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WATER QUALITY STUDIES IN CANADA FOR THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY 1958-1959

by

J. F. J. THOMAS AND JOHN UNGAR

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The results of analytical studies on the mineral content of six major rivers of Canada are reported in detail, together with available discharge data. This is part of a world wide study of the run-off of dissolved solids from the continents into the oceans, carried out for the Committee of World Wide Run-Off of Dissolved Solids of the International Association of Scientific Hydrology of the International Union of Geodesy and Geophysics.

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INTRODUCTION

Early in 1958, Mr. S.K. Love, Chief, Water Quality Branch, U.S. Geological Survey, Washington, D.C., requested the cooperation of the Industrial Waters Section, Mines Branch, in a world wide study being initiated by the Committee of World Wide Run-off of Dissolved Solids of the International Association of Scientific Hydrology of the International Union of Geodesy and Geophysics (IUGG). This Committee under the direction of Professor L.J. Tison, Gentbrugge, Belgium, plans to obtain data on the amount and nature of dissolved solids reaching the oceans from all the continents. As co-ordinator of this work on the North American continent, Mr. Love asked the Industrial Waters Section to carry out the collection and analysis of the run-off from major Canadian rivers draining into the oceans. The proposed study was to extend from June, 1958 to June, 1959 and quarterly samples were requested so that seasonal discharge and chemical quality could be correlated.

This report details the work of the Industrial Waters Section in assisting this Committee in determining the dissolved solids content and discharge of major Canadian rivers.

All discharge (flow) data were supplied by the Water Resources Branch, Department of Northern Affairs and National

Resources, Ottawa.

Mr. W.R. Bridges, Sanitary Inspector, Department of Health and Public Welfare of Manitoba, collected samples from the Nelson River at the Kelsey Power Project.

PROCEDURE

Arrangements were made to collect samples in accordance with the procedure of the Committee as outlined by the coordinator, Mr. S.K. Love. Special sampling equipment, originally loaned by the U.S. Geological Survey, was later acquired by this Section.

The following samples were collected whenever possible:

(1) one, one-half gallon sample representative of the river near its mouth, but above tidal influence on chemical quality,

(2) one, one-half gallon sample, immediately filtered and acidified (5 to 10 ml concentrated nitric acid) by the collector, and

(3) one small sample, filtered at the site and intended for the determination of iron and manganese.

The filtered and acidified sample was collected for the U.S. Geological Survey for chemical and spectrographic analysis for about 30 trace elements. Owing to lack of time and equipment no attempt was made by this Section to determine these trace elements, as

special techniques and methods must be developed or adapted for such work.

Initially, an extra sample of the raw water was collected and forwarded with the acidified sample to the U.S. Geological Survey, in order to correlate the analytical results of the two laboratories and, thereby, the results of the studies in Canada and the United States.

Analytical methods used in the Industrial Waters Section's laboratories were standard procedures, being either those of the American Public Health Association* or the American Society for Testing Materials**.

Difficulties were encountered in establishing suitable sampling stations on far northern rivers because of inaccessibility and resulting problems of sample collection and shipment during the winter months.

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*American Public Health Association, Standard Methods for the Examination of Water, Sewage and Industrial Wastes, 10th Edition, (1955), Am. Public Health Assn., New York, N.Y.

**American Society for Testing Materials, Manual on Industrial Water, 2nd printing (1954), ASTM Special Technical Publication No. 148-A, Am. Soc. for Testing Materials, Philadelphia, Pa.

The following rivers were chosen for study:

	Drainage basin in Canada (square miles)		Percentage of area of Canada*
Fraser River	91,440		
Mackenzie River	696,700		
Nelson River	375,555		
Churchill River	107,985		
St. Lawrence River	383,385		
	1,655,065	=	50.3
**Yukon River	129,000		
**Columbia River	40,055		
**Mississippi River	22,155		
	191,210		
Total area of Canada studied	1,846,275	=	56.6

*Total area, exclusive of the Arctic Archipelago - 3,296,521 sq miles

**To be studied by the U.S. Geological Survey since their mouths are in United States territory.

Only about 6.8 per cent of the area of Canada is drained by smaller rivers in the Maritimes and Pacific coastal regions. Discharge from these rivers is correspondingly small in comparison with the discharge of the rivers reported hereafter. No study was

made, therefore, of these rivers at this time, although data on discharge and chemical quality on many of them for other periods have already been published in Water Survey Reports (see Appendix A).

Flow records are not available on most of the rivers draining into the Arctic Ocean and Hudson Bay, nor are these rivers generally accessible for regular sampling. However, even though only about 56.6 per cent of Canada (excluding the Arctic Archipelago) is covered by this report, it is considered that the percentage run-off is considerably greater.

The larger rivers not reported (chiefly those in the relatively inaccessible northern part of Canada), are generally low in dissolved solids and similar in quality to the Churchill River (see Appendix A, Report No. 858, Water Survey Report No. 9).

SAMPLING LOCATIONS

Stations for the collection of samples were set up at Lévis on the St. Lawrence River, near Fort Churchill on the Churchill River, near Fort McPherson on the Mackenzie River, near Amery on the Nelson River and at Mission City on the Fraser River.

Difficulty in obtaining samples of the Nelson River at Amery resulted in the establishment of another station upstream at the site of the Kelsey Power Project. An additional check station on the St. Lawrence River at Québec was also operated. Additional samples of the Mackenzie River at its mouth were obtained during the summer of 1958 by field parties of the Geological Survey of Canada, Department of Mines and Technical Surveys.

Figure 1 shows the location of the sampling stations operated during this study; each location is further pinpointed on a separate map.

Station No. 1 - St. Lawrence River at Lévis, P.Q.

Samples were taken at the low-lift pump (raw water intake) of the waterworks of the City of Lévis which is across the river from the City of Québec. The intake extends about 400 ft into the river and is always at least 30 to 40 ft below the surface.

Station No. 2 - St. Lawrence River at Québec, P.Q.

Check samples of this important river were taken in midstream from the ferry linking the cities of Québec and Lévis.

Figure 2 shows the location of sampling stations No. 1 and 2.

Samples No. 1151 and 1152 (Table 1), taken from the ferry at low water and at high water respectively, show that water quality

is not affected by the tide, even though there is appreciable rise and fall in the water level between tides.

Station No. 3 - Nelson River near Amery, Man.

Samples were taken at Mile 352 on the Hudson Bay Railway near Amery, Man. As difficulty was encountered in 1958 in obtaining properly acidified samples from this location, raw water samples only were obtained in March and May, 1959 (Samples No. 1448 and 1529), and filtration and acidification of these were carried out later in the Section's laboratory.

Station No. 4 - Nelson River at the Kelsey Power Project, Man.

As a check on samples collected near Amery, additional samples of the Nelson River were obtained at the Kelsey Power Project. The two sampling locations on the Nelson River are shown in Figures 3 and 4.

In Figure 4 there are also sketch maps showing the flow of water and the exact location of the sampling at the Kelsey Power Project for the January and April samples (No. 1320 and 1495).

Station No. 5 - Churchill River near Churchill, Man.

Samples were collected 100 yards east of an island in the centre of the river, off Drachm Point and above the mouth of Goose Creek. This location, some 8 miles upstream from Churchill, is shown in Figure 5.

Station No. 6 - Fraser River at Mission City, B.C.

The location of this sampling station is shown in Figure 6. Samples were collected in mid-river, from the railway bridge.

Station No. 7 - Mackenzie River near Arctic Red River, N.W.T.

Three samples were obtained by Royal Canadian Mounted Police officers in mid-river, 3 miles upstream from Point Separation and below the mouth of the Arctic Red River. This location is shown in Figure 7, together with the location of the sampling points listed under Station No. 8.

Station No. 8 - Mackenzie River Delta, N.W.T.

During the summer of 1958 a number of samples from the several mouths of the Mackenzie River were collected by a field party of the Geological Survey of Canada. To illustrate the complexity of the problem of obtaining representative samples of the Mackenzie River, typical analyses of several of this river's outlets are included, namely:

(i) Peel River at Fort McPherson, N.W.T.

(ii) Husky Channel at the foot of Mt. Goodenough, N.W.T.

(iii) West Channel near Aklavik, N.W.T.

(iv) East Channel at Reindeer Depot, N.W.T.

