of eleven panels, six feeder panels, two generator panels, two exciter panels and one Turill regulator panel. There is also one auxiliary panel, controlling two 2,200 volt circuits, and a battery panel controlling a storage battery with the necessary charging set.

All the high tension transformers and apparatus are situated at the Horseshoe falls plant, which is less than 2 miles distant, and from which the 50-mile transmission line to Calgary leads. Current from the Kananaskis plant may either be sent to the Horseshoe falls plant at the generator voltage, and there stepped up to the Calgary transmission line voltage, or sent direct to the Exshaw Cement plant at the generator voltage over a line some 5 miles long. The power-house is equipped with one 50-ton, 3-motor Shaw crane.

Tailrace.

After passing through the wheels, the water from each unit is lead through concrete draft tubes moulded in place to tailrace tunnels which extend some 160 feet through solid rock to the river. These two tailrace tunnels are 14 feet wide inside and 11 feet high to the springing line, with a semi-circular arch of 7 feet 0 inches radius above that. They were first thoroughly timbered and lined with concrete to a minimum thickness of 6 inches. Their outlets are provided with stop-log gains and a slot for gauging purposes.

The driving of these tunnels presented no unusual difficulties and the usual top heading and bench method was used. Progress in the heading was made at the rate of about 6 feet per day of two 10-hour shifts.

GENERAL.

From a construction standpoint, the site of the Kananaskis falls developments is particularly well situated. It is directly on the main line of the Canadian Pacific Railway; gravel for concrete was found on the immediate grounds, while cement is manufactured within 5 miles of the site. On the other hand, at least two of these favourable features had some disadvantages; considerable expense was involved in protecting the Canadian Pacific railway against high water as previously outlined, and also in protecting the shale pit which provided the raw material for the cement plant. This shale pit adjoins the river within the flooded area, and, while attempts were made to secure shale elsewhere, it was in the end found necessary to build an earth dyke to protect this pit at a cost of some $8,000.

While the whole scheme of development presented no unusual difficulties, still there are some considerations which might be of special interest.

1. The system of drainage and inspection tunnels, combined with extensive drilling and grouting operations, the necessity and efficacy of which was conclusively shown throughout construction operations.

2. The method adopted for lining the canal, previously described, and the permanent success of which remains to be seen.

3. Concrete-lined pressure tubes excavated through rock to the scroll cases.

4. The use of Tainter gates at the intake to these pressure tubes.

5. The location of the power-house in a site almost wholly excavated. This site was chosen after very extensive investigations in various places, and the decision was based on questions of cost and hydraulic efficiency, having in mind the accessibility of the site from the railroad.

6. The use of vertical settings with Kingsbury bearings throughout.

7. It is expected that operation in conjunction with the Horseshoe falls plant of the same company, the normal headwater of which is practically the normal tailwater of the Kananaskis plant, will present an opportunity for high efficiency with respect to the power possibilities of this section of the river.

It is thought that this development throughout represents the best present day practice in hydro-electric design and construction, and its rapid and satisfactory completion is largely due to a particularly efficient and smooth working construction organization.

CANADIAN WATER-POWER EXHIBIT.

Panama Pacific Exhibition.

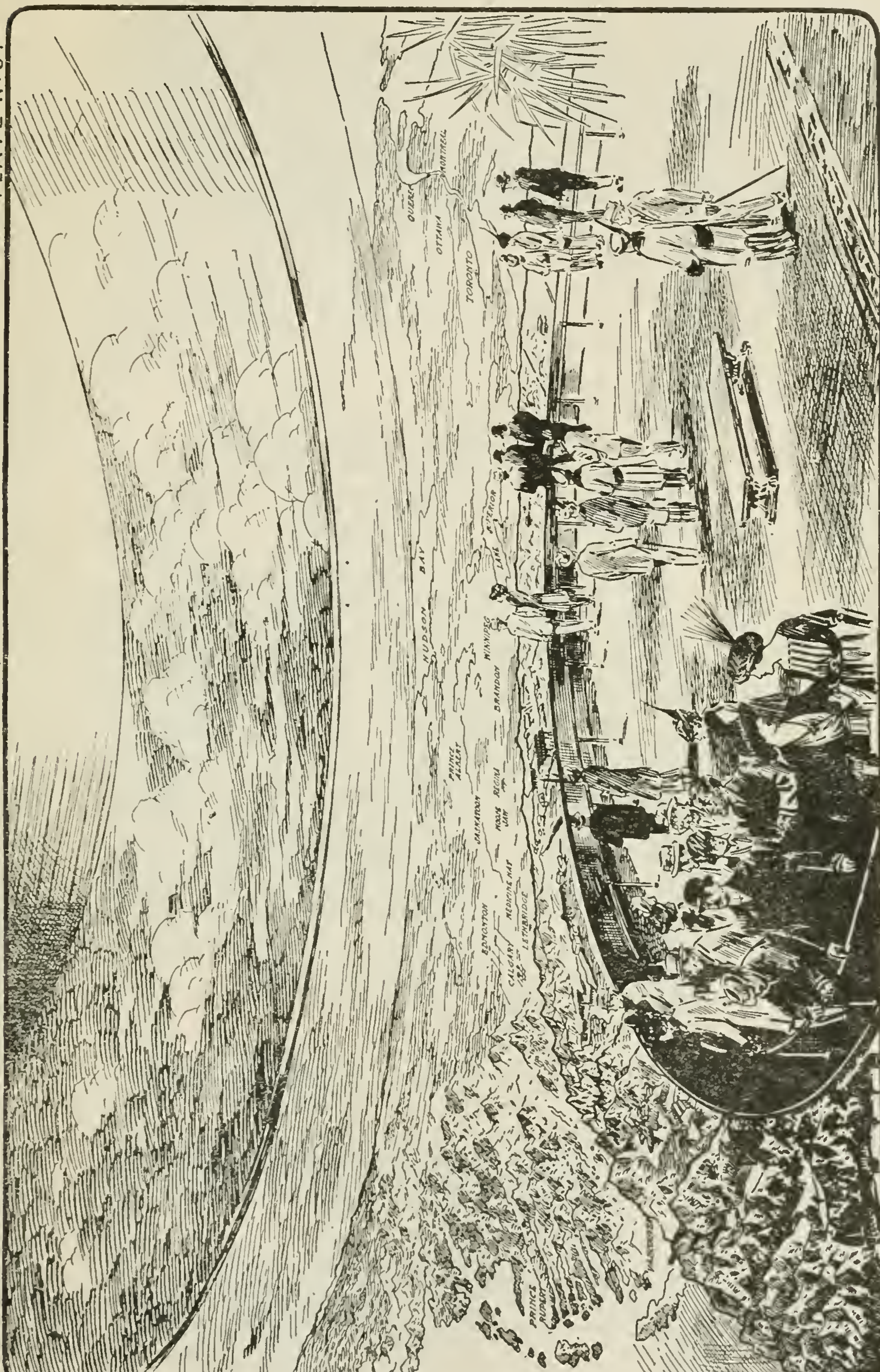
The idea of a Canadian Water-power exhibit at the San Francisco Exhibition was first discussed in August, 1913, with the Chief Engineer of the Vancouver Power Company, the officials of the Calgary Power Company and others. It received the hearty approval of all who were approached in the matter, including the officers of the Hydro-Electric Commission of Ontario, and in September, 1913, Dr. Roche, Minister of the Interior, gave permission to have the necessary investigations made to put the project on a definite footing. All the investigations were made in conjunction with Mr. William Hutchison, Chief Exhibition Commissioner. The result was that, in the latter part of December, 1913, a scheme was submitted which received the sanction of both the Department of Agriculture and of the Department of the Interior.

This scheme involved a large map of Canada in relief, on which were to be shown the main topographical features, the main railroads and water routes, the more important centres of population, and the various water powers developed and undeveloped. There were also to be shown working models to scale of ten to twelve of the larger power of developments of Canada.

On January 8, 1914, I received instructions to assume responsibility for carrying out the details of this project; to secure the necessary data for the models and to prepare suitable literature. On January 19, the services of Mr. J. T. Edwards, a model maker recommended to the department, were retained, and he was instructed to proceed immediately with the construction of the large map and models outlined above. For this purpose he was supplied at this time with sufficient maps, plans and general data to proceed with the large map of Canada; relief models of the Point du Bois, city of Winnipeg plant, and of the two developments of the Calgary Power Company on the Bow river.

I have spent the greater part of the months of February and March visiting various sites in the vicinity of Winnipeg and West including the following: Point

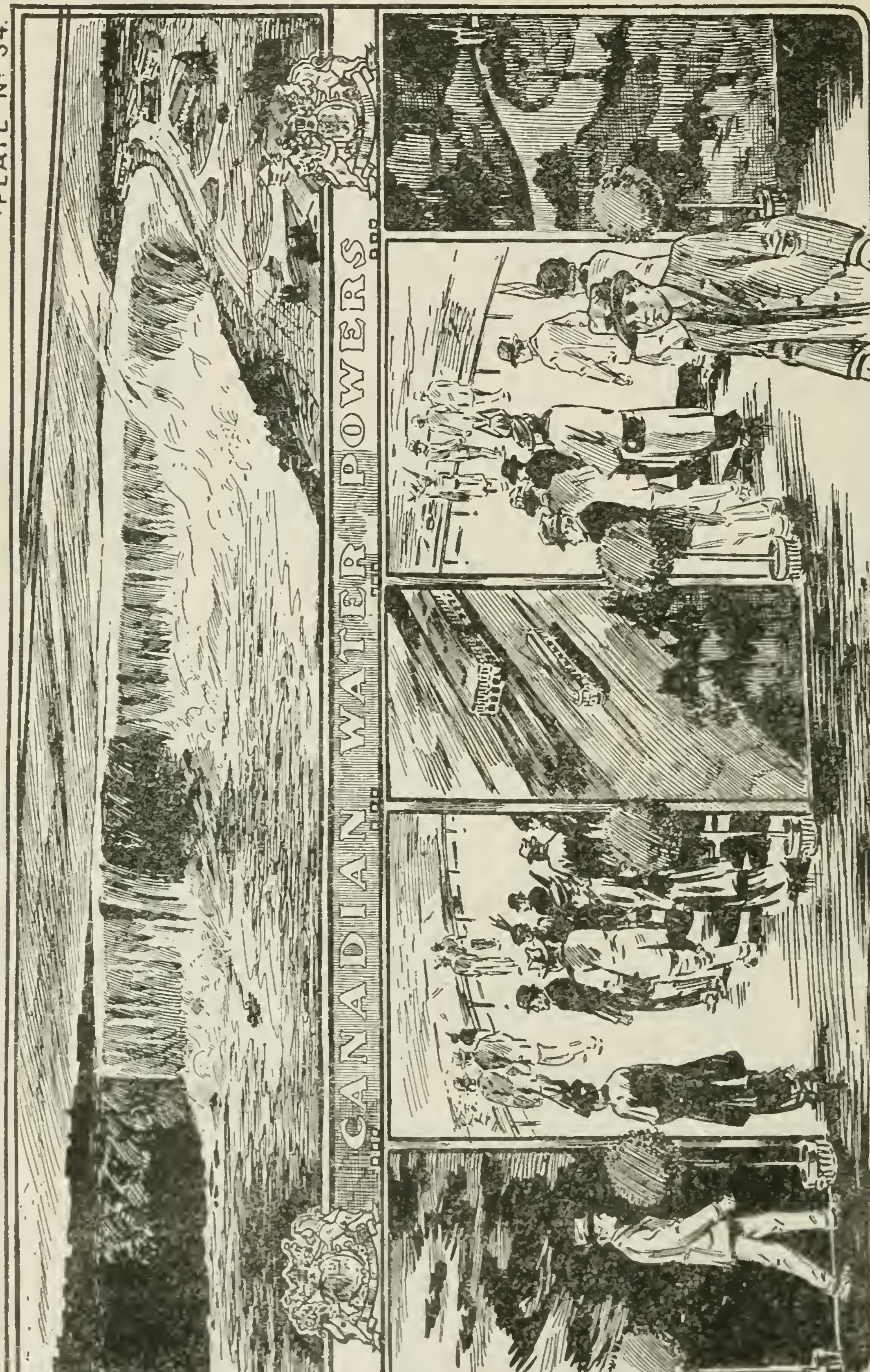
PLATE Nº 34 A



PROPOSED CANADIAN WATER POWER EXHIBIT
PANAMA EXPOSITION, SAN FRANCISCO 1915.

du Bois, city of Winnipeg plant; the Stave falls plant of the Western Canada Power Company; the Coquitlam-Buntzen and the Jordan river developments of the Vancouver Power Company; the Puntledge plant of the Canadian Collieries; the Powell river Pulp and Paper plant and the Bonnington falls development on the Kootenay river near Nelson.

PLATE No 34.



ENTRANCE TO
PROPOSED CANADIAN WATER POWER EXHIBIT
PANAMA EXPOSITION, SAN FRANCISCO 1915.

All those approached so far have expressed a desire to heartily co-operate in this exhibit and, at the time of writing, the preparatory work is progressing very satisfactorily. Considerable work has been done on the large map of Canada, while the basic contour work of the Point du Bois plant, and the Bow river developments is completed.

WATER-POWER EXHIBIT.

INDUSTRIAL EXHIBITION, WINNIPEG.

As the investigations for the Canadian Water-power exhibit at San Francisco were being carried forward, the idea was conceived of preparing a similar exhibit in connection with the power possibilities of the Winnipeg river, on which exhaustive studies had been made by the Water Power Branch. Mr. Roland, industrial commissioner of Winnipeg, was approached in the early part of January, 1914, and was very enthusiastic over the idea. He offered free space, light, etc., in the Industrial bureau at Winnipeg.

A scheme, which received the approval of the Department of the Interior, was evolved about the end of January. This contemplated retaining the services of Mr. J. T. Edwards, a model maker already at work on the Panama Pacific scheme, and the exhibit was to consist of the following main features,—

(1.) A relief map of the drainage basin of the Winnipeg river.

(2.) A more detailed model of the power section of the Winnipeg river.

(3.) Models of the present and proposed developments, except the Point du Bois plant which was to be shown as a 'bas relief.'

Mr. Edwards' services in connection with this work were not definitely retained however, until February 21, 1914, when he was instructed to proceed with the work as rapidly as possible. During the absence of myself in connection with the Panama Pacific exhibit, complete plans and photographs were forwarded to Mr. Edwards.

On going further into the matter, the original plan was found unworkable in the available space, and various schemes were proposed. At the time of writing, an arrangement is about completed, which promises to give satisfaction. In the meantime, however, work has been continued on the relief map of the Winnipeg river basin and it is at present in an advanced state.

It is confidently expected that this exhibit will shortly be completed, and will in every way be a credit to the department under whose direction it is being prepared.

I have the honour to be, Sir,

Your obedient servant,

K. H. SMITH,

Engineer.

No. 12a.

REPORT OF T. H. DUNN, ON COLUMBIA VALLEY RECLAMATION.

WINNIPEG, June 14, 1913.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Department of the Interior,
Ottawa, Ont.

SIR,—The question of reclaiming the bottom lands of the Columbia river between the town of Golden and the southern limit of the Railway Belt in British Columbia was brought before the Department of the Interior by the application of W. D. McKay, of Vancouver, B.C., on March 21, 1911. This application was followed by a preliminary report, dated March 1, 1912, by Messrs. Canavan & Mitchell, consulting engineers, of Victoria, B.C., acting for Mr. McKay. This deals very fully in a general way with the whole valley from Golden to the head waters.

There are also communications from F. W. Aylmer, resident engineer for the Public Works Department at Chase, B.C., to Mr. McKay, dated respectively, November 21, 1911 and January 26, 1912. The first is a report on that portion of the Columbia valley between Golden and the southern limit of the Railway Belt, and the second a report on the portion south of the Railway Belt. Both reports are highly favourable to the proposed reclamation.

On May 21, 1912, Mr. P. A. Carson, chief engineer of the Railway Belt Hydrographic Survey, filed a preliminary report, which also favours the granting of the application, and supports the finding of the other engineers, and makes some valuable suggestions for an agreement between the Minister and the applicant.

Finally, on April 18, 1913, Mr. McKay submitted a draft memorandum to be laid before the Governor-General in Council, outlining the conditions existing along the river, and setting out in detail the terms on which the application is made. Accompanying this memorandum is a draft agreement embodying the terms and conditions set forth in the application and memorandum.

On May 22, 1913, I was instructed to make a preliminary examination of the Upper Columbia river and the lands cited in the application of Mr. McKay. Upon receipt of your instructions, I went to Golden, B.C., arriving there on May 28, and went over the district with Mr. James McKay, who is a brother of the applicant, Mr. A. K. Mitchell, of Canavan & Mitchell, engineers for the applicant, and Mr. C. E. Richardson, an engineer of the Railway Belt Hydrographic Survey, of Kamloops, B.C.

We spent May 28, 29, and 30 on the ground, travelling the distance from Golden to Windermere lake, which is about eighty-five miles, by automobile over an excellent highway which traverses the east side of the valley. Crossing to the west side of the river at Windermere lake, we examined some of the upper waters tributary to the Columbia. On May 29, we returned to the southern limit of the Railway Belt, where Mr. McKay had a launch ready, and in this we completed the trip down the river to Golden on May 30.

Mr. Aylmer, Resident Engineer for the Public Works Department, very kindly came to Golden to see me, and gave me much valuable information. Mr. Aylmer has made a study of the river for some years past, and is strongly in favour of the proposed reclamation.

I beg to submit the following report, based on information gained from my examination of the locality and maps, and from the gaugings made by the Railway Belt Hydrographic Survey during the season of 1912.

GENERAL DESCRIPTION.

The Columbia river takes its rise in Columbia lake about latitude 50° 15′ N., and longitude 115° 50′ W. From Columbia lake it flows northwest through lake Windermere, and continues in the same general direction past the town of Golden, situated on the main line of the Canadian Pacific Railway at the junction of the Kicking Horse river with the Columbia.

The valley is bounded by the Rocky mountains on the east, and by the Selkirk mountains on the west, lying in parallel ranges. Running through this great valley is a low flat strip of land of considerable uniformity, averaging about a mile in width and extending from lake Windermere to a point near Donald. At extreme high water this is virtually the bed of the Columbia river, for it is practically covered with water at such times although no doubt, there is but little velocity outside of the low water channels. At low-water the river winds through this flat by many and devious channels ,while at extreme low water almost the whole flat is said to be dry, the water being confined chiefly to the main channel and a few sloughs and small ponds.

Adjoining this flat on both sides are high, dry, benches which have, for the most part, steep sides next the river and which shed little or no water, there being insufficient rainfall to satisfy the thirsty soil.

The range on the east side is narrow and precipitous, and its eastern slope feeds the Kootenay river which parallels the Columbia for about 60 miles of its course, at a distance of only about 12 miles to the east, but flowing in the opposite direction. From these conditions, it will be readily seen that there can be few creeks on the east side flowing to the Columbia; there are none of importance within the Railway Belt south of Golden. On the west side, the range is more broken and the creeks are longer and, of course, larger. Canyon creek, small as it is, is the only tributary of any importance within this portion of the Railway Belt.

South of the Railway Belt there are some good sized creeks, of which the most important are Spillimacheen, Bugaboo, No. 2, Horse Thief, and Toby. Spillimacheen, although situated within the Railway Belt, enters the Columbia just south of the southern limit of the Belt. These are all on the west side and, with Canyon creek and the discharge from Windermere lake, constitute the chief supply of the Columbia south of Golden. The discharge from Windermere lake is not great, and when Toby creek is in flood the water flows back into the lake, which was the condition at the time of my visit.

The water of all the creeks is heavily charged with silt, a large percentage of which is deposited on entering the comparatively sluggish water of the Columbia. This has resulted in the raising of a small section of the bottom lands above high water at and near the mouths of Toby, Horse Thief, and Canyon creeks.

At the time of my visit the water was high, but not within a couple of feet of the height to which it might rise under the influence of a week of hot days and warm nights. It was 1·10 feet lower at Golden than the maximum recorded height for 1912.

Given snow on the ranges and warm weather, the flats of the Columbia may be expected to be flooded on short notice. This flooded condition exists in varying degree throughout the greater part of the spring and summer I am told, but in the fall the water is said to be very low.

Transportation.

The Columbia valley is entered by the main line of the Canadian Pacific railway at Golden, which is situated at the confluence of the Kicking Horse river with the

Columbia. From Golden, the Canadian Pacific railway follows the valley of the Columbia down stream as far as Beavermouth. A branch of the Canadian Pacific railway, known as the Kootenay Central railway, is under construction between Golden and some point on the Crowsnest branch. This line follows the east side of the Columbia, and the rails are laid about half of the way from Golden to Windermere lake. In a year, or two years at most, this road will be in full operation.

There is a good highway along the east side of the valley from Golden to Athalmer. This road continues south down to Kootenay valley to Cranbrook on the Crowsnest branch. There is also a very good road which extends down the west side of the Columbia from Invermere for a considerable distance. An automobile highway from Banff to Windermere is under construction, and is well on the way towards completion. This road traverses the Kootenay valley and enters the Columbia valley by way of Sinclair pass and, when completed, will form one of the links of the much talked of National Highway to the coast, and will form a very attractive feature.

The Columbia is navigable between Golden and Windermere lake for flat-bottomed boats with stern-wheels, during the greater part of the open season. At the low-water period, however, there is considerable trouble, on account of numerous sandbars. It is quite true, as stated in the report of Messrs. Canavan & Mitchell, that some of the bends of the river channel are very short, and no doubt are a great trouble and annoyance in navigation. I am told there are six boats plying on the river from Golden south. I saw only three, but no doubt there are others which I did not see.

The navigation of this portion of the river is at present a very important matter, and is bound to become so in a greater degree as the valley becomes settled, until the Kootenay Central comes into operation; and, even then, it will be essential for the west side unless the bottoms are reclaimed, as there are at present few places where a crossing could be constructed.

With the unwatering of the flats, however, this difficulty would largely disappear. The west side, within the Railway Belt, and for some distance south, has never attracted any settlers, whether from the lack of roads, the height of the benches or other inhospitable conditions, I am unable to say.

There are, at present, no boats suitable for carrying tourists, but these will no doubt be constructed by the Canadian Pacific railway when there is a demand for such, as they will hardly allow the control of this traffic to pass into other hands, or permit the competition with the Kootenay Central which has been suggested in another report.

If the river is to be kept open for navigation, it will require annual dredging of the bars which will form below the mouths of the creeks. The silting of the river could be largely prevented, however, by the formation of silting basins at the mouths of the principal tributaries. For any dredging that may be necessary, the conditions are ideal for the operation of a suction dredge, the discharge from which could be applied to filling up some of the low places which it is sought to reclaim.

Settlement and Agriculture.

The principal town and the only one of any size is Golden, with a population of about 2,000. Lumbering and construction have been the chief employment of the people, agriculture holding a very unimportant place. However, the filling up of the larger valleys nearer the coast, and the scarcity of lands suitable for agricultural purposes, has directed attention to the upper Columbia valley, and during the last few years a small number of settlers have taken up land along the east side of the valley.

The very light rainfall in the upper valley, which makes irrigation of the benches necessary, has, more than anything else, retarded settlement, because irrigation is too difficult and expensive for individual effort in this land of sloping irregular benches, where the water supply must be drawn from deep and sometimes remote canyons. This condition is now being remedied by some large irrigation companies, who have acquired lands in the valley, and are carrying on extensive improvements preparatory to putting their lands on the market. I visited the townsite of the Columbia Valley Orchard Lands Company, where I found a large corps of labourers at work clearing the land of all trees, stumps, and stones, and constructing a complete system of irrigation for a large tract, which it is proposed to plant in apples or such other fruits as may be suitable to the climate. Considerable land on this tract is being ploughed this year.

Several townsites have been laid out in the valley and several small places, such as Athalmer, Invermere, and Wilmer, have a considerable number of houses. The largest of these is Athalmer, which is situated at the foot of lake Windermere.

It seems quite certain that, with the completion of the Kootenay Central railway and perfecting of the plans of the irrigation companies, the valley will receive a considerable influx in population.

With the settlement of the benches will come a strong demand for the reclamation of the bottom lands for the growth of hay. The local supply of hay has been almost a negligible quantity, and much hay is brought from outside points. The price varies, but is always high, being from $20 to $45 per ton and even higher at times.

Climate.

During the few days of my visit the weather was delightful, and I am given to understand that this is the prevailing condition during the summer. The weather is extremely cold during the winter season, the temperature falling as low as 50 degrees below zero at times.

There is usually a frost in every month of the year; this is not likely to cause much damage on the benches, but in the low lands along the river it would probably prevent the raising of tender vegetables or fruits. If the bottom lands are reclaimed, they will be best adapted to the growth of hardy and shallow rooting plants, both on account of the frost and of the sub-irrigation.

Area.

The flat is approximately one mile wide and, measured from the south limit of the Golden mining property along the centre line of the flooded belt, to the southern limit of the Railway Belt, it is 33.5 miles as nearly as may be judged from the plan. This would give a total area of 21,440 acres. Considerable land has, however, been alienated from Government control and some is occupied by the channels of the river. Counting up the quarter sections, and fractional quarter sections that are shown on the plan furnished me as being clear and available, I find about 17,000 acres including the channel of the river. The river channel with its artificial banks will not be less than 500 feet wide and would occupy at least 2,000 acres, leaving 15,000 of which, no doubt, a portion would always be waste land in spite of any reasonable effort at reclamation. Probably 12,000 or 13,000 acres might be reclaimed of the available land within the Railway Belt south of Golden.

Value.

The bench lands of the valley are said to be suitable for the cultivation of fruit, which probably means apples and small fruits. Where they have been cleared, subdivided, placed under irrigation, and otherwise improved, they are held at from $175 to $225 per acre. The bottom lands of course are alluvial, and consist of a very fine sand which is very unstable when subjected to the erosive action of rapidly-moving water. Men of much experience in the Columbia valley say that this will make first-class land. I believe it will make good productive land, but I am not prepared to say that I think the expectations of the residents will be fully realized. It will probably be worth $150 per acre.

Discharge.

An examination of the records, made by the Railway Belt Hydrographic Survey in 1912, indicates that the combined maximum discharge of all the creeks tributary to the Columbia south of Golden was, on June 24 of that year, about 16,500 second-feet. As this does not include several small creeks on the east side south of the Railway Belt, it might be considered safe to say that the total amount of water entering the Columbia on that date was 17,000 second-feet; but the record shows that the creeks were not all in maximum flood at the same time and, as a result, the maximum discharge of the Columbia would be considerably less than 17,000 second-feet.

Flowing at the rate of two miles per hour, this flood condition should reach Golden on May 26, but the record shows that the maximum discharge did not occur at Golden until May 30, when it amounted to 11,600 second-feet, which was but little less than the total amount entering through the tributaries on May 28. This shows that a considerable portion of the water entering the river on May 24 was stored in the numerous lagoons and sloughs.

Taking the creeks in order of their distance from Golden, the greatest combination that could occur in 1912 would amount to about 16,000 second-feet, and if the flats were all dyked, and there was no storage, practically all of this would have to pass Golden instead of the 11,600 second-feet which actually discharged there.

This increased discharge, and the consequent increase in the height of the water, might result in damage to certain low lands lying but little above high water mark, and not within the area covered by the application. Such steps as may be necessary to protect such lands may be taken when the report provided for in paragraph (*b*) of the draft agreement is submitted for the Minister's approval.

The minimum recorded discharge of the Columbia at Golden during 1912 was 1,550 cubic feet per second and occurred on April 30 and on October 31. The velocity was probably about 2 feet per second or less, and the area of the section about 775 feet with an average depth of about 4 feet. This would mean very low water in the upper reaches, and navigation would probably be out of the question.

As soon as the water commences to fall, the conditions existing during rising water are reversed, and the discharge at Golden exceeds the combined discharge of all the tributaries, indicating a reduction of the storage water.

At the period of minimum flow the discharge at Golden was practically the same as the combined discharge of all the tributaries.

The records cover the season of 1912 only, and no definite conclusions can be based on them, as the period of observations is much too short.

RECLAMATION.

(a) Dyking.

Of all the plans suggested for reclaiming these lands, dyking, combined with drainage and pumping, must be the method made use of, if any degree of success is to be attained within a reasonable time. Nevertheless, since the area to be treated is very long and comparatively narrow, and the main channel of the river cuts the flats into many sections by its meanderings, each section will have to be dealt with separately, and receive such treatment as would appear to be necessary from a study of all the conditions obtaining at that point.

In some places the main channel is very narrow, and a large portion of the flow is through sloughs or auxiliary channels and, as these would in most cases have to be closed, the dykes would require to be built of such height and such distance apart as would afford sufficient capacity for the whole discharge. The present banks, although perhaps 4 or 5 feet above the general elevation of the flats, could not be used to any extent as a base for the higher dykes, because they are too close together, too porous, and are covered with brush.

(b) *Sedimentation.*

The process of sedimentation may be utilized for reclaiming a limited area at the mouths of Canyon, Spillimacheen, Horse Thief, and Toby creeks, by conducting the silt-charged waters of these creeks first to the lower end of a closed district and later, when the down-stream end of the basin becomes sufficiently elevated by the deposit of silt, the outlet of the creek may be shifted to a point farther up-stream, and in this manner the whole basin may be raised to an elevation above high water. I do not think that this method can be applied to the flats in general as the velocity of the river is not great, and suffiicent head could not be obtained to permit the surface of the treated area to be raised above high water mark.

It has been suggested that if a section of the flat 3 miles long and with the river on one side of it were surrounded by a dyke, the whole top of which is level and slightly above high water at the upper end of the section, be used as a settling basin, the water could be admitted, silt-laden at the upper end and drawn off clear at the lower end, leaving the silt on the bottom of the basin. The trouble with this plan would seem to be that when the basin is emptied down to the elevation of the water in the river at the lower end, the total fall for the three miles would only be about 2·5 feet, and as the basin filled the fall would be reduced, with the result that little or no silt would ever reach the lower end of the basin. At the best, it would be very slow and the upper end would be the first to fill up, in which case it could not be raised up to the elevation of high water.

In case of the creeks, mentioned above, they could probably be intercepted at sufficient elevation to give all the fall required.

(c) *Improving Outlet.*

The fall of the river between Athalmer and Golden is very slight, being variously estimated at ·6 to ·8 feet per mile. North of Golden, the fall is somewhat greater, but there is no sharp fall for a considerable distance below, and I am not aware that any material relief could be afforded by deepening the river below Golden. There is a report current that the Canadian Pacific Railway Company intends building a dam at Donald and, if this is done, the back water would probably counteract any advantage that might otherwise be gained by deepening the outlet.

(d) *Storage.*

The suggestion to turn the waters of Toby creek in to lake Windermere, and store them there by means of a dam across the lower end of the lake, might prove a serious matter for the town of Athalmer, which would be entirely below the level of the lake, constituting a continual menace to the town. In addition to this, the dam would be long, and the cost would probably be out of proportion to the advantage gained.

THE AGREEMENT.

In the draft agreement submitted to the department paragraph (*a*) provides for reserving " all available Dominion Lands comprising the bottom lands of the Columbia river between Golden and the southern limit of the Railway Belt and within a contour 10 feet above ordinary high-water mark for a period of three years, etc.";

while paragraph (*h*) provides "That upon the completion of the work and reclamation within any area that may be designated by the Minister, the contractor shall be entitled to patents for all available Dominion Lands reserved by paragraph (*a*) of the agreement, etc."

This gives the applicant a patent on lands above the high-water mark. In most cases this would not mean very much, as the banks above high water mark are very steep as a rule, but there are certainly some exceptions to this rule, and there are some cases where a future patentee who would otherwise have access to the river would be cut off entirely by this provision. I am told that this 10 feet above high-water mark is required for purposes of construction only, and it might be very useful for diverting a small tributary to a lower outlet, and thus save the expense of carrying it across the reclaimed area with the consequent danger of seepage; but I respectfully submit that this might be provided for by a separate paragraph arranging for a right-of-way, which could be granted by the Minister where necessary for purposes of construction, as might be ascertained during the period of reservation as determined in paragraph (*a*).

It has been suggested to me that there might be small "islands" above high water that would come into the possession of someone other than the applicant and that this might give rise to trouble. I am of the opinion, however, that an "island" surrounded by the property of the applicant would be of no use to anyone except the applicant. Of course, if it joined a roadway, it might be valuable, but in that case, there need be no conflict with the applicant. Any such small "islands," however, might well be included in the area granted to the applicant even if above high-water mark.

SUMMARY.

From a personal examination of the upper Columbia district and for the reasons above stated, I conclude:—

(1) That the bottom lands are at present practically useless.

(2) That they cannot be reclaimed by individual effort because of the difficulty and expense connected therewith.

(3) That they may be reclaimed, at least in part, by dyking in conjunction with a proper system of drainage for low water periods and pumping during high water periods.

(4.) That certain limited areas about the mouths of the larger tributaries may be reclaimed by sedimentation.

(5.) That some small sections will not pay for reclaiming.

(6.) That the reclaimed lands will be suitable for the cultivation of shallow rooting plants not susceptible to damage from summer frosts.

(7.) That the area of available Dominion lands that may be economically reclaimed is approximately 13,000 acres.

All of which is respectfully submitted.

THOMAS H. DUNN, C.E.

Reclamation Engineer.

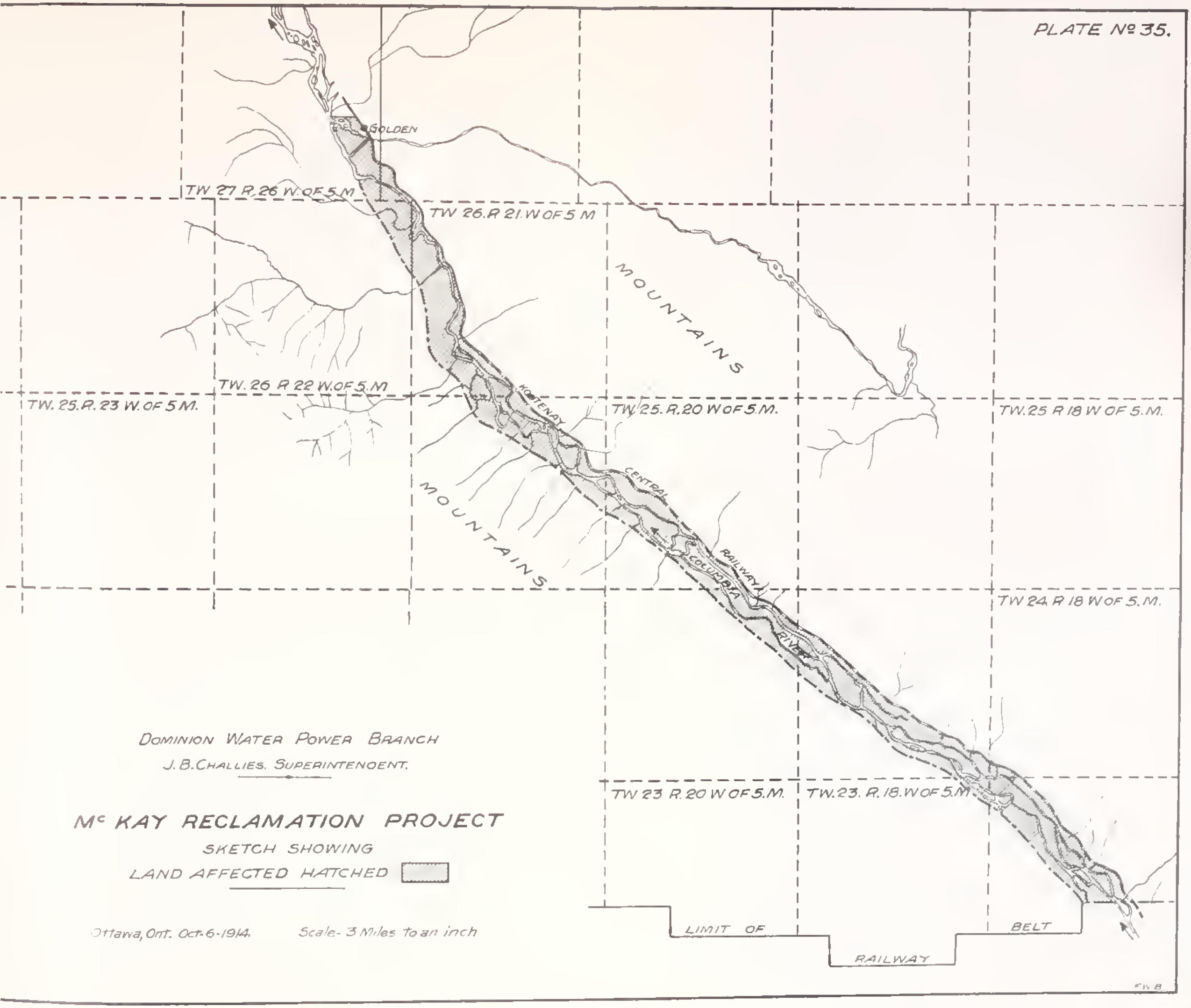


PLATE № 35.
GOLDEN
TW 27 R.26 W.OF 5 M.
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TW. 25. R. 23 W. OF 5 M.
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TW. 23. R. 18. W OF 5. M
MOUNTAINS
MOUNTAINS
KOOTENAY
CENTRAL
RAILWAY
COLUMBIA
RIVER
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RAILWAY
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DOMINION WATER POWER BRANCH
J. B. CHALLIES. SUPERINTENDENT.
Mc KAY RECLAMATION PROJECT
SKETCH SHOWING
LAND AFFECTED HATCHED
Ottawa, Ont. Oct-6-1914.
Scale- 3 Miles to an inch

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No. 12B.

REPORT ON PASQUIA RECLAMATION PROJECT.

Water Resources Paper No. 11.

OTTAWA, June 11, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—Following your instructions of May 7, 1913, I continued my examination of that portion of the Pasquia reclamation district tributary to the Saskatchewan river, and lying between The Pas and Grand Rapids in the province of Manitoba.

Work was commenced at Cross lake on June 3, which was the earliest date on which this lake could be reached, by causes owing to the presence of ice in Cedar lake. Camp was maintained at Cross lake until July 18, during which time a topographical survey was made of a considerable portion of the peninsula between the Saskatchewan river and Cross lake, together with a traverse of the shore line and soundings of the waters contiguous thereto. On completion of this work, camp was moved about five miles upstream to The Narrows, which is at the eastern extremity of Cedar lake. From this point the traverse and profile of the river was completed, and the topography of the various islands in the river and shores of Cedar lake in the vicinity of The Narrows taken. A very great number of soundings were taken in the river and in the eastern end of Cedar lake.

During June and part of July, the swamp in the interior of the Cross lake peninsula remained frozen to such an extent that no examination of the underlying materials could be made to a greater depth than 1 or 2 feet. For this reason a party had to be sent back to Cross lake to make tests later in the season.

In making soundings at Rabbit Point no shoal of importance was discovered. Nevertheless, it seems quite certain that a shoal exists slightly to the eastward of the point. Soundings were taken directly off, and also to the westward of the point, but none were taken to the eastward. The failure to locate and survey this shoal is the result of a misunderstanding of my instructions, and for the same reason no soundings were taken off Duncan island, which is located at the west end of Cedar lake near the entrance of the Saskatchewan river.

A line of levels was run across High Portage, and a very short series of simultaneous gauge-readings taken in both lakes. The survey work was concluded by a traverse of the Swallow creek branch of the Saskatchewan river, a traverse with profile and soundings of the boat channel of the Saskatchewan as far as Brown Rock and a traverse with soundings from the Brown Rock to The Fryingpan.

The Brown Rock is about 4 miles upstream from the Hudson's Bay Company's post at Chemawawin, and the Fryingpan is about 12½ miles up from the same point measured along the boat channel. There is an outcrop of rock at both these points as well as at Chemawawin, and they are the only places in this vicinity high enough to make camp on during high water.

The party started to break up on September 26 and by October 6 was so reduced as to make it impossible to continue the survey work; consequently the remainder was organized into a party for the securing of soil samples, of which, unfortunately, we have been unable to procure an analysis.

I regret that the work on the river could not be completed as far as The Pas, as a profile of this section from Cedar lake to The Pas would greatly assist in a solution of the reclamation problem. It is not absolutely essential at this stage, however, but the absence of the information leaves the question of the necessity for improvement of this part of the river somewhat obscure.

OBJECT OF THE INVESTIGATION.

On the 26th day of January, 1912, an application was made on behalf of the Dominion Land and Drainage Company for "authority to drain and reclaim all the ungranted lands on both sides of the Saskatchewan River and all the branches thereof, including the lands surrounding Cedar and Cross lakes, whether submerged or occasionally submerged, from The Pas to Grand Rapids.

The application further states that "the object of the applicants is to construct the necessary works to enable the said lands to be used for farming purposes."

On January 31, 1912, another application was made on behalf of the same company for "authority to drain and reclaim all the ungranted lands within the watersheds of Big Lake river and Overflowing river."

The application states further that "the object of the applicants is to construct the necessary works to enable the said lands to be used for farming purposes," and "it is the intention of my clients to construct one general system of drainage and reclamation works covering all the lands applied for both in this letter and in my previous letter of 26th of January last."

In view of these applications, I was instructed to examine the district and to inquire into the conditions as to drainage, etc. My investigations were conducted for the purpose mainly of determining:—

(1) The possibility of relieving from flooding the lands cited in the applications of the Dominion Land and Drainage Company.

(2) The cost of constructing the works necessary to afford such relief.

(3) The economic advantages to be derived from the construction of such works.

In addition to these considerations I also had regard to the effect which the construction of the reclamation works might have on navigation and the development of the power at Grand Rapids, but these may be said to be included in the third item cited above.

THE PASQUIA DISTRICT.

The name "Pasquia," as applied to this district by the late Mr. Ogilvie, was intended to include the entire area affected, in a greater or less degree, by the flooding of the lower Saskatchewan river. This he called the "Pasquia Reclamation District," and it has since been known by that name, although in my report on my 1912 work I applied the same name to the eastern half of the district. The district is about 150 miles long by 70 miles wide, and extends from near the head of the Sipanok channel on the west to Cross lake on the east. It is divided near the centre by a ridge of higher ground on which is situated the town of Le Pas, commonly called The Pas, the only town in the district outside of the Hudson's Bay trading posts. Besides the numerous channels of the Saskatchewan, the only rivers of importance are the Carrot and the Pasquia, both of which are in the western half of the district. In addition to the many small lakes and ponds, there are numerous lakes of considerable size such as Cumberland, Saskeram, Reeder and Pas lakes in the western half, and Atikameg or Clearwater, Cormorant, Moose, Cedar, and Big lakes in the eastern half.

West of the Sipanok channel the Saskatchewan flows over sharp grades and follows strictly the true channel of the river but, nearing the Sipanok, the grade flattens and the water divides, part going through the Sipanok in high water, a much larger part going northerly to Cumberland lake, and the balance following the old river-bed. The water all re-unites at The Pas to be again divided and finally re-united at Cedar lake. On this last stretch, from The Pas to Cedar lake, the principal channels are the Saskatchewan proper and the Summerberry, the latter of which receives the drainage from Clearwater, Cormorant and Moose lakes through Moose creek. In the vicinity of Cedar lake, and for some distance west, there is a perfect maze of channels, but all converge in Cedar lake.

It was reported to me that a very considerable volume of water is deflected from its proper outlet in the Churchill river to an outlet in the Saskatchewan river by way of Cumberland lake. Should this be found to be the case, it might be regulated at or near the point of overflow with considerable advantage to drainage in the Pasquia district.

The whole district comprises an area of about 10,000 square miles, but in this report we are concerned with only the eastern half. The total area of the eastern portion of the district draining to the Saskatchewan river and Cedar lake is approximately 5,230 square miles, but this includes a considerable area to the north of Cormorant lake that is well outside the reclamation district.

Discharge of Saskatchewan River.

Previous to the year 1913, but few measurements of the discharge of the lower Saskatchewan river had ever been made. In the year 1909, Mr. Forward, C.E., acting for the Public Works Department, made a measurement by means of surface floats at Grand Rapids, and another measurement at The Pas in the same year. In 1910 Mr. Wm. Ogilvie, D.L.S., made two meterings at Grand Rapids for the Water Power Branch. In 1911 the Department of Public Works secured two meterings at The Pas. Two meterings at The Pas and three at Grand Rapids were secured by the Water Power Branch in 1912. These three measurements made at Grand Rapids were taken at the same station as the two measurements made by Mr. Ogilvie in 1910, and the information afforded by this series made it possible to construct an approximate discharge curve for this station. No systematic series of gaugings or meterings were undertaken, however, until the year 1913, when the Water Power Branch established a new station at The Pas and procured twenty-seven meterings. Five meterings were also taken at the Grand Rapids station in 1913.

The station at Grand Rapids is near the eastern limit of the Pasquia district, while the station at The Pas is near the centre. It is much to be regretted that no metering station has been established at the western limit near the Sipanok channel, although this is not of so much importance in a study of the eastern portion of the district as of the western portion.

As previously stated, the ridge at The Pas divides the Pasquia district into two sections which are more or less distinct, and must be treated separately, except as to the final outlet which is common to both. Where the river passes through the ridge at The Pas, the cross section is somewhat contracted, and this regulates the discharge at this point by holding back a large percentage of the flood waters in storage between The Pas and the Sipanok channel. However, as long as the storage west of The Pas is not reduced, the discharge at The Pas, together with the run-off from the portion of the Pasquia district east of The Pas, will give a close approximation of the flow that will have to be provided for in any scheme of reclamation for the eastern district.

The condition of flooding on the lower Saskatchewan follows the melting of the snow in the Rocky Mountains, and hence varies in extent and duration according to the snowfall and temperature.

The rainfall, of course, is an important factor, and there are other influences which affect the result, but no possible combination of circumstances could cause a flood in the absence of snow in the mountains, or prevent a flood when there is a condition of plenty of snow followed by mild weather. A late cool spring invariably produces a flood of short duration with very high water in the summer, generally in the months of July and August; while an early spring produces moderately high water throughout both spring and summer with very low water in the fall. This is the case with all snow-fed streams subject to flooding.

In 1912 the spring was late and cold, and the water in the river was consequently low until the month of July, when the warm summer weather caused a steady rise until August 6. On this date the peak of the flood was reached, and lasted for three days when it fell somewhat, but remained comparatively high until the end of September, when it fell steadily at about the same rate that it rose in July. A slight rise early in November made unusually high water for that season of the year.

In 1913, the conditions were entirely different. The spring was early and warm, and the water rose in the latter part of April and first part of May almost to the maximum height for the season. It was only moderately high throughout the season, and fell uniformly from September 7 to a very low level in the following winter.

While the study of the flow in the river has not extended over a sufficient time to justify any very definite conclusions, an examination of the discharge data would seem to indicate: (1) Extremely high floods of short duration in short hot seasons; (2) Moderate floods in long mild seasons; (3) A return to approximately the same extremely low elevation in the month of February of each year.

The maximum discharge in a high-water year lasts only for two or three days and is not, therefore, so important a factor as the mean of the 15 days preceding and 15 days following the maximum. It is unnecessary to consider moderate floods even if of long duration.

The extremely low elevation which prevails every winter, although detrimental to power development is, in the abesnce of summer storage, of great value in the scheme of reclamation, as it will permit Cedar lake to be drained to an elevation but little above the elevation of Cross lake, without the construction of a very wide low level canal.

The flood discharge of the Saskatchewan river at The Pas is, in ordinary high water years about 60,000 to 75,000 cubic-feet per second while the lowest winter flow yet recorded was but little over 4,000 second-feet. The winter discharge at The Pas may be taken at 5,000 second-feet. This makes it possible to reduce the elevation of Cedar lake to such a point, that a channel of moderate width will be sufficient to prevent it rising high enough in summer to cause flooding of the reclaimed lands.

During flood periods, the Saskatchewan river flows in part into Moose lake, and it might be at first supposed that the storage in Moose lake would keep up the winter flow at The Narrows; but it will be readily seen that the lowering of Cedar lake will stop the flow which now passes from the Saskatchewan river into Moose lake during high water, and only the run-off from the Moose lake basin will come from that quarter.

