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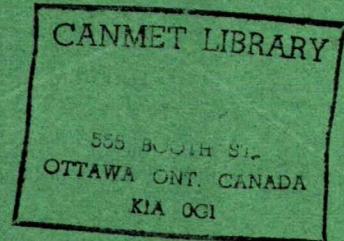
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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 60-41



A SURVEY OF WATER QUALITY AT CAMP MUSKWA, FORT NELSON, B. C., 1959

by

J. F. J. THOMAS

MINERAL PROCESSING DIVISION

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Mines Branch Investigation Report IR60-41

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SUMMARY OF RESULTS

A year long study of the chemical quality of Muskwa River water and the currently-used well water at Camp Muskwa, Fort Nelson, B.C. showed wide seasonal variation in each water, the river water being of superior quality during the winter while the well water is less mineralized during the summer. If problems related to obtaining the river water can be economically solved it, or a mixture of it and the well water, would provide a better quality water for the Camp.

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INTRODUCTION

The chemical quality of waters available to Camp Muskwa, Department of National Defence (Army) at Mile 256 on the Alaska Highway near Fort Nelson, B.C. has continually caused problems when used for domestic and general camp use. At the request of the Directorate of Works, Army Headquarters, Ottawa, the writer and Mr. R. Bowser, Public Utilities Section, Directorate of Works, visited Camp Muskwa in 1958 and carried out a limited study of the treatment then being applied to the well water supply to the Camp. A detailed report of this visit and all studies carried out up to December, 1958 at the Camp and in the Ottawa laboratories regarding treatment of this water was issued in March, 1959 (Mines Branch Investigation Report IR58-215).

A number of recommendations for improving both the plant operation and final quality of the well water supplied to the Camp were included in Report IR58-215. While it is not known how many of these recommendations have since been implemented, some major changes in treatment chemicals, especially the use of the coagulant aid, activated silica, were made during the visit.

The well water at Camp Muskwa is not a satisfactory supply because of its high mineralization and very high content of iron. The treatment being used is designed to remove the iron and the carbonate hardness but, even when such treatment is satisfactory, the final water is still very hard

and cannot be classed as a satisfactory municipal supply.

Since the change in treatment in October, 1958 monthly samples of the final water supply have been received in order to check the efficiency of these changes and to some extent the operation of the treatment plant.

At the time of the October, 1958 visit a search was underway for a more suitable water supply for the Camp and the Industrial Waters Section was asked to investigate the chemical quality of the nearby Muskwa River. As report IR58-215 had indicated possible seasonal changes of a significant nature in the well water supply this water was also investigated.

This report covers all studies on the Muskwa River, the untreated and the treated well waters at Fort Nelson, carried out by the Industrial Waters Section during the period December, 1958 to January, 1960 inclusive.

PROCEDURE

Monthly samples of the Muskwa River were requested from midriver at a location near the present well, which is situated in the flats alongside the river. An intake near this point would permit the use of river water alone or of a mixture of it with the well water since the pumps would be located at or near the present well.

Well water samples were collected monthly at the well pump at or about the time the pump was started and at

the plant prior to treatment, but after the pump had been operating for several hours. The well water is pumped a considerable distance uphill to the plant and there was some possibility of changes in the water during pumping or transit.

Monthly samples were also requested of the treated well water, i.e. the water coming from the plant reactor or softener just prior to its entrance into the storage reservoir or clear well. The water is then pumped from the reservoir to an elevated tank and the system, with no additional treatment other than ion-exchange softening of the water used as make-up to the boilers in the central heating plant.

Monthly samples of all these waters were collected by the chief operator of the Camp Muskwa plant from December, 1958 to January, 1960 inclusive, except for the months of September and December, 1959. These samples were analysed in the Industrial Waters Section laboratories at Ottawa by standard methods of water examination, a relatively complete analysis being carried out on each water sample.

RESULTS

Table 1 records the detailed analyses of the samples of the Muskwa River over the 14 month period.

Table 2 details the analytical results obtained on the well water sampled at the well pump and again later at the treatment plant.

The analyses of the treated well waters (final Camp supply) are tabulated in Table 3.

Changes in the major constituents or other important properties of the Muskwa River, untreated well and treated well waters are graphically shown in Figures 1, 2 and 3 respectively.

Owing to the high mineralization (especially carbonate hardness) and very high iron content, storage and shipment of the well waters can have a significant effect on several constituents. The iron precipitates as iron oxide and there may be a loss of some hardness with change in pH. Since the iron is often precipitated prior to sampling, especially by the time the water reaches the plant, variations caused by the sampling technique can also be expected. Variations, therefore, in some of the analyses reported in Tables 2 and 3 must be evaluated with these factors in mind.

TABLE I.

Chemical Analyses of Muskwa River near Fort Nelson, B.C.
 (In parts per million)

Sampling point Direct from River

Laboratory number	1196	1253	1361	1462
Date of sampling	Dec. 16/59	Jan. 13/59	Feb. 10/59	Mar. 24/59
Storage period (days)	20:27	11:14	7:13	13:23
Temp. at sampling ($^{\circ}\text{C}$)	0	0	0	1.1
Temp. at testing ($^{\circ}\text{C}$)	21.2	24.5	24.4	24.5
Appearance, odour, etc.				
Oxygen consumed (KMnO_4)	1.5	1.6	2.0	2.8
Chem. oxygen demand (C.O.D.)	3.4	3.7	4.0	2
Carbon dioxide (CO_2), calculated				
pH	8.0	8.0	7.9	8.1
Colour (Hazen units)	0	10	10	5
Turbidity	0	0	0	1
Alkalinity as f-Phenolphthalein	0	0	0	0
CrO_4	183	193	195	198
Total				
Susp. matter, dried at 105°C .				
" " , ignited at 550°C .				
Res. on evap., dried at 105°C .	310	333	329	340
" " " , ignited at 550°C .	272	282	306	279
Conductance, micromhos at 25°C .	487.4	506.6	509.2	535.7
Hardness as f-Total	259	274	277	287
CaCO_3	75.6	80.7	81.7	88.3
Non-carbonate				
Calcium (Ca)	70.3	73.6	74.5	79.6
Magnesium (Mg)	20.3	22.0	22.1	21.4
Strontium (Sr)				
Sodium (Na)	3.5	4.1	4.8	5.3
Potassium (K)	0.7	0.8	1.4	1.2
Lithium (Li)				
Iron (Fe)	Total	-	-	-
	Dissolved	0.0	0.0	0.00
Aluminum (Al)		0.08	0.04	0.40
Manganese (Mn)		0.0	0.0	0.01
Copper (Cu)		0.0	0.0	0.0
Zinc (Zn)		0.0	0.0	0.05
Lead (Pb)		0.1	Trace	0.1
Ammonia (NH_3)				0.3
Carbonate (CO_3)		0.0	0.0	0.0
Bicarbonate (HCO_3)		223	236	238
Sulphate (SO_4)		78.8	79.2	76.2
Chloride (Cl)		2.7	1.1	3.2
Fluoride (F)		0.0	0.0	0.0
Phosphate (PO_4)		-	-	0.0
Nitrate (NO_3)		0.2	0.6	0.6
Silica (SiO_4)		3.3	3.3	3.4
Sum of constituents		290	301	303
Saturation index at test temperature		+0.6	+0.7	+0.6
Stability Index at test temperature		6.8	6.6	6.7
% sodium		2.8	3.1	3.6
Remarks: Level:	Very low	Very low/14"	Very low	Very low