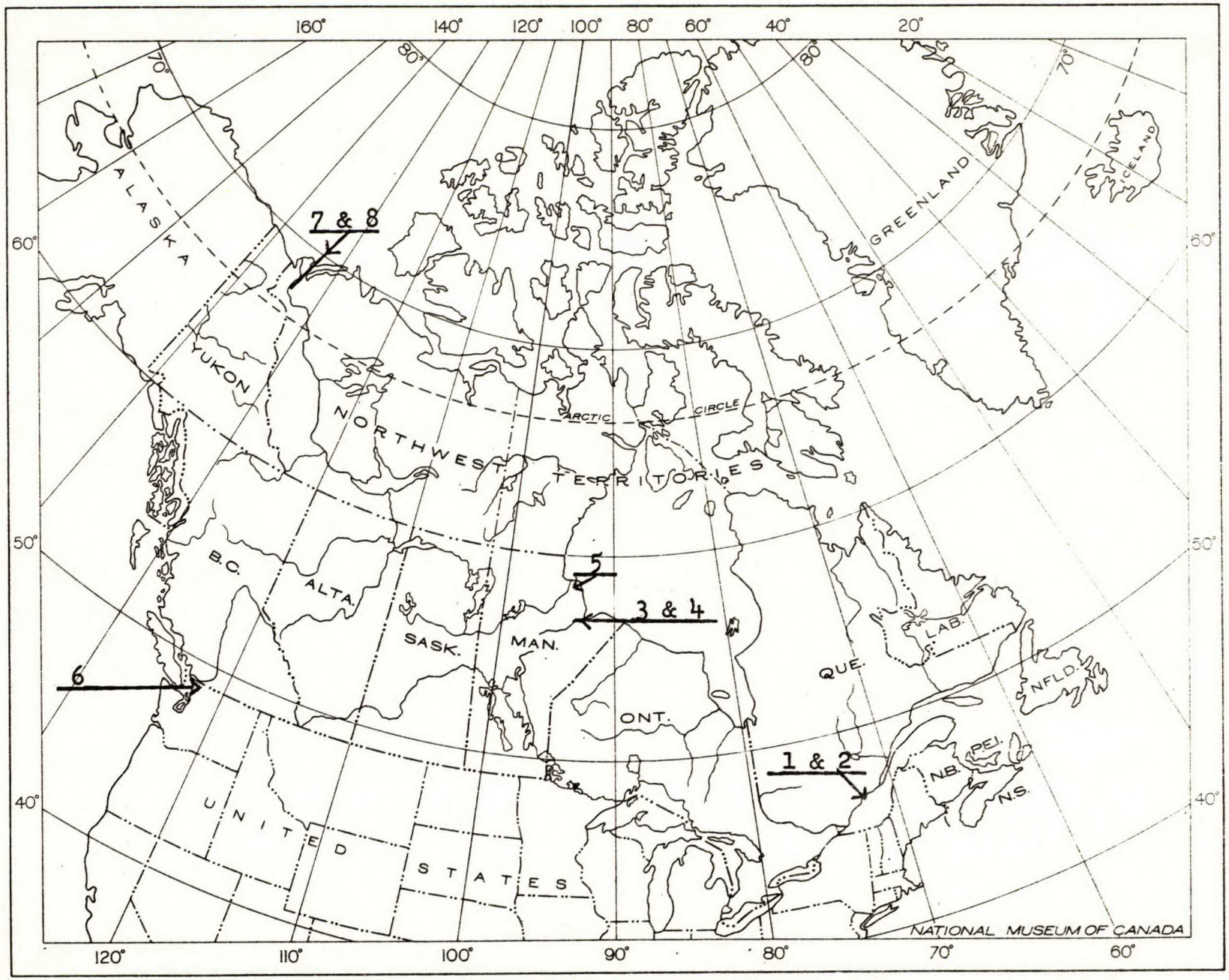


Figure 1: Distribution of Sampling Locations

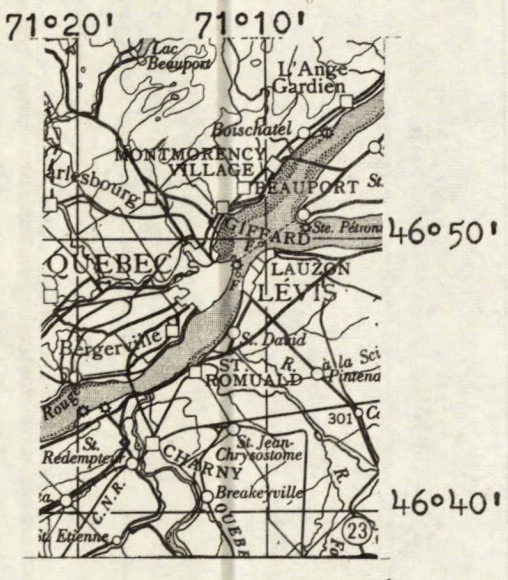
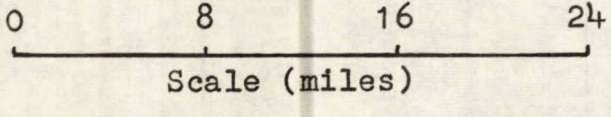


Figure 2: St. Lawrence River at Lévis and Quebec



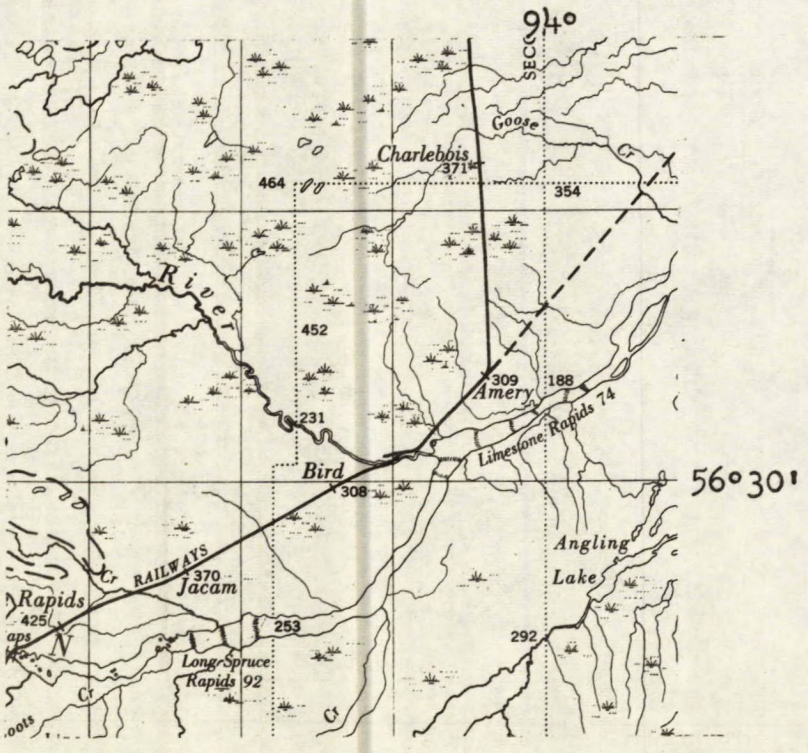
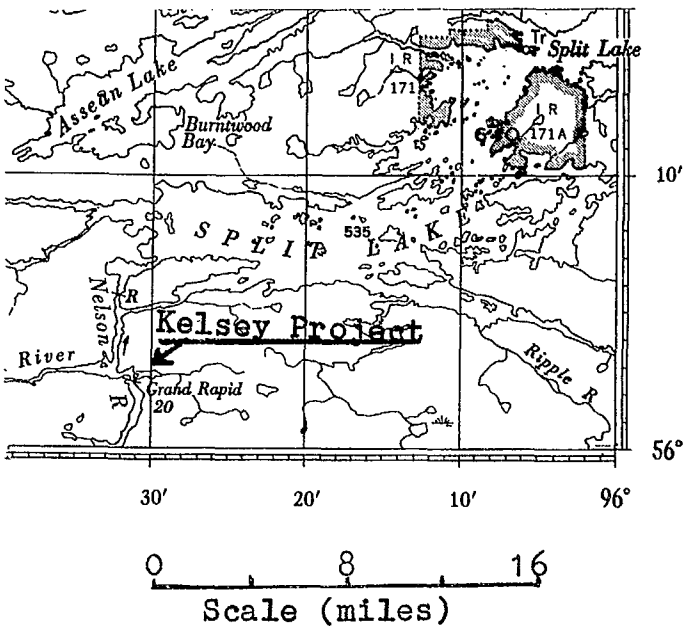
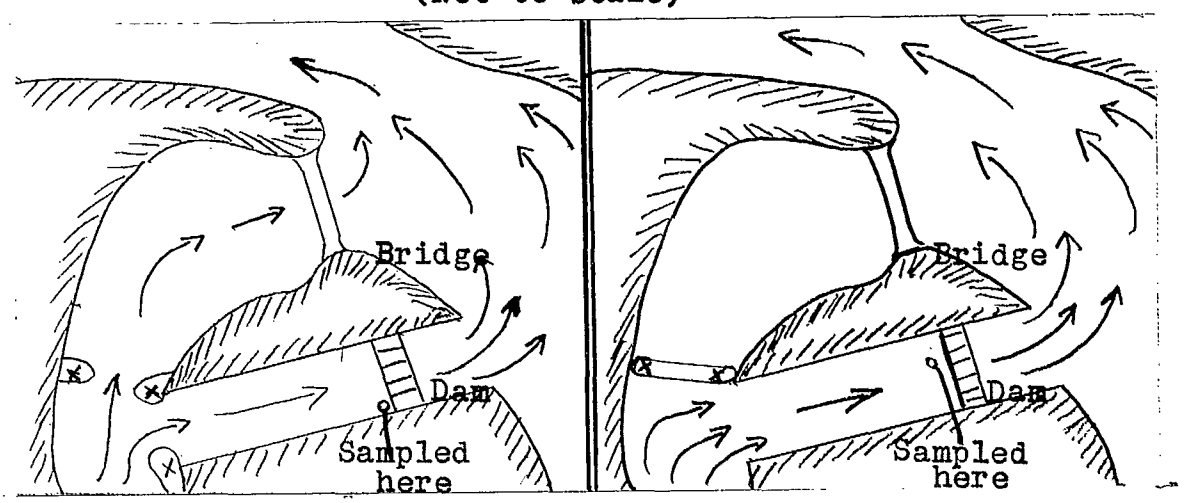


Figure 3: Nelson River at Amery, Man.



(Not to scale)



x: Coffer dams x - x: Coffer dam

Figure 4: Nelson River at Kelsey Power Project, Man.
Upper: Map reference
Lower left: Flow and sampling point, January, 1959
Lower right: Flow and sampling point, April, 1959

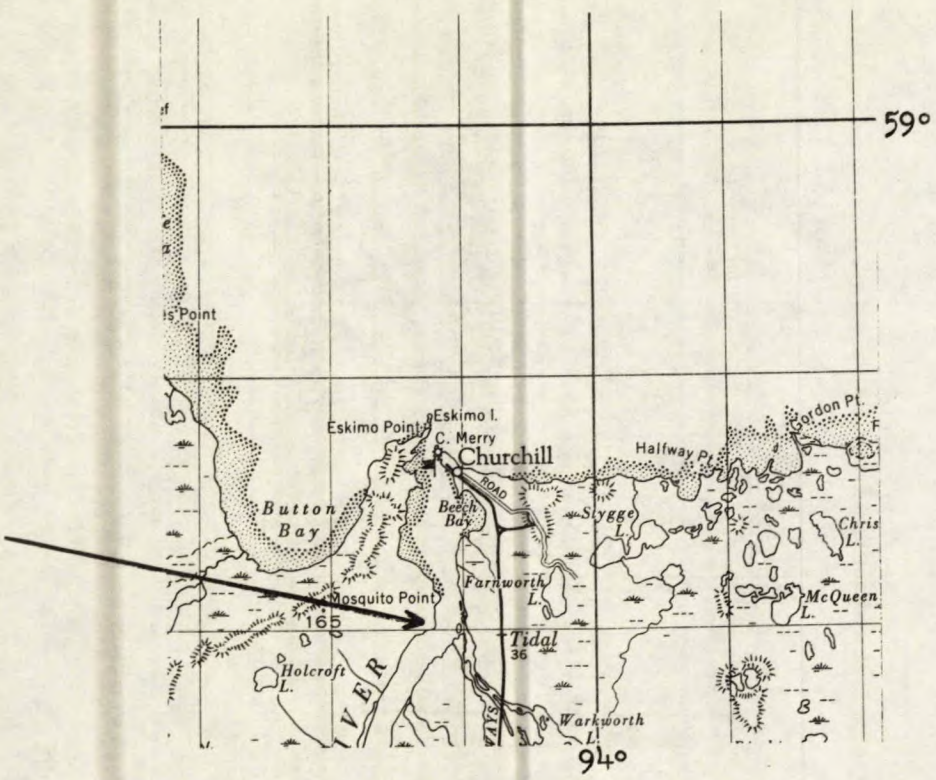


Figure 5: Churchill River near Churchill, Man.

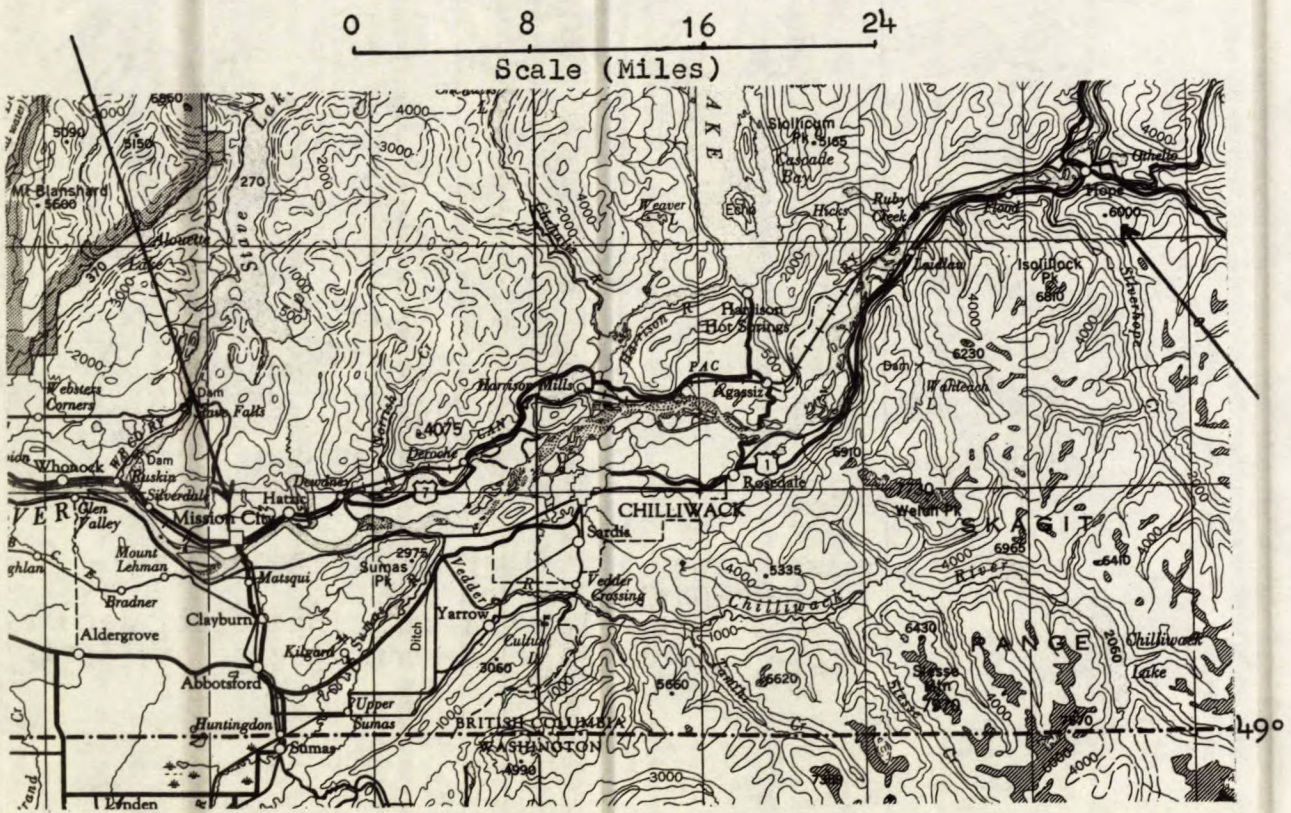


Figure 6: Fraser River at Mission City, B.C.