Should there be any considerable discharge from Cormorant lake to Moose lake by way of Frog creek, and thence to the Saskatchewan river by way of Moose creek, it could be regulated at the head of Moose creek; but Moose lake could not be held very high, as it would probably affect the drainage of a portion of the area which it is sought to reclaim and, again, the lake would be likely to overflow through Sturgeon river to the north arm of Cedar lake. Sturgeon river could not be readily dammed, as it rises in a muskeg which extends to Moose lake. The amount of possible regulation at Moose lake is, therefore, somewhat limited.

The greatest discharge at The Pas during the year 1912, the first year in which there is a complete record of gauge readings, was in the month of August, when the average for the month was 67,732 cubic feet per second. This was considered a high-water year, and was caused mainly by a late cold spring, which prevented any material run-off during the early part of the season, thus concentrating the flow in the warmer part of the summer. This condition was somewhat supplemented by heavy rains during July, a part of August and September. In the year 1913 the greatest flow was in July, when the average for the month was 60,402 second-feet.

A monthly average of 70,000 second-feet discharge at The Pas may be considered as very unusual, and a greater discharge than this is so rare as to be negligible for the purposes of this report.

Rainfall and Run-off.

The first report of the Meteorological station at The Pas appeared in the issue of the monthly weather review of June, 1910, since which time monthly reports have appeared but, with considerable irregularity.

From June to December, 1910, the seven months reported, the rainfall amounted to 12.75 inches. In ten months of 1911, omitting January and June, the total precipitation amounted to 16.23 inches, while in eleven months of 1912, omitting April, it was 16.09 inches. There is no report for the months of April or June in 1913, which leaves the data very incomplete for the year, as the rainfall during these two months is usually comparatively heavy. The greatest precipitation recorded at The Pas, according to the report of the Weather Bureau, was for the month of July, 1911, and amounted to 4·67 inches for the month. In the month of July, 1912, the rainfall was 4·39 inches, and in September of the same year it was 3·59 inches, which is a record for that month.

There are no other stations in the Pasquia district reporting rainfall. Some reports were made from Cumberland House in 1911, but these were discontinued with the November report of that year. The reports from Melfort, Swan river and Lost river are attached to this report; all these are in the Saskatchewan basin excepting Swan river.

The area of the Saskatchewan drainage basin lying between the Pas and the Narrows is approximately 5,230 square miles. Over this large area there are not likely to be any general storms of great violence. Very heavy storms will probably occur from time to time over some part of the drainage basin, but never over the whole area at the same time. While it will be imperative to provide for such storms, in designing the interior drainage, they will have but little effect on the outlet. If an outlet be provided with sufficient capacity to carry off the maximum monthly rainfall, no flooding will result from occasional heavy storms over small areas.

The annual precipitation in this district is light, the average amounting to about 17 or 18 inches. There is a record, however, of 6·04 inches having fallen at Melfort in July, 1912, although no such fall has ever been reported at The Pas. Assuming that 6 inches of rain may fall over the whole area in 30 days, and that the run-off during the growing season of June, July and August will not exceed 30 per cent of the rainfall, we have 1·8 inches run-off from the whole area in 30 days. This is equivalent to ·00252 cubic-feet per second per acre, or 1·6128 cubic feet per second per square mile. The total discharge from 5200 square miles at this rate would be 8,386 cubic feet per second. This run-off, taken in conjunction with the discharge at The Pas, gives an approximation of the discharge at the Narrows under reclamation conditions.

In the year 1901, there was a very unusual flood on the lower Saskatchewan, when almost the whole of the Pasquia district was covered with water. It has been estimated that the discharge at The Pas reached considerably over 100,000 second-feet, and possibly as much as 150,000 second-feet. The peculiar combination of circumstances which caused this enormous flood may never occur again, but in ordinary high-water years there may be as much as 75,000 second-feet passing The Pas for a few days at the peak of the flood. As previously stated, a monthly average of 70,000 second-feet is excessive, and this, in conjunction with the run-off of 8,386 second-feet, would give a discharge at the Narrows of 78,386 cubic feet per second.

An examination of the run-off data submitted herewith shows the maximum run-off to take place in the Little Saskatchewan in April, and amounts to 1·55 cubic feet per second per square mile. This is over the comparatively small area of 1,250 square miles, and is the maximum recorded in Manitoba by the Water Power branch. In view of this, and having regard to the large area and flat grades of the eastern Pasquia district, it seems unlikely that the run-off from the district will ever exceed my estimate of 1·61 cubic feet per second per square mile.

Temperature.

Maximum and minimum temperatures were observed at Cross lake and Cedar lake in 1912 during the period the party was on the ground, and a practically continuous record was obtained during the season 1913 from June 8 to September 28.

The following is a summary of the observations for 1912 and 1913:—

	Average Maximum.	Average Minimum.
1912.	°	°
August.......................30 days.....................	73·5	49·6
September.......................30 "	62·2	40·9
October.......................25 "	48.5	32.3
1913.	°	°
June.......................22 "	71·6	51·6
July.......................31 "	71·5	53·7
August.......................31 "	71·4	52·2
September.......................26 "	61·4	45·3

In 1912, rain fell on nine days in August, and rain or snow fell on nineteen days in September, and the weather was almost uniformly bad during the continuance of the party in the field. The season of 1913 was a great contrast to that of 1912, the weather being very fine, and all that could be desired for field work during the greater part of the season.

Outlet.

The outlet for the waters of the Saskatchewan river is at present, and probably always will be, in lake Winnipeg, which is reached after passing a series of rapids known as Flying Post, Demi-Charge, Cross Lake, Red Rock, and Grand Rapids, with a total fall of 119½ feet in 24 miles, or an average of about 5 feet per mile. This fall is not, however, distributed with any uniformity as the following table shows:—

	Feet.
Flying Post rapid, fall is..	3.71
Demi-Charge rapid, fall is..	5·91
Cross Lake rapid, fall is..	4.00
Red Rock rapid, fall is..	12.20
Grand Rapids rapid, fall is..	74·67
Total..	100.49

The balance of the fall is in the stretches of swift water between these rapids.

The western extremity of this rocky pitch is at Cedar lake, where the waters are dammed back by a rock barrier causing the rapid at Flying Post, while a few miles farther down is another rock outcrop causing the Demi-Charge rapid just at the entrance to Cross lake. The distance between Cedar and Cross lakes is about 6 miles, and the fall is 15·15 feet.

No substantial relief from flooding can be obtained except by the lowering of Cedar lake, which can only be effected by the improvement of the river between its eastern extremity and Cross lake. It was hoped that a short and easy route could be found for a drainage canal across the peninsula between the northerly expansions of the two lakes, but this was proven to be impracticable by the investigations of 1913, which showed that the interior between the lakes was too high and rocky to permit of economical construction.

There was at one time undoubtedly an outlet from the northeast arm of Moose lake by way of the Minago river to the Nelson, and thence to Hudson Bay without touching lake Winnipeg. The Geological Survey Report of 1902 contains a short description of this long since abandoned outlet. According to this report, the water of Moose lake all but overflows the summit of the divide, which is of limestone formation and extends for about 400 yards at an elevation of only about 3 feet above the water. It is said to be 1½ miles over a deep muskeg and this rocky divide, from the open water in Moose lake to a small stream which forms the headwaters of the Minago river. In this stream there are many rapids, and plenty of fall could be obtained in a distance of 9 or 10 miles to lower Moose lake 10 or 12 feet or perhaps more. To do this, however, would be costly and would not accomplish the desired end. It is not sufficient that a portion of the Saskatchewan water, however great, be diverted from the present channel, because even if 90 per cent of the flow should be thus diverted Cedar lake would not be lowered more than 4 or 5 feet, while the remaining 10 per cent would be insufficient for navigation and useless for power purposes. It will never do to divert any material quantity of water from the lower Saskatchewan without regulating works so that it can be turned back again during low water, as it seems to require 30,000 to 40,000 second-feet for navigation purposes, and this is enough to cause flooding. The same may be said of any attempt to divert the water to lake Winnipegosis.

The only complete remedy is by lowering the water of Cedar lake direct by improving the Saskatchewan river between this lake and Cross lake, with perhaps a diversion near Cedar lake and another near Cross lake.

No measurements were taken at the outlet of Cross lake. A short distance below the outlet are Cross lake rapids, with a fall of about 4½ feet from Cross lake to the foot of the rapid. It has been assumed that the outlet from Cross lake is sufficient to prevent the surface ever rising above elevation 820, and that only in case Cedar lake should rise to elevation 830 under reclamation conditions.

Although, in high water, there is no evidence of any rapids between The Pas and The Narrows, yet in low water there are a few points where considerable current is developed, and this is an indication of what might be expected should the water in Cedar lake be lowered. There is a hard bottom at Brown Rock, Fryingpan, Hill island, and Wooden Tent, and to obtain full benefit of the outlet would probably require some excavation at these points, as well as at Duncan island and Rabbit Point in Cedar lake. It may be possible to avoid the rock at Duncan island by seeking a route farther north.

Lake Winnipegosis.

Lake Winnipegosis lies to the south of Cedar lake, from which it is separated by a narrow strip of land about 4 miles wide at its narrowest point. The land between the lakes is very low on the Cedar lake side, but very high in the vicinity of Winnipegosis. Several surveys have been made at High Portage to determine the relative elevations of the two lakes and the ridge between them.

In 1858 Messrs. A. W. Wells and S. J. Dawson made a survey of the portage, and found the distance between the lakes to be slightly over 4 miles, and the elevation of the water in lake Winnipegosis to be 4 feet higher than the water in Cedar lake.

In 1873, another survey was made by Mr. H. B. Smith, when he found the two lakes to be of equal elevation, and the summit of the ridge was 93.14 feet above the water. The distance between the lakes in a straight line was found to be slightly less than 4 miles.

D. B. Dowling, in 1891, found lake Winnipegosis to be 9 inches above Cedar lake, and the summit of the ridge 93 feet above the water in lake Winnipegosis.

During the past season, I had a temporary gauge placed in Cedar lake, and another in lake Winnipegosis, and these were read daily for eight days, which was the limit of the time possible to spend at this point. Levels were taken between the two gauges, and Winnipegosis was found to be 1½ inches above Cedar lake, and the summit of the ridge was 91·8 feet above Winnipegosis. There seems little doubt that these two lakes are practically at the same level under normal conditions, in spite of the fact that there was a difference in the elevations of 4 feet in 1858; this must have been extremely low water for Cedar lake, and extremely high water for Winnipegosis. What influence keeps the lakes at or near the same level is not apparent; in fact there are many things that would seem to militate against it: Winnipegosis is fed from a comparatively small basin, with nothing but a rather light rainfall to replenish it, while Cedar lake is fed from an immense area whose discharge is rendered extremely variable by the melting snow in summer. It has been suggested that there is a subterranean connection between the lakes, but I consider this extremely doubtful, as water could hardly pass between the lakes in sufficient quantity to materially affect the relative elevations, without so disturbing the surface of the lakes as to make the fact apparent to travellers. Of course, if the opening were of enormous proportions, such as half a mile or more in width, it might not cause a noticeable disturbance.

The lowest point in the ridge between the lakes is believed to be much farther west than High Portage, and is approximately 45 feet above the water.

In considering the feasibility of using lake Winnipegosis as an outlet for the surplus water of the lower Saskatchewan river, I found serious objections, as stated elsewhere in this report; in addition to these, the fact that the two lakes are on the same level makes it out of the question. Of course it is possible, and perhaps desirable, to lower Winnipegosis by cutting a canal across Meadow Portage to Lake Manitoba, and then Cedar lake might be lowered by a canal across at some point west of High Portage; but the cost would be much greater than the cost of improving the Saskatchewan river between Cedar and Cross lakes, and the results infinitely less desirable as regards navigation and power. Mossy Portage is at the south end of lake Winnipegosis, and is about 9,400 feet in length to lake Manitoba. The summit is about 4 feet above lake Winnipegosis, and 23·7 feet above lake Manitoba, according to a survey made by the Public Works Department on April 5, 1913. It is not known how much Winnipegosis could be lowered by a canal at this point, as, although a good bay is reported at the upper end of the portage, there are rock reefs just outside the bay.

Elevations.

The elevations given in this report, and on the accompanying plans and profile, are based on the elevation of lake Winnipeg above mean sea-level at New York, U.S.A., as established by the United States and Canadian Government Geodetic Surveys, and corrected in 1913.

By a comparison of gauge readings at Winnipeg Beach, and at the mouth of the Saskatchewan river, near Grand Rapids, Manitoba, it was found that a correction of +2.30 feet must be applied to the datum used by Mr. Patterson in his power survey of Grand Rapids. Applying this correction to the elevation given for the bench-mark established by him near the southern extremity of the point of land between Cross lake and Portage bay, I found the corrected elevation to be 824·56.

From this point I started my survey whence I ran a line of levels along the east shore of Cross lake northerly to a point opposite the north end of Block island. The elevation of a bench-mark on the west shore of Cross lake was obtained by water transfer under most favourable weather conditions. On July 5, 1913, the elevation of Cross lake was found to be 818·44 feet above sea-level. A line of levels was run over Cross lake peninsula on cross-section line 8,800, and continued along the north-east shore of the Saskatchewan river to the head of Flying Post rapids, and thence across the river to The Narrows and Cedar lake. At this time the whole of Cross lake peninsula was cross-sectioned and contoured. Gauges were read at Cross lake and Cedar lake during the continuance of our camp in these localities. The elevation of Cedar lake in the small bay at the head of the Flying Post portage was 833·73 feet above sea level on August 11, 1913. As there is a slight fall in the lake between Rabbit Point and The Narrows, I estimated that the mean of Cedar lake on that date was 834·00 feet above sea-level.

As previously stated, a temporary gauge was placed in Cedar lake at the northerly extremity of High Portage, and another in lake Winnipegosis at the southern extremity of the portage; a line of levels was run over the portage, and the gauges read daily for eight consecutive days. Lake Winnipegosis was found to be 0.12 feet higher than Cedar lake. I therefore considered the two lakes to be at the same elevation, viz., 834.00 feet above sea-level.

Levels were continued from the west end of Cedar lake based on water-transfer, and were extended up the Saskatchewan river as far as Brown Rock, a distance of 4 miles above Cedar Lake Post. The elevation of the water at Cedar Lake Post was taken as 834.50, and at Brown Rock it was 836.00 above sea-level on September 25, 1913. These elevations must, however, be considered as a rough approximation. The water elevations given in this report and on the plans, must be read as applying only on the date on which they were taken, but the change of elevation during July and the first part of August was not sufficient to affect materially the water surface shown on the profile accompanying this report.

Proposed Improvement.

In designing a canal to lower Cedar lake sufficiently to reclaim the flooded area, it was necessary to determine whether it would be more economical and effective to improve the present river channel by deepening the bed, or by making a new canal independent of the present channel.

To confine the improvement to the present channel would mean the removal of a very large quantity of rock from the Flying Post and Demi-Charge rapids, which would be a difficult and expensive undertaking, especially in the case of the Demi-Charge where the water is very swift and turbulent. It is believed to be much cheaper to cut across the Cross Lake peninsula near its southern extremity than to excavate the Demi-Charge, in spite of the fact that the rock yardage is much in favour of the latter route. At the Cedar lake end it was found that the excavation would be less, and the cost per yard very much less, by cutting across the Narrows peninsula than by following the river by way of Flying Post rapid and around the head of Moose island. A combination of the two routes was, therefore, decided on.

In order to further lessen the cost, and at the same time preserve a sufficient depth of water for navigation during the low water periods, it is deemed advisable to construct two canals, one a low level canal and the other a high level canal. This will permit the low level canal to be made much narrower than would otherwise be the case, and will, by following the present river channel with the high level canal, effect a considerable saving in cost. By constructing the low level canal in sections, commencing at Cross lake, the bottom of the river may be unwatered so as to permit practically dry excavation of the high level canal. If the construction is carried out in this way, there should be less than a million yards of subaqueous excavation.

It is designed to cut a channel 600 feet wide, commencing at elevation 809.00 on the bottom of Cross lake about 900 feet from shore, and leaving the lake between cross-section lines 660 and 1,320, crossing the point of land between the lake and the river, and entering the river between cross-section lines 1320 and 1980, a distance of 2,400 feet from water to water. From this point, the canal will follow the deeper parts of the present river channel to the foot of the Flying Post rapid, a distance of 22,400 feet; thence across The Narrows peninsula to Cedar lake, a distance of 2,500 feet from water to water, and intersecting the bottom of Cedar lake at elevation 813, a distance of 4,250 feet from the shore line in the small bay south of The Narrows, or about 2750 feet from the regular shore line. This constitutes what I have termed the low level canal. The total length of this canal, including portions in Cedar and Cross lakes, will be 32,500 feet. It will be capable of lowering Cedar lake to elevation 817 in winter, and will discharge all the water leaving the lake, so long as the elevation of the lake does not exceed 821.00.

In addition to this low level canal, it is designed to construct a high level canal, also 600 feet in width, commencing at a point on the bottom of the Saskatchewan river at or near the head of Demi-Charge rapids, where the plane of elevation 814·00 intersects the bottom of the river and, following the present river channel, as shown on the accompanying plan, to intersect the bottom of Cedar lake at elevation 821.00 beyond the head of Moose island. This channel is not continuous, as the bottom of the river runs below the grade at chainage 18,100, and rises above the grade again at chainage 25,800, leaving a break without excavation of 7,700 feet.

The excavated material can, in most cases, be deposited near the canal, but one side of the river channel should be kept clear for a considerable width to provide for any overflow that might occur in a flood, such as the very extreme and unprecedented one of 1901. It is also important that the river channel be not obstructed on either side at the main curve near the centre of the canal route, nor at a point opposite the channel leading from The Narrows.

The cost might be reduced to some extent by making a cut through The Narrows 200 feet wide, and reducing the cut around the head of Moose island to about 400 feet in width.

There is a possible alternate route for the Cross lake end of the canal which would bear further investigation. It might be found advantageous to take the high level route north of Centre island and, entering the Cross lake peninsula between cross-section lines 7800 and 8800, pass south through the draw indicated on the contour map. On this route considerable soft material would be encountered and, in some places, no excavation would be necessary, as the material is muck and would be entirely removed by the action of the water.

It is desirable that the work of construction be commenced at Cross lake, and that the low level channel be excavated to near Anchor Point before work is commenced on the high level channel, as it is believed that this will have the effect of unwatering the Demi-Charge rapid for the greater portion of the season, and effect a great economy in the cost of excavating the high level channel. This principle can be carried out all through the work until, when the peninsula at The Narrows is cut through and Cedar lake lowered, the whole river bed will be dry from the foot of Flying Post rapid to the head of Moose island, except for a pond between Cedar island and the head of Flying Post, which will be drained by the excavation of Flying Post rapid.

Estimates.

The cost of excavation in the locality of the proposed improvement is very largely affected by a totally unknown item, viz., transportation. There are two routes by which the district may at present be entered, both of which present some difficulties. Machinery and supplies would have to enter either by way of lake Winnipeg, or down the Saskatchewan river from The Pas. Vessels plying on lake Winnipeg are able to enter the mouth of the Saskatchewan river, and to land goods at the foot of Grand rapids about 1½ miles from the lake. From here, it is about 4 miles to the head of Grand Rapids over an old horse tramway, or 9 miles to the head of Cross Lake rapids over a wagon road. With this road improved, and with a tug and scows on Cross lake, which is about 4 miles wide, machinery, etc., could be landed at the foot of Demi-Charge rapids. This road would probably not stand much heavy traffic in summer, but would make an excellent winter road; a tramway might be constructed from Grand Rapids to Cross lake. The developments of the power at Grand rapids would probably mean the construction of locks and the opening of navigation from lake Winnipeg up the Saskatchewan and this, of course, would solve the question of transportation.

The alternate route down the Saskatchewan river would be an all-rail route as far as The Pas, and from there by water to The Narrows at the western extremity of the proposed canals. Over this route there would be a draft of about 6 feet during high water.

There is at present a winter route from Mafeking, on the Canadian Northern railway, to Grand rapids, a distance of 90 miles. The distance from Mafeking to The Narrows by this route would be about 68 miles and is, therefore, out of the question.

A route which might possibly be developed would run by water from Winnipegosis to High Portage on lake Winnipegosis, and thence 4 miles over the portage to Cedar lake. There is at present a wagon road over High Portage which is high, except for a short distance at the Cedar lake end which is corduroyed.

Among the various elements of uncertainty usually present in every estimate, there is another outstanding one, which is the classification of materials. As it was not practicable to make borings, no real classification could be made. It was evident, however, that very much more rock would have to be excavated than was at first anticipated and, after considering the matter carefully, I have estimated it roughly at 65 per cent of the total excavation, including loose rock, the remaining 35 per cent being earth or uncemented gravel.

In view of the uncertainty regarding transportation and classification, I have not attempted to make a precise detailed estimate of all the items that go to make up the cost of excavation.

The cost of excavating limestone rock in the Chicago drainage canal averaged about 50 cents per cubic yard, or perhaps a little less, while in some cases the cost was as low as 40 cents. The difference in cost was due to different methods of handling and not to a difference in the rock.

The rock to be excavated in the Cedar Lake drainage canal is a magnesic limestone or Dolomite, and is thin-bedded and shaly in places, but much thicker in others.

The total estimated number of cubic yards to be excavated between Cedar and Cross lakes and, including the approaches in each lake, is 8,794,200, which may be roughly classified as follows:—

Low Level Channel.

	Yards.
Cross Lake peninsula	977,511
Old river-bed	3,386,008
The Narrows peninsula	2,652,622
Total yards in Low Level canal	7,016,141

High Level Channel.

Anchor Point cut	751,037
Moose Island and Flying Post cut	1,027,022
Total yards in High Level canal	1,778,059

Making a total of 8,794,200 yards in both canals.

As 65 per cent of this yardage is estimated to be rock and 35 per cent earth we have:—

Earth, dry, 1,750,000 yards at 12 cents	$ 210,000 00
" wet, 1,327,970 yards at 20 cents	265,594 00
Rock, dry, 3,000,000 yards at 85 cents	2,550,000 00
" wet, 2,000,000 yards at $1.65	3,300,000 00
" loose, 716,230 yards at 40 cents	286,492 00
Total for excavation	$6,612,086 00
Add for engineering, 2 per cent	132,242 00
Add for contingencies, 10 per cent	661,209 00
	$7,405,537 00
Add for interest during construction, five years at 4 per cent	444,332 00
Total cost of High and Low Level canals	$7,849,869 00
Estimate for work in Cedar lake and Saskatchewan river	400,000 00
Total cost of work	$8,249,869 00

It may be thought that the above unit prices are, in some circumstances, too low but it is believed that the enormous quantities to be removed justify a moderately low estimate.

It will be seen that this estimate is very much in excess of my former estimate for the same work. This is due to a change in classification which calls for the excavation of a much greater quantity of rock, and particularly of subaqueous rock.

This estimate is made on the basis of a continuation of the present conditions west of The Pas. Should improvements in that section tend to reduce the storage, the discharge at The Narrows would be somewhat increased but the amount of this increase would depend on the nature of the improvement.

AREA TO BE RECLAIMED.

To determine the area and value of the land which it is proposed to reclaim in the eastern Pasquia district will require a special survey on which a small party might easily spend a whole season without fully completing the work. No survey of the boundaries of this district has ever been made and the divide between the Saskatchewan river and Overflowing river has never been definitely located.

The total area tributary to the Saskatchewan river east of The Pas is approximately 5,200 square miles, while the area which has generally been considered as affected in some degree by the overflow of the Saskatchewan is roughly 2,650 square miles, or about 1,700,000 acres. This is the area within the dotted blue line on the field plan but does not include any of Cedar lake or Moose lake, which together occupy about 700 square miles within the blue line. A very considerable portion of Cedar lake will, however, be unwatered at the west end, and much good land be reclaimed. No doubt a large part of the bottom of Moose lake will also be uncovered, but it will probably be of little value for agricultural purposes.

The area drained by Overflowing river is approximately 690,000 acres. It flows into lake Winnipegosis, and is not included in any of the computations in this report.

The whole delta country at the west end of Cedar lake, together with the extensive rush-covered areas extending westward along the Saskatchewan river and northward to Moose lake, will undoubtedly make good land, and will receive immediate relief upon the lowering of Cedar lake. This area is probably not less than 400,000 acres in extent.

There are rocky areas around Cedar lake that are but thinly covered with soil, and still other quite extensive areas that can be classed as nothing else than muskegs. Such lands must for the present, and for a long time to come, be considered of very small value indeed. The absence of definite information as to the extent of the good land and the value of the poorer grades prevents even an approximate estimate.

Cedar lake.

The maximum elevation of Cedar lake in 1913 was 834·00 feet above sea-level, while in 1912 it was approximately 836·00 feet. The maximum discharge for 1913 occurred at The Pas on July 29, and amounted to 63,800 cubic feet per second. This occurred only on one day, but it was over 63,000 second-feet for a week, and over 60,000 second-feet for twenty-eight days. With the construction of the proposed works, the storage east of The Pas would be eliminated, and the run-off from the catchment area between The Pas and The Narrows would, as previously stated, be 8,400 second-feet. The maximum discharge at The Narrows would, therefore, be $63{,}800 + 8{,}400 = 72{,}200$ second-feet. With the two canals constructed and the lake lowered, this discharge, if continued long enough, would raise the lake to elevation 827·00, or possibly a little higher; under the conditions prevailing in 1913, the elevation would probably be a little less than 827·00 at the maximum. By an examination of the discharge curve for the two canals, we find the combined discharge to be 71,500 second-feet at elevation 827·00. This means a minimum lowering of Cedar lake in 1913, by the construction of the canals, of 7 feet.

In 1912, the maximum discharge at The Pas was 73,870 second-feet, which is equivalent to 82,270 second-feet discharge at The Narrows. With the canals constructed and the lake lowered, this flow, if persisted in, would raise the lake to near elevation 828·00 feet. The combined discharge of the two canals is 83,700 second-feet at elevation 828·00. The maximum elevation of Cedar lake under reclamation conditions in 1912 would, therefore, be somewhat less than 828·00 and, since the actual elevation was 836, the minimum reduction in elevation due to construction would be a little over 8 feet.

Should the canals be constructed as proposed, Cedar lake would rise in ordinary high water years to elevation 826·00, and occasionally to 827·00. In very high water years it would rise to 827·50, and very rarely perhaps to 828·00; but there is little likelihood that it would ever exceed 828·00 as, at this elevation, it would begin to discharge through the old river-bed which would prevent further rise.

The maximum elevation of Cedar lake would be reduced about 8 feet under construction, and it is believed that this will provide an outlet sufficient to reclaim all the area covered by the application, when such minor drains as may be necessary to make this outlet available have been constructed.

Time for Completion.

The time required for the completion of the work proposed in this report will depend on the equipment and management. In a work of ths size there is room for an almost unlimited amount of machinery. I do not, however, consider that the canals could be completed in less than four years without making the undertaking unnecessarily expensive.

The excavation of 8,794,200 yards in 4 years requires the removal of over 2,000,000 yards per year, and the working season will probably be limited to eight months. This amounts to 250,000 yards per month of earth and rock. Only the largest sized shovels could be used to advantage in this work, and it would probably require seven or eight of these.

The work at Rabbit Point could be carried on simultaneously with the work on the canals, and the work at Duncan island and in the river farther west should be left until after Cedar lake is lowered, as much of the work which now seems imperative may then be found to be unnecessary.

Navigation.

As stated in my report of last year, the navigation of the lower Saskatchewan, as it is at present, is very unimportant, being confined to occasional trips with supplies to the Hudson's Bay Company's posts at Cedar and Moose lakes. This traffic is carried in vessels of light draft, as 3 feet of water is all that can be depended on in some places in the Saskatchewan river near the west end of Cedar lake, where many bars have been formed by the deposit of sediment. A great deal of work is necessary to make the river suitable for navigation by vessels of 6 feet draught. Any work done for the purpose of improving the river or lakes, with a view to better drainage, will prove a benefit to navigation, as it will have the effect of removing the bars and other obstructions and distributing the fall, making it more uniform throughout the course.

The low level canal which it is proposed to construct between Cedar lake and Cross lake will have a width of 600 feet, and the water at the peak of the flood may have a velocity of 6 feet per second, or even more. This would be over four miles per hour, and might be dangerous at the curve where the channel through The Narrows peninsula joins the river. This could be remedied by a change in the alignment of the canal at this point, should the navigation of this part of the river ever become a live issue through the construction of a dam and locks at Grand Rapids. The big curve, which is located about half-way between the lakes, will not form any menace to navigation, as there is very little excavation at this point, and the navigable channel will be very much wider than the canal. This will have the double effect of reducing the velocity, and providing plenty of room for a vessel to manœuvre in. It should be noted, however, that this canal is designed especially for drainage purposes and not for navigation, although the idea of a narrow deep canal answers well for both purposes. The canal could be straightened at an increased cost, which would make it more readily navigable, and increase the discharge at the same time. There will be no difficulty, however, in navigating the canal, except possibly at the one point mentioned, and then only at extremely high water, if at all. This stretch of the river is at present unnavigable and, without the construction of this proposed drainage canal, could only be rendered navigable at enormous expense. It has been suggested that a canal and lock be constructed to overcome the Demi-Charge rapids, and that a dam be built across the river from Anchor Point at the head of the canal, to flood out the Flying Post rapids. This plan would meet with considerable difficulty, as the water could not be held up above elevation 829 without the construction of a second dam as long as the first one, owing to the existence of a draw to the north and east of the rocky ridge which trails for a short distance along the east shore at this point. It therefore seems desirable that, if there should be an insistent demand for the navigation of this part of the river, it should be worked out in conjunction with this drainage scheme.

The canal is designed to follow the deeper parts of the river, with a view to economy of construction. Undoubtedly the navigability of the river will be greatly improved by the construction of the drainage works herein proposed.

Power.

The interests of drainage are, in this case, opposed to those of water-power, for the reason that the minimum flow in the river is very small indeed, being only 4,000

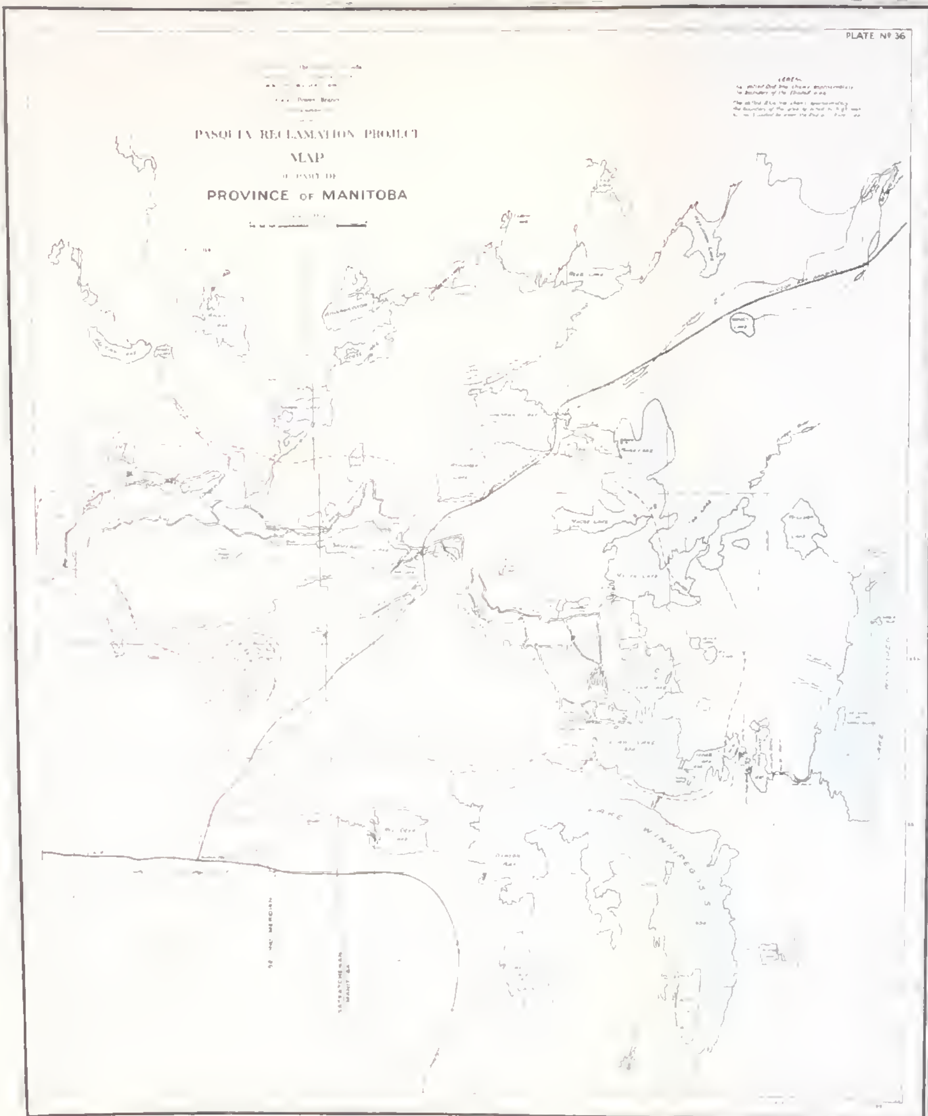
PLATE Nº 36
PASQUIA RECLAMATION PROJECT
MAP
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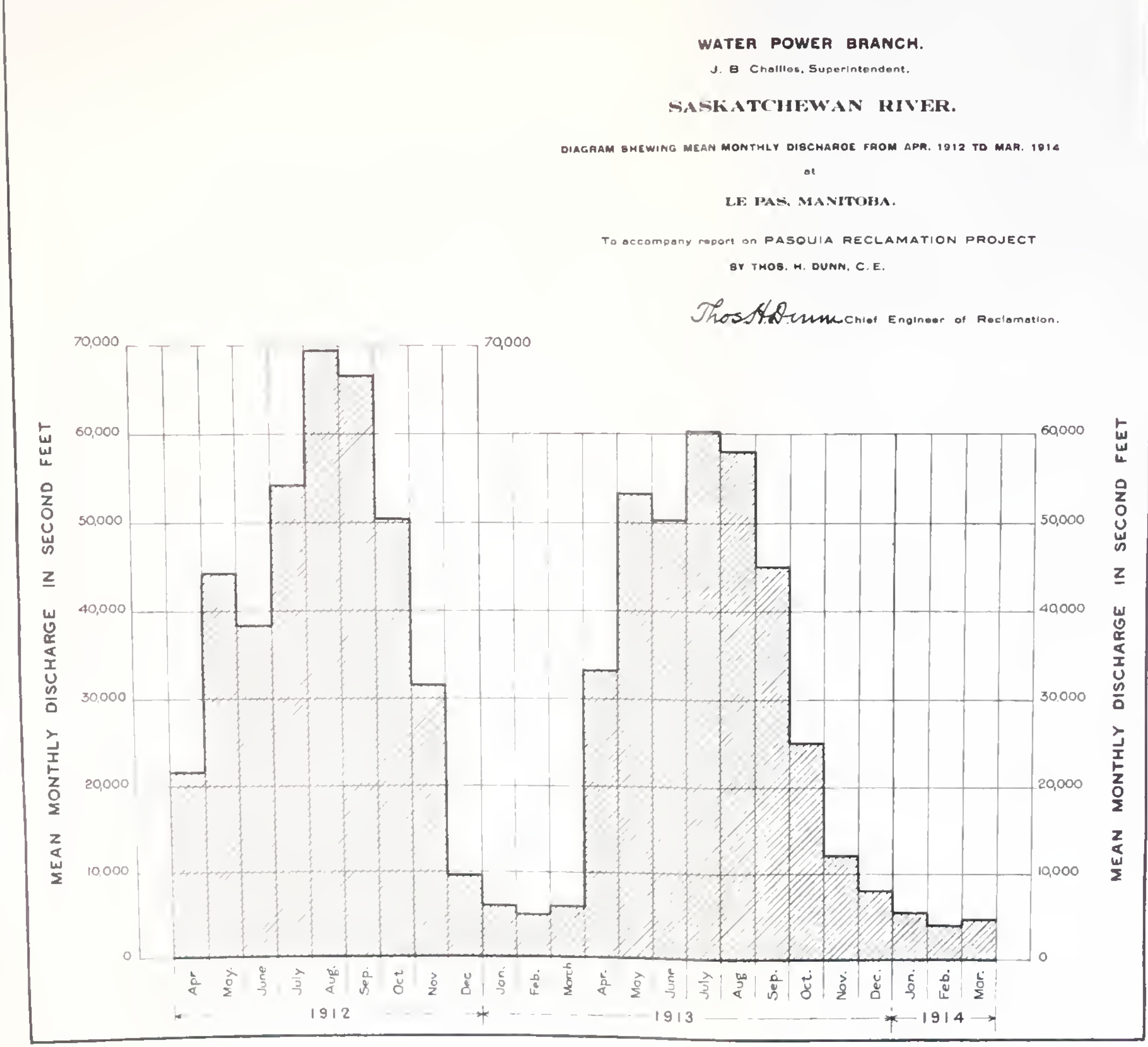
WATER POWER BRANCH.
J. B. Challies, Superintendent.
SASKATCHEWAN RIVER.
DIAGRAM SHEWING MEAN MONTHLY DISCHARGE FROM APR. 1912 TO MAR. 1914
at
LE PAS, MANITOBA.
To accompany report on PASQUIA RECLAMATION PROJECT
BY THOS. H. DUNN, C.E.
Thos H. Dunn Chief Engineer of Reclamation.
MEAN MONTHLY DISCHARGE IN SECOND FEET
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PLATE N° 38

WATER POWER BRANCH.

J. B. Challies, Superintendent

SASKATCHEWAN RIVER

DIAGRAM SHEWING MEAN MONTHLY DISCHARGE FROM AUG 1912 TO NOV 1913

at

GRAND RAPIDS.

To accompany report on PASQUIA RECLAMATION PROJECT

BY THOS H DUNN C. E.

Thos H Dunn Chief Engineer of Reclamation

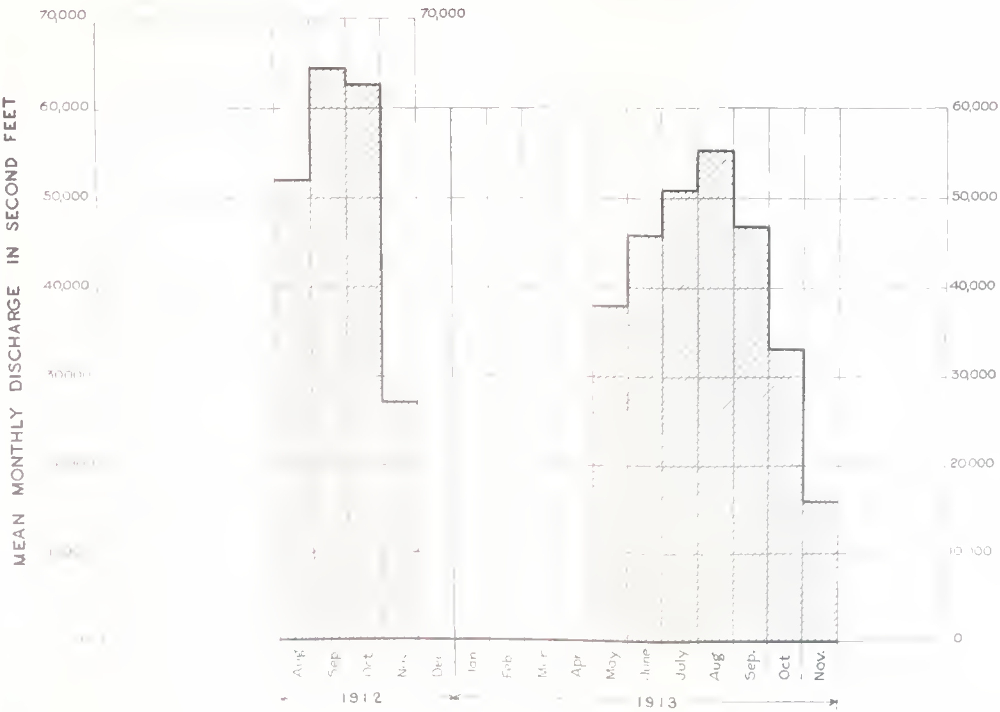

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PLATE Nº 39

WATER POWER BRANCH.

J B Challies, Superintendent.

SASKATCHEWAN RIVER

CEDAR LAKE TO CROSS LAKE.

DIAGRAM SHEWING COMBINED DISCHARGE CURVE OF HIGH & LOW LEVEL CHANNELS

To accompany report on PASQUIA RECLAMATION PROJECT

BY THOS H DUNN, C. E

Thos H Dunn Chief Engineer of Reclamation

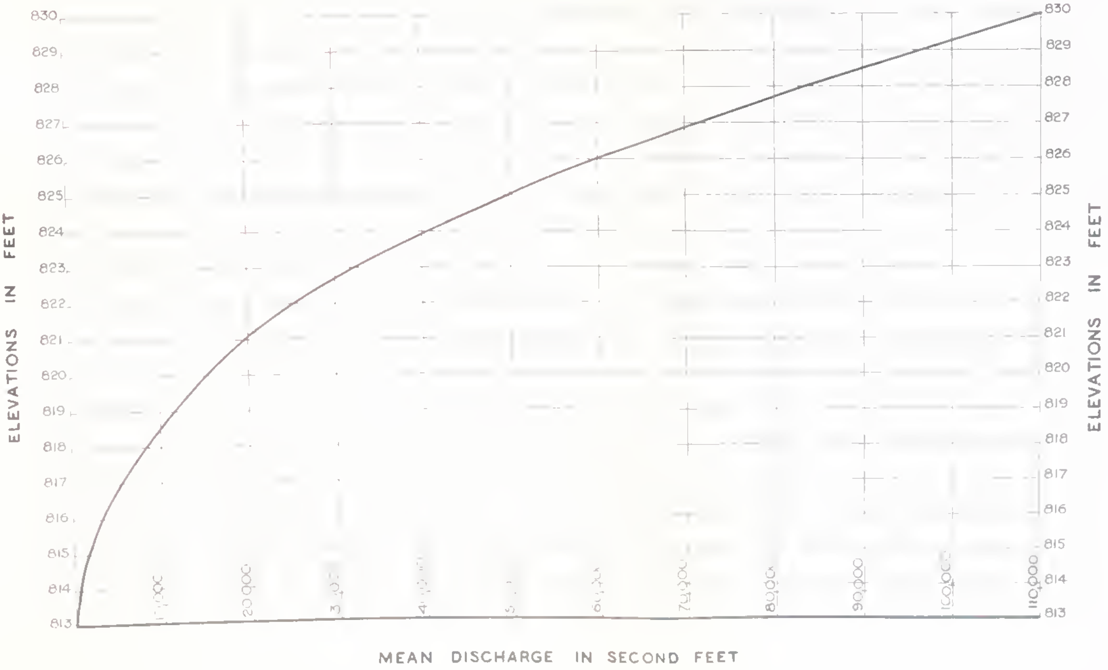

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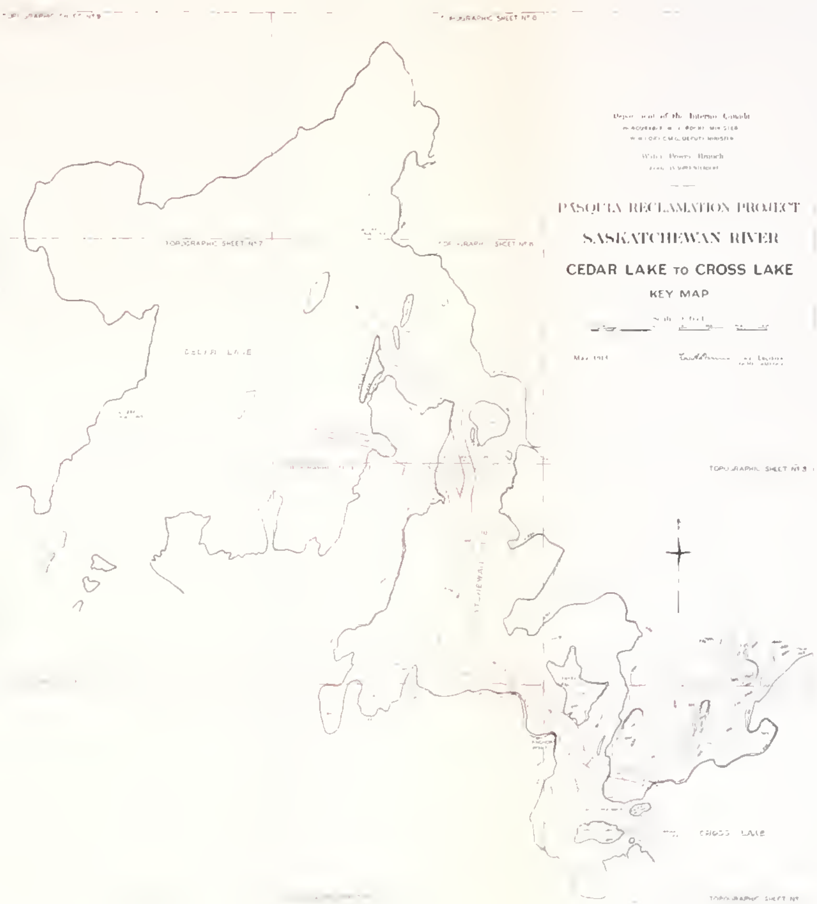
PLATE Nº 40



PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
KEY MAP
TOPOGRAPHIC SHEET Nº 7
TOPOGRAPHIC SHEET Nº 9
CROSS LAKE

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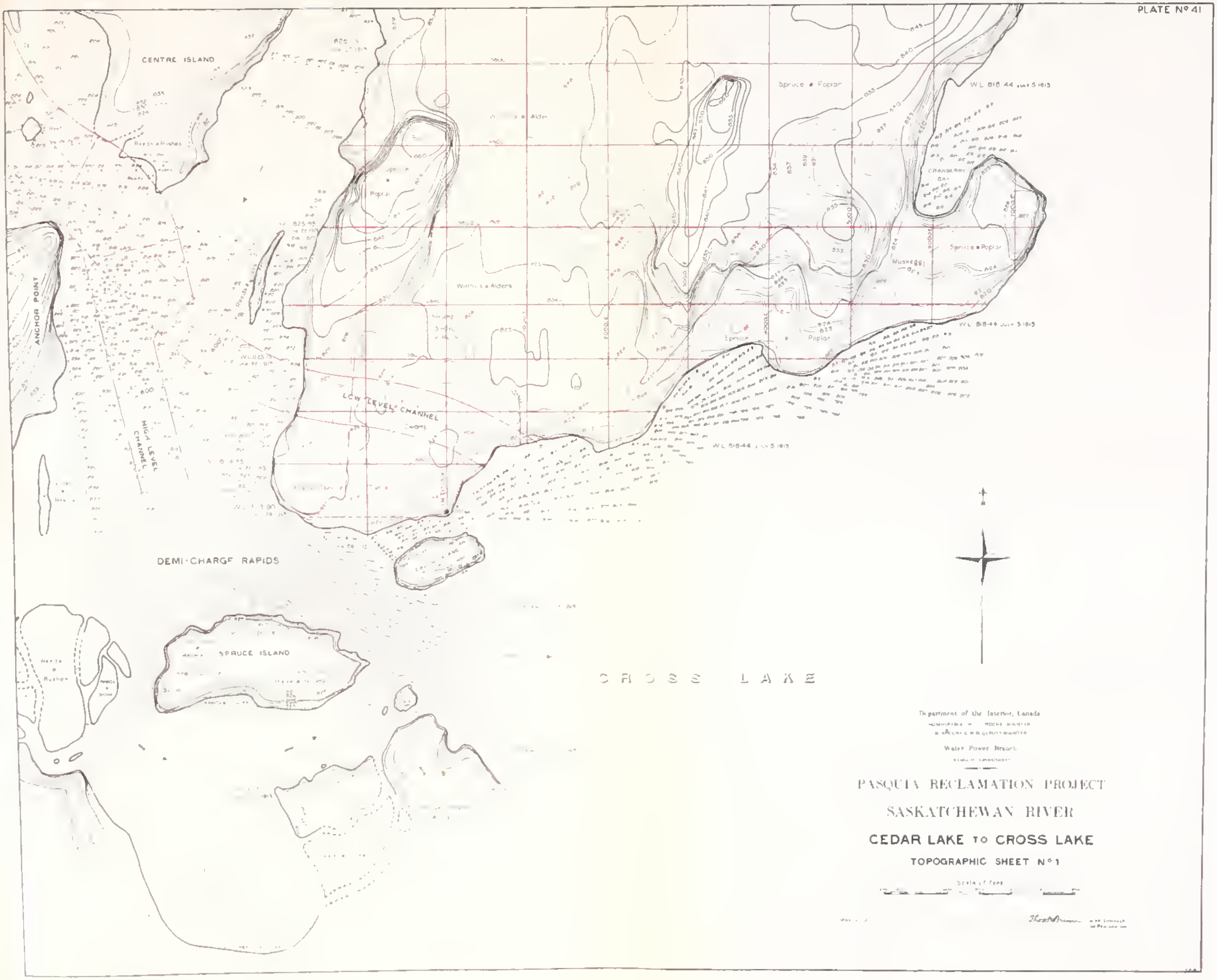
CENTRE ISLAND
ANCHOR POINT
HIGH LEVEL CHANNEL
LOW LEVEL CHANNEL
DEMI-CHARGE RAPIDS
SPRUCE ISLAND
CROSS LAKE
Spruce & Poplar
CRANBERRY BAY
Willows & Alders
Muskeg
Reeds & Rushes
WL 818·44
Department of the Interior, Canada
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 1
Scale of Feet

