ENVIRONMENT CANADA
CONSERVATION AND PROTECTION
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC AND YUKON REGION

SITE INSPECTION

WATER QUALITY RESULTS
FROM NOVEMBER 26, 1982 AND JULY 15, 1983
SAMPLING SURVEYS AT KINDRAT MINE NEAR SMITHERS, B.C.

Regional Data Report DR 86-05

By

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1 INTRODUCTION

The Kindrat Mine is situated in the head waters of the Zymoetz River. The river supports natural populations of sockeye, coho, chinook, steelhead trout and cutthroat trout (Figure 1). A salmon enhancement project is also planned for this area. The present mine is situated on the site of the old Duthie Mine which was in operation in the early 1950's with a milling capacity of 150 tonnes/day. The tailings were allowed to flow freely down the mountain side. Cyanide was used in the process. The operation ceased in 1954. The tailings have had a tendency to be acid generating. Kindrat discovered a rich silver ore body on the property and introduced a 50 ton per day lead-silver flotation system, which makes it subject to the Metal Mining Liquid Effluent Regulations (MMLER). This report presents data of two different monitoring surveys conducted November 26, 1982 and July 15, 1983.

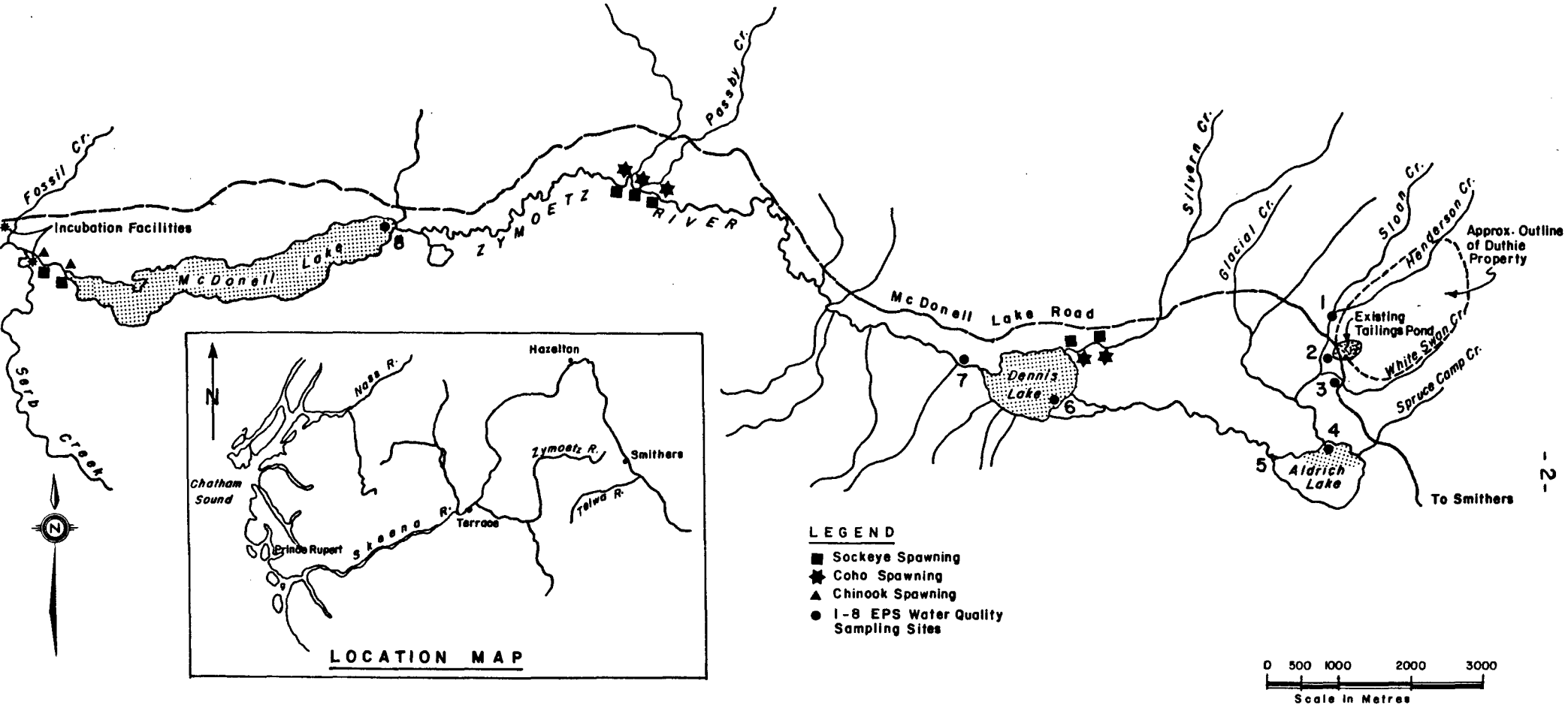

FIGURE 1 KINDRAT MINE RECEIVING WATER SAMPLING SITES

2 MATERIAL AND METHOD

Receiving water samplers were comprised of three sequential grab samples. The samples were analysed for both surveys for pH, sulphate, total residue, filterable residue, turbidity, conductivity and total and dissolved metals. In addition, alkalinity and acidity were analysed for the November survey while total cyanide and thiocyanate were analysed on September 9, 1982.

The conductivity, turbidity, residue, sulphates, alkalinity and acidity samples were kept cool with wet ice until analysed. Total metal samples of 250 ml each were preserved on site with 1 ml of nitric acid. Dissolved metal samples of 100 ml each were filtered on site through a 0.45 micron cellulose nitrate filter and then preserved with 0.5 ml nitric acid. All samples were delivered to the Environmental Protection Service Laboratory in West Vancouver.

The Inductively Coupled Argon Plasma or ICAP scan, an automatic atomic emissions spectrophotometer, was used for the total and dissolved metal analysis and gave a reading of twenty-six metals. If the copper, lead, or cadmium readings were below the ICAP detection limit, the samples were rerun on the graphite furnace of the atomic absorption spectrophotometer to obtain lower detection limit.