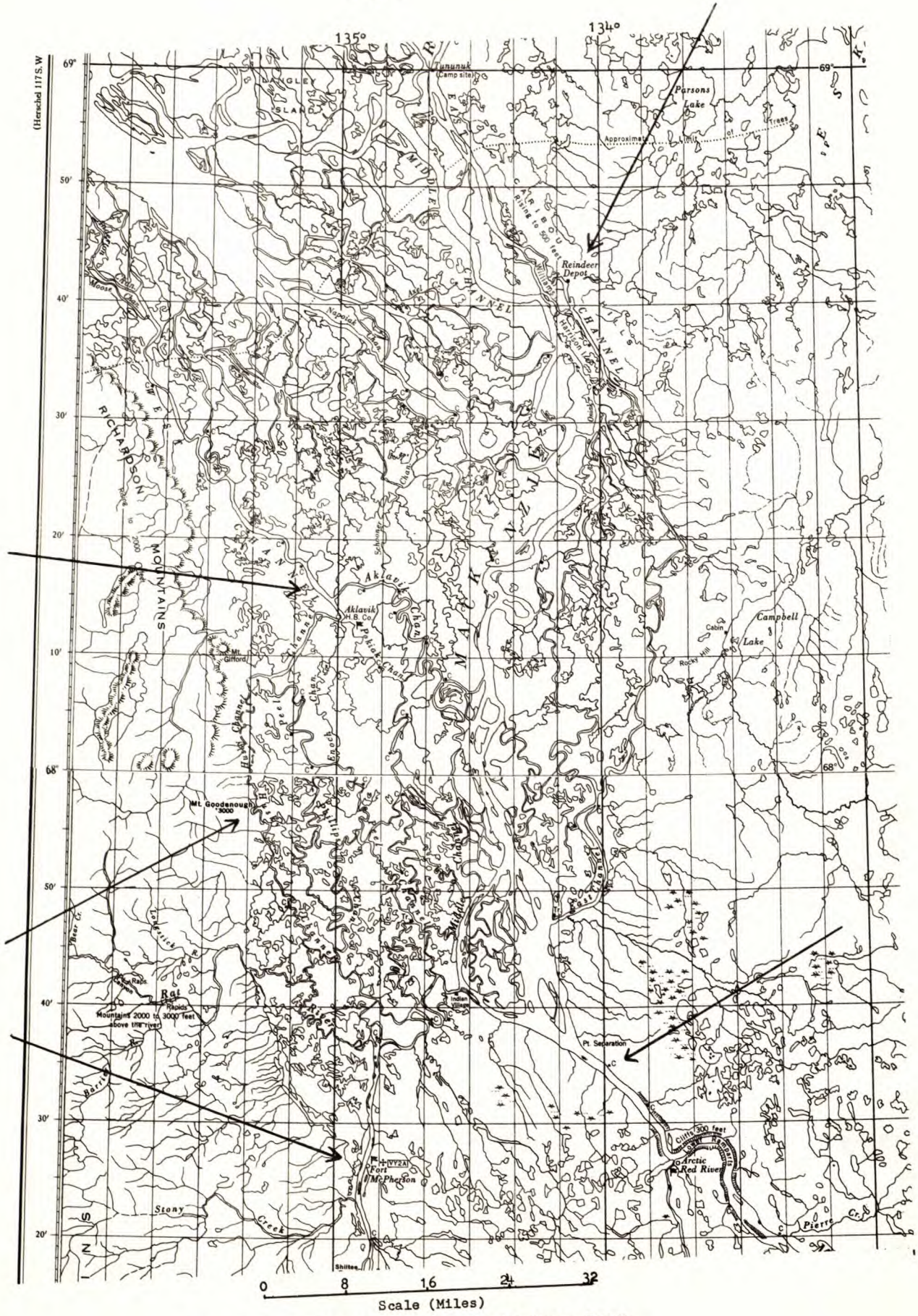


Figure 7: Mackenzie River near Arctic Red River, N.W.T. and Mackenzie River Delta

TABLE 1

Chemical Quality of River Waters

Station No. 1 - St. Lawrence River at Lévis, P.Q.

Laboratory number	9491	9659	M-82
Date of sampling	Feb. 20/57	Apr. 23/57	Apr. 21/57
Storage period (days)	14:23	6:21	6:23
Temp. at sampling (°C)	3.9	8.9	-
Temp. at testing (°C)	25.3	23.4	24.7
Level	30 ft.	35 ft.	30 ft.
Oxygen consumed ($KMnO_4$)		6.4	6.4
Chem. oxygen demand (C.O.D.)			
Carbon dioxide (CO_2), calculated	1.7	2.5	1.4
pH	7.9	7.7	8.0
Colour (Hazen units)	20	15	10
Turbidity	0	40	10
Alkalinity as $CaCO_3$ {-Phenolphthalein	0	0	0
Alkalinity as $CaCO_3$ {Total	72.9	62.9	74.6
Susp. matter, dried at 105°C.			17.2
" " , ignited at 550°C.			9.2
Res. on evap., dried at 105°C.			152
" " " , ignited at 550°C.			107
Conductance, micromhos at 25°C.	243.8	199.3	249.4
Hardness as $CaCO_3$ {Total	103	83.3	103
Hardness as $CaCO_3$ {Non-carbonate	29.7	20.4	28.5
Calcium (Ca)	31.4	24.8	29.8
Magnesium (Mg)	5.9	5.2	7.0
Strontium (Sr)			
Sodium (Na)	7.3	5.9	7.7
Potassium (K)	1.3	1.2	1.1
Lithium (Li)			
Iron (Fe) Total			0.04
Iron (Fe) Dissolved			0.01
Aluminum (Al)			0.01
Manganese (Mn)			0.0
Copper (Cu)			0.0
Zinc (Zn)			
Lead (Pb)			
Ammonia (NH_3)	0.0	0.0	0.0
Carbonate (CO_3)	0	0	0
Bicarbonate (HCO_3)	88.9	76.7	90.9
Sulphate (SO_4)	22.4	17.8	23.3
Chloride (Cl)	17.0	11.8	17.2
Fluoride (F)			0.0
Phosphate (PO_4)			
Nitrate (NO_3)	1.2	1.2	0.5
Silica (SiO_2)	2.1	2.6	1.9
Sum of constituents	132	108	133
Saturation index at test temperature	-0.2	-0.6	-0.1
Stability index at test temperature	8.3	8.9	8.2
% sodium	13.2	13.1	13.8
Boron	-	-	-
% error	-0.4	-0.7	-0.8

TABLE 1 (Cont'd)

Station No. 1 - St. Lawrence River at Levis, P.Q. (Cont'd)

Laboratory number	M-891	1155	1176	1496	1525
Date of sampling	Sept. 3/58	Sept. 25/58	Dec. 3/58	Apr. 20/59	Apr. 29/59
Storage period (days)	7:15	53:88	12:33	1:11	8:22
Temp. at sampling (°C)	-	-	3.9	-	-
Temp. at testing (°C)	21.7	23.6	24.2	21.5	24.0
Level	40 ft.	-	40 ft.	-	-
Oxygen consumed ($KMnO_4$)	4.4	4.9	4.4	8.1	4.9
Chem. oxygen demand (C.O.D.)					
Carbon dioxide (CO_2), calculated	4.0	6.7	3.3	1.5	0.9
pH	7.5	7.3	7.6	7.8	8.1
Colour (Hazen units)	15	15	20	15	25
Turbidity	6	5	8	25	5
Alkalinity as $CaCO_3$ {P-Phenolphthalein	0	0	0	0	0
Alkalinity as $CaCO_3$ {Total	66.7	67.0	69.1	46.2	57.3
Susp. matter, dried at 105°C.	12.2	27.2	12.8	40.9	23.2
" " , ignited at 550°C.	8.6	17.2	8.6	37.6	19.4
Res. on evap., dried at 105°C.	156	143	133	112	144
" " " , ignited at 550°C.	113	104	106	72.4	103
Conductance, micromhos at 25°C.	231.9	226.0	236.1	163.5	186.4
Hardness as $CaCO_3$ {Total	95.6	93.9	100	66.2	79.0
Hardness as $CaCO_3$ {Non-carbonate	28.9	26.9	31.0	20.0	21.7
Calcium (Ca)	28.1	26.6	28.4	19.6	23.6
Magnesium (Mg)	6.2	6.7	7.1	4.2	4.9
Strontium (Sr)					
Sodium (Na)	7.4	8.0	6.9	4.3	5.1
Potassium (K)	1.0	1.2	1.0	1.1	0.9
Lithium (Li)	0.1	Trace	Trace	-	-
Iron (Fe) Total	1.2	0.91	0.50	2.0	0.09
Dissolved	0.02	0.02	0.03	0.05	0.05
Aluminum (Al)	0.07	Trace	0.02	0.0	0.0
Manganese (Mn)	0.0	0.0	0.0	0.02	0.0
Copper (Cu)	0.0	0.0	0.0	Trace	0.0
Zinc (Zn)	0.0	0.0	0.0	0.0	0.0
Lead (Pb)	0.0	-	-	-	-
Ammonia (NH_3)	0.05	0.1	0.0	0.0	0.0
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	81.3	81.7	84.2	56.3	68.6
Sulphate (SO_4)	21.3	21.0	22.7	16.9	18.0
Chloride (Cl)	16.9	16.2	15.8	8.5	10.6
Fluoride (F)	0.1	0.1	0.0	0.0	0.0
Phosphate (PO_4)	0.5	-	-	0.0	0.2
Nitrate (NO_3)	0.2	0.1	0.1	0.8	0.5
Silica (SiO_2)	1.9	1.8	0.7	3.5	2.4
Sum of constituents	123	122	125	86.7	101
Saturation index at test temperature	-0.7	-0.9	-0.5	-0.7	-0.2
Stability index at test temperature	8.9	9.1	8.6	9.2	8.5
% sodium	14.1	15.4	12.9	12.1	12.1
Boron	0.11	-	0.0	-	-
% error	+0.5	+0.4	+0.6	+0.4	+0.8