TABLE I (cont'd)

Chemical Analyses of Muskwa River near Fort Nelson, B.C.
(In parts per million)

Sampling point	Direct from River			
Laboratory number	1487	1565	1657	1794
Date of sampling	April 13/59	May 12/59	June 27/59	July 25/59
Storage period (days)	8.10	21.29	10.16	24.32
Temp. at sampling (°C)	0	10	13.3	13.3
Temp. at testing (°C)	23.7	23.7	23.6	26.1
Appearance, odour, etc.	Clear			
Oxygen consumed (KMnO ₄)	-	24	7.0	2.6
Chem. oxygen demand (C.O.D.)	-	-	-	-
Carbon dioxide (CO ₂), calculated	2.5	2.5	3.5	4
pH	8.1	7.8	7.7	7.7
Colour (Hazen units)	5	150	20	10
Turbidity	-	300	370	90
Alkalinity as { -Phenolphthalein CaCO ₃ } Total	0 172	0 82.3	0 93.6	0 107
Susp. matter, dried at 105°C.	-	294	813 ^x	125
" " , ignited at 550°C.	-	269	782 ^x	118
Res. on evap., dried at 105°C.	294	216	211	187
" " " , ignited at 550°C.	274	159	163	161
Conductance, micromhos at 25°C.	469	253.8	253.8	270.8
Hardness as { Total CaCO ₃ } Non-carbonate	249 77.3	131 49.0	133 39.4	144 37.4
Calcium (Ca)	68.5	38.3	37.0	26.9
Magnesium (Mg)	19.0	8.7	9.9	18.8
Strontium (Sr)	-	-	-	-
Sodium (Na)	4.3	3.6	1.7	1.5
Potassium (K)	0.7	1.4	0.9	0.7
Lithium (Li)	-	-	-	-
Iron (Fe) Total	-	7.0	4.0	1.3
Dissolved	0.02	0.25	0.28	0.04
Aluminum (Al)	0.06	0.0	0.04	0.07
Manganese (Mn)	0.0	0.0	0.0	0.01
Copper (Cu)	-	0.0	0.0	0.0
Zinc (Zn)	-	0.0	0.0	0.0
Lead (Pb)	-	-	-	-
Ammonia (NH ₃)	-	-	0.0	0.0
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	209	100	114	130
Sulphate (SO ₄)	80.5	43.1	35.6	34.0
Chloride (Cl)	2.5	2.0	1.2	0.7
Fluoride (F ⁻)	0.0	-	0.0	0.0
Phosphate (PO ₄)	-	-	-	0.0
Nitrate (NO ₃)	0.2	0.2	0.8	0.2
Silica (SiO ₂)	3.0	3.7	4.3	2.3
Sum of constituents	282	151	148	154
Saturation index at test temperature	+0.5	-0.2	-0.2	-0.3
Stability index at test temperature	7.1	8.2	8.1	8.3
% sodium	3.6	5.5	2.7	2.2
Remarks: Level	Low	Low/30"	Average	-

TABLE I (concl'd)

Chemical Analyses of Muskwa River near Fort Nelson, B.C.
(In parts per million)

Sampling point		Direct from River			
Laboratory number	1847	1983	2124	2265	
Date of sampling	Aug. 23/59	Oct. 8/59	Nov. 16/59	Jan. 11/60	
Storage period (days)	11.18	25.35	17.70	10.22	
Temp. at sampling ($^{\circ}\text{C}$)	14.4	0.0	0.6	1.1	
Temp. at testing ($^{\circ}\text{C}$)	27.7	25.6	25.9	24.8	
Appearance, odour, etc.					
Oxygen consumed (KMnO_4)	20	8.7	8.4	-	
Chem. oxygen demand (C.O.D.)	2.5	2.7	2.5	6	
Carbon dioxide (CO_2), calculated					
pH	7.8	7.9	8.0	7.8	
Colour (Hazen units)	130 (approx.)	35	25	0	
Turbidity	3,000	35	4	5	
Alkalinity as { Phenolphthalein CaCO_3 Total	0 88.5	0 124	0 180	0 190	
Susp. matter, dried at 105°C		64.8			
" " , ignited at 550°C		56.0			
Res. on evap., dried at 105°C	256	237			
" " , ignited at 550°C	200	195			
Conductance, micromhos at 25°C	285.7	336.6	489.6	508.1	
Hardness as { Total	149	176	261	271	
CaCO_3 Non-carbonate	60.4	52.2	80.7	83.3	
Calcium (Ca)	45.0	49.2	73.2	74.8	
Magnesium (Mg)	8.9	12.9	19.7	20.6	
Strontium (Sr)					
Sodium (Na)	2.8	2.5	5.0	5.0	
Potassium (K)	1.8	0.5	1.0	0.9	
Lithium (Li)					
Iron (Fe) Total	7.0	0.94	0.23	0.15	
Dissolved	0.16	0.09	0.03	0.0	
Aluminum (Al)	0.0	0.06	0.05	0.07	
Manganese (Mn)	0.0	0.02	0.04	0.0	
Copper (Cu)	Trace	0.0	0.0	0.0	
Zinc (Zn)	0.0	0.0	0.0	0.0	
Lead (Pb)					
Ammonia (NH_3)		0.1	0.2	0.0	
Carbonate (CO_3)	0.0	0.0	0.0	0.0	
Bicarbonate (HCO_3)	108	151	220	231	
Sulphate (SO_4)	61.5	52.5	90.2	84.4	
Chloride (Cl)	1.3	1.1	1.5	1.7	
Fluoride (F)	0.0	0.1	0.0	0.0	
Phosphate (PO_4)	-	-	0.05	-	
Nitrate (NO_3)	0.2	0.0	0.2	2.0	
Silica (SiO_2)	4.1	3.1	4.3	4.0	
Sum of constituents	179	196	303	307	
Saturation index at test temperature	0.0	+0.3	+0.7	+0.5	
Stability index at test temperature	7.8	7.3	6.6	6.8	
% sodium	3.9	3.0	4.0	3.8	
Remarks: Level.....	Highest.....	Low.....	-	Low.....	