Total cyanide samples were collected in 500 ml bottles, preserved with sodium hydroxide pellets, and stored in the dark at 4°C. The samples were analysed at EPS, West Vancouver lab with the tetracyanonickelate colorimetric method. The detection limit of the analysis is 0.03 mg/l.

Buffered samples to pH 5 are used for cyanide weak acid dissociable complexed with nickel and read by colorimetric method. The detection limit is 0.03 mg/l. Thiocyanide samples are complexed with iron and analysed by colorimetric method. The detection limit is 2.0 mg/l.

3 RESULTS

3.1 Tailings and Runoff

Single grab water samples, collected on September 9, 1982, from the tailings pond runoff showed acidic drainage (Table 1). The pH was 3.4 and helped dissolve many chemicals, as seen in the filterable residue values (1323 mg/l). Significant elevation of heavy metals was found in the runoff sample, such as arsenic, cadmium, cobalt, chromium, copper, lead, zinc, manganese, iron, calcium, magnesium, strontium and aluminum. The sample was taken 2 days after a heavy rainfall. It was the first maximum flow in 2 months (Inland Waters, 1983). These values were reduced during the November 1982 survey when the creeks were covered with ice and had reduced flows. This discharge was out of compliance with the MMLER requirements for pH, suspended solids, arsenic and zinc.

The analysis of tailings sediments (Table 2) revealed high values of arsenic (17 500 mg/kg) and lead (2 840 mg/kg) compared to zinc (311 mg/kg). The concentrations of heavy metal in the tailings runoff showed a high concentration of zinc (29.1 mg/l) compared to arsenic (2.86 mg/l) and lead (0.2 mg/l). These metals did not represent the actual ratio of metals in the sediments.

This high concentration of zinc in tailings runoff could be explained by the zinc dissolution ability at low pH compared to arsenic and lead. The availabiility of arsenic at low pH can be reduced by its mineralization state which bound the metal strongly with other elements in a complex formation. The lead concentrations can be reduced through the formation of insoluble compounds such as sulphides and therefore decrease the release of the metal in the tailings runoff (Weast, 1985).

3.2 Spatial Differences

3.2.1 November 26, 1982. The control station on White Swan Creek (Station 3) was different from the acid mine drainage effluent in many aspects (Table 3). The levels of contaminants in the effluent were higher for residues, sulphate, conductivity, turbidity, alkalinity, acidity,