TABLE 1 (Cont'd)

Station No. 1 - St. Lawrence River at Lévis, P.Q. (Concl'd)

Laboratory number	1735	1619	1739	1841
Date of sampling	May 27/59	June 16/59	July 21/59	Aug. 25/59
Storage period (days)	33:73	3:16	3:17	9:10
Temp. at sampling (°C)	15.6	18.5	23.3	21.1
Temp. at testing (°C)	27.4	28.3	28.8	27.6
Level	45 ft	35 ft	40 ft	-
Oxygen consumed ($KMnO_4$)	4.5	6.8	5.1	-
Chem. oxygen demand (C.O.D.)				
Carbon dioxide (CO_2), calculated	3.0	5.0	1.5	2.5
pH	7.6	7.4	7.9	7.7
Colour (Hazen units)	15	30	20	25
Turbidity	6	15	12	15
Alkalinity as $CaCO_3$ {Phenolphthalein	0	0	0	0
Alkalinity as $CaCO_3$ {Total	66.2	62.8	73.1	66.9
Susp. matter, dried at 105°C.	15.9	37.9	17.0	-
" " , ignited at 550°C.	10.5	17.2	8.5	-
Res. on evap., dried at 105°C.	160	137	172	-
" " " , ignited at 550°C.	107	106	129	-
Conductance, micromhos at 25°C.	230.1	204.5	247.3	231.5
Hardness as $CaCO_3$ {Total	92.8	86.4	104	96.4
Hardness as $CaCO_3$ {Non-carbonate	26.6	23.6	30.7	29.5
Calcium (Ca)	27.8	26.4	30.9	28.1
Magnesium (Mg)	5.7	8.0	6.5	6.4
Strontium (Sr)				
Sodium (Na)	5.9	6.0	7.6	7.3
Potassium (K)	1.2	1.1	1.2	1.4
Lithium (Li)	-	-	-	-
Iron (Fe) Total	0.42	1.4	0.48	1.10
Iron (Fe) Dissolved	0.07	0.53	0.07	-
Aluminum (Al)	0.21	0.0	0.16	-
Manganese (Mn)	0.0	0.0	0.0	-
Copper (Cu)	0.0	0.0	Trace	-
Zinc (Zn)	0.0	0.0	0.1	-
Lead (Pb)	-	-	-	-
Ammonia (NH_3)	0.0	-	0.1	0.2
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	80.7	76.6	89.1	81.6
Sulphate (SO_4)	20.1	18.0	21.1	21.2
Chloride (Cl)	14.4	12.7	18.6	16.7
Fluoride (F)	0.0	0.0	0.0	-
Phosphate (PO_4)	0.07	0.02	0.07	-
Nitrate (NO_3)	0.4	0.2	0.6	0.4
Silica (SiO_2)	1.3	1.3	1.3	3.1
Sum of constituents	117	108	132	125
Saturation index at test temperature	-0.5	-0.8	-0.1	-0.4
Stability index at test temperature	8.6	9.0	8.1	8.5
% sodium	11.8	12.9	13.4	13.9
Boron	-	-	-	-
% error	+0.3	+0.7	+0.6	+0.6

TABLE 1 (Cont'd)

Station No. 2 - St. Lawrence River at Quebec, P.Q.

Laboratory number	M-889	1151	1152	1536
Date of sampling	Aug. 25/58	Sept. 24/58	Sept. 24/58	Apr. 23/59
Storage period (days)	20:24	51:82	51:82	32:34
Temp. at sampling (°C)	-	-	-	-
Temp. at testing (°C)	21.7	26.0	26.0	28.0
Level	-	low water	high water	150 ft
Oxygen consumed ($KMnO_4$)	4.1	4.9	5.1	6.5
Chem. oxygen demand (C.O.D.)				
Carbon dioxide (CO_2), calculated	4.0	5.0	3.0	2.5
pH	7.5	7.4	7.6	7.6
Colour (Hazen units)	20	20	20	20
Turbidity	2	15	7	13
Alkalinity as $CaCO_3$ - Phenolphthalein	0	0	0	0
Alkalinity as $CaCO_3$ - Total	65.7	64.0	67.2	57.3
Susp. matter, dried at 105°C.	-	17.2	13.5	-
" " , ignited at 550°C.	-	15.6	8.5	-
Res. on evap., dried at 105°C.	155	132	142	-
" " " , ignited at 550°C.	116	109	120	-
Conductance, micromhos at 25°C.	228.6	218.4	230.7	188.8
Hardness as $CaCO_3$ - Total	93.0	90.0	95.3	79.9
Hardness as $CaCO_3$ - Non-carbonate	27.3	26.0	28.1	22.6
Calcium (Ca)	26.9	25.7	27.5	23.3
Magnesium (Mg)	6.3	6.3	6.5	5.3
Strontium (Sr)				
Sodium (Na)	7.4	7.0	7.1	5.0
Potassium (K)	1.1	1.1	1.1	1.0
Lithium (Li)	0.1	Trace	Trace	
Iron (Fe) Total	-	-	-	-
Iron (Fe) Dissolved	0.02	0.03	0.01	0.09
Aluminum (Al)	0.02	0.04	0.05	0.0
Manganese (Mn)	0.0	0.0	0.0	0.0
Copper (Cu)	0.0	0.0	0.02	0.0
Zinc (Zn)	0.0	0.0	0.05	0.0
Lead (Pb)	0.0	-	-	-
Ammonia (NH_3)	0.1	0.1	0.1	0.1
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	80.1	78.0	81.9	69.8
Sulphate (SO_4)	20.5	21.3	20.2	18.8
Chloride (Cl)	16.6	15.7	16.6	10.4
Fluoride (F)	0.1	0.1	0.1	0.0
Phosphate (PO_4)	0.2	-	-	0.02
Nitrate (NO_3)	0.2	0.1	0.1	0.6
Silica (SiO_2)	1.7	2.0	1.8	4.0
Sum of constituents	121	118	121	103
Saturation index at test temperature	-0.7	-0.8	-0.6	-0.6
Stability index at test temperature	8.9	9.0	8.8	8.8
% sodium	14.4	14.2	13.7	11.8
Boron	0.05	0.05	0.05	-
% error	+0.1	-0.8	+0.5	+0.2

TABLE 1 (Cont'd)

Station No. 3 - Nelson River near Amery, Man.

Laboratory number	1023	1448	1529
Date of sampling	Oct. 5/58	Mar. 9/59	May 1/59
Storage period (days)	10:28	14:29	12:20
Temp. at sampling (°C)	-	-	-
Temp. at testing (°C)	26.5	24.4	21.9
Level	low	very low	-
Oxygen consumed ($KMnO_4$)	5.8	5.6	5.8
Chem. oxygen demand (C.O.D.)			
Carbon dioxide (CO_2), calculated	1.2	2	2
pH	8.2	8.0	8.0
Colour (Hazen units)	15	15	15
Turbidity	15	7	5
Alkalinity as $CaCO_3$ {-Phenolphthalein	0	0	0
Alkalinity as $CaCO_3$ {-Total	109	119	117
Susp. matter, dried at 105°C.	14.2	3.8	15.0
" " , ignited at 550°C.	14.2	3.8	9.2
Res. on evap., dried at 105°C.	216	237	240
" " " , ignited at 550°C.	171	180	192
Conductance, micromhos at 25°C.	346	393.5	381.7
Hardness as $CaCO_3$ {Total	130	144	140
Hardness as $CaCO_3$ {Non-carbonate	20.5	25.1	23.0
Calcium (Ca)	31.0	33.7	33.3
Magnesium (Mg)	12.7	14.6	13.8
Strontium (Sr)			
Sodium (Na)	20.0	24.0	22.7
Potassium (K)	2.3	2.7	2.6
Lithium (Li)	0.05	-	-
Iron (Fe) Total	0.40	0.59	0.28
Dissolved	0.06	Trace	0.0
Aluminum (Al)	0.06	0.02	0.0
Manganese (Mn)	0.0	0.0	0.0
Copper (Cu)	0.0	0.0	0.0
Zinc (Zn)	0.0	0.0	0.0
Lead (Pb)			
Ammonia (NH_3)	0.1	0	0.05
Carbonate (CO_3)	0	0.0	0.0
Bicarbonate (HCO_3)	133	145	142
Sulphate (SO_4)	27.7	36.8	34.2
Chloride (Cl)	25.9	31.0	28.7
Fluoride (F)	0.2	0.0	0.0
Phosphate (PO_4)	0.3	Trace	0.0
Nitrate (NO_3)	0.4	Trace	0.1
Silica (SiO_2)	3.5	2.9	2.6
Sum of constituents	190	217	208
Saturation index at test temperature	+0.3	+0.1	+0.1
Stability index at test temperature	7.6	7.9	7.8
% sodium	24.6	26.1	25.6
Boron	0.08	-	-
% error	+0.3	-0.3	-0.2

TABLE 1 (Cont'd)

Station No. 4 - Nelson River at the Kelsey Power Project, Man.

Laboratory number	1320	1495	1596
Date of sampling	Jan. 29/59	Apr. 9/59	June 3/59
Storage period (days)	7:13	12:22	12:21
Temp. at sampling (°C)	0.0	1.67	0.0
Temp. at testing (°C)	23.3	23.4	20.1
Level			
Oxygen consumed ($KMnO_4$)	5.5	7.3	6.9
Chem. oxygen demand (C.O.D.)			
Carbon dioxide (CO_2), calculated	1.5	2	2.5
pH	8.2	8.0	7.8
Colour (Hazen units)	25	15	25
Turbidity	6	7	5
Alkalinity as $CaCO_3$ {Phenolphthalein	0.0	0.0	0
Alkalinity as $CaCO_3$ {Total	119	117	85.2
Susp. matter, dried at 105°C.	5.3	13.2	10.6
" " , ignited at 550°C.	0.9	7.1	5.0
Res. on evap., dried at 105°C.	260	241	177
" " " , ignited at 550°C.	205	192	131
Conductance, micromhos at 25°C.	403	392	277
Hardness as $CaCO_3$ {Total	148	144	104
Hardness as $CaCO_3$ {Non-carbonate	28.6	27.6	19.0
Calcium (Ca)	34.3	33.0	25.1
Magnesium (Mg)	15.2	15.1	10.1
Strontium (Sr)			
Sodium (Na)	25.5	25.0	16.5
Potassium (K)	2.8	3.0	2.0
Lithium (Li)			
Iron (Fe) Total	0.08	0.03	0.03
Dissolved	0.01	0.0	0.02
Aluminum (Al)	0.0	0.0	0.0
Manganese (Mn)	0.0	0.0	0.0
Copper (Cu)	0.0	0.0	0.0
Zinc (Zn)	0.0	0.05	0.0
Lead (Pb)			
Ammonia (NH_3)	0.0	0.0	0.0
Carbonate (CO_3)	0.0	0.0	0
Bicarbonate (HCO_3)	146	142	104
Sulphate (SO_4)	36.1	37.8	24.8
Chloride (Cl)	32.2	31.5	20.5
Fluoride (F)	0.0	0.0	0.1
Phosphate (PO_4)	Trace	0.0	0.0
Nitrate (NO_3)	0.0	0.6	0.0
Silica (SiO_2)	3.9	2.9	1.3
Sum of constituents	222	219	151
Saturation index at test temperature	+0.3	+0.1	-0.4
Stability index at test temperature	7.6	7.8	8.6
% sodium	26.8	26.8	25.6
Boron			
% error	+1.2	+0.4	+1.0

TABLE 1 (Cont'd)

Station No. 5 - Churchill River near Churchill, Man.