TABLE 2

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after 30 hrs of pumping	At pump at start of pumping	At plant after 63 hrs of pumping
Laboratory number	1192	1203	1254	1262
Date of sampling	Dec. 10/58	Dec. 11/58	Jan. 10/59	Jan. 12/59
Storage period (days)	26:33	25:31	2:17	2:15
Temp. at sampling (°C)	7.8	7.8	6.7	6.6
Temp. at testing (°C)	21.0	21.2	24.4	24.3
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)	3.0			
Chem. oxygen demand (C.O.D.)	50	20	15	15
Carbon dioxide (CO ₂), calculated				
pH	7.3	7.7	7.8	7.8
Colour (Hazen units)	5	5	10	10
Turbidity				
Alkalinity as { f-Phenolphthalein CaCO ₃ , Total	0 587	0 572	0 550	0 548
Susp. matter, dried at 105°C.			151	
" ", ignited at 550°C.			110	
Res. on evap., dried at 105°C.	1,455		1,375	
" ", ignited at 550°C.	1,343		1,275	
Conductance, micromhos at 25°C.	1,816	1,770	1,731	1,728
Hardness as { Total	1,171	1,172	1,125	1,112
CaCO ₃ Non-carbonate	584	600	575	564
Calcium (Ca)	354	345	340	337
Magnesium (Mg)	70.0	75.5	67.3	66.0
Strontium (Sr)				
Sodium (Na)	7.1	7.1	7.1	7.1
Potassium (K)	2.5	2.5	2.7	2.7
Lithium (Li)				
Iron (Fe) . Total	85	80	74	75
Dissolved	0.12	-	1.0	-
Aluminum (Al)	0.28	-	0.12	-
Manganese (Mn) (Total)	0.76	0.88	1.0	0.9
Copper (Cu)	0.0	-	0.0	-
Zinc (Zn)	0.0	-	0.0	-
Lead (Pb)				
Ammonia (NH ₃)				
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	716	697	671	668
Sulphate (SO ₄)	584	581	550	548
Chloride (Cl)	2.5	3.4	0.4	0.5
Fluoride (F)	0.0	-	0.0	-
Phosphate (PO ₄)	-	-	-	-
Nitrate (NO ₃)	0.1	0.1	0.3	0.1
Silica (SiO ₄)	8.8	8.6	7.7	8.4
Sum of constituents	1,382	1,367	1,308	1,299
Saturation index at test temperature	+0.9	+1.3	+1.2	+1.2
Stability index at test temperature	5.5	5.5	5.4	5.4
% sodium	1.3	1.3	1.3	1.4

Remarks:

TABLE 2 (cont'd)

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after 51 hrs pumping	At pump at start of pumping	At plant after steady pumping
Laboratory number	1362	1363	1463	1464
Date of sampling	Feb. 8/59	Feb. 10/59	Mar. 18/59	Mar. 21/59
Storage period (days)	9:15	7:13	19:29	16:26
Temp. at sampling (°C)	6.1	5.0	4.5	6.1
Temp. at testing (°C)	24.4	24.4	24.4	24.1
Appearance, odour, etc. .....	.....	.....	.....	.....
Oxygen consumed (KMnO ₄)	3.5 .....	.....	.....	.....
Chem. oxygen demand (C.O.D.) .....	.....	.....	.....	.....
Carbon dioxide (CO ₂), calculated	45	18	13	10
pH	7.3	7.7	7.9	8.0
Colour (Hazen units)	10	10	5	10
Turbidity .....	.....	.....	.....	.....
Alkalinity as { -Phenolphthalein CaCO ₃	0	0	0	0
..... Total	554	544	516	507
Susp. matter, dried at 105°C. .....	.....	.....	.....	.....
" " , ignited at 550°C. .....	.....	.....	.....	.....
Res. on evap., dried at 105°C.	1,398 .....	.....	1,287 .....	.....
" " " , ignited at 550°C. .....	.....	.....	1,092 .....	.....
Conductance, micromhos at 25°C.	1,704	1,679	1,637	1,622
Hardness as { Total	1,111	1,106	1,060	1,066
..... CaCO ₃	557	562	544	559
Calcium (Ca)	340	336	323	320
Magnesium (Mg)	63.7	65.0	61.7	65.1
Strontium (Sr) .....	.....	.....	.....	.....
Sodium (Na)	6.9	6.9	6.7	6.6
Potassium (K)	2.8	2.7	2.6	2.6
Lithium (Li) .....	.....	.....	.....	.....
Iron (Fe) .....	.....	.....	.....	.....
..... Total	88	72	66	77
..... Dissolved	0.05	0.05	0.33	0.02
Aluminum (Al)	0.14 .....	.....	0.0	0.02
Manganese (Mn) (Total)	0.84	0.64	1.3	1.0
Copper (Cu)	0.0 .....	.....	.....	.....
Zinc ... (Zn)	0.0 .....	.....	.....	.....
Lead ... (Pb) .....	.....	.....	.....	.....
Ammonia (NH ₃) .....	.....	.....	.....	.....
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	675	663	629	618
Sulphate (SO ₄)	532	544	520	520
Chloride (Cl)	1.0	1.2	2.9	2.3
Fluoride (F) .....	.....	.....	0.0 .....	.....
Phosphate (PO ₄) .....	.....	.....	0.0 .....	.....
Nitrate (NO ₃)	0.5	0.1	Trace	Trace
Silica (SiO ₂)	9.1	8.9	9.5	9.8
Sum of constituents	1,289	1,292	1,238	1,340
Saturation index at test temperature	+0.8	+1.2	+1.5	+1.6
Stability index at test temperature	5.7	5.1	4.9	4.8
% sodium	1.3	1.3	1.3	1.3

Remarks:

TABLE 2 (cont'd)

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after steady pumping	At pump at start of pumping	At plant after steady pumping
Laboratory number	1488	1489	1566	1567
Date of sampling	April 9/59	April 11/59	May 12/59	May 13/59
Storage period (days)	12.14	10.12	21.29	20.28
Temp. at sampling (°C)	7.8	6.7	6.7	5.6
Temp. at testing (°C)	23.6	22.7	23.7	23.7
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)	"	"	"	"
Chem. oxygen demand (C.O.D.)	15	10	12	7
Carbon dioxide (CO ₂), calculated				
pH	7.8	8.0	7.9	8.1
Colour (Hazen units)	0	5	10	10
Turbidity				
Alkalinity as { Phenolphthalein CaCO ₃ } Total	0 506	0 502	0 489	0 465
Susp. matter, dried at 105°C.				
" " , ignited at 550°C.				
Res. on evap., dried at 105°C.	1,298	"	1,254	"
" " " , ignited at 550°C.	1,244	"	1,067	"
Conductance, micromhos at 25°C.	1,616	1,616	1,550	1,456
Hardness as { Total	1,042	1,057	993	914
CaCO ₃ Non-carbonate	536	555	504	449
Calcium (Ca)	322	318	309	285
Magnesium (Mg)	58.3	63.9	54.1	49.1
Strontrium (Sr)				
Sodium (Na)	6.7	6.7	7.1	6.9
Potassium (K)	2.6	2.6	2.7	2.6
Lithium (Li)				
Iron (Fe) Total	88	71	73	60
Dissolved	0.08	0.08	0.19	0.03
Aluminum (Al)	0.20	0.20	0.03	
Manganese (Mn) (Total)	0.8	0.8	0.50	0.50
Copper (Cu)	"	"	"	"
Zinc (Zn)	"	"	"	"
Lead (Pb)				
Ammonia (NH ₃)				
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	617	612	596	567
Sulphate (SO ₄)	514	515	449	416
Chloride (Cl)	1.2	0.8	1.6	1.8
Fluoride (F)	0.0	0.0	"	"
Phosphate (PO ₄)	"	"	"	"
Nitrate (NO ₃)	0.0	0.0	1.0	0.2
Silica (SiO ₂)	9.0	9.9	7.9	"
Sum of constituents	1,218	1,220	1,127	1,034
Saturation index at test temperature	+1.4	+1.6	+1.5	+1.5
Stability index at test temperature	5.0	4.8	4.9	5.0
% sodium	1.4	1.4	1.5	1.6

Remarks:

.....