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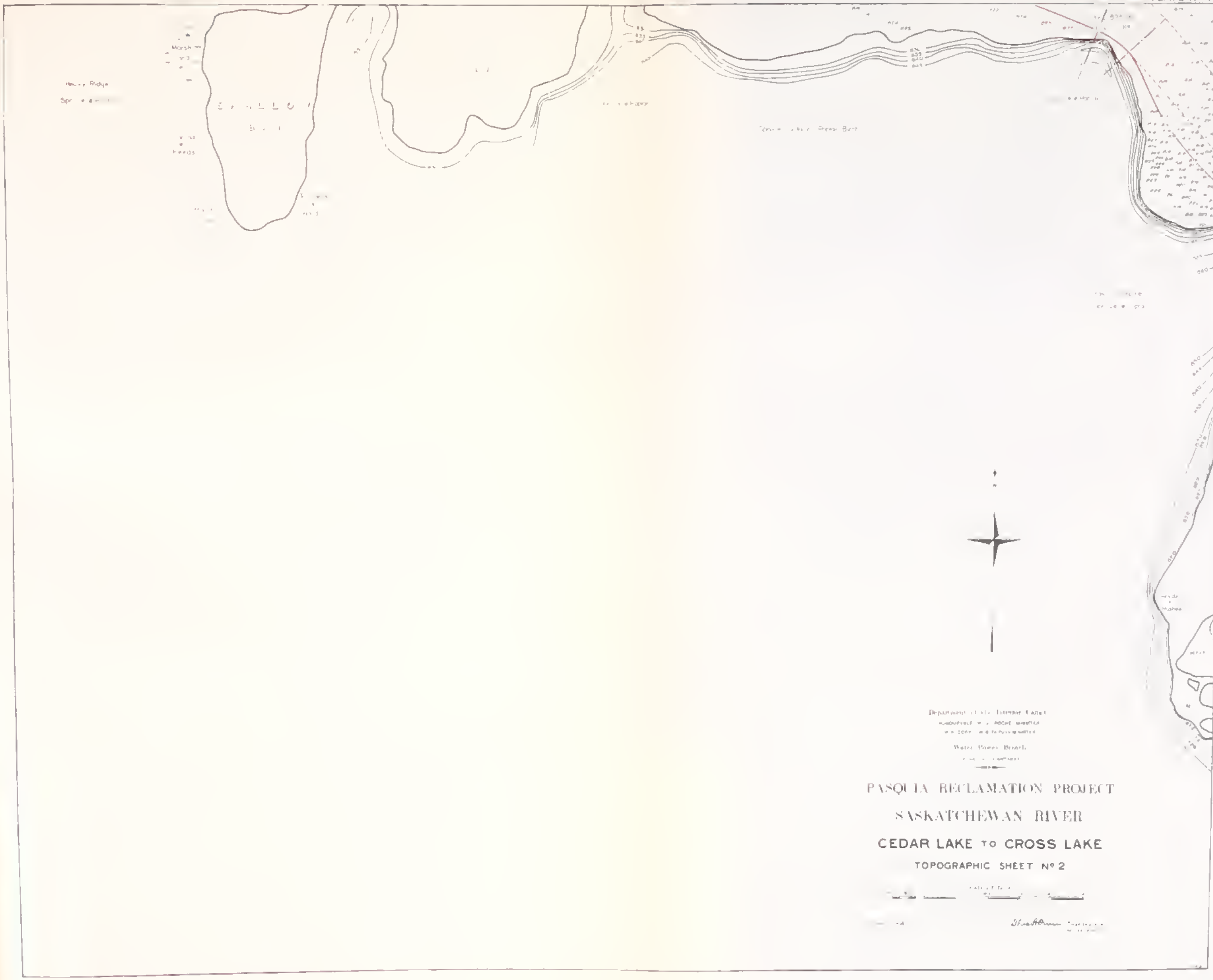
Marsh
Reeds
Water Power Board
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 2

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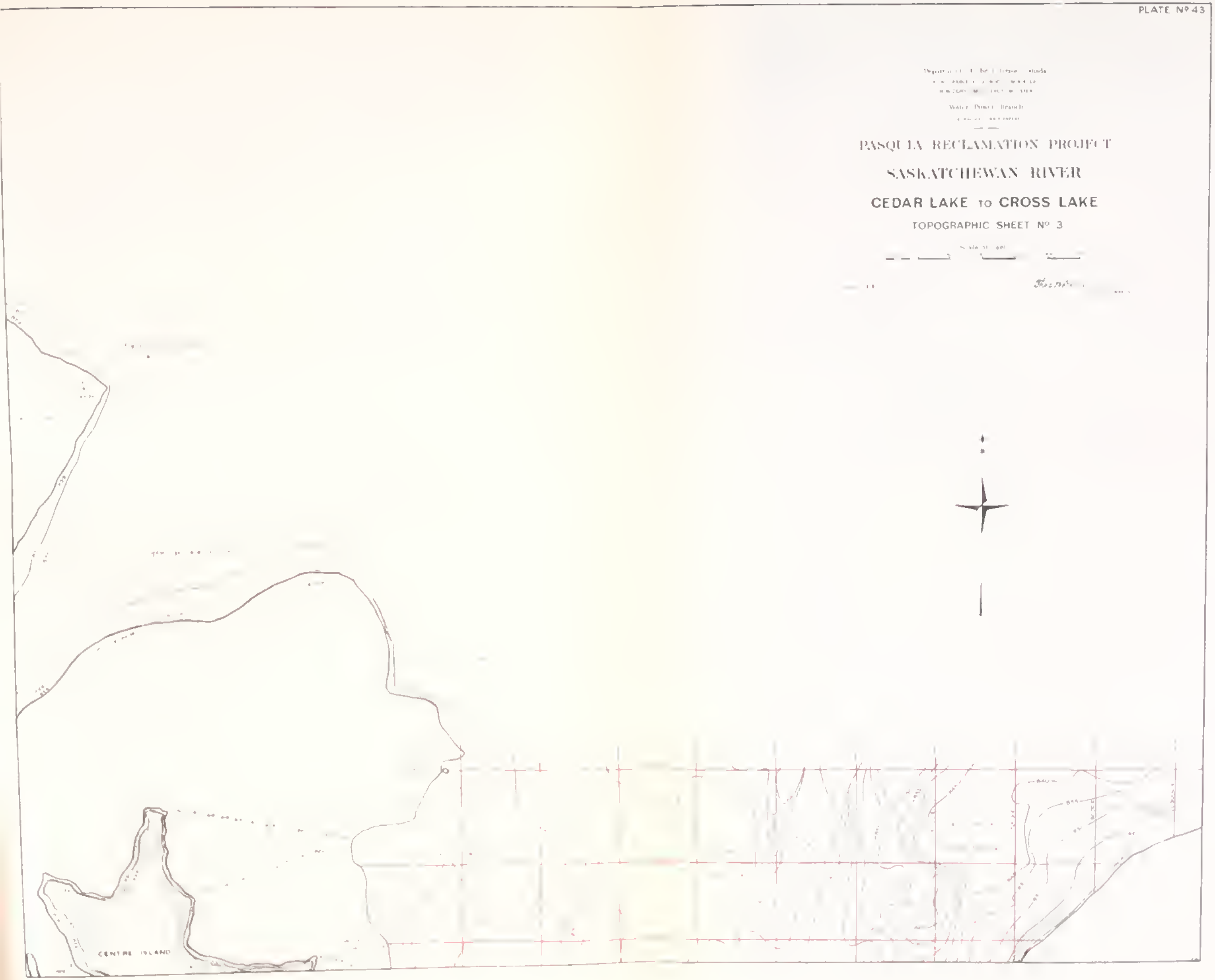
PLATE Nº 43


Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 3
CENTRE ISLAND

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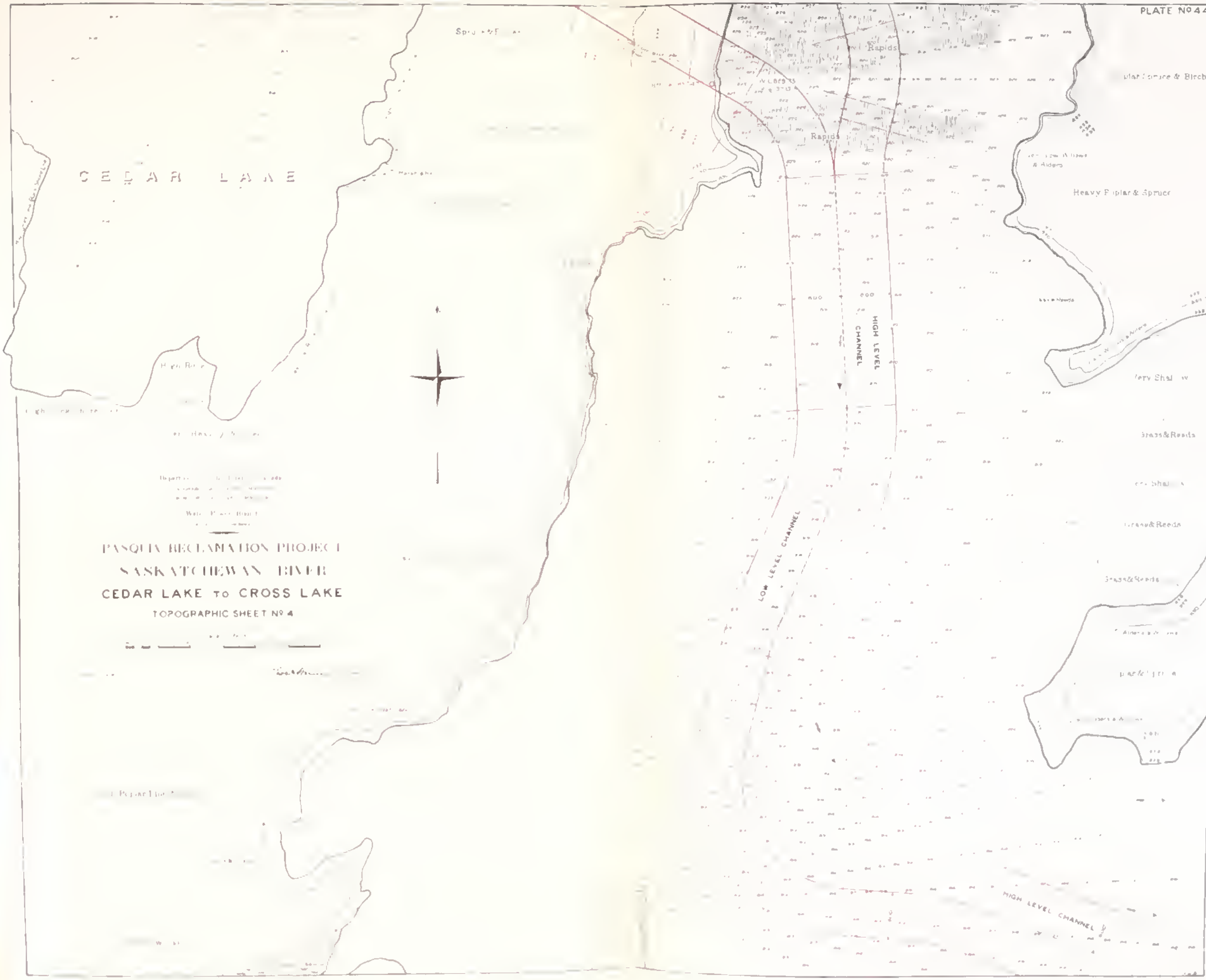


PLATE Nº 44
CEDAR LAKE
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE to CROSS LAKE
TOPOGRAPHIC SHEET Nº 4
Rapids
Rapids
Heavy Poplar & Spruce
Grass&Reeds
Grass&Reeds
Grass&Reeds
HIGH LEVEL CHANNEL
LOW LEVEL CHANNEL
HIGH LEVEL CHANNEL

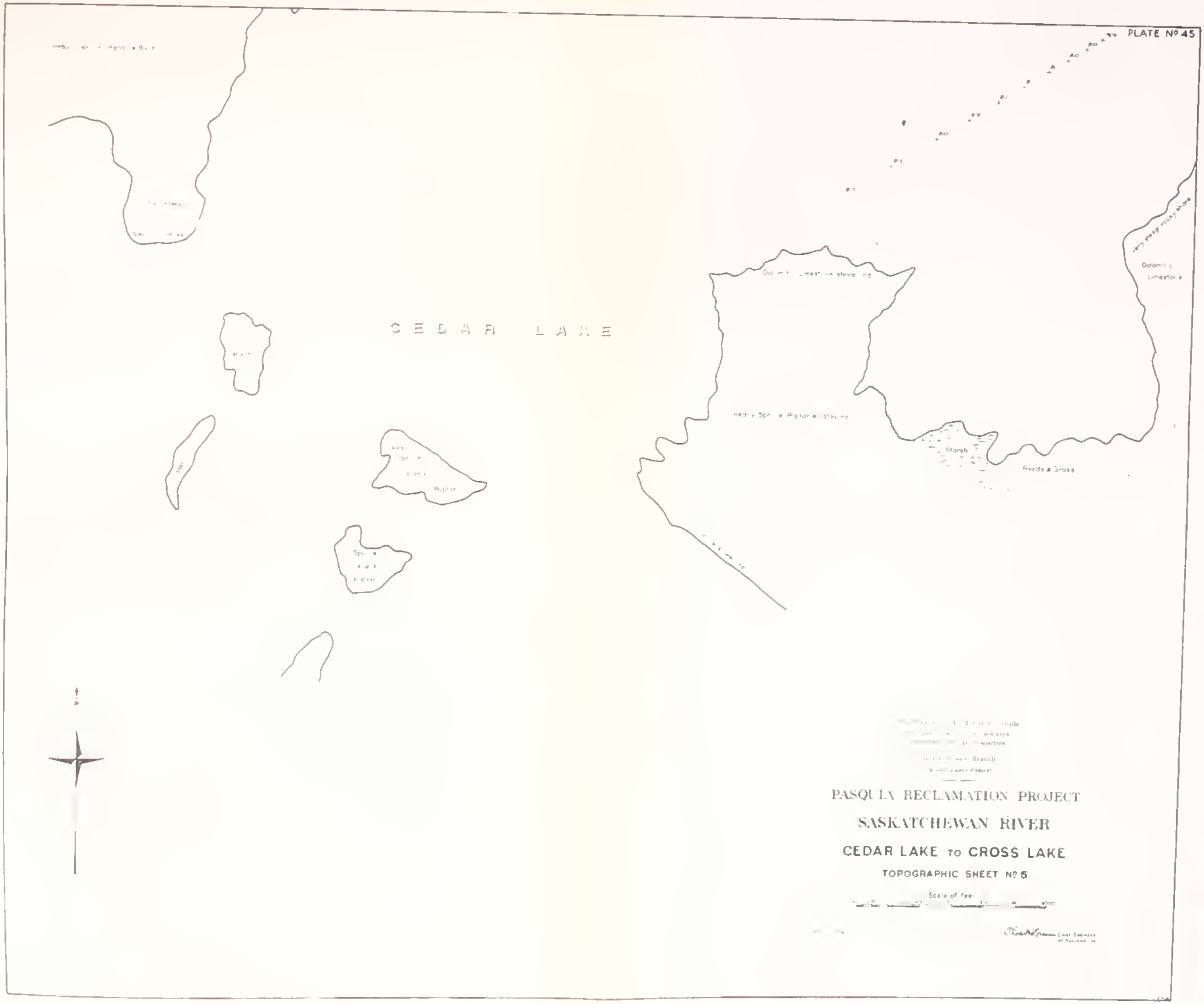


PLATE Nº 45
CEDAR LAKE
Marsh
Reeds & Grass
Dolomitic Limestone
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 5
Scale of feet

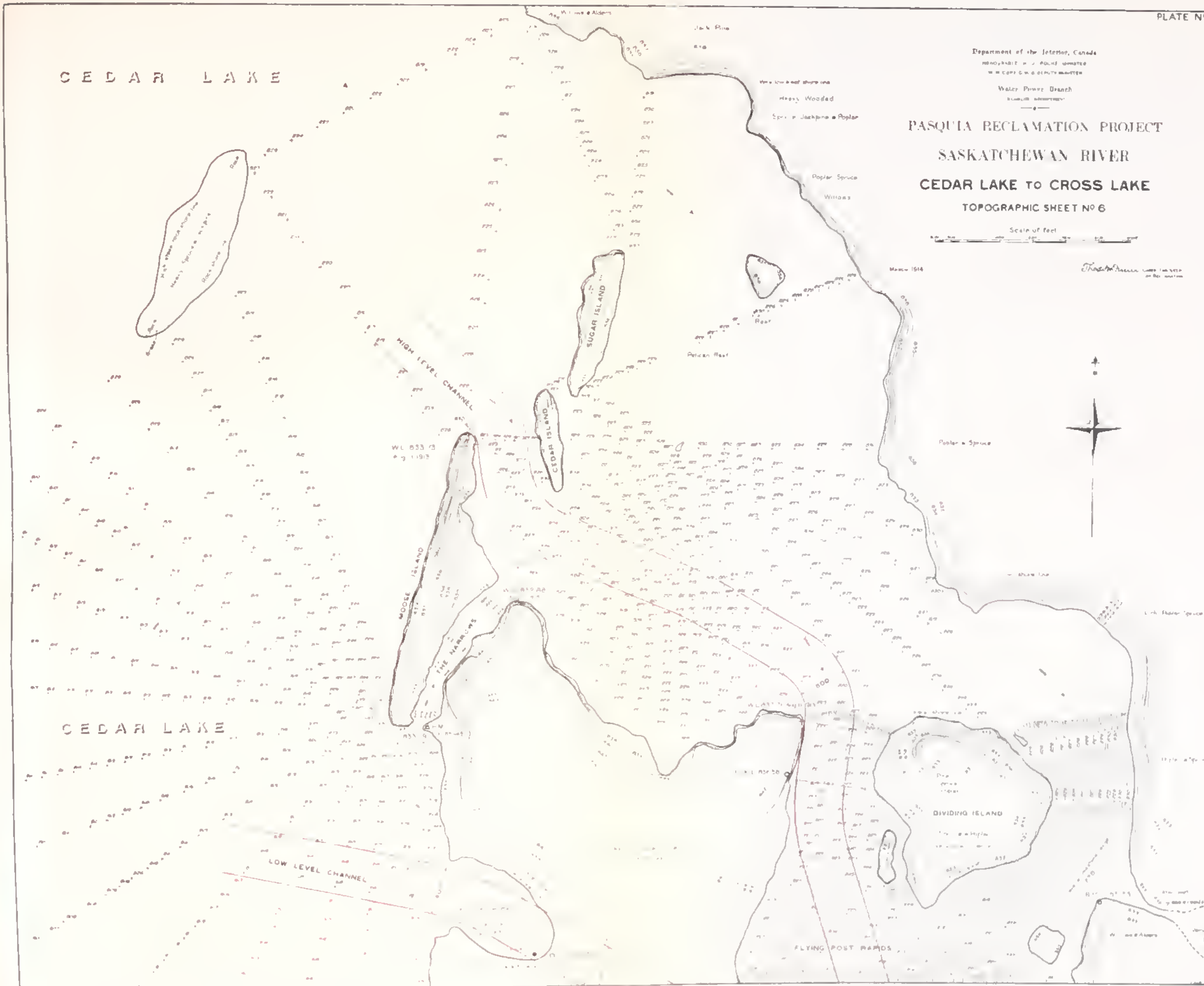
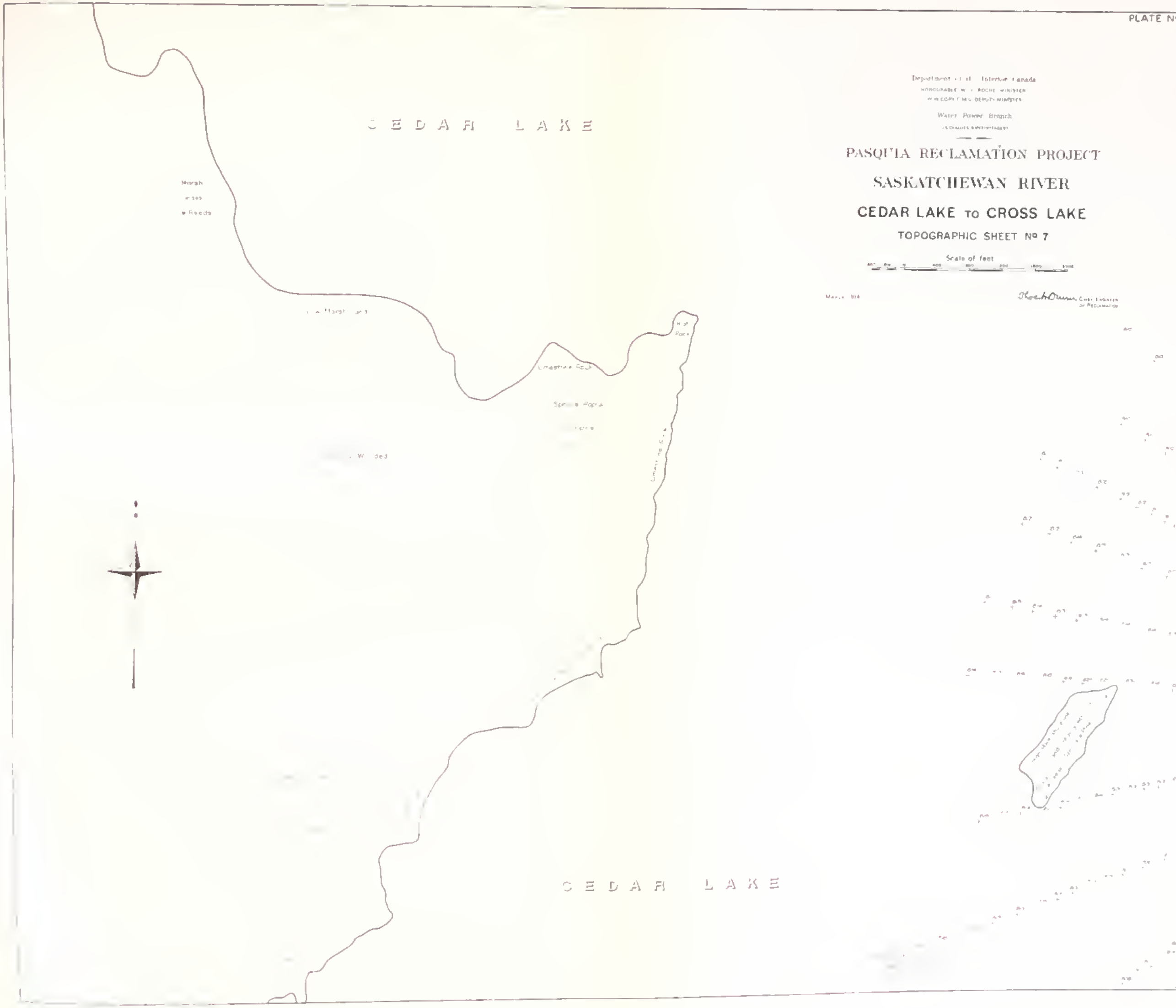


PLATE No 46
Department of the Interior, Canada
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET No 6
Scale of feet
March 1914
CEDAR LAKE
Jack Pine
Heavy Wooded
Poplar Spruce
Willows
Reef
Pelican Reef
HIGH LEVEL CHANNEL
SUGAR ISLAND
CEDAR ISLAND
Poplar & Spruce
MOOSE ISLAND
THE NARROWS
CEDAR LAKE
DIVIDING ISLAND
LOW LEVEL CHANNEL
FLYING POST RAPIDS

PLATE Nº 47



Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 7
Scale of feet
CEDAR LAKE
Marsh
CEDAR LAKE

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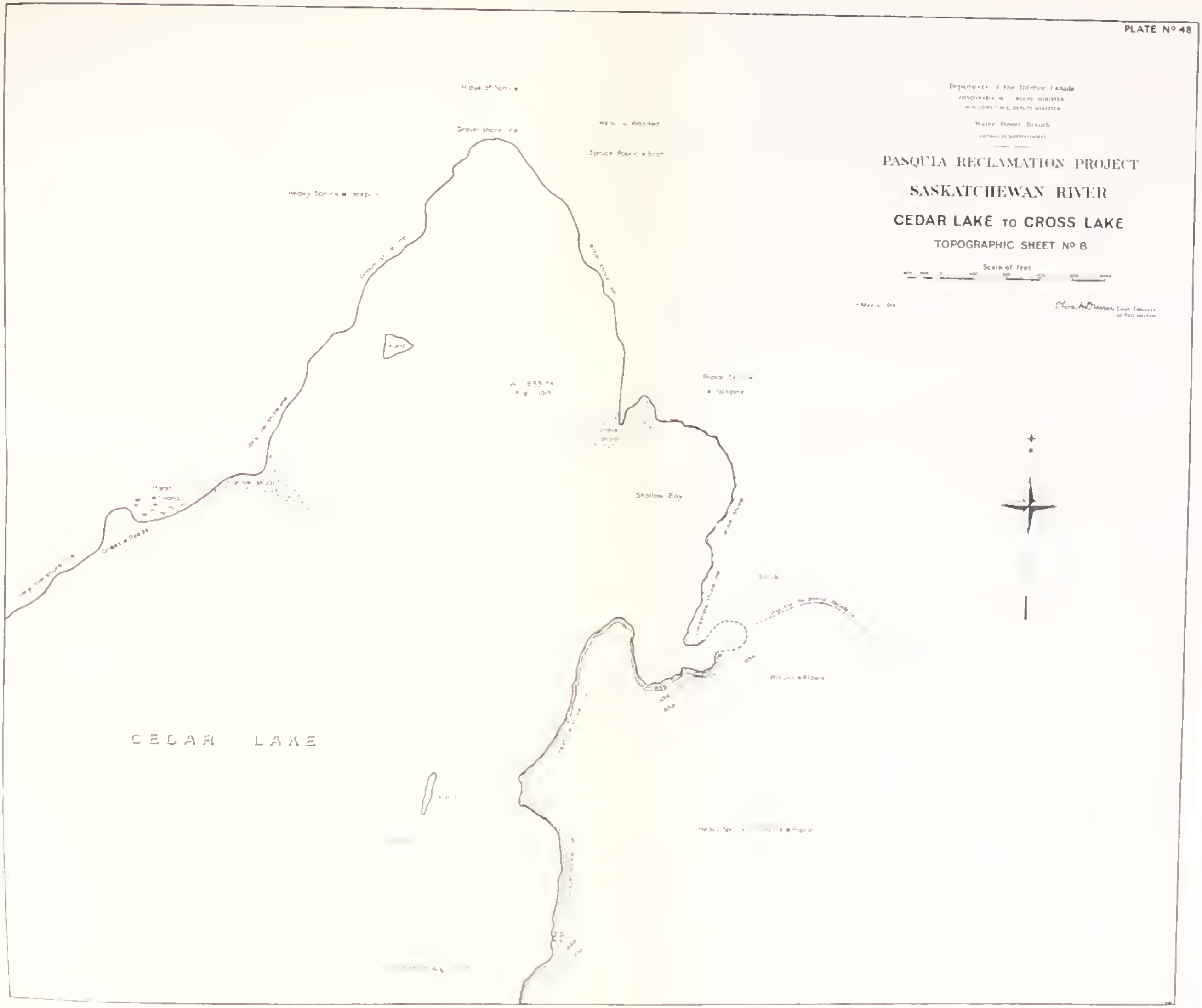
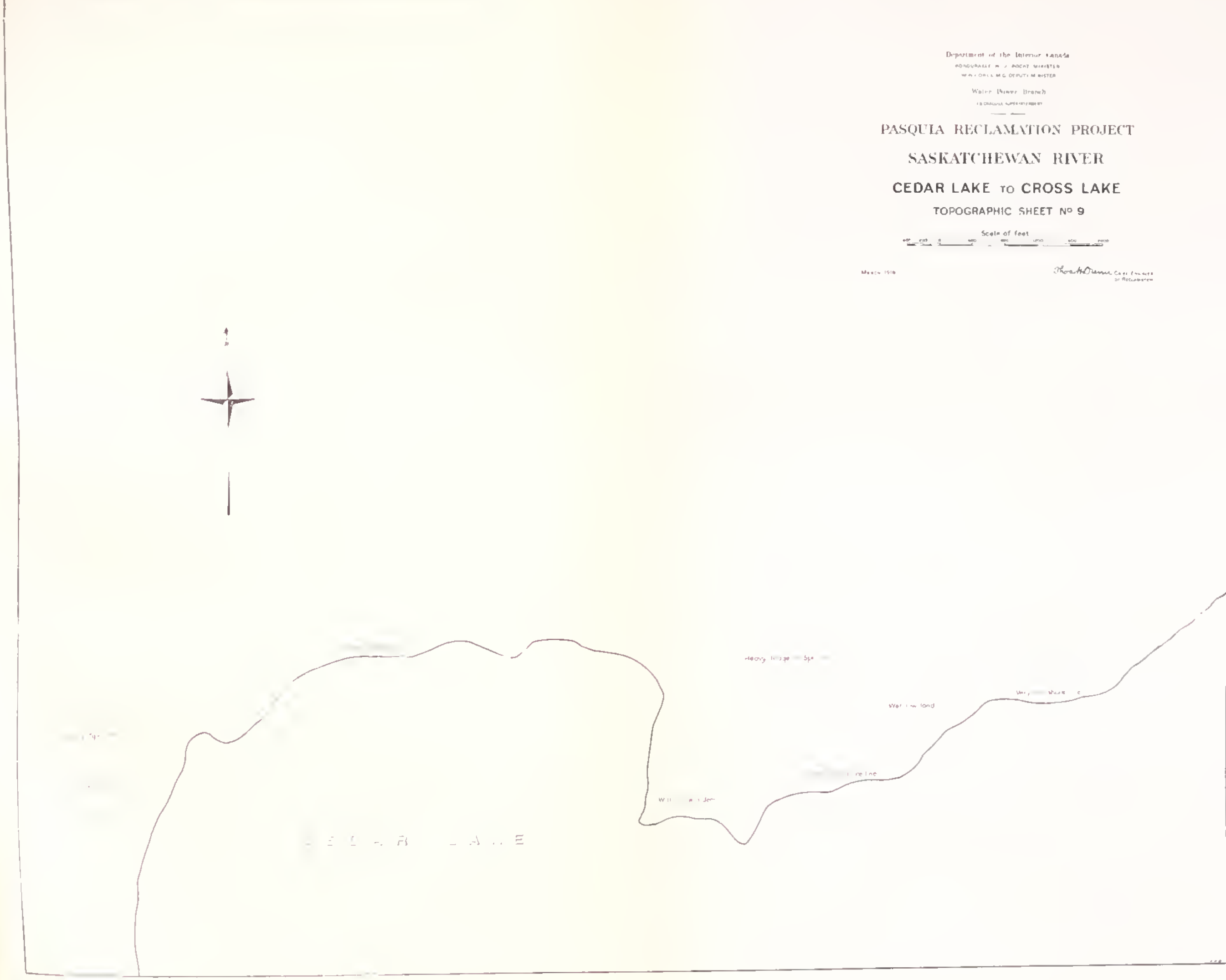


PLATE Nº 48
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº B
Scale of feet
Gravel shore line
Spruce Poplar & Birch
Shallow Bay
Willows & Alders
CEDAR LAKE

1

PLATE Nº 49



Department of the Interior Canada
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO CROSS LAKE
TOPOGRAPHIC SHEET Nº 9
Scale of feet


PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE to FRYING PAN
TOPOGRAPHIC SHEET No 1
DUNCAN ISLAND
CEDAR LAKE
OLESON'S POINT

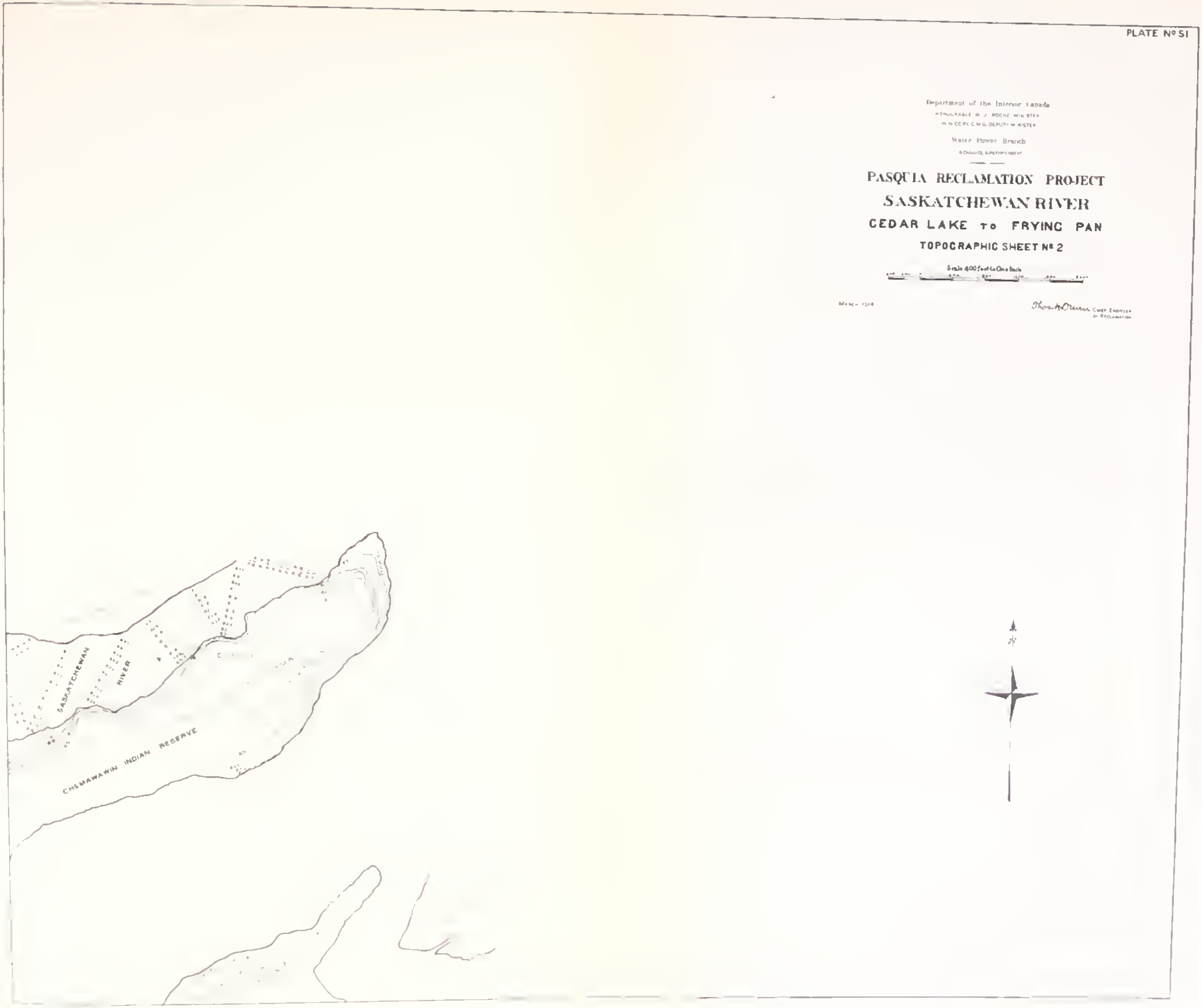
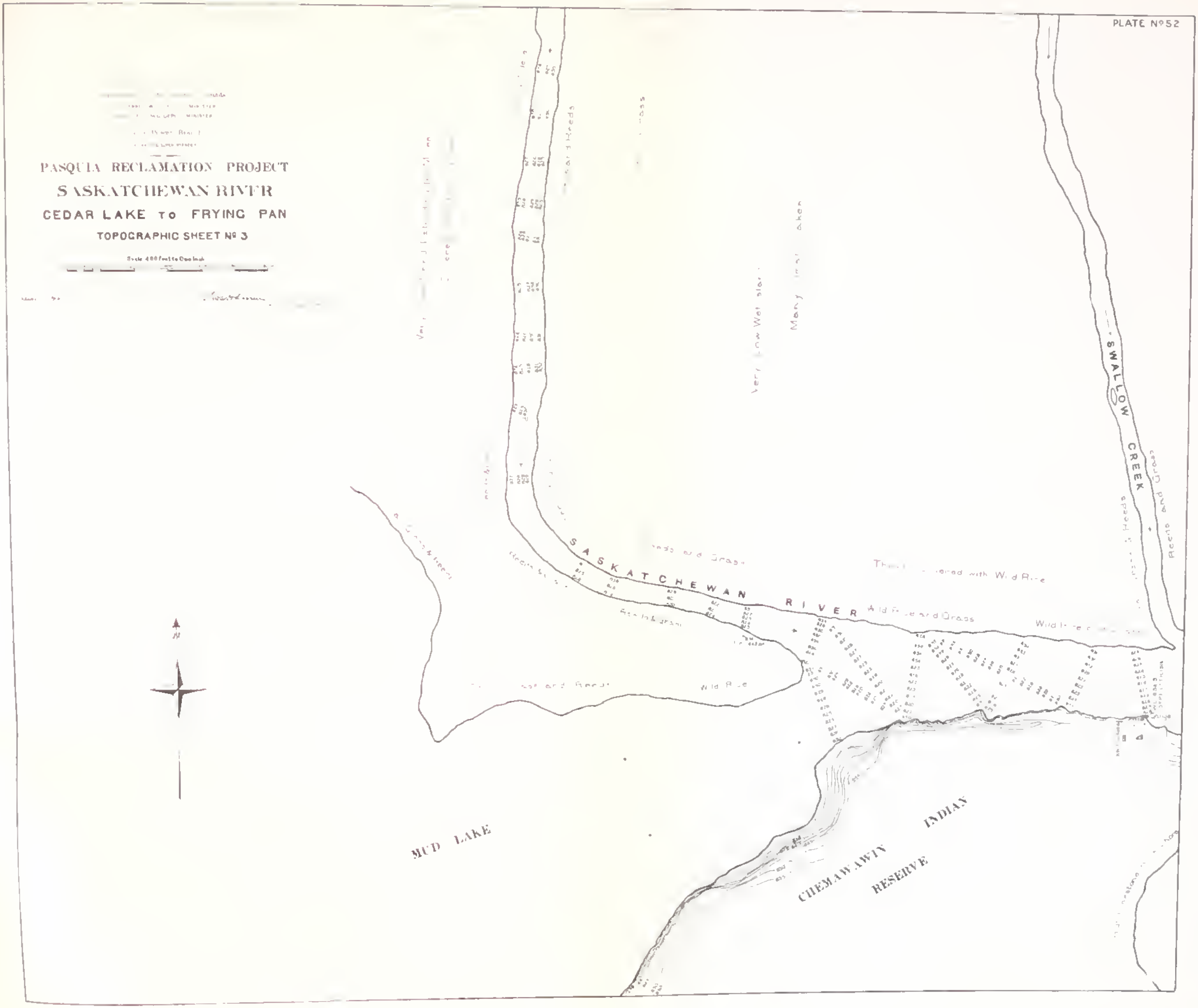


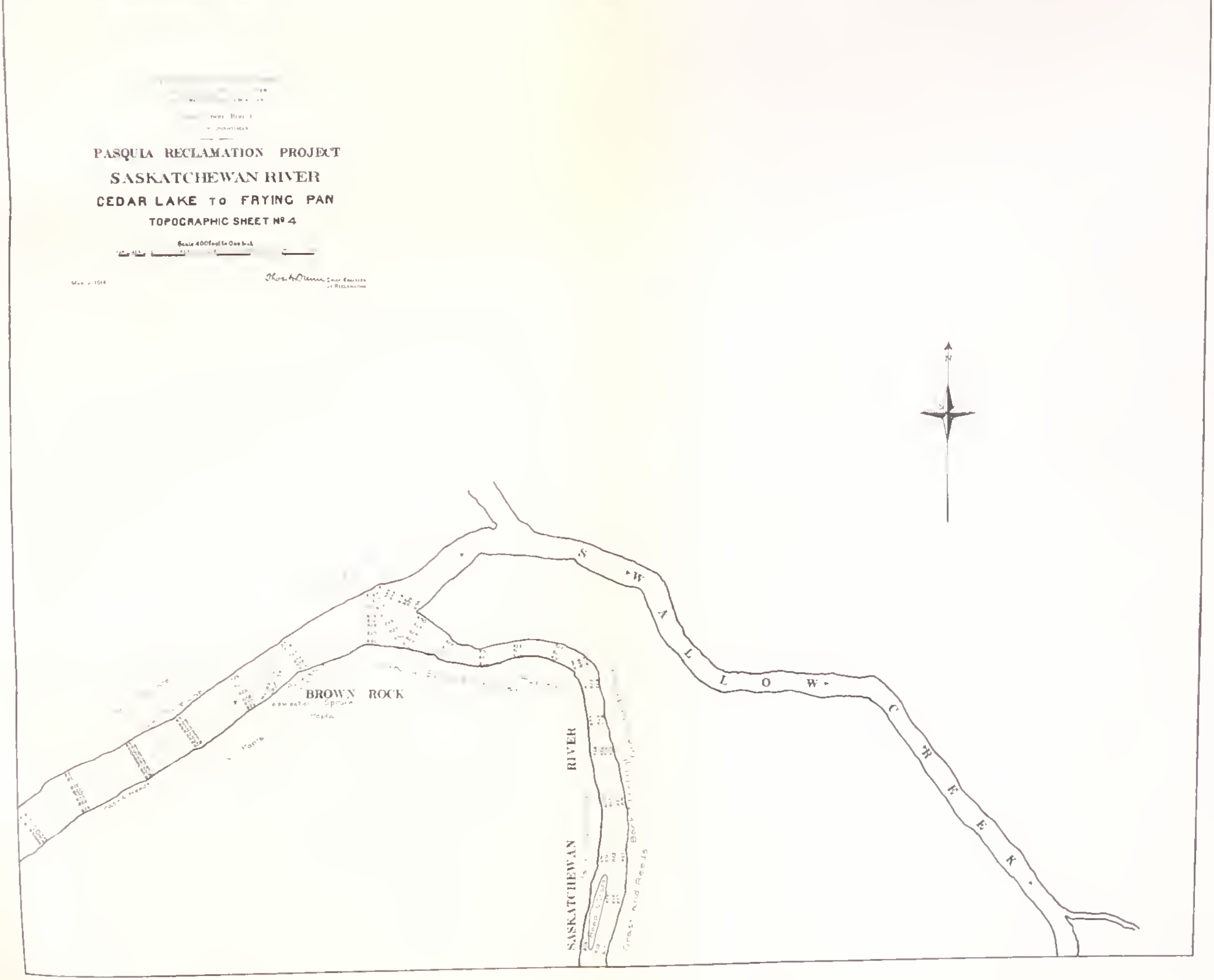
PLATE Nº 51
Department of the Interior Canada
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE to FRYING PAN
TOPOGRAPHIC SHEET Nº 2
Scale 400 feet to One Inch
Chief Engineer of Reclamation
SASKATCHEWAN
RIVER
CHEMAWAWIN INDIAN RESERVE

PLATE Nº 52



PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO FRYING PAN
TOPOGRAPHIC SHEET Nº 3
SASKATCHEWAN RIVER
SWALLOW CREEK
MUD LAKE
CHEMAWAWIN INDIAN RESERVE

PLATE No 53


PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO FRYING PAN
TOPOGRAPHIC SHEET No 4
Scale 400 feet to One Inch
BROWN ROCK
SASKATCHEWAN RIVER
SWALLOW CREEK
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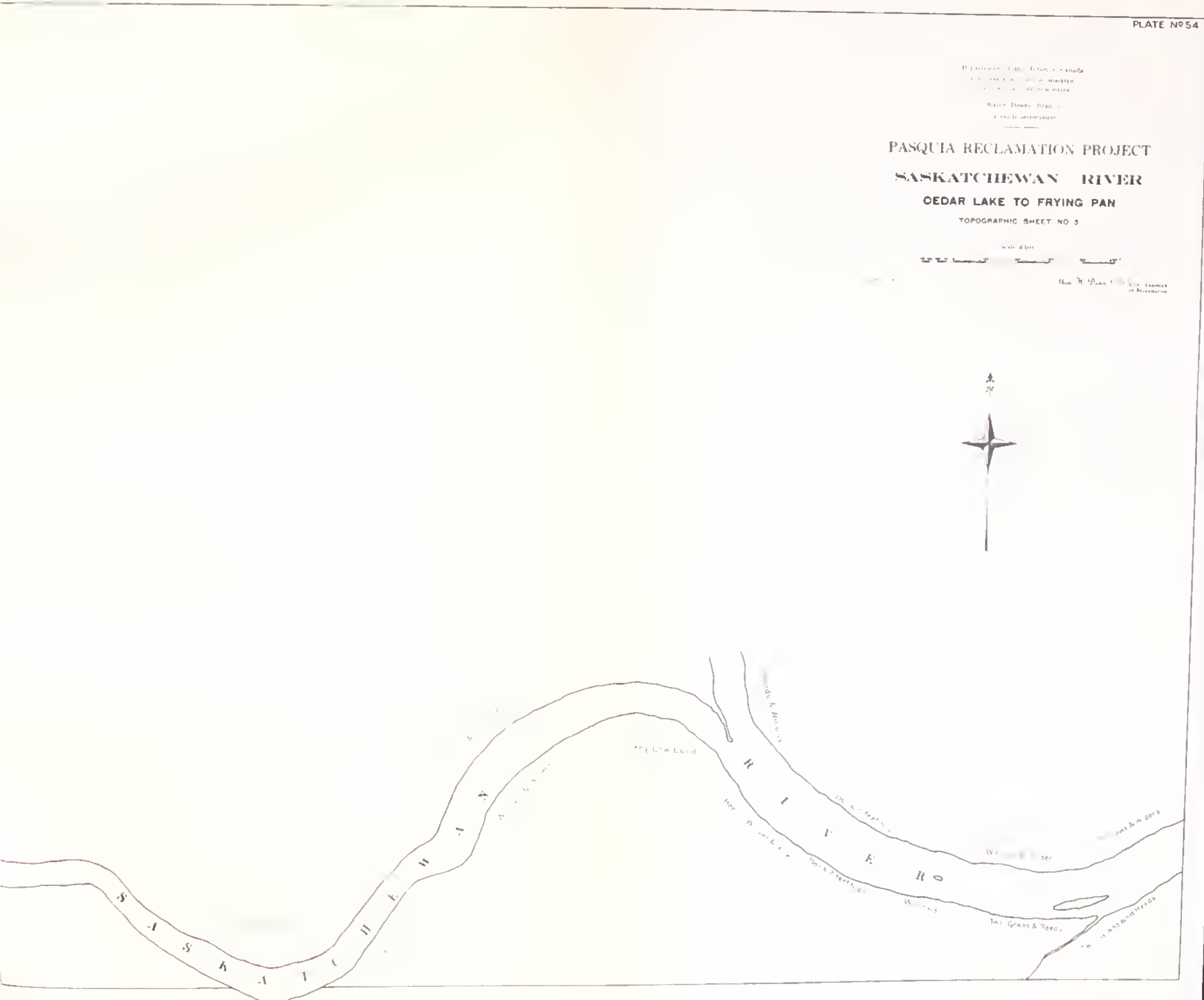


