An Investigation of
THE RECOVERY OF COPPER, NICKEL and PG METALS
from ROBY ZONE project samples
submitted by
LAC des ILES MINES LTD.

Progress Report No. 1

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LAKEFIELD RESEARCH
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INTRODUCTION

This report presents testwork conducted from February to June, 1992, on Composite M92 and a Roby Zone composite prepared from drill chips submitted by Lac des Iles Mines Ltd. This testwork investigated recovery of platinum group metals in copper - nickel flotation concentrates.

The test program was discussed regularly with Mr. R.F. Down, consultant and Mr. G.R. Clark, Lac des Iles Mines.

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SUMMARY

1.0 Description of Samples

Approximately 200 kilograms of Roby Zone sample were blended and crushed to nominal minus 10 mesh. A head sample was removed, 80 kilograms was riffled into 2 kilogram charges for testwork and the remainder was stored. All samples were stored at minus 5° C. The assay heads, presented in Table 1, were lower grade than desired for the test program. The sample was reserved for possible Bond Grindability testwork. Sixteen additional samples were received, individually crushed and sampled for analysis. The individual assays are presented in the Sample Preparation section. Twelve of the sixteen bags, as indicated in the Sample Preparation, were blended as Composite M92 for testwork.

Table 1: Head Analyses

Sample	Assays, %, g/t									
	Cu	Ni	Au	Pt	Pd	As	S	Fe_t	Fe_{py}	Fe_{po}
Roby	0.16	0.16	0.30	0.29	2.40	<0.001	0.59	4.61	0.58	0.73
M92	0.18	0.24	0.42	0.59	9.87	<0.001	1.03	7.91	1.18	1.04

Standard Bond Ball Mill Grindability tests are summarized in Table 2.

Table 2: Bond Grindability Tests

Sample	Mesh of Grind	Feed k80, microns	Product k80, microns	Bond Work Index, metric
Roby	150	1328	78	18.6
M92	150	1053	75	15.3

2. Rougher Flotation Circuit

The effect of primary grind fineness, circuit pH, collector and frother selection, sodium sulphide addition level and reagent addition point were investigated in rougher flotation tests. Flash flotation was simulated in two tests.

2.1 Primary Grind

Flotation response was compared for mill discharge ranging from 40% passing 200 mesh to 97% minus 200 mesh. The results are presented in Table 3.

Table 3: Primary Grind

Test % Pass 200 mesh	Product	Wt %	Assays, %, g/t						% Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
2 47	Ro Conc 1	4.4	5.60	6.12	131	2.10	2.32	12.3	44.9	46.5	55.5	41.7	54.4	60
	Ro Conc 1+2	11.0	2.78	3.12	65.0	1.11	1.11	6.67	55.2	58.9	68.1	55.0	64.5	82
	Scav Conc 1	3.6	0.84	1.17	18.8	0.34	0.24	1.47	5.4	7.2	6.4	5.4	4.5	6
	Sc Conc 1+2	6.5	0.65	0.90	14.2	0.28	0.20	1.01	7.6	10.0	8.8	8.2	6.9	7
	Comb Conc	17.6	1.98	2.30	46.1	0.80	0.77	4.57	62.8	69.0	76.9	63.2	71.3	89
	Scav Tail	82.4	0.25	0.22	2.95	0.10	0.066	0.12	37.2	31.0	23.1	36.8	28.7	11
	Head(calc)	-	0.55	0.58	10.5	0.22	0.19	0.90	-	-	-	-	-	-
1 61	Ro Conc 1	4.1	7.18	6.45	137	2.95	3.40	13.5	47.7	47.6	55.3	48.0	68.4	62
	Ro Conc 1+2	7.8	4.83	4.21	87.2	1.88	1.99	9.44	61.4	59.5	67.4	58.6	76.5	83
	Scav Conc 1	2.7	2.14	1.60	22.1	0.41	0.42	2.70	9.5	7.9	6.0	4.5	5.7	8
	Sc Conc 1+2	4.9	1.46	1.19	16.6	0.34	0.31	1.79	11.8	10.7	8.2	6.7	7.6	10
	Comb Conc	12.8	3.52	3.03	59.8	1.28	1.33	6.46	73.1	70.1	75.6	65.3	84.1	93
	Scav Tail	87.2	0.19	0.19	2.84	0.10	0.037	0.07	26.9	29.9	24.4	34.7	15.9	7
	Head(calc)	-	0.62	0.55	10.1	0.25	0.20	0.89	-	-	-	-	-	-
3 90	Ro Conc 1	6.5	6.03	5.44	114	1.86	2.18	11.2	67.2	64.9	73.4	52.8	78.6	78
	Ro Conc 1+2	11.9	3.60	3.35	68.5	1.16	1.28	7.26	73.5	73.3	81.0	60.3	84.9	92
	Scav Conc 1	3.7	0.40	0.55	8.93	0.21	0.11	0.61	2.5	3.7	3.2	3.3	2.2	2
	Sc Conc 1+2	7.2	0.36	0.45	7.15	0.19	0.097	0.43	4.4	6.0	5.1	5.8	3.9	3
	Comb Conc	19.2	2.37	2.25	45.3	0.79	0.84	4.68	77.9	79.3	86.1	66.2	88.8	96
	Scav Tail	80.8	0.16	0.14	1.74	0.096	0.025	0.05	22.1	20.7	13.9	33.8	11.2	4
	Head(calc)	-	0.58	0.55	10.1	0.23	0.18	0.94	-	-	-	-	-	-

Increasing the primary grind from 47 to 61% minus 200 mesh, improved the gold, platinum and palladium rougher grade - recovery relationship. Grinding to 90% minus 200 mesh improved recoveries as compared to recoveries from the 61% passing feed size.

Later in the test program, following definition of reagent requirements, the primary grind was examined again. The results are compared in Table 4.

Table 4: Different Primary Grinds with Cleaner Stages.

Test % Pass 200M	Product	Wt %	Assays, %, g/t					%Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
26	5th Cl Conc	3.5	10.2	9.26	181	2.62	3.27	57.7	54.5	60.7	42.1	66.8
59	4th Cl Conc	6.0	6.45	6.05	115	1.66	2.05	63.6	59.0	64.3	46.3	72.9
	3rd Cl Conc	7.7	5.29	5.08	94.8	1.38	1.67	66.6	62.6	67.8	49.3	76.0
	2nd Cl Conc	9.9	4.23	4.13	76.8	1.14	1.34	68.9	66.8	72.1	52.7	78.6
	1st Cl Conc	14.2	3.11	3.07	57.0	0.88	0.97	72.2	71.3	76.6	57.8	81.6
	Scav Conc	22.3	2.07	2.07	38.3	0.63	0.65	75.8	75.9	81.1	65.0	85.7
	Scav Tail	77.7	0.19	0.16	2.26	0.097	0.031	24.2	21.2	17.1	35.0	14.3
	Head(calc)	-	0.61	0.59	10.3	0.22	0.17	-	-	-	-	-
24	4th Cl Conc	9.0	4.28	4.71	91.0	1.27	1.55	71.5	74.0	76.5	53.7	80.1
68	3rd Cl Conc	10.6	3.78	4.12	79.4	1.12	1.34	74.3	76.0	78.6	55.8	81.6
	2nd Cl Conc	12.4	3.31	3.61	69.6	1.00	1.17	75.9	77.7	80.3	57.8	83.0
	1st Cl Conc	16.2	2.61	2.86	55.2	0.81	0.92	78.0	80.3	83.0	61.5	85.0
	Scav Conc	22.5	1.92	2.11	40.7	0.63	0.68	79.9	82.5	85.2	66.2	87.1
	Scav Tail	77.5	0.14	0.13	2.05	0.093	0.029	20.1	17.5	14.8	33.8	12.9
	Head(calc)	-	0.54	0.58	10.7	0.21	0.17	-	-	-	-	-
25	4th Cl Conc	5.8	7.13	7.61	136	1.94	2.37	70.5	70.1	74.1	50.4	79.4
86	3rd Cl Conc	7.2	5.89	6.35	113	1.63	1.96	72.6	72.9	76.9	52.7	81.8
	2nd Cl Conc	9.2	4.76	5.17	92.0	1.34	1.58	74.2	75.1	79.2	55.1	83.5
	1st Cl Conc	12.8	3.48	3.80	67.7	1.02	1.15	75.9	77.1	81.5	58.3	85.2
	Scav Conc	22.6	2.05	2.24	40.0	0.65	0.68	78.9	80.4	85.1	65.4	88.4
	Scav Tail	77.4	0.16	0.16	2.05	0.100	0.026	21.1	19.6	14.9	34.6	11.6
	Head(calc)	-	0.59	0.63	10.6	0.22	0.17	-	-	-	-	-

Comparison of the rougher concentrate recoveries for all six tests, in Figure 1, indicates a slight improvement in copper and palladium recoveries with primary grinds finer than 68% minus 200 mesh. A decrease in gold and platinum recoveries is noted.

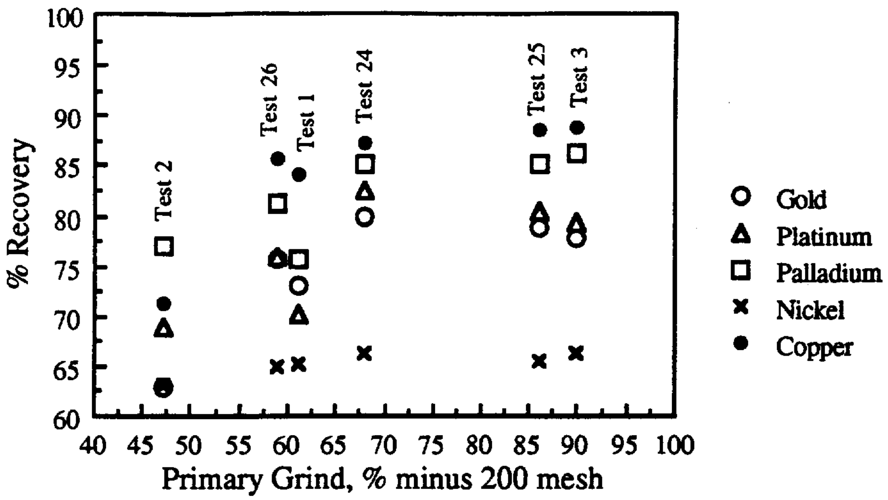


Figure 1: Rougher Recovery vs Flotation Feed Size

2.2 Rougher pH

Using Test 3, at pH 10 with Na_2CO_3 as a baseline, flotation was conducted at natural pH and at pH 6.5 with SO_2. Figures 2 and 3 illustrate the combined Cu+Ni and Platinum Group metal grade - recovery curves. The results are contained in Table 5.

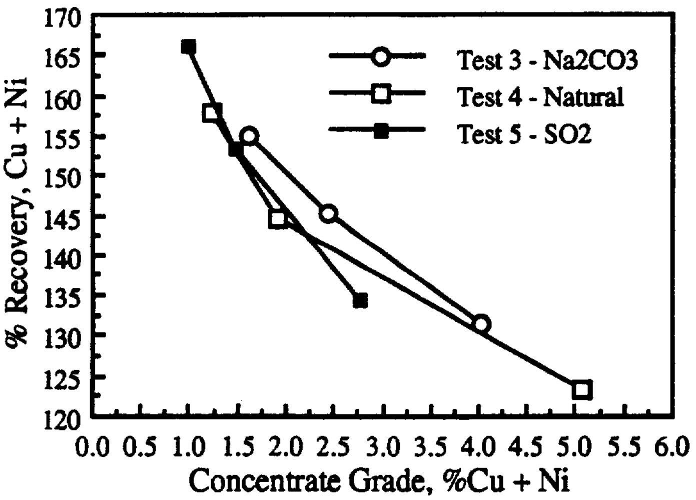


Figure 2: Effect of pH on Base Metal Flotation

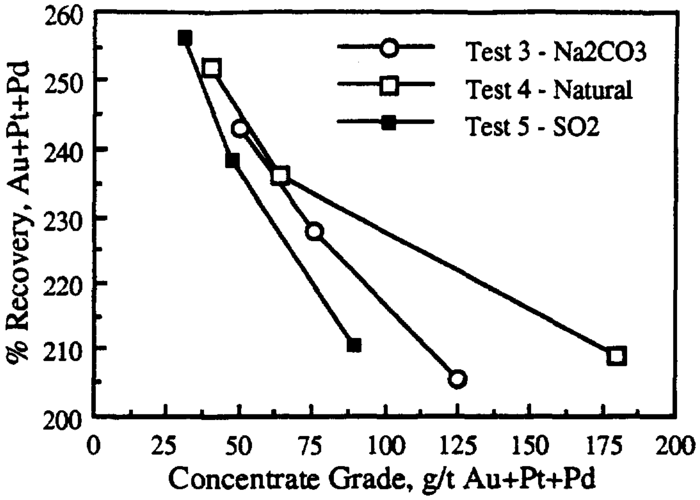


Figure 3: Effect of pH on Platinum Group Metals Flotation

Table 5: Rougher Scavenger pH

Test	Product	Wt	Assays, %, g/t						%Distribution					
pH		%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
3	Ro Conc 1	6.5	6.03	5.44	114	1.86	2.18	11.2	67.2	64.9	73.4	52.8	78.6	78
10	Ro Conc 1+2	11.9	3.60	3.35	68.5	1.16	1.28	7.26	73.5	73.3	81.0	60.3	84.9	92
with	Scav Conc 1	3.7	0.40	0.55	8.93	0.21	0.11	0.61	2.5	3.7	3.2	3.3	2.2	2
Na_2CO_3	Sc Conc 1+2	7.2	0.36	0.45	7.15	0.19	0.097	0.43	4.4	6.0	5.1	5.8	3.9	3
	Comb Conc	19.2	2.37	2.25	45.3	0.79	0.84	4.68	77.9	79.3	86.1	66.2	88.8	96
	Scav Tail	80.8	0.16	0.14	1.74	0.096	0.025	0.05	22.1	20.7	13.9	33.8	11.2	4
	Head(calc)	-	0.58	0.55	10.1	0.23	0.18	0.94	-	-	-	-	-	-
4	Ro Conc 1	5.0	7.27	7.54	165	2.35	2.73	12.8	67.4	66.9	74.7	49.5	73.9	69
8.5	Ro Conc 1+2	15.6	2.60	2.76	58.7	0.92	0.99	5.32	75.8	76.9	83.5	60.7	83.7	90
with-	Scav Conc 1	5.4	0.29	0.37	6.42	0.20	0.11	0.69	2.9	3.6	3.2	4.6	3.3	4
out	Sc Conc 1+2	10.7	0.25	0.31	5.29	0.18	0.092	0.48	4.9	5.9	5.2	8.0	5.4	6
soda	Comb Conc	26.2	1.64	1.76	37.0	0.62	0.62	3.35	80.7	82.8	88.6	68.7	89.1	96
ash	Scav Tail	73.8	0.14	0.13	1.69	0.100	0.027	0.05	19.3	17.2	11.4	31.3	10.9	4
	Head(calc)	-	0.53	0.56	10.9	0.24	0.18	0.92	-	-	-	-	-	-
5	Ro Conc 1	9.4	3.78	4.07	82.1	1.25	1.52	8.06	68.1	68.9	73.5	52.8	81.7	86
6.5	Ro Conc 1+2	20.0	1.99	2.18	43.7	0.71	0.78	4.17	76.5	78.7	83.2	64.2	89.0	94
with	Scav Conc 1	7.9	0.24	0.33	5.48	0.16	0.058	0.30	3.6	4.7	4.1	5.7	2.6	3
SO_2	Sc Conc 1+2	13.1	0.22	0.29	4.65	0.15	0.055	0.24	5.5	6.9	5.8	8.7	4.1	4
	Comb Conc	33.1	1.29	1.43	28.2	0.49	0.49	2.61	82.0	85.5	89.0	72.9	93.1	98
	Scav Tail	66.9	0.14	0.12	1.72	0.090	0.018	0.03	18.0	14.5	11.0	27.1	6.9	2
	Head(calc)	-	0.52	0.55	10.5	0.22	0.17	0.88	-	-	-	-	-	-

Soda ash seems to be of little benefit and SO_2 to pH 6.5 increased recoveries at the expense of concentrate grade. Weight recovery increased to 33%.

2.3 Collectors

Maintaining Test 3 as a baseline, collectors Aero 404 and Aero 3501 were substituted for Aerofloat 208. Potassium amyl xanthate was used as the primary collector in these tests. In Test 8, Aero 3501 was used as the auxiliary collector and sodium isopropyl xanthate replaced the potassium amyl xanthate. These results are summarized in Table 5A.

Table 5A: Auxiliary Collectors

Test Cltr. Chng.	Product	Wt %	Assays, %, g/t						%Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
3	Ro Conc 1	6.5	6.03	5.44	114	1.86	2.18	11.2	67.2	64.9	73.4	52.8	78.6	78
10	Ro Conc 1+2	11.9	3.60	3.35	68.5	1.16	1.28	7.26	73.5	73.3	81.0	60.3	84.9	92
with	Scav Conc 1	3.7	0.40	0.55	8.93	0.21	0.11	0.61	2.5	3.7	3.2	3.3	2.2	2
10g/t	Sc Conc 1+2	7.2	0.36	0.45	7.15	0.19	0.097	0.43	4.4	6.0	5.1	5.8	3.9	3
R208	Comb Conc	19.2	2.37	2.25	45.3	0.79	0.84	4.68	77.9	79.3	86.1	66.2	88.8	96
	Scav Tail	80.8	0.16	0.14	1.74	0.096	0.025	0.05	22.1	20.7	13.9	33.8	11.2	4
	Head(calc)	-	0.58	0.55	10.1	0.23	0.18	0.94	-	-	-	-	-	-
6	Ro Conc 1	6.7	5.73	5.64	119	1.74	2.10	9.89	70.8	68.2	74.6	48.2	76.0	73
with	Ro Conc 1+2	14.5	2.92	2.96	61.1	0.97	1.06	5.75	78.5	77.9	83.3	58.3	83.3	92
10	Scav Conc 1	4.5	0.28	0.40	6.78	0.20	0.085	0.46	2.3	3.2	2.9	3.7	2.1	2
g/t	Sc Conc 1+2	8.6	0.28	0.34	5.63	0.18	0.080	0.34	4.4	5.3	4.6	6.5	3.7	3
404	Comb Conc	23.1	1.93	1.98	40.4	0.67	0.69	3.73	82.9	83.2	87.9	64.8	87.0	96
	Scav Tail	76.9	0.12	0.12	1.67	0.11	0.031	0.05	17.1	16.8	12.1	35.2	13.0	4
	Head(calc)	-	0.54	0.55	10.6	0.24	0.18	0.90	-	-	-	-	-	-
7	Ro Conc 1	6.5	6.15	5.86	120	1.82	2.18	10.0	72.4	68.0	74.3	49.0	78.9	75
with	Ro Conc 1+2	16.3	2.73	2.69	54.1	0.93	0.96	4.99	80.8	78.5	84.3	62.9	87.2	94
10	Scav Conc 1	5.3	0.27	0.37	5.89	0.17	0.088	0.33	2.6	3.5	3.0	3.8	2.6	2
g/t	Sc Conc 1+2	9.3	0.25	0.33	5.12	0.17	0.078	0.28	4.3	5.5	4.6	6.4	4.1	3
3501	Comb Conc	25.6	1.83	1.83	36.2	0.65	0.64	3.28	85.1	84.0	88.8	69.3	91.3	97
	Scav Tail	74.4	0.11	0.12	1.57	0.099	0.021	0.04	14.9	16.0	11.2	30.7	8.7	3
	Head(calc)	-	0.55	0.56	10.4	0.24	0.18	0.87	-	-	-	-	-	-
8	Ro Conc 1	9.2	4.39	4.60	91.2	1.33	1.55	7.96	72.0	74.6	77.4	53.3	80.2	82
with	Ro Conc 1+2	19.1	2.36	2.45	48.1	0.75	0.80	4.40	80.7	82.8	85.1	62.8	86.4	94
250	Scav Conc 1	6.5	0.25	0.30	5.03	0.16	0.075	0.28	2.9	3.5	3.0	4.6	2.8	2
g/t	Sc Conc 1+2	10.3	0.22	0.26	4.37	0.15	0.069	0.23	4.1	4.7	4.2	6.9	4.1	3
SIPX	Comb Conc	29.4	1.61	1.68	32.8	0.54	0.54	2.94	84.8	87.5	89.3	69.7	90.4	97
	Scav Tail	70.6	0.12	0.10	1.63	0.098	0.024	0.04	15.2	12.5	10.7	30.3	9.6	3
	Head(calc)	-	0.56	0.56	10.8	0.23	0.18	0.89	-	-	-	-	-	-

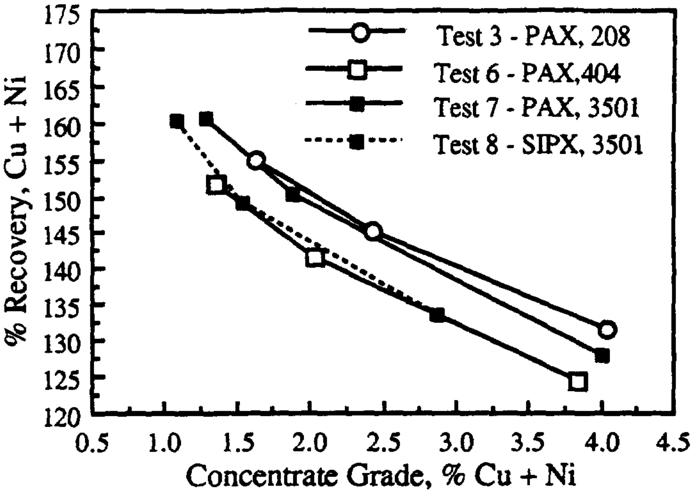


Figure 4: Effect of Collector Type on Base Metal Flotation

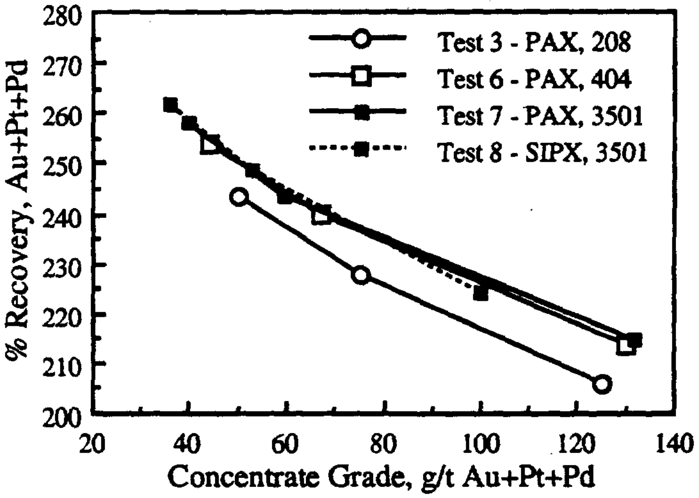


Figure 5: Effect of Collector on Platinum Group Metals Flotation

Figures 4 and 5 show potassium amyl xanthate with 3501 or 208 gave similar copper plus nickel grades and recoveries but the 3501 improved combined platinum group metal recovery.

In another collector series, the Na_2S was reduced from 375 g/t to 175 g/t, potassium amyl xanthate was used as the primary collector with auxiliary collectors Aerofloat 208, Aero 3501 and Aero 3477. The results are presented in Table 5B and Figures 6 and 7.

Table 5B: Collectors at 175 g/t Na_2S

Test		Wt	Assays, %, g/t						%Distribution					
Coll	Product	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
12 PAX, 208	Ro Conc 1	7.0	6.19	5.30	111	1.68	1.99	9.88	75.2	67.9	73.9	50.2	78.6	78
	Ro Conc 1+2	15.6	3.02	2.71	55.8	0.91	0.97	5.33	82.1	77.7	83.2	60.6	85.9	94
	Scav Conc 1	5.3	0.24	0.40	7.02	0.20	0.084	0.47	2.2	3.9	3.5	4.5	2.5	3
	Sc Conc 1+2	9.4	0.21	0.33	5.64	0.18	0.073	0.34	3.5	5.7	5.1	7.2	3.9	4
	Comb Conc	25.0	1.96	1.82	36.9	0.63	0.63	3.45	85.6	83.4	88.2	67.8	89.8	98
	Scav Tail	75.0	0.11	0.12	1.64	0.10	0.024	0.03	14.4	16.6	11.8	32.2	10.2	3
	Head(calc)	-	0.57	0.54	10.5	0.23	0.18	0.88	-	-	-	-	-	-
15 PAX, 3501	Ro Conc 1	9.6	4.72	4.90	88.3	1.32	1.58	-	72.5	74.2	76.9	55.2	81.4	-
	Ro Conc 1+2	19.5	2.52	2.68	47.9	0.76	0.84	-	79.1	82.8	85.1	64.8	87.8	-
	Scav Conc 1	8.0	0.25	0.32	5.09	0.16	0.075	-	3.2	4.1	3.7	5.6	3.2	-
	Sc Conc 1+2	12.6	0.39	0.27	4.35	0.15	0.067	-	7.8	5.4	5.0	8.2	4.5	-
	Comb Conc	32.1	1.69	1.74	30.8	0.52	0.53	-	86.9	88.2	90.1	73.0	92.3	-
	Scav Tail	67.9	0.12	0.11	1.61	0.091	0.021	-	13.1	11.8	9.9	27.0	7.7	-
	Head(calc)	-	0.62	0.63	11.0	0.23	0.19	-	-	-	-	-	-	-
16 PAX, 3477	Ro Conc 1	9.5	5.47	4.86	86.0	1.30	1.54	-	75.8	73.0	76.2	54.6	81.6	-
	Ro Conc 1+2	19.5	2.86	2.62	46.0	0.74	0.80	-	81.5	80.9	83.9	63.9	87.2	-
	Scav Conc 1	6.7	0.23	0.32	5.32	0.16	0.068	-	2.2	3.4	3.3	4.7	2.5	-
	Sc Conc 1+2	10.9	0.21	0.28	4.63	0.16	0.063	-	3.3	4.8	4.7	7.5	3.8	-
	Comb Conc	30.5	1.91	1.78	31.2	0.53	0.54	-	84.8	85.7	88.6	71.4	91.1	-
	Scav Tail	69.5	0.15	0.13	1.75	0.093	0.023	-	15.2	14.3	11.4	28.6	8.9	-
	Head(calc)	-	0.69	0.63	10.7	0.23	0.18	-	-	-	-	-	-	-

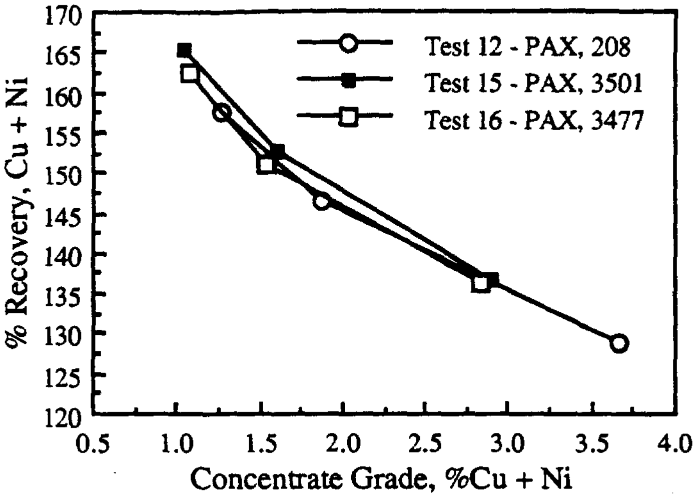


Figure 6: Effect of Collector at Reduced Na_2S Levels on Base Metal Flotation

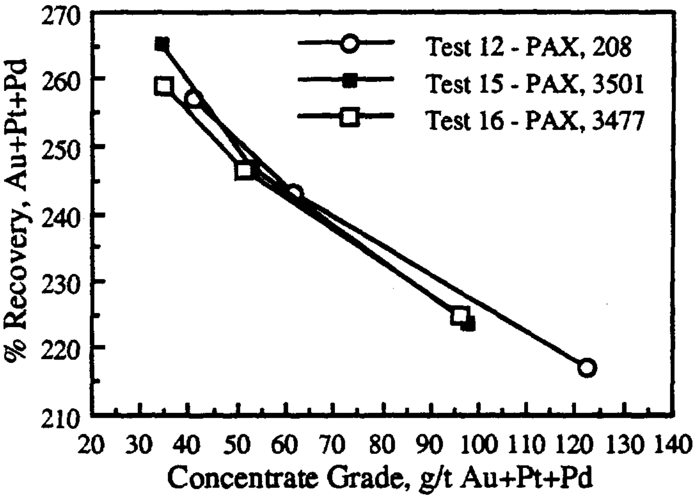


Figure 7: Effect of Collector at Reduced Na_2S Levels on Platinum Group Metals Flotation

The auxiliary collectors tested had little affect at the reduced Na_2S level.

2.4 Na_2S Addition

The level of Na_2S added to the primary grind was varied from 0 to 375 g/t. Figures 8 and 9 illustrate the combined grades and recoveries outlined in Table 7.

Table 7: Na_2S Addition

Test		Wt			Assays, %, g/t				%Distribution					
Na_2S	Product	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
3	Ro Conc 1	6.5	6.03	5.44	114	1.86	2.18	11.2	67.2	64.9	73.4	52.8	78.6	78
10	Ro Conc 1+2	11.9	3.60	3.35	68.5	1.16	1.28	7.26	73.5	73.3	81.0	60.3	84.9	92
with	Scav Conc 1	3.7	0.40	0.55	8.93	0.21	0.11	0.61	2.5	3.7	3.2	3.3	2.2	2
375g/t	Sc Conc 1+2	7.2	0.36	0.45	7.15	0.19	0.097	0.43	4.4	6.0	5.1	5.8	3.9	3
Na_2S	Comb Conc	19.2	2.37	2.25	45.3	0.79	0.84	4.68	77.9	79.3	86.1	66.2	88.8	96
	Scav Tail	80.8	0.16	0.14	1.74	0.096	0.025	0.05	22.1	20.7	13.9	33.8	11.2	4
	Head(calc)	-	0.58	0.55	10.1	0.23	0.18	0.94	-	-	-	-	-	-
12	Ro Conc 1	7.0	6.19	5.30	111	1.68	1.99	9.88	75.2	67.9	73.9	50.2	78.6	78
with	Ro Conc 1+2	15.6	3.02	2.71	55.8	0.91	0.97	5.33	82.1	77.7	83.2	60.6	85.9	94
175g/t	Scav Conc 1	5.3	0.24	0.40	7.02	0.20	0.084	0.47	2.2	3.9	3.5	4.5	2.5	3
Na_2S	Sc Conc 1+2	9.4	0.21	0.33	5.64	0.18	0.073	0.34	3.5	5.7	5.1	7.2	3.9	4
	Comb Conc	25.0	1.96	1.82	36.9	0.63	0.63	3.45	85.6	83.4	88.2	67.8	89.8	98
	Scav Tail	75.0	0.11	0.12	1.64	0.10	0.024	0.03	14.4	16.6	11.8	32.2	10.2	3
	Head(calc)	-	0.57	0.54	10.5	0.23	0.18	0.88	-	-	-	-	-	-
11	Ro Conc 1	6.0	6.51	6.08	123	1.81	2.28	10.7	69.9	64.4	70.2	47.2	78.6	73
with-	Ro Conc 1+2	13.9	3.13	3.06	61.5	0.97	1.08	5.84	78.0	75.0	81.3	58.9	85.8	93
out	Scav Conc 1	4.9	0.27	0.43	7.64	0.21	0.087	0.49	2.4	3.7	3.6	4.5	2.5	3
Na_2S	Sc Conc 1+2	8.8	0.26	0.38	6.45	0.20	0.079	0.38	4.0	5.9	5.4	7.5	4.0	4
	Comb Conc	22.7	2.02	2.02	40.1	0.67	0.69	3.73	82.0	80.9	86.7	66.4	89.8	97
	Scav Tail	77.3	0.13	0.14	1.81	0.10	0.023	0.04	18.0	19.1	13.3	33.6	10.2	3
	Head(calc)	-	0.56	0.57	10.5	0.23	0.17	0.88	-	-	-	-	-	-

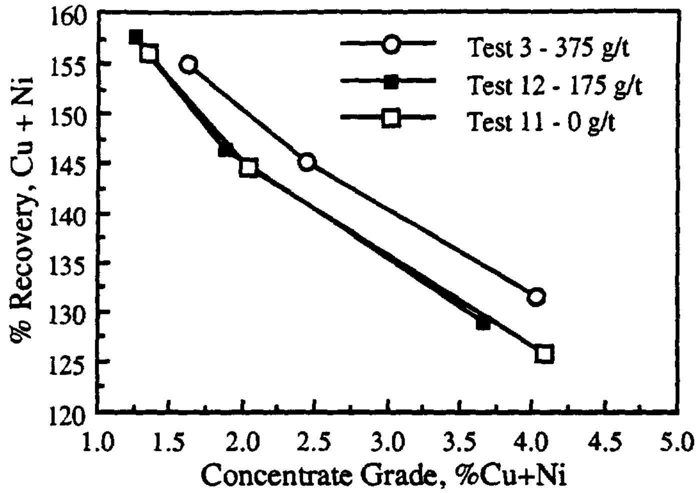


Figure 8: Effect of Na2S on Base Metal Flotation

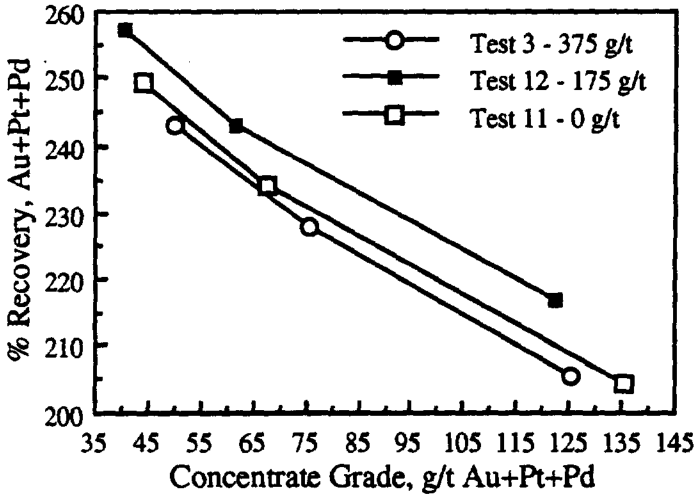


Figure 9: Effect of Na2S on Platinum Group Metals Flotation

Additions of Na_2S may be beneficial to metal recoveries. More testwork would be required to determine the optimum amount.

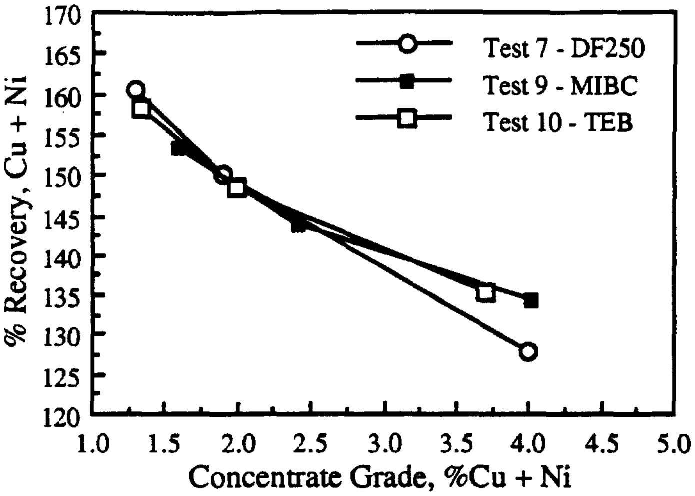


Figure 10: Effect of Frother on Base Metal Flotation

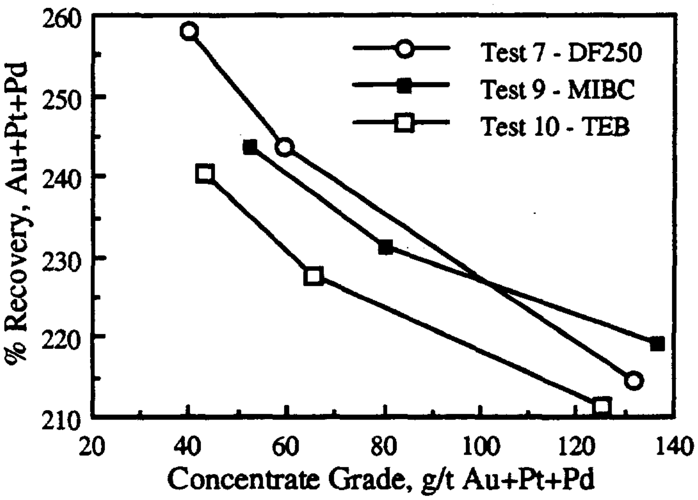


Figure 11: Effect of Frother on Platinum Group Metals Flotation

Frother selection did not affect base metal flotation. Both MIBC and DF250 improved PGM recoveries.

2.6 Gravity - Flotation

In Test 13 Composite M92 was ground and passed across the 1/8 size Wilfley Table. The table concentrate was upgraded on a Mozley Mineral Separator. Using the reagent balance derived from the testwork to date, a flotation test was conducted on fresh mill discharge (Test 14) and on the gravity tail. The results are contained in Table 9.

Table 9: Gravity Flotation

Test	Product	Wt %	Assays, %, g/t						%Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
14	Ro Conc 1	12.6	3.79	3.13	64.6	1.01	1.11	6.08	76.2	71.7	76.4	55.5	78.3	87
	Ro Conc 1+2	21.1	2.42	2.09	42.0	0.69	0.72	3.95	81.4	80.1	83.3	63.7	85.0	94
	Scav Conc 1	7.7	0.26	0.32	5.65	0.17	0.081	0.37	3.2	4.5	4.1	5.7	3.5	3
	Sc Conc 1+2	11.8	0.25	0.30	5.28	0.17	0.079	0.31	4.7	6.5	5.8	8.6	5.2	4
	Comb Conc	32.9	1.64	1.45	28.9	0.50	0.49	2.64	86.1	86.6	89.1	72.2	90.2	99
	Scav Tail	67.1	0.13	0.11	1.73	0.095	0.026	0.02	13.9	13.4	10.9	27.8	9.8	2
	Head(calc)	-	0.63	0.55	10.7	0.23	0.18	0.88	-	-	-	-	-	-
13 Grav/ Flot.	Mozley Conc	0.2	74.1	20.5	402	-	-	-	27.2	8.7	9.0	-	-	-
	Ro Conc 1+2	24.0	1.54	1.72	34.3	0.58	0.63	-	55.9	71.9	75.6	64.7	86.2	-
	Sc Conc 1+2	13.8	0.23	0.27	4.52	0.15	0.072	-	4.8	6.5	5.7	9.3	5.7	-
	Comb Ro/Sc	37.8	1.06	1.19	23.4	0.42	0.43	-	60.7	78.4	81.4	74.1	91.9	-
	Comb Conc	38.0	1.53	1.31	25.8	-	-	-	87.8	87.0	90.3	-	-	-
	Scav Tail	62.0	0.13	0.12	1.70	0.090	0.023	-	12.2	13.0	9.7	25.9	8.1	-
	Head(calc)	-	0.66	0.57	10.9	0.21	0.18	-	-	-	-	-	-	

The overall results were similar. A Mozley concentrate was produced which assayed 74 g/t Au, 20 g/t Pt and 402 g/t Pd. Recoveries to this concentrate were 27%, 8.7% and 9%, respectively.

2.7 Point of Reagent Addition

When the CMC is added to the rougher conditioner the pulp is very viscous and poorly dispersed. Excessive amounts of liberated gangue are entrained in the froth. Adding the CMC to the last 5 minutes of the primary grind improved the pulp dispersion. The PAX dosage was reduced by 100 g/t and the flotation time extended to recover a cleaner rougher

concentrate but recoveries were much lower. Adding the CMC to the grind, but omitting the Na_2CO_3 from the circuit, improved recoveries but they remain lower than Test 24 where CMC is added to the conditioner. The results are condensed in Table 10.

Table 10: Point of Reagent Addition

Test Add	Product	Wt %	Assays, %, g/t					%Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
24 Ro Cond	Scav Conc	22.5	1.92	2.11	40.7	0.63	0.68	79.9	82.5	85.2	66.2	87.1
	Scav Tail	77.5	0.14	0.13	2.05	0.093	0.029	20.1	17.5	14.8	33.8	12.9
	Head(calc)	-	0.54	0.58	10.7	0.21	0.17	-	-	-	-	-
28 PG	Scav Conc	9.6	4.00	3.89	74.4	1.20	1.30	64.0	69.8	74.5	53.7	78.6
	Scav Tail	90.4	0.24	0.18	2.72	0.11	0.038	36.0	30.2	25.5	46.3	21.4
	Head(calc)	-	0.60	0.54	9.63	0.21	0.16	-	-	-	-	-
29 PG No Na_2CO_3	Scav Conc	16.2	2.42	2.60	52.8	0.85	0.88	74.0	75.2	82.3	59.9	85.5
	Scav Tail	83.8	0.17	0.17	2.20	0.11	0.029	26.0	24.8	17.7	40.1	14.5
	Head(calc)	-	0.53	0.56	10.4	0.23	0.17	-	-	-	-	-

A polished thin section was prepared from Test 28 scavenger tailing to determine the nature of the nickel minerals remaining. All non - opaque minerals present were as inclusions in silicate particles ranging in size from 15 micrometres to less than 4 micrometres. At least 50% of the nickel is likely to be present in a silicate mineral - either serpentine or chlorite. Chlorite is present in the tailing; electron probe analysis would be required to prove the presence of nickel in chlorite. The complete report is contained in Appendix 2.

2.8 Flash Flotation

Two tests were performed to simulate flash flotation. The minus 10 mesh feed was ground for 5 minutes in Test 34 and 2 minutes in Test 35, Flash Conc 1 was floated with 50 g/t PAX and 25 g/t Aero 3501. The tailings were ground for 10 and 5 minutes respectively, and a second flotation stage performed with 100 g/t PAX and 50 g/t Aero 3501. This tailing was ground for 10 and 5 minutes respectively and floated for 30 minutes with staged collector additions. CMC was added to all grinds in Test 35. The results are summarized in Table 11.

Table 11: Flash Flotation

Test	Product	Wt	Assays, %, g/t					%Distribution				
		%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
34	Flash 1	2.4	9.24	7.17	169	1.93	3.00	35.0	26.8	35.5	19.9	42.7
M92	Flash 1+2	9.1	4.50	4.13	86.5	1.24	1.35	65.1	59.0	69.5	49.0	73.6
	Scav Conc	20.0	2.56	2.56	49.5	0.76	0.76	81.0	79.9	86.9	65.5	90.5
	Scav Tail	80.0	0.15	0.16	1.86	0.10	0.020	19.0	20.1	13.1	34.5	9.5
	Head(calc)	-	0.63	0.64	11.4	0.23	0.17	-	-	-	-	-
35	Flash 1	2.9	6.45	5.98	141	1.87	2.53	28.1	28.3	36.6	23.9	43.3
M92	Flash 1+2	4.8	6.98	5.49	122	1.69	2.08	51.6	44.0	53.9	36.7	60.4
	Scav Conc	20.1	2.46	2.28	45.1	0.71	0.72	75.6	76.2	82.7	64.1	87.0
	Scav Tail	79.9	0.20	0.18	2.38	0.10	0.027	24.4	23.8	17.3	35.9	13.0
	Head(calc)	-	0.65	0.60	11.0	0.22	0.17	-	-	-	-	-

Overall grades and recoveries are similar to previous tests. Earlier staged rougher floats indicated 70 to 80% of the PGM minerals, 50% of the nickel and 80 to 85% of the copper are recovered in the first 3 to 5 minutes flotation. It would be difficult to determine, on a laboratory scale if flash flotation would be beneficial and if a final grade concentrate could be produced.

3.0 Cleaner Flotation Circuit

The rougher conditions were held constant while the effect of regrind fineness and depressant selection were investigated.

3.1 Regrind

The effect of fineness of cleaner circuit feed size is compared in Table 12 and Figures 12 and 13.