TABLE 1 KINDRAT MINE, SMITHERS, B.C. - WATER QUALITY ANALYSES FROM GRAB SAMPLES COLLECTED ON SEPTEMBER 9, 1982

PARAMETER[1] (mg/l)	TAILINGS RUNOFF (mg/l) September 9		DETECTION LIMIT (mg/l)	
pH (relative units)	3.4		0.1	
non-filterable residue	57		5.0	
total residue	1380		1.0	
sulphate	663		1.0	
total CN	< 0.03		0.03	
thiocyanate (CNS)	< 2.0		2.0	
hardness, total	505		1.0	
	Total	Diss.	Total	Diss.
As	2.86	0.75	0.06	0.05
B	< 0.001	0.019	0.001	0.001
Ba	0.018	0.016	0.001	0.001
Be	< 0.001	< 0.001	0.001	0.001
Cd	0.066	0.061	0.002	0.002
Co	0.156	0.217	0.006	0.005
Cr	0.01	0.007	0.006	0.005
Cu	0.435	0.402	0.005	0.005
Hg	< 0.06	< 0.05	0.06	0.05
Mn	8.71	4.85	0.001	0.001
Mo	0.014	< 0.005	0.006	0.005
Ni	0.03	0.03	0.02	0.02
P	0.18	0.14	0.06	0.05
Pb	0.2	0.57	0.001	0.001
Sb	< 0.06	< 0.05	0.06	0.05
Se	< 0.06	< 0.05	0.06	0.05
Sn	< 0.01	< 0.01	0.01	0.01
Sr	0.245	0.21	0.001	0.001
Ti	< 0.002	< 0.002	0.002	0.002
V	< 0.01	< 0.01	0.01	0.01
Zn	29.1	25.9	0.002	0.002
Al	5.48	4.71	0.05	0.05
Fe	95.8	67.3	0.005	0.005
Si	10	11.3	0.10	0.10
Ca	95.7	83.0	0.10	0.10
Mg	29.4	24.9	0.10	0.10
Na	6	5.2	0.10	0.10

1 = units in mg/l unless otherwise stated Diss. = dissolved
- = not sampled

TABLE 2 DETAILED SEDIMENT ANALYSIS OF EXISTING TAILINGS (Duthie Mine) KINDRAT MINE, SMITHERS, B.C. - SEPTEMBER 9, 1982

PARAMETER (ug/g)	OLD DUTHIE TAILINGS
AS	17500.1
B	22.1
BA	67.6
BE	< .2
CD	< .3
CO	< .8
CR	18.5
CU	177
MN	907
MO	23.9
NI	< 3
P	724
PB	2840
SN	< 2
SR	9.8
TI	51.5
V	27
ZN	311
AL	9970
FE	74800
SI	6540
CA	1190
MG	2410
NA	210
REPLICATES IN AVERAGE	2

TABLE 3 WATER QUALITY ANALYSES OF THE FRESHWATER SITES - KINDRAT MINES - NOVEMBER 26, 1982

PARAMETER[1]	STATION 2 ACID MINE DRAINAGE BELOW MCDONNEL ROAD		STATION 3 WHITE SWAN CREEK BELOW MCDONNEL ROAD		STATION 4 ALDRICH LAKE AT GLACIAL CREEK	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
pH	6.3	0	6.9	0.06	6.5	0
total residue	455.00	19.97	52.00	1.00	57.33	1.15
non-filterable residue	30.0	5.57	< 5	0	< 5	0
sulphate	210.00	1.73	3.53	0.12	8.77	0.06
conductivity (umhos/cm)	496.00	2.65	41.93	0.12	55.8	0
turbidity (FTU)	78.0	0	0.1	0	0.8	0
total alkalinity	22.33	0.58	15.67	0.58	15.17	0.76
total acidity	40.00	0	5.33	0.58	13.33	0.58
hardness, Ca, Mg	194.33	0.58	16.80	0.17	21.07	0.23
hardness, total	242.00	1.00	17.00	0.17	22.50	0.26