PLATE No 54
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO FRYING PAN
TOPOGRAPHIC SHEET NO 5
SASKATCHEWAN RIVER

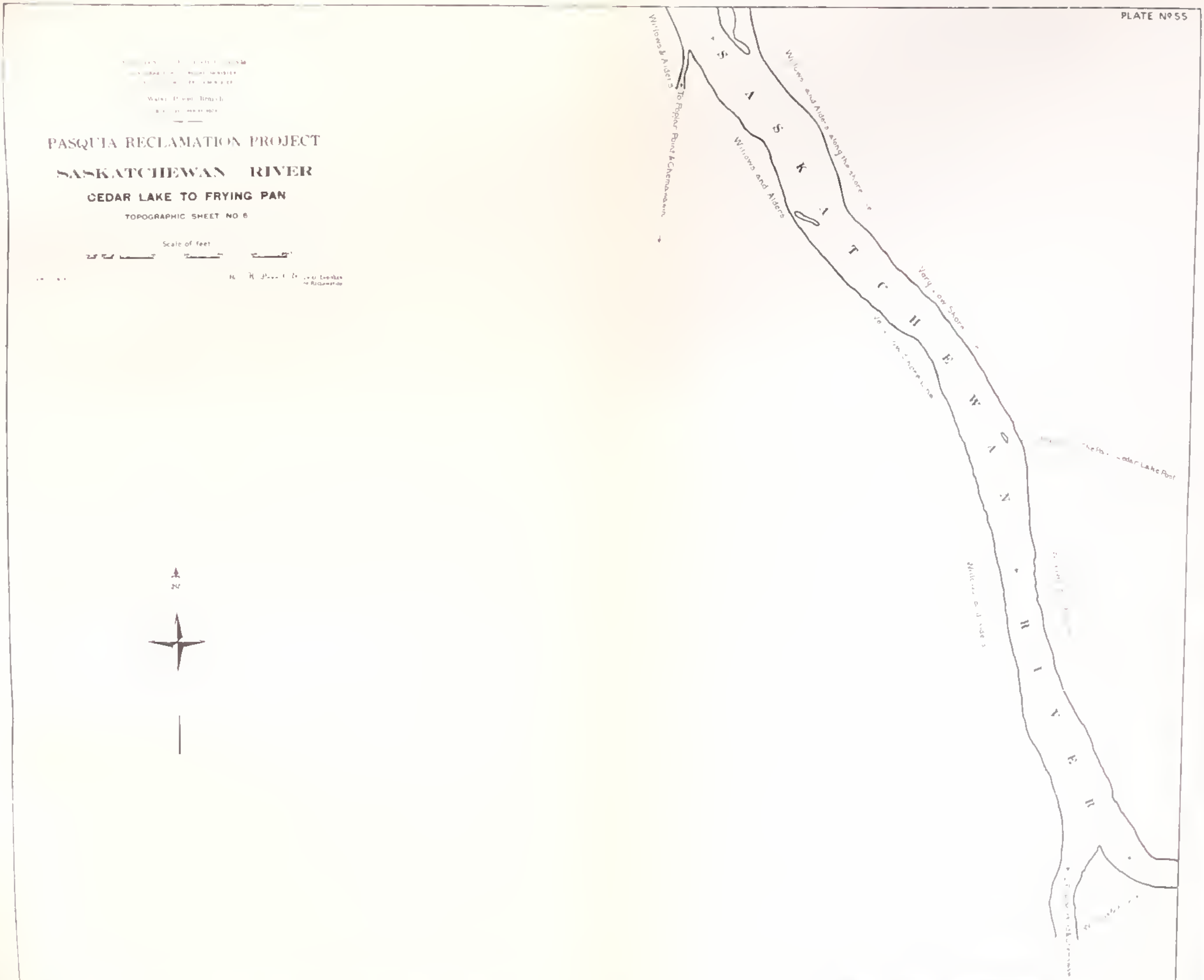
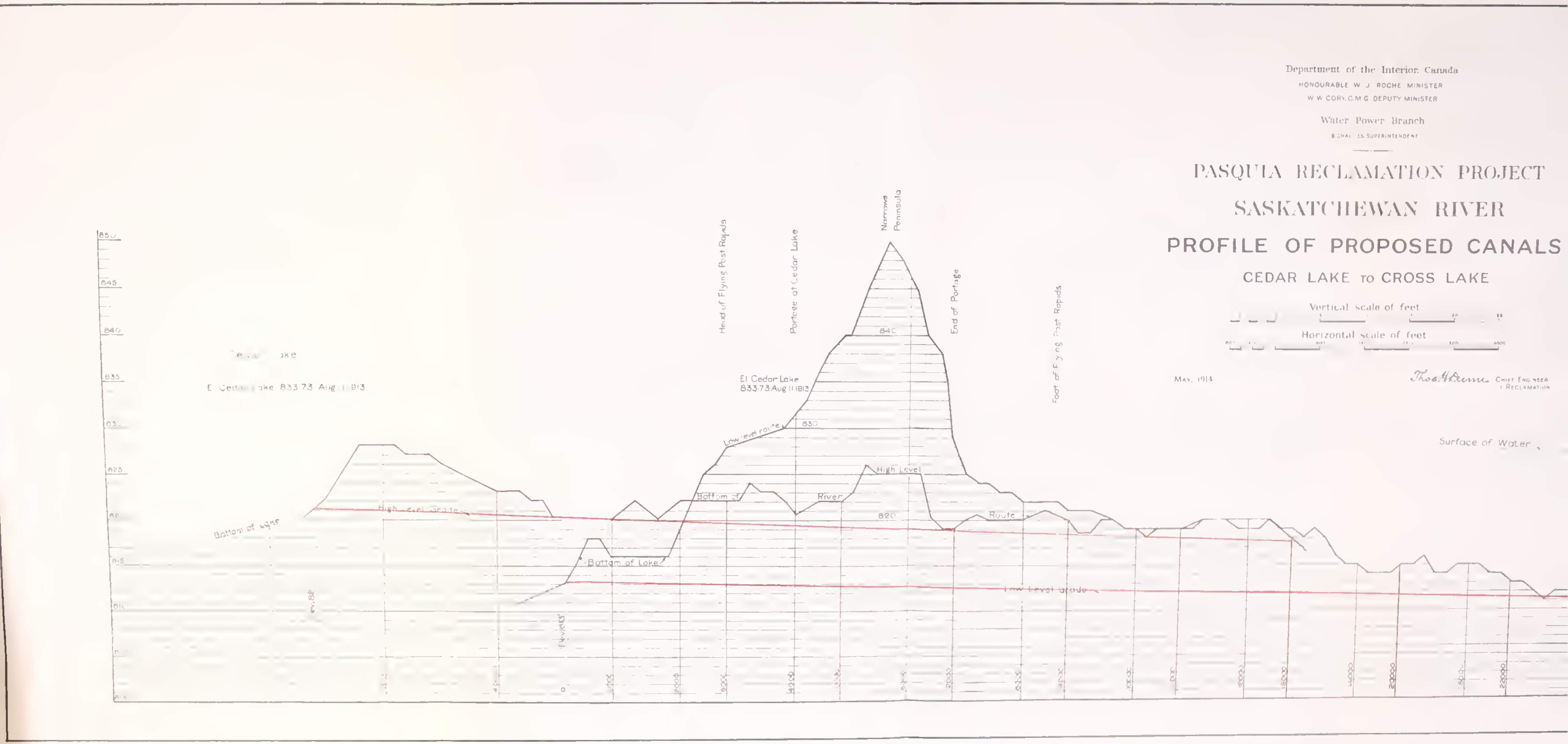

PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO FRYING PAN
TOPOGRAPHIC SHEET NO 6
Scale of feet
SASKATCHEWAN RIVER
Willows & Alders
To Poplar Point & Chemawawin
Willows and Alders along the shore
Willows and Alders
Very Low Shore
Cedar Lake Post

PLATE Nº 56


PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
CEDAR LAKE TO FRYING PAN
TOPOGRAPHIC SHEET NO 7
FRYING PAN
SASKATCHEWAN RIVER



Department of the Interior Canada
HONOURABLE W. J. ROCHE MINISTER
W. W. CORY, C.M.G. DEPUTY MINISTER
Water Power Branch
PASQUIA RECLAMATION PROJECT
SASKATCHEWAN RIVER
PROFILE OF PROPOSED CANALS
CEDAR LAKE TO CROSS LAKE
Vertical scale of feet
Horizontal scale of feet
May, 1914
850
845
840
835
825
815
El Cedar Lake 833.73 Aug 11 1913
Head of Flying Post Rapids
Portage at Cedar Lake
Narrows
Peninsula
End of Portage
Foot of Flying Post Rapids
Bottom of Lake
High level grade
Bottom of Lake
Low level route
Bottom of
River
High Level
Route
Low Level grade
Surface of Water
830
840
820

PLATE Nº 57

Department of the Interior, Canada

HONOURABLE W. J. ROCHE MINISTER

W. W. CORY C.M.G. DEPUTY MINISTER

Water Power Branch

QUIA RECLAMATION PROJECT

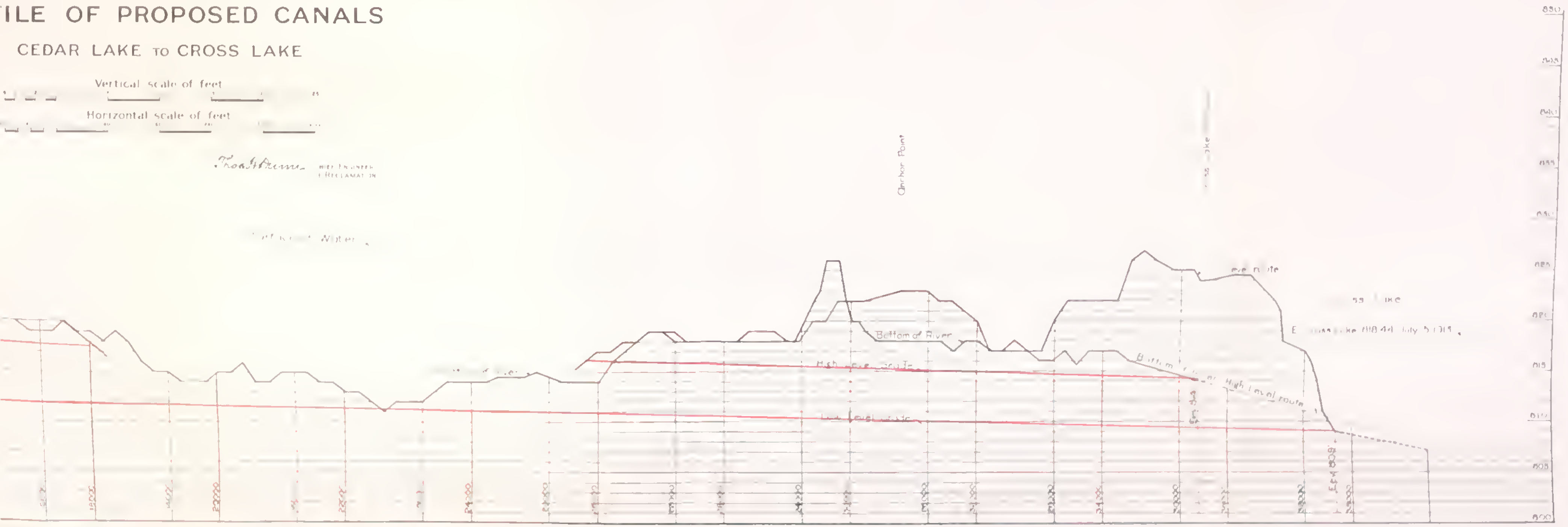
SASKATCHEWAN RIVER

ILE OF PROPOSED CANALS

CEDAR LAKE TO CROSS LAKE

Vertical scale of feet

Horizontal scale of feet



or 5,000 second-feet, and to regulate the flow requires a very large storage area. The interests of reclamation demand that storage be done away with, that the lands be protected from flooding, and that the lakes into which they drain have a free outlet.

It is true that the water in Cedar lake could be so regulated as to increase the winter flow to some extent, but it would be of little value, and this treatment would require a larger canal to prevent the lake from rising too high during the flood period.

As the power at Grand Rapids is being investigated by the Water Power Branch, any discussion of it is out of place at this time.

SUMMARY.

Judging from the information that has been secured and recorded in the foregoing report, I am of the opinion that the area applied for, viz., the eastern Pasquia district, may be reclaimed at a cost of approximately $7,160,000, exclusive of the cost of the service drains which are necessary to connect the interior districts with the outlet; that the cost of the work seems out of proportion to the benefits to be derived, but the value of the lands thus reclaimed is not known with sufficient accuracy to justify an expression of opinion as to the economy of the scheme; that the navigability of the river will be greatly improved by the construction of the works; that the interests of water-power development at Grand Rapids will be adversely affected, and that the time required for the completion of the canals will be not less than four years from the time excavation is actually commenced.

CONCLUSION.

In a consideration of this report and estimates, due allowance must be made for the indefiniteness arising from lack of data concerning the value and extent of the reclamation district, the classification of materials of excavation, the nature and extent of the work, which may be necessary west of The Narrows, and such other matters as have been cited in the report.

From the information presented herein, I do not consider the proposition a very attractive one as an investment at the prevailing price of land. A more intimate knowledge of the value of the lands in the interior might, however, make it necessary to alter this view.

It seems probable, however, that with the completion of the proposed power development at Grand Rapids and the consequent opening up of the Saskatchewan river to navigation, and the cheap power and cheap transportation thus supplied, the cost of constructing the Cedar lake drainage canals would be much reduced. If, in addition, the drainage scheme could be worked out in conjunction with the navigation plans of the Department of Public Works, and the reclamation scheme now being investigated west of The Pas, with a fair division of the costs, there is no doubt that the reclamation and sale of the lands in the eastern Pasquia district could be made to return a fair profit on the investment.

The drainage and settlement of this immense district is most desirable, and of great importance to the province of Manitoba, as well as to Canada, not only because of the agricultural and industrial development of the flooded district itself, but because of the adjoining areas which are at present more or less isolated or rendered undesirable by the proximity of the wet and swampy areas, and also because it is by the drainage of this area that the very desirable and enormous flooded area west of The Pas may best be reclaimed.

I have the honour to be, sir,

Your obedient servant,

THOS. H. DUNN,

Chief Engineer of Reclamation.

Discharge Measurements of Saskatchewan River near Le Pas, 1912-13.

Date.	Hydrographer.	Meter No.	Width.	Area of section.	Mean velocity	Gauge height.	Discharge
1912.			Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
Oct. 21, 22..	W. G. Worden...	1,196	914	18,093	2·11	....	38,123
Dec. 14.....	G. J. Lamb......................	1,187	834	12,848	0·68	....	*8,772
1913.							
Feb. 8, 9....	A. Pirie............................	1,469	771	9,563	0·53	....	*5,105
Apr. 9.....	"	1,186	775	10,548	0·72	....	*7,562
May 31.....	E. Bankson......................	1,469	761	14,233	3·10	9·46	45,182
June 4.....	G. Ebner.........................	1,186	750	13,331	3·31	9·37	44,124
" 10.....	"	1,186	750	13,899	3·38	9·79	46,979
" 12.....	"	1,186	760	14,041	3·51	10·14	49,285
" 14.....	"	1,186	739	14,197	3·63	10·35	51,534
July 10.....	"	1,196	758	15,446	3·69	11·98	56,948
" 12.....	"	1,196	760	15,587	3·58	12·15	57,743
" 15.....	"	1,196	756	15,848	3·79	12·37	60,114
" 18.....	"	1,196	756	16,000	3·93	12·58	62,883
" 21.....	"	1,196	780	16,066	3·98	12·76	63,970
" 23.....	"	1,196	673	16,107	3·86	12·80	62,120
" 25.....	"	1,196	756	16,309	3·93	12·91	64,199
" 28.....	"	1,196	750	16,342	3·91	12·96	63,869
" 30.....	"	1,196	756	16,332	3·85	12·94	63,025
Aug. 1.....	"	1,196	756	16,311	3·82	12·85	62,385
" 4.....	"	1,196	756	16,146	3·84	12·65	62,029
" 6.....	"	1,196	756	16,043	3·75	12·50	60,357
" 28.....	W. J. Ireland....................	1,469	774	15,229	3·62	11·41	55,101
Sept. 20.....	"	1,469	729	13,422	3·03	8·98	40,707
Oct. 9.....	C. O. Allen......................	1,435	648	11,040	2·50	6·07	27,532
" 23.....	"	1,435	648	11,171	2·15	6·35	†24,025
Nov. 18.....	A. Pirie...........................	1,496	830	12,938	0·92	3·70	*11,890

*Ice Measurement.
†Ice running in river.

Approximate Daily Gauge Height and Discharge for the year 1912, Saskatchewan River near The Pas, Manitoba.
(Drainage area, 149,500 square miles.)

Day.	April. Gauge height.	April. Dis-charge.	May. Gauge height.	May. Dis-charge.	June. Gauge height.	June. Dis-charge.	July. Gauge height.	July. Dis-charge.	August. Gauge height.	August. Dis-charge.	September. Gauge height.	September. Dis-charge.	October. Gauge height.	October. Dis-charge.	November. Gauge height.	November. Dis-charge.	Day.
1	…	…	10·8	52,140	8·6	40,480	8·25	38,625	13·8	68,040	13·4	65,920	13·1	64,330	7·7	35,710	1
2	…	…	11·2	54,260	8·6	40,480	8·4	39,420	13·8	68,040	13·4	65,920	13·0	63,800	7·5	34,650	2
3	…	…	11·1	53,730	8·6	40,480	8·5	39,950	13·8	68,040	13·45	66,185	12·9	63,270	7·3	33,590	3
4	…	…	11·0	53,200	8·6	40,480	8·7	41,010	13·8	68,040	13·45	66,185	12·7	62,210	7·4	34,120	4
5	…	…	10·8	52,140	8·6	40,480	8·9	42,070	14·6	72,280	13·45	66,185	12·5	61,150	7·5	34,650	5
6	…	…	10·3	49,490	8·6	40,480	9·1	43,130	14·9	73,870	13·45	66,185	12·3	60,090	7·6	35,180	6
7	…	…	10·1	48,430	8·7	41,010	9·3	44,190	14·9	73,870	13·45	66,185	12·1	59,030	7·6	35,180	7
8	…	…	9·8	46,840	8·9	42,070	9·5	45,250	14·9	73,870	13·45	66,185	11·9	57,970	7·65	35,445	8
9	…	…	9·6	45,790	9·0	42,600	9·75	46,575	14·8	73,340	13·45	66,185	11·7	56,910	7·75	35,975	9
10	…	…	9·5	45,250	9·0	42,600	10·0	47,900	14·7	72,810	13·45	66,185	11·55	56,115	7·9	36,770	10
11	…	…	9·3	44,190	9·05	42,865	10·25	49,225	14·6	72,280	13·5	66,450	11·35	55,035	8·05	37,565	11
12	…	…	9·2	43,660	8·9	42,070	10·6	51,080	14·5	71,750	13·55	66,715	11·15	53,955	8·25	38,625	12
13	…	…	9·1	43,130	8·8	41,540	10·8	52,140	14·4	71,220	13·6	66,980	10·9	52,670	8·4	39,420	13
14	…	…	8·8	41,540	8·7	41,010	11·0	53,200	14·3	70,690	13·6	66,980	10·7	51,610	8·5	39,950	14
15	…	…	8·7	41,010	8·6	40,480	11·2	54,260	14·25	70,425	13·6	66,980	10·5	50,550	8·5	39,950	15
16	…	…	8·8	41,540	8·5	39,950	11·4	55,320	14·2	70,160	13·6	66,980	10·3	49,490	8·5	39,950	16
17	…	…	8·8	41,540	8·3	38,890	11·5	55,850	14·15	69,895	13·6	66,980	10·1	48,430	8·55	40,225	17
18	…	…	8·8	41,540	8·2	38,360	11·6	56,380	14·1	69,630	13·6	66,980	9·9	47,370	8·55	40,225	18
19	…	…	8·75	41,245	8·0	37,300	11·7	56,910	14·0	69,100	13·6	66,980	9·7	46,310	8·55	40,225	19
20	…	…	8·75	41,245	7·8	36,240	11·9	57,970	13·9	68,570	13·6	66,980	9·5	45,250	8·6	40,480	20
21	…	…	8·6	40,480	7·6	35,180	12·2	59,560	13·8	68,040	13·6	66,980	9·3	44,190	8·6	40,480	21
22	…	…	8·6	40,480	7·3	33,590	12·4	60,620	13·75	67,775	13·6	66,980	9·2	43,660	8·6	40,480	22
23	…	…	8·6	40,480	7·2	33,060	12·6	61,680	13·7	67,510	13·6	66,980	9·1	43,130	…	…	23
24	…	…	8·6	40,480	7·0	32,000	12·8	62,740	13·6	66,980	13·6	06,980	9·0	42,600	…	…	24
25	…	…	8·6	40,480	6·8	30,940	13·0	63,800	13·55	66,715	13·55	66,715	8·9	42,070	…	…	25
26	10·3	49,490	8·6	40,480	6·9	31,470	13·2	64,860	13·5	66,450	13·55	66,715	8·8	41,540	…	…	26
27	10·2	48,960	8·6	40,480	7·2	33,060	13·3	65,390	13·4	65,920	13·5	66,450	8·65	40,745	…	…	27
28	10·3	49,490	8·6	40,480	7·3	33,590	13·4	65,920	13·4	65,920	13·4	65,920	8·5	39,950	…	…	28
29	10·5	50,550	8·6	40,480	7·9	36,770	13·5	66,450	13·4	65,920	13·3	65,390	8·35	39,155	…	…	29
30	10·6	51,080	8·6	40,480	8·1	37,830	13·6	72,280	13·4	65,920	13·2	64,860	8·1	37,830	…	…	30
31	…	…	8·6	40,480	…	…	13·7	67,510	13·4	65,920	…	…	7·9	36,770	…	…	31

Note.—These gauge readings refer to the Water Power gauge at the H.B. Ry. Bridge and are reduced from the readings on the Public Works gauge at the Pas River dock. They must be considered as an estimate.

DAILY GAUGE HEIGHT AND DISCHARGE for the year 1913, Saskatchewan River near Le Pas.
(Drainage area, 149,500 square miles.)

Day.	April.		May.		June.		July.		August.		September.		October.		Day.
	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	
1	....	....	12·30	60,090	9·45	44,985	11·50	55,850	12·85	63,005	11·35	55,055	....	....	1
2	....	....	·30	60,090	·40	44,720	·50	55,850	·80	62,740	·24	54,472	....	....	2
3	....	....	·30	60,090	·30	44,190	·60	56,380	·70	62,210	·10	53,730	....	....	3
4	....	....	·20	59,560	·40	44,720	·70	56,910	·65	61,945	11·00	53,200	....	....	4
5	....	....	·24	59,772	·35	44,455	·80	57,440	·60	61,680	10·90	52,670	....	....	5
6	....	....	12·25	59,825	9·30	44,190	11·80	57,440	12·50	61,150	10·86	52,458	....	....	6
7	....	....	·20	59,560	·30	44,190	·85	57,705	·50	61·150	·86	52,458	....	....	7
8	....	....	·40	60,620	·50	45,250	·83	57,599	·40	60·620	·70	51,610	6·30	28,290	8
9	....	....	·60	61,680	·60	45,780	·90	57,970	·30	60·090	·50	50,550	·12	27,336	9
10	....	....	·80	62,740	·80	46,840	·90	57,970	·20	59·560	·26	49,278	5·95	26,435	10
11	....	....	11·20	54,260	9·80	46,840	12·00	58,500	12·25	59,825	10·20	48,960	5·95	26,435	11
12	....	....	·30	54,790	10·00	47,900	·10	59,030	·25	59·825	·00	47,900	·58	24,474	12
13	7·2	33,060	·50	55,850	·20	48,960	·40	60,620	12·00	58,500	9·90	47,370	....	....	13
14	·3	33,590	·60	56,380	·35	49,755	·30	60,090	11·90	57,970	·75	46,575	....	....	14
15	·4	34,120	·70	56,910	·40	50,020	·40	60,620	·90	57,970	·60	45,780	....	....	15
16	9·25	43,925	11·50	55,850	10·50	50,550	12·40	60,620	11·90	57,970	9·30	44,190	....	....	16
17	10·20	48,960	·30	54,790	·60	51,080	·50	61,150	·80	57,440	·17	43,501	....	....	17
18	·90	52,670	10·20	48,960	·70	51,610	·60	61,680	·70	56,910	·04	42,812	....	....	18
19	11·20	54,260	·25	49,225	·90	52,670	·60	61,680	·60	56,380	·10	43,130	....	....	19
20	12·20	59,560	·23	49,119	11·00	53,200	·70	62,210	·50	55,850	·05	42,865	....	....	20
21	11·65	56,645	10·30	49,490	11·00	53,200	12·80	62,740	11·40	55,320	8·54	40,162	....	....	21
22	·50	55,850	·20	48,960	·00	53,200	·80	62,740	·40	55,320	·42	39,526	....	....	22
23	·60	56,380	·00	47,900	·90	57,970	·80	62,740	·35	55,055	·34	39,102	....	....	23
24	·70	56,910	9·60	45,780	·80	57,440	·80	62,740	·40	55,320	·25	38,625	....	....	24
25	·90	57,970	·50	45,250	·70	56,910	·90	63,270	·40	55,320	·14	38,042	....	....	25
26	12·00	58,500	9·55	45,515	11·60	56,380	12·95	63,535	11·40	55,320	7·81	36,293	....	....	26
27	12·20	59,560	·50	45,250	·50	55,850	·95	63,535	·39	55,267	·74	35,922	....	....	27
28	·20	59,560	·40	44,720	·50	55,850	·95	63,535	·43	55,479	·20	33,060	....	....	28
29	·35	60,355	·50	45,250	·50	55,850	13·00	63,800	·40	55,320	....	....	....	....	29
30	....	....	·50	45,250	·50	55,850	12·90	63,270	·40	55,320	....	....	....	....	30
31	....	....	·50	45,250	....	....	·90	63,270	·30	54,790	....	....	....	....	31

DISCHARGE MEASUREMENTS of Saskatchewan River near Grand Rapids, Man., 1909.

Date.	Hydrographer.	Meter No.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
			Feet.	Sq. ft.	Ft.per sec.	Feet.	Sec.-ft.
Oct. 21	F. A. Forward..............	....	876	5,714	89·2% 4·84	....	24,669

Above rapids. No wind. Surface floats. Mean of five good results taken. Course=1,100 ft. Mean time for course =227·4 sec. Surface rate of flow=4·84 ft. sec. Ratio mean to surface flow=89·2 for roughly contoured rock bottom. H.W. level six feet above present level. Flood section=11,114 sq. ft. Probable rate of flow=6 ft. sec. The maximum discharge=66,684 sec. ft.

DISCHARGE MEASUREMENTS of Saskatchewan River near Grand Rapids, Man., 1910.

Date.	Hydrographer.	Meter No.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
			Feet.	Sq. ft.	Ft.per sec.	Feet.	Sec.-ft.
1910.							
July.....	Wm. Ogilvie................	....	1,048	13,341	2·65	786·22	35,322
October.	"	....	....	....	....	....	24,433

Taken on section later used by W.P.S. Approximate elevation of gauge=786·22.

DISCHARGE MEASUREMENTS of Saskatchewan River at Grand Rapids, 1912.

Date.	Hydrographer.	Meter No.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
			Feet.	Ft.per sec.	Feet.	Sq. ft.	Sec.-ft.
Aug. 8	E. B. Patterson................	285	1,055	15,061	3·47	788·18	52,262
Sept. 18	"	3	1,056	15,853	4·01	788·96	63,570
Sept. 23	"	3	1,058	15,957	3·98	789·06	63,510

DISCHARGE MEASUREMENTS of Saskatchewan river at Grand Rapids, 1913.

Date.	Hydrographer.	Meter No.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
			Feet.	Sq. ft.	Ft.per sec.	Feet.	Sec. ft.
Aug. 27	A. Pirie........................	1496	1,054	15,422	3·71	788·31	57,206
Aug. 29	"	1497	1,054	15,485	3·57	788·36	55,266
Aug. 30	"	1497	1,054	15,427	3·55	788·29	54,718
Nov. 10	"	1496	1,016	11,872	1·66	786·01	19,727
Nov. 11	"	1496	1,012	11,963	1·71	785·97	20,548

Daily Gauge Height and Discharge for the year 1912, Saskatchewan River near Head or Grand Rapids.

Day.	August.		September.		October.		November.	
	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.
1	....	....	788·79	62,000	....	65,000	....	38,750
2	....	....	·84	62,750	....	65,000	....	38,750
3	787·88	48,500	·80	62,000	....	65,000	....	38,750
4	....	49,000	·74	61,250	....	65,000	787·23	38,750
5	787·93	49,250	·77	61,250	....	65,000	....	38,750
6	788·00	50,000	788·89	63,500	....	65,000	....	37,250
7	·04	50,750	789·11	66,500	789·02	65,000	....	35,750
8	·13	52,250	....	66,250	....	66,500	....	34,250
9	·21	53,000	....	66,000	....	68,000	....	32,750
10	....	51,500	789·06	65,750	....	69,500	....	31,250
11	....	50,000	788·99	65,000	....	71,000	786·67	29,750
12	....	48,500	·99	65,000	....	72,500	....	29,000
13	....	47,000	789·07	65,750	....	74,000	....	28,250
14	787·82	47,000	788·96	64,250	789·60	74,000	....	27,500
15	....	47,000	·98	65,000	....	74,000	....	26,750
16	....	47,000	788·99	65,000	....	74,000	....	26,000
17	....	47,750	·94	64,250	....	74,000	....	25,250
18	....	47,750	·96	64,250	....	72,500	786,28	24,500
19	787·83	47,750	·98	65,000	....	72,500	....	24,500
20	....	47,750	789·01	65,000	....	72,500	....	24,500
21	....	47,000	788·99	65,000	789·50	72,500	....	23,750
22	787·79	47,000	789·01	65,000	....	67,250	....	23,750
23	....	50,750	·10	66,500	....	62,000	....	23,000
24	....	54,500	·06	65,750	....	56,750	....	23,000
25	....	57,500	788·96	64,250	....	51,500	786·22	23,000
26	788·74	61,250	....	64,250	....	46,250	....	....
27	....	61,250	....	64,250	....	41,000	....	....
28	....	61,250	....	64,250	787·29	39,500	....	....
29	....	61,250	....	64,250	....	39,500	785·45	....
30	....	62,000	....	64,250	....	39,500	....	....
31	....	62,000	....	....	....	39,500	....	....

Daily Gauge Height and Discharge for the year 1913, Saskatchewan River near Head of Grand Rapids.

Day.	May.		June.		July.		August.		September.		October.		November.		Day.
	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	Gauge height.	Dis-charge.	
1	....	....	....	48,500	....	46,500	....	54,500	....	53,000	....	39,950	....	24,500	1
2	....	....	787·89	48,500	....	46,500	....	54,500	788·19	53,000	....	39,500	....	23,900	2
3	....	....	....	48,500	....	46,500	....	54,500	....	52,550	....	39,050	....	23,300	3
4	....	....	....	48,500	....	47,500	788·29	54,500	....	52,100	....	38,600	....	22,700	4
5	....	....	....	47,500	....	47,500	....	54,500	....	51,650	....	38,150	....	22,100	5
6	....	....	....	47,500	....	47,500	....	54,500	....	51,200	....	37,700	....	21,500	6
7	....	....	....	46,500	787·89	48,500	....	54,500	....	50,750	....	37,250	786·12	21,500	7
8	....	....	....	46,500	....	48,500	....	56,000	....	50,300	....	36,800	·06	20,750	8
9	....	....	787·69	45,500	....	48,500	....	56,000	....	49,850	....	36,350	·25	23,750	9
10	....	....	....	45,500	....	48,500	....	56,000	....	49,400	....	35,900	785·95	19,250	10
11	....	....	....	45,500	....	47,000	788·39	56,000	....	48,950	....	35,450	785·96	19,250	11
12	....	....	....	45,500	....	47,000	....	56,000	....	48,500	....	35,000	·01	....	12
13	....	....	....	45,500	....	47,000	....	56,000	....	48,050	786·99	35,000	·06	....	13
14	....	....	....	45,500	787·79	47,000	....	56,000	....	47,600	·97	34,250	784·95	....	14
15	....	....	....	45,500	....	48,000	....	54,500	....	47,150	·96	34,250	·78	....	15
16	....	....	787·69	45,500	....	49,000	....	54,500	....	46,700	786·92	33,500	....	....	16
17	....	....	....	45,500	....	50,000	....	54,500	....	46,250	....	33,500	....	....	17
18	....	....	....	45,500	....	51,000	788·29	54,500	....	45,800	....	32,900	....	....	18
19	786·99	35,000	....	45,500	....	52,000	....	54,500	....	45,350	....	32,300	....	....	19
20	....	37,250	....	45,500	....	53,000	....	55,250	....	44,900	....	31,700	....	....	20
21	....	39,500	....	45,500	788·29	54,500	....	55,250	....	44,450	....	31,100	....	....	21
22	....	41,750	....	45,500	....	54,500	....	56,000	....	44,000	....	30,500	....	....	22
23	....	44,000	787·69	45,500	....	54,500	....	56,000	....	43,550	....	29,900	....	....	23
24	....	46,250	....	45,500	....	54,500	....	56,000	....	43,100	....	29,300	....	....	24
25	....	48,500	....	45,500	....	56,000	....	56,750	....	42,650	....	28,700	....	....	25
26	787·99	50,000	....	45,500	....	56,000	788·45	56,750	....	42,200	....	28,100	....	....	26
27	....	50,000	....	45,500	....	56,000	788·33	55,250	....	41,750	....	27,500	....	....	27
28	....	50,000	....	45,500	788·39	56,000	....	55,250	....	41,300	....	26,900	....	....	28
29	....	50,000	....	45,500	....	56,000	788·38	56,000	....	40,850	....	26,300	....	....	29
30	....	48,500	787·69	45,500	....	56,000	·31	54,500	....	40,400	....	25,700	....	....	30
31	....	48,500	....	....	....	56,000	....	54,500	....	....	....	25,100	....	....	31

PRECIPITATION, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

——	1910.	1911.	1912.	1913.
	inches.	inches.	inches.	inches.
January	....	....	0·02	1·17
February	....	0·20	0·14	0·27
March	....	0·52	0·49	0·06
April	....	2·64	....	....
May	....	1·18	0·56	1·51
June	....	....	1·22	....
July	2·60	4·67	4·39	2·42
August	3·27	2·35	2·61	2·92
September	1·92	1·92	3·54	....
October	0·57	0·40	0·82	0·61
November	2·43	1·65	1·65	0·33
December	0··1	0·70	0·60	0·13

PRECIPITATION, Swan River, Man. Latitude, 52° 06′; longitude. 101° 15′.

——	1909.	1910.	1911.	1912.
	inches.	inches.	inches.	inches.
January	....	0·10	....	0·20
February	....	0·50	....	0·30
March	....	0·45	....	....
April	....	1·86	0·31	....
May	0·73	2·63	2·96	....
June	2·21	3·17	3·52	....
July	3·67	1·30	2·64	....
August	2·57	4·47	3·68	....
September	0·49	0·79	2·37	....
October	0·89	0·22	1·12	....
November	0·80	0·75	1·40	....
December	....	1·30	1·20	....

PRECIPITATION, Melfort, Sask. Latitude, 52° 47′; longitude, 104° 30′.

——	1909.	1910.	1911.	1912.	1913.
	inches.	inches.	inches.	inches.	inches.
January	....	0·05	0·80	0·10	0·95
February	....	0·50	0·20	0·40	0·15
March	....	0·20	0·20	0·95	0·55
April	....	1·07	1·57	0·47	0·50
May	....	0·81	1·60	1·88	1 43
June	....	1·32	3·07	3·60	. .....
July	....	2·10	4·28	6·04	3·90
August	....	2·66	2·65	2·23	2·27
September	0·74	0·84	1·61	2·71	....
October	0·51	1·03	1·10	0·29	0·47
November	0·26	0·40	1·70	0·34	0·20
December	....	1·80	0·40	0·50	0·15

PRECIPITATION, Cumberland, Sask. Latitude, 53° 56′; longitude, 102° 16′.

Year, 1911.	Inches.
January	
February	
March	
May	
April	
June	3.69
July	3.95
August	3.95
September	3.60
October	0.60
November	2.55
December	

PRECIPITATION, Lost River, Sask. Latitude, 52° 17′; longitude, 104° 21′.

	1911	1912	1913
	inches.	inches.	inches.
January			
February			
March			
April		1·14	0·52
May		2·56	
June	3·21		2·10
July	1·29	5·18	5·36
August	1·56	2·40	4·46
September	1·63	4·20	
October	1·09	0·45	0·–2
November	0·54		
December			

TEMPERATURE, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

Year, 1910.	Mean.	Maximum	Date.	Minimum	Date.
	°	°	°	°	
January					
February					
March					
April					
May					
June	61·8	86	21	30	1
July	64·5	85	18	46	31
August	56·8	80	19	30	27
September	46·4	74	16	24	23
October	40·0	74	9	19	19 & 28
November	13·9	27	12	–2·5	10
December	2·2	34		–42	

TEMPERATURE, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

Year, 1911.	Mean.	Maximum	Date.	Minimum	Date.
	°	°		°	
January	...	...	...	...	...
February	0·6	39·0	24	-42·0	4
March	13·5	47·0	13	-16·0	5
April	33·0	70·0	24 & 25	-8·0	2
May	48·2	83·2	5	22·0	1
June	...	...	...	...	...
July	59·0	8–·0	26	43·0	17
August	57·6	81·0	19	34·0	25
September	46·0	67·1	2	15·0	27
October	38·3	79·0	9	3·0	31
November	9·9	40·0	3	-17	11-14
December	3·5	35·0	3	-51	29

TEMPERATURE, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

Year 1912.	Mean.	Maximum	Date.	Minimum	Date.
	°	°		°	
Januray	-7·7	23·0	30	-54·0	10
February	-2·3	34·0	16	-34·0	25
March	2·9	35·0	27	-32·0	1
April	...	...	...	...	...
May	57·5	82·0	25	26·0	19
June	61·5	92·0	27	34·0	2
July	58·0	82·0	1	38·0	21
August	58·3	80·0	10	40·0	27
September	48·6	76·0	11	26·0	26
October	38·6	65·0	1	17·9	30
November	22·3	36·0	2	-8·0	29
December	4·3	38·0	27	-26·0	2

TEMPERATURE, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

Year, 1913.	Mean.	Maximum	Date.	Minimum.	Date.
	°	°		°	
January	-17·9	12·0	29	-51·0	...
February	5·2	18·0	22	-33·0	...
March	2·8	42·0	31	-36·0	...
April	...	...	...	...	...
May	46·1	79·0	30	22·0	...
June	...	...	...	...	...
July	63·0	83·0	29 & 30	41·0	...
August	61·4	80·0	20 & 29	38·0	...
September	...	...	...	...	...
October	31·4	62·2	1	2·0	...
November	21·7	63·2	4	-3·0	...
December	12·1	40·0	4	-27·0	24

TEMPERATURE, The Pas, Man. Latitude, 53° 49′; longitude, 101° 15′.

Year, 1914.	Mean.	Maximum	Date.	Minimum.	Date.
	°	°		°	
January	-2·3	30·0	5	-32·0	20

Temperature and Barometric Readings. Eastern Pasquia District.

Date.	Temperature. Max.	Min.	Barometer. A. M.	P. M.	Remarks.
1912.	°	°	In.	In.	
August 2	73	54	30·15	30·00	
" 3	77	53	30·25	29·91	Fair.
" 4	74	54	28·91	29·97	Fair.
" 5	75	52	28·72	28·85	Cloudy.
" 6	74	46	28·79	28·70	Cloudy and rain.
" 7	77	51	29·00	28·81	Cloudy and fog.
" 8	76	52	28·95	29·21	Fog—Fine.
" 9	75	54	28·83	29·81	Fair.
" 10	80	55	28·80	28·65	Fair.
" 11	76	53	28·53	28·52	Rain.
" 12	77	55	28·00	27·70	Rain and cold.
" 13	70	59	28·74	28·51	Cloudy and cold.
" 14	72	57	28·71	28·76	Fair and cold.
" 15	76	54	28·79	29·05	Fair and cold.
" 16	76	58	29·10	28·81	Cloudy.
" 17	74	57	28·85	28·91	Cloudy.
" 18	76	50	28·87	28·81	Fair.
" 19	78	51	28·91	28·87	Cloudy.
" 20	78	52	28·95	28·70	Cloudy.
" 21	68	50	28·62	28·60	Rain.
" 22	78	51	28·75	28·76	Cloudy and cold.
" 23	79	49	28·73	28·56	Cloudy and cold.
" 24	70	47	28·59	28·70	Rain.
" 25	76	48	28·72	28·70	Rain and cold.
" 26	77	42	28·90	28·92	Cloudy.
" 27	69	43	29·00	28·91	Cloudy.
" 28	68	46	28·95	28·93	Rain.
" 29	68	44	28·77	28·55	Rain.
" 30	67	53	28·54	28·62	Rain.
" 31	75	50	28·73	28·42	Cloudy.
September 1	77	47	28·51	28·62	Rain.
" 2	76	46	28·79	28·85	Fine.
" 3	75	48	28·81	28·75	Rain.
" 4	73	46	28·79	28·85	Rain.
" 5	78	52	28·75	27·50	Rain and cold.
" 6	67	53	27·75	28·70	Rain and gales.
" 7	69	49	28·66	28·74	Fine.
" 8	68	49	28·73	28·79	Fine.
" 9	69	50	28·74	28·74	Fine.
" 10	70	56	28·90	28·79	Fine.
" 11	72	54	29·10	28·95	Fine.
" 12	76	54	28·90	29·00	Fine—Rain.
" 13	74	53	28·62	28·82	Rain and gales.
" 14	70	52	29·30	28·71	Rain and gales.
" 15	66	28	29·45	29·45	Fair and cold.
" 16	65	33	29·10	28·95	Cloudy and cold.
" 17	66	34	28·95	28·85	Cloudy and cold.
" 18	63	40	29·70	28·90	Fine—Rain.
" 19	64	41	29·21	29·00	Rain and gales.
" 20	64	40	28·50	28·85	Rain and gales.
" 21	66	39	29·10	28·55	Rain and gales.
" 22	66	41	28·45	28·30	Rain and snow.
" 23	57	30	28·91	28·90	Snow flurries.
" 24	56	27	29·25	29·10	Cloudy and cold.
" 25	57	26	29·20	29·15	Fine.
" 26	54	24	29·10	28·95	Snow flurries.
" 27	44	30	29·10	29·25	Rain and snow.
" 28	47	27	29·45	29·40	Cold and windy.
" 29	54	29	29·05	29·32	Fair and cold.
" 30	57	30	29·00	28·85	Fair and cold.
October 1	60	36	28·75	28·60	Cloudy and rain.
" 2	64	37	28·49	28·45	Fair and mild.
" 3	60	41	28·50	28·40	Cloudy and cold.

Date.	Temperature.		Barometer.		Remarks.
	Max.	Min.	A. M.	P. M.	
1912.	°	°	In.	In.	
October 4	61	40	28·50	28·57	Cold rain.
" 5	49	37	29·10	29·15	Cold rain.
" 6	47	31	29·15	29·00	Cloudy and cold.
" 7	51	34	28·70	28·70	Cloudy—Rain.
" 8	48	35	28·75	28·95	Rain and snow.
" 9	48	30	29·23	29·12	Cloudy and cold.
" 10	43	26	28·91	28·87	Cloudy and cold.
" 11	46	34	29·00	28·80	Fine.
" 12	47	33	29·15	29·10	Cloudy and gales.
" 13	54	24	28·75	28·60	Cloudy and cold.
" 14	55	27	28·82	28·89	Fair and cold.
" 15	50	32	29·10	28·95	Fair and mild.
" 16	46	34	29·00	28·70	Fair and mild
" 17	49	33	28·80	28·82	Cloudy and cold.
" 18	47	36	28·81	28·85	Light snow.
" 19	45	35	29·00	28·80	Fair.
" 20	41	33	28·75	28·55	Snow, 3 in.
" 21	41	28	28·70	28·90	Fair and cold.
" 22	40	27	29·15	29·00	Fair and cold.
" 23	38	27	28·32	28·82	Fair and milder.
" 24	39	28	28·41	28·63	
" 25	47	29	29·15	28·94	

Fine is intended to mean *Clear.*
Fair is intended to mean *Partly Cloudy.*

The following summary shows the highest and lowest readings and the average temperatures for each month together with the number of times the mercury fell below the freezing point:—

August—

Highest reading on 10th	80°
Lowest reading on 26th	42°
Average maximum	73°.5
" minimum	49°.6
Number of times below 32°	None.

September—

Highest reading on 5th	78°
Lowest reading on 26th	24°
Average maximum	62°.2
" minimum	40°.9
Number of times below 32°	9

October (1st to 25th)—

Highest reading on 2nd	64°
Lowest reading on 13th	24°
Average maximum	48°.5
" minimum	32°.3
Number of times below 32°	11

Temperatures, Pasquia District, year 1913.

Date.	Maximum.	Minimum.
	°	°
June 1	...	...
" 2	...	...
" 3	...	...
" 4	...	...
" 5	...	...
" 6	...	...
" 7	...	...
" 8	72	48
" 9	51	39
" 10	56	40
" 11	75	56
" 12	77	53
" 13	75	50
" 14	84	48
" 15	77	60
" 16	83	59
" 17	82	63
" 18	69	45
" 19	...	...
" 20	59	44
" 21	67	42
" 22	71	47
" 23	77	52
" 24	81	61
" 25	80	61
" 26	69	53
" 27	64	53
" 28	69	52
" 29	73	61
" 30	65	49
July 1	69	45
" 2	67	58
" 3	65	51
" 4	67	46
" 5	70	50
" 6	75	48
" 7	77	54
" 8	65	48
" 9	73	47
" 10	69	57
" 11	66	55
" 12	63	50
" 13	69	46
" 14	66	56
" 15	76	57
" 16	75	57
" 17	75	58
" 18	77	57
" 19	73	53
" 20	73	63
" 21	74	61
" 22	68	52
" 23	73	46
" 24	79	50
" 25	74	58
" 26	58	49
" 27	73	48
" 28	79	60
" 29	85	62
" 30	65	59
" 31	77	55
August 1	78	62
" 2	75	48
" 3	79	46
" 4	75	57
" 5	76	53
" 6	77	53
" 7	65	59
" 8	66	53
" 9	63	42

TEMPERATURES, Paspuia District, year 1913—*Concluded.*

Date.	Maximum.	Minimum.
August 10	63	40
" 11	65	48
" 12	75	45
" 13	80	57
" 14	63	51
" 15	73	59
" 16	67	55
" 17	67	42
" 18	67	42
" 19	77	59
" 20	78	51
" 21	73	55
" 22	75	55
" 23	69	53
" 24	75	49
" 25	71	61
" 26	72	55
" 27	71	55
" 28	69	58
" 29	79	54
" 30	69	52
" 31	60	50
September 1	63	55
" 2	67	49
" 3	71	51
" 4	77	53
" 5	80	61
" 6	72	55
" 7	63	51
" 8	65	48
" 9	66	61
" 10	63	59
" 11	60	56
" 12	58	39
" 13	60	41
" 14	61	48
" 15	62	44
" 16	66	42
" 17	74	50
" 18	72	51
" 19	49	40
" 20	.....	.....
" 21	.....	.....
" 22	47	33
" 23	38	36
" 24	40	25
" 25	50	28
" 26	60	28
" 27	71	40
" 28	40	34
" 29	.....	.....
" 30	.....	.....