Laboratory number	M-782	1021	1399	1673
Date of sampling	June 24/58	Sept. 25/58	Feb. 20/59	June 27/59
Storage period (days)	29:30	13:39	10:19	11:20
Temp. at sampling (°C)	-	-	0.0	-
Temp. at testing (°C)	25.0	25.8	27.9	25.1
Level	11 ft	Low	9 ft 6 in	11 ft
Oxygen consumed ($KMnO_4$)	9.3	9.3	5.8	7.8
Chem. oxygen demand (C.O.D.)				
Carbon dioxide (CO_2), calculated	5.8	1.8	3	4
pH	7.3	7.7	7.5	7.3
Colour (Hazen units)	20	35	15	30
Turbidity	High	1	2	15
Alkalinity as $CaCO_3$ - Phenolphthalein	0	0	0.0	0
Alkalinity as $CaCO_3$ - Total	58.6	49.9	52.3	48.3
Susp. matter, dried at 105°C.	19.1	3.2	-	30.4
" " , ignited at 550°C.	16.0	3.2	-	22.5
Res. on evap., dried at 105°C.	96.4	87.6	76.4	84.4
" " " , ignited at 550°C.	62.4	59.2	36.4	43.2
Conductance, micromhos at 25°C.	121.6	107.7	118.5	103.9
Hardness as $CaCO_3$ - Total	55.3	51.4	53.5	50.5
Hardness as $CaCO_3$ - Non-carbonate	0.0	1.5	1.2	2.2
Calcium (Ca)	14.6	13.2	13.2	13.3
Magnesium (Mg)	4.6	4.5	5.0	4.2
Strontium (Sr)				
Sodium (Na)	3.2	2.5	3.3	2.2
Potassium (K)	1.2	0.9	1.4	0.9
Lithium (Li)	0.1	0.05	-	-
Iron (Fe) Total	1.2	0.10	0.02	1.2
Iron (Fe) Dissolved	Trace	0.02	0.02	0.00
Aluminum (Al)	0.03	0.0	0.0	0.00
Manganese (Mn)	0.0	0.0	0.0	0.0
Copper (Cu)	0.01	0.0	0.0	Trace
Zinc (Zn)	0.05	0.0	0.1	0.1
Lead (Pb)	0.0	-	-	-
Ammonia (NH_3)	0.05	0.05	0.05	0.1
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	71.4	60.8	63.8	58.9
Sulphate (SO_4)	3.5	3.2	4.6	3.4
Chloride (Cl)	1.7	1.9	1.6	1.7
Fluoride (F)	0.2	0.2	0.0	0.0
Phosphate (PO_4)	0.1	0.7	0.0	0.04
Nitrate (NO_3)	0.1	0.4	0.2	0.0
Silica (SiO_2)	2.4	1.9	3.5	1.6
Sum of constituents	67.0	58.6	64.3	56.4
Saturation index at test temperature	-1.2	-0.8	-1.0	-1.3
Stability index at test temperature	9.7	9.3	9.5	9.9
% sodium	10.7	9.3	11.5	8.6
Boron	-	0.11	-	-
% error	-0.4	+1.5	+2.6	+1.1

TABLE 1 (Cont'd)

Station No. 6 - Fraser River at Mission City, B.C.

Laboratory number	M-803	1022	1397	1621
Date of sampling	July 1/58	Oct. 1/58	Feb. 12/59	June 12/59
Storage period (days)	22:35	7:33	18:27	3:20
Temp. at sampling (°C)				
Temp. at testing (°C)	25.0	25.7	29.0	28.1
Level	202 ft	-	4.20'	15.30'
Oxygen consumed ($KMnO_4$)	3.6	4.0	2.1	4.3
Chem. oxygen demand (C.O.D.)				
Carbon dioxide (CO_2), calculated	2.0	1.6	2	2
pH	7.6	7.8	7.7	7.6
Colour (Hazen units)	10	25	10	30
Turbidity		40	3	30
Alkalinity as $CaCO_3$ - Phenolphthalein	0	0	0.0	0
Alkalinity as $CaCO_3$ - Total	41.9	51.2	50.6	40.4
Susp. matter, dried at 105°C.	82.7	128	12.7	67.2
" " , ignited at 550°C.	80.8	125	8.7	2.4
Res. on evap., dried at 105°C.	76.4	77.6	80.0	69.2
" " " , ignited at 550°C.	64.8	65.6	48.0	50.4
Conductance, micromhos at 25°C.	94.9	111.3	128.6	95.2
Hardness as $CaCO_3$ - Total	44.5	56.5	58.0	44.7
Hardness as $CaCO_3$ - Non-carbonate	2.6	5.3	7.4	4.3
Calcium (Ca)	13.7	16.4	16.5	13.8
Magnesium (Mg)	2.5	3.8	4.1	2.8
Strontium (Sr)				
Sodium (Na)	1.2	1.3	1.9	1.2
Potassium (K)	0.7	0.6	0.7	0.6
Lithium (Li)	0.05			
Iron (Fe) Total	3.6	2.8	0.08	0.58
Iron (Fe) Dissolved	0.08	0.12	0.02	0.06
Aluminum (Al)	0.0	0.07	0.05	0.03
Manganese (Mn)	0.0	0.0	Trace	0.0
Copper (Cu)	0.0	0.0	0.0	0.0
Zinc (Zn)	0.0	0.05	0.05	0.0
Lead (Pb)	0.0			
Ammonia (NH_3)	0.05	0.05	0.0	-
Carbonate (CO_3)	0	0	0	0
Bicarbonate (HCO_3)	51.1	62.4	61.7	49.2
Sulphate (SO_4)	6.2	7.2	9.1	5.7
Chloride (Cl)	0.4	0.5	0.6	0.8
Fluoride (F)	0.1	0.1	0.0	0.0
Phosphate (PO_4)	0.1	0.3	0.0	0.03
Nitrate (NO_3)	0.1	0.2	0.3	0.0
Silica (SiO_2)	4.7	4.0	6.1	4.4
Sum of constituents	55.0	65.4	69.8	53.3
Saturation index at test temperature	-1.0	-0.6	-0.7	-1.0
Stability index at test temperature	9.6	9.0	9.1	9.6
% sodium	5.4	4.6	6.5	5.4
Boron	-	0.05	-	-
% error	-1.1	+0.5	+1.9	+1.0

TABLE 1 (Cont'd)

Station No. 7 - Mackenzie River near Arctic Red River, N.W.T.

Laboratory number	M-854	1024	1628
Date of sampling	July 24/58	Oct. 2/58	June 9/59
Storage period (days)	29:40	13:31	15:23
Temp. at sampling (°C)			6.7
Temp. at testing (°C)	23.6	26.3	24.2
Level			high
Oxygen consumed ($KMnO_4$)	5.5	5.2	4.9
Chem. oxygen demand (C.O.D.)			
Carbon dioxide (CO_2), calculated	3.0	1.6	3
pH	7.8	8.0	7.7
Colour (Hazen units)	15	15	50
Turbidity		10.9	95
Alkalinity as $CaCO_3$ -Phenolphthalein	0	0	0
Alkalinity as $CaCO_3$ -Total	94.0	90.3	76.8
Susp. matter, dried at 105°C.	21.6	40.0	172
" " , ignited at 550°C.	20.8	39.0	14
Res. on evap., dried at 105°C.	175	170.8	180.8
" " " , ignited at 550°C.	152	148.8	144.0
Conductance, micromhos at 25°C.	261.1	269.0	213.0
Hardness as $CaCO_3$ Total	118	120	103
Hardness as $CaCO_3$ Non-carbonate	24.2	29.3	26.0
Calcium (Ca)	33.7	32.9	29.5
Magnesium (Mg)	8.3	9.1	7.1
Strontium (Sr)			
Sodium (Na)	6.1	7.7	5.1
Potassium (K)	0.9	0.8	1.0
Lithium (Li)	0.1	0.1	
Iron (Fe) Total	2.38	0.88	0.05
Iron (Fe) Dissolved	0.02	0.05	0.05
Aluminum (Al)	0.03	0.05	0.00
Manganese (Mn)	0.0	0.0	0.0
Copper (Cu)	0.0	0.0	trace
Zinc (Zn)	0.0	0.0	0.0
Lead (Pb)	0.0		
Ammonia (NH_3)	0.35	0.1	0.1
Carbonate (CO_3)	0.0	0.0	0.0
Bicarbonate (HCO_3)	114.6	110.0	93.6
Sulphate (SO_4)	28.0	31.4	23.0
Chloride (Cl)	8.0	10.0	6.9
Fluoride (F)	0.1	0.2	0.0
Phosphate (PO_4)	0.1	0.3	0.04
Nitrate (NO_3)	0.2	0.2	0.0
Silica (SiO_2)	4.0	3.2	3.2
Sum of constituents	146	150.2	122
Saturation index at test temperature	-0.2	+0.1	-0.4
Stability index at test temperature	8.2	7.8	8.5
% sodium	9.9	12.4	9.6
Boron	0.0	0.11	
% error	-0.5	+0.2	+2.2

TABLE 1 (Concl'd)

Station No. 8 - Mackenzie River Delta, N.W.T.

	Peel River		Husky Channel	West Channel	East Channel
Laboratory number	M-926	M-939	M-944	M-945	M-921
Date of sampling	July 18/58	Aug. 2/58	Sept. 1/58	Sept. 4/58	Aug. 1/58
Storage period (days)	61:76	46:66	17:37	13:33	48:63
Temp. at sampling (°C)	15.0	10.0	7.8	6.7	
Temp. at testing (°C)	24.8	25.4	25.4	23.8	24.8
Level					
Oxygen consumed ($KMnO_4$)	—	—	—	—	—
Chem. oxygen demand (C.O.D.)					
Carbon dioxide (CO_2), calculated	2.5	4.0	2.3	3.8	2.2
pH	7.9	7.6	7.9	7.7	7.9
Colour (Hazen units)	25	50	60	45	15
Turbidity	280	1,300	325	220	120
Alkalinity as $CaCO_3$ — Phenolphthalein	0.0	0.0	0.0	0.0	0.0
Alkalinity as $CaCO_3$ — Total	100	83.2	94.4	97.5	89.8
Susp. matter, dried at 105°C.	243	1,227	237	165	128
" " , ignited at 550°C.	223	1,130	206	142	115
Res. on evap., dried at 105°C.	190	254	241	199	172
" " " , ignited at 550°C.	139	184	178	167	141
Conductance, micromhos at 25°C.	297.8	319.1	280.2	290.5	261.3
Hardness as $CaCO_3$ — Total	150	152	140	145	118
Hardness as $CaCO_3$ — Non-carbonate	49.8	68.8	45.6	47.5	28.3
Calcium (Ca)	40.3	41.3	37.5	39	34
Magnesium (Mg)	12.0	11.9	11.3	11.6	8.1
Strontium (Sr)					
Sodium (Na)	4.1	5.0	3.5	4.0	7.1
Potassium (K)	1.0	1.0	0.6	0.6	1.0
Lithium (Li)					
Iron (Fe) Total	10.5	47.8	12.9	1.1	5.2
Iron (Fe) Dissolved	0.14	0.13	0.08	0.05	0.03
Aluminum (Al)	0.0	0.0	0.0	0.0	0.04
Manganese (Mn)	0.0	0.0	0.0	0.0	0.0
Copper (Cu)	0.0	0.0	0.0	0.0	0.0
Zinc (Zn)	0.0	0.0	0.0	0.0	0.0
Lead (Pb)					
Ammonia (NH_3)					
Carbonate (CO_3)	0.0	0.0	0.0	0.0	0.0
Bicarbonate (HCO_3)	122	101	115	119	110
Sulphate (SO_4)	46.4	69.7	43.3	50.5	29.2
Chloride (Cl)	2.5	1.9	2.9	2.1	8.3
Fluoride (F)	0.1	0.0	0.0	0.0	0.1
Phosphate (PO_4)					
Nitrate (NO_3)	0.2	0.2	0.4	0.4	0.2
Silica (SiO_2)	5.5	4.4	4.2	3.6	5.2
Sum of constituents	172	186	161	170	147
Saturation index at test temperature	+0.1	-0.3	0.0	-0.2	0.0
Stability index at test temperature	7.7	8.2	7.9	8.1	7.9
% sodium	5.6	6.6	5.1	5.6	11.4
Boron					
% error	+2.6	+1.8	+1.6	+0.4	+1.1

TABLE 2

Comparison of Analytical Results Obtained by Department of Mines and Technical Surveys, Ottawa and by U.S. Geological Survey, Washington, D.C.