	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.
As (ppb)	111.67	60.67	9.07	4.16	0.76	0.63	0.30	0.23	7.90	5.50	0.20	0.10
B	< 0.001	< 0.001	0	0	0.003	< 0.001	0.002	0	< 0.001	< 0.001	0	0
Ba	0.034	0.033	0.001	0	0.011	0.01	0	0	0.008	0.008	0.001	0
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Cd	0.006	0.005	0.001	0	< 0.0006	< 0.0005	0	0	< 0.0006	< 0.0005	0	0
Co	< 0.006	< 0.005	0	0	0.005	< 0.005	0.003	0	0.006	< 0.005	0.004	0
Cr	0.007	< 0.005	0.003	0	0.006	< 0.005	0.003	0	0.009	< 0.005	0.005	0
Cu	0.018	0.008	0.011	0.001	< 0.001	< 0.001	0	0	0.006	0.002	0.006	0.001
Mn	13.13	12.5	0.05	0	0.009	0.01	0.008	0.02	0.293	0.32	0.010	0
Mo	< 0.006	< 0.005	0	0	0.004	< 0.005	0.002	0	0.005	< 0.005	0.003	0
Ni	0.03	< 0.02	0.02	0.01	0.043	< 0.02	0.029	0	0.067	< 0.02	0.049	0
P	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0.024	0
Pb	0.015	0.003	0.001	0.002	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Sb	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Se	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	0.012	< 0.01	0.006	0	0.015	< 0.01	0.011	0
Sr	0.203	0.210	0.002	0	0.016	0.020	0.001	0	0.016	0.017	0.001	0
Ti	0.045	< 0.002	0.002	0	0.044	< 0.002	0.001	0	0.044	< 0.002	0.001	0
V	0.01	< 0.01	0	0	0.007	< 0.01	0.002	0	0.01	< 0.01	0.007	0
Zn	2.05	2.13	0.01	0.01	0.013	0.006	0.005	0.003	0.131	0.14	0.003	0
Al	0.45	0.07	0.09	0.02	< 0.06	< 0.05	0	0	0.047	< 0.05	0.024	0
Fe	13.53	11.93	0.33	0.06	0.060	0.04	0.005	0.02	0.418	0.29	0.013	0
Si	3.5	3.8	0.1	0.1	2.9	3.3	0.1	0.1	2.3	2.7	0.9	0
Ca	56.0	49.9	0.3	0.2	4.6	5.1	0	0.1	6.3	7.2	0.2	0.1
Mg	10.3	10.9	0.1	0.1	0.9	1.0	0	0	0.7	0.8	0.1	0
Na	5.1	5.4	0.1	0	1.2	1.2	0	0.1	1.2	1.3	0.1	0.1

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

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TABLE 3 WATER QUALITY ANALYSES OF THE FRESHWATER SITES - KINDRAT MINES - NOVEMBER 26, 1982

PARAMETER[1]	STATION 5 ALDRICH LAKE OUTLET				STATION 6 DENNIS LAKE INLET BELOW MCDONNEL ROAD			
	$\bar{x}$		s		$\bar{x}$		s	
pH	6.9		0		6.6		0	
total residue	51.33		0.58		52.00		10.44	
non-filterable residue	< 5		0		< 5		0	
sulphate	5.93		0.12		4.83		0.21	
conductivity (umhos/cm)	42.97		0.12		62.2		0	
turbidity (FTU)	1.1		0		1.6		0	
total alkalinity	12.17		0.29		22.67		0.58	
total acidity	2.0		0		9.33		0.58	
hardness, Ca, Mg	16.87		0.06		26.53		0.06	
hardness, total	17.33		0.12		27.5		0	
	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.
As (ppb)	17.47	10.08	0.95	5.03	6.13	4.43	0.21	0.15
B	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Ba	0.007	0.007	0	0	0.008	0.009	0.001	0
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Cd	< 0.0006	< 0.0005	0	0	< 0.0006	< 0.0005	0	0
Co	< 0.006	< 0.005	0	0	< 0.006	< 0.005	0	0
Cr	< 0.006	< 0.005	0	0	< 0.006	< 0.005	0	0
Cu	< 0.001	0.001	0	0.001	< 0.001	< 0.001	0	0.001
Mn	0.015	0.004	0.009	0.001	0.143	0.162	0.002	0.001
Mo	< 0.006	< 0.005	0	0	< 0.006	< 0.005	0	0
Ni	0.017	< 0.02	0.009	0	0.017	< 0.02	0.009	0
P	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Pb	0.001	< 0.001	0.001	0	< 0.001	< 0.001	0	0
Sb	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Se	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Sr	0.014	0.015	0	0	0.018	0.020	0.001	0.001
Ti	0.042	< 0.002	0.002	0	0.041	< 0.002	0.001	0
V	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Zn	0.035	0.036	0.001	0	0.020	0.022	0.005	0.001
Al	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Fe	0.26	0.195	0.008	0.002	0.513	0.329	0.007	0.009
Si	1.2	1.4	0	0.1	1.8	2.1	0	0
Ca	5.0	5.57	6.1	0.1	7.5	8.6	0.1	0.1
Mg	0.6	0.7	0.1	0	1.1	1.23	0	0.1
Na	1.0	1.2	0.1	0.2	1.1	1.3	0	0.1

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

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TABLE 3 WATER QUALITY ANALYSES OF THE FRESHWATER SITES - KINDRAT MINES - NOVEMBER 26, 1982