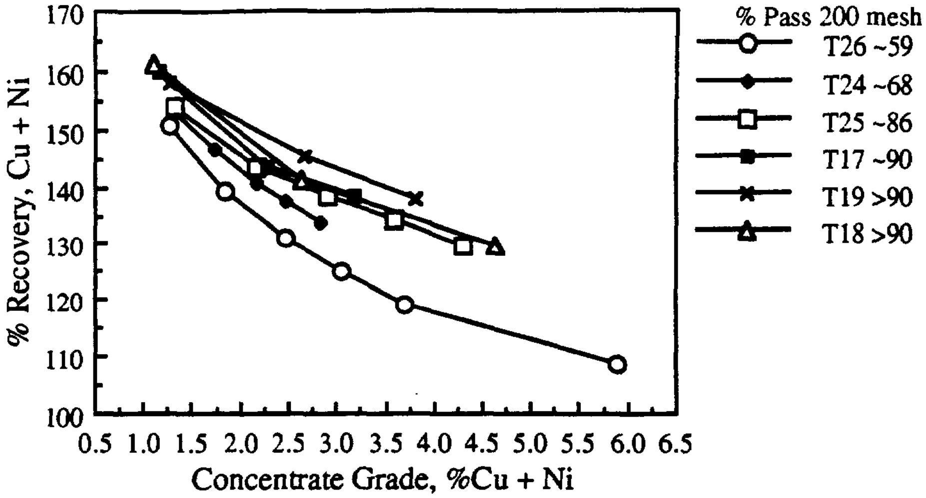


Figure 12: Effect of Regrind Fineness on Base Metal Flotation

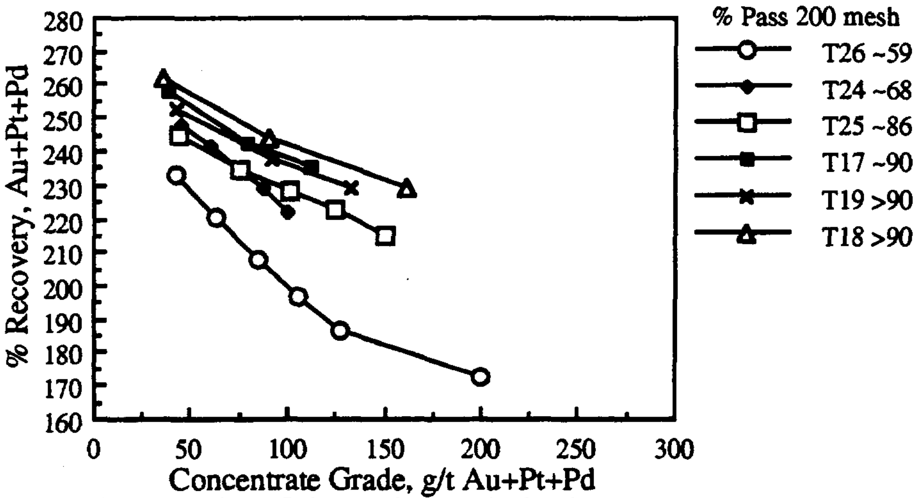


Figure 13: Effect of Regrind Fineness on Platinum Group Metals Flotation

Table 12: Regrind Times

Test Reg	Product	Wt %	Assays, %, g/t					%Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
26 59PG No Reg	5th Cl Conc	3.5	10.2	9.26	181	2.62	3.27	57.7	54.5	60.7	42.1	66.8
	4th Cl Conc	6.0	6.45	6.05	115	1.66	2.05	63.6	59.0	64.3	46.3	72.9
	3rd Cl Conc	7.7	5.29	5.08	94.8	1.38	1.67	66.6	62.6	67.8	49.3	76.0
	2nd Cl Conc	9.9	4.23	4.13	76.8	1.14	1.34	68.9	66.8	72.1	52.7	78.6
	1st Cl Conc	14.2	3.11	3.07	57.0	0.88	0.97	72.2	71.3	76.6	57.8	81.6
	Scav Conc	22.3	2.07	2.07	38.3	0.63	0.65	75.8	75.9	81.1	65.0	85.7
	Scav Tail	77.7	0.19	0.16	2.26	0.097	0.031	24.2	21.2	17.1	35.0	14.3
	Head(calc)	-	0.61	0.59	10.3	0.22	0.17	-	-	-	-	-
24 68PG No Reg	4th Cl Conc	9.0	4.28	4.71	91.0	1.27	1.55	71.5	74.0	76.5	53.7	80.1
	3rd Cl Conc	10.6	3.78	4.12	79.4	1.12	1.34	74.3	76.0	78.6	55.8	81.6
	2nd Cl Conc	12.4	3.31	3.61	69.6	1.00	1.17	75.9	77.7	80.3	57.8	83.0
	1st Cl Conc	16.2	2.61	2.86	55.2	0.81	0.92	78.0	80.3	83.0	61.5	85.0
	Scav Conc	22.5	1.92	2.11	40.7	0.63	0.68	79.9	82.5	85.2	66.2	87.1
	Scav Tail	77.5	0.14	0.13	2.05	0.093	0.029	20.1	17.5	14.8	33.8	12.9
	Head(calc)	-	0.54	0.58	10.7	0.21	0.17	-	-	-	-	-
25 86 No Reg	4th Cl Conc	5.8	7.13	7.61	136	1.94	2.37	70.5	70.1	74.1	50.4	79.4
	3rd Cl Conc	7.2	5.89	6.35	113	1.63	1.96	72.6	72.9	76.9	52.7	81.8
	2nd Cl Conc	9.2	4.76	5.17	92.0	1.34	1.58	74.2	75.1	79.2	55.1	83.5
	1st Cl Conc	12.8	3.48	3.80	67.7	1.02	1.15	75.9	77.1	81.5	58.3	85.2
	Scav Conc	22.6	2.05	2.24	40.0	0.65	0.68	78.9	80.4	85.1	65.4	88.4
	Scav Tail	77.4	0.16	0.16	2.05	0.10	0.026	21.1	19.6	14.9	34.6	11.6
	Head(calc)	-	0.59	0.63	10.6	0.22	0.17	-	-	-	-	-
17 90PG No Reg	2nd Cl Conc	8.6	4.71	5.31	102	1.43	1.76	77.8	76.9	80.7	54.0	84.5
	1st Cl Conc	12.5	3.35	3.78	72.5	1.05	1.24	79.8	79.1	83.1	57.4	86.2
	Scav Conc	27.8	1.60	1.81	34.7	0.57	0.59	84.8	84.3	88.7	68.8	91.2
	Scav Tail	72.2	0.11	0.13	1.70	0.099	0.022	15.2	15.7	11.3	31.2	8.8
	Head(calc)	-	0.52	0.60	10.9	0.23	0.18	-	-	-	-	-
19 90PG 20 Min. Reg	2nd Cl Conc	7.1	6.91	6.35	120	1.70	2.11	76.2	75.2	77.7	53.4	84.7
	1st Cl Conc	10.8	4.66	4.36	83.2	1.23	1.43	77.9	78.3	81.7	58.4	87.0
	Scav Conc	24.7	2.15	2.03	38.5	0.61	0.65	82.5	83.7	86.7	67.0	91.1
	Scav Tail	75.3	0.15	0.13	1.93	0.099	0.021	17.5	16.3	13.3	33.0	8.9
	Head(calc)	-	0.64	0.60	11.0	0.23	0.18	-	-	-	-	-
18 90PG 40 Min. Reg	2nd Cl Conc	5.4	8.89	8.12	145	2.03	2.62	77.3	75.6	76.0	48.3	81.5
	1st Cl Conc	10.3	4.81	4.51	81.1	1.21	1.43	80.8	81.2	82.1	55.6	85.8
	Scav Conc	28.8	1.81	1.75	31.6	0.54	0.55	85.0	87.6	89.1	69.6	91.7
	Scav Tail	71.2	0.13	0.10	1.56	0.096	0.020	15.0	12.4	10.9	30.4	8.3
	Head(calc)	-	0.62	0.57	10.2	0.22	0.17	-	-	-	-	-

Although there are differences in the primary grind fineness in this series of tests, the results indicate that the metals recovery increases with finer cleaner circuit feed size up to approximately 85% minus 200 mesh.

3.2 Depressants

To determine the effect of various depressants, the roughers were floated without depressant, followed by cleaning using Aqualon's CMC-T, Ogilive's WC9524, Aqualon's PA MED or a SO_2/Jaguar MDD depressant system. Table 13 presents the results.

Table 13: Depressants in Cleaner Stages Only

Test Dep	Product	Wt %	Assays, %, g/t					%Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
20 CMC (in Cl'ng only)	2nd Cl Conc	10.6	4.13	4.19	78.0	1.18	1.37	78.2	78.7	80.9	55.6	84.3
	1st Cl Conc	16.1	2.80	2.88	53.7	0.85	0.93	80.7	82.2	84.8	61.0	87.2
	Scav Conc	27.4	1.72	1.76	32.8	0.56	0.57	84.4	85.8	88.3	68.6	90.3
	Scav Tail	72.6	0.12	0.11	1.64	0.097	0.023	15.6	14.2	11.7	31.4	9.7
	Head(calc)	-	0.56	0.56	10.2	0.22	0.17	-	-	-	-	-
21 WC 9524	4th Cl Conc	5.2	9.30	8.00	150	2.18	2.74	74.1	68.0	73.8	50.5	77.1
	3rd Cl Conc	7.1	7.07	6.21	116	1.70	2.10	76.8	71.9	77.5	53.7	80.6
	2nd Cl Conc	10.8	4.86	4.34	80.8	1.22	1.46	79.7	76.0	81.8	58.4	84.5
	1st Cl Conc	16.4	3.29	2.97	55.1	0.87	0.99	82.0	78.8	84.8	62.8	86.9
	Scav Conc	29.4	1.90	1.73	32.1	0.54	0.57	84.9	82.8	88.6	70.9	90.5
	Scav Tail	70.6	0.14	0.15	1.71	0.093	0.025	15.1	17.2	11.4	29.1	9.5
	Head(calc)	-	0.66	0.62	10.6	0.23	0.19	-	-	-	-	-
22 PA MED	4th Cl Conc	4.3	9.24	9.32	171	2.56	3.12	69.7	69.8	71.3	48.0	77.0
	3rd Cl Conc	5.7	7.23	7.31	134	2.01	2.42	72.6	72.8	74.2	50.1	79.5
	2nd Cl Conc	8.1	5.26	5.36	98.4	1.50	1.76	74.8	75.7	77.3	53.1	81.8
	1st Cl Conc	14.0	3.21	3.29	61.0	0.97	1.07	78.9	80.1	82.7	59.2	85.9
	Scav Conc	27.0	1.76	1.81	33.6	0.58	0.58	83.4	84.8	87.6	68.3	90.4
	Scav Tail	73.0	0.13	0.12	1.76	0.10	0.023	16.6	15.2	12.4	31.7	9.6
	Head(calc)	-	0.57	0.58	10.4	0.23	0.17	-	-	-	-	-
23 Jaguar MDD with SO_2	4th Cl Conc	1.9	14.5	13.4	257	3.55	4.26	44.9	43.5	45.7	29.7	47.2
	3rd Cl Conc	2.5	12.3	12.1	227	3.16	3.83	50.9	52.7	54.1	35.4	56.9
	2nd Cl Conc	3.7	9.29	9.45	176	2.47	2.98	56.4	60.2	61.3	40.6	64.8
	1st Cl Conc	7.5	5.23	5.43	101	1.48	1.72	64.6	70.2	71.9	49.4	75.8
	Scav Conc	26.8	1.70	1.84	34.5	0.57	0.57	74.7	84.9	87.3	67.4	90.5
	Scav Tail	73.2	0.21	0.12	1.84	0.10	0.022	25.3	15.1	12.7	32.6	9.5
	Head(calc)	-	0.61	0.58	10.6	0.22	0.17	-	-	-	-	-

There was very little difference between the two Aqualon carboxymethyl cellulose products and the wheat dextrin WC9524. The SO_2/guar system was not as effective.

The 4th cleaner concentrate from Test 23 was submitted for a NaOH fusion to isolate palladium for examination. Prior to fusion, vysotskite (Pd, Pt, Ni, S), kotulskite (Pd, Pt, Te, Bi) and braggite (Pd, Pt, Ni)S were identified in the concentrate. Unfortunately the fusion was not successful in isolating the PGE minerals. The full report is contained in Appendix 1.

3.3 Reverse Flotation

The rougher concentrate was reground and conditioned with 1625 g Na_2S /t of feed to depress the sulphides. The froth product was conditioned with another 813 g Na_2S/t of feed and recleaned. Complete depression of the sulphides was not achieved.

Table 14: Reverse Flotation

Test	Product	Wt %	Assays, %, g/t					%Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
31	2nd Cl Froth	1.7	10.7	10.0	229	2.80	2.72	35.6	30.1	37.9	21.3	27.3
	2nd Cl Cell	4.8	1.94	2.76	55.2	0.95	0.99	18.1	23.3	25.5	20.3	27.8
	1st Cl Froth	6.6	4.25	4.65	101	1.44	1.45	53.7	53.4	63.4	41.6	55.2
	1st Cl Cell	11.7	0.94	1.09	17.6	0.44	0.45	21.1	22.2	19.7	22.6	30.5
	Scav Froth	18.2	2.13	2.37	47.6	0.80	0.81	74.8	75.7	83.1	64.2	85.7
	Scav Cell	81.8	0.16	0.17	2.16	0.099	0.030	25.2	24.3	16.9	35.8	14.3
	Head(calc)	-	0.52	0.57	10.4	0.23	0.17	-	-	-	-	-

3.4 NaCl in Grind

Some Australian Cu Ni deposits have shown improved flotation response when floated in a brackish solution (site water) or in sodium chloride solution. In Test 26 the final cleaner was performed in a 10% NaCl solution. The froth appearance improved. A full test was conducted on each ore type where the primary grind was performed in a NaCl solution. The CMC and Na_2CO_3 were both omitted from the reagent balances. The results are compared with tests using CMC in the primary grind. The results are presented in Table 15.

Table 15: Effect of NaCl

		Wt	Assays, %, g/t						%Distribution					
Test	Product	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
30	4th Cl Conc	0.8	20.3	18.7	163	7.27	11.0	-	52.9	51.3	58.5	44.3	67.6	-
	3rd Cl Conc	0.9	19.1	17.7	154	6.91	10.3	-	53.8	52.6	59.7	45.6	68.3	-
	2nd Cl Conc	1.0	16.6	15.5	135	6.12	8.91	-	54.4	53.7	60.9	46.9	68.9	-
	1st Cl Conc	2.3	7.60	7.19	62.1	2.90	3.99	-	56.6	56.5	63.7	50.5	70.3	-
Roby	Scav Conc	7.8	2.56	2.47	21.0	1.03	1.26	-	64.5	65.7	72.7	60.5	74.9	-
Zone	Scav Tail	92.2	0.12	0.11	0.67	0.057	0.036	-	35.5	34.3	27.3	39.5	25.1	-
	Head(calc)	-	0.31	0.30	2.26	0.13	0.13	-	-	-	-	-	-	-
32	3rd Cl Conc	1.1	22.9	15.8	132	5.20	9.53	21.0	61.7	53.3	57.3	38.3	70.0	57.8
Roby	2nd Cl Conc	1.4	18.0	12.6	105	4.31	7.46	17.0	62.9	55.3	59.6	41.4	71.2	60.7
Zone	1st Cl Conc	3.7	7.52	5.69	48.3	2.25	3.10	7.63	68.1	64.6	70.7	55.8	76.7	70.7
	Scav Conc	9.2	3.20	2.51	21.0	1.02	1.28	3.80	73.1	71.9	77.5	63.7	79.8	88.5
5%	Scav Tail	90.8	0.12	0.10	0.62	0.059	0.033	0.05	26.9	28.1	22.5	36.3	20.2	11.5
NaCl	Head(calc)	-	0.40	0.32	2.50	0.15	0.15	0.40	-	-	-	-	-	
29	4th Cl Conc	1.8	17.1	14.9	332	4.50	6.12	-	58.1	47.9	57.6	35.3	65.9	-
	3rd Cl Conc	2.0	15.4	13.7	303	4.12	5.57	-	59.3	50.1	59.6	36.7	68.0	-
M92	2nd Cl Conc	2.6	12.5	11.5	250	3.42	4.56	-	61.1	53.7	62.6	38.8	71.0	-
	1st Cl Conc	6.0	5.95	6.08	127	1.86	2.20	-	67.6	65.6	73.8	48.9	79.6	-
	Scav Conc	16.2	2.43	2.60	52.8	0.85	0.88	-	74.0	75.2	82.3	59.9	85.5	-
	Scav Tail	83.8	0.17	0.17	2.20	0.11	0.029	-	26.0	24.8	17.7	40.1	14.5	-
	Head(calc)	-	0.53	0.56	10.4	0.23	0.17	-	-	-	-	-	-	-
33	3rd Cl Conc	5.2	7.07	7.71	156	2.16	2.64	15.2	68.5	68.9	75.3	50.2	83.1	84.0
M92	2nd Cl Conc	7.0	5.37	5.97	120	1.72	2.00	11.8	70.7	72.5	78.8	54.2	85.7	88.4
	1st Cl Conc	9.5	4.11	4.54	91.5	1.35	1.50	8.96	73.4	74.7	81.2	57.5	87.1	91.2
2.5%	Scav Conc	18.4	2.23	2.52	50.0	0.79	0.81	4.91	77.0	80.2	85.8	65.1	90.5	96.5
NaCl	Scav Tail	81.6	0.15	0.14	1.87	0.095	0.019	0.04	23.0	19.8	14.2	34.9	9.5	3.5
	Head(calc)	-	0.53	0.58	10.7	0.22	0.16	-	-	-	-	-	-	-

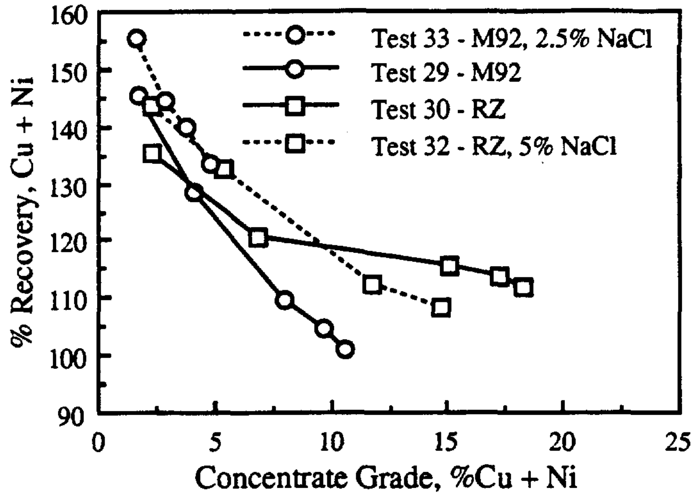


Figure 14: Effect of NaCl on Base Metals Flotation

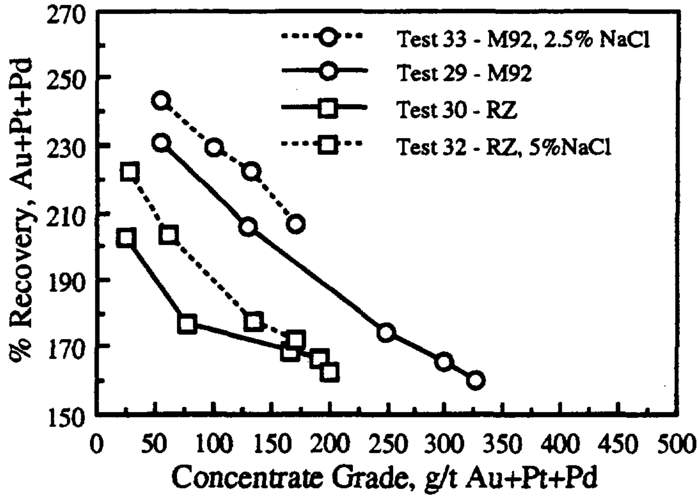


Figure 15: Effect of NaCl on Platinum Group Metals Flotation

The metallurgical response of the two composites is similar. All metal recoveries improved when grinding was performed in NaCl solutions.

The settling characteristics improved when the primary grind was performed in sodium chloride solution.

4.0 Testwork on Tailing

4.1 Settling Tests

The settling characteristics of flotation rougher tailings from Test 31 were investigated. Small pulp samples were used to scope flocculants and the best flocculant tested at various lime - pH levels. The results are presented in Table 16.

Table 16: Settling Rates and Thickener Areas

Test	Percol 156 g/t	pH	% Solids		Feed Conc. Zone		Compression Zone	
			Initial	Final	Rate*	Area**	Rate*	Area**
S1	0	8.2	23.4	66.1	0.33	0.35	0.10	0.50
S2	0	10.4	23.4	65.4	0.33	0.35	0.09	0.50
S7	0	12.0	23.4	68.0	0.53	0.22	0.10	0.37
S3	5	8.2	27.4	65.3	0.38	0.24	0.10	0.39
S4	5	10.0	28.4	64.8	0.42	0.20	0.10	0.37
S5	10	8.2	27.4	65.6	0.54	0.17	0.11	0.34
S6	10	10.0	28.4	64.5	0.63	0.13	0.10	0.30
S8	15	8.2	27.4	65.0	0.87	0.10	0.11	0.25
S9	15	10.0	28.4	64.2	0.93	0.10	0.09	0.23
S10	15	11.7	28.4	63.7	0.62	0.13	0.10	0.28

* meters per hour

** square meter per tonne of dry solids per 24 hours (no safety factor applied)

At natural pH, with <10 g Percol 156/t the supernatant remained cloudy after 24 hours. The supernatant clarity improves at pH ≥10 with or without flocculant. At pH 11.7 with 15 g Percol 156/t the solution cleared rapidly.

4.2 Tailing Decant Analysis

The supernatant from Test S10 was decanted and submitted for analysis. The results are presented in Table 17.

Table 17: 24 Element Semi-Quantitative ICP Scan: Drinking Water Quality

Sample Description		Concentration *
Reporting Limit, mg/L	Element	Tailing Decant Test S10
0.2	Al	1.0
0.1	As	<0.1
0.05	Ba	<0.05
0.01	Be	<0.01
0.2	Ca	120
0.05	Cd	<0.05
0.05	Co	<0.05
0.05	Cr	<0.05
0.05	Cu	<0.05
0.05	Fe	<0.05
0.10	Mg	0.10
0.05	Mn	<0.05
0.1	Mo	<0.1
0.10	Na	37
0.05	Ni	<0.05
0.2	P	<0.2
0.1	Pb	<0.1
2	S	67
0.1	Sb	<0.1
0.5	Se	<0.5
0.1	Si	12
0.2	Sn	<0.2
0.1	Te	<0.1
0.05	Zn	<0.05
1.0	Hardness	300

* All results are reported in mg/L. Some detection limits may be elevated due to interference

CONCLUSIONS

The lower grade Roby Zone sample has a Bond Work Index of 18.6, Composite M92 would grind slightly finer with identical power input with a Bond Work Index of 15.3.

The optimum primary grind for Composite M92, based on this investigation, is ≥ 68% minus 200 mesh. A rougher concentrate regrind of ≥ 85% minus 200 mesh is recommended prior to cleaning.

In one test a gravity concentrate was recovered by tabling prior to flotation. This concentrate was upgraded on the Mozley separator to 74 g/t Au, 20.5 g/t Pt and 402 g/t Pd. Gold recovery was 27%, Pt and Pd recoveries were <10%.

Flash flotation may be applicable. This is difficult to simulate on a laboratory scale. Results obtained were similar to batch staged rougher flotation. A unit recovery cell could be included in a pilot scale investigation.

Frother performance is also difficult to evaluate in batch laboratory tests. Our tests indicate MIBC and DF250C performed better than TEB. Pilot scale testing would be required for confirmation.

Using Na_2S as an activator was beneficial to recoveries. Further testwork would be required to optimize the addition rate. Test results indicate 175 g/t is preferable to 375 g/t.

Grinding in a NaCl solution improved results, increasing recoveries of all metals. The pulp thickening characteristics were also improved. However, a NaCl solution would be corrosive to equipment. Further testwork would be required to determine the lower limit of NaCl which would improve the metallurgical response or if an alternate less corrosive chemical can be substituted for NaCl.

The addition point for CMC seems to be critical for adequate dispersion or talc depression. The CMC was much more effective when added to the final 5 minutes of the grind than when added to the rougher conditioner.

Na_2CO_3 was of little benefit as a pulp dispersant and flotation at natural pH appears to be preferable.

Several collectors were tested. Potassium amyl xanthate with a dithiophosphate as a secondary collector performed the best. The dodecyl mercaptan, P3, was only tested in the NaCl circuit and should be evaluated in the standard circuit.

Further batch testwork should emphasize improving the cleaner circuit performance to improve final concentrate grade while maintaining or improving final recovery. Cycle tests should be performed to determine the disposition of the metals in the cleaner tailings.

SAMPLE PREPARATION

On January 20, 1992 10 bags containing approximately 200 kilograms of Roby Zone ore were received under our reference number LR9238328. The sample was air dryed, blended and crushed to nominal 10 mesh. Head samples were removed for analysis, mineralogy and size analysis. Forty 2 kilogram charges and three 40 kilogram charges were stored in 2 boxes and 1 barrel at minus 5° C. This composite was rejected for flotation testwork because of low PGM content (0.3 g/t Au, 0.29 g/t Pt, 2.4 g/t Pt).

Screen Analysis Roby Zone

Mesh Size (Tyler)	Micron Size	% Retained		% Passing
		Individual	Cumulative	Cumulative
+ 10	1,651	4.2	4.2	95.8
14	1,168	22.8	27.0	73.0
20	833	16.4	43.4	56.6
28	589	12.8	56.1	43.9
35	417	8.2	64.4	35.6
48	295	6.7	71.1	28.9
65	208	4.9	76.1	23.9
100	147	4.3	80.4	19.6
150	104	3.3	83.7	16.3
200	74	2.7	86.4	13.6
270	53	2.1	88.5	11.5
400	38	2.4	90.9	9.1
- 400	- 38	9.1	-	-
	Total	100.0	-	-

On February 5, 1992 16 bags containing approximately 2400 kilograms of drill chips were received under our reference number LR9238472. The samples were individually crushed to nominal 1/4 inch. Head samples were removed from each bag for analysis.

Sample Number			Assays, %, g/t		
	Cu	Ni	Au	Pt	Pd
92 M1 28841 A	0.058	0.10	0.67	1.03	20.4
92 M1 28841 B	0.058	0.10	0.40	1.00	20.8
92 M1 28842	0.040	0.096	0.36	0.76	16.5
92 M1 28843	0.025	0.096	0.25	0.93	22.2
92 M2 28845 A	0.14	0.18	0.30	0.35	5.28
92 M2 28845 B	0.18	0.24	0.96	0.44	6.01
92 M2 28846 A	0.34	0.48	0.75	0.64	11.9
92 M2 28846 B	0.30	0.42	0.73	0.62	12.0
92 M2 28847 A	0.17	0.20	0.51	0.33	4.35
92 M2 28847 B	0.23	0.35	0.53	0.55	8.03
92 M3 38849 A	0.16	0.19	0.55	0.41	7.08
92 M3 38849 B	0.15	0.18	0.50	0.49	8.70
92 M3 38850 A	0.092	0.12	0.23	0.44	8.45
92 M3 38850 B	0.10	0.13	0.33	0.43	8.31
92 M3 38851 A	0.081	0.13	0.32	0.76	16.6
92 M3 38851 B	0.10	0.14	0.37	0.65	14.3

All 92 M1 samples were excluded from Composite M92, they remain at minus 1/4 inch in cold storage. The remaining bags were combined and crushed to nominal minus 10 mesh. A head sample was removed for analysis and size analysis. Twenty 2 kilogram charges and eight 40 kilogram charges were stored in 2 barrels at minus 5° C. This composite was used for flotation testwork.

Screen Analysis Composite M92

Mesh Size (Tyler)	Micron Size	% Retained		% Passing Cumulative
		Individual	Cumulative	
+ 10	1,651	3.2	3.2	96.8
14	1,168	13.2	16.4	83.6
20	833	10.5	26.9	73.1
28	589	9.2	36.2	63.8
35	417	7.2	43.3	56.7
48	295	7.1	50.4	49.6
65	208	6.2	56.6	43.4
100	147	5.8	62.4	37.6
150	104	4.9	67.3	32.7
200	74	4.3	71.6	28.4
270	53	4.0	75.7	24.3
400	38	4.1	79.8	20.2
- 400	- 38	20.2	100.0	-
	Total	100.0	-	-

REAGENTS

$Ca(OH)_2$	Calcium Hydroxide	Nymoc Chemicals
Na_2CO_3	Sodium Carbonate	Fisher Scientific
SO_2	Sulphur Dioxide H_2SO_3	Fisher Scientific
Na_2S	Sodium Sulphide	Nymoc Chemicals
$CuSO_4 \cdot 5H_2O$	Copper Sulphate	Nymoc Chemicals
NaCl	Sodium Chloride	Nymoc Chemicals
Aerofloat 208 promoter	Dithiophosphate collector	Cyanamid
Aero 3477 promoter	Dithiophosphate collector	Cyanamid
Aero 404 promoter	Mercaptobenzothizole collector	Cyanamid
Aero 3501 promoter	Dithiophosphate collector	Cyanamid
Pennfloat 3	Dodecyl Mercaptan collector	Pennwalt
SIPX	Sodium IsoPropyl Xanthate	Hoechst
PAX	Potassium Amyl Xanthate	Hoechst
MIBC	Methyl IsoButyl Carbinol	CIL Chemicals
DF250C	polyglycol frother	Dow
TEB	Triethoxy butane frother	Stanfroth
WC 9524	Wheat Dextrine	Ogilive
PA MED	Carboxyl Methyl Cellulose	Aqualon
CMC 7LT	Carboxyl Methyl Cellulose medium viscosity	Aqualon
Jaguar MDD	Guar depressant	Hi Tek
Percol 156	Anionic polyacrylamide flocculant	Allied Colloids

Percol 611	Anionic polyacrylamide flocculant, very high molecular wt	Allied Colloids
Percol 351	Non ionic polyacrylamide flocculant	Allied Colloids
Percol 352	Cationic polyacrylamide flocculant, low molecular wt	Allied Colloids
Percol 368	Cationic polyacrylamide flocculant, high molecular wt	Allied Colloids

DETAILS OF TESTWORK

Comp M92 - Calculated Heads from Testwork

Au	Pt	Pd	Ni	Cu	S	
0.65	0.60	11.0	0.22	0.17		
0.63	0.64	11.4	0.23	0.17		
0.53	0.58	10.7	0.22	0.16	0.93	
0.52	0.57	10.4	0.23	0.17		
0.53	0.56	10.4	0.23	0.17		
0.60	0.54	9.63	0.21	0.16		
0.61	0.59	10.3	0.22	0.17		
0.59	0.63	10.6	0.22	0.17		
0.54	0.58	10.7	0.21	0.17		
0.61	0.58	10.6	0.22	0.17		
0.57	0.58	10.4	0.23	0.17		
0.66	0.62	10.6	0.23	0.19		
0.56	0.56	10.2	0.22	0.17		
0.64	0.60	11.0	0.23	0.18		
0.62	0.57	10.2	0.22	0.17		
0.52	0.60	10.9	0.23	0.18		
0.69	0.63	10.7	0.23	0.18		
0.62	0.63	11.0	0.23	0.19		
0.63	0.55	10.7	0.23	0.18		
0.66	0.57	10.9	0.21	0.18		
0.57	0.54	10.5	0.23	0.18		
0.56	0.57	10.5	0.23	0.17	0.88	
0.53	0.58	11.0	0.23	0.18	0.88	
0.52	0.59	10.8	0.23	0.18	0.87	
0.56	0.56	10.8	0.23	0.18	0.89	
0.55	0.56	10.4	0.24	0.18	0.87	
0.54	0.55	10.6	0.24	0.18	0.90	
0.52	0.55	10.5	0.22	0.17	0.88	
0.53	0.56	10.9	0.24	0.18	0.92	
0.58	0.55	10.1	0.23	0.18	0.94	
0.55	0.58	10.5	0.22	0.19	0.90	
0.62	0.55	10.1	0.25	0.20	0.89	
0.58	0.58	10.6	0.23	0.18	0.90	Average
0.69	0.64	11.4	0.25	0.20	0.94	High
0.52	0.54	9.63	0.21	0.16	0.87	Low
0.050	0.028	0.346	0.009	0.009	0.023	Std Dev

LAKEFIELD RESEARCH

Standard Bond Ball Mill Grindability Test

Project No. 4255 | Product: Minus 10 Mesh | Date: 22-May-92

Sample: Roby Zone

Purpose: To determine the ball mill grindability of the sample in terms of a Bond work index number.

Procedure: The equipment and procedure duplicate the Bond method for determining ball mill work indices.

Test Conditions:	Mesh of grind:	150	mesh
	Test feed weight (700 mL):	1256	grams
	Equivalent to : 1794 kg/m^3 at Minus 6 mesh		
	Weight % of the undersize material in the ball mill feed	16.3	%
	Weight of undersize product for 100% circulating load:	359	grams

Results: Average for last three stages = 360 g : 249 % circulation load

CALCULATION OF A BOND WORK INDEX

$$\mathrm{BWI} = \frac{44.5}{\mathrm{P1}^{0.23} \times \mathrm{Grp}^{0.82} \times \left\{ \frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}} \right\}}$$

P1 = 100% passing size of the product	104	microns
Grp = Grams per revolution	1.06	grams
P80 = 80% passing size of product	78	microns
F80 = 80% passing size of the feed	1328	microns

BWI = 16.9 (imperial)

BWI = 18.6 (metric)

Grindability Test Data		Project No. 4255		Sample: Roby Zone

Stage No.	Revs	New Feed (grams)	Undersize		U'Size In Product (grams)	Undersize Product	
			In Feed (grams)	To Be Ground (grams)		Total (grams)	Per Mill Rev (grams)
1	150	1,256	205	154	398	193	1.29
2	228	398	65	294	311	246	1.08
3	286	311	51	308	347	296	1.04
4	291	347	57	302	368	311	1.07
5	280	368	60	299	364	304	1.09

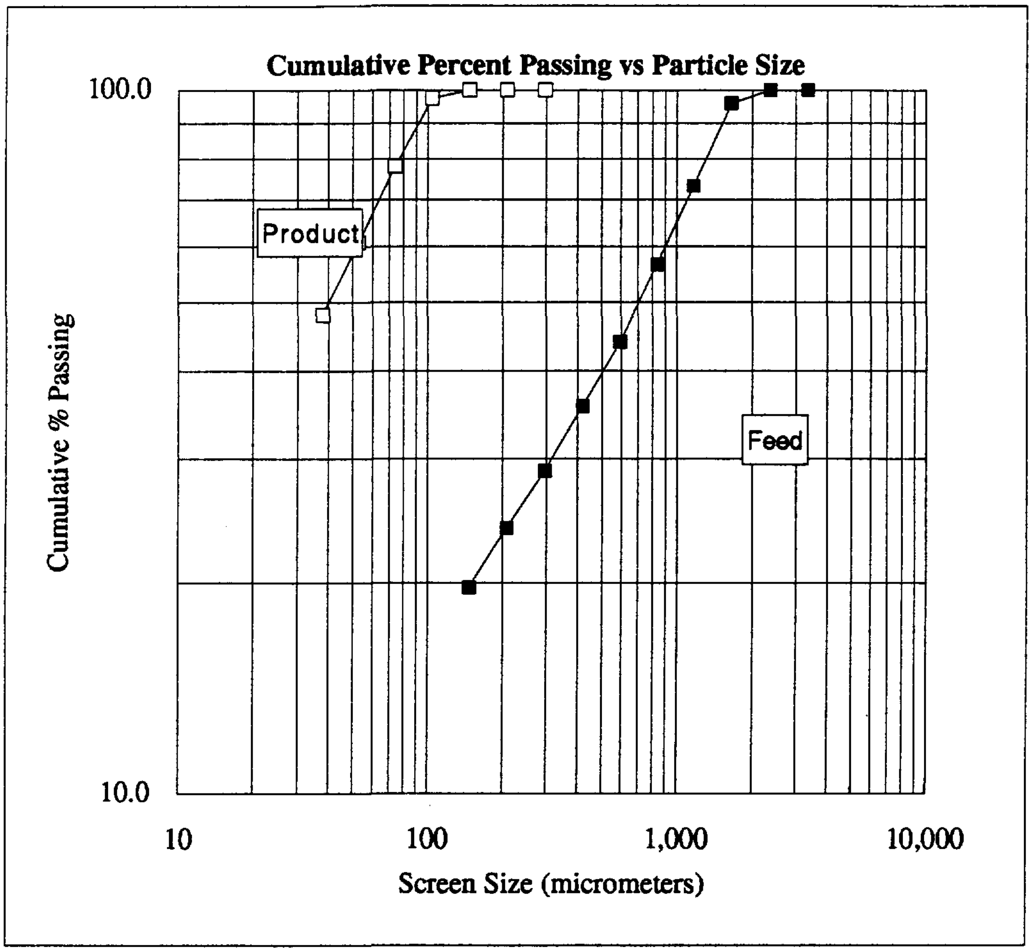
Average for Last Three Stages = 1.06

Feed K80

Size		Weight grams	% Retained		% Passing Cumulative
Mesh	µm		Individual	Cumulative	
6	3,327	0.0	0.0	0.0	100.0
8	2,362	0.0	0.0	0.0	100.0
10	1,651	4.2	4.2	4.2	95.8
14	1,168	22.8	22.8	27.0	73.0
20	833	16.4	16.4	43.4	56.6
28	589	12.8	12.8	56.2	43.8
35	417	8.2	8.2	64.4	35.6
48	295	6.7	6.7	71.1	28.9
65	208	4.9	4.9	76.0	24.0
100	147	4.3	4.3	80.3	19.7
150	104	3.3	3.3	83.6	16.4
200	74	2.7	2.7	86.3	13.7
270	53	2.1	2.1	88.4	11.6
400	38	2.4	2.4	90.8	9.2
Pan	-38	9.2	9.2	100.0	0.0
Total	-	**100.0**	**100.0**	-	-
K80	**1,328**				

Product K80

Size		Weight grams	% Retained		% Passing Cumulative
Mesh	µm		Individual	Cumulative	
48	295	0.0	0.0	0.0	100.0
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	3.7	2.6	2.6	97.4
200	74	27.8	19.5	22.1	77.9
270	53	24.4	17.1	39.2	60.8
400	38	18.3	12.8	52.0	48.0
Pan	-38	68.4	48.0	100.0	0.0
Total	-	**142.6**	**100.0**	-	-
K80	**78**				


Cumulative Percent Passing vs Particle Size
100.0
10.0
Cumulative % Passing
Product
Feed
10
100
1,000
10,000
Screen Size (micrometers)

LAKEFIELD RESEARCH

Standard Bond Ball Mill Grindability Test

Project No. 4255 Product: Minus 10 Mesh Date: May 22,1992

Sample: Comp. M92

Purpose: To determine the ball mill grindability of the sample in terms of a Bond work index number.

Procedure: The equipment and procedure duplicate the Bond method for determining ball mill work indices.