Month.	Days.	Average.
		°
June	22	Max. 71·6 Min. 51·6
July	31	Max. 71·5 Min. 53·7
August	31	Max. 71·4 Min. 52·2
September	26	Max. 61·4 Min. 45·3

RUN-OFF.

River.	Area.	Month.	Monthly Mean.	Maximum per square mile.
	Sq. miles.		Cu. ft. per sec.	cu. ft. per sec.
				1912.
Red	34,600	May	·068	·0849
"	"	June	·050	·0765
"	"	July	·033	·0552
"	"	August	·030	·0495
"	"	September	·032	·0698
"	"	October	·066	·1030
"	"	November	·046	·0445
"	"	December	·023	
				1913
"	"	January	·015	
"	"	February	·009	
"	"	March	·099	
"	"	April	·380	·752
"	"	May	·092	·151
"	"	June	·050	·0649
"	"	July	·038	·0510
"	"	August	·027	·0349
"	"	September	·033	·0466
"	"	October	·035	·0426
"	"	November		
"		December		
				1912.
Souris	22,500	October	·0035	
"	"	November	·0024	
"	"	December	·0009	
				1913
"	"	January	·0004	
"	"	February	·0002	
"	"	March	·1044	
"	"	April	·1043	
"	"	May	·041	·064
"	"	June	·006	·0104
"	"	July	·0026	·0034
"	"	August	·0024	·0031
"	"	September	·0024	·00275
"	"	October	·0022	
"	"	November		
"	"	December		
Mossy	3,950	July	·039	
				1913
"	"	August	·031	·377
"	"	September	·023	·379
"	"	October	·018	·202
"	"	November		
"	"	December		
				1913.
Little Saskatchewan	1,250	January	·04	
" "	"	February	·05	
" "	"	March	·05	
" "	"	April	·74	1·55
" "	"	May	·42	·720
" "	"	June	·26	·389
" "	"	July	·30	·405
" "	"	August	·19	·38
" "	"	September	·049	·1008
" "	"	October	·058	·216
" "	"	November		
"	"	December		
				1913
North Saskatchewan	149,500	January	·041	
" "	"	February	·033	
" "	"	March	·041	
" "	"	April	·229	
" "	"	May	·355	·419
" "	"	June	·337	·387
" "	"	July	·404	·426
" "	"	August	·388	·421
" "	"	September	·030	·368
" "	"	October	·017	
" "	"	November		
" "	"	December		

RUN-OFF.

River.	Area.	Month.	Monthly Mean.	Maximum per square mile.
	Sq. miles.		Cu. ft. per sec.	Cu. ft. per sec. 1913
Red Deer	4,900	July	·710	
"	"	August	·406	·514
"	"	September	·195	·296
"	"	October	·530	·127
"	"	November		
"	"	December		
				1913
Assiniboine	7,590	January	·022	
"	"	February	·021	
"	"	March	·026	
"	"	April	·632	
"	"	May	·596	·836
"	"	June	·245	·426
"	"	July	·445	·536
"	"	August	·334	·514
"	"	September	·145	·211
"	"	October	·093	·0982
"	"	November		
"	"	December		

No. 13.

REPORT ON SMALL WATER-POWERS.

A. M. BEALE.

Water Resources Paper No. 12.

OTTAWA, March 31, 1914.

J. B. CHALLIES, Esq.,
Superintendent, Water Power Branch,
Ottawa.

SIR,—I have the honour to submit herewith a report on Small Water-powers. This has been summarized in No. 3 above, and the reasons for ordering this investigation have been dealt with.

It soon became manifest that this problem was not susceptible of any "cut-and-dried" solution, in so far as the West was concerned, and the obvious lack of suitable water-power sites in the prairies directed my attention to possible substitutes.

The water-power studies were made during an inspection trip which I made during the last three months of 1913, and the study of other small powers—oil, gasoline, etc.—has been made since my return to Ottawa. For convenience it has seemed advisable to divide my subject into two parts, the first deals with the inspections made in the West, while in the second part the problem of "power for the farm" has been dealt with. It cannot be claimed that any definite solution of this problem has been reached, the various alternatives have been considered fully—perhaps too fully—with the idea of submitting all the available evidence for those interested to make their own deductions.

It should be remembered that cost figures for small powers are extremely hard to obtain with any accuracy; original cost figures are but seldom available, and actual annual cost data never. Manufacturers supply figures of the latter founded on certain percentage allowances for overhead charges, and upon figures for fuel consumption founded on test; actually these charges must vary through very wide limits, depending on the requirements and skill of the purchaser.

PART I.

Disregarding the chronological order of inspection I will deal first with the actual plants visited, namely:—

Canadian Pacific Railway plant at Lake Louise, Alta.
" " Glacier, B.C.
Mount Stephen Mines Plant near Field, B.C.
Municipal Plant, Armstrong, B.C.
Private Plant at Spences Bridge, B.C.
Small Saw-mill at Louis Creek, North Thompson River, B.C.

LAKE LOUISE, ALTA.

This plant is situated about one-half mile from the chalet, and supplies current for lighting the chalet and the station at Laggan. This is practically a new development, for very little of the old remains. A concrete bridge, recently constructed at the mouth of the lake, was designed with spillway sections between the bridge piers; only a small degree of regulation is desirable as this lake is situated in the Rocky Mountains park, and anything detrimental to the scenery must be avoided.

Water is brought from lake Louise in a 20-inch wood stave pipe 2,800 feet to the power-house. The actual fall in this distance is 140 feet, a portion of this, however, is wasted in pipe friction. The pipe line is designed for 100 horse-power, and should more power be required another pipe would be necessary.

The turbine is a 24-inch Morgan-Smith wheel running at 600 r.p.m. and rated at 100 h.p., it is belted to a 75-k.w., 3-phase generator, with a separate exciter on the same shaft, these running at 1,200 r.p.m. Current is transmitted at 2,500 volts, being transformed to 125 volts at the chalet and at Laggan station.

This plant would probably compare favourably as to cost with any rival source of power, though data on this point were not available. In any case, cost is of secondary importance here, and ordinary considerations of dollars per horse-power do not apply; electricity available without noise, smoke, or unsightly buildings, is a great asset to a tourist resort, where the transient population can and does spend freely, and where every convenience has a bearing on the general attractiveness of the resort.

The demand for power is heavy only during the summer tourist season, and it is possible that, even with the small degree of regulation available on lake Louise, a larger amount of power could be developed at this season if required.

In the development of tourist centres in the Dominion parks, and in locating new resorts, the existence or otherwise of a suitable small water-power should be taken into account.

GLACIER, B.C.

This objective for tourists is situated on the western slope of the Selkirks, the main attraction being the famous Illecillewaet glacier. The Canadian Pacific Railway has a station and comfortable hotel, and it is for lighting these buildings that a small power-plant has been installed on the creek flowing from the glacier.

Owing to the deep snow, I was unable to make as thorough an examination as was desired, and the weather prevented the taking of good photographs. The following particulars have been courteously supplied by Mr. McQuarrie, the resident engineer of the Canadian Pacific Railway at Revelstoke.

A 12-foot concrete dam has been constructed across the Glacier creek and forms a forebay, the intake is a 24-inch pipe reduced just below the dam to 18-inch, and a wooden stave pipe of this diameter 1,000 feet long carries the water to the power-house.

The power-house is a 17-foot by 21-foot foot frame building, 10 feet to ceiling, constructed on a solid rock foundation levelled up with concrete.

The water wheel is a Morgan-Smith turbine running at 900 r.p.m., it has a 24-inch intake, 2⅜-inch shaft with two 18-foot pulleys driving two dynamos; these are 25 k.w., 125 volts, shunt-wound, bi-polar machines running at 1,050 r.p.m.

The transmission line consists of two No. 00 solid wires on 25 foot poles, with double cross-arms and strain insulators at each end, the line being 1,800 feet long.

The water supply is very irregular, but sufficient to run the plant all the year round. Heavy freshets occur during the hot season. The working head is 90 feet.

Cost.

Two dynamos at $600	$ 1,200 00
Turbine (about)	500 00
Switchboard complete	250 00
Belting and cost of installing in power-house	200 00
Cost of pole line (including construction)	500 00
Cost of dam	4,500 00
Cost of power-house and foundations	1,000 00
	$8,150 00

This cost may be considered a trifle high, which would be chiefly due to the inaccessibility of the plant, and the consequent high cost of getting in material; when we consider the value of a reliable electric light service to the hotel the cost is not excessive.

MOUNT STEPHEN MINES, B.C.

Ore mined on Mount Stephen is brought down by an aerial tramway to the mill, which is situated about 3 miles east of Field and just above the Canadian Pacific Railway track.

The power for the mill is obtained from Cathedral creek in the summer, but a 100 h.p. steam engine is used when the mill is operated during the winter; last winter it was closed down.

Here, as at Glacier, weather conditions and the depth of snow rendered out of door measurements impracticable, and the following figures are merely approximate.

Cathedral creek is fed by the glacier between Mount Stephen and Cathedral mountain; on this creek a 9-foot dam has been constructed to form an intake, and a 12-inch wood stave pipe conducts the water 1,500 to 1,700 feet to the mill, where it drives a 100 h.p. Pelton wheel under a head of some 300 feet.

The wheel is securely set upon a concrete foundation, and the driving pulley, 3 feet diameter, is belted to the main shafting, from which all the machinery in the mill is driven.

The head could be increased considerably by placing the machinery lower down the mountain side, but for the purpose for which it is required it would be inconvenient to do so. The stream is being studied by the British Columbia Hydrographic Survey, and present information leads to the belief that there is practically no winter flow, the water-power being available only during June, July, August, and September.

Mr. John A. Thompson, manager of the Mount Stephen mines stated that the development cost approximately as follows:—

1,700 feet pipe line	$1,500 installed.
Dam	600
Pelton wheel (100 b.h.p.)	1,800
	$3,900

He further stated that, in four months' steady operation, the saving on the steam plant would amount to $4,000 or practically the capital invested.

ARMSTRONG, B.C.

This city has a thoroughly up-to-date municipal plant on Fortune's creek, 3 miles from the city. For nine months of the year the water-power of this creek supplies all demands, during the balance of the year a Diesel engine auxiliary set supplies any deficiencies, and also acts as an emergency plant at all seasons. This plant is particularly interesting for, to quote the *Electrical News* of November 1, 1913: 'The revenue from the electric plant for the last year was approximately eleven thousand dollars, or over seven dollars per capita. A very considerable portion of this is due to the general use of fans and heating appliances. The system is entirely self-sustaining, and is being extended to all agricultural districts within a radius of five miles, the ranches being quick to seize the opportunity of improving their property and rendering home life more attractive to the younger generation.'

The water-power plant was purchased from the Armstrong Light and Power Company, and completely remodelled. A new power-house has been built, the greater portion of the wooden stave pipe line has been replaced by a steel pipe, and a new Pelton wheel purchased.

The water-power section of the plant is as follows: A small timber dam on Fortune's creek about three-quarters of a mile above the power-house forms an intake; a wood stave pipe leads the water nearly one-quarter of a mile to the edge of a steep cliff, where the new 10-inch steel pipe begins. The water reaches the power-house under a head of 550 feet, and drives a 150 h.p. Pelton wheel direct coupled to a 100-k.w. Canadian General Electric generator running at 900 r.p.m. The auxiliary set consists of a 200 b.h.p. Carel-Diesel engine direct connected to a 125-k.w. Swedish General Electric generator. Both generators are three phase, 60 cycle, 2,500 volt machines and can be operated singly or in parallel. The switchboard consists of two generator and one feeder panels.

The costs of this plant have been supplied through the courtesy of the municipal authorities. The plant, as it now stands, has cost in the neighbourhood of $92,300, of which $68,300 is for new equipment and engineering, the balance being the purchase price.

The following are the principal items of cost:—

Purchase price of old plant	$24,000
New steel pipe line	21,000
New power-house (reinforced concrete)	28,800
Diesel oil engine (200 b.h.p.)	11,850
Oil tanks	934
Pelton water-wheel (150 h.-p.)	845
Governor	780
Generator (156·5 k.v.a.)	3,090
Switchboard	997
Total	$92,296

The monthly costs are given as—

Interest and sinking fund	$425 40
Wages	310 00
	$735 40

That is, $8,824.80 per annum.

Such a plant as the above is difficult to criticise, especially as it is hardly a completed commercial proposition. Undoubtedly, an efficient electric light and power service is a large factor in the development of a city, and an indirect revenue producer. Whether the plant taken over from the Light & Power Company was actually worth $24,000, in view of the large proportion of it that was replaced, does not appear If we add the cost of the new water-power equipment to the purchase price, and allow only $3,375 for a power-house sufficient to house the wheel and dynamo (the oil-engine set takes up much the greater space in the $28,800 power-house), we obtain the result that a 150 h.p. water-power development cost $50,000. This, while not necessary uneconomical, must be considered expensive.

The monthly costs as given indicate that the interest and sinking fund on $92.296 is roughly 5½ per cent, no allowance is made, apparently, for repairs or depreciation; the running cost is given as $310 per month for wages—when the Diesel engine is running the costs will be much higher. It would appear therefore that the annual costs will be considerably more than $8,824.80. The writer has not been able to thoroughly investigate the costs in every detail.

SPENCES BRIDGE, B.C.

This plant is situated about three-quarters of a mile from the Canadian Pacific Railway station at Spences bridge, and near the mouth of Murray creek which flows into the Thompson river.

About a quarter of a mile from the mouth of this creek, there is a fall of over two hundred feet, at the crest of which a very small timber dam has been constructed, forming a pool a few square yards in area. A tunnel 200 feet long has been driven through the rock, and delivers water from this pool to a 10-inch pipe which carries it to a concrete power-house below.

The power-house is 34 feet by 24 feet inside and substantially built. Water is delivered to a 48-inch wood mounted Pelton wheel running at 250 r.p.m., which is supplied with a 10-inch standard gate and double nozzle. The speed is regulated by means of 3-inch stream deflectors controlled by a standard Pelton governor. This wheel is belted to a 75 k.w., 6 pole single-phase alternator running at 200 r.p.m.; the exciter is a 125 volt, 20 ampere machine, running at 1,800 r.p.m. Power for lighting is transmitted to Spences Bridge at 7,500 volts and is there transformed to 110 volts.

Water supply.—The B. C. Hydrographic survey has established a station on this creek, and records are available from May to December, 1912 (inclusive). The lowest daily flow during this period was 6 c.f.s., and the discharge will probably be even lower during the succeeding three months. With a head of 255 feet and efficiency of 80 per cent (allowing also for pipe friction), the flow necessary to give 75 k.w. would be about 5 c.f.s. There are irrigation and water supply diversions from this creek, the former occurs when there is ample supply and the effect of the latter on the supply for power is negligible.

This plant was installed as a private undertaking by Mr. Clemens who stated that the total cost was approximately $12,500; $2,500 of this represented replacements, etc. which initial errors in design and construction rendered necessary.

At present the only demand for power is for lighting in Spences Bridge; probably this does not exceed 10 h.p. for a short part of the day, consequently the plant is actually run at a loss as, making no allowance for depreciation, interest on capital, etc., the revenue does not pay the attendant's wages.

Mr. Clemes hopes that, when the Canadian Northern Pacific railway is completed, he will sell power for lighting the new station and possibly for other railroad purposes, he also hopes that it will cause the town to grow and thereby increase his general business.

LOUIS CREEK.

This is about 36 miles from Kamloops up the north Thompson river, and is an example of a primitive application of water-power.

A flume of 15 second-feet capacity, about one-quarter to one-half mile long, brings water to a rough-timber undershot wheel (formerly an overshot wheel). The wheel is about 12 feet in diameter, and operates under a head of approximately 14 feet. The wheel is about 5 to 6 feet wide, and the large driving pulley is belted to a countershaft from which the saw-mill machinery is operated. (*See* plates.) The probable efficiency would be in the neighbourhood of 50 per cent. This wheel has served its purpose for a number of years but it will, it is expected, fall into disuse when the Canadian Northern Railway is completed, as the up-to-date Kamloops mills will probably be able to deliver lumber at a rate cheaper than the owner could offer.

Mr E. M. Dann, of Kamloops, division engineer British Columbia Hydrographic Survey, has supplied a series of photographs (with notes), of two primitive developments in his district and these are attached hereto.

KINCOLITH PACKING COMPANY.

Mr. Henry Doyle, the managing director of this company, kindly supplied information concerning the water-power plant at Mill bay, Naas River, British Columbia.

The hydrographic layout is as follows: Lake No. 3 with an area of 1,500,000 square feet is at an altitude of 1,360 feet and drains by a small creek into Lake No. 1 Lake No. 2 has an area of 1,700,000 square feet and is drained into Lake No. 1 by a creek 600 feet long. Lake No. 1, area 900,000 square feet at an altitude of 360 feet drains into a bay at sea-level.

The rainfall in this district is considerable, but runs off very rapidly so that, except during the rainy season, the natural discharge is small; the actual quantity of water available is not known but, so far, has proved sufficient to supply the power required to run the cannery, i.e., lighting, freezing, and canning machinery—during the season.

The outlet of each lake is narrow, good rock foundation is available, so that it is a comparatively simple operation to convert the lakes into storage basins. At the outlet of Lake No. 1, a 10-foot dam has been constructed, while on the creek between Lakes 1 and 2 an 18-foot dam has been built with a 12-inch gate valve. It has been found that the small lake is drawn down 2 inches per working day, so when the water is only 4 feet above the intake, the 12-inch gate valve is opened and the lake is raised 2 feet, sufficient to run the plant for twelve days. It is proposed to construct a 10-foot dam at the outlet of Lake No. 3, and store the water from that drainage area also.

A 2,000-foot 8-inch wood stave pipe line brings the water to the cannery, where there are, three 18-inch and one 36-inch Pelton wheels, all of which are not used simultaneously. If the size and length of the pipe-line are correctly given, the maximum power available, allowing an 85 per cent efficiency for the wheels, would be about 90 h.p.; 120 feet of the 360 feet (i.e., one-third of the head), being wasted in pipe friction, without undue friction loss from 50 to 65 h.p. could be obtained.

If the wheels are designed for 350-foot head, their combined horse power would be 190, which would necessitate a pipe 12 inches to 14 inches internal diameter, and would draw down the lake 6.6 inches per twenty-four hours' operation. If the wheels are designed for 300-foot head, their combined horse-power would be 150 h.p., drawing down the lake 6 inches per twenty-four hours, and requiring a new 8-inch pipe. These remarks, however, are by the way.

The cost of the plant was approximately:—

Engineer	$ 100
First dam	400
Pipeline	1,400
Valve	50
3 [illegible]-inch wheel ....(installed)	500
3 18-inch wheels	450
	$3,650

Mr. Doyle states that the plant is operated approximately 200 days per annum, and that if coal were used the consumption would be 5 tons per day; coal being worth $8.50 per ton here, the cost would be $42.50 per day or $8,500 per annum for coal alone.

This is a case where a small water-power is extraordinarily valuable, and I was informed that this plant is not an isolated instance of the use of water-power in connection with the canning industry. The fishing industry lends itself to the construction of a power plant at a reasonable cost, as it is not necessary to transport a force of men a long distance for a few week's work. The men who are to be engaged in the cannery during the season can be taken up sufficiently early to do all the necessary work, such as building dams, laying pipe, etc., before the fish begin to run.

A sufficient number of varied examples has been given here to indicate the possibilities of water-power in mountainous districts, there are probably an immense number of sites available which will be capable of economical development when the power demand permits.

The power available being proportional to the product of quantity of water and the head, it is evident that a high-head development requires proportionately less water than one of low-head. The comparatively small quantity of water necessary for a high-head power assists the economy of development, for the dam is, as a rule, small, being constructed merely to form an intake; turbines of the same power are smaller and cheaper for high than low heads.

The pipeline is a feature not met with in low-head construction, its cost will generally be more than covered by the saving in other directions, for the gradient is nearly always steep and the length, therefore, not excessive.

PRAIRIE SECTION.

It will be well to state at once that the prairie country is, as a whole, unsuited to the development of small water-powers. In the spring time, there being no shelter nor shade, the snow rapidly melts, and in two weeks or so the bulk of from four to six months' precipitation runs off, producing high stream-discharge which any dams or head works must be constructed to cope with. The flood having passed, the flow drops to normal, and as the rainfall is comparatively light, the natural gradient of the ground slight, and the soil absorbent and unsheltered, comparatively little water is available to swell the run-off.

As winter comes on the springs begin to freeze solid, and during the severe weather the flow of all, except the larger streams, is suspended. Thus a stream which may have a flood discharge of 500 second feet has practically no winter flow. In other words, a structure must be able to withstand a big flow carrying probably, logs, ice, etc.; while, as a power producer, it will probably be inoperative for at least four months of the year.

Surface rock is seldom available, the banks of the creek are alluvial, making for instability of dams or requiring extra cost to make them secure. The banks as a rule are not steep, so that the length of the dam increases rapidly with the height.

As a rule there are no falls; a few rapids may be caused by gravel bars but, in general, to obtain a head of 10 feet it will be necessary to construct a dam possibly 15 feet high (from the impervious clay foundation—if it is to be found—to the crest), and timber suitable for construction work is not available.

It is obvious, therefore, that unless the power is only required temporarily, for a special summer industry, the fact that the power is not available during the winter will be a great drawback. It practically puts it out of the running as a source of electric power for the farm.

A water-power will only be useful where a farmer or settler in a remote district has sufficient skill to build a dam and wheel in his spare time. The investment would be slight and the power could be profitably used to cut lumber, saw up firewood, chop and grind feed, etc., in sufficient quantities during the open season to last the whole year.

A site on the Medicine river was inspected, and was one of the very few prairie sites which could be considered economically feasible; even here the country is not real prairie for there is some timber, this location being on the borders of the foot-hill country. At this site the settler, Mr. Fritz Kinna, has built a power-house, and has constructed from wood and sheet-metal a 5-foot inward flow, vertical turbine, with draft tube, cylinder gate, etc. This settler, a Norwegian, has had experience of these developments in Norway, and has built his turbine from patterns obtained from there: the workmanship was excellent, and the wheel will probably prove quite as efficient as a home-made overshot wheel. Exclusive of his own time Mr. Kinna has expended $160 in all, for lumber, bearings, shafting and bevel gears for the wheel and driving shaft; it is probable that, another two hundred dollars will complete the dam, and that for an outlay of $350—$400 he will have from 16 to 20 horse-power for six months of the year.

The other sites inspected in the prairie region have been already reported upon in dealing with the individual cases, one or two of these might, in the hands of a settler such as Mr. Kinna, prove worth developing; the remainder were quite unfeasible. In any case where no technical skill can be anticipated, and where conditions of insecure foundations, pervious banks, heavy spring flood with floating ice are likely to be met with, it will not be wise to encourage the development of water-power.

NORTH OF THE PRAIRIE.

Here the prairie conditions are modified in several important particulars, the run-off is better regulated, large lakes, muskegs and swamps equalize the flow to a considerable extent, and the country is timbered. Rapids and falls become more frequent, the rainfall is greater and materials for construction are close at hand. The population of this area is inconsiderable and scattered, until recently the Indian and fur-trader were in undisputed possession. Settlers are gradually moving northward, and some of the small power-sites will doubtless be used at some future time.

In 1909 and 1910 I travelled extensively in northern Saskatchewan and Alberta, and saw many sites where a small power could be developed; there was also one where the water had been successfully harnessed. At the Roman Catholic mission, where the La Plonge river enters the Beaver river in Saskatchewan, a saw mill has been in operation for some years, driven by the waters of the La Plonge river, (see photographs). This saw mill supplies all the lumber used around the mission, and has rendered the whip-saw obsolete in the large area bordering on the waters of Ile à la Crosse, Buffalo, Clear, and Island lakes. Indians and settlers obtaining their lumber from the mission.

A lengthy discussion of the small power situation in the country north of the prairies would be out of place here, sufficient has been said, however, to draw attention to the fact that there are possibilities which may be further considered when the probable demand is less remote.

RECOMMENDATIONS.

Knowledge of the discharge is essential in dealing with any water-power, large or small, and in the case of small streams, information in this regard is usually conspicuous by its absence. The average untrained individual, acting in perfectly good faith, makes most absurd statements regarding the flow of the stream in which he is interested. During the open season, in estimating the flow, he will get the cross-section reasonably accurate, perhaps, but will estimate the flow at the swiftest place, and assume it to be uniform across the section and, more often than not, will overestimate the velocity 100 per cent or more. The winter flow is an unknown quantity, but if there is a stream under two or three feet of ice, and the water rises to the surface when a hole is cut in the ice, he will say "the stream runs all winter, just about as much as before freeze-up," when in reality it is, perhaps, only one-tenth of the fall flow.

I would suggest that the possibility of small water-power developments be brought to the notice of hydrographers, so that they may make estimates, at different seasons, of creeks which may, in their opinion, be utilized in the future. It is not expected that any extensive work be done along these lines, as the expenditure of time and money would not be justified; it is thought nevertheless that opportunities arise from time to time which might well be utilized.

I would further repeat my recommendation that no small water-power development be authorized without inspection of the site by a qualified technical officer of the department. Apart from the question of flow, are those of head, area flooded, material for dam, stability, etc., all of which have serious bearing on the economic aspects of a site, and regarding which the applicant has frequently very erroneous ideas; it will be seen, therefore, that considerable individual hardship may be avoided if the inspection is insisted upon.

Part II of this report deals with power for the farm, discussing different sources of energy. It is suggested that this branch endeavour to keep abreast of future developments, so that up-to-date information will be available, enabling the officer in charge to give definite advice to an applicant, as to the comparative value of his proposed water-power plant.

PART II.

POWER ON THE FARM.

The use of power on the farm has recently been attracting much attention; the benefit of having mechanical devices, which will not only reduce the number of hired men required, but which will be available at any hour of the day or night, is being widely advertised. In almost every case electrical energy is the kind dealt with, several books and pamphlets on the subject have been published, and the technical press is constantly referring to one phase or another, of the supply of current to the farm.

Mr. David R. Cooper, of the Conservation Commission of the state of New York brought out, in 1911, a pamphlet on the use of water-power for the farm and country home, the Ontario Hydro-electric Commission has done much pioneer work on the farms of western Ontario, and Messrs. Purcell and Espenschied, of the technical staff, recently gave valuable evidence before the committee of the Dominion House of Commons on Colonization and Agriculture. The sixth annual report of the Hydro-electric Commission contains a wealth of valuable information. Possibly the subject of agricultural electricity is most fully treated by Koester in his book "Electricity for the Farm and Home," in this work he deals with the general advantages of the power, generation, distribution and utilization of the electricity, going quite fully into costs and demonstrates very convincingly the numerous and diverse applications to which electricity may be put.

The remarks that follow must be largely a compilation from the above and other sources. Some of the more specific information has been tabulated elsewhere.

Agriculture, the oldest industry in the world, is the most ancient in its methods. Until quite recently the horse-drawn single plough had not been improved upon, it is but the other day that the first effort was made to use steam-power to do some of the work hitherto done by man or beast. In Germany the steam plough first came into extensive use about fifteen years ago and, ever since, that country has led in the field of agricultural technology; at the present time much ploughing is done by electricity, which method, it is claimed, is faster, cheaper, leaves less unutilized area in the field than other methods, and is applicable to rough ground. Koester states that "by a proper rotation and selection of crops, and by the time saved between the harvest of one crop and the sowing of the next, largely effected by the speediness of the electric plough, the German farmer reaps with its aid two crops a year on much of his land, harvesting on an average 2,600 acres of crops from 1,600 acres of land." The use of this plough is, owing to its high initial cost, confined to the large farms, except where the owner rents it out or the outfit is purchased by a group of small farmers. The long-suffering agriculturist was for generations the butt of the citizen, many opprobrious terms were coined at his expense, but his inertia is being overcome, and he is taking his rightful place near the top of the economic ladder.

Probably the chief cause of the comparative mechanical inefficiency of the farm has been the intermittent nature of agricultural tasks. Ploughing, seeding, reaping, threshing, and other seasonal operations each lasting but a small portion of the year; the daily operations being numerous but brief. One of the greatest aids to invention has been the existence of a continuous monotonous task, *i.e.*, "mechanical," for which a machine is soon found. The farmer's day, though monotonous according to some critics, contained so many varied duties that it probably never occurred to him to find a machine for an operation, unless it was particularly irksome, or required greater power than a team of horses could give him. Other reasons might be multiplied—absence of capital—his isolation, which has made a mutual understanding with engineers difficult; the fact, however, remains that the average farmer, particularly in Canada, needs waking up to the greater possibilities of his land.

It is not an easy task to reach and influence a farmer; he is isolated in position works longer hours than most men, and has little time to study. The inhabitants of his house work just as hard, so that the only method of attack is by missionary work, coupled with articles in the farm journals. Recently, especially where electric power is available, electric appliance salesmen have commenced work in this field.

At the convention in Toronto of the Electrical Association, one speaker attacked the advertising matter used, stating that the farmer did not expect his women folk to be able to sit around, therefore the picture of a lady in neat attire, reading a magazine whilst the washer worked by itself, did not appeal to him at all. The real argument according to this speaker was to show the farmer where he could increase his earning power. This is being done in Eastern Canada, and it is the object of this paper to draw the western farmers' attention to what is being done, so that they will take advantage of central station service as soon as such is available for them. It is also hoped that the data on private station costs will be of use.

SOURCES OF POWER AVAILABLE IN THE WEST.

WATER-POWER.

Large Central Station Service.

Power in Western Canada is at present an expensive commodity, as compared with costs in Europe, the United States and Eastern Canada. The Ontario Hydro-electric Commission purchases power in bulk at Niagara for $9 per h.p. year, and transmits it long distances; transmission lines are expensive, but when a line is being tapped every few miles to supply a city, town or municipality, the line is revenue-earning along its whole length, and can pay interest on the investment, without making the cost excessive to the various consumers. The wide distribution of the load, and the multiplicity of purposes to which the power is put, improves the load-factor thus cheapening the production.

The Hydro-electric Commission has a contract for up to 100,000 h.p. with the Ontario Power Company and obtains the power at 13,000 volts at the figure already stated of $9 per h.p. The voltage is stepped-up to 110,000 volts for distribution to the main stations such as Dundas, Hamilton, Toronto, etc.; a pressure as high as this requires expensive equipment, so that it is stepped-down at the larger stations to 13,200 or some other convenient secondary voltage, for transmission to the smaller towns or villages, where it is again transformed for still further distribution, the voltage finally being lowered to 110 volts for lighting and to 550, 220 or 110 volts for motors.

The price of power naturally varies with the distance from Niagara; in Hamilton, the price is now $15 per h.p. year, in St. Thomas, $28, and at distant Seaforth, $40. The cost of rural electric service in these localities will bear a fixed relation to that of city supply.

The farmer is charged in two amounts, one a "service charge," to cover the annual fixed charges on the capital expended in the township by the Hydro-Electric Commission and by the township, and varies with the number of users in the township; the other a "power charge," for the actual current used. The former charge is $3 per month when there are three consumers to the mile, $2.50 with four, and $2 with five. The "power charge" varies of course with the locality: In West Oxford, the total cost per h.p. year on the farm is for 1 h.p., $66, and for 2 h.p., $96; in the neighbourhood of Chatham, the respective figures would be $76, and $116, assuming a service charge of $3 per month and a power charge of $40 per h.p. year. In the neighbourhood of Dundas, the charges would be roughly $52 and $78 for 1 h.p. and 2 h.p. respectively.

Further detail is not desirable here, any one interested will find full particulars in the evidence given before the Select Standing Committee on Agriculture and Colonization of the Dominion House of Commons, session 1914, by Messrs. G. C. Wilson, M.P., F. F. Espenschied, and J. W. Purcell, this evidence is reprinted under title "Hydro-Electric power as applicable to the farm."

Travelling farther west, the next large centre for hydro-electric power is Winnipeg. Power is received here from the Winnipeg river, where the city of Winnipeg has a plant of which the present capacity is 15,000 k.w. at normal load, the power-house as at present constructed can house machines for a further 9,000 k.w. and is designed for extension to an ultimate capacity of 48,000 k.w. At present, however, the indications are that, without storage, the minimum river flow will only provide 34,000 k.w.

The Winnipeg Electric railway has a station on the Pinawa channel capable of giving some 20,000 k.w. at 50 per cent overload; this power is not capable of any considerable extensions, and is fully loaded. The same interests are about to develop the site at Little du Bonnet falls, where, under present flow conditions with 56 foot head and 75 per cent efficiency, 43,000 k.w. is available.

The Winnipeg river has within transmission distance sites where some 226,000 k.w. is capable of development at a reasonable cost; of this some 35,000 k.w. is already developed. It would seem that the Manitoba farmer might hope for a small share of this vast supply at rates profitable to him, yet H. A. Robson, K.C., Public Utilities Commissioner, in his report on "projected Hydro-electric system for the province of

Manitoba," shows that the cost of any system similar to that of the Ontario Hydro-electric Commission, would be excessive, and says:—

"Until such time as the development of the province will warrant building long transmission lines, it seems that the cheapest power for farmers obtainable must come from small gasolene installation, unless it is desired to promote the industrial development of the province by carrying a heavy deficit for a considerable period of years. It is clear that a general hydro-electric undertaking for the provision of electric service, merely for the use of the agriculturist, could not be accomplished on any satisfactory financial basis, and that such a scheme would depend on the growth of towns and villages, which would make such demand for power as to give a foundation for the enterprise."

The same report shows that the cost of power to towns and villages would amount to 16·2 cents per k.w.h., and to 19·27 cents to individual consumers.

It must be remembered however that, as Judge Robson says no report of this nature can be considered final: it will be modified by the increase of population, and by the progress of hydraulic development and electrical transmission. As time progresses, these different influences may bring the schemes within the economic limits, outside of which it now lies.

The above mentioned report contains a preliminary report by W. E. Skinner, Limited, Consulting Engineers, which deals in detail with the costs of transmission, etc., and contains also tables giving the comparative cost of purchasing power and of generating it in small quantities by steam or gasoline; these tables contain useful information, and will be reproduced in this report under their respective headings.

The first of these is that on purchased power.

	Cost of Electric Power.			
Size of plant in horse-power	2	6	10	20
	$ cts.	$ cts.	$ cts.	$ cts.
Cost of motor installed	125 00	150 00	300 00	450 00
Cost of electricity, 3,000 hours	409 40	858 75	1,028 95	2,023 00
Attendance per year	20 00	30 00	50 00	50 00
Interest, 5 per cent	6 25	7 50	15 00	22 50
Depreciation, 10 per cent	12 50	15 00	30 00	45 00
Repairs, 5 per cent	6 25	7 50	15 00	22 50
Supplies, 1 per cent	1 25	1 50	3 00	4 50
Insurance, 2 per cent	2 50	3 00	6 00	9 00
Taxes, 1 per cent	1 25	1 50	3 00	4 50
Total cost per annum	459 30	924 75	1,150 95	2,181 00
Cost of 1 horse-power per annum of 10 hour basis	229 65	154 15	115 09	109 05
Cost of 1 horse-power per hour	·07655	·05138	·03836	·03635

(*See below—Base price, Discount, and method of obtaining total cost.*)

Base Price for cost of Electric Power—10 cents per k.w. hour—Discount on Monthly Bills:

$ 5 00	10 per cent.	$100 00 to $125 00	40 per cent.
10 00 to $ 20 00	15 per cent.	125 00 to 150 00	45 per cent.
20 00 to 25 00	20 per cent.	150 00 to 175 00	50 per cent.
25 00 to 50 00	25 per cent.	175 00 to 200 00	55 per cent.
50 00 to 75 00	30 per cent	200 00 to 500 00	60 per cent.
75 00 to 100 00	35 per cent.	500 00 and ov	65 per cent

COST PER ANNUM.

2 Horse-power Plant.

3,000 hours x 2 horse-power x ·746 / 82 per cent efficiency.	=	5,458·53 k.w. hours.
5,458·5 k.w. hours x 10c.	=	$545 85 annual cost without discount.
$545 85 / 12	=	$45 49 monthly bill-discount, 25 per cent.

75 per cent of $545 85 or $409 40, *annual cost.*

6 Horse-power Plant.

3,000 x 6 x ·746 x 10 x 55 per cent / 86	=	$858 75.

Monthly bill, $130 = Discount 45 per cent.

10 horse-power Plant.

40 per cent of 3,000 x 10 x·746 x 10c / 87	=	$1,028 95.

Monthly bill, $214 36 = Discount 60 per cent.

20 Horse-power Plant.

40 per cent of 3,000 x 10 x 20 x ·746 / 88·5	=	$2,023

Monthly bill $421. = Discount 60 per cent.

The costs for purchased power depend on: A basic rate of 10 cents per k.w. hour, a discount proportional to the monthly bill, the use of all the power for 3,000 hours per annum. On another page in Judge Robson's report, the cost in Manitoba is figured at 19·27 cents for generation and distribution, and makes no allowance for any discounts; this would appear to show that the above costs do not apply. The outlay for apparatus necessary to use full power for 3,000 hours per annum will be far beyond the means of the average farmer.

The next big centre with a large supply of water-power is Calgary. The Dominion Water Power Branch has made extensive surveys on the Bow river, and the following particulars are taken from the report of Mr. M. C. Hendry, B.A.Sc., on this work.

The Calgary Power Company has so far developed an aggregate of 28,000 h.p. at Kananaskis falls and Horshoe falls. There remain four undeveloped sites to develop, which would cost in all some $3,800,000 delivered in Calgary, giving a further 24,000 horse-power, these figures including a pro-rata charge for the cost of storage; this storage has been thoroughly investigated, and a portion of the work completed, it is designed to regulate the flow of the river and benefit all the power developments. Mr. Hendry estimates that this power will cost delivered in Calgary from 0·49 to 0·60 cent, per k.w.h. at a 50 per cent load factor, or roughly from $49 to $53 per horse-power year.

The rates at present in force in Calgary are, for lighting 7½ cents per k.w.h., and for power:—

Motor Rating.	Charge per Horse-Power year.
1— 3	$41·89
4— 9	37·71
10—18	33·52
19—54	27·23
55 and over	23·04

The "load factor" of a plant during a given period is the ratio of the average load to the full load capacity of the plant while running. The capacity of any plant will be governed by the "peak," i.e., the maximum load, and it is accepted that any increase in the load factor makes for the economy of the plant. Any power user, who refrains from using power when the demand on the central station is high, restricting his use of energy to the hours when the load is light, is entitled to and obtains a cheaper rate than that quoted to the unrestricted consumer. It is easily possible for a farmer to confine his use of electricity to "off-peak" hours, and take advantage of the cheaper rate.

At the present time there cannot be said to be any other centres in Manitoba, Saskatchewan or Alberta, except the Edmonton and Prince Albert districts, where water-power is an active contender in the power market, and there is no indication of any immediate development of sites other than those already mentioned.

Sites on the Athabaska, Saskatchewan, Nelson, Churchill, and other rivers have been investigated in a preliminary way, but as these are all remote from the present centres of population, their economic value is prospective and a discussion thereon would be out of place here.

British Columbia has many water-powers, large and small. The Kootenays have much power, there being extensive developments at Bonnington falls near Nelson. Vancouver is well supplied from the Burrard Inlet and Stave River sites, where a total of 150,000 h.p. is available. Vancouver Island, too, is well supplied.

Passing to other sources of power for large central stations, the questions of cost are problematic and vary so much with local conditions that a long and careful study on the ground, such as I have had no opportunity to make, would be necessary to develop reliable figures as to the cost of production in any given locality.

Actual figures from municipalities are frequently misleading, in many cases power is sold more cheaply than the cost of production would justify, in order to induce industries to locate within the municipality. Fair allowance for interest, sinking fund, depreciation and repairs is not always made, and some plants show a profit where in reality, proper accounting would reveal a loss. Actual expert estimates for power plants in one locality cannot be adapted for another locality, where the conditions are apparently only slightly different.

The Department of Mines has been studying the production of power from various fuels in a most comprehensive manner, and has already issued a report upon the utilization of peat fuel for the production of power. A new report is already in the press, dealing with producer gas in general, and deals in considerable detail with central stations in Germany and the use of electricity on farms; this being the case it is unnecessary here to go further into the subject, except to state that a well-designed producer plant using peat, lignite or bituminous coal, with complete installation for the recovery of by-products can, under favourable conditions, produce power at a very cheap rate.

In 1912-13 an investigation was made for the Dominion Water Power Branch by Mr. H. E. M. Kensit, concerning the best method of producing power for the necessary pumping for the supply of water to the cities of southern Saskatchewan.

In this report, Mr. Kensit states that a well-designed steam plant of from 3,000 to 5,000 k.w. capacity, having a load factor of 35 per cent can be operated for 0·921 cents per k.w.h. (0·518 cents being the cost of coal at $3.50 per ton), and total cost of 1·524 cents.

In Edmonton (see *Electrical News*, June 1, 1914) the rates are:—

"Domestic Lighting—7½ cents for the first 100 k.w.h.; 101 to 400 k.w.h., 7 cents; 401 to 1,000 k.w.h., 6½ cents; 1,001 to 2,200 k.w.h. 6 cents; 2,200 k.w.h. and over, 5½ cents. Minimum charge per month to be 75 cents. Discount of 5 per cent, if paid within ten days from date of bill. No discounts allowed on accounts of less than $1.

"Power—6 cents per k.w.h. for the first 150 k.w.h.; 150 to 300 k.w.h., 5 cents; 301 to 5,000 k.w.h., 3 cents; 5,001 and up 2 cents per k.w.h. Minimum charge on motors up to 15 h.p., 75 cents per h.p. per month on total connected load. Minimum charge on motors above 15 h.p., 50 cents per h.p. per month on total connected load. Ten per cent discount allowed on all accounts exceeding $1. No bill issued for less than the following amounts: Single-phase connections 75 cents per month; three-phase connections, $2.25 per month."

The existing rates in Calgary have already been given. In a report made to that city by a prominent engineer, it was stated that a steam, coal fired plant with a 50 per cent load factor, would give power at the generator terminals at a price falling from 0.85 to 0.74 cents per kilowatt hour, as the size of the plant varied from 5,000 to 45,000 horse-power.

The Moosejaw electric railway uses Mirrless-Diesel oil-engines for power, the present capacity is 900 b.h.p., but is being increased. This plant has given great satisfaction, and with fuel oil at 14 cents per gallon, and an average load factor of 47.23 per cent the operating cost per k.w.h. delivered at the switch board last December was 1.76 cents.

Mr. Kensit prepared a table for cost of pumping at the Elbow, Saskatchewan: this table includes transmission of power or haulage of fuel to this site and also the cost of pumping machinery, the power is given in w.h.p. or water horse-power, and means the power actually used in elevating the water.

Type.	Cost per W.H.P. Year.[1]		Remarks.
	Initial Inst.	Final Inst.	
	$ cts.	$ cts.	
High duty pumping engines	100 00	66·50	Crowsnest coal at $5 85 per ton. Cost of fuel = 32·8 per cent and 47·3 per cent respectively.
Steam turbines and centrif. pumps (coal).	90 00	66 00	Same fuel cost being 52 per cent and 67·6 per cent respectively.
Steam turbines and centrif. pumps (nat. gas).	85 20	63 50	Natural gas at 25 cents per 1,000 cubic feet. Fuel cost 50 per cent. and 66·7 per cent respectively.
Water-power no steam res.	110 00	27 60	
Water-power with steam res.	121 00	35 00	
Producer gas with electric transmission.	187 00 (48·60 = cost of gen. at mine)	57 00 (15·00 = cost of gen. at mine.)	$1.00 per ton at mine. Cost of fuel 18·87 per cent and 30·50 per cent respectively.
Purchased power	83 00	66 00	Based on an offer of $33.75 per E.H.P. per year of 300 days i.e. $38.80 per whole year, delivered.
Diesel oil engines	129 00	93 50	Fuel oil at 15 cents. Cost of fuel 51·75 and 63·48 resp. 10 per cent change in cost of oil changes cost of power 5·2 per cent and 6·3 per cent respectively.

[1] Initial installation, 1,375 w.h.p.
Final installation, 6,875 w.h.p.

If the above figures were corrected for cost of pumping, the cost for power alone might be considerably less; also any change in locality that brought the plant nearer some source of power would bring about a great reduction in power cost; the figures, however, give one an idea of power costs in the west.

PRIVATE STATIONS.

Water-Power.

Messrs. Koester & Cooper, in the works already referred to, devote considerable space to actual small water-power plants and their cost, the following are examples:—

(1) An Illinois farmer has a 15 h.p. water-wheel which generates power for lighting and general farm machinery, the plant cost $1,200 and is operated for $10 per year.

(2) An Ohio plant which cost $1,022 will furnish current for 100 16 c.p. lamps or their equivalent.

(3) In New York state there is a 17 h.p. plant which is estimated to have cost $1,800.

(4) In the same state a 3 k.w. generator plant cost $518.

In most of the above cases the farmer did much of the work himself, and the value of his time is not included.

Briefly stated, some of the principal considerations for cheap production of reliable water-power are: (1) That an actual fall be available; (2) that a convenient and safe site be located near to the place where the power will be used; (3) that the flow be adequate at all seasons of the year, and that there be no excessive floods to endanger the structure or complicate the design.

Part I of this report has dealt, at sufficient length, with the prospects for small water-powers in the West, I will merely recapitulate to this extent.

In the mountainous districts the first two conditions are frequently fulfilled, the third being doubtful. In the prairies all the conditions are difficult of fulfilment, whilst north of the prairies it is thought that, when a demand arises, many available sites will be found.

OTHER SMALL POWER POSSIBILITIES.

This opens up many alternatives each of which will have advocates. Conditions both of fuel supply and power demand will vary so that, where one small power plant will meet one set of conditions, a slight change in these will render a rival form of development more suitable.

Most of the literature on private electric plants is of the trade variety, either from catalogues or trade journals; reasonably enough, therefore, each writer cries his own wares and the unbiased reader must bear this in mind, nevertheless a judicious study of the publications of reliable firms, will enable one to form a fair idea as to what outfit will prove most suitable for a given set of conditions.

The accuracy of any of the following statements and figures is not guaranteed, considerable care has been exercised in their preparation, however, and their object is to give an approximate idea of the principal features to be examined into by the prospective owner of a small plant.

The prime-movers which may be enumerated are engines driven by steam, gasolene, coal-oil or gas; electric accumulators can also be considered in conjunction with any of these.

Steam Engines.

Steam engines for farm power cannot be very favourably considered. The small engine is thermally inefficient, and the necessity of a boiler increases the first cost of the plant, space charges will also be increased. Attendance will cost more, and where power is wanted at short notice or for short periods the use of fuel consumed for keeping up or raising steam will be very wasteful.

Even close to a coal-mine where coal can be obtained cheaply, handling of coal, ashes, &c. will prove expensive. Wood is usually out of the question owing to the expense of cutting and hauling, though a saw-mill might well be driven by steam, the waste material being used for fuel. Oil or gas will generally prove more convenient used directly in an engine of the explosion type.

The following table is taken from the report of W. E. Skinner, to which reference has already been made:—

Cost of Steam Power.

Size of plant	6 H.P.	10 H.P.	20 H.P.
	$ cts.	$ cts.	$ cts.
Cost of plant per H.P.	220 00	150 00	100 00
Interest, 5 per cent	11.00	7 50	5 00
Depreciation, 5 per cent	11.00	7 50	5 00
Insurance, 2 per cent	4 40	3 00	2 00
Taxes, 1 per cent	2 20	1 50	1 00
Repairs, 10 per cent	22 00	15 00	10 00
Oil, waste, and supplies, 5 per cent	11 00	7 50	5 00
	61 60	42 00	28 00
Coal per horse-power, per hour, in pounds	20	15	12
Cost per horse-power at $6.50 per ton for 3,000 hours	195 00	146 25	117 00
Attendance per horse-power for 3,000 hours	75 00	50 00	30 00
Incidentals per horse-power (as above)	61 60	42 00	28 00
Cost of 1 horse-power per annum, 10-hour basis	331 60	238 25	175 00
Cost of 1 horse-power per hour	0·1105	0·0794	0·0583

This table contains details of cost, from which a revised table has been prepared more closely applicable to farm conditions.