PARAMETER[1]	STATION 7 ZYMOETZ RIVER BELOW DENNIS LAKE				STATION 8 MCDONNEL LAKE INLET			
	$\bar{x}$		s		$\bar{x}$		s	
pH	6.9		0.06		7.0		0	
total residue	72.67		1.53		82.00		1.00	
non-filterable residue	< 5		0		< 5		0	
sulphate	4.50		0.10		4.17		0.06	
conductivity (umhos/cm)	75.1		0		89.0		0	
turbidity (FTU)	0.7		0		1.3		0	
total alkalinity	29.67		0.58		36.67		0.58	
total acidity	4.0		0		6.33		0.58	
hardness, Ca, Mg	33.13		0.06		38.8		0	
hardness, total	33.57		0.06		39.53		0.06	
	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.
As (ppb)	2.37	1.77	0.06	0.06	0.77	0.63	0.04	0.12
B	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Ba	0.008	0.008	0	0	0.012	0.013	0	0
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Cd	< 0.0006	< 0.0005	0	0	< 0.0006	< 0.0005	0	0
Co	< 0.006	< 0.002	0	0	< 0.006	< 0.005	0	0
Cr	< 0.006	< 0.005	0	0	0.004	< 0.005	0.002	0
Cu	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Mn	0.034	0.006	0.007	0.005	0.051	0.070	0.003	0.001
Mo	< 0.006	0.045	0	0	< 0.006	< 0.005	0	0
Ni	0.027	< 0.02	0.024	0	0.023	< 0.02	0.019	0
P	< 0.06	< 0.02	0	0	< 0.06	< 0.05	0	0
Pb	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Sb	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Se	< 0.06	< 0.05	0	0	< 0.06	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Sr	0.019	0.021	0.001	0	0.034	0.036	0.002	0.001
Ti	0.045	< 0.002	0.006	0	0.043	< 0.002	0.002	0
V	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Zn	0.003	0.009	0.002	0.005	0.002	0.003	0.001	0.001
Al	0.073	< 0.05	0.061	0	< 0.06	< 0.05	0	0
Fe	0.248	0.159	0.024	0.001	0.415	0.266	0.016	0.003
Si	2.0	2.2	0.1	0	2.6	3.0	0.1	0
Ca	8.6	8.7	0.2	0.1	10.7	11.8	0.5	0
Mg	1.9	2.2	0	0.1	2.1	2.3	0.1	0
Na	1.2	1.3	0	0.1	1.7	1.8	0.1	0

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

hardness, arsenic, copper, manganese, lead, strontium, zinc, aluminum, iron, calcium, magnesium and sodium. pH was higher in White Swan Creek. These high values in the acid mine drainage contributed to the elevated concentrations of sulfate, acidity and hardness at Station 4. As well, arsenic, manganese, zinc and iron levels were significantly higher than Station 3. Sulphate, arsenic and iron were significantly different than Station 3 at Station 5. Evidence of arsenic and iron were still significantly higher at Stations 6 and 7 than the control station, Station 3.

3.2.2 July 15, 1983. Station 1 on Henderson Creek was different from Station 3 for hardness and iron which was lower at Station 1 and zinc which was higher in concentration than Station 3 (Table 4).

The zinc level was found elevated at Stations 4 and 5 compared to Stations 1 and 3. Concentrations at Stations 6 and 7 were significantly reduced compared to Station 1 but not from Station 3.

Conductivity, hardness, manganese and pH were found elevated downstream of the mine influence stations, compared to Stations 1 and 3.

Calcium, manganese and strontium at Stations 6 and 7 were elevated compared to Stations 1 and 3.

3.3 Temporal Variation

The acid mine drainage water (Station 2) characteristics were significantly different ($p < .05$) between November 26, 1982 and July 15, 1983 for: total residues, turbidity, conductivity, total hardness, sulphate, manganese (Mn), lead (Pb), strontium (Sr), titanium (Ti), iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na) and cobalt (Co). All values, except cobalt, were higher in November (Tables 3 and 4).

Station 3 was similar for most parameters except conductivity, nickel and titanium. The differences between November 1982 and July 1983 at Station 4 concerns the following parameters: pH, turbidity, conductivity, hardness, manganese, titanium and zinc. At Station 5 the same parameters were different plus sulphate and iron. The values were higher in November except for pH and at Station 5 for manganese, zinc and iron.

Conductivity and titanium were the only parameters that were different at all seven stations.

A comparison between November 26, 1982 with samples collected by the Waste Management Branch on October 12, 1982 at Stations 3 and 4, showed some variation with arsenic and zinc, while the other metal concentrations were in agreement (Table 5). At Stations 3 and 4, the zinc concentration was similar in October and November. The arsenic level was higher in October at Station 4 only. It seems that the level of the principal contaminant varies with environmental conditions.