Test Conditions:
Mesh of grind: 150 mesh
Test feed weight (700 mL): 1397 grams
Equivalent to : 1996 kg/m^3 at Minus 6 mesh
Weight % of the undersize material in the ball mill feed 32.7 %
Weight of undersize product for 100% circulating load: 399 grams

Results: Average for last two stages = 396 g : 253 % circulation load

CALCULATION OF A BOND WORK INDEX

$$BWI = \frac{44.5}{P1^{0.23} \times Grp^{0.82} \times \left\{ \frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}} \right\}}$$

P1 = 100% passing size of the product 104 microns
Grp = Grams per revolution 1.38 grams
P80 = 80% passing size of product 75 microns
F80 = 80% passing size of the feed 1053 microns

BWI = 13.9 (imperial)

BWI = 15.3 (metric)

Test: 12

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	138.1	7.0	6.19	5.30	111	1.68	1.99	9.88	75.2	67.9	73.9	50.2	78.6	77.8
2 CuNi Ro Conc 2	170.6	8.6	0.46	0.62	11.2	0.28	0.15	1.65	6.9	9.8	9.2	10.3	7.3	16.0
3 CuNi Sc Conc 1	104.6	5.3	0.24	0.40	7.02	0.20	0.084	0.47	2.2	3.9	3.5	4.5	2.5	2.8
4 CuNi Sc Conc 2	82.0	4.1	0.18	0.24	3.87	0.15	0.060	0.18	1.3	1.8	1.5	2.7	1.4	0.8
5 Cu Ni Scav Tail	1488.2	75.0	0.11	0.12	1.64	0.100	0.024	0.030	14.4	16.6	11.8	32.2	10.2	2.5
Head (calc)	1983.5	100.0	0.57	0.54	10.5	0.23	0.18	0.88	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		15.6	3.02	2.71	55.8	0.91	0.97	5.33	82.1	77.7	83.2	60.6	85.9	93.8
CuNi Sc Conc (3 + 4)		9.4	0.21	0.33	5.64	0.18	0.073	0.34	3.5	5.7	5.1	7.2	3.9	3.6
Ro + Sc Conc (1 to 4)		25.0	1.96	1.82	36.9	0.63	0.63	3.45	85.6	83.4	88.2	67.8	89.8	97.5

Test: 12 Project: 4255 Date: Mar. 3/92 Operator: BW

Purpose: To repeat conditions of Test 11 with 125 g/t Na2S to the primary grind and 50 g/t Na2S to the 1st scavenger.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	A208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.4
Condition 1		2000							2		10.1
2				250					5		10.0
3			400		10	100			3		10.0
Rougher 1							50		1	3	
2							25		1	5	
Scavenger 1	50					100	12.5		2	5	9.9
2						50	12.5		2	5	9.8

Test: 11

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	118.9	6.0	6.51	6.08	123	1.81	2.28	10.7	69.9	64.4	70.2	47.2	78.6	73.3
2 CuNi Ro Conc 2	156.5	7.9	0.57	0.76	14.7	0.34	0.16	2.15	8.1	10.6	11.0	11.7	7.3	19.4
3 CuNi Sc Conc 1	97.3	4.9	0.27	0.43	7.64	0.21	0.087	0.49	2.4	3.7	3.6	4.5	2.5	2.7
4 CuNi Sc Conc 2	76.9	3.9	0.24	0.31	4.94	0.18	0.069	0.24	1.7	2.1	1.8	3.0	1.5	1.1
5 Cu Ni Scav Tail	1531.0	77.3	0.13	0.14	1.81	0.100	0.023	0.040	18.0	19.1	13.3	33.6	10.2	3.5
Head (calc)	1980.6	100.0	0.56	0.57	10.5	0.23	0.17	0.88	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		13.9	3.13	3.06	61.5	0.97	1.08	5.84	78.0	75.0	81.3	58.9	85.8	92.7
CuNi Sc Conc (3 + 4)		8.8	0.26	0.38	6.45	0.20	0.079	0.38	4.0	5.9	5.4	7.5	4.0	3.8
Ro + Sc Conc (1 to 4)		22.7	2.02	2.02	40.1	0.67	0.69	3.73	82.0	80.9	86.7	66.4	89.8	96.5

Test: 11 Project: 4255 Date: Feb 27/92 Operator: BW

Purpose: To repeat conditions of Test 3 without Na2S.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2CO3	CMC 7LT	CuSO4	A208	PAX	DF 250C		Grind	Cond.	Froth	
Primary Grind								45			8.5
Condition 1	2000								2		10.2
2			250						5		9.9
3		400		10	100				3		9.8
Rougher 1						50			1	3	
2						25			1	5	
Scavenger 1					100	12.5			2	5	9.7
2					50	12.5			2	5	9.6

Test: 10

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	142.8	7.2	4.95	5.44	115	1.71	2.00	10.3	67.8	68.3	75.2	54.8	80.6	84.8
2 CuNi Ro Conc 2	150.9	7.6	0.35	0.44	7.65	0.23	0.12	1.05	5.1	5.8	5.3	7.8	5.1	9.1
3 CuNi Sc Conc 1	129.4	6.5	0.28	0.34	5.57	0.16	0.079	0.29	3.5	3.9	3.3	4.6	2.9	2.2
4 CuNi Sc Conc 2	48.4	2.4	0.13	0.19	3.40	0.16	0.059	0.17	0.6	0.8	0.8	1.7	0.8	0.5
5 Cu Ni Scav Tail	1504.7	76.1	0.16	0.16	2.24	0.092	0.025	0.040	23.1	21.2	15.4	31.1	10.6	3.5
Head (calc)	1976.2	100.0	0.53	0.58	11.0	0.23	0.18	0.88	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		14.9	2.59	2.87	59.8	0.95	1.03	5.55	72.8	74.2	80.5	62.6	85.7	93.9
CuNi Sc Conc (3 + 4)		9.0	0.24	0.30	4.98	0.16	0.074	0.26	4.1	4.7	4.1	6.4	3.7	2.6
Ro + Sc Conc (1 to 4)		23.9	1.70	1.90	39.2	0.65	0.67	3.55	76.9	78.8	84.6	68.9	89.4	96.5

Test: 10 Project: 4255 Date: March 4/92 Operator: BW

Purpose: To repeat conditions of Test 7 with TEB in place of DF250C.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	TEB	Grind	Cond.	Froth	
Primary Grind	250							45			8.5
Condition 1		2000							2		10.2
2				250					5		10.0
3			400		10	100			3		9.9
Rougher 1							37.5		1	3	
2							25		1	5	
Scavenger 1	100					100	12.5		2	5	9.9
2	25					50	12.5		2	5	9.9

Test: 9

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	132.1	6.7	5.50	6.19	125	1.86	2.16	11.0	71.0	70.6	77.7	53.8	80.7	84.5
2 CuNi Ro Conc 2	104.2	5.3	0.35	0.48	8.52	0.25	0.12	1.32	3.6	4.3	4.2	5.7	3.5	8.0
3 CuNi Sc Conc 1	89.1	4.5	0.29	0.43	7.04	0.19	0.099	0.41	2.5	3.3	3.0	3.7	2.5	2.1
4 CuNi Sc Conc 2	58.7	3.0	0.22	0.23	4.16	0.16	0.070	0.21	1.3	1.2	1.1	2.1	1.2	0.7
5 Cu Ni Scav Tail	1586.4	80.5	0.14	0.15	1.87	0.100	0.027	0.050	21.7	20.6	14.0	34.7	12.1	4.6
Head (calc)	1970.5	100.0	0.52	0.59	10.8	0.23	0.18	0.87	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		12.0	3.23	3.67	73.6	1.15	1.26	6.73	74.5	75.0	81.9	59.5	84.2	92.5
CuNi Sc Conc (3 + 4)		7.5	0.26	0.35	5.90	0.18	0.087	0.33	3.8	4.5	4.1	5.8	3.7	2.8
Ro + Sc Conc (1 to 4)		19.5	2.09	2.39	47.6	0.78	0.81	4.27	78.3	79.4	86.0	65.3	87.9	95.4

Test: 9 Project: 4255 Date: March 4/92 Operator: BW

Purpose: To repeat conditions of Test 7 with MIBC in place of DF250C.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	250							45			8.6
Condition 1		2000							2		10.2
2				250					5		10.0
3			400		10	100			3		10.0
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	100					100	12.5		2	5	10.0
2	25					50	12.5		2	5	10.0

Test: 8

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	181.2	9.2	4.39	4.60	91.2	1.33	1.55	7.96	72.0	74.6	77.4	53.3	80.2	81.7
2 CuNi Ro Conc 2	196.6	9.9	0.49	0.47	8.39	0.22	0.11	1.12	8.7	8.3	7.7	9.6	6.2	12.5
3 CuNi Sc Conc 1	129.1	6.5	0.25	0.30	5.03	0.16	0.075	0.28	2.9	3.5	3.0	4.6	2.8	2.0
4 CuNi Sc Conc 2	75.3	3.8	0.17	0.18	3.23	0.14	0.060	0.15	1.2	1.2	1.1	2.3	1.3	0.6
5 Cu Ni Scav Tail	1397.5	70.6	0.12	0.10	1.63	0.098	0.024	0.040	15.2	12.5	10.7	30.3	9.6	3.2
Head (calc)	1979.7	100.0	0.56	0.56	10.8	0.23	0.18	0.89	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		19.1	2.36	2.45	48.1	0.75	0.80	4.40	80.7	82.8	85.1	62.8	86.4	94.1
CuNi Sc Conc (3 + 4)		10.3	0.22	0.26	4.37	0.15	0.069	0.23	4.1	4.7	4.2	6.9	4.1	2.7
Ro + Sc Conc (1 to 4)		29.4	1.61	1.68	32.8	0.54	0.54	2.94	84.8	87.5	89.3	69.7	90.4	96.8

Test: 8 Project: 4255 Date: March 4/92 Operator: BW

Purpose: To repeat conditions of Test 7 with SIPX in place of PAX.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	SIPX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250							45			8.5
Condition 1		2000							2		10.3
2				250					5		10.0
3			400		10	100			3		9.9
Rougher 1							50		1	3	
2							25		1	5	
Scavenger 1	100					100	12.5		2	5	9.9
2	25					50	12.5		2	5	9.8

Test: 7

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	128.2	6.5	6.15	5.86	120	1.82	2.18	10.0	72.4	68.0	74.3	49.0	78.9	74.5
2 CuNi Ro Conc 2	194.5	9.8	0.47	0.60	10.6	0.34	0.15	1.69	8.4	10.6	10.0	13.9	8.2	19.1
3 CuNi Sc Conc 1	105.2	5.3	0.27	0.37	5.89	0.17	0.088	0.33	2.6	3.5	3.0	3.8	2.6	2.0
4 CuNi Sc Conc 2	79.6	4.0	0.23	0.27	4.10	0.16	0.065	0.21	1.7	1.9	1.6	2.7	1.5	1.0
5 Cu Ni Scav Tail	1474.0	74.4	0.11	0.12	1.57	0.099	0.021	0.040	14.9	16.0	11.2	30.7	8.7	3.4
Head (calc)	1981.5	100.0	0.55	0.56	10.4	0.24	0.18	0.87	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		16.3	2.73	2.69	54.1	0.93	0.96	4.99	80.8	78.5	84.3	62.9	87.2	93.6
CuNi Sc Conc (3 + 4)		9.3	0.25	0.33	5.12	0.17	0.078	0.28	4.3	5.5	4.6	6.4	4.1	3.0
Ro + Sc Conc (1 to 4)		25.6	1.83	1.83	36.2	0.65	0.64	3.28	85.1	84.0	88.8	69.3	91.3	96.6

Test: 7 Project: 4255 Date: Feb 27/92 Operator: BW

Purpose: To repeat conditions of Test 3 with 3501 in place of A208.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	pH
Primary Grind	250							45			8.7
Condition 1		2000							2		10.3
2				250					5		10.0
3			400		10	100			3		10.0
Rougher 1							50		1	3	
2							25		1	5	
Scavenger 1	100					100	12.5		2	5	10.0
2	25					50	12.5		2	5	9.9

Test: 6

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	132.0	6.7	5.73	5.64	119	1.74	2.10	9.89	70.8	68.2	74.6	48.2	76.0	73.0
2 CuNi Ro Conc 2	155.6	7.8	0.53	0.68	11.9	0.31	0.17	2.23	7.7	9.7	8.8	10.1	7.3	19.4
3 CuNi Sc Conc 1	88.6	4.5	0.28	0.40	6.78	0.20	0.085	0.46	2.3	3.2	2.9	3.7	2.1	2.3
4 CuNi Sc Conc 2	82.1	4.1	0.27	0.27	4.39	0.16	0.074	0.22	2.1	2.0	1.7	2.8	1.7	1.0
5 Cu Ni Scav Tail	1526.5	76.9	0.12	0.12	1.67	0.11	0.031	0.050	17.1	16.8	12.1	35.2	13.0	4.3
Head (calc)	1984.8	100.0	0.54	0.55	10.6	0.24	0.18	0.90	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		14.5	2.92	2.96	61.1	0.97	1.06	5.75	78.5	77.9	83.3	58.3	83.3	92.4
CuNi Sc Conc (3 + 4)		8.6	0.28	0.34	5.63	0.18	0.080	0.34	4.4	5.3	4.6	6.5	3.7	3.3
Ro + Sc Conc (1 to 4)		23.1	1.93	1.98	40.4	0.67	0.69	3.73	82.9	83.2	87.9	64.8	87.0	95.7

Test: 6 Project: 4255 Date: Feb 27/92 Operator: BW

Purpose: To repeat conditions of Test 3 with 404 in place of A208.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	404	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250							45			8.6
Condition 1		2000							2		10.3
2				250					5		10.0
3			400		10	100			3		10.0
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	100					100	12.5		2	5	10.0
2	25					50	12.5		2	5	9.9

Test: 5

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	186.6	9.4	3.78	4.07	82.1	1.25	1.52	8.06	68.1	68.9	73.5	52.8	81.7	85.6
2 CuNi Ro Conc 2	210.2	10.6	0.41	0.51	9.67	0.24	0.12	0.71	8.3	9.7	9.7	11.4	7.3	8.5
3 CuNi Sc Conc 1	156.1	7.9	0.24	0.33	5.48	0.16	0.058	0.30	3.6	4.7	4.1	5.7	2.6	2.7
4 CuNi Sc Conc 2	104.7	5.3	0.19	0.23	3.42	0.13	0.050	0.16	1.9	2.2	1.7	3.1	1.5	1.0
5 Cu Ni Scav Tail	1330.4	66.9	0.14	0.12	1.72	0.090	0.018	0.030	18.0	14.5	11.0	27.1	6.9	2.3
Head (calc)	1988.0	100.0	0.52	0.55	10.5	0.22	0.17	0.88	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		20.0	1.99	2.18	43.7	0.71	0.78	4.17	76.5	78.7	83.2	64.2	89.0	94.1
CuNi Sc Conc (3 + 4)		13.1	0.22	0.29	4.65	0.15	0.055	0.24	5.5	6.9	5.8	8.7	4.1	3.6
Ro + Sc Conc (1 to 4)		33.1	1.29	1.43	28.2	0.49	0.49	2.61	82.0	85.5	89.0	72.9	93.1	97.7

Test: 5 Project: 4255 Date: Feb 26/92 Operator: BW

Purpose: To repeat conditions of Test 3 at pH 6.5 with SO2.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	SO2	CMC 7LT	CuSO4	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250							45			8.6
Condition 1		600							2		6.5
2				250					5		6.5
3			400		10	100			3		6.5
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	100	150				100	12.5		2	5	6.5
2	25	75				50	12.5		2	5	6.5

Test: 4

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	98.5	5.0	7.27	7.54	165	2.35	2.73	12.8	67.4	66.9	74.7	49.5	73.9	69.3
2 CuNi Ro Conc 2	210.8	10.6	0.42	0.53	9.00	0.25	0.17	1.82	8.3	10.1	8.7	11.3	9.8	21.1
3 CuNi Sc Conc 1	107.6	5.4	0.29	0.37	6.42	0.20	0.11	0.69	2.9	3.6	3.2	4.6	3.3	4.1
4 CuNi Sc Conc 2	104.6	5.3	0.20	0.25	4.12	0.15	0.074	0.27	2.0	2.4	2.0	3.4	2.1	1.6
5 Cu Ni Scav Tail	1466.0	73.8	0.14	0.13	1.69	0.100	0.027	0.050	19.3	17.2	11.4	31.3	10.9	4.0
Head (calc)	1987.5	100.0	0.53	0.56	10.9	0.24	0.18	0.92	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		15.6	2.60	2.76	58.7	0.92	0.99	5.32	75.8	76.9	83.5	60.7	83.7	90.3
CuNi Sc Conc (3 + 4)		10.7	0.25	0.31	5.29	0.18	0.092	0.48	4.9	5.9	5.2	8.0	5.4	5.6
Ro + Sc Conc (1 to 4)		26.2	1.64	1.76	37.0	0.62	0.62	3.35	80.7	82.8	88.6	68.7	89.1	96.0

Test: 4 Project: 4255 Date: Feb 26/92 Operator: BW

Purpose: To repeat conditions of Test 3 without Na2CO3.

Procedure: As shown Below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	CMC 7LT	CuSO4	R208	PAX	DF 250C		Grind	Cond.	Froth	pH
Primary Grind	250							45			8.5
Condition 1			250						5		8.2
2		400		10	100				3		8.2
Rougher 1						37.5			1	3	
2						25			1	5	
Scavenger 1	100				100	-			2	5	8.7
2	25				50	12.5			2	5	8.7

Test: 3

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	128.3	6.5	6.03	5.44	114	1.86	2.18	11.2	67.2	64.9	73.4	52.8	78.6	77.7
2 CuNi Ro Conc 2	107.0	5.4	0.68	0.84	14.0	0.32	0.21	2.53	6.3	8.4	7.5	7.6	6.3	14.6
3 CuNi Sc Conc 1	72.0	3.7	0.40	0.55	8.93	0.21	0.11	0.61	2.5	3.7	3.2	3.3	2.2	2.4
4 CuNi Sc Conc 2	70.8	3.6	0.31	0.35	5.33	0.16	0.084	0.25	1.9	2.3	1.9	2.5	1.7	1.0
5 Cu Ni Scav Tail	1592.4	80.8	0.16	0.14	1.74	0.096	0.025	0.050	22.1	20.7	13.9	33.8	11.2	4.3
Head (calc)	1970.5	100.0	0.58	0.55	10.1	0.23	0.18	0.94	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		11.9	3.60	3.35	68.5	1.16	1.28	7.26	73.5	73.3	81.0	60.3	84.9	92.4
CuNi Sc Conc (3 + 4)		7.2	0.36	0.45	7.15	0.19	0.097	0.43	4.4	6.0	5.1	5.8	3.9	3.3
Ro + Sc Conc (1 to 4)		19.2	2.37	2.25	45.3	0.79	0.84	4.68	77.9	79.3	86.1	66.2	88.8	95.7

Test: 3 Project: 4255 Date: Feb 19/92 Operator: BW

Purpose: To repeat conditions of Test 1 but target a primary grind size of 80% minus 200 mesh.

Procedure: Targeted flotation feed size 80% minus 200 mesh
Actual flotation feed size 90% minus 200 mesh

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	Na2CO3	CMC 7LT	CuSO4	A208	PAX	DF 250C	Grind	Cond.	Froth	pH
Primary Grind	250							45			8.8
Condition 1		2000							2		10.5
2				250					5		10.1
3			400		10	100			3		10.1
Rougher 1							25		1	3	
2							12.5		1	5	
Scavenger 1	100					100	12.5		2	5	10.0
2	25					50	12.5		2	5	10.0

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
208	65	0.1	0.1	0.1	99.9
147	100	0.4	0.4	0.5	99.5
104	150	2.6	2.6	3.1	96.9
74	200	6.9	6.9	10.0	90.0
53	270	11.8	11.8	21.8	78.2
38	400	14.6	14.6	36.4	63.6
-38	-400	63.6	63.6	100.0	-
	Total	100.0	100.0	-	-

Test: 2

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	88.3	4.4	5.60	6.12	131	2.10	2.32	12.3	44.9	46.5	55.5	41.7	54.4	60.7
2 CuNi Ro Conc 2	130.9	6.6	0.87	1.10	20.2	0.45	0.29	2.88	10.3	12.4	12.6	13.3	10.1	21.1
3 CuNi Sc Conc 1	71.1	3.6	0.84	1.17	18.8	0.34	0.24	1.47	5.4	7.2	6.4	5.4	4.5	5.8
4 CuNi Sc Conc 2	58.6	3.0	0.41	0.57	8.55	0.21	0.15	0.45	2.2	2.9	2.4	2.8	2.3	1.5
5 Cu Ni Scav Tail	1637.3	82.4	0.25	0.22	2.95	0.100	0.066	0.12	37.2	31.0	23.1	36.8	28.7	11.0
Head (calc)	1986.2	100.0	0.55	0.58	10.5	0.22	0.19	0.90	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		11.0	2.78	3.12	65.0	1.11	1.11	6.67	55.2	58.9	68.1	55.0	64.5	81.7
CuNi Sc Conc (3 + 4)		6.5	0.65	0.90	14.2	0.28	0.20	1.01	7.6	10.0	8.8	8.2	6.9	7.3
Ro + Sc Conc (1 to 4)		17.6	1.98	2.30	46.1	0.80	0.77	4.57	62.8	69.0	76.9	63.2	71.3	89.0

Test: 2 Project: 4255 Date: Feb 21/92 Operator: BW

Purpose: To repeat conditions of Test 1 and target a primary grind size of 38.7% minus 200 mesh.

Procedure: Targeted flotation feed size 38.7% minus 200 mesh, assuming a Wi of 16
Actual flotation feed size 47% minus 200 mesh

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 7.5 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250							7.5			8.8
Condition 1		2000							2		10.2
2				250					5		10.2
3			400		10	100			3		10.2
Rougher 1							37.5		1	3	
2							25		1	5	
Scavenger 1	100					100	-		2	5	10.1
2	25					50	12.5		2	5	10.0

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
1,651	10	0.6	0.2	0.2	99.8
1,168	14	6.1	1.8	2.0	98.0
833	20	8.9	2.6	4.6	95.4
589	28	14.0	4.1	8.7	91.3
417	35	18.3	5.4	14.0	86.0
295	48	28.1	8.2	22.2	77.8
208	65	29.5	8.6	30.9	69.1
147	100	29.2	8.5	39.4	60.6
104	150	25.7	7.5	46.9	53.1
74	200	22.1	6.5	53.4	46.6
53	270	21.0	6.1	59.5	40.5
38	400	24.5	7.2	66.7	33.3
-38	-400	113.8	33.3	100.0	-
	Total	341.8	100.0	-	-

Test: 1

<u>Metallurgical Balance</u>

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	80.2	4.1	7.18	6.45	137	2.95	3.40	13.5	47.7	47.6	55.3	48.0	68.4	62.1
2 CuNi Ro Conc 2	73.4	3.7	2.26	1.76	32.8	0.71	0.44	5.00	13.7	11.9	12.1	10.6	8.1	21.0
3 CuNi Sc Conc 1	53.7	2.7	2.14	1.60	22.1	0.41	0.42	2.70	9.5	7.9	6.0	4.5	5.7	8.3
4 CuNi Sc Conc 2	44.0	2.2	0.62	0.68	9.90	0.25	0.18	0.68	2.3	2.8	2.2	2.2	2.0	1.7
5 Cu Ni Scav Tail	1708.0	87.2	0.19	0.19	2.84	0.100	0.037	0.070	26.9	29.9	24.4	34.7	15.9	6.9
Head (calc)	1959.3	100.0	0.62	0.55	10.1	0.25	0.20	0.89	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		7.8	4.83	4.21	87.2	1.88	1.99	9.44	61.4	59.5	67.4	58.6	76.5	83.1
CuNi Sc Conc (3 + 4)		5.0	1.46	1.19	16.6	0.34	0.31	1.79	11.8	10.7	8.2	6.7	7.6	10.0
Ro + Sc Conc (1 to 4)		12.8	3.52	3.03	59.8	1.28	1.33	6.46	73.1	70.1	75.6	65.3	84.1	93.1

Test: 1 Project: 4255 Date: Feb 19/92 Operator: BW

Purpose: To repeat conditions of testwork provided by Lac des Iles.

Procedure: Targeted flotation feed size 38.7% minus 200 mesh, assuming a Wi of 16
Actual flotation feed size 60.8% minus 200 mesh

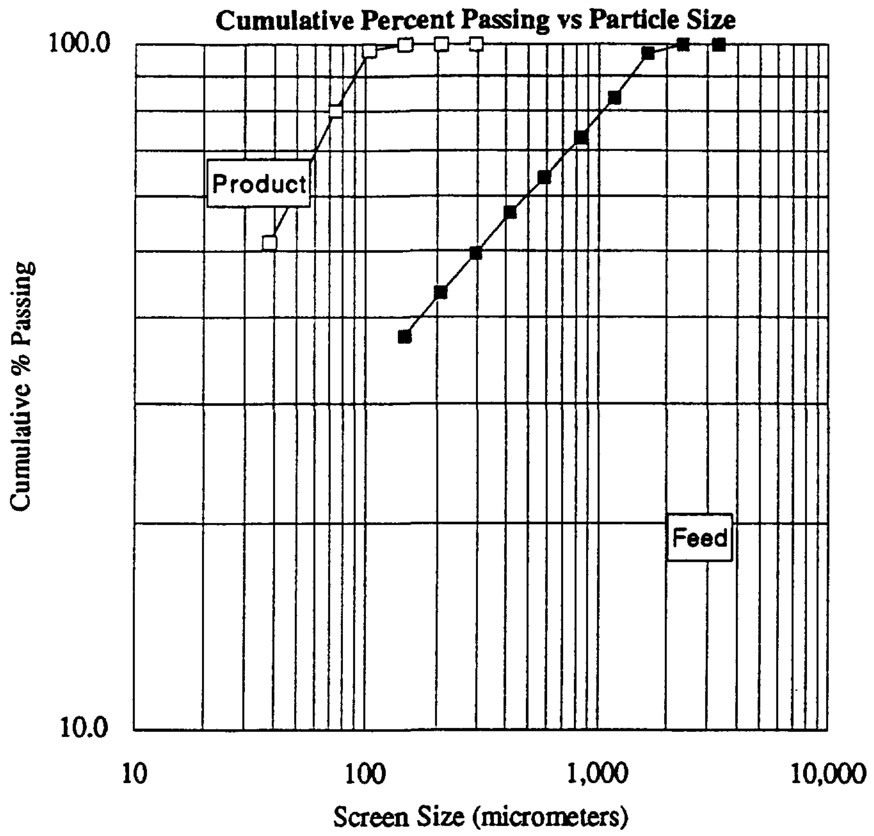
Feed: 2000 grams minus 10 mesh Comp M92

Grind: 15 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250							15			8.8
Condition 1		2000							2		10.5
2				250					5		10.2
3			400		10	100			3		10.2
Rougher 1							25		1	3	
2							12.5		1	5	
Scavenger 1	100					100	12.5		2	5	10.0
2	25					50	12.5		2	5	-

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
295	48	3.5	3.5	3.5	96.5
208	65	5.9	5.9	9.4	90.6
147	100	9.9	9.9	19.3	80.7
104	150	10.6	10.6	29.9	70.1
74	200	9.3	9.3	39.2	60.8
53	270	8.0	8.0	47.2	52.8
38	400	8.8	8.8	56.0	44.0
-38	-400	44.0	44.0	100.0	-
	Total	100.0	100.0	-	-


Cumulative Percent Passing vs Particle Size
100.0
10.0
Cumulative % Passing
Product
Feed
10
100
1,000
10,000
Screen Size (micrometers)

Grindability Test Data   Project No. 4255   Sample: Comp. M92

Stage No.	Revs	New Feed (grams)	Undersize		U'Size In Product (grams)	Undersize Product	
			In Feed (grams)	To Be Ground (grams)		Total (grams)	Per Mill Rev (grams)
1	150	1,397	457	-58	628	171	1.14
2	170	628	205	194	455	250	1.47
3	170	455	149	250	394	245	1.44
4	188	394	129	270	405	276	1.47
5	164	405	132	267	365	233	1.42
6	197	365	119	280	393	274	1.39
7	195	393	129	271	398	269	1.38

Average for Last Two Stages = 1.38

Feed K80

Size		Weight grams	% Retained		% Passing Cumulative
Mesh	µm		Individual	Cumulative	
6	3,327	0.0	0.0	0.0	100.0
8	2,362	0.0	0.0	0.0	100.0
10	1,651	19.7	3.2	3.2	96.8
14	1,168	81.0	13.2	16.4	83.6
20	833	64.2	10.5	26.9	73.1
28	589	56.6	9.2	36.2	63.8
35	417	43.8	7.2	43.3	56.7
48	295	43.6	7.1	50.4	49.6
65	208	37.9	6.2	56.6	43.4
100	147	35.7	5.8	62.4	37.6
150	104	29.9	4.9	67.3	32.7
200	74	26.4	4.3	71.6	28.4
270	53	24.7	4.0	75.7	24.3
400	38	25.4	4.1	79.8	20.2
Pan	-38	123.6	20.2	100.0	0.0
Total	-	**612.5**	**100.0**	-	-
K80	**1,053**				

Product K80

Size		Weight grams	% Retained		% Passing Cumulative
Mesh	µm		Individual	Cumulative	
48	295	0.0	0.0	0.0	100.0
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	2.8	2.1	2.1	97.9
200	74	24.3	17.9	19.9	80.1
270	53	22.1	16.3	36.2	63.8
400	38	17.0	12.5	48.7	51.3
Pan	-38	69.8	51.3	100.0	0.0
Total	-	**136.0**	**100.0**	-	-
K80	**75**				

Test: 13 Project: 4255 Date: March 13/92 Operator: BW

Purpose: To conduct a gravity test followed by a flotation test on the gravity tails using the conditions of Test 14.

Procedure: The sample was ground and tabled on a Wilfley table. The Wilfley table concentrate was upgraded on a Mozley table and this table concentrate was submitted for assays.(Au,Pt,Pd). The table tails were combined, thickened and became the flotation feed.

Feed: Approx. 2000g of gravity tails.

Grind: 2 kg of minus 10 mesh (Comp M92) ground for 45 minutes at 65 % solids in a laboratory ball mill

Conditions:

Stage	Reagents, g/t						Time, minutes			pH
	Na2S	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
										7.9
Condition 1	125							2		8.6
Condition 2			250					5		7.7
Condition 3		400		10	100			3		7.0
Rougher 1						50		1	3	
2						25		1	5	
Scavenger 1					100	12.5		2	5	7.9
2					50	12.5		2	5	7.9

NOTE : Rougher concentrates 1 and 2 in this test were combined as well as Scavenger concentrates 1 and 2.

Test: 13

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Mozley Conc.	4.7	0.2	74.1	20.5	402	-	-	27.2	8.7	9.0	-	-
2 CuNi Ro Conc	467.2	24.0	1.54	1.72	34.3	0.58	0.63	55.9	71.9	75.6	64.7	86.2
3 CuNi Sc Conc	269.0	13.8	0.23	0.27	4.52	0.15	0.072	4.8	6.5	5.7	9.3	5.7
4 Cu Ni Scav Tail	1206.4	62.0	0.13	0.12	1.70	0.090	0.023	12.2	13.0	9.7	25.9	8.1
Head (calc)	1947.3	100.0	0.66	0.57	10.9	0.21	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
Ro + Sc Conc (2 & 3)		37.8	1.06	1.19	23.4	0.42	0.43	60.7	78.4	81.4	74.1	91.9
Mozley + Ro Conc(1+2)		24.2	2.27	1.91	38.0	-	-	83.0	80.6	84.6	-	-
Comb Conc(1 to 3)		38.0	1.53	1.31	25.8	-	-	87.8	87.0	90.3	-	-

Test: 14 Project: 4255 Date: March 10/92 Operator: BW

Purpose: To conduct a flotation test with a reagent scheme derived from the best conditions from all of the reagent scoping test.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t						Time, minutes			pH
	Na2S	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125						45			8.7
Condition 1			250					5		8.2
Condition 2		400		10	100			3		8.1
Rougher 1						50		1	3	
2						25		1	5	
Scavenger 1					100	12.5		2	5	8.6
2					50	12.5		2	5	8.4

Test: 14

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	250.1	12.6	3.79	3.13	64.6	1.01	1.11	6.08	76.2	71.7	76.4	55.5	78.3	86.7
2 CuNi Ro Conc 2	168.8	8.5	0.38	0.54	8.62	0.22	0.14	0.79	5.2	8.4	6.9	8.2	6.7	7.6
3 CuNi Sc Conc 1	152.8	7.7	0.26	0.32	5.65	0.17	0.081	0.37	3.2	4.5	4.1	5.7	3.5	3.2
4 CuNi Sc Conc 2	81.5	4.1	0.23	0.27	4.58	0.16	0.076	0.21	1.5	2.0	1.8	2.9	1.7	1.0
5 Cu Ni Scav Tail	1330.1	67.1	0.13	0.11	1.73	0.095	0.026	0.020	13.9	13.4	10.9	27.8	9.8	1.5
Head (calc)	1983.3	100.0	0.63	0.55	10.7	0.23	0.18	0.88	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	1.03						
Combined Products														
CuNi Ro Conc (1 + 2)		21.1	2.42	2.09	42.0	0.69	0.72	3.95	81.4	80.1	83.3	63.7	85.0	94.3
CuNi Sc Conc (3 + 4)		11.8	0.25	0.30	5.28	0.17	0.079	0.31	4.7	6.5	5.8	8.6	5.2	4.2
Ro + Sc Conc (1 to 4)		32.9	1.64	1.45	28.9	0.50	0.49	2.64	86.1	86.6	89.1	72.2	90.2	98.5

Test: 15 Project: 4255 Date: Mar. 17/92 Operator: BW

Purpose: To repeat conditions of Test 12 with 3501 replacing A208.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	pH
Primary Grind	125							45			8.5
Condition 1		2000							2		10.1
2				250					5		9.8
3			400		10	100			3		9.7
Rougher 1							50		1	3	
2							25		1	5	
Scavenger 1	50					100	12.5		2	5	9.6
2						50	12.5		2	5	9.4

Test: 15

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 CuNi Ro Conc 1	184.5	9.6	4.72	4.90	88.3	1.32	1.58	72.5	74.2	76.9	55.2	81.4
2 CuNi Ro Conc 2	192.1	10.0	0.41	0.55	9.03	0.22	0.12	6.6	8.7	8.2	9.6	6.4
3 CuNi Sc Conc 1	154.5	8.0	0.25	0.32	5.09	0.16	0.075	3.2	4.1	3.7	5.6	3.2
4 CuNi Sc Conc 2	88.2	4.6	0.63	0.18	3.06	0.13	0.052	4.6	1.3	1.3	2.6	1.3
5 Cu Ni Scav Tail	1307.6	67.9	0.12	0.11	1.61	0.091	0.021	13.1	11.8	9.9	27.0	7.7
Head (calc)	1926.9	100.0	0.62	0.63	11.0	0.23	0.19	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
CuNi Ro Conc (1 + 2)		19.5	2.52	2.68	47.9	0.76	0.84	79.1	82.8	85.1	64.8	87.8
CuNi Sc Conc (3 + 4)		12.6	0.39	0.27	4.35	0.15	0.067	7.8	5.4	5.0	8.2	4.5
Ro + Sc Conc (1 to 4)		32.1	1.69	1.74	30.8	0.52	0.53	86.9	88.2	90.1	73.0	92.3

Test: 16 Project: 4255 Date: Mar. 17/92 Operator: BW

Purpose: To repeat conditions of Test 12 with 3477 replacing A208.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3477	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.5
Condition 1		2000							2		10.0
2				250					5		9.8
3			400		10	100			3		9.6
Rougher 1							50		1	3	
2							25		1	5	
Scavenger 1	50					100	12.5		2	5	9.5
2						50	12.5		2	5	9.4

Test: 16

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 CuNi Ro Conc 1	188.6	9.5	5.47	4.86	86.0	1.30	1.54	75.8	73.0	76.2	54.6	81.6
2 CuNi Ro Conc 2	199.3	10.0	0.39	0.50	8.20	0.21	0.100	5.7	7.9	7.7	9.3	5.6
3 CuNi Sc Conc 1	132.4	6.7	0.23	0.32	5.32	0.16	0.068	2.2	3.4	3.3	4.7	2.5
4 CuNi Sc Conc 2	84.5	4.3	0.17	0.21	3.55	0.15	0.055	1.1	1.4	1.4	2.8	1.3
5 Cu Ni Scav Tail	1380.6	69.5	0.15	0.13	1.75	0.093	0.023	15.2	14.3	11.4	28.6	8.9
Head (calc)	1985.4	100.0	0.69	0.63	10.7	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
CuNi Ro Conc (1 + 2)		19.5	2.86	2.62	46.0	0.74	0.80	81.5	80.9	83.9	63.9	87.2
CuNi Sc Conc (3 + 4)		10.9	0.21	0.28	4.63	0.16	0.063	3.3	4.8	4.7	7.5	3.8
Ro + Sc Conc (1 to 4)		30.5	1.91	1.78	31.2	0.53	0.54	84.8	85.7	88.6	71.4	91.1

Test: 17 Project: 4255 Date: Mar. 23/92 Operator: BW

Purpose: To repeat conditions of Test 15 with cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	pH
Primary Grind	125							45			8.2
Condition 1		2000							2		10.0
2				250					5		9.8
3			400		25	100			3		9.5
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.7
2						50	12.5		2	5	9.9
1st Cleaner			100						1	5	9.8
					5	20			1	5	
2nd Cleaner			50						1	6	9.3

Test: 17

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	170.8	8.6	4.71	5.31	102	1.43	1.76	77.8	76.9	80.7	54.0	84.5
2 2nd Cleaner Tail	75.8	3.8	0.28	0.34	6.94	0.20	0.080	2.1	2.2	2.4	3.4	1.7
3 1st Cleaner Tail	303.2	15.3	0.17	0.20	3.96	0.17	0.059	5.0	5.1	5.6	11.4	5.0
4 Scavenger Tail	1426.3	72.2	0.11	0.13	1.70	0.099	0.022	15.2	15.7	11.3	31.2	8.8
Head (calc)	1976.1	100.0	0.52	0.60	10.9	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
1st Cleaner Conc (1 + 2)		12.5	3.35	3.78	72.5	1.05	1.24	79.8	79.1	83.1	57.4	86.2
Scavenger Conc (1 to 3)		27.8	1.60	1.81	34.7	0.57	0.59	84.8	84.3	88.7	68.8	91.2

Test: 18 Project: 4255 Date: Mar. 24/92 Operator: BW

Purpose: To repeat conditions of Test 17 with a 40 minute pebble mill regrind before the cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.5
Condition 1		2000							2		10.2
2				250					5		9.8
3			400		25	100			3		9.6
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.9
2						50	12.5		2	5	9.8
P.M. Regrind								40			
1st Cleaner			100						1	5	9.4
					5	20			1	5	
2nd Cleaner			50						1	6	8.9

Product: Combined Cleaner Product Test No: 18 S.G.- 3.03

Mesh	Weight Grams	% Weight		
		Ind.	Cum.	Passing
41.4µ	0.16	0.3	0.3	99.7
32.1	0.48	1.0	1.3	98.7
22.4	2.76	5.5	6.8	93.2
15.4	5.50	11.0	17.8	82.2
11.9	3.23	6.5	24.3	75.7
-11.9	37.87	75.7	100.0	-
Total	50.00	100.0	-	-

Test: 18

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	106.2	5.4	8.89	8.12	145	2.03	2.62	77.3	75.6	76.0	48.3	81.5
2 2nd Cleaner Tail	99.0	5.0	0.43	0.64	12.5	0.33	0.15	3.5	5.6	6.1	7.3	4.3
3 1st Cleaner Tail	366.8	18.5	0.14	0.20	3.86	0.17	0.055	4.2	6.4	7.0	14.0	5.9
4 Scavenger Tail	1412.0	71.2	0.13	0.100	1.56	0.096	0.020	15.0	12.4	10.9	30.4	8.3
Head (calc)	1984.0	100.0	0.62	0.57	10.2	0.22	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

1st Cleaner Conc (1 + 2)		10.3	4.81	4.51	81.1	1.21	1.43	80.8	81.2	82.1	55.6	85.8
Scavenger Conc (1 to 3)		28.8	1.81	1.75	31.6	0.54	0.55	85.0	87.6	89.1	69.6	91.7

Test: 19 Project: 4255 Date: Mar. 24/92 Operator: BW

Purpose: To repeat conditions of Test 17 with a 20 minute pebble mill regrind before the cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.6
Condition 1		2000							2		10.3
2				250					5		10.1
3			400		25	100			3		10.0
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.6
2						50			2	5	9.9
P.M. Regrind								20			
1st Cleaner			100						1	5	9.6
					5	20			1	5	
2nd Cleaner			50						1	6	9.6

Product: Combined Cleaner Product Test No: 19 S.G.- 3.05

Mesh	Weight Grams	% Weight		
		Ind.	Cum.	Passing
41.4μ	0.51	1.0	1.0	99.0
32.1	1.36	2.7	3.7	96.3
22.4	4.25	8.5	12.2	87.8
15.4	6.10	12.2	24.4	75.6
11.9	3.20	6.4	30.8	69.2
-11.9	34.58	69.2	100.0	-
Total	50.00	100.0	-	-

Test: 19

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	141.2	7.1	6.91	6.35	120	1.70	2.11	76.2	75.2	77.7	53.4	84.7
2 2nd Cleaner Tail	73.0	3.7	0.30	0.51	11.9	0.31	0.11	1.7	3.1	4.0	5.0	2.3
3 1st Cleaner Tail	276.8	13.9	0.21	0.23	3.95	0.14	0.052	4.5	5.3	5.0	8.6	4.1
4 Scavenger Tail	1496.5	75.3	0.15	0.13	1.93	0.099	0.021	17.5	16.3	13.3	33.0	8.9
Head (calc)	1987.5	100.0	0.64	0.60	11.0	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

1st Cleaner Conc (1 + 2)		10.8	4.66	4.36	83.2	1.23	1.43	77.9	78.3	81.7	58.4	87.0
Scavenger Conc (1 to 3)		24.7	2.15	2.03	38.5	0.61	0.65	82.5	83.7	86.7	67.0	91.1

Test: 20 Project: 4255 Date: Mar. 25/92 Operator: BW

Purpose: To repeat conditions of Test 17 without CMC in the rougher but with CMC added to the cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	CMC 7LT	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.4
Condition 1		2000							2		10.2
2				250					5		9.8
3					25	100			3		9.8
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.7
2						50	12.5		2	5	9.7
1st Cleaner			300						1	5	9.6
					5	20			1	5	
2nd Cleaner			100						1	6	9.5

Test: 20

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	208.8	10.6	4.13	4.19	78.0	1.18	1.37	78.2	78.7	80.9	55.6	84.3
2 2nd Cleaner Tail	108.8	5.5	0.25	0.36	7.12	0.22	0.091	2.5	3.5	3.8	5.4	2.9
3 1st Cleaner Tail	224.2	11.3	0.18	0.18	3.18	0.15	0.047	3.7	3.6	3.5	7.6	3.1
4 Scavenger Tail	1435.6	72.6	0.12	0.11	1.64	0.097	0.023	15.6	14.2	11.7	31.4	9.7
Head (calc)	1977.4	100.0	0.56	0.56	10.2	0.22	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

1st Cleaner Conc (1 + 2)		16.1	2.80	2.88	53.7	0.85	0.93	80.7	82.2	84.8	61.0	87.2
Scavenger Conc (1 to 3)		27.4	1.72	1.76	32.8	0.56	0.57	84.4	85.8	88.3	68.6	90.3

Test: 21 Project: 4255 Date: Mar. 27/92 Operator: BW

Purpose: To repeat conditions of Test 20 replacing CMC with WC 9524 and completing 4 cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S	Na2CO3	WC 9524	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	pH
Primary Grind	125							45			8.4
Condition 1		2000							2		10.1
2				250					5		9.7
3					25	100			3		9.7
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.6
2						50	12.5		2	5	9.5
1st Cleaner			300						1	5	9.5
					5	20			1	5	
2nd Cleaner			100						1	6	9.3
3rd Cleaner			50						1	5	9.0
4th Cleaner			25						1	5	8.1

Test: 21

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	104.0	5.2	9.30	8.00	150	2.18	2.74	74.1	68.0	73.8	50.5	77.1
2 4th Cleaner Tail	37.8	1.9	0.92	1.27	20.7	0.38	0.34	2.7	3.9	3.7	3.2	3.5
3 3rd Cleaner Tail	72.2	3.6	0.53	0.69	12.7	0.29	0.20	2.9	4.1	4.3	4.7	3.9
4 2nd Cleaner Tail	111.2	5.6	0.26	0.31	5.62	0.18	0.080	2.2	2.8	3.0	4.5	2.4
5 1st Cleaner Tail	259.1	13.0	0.15	0.19	3.13	0.14	0.051	3.0	4.0	3.8	8.1	3.6
6 Scavenger Tail	1404.2	70.6	0.14	0.15	1.71	0.093	0.025	15.1	17.2	11.4	29.1	9.5
Head (calc)	1988.5	100.0	0.66	0.62	10.6	0.23	0.19	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
3rd Cleaner Conc (1 + 2)		7.1	7.07	6.21	116	1.70	2.10	76.8	71.9	77.5	53.7	80.6
2nd Cleaner Conc (1 to 3)		10.8	4.86	4.34	80.8	1.22	1.46	79.7	76.0	81.8	58.4	84.5
1st Cleaner Conc (1 to 4)		16.4	3.29	2.97	55.1	0.87	0.99	82.0	78.8	84.8	62.8	86.9
Scavenger Conc (1 to 5)		29.4	1.90	1.73	32.1	0.54	0.57	84.9	82.8	88.6	70.9	90.5

Test: 22 Project: 4255 Date: Mar. 28/92 Operator: BW

Purpose: To repeat conditions of Test 20 replacing CMC with PA MED and completing 4 cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							45			8.4
Condition 1		2000							2		10.1
2				250					5		9.2
3					25	100			3		
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	6		2	5	9.5
2						50	12.5		2	5	9.5
1st Cleaner			300						1	5	9.4
					5	20			1	5	
2nd Cleaner			100						1	6	9.4
3rd Cleaner			50						1	5	8.7
4th Cleaner			25						1	5	7.8

Test: 22

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	85.3	4.3	9.24	9.32	171	2.56	3.12	69.7	69.8	71.3	48.0	77.0
2 4th Cleaner Tail	28.2	1.4	1.14	1.24	21.0	0.34	0.30	2.8	3.1	2.9	2.1	2.4
3 3rd Cleaner Tail	47.3	2.4	0.54	0.68	13.2	0.28	0.17	2.3	2.8	3.0	2.9	2.3
4 2nd Cleaner Tail	116.8	5.9	0.39	0.43	9.51	0.24	0.12	4.0	4.4	5.4	6.2	4.1
5 1st Cleaner Tail	256.8	13.0	0.20	0.21	3.90	0.16	0.061	4.5	4.7	4.9	9.0	4.5
6 Scavenger Tail	1443.0	73.0	0.13	0.12	1.76	0.100	0.023	16.6	15.2	12.4	31.7	9.6
Head (calc)	1977.4	100.0	0.57	0.58	10.4	0.23	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

3rd Cleaner Conc (1 + 2)		5.7	7.23	7.31	134	2.01	2.42	72.6	72.8	74.2	50.1	79.5
2nd Cleaner Conc (1 to 3)		8.1	5.26	5.36	98.4	1.50	1.76	74.8	75.7	77.3	53.1	81.8
1st Cleaner Conc (1 to 4)		14.0	3.21	3.29	61.0	0.97	1.07	78.9	80.1	82.7	59.2	85.9
Scavenger Conc (1 to 5)		27.0	1.76	1.81	33.6	0.58	0.58	83.4	84.8	87.6	68.3	90.4

Test: 23 Project: 4255 Date: Mar. 28/92 Operator: BW

Purpose: To repeat conditions of Test 20 with 4 cleaning stages, replacing CMC with Jaguar MDD and using SO2 to modify the pH.(7.0 in the first cleaner, 6.5 in the second, 5.5 in the third and 4.5 in the fourth cleaning stage.)