TABLE 2 (cont'd)

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after steady pumping	At pump at start of pumping	At plant after steady pumping
Laboratory number	1658	1659	1795	1796
Date of sampling	June 25/59	June 26/59	July 22/59	July 24/59
Storage period (days)	12.18	11.17	27.35	25.33
Temp. at sampling (°C)	5.5	5.5	6.7	6.7
Temp. at testing (°C)	23.8	23.8	26.0	26.0
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)	2.0	—	3.9	—
Chem. oxygen demand (C.O.D.)	60	25	40	20
Carbon dioxide (CO ₂), calculated				
pH	7.1	7.5	7.2	7.5
Colour (Hazen units)	20	5	10	10
Turbidity				
Alkalinity as { ChCO ₃ Phenoxyphthalain Total	0 419	0 423	0 372	0 348
Susp. matter, dried at 105°C.				
" " , ignited at 550°C.				
Res. on evap., dried at 105°C.	954		870	
" " , ignited at 550°C.	874		789	
Conductance, micromhos at 25°C.	1,253	1,279	1,135	1,074
Hardness as { CaCO ₃ Total Non-carbonate	795 376	815 392	705 333	637 289
Calcium (Ca)	236	248	210	198
Magnesium (Mg)	50.3	47.9	43.9	34.4
Strontium (Sr)				
Sodium (Na)	6.0	6.0	5.7	5.5
Potassium (K)	2.2	2.2	2.3	2.2
Lithium (Li)				
Iron (Fe) Total	58	56	37	35
Dissolved	0.07	0.0	0.31	0.03
Aluminum (Al)	0.17	0.18	0.11	0.08
Manganese (Mn) (Total)	0.30	0.47	0.44	0.34
Copper (Cu)	0.0	—	—	—
Zinc (Zn)	0.0	—	—	—
Lead (Pb)				
Ammonia (NH ₃)				
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	511	515	454	424
Sulphate (SO ₄)	334	354	282	265
Chloride (Cl)	2.0	2.4	2.2	2.6
Fluoride (F)	0.0	—	0.0	—
Phosphate (PO ₄)	—	—	0.01	—
Nitrate (NO ₃)	0.0	0.3	0.2	0.4
Silica (SiO ₂)	15	15	7.5	7.3
Sum of constituents	897	929	778	726
Saturation index at test temperature	+0.5	+0.9	+0.6	+0.9
Stability index at test temperature	6.1	5.7	6.0	5.7
% sodium	1.6	1.6	1.7	1.8

Remarks:

TABLE 2 (cont'd)

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after 24 hrs pumping	At pump at start of pumping	At plant after 24 hrs pumping
Laboratory number	1848.....	1849.....	1984.....	1985.....
Date of sampling	Aug. 24/59.....	Aug. 25/59.....	Oct. 7/59.....	Oct. 8/59.....
Storage period (days)	10.17.....	9.16.....	26.36.....	25.35.....
Temp. at sampling ($^{\circ}$ C)	10.0.....	24.0.....	5.6.....	7.8.....
Temp. at testing ($^{\circ}$ C)	27.6.....	27.7.....	25.1.....	25.2.....
Appearance, odour, etc. ....	.....	.....	.....	.....
Oxygen consumed (KMnO_4) .....	.....	.....	.....	.....
Chem. oxygen demand (C.O.D.) .....	.....	.....	.....	.....
Carbon dioxide (CO_2), calculated	22.....	15.....	28.....	11.....
pH	7.5.....	7.7.....	7.5.....	7.8.....
Colour (Hazen units)	10.....	10.....	5.....	5.....
Turbidity .....	.....	.....	.....	.....
Alkalinity as { Phenolphthalein CaCO ₃ } Total	0..... 388.....	0..... 415.....	0..... 402.....	0..... 373.....
Susp. matter, dried at 105 $^{\circ}$ C. ....	.....	.....	.....	.....
" " , ignited at 550 $^{\circ}$ C. ....	.....	.....	.....	.....
Res. on evap., dried at 105 $^{\circ}$ C.	934.....	—.....	540.....	—.....
" " , ignited at 550 $^{\circ}$ C.	848.....	.....	447.....	.....
Conductance, micromhos at 25 $^{\circ}$ C.	1,229.....	1,310.....	1,201.....	1,181.....
Hardness as { Total	775.....	815.....	731.....	712.....
CaCO ₃ } Non-carbonate	387.....	400.....	329.....	339.....
Calcium (Ca)	228.....	244.....	225.....	223.....
Magnesium (Mg)	50.3.....	50.3.....	41.6.....	37.8.....
Strontium (Sr) .....	.....	.....	.....	.....
Sodium (Na)	5.8.....	6.2.....	5.5.....	5.5.....
Potassium (K)	2.5.....	2.5.....	2.2.....	2.1.....
Lithium (Li) .....	.....	.....	.....	.....
Iron (Fe) Total	48.....	51.....	48.....	57.....
Dissolved	0.0.....	0.0.....	0.0.....	0.0.....
Aluminum (Al)	0.07.....	0.07.....	0.15.....	0.17.....
Manganese (Mn) (Total)	0.64.....	0.68.....	0.53.....	0.41.....
Copper (Cu)	Trace.....	—.....	—.....	—.....
Zinc (Zn)	0.0.....	—.....	—.....	—.....
Lead (Pb) .....	.....	.....	.....	.....
Ammonia (NH ₃) .....	.....	.....	.....	.....
Carbonate (CO ₃)	0.0.....	0.0.....	0.0.....	0.0.....
Bicarbonate (HCO ₃)	473.....	505.....	490.....	454.....
Sulphate (SO ₄)	347.....	349.....	329.....	330.....
Chloride (Cl)	0.5.....	0.7.....	1.3.....	2.8.....
Fluoride (F)	0.0.....	—.....	0.0.....	0.0.....
Phosphate (PO ₄)	—.....	—.....	—.....	—.....
Nitrate (NO ₃)	0.6.....	0.0.....	0.8.....	0.8.....
Silica (SiO ₂)	7.8.....	8.1.....	7.2.....	7.0.....
Sum of constituents	876.....	910.....	853.....	833.....
Saturation Index at test temperature	+0.9.....	+1.2.....	+0.9.....	+1.2.....
Stability Index at test temperature	5.7.....	5.3.....	5.7.....	5.4.....
% sodium	1.6.....	1.6.....	1.6.....	1.6.....