3.4 Arsenic and Zinc

On November 26, 1982, the arsenic levels downstream of the mine were below the recommended level for water quality objectives for protection of aquatic life set at 0.05 mg/l (Reeder 1979). The tailings drainage arsenic concentration was above this guideline on both surveys. The impact of arsenic was found as far as Station 7 on November 26, 1982. No such impact could be traced on July 15, 1983.

On November 26, 1982 zinc impact was found in Aldrich Lake at Station 4 and Stations 4 and 5 on July 15, 1983. These levels were above the recommended level for water quality objectives for protection of aquatic life at a low hardness (Reeder 1979), established at 0.5 mg/l. Both days the discharge was above the MMLER requirement of 1.0 mg/l in a single grab.

TABLE 4 WATER QUALITY ANALYSES OF THE FRESHWATER SITES - KINDRAT MINES - JULY 15, 1983

PARAMETER[1]	STATION 3 WHITE SWAN CREEK				STATION 4 ALDRICH LAKE GLACIAL CREEK INLET				STATION 5 ALDRICH LAKE OUTLET			
	$\bar{x}$		s		$\bar{x}$		s		$\bar{x}$		s	
pH (relative units)	6.8		0		7.7		0.06		7.4		0.12	
turbidity (FTU)	0.1		0		0.2		0		0.2		0	
conductivity (umhos/cm)	28.0		0		35.4		0.17		34.7		0	
filterable residue	40.0		8.5		40.3		7.5		38.3		5.8	
non-filterable residue	< 5		0		< 5		0		< 5		0	
total residue	40.0		8.5		40.3		7.5		38.3		5.8	
sulphate	4.9		0.25		8.7		0.6		8.0		0.10	
hardness, Ca, Mg	18.9		0.231		14.1		0.06		14.1		0.15	
hardness, Total	19.7		0.265		14.7		0.12		14.8		0.21	
	Total	Diss.[2]	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.
As	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
B	< 0.001	0.056	0	0.004	< 0.001	0.002	0	0.003	< 0.001	0.033	0	0.010
Ba	0.011	0.01	0.002	0	0.008	0.008	0	0	0.008	0.009	0.0006	0.0006
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Cd	< 0.0005	< 0.0005	0	0	< 0.0005	< 0.0005	0	0	< 0.0005	< 0.0005	0	0
Co	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0
Cr	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0
Cu	< 0.001	< 0.001	0	0	0.002	< 0.001	0.001	0	0.001	< 0.001	0.001	0
Mn	0.018	0.006	0.017	0.004	0.112	0.109	0.0006	0	0.117	0.118	0.001	0.004
Mo	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0
Ni	< 0.02	< 0.02	0	0	< 0.02	< 0.02	0	0	< 0.02	< 0.02	0	0
P	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Pb	< 0.001	< 0.001	0	0	0.001	< 0.001	0	0	0.002	< 0.001	0	0
Sb	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Se	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Sr	0.012	< 0.012	0	0	0.012	0.013	0.0006	0.0006	0.013	0.014	0	0.0006
Ti	0.005	< 0.002	0.004	0	< 0.002	< 0.002	0	0	0.003	< 0.002	0.003	0
V	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Zn	0.003	< 0.002	0.003	0	0.083	0.079	0.004	0.001	0.07	0.07	0.003	0.002
Al	0.18	< 0.05	0.16	0	0.087	< 0.05	0.029	0	0.10	< 0.05	0.04	0
Fe	0.23	0.028	0.24	0.002	0.369	0.170	0.104	0.014	0.379	0.194	0.017	0.015
Si	2.7	2.6	0.17	0	1.7	1.6	0.06	0	1.7	1.6	0.06	0
Ca	3.7	3.8	0.153	0.06	4.6	4.6	0.12	0.06	4.6	4.6	0.10	0
Mg	0.6	0.6	0.06	0	0.7	0.6	0	0	0.7	0.7	0	0
Na	1.2	1.1	0.06	0	1.0	0.9	0	0	1.0	0.9	0.06	0