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 45 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2S	SO2	Na2CO3	Jaguar MDD	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125								45			8.3
Condition 1			2000							2		10.1
2					250					5		9.2
3						25	100			3		
Rougher 1								50		1	3	
2								12.5		1	5	
Scavenger 1	50						100	6		2	5	9.5
2							50	12.5		2	5	9.5
1st Cleaner		300		400						1	5	6.8
						5	20			1	5	
2nd Cleaner		180		100						1	6	6.5
3rd Cleaner		120		50						1	5	5.5
4th Cleaner		90		25						1	5	3.6

Test: 23

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	37.3	1.9	14.5	13.4	257	3.55	4.26	44.9	43.5	45.7	29.7	47.2
2 4th Cleaner Tail	12.7	0.6	5.68	8.36	140	2.00	2.56	6.0	9.2	8.4	5.7	9.7
3 3rd Cleaner Tail	23.2	1.2	2.89	3.71	64.7	0.99	1.15	5.6	7.5	7.1	5.2	7.9
4 2nd Cleaner Tail	75.5	3.8	1.30	1.53	29.5	0.52	0.49	8.1	10.0	10.6	8.8	11.0
5 1st Cleaner Tail	382.1	19.3	0.32	0.44	8.48	0.21	0.13	10.1	14.6	15.4	18.0	14.8
6 Scavenger Tail	1450.9	73.2	0.21	0.12	1.84	0.100	0.022	25.3	15.1	12.7	32.6	9.5
Head (calc)	1981.7	100.0	0.61	0.58	10.6	0.22	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
3rd Cleaner Conc (1 + 2)		2.5	12.3	12.1	227	3.16	3.83	50.9	52.7	54.1	35.4	56.9
2nd Cleaner Conc (1 to 3)		3.7	9.29	9.45	176	2.47	2.98	56.4	60.2	61.3	40.6	64.8
1st Cleaner Conc (1 to 4)		7.5	5.23	5.43	101	1.48	1.72	64.6	70.2	71.9	49.4	75.8
Scavenger Conc (1 to 5)		26.8	1.70	1.84	34.5	0.57	0.57	74.7	84.9	87.3	67.4	90.5

Test: 24 Project: 4255 Date: April 3rd/92 Operator: BW

Purpose: To repeat conditions of Test 17 at 68% minus 200 mesh, with PA MED replacing CMC and with 4 cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							22			8.2
Condition 1		2000							2		10.1
2				250					5		9.6
3			400		25	100			3		9.5
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100	12.5		2	5	9.7
2						50	12.5		2	5	9.6
1st Cleaner			100						1	5	9.5
					5	20			1	5	
2nd Cleaner			50						1	6	9.3
3rd Cleaner			25						1	4	9.1
4th Cleaner			10						1	3	8.7

Size Analysis:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	3.6	2.8	2.8	97.2
147	100	8.0	6.2	9.0	91.0
104	150	14.9	11.6	20.6	79.4
74	200	14.8	11.5	32.1	67.9
53	270	14.9	11.6	43.7	56.3
38	400	12.7	9.9	53.6	46.4
-38	-400	59.7	46.4	100.0	-
	Total	128.6	100.0	-	-

Test: 24

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	166.4	9.0	4.28	4.71	91.0	1.27	1.55	71.5	74.0	76.5	53.7	80.1
2 4th Cleaner Tail	29.3	1.6	0.96	0.75	13.8	0.28	0.17	2.8	2.1	2.0	2.1	1.5
3 3rd Cleaner Tail	32.6	1.8	0.48	0.55	10.2	0.24	0.14	1.6	1.7	1.7	2.0	1.4
4 2nd Cleaner Tail	69.5	3.8	0.31	0.39	7.92	0.21	0.089	2.2	2.6	2.8	3.7	1.9
5 1st Cleaner Tail	116.4	6.3	0.16	0.20	3.67	0.16	0.060	1.9	2.2	2.2	4.7	2.2
6 Scavenger Tail	1428.9	77.5	0.14	0.13	2.05	0.093	0.029	20.1	17.5	14.8	33.8	12.9
Head (calc)	1843.1	100.0	0.54	0.58	10.7	0.21	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

3rd Cleaner Conc (1 + 2)		10.6	3.78	4.12	79.4	1.12	1.34	74.3	76.0	78.6	55.8	81.6
2nd Cleaner Conc (1 to 3)		12.4	3.31	3.61	69.6	1.00	1.17	75.9	77.7	80.3	57.8	83.0
1st Cleaner Conc (1 to 4)		16.2	2.61	2.86	55.2	0.81	0.92	78.0	80.3	83.0	61.5	85.0
Scavenger Conc (1 to 5)		22.5	1.92	2.11	40.7	0.63	0.68	79.9	82.5	85.2	66.2	87.1

Test: 25 Project: 4255 Date: April 6th/92 Operator: BW

Purpose: To repeat conditions of Test 24 at 86% minus 200 mesh.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 35 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							35			8.3
Condition 1		2000							2		10.1
2				250					5		9.6
3			400		25	100			3		
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100			2	5	
2						50	12.5		2	5	9.5
1st Cleaner			100						1	5	9.5
					5	20			1	5	
2nd Cleaner			50						1	6	9.3
3rd Cleaner			25						1	4	8.7
4th Cleaner			10						1	3	7.9

Size Analysis:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	0.1	0.1	0.1	99.9
147	100	0.9	0.7	0.8	99.2
104	150	4.9	3.8	4.6	95.4
74	200	11.9	9.2	13.8	86.2
53	270	16.1	12.5	26.3	73.7
38	400	19.0	14.7	41.0	59.0
-38	-400	76.0	59.0	100.0	-
	Total	128.9	100.0	-	-

Test: 25

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	107.2	5.8	7.13	7.61	136	1.94	2.37	70.5	70.1	74.1	50.4	79.4
2 4th Cleaner Tail	26.4	1.4	0.87	1.24	20.6	0.35	0.29	2.1	2.8	2.8	2.2	2.4
3 3rd Cleaner Tail	35.5	1.9	0.51	0.71	12.6	0.28	0.15	1.7	2.2	2.3	2.4	1.7
4 2nd Cleaner Tail	67.3	3.6	0.27	0.35	6.85	0.20	0.080	1.7	2.0	2.3	3.3	1.7
5 1st Cleaner Tail	181.7	9.8	0.18	0.21	3.84	0.16	0.057	3.0	3.3	3.6	7.0	3.2
6 Scavenger Tail	1428.0	77.4	0.16	0.16	2.05	0.100	0.026	21.1	19.6	14.9	34.6	11.6
Head (calc)	1846.1	100.0	0.59	0.63	10.6	0.22	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

3rd Cleaner Conc (1 + 2)	7.2	5.89	6.35	113	1.63	1.96	72.6	72.9	76.9	52.7	81.8
2nd Cleaner Conc (1 to 3)	9.2	4.76	5.17	92.0	1.34	1.58	74.2	75.1	79.2	55.1	83.5
1st Cleaner Conc (1 to 4)	12.8	3.48	3.80	67.7	1.02	1.15	75.9	77.1	81.5	58.3	85.2
Scavenger Conc (1 to 5)	22.6	2.05	2.24	40.0	0.65	0.68	78.9	80.4	85.1	65.4	88.4

Test: 26 Project: 4255 Date: April 8th/92 Operator: BW

Purpose: To repeat conditions of Test 17 at 59% minus 200 mesh, PA MED replacing CMC and with 4 cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 16 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							16			8.2
Condition 1		2000							2		10.2
2				250					5		
3			400		25	100			3		9.8
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100			2	5	9.8
2						50	12.5		2	5	
1st Cleaner			100						1	5	9.7
					5	20			1	5	
2nd Cleaner			50						1	6	9.3
3rd Cleaner			25						1	4	8.9
4th Cleaner			10						1	3	8.3
5th Cleaner	Flotation was performed in a 10 % NaCl solution.								1	2	

Size Analysis:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
589	28	0.0	0.0	0.0	100.0
417	35	1.4	1.3	1.3	98.7
295	48	2.1	2.0	3.3	96.7
208	65	5.9	5.6	8.9	91.1
147	100	9.7	9.2	18.2	81.8
104	150	12.8	12.2	30.3	69.7
74	200	10.9	10.4	40.7	59.3
53	270	10.3	9.8	50.5	49.5
38	400	9.8	9.3	59.8	40.2
-38	-400	42.3	40.2	100.0	-
	Total	105.2	100.0	-	-

Test: 26

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	64.1	3.5	10.2	9.26	181	2.62	3.27	57.7	54.5	60.7	42.1	66.8
2 5th Cleaner Tail	47.4	2.6	1.39	1.71	25.6	0.36	0.40	5.8	7.4	6.3	4.3	6.0
3 4th Cleaner Tail	31.0	1.7	1.11	1.58	22.5	0.38	0.32	3.0	4.5	3.6	2.9	3.2
4 3rd Cleaner Tail	42.1	2.3	0.63	0.91	15.7	0.32	0.19	2.3	3.5	3.5	3.4	2.6
5 2nd Cleaner Tail	78.6	4.2	0.47	0.58	10.5	0.26	0.12	3.3	4.2	4.3	5.1	3.0
6 1st Cleaner Tail	151.0	8.1	0.27	0.33	5.66	0.19	0.086	3.6	4.6	4.5	7.2	4.1
7 Scavenger Tail	1442.8	77.7	0.19	0.16	2.26	0.097	0.031	24.2	21.2	17.1	35.0	14.3
Head (calc)	1857.0	100.0	0.61	0.59	10.3	0.22	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
4th Cleaner Conc (1 + 2)		6.0	6.45	6.05	115	1.66	2.05	63.6	59.0	64.3	46.3	72.9
3rd Cleaner Conc (1 to 3)		7.7	5.29	5.08	94.8	1.38	1.67	66.6	62.6	67.8	49.3	76.0
2nd Cleaner Conc (1 to 4)		9.9	4.23	4.13	76.8	1.14	1.34	68.9	66.8	72.1	52.7	78.6
1st Cleaner Conc (1 to 5)		14.2	3.11	3.07	57.0	0.88	0.97	72.2	71.3	76.6	57.8	81.6
Scavenger Conc (1 to 6)		22.3	2.07	2.07	38.3	0.63	0.65	75.8	75.9	81.1	65.0	85.7

Test: 27 Project: 4255 Date: April 8th/92 Operator: BW

Purpose: To repeat conditions of Test 17 at 76.5% minus 200 mesh, PA MED replacing CMC and with 4 cleaning stages.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 27 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125							27			8.1
Condition 1		2000							2		10.1
2				250					5		
3			400		25	100			3		9.6
Rougher 1							50		1	3	
2							12.5		1	5	
Scavenger 1	50					100			2	5	9.5
2						50	12.5		2	5	
1st Cleaner			100						1	5	9.5
					5	20			1	5	
2nd Cleaner			50						1	6	9.4
3rd Cleaner			25						1	4	9.0
4th Cleaner			10						1	3	8.4

Size Analysis:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	1.0	0.8	0.8	99.2
147	100	4.1	3.2	4.0	96.0
104	150	10.8	8.4	12.3	87.7
74	200	14.4	11.2	23.5	76.5
53	270	15.1	11.7	35.2	64.8
38	400	16.4	12.7	47.9	52.1
-38	-400	67.2	52.1	100.0	-
	Total	129.0	100.0	-	-

Test: 28 Project: 4255 Date: April 9th/92 Operator: BW

Purpose: To conduct a flotation test on Comp. M92 at 68% minus 200 mesh with the following procedure.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	Na2CO3	PA MED	CuSO4	3501	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	125	*2000	*400		*25	*50		22			9.8
Rougher 1							25		1	3	
							MIBC				
2							5		1	5	
Scavenger 1	50			50		25	10		1	7	9.8
2						25			1	5	
						25			1	5	
						25			1	5	
PM Regrind			*100		*5	*20		15			
1st Cleaner									1	7	9.2
						10			1	5	
						5			1	3	
2nd Cleaner			50						1	3.5	8.0
						5			1	2	
						5	2.5		1	3	
3rd Cleaner			10						1	3	7.7
						5			1	2	
4th Cleaner									1	3	
						5			1	2	8.0

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage.

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750
1st & 2nd Cl's	D-1 , 500g	1300
3rd &4th Cl's	D-1 , 250g	1100

Test: 28

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	27.1	1.4	23.6	20.1	372	4.64	7.76	53.6	51.2	52.9	29.6	66.4
2 4th Cleaner Tail	2.8	0.1	3.95	5.80	141	2.93	1.32	0.9	1.5	2.1	1.9	1.2
3 3rd Cleaner Tail	7.0	0.4	2.72	4.46	101	2.03	1.00	1.6	2.9	3.7	3.3	2.2
4 2nd Cleaner Tail	26.1	1.3	1.35	2.21	46.3	1.00	0.48	3.0	5.4	6.3	6.1	4.0
5 1st Cleaner Tail	127.7	6.5	0.46	0.72	14.0	0.42	0.12	4.9	8.6	9.4	12.6	4.8
6 Scavenger Tail	1787.2	90.4	0.24	0.18	2.72	0.11	0.038	36.0	30.2	25.5	46.3	21.4
Head (calc)	1977.9	100.0	0.60	0.54	9.63	0.21	0.16	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

3rd Cleaner Conc (1 + 2)		1.5	21.8	18.8	350	4.48	7.16	54.6	52.7	55.0	31.6	67.6
2nd Cleaner Conc (1 to 3)		1.9	18.1	16.0	303	4.02	5.99	56.2	55.7	58.7	34.9	69.8
1st Cleaner Conc (1 to 4)		3.2	11.2	10.3	197	2.77	3.71	59.1	61.1	65.1	41.1	73.7
Scavenger Conc (1 to 5)		9.6	4.00	3.89	74.4	1.20	1.30	64.0	69.8	74.5	53.7	78.6

Test: 29 Project: 4255 Date: April 20th/9 Operator: BW

Purpose: To repeat test 28 without Na2CO3, with Na2S added to the last 5 minutes of the primary grind and with MIBC only for frother.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			8.5
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	8.5
2						25			1	5	
						25			1	5	
						25			1	5	
PM Regrind			*100		*5	*20		15			
1st Cleaner									1	7	8.3
						10			1	5	
						5			1	3	
2nd Cleaner			50						1	3.5	8.2
						5	2.5		1	2	
						5			1	3	
3rd Cleaner			10						1	3	8.0
						5	2.5		1	2	
						5			1	3	
4th Cleaner							2.5		1	3	
						5			1	2	8.0

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750
1st & 2nd Cl's	D-1 , 500g	1300
3rd &4th Cl's	D-1 , 250g	1100

Test: 29

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Rh	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	35.9	1.8	17.1	14.9	332	4.50	6.12	0.08	58.1	48.0	57.6	35.3	65.9
2 4th Cleaner Tail	4.8	0.2	2.67	5.06	85.4	1.26	1.45	-	1.2	2.2	2.0	1.3	2.1
3 3rd Cleaner Tail	11.2	0.6	1.74	3.55	56.6	0.89	0.88	-	1.8	3.6	3.1	2.2	3.0
4 2nd Cleaner Tail	68.4	3.4	1.01	1.94	33.8	0.67	0.42	-	6.5	11.9	11.2	10.0	8.6
5 1st Cleaner Tail	202.3	10.2	0.33	0.53	8.68	0.25	0.097	-	6.3	9.6	8.5	11.1	5.9
6 Scavenger Tail	1666.1	83.8	0.17	0.17	2.20	0.11	0.029	-	26.0	24.8	17.7	40.1	14.5
Head (calc)	1988.7	100.0	0.53	0.56	10.4	0.23	0.17	-	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18	-					

Combined Products

3rd Cleaner Conc (1 + 2)		2.0	15.4	13.7	303	4.12	5.57	-	59.3	50.1	59.6	36.7	68.0
2nd Cleaner Conc (1 to 3)		2.6	12.5	11.5	250	3.42	4.56	-	61.1	53.7	62.6	38.8	71.0
1st Cleaner Conc (1 to 4)		6.0	5.95	6.08	127	1.86	2.20	-	67.7	65.6	73.8	48.9	79.6
Scavenger Conc (1 to 5)		16.2	2.42	2.60	52.8	0.85	0.88	-	74.0	75.2	82.3	59.9	85.5

Test: 30 Project: 4255 Date: April 23th/92 Operator: BW

Purpose: To repeat test 29 on the Roby Zone composite.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Roby Zone composite.

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			9.7
Rougher 1							25		1	3	
2							10		1	5	
Scavenger 1	50			50		25	5		1	5	9.5
2						25			1	5	
						25	5		1	5	
						25			1	5	
PM Regrind			*100		*5	*20		15			
1st Cleaner							2.5		1	7	9.0
						10	2.5		1	5	
						5	2.5		1	3	
2nd Cleaner			50				5		1	3.5	8.9
						5	2.5		1	2	
						5			1	3	
3rd Cleaner			10						1	3	8.5
						5	2.5		1	2	
4th Cleaner									1	2.5	
						5	2.5		1	1	8.0

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage.

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750
1st & 2nd Cl's	D-1 , 500g	1300
3rd &4th Cl's	D-1 , 250g	1100

NOTE : The products from this test with Roby Zone as feed had a settling rate much poorer than Test 29 which used Comp. M92 for feed.

Test: 30

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Cleaner Conc.	15.9	0.8	20.3	18.7	163	7.27	11.0	52.9	51.3	58.5	44.3	67.6
2 4th Cleaner Tail	1.3	0.1	4.12	5.71	43.3	2.54	1.40	0.9	1.3	1.3	1.3	0.7
3 3rd Cleaner Tail	2.8	0.1	1.32	2.13	17.8	1.22	0.52	0.6	1.0	1.1	1.3	0.6
4 2nd Cleaner Tail	25.5	1.3	0.54	0.65	5.00	0.37	0.14	2.3	2.9	2.9	3.6	1.4
5 1st Cleaner Tail	108.2	5.5	0.44	0.49	3.67	0.24	0.11	7.8	9.2	9.0	10.0	4.6
6 Scavenger Tail	1807.3	92.2	0.12	0.11	0.67	0.057	0.036	35.5	34.3	27.3	39.5	25.1
Head (calc)	1961.0	100.0	0.31	0.30	2.26	0.13	0.13	100.0	100.0	100.0	100.0	100.0
(direct)			0.30	0.29	2.40	0.16	0.16					

Combined Products

3rd Cleaner Conc (1 + 2)		0.9	19.1	17.7	154	6.91	10.3	53.8	52.6	59.7	45.6	68.3
2nd Cleaner Conc (1 to 3)		1.0	16.6	15.5	135	6.12	8.91	54.4	53.7	60.9	46.9	68.9
1st Cleaner Conc (1 to 4)		2.3	7.60	7.19	62.1	2.90	3.99	56.6	56.5	63.7	50.5	70.3
Scavenger Conc (1 to 5)		7.8	2.56	2.47	21.0	1.03	1.26	64.5	65.7	72.7	60.5	74.9

Test: 31 Project: 4255 Date: April 20th/9 Operator: BW

Purpose: To repeat test 29 without reagents in the regrind and with the changes shown in the cleaning stages

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			8.5
Scavenger 1	50			50		25	7.5		1	7	8.4
2						25			1	5	
						25	2.5		1	5	
						25			1	5	
PM Regrind								15			8.4
1st Cleaner	1625									5	11.8
2nd Cleaner	813									2	12.0

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750
1st & 2nd Cl's	D-1 , 500g	1300

Test: 31

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 2nd Cl. Froth	34.3	1.7	10.7	10.0	229	2.80	2.72	35.6	30.1	37.9	21.3	27.3
2 2nd Cl. Cell Prod.	95.9	4.8	1.94	2.76	55.2	0.95	0.99	18.1	23.3	25.5	20.3	27.8
3 1st Cl. Cell Prod.	231.5	11.7	0.94	1.09	17.6	0.44	0.45	21.1	22.2	19.7	22.6	30.5
4 Scav. Cell Prod.	1625.0	81.8	0.16	0.17	2.16	0.099	0.030	25.2	24.3	16.9	35.8	14.3
Head (calc)	1986.7	100.0	0.52	0.57	10.4	0.23	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
1st Cl. Froth (1 & 2)		6.6	4.25	4.65	101	1.44	1.45	53.7	53.4	63.4	41.6	55.2
Scavenger Froth (1 to 3)		18.2	2.13	2.37	47.6	0.80	0.81	74.8	75.7	83.1	64.2	85.7

Test: 32 Project: 4255 Date: May 5th/92 Operator: SP

Purpose: To conduct a flotation test on Roby Zone at 68% minus 200 mesh ground in a 5% NaCl solution , using collector P3.

Procedure: As shown below. Settling and filtration were good throughout test.

Feed: 2000 grams minus 10 mesh Roby Zone Comp

Grind: 25 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	NaCl			Na2S	A350	P3	MIBC	Grind	Cond.	Froth	
Primary Grind	25000				50	25		25			
Rougher							5		1	3	
					25	10	15		1	3	8.7
					25	10	5		2	3	
					10	5			1	3	
				125	25	10	5		2	3	9.2
				125	25	10	10		2	3	
					25	10	10		1	3	
				125	25	10	10		2	3	
					25	10	10		2	3	
					25	10	10		1	3	
PM Regrind						10		30			
1st Cleaner										5	
					10	5			1	5	
					10	5			1	5	
2nd Cleaner									1	5	
3rd Cleaner									1	5	

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	2100
1st Cl	D-1 , 500g	1600
2nd & 3rd Cl's	D-1 , 250g	1100

Test: 32

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Cleaner Conc.	21.7	1.1	22.9	15.8	132	5.20	9.53	21.0	61.7	53.3	57.3	38.3	70.0	57.8
2 3rd Cleaner Tail	6.5	0.3	1.55	1.97	17.6	1.36	0.55	3.45	1.3	2.0	2.3	3.0	1.2	2.8
3 2nd Cleaner Tail	44.8	2.2	0.93	1.33	12.3	0.95	0.36	1.76	5.2	9.3	11.0	14.5	5.5	10.0
4 1st Cleaner Tail	110.8	5.6	0.36	0.42	3.09	0.21	0.082	1.27	5.0	7.2	6.9	7.9	3.1	17.9
5 Rougher Tail	1809.1	90.8	0.12	0.100	0.62	0.059	0.033	0.050	26.9	28.1	22.5	36.3	20.2	11.5
Head (calc)	1992.9	100.0	0.40	0.32	2.50	0.15	0.15	0.40	100.0	100.0	100.0	100.0	100.0	100.0

Combined Products

2nd Cleaner Conc (1 + 2)	1.4	18.0	12.6	105	4.31	7.46	17.0	62.9	55.3	59.6	41.4	71.2	60.7
1st Cleaner Conc (1 to 3)	3.7	7.52	5.69	48.3	2.25	3.10	7.63	68.1	64.6	70.7	55.8	76.7	70.7
Rougher Conc (1 to 4)	9.2	3.20	2.51	21.0	1.02	1.28	3.80	73.1	71.9	77.5	63.7	79.8	88.5

Test: 33 Project: 4255 Date: May 11th/92 Operator: BW

Purpose: To conduct a flotation test on Comp M92 at 68% minus 200 mesh ground in a 2.5% NaCl solution , using collector P3.

Procedure: As shown below. Settling and filtration were good throughout test.

Feed: 2000 grams minus 10 mesh Comp. M92.

Grind: 25 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	NaCl			Na2S	A350	P3	MIBC	Grind	Cond.	Froth	
Primary Grind	25000			125	50	25		25			8.2
Rougher							5		1	3	
					50	20	15		2	6	
					50	20	15		2	6	
					50	20	10		2	6	
					50	20			2	6	
					50	20			2	6	
PM Regrind				50		10		30			
1st Cleaner										5	
					10	5			2	5	
					10	5			2	5	
2nd Cleaner										5	
					10	5			2	5	
3rd Cleaner										5	

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	2100
1st Cl	D-1 , 500g	1600
2nd & 3rd Cl's	D-1 , 250g	1100

Test: 33

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Cleaner Conc.	102.3	5.2	7.07	7.71	156	2.16	2.64	15.2	68.5	68.9	75.3	50.2	83.1	84.0
2 3rd Cleaner Tail	36.7	1.9	0.64	1.12	20.3	0.48	0.23	2.22	2.2	3.6	3.5	4.0	2.6	4.4
3 2nd Cleaner Tail	49.3	2.5	0.57	0.52	10.1	0.30	0.088	1.03	2.7	2.2	2.3	3.4	1.3	2.7
4 1st Cleaner Tail	175.7	8.9	0.22	0.36	5.55	0.19	0.064	0.56	3.7	5.5	4.6	7.6	3.5	5.3
5 Rougher Tail	1617.1	81.6	0.15	0.14	1.87	0.095	0.019	0.040	23.0	19.8	14.2	34.9	9.5	3.5
Head (calc)	1981.1	100.0	0.53	0.58	10.72	0.22	0.16	0.93	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							

Combined Products

2nd Cleaner Conc (1 + 2)		7.0	5.37	5.97	120	1.72	2.00	11.8	70.7	72.5	78.8	54.2	85.7	88.4
1st Cleaner Conc (1 to 3)		9.5	4.11	4.54	91.5	1.35	1.50	8.96	73.4	74.7	81.2	57.5	87.1	91.2
Rougher Conc (1 to 4)		18.4	2.23	2.52	50.0	0.79	0.81	4.91	77.0	80.2	85.8	65.1	90.5	96.5

Test: 34 Project: 4255 Date: May 15th/92 Operator: BW

Purpose: To conduct a flash flotation test on Comp M92.

Procedure: The sample was ground for 5 minutes in a laboratory ball mill and flash floated with 50 g/t of PAX and 25g/t of 3501. The tailings were screened at 48 mesh and the screen oversize was ground for 10 minutes in a ball mill. The ground product was recombined with the screen undersize and flash floated with 50 g/t of PAX and 25 g/t 3501. The tailings were screened at 100 mesh and the screen oversize was ground for 10 minutes with 125 g/t of Na2S, 200 g/t of CMC (PA Med.) and 25 g/t 3501. The ground product was recombined with the screen undersize and floated in several stages, with additions of PAX and 3501, for a total of 30 minutes. A small representative sample of about 100 mls of the final tailings was upgraded on a Mozley table.

All the products were filtered and submitted for weights and analyses. Details of the flotation procedures are shown below.

Feed: 2000 grams minus 10 mesh Comp. M92.

Grind: 5 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t						Time, minutes			pH
	A350 (PAX)	3501	Na2S	CMC (PA Med)	DF250		Grind	Cond.	Froth	
Primary Grind							5			
Flash Float 1	50	25			10			1	1	8.2
Screen (48 mesh)										
Grind Screen O/S							10			
Flash Float 2	50	25						1	1	8
	50	25						1	2	
Screen (100 mesh)										
Grind Screen O/S		25	125	200			10			
Rougher Float 1					5			1	5	8.2
2	25	10			5			1	5	
3	25	10						1	5	
4	25	10						1	5	
5	25	10						1	5	
6	25	10						1	5	

Test: 34

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Flash 1 Conc.	46.7	2.4	9.24	7.17	169	1.93	3.00	10.5	35.0	26.8	35.5	19.9	42.7	27.1
2 Flash 2 Conc.	131.7	6.7	2.82	3.05	57.2	1.00	0.77	6.67	30.1	32.2	33.9	29.1	30.9	48.5
3 Ro Float Conc.	197.4	10.1	0.95	1.27	19.0	0.36	0.27	1.74	15.2	20.1	16.9	15.7	16.2	19.0
4 Ro Scav. Conc.	14.2	0.7	0.54	0.70	8.57	0.24	0.14	0.61	0.6	0.8	0.5	0.8	0.6	0.5
5 Ro Scav. Tail	1563.9	80.0	0.15	0.16	1.86	0.100	0.020	0.058	19.0	20.1	13.1	34.5	9.5	5.0
Head (calc)	1953.9	100.0	0.63	0.64	11.4	0.23	0.17	0.93	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							
Combined Products														
Flash 1&2 Conc. (1&2)		9.1	4.50	4.13	86.5	1.24	1.35	7.67	65.1	59.0	69.5	49.0	73.6	75.6
Flash+Ro Conc. (1 to 3)		19.2	2.64	2.63	51.0	0.78	0.78	4.56	80.3	79.1	86.4	64.7	89.9	94.5
Comb. Conc's. (1 to 4)		20.0	2.56	2.56	49.5	0.76	0.76	4.41	81.0	79.9	86.9	65.5	90.5	95.0
Mozley Sep'n of Scav Tailing														
Mozley Conc	0.48	0.6	0.15	1.53	7.34	1.33	0.16	5.26	0.1	1.4	0.4	3.3	0.5	3.3
Mozley Tailing	65.7	79.5	0.15	0.15	1.82	0.091	0.019	0.020	18.9	18.7	12.7	31.2	9.0	1.7
Scav Tailing	66.18	80.0	0.15	0.16	1.86	0.100	0.020	0.058	19.0	20.1	13.1	34.5	9.5	5.0

Test: 35 Project: 4255 Date: May 27th/92 Operator: BW

Purpose: To conduct a flash flotation test on Comp M92.

Procedure: The sample was ground for 2 minutes in a laboratory ball mill with 25 g/t of 3501 and 100g/t of CMC (PA Med). The ground product was floated for 1 minute with 50g/t of PAX and 10 g/t of DF 250. The tailings were decanted and the decant product was saved. The remaining tails were ground for 5 minutes in a ball mill with 25 g/t 3501 and 200 g/t of CMC (PA Med). The ground product was floated for 3 minutes with 100 g/t of PAX and 25 g/t 3501. The tailings were decanted and the decant product was saved. The remaining tails were ground for 5 minutes with 25 g/t of 3501, 125 g/t of Na2S and 200 g/t of CMC (PA Med). The ground product was recombined with the decant products and floated in several stages, with additions of PAX and 3501 for a total of 30 minutes.

All the products were filtered and submitted for weights and analyses. Details of the flotation procedures are shown below.

Feed: 2000 grams minus 10 mesh Comp. M92.

Grind: 2 minutes at 65% solids in the yellow ball mill.

Conditions:

	Reagents, g/t						Time, minutes			
Stage	A350 (PAX)	3501	Na2S	CMC (PA Med)	DF250		Grind	Cond.	Froth	pH
Primary Grind		25		100			2			
Flash Float 1	50				10			1	1	8.1
Grind Decant U/S		25		200			5			
Rougher Float	100	25						1	3	8.1
Tailings Decanted										
Grind Decant U/S		25	125	200			5			
Scavenger Float 1					10			1	5	8.2
2	25	10			10			1	5	
3	25	10						1	5	
4	25	10						1	5	
5	25	10						1	5	
6	25	10						1	5	

Test: 35

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Flash Conc.	55.8	2.9	6.45	5.98	141	1.87	2.53	11.2	28.1	28.3	36.6	23.9	43.3	38.1
2 Rougher Conc.	38.9	2.0	7.73	4.78	95.3	1.43	1.43	10.8	23.5	15.7	17.3	12.8	17.1	25.6
3 Scav. Conc.	299.0	15.3	1.03	1.27	20.7	0.40	0.29	1.88	24.0	32.2	28.8	27.4	26.6	34.3
4 Scav. Tail	1562.6	79.9	0.20	0.18	2.38	0.100	0.027	0.020	24.4	23.8	17.3	35.9	13.0	1.9
Head (calc)	1956.3	100.0	0.65	0.60	11.0	0.22	0.17	0.84	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							
Combined Products														
Products 1 & 2		4.8	6.98	5.49	122	1.69	2.08	11.0	51.6	44.0	53.9	36.7	60.4	63.8
Products 1 to 3		20.1	2.46	2.28	45.1	0.71	0.72	4.08	75.6	76.2	82.7	64.1	87.0	98.1

Flocculant Scoping Tests **Project: 4255** **Date: April 29th/92** **Operator: BW**

Purpose: To scope potential flocculants to determine which would produce acceptable settling qualities in order to do a series of settling tests.

Procedure: A small amount of representative pulp was placed in a small beaker (50ml). The selected flocculant was added as a 0.10% solution in increments of 2 to 5 drops. The pulp was gently agitated (after each addition of flocculant) and then allowed to settle. The pulp was observed and any observations were recorded.

Feed: Test 31 Scavenger Tails (Comp M92)

Data:

Flocculant	Number of Drops	Observations
-	-	On its own the pulp is a pale green/grey colour. The pulp contained sands which settled out quickly leaving a grey pulp above with a mudline of its own. The solution above the mudline was cloudy and the pulp settled slowly. After sitting for a short time the sands and any settled pulp form a packed bed.
155 (Medium Anionic)	5	Small flocs were noticed and the settling rate was improved slightly. The solution remains cloudy.
	8	Quite noticeable flocs were present and the settling rate was favourable however the solution showed no signs of improvement.
	10	Not much change. Solution clarity is beginning to improve.
	14	Solution showing more signs of improvement but not clear.
	16	Solution is clear. Settling and flocculation is favourable as well.

4255 Flocculant Scoping Tests Continued

Data:

Flocculant	Number of Drops	Observations
156 (High Anionic)	5	Some small flocculated particles forming. Settling rate is fair but the solution is cloudy.
	8	Noticeable flocculation and quicker settling. Solution is still cloudy
	10	Settling and flocculation is good now and although the solution is not clear it is showing signs of improvement.
	12	Not much change but solution is only slightly hazy.
	14	Settling very well and the solution is clearing nicely.
	16	Solution is clear and settling and flocculation is good.
611 (Very High Anionic)	8	Some noticeable flocculation and not bad settling but the solution is cloudy.
	10	Very little change observed.
	13	Better settling and flocculation but no change in solution clarity.
	16	Very little change occurred.
	> 16	Very little change occurred except a very small change in solution clarity.

4255 Flocculant Scoping Tests Continued

Data:

Flocculant	Number of Drops	Observations
351 (Non-Ionic)	5	Very small flocculated particles and slow settling pulp. Solution clarity was poor.
	10	Flocculation and settling were good but clarity was still poor.
	15	Very little change observed.
	20	Large flocculated particles, good settling and good solution clarity.
352 (Low Cationic)	5	Very cloudy solution, slow settling rate and small flocculated particle size.
	8	Increased flocculated particle size and an increase in in the settling rate but the solution remains cloudy.
	11	Good settling and flocculation but the solution is still hazy.
	14	No change other than the solution cleared slightly.
	16	Solution was clear, settling and flocculation were good.

4255 Flocculant Scoping Tests Continued

Data:

Flocculant	Number of Drops	Observations
368 (High Cationic)	5	Very small flocculated particles, slow settling and cloudy solution.
	8	No apparent change.
	10	Slightly more flocculation. The solution is only hazy but the settling rate is slow.
	12	Excellent solution clarity but poor flocculation and settling rate.
	14	Not much change occurred other than the solution was very clear.

4255 Flocculant Scoping Tests Continued

Conclusions : From the data listed above, it was concluded that the feed responded the best to Percol 156. Also, it was found during the lab flotation tests, that increasing the pH of the pulp with lime greatly increased the effect of the flocculant.

NOTE :

Scoping tests were performed with mixed flocculants (example: 156/368 , 1:1) to investigate the possibility of combining their desired qualities. The results showed no improvements.

Settling Test Report

Test No. S-1 Project No. 4255 Date: April 29/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails without a pH modifier or flocculant.

Feed: Test 31 Ro Tails

Lime: 0 g/t pH: 8.2 Flocculant: none

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
1:12 PM	0	1890		79	620
	5	1770		87	600
	10	1621		95	598
	14	1520		145	550
	18	1420		211	520
	27	1170	Final	1080	505
	35	990			
	43	870			
	52	790			
	57	740			
	61	700			
	70	640			
	73	630			

Observations: The mudline was visible but not clearly defined. The solution was very cloudy and was still hazy after 18 hours.

Initial Pulp Weight	2.2316 kg
Initial Pulp Volume	1.890 L
Initial Pulp Height	38.7 cm
Weight of Dry Solids	0.589 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.505 L
Tangent Intersect Y (vol.)	1.182 L
Corresponding X value (Time)	26.2 min
Slope of Tangent Y (mudline)	0.471 L
Slope of Tangent X (time)	90 min

Test No. S-1

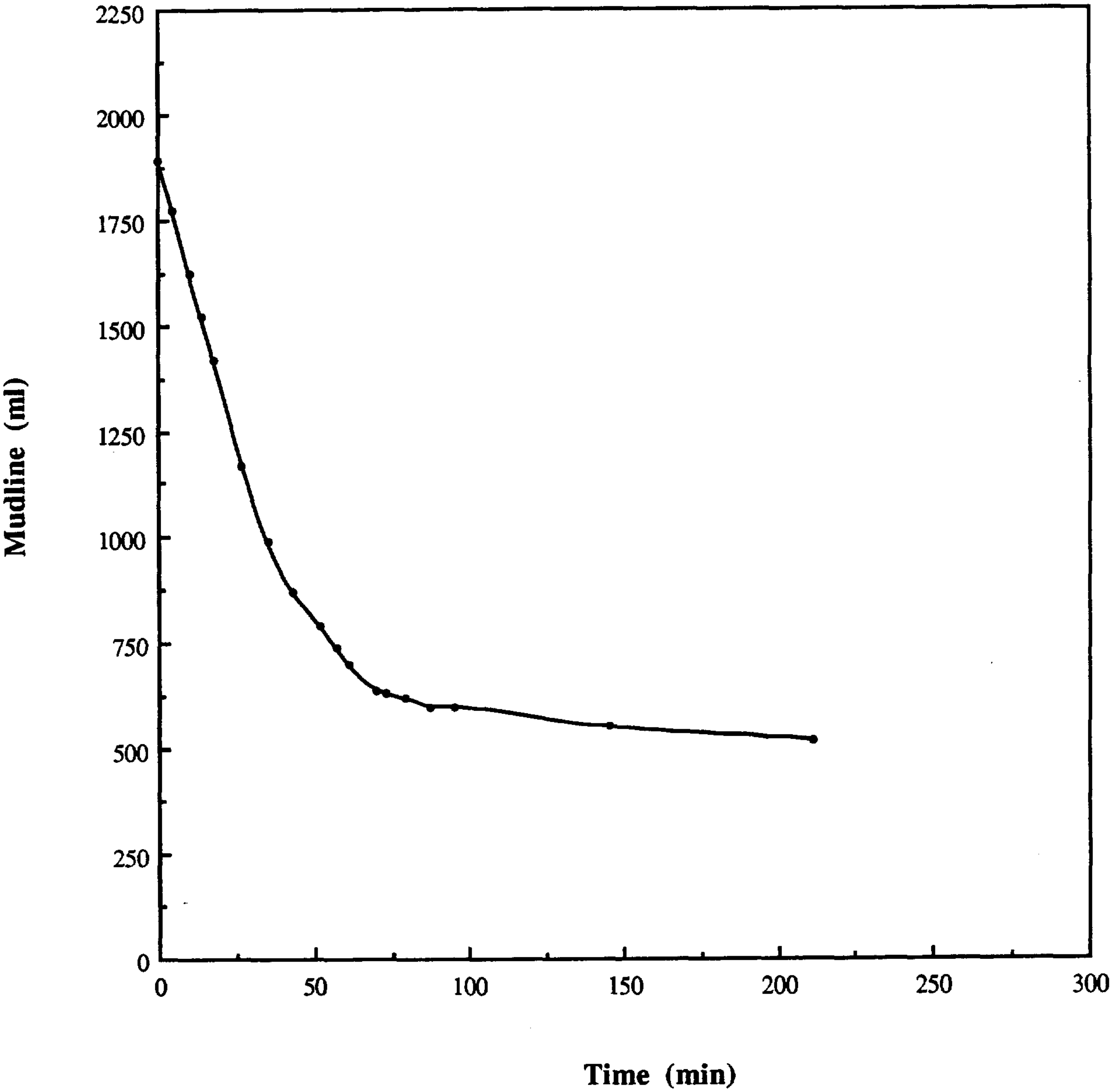
FEED CONCENTRATION ZONE

Initial Pulp Density: 1181 g/L
Initial Percent Solids: 23.4 %
Rate: 0.332 m/h
Thickener Area Required: 0.350 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1326 g/L
Initial Percent Solids: 37.6 %
Final Pulp Density: 1764 g/L
Final Percent Solids: 66.1 %
Rate: 0.097 m/h
Thickener Area Required: 0.498 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 1 Mudline
vs
Time



Settling Test Report

Test No. S-2 Project No. 4255 Date: April 30/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 340 g/t CaOH2.

Feed: Test 31 Ro Tails

Lime: 340 g/t pH: 10.4 Flocculant: none

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:00 AM	0	1890		90	600
	4	1770		107	595
	6	1700		125	575
	8	1655		143	560
	12	1540		153	550
	23	1258		176	530
	28	1130	Final	1440	515
	39	915			
	47	820			
	53	760			
	56	740			
	58	720			
	60	700			

Observations: The solution was cloudy throughout the test but clearing very gradually. It was clear 24 hours.

Initial Pulp Weight	2.2316 kg
Initial Pulp Volume	1.890 L
Initial Pulp Height	38.7 cm
Weight of Dry Solids	0.589 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.515 L
Tangent Intersect Y (vol.)	1.136 L
Corresponding X value (Time)	28 min
Slope of Tangent Y (mudline)	0.36 L
Slope of Tangent X (time)	107 min

Test No. S-2

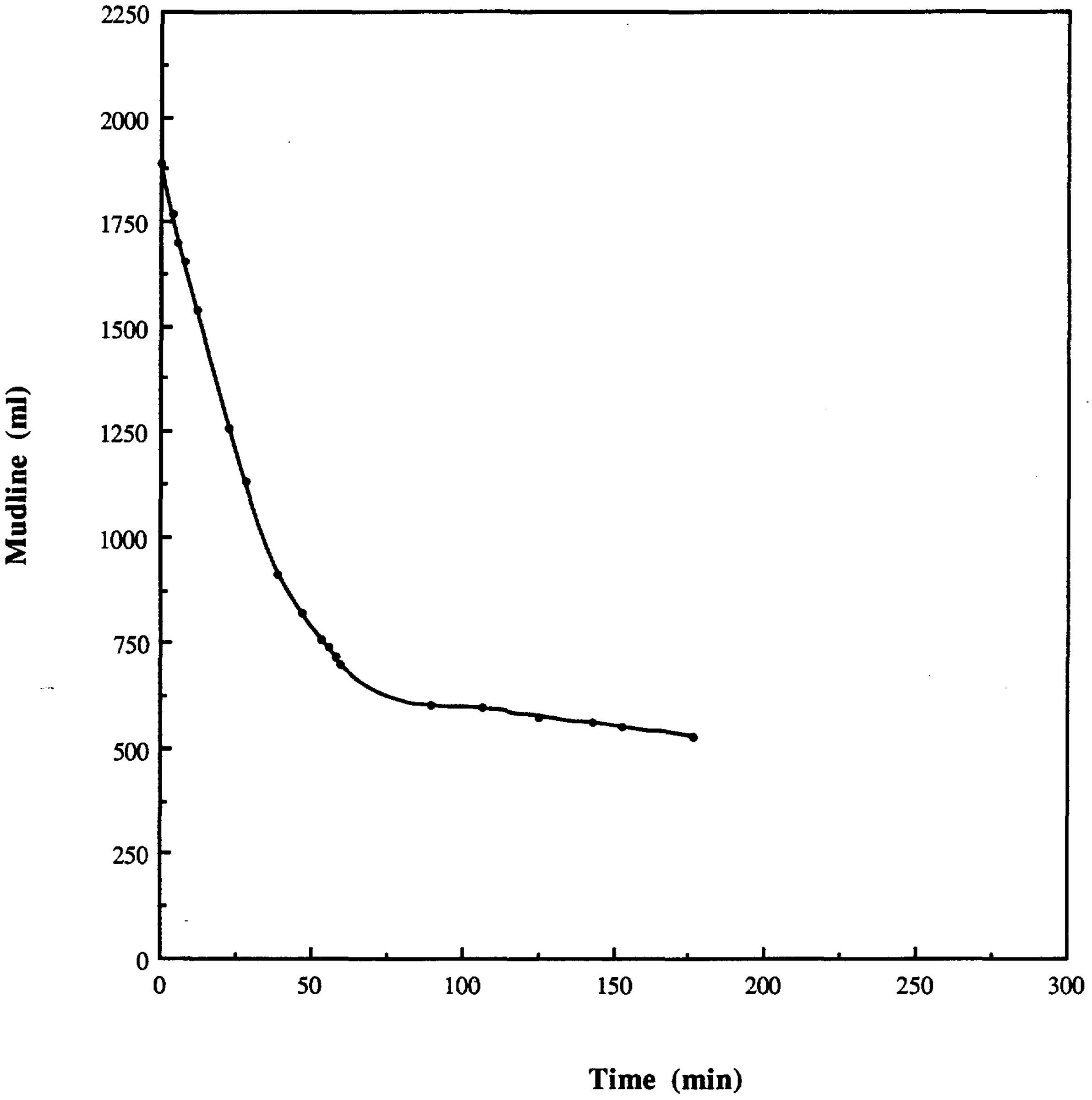
FEED CONCENTRATION ZONE

Initial Pulp Density: 1181 g/L
Initial Percent Solids: 23.4 %
Rate: 0.331 m/h
Thickener Area Required: 0.349 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1340 g/L
Initial Percent Solids: 38.7 %
Final Pulp Density: 1749 g/L
Final Percent Solids: 65.4 %
Rate: 0.089 m/h
Thickener Area Required: 0.497 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 2 Mudline
vs
Time



Settling Test Report

Test No. S-3 Project No. 4255 Date: April29/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 5 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 0 g/t pH: 8.2 Flocculant: 5 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
1:14 PM	0	1890		59	845
	3	1930		68	820
	8	1738		71	810
	12	1580		77	800
	16	1480		85	780
	25	1280		93	770
	33	1135		153	700
	41	1000		219	660
	50	900	Final	1080	645
	55	860			

Observations: Small flocculated particles were present and the mudline was obvious. The solution was cloudy but had cleared to a slight haze after 18 hours.