The 20-h.p. engine, which is too large for anything but silo-filling or threshing on the average farm, especially in the West, has been omitted. In any case, the threshing outfit will probably burn wood when travelling and straw when threshing so that the above figures will not apply.

In considering the 6-h.p. and 10-h.p. engines, 500 hours per year has been assumed as the average service, and it is thought that unless the engine is used in conjunction with a storage battery for lighting, this time will be ample to do all the necessary wood-cutting, hay-baling, feed-grinding, etc.

Interest, depreciation, insurance, taxes, and repairs are all combined at 20 per cent.

Size of plant	6 H.P.	10 H.P.
	$ cts.	$ cts.
Cost of plant	1,320 00	1,500 00
Interest, etc. (20 per cent)	264 00	300 00
Oil, waste, etc., (2 per cent)	26 40	30 00
	290 40	330 00
Coal per H.P. per hour, pounds	20	15
Cost at $6.50 per ton for 500 hours	195 00	243 75
Attendance	75 00	75 00
Incidentals (above)	290 40	330 00
Cost per annum	560 40	648 75
Cost per H.P. hour	0·1868	0·12975

Thus, assuming the accuracy of Mr. Skinner's figures, and that the modifications are reasonable, we obtain the result that a 6-h.p. steam plant will cost for 500 hours' service per year 18.68 cents per horse-power hour and a 10-h.p. plant approximately 13 cents per horse-power hour.

It will be shown that the figures can be cut down considerably by using gasolene or oil engines, justifying the statement previously made that steam plants for farm use are not economical.

Coming to the explosion-type of engine we have gas, gasolene and oil.

Gas engines.—The field for these is restricted for agricultural use, for though a gas-producer plant using peat or coal is a possibility it cannot be looked on at all favourably at this stage. Future improvements may make the gas engine and gas-producer combination an active contender in the field of small farm power plants: the suction gas-producer is already receiving attention in England for country house lighting. · Town-gas is generally not obtainable and in cases where it is, electric power from a central station is probably also available. The gas engine on the farm will probably be confined to one or two isolated cases where a farmer has sunk a well for, and obtained, a supply of natural gas.

Gasolene and Oil Engines.—The manufacturers of gasolene engines are well to the fore in laying their wares before the agriculturist. It is no uncommon thing to hear an 'exhaust' when driving across the western prairies, and the use of engines seems to be increasing.

Mr. Skinner, whose report to H. A. Robson, K.C., on the proposed Manitoba Hydro-Electric system has already been referred to, gives the following figures:—

COST of Gasolene Power.

Size of plant in H.P.	2	6	10	20
Price installed	$ 200 00	$ 433 00	$ 666 00	$ 1,000 00
Gasolene per B.H.P. hour, in gallons	1/3	1/4	1/6	1/8
Cost per gallon	20c.	20c.	20c.	20c.
Cost per 3,000 hours	400 00	900 00	1,000 00	1,500 00
Attendance at $1 per day	300 00	300 00	300 00	300 00
Interest, 5 per cent	10 00	21 65	33 30	50 00
Depreciation, 5 per cent	10 00	21 65	33 30	50 00
Repairs, 10 per cent	20 00	43 30	66 60	100 00
Supplies, 20 per cent	40 00	86 60	133 20	200 00
Insurance, 2 per cent	4 00	8 65	13 30	20 00
Taxes, 1 per cent	2 00	4 35	86 65	10 00
Power cost	$ 786 00	$ 1,386 20	1,666 35	$ 2,230 00

Size of plant in H.P.	2	6	10	15
Value of space occupied	$ 100 00	150 00	200 00	300 00
Interest, 5 per cent	5 00	7 50	10 00	15 00
Repairs, 2 per cent	2 00	3 00	4 00	6 00
Insurance, 1 per cent	1 00	1 50	2 00	3 00
Taxes, 1 per cent	1 00	1 50	2 00	3 00
	9 00	13 50	18 00	27 00
Power cost	786 00	1,386 20	1,666 35	2,230 00
Total cost per annum	$ 795 00	1,399 70	1,684 35	2,257 00
Cost of 1 H.P. per annum–10 hour basis	$ 397 50	233 28	168 45	112 85
Cost per 1 H.P. per hour	$ ·1325	·0778	·0561	·0376

On the same basis as that assumed when dealing with the steam plant—

Size of plant in H.P.	2	6	10	20
Price installed	$ 200 00	433 00	666 00	1,000 00
Gasolene per B.H.P. hour, gallons	1/3	1/4	1/6	1/8
Cost per gallon	20c.	20c.	20c.	20c.
Cost per 500 hours	$ 66 67	150 00	166 67	250 00
Attendance	50 00	50 00	50 00	50 00
Interest, etc. (20 per cent)	40 00	86 60	133 20	200 00
Supplies, (20 per cent)	40 00	86 60	133 20	200 00
Space charges	9 00	13 50	18 00	27 00
	205 67	386 70	501 07	727 00
Cost per B.H.P. hour	0·2057	0·1289	0·1002	0·0727

If we compare the 6-h.p. size we find the cost per h.p. gasolene and steam to be 13 cents and 19 cents respectively while for the 10-h.p. size the ratio is 10 cents to 13 cents.

Reliable figures as to gasolene consumption per h.p. hour are hard to obtain, my own estimates farther on in this report have been based on a consumption of one-eighth of an imperial gallon per h.p. hour, assuming full load conditions and efficient attendance. The foregoing table, however, shows a widely varying consumption, also it does not state whether the imperial or United States gallon is intended, the latter being five-sixths of the former. The above table probably deals with engines designed for rough usage for direct drive, in which case the consumption of gasolene would be higher than for the better class engines considered later, which have been designed for the more exacting duty of driving electric machinery, and which require very much more accurate regulation. In Bulletin No. 25, "Electric Power on the Farm," by Adolph Shane, issued by the Iowa State College, is the following: "The sizes of gasolene engines referred to in these pages (2 to 10 h.p.), will operate on between a sixth and an eighth of a gallon of fuel an hour for each horse-power when running under full load. At a third load these figures will about double." Those interested in the question of farm power would do well to study this bulletin, also "Lighting Country Homes by Private Electric Plants," by T. H. Amrine, issued by the University of Illinois.

The following cost data have all been worked out on the consumption basis already stated, namely, one-eighth imperial gallon per h.p. hour at full load, and the cost is taken as 30 cents per imperial gallon—a fair average price in the West.

The first table is adapted from a detailed statement of the costs of a 15 k.w. gasolene-electric set. This information was supplied by the Sturtevant Co., of Hyde Park, Mass., who manufacture six and four-cylinder sets particularly designed for this class of service. The weight and cost of the smaller sets were also supplied by this firm. In drawing up the following statement 50 per cent has been added to the capital cost as stated by the Sturtevant Co. for freight and duty, and the interest on capital and cost of gasolene are as shown, being corrected to conform more closely with western conditions.

Size of set	5 k.w.	10 k.w.	15 k.w.
Weight, pounds	1,400	2,600	3,175
(1) Cost of complete set	$ 1,370 00	$ 1,925 00	$ 2,430 00
(2) Foundations	20 00	25 00	30 00
(3) Total generating plant	1,390 00	1,950 00	2,460 00
(4) Depreciation (8 per cent)	111 20	156 00	196 80
(5) Repairs (3 per cent)	41 70	58 50	73 80
(6) Interest (8 per cent)	111 20	156 00	196 80
(7) Total fixed charge	264 10	370 50	467 40
(8) Gasolene per k.w. hour (⅛ per horse-power hour) imp. gals	⅙	⅙	⅙
(9) Cost of gasoline per 10-hr. day at full load at 30 cents per gal	2 50	5 00	7 50
(10) Attendance per day	15	15	15
(11) Oil waste and supplies	35	45	55
(12) Total daily expense	3 00	5 60	8 20
(13) Yearly running expense (300 days)	900 00	1,680 00	2,460 00
(14) Total yearly expense (items 7 and 13)	1,164 00	2,050 00	2,927 00
(15) Total k.w. hours per year	15,000 00	30,000 00	45,000 00
(16) Cost per k.w. hour, cents	7¾	6⅞	6½
(17) Cost per horse-power hour, cents	5 13/16	5 5/32	4⅞

It must be borne in mind that the above figures can only be approximate and that the cost per k.w. hour represents, merely, that of manufacture; switching apparatus, wiring, motors, lamps, machinery, etc., is absolutely excluded.

These "gasolene-electric" sets are, according to the makers, intended to be used in direct connection with lighting and power circuits and not through a storage battery, though a storage battery can be used if desired. This, of course, means a particularly efficient governor control to insure a constant voltage through wide variations of load, if the sets are to be run without constant attention.

The oil engine has had a wide application for many years in Great Britain as well as the continent of Europe, many 1 to 2 h.p. engines being in use for pumping domestic water for country houses and farms. The coast defence stations were, many of them, equipped with 15 h.p. oil-engines which drove the dynamos supplying the current for search-lights, these being but examples of a wide application. These engines were generally regulated by a "hit and miss" governor, the fuel valve is opened at the beginning of every admission stroke, or left closed, according as the speed is below, or above, normal; this method of regulation did not admit of such refinement as does the throttling governor which is now more generally used on all but the smallest sizes.

Prices cannot be given accurately: trade discounts, freight, and many other considerations enter largely into their determination, not to mention the commercial rating of the individual customer, and his accessibility. The only way of obtaining an actual net price would be by submitting an actual proposition and furnishing the necessary references. It is thought, however, that the costs given below will be found to represent approximately the cost to the Westerner. Where eastern prices were obtained a rough allowance has been made for freight

The cost of gasolene engines in the East of from 3 to 10 h.p. varies from $70 to $50 per horse-power, according to manufacture and size, the bigger machines being, naturally, cheaper per horse-power. The following table gives figures for gasolene and coal-oil electric sets, and has been worked out from data courteously supplied by the Canadian General Electric Company.

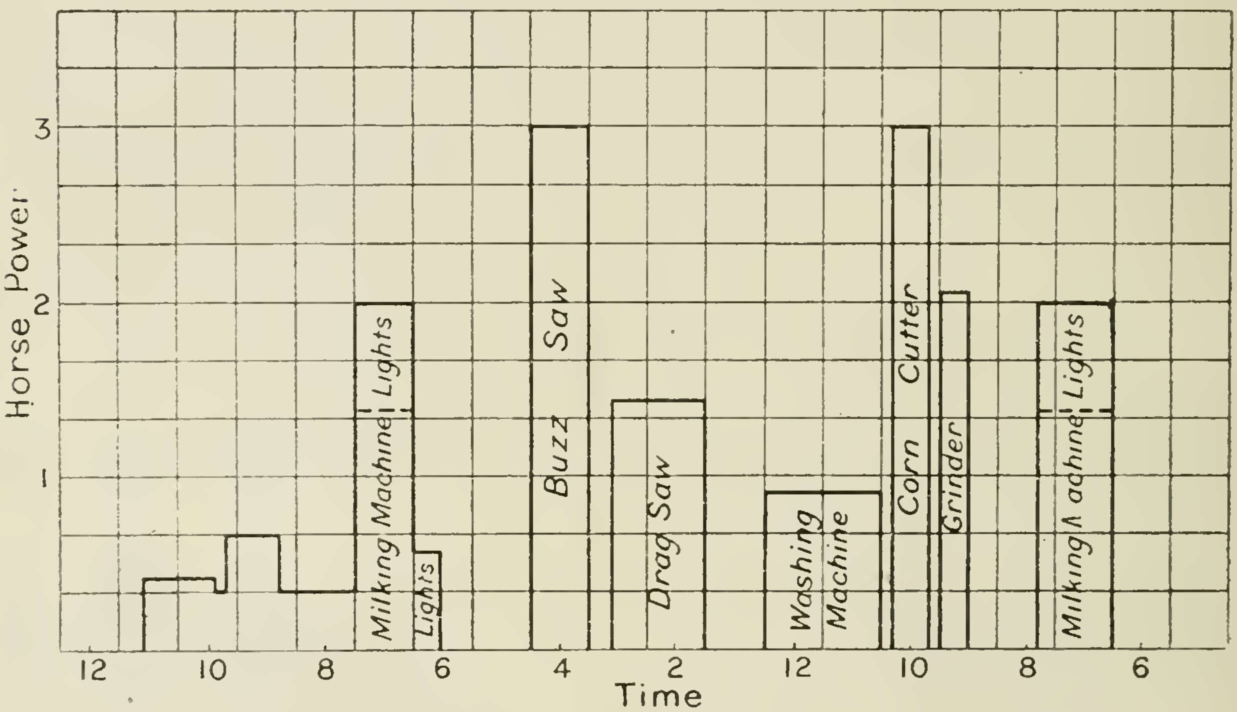
—		Gasoline.		Coal Oil.
(1) Size of engine	h.p.	4	6	6
(2) Size of dynamo	k.w	3	4·5	4·5
(3) Estimated cost erected in Calgary		$ 520 00	720 00	730 00
(4) Depreciation, repairs and interest (20 per cent)		106 00	144 00	146 00
(5) Gallons of fuel per horse-power hour		$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{5}$
(6) Cost of fuel per 10-hour day		1 50	2 25	1 80
(7) Attendance, oil, waste and supplies		40	50	50
(8) Daily expense		1 90	2 75	2 30
(9) Yearly running expense (300 days)		570 00	825 00	690 00
(10) Total yearly expense (4 and 9)		676 00	969 00	836 00
(11) Total horse-power years		12,000 00	18,000 00	18,000 00
(12) Cost per horse-power hour	cents.	$5\frac{2}{3}$	$5\frac{1}{3}$	$4\frac{2}{3}$
(13) Cost per k.w. hour	cents	$7\frac{1}{2}$	$7\frac{1}{5}$	$6\frac{1}{5}$

These costs work out a trifle cheaper than those for the Sturtevant sets, for gasolene, and more than one per cent per h.p. hour cheaper for coal-oil. It must be remembered, however, that this outfit is a cheaper one and, not being particularly designed for variable loads, could not fairly be expected to be as uniform, in its action, under extreme variations of load, as the more expensive set.

The above analyses of cost assume a constant load for 10 hours a day, 300 days in the year. On a farm, energy may be required at any hour between 5 a.m. and midnight, and the load may vary from one-half h.p. to the maximum capacity of the plant. anything approaching full load will be the exception, rather than the rule. According to a diagram, given in Messrs. Sturtevant's catalogue, the quantity of gasolene required per k.w. hour at one-quarter load is three times that used at full load—this for a 10-k.w. gasolene electric set. The fuel efficiency of any other set under light load would hardly be any greater. Probably the most satisfactory method of attacking the problem, is to consider the power requirements of the average farmer. Here again we have to make many assumptions based on comparatively little positive information.

The Electric Power Co., Limited, of Belleville, has developed an extensive rural business and have furnished the following notes: "Farms in different localities vary as to class of farming and the methods of using electric current vary accordingly. For instance, in localities where fruit-growing predominates, the farms should not be looked upon as being able to use electricity to as good advantage as mixed farming, on farms of from 150 to 200 acres. The fact that electricity appears most attractive in stock-raising and dairying sections seems to be fairly well established." This company further states that occupants of farms varying from 150 to 200 acres are usually able to use from 2 to 4 h.p. to good advantage.

The Ontario Hydro-electric Power Commission's reports for 1912 and 1913 furnish valuable information, and on page 161 of the 1912 report a typical farm load diagram is given. This diagram shows energy used in water and air heaters which, though desirable when power is furnished at a flat monthly rate and is available at all times, cannot be looked upon favourably when the electricity has to be privately generated.



TYPICAL FARM LOAD DIAGRAM

(Adapted from Diagram on p. 161 of Fifth Annual Report of the Ontario Hydro-electric Commission)

The diagram given here is the same as the one just mentioned with the exception of the omission of the heaters, and it is proposed to use it as representing the power problem to be solved. An analysis of the diagram shows that there is a lighting load for 6½ hours of less than 1 h.p. while milking and other machines require power for 8¼ hours in all.

There are almost innumerable ways of handling this load suited to varying purses.

(1.) Electricity might be eliminated altogether and a portable 3-h.p. gasolene or oil engine might be used to operate the saws, cutters, grinders, etc.

(2.) The lighting might be done by an automatic lighting set, the milking and washing by hand and the balance of the work as in (1) or the same engine could be arranged for lighting and power.

(3.) The lighting set might be made a trifle larger, it would then drive the washing machine and might be arranged to work the milking machines and do any necessary pumping (an automatic set being able to handle any small uniform load). The other machinery being handled by the same engine through a line shaft or by a separate engine.

(4.) A gasolene-electric set could be purchased and run all the time, coal oil lamps being used to save expense at very light loads.

(5.) A gasolene-electric set in conjunction with a well equipped storage battery could be arranged so that the running time of the engine could be reduced and the load upon it kept as high as possible.

POWER COST.

CASE 1.—3-h.p. gasolene engine would cost with belting, etc., about $250, this engine would work about 3½ hours per day using approximately 1⅓ gallons or 40 cents worth of gasolene per day, allowing 50 cents per day in all we have:—

Capital invested	$250
Interest depreciation, and repairs (20 per cent)	$ 50
Running expenses, 50 cents per day for 300 days	$150
Total annual cost for power	$200

CASE II.—Messrs. R. A. Lister and Company, Limited, have kindly supplied information concerning automatic plants of their manufacture, and state that for farm use some of their customers prefer the following non-automatic outfit: A 5-h.p. engine with a one-half k.w. generator and a small storage battery of say twenty-four ampere-hours capacity, the battery being used when only a small amount of lighting has to be done and when no motors, electric irons, etc., are in use. The only additional attention required is that of starting up the engine to charge the battery in the day time. There is an automatic charging switch which cuts out the battery when it is fully charged.

This outfit would cost about $820 f.o.b. Winnipeg, and consists of:—

1 5 h.p. engine with necessary accessories complete.
1 ½ k.w. generator (57 volts) on sliding bed-plate connected to engine by leather belt.
1 switchboard with necessary instruments, switches and fuses.
1 storage battery of 27 glass cells of 24 amp. hour capacity capable of lighting 11 to 15 watt lamps for 8 hours, 17 for 5 hours or 22 for 3 hours.

CASE III.—The same firm have furnished particulars of a combination similar to that above except that the same is automatic: the dynamo in this case would be of 1.5 k.w., and the battery would consist of twenty-seven or fifty-four cells of the thirty-six or twenty-four ampere-hour capacity respectively at the 8-hour rate. This outfit would cost in the neighbourhood of $1,200, and the following running costs are given:

Running cost (6 hours per day except Sundays)	$100 00
Interest at 5 per cent	60 00
Depreciation and repairs, 10 per cent	120 00
	$280 00

If the above allowances are sufficient the costs would be very attractive, but if we allow, as in outfit *B* Case V (see below) about $300 for gasolene and 20 per cent for fixed charges we have:—

Running cost	$300
Depreciation, interest and repairs (20 per cent)	240
	$540

still a very reasonable proposition.

CASE V.—This presupposes that every operation shown in the diagram is performed by electricity, but account is also taken of the fact that the battery and dynamo may be used in parallel to supply excessive power demands for silo filling and threshing; thus if a 3-h p. engine is in use the battery will probably give 2-h.p. if required enabling us to drive a 5-h.p. motor. Thus it will be seen that such a set can look after maximum demands more readily than any other, for instance, suppose, 8 h.p. must be supplied on occasion; without a storage battery the engine itself would have to give this power or a special engine would have to be installed: with a storage battery a 5-h.p. engine will be sufficient for all purposes.

Also, for very light loads, the power can be given by the battery which works more efficiently at low discharge rates, the engine only being used at or near its rated capacity.

Two outfits are considered here and should be studied in conjunction with the load diagram given above.

Outfit A.—This is a 4-h.p. gasolene engine driving a 3-h.p. generator used in conjunction with a 62 chloride accumulator battery as listed by the Electric Storage Battery Company as No. 5663.

This battery discharging at 110 volts will give:—

20 amps. for 2¾ hours = 2·20 k.w. or 2·93 h.-p.
14 " 4¾ " = 1·54 " 2·05 "

It will require to charge it at 161 volts:—

14 amps. = 2.254 k.w. = 3 h.-p. (maximum charging rate).
10 " = 1.61 " = 2·14 " (normal rate).

If the cells are arranged for charging in parallel, a different voltage, but an equivalent quantity of power, will be required. The following table indicates the use of this outfit in handling the load:—

Time.	Farm Load.	Engine.	Charge.	Discharge.
a.m. 6.30— 8.00	Milking machine and lights	Running	None	None.
8.00— 9.00	None	"	14 amps, 14 amp-hours	"
9.00—10.15	Grinder and cutter	"	None	"
10.30—12.30	Washing machine	"	10 amps, 20 amp-hours	"
p.m. 12.30— 1.30	None	Stopped	None	"
1.30— 3.00	Drag saw	Running	"	"
3.00— 3.30	None	Stopped	"	"
3.30— 4.30	Buzz saw	Running	"	"
6.00— 6.30	Lights	Stopped	"	(4 amps, 2 amp-hours.
6.30— 7.30	Milking machine and lights	"	"	14 amps, 14 amp-hours.
7.30—11 00	Lights	"		4 amps, 14 amp-hours.
			34 amp-hours	30 amp-hours.

Engine runs 8½ hours.

Thus a 4-h.p. engine, in conjunction with a 3-k.w. dynamo and battery will, by running 8½ hours, handle the normal daily load and give a total amount of 6·93 electrical horse-power for 2¾ hours, or 6·05 for 4¾, without overloading engine, battery, or dynamo, less any line or motor losses.

The following costs have been worked out for this outfit:—

4-h.p. gasolene engine and 3-k.w. dynamo erected Calgary........	$ 520
Battery and switchboard delivered and installed................	1,430
Capital cost of plant (exclusive of wiring, motors, etc.)..........	$1,950
Depreciation, interest and repairs, 20 per cent...................	390
Gasolene per h.p. hour—$\frac{1}{8}$ gal. at 30 cents per gal.—Cost of gasolene per day of $8\frac{1}{2}$ hours..................................	1.275
Attendance, oil, waste and supplies..........................	.40
Daily cost	1.675
Yearly running expense (300 days)	$502 50
Total annual cost	892 50

Outfit B.—This consists of a 6-h.p. gasolene or coal oil engine, a $4\frac{1}{2}$-k.w. generator and a battery listed as No. 5664.

This battery discharging at 110 volts will give:—

30 amps. for $2\frac{3}{4}$ hours = 3.30 k.w. or 4.4 h.p.
21 " $4\frac{3}{4}$ " = 2.31 " 3.08 h.p.

Charging at 161 volts the power required is:—

21 amps. = 3.38 k.w. = 5 h.p.
15 " = 2.41 " = $3\frac{1}{4}$ h.p.

Considering the same loading conditions as before we have:—

Time.	Farm Load.	Engine.	Charge.	Discharge.
a.m. 6.30— 8.00.........	Milking machine and lights.........	Running...........	18 amps., 27 amp.-hours............	None.
8.00— 9.00.........	None..............	"	21 amps., 21 amp.-hours.	"
9.00—10.15.........	Grinder and cutter.	Stopped	None...............	18 amps., 22·5 amp.-hours.
10.30— 12.30........	Washing machine...	Running...........	21 amps., 42 amp.-hours.	None.
p.m. 1.30— 3............	Drag saw...........	Stopped............	None......	10 amps., 15·0 amp.-hours.
3.30— 4.30.........	Buzz saw...........	"	"	21 amps., 21·0 amp.-hours.
6.00—6.30..........	Lights..............	"	"	4 amps., 2·0 amp.-hours.
6.30—7.30..........	Milking machine and lights.........	"	"	14 amps., 14·0 amp.-hours.
7.30—11.00.........	Lights..............	"	"	4 amps., 14·0 amp.-hours.

Engine runs $4\frac{1}{2}$ hours. Chge. 90 amp.-hours. Disch. 88·5 amp.-hours.

In this case a 6-h.p. engine, either gasolene or oil, in conjunction with a $4\frac{1}{2}$ k.w. and battery will carry the farm load by working $4\frac{1}{2}$ hours per day and will, if required, combine with the battery to give 10 h.p. for $2\frac{3}{4}$ hours or 9 h.p. for $4\frac{3}{4}$ hours at the generator terminals.

The following costs have been worked out for this outfit (1) for gasolene and (2) for coal oil:—

(1) 6 h.p. gasolene engine, 4½ k.w. dynamo erected at Calgary......	$ 720 00
Battery and switchboard delivered and installed	1,800 00
Capital cost of plant (exclusive of wiring, motors, etc.).........	2,520 00
Interest, repairs and depreciation (20 per cent)................	504 00
Gasolene per horse-power, hour = ⅛ gal. at 30 cents. Cost of gasolene per 4½-hour day	1 01
Attendance, oil, waste, and supplies..............................	0 39
Daily running cost	1 40
Yearly running expense (300 days)	420 00
Total annual cost	924 00

This is practically the same as for the smaller outfit; the capital costs are larger, but the running expenses are smaller, and we have a largely increased maximum capacity of plant.

(2) 6 h.p. coal oil engine, etc..................................	$ 730 00
Battery, switchboard, etc., as before	1,800 00
Capital cost of plant (exclusive of wiring, motors, etc.)..........	2,530 00
Interest, repairs and depreciation (20 per cent)................	506 00
Coal oil per h.p. hour = ⅛ gal. at 15 cents. Cost of coal oil per day (4½ hours)	0 81
Attendance, oil, waste and supplies..............................	0 39
Daily running cost	1 20
Yearly running expense (300 days)	360 00
Total annual cost	866 00

This is a saving of about $60 per year on the gasolene plant of the same size, the cost per k.w. hour is somewhat misleading as the load-factor of the 4 h.p. and 6-h.p. plants are different. The actual work done during the day shown in the diagram is 18-h.p. hours, so that the load-factor for the 4-h.p. plant working 8½ hours is 18 ÷ 34 or 53 per cent; while for the 6-h.p. plant working for 4½ hours it is 18 ÷ 27, or 67 per cent. The fairest way is to consider the actual work done, in which case this is 18 h.p. hours, or 13½ k.w. hours per day, and 4,050 k.w. hours per year, whence we have:—

Cost per k.w. hour for 4-h.p. gasolene engine and storage battery = 22 cents.
" " " 6-h.p. " " " " = 22.8 cents.
" " " 6-h.p. oil " " " = 21.4 cents.

With the outfits outlined above, an increase in use of current will reduce the cost per k.w. hour, as the overhead charges will not vary a great deal; while any decrease in power used will have a contrary effect.

The load diagram upon which the above estimates are founded gives, I imagine, a greater load than the average; in the summer the lighting will be less; the milking load will be fairly constant all the year round but, in the season when work is being done in the fields, the use of saws, grinders, etc., will be materially reduced.

The estimates given above are for the bare power-producing equipment: building for housing the plant, all wiring, motors and electrical devices, being absolutely excluded; these will increase the costs very materially.

The Electric Power Company, Limited, of Belleville, states that "The cost of an installation covering a 3 h.p. contract varies considerably, depending largely on the extent to which the party wishes to use the current. A holder of the above-mentioned amount may use, at different intervals, the following: 2,000 watt electric range, toaster, electric iron, radiator (not water heater), vacuum cleaner, pressure pumping installation, a general utility motor (⅛ h.p.) which can be used to operate the washing machine, churn, buffing machine, etc.; while at the barn, a 3-h.p. motor can be connected to a countershaft and operate straw cutter, root pulper, milking machine, cream separator and wood saw. Together with the necessary wiring, this installation might cost $550. At the present time, it cannot be termed a representative installation as the usual investment will be approximately $250."

The question of the power necessary for silo-filling and threshing is not quite settled. Mr. Purcell, of the Ontario Hydro-electric Commission, has stated that a 5-h.p. motor will drive a small thresher or silo-filler, and that these will operate quite satisfactorily; whether these smaller machines will ever become popular remains to be seen. The Electric Power Company, already referred to, state that "should small threshing outfits, which may be used at opportune time, and the carrier ensilage cutter replace the equipment most used now, it is our opinion that 5 h.p. will be quite adequate."

The writer perfectly realizes that the above estimates may well be wide of the mark, the assumption as to load is entirely arbitrary; until a large number of diagrams for many farms, extending over long periods have been taken, a fair estimate of power demand cannot be made. The prices are, except where otherwise stated, given for plant erected near Calgary, long road hauls will affect these costs considerably, and as was stated previously the prices given can only be taken as fair approximations. The figure for overhead charges (20 per cent) will have to be verified or revised by experience.[1] The use of batteries, too, may prove unsatisfactory in the hands of the average farmer; as a general rule a storage battery requires reasonably careful handling to give its best results. Attention was perhaps not sufficiently directed to the fact that the loss in charging and discharging a battery is about 40 per cent.

[1] Recent figures supplied me by manufacturers place depreciation of batteries at 10 per cent, and gasolene-electric sets at from 5 to 10 per cent according to hours of service. If continuous service, of say 18 hours, is required, if no battery is used, the engine will be running long hours and the depreciation will be high and the gasolene consumption, owing to the high proportion of light load, will be inefficient.

If a large storage battery is used the engine depreciation will be low; but the increased gasolene efficiency will be counterbalanced by the electrical inefficiency of the battery, also the 10 per cent depreciation on the expensive battery will amount to a considerable sum.

The automatic set, it is claimed, avoids the above disadvantages, the engine does not operate for very light loads, while the battery is cheap and is only used to supply a small portion of the energy used. So we have greater gasolene efficiency and lower depreciation charges.

The cost and consumption of fuel are believed to be reasonably correct, these items are variable in any case and difference will affect daily and annual costs in a very marked degree.

The advantages to be gained by using electricity on a farm have been enumerated again and again, in technical papers and trade publications. Special stress has been laid upon the convenience and cleanliness of a house and farm completely equipped electrically, and it is here taken for granted that the proposition has been sufficiently demonstrated as to convenience. With regard to economy, it can but be obvious that any device that increases the efficiency of the hired man 300 per cent or more, or reduces the number of men required, is a great saving when one considers the costliness and difficulty of obtaining and keeping farm help.

The General Electric Company has issued a well arranged, illustrated bulletin '*Electricity on the Farm*' which treats very fully of the applications of electricity. and some of the data in this publication are incorporated in the appendix. I have not, therefore, elaborated on the uses of electricity, but have confined these notes to the sources of power available to the Western farmer, and it is hoped that these together with the appendices and some photographic illustrations will be of interest to the agriculturist and not prove misleading.

CONCLUSIONS.

It may be thought that some of the outfits elaborated on have proved unworthy of the space devoted to their discussion; I have thought it well, however, to treat the matter fully, so that those interested may study all the alternatives and select the outfit best suited to their needs and resources. I do not feel called upon to make any recommendations, on what is, largely, a theoretical study of the question.

It is not claimed that every alternative has been looked into, nor that the figures given are accurate. The assumptions have, of necessity, been somewhat arbitrary. The data given have been collected with great care from all available sources and, it is thought, are free from any gross errors.

An appendix is given containing a bibliography, and a collection of information as to power consumption on the farm.

I have the honour to be, Sir.

Your obedient servant,

A. M. BEALE,

Engineer.

BIBLIOGRAPHY.

The following list gives some of the sources of information referred to by the writer:—

Hydro-Electric Power Commission of Ontario, Fifth Annual Report.

Hydro-Electric Power Commission of Ontario, Sixth Annual Report.

Evidence of Messrs. Purcell and Espenschied before the Committee on Agriculture and Colonization, Parliament of Canada, Session 1914.

Report on Projected Hydro-Electric System for Manitoba, by H. A. Robson, K.C.

Bulletin No. 25, Iowa State College, Ames, Iowa. "Electric Power on the Farm," by Adolph Shane.

Bulletin No. 25, University of Illinois, Urbana, Ill. "Lighting Country Homes by Private Electric Plants." T. H. Amrine.

Bulletin No. 146, United States Department of Agriculture, Washington, D.C. "Current Wheels—their use for lifting water for Irrigation."

Bulletin No. 529, University of Wisconsin, Madison, Wis. "Theory and Test of an Overshot Water Wheel." C. R. Weidner, C.E.

"Electricity for the Farm and Home." By Frank Koester.

"Water Power for the Farm and Country Home. David R. Cooper, State Water Supply Commission, New York.

Frequent reference is to be found in technical journals such as the *Electrical News* and the *Transactions of Electrical Societies.* Many reputable manufacturing firms have issued catalogues, pamphlets, bulletins or other advertising matter, which contains much interesting information on one phase or another of the small power question.

APPENDIX.

AMOUNT OF POWER CONSUMED BY FARM MACHINERY.

Mr. Purcell, Assistant Engineer Ontario Hydro-Electric Power Commission

½ h.p. Will light fifteen 20 c.p., nine 32 c.p. or six 48 c.p. Tungsten lights. It will supply energy for a pump of average lift, electric iron, washing machine, coffee percolater, toaster, cream-separator, churn, buttermaker, grindstone, cider-mill, fanning mill, etc., some cases more than one at a time.

1 h.p. The above, also small stove of fireless cooker type; some milking machines, some circular saws, water heater for night load.

2 h.p. All above, any milking machine, most types of cutting box, 6-inch or 8-inch choppers of 10 bushels capacity per hour suitable for horses or cattle, or 6 bushels for pigs.

5 h.p. Can do almost any operation required on the farm.

"*Small Water-power for the Farm and Country Home.*"—David R. Cooper.

1 h.p. Will pump all water from a well of ordinary depth for ordinary farm-house and building requirements.

3 h.p. Converts 6,000 pounds milk per day into cheese.

5 h.p. Grinds 25 to 40 bushels feed per hour, grinds 10 to 12 bushels ear-corn per hour, drives 30-inch circular saw cutting 50 to 75 cords stovewood from hard oak in ten hours.

6 h.p. Will drive grain separator and thresh 2,500 bushels of oats in ten hours, will run a feed-mill grinding 20 bushels corn an hour, runs heavy apple grater, grinding and pressing 200 to 250 bushels per hour, saws all the wood four men can pile in cords.

7 h.p. Drives an 18-inch separator, burr-mill and corn and cob crusher and corn sheller grinding from 12 to 15 bushels of feed per hour and 5 to 8 bushels of good fine meal.

10 h.p. Will run 16-inch ensilage cutter and blower[1] and elevate the ensilage into a silo 30 feet high at the rate of 7 tons per hour.

12 h.p. Will drive a 50-inch circular saw, sawing 4,000 feet of oak or 5,000 feet of poplar a day.

"*Electricity for the Farm and Home.*"—Frank Koester.

All costs are figured for power at 5 cents per k.w.h. Machinery prices are for United States, and to these must be added freight and duty. Power required for farm machinery (pp. 103-104) :—

Thresher	5 h.-p.
Cow milker	½ h.-p.
Grindstone	¼ h.-p.
Grist-mill	15 to 30 h.-p.
Refrigerator	5 to 25 h.-p.
Pump	½ to 25 h.-p.

[1]Mr. Purcell considers blower outfits prodigal of power, and recommends elevator.

Hay press (120-pound bales)—

14-inch by	18-inch bale chamber; capacity	12 tons per day,	3 h.-p.
16 "	18 " " "	14 " "	4 "
17 "	22 " " "	16 " "	6 "
14 "	18 " " "	10 " "	2 "
16 "	18 " " "	10 " "	2 "
17 "	22 " " "	12 " "	3 "

Feed grinder—

8-inch large or small; capacity	8 bushels per hour,	4 h.p.
16 " " " "	36 " "	10 "
10 " " " "	15 " "	6 "
10 " " " "	50 " "	15 "

Husker—

6 roll; capacity, all that one man can carry	15 h.-p.
Two 6 " " 300 to 400 bushels per hour	12 "
4 " " 175 to 250 " "	8 "
2 " " 100 to 200 " "	4 "

Combination churn and buttermaker—

Capacity, 50 gallons	1 h.-p.
100 "	1 "
200 "	2 "
300 "	2 "

Pasteurizer—

600 gallons	2 h.-p.

Cream separator—

350 gallons of milk per hour	½ h.-p.
450 " " "	½ "
650 " " "	½ "
850 " " "	1 "
1,000 " " "	1 "

Pumping 1,000 gallons per day elevated 35 feet, $18.25 for energy.

Threshing 80 to 200 bushels per 10 hours (threshing, cleaning and sacking) 3 to 5 k.w.; 160 to 240 bushels per 10 hours (threshing, cleaning and sacking) 5 to 7 k.w.; 300 to 800 bushels per 10 hours (threshing, cleaning and sacking) 10 to 20 k.w.

The energy required per 100 bushels is: rye, 25 k.w.h.; wheat, 22 k.w.h.; oats, 19 k.w.h.; barley, 21 k.w.h., or an average of 1·1 cents per bushel.

Fodder cutters, 1 to 2 h.p. use 1/80 k.w.h. per 100 pounds; 10 head of cattle consume 60,000 pounds of cut beet, etc., per annum, energy costing 50 cents per head.

Oil-cake breakers, ten head use 9,000 pounds per annum, energy costing 25 cents per head.

Grain crusher, ten head use 9,000 pounds per annum, energy costing 27 cents per head.

Cream separating and churning, ten cows give 30,000 quarts per year costing $1.50 for energy.

Vacuum cleaners, ¼ h.p. machine costs $125; one woman working 260 hours cleans 208,000 square feet costing $43.19 yer year (interest, depreciation, labour, energy); 3 h.p. machine costs $1,365, cleans 2,500 square feet in 1 hour 53 minutes, working 156 hours per annum cleans 260,000 square feet at 9½ cents per 100 square feet or $248 per year (interest, depreciation, labour, energy, etc.).

Washing machine, ¼ h.p., costs $165 complete, 260 hours per year, 780 washes, $35.41 in all.

Horse groomer, costs $75. 1 h.p. motor cleans four horses in 36 minutes, one man working 328½ hours per year can do 2,190 groomings at $72.93 or 3½ cents per grooming.

Separator and churn, 1½ h.p. motor, 183 hours per year, 237,900 pounds milk at $88, or 3·7 cents per 100 pounds; butter churn, 0·2 cents per pound.

Sausage machine grinder costs $71, capacity 750 pounds per hour, 4 h.p. motor costing $145. Eighty hours per year, 60,000 pounds at $60 or, 1 cent per pound.

Stuffer costs $229, 116 pounds per hour with two operators, 517 hours per year for 60,000 pounds, or 0·37 cents per pound.

Hay hoist, 10 h.p., $163; rigging, $105; 2,450 pounds placed in thirteen minutes, or 3½ cents per ton for power, and 10 cents for labour.

Root cutter, 6 tons turnips per hour costs $26.30; 2 h.p. motor, costing $86, in 52 hours cuts 300 tons beets and turnips at $35.94 or 11·9 cents per ton.

Milling, 25 h.p. motor works roller, rolls 40,000 bushels oats per year at ⁴⁄₁₀ cents per bushel for power and labour. Same motor has power to run grist mill of capacity 70 bushels cracked corn per hour, and can run cracking machine for this.

Fodder cutter, capacity 3 tons dry fodder per hour, costs $128.10, and is operated by 10 h.p. motor ($118.50), in 88·70 hours per year cuts 180 tons at cost of $54.85, with one operator, at 30 cents per ton.

Electric ploughing, one motor 80 to 120 h.p. plough system cost $8,000; two motor system $11,000. Steam plough of same capacity $14,000 to $15,000. Disadvantage, not self-propelled to field. Advantages, all other points.

Cost of Electric Ploughing at 3 cents per k.w.h.

Depth of furrow inches	8¾	10¾	14½
Acres per hour	2.25	1.92	1.70
Minutes per acre	27	31	35
Kilowatt-hours per acre	19·2	23·2	33·6
Cost of electricity per acre in cents	57·6	69·6	100·8
Wages per acre for three men in cents	20	24·9	27·9
Total cost of ploughing per acre in cents	77·6	94·5	128·7

Average speed of 80 to 120 h.p. plough with four shares for 9 inch furrows, including time lost in tilting at end of furrows, is 315 feet per minute (about 3½ miles per hour).

Tree cutting, by hot wire (this wire is heated by the friction):—

Diameter of Scotch fir, inches	7·6	12	19·2	
Minutes for hand sawing	1·5	4	12	
" hot-wire cutting	0·7	1·8	4·5	
Diameter of beech, inches	7·6	12	19·2	30
Minutes for hand sawing	2·7	6·9	18·9	120
" hot-wire cutting	1·3	3·4	8·5	20·8

Steam saws may be even faster than hot wire on very big trees, but require four men and a team of horses, besides leaving a stump, whereas by the hot-wire method trees can be cut even below ground.

General Electric Company's Bulletin.

Household Uses.—One cent's worth of electricity at 10 cents per kilowatt-hour will operate:—

A 16 c.p. Tungsten lamp for five hours.

An electric washer, capacity 12 sheets, long enough to wash 20 sheets.

A toaster to produce 10 slices of toast.

A 12-inch fan for two hours.

A heating pad from two to four hours.

A chafing dish twelve minutes.

A water heater to bring 1 quart water to boil.
A griddle eight minutes.
A radiant grill for ten minutes.
A 4-inch disk stove for twelve minutes.
A 6-pound flat iron fifteen minutes.
A vacuum cleaner long enough to clean 450 square feet.
A pump to raise 100 gallons of water 100 feet.
A sewing machine for two hours.
A coffee percolator to produce 3 cups of coffee.
A domestic buffer and grinder for 1¼ hours.
A foot warmer ½ hour.
A broiler six minutes.
An electric curling iron once a day for two weeks.

SIZE OF MOTORS.

Machine.	Horse-power of Motor.		
	Minimum.	Maximum.	Size most commonly used
Sewing machine			1/30
Buffer and grinder	1/30	1/30	1/30
Vacuum cleaner	⅛	5	⅛ to ½
Ice cream freezer	⅛	¼	⅛
Washing machine	⅛	2	⅛ to 1½
Meat grinder	¼	¾	¼
Water pump	¼	1	½

Dairy uses.—One cent's worth of electricity at 10 cents per k.w. hour will separate 700 pounds milk, will churn 10 pounds butter, or milk five cows if machine is capable of milking sixteen cows at a time. This bulletin gives in all some twenty uses for electricity in the dairy, such as bottle-washing, pasteurizing, &c.

SIZE OF MOTORS.

Machine.	Horse-power of motor.		
	Minimum.	Maximum.	Size most commonly used.
Water pump	½	5	3
Cream separator	1/10	¼	⅛
Churn	⅛	3	¼
Milking machine (vacuum system)	1	3	3
Refrigerator	½	10	5

General Farm Uses.—With current at 10 cents per k.w. hour, 0.7 cents will thresh a bushel of oats, 1 cent a bushel of barley, and 1.6 cents one of wheat; root-cutting will cost 1.6 cents a ton; $1.10 will pay for the current for a 60-egg incubator hatching and $1.60 for a 250-egg incubator. The following are the costs per bushel for grinding:—

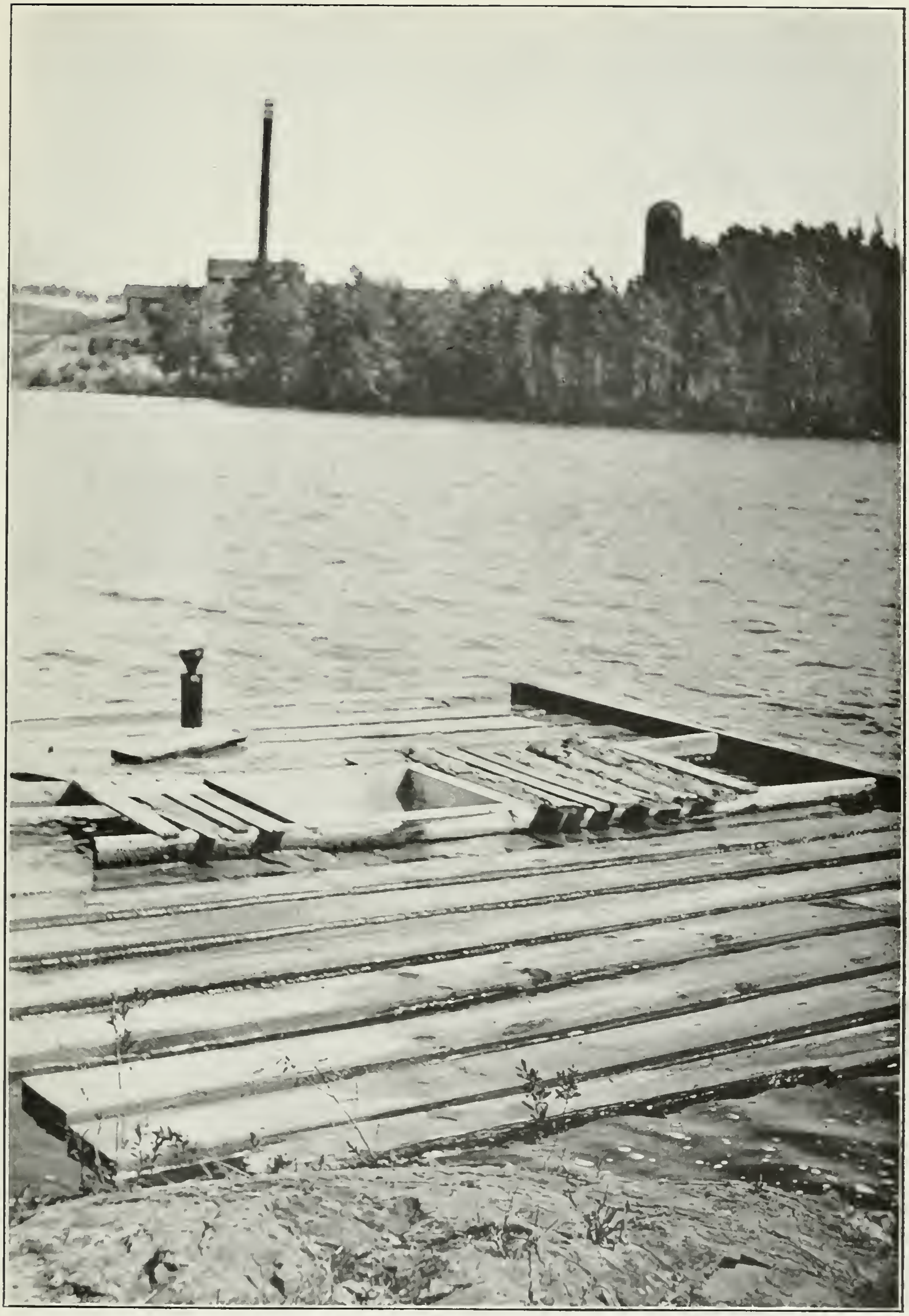
Corn on the cob, 4.1 cents; oats, 3.7 cents; crushing oats, 0.45 cents; grinding shelled corn, 2.7 to 4.3 cents according as size of motor decreased from 15 to 5 h.p. Cracking corn, 0.86 cents.

Attention is called to the cost of hauling grain to the mill and back, which may be from 1 to 6 cents per bushel according to the grain and distance to mill (1 to 7 miles).