Remarks:

TABLE 2 (concl'd)

Chemical Analyses of Well Water at Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point	At pump at start of pumping	At plant after steady pumping	At pump at start of pumping	At plant after steady pumping
Laboratory number	2125	2126	2267	2268.
Date of sampling	Nov. 13/59.	Nov. 14/59	Jan. 8/60.	Jan. 9/60
Storage period (days)	20.73	19.72	17.25	16.24
Temp. at sampling (°C)	6.7	5.0	5.6	6.7
Temp. at testing (°C)	26.0	25.9	25.6	25.5
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)	7			
Chem. oxygen demand (C.O.D.)	22	12	70	40
Carbon dioxide (CO ₂), calculated				
pH	7.5	7.8	7.0	7.3
Colour (Hazen units)	10	10	0	0
Turbidity				
Alkalinity as { Phenolphthalein CuCO ₃ } Total	0 396	0 387	0 434	0 425
Susp. matter, dried at 105°C.				
" " , ignited at 550°C.				
Res. on evap., dried at 105°C.				
" " " , ignited at 550°C.				
Conductance, micromhos at 25°C.	1,218	1,188	1,337	1,323
Hardness as { Total	769	740	837	817
CaCO ₃ { Non-carbonate	573	353	393	392
Calcium (Ca)	225	221	250	247
Magnesium (Mg)	50.9	46.1	52.0	49.0
Strontrium (Sr)				
Sodium (Na)	5.7	5.6	6.3	6.2
Potassium (K)	2.2	2.2	2.6	2.6
Lithium (Li)				
Iron (Fe) Total	48	46	55	52
Dissolved	Trace	0.02	0.0	
Aluminum (Al)	0.08	0.05	0.14	0.20
Manganese (Mn) (Total)	0.50	0.40	0.8	0.8
Copper (Cu)	0.0			
Zinc (Zn)	0.0			
Lead (Pb)				
Ammonia (NH ₃)				
Carbonate (CO ₃)	0.0	0.0	0.0	0.0
Bicarbonate (HCO ₃)	483	471	529	518
Sulphate (SO ₄)	324	319	370	372
Chloride (Cl)	0.8	1.2	1.8	1.0
Fluoride (F)	0.0	0.0	0.1	—
Phosphate (PO ₄)	0.04	—	—	—
Nitrate (NO ₃)	1.8	0.2	5.0	3.2
Silica (SiO ₂)	8.1	7.7	7.8	6.9
Sum of constituents	856	835	956	995
Saturation index at test temperature	+0.9	+1.2	+0.5	+0.7
Stability index at test temperature	5.7	5.4	6.0	5.9
% sodium	1.6	1.6	1.6	1.6

Remarks:
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TABLE 3

Chemical Analyses of Water Supply to Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point Overflow from softener (reactor) prior
 to storage and pumping to system

	1204	1261	1364	1465
Laboratory number				
Date of sampling	Dec. 11/58	Jan. 12/59	Feb. 10/59	Mar. 23/59
Storage period (days)	26.31	9.15	7.13	14.24
Temp. at sampling ($^{\circ}$ C)	25.0	30.6	23.4	27.8
Temp. at testing ($^{\circ}$ C)	21.2	24.2	24.4	23.9
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)				
Chem. oxygen demand (C.O.D.)				
Carbon dioxide (CO ₂), calculated	2.8	0	0.8	0.5
pH	7.9	8.8	8.0	8.2
Colour (Hazen units)	5	10	10	10
Turbidity				
Alkalinity as { Phenolphthalein CuCO ₃ , Total	0 108	4.1 19.3	0 47.8	0 25.0
Susp. matter, dried at 105 $^{\circ}$ C.				
" " , ignited at 550 $^{\circ}$ C.				
Res. on evap., dried at 105 $^{\circ}$ C.				
" " " , ignited at 550 $^{\circ}$ C.				
Conductance, micromhos at 25 $^{\circ}$ C.	1,169	984	1,019	945
Hardness as { Total	668	539	570	516
CaCO ₃ Non-carbonate	560	520	522	491
Calcium (Ca)	174	189	139	138
Magnesium (Mg)	56.8	16.4	54.0	42.0
Strontrium (Sr)				
Sodium (Na)	8.5	7.8	7.7	7.9
Potassium (K)	2.5	2.9	2.8	2.8
Lithium (Li)				
Iron (Fe) Total	1.2	0.10	0.50	0.52
Dissolved	—	—	0.49	0.01
Aluminum (Al)	—	—	—	0.10
Manganese (Mn)	0.04	0.0	0.01	0.02
Copper (Cu)	—	—	—	—
Zinc (Zn)	—	—	—	—
Lead (Pb)	—	—	—	—
Ammonia (NH ₃)	—	—	—	—
Carbonate (CO ₃)	0.0	4.9	0.0	0.0
Bicarbonate (HCO ₃)	132	13.5	58.3	30.5
Sulphate (SO ₄)	564	515	502	500
Chloride (Cl)	9.7	3.5	3.0	6.3
Fluoride (F)	—	—	—	—
Phosphate (PO ₄)				
Nitrate (NO ₃)	0.1	0.6	0.8	0.0
Silica (SiO ₂)	5.5	2.7	2.7	3.6
Sum of constituents	886	750	741	715
Saturation index at test temperature	+0.6	+0.9	+0.3	+0.2
Stability index at test temperature	6.7	7.0	7.4	7.8
% sodium	2.7	3.0	2.8	3.2

Remarks:

TABLE 3 (cont'd)

Chemical Analyses of Water Supply to Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point Overflow from softener (reactor) prior to storage and pumping to system

Laboratory number	1490	1568	1660	1797	
Date of sampling	April 11/59	May 13/59	June 26/59	July 24/59	
Storage period (days)	10.12	20.28	11.17	25.33	
Temp. at sampling ($^{\circ}\text{C}$)	26.7	33.9	28.3	18.9	
Temp. at testing ($^{\circ}\text{C}$)	22.5	23.8	23.7	25.8	
Appearance, odour, etc.					
Oxygen consumed (KMnO_4)					
Chem. oxygen demand (C.O.D.)	0.6	0	0	0	
Carbon dioxide (CO_2), calculated					
pH	7.6	8.8	9.1	8.8	
Colour (Hazen units)	5	10	5	10	
Turbidity		Clear			
Alkalinity as CaCO_3	0	2.0	4.5	2.9	
Total	16.3	15.7	17.7	14.9	
Susp. matter, dried at 105°C .					
" " , ignited at 550°C .					
Res. on evap., dried at 105°C .					
" " , ignited at 550°C .					
Conductance, micromhos at 25°C .	909	828	723	606	
Hardness as CaCO_3	51.5	43.1	36.4	29.6	
Total	49.9	41.5	34.6	28.1	
Calcium (Ca)	139	144	132	98.0	
Magnesium (Mg)	41.3	17.2	8.4	12.5	
Strontrium (Sr)					
Sodium (Na)	7.4	7.4	7.5	6.3	
Potassium (K)	2.7	2.6	3.1	2.4	
Lithium (Li)					
Iron (Fe)	Total	0.15	0.49	0.31	0.48
	Dissolved	0.06	-	0.09	0.03
Aluminum (Al)		0.17	0.01	0.22	0.11
Manganese (Mn) (Total)		0.0	-	0.0	0.0
Copper (Cu)		Trace	-	-	-
Zinc (Zn)		0.0	-	-	-
Lead (Pb)		0.0	-	-	2.5
Ammonia (NH_3)		0.0	-	-	
Carbonate (CO_3)		0.0	2.4	5.4	3.5
Bicarbonate (HCO_3)		19.9	14.3	10.6	11.1
Sulphate (SO_4)		494	391	344	276
Chloride (Cl)		3.5	2.9	7.0	3.2
Fluoride (F)		0.0	-	-	-
Phosphate (PO_4)		0.0	0.4	0.0	0.0
Nitrate (NO_3)		0.0	-	-	2.1
Silica (SiO_2)		2.9	-	3.0	
Sum of constituents	700	496	516	410	
Saturation index at test temperature	-0.6	+0.7	+0.9	+0.5	
Stability index at test temperature	8.8	7.4	7.3	7.8	
% sodium	3.0	3.5	4.2	4.4	

Remarks.