Initial Pulp Weight	2.4873 kg
Initial Pulp Volume	2.040 L
Initial Pulp Height	41.6 cm
Weight of Dry Solids	0.736 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.645 L
Tangent Intersect Y (vol.)	1.302 L
Corresponding X value (Time)	24 min
Slope of Tangent Y (mudline)	0.61 L
Slope of Tangent X (time)	87 min

Test No. S-3

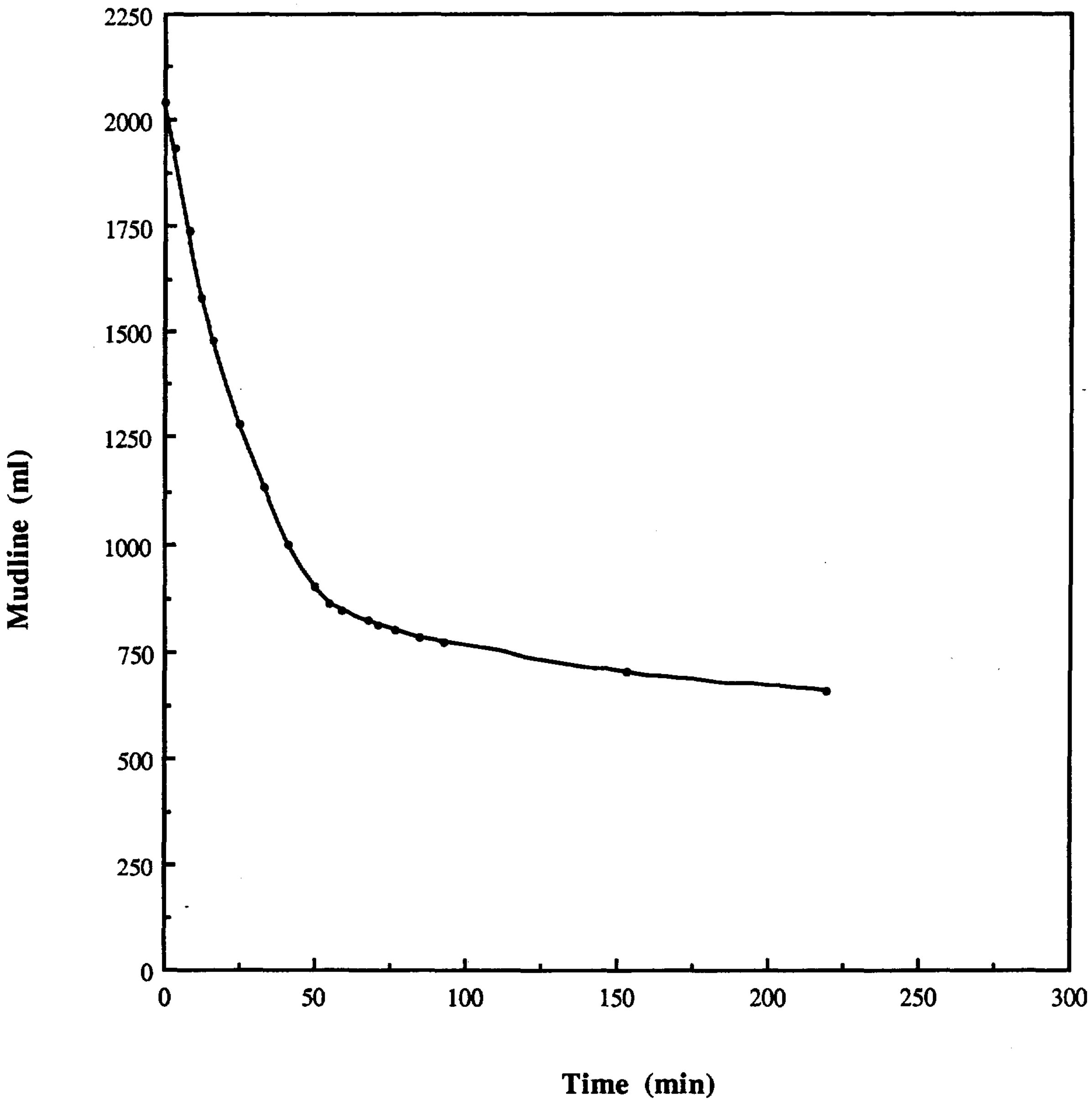
FEED CONCENTRATION ZONE

Initial Pulp Density: 1219 g/L
Initial Percent Solids: 27.4 %
Rate: 0.376 m/h
Thickener Area Required: 0.236 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1370 g/L
Initial Percent Solids: 41.2 %
Final Pulp Density: 1747 g/L
Final Percent Solids: 65.3 %
Rate: 0.097 m/h
Thickener Area Required: 0.385 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 3 Mudline
vs
Time



Settling Test Report

Test No. S-4 Project No. 4255 Date: April29/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 267 g/t CaOH2 and 5 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 267.0 g/t pH: 10.0 Flocculant: 5 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
1:15 PM	0	2030		67	800
	2	1960		76	780
	7	1738		84	760
	11	1560		92	748
	15	1460		142	682
	24	1240		208	660
	32	1070	Final	1080	660
	40	950			
	49	878			
	54	840			
	58	830			

Observations: Small flocculated particles were present and the mudline was obvious. The solution was cloudy but better than in test 3. A slight haze remained at 18 hours.

Initial Pulp Weight	2.4944 kg
Initial Pulp Volume	2.030 L
Initial Pulp Height	39.7 cm
Weight of Dry Solids	0.743 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.660 L
Tangent Intersect Y (vol.)	1.28 L
Corresponding X value (Time)	21 min
Slope of Tangent Y (mudline)	0.47 L
Slope of Tangent X (time)	100 min

Test No. S-4

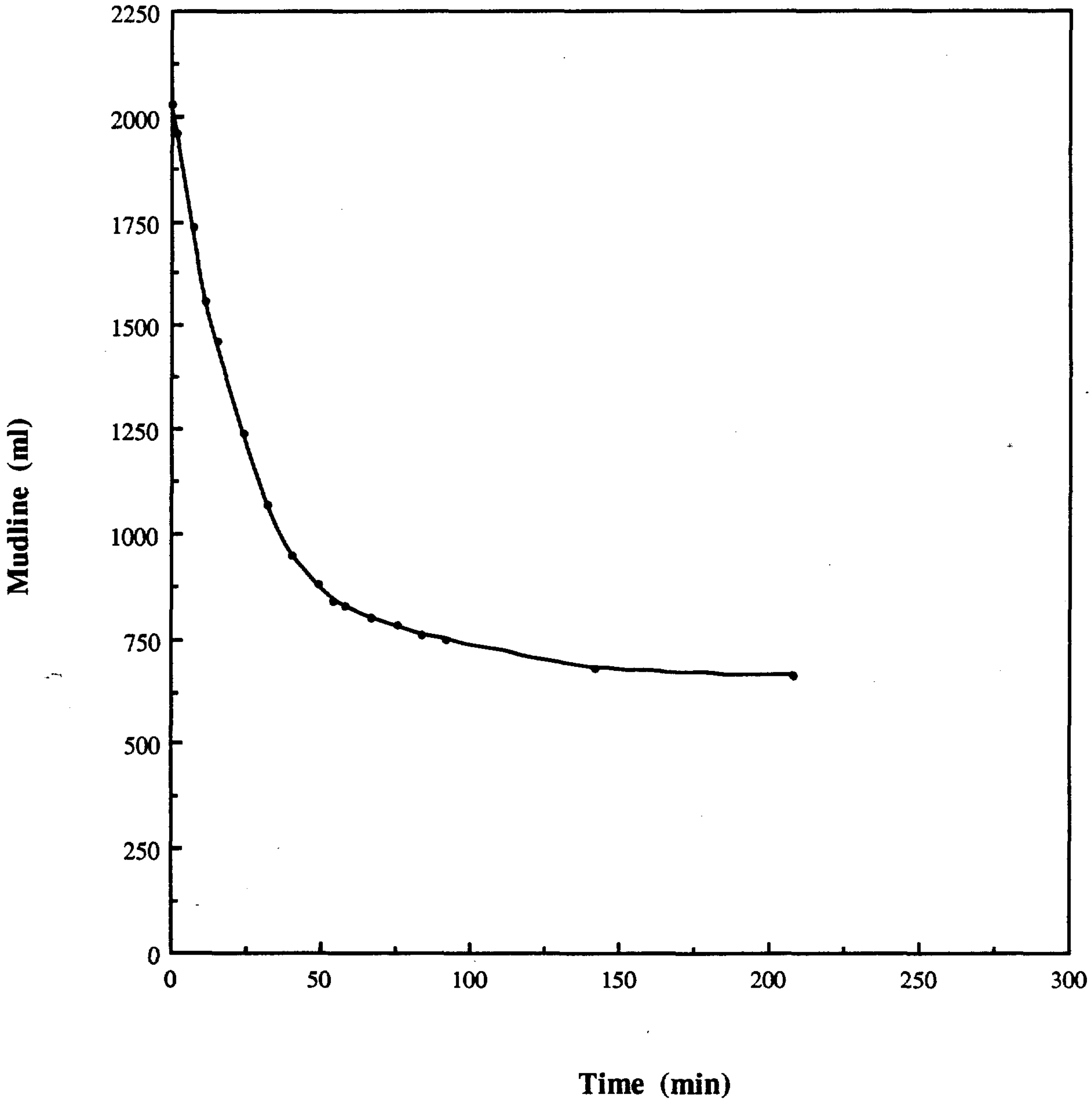
FEED CONCENTRATION ZONE

Initial Pulp Density:	1229 g/L
Initial Percent Solids:	28.4 %
Rate:	0.419 m/h
Thickener Area Required:	0.198 sq. meters/tonne/day (no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density:	1380 g/L
Initial Percent Solids:	42.0 %
Final Pulp Density:	1737 g/L
Final Percent Solids:	64.8 %
Rate:	0.095 m/h
Thickener Area Required:	0.369 sq. meters/tonne/day (no safety factor applied)

Graph of Test 4 Mudline
vs
Time



Settling Test Report

Test No. S-5 Project No. 4255 Date: April30/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 10 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 0 g/t pH: 8.2 Flocculant: 10 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:01 AM	0	2040		59	800
	3	1860		89	740
	5	1720		106	715
	7	1620		124	700
	11	1470		142	685
	22	1160		152	680
	27	1050		175	670
	38	900	Final	1440	640
	46	860			
	52	835			
	55	820			
	57	805			

Observations: Larger flocculated particles were present and the the solution was cloudy. The solution was clearing as the test continued and was clear after 24 hours.

Initial Pulp Weight	2.4873 kg
Initial Pulp Volume	2.040 L
Initial Pulp Height	41.6 cm
Weight of Dry Solids	0.736 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.640 L
Tangent Intersect Y (vol.)	1.27 L
Corresponding X value (Time)	17.5 min
Slope of Tangent Y (mudline)	0.27 L
Slope of Tangent X (time)	115 min

Test No. S-5

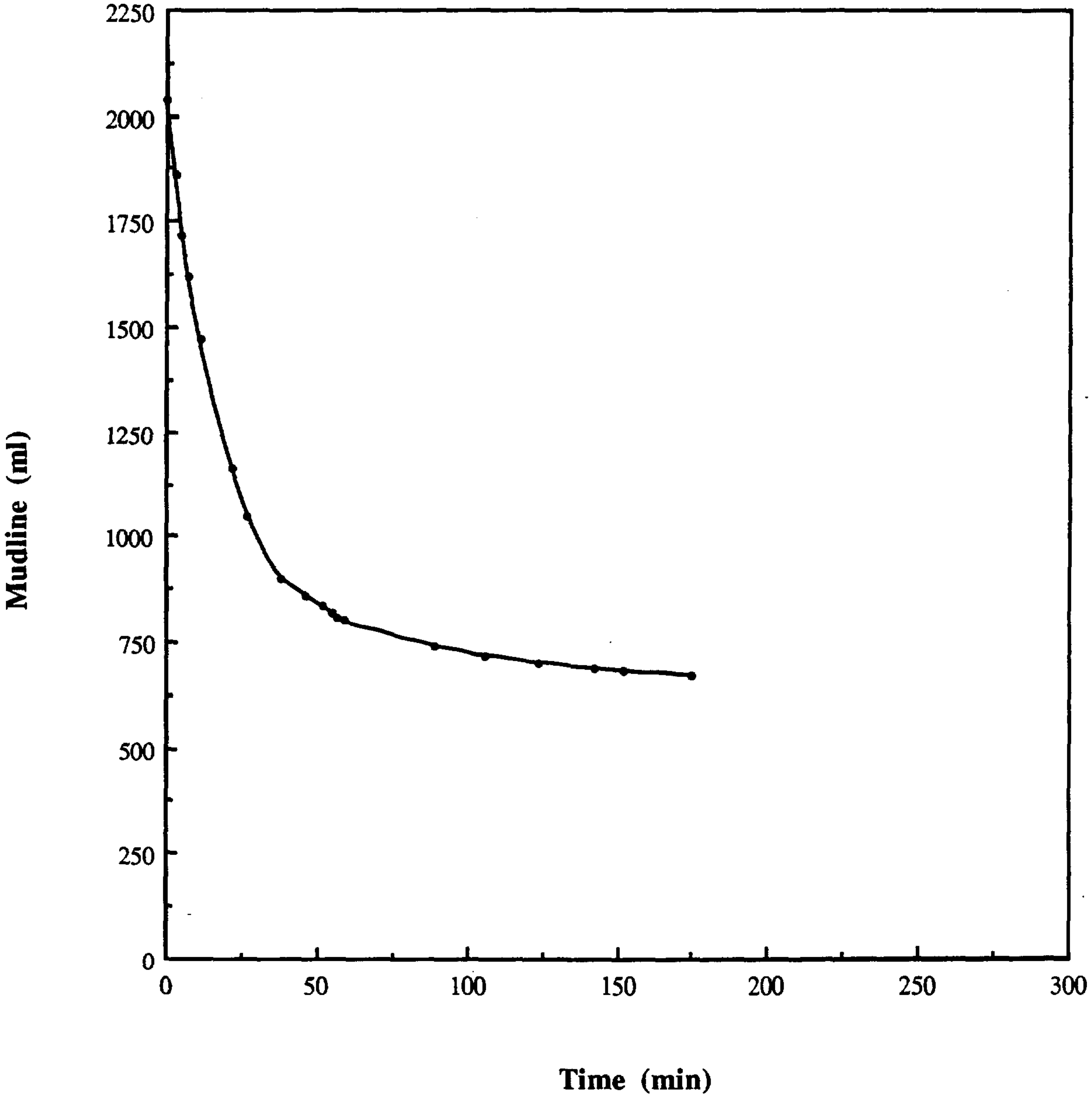
FEED CONCENTRATION ZONE

Initial Pulp Density: 1219 g/L
Initial Percent Solids: 27.4 %
Rate: 0.538 m/h
Thickener Area Required: 0.165 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1380 g/L
Initial Percent Solids: 42.0 %
Final Pulp Density: 1753 g/L
Final Percent Solids: 65.6 %
Rate: 0.106 m/h
Thickener Area Required: 0.338 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 5 Mudline
vs
Time



Settling Test Report

Test No. S-6 Project No. 4255 Date: April30/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 267 g/t CaOH2 and 10 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 267 g/t pH: 10.0 Flocculant: 10 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:02 AM	0	2030		56	775
	2	1860		58	765
	4	1680		88	700
	6	1560		105	690
	10	1400		123	670
	21	1060		141	665
	26	970		151	665
	37	860		174	665
	45	820	Final	1440	665
	51	800			
	54	780			

Observations: Larger flocculated particles were present.
The solution clarity was not as good as test 5.
After 24 hours, however, the solution was clear.

Initial Pulp Weight	2.4944 kg
Initial Pulp Volume	2.030 L
Initial Pulp Height	39.7 cm
Weight of Dry Solids	0.743 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.665 L
Tangent Intersect Y (vol.)	1.17 L
Corresponding X value (Time)	16 min
Slope of Tangent Y (mudline)	0.51 L
Slope of Tangent X (time)	80 min

Test No. S-6

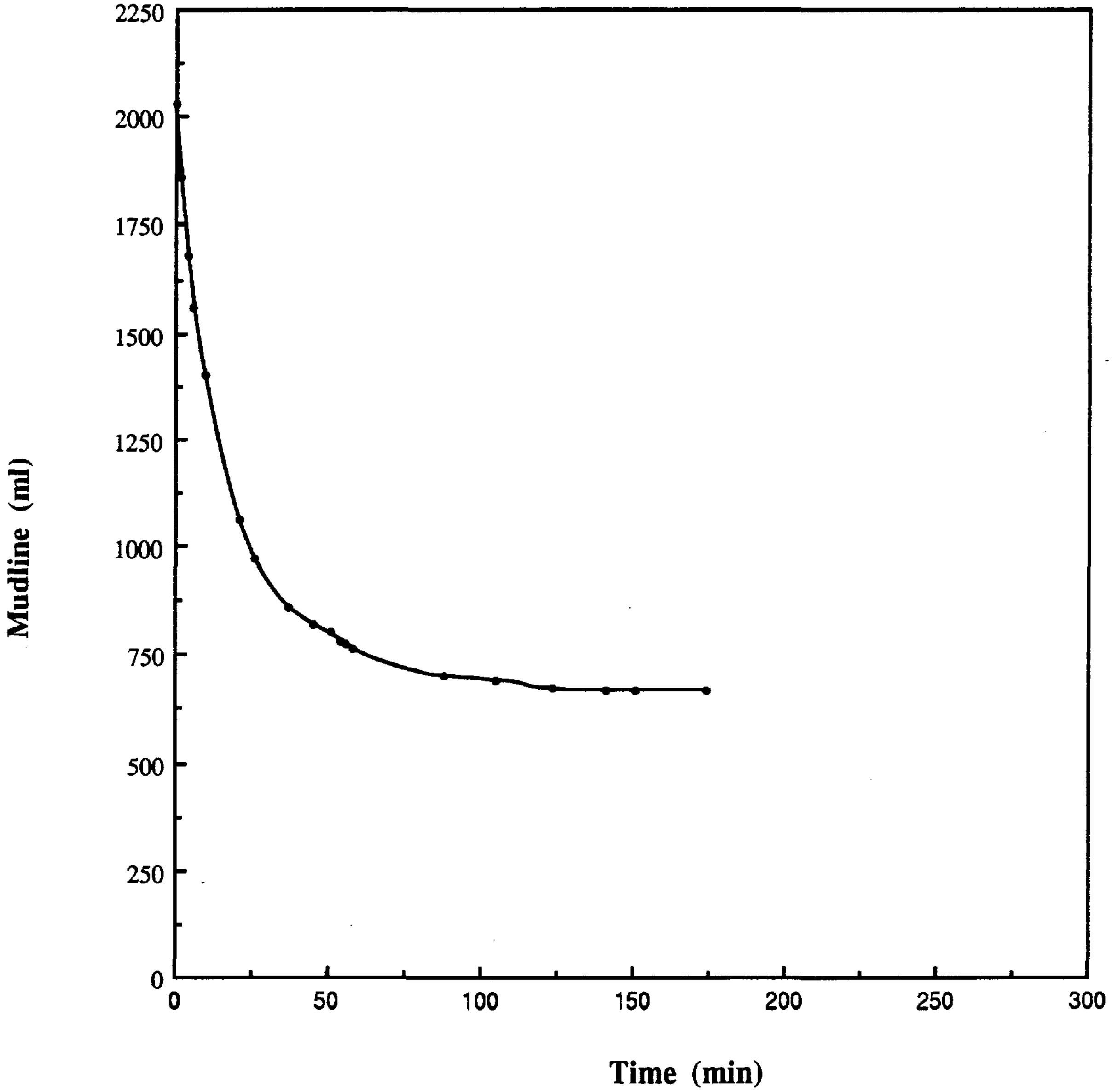
FEED CONCENTRATION ZONE

Initial Pulp Density: 1229 g/L
Initial Percent Solids: 28.4 %
Rate: 0.631 m/h
Thickener Area Required: 0.131 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1416 g/L
Initial Percent Solids: 44.8 %
Final Pulp Density: 1732 g/L
Final Percent Solids: 64.5 %
Rate: 0.097 m/h
Thickener Area Required: 0.295 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 6 Mudline
vs
Time



Settling Test Report

Test No. S-7 Project No. 4255 Date: April 30/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 1698 g/t CaOH2.

Feed: Test 31 Ro Tails

Lime: 1698 g/t pH: 12.0 Flocculant: none

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:09 AM	0	1890		44	640
	4	1650		77	580
	8	1450		95	560
	15	1240		165	555
	21	960	Final	1440	480
	30	800			
	32	765			
	35	720			
	38	690			
	41	660			

Observations: The solution clarity was good throughout the test.
(Solution was totaly clear at 20 minutes.)

Initial Pulp Weight	2.2316 kg
Initial Pulp Volume	1.890 L
Initial Pulp Height	38.7 cm
Weight of Dry Solids	0.589 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.480 L
Tangent Intersect Y (vol.)	0.982 L
Corresponding X value (Time)	21 min
Slope of Tangent Y (mudline)	0.43 L
Slope of Tangent X (time)	70 min

Test No. S-7

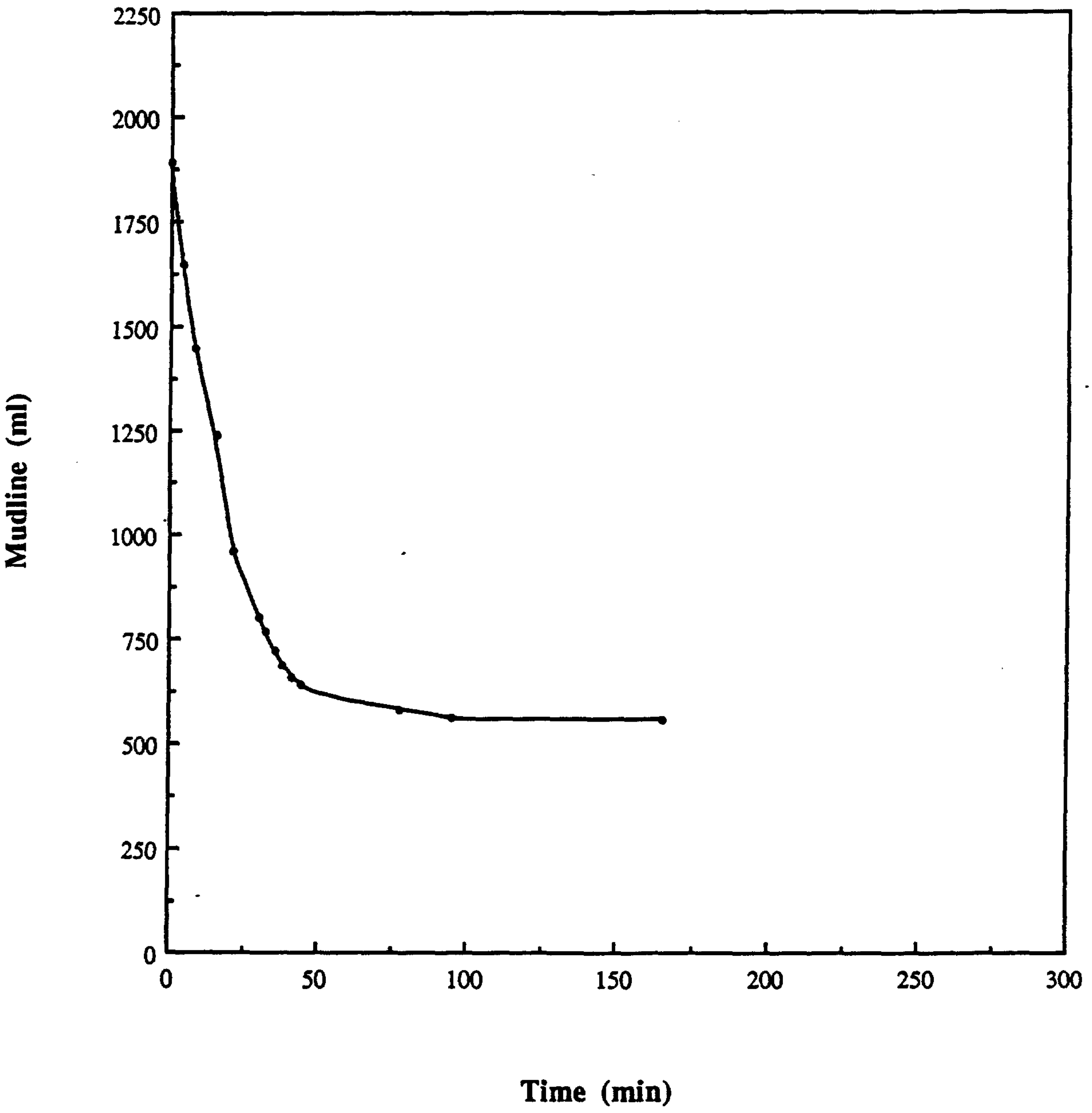
FEED CONCENTRATION ZONE

Initial Pulp Density: 1181 g/L
Initial Percent Solids: 23.4 %
Rate: 0.531 m/h
Thickener Area Required: 0.222 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1393 g/L
Initial Percent Solids: 43.0 %
Final Pulp Density: 1804 g/L
Final Percent Solids: 68.0 %
Rate: 0.097 m/h
Thickener Area Required: 0.370 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 7 Mudline
vs
Time



Settling Test Report

Test No. S-8 Project No. 4255 Date: May 1/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 15 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 0 g/t pH: 8.2 Flocculant: 15 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:10 AM	0	2040		37	810
	3	1705		40	795
	7	1450		43	785
	14	1115		76	725
	20	960		94	705
	29	860		164	670
	31	840	Final	1440	650
	34	820			

Observations: Large flocculated particles were present and the solution was slightly cloudy.
The solution was clear after 24 hours.

Initial Pulp Weight	2.4873 kg
Initial Pulp Volume	2.040 L
Initial Pulp Height	41.6 cm
Weight of Dry Solids	0.736 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.650 L
Tangent Intersect Y (vol.)	1.115 L
Corresponding X value (Time)	13 min
Slope of Tangent Y (mudline)	0.23 L
Slope of Tangent X (time)	100 min

Test No. S-8

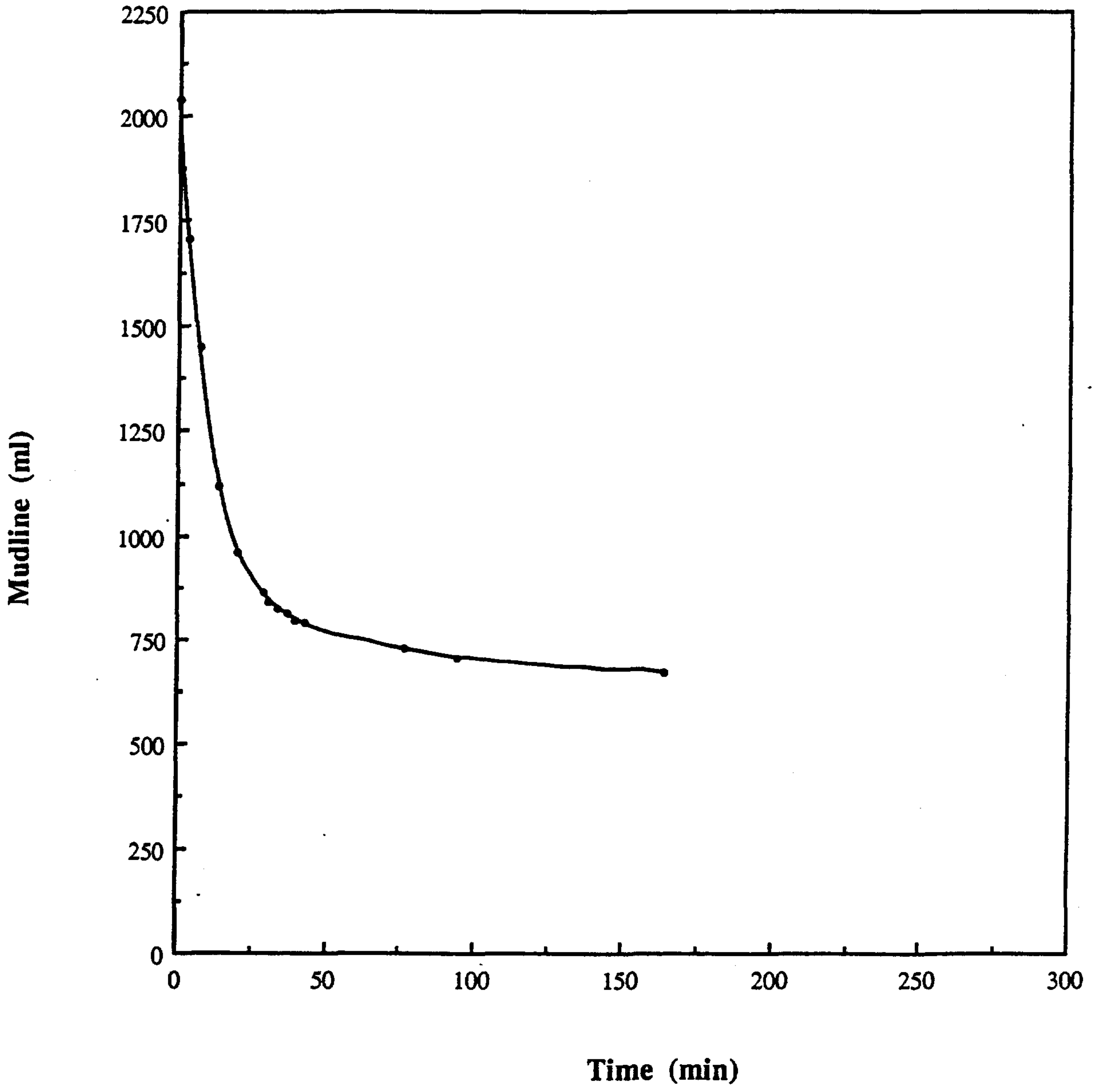
FEED CONCENTRATION ZONE

Initial Pulp Density: 1219 g/L
Initial Percent Solids: 27.4 %
Rate: 0.871 m/h
Thickener Area Required: 0.102 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1432 g/L
Initial Percent Solids: 46.1 %
Final Pulp Density: 1742 g/L
Final Percent Solids: 65.0 %
Rate: 0.108 m/h
Thickener Area Required: 0.245 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 8 Mudline
vs
Time



Settling Test Report

Test No. S-9 Project No. 4255 Date: May 1/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 267 g/t CaOH2 and 15 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 267 g/t pH: 10.0 Flocculant: 15 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
9:11 AM	0	2030		39	760
	2	1700		42	755
	6	1390		75	705
	13	1040		93	700
	19	910		163	690
	28	820	Final	1440	670
	30	810			
	33	790			
	36	770			

Observations: Large flocculated particles were present.
The solution clarity was not as good as test 8.
After 24 hours, however, the solution was clear.

Initial Pulp Weight	2.4944 kg
Initial Pulp Volume	2.030 L
Initial Pulp Height	39.7 cm
Weight of Dry Solids	0.743 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.670 L
Tangent Intersect Y (vol.)	1.075 L
Corresponding X value (Time)	12 min
Slope of Tangent Y (mudline)	0.15 L
Slope of Tangent X (time)	110 min

Test No. S-9

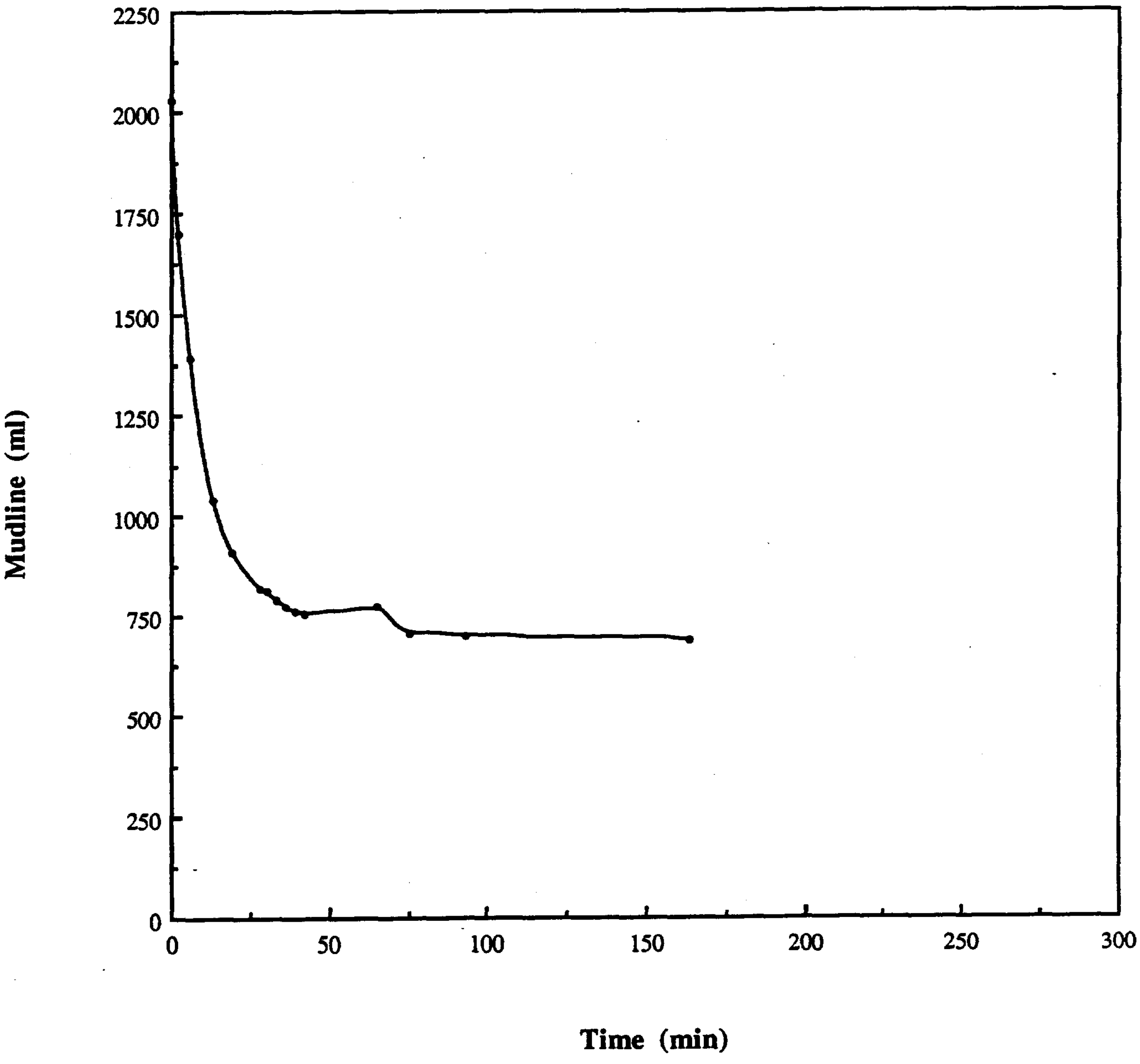
FEED CONCENTRATION ZONE

Initial Pulp Density: 1229 g/L
Initial Percent Solids: 28.4 %
Rate: 0.934 m/h
Thickener Area Required: 0.088 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1453 g/L
Initial Percent Solids: 47.6 %
Final Pulp Density: 1726 g/L
Final Percent Solids: 64.2 %
Rate: 0.099 m/h
Thickener Area Required: 0.232 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 9 Mudline
vs
Time



Settling Test Report

Test No. S-10 Project No. 4255 Date: May 5/92 Operator B.W.

Purpose: To investigate the settling characteristics of 4255 Test 31 Rougher Tails with 1403 g/t CaOH2 and 15 g/t P - 156.

Feed: Test 31 Ro Tails

Lime: 1403 g/t pH: 11.7 Flocculant: 15 g/t P-156

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
8:47 AM	0	2030		51	820
	3	1850		53	810
	8	1560		61	780
	18	1120		65	770
	21	1040		67	765
	28	940		110	710
	33	900	Final	1440	680
	39	870			
	43	850			

Observations: Large flocculated particles were present.
The solution clarity was excellent.
The solution cleared as the pulp settled .

Initial Pulp Weight	2.4944 kg
Initial Pulp Volume	2.030 L
Initial Pulp Height	39.7 cm
Weight of Dry Solids	0.743 kg
Dry Solids S.G.	2.9 g/cc or kg/L
Liquid S.G.	1.0 g/cc or kg/L
Final Mudline	0.680 L
Tangent Intersect Y (vol.)	1.19 L
Corresponding X value (Time)	16 min
Slope of Tangent Y (mudline)	0.49 L
Slope of Tangent X (time)	80 min

Test No. S-10

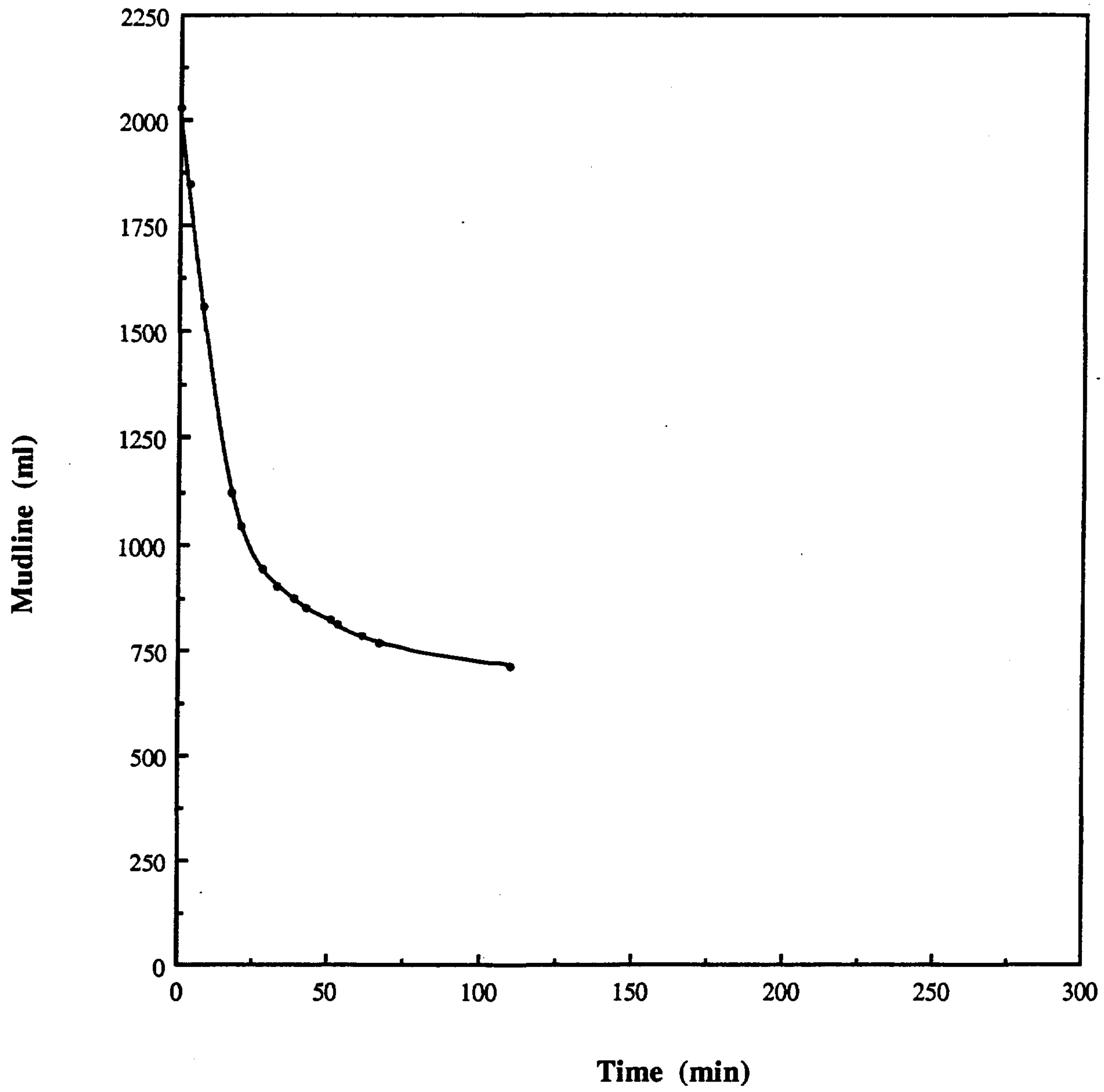
FEED CONCENTRATION ZONE

Initial Pulp Density: 1229 g/L
Initial Percent Solids: 28.4 %
Rate: 0.616 m/h
Thickener Area Required: 0.133 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1409 g/L
Initial Percent Solids: 44.3 %
Final Pulp Density: 1716 g/L
Final Percent Solids: 63.7 %
Rate: 0.103 m/h
Thickener Area Required: 0.281 sq. meters/tonne/day
(no safety factor applied)

Graph of Test 10 Mudline
vs
Time



Appendix 1

Mineralogical Examination
of a sample of cleaner concentrate
submitted on behalf of
Richard Down, Ph.D.

SUMMARY

The platinum group minerals identified in the sample were vysotskite (Pd, Pt, Ni, S), kotulskite (Pd, Pt, Te, Bi) and braggite (Pd, Pt, Ni) S. These minerals were associated with pyrrhotite, chalcopyrite, pyrite and millerite as inclusions; interstitially between grains and as attached particles (vysotskite). Other minerals present in the sample were: marcasite, chalocite, covellite, sphalerite, galena, magnetite and violarite.

No free/liberated P G E mineral was identified but undoubtedly were present. Particle sizes ranged from 10 micrometers to smaller than 3 micrometers.

The fusion test was not successful in fielding material for examination for palladium.

INTRODUCTION

A sample identified as LR4255 - Test 23 - Cu Ni 4th cleaner concentrate was received in the Mineralogy laboratory for examination. The sample was derived from testwork done on composite Sample M92 of Project No. LR 4255.

On instructions from Mr. Richard Down, P.Eng., the sample was submitted for mineralogical examination with special attention paid to identification of any Platinum Group Element minerals present. In addition, a portion of the sample was to be submitted for a fusion test employing sodium hydroxide to dissolve the silicate minerals present. The residue would be submitted for determination of the character, association and mode of occurrence of the Platinum Group metals present in the residue.

R.W. Deane
Mineralogist

PREPARATION AND PROCEDURE

A portion of the sample was split into four similar fractions and each fraction was then briquetted and polished for incident light microscopic examination. A further portion of the sample was submitted for the sodium hydroxide fusion test. This latter portion first was roasted in air at a temperature between 500°C and 600°C before being fused in the muffle furnace. The residue obtained was examined.

A further small sample was submitted for semi-quantitative spectrometry in an attempt to identify trace elements useful for the identification of the PGE minerals.

RESULTS

Microscopic

The following three Platinum Group Metal Minerals were identified and are listed in decreasing order of abundance:

Vysotskite	$(Pd, Ni, Pt)S$
Kotulskite	$Pd(Te, Bi)_{1-2}$
Braggite	$(Pt, Pd, Ni)S$

Other PGE minerals identified in earlier investigations on this occurrence were not identified but may well have been present. The minerals identified were present as particles measuring 10 micrometers and smaller and, were associated with pyrrhotite, chalcopyrite, pyrite plus millerite as inclusions, an attached particle (vysotskite) and interstitially between grains. The combined total of PGE minerals seen accounted for an estimated 40 percent of the palladium and platinum known present, i.e., 257 g/t and 13.4 g/t respectively. Rapid identification of free grains of these PGE minerals in a host of equally free and fine grained chalcopyrite, pyrite, millerite, pentlandite and pyrrhotite is almost impossible, particularly when the sample examined is sulphide concentrate, and the minerals measure 5 or less micrometers in section.