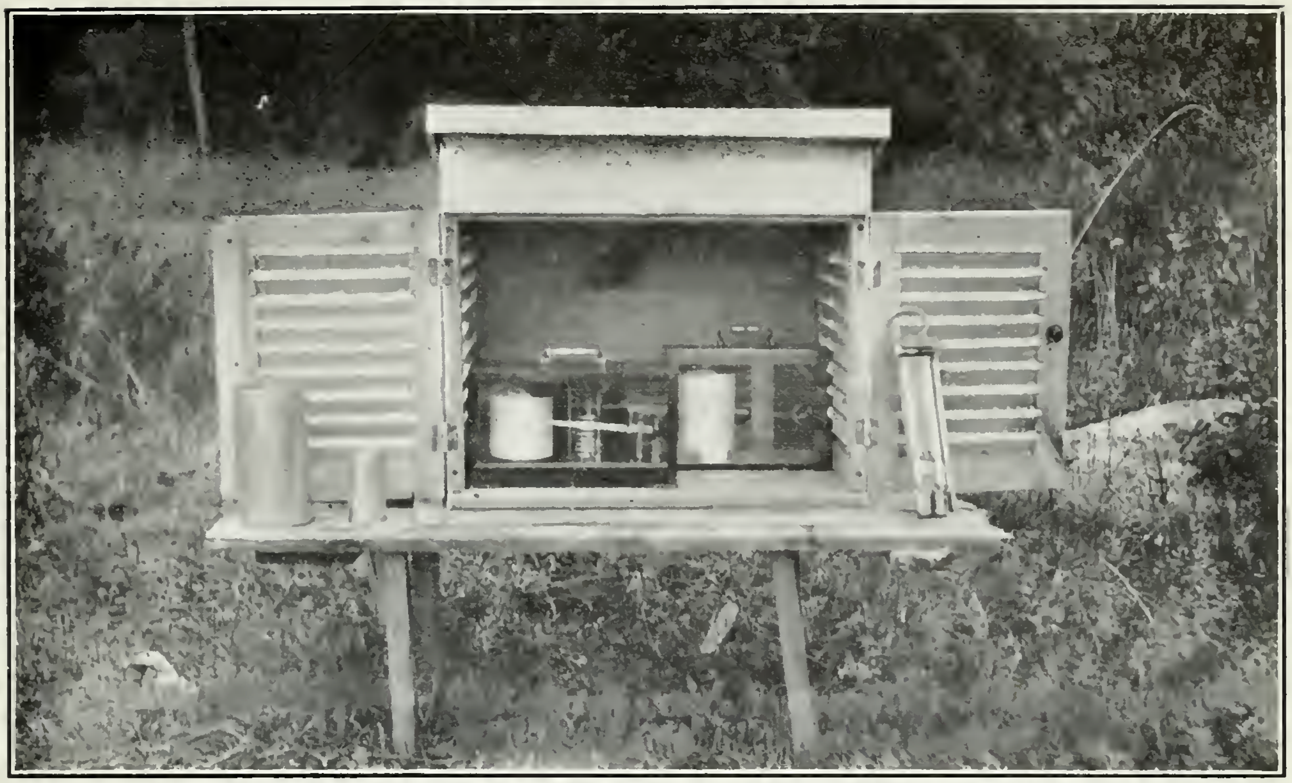
SIZE OF MOTORS.

Machine.	Horse Power of Motor.		
	Minimum.	Maximum.	Size most commonly used on average farms
Feed grinders (small)	3	10	5
Feed grinders (large)	10	30	15
Ensilage cutters	10	25	15 to 20
Shredders and huskers	10	20	15
Threshers, 19-inch cylinder	12	18	15
Threshers, 32-inch cylinder	30	50	40
Corn shellers, single hole	$\frac{3}{4}$	$1\frac{1}{2}$	1
Power shellers	10	15	15
Fanning mills			$\frac{1}{4}$
Grain graders			$\frac{1}{4}$
Grain elevators	15	5	3
Concrete mixers	2	10	5
Groomer, vacuum system	1	3	2
Groomer, revolving system	1	2	1
Hay hoists	3	15	5
Root cutters	1	5	2
Cord wood saws	3	10	5
Wood splitters	1	4	2
Hay balers	3	10	$7\frac{1}{2}$
Oat crushers	2	10	5

Many of the values given for minimum horse-power exceed 5 h.p.; probably, however, machines using not more than 5 h.p. can and will be built if there is a demand for them.



Manitoba Hydrographic Survey. Evaporation Station at Keewatin, Ont.



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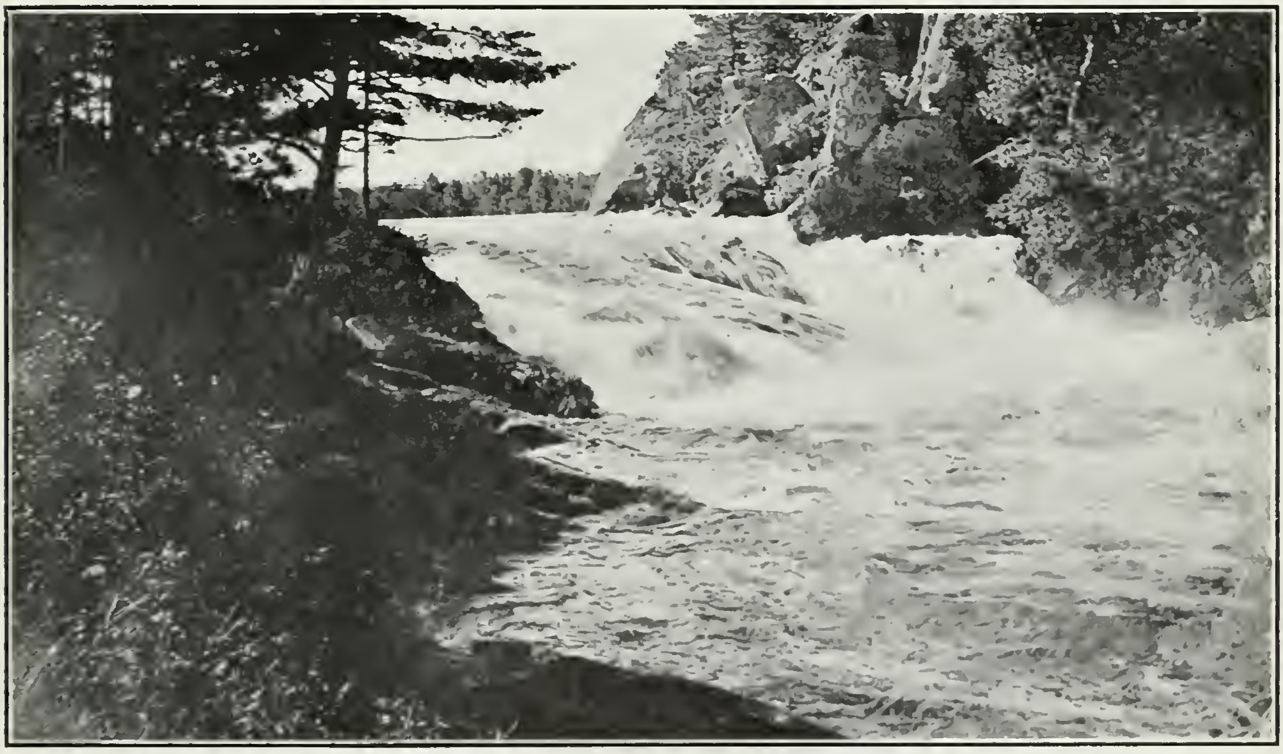
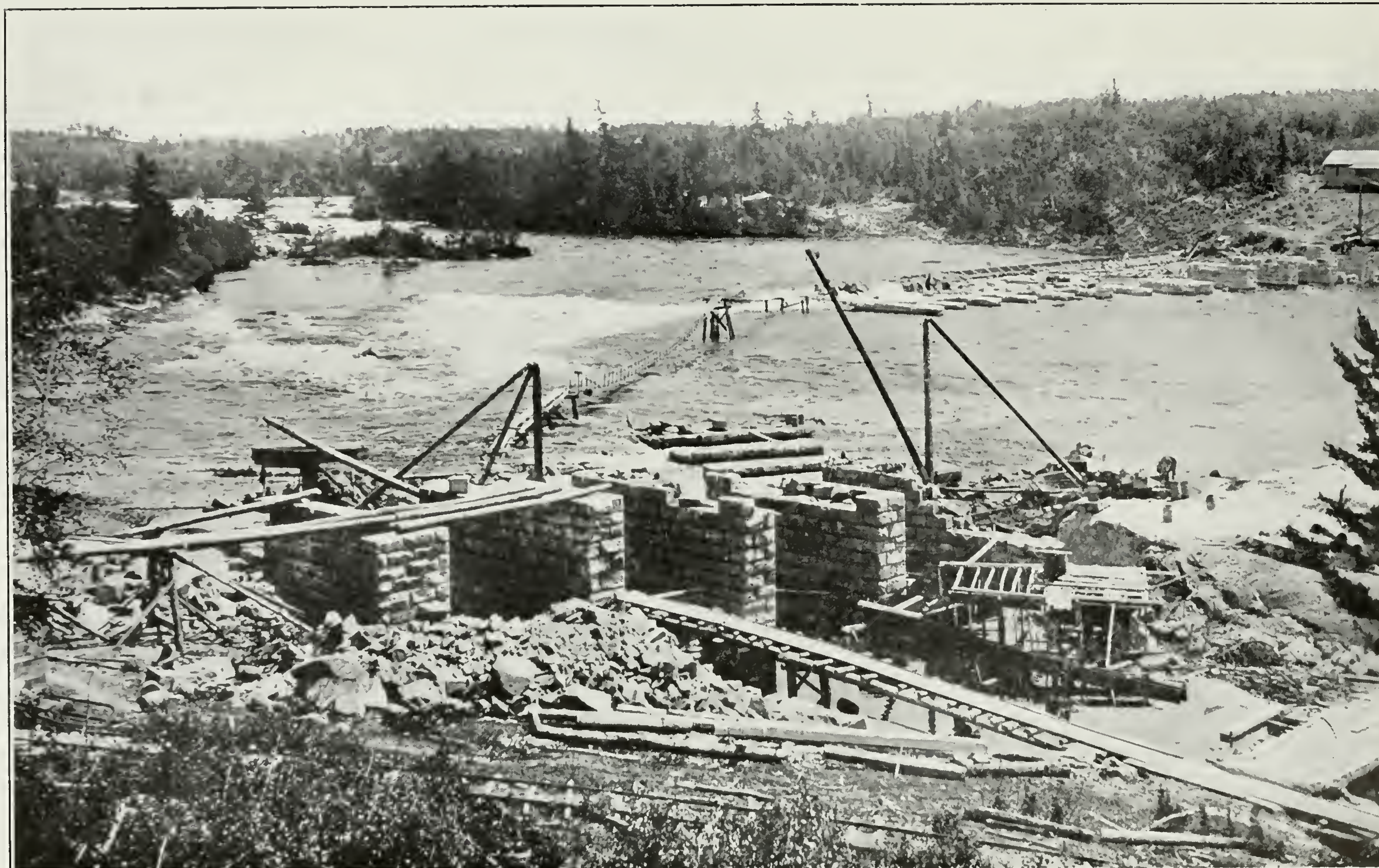


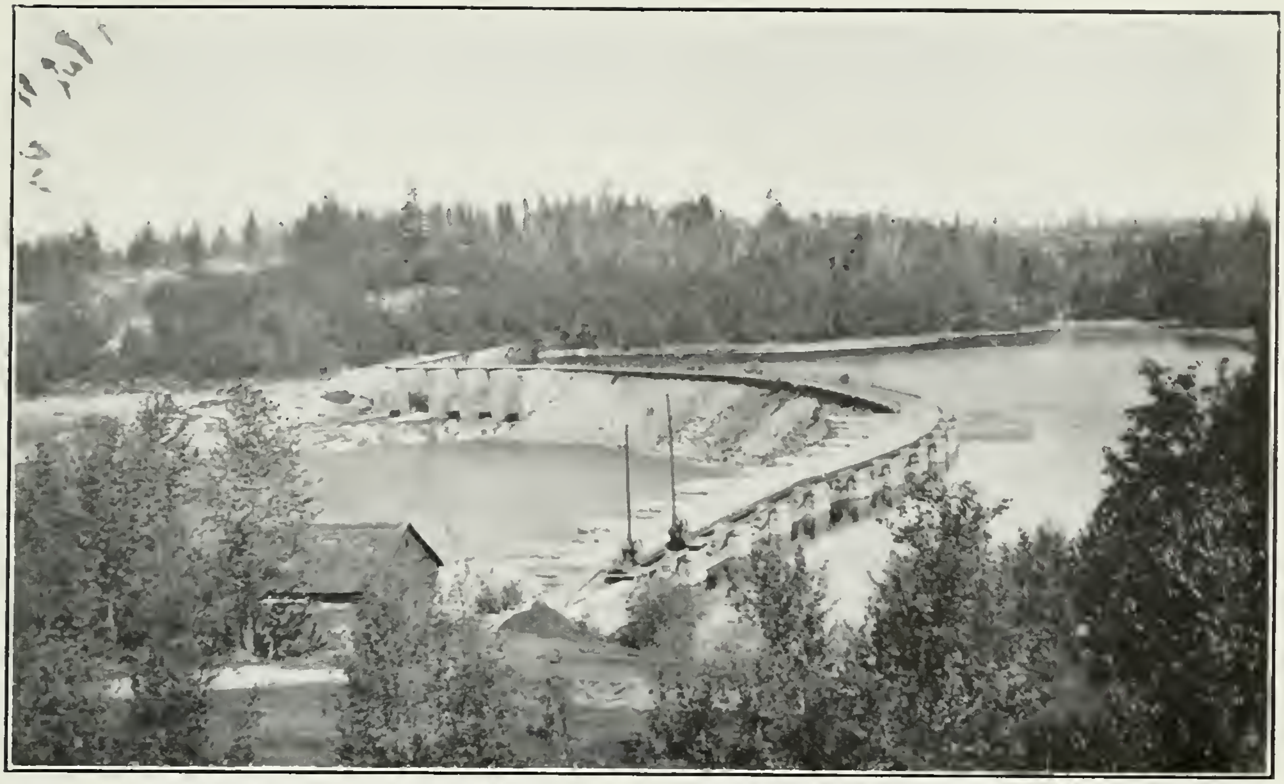
Winnipeg River. Eastern Outlet before construction of Kenora Power House.

Winnipeg River. Norman Dam during construction.

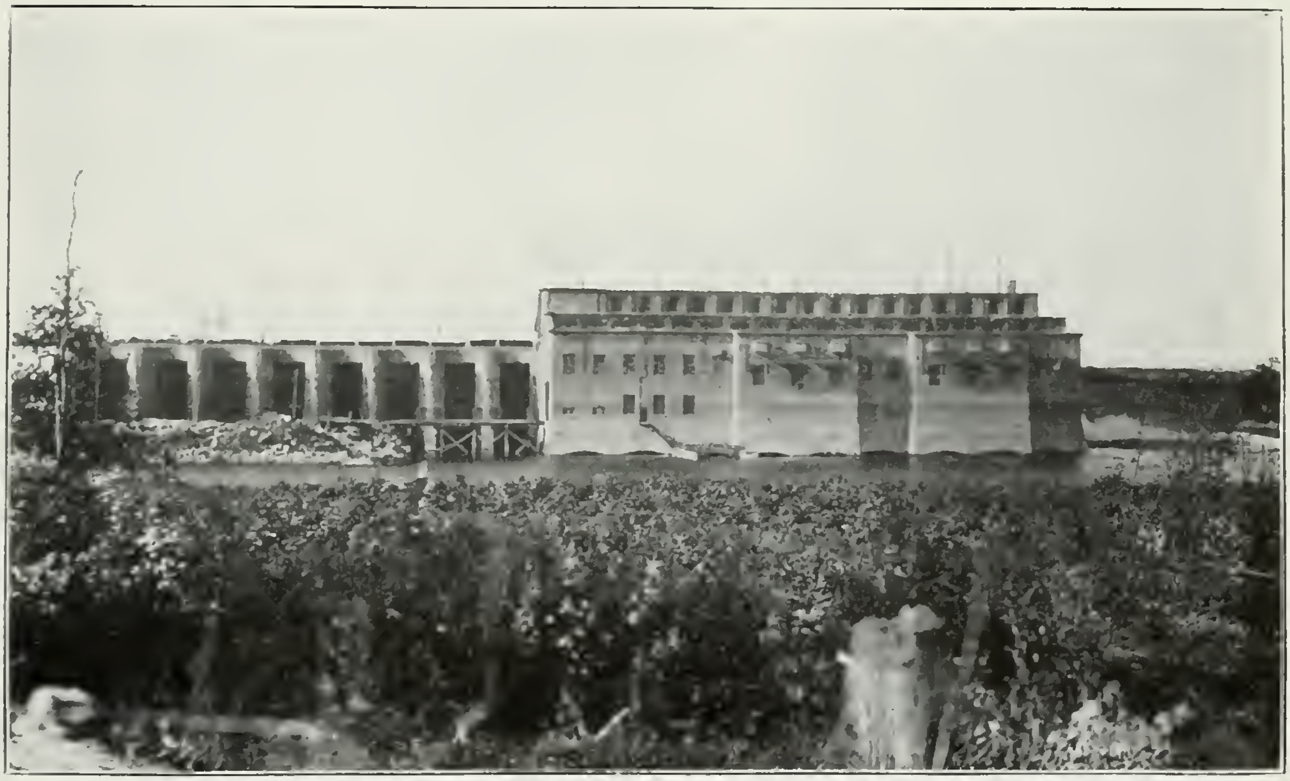


Winnipeg River. Norman Dam during construction.

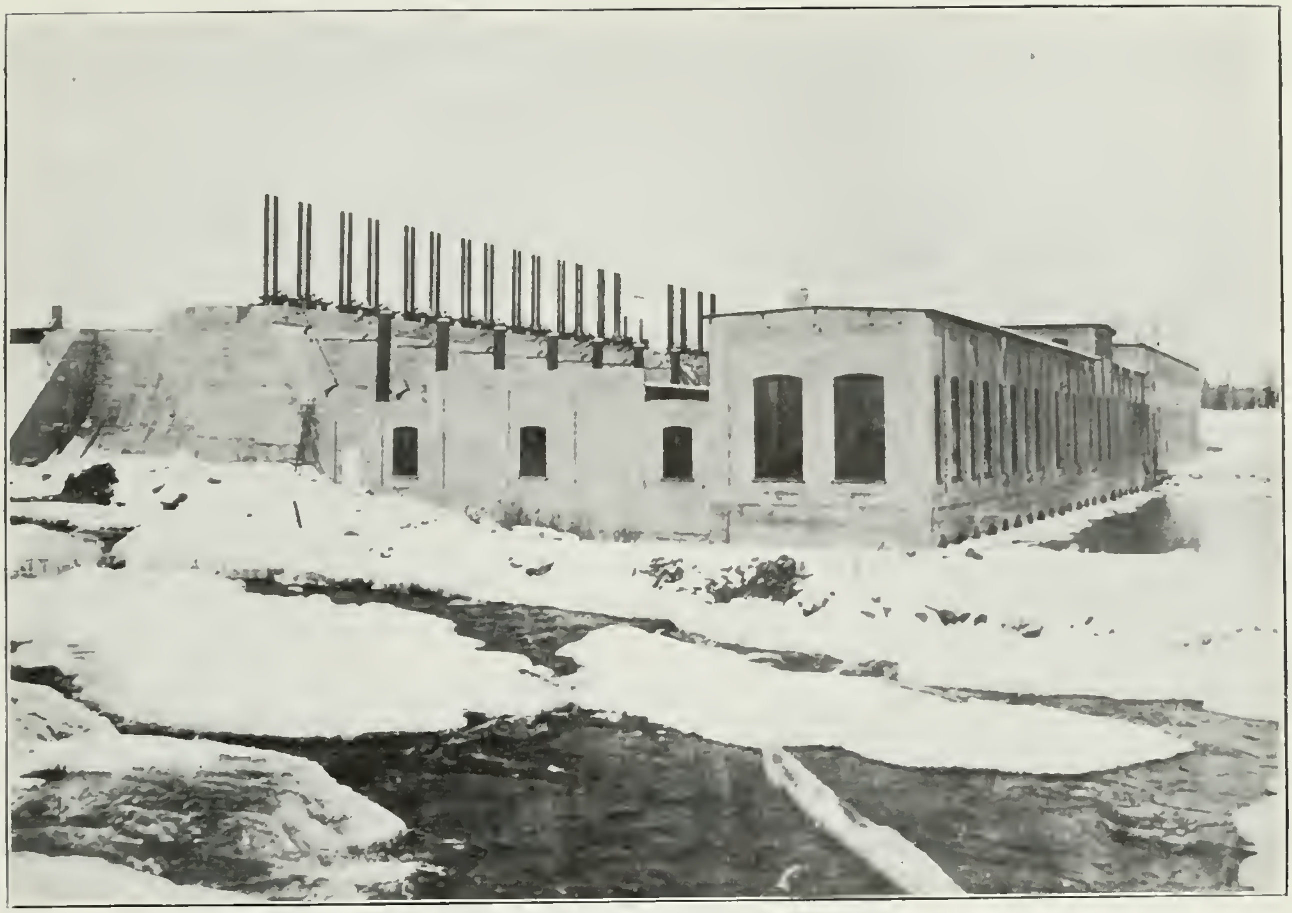
Winnipeg River. Norman Dam nearing completion.



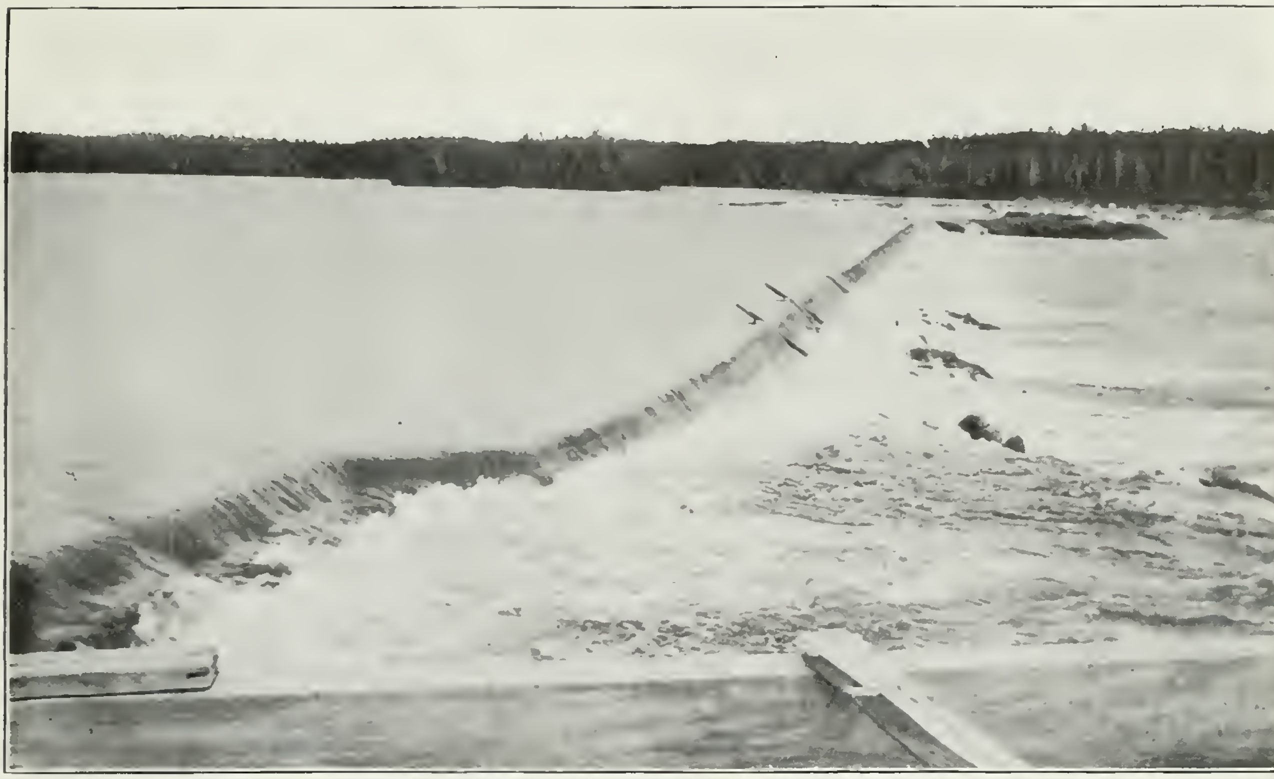
Winnipeg River. Norman Dam.



Winnipeg River. City of Winnipeg Development. Power House.



Winnipeg River. Winnipeg Electric Railway Power House, Pinawa Channel.

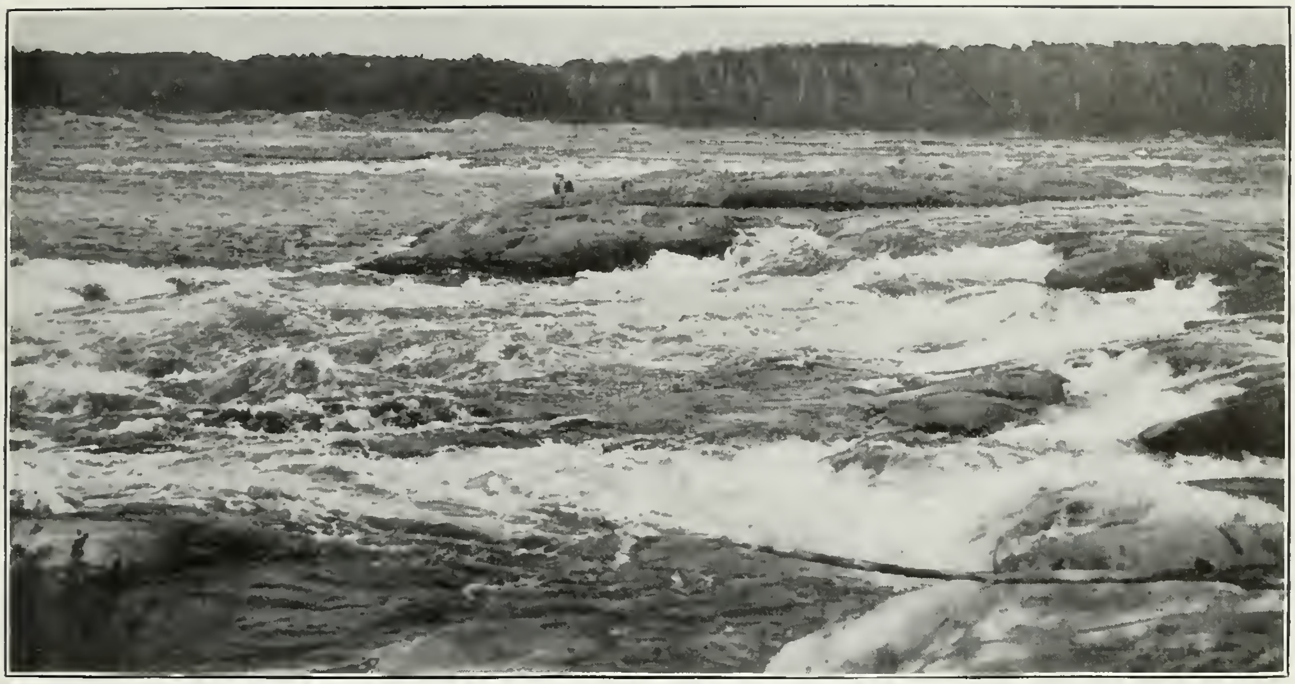


Winnipeg River. Winnipeg Electric Railway Plant. Main Weir.

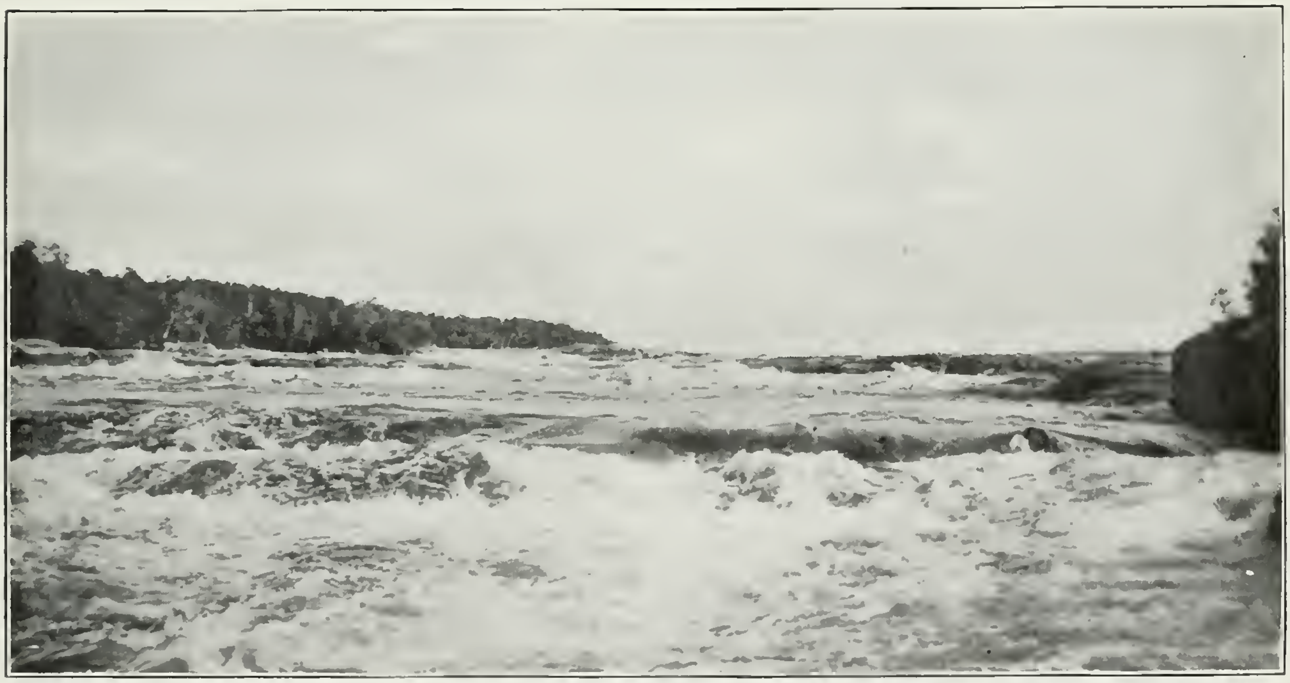
Manitoba Hydrographic Survey. Pinawa Channel Metering Station below Control Dam.

Winnipeg River - 2nd McArthur Falls, Main Drop.

Winnipeg River. Littie du Bonnet Falls.



Winnipeg River, Whitemouth Falls.



Winnipeg River, Silver Falls.

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Manitoba Hydrographic Survey. Whitemouth River. Bridge and Gauge at Whitemouth.

Manitoba Power Surveys. Manigotagan River. Wood Falls.

Manitoba Power Surveys. Manigotagan River. Pillow Falls.

Manitoba Power Surveys. Manigotagan River. Cascade below Turtle Lake.

Manitoba Power Surveys. Little Saskatchewan River. Damsite No. 3.

Manitoba Power Surveys. Valley River Damsite No. 2.

Manitoba Power Surveys. Mossy River. Bell's Rapids Damsite.

Manitoba Power Surveys. Meadow Portage. Lake Manitoba Side.

Manitoba Power Surveys. Fairford River. Fairford Damsite.

Manitoba Power Surveys. Dauphin River. Damsite No. 4.

Pasquia Reclamation Project. The Narrows.

Pasquia Reclamation Project. Summerberry River, five miles from head.

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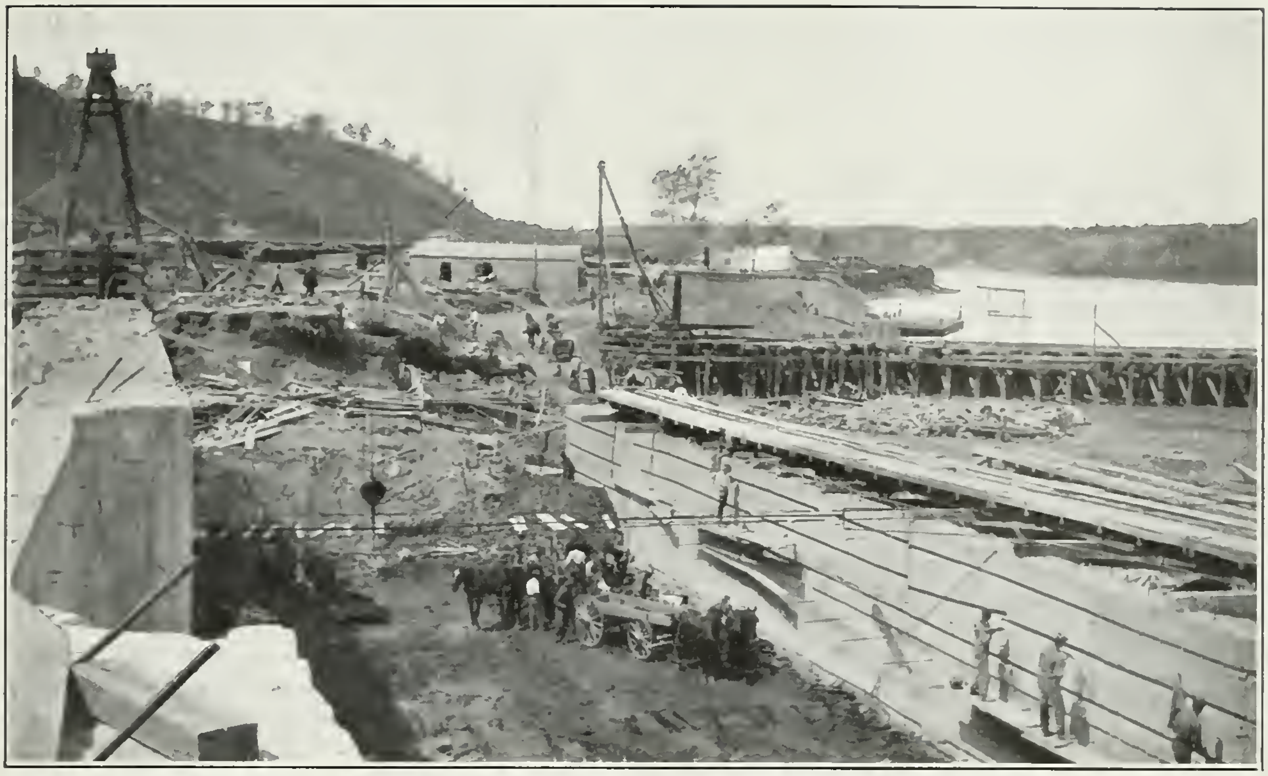
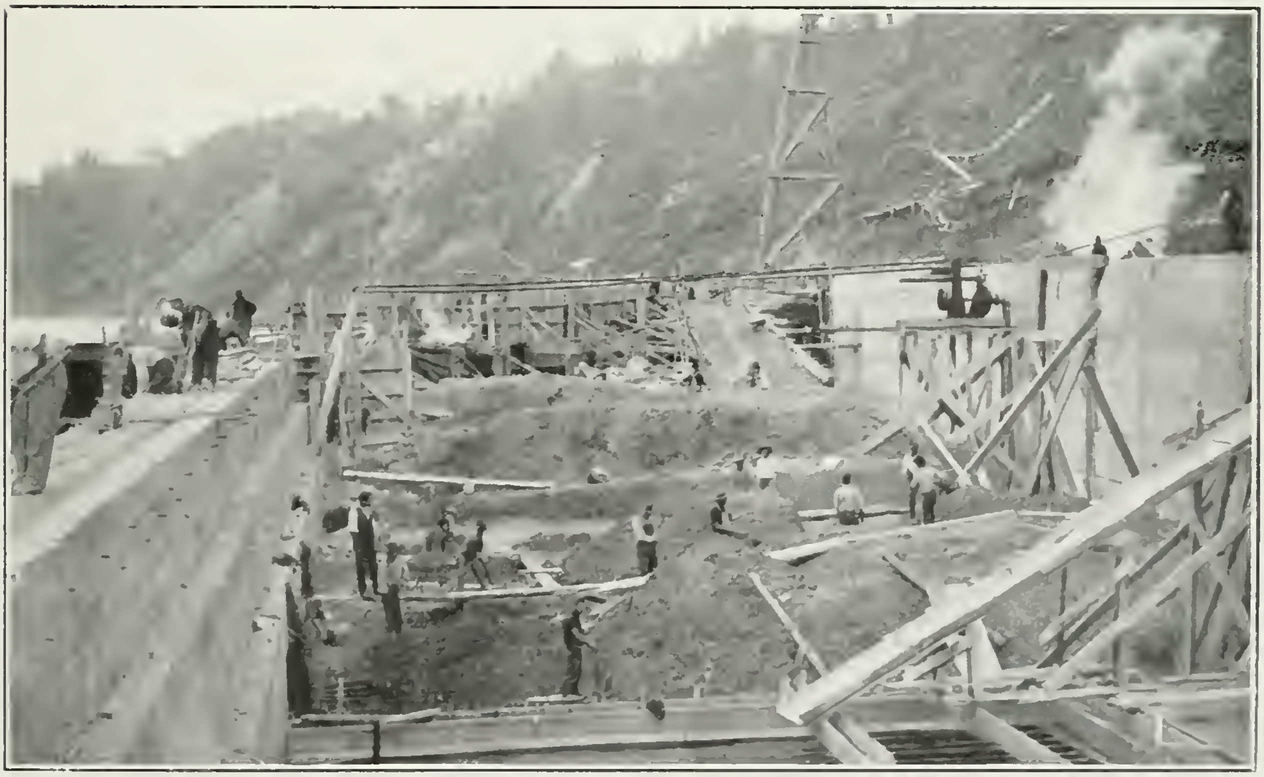
Pasquia Reclamation Project. Big Lake at low Water.

Pasquia Reclamation Project. Saskatchewan River. Shore line near Frying Pan Rapids.

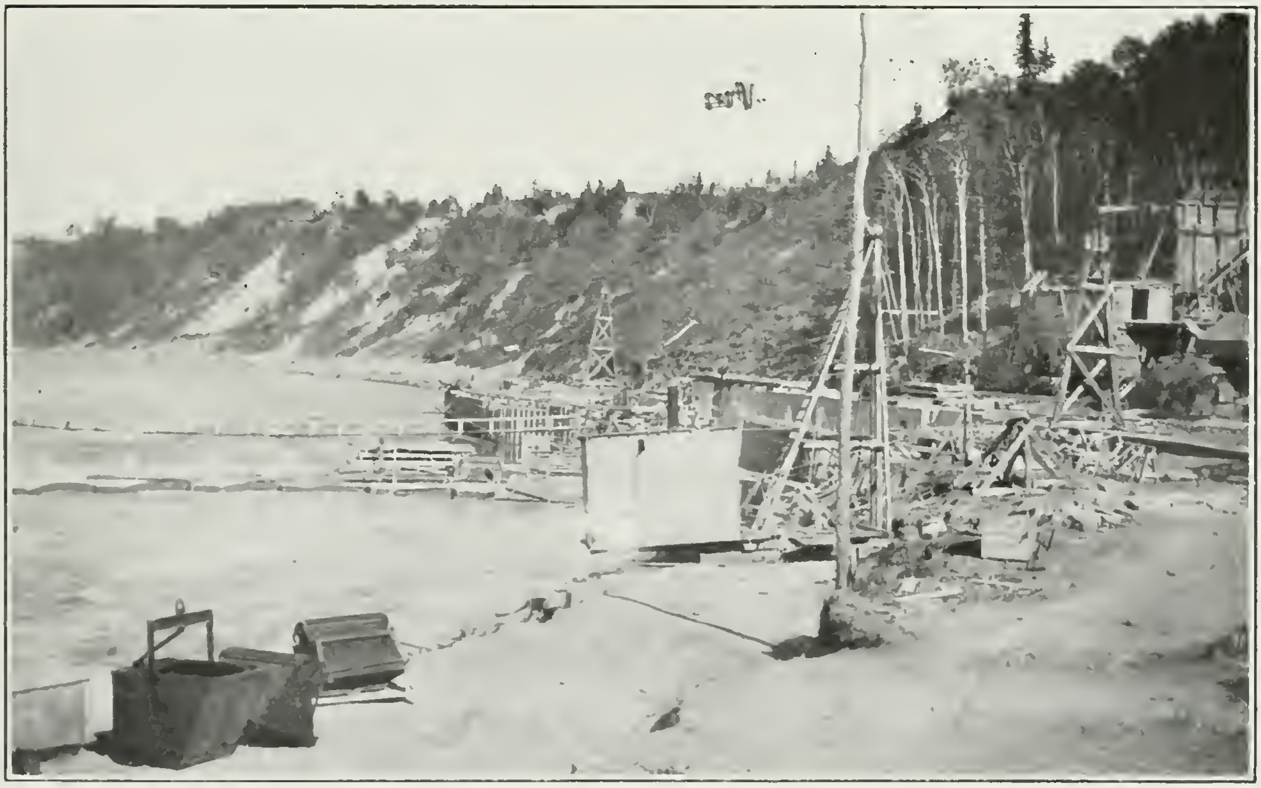


City of Prince Albert Power Development. La Colle Falls. Lock Excavation.

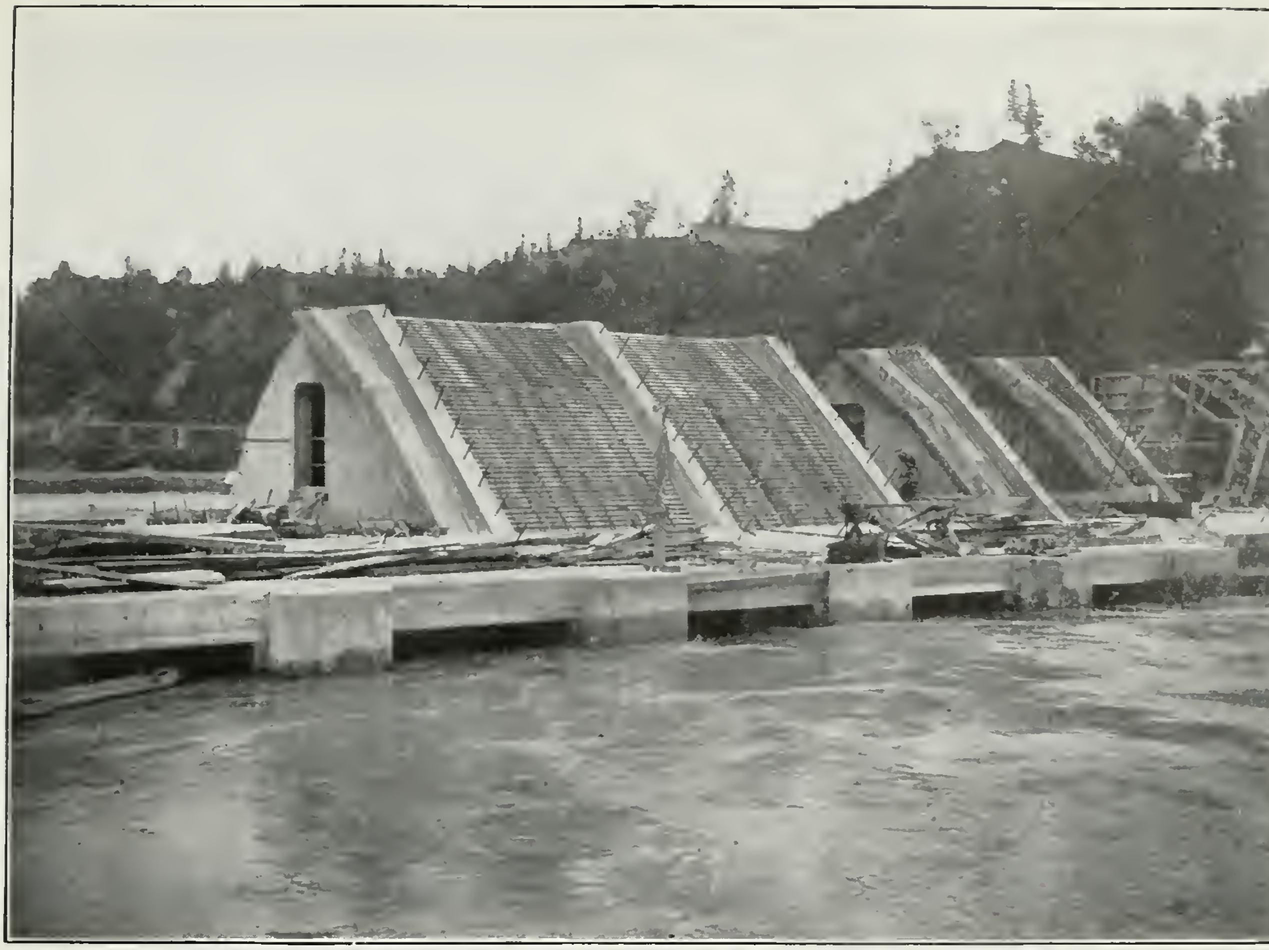


City of Prince Albert Power Development. La Colle Falls. Excavation for Extension of Lock Floor.

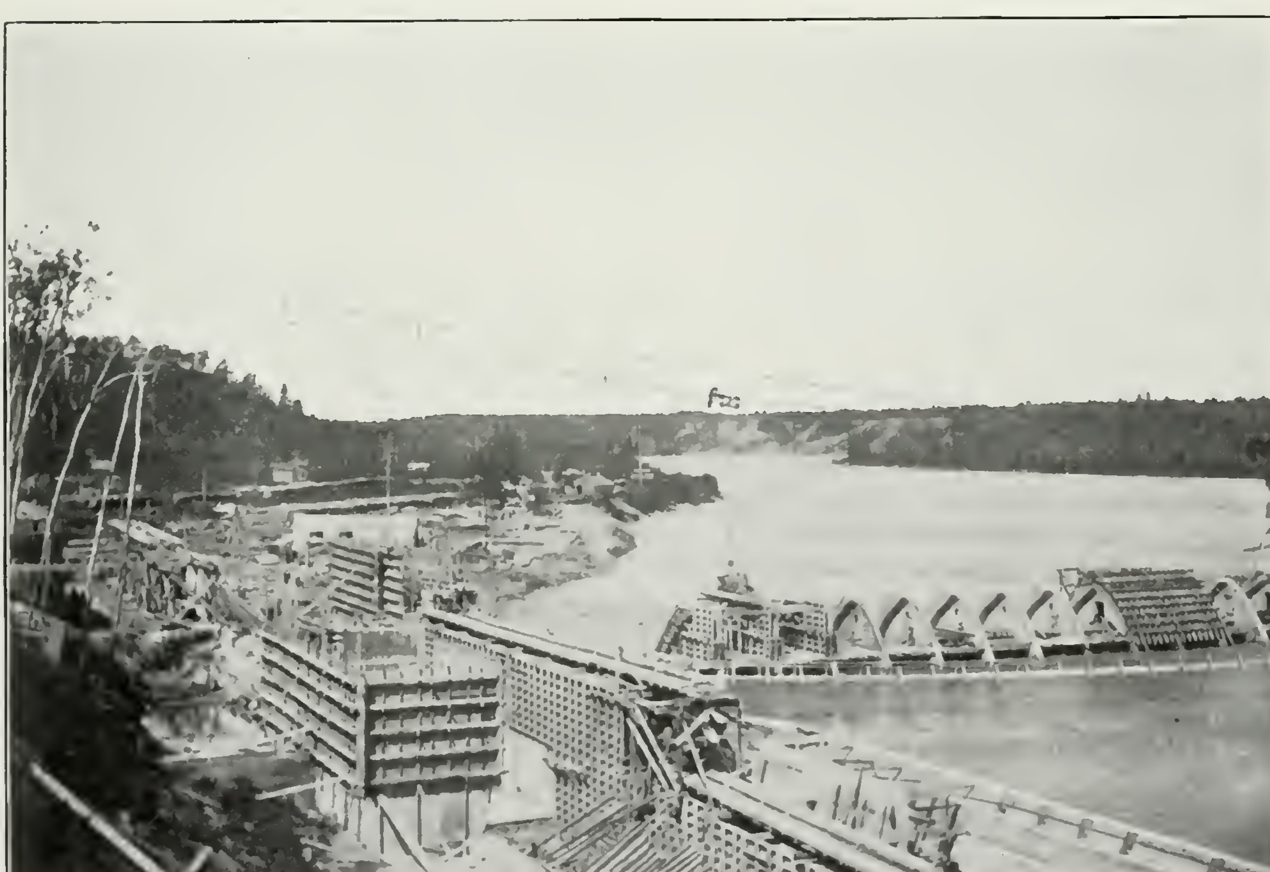
City of Prince Albert Power Development. La Colle Falls. Lower curve of Spillway.