TABLE 3 (concl'd)

Chemical Analyses of Water Supply to Camp Muskwa, Fort Nelson, B.C.
(In parts per million)

Sampling point Overflow from softener (reactor) prior to storage and pumping to systems

Laboratory number	1850	1986	2127	2269
Date of sampling	Aug. 25/59	Oct. 8/59	Nov. 14/59	Jan. 9/60
Storage period (days)	9.16	25.35	19.71	16.24
Temp. at sampling (°C)	16.7	23.9	23.5	24.4
Temp. at testing (°C)	27.7	25.0	25.7	25.5
Appearance, odour, etc.				
Oxygen consumed (KMnO ₄)				
Chem. oxygen demand (C.O.D.)	0.9	1.2	3.0	0
Carbon dioxide (CO ₂), calculated				
pH	7.7	7.9	7.9	10.0
Colour (Hazen units)	10	5	5	0
Turbidity				
Alkalinity as { CaCO ₃	0 25.8	0 59.0	0 17.9	28.3 53.6
L-Total				
Susp. matter, dried at 105°C.				
" " , ignited at 550°C.				
Res. on evap., dried at 105°C.				
" " " , ignited at 550°C.				
Conductance, micromhos at 25°C.	759	750	691	899
Hardness as { CaCO ₃	Total Non-carbonate	392 366	391 341	349 331
Total				428
Non-carbonate				374
Calcium (Ca)	105	106	97.7	172
Magnesium (Mg)	29.7	30.7	25.7	0.0
Strontrium (Sr)				
Sodium (Na)	6.6	6.5	6.6	7.0
Potassium (K)	2.8	2.1	2.3	2.7
Lithium (Li)				
Iron (Fe)	Total	0.01	1.5	2.7
	Dissolved	0.01	0.0	Trace
Aluminum (Al)		0.21	0.38	0.15
Manganese (Mn) (Total)		0.02	0.14	0.02
Copper (Cu)		—	—	—
Zinc (Zn)		—	—	—
Lead (Pb)		—	—	—
Ammonia (NH ₃)		3.5	—	—
Carbonate (CO ₃)	0.0	0.0	0.0	30.4 / OH: 1.0
Bicarbonate (HCO ₃)	31.5	61.0	21.8	0.0
Sulphate (SO ₄)	362	338	321	364
Chloride (Cl)	0.9	8.0	2.9	3.9
Fluoride (F)	—	0.0	—	0.1
Phosphate (PO ₄)				
Nitrate (NO ₃)	0.0	0.1	0.1	0.4
Silica (SiO ₂)	1.4	2.0	1.8	4.4
Sum of constituents	524	523	469	586
Saturation index at test temperature	-0.3	+0.1	+1.3	+2.4
Stability index at test temperature	8.3	7.7	6.4	5.2
% sodium	3.5	3.3	3.9	3.4

Remarks: _____

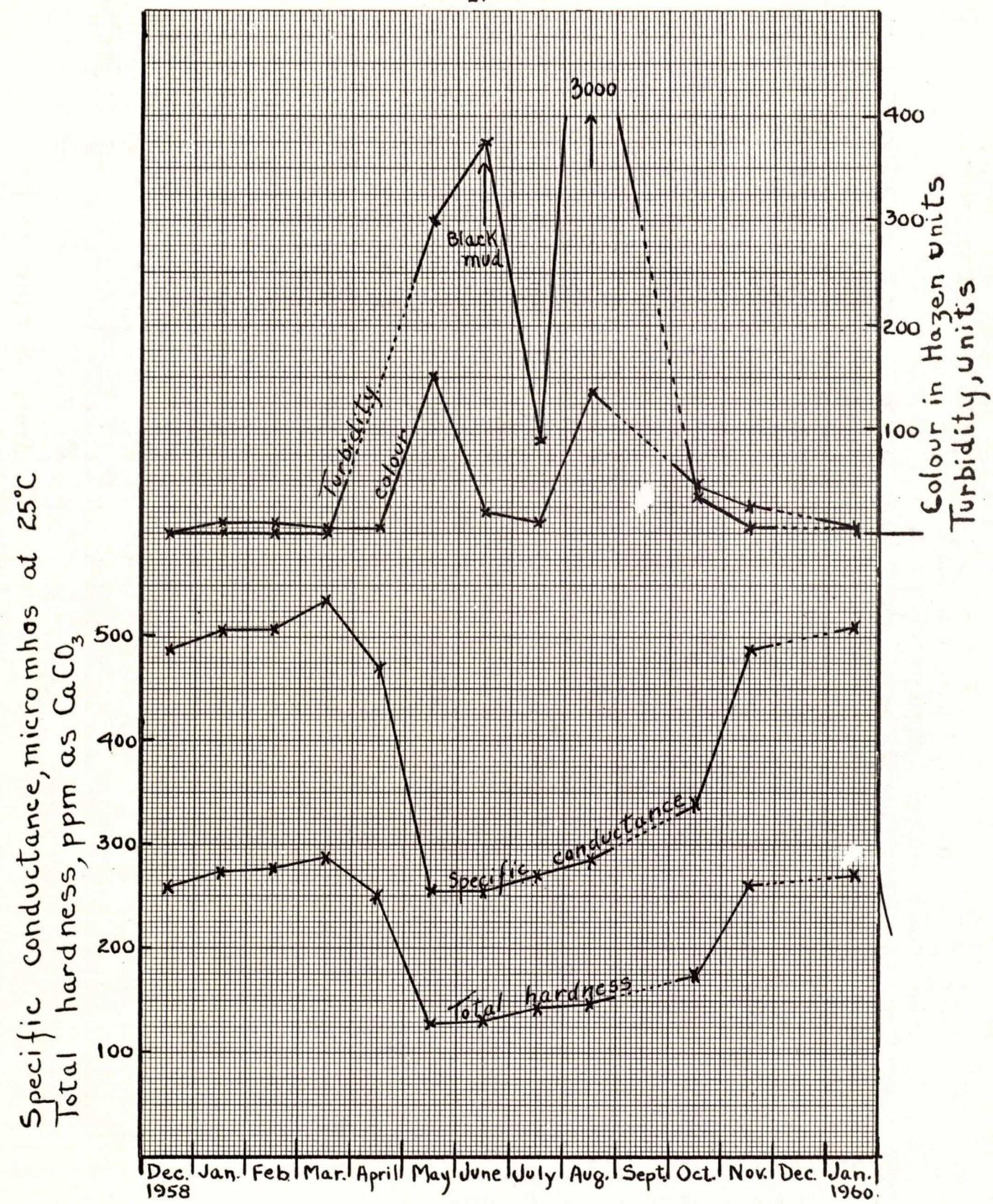


Figure 1.- Chemical Quality Variations in the Muskwa River,
Fort Nelson, B.C. during 1959.