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

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PARAMETER[1]	STATION 6 DENIS LAKE INLET				STATION 7 DENIS LAKE OUTLET			
	$\bar{x}$		s		$\bar{x}$		s	
pH (relative units)	7.3		0.06		7.2		0	
turbidity (FTU)	0.1		0		0.3		0	
conductivity (umhos/cm)	56.8		0.35		59.7		0	
filterable residue	60.7		5.1		63.7		6.8	
non-filterable residue	< 5		0		< 5		0	
total residue	60.7		5.1		63.7		6.8	
sulphate	5.7		0.42		5.7		0.30	
hardness, Ca, Mg	26.8		0.23		28.7		0.100	
hardness, Total	27.1		0.27		29.0		0.173	
	Total	Diss.[2]	Total	Diss.	Total	Diss.	Total	Diss.
As	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
B	< 0.001	< 0.001	0	0	< 0.001	0.017	0	0.017
Ba	0.008	0.008	0	0	0.008	0.008	0.0006	0.0006
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Cd	< 0.0005	< 0.0005	0	0	< 0.0005	< 0.0005	0	0
Co	0.021	< 0.005	0.033	0	< 0.005	< 0.005	0	0
Cr	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0
Cu	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Mn	0.031	0.028	0.001	0.001	0.036	0.030	0.001	0
Mo	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0	0
Ni	< 0.02	< 0.02	0	0	< 0.02	< 0.02	0	0
P	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Pb	< 0.001	< 0.001	0	0	< 0.001	< 0.001	0	0
Sb	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Se	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Sr	0.019	0.019	0.001	0.001	0.019	0.019	0	0.001
Ti	< 0.002	< 0.002	0	0	0.002	< 0.002	0.002	0
V	< 0.01	< 0.01	0	0	< 0.01	< 0.01	0	0
Zn	0.009	0.009	0.002	0	0.008	0.007	0.004	0
Al	0.04	< 0.05	0.02	0	0.053	< 0.05	0.049	0
Fe	0.210	0.116	0.033	0.004	0.215	0.103	0.018	0.002
Si	1.8	1.8	0	0	1.9	1.8	0	0
Ca	8.1	8.4	0.06	0.12	8.3	8.6	0	0
Mg	1.4	1.4	0	0	1.8	1.8	0	0
Na	1.2	1.1	0.06	0	1.2	1.1	0	0

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

TABLE 4 WATER QUALITY ANALYSES OF THE FRESHWATER SITES - KINDRAT MINES - JULY 15, 1983

PARAMETER[1]	STATION 1						STATION 2			
	HENDERSON CREEK ABOVE MCDONNEL ROAD BRIDGE				KINDRAT MINEWATER EFFLUENT		ACID MINE DRAINAGE BELOW MCDONNEL LAKE ROAD			
	$\bar{x}$		s				$\bar{x}$		s	
pH (relative units)	6.8		0.06		7.5		6.1		0	
turbidity (FTU)	< 0.1		0		3.8		25.3		2.31	
conductivity (umhos/cm)	24.3		0		271		230		0	
filterable residue	40.3		3.1		181		172.		7.0	
non-filterable residue	< 5		0		< 5		17.3		1.53	
total residue	40.0		3.1		181		189.3		7.6	
sulphate	6.7		0.29		77.0		100.2		0.76	
hardness, Ca, Mg	9.31		0.085		124		87.2		0.38	
hardness, Total	9.42		0.121		131		106		0	
	Total	Diss.[2]	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.
As	< 0.05	< 0.05	0	0	< 0.05	< 0.05	0.12	< 0.05	0.02	0
B	< 0.001	< 0.001	0	0	< 0.001	< 0.001	< 0.001	< 0.001	0	0
Ba	0.007	0.007	0.001	0	0.02	0.02	0.030	0.03	0.001	0.0006
Be	< 0.001	< 0.001	0	0	< 0.001	< 0.001	< 0.001	< 0.001	0	0
Cd	< 0.0005	< 0.0005	0	0	0.024	0.021	0.003	0.004	0.0002	0.0005
Co	< 0.005	< 0.005	0	0	< 0.005	< 0.005	0.015	0.015	0.002	0.001
Cr	< 0.005	< 0.005	0	0	< 0.005	< 0.005	< 0.005	< 0.005	0	0
Cu	< 0.001	< 0.001	0	0	0.004	0.001	0.020	0.005	0.002	0.0006
Mn	0.002	0.002	0.002	0.003	0.159	0.135	4.52	4.68	0.07	0.04
Mo	< 0.005	< 0.005	0	0	< 0.005	< 0.005	< 0.005	< 0.005	0	0
Ni	< 0.02	< 0.02	0	0	< 0.02	< 0.02	< 0.02	< 0.02	0	0
P	< 0.05	< 0.05	0	0	< 0.05	< 0.05	< 0.05	< 0.05	0	0
Pb	< 0.001	< 0.001	0	0	0.25	0.08	0.004	< 0.001	0.0006	0
Sb	< 0.05	< 0.05	0	0	< 0.05	< 0.05	< 0.05	< 0.05	0	0
Se	< 0.05	< 0.05	0	0	< 0.05	< 0.05	< 0.05	< 0.05	0	0
Sn	< 0.01	< 0.01	0	0	< 0.01	< 0.01	< 0.01	< 0.01	0	0
Sr	0.006	0.006	0.001	0	0.271	0.286	0.103	0.107	0.002	0.001
Ti	< 0.002	< 0.002	0	0	< 0.002	< 0.002	0.001	< 0.002	0.0006	0
V	< 0.01	< 0.01	0	0	< 0.01	< 0.01	< 0.01	< 0.01	0	0
Zn	0.045	0.046	0.002	0.001	3.95	3.85	2.04	2.07	0.031	0.01
Al	0.04	< 0.05	0.02	0	0.11	< 0.05	0.54	< 0.05	0.05	0
Fe	0.014	0.010	0.009	0.007	0.331	0.03	6.20	3.89	0.30	0.03
Si	1.7	1.7	0	0	3.1	3.0	3.8	3.6	0.1	0.06
Ca	3.3	3.3	0.10	0	39.0	49.0	26.1	26.9	0.21	0.10
Mg	0.3	0.3	0	0	6.0	5.9	4.9	4.8	0.10	0.06
Na	0.7	0.6	0	0	3.5	3.5	3.0	2.9	0.06	0.06