City of Prince Albert Power Development. La Colle Falls. Construction of Lock.

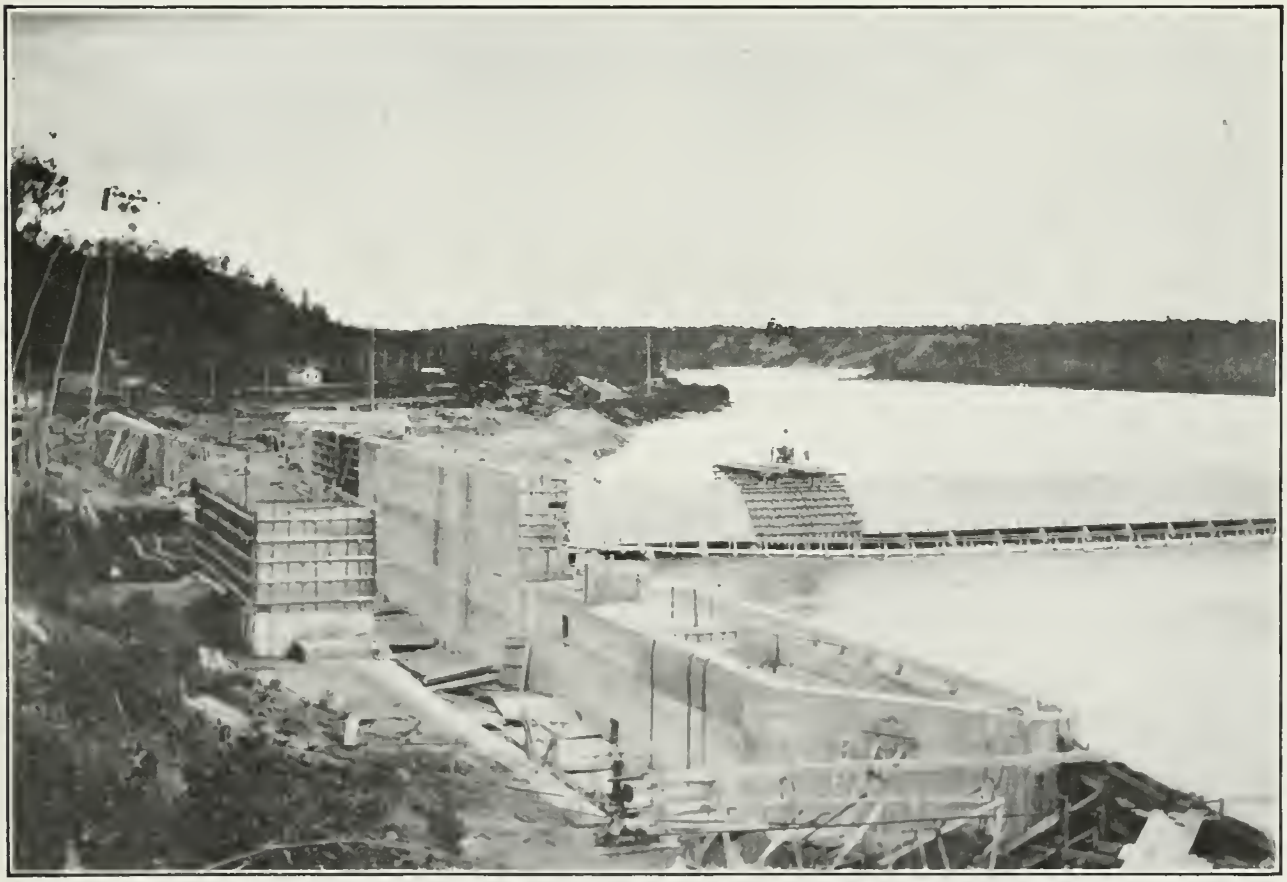


City of Prince Albert Power Development, La Colle Falls Deck Reinforcing.



City of Prince Albert Power Development. La Colle Falls. Lock and Dam under construction.

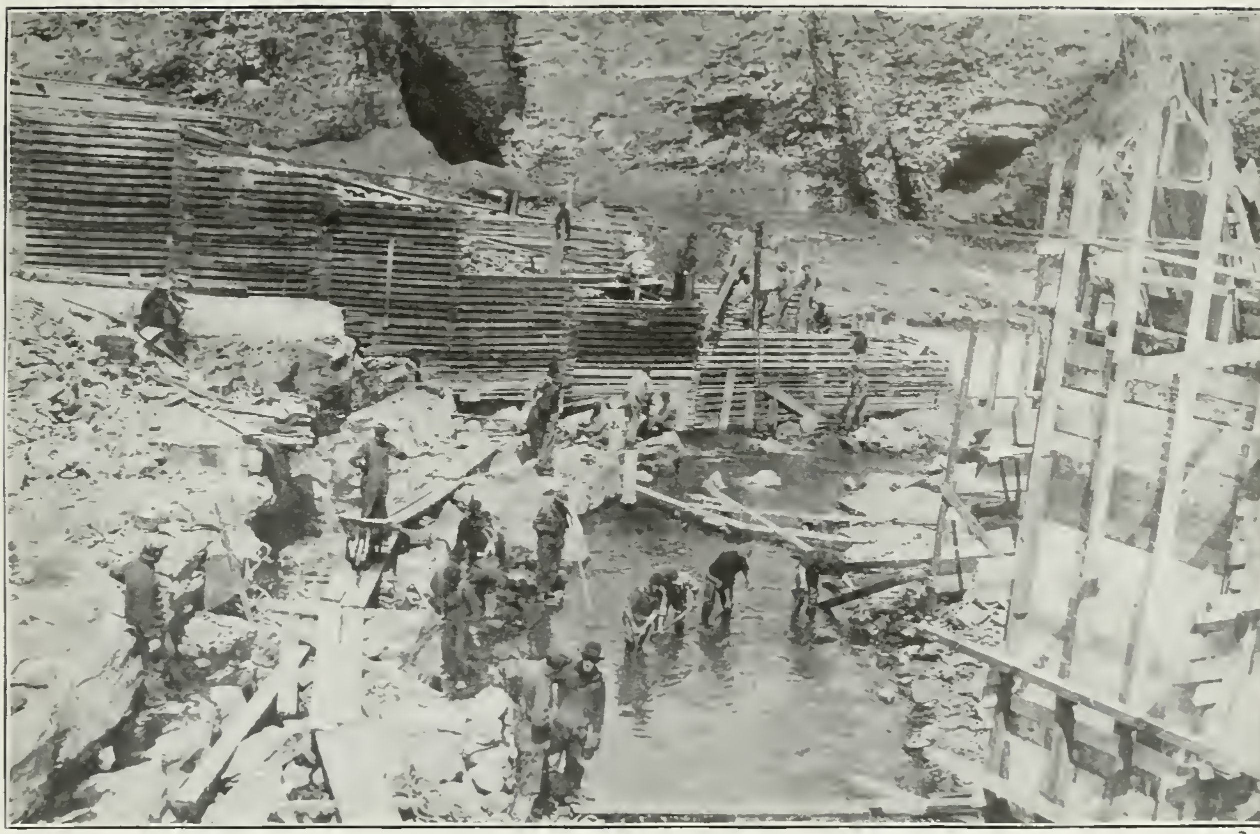
City of Prince Albert Power Development. La Colle Falls. Excavation on North Shore for Dam.



City of Prince Albert Power Development. La Colle Falls. Lock and Dam.

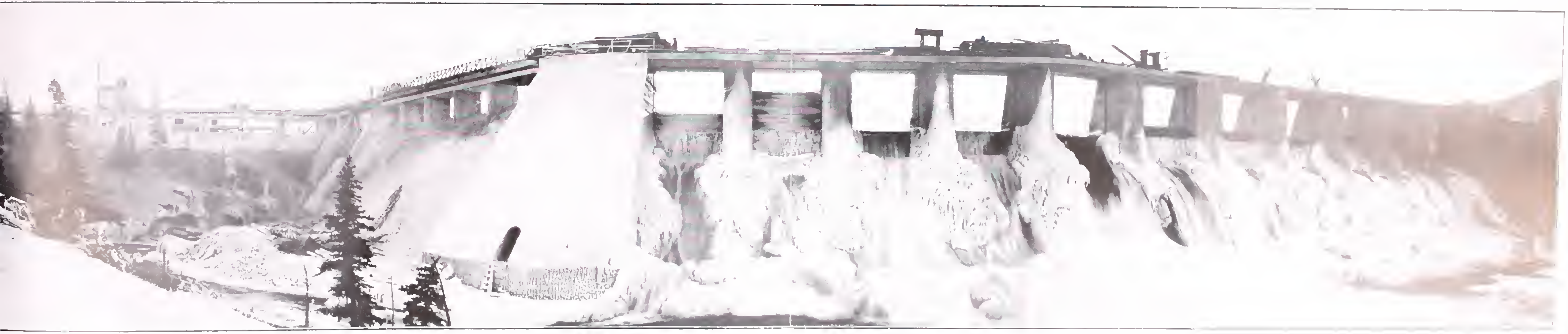
City of Prince Albert Power Development. La Colle Falls. Passage through Dam.

Calgary Power Company. Kananaskis Falls Development. Looking downstream from below Dam.

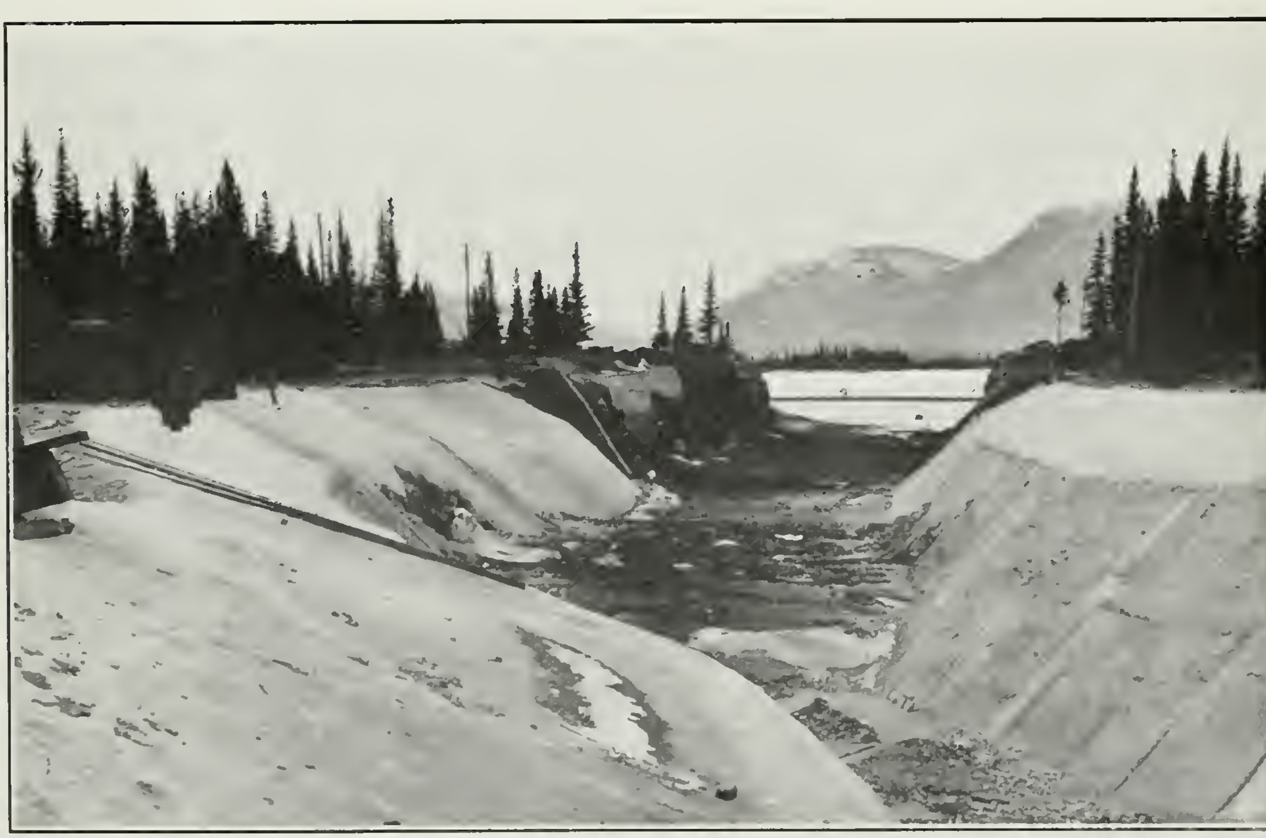


Calgary Power Company. Kananaskis Falls Development. Part of interior of Main Cofferdam.

Calgary Power Company. Kananaskis Falls Development. Interior of Main Cofferdam showing section of Piers.



Calgary Power Company. Kananaskis Falls Development Dam during construction.



Calgary Power Company. Kananaskis Falls Development. Intake Canal.

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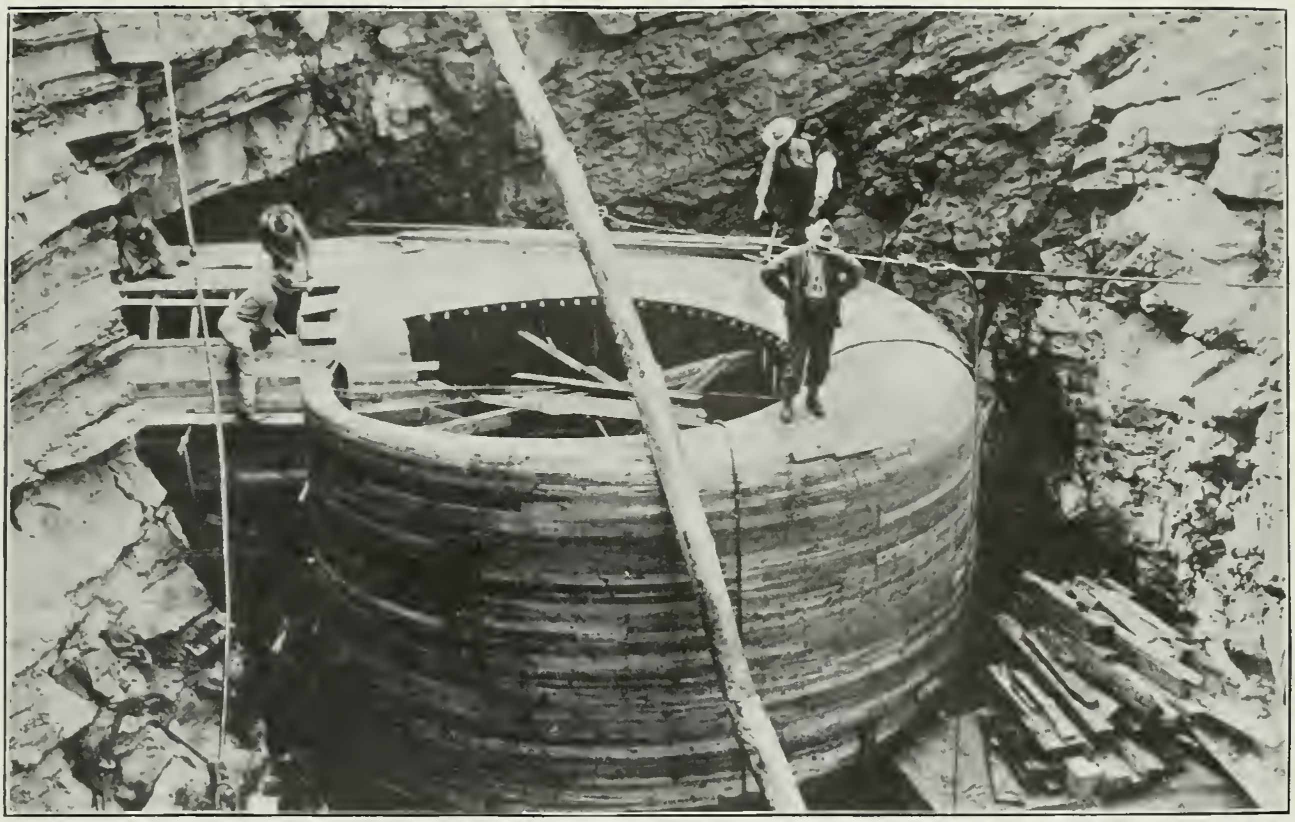
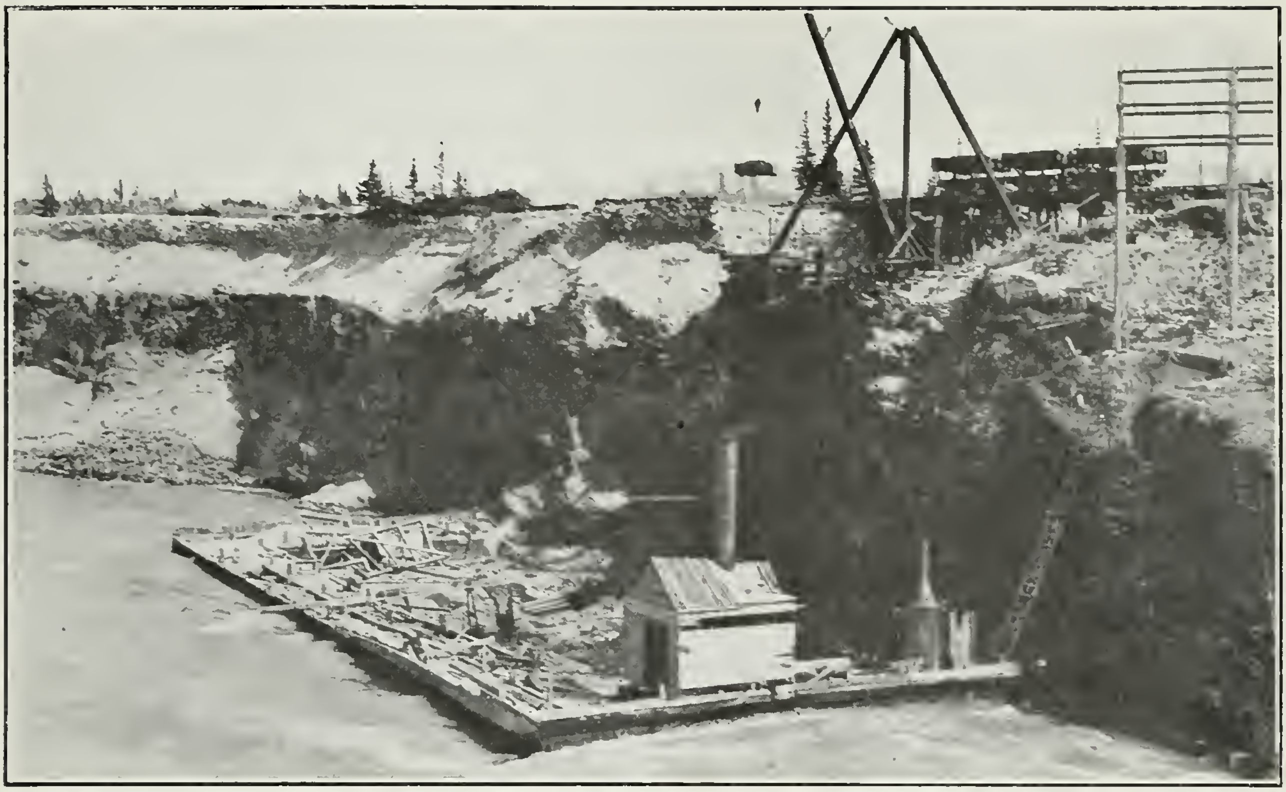


Calgary Power Company. Kananaskis Falls Development. Formwork for Scroll-case in place.

Calgary Power Company. Kananaskis Falls Development. Tailrace openings and Dam.



Calgary Power Company. Kananaskis Falls Development. Tailrace Cofferdam showing method of handling material.

Alberta Power Surveys. Athabasca River. Looking upstream from Site No. 1.

Alberta Power Surveys. Athabasca River. Looking upstream from Site No. 2.

Alberta Power Surveys. Slave River. South shore and flats at Sawridge.

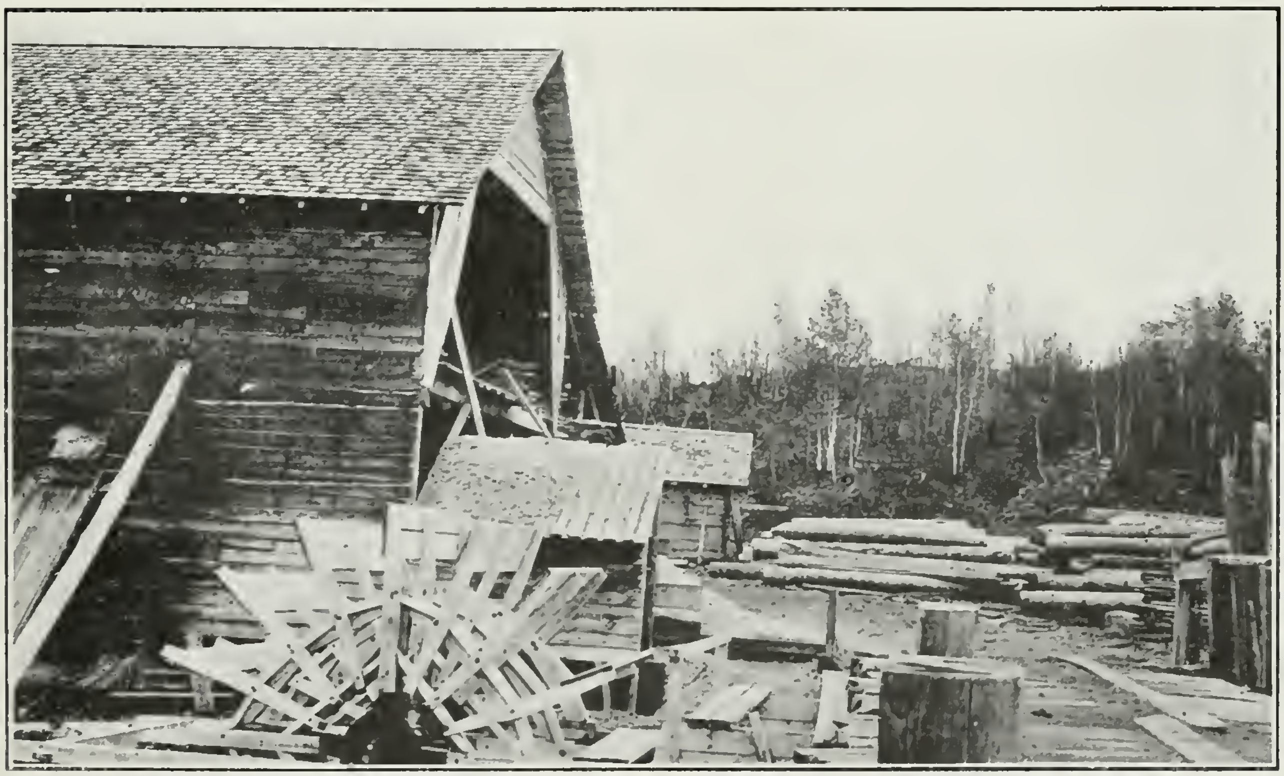
Alberta Power Surveys. Athabasca River looking up Brule Lake.

Alberta Power Surveys. Athabasca River. Outlet of Jasper Lake.

Alberta Power Surveys. Stony River. Stony Falls, 60 ft. drop.

Alberta Power Surveys. Embarras River. Probable power site.

Alberta Power Surveys. Stony River. Stony Falls and Canyon.



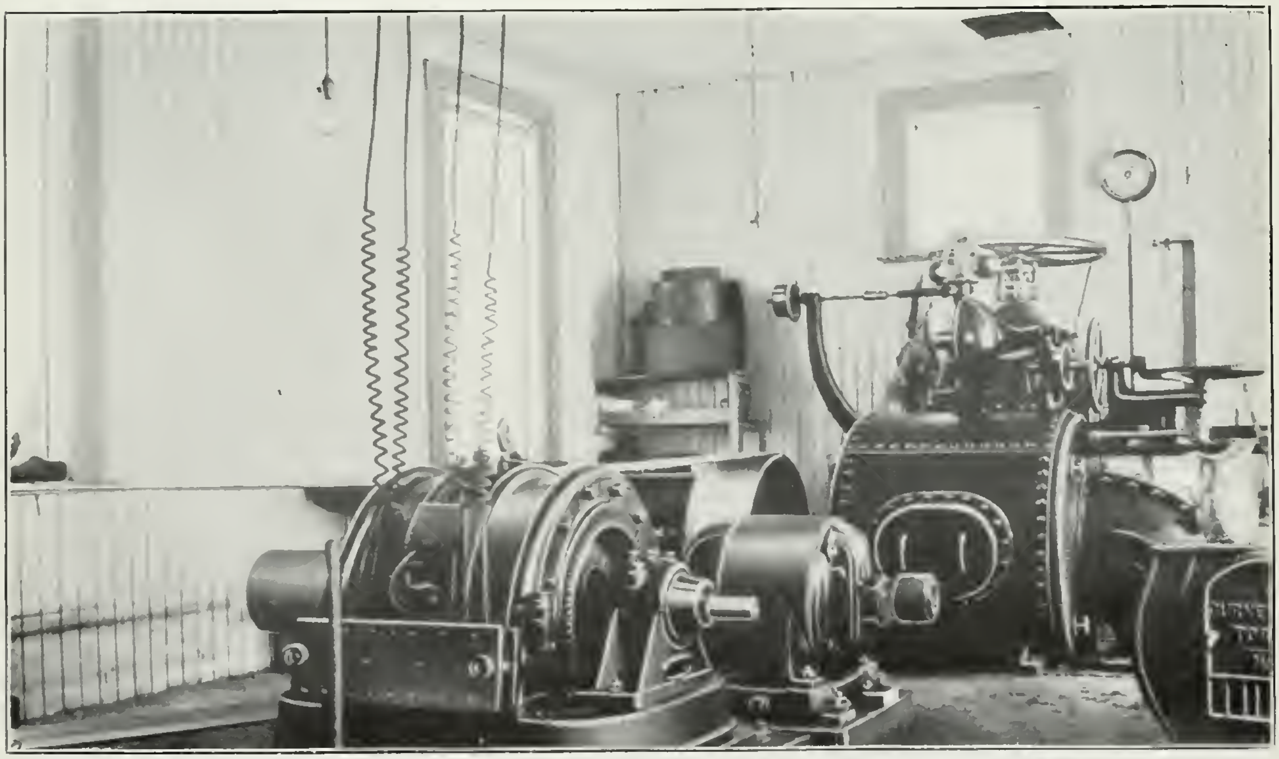
Small Water Power. La Plonge River, Sask. Operated for some years by R. C. Mission.

Cascade River Power Development. Rocky Mountains Park. Competitive Designs for proposed Power House.

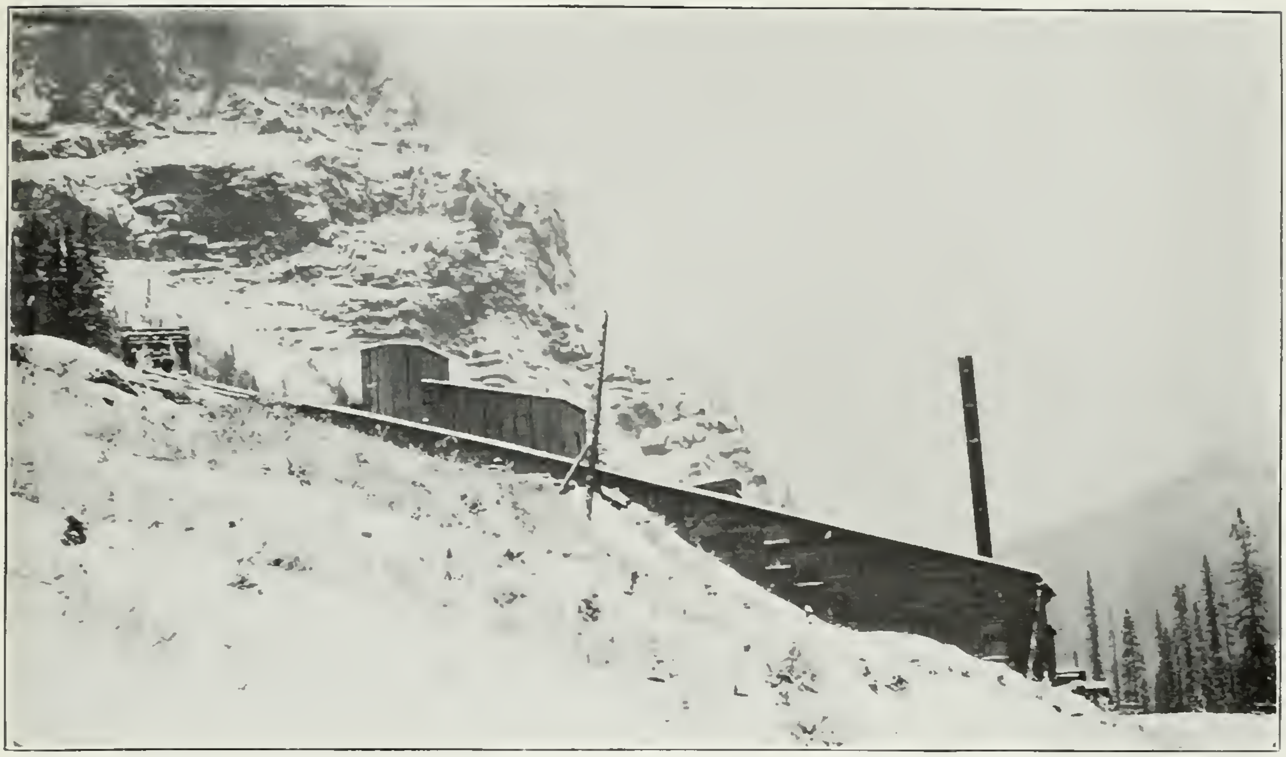
Cascade River Power Development. Rocky Mountains Park. Competitive Designs for proposed Power House.


CONTOUR MAP
BOW RIVER BASIN ABOVE CALGARY

Small Water Power. Lake Louise Development. Power House.

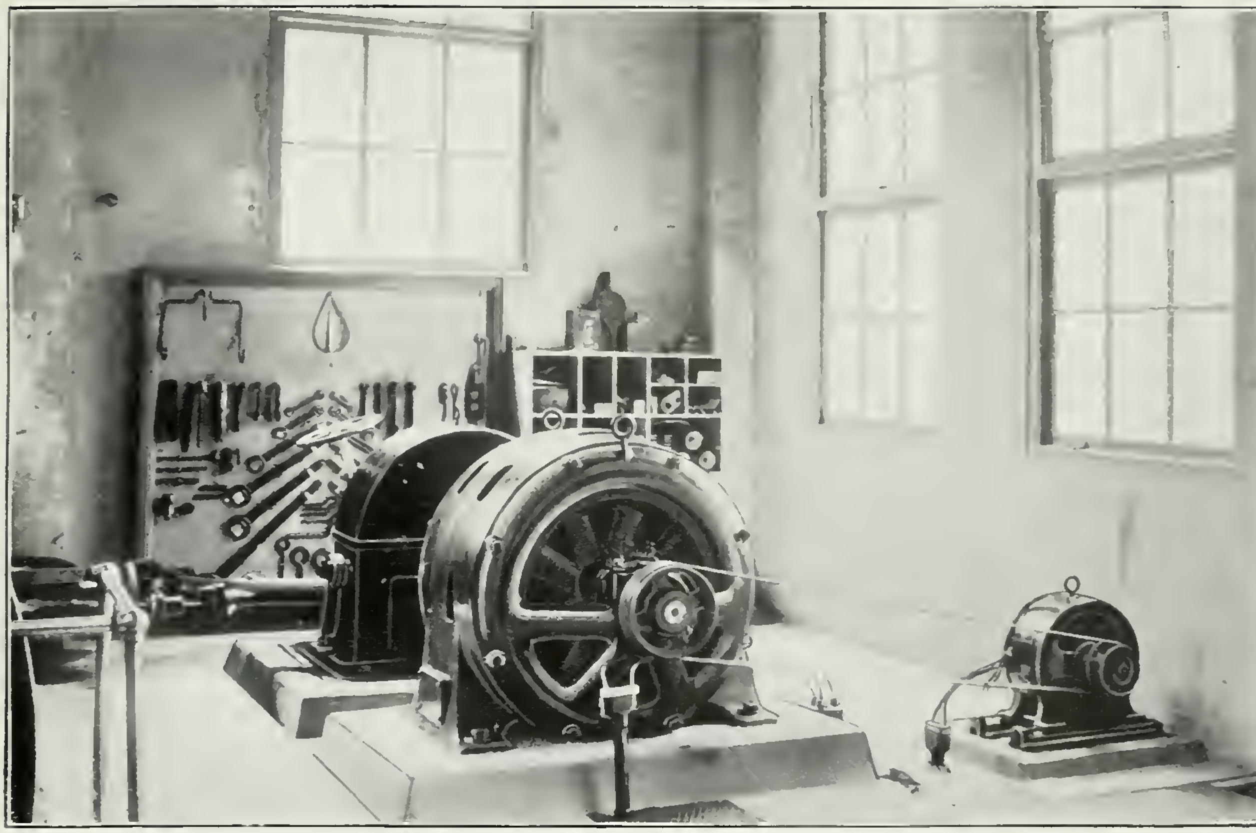


Small Water Power. Lake Louise Development. Interior of Power House.



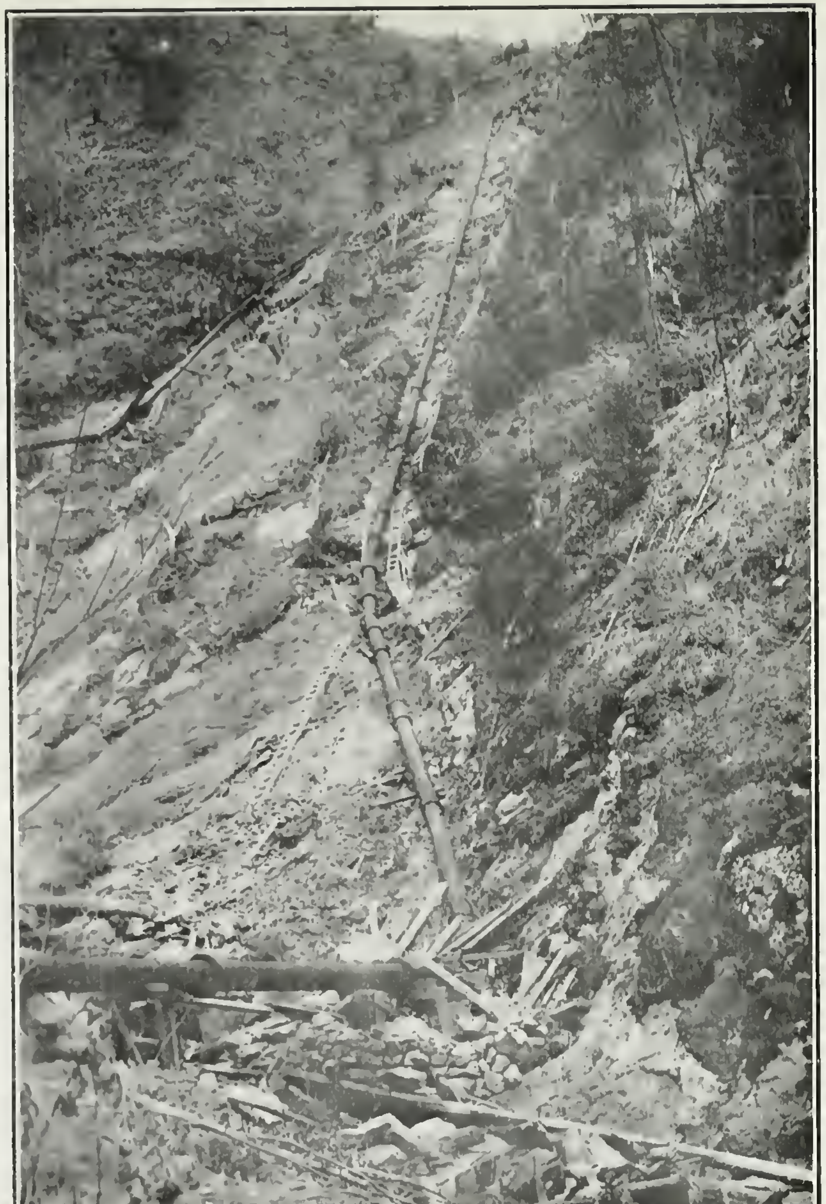
Small Water Power. Mount Stephen Mines, Field, B.C. Concentration Plant operated by water power.

Small Water Power. Fadear Creek, near Cahilty, B. C. Typical overshot wheel for farm power.



Small Water Power. Municipal Plant, Armstrong, B.C. Pelton Wheel and Dynamo.

Small Water Power. Louis Creek. B.C. Wooden Undershot Wheel driving Sawmill.



Small Water Power. Municipal Plant, Armstrong, B. C. Pipe line.

Small Water Power. Crazy Creek, near Taft, B. C. Overflow, Oct. 25, 1913. A small portion of power used by Forest Mills, Ltd.

B. C. Hydrographic Survey. Capilane Creek. Gauging Station.

B. C. Hydrographic Survey. Coquihalla River. Gauging Station.

B. C. Hydrographic Survey. Elk River Cable Station.

B. C. Hydrographic Survey. Seymour River Falls.

B. C. Hydrographic Survey. Shuswap River, near Coteau Falls.

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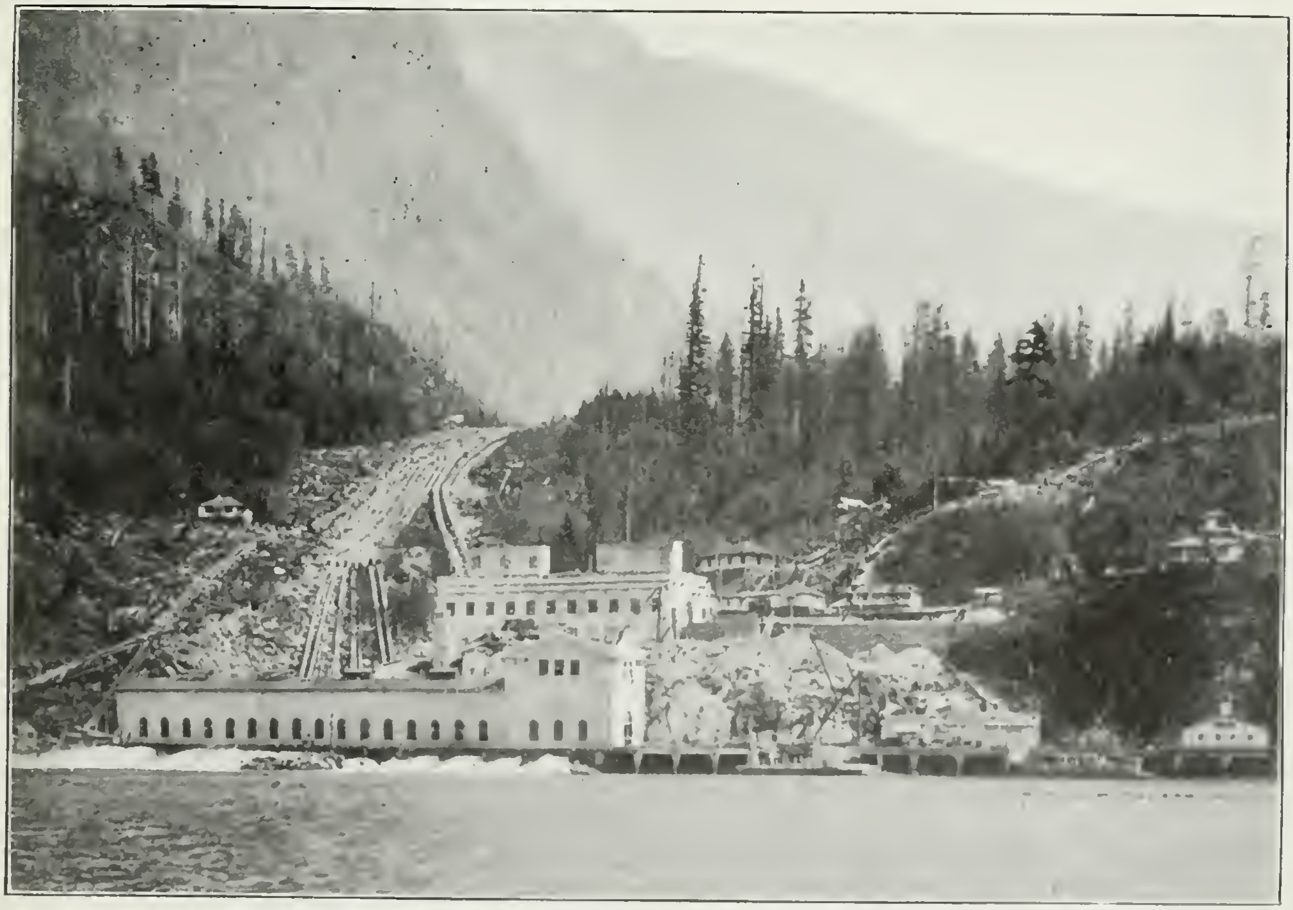
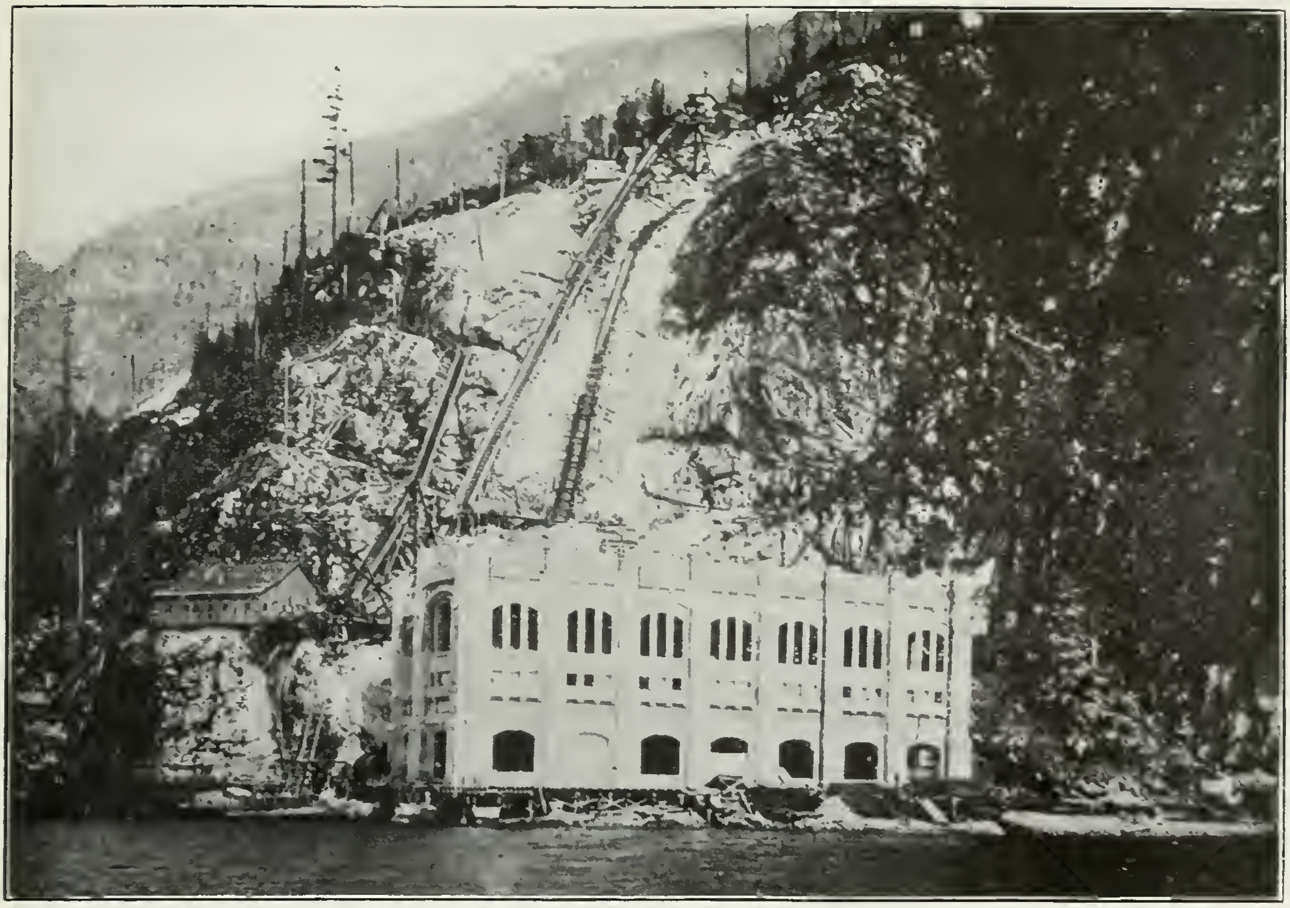
B. C. Hydrographic Survey. Cottonwood Falls.

Vancouver Power Company. Coquitlam Dam, B.C. Dam under construction.

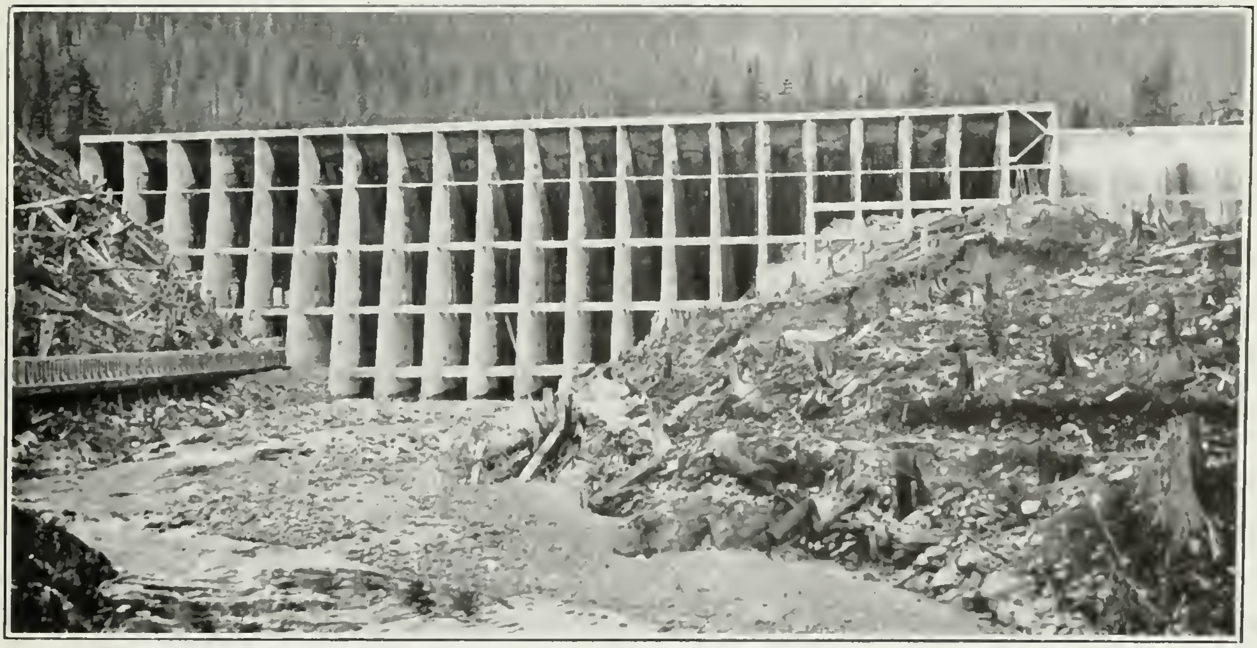
Vancouver Power Company. Coquitlam Dam, B.C.



Vancouver Power Company, Burrard Inlet, B.C., Power House No. 1.



Vancouver Power Company, Burrard Inlet, B.C. Power House No. 2.



Vancouver Island, B. C. Jordan River. Ambursen Dam.