Station No. 1 - St. Lawrence River at Levis, P.Q.

Laboratory number	M-891	USGS 54774
Date of sampling	September 3, 1958	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	4.0	2.7
pH	7.5	7.7
Colour (Hazen units)	15	7
Turbidity		
Alkalinity as $CaCO_3$ — Phenolphthalein		
Alkalinity as $CaCO_3$ — Total	66.7	70
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	156	149
" " " , ignited at 550°C.	113	129
Conductance, micromhos at 25°C.	231.9	238
Hardness as $CaCO_3$ — Total	95.6	97
Hardness as $CaCO_3$ — Non-carbonate	28.9	27
Calcium (Ca)	28.1	29
Magnesium (Mg)	6.2	6.0
Strontium (Sr)		0.19
Sodium (Na)	7.4	8.0
Potassium (K)	1.0	1.1
Lithium (Li)	0.1	0.0
Iron (Fe) Total	1.2	0.52
Iron (Fe) Dissolved	0.02	0.02
Aluminum (Al)	0.07	0.1
Manganese (Mn)	0.0	0.01
Copper (Cu)	0.0	0.0
Zinc (Zn)	0.0	0.0
Lead (Pb)	0.0	
Ammonia (NH_3)	0.05	
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	81.3	85
Sulphate (SO_4)	21.3	20
Chloride (Cl)	16.9	17
Fluoride (F)	0.1	0.0
Phosphate (PO_4)	0.5	0.0
Nitrate (NO_3)	0.2	0.4
Silica (SiO_2)	1.9	1.6
Sum of constituents	123	125
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Chromium		0.0

TABLE 2 (Cont'd)

Station No. 2 - St. Lawrence River at Quebec, P.Q.

Laboratory number	M-889	USGS 54715
Date of sampling	August 25, 1958	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	4.0	2.7
pH	7.5	7.7
Colour (Hazen units)	20	7
Turbidity		
Alkalinity as $CaCO_3$ — Phenolphthalein		
Alkalinity as $CaCO_3$ — Total	65.7	69
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	155	141
" " " , ignited at 550°C.	116	120
Conductance, micromhos at 25°C.	228.6	229
Hardness as $CaCO_3$ — Total	93.0	94
Hardness as $CaCO_3$ — Non-carbonate	27.3	25
Calcium (Ca)	26.9	28
Magnesium (Mg)	6.3	5.8
Strontium (Sr)		0.14
Sodium (Na)	7.4	8.0
Potassium (K)	1.1	1.1
Lithium (Li)	0.1	0.0
Iron (Fe) Total		0.20
Iron (Fe) Dissolved	0.02	0.02
Aluminum (Al)	0.02	0.1
Manganese (Mn)	0.0	0.01
Copper (Cu)	0.0	0.00
Zinc (Zn)	0.0	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	80.1	84
Sulphate (SO_4)	20.5	20
Chloride (Cl)	16.6	16
Fluoride (F)	0.1	0.0
Phosphate (PO_4)	0.2	0.0
Nitrate (NO_3)	0.2	0.4
Silica (SiO_2)	1.7	1.7
Sum of constituents	121	122
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Chromium		0.00

TABLE 2 (Cont'd)

Station No. 3 - Nelson River near Amery, Man.

Laboratory number	1448	USGS 55365
Date of sampling	March 9, 1959	
Storage period (days)	2	12
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	2	12
pH	8.0	7.3
Colour (Hazen units)	15	13
Turbidity		
Alkalinity as $CaCO_3$ {-Phenolphthalein		
Alkalinity as $CaCO_3$ {-Total	119	121
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	237	258
" " " , ignited at 550°C.	180	205
Conductance, micromhos at 25°C.	393.5	393
Hardness as $CaCO_3$ {Total	144.1	141
Hardness as $CaCO_3$ {Non-carbonate	25.1	20
Calcium (Ca)	33.7	35
Magnesium (Mg)	14.6	13
Strontium (Sr)		0.10
Sodium (Na)	24.0	25
Potassium (K)	2.7	3.1
Lithium (Li)		0.0
Iron (Fe) Total	0.59	0.15
Iron (Fe) Dissolved	Trace	0.00
Aluminum (Al)	0.02	0.1
Manganese (Mn)	0.0	0.00
Copper (Cu)	0.0	0.00
Zinc (Zn)	0.0	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0.0	0
Bicarbonate (HCO_3)	145	147
Sulphate (SO_4)	36.8	34
Chloride (Cl)	31.0	31
Fluoride (F)	0.0	0.0
Phosphate (PO_4)	Trace	0.0
Nitrate (NO_3)	Trace	0.1
Silica (SiO_2)	2.9	2.4
Sum of constituents	217	216
Saturation index at test temperature		
Stability index at test temperature		
% Sodium		
Boron		0.01
Chromium		0.00

TABLE 2 (Cont'd)

Station No. 4 - Nelson River at the Kelsey Power Project, Man.

Laboratory number	1495	USGS 55363
Date of sampling	April 9, 1959	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	2	3.8
pH	8.0	7.8
Colour (Hazen units)	15	16
Turbidity		
Alkalinity as $CaCO_3$ {-Phenolphthalein		
Alkalinity as $CaCO_3$ {-Total	117	122
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	241	278
" " " , ignited at 550°C.	192	196
Conductance, micromhos at 25°C.	392	399
Hardness as $CaCO_3$ {Total	144	141
Hardness as $CaCO_3$ {Non-carbonate	27.6	19
Calcium (Ca)	33.0	35
Magnesium (Mg)	15.1	13
Strontium (Sr)		0.10
Sodium (Na)	25.0	25
Potassium (K)	3.0	3.1
Lithium (Li)		0.0
Iron (Fe) Total	0.03	0.15
Dissolved	0.0	0.01
Aluminum (Al)	0.0	0.1
Manganese (Mn)	0.0	0.02
Copper (Cu)	0.0	0.01
Zinc (Zn)	0.05	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0.0	0
Bicarbonate (HCO_3)	142	149
Sulphate (SO_4)	37.8	35
Chloride (Cl)	31.5	32
Fluoride (F)	0.0	0.0
Phosphate (PO_4)	0.0	0.0
Nitrate (NO_3)	0.6	0.1
Silica (SiO_2)	2.9	2.2
Sum of constituents	219	219
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Boron		0.01
Chromium		0.00

TABLE 2 (Cont'd)

Station No. 5 - Churchill River near Churchill, Man.

	1021	USGS 54775
Laboratory number		
Date of sampling	September 25, 1958	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	1.8	2.6
pH	7.7	7.6
Colour (Hazen units)	35	28
Turbidity		
Alkalinity as $CaCO_3$ -Phenolphthalein		
Alkalinity as $CaCO_3$ -Total	49.9	53
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	87.6	82
" " " , ignited at 550°C.	59.2	71
Conductance, micromhos at 25°C.	107.7	111
Hardness as $CaCO_3$ Total	51.4	53
Hardness as $CaCO_3$ Non-carbonate	1.5	0
Calcium (Ca)	13.2	14
Magnesium (Mg)	4.5	4.3
Strontium (Sr)		0.05
Sodium (Na)	2.5	3.2
Potassium (K)	0.9	1.0
Lithium (Li)	0.05	0.0
Iron (Fe) Total	0.10	0.10
Iron (Fe) Dissolved	0.02	0.06
Aluminum (Al)	0.0	0.1
Manganese (Mn)	0.0	0.00
Copper (Cu)	0.0	0.00
Zinc (Zn)	0.0	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	60.8	65
Sulphate (SO_4)	3.2	0.4
Chloride (Cl)	1.9	1.6
Fluoride (F)	0.2	0.0
Phosphate (PO_4)	0.7	0.0
Nitrate (NO_3)	0.4	0.8
Silica (SiO_2)	1.9	1.4
Sum of constituents	58.6	59
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Chromium		0.00

TABLE 2 (Cont'd)

Station No. 6 - Fraser River at Mission City, B.C.

Laboratory number	1022	USGS 54773
Date of sampling	October 1, 1958	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	1.6	2.0
pH	7.8	7.7
Colour (Hazen units)	25	3
Turbidity		
Alkalinity as $CaCO_3$ - Phenolphthalein		
Alkalinity as $CaCO_3$ - Total	51.2	52
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	77.6	73
" " " , ignited at 550°C.	65.6	65
Conductance, micromhos at 25°C.	111.3	116
Hardness as $CaCO_3$ - Total	56.5	54
Hardness as $CaCO_3$ - Non-carbonate	5.3	2
Calcium (Ca)	16.4	17
Magnesium (Mg)	3.8	2.9
Strontium (Sr)		0.01
Sodium (Na)	1.3	1.3
Potassium (K)	0.6	0.6
Lithium (Li)		0.0
Iron (Fe) Total	2.8	0.44
Iron (Fe) Dissolved	0.12	0.11
Aluminum (Al)	0.07	0.1
Manganese (Mn)	0.0	0.01
Copper (Cu)	0.0	0.00
Zinc (Zn)	0.05	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	62.4	64
Sulphate (SO_4)	7.2	7.6
Chloride (Cl)	0.5	0.0
Fluoride (F)	0.1	0.0
Phosphate (PO_4)	0.3	0.0
Nitrate (NO_3)	0.2	0.5
Silica (SiO_2)	4.0	4.5
Sum of constituents	65.4	66
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Chromium		0.00

TABLE 2 (Concl'd)

Station No. 7 - Mackenzie River, near Arctic Red River, N.W.T.