Minerals other than PGE minerals present in the sample were:

Pyrite	FeS_2
Pyrrhotite	Fe
Chalcopyrite	$CuFeS_2$
Pentlandite	$(Fe, Ni)_9S_8$
Violarite	$(Ni,Fe)_3S_4$
Millerite	NiS
Marcasite	FeS_2
Sphalerite	ZnS
Covellite	CuS
Chalcocite	Cu_2S
Galena	PbS
Molybdenite	MoS_2
Magnetite	Fe_3O_4
Quartz	SiO_2

The grain sizes ranged from 60 to smaller than 3 micrometers.

Roasting and Fusion

The reject left from preparation of the polished sections was roasted in air in a muffle furnace for one hour a 700°C. The calcine obtained was fused using NaOH (sodium hydroxide). Fusion was carried out using a sample to NaOH ratio of about 1:10 with the fusion taking place in a 300 mL Ni crucible placed in a muffle furnace for one hour at 500°C. The resulting product was leached in boiling water. A portion of the residue obtained was used in the preparation of two polished sections for incident light microscopic examination and the remaining reject was set aside for possible analytical determinations.

Weight loss of sample after roasting was 30.5 percent, and further 1.2 percent was lost in leaching after fusion.

Examination of the briquetted leach residue showed that less than 0.5% sulphide (pyrite) remained unoxidized. In addition, there was present in each briquette one grain of what may have been an alloy of gold/electrum and other metal. The remainder of the grains in the briquettes were Fe-OOH. An electron micro probe analysis would be necessary for the identification of any other oxides (eg. Ni, Cu or Pd).

The weight loss resulting after roasting was due to oxidation of the sulphide minerals - loss of sulphur to the atmosphere. The loss resulting from leaching following fusion primarily was due to removal of sodium silicate and of any oxide soluble in the caustic leach.

We do not consider the fusion treatment to have been successful. The preliminary roasting stage was necessary for the break down of the sulphide particle and removal of the sulphur for the fusion process to have a chance of success. Furthermore, roasting probably would oxidize any PGE sulphides present, i.e. vysotskite, kotulskite, etc. and the Rabber Manufacturers Handbook of Chemistry indicates that such oxides are soluble in a caustic solution. Some of the oxidized palladium may have been dissolved in the hot NaOH melt.

Conventional treatment of flotation concentrates containing PGE minerals is made on concentrates containing 100 g/t or more Pt. Treatment is by leaching using aqua-regia or a combination of hydrochloric acid and chlorine which takes the PGE metals into solution from which these elements are recovered.

Appendix 2

Mineralogical Examination of a Scavenger Tailing Sample submitted on behalf of Richard Down, P. Eng.

Project No. L.R. 4255

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research.

LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
June 24th,1992

SUMMARY

The non-opaque minerals identified were:

pyrite
chalcopyrite
pyrrhotite
millerite (?)
pentlandite (?)
magnetite
ilmenite

All of these minerals were present as inclusions in silicate minerals as particles which ranged in size from about 12-15 micrometres to smaller than 4 micrometres in section. No nickel mineral larger than 5 by 5 micrometres was identified with certainty.

Analyses performed on the sample yielded the following results

0.24 g/t Au
0.18 g/t Pt
2.72 g/t Pd
0.04 % Cu
0.11% Ni
0.09% S

from which it will be plain that not all of the nickel present was so as sulfide. We concluded that as much as 50 percent of the nickel present was so in a silicate - in a serpentine or chlorite group mineral.

INTRODUCTION

A sample identified as 4255-28 Scavenger Tails was received in the Mineralogy laboratory for examination. The purpose of the examination was to identify the nickel minerals present and determine the cause for their remaining in the flotation tailings.

LAKEFIELD RESEARCH

R.W. Deane.

R.W. Deane
Consultant

PREPARATION AND PROCEDURE

A portion of the sample was used to prepare two polished, briquetted grain mounts and for analyses for Au, Pt, Pd, Cu, Ni and S.

RESULTS

The results of the analytical procedure were as follows:

0.24 g/t Au
0.18 g/t Pt
2.72 g/t Pd
0.04 % Cu
0.11 % Ni
0.09% S

The opaque minerals identified with certainty were:

pyrite
marcasite
chalcopyrite
pyrrhotite
magnetite
ilmenite

Tentatively identified were:

pentlandite
millerite

The particle size of the sulfide minerals ranged from a maximum of 12 to 15 micrometres to smaller than 4 by 4 micrometres in section.

Pyrite and chalcopyrite were present in the coarser range and the remaining sulfide minerals were smaller than 10 micrometres in section. One grain of pentlandite measuring 6 by 8 micrometres was identified. All other identification of nickel minerals were tentative because of the small grain size.

Not all of the nickel was present as sulfide nickel. Reference to the tabulation of analytical results confirms this. Allowing 0.04 percent sulfur for chalcopyrite and 0.02 percent sulfur for pyrite plus pyrrhotite plus marcasite leaves 0.03 percent sulfur for 0.11 percent nickel. Were all of the nickel present as millerite at least 0.06 percent sulfur would be necessary for stochiometry. Therefore 50 percent or more of the nickel must be present in a silicate mineral - either serpentine or chlorite.

Examination of grains mounted in refractive index oils proved the presence of a sheet structure mineral such as chlorite but electron probe analysis is required to prove the presence of nickel in this silicate.

52H04NE0013 2.15334 LAC DES ILES

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MAR 7 - 1994

MINING LANDS BRANCH

An Investigation of
THE RECOVERY OF COPPER, NICKEL and PG METALS
from ROBY ZONE project samples
submitted by
LAC des ILES MINES LTD.

Progress Report No. 2

2.15334

Project No. L.R. 4255

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research.

LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
November 4, 1992

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INTRODUCTION

This report presents testwork conducted from June to September, 1992, on Composite M92 prepared from drill chips submitted by Lac des Iles Mines Ltd., and on five variability composites. This testwork investigated recovery of platinum group metals in copper-nickel flotation concentrates.

The test program was discussed regularly with Mr. G. Reschke and Mr. G.R. Clark, Lac des Iles Mines.

LAKEFIELD RESEARCH

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Report preparation by: B.J. Scobie

SUMMARY

1. Description of Samples

Composite M92 and the Roby Zone sample, as described in LR 4255, Progress Report 1 were used for the flotation program. The variability samples, designated as Groups 1 to 5, were prepared by blending equal weights of sub-samples:

Group	Sub-samples
1	25643 and 25644
2	25635 to 25640
3	25631 to 25630
4	25627 to 25630
5	25680 to 25681

The head analyses are presented in Table 1.

Table 1: Head Analyses

	Assays, %, g/t									
Sample	Cu	Ni	Au	Pt	Pd	As	S	Fe_t	Fe_{py}	Fe_{po}
M92	0.18	0.24	0.42	0.59	9.87	<0.001	1.03	7.91	1.18	1.04
Roby	0.16	0.16	0.30	0.29	2.40	<0.001	0.59	4.61	0.58	0.73
92M1 28843	0.025	0.096	0.25	0.93	22.2	-	-	-	-	-
G1	0.045	0.091	0.23	0.49	6.47	-	0.15	-	-	-
G2	0.11	0.15	0.27	0.30	2.90	-	0.24	-	-	-
G3	0.16	0.20	0.68	0.35	4.35	-	0.43	-	-	-
G4	0.17	0.28	0.94	0.40	7.54	-	0.51	-	-	-
G5	0.039	0.11	0.23	0.67	17.2	-	0.14	-	-	-
Roby	0.16	0.16	0.30	0.29	2.40	<0.001	0.59	4.61	0.58	0.73

A sub-sample of Composite M92 weighing 25 kg was prepared for Mr. G. Clark in September assaying:

%Cu	%Ni	g/t Au	g/t Pt	g/t Pd
0.17	0.24	0.60	0.66	10.7

2. Flotation Testwork

This phase of the testwork investigated the effect of the water source, rougher flotation density, magnetic separation and the reagent balance on the flotation response. Much of the testwork was performed with the assistance of Mr. G. Reschke, Lac des Iles Mines.

2.1 Site Water

Flotation tests were conducted on Composite M92 using Camp Lake (CL), Lac des Iles (LdI) and Lakefield (Lkfd) water. The primary grind was 70% minus 200 mesh in Test 36 but adjusted to 78% minus 200 mesh for subsequent tests. Some adjustments were made to the reagent balance and the flotation density. The results are compared with earlier testwork in Table 2.

Table 2: Water Source

Test % Pass 200 mesh	Product	Wt %	Assays, %, g/t						% Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1	Ro Conc 1	4.1	7.18	6.45	137	2.95	3.40	13.5	47.7	47.6	55.3	48.0	68.4	62
61	Ro Conc 1+2	7.8	4.83	4.21	87.2	1.88	1.99	9.44	61.4	59.5	67.4	58.6	76.5	83
	Scav Conc 1	2.7	2.14	1.60	22.1	0.41	0.42	2.70	9.5	7.9	6.0	4.5	5.7	8
Lkfd	Sc Conc 1+2	4.9	1.46	1.19	16.6	0.34	0.31	1.79	11.8	10.7	8.2	6.7	7.6	10
water	Comb Conc	12.8	3.52	3.03	59.8	1.28	1.33	6.46	73.1	70.1	75.6	65.3	84.1	93
33% solids	Scav Tail	87.2	0.19	0.19	2.84	0.10	0.037	0.07	26.9	29.9	24.4	34.7	15.9	7
	Head(calc)	-	0.62	0.55	10.1	0.25	0.20	0.89	-	-	-	-	-	-
36	Ro Conc 1	3.4	8.82	8.36	170	2.09	3.21	12.6	47.1	47.8	53.8	32.1	63.0	52
70	Ro Conc 1+2	6.9	5.19	5.20	108	1.48	1.84	8.51	57.0	61.1	70.3	46.9	74.1	72
	Scav Conc	4.0	0.96	1.46	22.1	0.45	0.28	3.99	6.2	10.0	8.4	8.3	6.6	20
CL	Comb Conc	10.9	3.63	3.82	76.5	1.10	1.26	6.84	63.2	71.2	78.7	55.2	80.7	92
water	Scav Tail	89.1	0.25	0.19	2.55	0.11	0.037	0.07	36.8	28.8	21.3	44.8	19.3	8
20% solids	Head(calc)	-	0.63	0.59	10.6	0.22	0.17	0.81	-	-	-	-	-	-
40	Ro Conc 1	2.8	12.9	9.82	192	2.26	3.84	-	60.5	49.3	52.7	27.8	59.8	-
78	Ro Conc 1+2	5.7	7.12	5.92	122	1.72	2.22	-	68.1	60.7	68.5	43.1	70.3	-
	Scav Conc 1	4.4	0.65	1.10	19.8	0.50	0.27	-	4.7	8.6	8.5	9.6	6.5	-
LdI	Comb Conc	10.1	4.32	3.84	78.0	1.19	1.38	-	72.9	69.3	77.0	52.6	77.0	-
water	Scav Tail	89.9	0.18	0.19	2.61	0.12	0.046	-	27.1	30.7	23.0	47.4	23.0	-
20% solids	Head(calc)	-	0.60	0.56	10.2	0.23	0.18	-	-	-	-	-	-	-

No differences in flotation response were noticed when the water source was varied.

2.2 Sodium Silicate

Metso granular sodium silicate, Na_2SiO_3, was tested as an auxiliary dispersant and as the sole dispersant. Camp Lake water was used in these tests. The test results are condensed in Table 3.

Table 3: Effect of Na_2SiO_3

Test g/t Na_2SiO_3	Product	Wt %	Assays, %, g/t						% Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
36	Ro Conc 1	3.4	8.82	8.36	170	2.09	3.21	12.6	47.1	47.8	53.6	32.1	63.0	52
0	Ro Conc 1+2	6.9	5.19	5.20	108	1.48	1.84	8.51	57.0	61.1	70.3	46.9	74.1	72
2000g/t	Scav Conc 1	4.0	0.96	1.46	22.1	0.45	0.28	3.99	6.2	10.0	8.4	8.3	6.6	20
Na_2CO_3	Comb Conc	10.9	3.63	3.82	76.5	1.10	1.26	6.84	63.2	71.2	78.7	55.2	80.7	92
250 g/t	Scav Tail	89.1	0.26	0.19	2.55	0.11	0.037	0.07	36.8	28.8	21.3	44.8	19.3	8
Na_2S														
	Head(calc)	-	0.63	0.59	10.6	0.22	0.17	0.81	-	-	-	-	-	-
37	Ro Conc 1	1.9	15.3	12.7	225	2.06	5.10	16.4	47.5	40.9	40.4	18.1	57.3	35
2000	Ro Conc 1+2	3.5	9.86	9.03	170	1.97	3.29	12.6	56.9	54.0	56.8	32.2	68.7	51
1000g/t	Scav Conc 1	5.1	1.52	1.85	39.2	0.87	0.40	4.68	12.7	16.1	19.0	20.6	12.1	27
Na_2CO_3	Comb Conc	8.5	4.92	4.78	92.5	1.32	1.58	7.91	69.7	70.1	75.8	52.8	80.8	78
250 g/t	Scav Tail	91.5	0.20	0.19	2.76	0.11	0.035	0.21	30.3	29.9	24.2	47.2	19.2	22
Na_2S														
	Head(calc)	-	0.60	0.58	10.4	0.21	0.17	0.87	-	-	-	-	-	-
38	Ro Conc 1	2.9	11.7	9.66	198	2.22	3.80	14.7	54.2	47.6	52.9	29.4	65.1	49
1000	Ro Conc 1+2	4.9	7.69	7.00	145	1.84	2.54	10.7	60.8	58.9	66.2	41.7	74.1	60
1000g/t	Scav Conc 1	5.0	1.07	1.36	24.6	0.54	0.29	3.44	8.6	11.7	11.4	12.5	8.7	20
Na_2CO_3	Comb Conc	9.9	4.35	4.15	84.2	1.18	1.40	7.02	69.4	70.6	77.6	54.2	82.8	80
250 g/t	Scav Tail	90.1	0.21	0.19	2.67	0.11	0.032	0.19	30.6	29.4	22.4	45.8	17.2	20
Na_2S														
	Head(calc)	-	0.62	0.58	10.7	0.22	0.17	0.87	-	-	-	-	-	-
39	Ro Conc 1	8.7	4.08	4.01	87.5	1.16	1.44	6.29	65.0	62.4	70.0	44.9	75.1	63
2000	Ro Conc 1+2	12.5	3.02	3.07	66.0	0.92	1.07	5.03	69.3	68.7	75.9	51.3	80.4	73
	Scav Conc 1	4.5	0.51	0.78	13.3	0.34	0.17	2.23	4.2	6.3	5.5	6.8	4.6	12
no	Comb Conc	18.7	2.18	2.30	48.2	0.73	0.77	4.15	74.7	76.8	82.9	60.3	86.4	90
Na_2CO_3	Scav Tail	81.3	0.17	0.16	2.29	0.11	0.028	0.11	25.3	23.2	17.1	39.7	13.6	10
250 g/t														
Na_2S	Head(calc)	-	0.55	0.56	10.9	0.23	0.17	0.87	-	-	-	-	-	-

Sodium silicate was less effective as a dispersant than Na_2CO_3, recoveries increased but concentrate grades were much lower. Used with Na_2CO_3, grades and recoveries were similar to those achieved with 400 g/t CMC.

2.3 Sodium Sulphide and CMC Levels

These tests used Lac des Iles water and 1000 g/t Na_2CO_3. The primary grind was 78% minus 200 mesh. The results of testwork with and without Na_2S and CMC additions are presented in Table 4.

Table 4: Effect of Na_2S and CMC

Test	Product	Wt	Assays, %, g/t					% Distribution				
		%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
40	Ro Conc 1	2.8	12.9	9.82	192	2.26	3.84	60.5	49.3	52.7	27.8	59.8
	Ro Conc 1+2	5.7	7.12	5.92	122	1.72	2.22	68.1	60.7	68.5	43.1	70.3
125g/t	Scav Conc 1	4.4	0.65	1.10	19.8	0.50	0.27	4.7	8.6	8.5	9.6	6.5
Na_2S	Comb Conc	10.1	4.32	3.84	78.0	1.19	1.38	72.9	69.3	77.0	52.6	77.0
	Scav Tail	89.9	0.18	0.19	2.61	0.12	0.046	27.1	30.7	23.0	47.4	23.0
400g/t CMC	Head(calc)	-	0.60	0.56	10.2	0.23	0.18	-	-	-	-	-
41	Ro Conc 1	5.0	7.26	6.77	137	1.79	2.45	64.5	60.0	64.6	42.0	66.5
	Ro Conc 1+2	7.6	5.19	5.08	103	1.43	1.79	69.5	67.8	73.0	50.4	73.1
0g/t	Scav Conc 1	3.9	0.59	1.07	18.7	0.47	0.26	4.0	7.3	6.8	8.5	5.4
Na_2S	Comb Conc	11.5	3.63	3.72	74.3	1.10	1.27	73.5	75.1	79.8	58.9	78.6
	Scav Tail	88.5	0.17	0.16	2.44	0.10	0.045	26.5	24.9	20.2	41.1	21.4
400g/t CMC	Head(calc)	-	0.57	0.57	10.7	0.22	0.19	-	-	-	-	-
42	Ro Conc 1	6.3	5.83	5.36	113	1.46	1.92	63.1	57.4	65.6	40.7	66.4
	Ro Conc 1+2	9.6	4.17	4.03	84.1	1.16	1.40	69.3	66.3	74.8	49.5	74.1
0g/t	Scav Conc 1	5.1	0.49	0.87	14.8	0.39	0.22	4.3	7.6	7.0	8.9	6.2
Na_2S	Comb Conc	14.8	2.89	2.94	60.0	0.89	0.99	73.6	73.9	81.8	58.4	80.3
	Scav Tail	85.2	0.18	0.18	2.31	0.11	0.042	26.4	26.1	18.2	41.6	19.7
200g/t CMC	Head(calc)	-	0.58	0.59	10.8	0.23	0.18	-	-	-	-	-
43	Ro Conc 1	7.7	5.71	4.65	96.7	1.26	1.65	69.4	60.5	67.3	41.9	67.9
	Ro Conc 1+2	11.9	3.98	3.45	71.2	1.01	1.18	74.7	69.3	76.5	51.7	75.3
0g/t	Scav Conc 1	6.1	0.47	0.69	11.4	0.35	0.19	4.5	7.1	6.3	9.2	6.2
Na_2S	Comb Conc	17.9	2.79	2.51	50.9	0.78	0.85	79.2	76.4	82.8	60.9	81.5
	Scav Tail	82.1	0.16	0.17	2.31	0.11	0.042	20.8	23.6	17.2	39.1	18.5
0g/t CMC	Head(calc)	-	0.63	0.59	11.0	0.23	0.19	-	-	-	-	-

Omitting the sodium sulphide addition increased metal recoveries, especially platinum and nickel. Concentrate grades were somewhat lower. Reducing the CMC to 200 g/t allowed more gangue to float reducing concentrate grade without increasing metal recoveries, the the exception of palladium. Omitting the CMC further increased the concentrate weight recovery, increasing metal recoveries at lower grades.

2.4 Ammonium Sulphate Addition

Table 5 compares results of tests with Na_2S and $(NH_4)_2SO_4$.

Table 5: $(NH_4)_2SO_4$ Addition

Test	Product	Wt	Assays, %, g/t						% Distribution					
		%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
37	Ro Conc 1	1.9	15.3	12.7	225	2.06	5.10	16.4	47.5	40.9	40.4	18.1	57.3	35
	Ro Conc 1+2	3.5	9.86	9.03	170	1.97	3.29	12.6	56.9	54.0	56.8	32.2	68.7	51
250g/t	Scav Conc 1	5.1	1.52	1.85	39.2	0.87	0.40	4.68	12.7	16.1	19.0	20.6	12.1	27
Na_2S	Comb Conc	8.5	4.92	4.78	92.5	1.32	1.58	7.91	69.7	70.1	75.8	52.8	80.8	78
	Scav Tail	91.5	0.20	0.19	2.76	0.11	0.035	0.21	30.3	29.9	24.2	47.2	19.2	22
	Head(calc)	-	0.60	0.58	10.4	0.21	0.17	0.87	-	-	-	-	-	-
50	Ro Conc 1	4.1	9.48	8.60	162	2.08	3.02	12.6	63.7	55.5	60.1	38.0	68.9	54
	Ro Conc 1+2	6.6	6.39	6.15	118	1.64	2.06	9.63	69.4	64.1	70.8	48.5	76.0	66
250g/t	Scav Conc 1	4.1	0.62	0.97	17.6	0.41	0.22	3.52	4.2	6.3	6.5	7.5	5.0	15
$(NH_4)_2$	Comb Conc	10.7	4.18	4.17	79.6	1.17	1.36	7.29	73.5	70.4	77.3	56.0	81.0	81
SO_4	Scav Tail	89.3	0.18	0.21	2.79	0.11	0.038	0.20	26.5	29.6	22.7	44.0	19.0	19
	Head(calc)	-	0.61	0.63	11.0	0.22	0.18	0.96	-	-	-	-	-	-

At addition rates of 250 g/t ammonium sulphate and sodium sulphide, the test with ammonium sulphate was less selective.

2.5 Flotation Density

Flotation was conducted at approximately 33 and 20% solids. The pulp viscosity was reduced and froth appearance and concentrate grades, especially the platinum group metals, improved at the lower density. The results are compared in Table 6.

Table 6: Effect of Flotation Density

Test	Product	Wt %	Assays, %, g/t						% Distribution					
			Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
29	4th Cl Conc	1.8	17.1	14.9	295	4.50	6.12	-	58.1	47.9	54.2	35.3	65.9	-
	3rd Cl Conc	2.0	15.4	13.7	270	4.12	5.57	-	59.3	50.1	56.3	36.7	68.0	-
33%	2nd Cl Conc	2.6	12.5	11.5	225	3.42	4.56	-	61.1	53.7	59.7	38.8	71.0	-
solids	1st Cl Conc	6.0	5.95	6.08	117	1.86	2.20	-	67.6	65.6	72.2	48.9	79.6	-
	Scav Conc	16.2	2.43	2.60	49.2	0.85	0.88	-	74.0	75.2	81.2	59.9	85.5	-
	Scav Tail	83.8	0.17	0.17	2.20	0.11	0.029	-	26.0	24.8	18.8	40.1	14.5	-
	Head(calc)	-	0.53	0.56	10.4	0.23	0.17	-	-	-	-	-	-	-
51	4th Cl Conc	1.7	25.8	20.2	356	4.88	6.63	31.0	58.2	52.6	55.6	36.4	68.5	60
	3rd Cl Conc	1.9	23.4	18.6	329	4.53	6.03	28.5	59.4	54.3	57.7	38.1	70.1	62
20%	2nd Cl Conc	2.2	20.7	16.4	291	4.03	5.30	25.2	60.6	55.6	59.0	39.1	71.1	63
solids	1st Cl Conc	4.2	11.5	9.75	174	2.46	3.01	15.2	64.6	63.1	67.5	45.7	77.4	73
	Ro Conc	13.5	4.42	3.48	62.5	0.98	1.02	6.01	79.2	72.0	77.7	58.0	84.1	92
	Ro Tail	86.5	0.18	0.21	2.79	0.11	0.03	0.08	20.8	28.0	22.3	42.0	15.9	8
	Head(calc)	-	0.75	0.65	10.8	0.23	0.16	0.88	-	-	-	-	-	-

2.6 Magnetic Separation

A Jeffrey magnetic separation was conducted on the mill discharge prior to conditioning for flotation. Very little magnetic material was recovered. Table 7 contains the results.

Table 7: Magnetic Separation

Test	Product	Wt %	Assays, %, g/t					% Distribution				
			Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
44	Jeff Mags	1.0	3.72	1.27	20.2	0.48	0.50	6.9	2.1	1.9	2.1	2.8
	Ro Conc 1	4.4	6.29	7.07	129	1.89	2.60	51.7	51.0	55.4	37.0	64.0
	Ro Conc 1+2	6.8	4.50	5.28	97.0	1.46	1.85	57.1	58.7	64.2	44.1	70.2
	Scav Conc 1	4.8	0.58	1.00	17.4	0.34	0.21	5.2	7.8	8.1	7.2	5.6
	Comb Conc	12.6	2.95	3.33	60.7	0.96	1.12	69.1	68.6	74.3	53.5	78.5
	Scav Tail	87.4	0.19	0.22	3.03	0.12	0.044	30.9	31.4	25.7	46.5	21.5
	Head(calc)	-	0.54	0.61	10.3	0.23	0.18	-	-	-	-	-
38	Ro Conc 1	2.9	11.7	9.66	198	2.22	3.80	54.2	47.6	52.9	29.4	65.1
	Ro Conc 1+2	4.9	7.69	7.00	145	1.84	2.54	60.8	58.9	66.2	41.7	74.1
	Scav Conc 1	5.0	1.07	1.36	24.6	0.54	0.29	8.6	11.7	11.4	12.5	8.7
	Comb Conc	9.9	4.35	4.15	84.2	1.18	1.40	69.4	70.6	77.6	54.2	82.8
	Scav Tail	90.1	0.21	0.19	2.67	0.11	0.032	30.6	29.4	22.4	45.8	17.2
	Head(calc)	-	0.62	0.58	10.7	0.22	0.17	-	-	-	-	-

2.7 Variability

The variability of the flotation response was scoped in a series of three rougher tests and six rougher - cleaner tests. Eight different samples, with various base metal and PGM contents and ratios, were tested.

2.7.1 Series A - Rougher Circuit

The variability of rougher flotation response was compared for Composite M92, Roby Zone Composite and sub-sample 92 M1 28843. The results are compared in Table 8 and Figures 1 and 2.

Table 8: Variability - Rougher Circuit

Test	Product	Wt %	Assays, %, g/t Au	Pt	Pd	Ni	Cu	S	% Distribution Au	Pt	Pd	Ni	Cu	S
45/46 M92	Ro Conc 1	1.7	19.1	13.1	216	2.06	4.93	16.8	50.8	38.3	37.2	16.0	48.9	33
	Comb Conc	4.0	10.6	8.69	159	2.22	2.87	12.5	65.6	59.0	64.0	40.0	66.4	57
	Ro + Sc Conc	8.2	5.54	4.84	88.9	1.44	1.60	7.31	69.6	66.7	72.4	52.7	74.9	67
	Scav Tail	91.8	0.22	0.21	3.02	0.11	0.05	0.31	30.4	33.3	27.6	47.3	25.1	33
	Head(calc)	-	0.65	0.59	10.0	0.22	0.17	0.89	-	-	-	-	-	-
47/48 Roby Zone	Ro Conc 1	1.1	11.1	10.0	82.5	3.81	5.69	16.8	35.4	34.7	38.7	34.7	44.6	42
	Comb Conc	2.5	6.73	6.24	52.4	2.46	3.28	11.1	39.5	50.9	57.7	52.5	60.2	65
	Ro + Sc Conc	6.4	3.13	3.04	25.1	1.17	1.54	5.33	63.7	62.3	69.7	63.2	71.1	78
	Scav Tail	93.6	0.11	0.12	0.75	0.047	0.043	0.10	34.1	37.7	30.3	36.8	28.9	22
	Head(calc)	-	0.30	0.31	2.30	0.12	0.14	0.43	-	-	-	-	-	-
49 92-M1 28843	Ro Conc 1	4.1	3.26	13.1	295	0.24	0.44	1.63	51.2	54.2	54.2	10.4	55.3	44
	Ro Conc 1+2	11.5	1.45	6.22	139	0.18	0.19	0.86	63.2	71.5	71.0	22.0	68.0	63
	Scav Conc 1	14.0	0.16	0.55	12.6	0.10	0.022	0.14	8.5	7.7	7.8	14.6	9.3	13
	Comb Conc	25.5	0.74	3.11	69.7	0.14	0.10	0.46	71.7	79.1	78.8	36.7	77.4	76
	Scav Tail	74.5	0.10	0.28	6.42	0.081	0.010	0.05	28.3	20.9	21.2	63.3	22.6	24
	Head(calc)	-	0.26	1.00	22.5	0.095	0.033	0.16	-	-	-	-	-	-

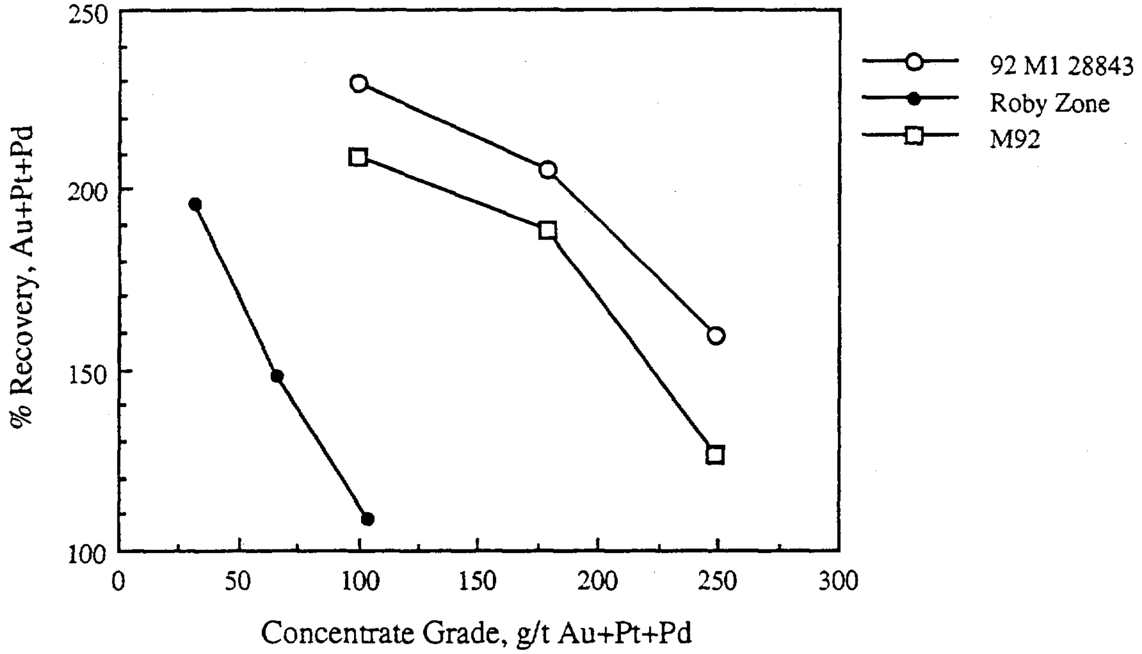


Figure 1: Variability - PGM Rougher Flotation

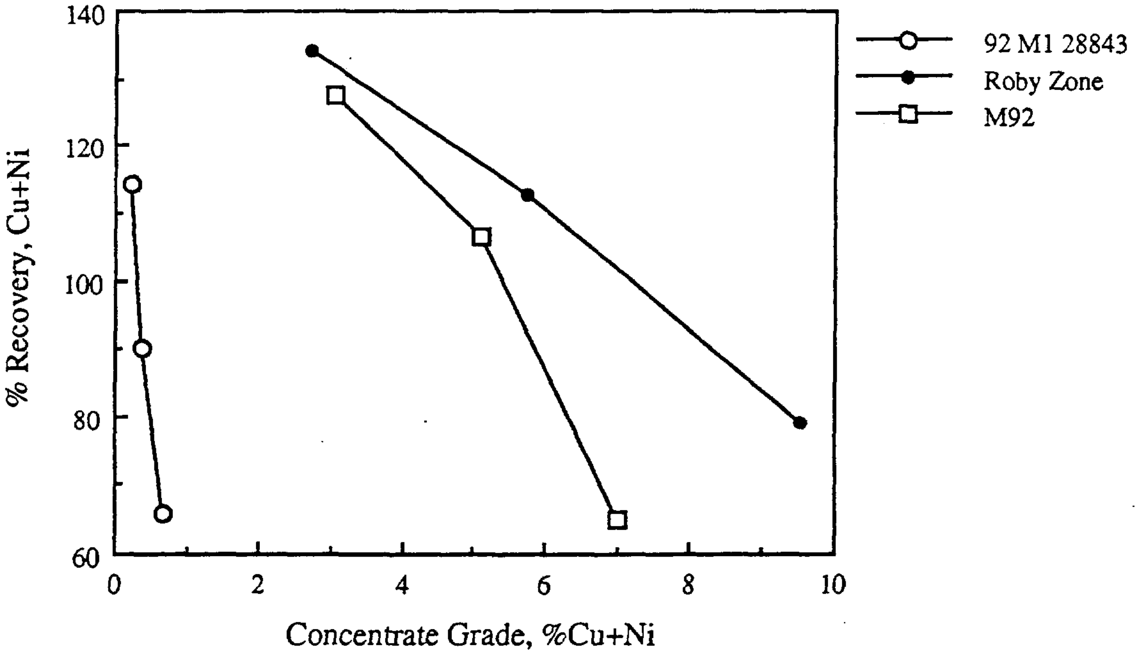


Figure 2: Variability - Rougher Base Metal Flotation

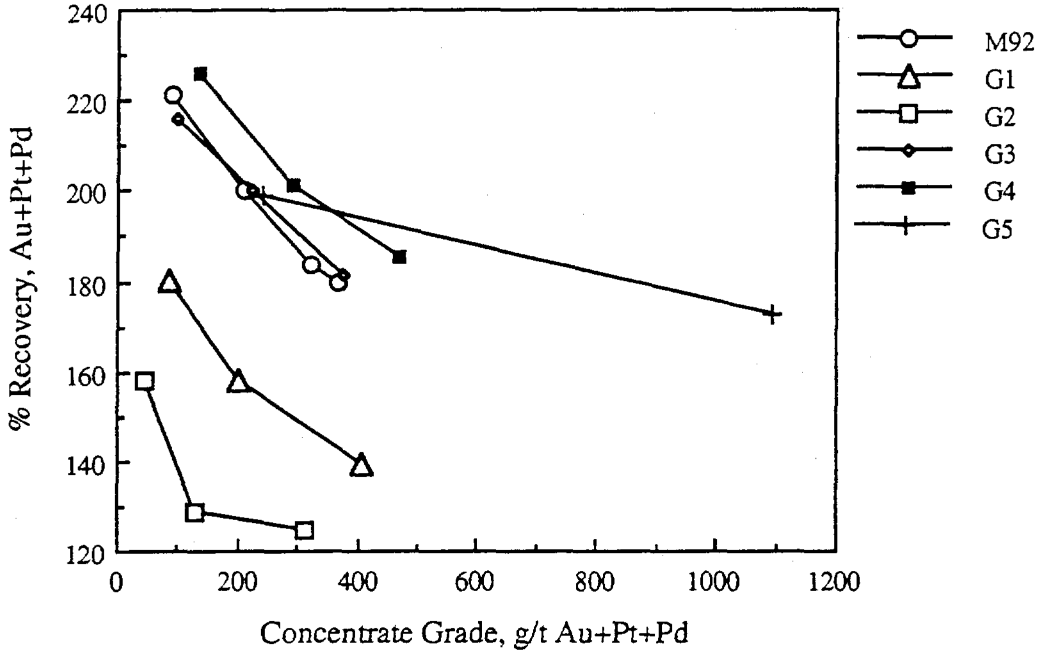


Figure 3: Variability - Cleaner Circuit PGM

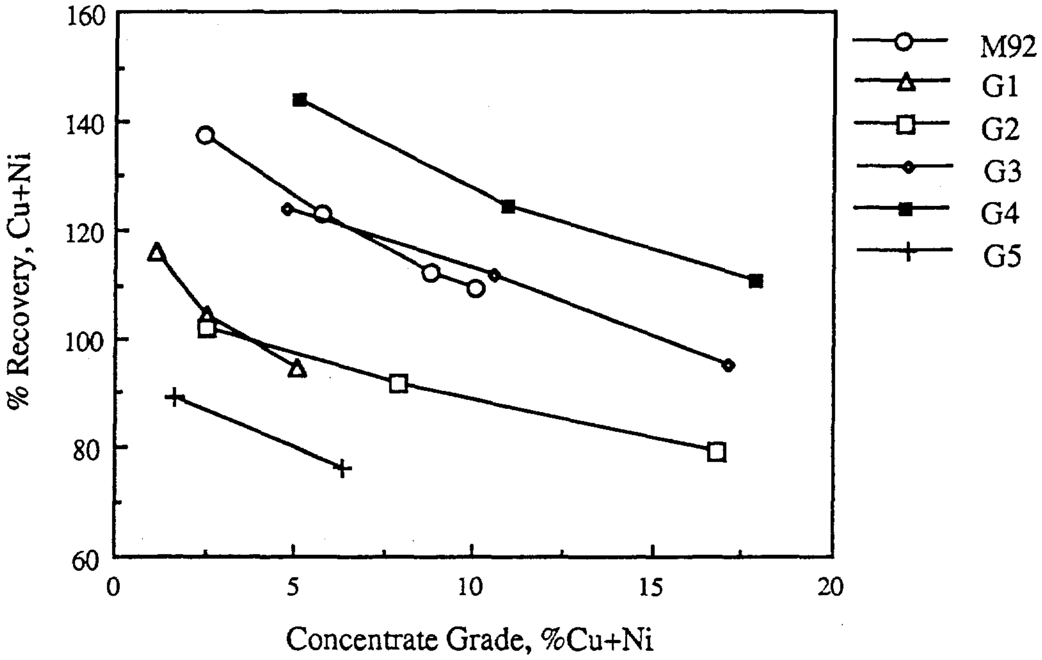


Figure 4: Variability - Cleaner Circuit Base Metals

The concentrate grades and recoveries of the samples varied considerably. No correlation has been noted between feed grades or the Ni:Cu ratio and the metallurgical response. Table 10 summarizes the feed grades, rougher recoveries and Ni:Cu ratio of the samples used in the variability study.

Table 10: Variability Feed Samples

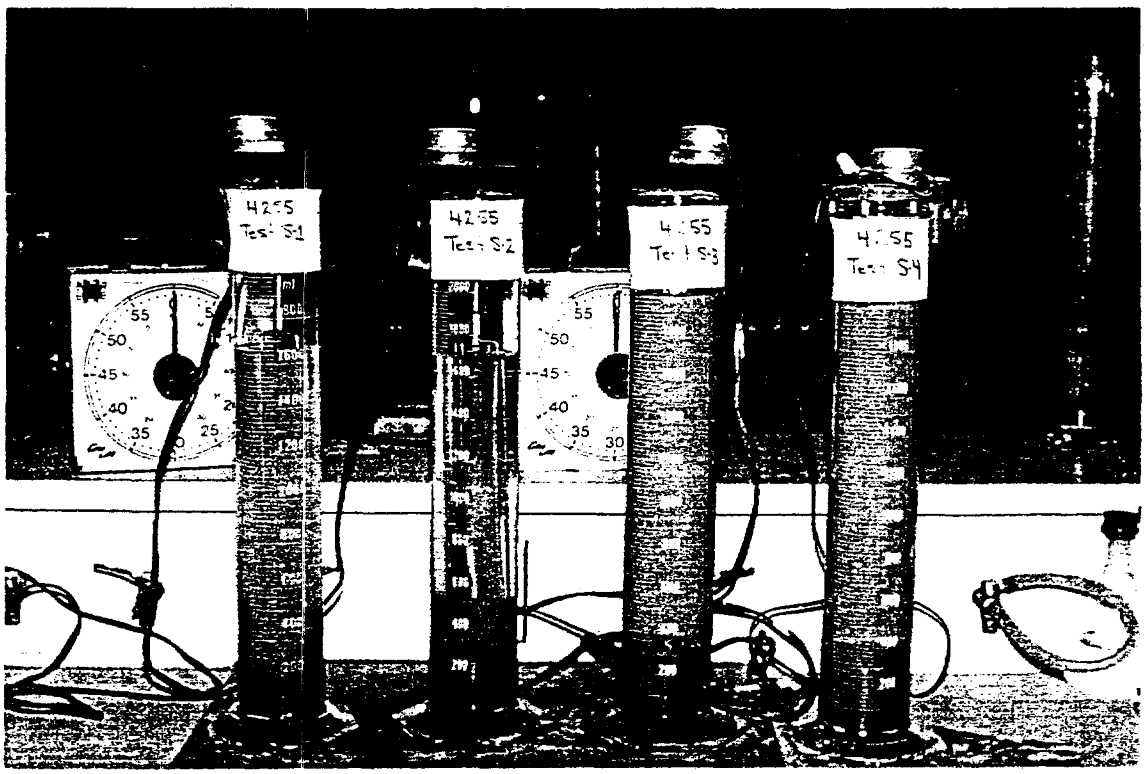
	Head Assays, g/t			Total	Ro	Head, %		Total	Ratio	Ro
Comp	Au	Pt	Pd	PGM	Rec'y PGM	Ni	Cu	BM	Ni:Cu	Rec'y BM
92M1	0.26	1.00	22.5	23.8	230	0.095	0.033	0.13	2.88	114
G4	0.72	0.41	6.67	7.80	226	0.18	0.15	0.33	1.20	144
M92	0.65	0.59	10.0	11.2	221	0.22	0.17	0.39	1.29	138
G3	0.59	0.33	4.07	4.99	216	0.17	0.13	0.30	1.31	124
G5	0.34	0.51	11.4	12.3	199	0.28	0.39	0.32	7.18	89
Roby	0.30	0.31	2.30	2.91	196	0.12	0.14	0.26	0.86	134
G1	0.24	0.49	6.47	7.20	180	0.091	0.045	0.14	2.02	116
G2	0.38	0.27	2.51	3.16	158	0.13	0.091	0.22	1.43	102

3. Settling Testwork

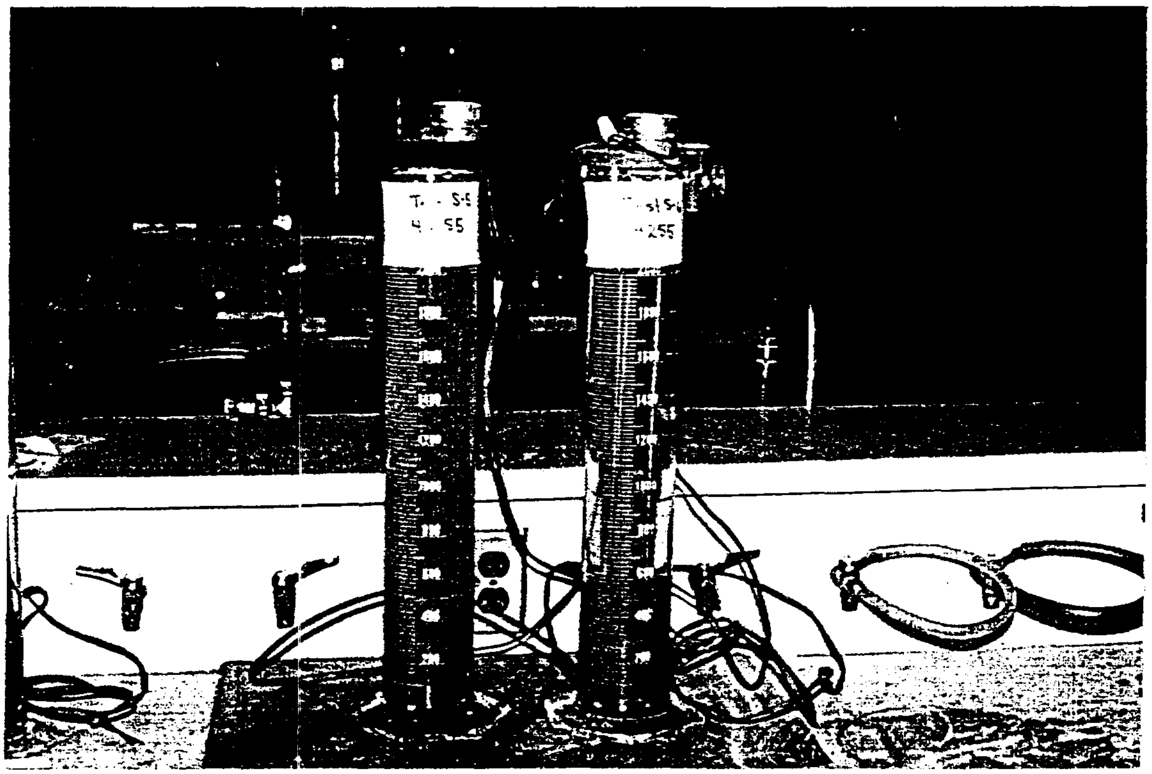
Settling tests were conducted on flotation tailing from Test 52 with CMC PA MED, no Na_2CO_3, no Na_2SiO_3 and from Test 53 with CMC 7MF, Na_2CO_3 and Na_2SiO_3. Supernatant from Test 52, with and without flocculant was submitted for water quality analysis.