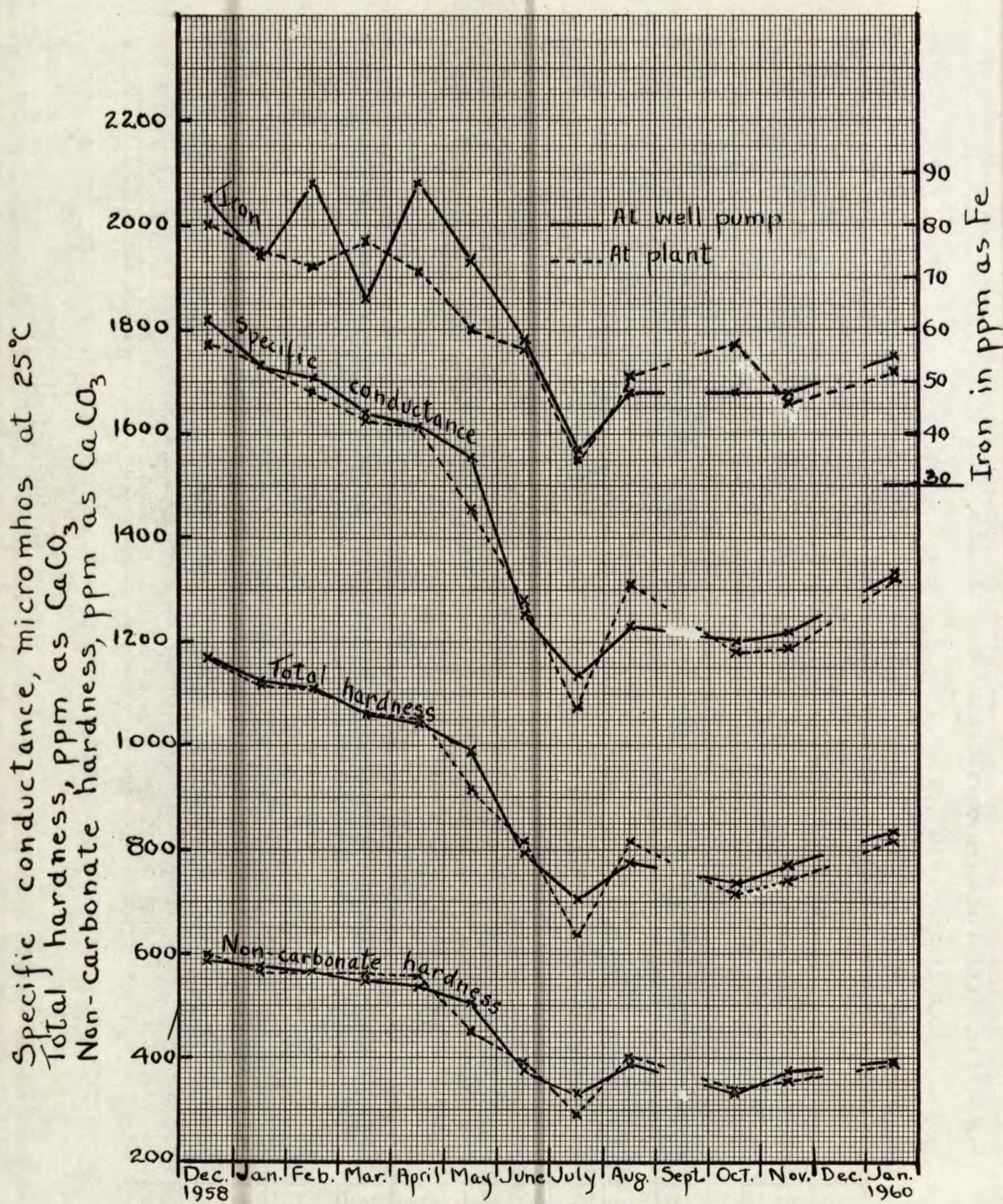


Figure 2.- Chemical Quality Variations in the Untreated Well Water at Camp Muskwa, Fort Nelson, B.C., in 1959