Laboratory number	1024	USGS 54776
Date of sampling	October 2, 1958	
Storage period (days)		
Temp. at sampling (°C)		
Temp. at testing (°C)		
Appearance, odour, etc.		
Oxygen consumed ($KMnO_4$)		
Chem. oxygen demand (C.O.D.)		
Carbon dioxide (CO_2), calculated	1.6	2.9
pH	8.0	7.8
Colour (Hazen units)	15	7
Turbidity		
Alkalinity as $CaCO_3$ -Phenolphthalein		
Alkalinity as $CaCO_3$ -Total	90.3	95
Susp. matter, dried at 105°C.		
" " , ignited at 550°C.		
Res. on evap., dried at 105°C.	171	169
" " " , ignited at 550°C.	149	158
Conductance, micromhos at 25°C.	269.0	274
Hardness as $CaCO_3$ Total	120	120
Hardness as $CaCO_3$ Non-carbonate	29.3	25
Calcium (Ca)	32.9	30
Magnesium (Mg)	9.1	11
Strontium (Sr)		0.21
Sodium (Na)	7.7	8.6
Potassium (K)	0.8	0.9
Lithium (Li)	0.1	0.0
Iron (Fe) Total	0.88	0.34
Iron (Fe) Dissolved	0.05	0.04
Aluminum (Al)	0.05	0.1
Manganese (Mn)	0.0	0.00
Copper (Cu)	0.0	0.00
Zinc (Zn)	0.0	0.00
Lead (Pb)		
Ammonia (NH_3)		
Carbonate (CO_3)	0	0
Bicarbonate (HCO_3)	110	116
Sulphate (SO_4)	31.4	30
Chloride (Cl)	10.0	9.0
Fluoride (F)	0.2	0.1
Phosphate (PO_4)	0.3	0.0
Nitrate (NO_3)	0.2	0.3
Silica (SiO_2)	3.2	3.5
Sum of constituents	150	151
Saturation index at test temperature		
Stability index at test temperature		
% sodium		
Chromium		0.01

RESULTS

Table 1 tabulates the results of chemical analyses on all raw water samples received during this study. Ionic concentrations are reported in parts per million (≡ milligrams per litre). The factors given in Appendix C will convert parts per million to milliequivalents per litre, the method of reporting recommended by the World Health Organization*.

Table 2 shows the analytical results obtained on duplicate samples by the Quality of Water Branch laboratory, U.S. Geological Survey and the Industrial Waters Section laboratory, Mines Branch. Except for some minor constituents, the agreement between the two laboratories was very satisfactory.

Flow records available on each river are given in Table 3. These records were supplied by the Water Resources Branch, Department of Northern Affairs and National Resources. A summary of their comments relative to these river flows is also included. Records are complete only on the more southerly rivers and rather meagre records are available on the Mackenzie River.

Wherever data are available, the run-off in dissolved solids from the rivers at the time of sampling is reported in Table 3.

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*International Standards for Drinking Water, World Health Organization, Geneva (1958).

DISCUSSION

Although only about 56.6 per cent of the total area of Canada, exclusive of the Arctic Archipelago, is included these studies do include most of the major rivers in accessible areas. Much of the Canadian Shield Region draining into the Atlantic and Arctic Oceans, including Hudson Bay, is drained by rivers inaccessible for study upon short notice. If further information is required by the IUGG Committee more time should be allowed prior to initiation of the work so that arrangements can be made for more accurate sampling and gauging of these northern rivers.

This study was not continued past June, 1959, except at Station No. 1 (St. Lawrence River at Lévis, P.Q.), which will be operated on a monthly sampling basis over a long-term period.

The run-off on the days when samples were collected is estimated (Table 3) but no attempt is made to assess further the overall run-off as this will no doubt be carried out by the coordinator, Mr. S.K. Love, in a manner approved by the IUGG Committee.

DISCHARGE DATA

Table 3 shows the discharge data available for the actual sampling dates, the average discharges for the years 1957 and 1958

and the mean discharge for the 10 year period, 1949 to 1958 inclusive.

Comments received from the Water Resources Branch, Department of Northern Affairs and National Resources on these discharge values are reproduced below.

Stations No. 1 and 2. - St. Lawrence River at Lévis and Québec

The daily flows for the St. Lawrence River at Lévis and Québec were computed by the use of a tentative stage-discharge relationship for the St. Lawrence River at Montréal, with the addition of inflows of major tributaries entering the main river between Montréal and Québec.

"In view of the estimated long-term average discharge of 389,000 cfs for the St. Lawrence River at Québec, P.Q. (Table 3), it is considered that the average discharge of 500,000 cfs, quoted by the International Union of Geodesy and Geophysics, is a reasonable estimate of the long-term average discharge of this river at its mouth".

Station No. 3 - Nelson River near Amery, Man.

The approximate discharge of 87,400 cgs for the Nelson River at Amery was estimated from the discharges measured for the Nelson River below Sipiwesk Lake, together with the figures obtained on the Burntwood River and the Grass River. The Water

Resources Branch comments, that these combined figures "will give an indication of the approximate discharges to be expected ....however, the combined figures probably would represent slightly less than the total Nelson River flow at Amery, because some of the drainage area contributing to the flow at Amery is not accounted for in the addition of the individual discharges at the three locations".

"The average discharge for the Nelson River below Sipiwesk Lake for the period 1949-58 has been computed at 87,400 cfs (by the Water Resources Branch); therefore, the corresponding average discharge at Amery, Man., for this period would probably be greater than 90,000 cfs. However, the average discharge for the Nelson River below Sipiwesk Lake for a period of 43 years has been computed at 72,000 cfs, so that the long-term average flow at Amery or at the mouth of the Nelson River would probably be of the order of about 80,000 cfs. Accordingly, the average discharge of 125,000 cfs quoted by the IUGG for the Nelson River would appear to be too high".

Station No. 4 - Nelson River at the Kelsey Power Project, Man.

"The discharges were determined for the gauging station on the Nelson River below Sipiwesk Lake. Although they are probably slightly less than the corresponding discharges at the Kelsey Power Project, owing to a slightly smaller drainage area at the gauging site, these figures will give an indication of the approximate discharge

to be expected at the Kelsey Power Project."

Station No. 5 - Churchill River near Churchill, Man.

"The daily discharges measured on the Churchill River below Billard Lake, although slightly less than the corresponding discharge at Churchill, will give an indication of the approximate discharges to be expected at Churchill, Man."

The average discharges listed in Table 3 were obtained by multiplying the figures obtained above Granville Falls by a factor of 1.3. This was recommended by the Water Resources Branch as the drainage area of the Churchill River at Churchill is about 109,000 square miles, while at the gauging site above Granville Falls it is only 82,000 square miles.

Station No. 6 - Fraser River at Mission City, B.C.

The discharges for this location were calculated by the Water Resources Branch by the application of percentage factors to the river discharges at Hope, B.C.

"With reference to the long-term average discharge for the Fraser River quoted by the IUGG, 94,000 cfs, it appears that the figure is for the Fraser River at Hope and that it was based on tentative data. The latest figure for this station for the period 1912-1958 inclusive is 92,900 c/s. Estimated long-term average discharge for the Fraser River at Mission City for the same period

is 113,000 cfs."

Station No. 7 - Mackenzie River near Arctic Red River, N. W. T.

The estimate of the discharge by the Water Resources Branch includes the discharge of the Arctic Red River. It is stated that these estimates are based on very limited information and that the range of probable error is such that the effect of the Arctic Red River one way or the other is probably not significant.

"It would appear that the long-term average discharge quoted for the Mackenzie River by the IUGG (260,000 cfs) is probably a very reasonable figure. The estimate of 290,000 cfs at Arctic Red River for the period 1949-58 (Table 3) is likely to be greater than the long-term figure because it includes one year (1949) of relatively high flow in the 1949-58 period. Probably, the frequency of the magnitude of run-off experienced in 1949 has been less than one in ten, so that the ten-year average including that year would be greater than the long-term average discharge."

Station No. 8 (i) - Peel River at Fort McPherson, N. W. T.

Of the four sampling points in the Mackenzie River Delta, flow records are available only at Fort McPherson, and even here, the Water Resources Branch states that "the estimated flows are based on very meagre information, and the range of probable error is no doubt quite large."

TABLE 3

Discharge and Run-off Data

Station	Sampling date	Sample No.	Discharge, cfs	Dissolved solids, ppm	Run-off per day thousands of tons	metric tons*
No. 1 - St. Lawrence River at Lévis, P.Q.	Feb. 20/57	9491	340,000	150	137.7	125.0
Average annual discharge:	April 23/57	9659	458,000	110	136.0	123.5
1957: 334,000 cfs	Aug. 21/57	M-82	330,000	153	136.3	123.8
1958: 337,000 cfs	Sept. 3/58	M-891	340,000	156	143.2	130.0
Mean (1949-58): 389,000 cfs	Sept. 25/58	1155	342,000	143	132.0	119.9
Average long-term discharge quoted by IUGG: 500,000 cfs	Dec. 3/58	1176	348,000	133	125.0	113.5
	April 20/59	1496	551,000	112	166.6	151.3
	April 29/59	1525	578,000	144	224.7	204.0
	May 27/59	1735	448,000	160	193.5	175.7
	June 16/59	1619	404,000	137	149.4	135.7
	July 21/59	1739	345,000	172	160.2	145.5
	Aug. 25/59	1841	345,000	160	149.0	135.3

* One metric ton equals 1,000 kilograms or 1.1013 tons

TABLE 3 (Continued)

Discharge and Run-off Data

Station	Sampling date	Sample No.	Discharge, cfs	Dissolved solids, ppm	Run-off per day thousands of tons	metric tons*
No. 2 - St. Lawrence River at Quebec, P.Q.	Aug. 25/58	M-889	342,000	155	143.1	129.9
Average annual discharge: see Station No. 1	Sept. 24/58	1151	366,000	132	130.4	118.4
	April 23/59	1536	550,000	140	207.9	188.8
No. 3 - Nelson River at Amery, Man.	Oct. 5/58	1023	85,000 (Sept.25)**	216	49.6	45.0
Average annual discharge: Mean (1949-58): 87,400 cfs	Mar. 9/59	1448	38,000 (Mar. 19)**	237	24.3	22.1
	May 1/59	1529	75,000 (est.)	240	48.6	44.1
Average long-term discharge quoted by IUGG: 125,000 cfs						
No. 4 - Nelson River at Kelsey Power Project, Man.	Jan. 29/59	1320	49,000 (Jan. 27)**	260	34.4	31.2
Average annual discharge: 1957: 84,200 cfs 1958: 71,300 cfs Mean (1949-58): 87,400 cfs	April 9/59	1495	36,000 (Mar. 19)**	241	23.4	21.2
	June 3/59	1596	84,800 (May 28)**	177	40.5	36.8
Average long-term discharge quoted by IUGG: 125,000 cfs						

* One metric ton equals 1,000 kilograms or 1.1013 tons

** Actual date of discharge record, therefore run-off approximation only

TABLE 3 (Continued)

Discharge and Run-off Data

Station	Sampling date	Sample No.	Discharge, cfs	Dissolved solids, ppm	Run-off per day thousands of tons	metric tons*
No. 5 - Churchill River at Churchill, Man.						
Average annual discharge:	June 24/58	M-782	40,700 (June 20)**	96	10.5	9.5
1957: 29,900 cfs						
1958: 34,600 cfs	Sept. 25/58	1021	42,500 (Sept.24)**	88	10.1	9.2
Mean (1952-58): 32,900 cfs						
	Feb. 20/59	1399	27,000 (Jan. 24)** (Mar. 20)**	76	5.5	5.0
Average long-term discharge quoted by IUGG:						
none	June 27/59	1673	61,000 (June 19)**	84	13.8	12.5
No. 6 - Fraser River at Mission City, B.C.						
Average annual discharge:	July 1/58	M-803	255,000	76	52.3	47.5
1957: 124,000 cfs						
1958: 123,000 cfs	Oct. 1/58	1022	166,000	78	35.0	31.8
Mean (1949-58): 117,000 cfs						
	Feb. 12/59	1397	37,100	80	8.0	7.3
Average long-term discharge quoted by IUGG: 94,000 cfs	June 12/59	1621	275,000	69	51.2	46.5

* One metric ton equals 1,000 kilograms or 1 1013 tons

** Actual date of discharge record, therefore run-off approximation only

TABLE 3 (Concl'd)