3.1 Thickening Tests

The tailing from Test 53 (Tests S3 and S4) was so well dispersed that no visible settling occurred prior to the addition of 1950 g/t $CuSO_4$. Photograph 1 shows the supernatant clarity after 24 hours of settling tests on the two different tailings with and without flocculant. Photograph 2 shows the effect of the $CuSO_4$ addition on Tests S3 and S4. The thickening test results are summarized in Table 11.



Photograph 1



Photograph 2

Table 12: Semi-Quantitative Water Analysis

Element	Detection Limit,mg/L	Concentration, mg/L						
		Dissolved				Total		
		Blank	S1-24 h	S2-24 h	S1-72 h	S1-24 h	S2-24 h	S1-72 h
Al	0.1	<0.1	<0.1	<0.1	<0.1	1.61	1344	0.30
As	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Be	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ca	0.1	<0.1	37.2	37.2	38.4	37.2	37.2	38.4
Cd	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Co	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cr	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cu	0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	<0.02
Fe	0.02	<0.02	<0.02	<0.02	<0.02	1.74	1.29	0.39
Mg	0.05	<0.05	17	17	17.3	17.0	17.0	17.3
Mn	0.01	<0.01	0.02	0.01	0.02	0.04	0.03	0.02
Mo	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Na	0.05	<0.05	29	30	29.3	29.0	29.0	29.3
Ni	0.02	<0.02	0.02	0.02	0.02	0.08	0.07	0.03
P	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
S	1.0	<1.0	58	56	50.7	69.2	68.2	50.7
Sb	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Se	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Si	0.05	0.05	3.4	3.3	3.60	3.95	3.61	3.60
Sn	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Te	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zn	0.01	<0.01	<0.01	<0.01	0.02	0.14	0.05	0.24
Hardness			163	163				

Table 13: Quantitative Water Analysis

Sample	Concentration, mg/L					
	Cu	Se	Pb	Cd	TSS	TDS
S1, 24 h TM	0.021	<0.10	0.017	0.0003	39	-
S1, 24 h DM	0.007	<0.10	0.006	0.0002	-	346
S1, 72 h TM	0.010	<0.10	0.010	<0.0002	-	-
S1, 72 h DM	<0.003	<0.10	<0.005	<0.0002	-	-
S2, 24 h TM	0.022	<0.10	0.008	<0.0002	20	-
S2, 24 h DM	0.004	<0.10	<0.005	<0.0002	-	340
Blank DM	<0.003	<0.10	-	-	-	-

TM = total metal
DM = dissolved metal

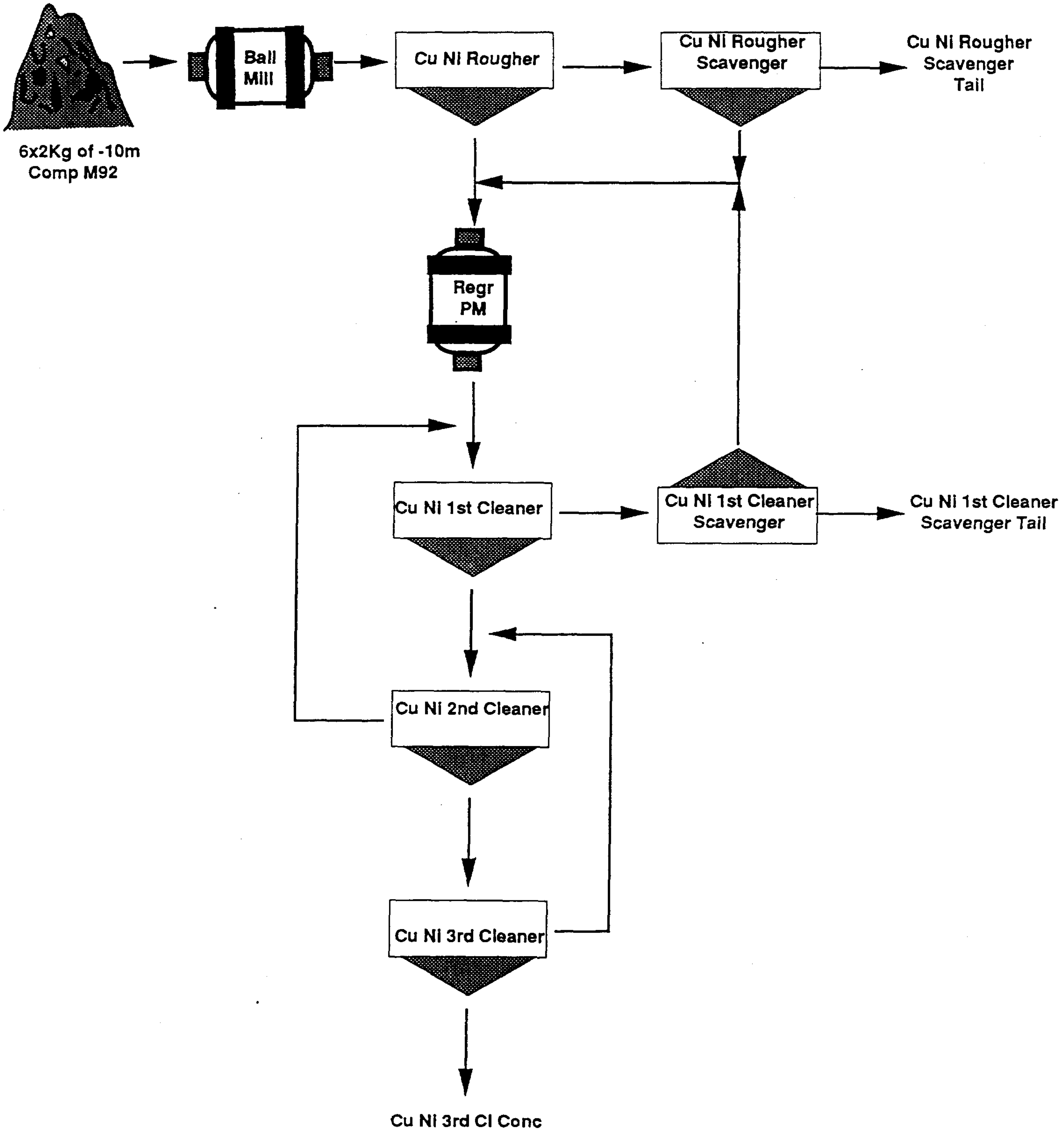
4. Cycle Test

A six stage cycle test was conducted using these conditions:

Primary Grind:	65% minus 200 mesh with reagents added to last 5 minutes of grind 125 g/t Na_2S 400 g/t PA MED 25 g/t 3501 50 g/t PAX
Rougher:	25 g/t MIBC 8 minutes flotation
Scavenger:	50 g/t Na_2S 50 g/t $CuSO_4$ 4 x 5 g/t stages PAX MIBC as required 7+5+5+5 minutes flotation stages
Regrind:	90% minus 400 mesh with reagents added to last 5 minutes of grind 100 g/t PA MED 5 g/t 3501 20 g/t PAX
1st Cleaner:	15 g/t PAX 15 minutes flotation
1st Cleaner Scav:	50 g/t Na_2S 20 g/t PAX 10 minutes flotation
2nd Cleaner:	50 g/t PA MED 5 g/t 3501 15 g/t PAX 8.5 minutes flotation
3rd Cleaner:	10 g/t PA MED 2.5 g/t 3501 10 g/t PAX 8 minutes flotation

The flowsheet is shown in Figure 5.

Figure 5: Cycle Test Flowsheet



4.1 Metallurgical Results

The results of a batch test under similar conditions are compared with the cycle test in Table 14.

Table 14: Test Results

Test	Product	Wt	Assays, %, g/t						% Distribution					
		%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
53A	3rd Cl Conc	2.0	16.1	15.5	336	4.05	6.00	27.0	60.8	55.8	63.1	36.7	72.7	32
	2nd Cl Conc	2.3	13.9	13.6	293	3.59	5.19	23.8	61.8	57.4	64.8	38.2	73.9	33
	1st Cl Conc	3.9	8.67	8.89	190	2.47	3.25	16.0	65.3	63.8	71.3	44.5	78.4	38
	Ro Conc	10.3	3.56	3.81	80.1	1.14	1.31	7.15	70.5	71.9	78.9	54.3	83.3	45
	Ro Tail	89.8	0.17	0.17	2.45	0.11	0.030	1.01	29.5	28.1	21.1	45.7	16.7	55
	Head(calc)	-	0.52	0.54	10.4	0.22	0.16	1.64	-	-	-	-	-	-
54	CuNi Conc	3.3	12.1	11.6	229	3.04	3.88	-	69.5	67.3	73.0	47.1	78.0	-
	Comb Tail	96.7	0.18	0.19	2.91	0.12	0.038	-	30.5	32.7	27.0	52.9	22.0	-
	Head(calc)	-	0.58	0.57	10.4	0.21	0.17	-	-	-	-	-	-	-

Recoveries above the batch test 1st cleaner concentrate level were achieved with recirculation of the 2nd and 3rd cleaner tailings and 1st cleaner scavenger concentrate, however the final concentrate grade was lower.

4.2 Concentrate Quality

Table 15 and Figure 6 illustrate the effect of weight recovery and concentrate grade (concentrates from Composite M92) on MgO content.

Table 15: MgO Content of Concentrates

Test	Product	Wt	Assays, g/t, %					
		%	Au	Pt	Pd	Ni	Cu	MgO
51	4th Cl Conc	1.7	25.8	20.2	356	4.88	6.63	3.79
51	2nd Cl Conc	2.2	20.7	16.4	291	4.03	5.30	6.58
54	3rd Cl Conc	3.3	12.1	11.6	229	3.04	3.88	9.12

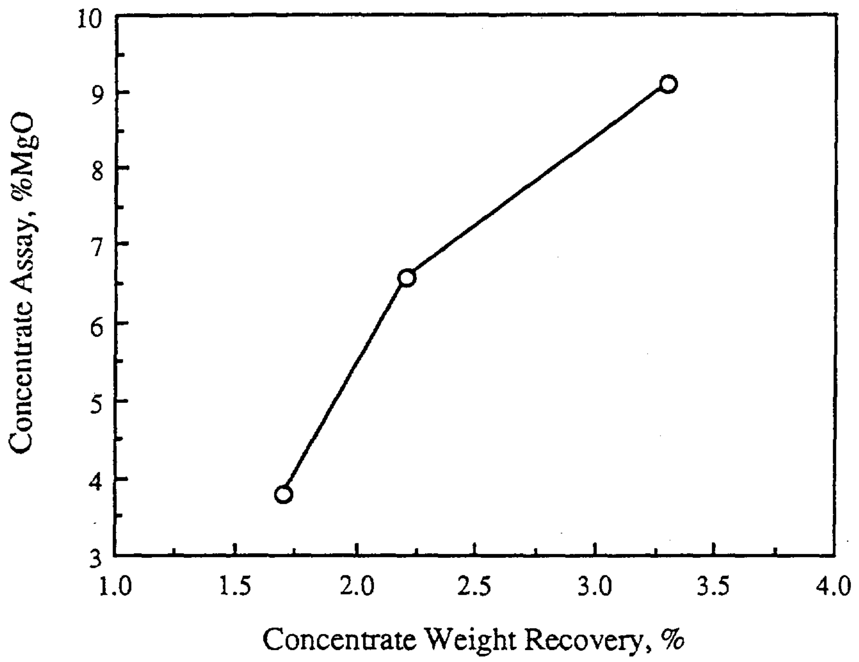


Figure 6: Weight Recovery vs MgO Assay

A 24 element semi quantitative scan of the final concentrate from the cycle test is reported in Table 16.

Table 16: Concentrate Scan

Element	Detection Limit %	Concentration, % 3rd Cl Conc D-F Test 54
Ba	0.0005	0.002
Be	0.0001	<0.0001
Ca	0.02	1.31
Cd	0.0005	0.001
Co	0.0005	0.13
Cr	0.0005	0.020
Cu	0.0005	3.72
Fe	0.0005	26.0
La	0.001	<0.001
Mg	0.0005	5.50
Mn	0.005	0.044
Mo	0.001	<0.01
Na	0.0005	0.20
Nd	0.005	<0.005
Ni	0.0005	2.66
P	0.002	<0.002
Pb	0.001	0.083
S	0.02	14.1
Sb	0.001	<0.001
Se	0.005	0.008
Sn	0.002	<0.002
Te	0.01	<0.003
Y	0.001	<0.001
Zn	0.0005	0.26

4.3 Cyanidation of 1st Cleaner Scavenger Tailing

The 1st cleaner scavenger tailings, cycles A to F were combined, and split into three charges for bottle roll leaching. The preliminary test was a single stage 48 hour cyanide leach. Two additional tests were conducted to confirm results, investigate the effect of a finer leach feed size, and investigate the effect of retention time. The results are presented in Table 17.

Table 17: Cyanide Leach Results

Test	Regrind	Reag Cons kg/t		% Extraction									Head, Au g/t Calc		
				48 hour			72 hour			96 hour					
		NaCN	CaO	Au	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd
54C	no	5.16	0.97	88.6	13.2	65.3	-	-	-	-	-	-	0.52	0.59	10.0
1C	no	5.91	1.78	-	-	-	51.1	6.1	51.2	83.3	21.6	61.2	0.54	0.67	9.54
2C	yes	7.96	1.25	59.3	6.3	60.2	60.6	6.9	65.3	77.4	21.3	65.5	0.62	0.65	9.03

Residue assays(g/t) were:

Test	Au	Pt	Pd
54C	0.05, 0.07	0.46, 0.52	3.63, 3.46
1C	0.11, 0.07	0.52, 0.53	3.75, 3.65
2C	0.21, 0.07	0.50, 0.52	3.15, 3.08

Extended leach time and fine grinding did not improve extractions.

CONCLUSIONS

The use of waters obtained from the Lac des Iles Mine site throughout batch laboratory tests did not effect results. A lower flotation density of 18-20% solids improved the grade-recovery relationship slightly. A soda-ash, sodium silicate circuit gave similar metallurgical results as the CMC circuit. However, the settling characteristics of the tailings was adversely affected.

The predicted results from composite M92, based on a six stage locked cycle test, Test 54, are:

Product	Weight	Assays, %, g/t					% Distribution				
	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
3rd Cl Conc	3.32	12.1	11.6	229	3.04	3.88	69.5	67.3	73.0	47.1	78.0
1st Cl Sc Tail	8.27	0.42	0.56	9.91	0.27	0.10	6.0	8.0	7.9	10.3	5.0
Ro Tail	88.41	0.16	0.16	2.26	0.10	0.032	24.5	24.7	19.1	42.6	16.9
Head(calc)	100.00	0.58	0.57	10.4	0.21	0.17	100.0	100.0	100.0	100.0	100.0
Comb Tail	96.68	0.18	0.19	2.91	0.12	0.038	30.5	32.7	27.0	52.9	22.0

Final concentrate weight recovery below 2% would be required to obtain MgO levels below 5%. The above concentrate assays 9.12% MgO.

Of the PGM's contained in the 1st cleaner scavenger tailing, approximately 80% of the gold and 65% of the Pd could be extracted by direct cyanidation of this tailing. This would represent an additional overall extraction of approximately 5% each of Au and Pd.

The samples submitted for variability testwork were quite different in feed grades and metallurgical response.

SAMPLE PREPARATION

Preparation of Composite M92 is detailed in LR4255, Progress Report 1.

Ten kilograms of Sample 92M1 28843, which was excluded from Composite M92 because of the low Cu Ni content and high Pd, was crushed to minus 10 mesh and ten 1 kilogram charges prepared.

The variability samples were received under our reference numbers LR9239846 and LR9239887. Eight 1 kilogram charges of Group 1 were blended using equal weights of samples 25643 and 25644. Twenty-five 1 kilogram charges of Group 2 were blended using equal weights of samples 25635 to 25640. Sixteen 1 kilogram charges of Group 3 were blended using equal weights of samples 25631 to 25634. Sixteen 1 kilogram charges of Group 4 were blended using equal weights of samples 25627 to 25630. Six 1 kilogram charges of Group 5 were blended using equal weights of samples 25680 and 25681.

REAGENTS

$Ca(OH)_2$	Calcium Hydroxide	Nymoc Chemicals
Na_2CO_3	Sodium Carbonate	Fisher Scientific
Na_2S	Sodium Sulphide	Nymoc Chemicals
$CuSO_4 \bullet 5H_2O$	Copper Sulphate	Nymoc Chemicals
NaCN	Sodium Cyanide	Nymoc Chemicals
$(NH_4)_2SO_4$	Ammonium Sulphate	Fisher Scientific
Aerofloat 208 promoter	Dithiophosphate collector	Cyanamid
Aero 3501 promoter	Dithiophosphate collector	Cyanamid
PAX	Potassium Amyl Xanthate	Hoechst
MIBC	Methyl IsoButyl Carbinol	CIL Chemicals
DF250C	polyglycol frother	Dow
DF250	polyglycol frother	Dow
PA MED	Carboxyl Methyl Cellulose	Aqualon
CMC 7LT	Carboxyl Methyl Cellulose medium viscosity	Aqualon
CMC 7MF	Carboxyl Methyl Cellulose	Aqualon
Na_2SiO_3	Sodium silicate	National Silicate
Percol 156	Anionic polyacrylamide flocculant, high molecular wt	Allied Colloids

DETAILS OF TESTWORK

Test	Composite	Conditions
36	M92	70% minus 200 mesh, 20% solids, Camp Lake water
37	M92	78% minus 200 mesh, 20% solids, Na2SIO3, Camp Lake water
38	M92	Repeat 37, reduce Na2SiO3
39	M92	Repeat 37 without Na2CO3
40	M92	Reduced Na2S, Na2CO3, Lac des Iles water
41	M92	Repeat 40 without Na2S
42	M92	Repeat 41 with reduced CMC
43	M92	Repeat 42 without CMC
44	M92	Repeat 38 no Na2SiO3, Jeffery sep'n flot feed, Lakefield water
45,46	M92	Repeat 37, GR operator
47,48	Roby Zone	Repeat 45,46, GR operator
49	92M1 28843	Repeat 37, LP operator
50	M92	Repeat 37, with (NH4)2SO4, LP operator
51	M92	Repeat 29 at low density
52	M92	Repeat 31 to produce tailing for settling tests
53	M92	Repeat 37 to produce tailing for settling tests
S1 to 6	Tailings	Settling tests
53A	M92	Precycle test, GC operator
54	M92	Cycle Test, GC operator
54C	M92	48h CN Leach 1st Cl Tailing
1C	M92	96h CN Leach 1st Cl Tailing
2C	M92	96h CN Leach reground1st Cl Tailing
55	G1	Variability test, GC operator
56	G2	Variability test
57	G3	Variability test
58	G4	Variability test
59	G4	Variability test

Test: 36 Project: 4255 Date: May 27th/92 Operator: BW

Purpose: To conduct a flotation test on 1000 g of Comp M92 at 70% minus 200 mesh using Camp Lake water throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 12 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2CO3	Na2S	CMC 7LT	CuSO4	A350	R-208	DF-250	Grind	Cond.	Froth	
Primary Grind	2000	250						12			9.8
Rougher Cond. 1			400						3		
Rougher Cond. 2				250					5		
Rougher Cond. 3					100	40			3		
Rougher 1							5		1	2	
Rougher 2					50	20	10		1	2	9.6
Scavenger Cond.		100							2		9.7
										5	
Scavenger					100	20			2	6	9.6

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Size Analysis of Combined Products:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	4.2	4.2	4.2	95.8
147	100	5.0	5.0	9.2	90.8
104	150	10.3	10.3	19.5	80.5
74	200	10.2	10.2	29.7	70.3
45	325	16.7	16.7	46.4	53.6
-45	-325	53.6	53.6	100.0	-
	Total	100.0	100.0	-	-

Test: 36

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Rougher Conc. 1	32.9	3.4	8.82	8.36	170	2.09	3.21	12.6	47.1	47.8	53.6	32.1	63.0	52.2
2 Rougher Conc. 2	34.7	3.5	1.75	2.21	50.0	0.91	0.54	4.64	9.9	13.3	16.6	14.7	11.2	20.3
3 Scav. Conc.	39.6	4.0	0.96	1.46	22.1	0.45	0.28	3.99	6.2	10.0	8.4	8.3	6.6	19.9
4 Scav. Tail	872.8	89.1	0.26	0.19	2.55	0.11	0.037	0.070	36.8	28.8	21.3	44.8	19.3	7.7
Head (calc)	980.0	100.0	0.63	0.59	10.6	0.22	0.17	0.81	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							
Combined Products														
Products 1 & 2		6.9	5.19	5.20	108	1.48	1.84	8.51	57.0	61.1	70.3	46.9	74.1	72.4
Products 1 to 3		10.9	3.63	3.82	76.5	1.10	1.26	6.84	63.2	71.2	78.7	55.2	80.7	92.3

Test: 37 Project: 4255 Date: May 28th/92 Operator: BW

Purpose: To repeat Test 36 with the CMC 7MF replacing CMC 7LT, and with the addition of Sodium Silicate type "O" (Na2SiO3). Other changes are shown below.
Camp Lake water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2CO3	Na2S	CMC 7MF	Na2SiO3	CuSO4	A350	R 208	DF-250	Grind	Cond.	Froth	
Primary Grind	1000	250		2000					15			9.6
Rougher Cond. 1			400							3		
Rougher Cond. 2					250					5		
Rougher Cond. 3						100	40			3		
Rougher 1								20		1	2	9.3
Rougher 2						100	20			2	2	9.3
Scavenger Cond.		100								2		
Scavenger						100	20			2	6	9.3

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Size Analysis of Combined Products:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	1.2	1.2	1.2	98.8
147	100	3.4	3.4	4.6	95.4
104	150	7.5	7.5	12.1	87.9
74	200	9.9	9.9	22.0	78.0
53	270	11.1	11.1	33.1	66.9
38	400	12.4	12.4	45.5	54.5
-38	-400	54.5	54.5	100.0	-
	Total	100.0	100.0	-	-

Test: 37

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Rougher Conc. 1	18.4	1.9	15.3	12.7	225	2.06	5.10	16.4	47.5	40.9	40.4	18.1	57.3	35.4
2 Rougher Conc. 2	15.8	1.6	3.53	4.75	106	1.87	1.18	8.16	9.4	13.1	16.3	14.1	11.4	15.1
3 Scav. Conc.	49.7	5.1	1.52	1.85	39.2	0.87	0.40	4.68	12.7	16.1	19.0	20.6	12.1	27.3
4 Scav. Tail	899.4	91.5	0.20	0.19	2.76	0.11	0.035	0.21	30.3	29.9	24.2	47.2	19.2	22.2
Head (calc)	983.3	100.0	0.60	0.58	10.4	0.21	0.17	0.87	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							

Combined Products

Products 1 & 2		3.5	9.86	9.03	170	1.97	3.29	12.6	56.9	54.0	56.8	32.2	68.7	50.5
Products 1 to 3		8.5	4.92	4.78	92.5	1.32	1.58	7.91	69.7	70.1	75.8	52.8	80.8	77.8

Test: 38　　Project: 4255　　Date: May 28th/92　　Operator: BW

Purpose: To repeat Test 37 with 1000 g/t of Na2SiO3.
Camp Lake water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2CO3	Na2S	CMC 7MF	Na2SiO3	CuSO4	A350	R 208	DF-250	Grind	Cond.	Froth	
Primary Grind	1000	250		1000					15			9.5
Rougher Cond. 1			400							3		
Rougher Cond. 2					250					5		9.1
Rougher Cond. 3						100	40			3		
Rougher 1								40		1	2	9.0
Rougher 2						100	20			2	2	9.0
Scavenger Cond.		100								3		9.1
Scavenger						100	20			2	6	9.1

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Size Analysis of Combined Products:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	1.3	1.3	1.3	98.7
147	100	3.0	3.0	4.3	95.7
104	150	7.1	7.1	11.4	88.6
74	200	10.1	10.1	21.5	78.5
53	270	12.0	12.0	33.5	66.5
38	400	13.0	13.0	46.5	53.5
-38	-400	53.5	53.5	100.0	-
	Total	100.0	100.0	-	-

Test: 38

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Rougher Conc. 1	27.9	2.9	11.7	9.66	198	2.22	3.80	14.7	54.2	47.6	52.9	29.4	65.1	48.7
2 Rougher Conc. 2	19.7	2.0	2.02	3.23	70.3	1.31	0.75	4.97	6.6	11.2	13.3	12.3	9.1	11.6
3 Scav. Conc.	48.6	5.0	1.07	1.36	24.6	0.54	0.29	3.44	8.6	11.7	11.4	12.5	8.7	19.9
4 Scav. Tail	876.3	90.1	0.21	0.19	2.67	0.11	0.032	0.19	30.6	29.4	22.4	45.8	17.2	19.8
Head (calc)	972.5	100.0	0.62	0.58	10.7	0.22	0.17	0.87	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							
Combined Products														
Products 1 & 2		4.9	7.69	7.00	145	1.84	2.54	10.7	60.8	58.9	66.2	41.7	74.1	60.4
Products 1 to 3		9.9	4.35	4.15	84.2	1.18	1.40	7.02	69.4	70.6	77.6	54.2	82.8	80.2

Test: 39 Project: 4255 Date: May 28th/92 Operator: BW

Purpose: To repeat Test 38 with 2000 g/t of Na2SiO3 and without Na2CO3.
Camp Lake water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S	CMC 7MF	Na2SiO3	CuSO4	A350	R-208	DF-250	Grind	Cond.	Froth	
Primary Grind	250		2000					15			8.9
Rougher Cond. 1		400							3		
Rougher Cond. 2				250					5		8.5
Rougher Cond. 3					100	40			3		
Rougher 1							40		1	2	8.5
Rougher 2					100	20			2	2	8.5
Scavenger 1 Cond.	100								3		8.9
Scavenger 1					100	20			2	6	8.5
Scavenger 2 Cond.	100								2		8.9
Scavenger 2					50	20			2	5	8.6

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Size Analysis of Combined Products:

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Pass.
208	65	1.4	1.4	1.4	98.6
147	100	4.5	4.5	5.9	94.1
104	150	8.5	8.5	14.4	85.6
74	200	10.6	10.6	25.0	75.0
53	270	11.9	11.9	36.9	63.1
38	400	13.3	13.3	50.2	49.8
-38	-400	49.8	49.8	100.0	-
	Total	100.0	100.0	-	-

Test: 39

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 Rougher Conc. 1	84.6	8.7	4.08	4.01	87.5	1.16	1.44	6.29	65.0	62.4	70.0	44.9	75.1	63.2
2 Rougher Conc. 2	37.0	3.8	0.61	0.93	16.9	0.38	0.23	2.16	4.3	6.3	5.9	6.4	5.2	9.5
3 Scav. 1 Conc.	43.7	4.5	0.51	0.78	13.3	0.34	0.17	2.23	4.2	6.3	5.5	6.8	4.6	11.6
4 Scav. 2 Conc.	16.5	1.7	0.41	0.60	9.82	0.30	0.14	2.76	1.3	1.8	1.5	2.3	1.4	5.4
5 Scav. Tail	789.1	81.3	0.17	0.16	2.29	0.11	0.028	0.11	25.3	23.2	17.1	39.7	13.6	10.3
Head (calc)	970.9	100.0	0.55	0.56	10.9	0.23	0.17	0.87	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							
Combined Products														
Products 1 & 2		12.5	3.02	3.07	66.0	0.92	1.07	5.03	69.3	68.7	75.9	51.3	80.4	72.7
Products 1 to 3		17.0	2.36	2.47	52.1	0.77	0.83	4.29	73.5	75.0	81.4	58.1	85.0	84.3
Products 1 to 4		18.7	2.18	2.30	48.2	0.73	0.77	4.15	74.7	76.8	82.9	60.3	86.4	89.7

Test: 40 Project: 4255 Date: June 4th/92 Operator: BW

Purpose: To repeat Test 39 without Na2SiO3 and with 1 g/t Na2CO3.
Lac des Iles water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Na2S	CMC 7MF	Na2CO3	CuSO4	A350	R-208	DF-250	Time, minutes			pH
								Grind	Cond.	Froth	
Primary Grind	125		1000					15			9.5
Rougher Cond. 1		400							3		
Rougher Cond. 2				250					5		9.2
Rougher Cond. 3					100	40			3		
Rougher 1							40		1	2	9.0
Rougher 2					100	20			2	2	8.8
Scavenger Cond.	125								2		9.1
Scavenger Cond.				250					5		8.8
Scavenger					100	40			3	6	8.5

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 40

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Rougher Conc. 1	27.2	2.8	12.9	9.82	192	2.26	3.84	60.5	49.3	52.7	27.8	59.8
2 Rougher Conc. 2	28.3	2.9	1.56	2.18	55.4	1.20	0.66	7.6	11.4	15.8	15.3	10.7
3 Scav. 1 Conc.	42.3	4.4	0.65	1.10	19.8	0.50	0.27	4.7	8.6	8.5	9.6	6.5
4 Scav. Tail	874	89.9	0.18	0.19	2.61	0.12	0.046	27.1	30.7	23.0	47.4	23.0
Head (calc)	971.8	100.0	0.60	0.56	10.2	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
Products 1 & 2		5.7	7.12	5.92	122	1.72	2.22	68.1	60.7	68.5	43.1	70.5
Products 1 to 3		10.1	4.32	3.84	78.0	1.19	1.38	72.9	69.3	77.0	52.6	77.0

Test: 41 Project: 4255 Date: June 4th/92 Operator: BW

Purpose: To repeat Test 40 without Na2S in the primary grind
Lac des Iles water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage								Time, minutes			pH
	Na2S	CMC 7MF	Na2CO3	CuSO4	A350	R-208	DF-250	Grind	Cond.	Froth	
Primary Grind			1000					15			9.0
Rougher Cond. 1		400							3		
Rougher Cond. 2				250					5		8.5
Rougher Cond. 3					100	40			3		
Rougher 1							40		1	2	8.6
Rougher 2					100	20			2	2	8.5
Scavenger Cond.	250								2		9.1
Scavenger Cond.				250					5		8.9
Scavenger					100	40			3	6	8.6

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 41

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Rougher Conc. 1	50.2	5.0	7.26	6.77	137	1.79	2.45	64.5	60.0	64.6	42.0	66.5
2 Rougher Conc. 2	25.4	2.6	1.10	1.75	35.0	0.71	0.48	4.9	7.8	8.4	8.4	6.6
3 Scav. 1 Conc.	38.7	3.9	0.59	1.07	18.7	0.47	0.26	4.0	7.3	6.8	8.5	5.4
4 Scav. Tail	880.9	88.5	0.17	0.16	2.44	0.100	0.045	26.5	24.9	20.2	41.1	21.4
Head (calc)	995.2	100.0	0.57	0.57	10.7	0.22	0.19	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
Products 1 & 2		7.6	5.19	5.08	103	1.43	1.79	69.5	67.8	73.0	50.4	73.1
Products 1 to 3		11.5	3.63	3.72	74.3	1.10	1.27	73.5	75.1	79.8	58.9	78.6

Test: 42 Project: 4255 Date: June 4th/92 Operator: BW

Purpose: To repeat Test 41 with half of the CMC 7MF.
Lac des Iles water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Na2S	CMC 7MF	Na2CO3	CuSO4	A350	R-208	DF-250	Time, minutes Grind	Cond.	Froth	pH
Primary Grind			1000					15			9.0
Rougher Cond. 1		200							3		
Rougher Cond. 2				250					5		8.6
Rougher Cond. 3					100	40			3		
Rougher 1							40		1	2	8.6
Rougher 2					100	20			2	2	8.5
Scavenger Cond.	250								2		9.1
Scavenger Cond.				250					5		9.0
Scavenger					100	40			3	6	8.6

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 42

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Rougher Conc. 1	62.4	6.3	5.83	5.36	113	1.46	1.92	63.1	57.4	65.6	40.7	66.4
2 Rougher Conc. 2	33.3	3.4	1.07	1.55	29.9	0.59	0.42	6.2	8.9	9.3	8.8	7.7
3 Scav. 1 Conc.	50.9	5.1	0.49	0.87	14.8	0.39	0.22	4.3	7.6	7.0	8.9	6.2
4 Scav. Tail	845.8	85.2	0.18	0.18	2.31	0.11	0.042	26.4	26.1	18.2	41.6	19.7
Head (calc)	992.4	100.0	0.58	0.59	10.8	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
Products 1 & 2		9.6	4.17	4.03	84.1	1.16	1.40	69.3	66.3	74.8	49.5	74.1
Products 1 to 3		14.8	2.89	2.94	60.0	0.89	0.99	73.6	73.9	81.8	58.4	80.3

Test: 43 Project: 4255 Date: June 4th/92 Operator: BW

Purpose: To repeat Test 42 without CMC 7MF.
Lac des Iles water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage								Time, minutes			pH
	Na2S	CMC 7MF	Na2CO3	CuSO4	A350	R-208	DF-250	Grind	Cond.	Froth	
Primary Grind			1000					15			9.0
Rougher Cond. 1				250					5		8.5
Rougher Cond. 2					100	40			3		
Rougher 1							40		1	2	8.5
Rougher 2					100	20			2	2	8.5
Scavenger Cond.	250								2		9.1
Scavenger Cond.				250					5		9.0
Scavenger					100	40			3	6	8.6

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 43

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Rougher Conc. 1	76.2	7.7	5.71	4.65	96.7	1.26	1.65	69.4	60.5	67.3	41.9	67.9
2 Rougher Conc. 2	41.5	4.2	0.79	1.24	24.5	0.54	0.33	5.2	8.8	9.3	9.8	7.4
3 Scav. 1 Conc.	60.4	6.1	0.47	0.69	11.4	0.35	0.19	4.5	7.1	6.3	9.2	6.2
4 Scav. Tail	814.4	82.1	0.16	0.17	2.31	0.11	0.042	20.8	23.6	17.2	39.1	18.5
Head (calc)	992.5	100.0	0.63	0.59	11.0	0.23	0.19	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					

Combined Products

Products 1 & 2		11.9	3.98	3.45	71.2	1.01	1.18	74.7	69.3	76.5	51.7	75.3
Products 1 to 3		17.9	2.79	2.51	50.9	0.78	0.85	79.2	76.4	82.8	60.9	81.5

Test: 44 Project: 4255 Date: June 8th/92 Operator: BW

Purpose: To repeat Test 38 without 1000 g/t of Na2SiO3 and with a Jeffery Magnetic separation done on the feed before the flotation stages.
Lakefield Research water was used throughout the test.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2CO3	Na2S	CMC 7MF		CuSO4	A350	R 208	DF-250	Grind	Cond.	Froth	
Primary Grind									15			
Magnetic Separation	(Jeffery Magnetic separation at 2.0 amps.)											
Rougher Cond. 1	1000	250								3		9.9
Rougher Cond. 2			400							3		
Rougher Cond. 3					250					5		9.8
Rougher Cond. 4						100	40			3		
Rougher 1								20		1	2	
Rougher 2						100	20			2	2	9.5
Scavenger Cond.		100								3		
Scavenger						100	20	10		2	6	9.4

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 44

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 Jeffery Magnetics	9.5	1.0	3.72	1.27	20.2	0.48	0.50	6.9	2.1	1.9	2.1	2.8
2 Rougher Conc. 1	42.4	4.4	6.29	7.07	129	1.89	2.60	51.7	51.0	55.4	37.0	64.0
3 Rougher Conc. 2	23.0	2.4	1.20	1.97	38.0	0.67	0.46	5.4	7.7	8.8	7.1	6.1
4 Scav. Conc.	46.0	4.8	0.58	1.00	17.4	0.34	0.21	5.2	7.8	8.1	7.2	5.6
5 Scav. Tail	839.4	87.4	0.19	0.22	3.03	0.12	0.044	30.9	31.4	25.7	46.5	21.5
Head (calc)	960.3	100.0	0.54	0.61	10.3	0.23	0.18	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
Products 2 & 3		6.8	4.50	5.28	97.0	1.46	1.85	57.1	58.7	64.2	44.1	70.2
Products 2 to 4		11.6	2.88	3.51	64.1	1.00	1.17	62.2	66.5	72.3	51.4	75.8
Products 1 to 4		12.6	2.95	3.33	60.7	0.96	1.12	69.1	68.6	74.3	53.5	78.5

Test: 45,46 Project: 4255 Date: June 18/92 Operator: George Reschke

Purpose: To repeat test 37 with two cleaning stages.

Procedure: The rougher and scavenger stages were conducted on tests 45 and 46. The rougher and scavenger concentrates from tests 45 and 46 were combined for cleaning.

Feed: 2 X 1000 grams minus 10 mesh Comp M92

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH 45/46
	Na2S	Na2CO3	Na2SiO3	CMC 7MF	CuSO4	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250	1000	2000	-	-	-	-	-	15			
Ro Condition 1	-	-	-	400	-	-	-	-		3		9.9/9.9
2	-	-	-	-	250	-	-	-		5		9.69/9.76
3	-	-	-	-	-	* 40	100	-		3		
Rougher 1	-	-	-	-	-	-	-	40		1	2	
2	-	-	-	-	-	20	100	-		2	2	9.60/9.73
Scav Cond 1	100	-	-	-	-	-	-	-		2		9.76/9.80
2	-	-	-	-	250	-	-	-		5		9.63/9.67
3	-	-	-	-	-	40	100	-		3		
Scavenger 1	-	-	-	-	-	-	-	-			6	
	Combine rougher concentrates and scavenger concentrates from tests 45 and 46.											
Cleaner 1	-	-	-	-	-	10	25	-		2	5	9.18
Cleaner 2	-	250	-	50	-	-	-	-		2		
	-	-	-	-	-	10	-	12.5		2	3	10.38
	-	-	-	50	-	-	-	-		2	3	

Stage	Cond.	Ro 1	Ro 2	Scav.	Cl 1	Cl 2
Flotation Cell		D-1000			D-1000	
Speed R.P.M.	1500	2100	2100	2100	2100	2100
Pulp Density	Approx. 20 % soilids					

* Reagent addition unknown in test 45. > 40 g/t added.

** All reagents in the rougher and scavenger stages are calculated in g/t based on 1000 grams of feed. All reagents in the two cleaning stages are calculated in g/t based on 2000 grams of feed.

Test: 45,46
M92

Product	Weight		Assays, %, g/t					% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1A	19.7	1.0	15.0	11.9	206	2.11	4.56	16.1	22.9	19.9	20.4	9.4	26.0	18.0
2 CuNi Ro Conc 1B	14.6	0.7	24.6	14.8	229	2.00	5.42	17.7	27.9	18.4	16.8	6.6	22.9	14.7
3 CuNi 2nd Cl Conc	45.6	2.3	4.19	5.35	117	2.33	1.32	9.27	14.8	20.7	26.8	24.0	17.4	24.1
4 CuNi 2nd Cl Tail	18.7	0.9	1.05	2.11	41.2	0.35	0.19	3.96	1.5	3.4	3.9	1.5	1.0	4.2
5 CuNi 1st Cl Tail	63.4	3.2	0.50	0.80	14.0	0.79	0.41	1.76	2.5	4.3	4.5	11.3	7.5	6.3
6 CuNi Scav Tail A	904.8	45.6	0.21	0.22	3.00	0.12	0.047	0.35	14.7	16.9	13.6	24.5	12.3	18.0
7 Cu Ni Scav Tail B	916.5	46.2	0.22	0.21	3.04	0.11	0.048	0.28	15.6	16.4	14.0	22.8	12.7	14.6
Head (calc)	1983.3	100.0	0.65	0.59	10.0	0.22	0.17	0.89	100.0	100.0	100.0	100.0	100.0	100.0
Combined Products														
CuNi Ro Conc (1 + 2)		1.7	19.1	13.1	216	2.06	4.93	16.8	50.8	38.3	37.2	16.0	48.9	32.8
CuNi Comb Conc (1 to 3)		4.0	10.6	8.69	159	2.22	2.87	12.5	65.6	59.0	64.0	40.0	66.4	56.8
CuNi Comb Conc (1 to 4)		5.0	8.78	7.44	137	1.86	2.36	10.9	67.1	62.4	67.9	41.4	67.4	61.0
CuNi Comb Conc (1 to 5)		8.2	5.54	4.84	88.9	1.44	1.60	7.31	69.6	66.7	72.4	52.7	74.9	67.4
Scav Tail A+B (6+7)		91.8	0.22	0.21	3.02	0.11	0.05	0.31	30.4	33.3	27.6	47.3	25.1	32.6

Test: 47,48 Project: 4255 Date: June 19/92 Operator: George Reschke

Purpose: To repeat test 45,46 on the Roby Zone Composite.

Procedure: The rougher and scavenger stages were conducted on tests 47 and 48. The rougher and scavenger concentrates from tests 47 and 48 were combined for cleaning.

Feed: 2 X 1000 grams minus 10 mesh Comp M92

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH 47/48
	Na2S	Na2CO3	Na2SiO3	CMC 7MF	CuSO4	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250	1000	2000	-	-	-	-	-	15			
Ro Condition 1	-	-	-	400	-	-	-	-		3		10.1/10.13
2	-	-	-	-	250	-	-	-		5		9.69/9.76
3	-	-	-	-	-	40	100	-		3		
Rougher 1	-	-	-	-	-	-	-	40		1	2	
2	-	-	-	-	-	20	100	-		2	2	
Scav Cond 1	100	-	-	-	-	-	-	-		2		9.90/9.97
2	-	-	-	-	250	-	-	-		5		
3	-	-	-	-	-	40	100	-		3		
Scavenger 1	-	-	-	-	-	-	-	-			6	
	Combine rougher concentrates and scavenger concentrates from tests 45 and 46.											
Cleaner 1	-	-	-	100	-	-	-	-		2	4	8.40
Cleaner 2	-	125	-	100	-	-	-	-		2	3	9.65
Cleaner 3	-	125	-	-	-	-	-	-		2	3	9.67

Stage	Cond.	Ro 1	Ro 2	Scav.	Cl 1	Cl 2
Flotation Cell		D-1000			D-1000	
Speed R.P.M.	1500	2100	2100	2100	2100	2100
Pulp Density	Approx. 20 % soilids					

** All reagents in the rougher and scavenger stages are calculated in g/t based on 1000 grams of feed. All reagents in the two cleaning stages are calculated in g/t based on 2000 grams of feed.

Test: 47,48
Roby Zone

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1A	9.9	0.5	11.4	10.3	89.0	4.04	6.04	18.1	18.8	16.6	19.3	17.0	21.9	20.8
2 CuNi Ro Conc 1B	11.5	0.6	10.9	9.70	76.9	3.61	5.39	15.7	20.9	18.1	19.4	17.7	22.7	21.0
3 CuNi 3rd Cl Conc	28.8	1.5	3.46	3.47	30.1	1.45	1.48	6.81	16.6	16.2	19.0	17.8	15.6	22.8
4 CuNi 3rd Cl Tail	15.2	0.8	1.61	2.01	14.4	0.58	0.81	2.80	4.1	5.0	4.8	3.8	4.5	4.9
5 CuNi 2nd Cl Tail	16.2	0.8	1.03	1.33	10.5	0.50	0.53	2.36	2.8	3.5	3.7	3.5	3.1	4.4
6 CuNi 1st Cl Tail	44.8	2.3	0.37	0.41	3.49	0.18	0.20	0.84	2.8	3.0	3.4	3.4	3.3	4.4
7 CuNi Scav Tail A	933.3	47.0	0.12	0.11	0.80	0.048	0.045	0.08	18.7	16.7	16.4	19.1	15.4	8.7
8 Cu Ni Scav Tail B	924.2	46.6	0.10	0.14	0.69	0.045	0.040	0.12	15.4	21.0	14.0	17.7	13.5	12.9
Head (calc)	1983.9	100.0	0.30	0.31	2.30	0.12	0.14	0.43	100.0	100.0	100.0	100.0	100.0	100.0
Combined Products														
CuNi Ro Conc (1 + 2)		1.1	11.1	10.0	82.5	3.81	5.69	16.8	35.4	34.7	38.7	34.7	44.6	41.8
CuNi Comb Conc (1 to 3)		2.5	6.73	6.24	52.4	2.46	3.28	11.1	39.5	50.9	57.7	52.5	60.2	64.6
CuNi Comb Conc (1 to 4)		3.3	5.54	5.26	43.6	2.02	2.70	9.15	42.3	55.8	62.5	56.3	64.7	69.6
CuNi Comb Conc (1 to 5)		4.1	4.64	4.48	37.0	1.72	2.27	7.80	45.0	59.3	66.2	59.7	67.8	74.0
CuNi Comb Conc (1 to 6)		6.4	3.13	3.04	25.1	1.17	1.54	5.33	63.7	62.3	69.7	63.2	71.1	78.4
Scav Tail A+B (7+8)		93.6	0.11	0.12	0.75	0.047	0.043	0.10	34.1	37.7	30.3	36.8	28.9	21.6

Test: 49 Project: 4255 Date: June 19/92 Operator: LP

Purpose: To repeat test 37 on 92 M1 28843 Composite.