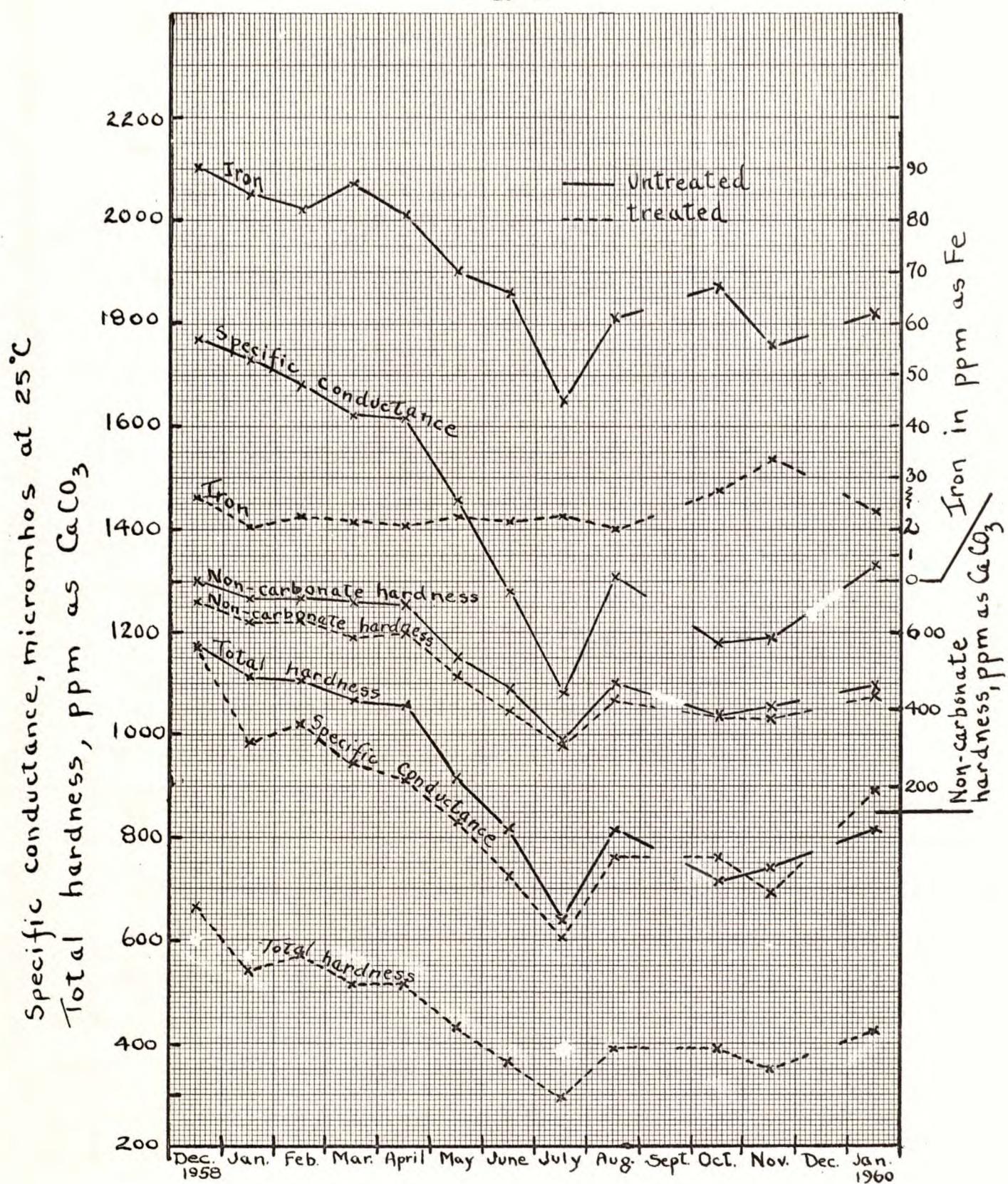


Figure 3.- Chemical Quality Variations in the Untreated and Treated Well Waters at Camp Muskwa, Fort Nelson, B.C. in 1959

DISCUSSION

As expected from previous studies of rivers in other parts of this drainage basin, Muskwa River showed (Table 1 and Figure 1) a wide seasonal variation in chemical quality. During the period of low flow (about October to April) the chemical quality of the river water was satisfactory for general Camp use. Although it is still classed as a very hard water, it is not particularly high in mineralization. It is low in iron and manganese and for most of this period low in colour and turbidity. Chemically, the river water during this period is a much superior water to the present Camp supply (see Table 3 and Figure 3).

However, during the spring and summer, especially at times of high discharge, the colour and turbidity of the river rise very sharply and treatment of the water for their removal would be required. In 1959 colour and turbidity rose almost concurrently showing two major peaks, one in May-June and the other in August. The first is no doubt caused by high water and run-off from the local spring break-up; the August peak may be due to a later break-up in the upper reaches of the river or to heavy rains and subsequent flooding. These peaks may vary from year to year and there may be other periods of high colour and turbidity. Also, monthly sampling may miss peak periods of short duration caused by local flash flooding.

When high colour and turbidity occur the quality of the river water is otherwise improved as the hardness and total mineralization then decreases. This is to be expected when colour and turbidity are caused by rapid run-off of melted snow, or rain. During periods of high turbidity and colour no softening of the water would be required, except for special uses such as boiler make-up.

Unfortunately, information on the discharge of this river and its depth is meagre. The collector of the river water samples reported that during the winter period when the water quality is most satisfactory there was a heavy ice cover and very little water at the sampling point. A depth of only 14 in. water was recorded at one time.

Successful use of the river will depend upon being able to obtain a satisfactory location for an intake, such that there is sufficient water depth, no major problem with frazil or anchor ice or from shifting of the river channel during flood periods. If this problem can be economically solved it is considered that the river water could be used during the winter period with very little treatment. In the summer the present plant should be able to treat either the river water or a mixture of river and well water to produce a superior final product. A basin or reservoir near the well that would permit settling and storage prior to pumping to the plant would probably reduce much of the turbidity during peak periods.

Table 2 and Figure 2 confirm what was indicated from previous studies (Report IR58-215), i.e. the well water varies markedly with the season. During the summer period this water decreases markedly in total mineralization, hardness and iron content. Figures 1 and 2 show that this change roughly corresponds with the change in river water with a low in July, 1959. The marked rise in mineralization of the river water in October - November, 1959 is, however, not immediately noted in the well water and although the well water continues to increase in mineralization this, in January, 1960 did not reach that of January, 1959. However, these results do indicate a possible connection between the well aquifer and the river, at least during the summer period.

The variations in the well water are such that careful control of plant treatment and operation are necessary. A fixed feed of chemicals will not permit the most economical and best treatment of the well water.

Table 2 and Figure 2 also show some variation in quality between the well water at the pump and the well water after a period of pumping and sampling at the plant. Some of this variation can be due to sampling errors and loss of constituents during transit from the well to the plant. As previously pointed out, some of these changes may be prevented if any leak in the pipe from the well to the plant is also eliminated. Further sampling of the well at start up of the pump and again at the pump after several hours pumping would more clearly show if the changes are due to continued pumping

or to transit and sampling error. However, these variations are not considered significant in so far as treatment is concerned.

Table 3 and Figure 3 show the chemical quality of the water now being supplied from the plant. However, if settling is allowed in the reservoir prior to pumping to the system some improvement in quality will result, especially in waters having a high iron content.

It is noted that, except for the iron content of these waters, the final water generally varies with the quality of the raw well water. This is mainly due to the fact that much of the non-carbonate hardness is not removed by the present lime treatment and the amount of such hardness varies markedly in the well water. The amount of non-carbonate hardness removed by the present treatment is also dependent on a number of factors, already discussed in Report IR58-215, principally the pH of treatment and the amount of lime added.

However, except for the occasional sample, the water is as satisfactory as can be expected in view of other problems still outstanding at this plant. The final iron content is, at times, much too high and unless this settles out in the reservoir can cause trouble in the system. The variability of the final pH, especially the very high pH of sample No. 2269 (Table 3), indicates inconsistency in the plant operation as well as the result of using a fixed chemical feed on a variable water. As previously pointed

out, while it is necessary to operate at a high pH for maximum softening, some compromise has had to be made at this plant since no treatment to reduce the pH prior to use is carried out.

Attention is directed to the fact that, at all times even the best water produced from the well supply is harder and more highly mineralized than the river water.

The quality of the river water is best during the winter period when the well water supply is at its worst and vice versa. Therefore, if the problem of obtaining river water can be economically solved the use of these two waters, one at different periods of the year or a mixture of the two at other times, could produce a superior water to that now supplied, probably with much less treatment.

SUMMARY

1. The Muskwa River is, except for certain periods when colour and turbidity are high, a better quality water than the currently-treated well water.
2. Problems regarding the quantity of river water available and the construction of a suitable intake into the river are major drawbacks to its use.
3. The well water varies markedly in quality with the

time of year and treatment must be varied and controlled accordingly, if the best possible water is to be obtained.

4. From this limited study the water now produced from the plant appears to be of better quality than that produced prior to the change in treatment in October, 1958, but failure of the treatment occurs periodically. This is no doubt due to deficiencies in the present treatment plant and to fixed operation on a variable water.

5. Since the well water is of better quality in the summer when the river water is at its worst and vice versa the possible alternate use of these waters and/or of a mixture of the waters is worthy of further consideration.

6. Additional study of the river and well waters with regard to quality, and particularly the former as to quantity, is recommended if other problems related to use of the river water can be solved.

7. The economics of the use of river water must consider, beside the adverse cost of an intake to the river, etc., a decrease in treatment costs and savings resulting from the use of a superior water to the Camp. The latter are very difficult to determine as they include savings in household use, in scaling and corrosion of equipment, and in softening of boiler make-up besides an improvement in personnel morale and possibly health.