Discharge and Run-off Data

Station	Sampling date	Sample No.	Discharge, cfs	Dissolved solids, ppm	Run-off: thousands of tons	metric tons*
No. 7 - Mackenzie River near Arctic Red River, N.W.T.	July 24/58	M-854	470,000	175	222.1	201.7
Average annual discharge: Mean (1949-58): 290,000 cfs	Oct. 2/58	1024	270,000	171	124.7	113.2
Average long-term discharge quoted by IUGG: 260,000 cfs	June 9/59	1628	360,000	181	175.9	159.7
No. 8 - Mackenzie River Delta						
Peel River at Fort MacPherson, N.W.T.	July 18/58	M-926	about 20,000	190	10.3	9.4
Average annual discharge: Mean (1949-58): 17,000 cfs	Aug. 2/58	M-939	" 20,000	254	13.7	12.4
Husky Channel at Mt. Goodenough, N.W.T.						
No discharge data available	Sept. 1/58	M-944	-	241	-	-
West Channel near Aklavik, N.W.T.						
No discharge data available	Sept. 4/58	M-945	-	199	-	-
East Channel at Reindeer Depot, N.W.T.						
No discharge data available	Aug. 1/58	M-921	-	172	-	-

* One metric ton equals 1,000 kilograms or 1.1013 tons

APPENDIX A

WATER SURVEY REPORTS

Mines Branch Report No. 819, "Industrial Waters of Canada", a report on investigations covering the period 1934 to 1943, was the last general report published and is now out of print. In recent years the Mines Branch has published the following reports on chemical quality of surface and municipal waters, specific to certain water courses:

Report No. 833 - Industrial Water Resources of Canada - Water Survey Report No. 1, THE AIM, SCOPE PROCEDURE AND INTERPRETATION OF SURVEY STUDIES, by J.F.J. Thomas, 1953 (75 cents)

Report No. 834 - Industrial Water Resources of Canada, Water Survey Report No. 2, CHEMICAL QUALITY OF SURFACE AND CIVIC WATER SUPPLIES, OTTAWA RIVER DRAINAGE BASIN, 1947-1948, by J.F.J. Thomas, 1952 (75 cents)

Report No. 837 - Industrial Water Resources of Canada - Water Survey Report No. 3, UPPER ST. LAWRENCE RIVER - CENTRAL GREAT LAKES DRAINAGE BASIN, by J.F.J. Thomas, 1954 ($1.50)

Report No. 838 - Industrial Water Resources of Canada - Water Survey Report No. 4, COLUMBIA RIVER DRAINAGE BASIN, 1949-1950, by J.F.J. Thomas, 1953 (75 cents)

Report No. 839 - Industrial Water Resources of Canada - Water Survey Report No. 5, SKEENA RIVER, VANCOUVER ISLAND, AND COASTAL AREAS OF BRITISH COLUMBIA, 1949-1951, by J.F.J. Thomas, 1953 (75 cents)

Report No. 842 - Industrial Water Resources of Canada - Water Survey Report No. 6, FRASER RIVER DRAINAGE BASIN, 1950-1951, by J.F.J. Thomas, 1954 (75 cents)

Report No. 849 - Industrial Water Resources of Canada - Water Survey Report No. 7, SASKATCHEWAN RIVER DRAINAGE BASIN, 1951-1952, by J.F.J. Thomas, 1956 (75 cents)

Report No. 856 - Industrial Water Resources of Canada - Water Survey Report No. 8, MACKENZIE RIVER AND YUKON RIVER DRAINAGE BASIN, 1952-1953, by J.F.J. Thomas, 1957 ($1.00)

Report No. 858 - Industrial Water Resources of Canada - Water Survey Report No. 9, CHURCHILL RIVER AND MISSISSIPPI RIVER DRAINAGE BASINS, 1952-1954, by J.F.J. Thomas, 1958, (50 cents)

Report No. 861 - Industrial Water Resources of Canada - Water Survey Report No. 10, NELSON RIVER DRAINAGE BASIN IN CANADA, 1953-1956 by J.F.J. Thomas, 1959 ($1.00)

Report No. 864 - Industrial Water Resources of Canada - Water Survey Report No. 11, THE ATLANTIC PROVINCES, AND THE SAINT JOHN RIVER DRAINAGE BASIN IN CANADA, 1954-1956, by J.F.J. Thomas (in press)

Report No. 865 - Industrial Water Resources of Canada - Water Survey Report No. 12, WATER QUALITY AT SOME CANADIAN MILITARY ESTABLISHMENTS, 1956-1957, by J.F.J. Thomas, 1959 ($1.25)

Memorandum

Series No. 132 - INTERIM REPORT ON HARDNESS OF MAJOR CANADIAN WATER SUPPLIES, by J.F.J. Thomas, 1956 (25 cents)

Any of the above mentioned publications can be obtained on prepayment by cheque or money order payable to the Receiver General of Canada and addressed to the Mines Branch Publication Distribution Office, Ottawa, Ontario.

APPENDIX B

LIST OF WATER RESOURCES PAPERS

Subdivided according to the four drainage divisions of Canada, a list is given below of the official numbers of all Water Resources Papers, dealing with surface water supply of Canada, which have been published and which are available. While some of the earlier reports cover only one calendar year, or one climatic year ending September 30, the more recent issues cover two climatic years; the years (or year) covered are shown in brackets following the paper number. Certain issues contain a summary of the mean monthly flows for the whole period of record for those rivers for which other discharge data are given; in the lists below these are marked by an asterisk.

ATLANTIC DRAINAGE, INCLUDING SOUTHEASTERN QUEBEC, NEW BRUNSWICK, NOVA SCOTIA, PRINCE EDWARD ISLAND AND NEWFOUNDLAND

Water Resources Papers Nos. 29* (1918-19 & 1919-20), 37* (1920-21 & 1921-22), 45* (1922-23 & 1923-24), 52 (1924-25 & 1925-26), 63* (1926-27 & 1927-28), 69 (1928-29 & 1929-30), 73* (1930-31 & 1931-32), 77 (1932-33 & 1933-34), 81 (1934-35 & 1935-36), 83* (1936-37 & 1937-38), 87 (1938-39 & 1939-40), 91 (1940-41 & 1941-42), 96* (1942-43 & 1943-44), 100 (1944-45 & 1945-46), 104 (1946-47 & 1947-48), 108 (1948-49 & 1949-50), 112 (1950-51 & 1951-52), 116 (1952-53 & 1953-54), 120 (1954-55 & 1955-56).

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO AND QUEBEC

The earlier papers in this series covered the Province of Ontario only, two bilingual volumes were issued covering Quebec only, but subsequent issues included both provinces in one bilingual volume

Ontario - Water Resources Papers Nos. 28* (1919-20), 34* (1920-21), 38* (1921-22), 42* (1922-23), 49 (1923-24 & 1924-25).

Quebec (Bilingual) - Water Resources Papers Nos. 41* (1922-23), 48* (1923-24 & 1924-25).

Ontario and Quebec (Bilingual) - Water Resources Papers Nos. 58* (1925-26 & 1926-27), 64 (1927-28 & 1928-29), 70 (1929-30 & 1930-31), 74* (1931-32 & 1932-33), 76 (1933-34 & 1934-35), 79 (1935-36 & 1936-37), 85* (1937-38 & 1938-39), 89 (1939-40 & 1940-41), 93 (1941-42 & 1942-43), 95* (1943-44 & 1944-45), 99 (1945-46 & 1946-47), 103 (1947-48 & 1948-49), 107 (1949-50 & 1950-51), 111 (1951-52 & 1952-53), 115 (1953-54 & 1954-55).

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPI DRAINAGE IN CANADA) IN BRITISH COLUMBIA, ALBERTA, SASKATCHEWAN, MANITOBA, THE NORTHWEST TERRITORIES AND WESTERN ONTARIO

For the years 1908 to 1919 inclusive, reports on Hydrometric Surveys in Alberta and Saskatchewan were issued by the Department of the Interior; these reports are now out of print, but copies are on file in the offices of the Water Resources Branch. The first five Water Resources Papers for Arctic and Hudson Bay Drainage cover Manitoba only but subsequent issues cover the whole of the drainage division.

Manitoba - Water Resources Papers Nos. 4 (1912, 1913 & 1914), 19 (1915), 22 (1916), 24 (1916-17 & 1917-18), 26 (1918-19).

Whole Drainage - Water Resources Papers Nos. 31* (1919-20), 36* (1920-21), 40 (1921-22), 44 (1922-23), 46 (1923-24), 50 (1924-25), 54* (1925-26), 57 (1926-27), 62 (1927-28), 66 (1928-29), 68* (1929-30 & 1930-31), 71 (1931-32 & 1932-33), 75 (1933-34 & 1934-35), 82* (1935-36 & 1936-37), 84 (1937-38 & 1938-39), 88 (1939-40 & 1940-41), 92* (1941-42 & 1942-43), 97 (1943-44 & 1944-45), 101 (1945-46 & 1946-47), 105 (1947-48 & 1948-49), 109 (1949-50 & 1950-51), 113 (1951-52 & 1952-53), 117 (1953-54 & 1954-55).

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND YUKON TERRITORY

Water Resources Papers Nos. 1 (1911 & 1912), 8 (1913), 14 (1914), 18 (1915), 21 (1916), 23 (1916-17 & 1917-18), 25 (1918-19, out of print), 30* (1919-20), 35 (1920-21), 39 (1921-22), 43 (1922-23), 47 (1923-24), 51* (1924-25), 53 (1925-26), 59 (1926-27), 61 (1927-28), 65 (1928-29), 67* (1929-30), 72 (1930-31 & 1931-32), 78 (1932-33 & 1933-34), 80* (1934-35 & 1935-36), 86 (1936-37 & 1937-38), 90 (1938-39 & 1939-40), 94* (1940-41 & 1941-42), 98 (1942-43 & 1943-44), 102 (1944-45 & 1945-46), 106 (1946-47 & 1947-48), 110 (1948-49 & 1949-50), 114 (1950-51 & 1951-52), 118 (1952-53 & 1953-54), 122 (1954-55 & 1955-56).

* Included summaries of mean monthly flows for period of record.

Copies of the above publications may be obtained on application to the Director, Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa 4, Ontario. The price of Atlantic Drainage papers is 50 cents per copy for volume No. 104 and previous issues and $1.50 per copy for volume No. 108 and subsequent issues; for other drainage divisions, the price is $1.00 per copy for volumes Nos. 97, 99 and 102 and previous issues and $3.00 per copy for volumes Nos. 101, 103 and 106 and subsequent issues.

APPENDIX C

CONVERSION FACTORS FOR ANALYTICAL RESULTS:

PARTS PER MILLION TO MILLIEQUIVALENTS/LITRE

Parts per million (= mg/l)	Divide by
Oxygen consumed	8.0
Carbon dioxide (CO_2)	22.0
Alkalinity ($CaCO_3$)	50.0
Hardness ($CaCO_3$)	50.0
Calcium (Ca)	20.0
Magnesium (Mg)	12.2
Strontium (Sr)	43.9
Sodium (Na)	23.0
Potassium (K)	39.1
Lithium (Li)	6.9
Iron (Fe)	18.6
Aluminium (Al)	9.0
Manganese (Mn)	27.5
Copper (Cu)	31.8
Zinc (Zn)	32.7
Lead (Pb)	103.6
Ammonia (NH_3)	17.0
Carbonate (CO_3)	30.0
Bicarbonate (HCO_3)	61.0
Sulphate (SO_4)	48.0
Chloride (Cl)	35.5
Fluoride (F)	19.0
Phosphate (PO_4)	31.7
Nitrate (NO_3)	62.0
Silica (SiO_2)	30.0
Boron (B)	3.6
Chromium (Cr)	8.7

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