[1]All units in mg/l unless otherwise stated
[2]Diss. = Dissolved

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TABLE 5 KINDRAT MINES, SMITHERS, B.C. - COMPARISON OF EPS AND WMB RESULTS FOR SOME FRESHWATER SAMPLING SITES

	EPS SITE				WMB SITES		EPS SITE				WMB SITE	
	STATION 4 ALDRICH LAKE AT GLACIAL CREEK INLET Nov. 26/82 (mg/l) triplicate samples				ALDRICH LK. AT TRAMWAY RD. Oct. 12/82 (mg/l) single sample		STATION 3 WHITE SWAN CR. BELOW MCDONNEL LK. ROAD Nov. 26/82 (mg/l) triplicate samples				WHITE SWAN CR. AT MCDONNEL LK. RD. CROSSING Oct. 12/82 (mg/l) single sample	
	$\bar{x}$		s		Total	Diss.	$\bar{x}$		s		Total	Diss.
	Total	Diss.	Total	Diss.			Total	Diss.	Total	Diss.		
As	0.0079	0.0055	0.0002	0.0001	0.038+	0.02+	0.00076	0.00063	0.0003	0.00023	< 0.005	< 0.005
Cd	< 0.0006	< 0.0005	0	0	< 0.0005	< 0.0005	< 0.0006	< 0.0005	0	0	< 0.0005	< 0.0005
Cu	< 0.0055	0.0015	0.006	0.0005	0.002	0.001	< 0.001	< 0.001	0	0	< 0.001	< 0.001
Pb	< 0.001	0.001	0	0	0.002+	0.002+	< 0.001	< 0.001	0	0	< 0.001	< 0.001
Ni	0.067	< 0.02	0.049	0	< 0.01*	< 0.01*	0.043	< 0.02	0.029	0	< 0.001	< 0.01
Zn	0.131	0.14	0.003	0	0.021*	--	--	0.006	0.005	0.003	< 0.005	< 0.005
B	--	< 0.001	--	0	--	< 0.01	--	< 0.001	--	0	--	< 0.01
Cr	0.009	< 0.005	0.005	0	< 0.01	< 0.01	0.006	< 0.005	0.003	0	< 0.01	< 0.01
Fe	0.418	0.29	0.013	0	0.27*	0.24	0.060	0.04	0.005	0.02	0.06	0.05
Mg	0.73	0.80	0.05	0	0.47*	0.47*	0.90	1.00	0	0	0.96	0.96
Mn	0.293	0.32	0.010	0	0.03*	0.03*	0.009	0.01	0.008	0.02	< 0.01	< 0.01
Mo	0.005	0.005	0.003	0	< 0.01	< 0.01	0.004	< 0.005	0.002	0	< 0.01	< 0.01
Al	0.047	< 0.05	0.024	0	0.02	< 0.02	< 0.06	< 0.05	0	0	0.05	0.02
Co	0.006	< 0.005	0.004	0	< 0.10	< 0.10	0.005	< 0.005	0.003	0	< 0.10	< 0.10
Ba	--	0.008	--	0	--	< 0.01	--	0.01	--	0	--	0.01
V	0.01	< 0.01	0.007	0	< 0.01	< 0.01	0.007	< 0.01	0.002	0	< 0.01	< 0.01
Ca	6.33	7.17	0.19	0.06	4.46	4.46*	4.6	5.13	0	0.06	5.70	5.47

* less than EPS results
+ greater than EPS results

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