Procedure: As outlined below.

Feed: 1000 grams minus 10 mesh Comp 92 M1 28843

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na_2S	Na_2CO_3	Na_2SiO_3	CMC 7MF	$CuSO_4$	R208	PAX	DF 250C	Grind	Cond.	Froth	
Primary Grind	250	1000	2000	-	-	-	-	-	15			
Ro Condition 1	-	-	-	400	-	-	-	-		3		9.96
2	-	-	-	-	250	-	-	-		5		9.78
3	-	-	-	-	-	40	100	-		3		
Rougher 1	-	-	-	-	-	-	-	40		1	2	
2	-	-	-	400	-	40	100	-		2	2	
Scav Cond 1	100	-	-	400	-	-	-	-		2		
2	-	-	-	-	-	40	100	-		2	6	

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell		D-1000		
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Observations: Extremely talcy.

Product: Combined Product Test No: 49

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
208	65	0.3	0.3	0.3	99.7
147	100	1.9	1.9	2.2	97.8
104	150	5.3	5.3	7.5	92.5
74	200	8.7	8.7	16.2	83.8
53	270	11.6	11.6	27.8	72.2
38	400	13.4	13.4	41.2	58.8
-38	-400	58.8	58.8	100.0	-
	Total	100.0	100.0	-	-

Test: 49

Sample 92M128843 ground to 84% minus 200 mesh

<u>Metallurgical Balance</u>

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi Ro Conc 1	40.7	4.1	3.26	13.1	295	0.24	0.44	1.63	51.2	54.2	54.2	10.4	55.3	43.5
2 CuNi Ro Conc 2	72.3	7.4	0.43	2.34	51.2	0.15	0.057	0.42	12.0	17.2	16.7	11.6	12.7	19.9
3 CuNi Sc Conc	137.2	14.0	0.16	0.55	12.6	0.10	0.022	0.14	8.5	7.7	7.8	14.6	9.3	12.6
4 Cu Ni Scav Tail	732.5	74.5	0.10	0.28	6.42	0.081	0.010	0.050	28.3	20.9	21.2	63.3	22.6	24.0
Head (calc)	982.7	100.0	0.26	1.00	22.5	0.095	0.033	0.16	100.0	100.0	100.0	100.0	100.0	100.0
Combined Products														
CuNi Ro Conc (1 + 2)		11.5	1.45	6.22	139	0.18	0.19	0.86	63.2	71.5	71.0	22.0	68.0	63.4
Ro + Sc Conc (1 to 3)		25.5	0.74	3.11	69.7	0.14	0.100	0.46	71.7	79.1	78.8	36.7	77.4	76.0

Test: 50 Project: 4255 Date: June 19/92 Operator: LP

Purpose: To repeat test 37 with (NH4)2SO4 instead of Na2S.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2CO3	(NH4)2SO4	CMC 7MF	Na2SiO3	CuSO4	A350	R 208	DF-250	Grind	Cond.	Froth	
Primary Grind	1000	250	400	2000	-	-	-		15			9.2
							-					
Rougher Cond. 1	-	-	-	-	250	-	40			5		9.0
Rougher Cond. 2	-	-	-	-	-	100	-			3		
Rougher 1	-	-	-	-	-	-	-	20		1	2	9.0
Rougher 2	-	-	-	-	-	100	20			2	2	8.9
Scavenger Cond.	-	100	-	-	-	-	-			2		
			-	-	-	-	-					
Scavenger	-	-	-	-	-	100	20			2	6	8.8

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Test: 50
Sample M92

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
CuNi Ro Conc 1	40.5	4.1	9.48	8.60	162	2.08	3.02	12.6	63.7	55.5	60.1	38.0	68.9	53.7
CuNi Ro Conc 2	25.0	2.5	1.38	2.17	46.6	0.93	0.50	4.81	5.7	8.6	10.7	10.5	7.0	12.7
CuNi Sc Conc	40.5	4.1	0.62	0.97	17.6	0.41	0.22	3.52	4.2	6.3	6.5	7.5	5.0	15.0
Cu Ni Scav Tail	886.2	89.3	0.18	0.21	2.79	0.11	0.038	0.20	26.5	29.6	22.7	44.0	19.0	18.6
Head (calc)	992.2	100.0	0.61	0.63	11.0	0.22	0.18	0.96	100.0	100.0	100.0	100.0	100.0	100.0
Combined Products														
CuNi Ro Conc (1 + 2)		6.6	6.39	6.15	118	1.64	2.06	9.63	69.4	64.1	70.8	48.5	76.0	66.3
Ro + Sc Conc (1 to 3)		10.7	4.18	4.17	79.6	1.17	1.36	7.29	73.5	70.4	77.3	56.0	81.0	81.4

Test: 51 Project: 4255 Date: June 19/92 Operator: LP

Purpose: To repeat test 29 at a lower density in the rougher and scavenger stages.

Procedure: As shown below using a 2000 g D-1 cell instead of a 1000 g D-1.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			8.5
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	8.4
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	
PM Regrind			*100		*5	*20		15			
1st Cleaner							5		1	7	8.2
						10			1	5	
						5			1	3	
2nd Cleaner			50						1	3.5	7.4
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner			10				5		1	3	7.2
					2.5	5	2.5		1	2	
						5			1	3	
4th Cleaner							2.5		1	3	
						5			1	2	7.3

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage.

Circuit	Cell	RPM
Ro/Scav	D-1 , 2000g	1750
1st & 2nd Cl's	D-1 , 500g	1300
3rd &4th Cl's	D-1 , 250g	1100

Test: 51

Sample M92 Repeat Test 29 with lower Ro Density

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 CuNi 4th Cl Conc	33.5	1.7	25.8	20.2	356	4.88	6.63	31.0	58.2	52.6	55.6	36.4	68.5	59.7
2 CuNi 4th Cl Tail	4.2	0.2	4.25	5.43	110	1.74	1.24	8.90	1.2	1.8	2.2	1.6	1.6	2.1
3 CuNi 3rd Cl Tail	5.8	0.3	3.11	2.71	49.0	0.76	0.56	3.53	1.2	1.2	1.3	1.0	1.0	1.2
4 CuNi 2nd Cl Tail	39.8	2.0	1.49	2.43	45.4	0.75	0.51	4.24	4.0	7.5	8.4	6.7	6.3	9.7
5 CuNi 1st Cl Tail	183.4	9.3	1.19	0.63	12.0	0.30	0.12	1.84	14.7	9.0	10.3	12.3	6.8	19.4
6 Cu Ni Scav Tail	1714.2	86.5	0.18	0.21	2.79	0.11	0.03	0.08	20.8	28.0	22.3	42.0	15.9	7.9
Head (calc)	1980.9	100.0	0.75	0.65	10.8	0.23	0.16	0.88	100.0	100.0	100.0	100.0	100.0	100.0
Combined Products														
CuNi 3rd Cl Conc (1 + 2)		1.9	23.4	18.6	329	4.53	6.03	28.5	59.4	54.3	57.7	38.1	70.1	61.8
CuNi 2nd Cl Conc (1 to 3)		2.2	20.7	16.4	291	4.03	5.30	25.2	60.6	55.6	59.0	39.1	71.1	63.0
CuNi 1st Cl Conc (1 to 4)		4.2	11.5	9.75	174	2.46	3.01	15.2	64.6	63.1	67.5	45.7	77.4	72.7
Ro Conc (1 to 5)		13.5	4.42	3.48	62.5	0.98	1.02	6.01	79.2	72.0	77.7	58.0	84.1	92.1

	%MgO
CuNi 4th Cl Conc:	3.76
CuNi 2nd Cl Conc:	6.58

Test: 52 Project: 4255 Date: July 6/92 Operator: LP

Purpose: Repeat test 31 to produce tailings for settling tests.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			8.2
Scavenger 1	50			50		25	7.5		1	7	8.3
2						25			1	5	
						25	2.5		1	5	
						25			1	5	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 53 Project: 4255 Date: July 6/92 Operator: LP

Purpose: Repeat test 37 to produce tailing for settling tests.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh Comp. M92.

Grind: 15 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t								Time, minutes			pH
	Na2CO3	Na2S	CMC 7MF	Na2SiO3	CuSO4	A350	R 208	DF-250	Grind	Cond.	Froth	
Primary Grind	1000	250		2000					15			9.3
Rougher Cond. 1			400							3		9.2
Rougher Cond. 2					250					5		
Rougher Cond. 3						100	40			3		
Rougher 1								20		1	2	9.0
Rougher 2						100	20			2	2	9.0
Scavenger Cond.		100								2		
Scavenger						100	20			2	6	9.0

Stage	Cond.	Ro 1	Ro 2	Scav.
Flotation Cell	D-1000			
Speed R.P.M.	1500	2100	2100	2100
Pulp Density	Approx. 20 % soilids			

Settling Test Report

Test No. S-1   Project No.: 4255   Date: July 7/92/92   Operator: LP

Purpose: To investigate the settling characteristics of test 52 tailing.

Feed: Test 52 tailing

Flocculant: -   pH: 8.0

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2000		280	530
	2	1950		350	510
	5	1895		410	490
	10	1770		Final	480
	15	1680			
	20	1580			
	25	1490			
	30	1390			
	35	1300			
	40	1230			
	45	-			
	50	1080			
	55	1020			
	60	970			
	80	840			
	95	730			
	120	620			
	180	565			

Observations: After 2 minutes, sands had settled to 250 mL.
The supernatant was very cloudy until 970 mL.

Initial Pulp Weight	2.3216 kg
Initial Pulp Volume	2.000 L
Initial Pulp Height	42.0 cm
Weight of Dry Solids	0.5207 kg
Dry Solids S.G.	2.94 g/cc or kg/L
Liquid S.G.	1.00 g/cc or kg/L
Final Mudline	0.480 L
Tangent Intersect Y (vol.)	0.95 L
Corresponding X value (Time)	64 min
Slope of Tangent Y (mudline)	0.280 L
Slope of Tangent X (time)	280 min

Test No. S-1 Project No.: 4255 Date: July 7/92/92 Operator: LP

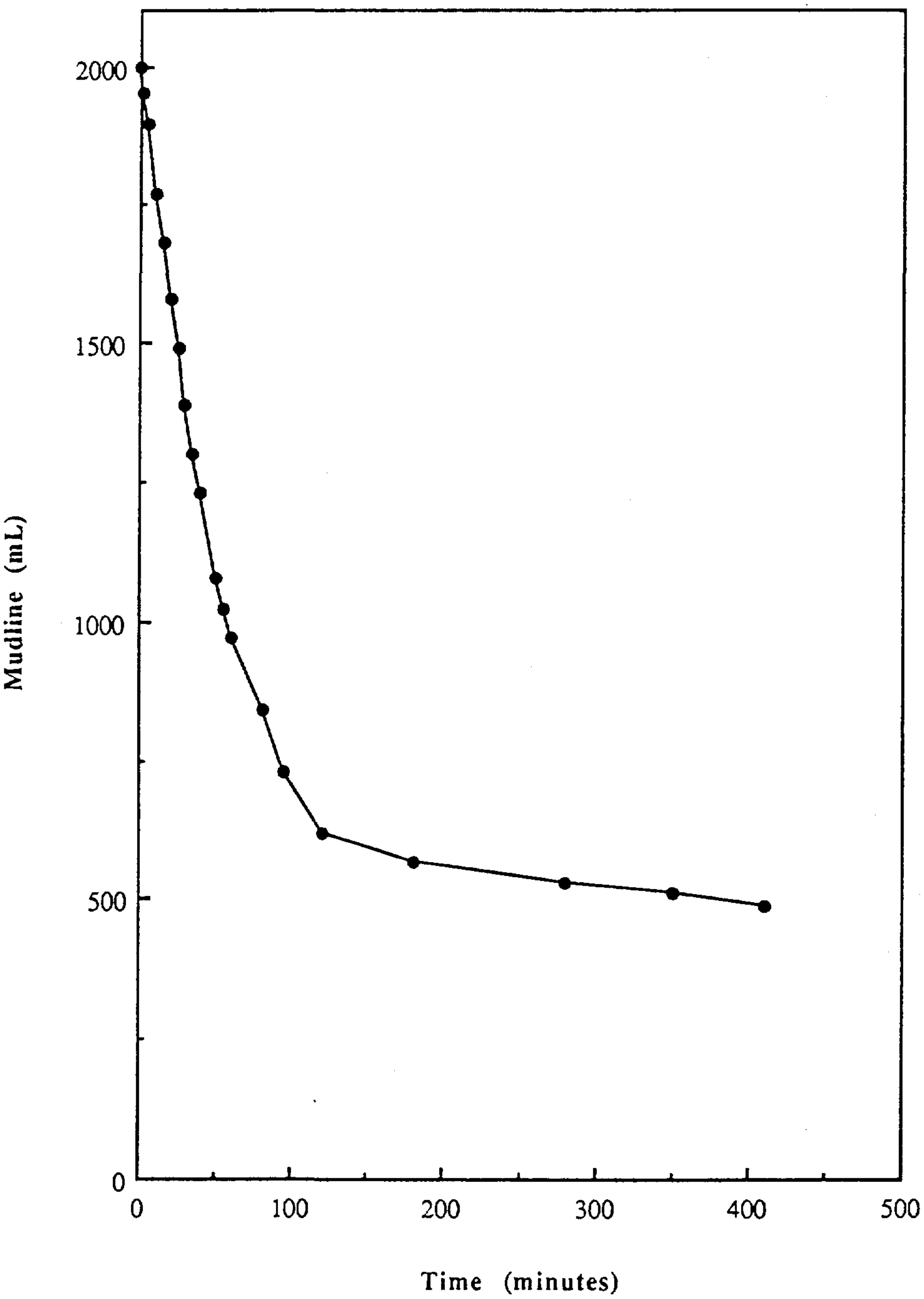
FEED CONCENTRATION ZONE

Initial Pulp Density: 1161 g/L
Initial Percent Solids: 21.0 %
Rate: 0.207 m/h
Thickener Area Required: 0.646 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1362 g/L
Initial Percent Solids: 40.3 %
Final Pulp Density: 1716 g/L
Final Percent Solids: 63.2 %
Rate: 0.030 m/h
Thickener Area Required: 1.257 sq. meters/tonne/day
(no safety factor applied)

S-1


Mudline (mL)
2000
1500
1000
500
0
0
100
200
300
400
500
Time (minutes)

Settling Test Report

Test No. S-2 Project No.: 4255 Date: July 7/92/92 Operator: LP

Purpose: To investigate the effect of 15 g/t Percol 156 on the settling characteristics of test 52 tailing.

Feed: Test 52 tailing

Flocculant: 15 g/t Percol 156 pH: 8.0

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2040		18	820
	1	1880		20	790
	1.5	1800		25	740
	2	1710		30	700
	2.5	1610		35	-
	3	1540		40	650
	3.5	1480		45	630
	4	1430		50	620
	4.5	1390		70	600
	5	1350		85	580
	6	1290		110	575
	7	1210		170	565
	8	1160		270	560
	9	1100		340	560
	10	1050		400	560
	12	-		Final	550
	14	900			
	16	850			

Observations: The supernatant was cloudy throughout the test.

Initial Pulp Weight	2.4152 kg
Initial Pulp Volume	2.040 L
Initial Pulp Height	41.0 cm
Weight of Dry Solids	0.5992 kg
Dry Solids S.G.	2.94 g/cc or kg/L
Liquid S.G.	1.00 g/cc or kg/L
Final Mudline	0.550 L
Tangent Intersect Y (vol.)	0.825 L
Corresponding X value (Time)	16 min
Slope of Tangent Y (mudline)	0.180 L
Slope of Tangent X (time)	160 min

Test No. S-2 Project No.: 4255 Date: July 7/92/92 Operator: LP

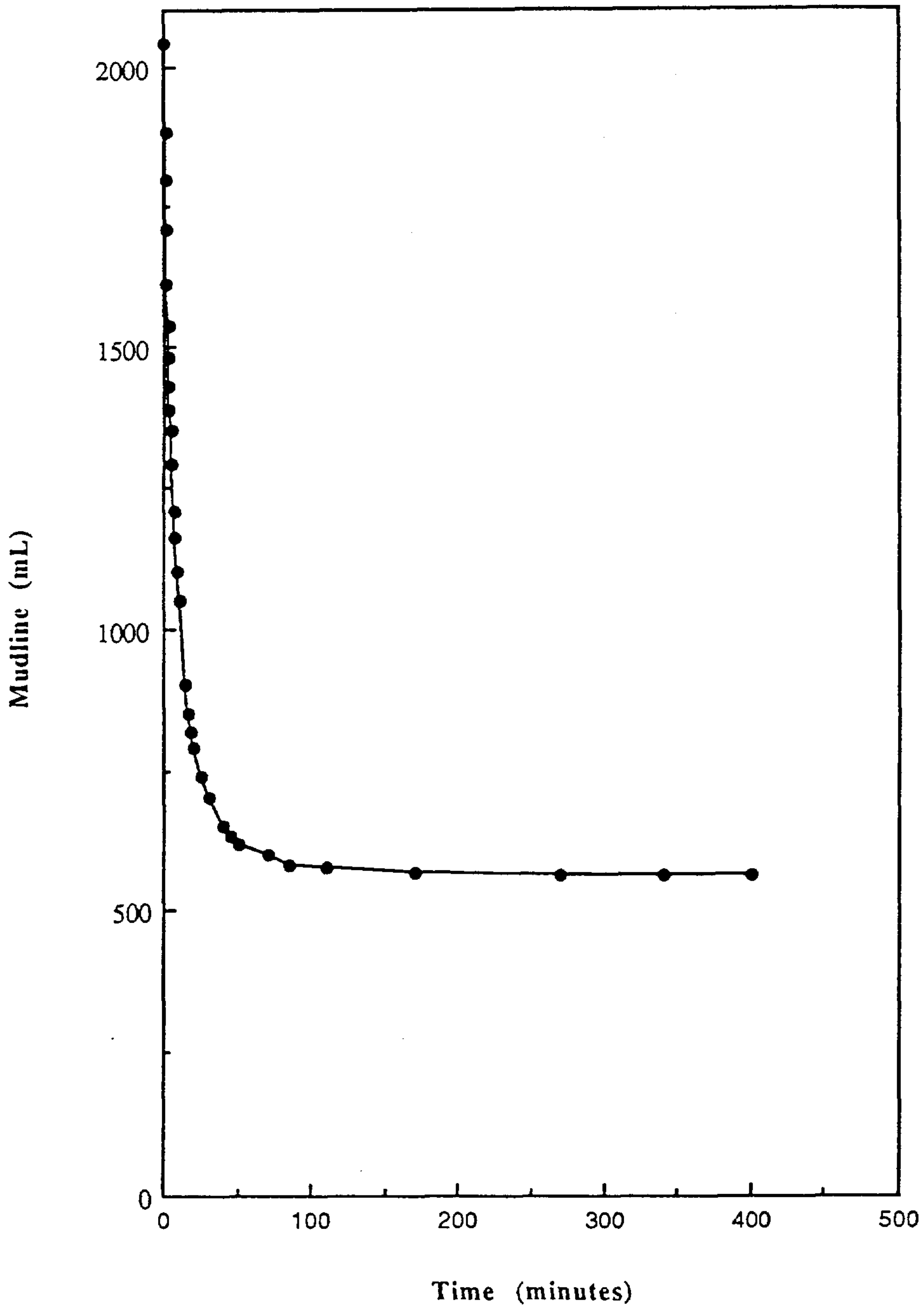
FEED CONCENTRATION ZONE

Initial Pulp Density: 1184 g/L
Initial Percent Solids: 23.5 %
Rate: 0.916 m/h
Thickener Area Required: 0.122 sq. meters/tonne/day
(no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density: 1479 g/L
Initial Percent Solids: 49.1 %
Final Pulp Density: 1719 g/L
Final Percent Solids: 63.4 %
Rate: 0.049 m/h
Thickener Area Required: 0.397 sq. meters/tonne/day
(no safety factor applied)

Test S-2



Mudline (mL)
2000
1500
1000
500
0
0
100
200
300
400
500
Time (minutes)

Settling Test Report

Test No. S-3 Project No.: 4255 Date: July 7/92/92 Operator: LP

Purpose: To investigate the settling characteristics of test 53 tailing.

Feed: Test 53 tailing

Flocculant: - pH: 8.8

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2000 (initial mudline)		30	* 380
	1	* 170		60	* 390
	1.5	* 190		120	* 405
	2	* 210		220	* 405
	2.5	* 230		290	* 415
	3	* 250		350	* 415
	3.5	* 260		Final	* 425
	4	* 275			
	4.5	* 280			
	5	* 290			
	7	* 310			
	8.5	* 320			
	10	* 330			
	12	* 340			
	14	* 345			
	16	* 350			
	18	* 360			
	20	* 360			

Observations: There was no visible mudline.
* The mudlines recorded are the volume of the sands which have settled at the bottom of the cylinder. This made graphing of the results impossible.

Initial Pulp Weight	2.3063	kg
Initial Pulp Volume	2.000	L
Initial Pulp Height	39.5	cm
Weight of Dry Solids	0.5143	kg
Dry Solids S.G.	2.84	g/cc or kg/L
Liquid S.G.	1.00	g/cc or kg/L
Final Mudline	0.425	L
Tangent Intersect Y (vol.)	-	L
Corresponding X value (Time)	-	min
Slope of Tangent Y (mudline)	-	L
Slope of Tangent X (time)	-	min

Settling Test Report

Test No. S-4 Project No.: 4255 Date: July 7/92/92 Operator: LP

Purpose: To investigate the effect of 15 g/t Percol 156 on the settling characteristics of the test 53 tailing.

Feed: Test 53 tailing

Flocculant: 15 g/t Percol 156 pH: 8.8 CuSO4: -

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2030 (initial mudline)		110	*445
	0.5	*100		210	*450
	1	*150		280	*460
	1.5	*190		340	*460
	2	*220		Final	*465
	2.5	*240			
	3	*260			
	3.5	*280			
	4	*300			
	4.5	*320			
	5	*330			
	6	*340			
	7	*360			
	8	*370			
	9	*380			
	10	*390			
	20	*420			
	50	*440			

Observations: There was no apparent mudline. *The mudlines recorded are the volume of the sands which have settled at the bottom of the cylinder.
This made graphing of the results impossible.

Initial Pulp Weight	2.3355	kg
Initial Pulp Volume	2.030	L
Initial Pulp Height	40.5	cm
Weight of Dry Solids	0.5184	kg
Dry Solids S.G.	2.84	g/cc or kg/L
Liquid S.G.	1.00	g/cc or kg/L
Final Mudline	0.465	L
Tangent Intersect Y (vol.)	-	L
Corresponding X value (Time)	-	min
Slope of Tangent Y (mudline)	-	L
Slope of Tangent X (time)	-	min

Settling Test Report

Test No. S-5 Project No.: 4255 Date: July 8/92 Operator: LP

Purpose: To investigate the effect of 1950 g/t CuSO4 on the settling characteristics of the test 53 tailing.

Feed: Test 53 tailing

Flocculant: - pH: 7.3 CuSO4: 1950 g/t

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2020		24	790
	0.5	1960		26	750
	1	1900		28	720
	2	1790		30	710
	3	1700		35	675
	4	1600		40	650
	5	1520		45	630
	6	1450		60	575
	7	1400		85	540
	8	1340		Final	510
	9	1290			
	10	1240			
	12	-			
	14	1080			
	16	1005			
	18	940			
	20	880			
	22	830			

Observations: The supernatant was very cloudy throughout the test.

Initial Pulp Weight	2.3063 kg
Initial Pulp Volume	2.020 L
Initial Pulp Height	40.0 cm
Weight of Dry Solids	0.5143 kg
Dry Solids S.G.	2.84 g/cc or kg/L
Liquid S.G.	1.00 g/cc or kg/L
Final Mudline	0.510 L
Tangent Intersect Y (vol.)	1.1 L
Corresponding X value (Time)	13 min
Slope of Tangent Y (mudline)	0.440 L
Slope of Tangent X (time)	50 min

Test No. S-5 Project No.: 4255 Date: July 8/92 Operator: LP

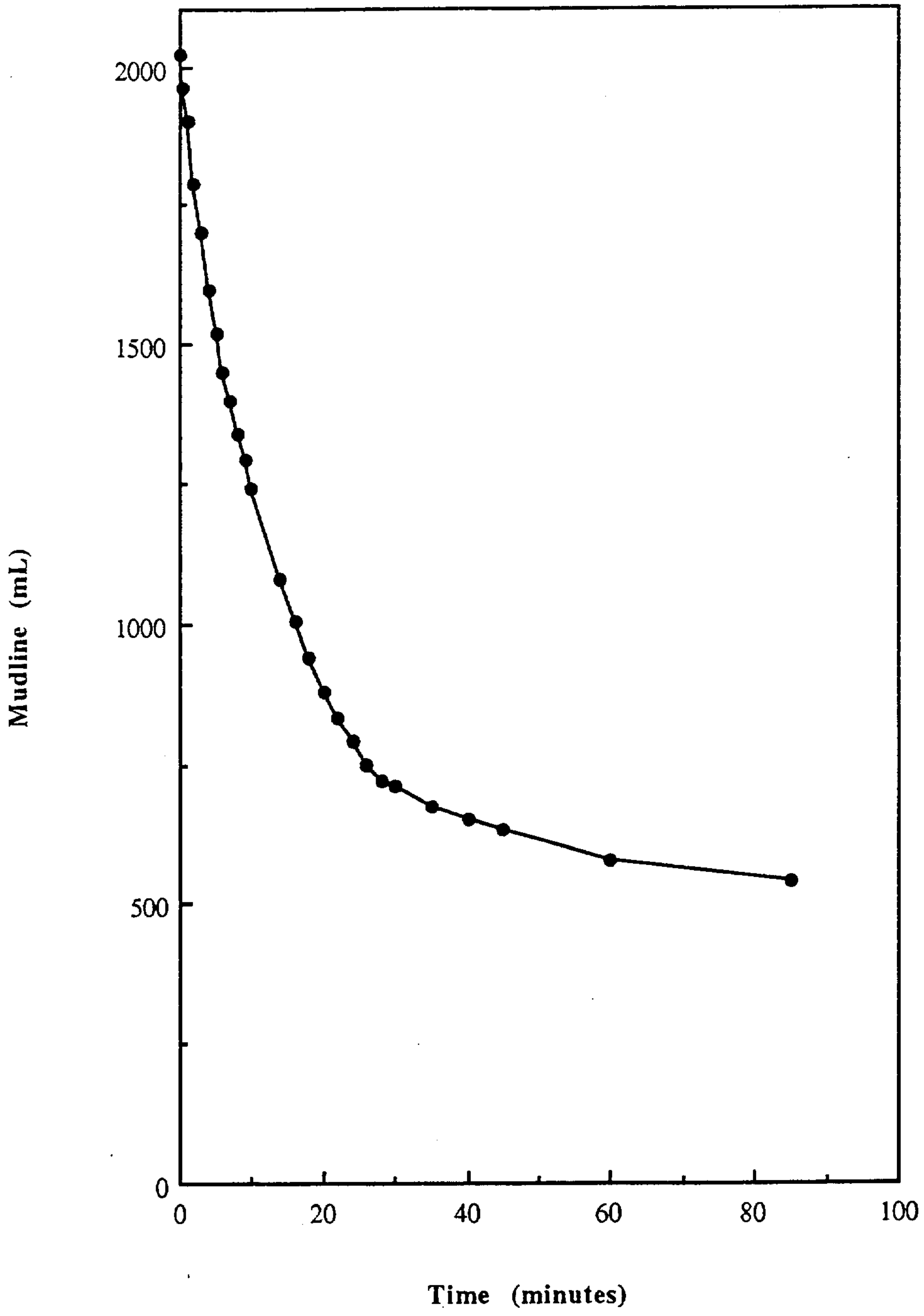
FEED CONCENTRATION ZONE

Initial Pulp Density:	1142 g/L
Initial Percent Solids:	19.2 %
Rate:	0.841 m/h
Thickener Area Required:	0.179 sq. meters/tonne/day (no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density:	1303 g/L
Initial Percent Solids:	35.9 %
Final Pulp Density:	1653 g/L
Final Percent Solids:	61.0 %
Rate:	0.157 m/h
Thickener Area Required:	0.307 sq. meters/tonne/day (no safety factor applied)

Test S-5



Settling Test Report

Test No. S-6 Project No.: 4255 Date: July 8/92 Operator: LP

Purpose: *To investigate the effect of 1950 g/t CuSO4 and 15 g/t* Percol 156 *on the settling characteristics of the test 53 tailing.*

Feed: Test 53 tailing

Flocculant: 15 g/t Percol 156 pH: 7.3 CuSO4: 1950 g/t

Time		Mudline	Time		Mudline
a.m./p.m.	elapsed,min.	mL	a.m./p.m.	elapsed,min.	mL
	0	2040		35	625
	1	1910		50	590
	2	1780		75	550
	3	1680		Final	540
	4	1580			
	5	1480			
	6	1390			
	7	1290			
	8	1220			
	9	1140			
	10	1080			
	12	960			
	14	880			
	16	820			
	18	780			
	20	750			
	25	685			
	30	640			

Observations: The supernatant was somewhat cloudy throughout the test.

Initial Pulp Weight	2.3355 kg
Initial Pulp Volume	2.040 L
Initial Pulp Height	40.5 cm
Weight of Dry Solids	0.5184 kg
Dry Solids S.G.	2.84 g/cc or kg/L
Liquid S.G.	1.00 g/cc or kg/L
Final Mudline	0.540 L
Tangent Intersect Y (vol.)	1.05 L
Corresponding X value (Time)	10.5 min
Slope of Tangent Y (mudline)	0.320 L
Slope of Tangent X (time)	50 min

Test No. S-6 Project No.: 4255 Date: July 8/92 Operator: LP

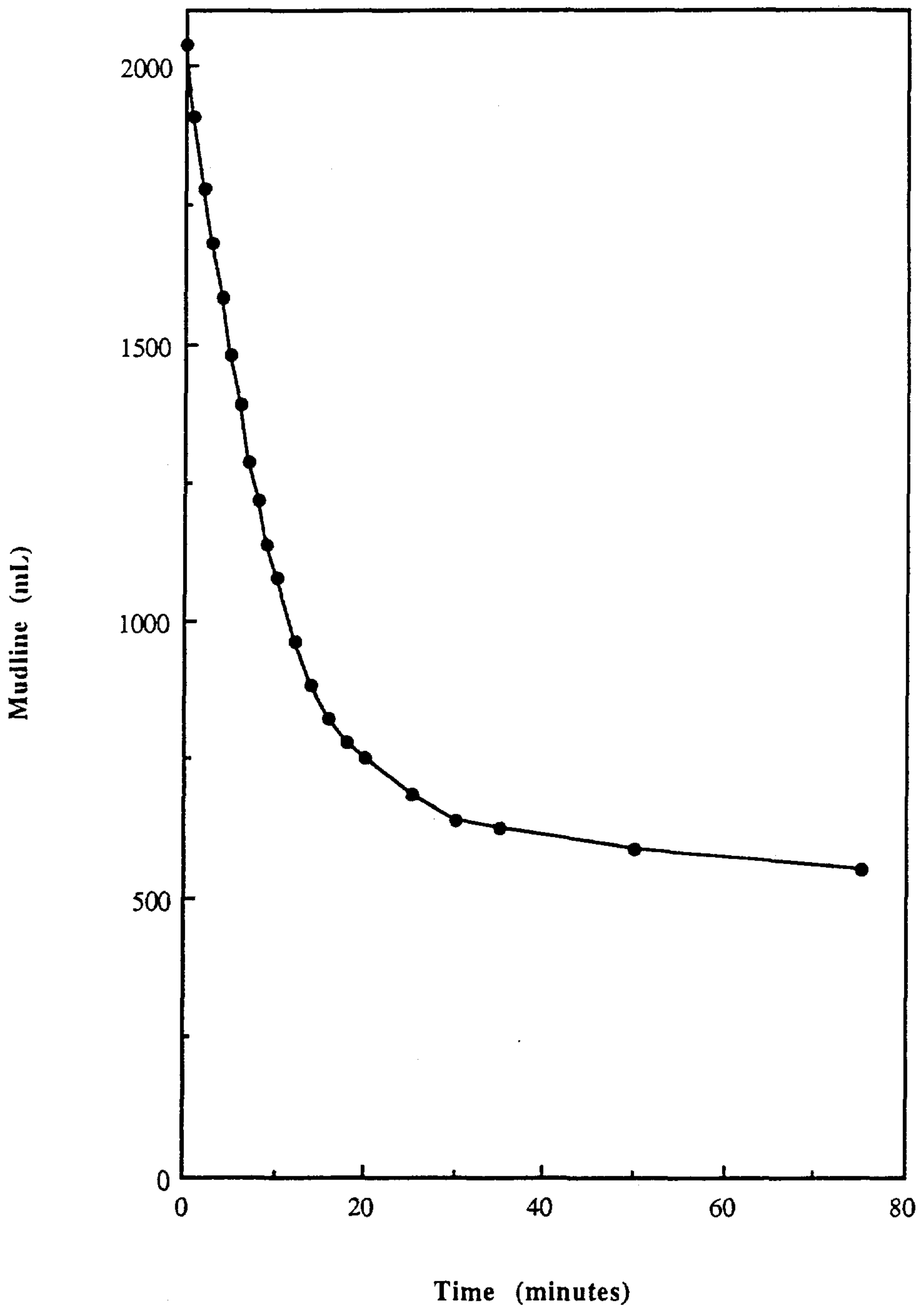
FEED CONCENTRATION ZONE

Initial Pulp Density:	1145 g/L
Initial Percent Solids:	19.5 %
Rate:	1.123 m/h
Thickener Area Required:	0.128 sq. meters/tonne/day (no safety factor applied)

ENTRANCE TO COMPRESSION ZONE

Initial Entr Zone Pulp Density:	1320 g/L
Initial Percent Solids:	37.4 %
Final Pulp Density:	1622 g/L
Final Percent Solids:	59.2 %
Rate:	0.174 m/h
Thickener Area Required:	0.238 sq. meters/tonne/day (no safety factor applied)

Test S-6



Test: 53a Project: 4255 Date: July 28/92 Operator: GC

Purpose: Conduct a batch test using cycle test conditions.

Procedure: As shown below.

Feed: 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			7.9
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	8.3
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	8.1
PM Regrind			*100		*5	*20		15			
1st Cleaner							5		1	7	8.2
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	8.8
2nd Cleaner			50						1	3.5	8.5
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner			10				5		1	3	8.6
					2.5	5	2.5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 53a

Metallurgical Balance

Product	Weight		Assays, %, g/t						% Distribution					
	g	%	Au	Pt	Pd	Ni	Cu	S	Au	Pt	Pd	Ni	Cu	S
1 3rd Cl Conc	38.6	2.0	16.1	15.5	336	4.05	6.00	27.0	60.8	55.8	63.1	36.7	72.7	32.2
2 3rd Cl Tail	5.2	0.3	2.00	3.31	66.3	1.28	0.74	7.33	1.0	1.6	1.7	1.6	1.2	1.2
3 2nd Cl Tail	31.6	1.6	1.12	2.17	42.0	0.85	0.46	4.77	3.5	6.4	6.5	6.3	4.6	4.7
4 1st Cl Sc Conc	10.8	0.5	1.02	2.48	50.0	1.10	0.38	8.93	1.1	2.5	2.6	2.8	1.3	3.0
5 1st Cl Sc Tail	114.5	5.8	0.37	0.53	8.94	0.26	0.10	1.04	4.1	5.7	5.0	7.0	3.6	3.7
6 Scav Tail	1772.3	89.8	0.17	0.17	2.45	0.11	0.030	1.01 *	29.5	28.1	21.1	45.7	16.7	55.3
Head (calc)	1973.0	100.0	0.52	0.54	10.4	0.22	0.16	1.64	100.0	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18							

?

Combined Products

2nd Cl Conc (1 & 2)	2.3	13.9	13.6	293	3.59	5.19	23.8	61.8	57.4	64.8	38.2	73.9	33.4
1st Cl Conc (1 to 3)	3.9	8.67	8.89	190	2.47	3.25	16.0	65.3	63.8	71.3	44.5	78.4	38.0
Ro Conc (1 to 5)	10.3	3.56	3.81	80.1	1.14	1.31	7.15	70.5	71.9	78.9	54.3	83.3	44.7

* S assay of Scav Tail has to be wrong! Calc S head 1.64% is double that of other tests (0.8-0.9%).

Test: 54 Project: 4255 Date: July 28/92 Operator: GC

Purpose: To conduct a 6 cycle locked test.

Procedure: As shown below using a 2000 g D-1 cell instead of a 1000 g D-1 cell.

Feed: 6 x 2000 grams minus 10 mesh Comp M92

Grind: 22 minutes per 2000 g charge at 65% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		22			8.5
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	8.4
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	8.1
PM Regrind			*100		*5	*20		15			
1st Cleaner							5		1	7	8.2
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	
2nd Cleaner			50						1	3.5	7.4
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner			10				5		1	3	7.2
					2.5	5	2.5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 2000g	1750
1st & 2nd Cl	D-1 , 500g	1300
3rd & 4th Cl	D-1 , 250g	1100

Test: 54

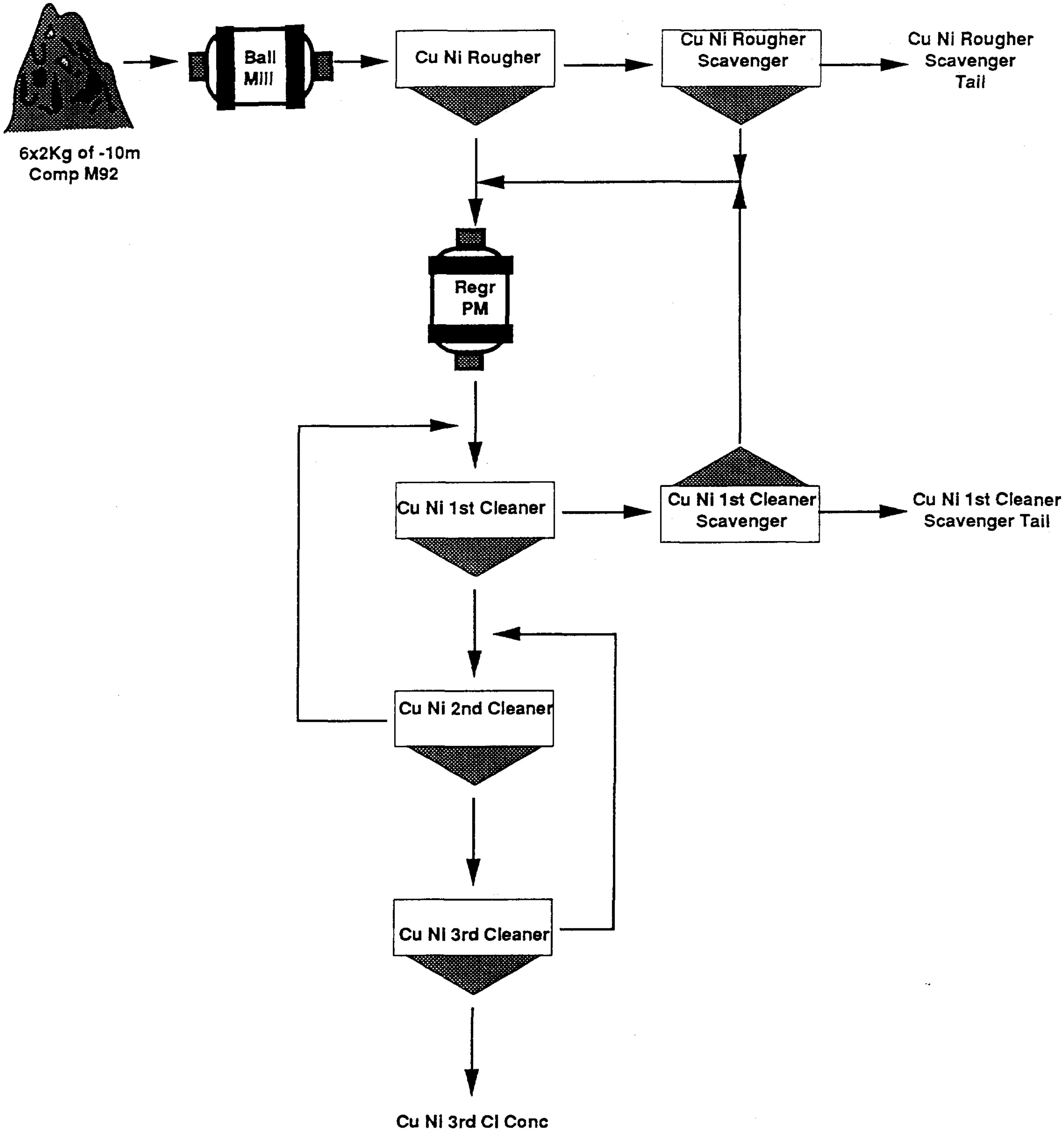
Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 3rd Cl Conc A	54.2	0.45	12.8	12.5	250	3.27	4.52	10.0	9.9	11.0	6.9	12.3
2 3rd Cl Conc B	51.2	0.43	13.1	12.8	257	3.25	4.57	9.6	9.6	10.6	6.5	11.8
3 3rd Cl Conc C	54.1	0.45	15.5	13.1	254	3.25	4.67	12.0	10.4	11.1	6.8	12.7
4 3rd Cl Conc D	60.4	0.50	13.4	12.4	244	3.14	4.26	11.6	11.0	11.9	7.4	12.9
5 3rd Cl Conc E	69.2	0.58	12.5	11.8	234	3.19	3.90	12.4	12.0	13.1	8.6	13.6
6 3rd Cl Conc F	71.6	0.60	10.6	10.8	211	2.81	3.54	10.9	11.3	12.2	7.8	12.7
7 3rd Cl Tail F	15.2	0.13	1.48	2.24	42.1	0.78	0.43	0.3	0.5	0.5	0.5	0.3
8 2nd Cl Tail F	73.9	0.61	0.92	1.59	31.7	0.64	0.30	1.0	1.7	1.9	1.8	1.1
9 1st Cl Sc Conc F	28.6	0.24	1.11	1.55	32.9	0.75	0.32	0.5	0.6	0.8	0.8	0.5
10 1st Cl Sc Tail A	139.4	1.16	0.35	0.48	8.10	0.23	0.099	0.7	1.0	0.9	1.2	0.7
11 1st Cl Sc Tail B	126.3	1.05	0.37	0.55	10.7	0.31	0.11	0.7	1.0	1.1	1.5	0.7
12 1st Cl Sc Tail C	165.9	1.38	0.35	0.50	9.64	0.26	0.10	0.8	1.2	1.3	1.7	0.8
13 1st Cl Sc Tail D	175.9	1.46	0.47	0.61	11.1	0.30	0.11	1.2	1.6	1.6	2.0	1.0
14 1st Cl Sc Tail E	175.8	1.46	0.38	0.51	9.27	0.26	0.094	1.0	1.3	1.3	1.8	0.8
15 1st Cl Sc Tail F	145.7	1.21	0.41	0.55	9.25	0.24	0.097	0.9	1.2	1.1	1.4	0.7
16 Ro Tail A	1752.6	14.57	0.20	0.17	2.25	0.11	0.032	5.0	4.4	3.2	7.5	2.8
17 Ro Tail B	1794.9	14.92	0.19	0.18	2.42	0.11	0.035	4.9	4.7	3.5	7.7	3.2
18 Ro Tail C	1755.8	14.60	0.17	0.16	2.23	0.10	0.032	4.3	4.1	3.2	6.8	2.8
19 Ro Tail D	1765.8	14.68	0.15	0.16	2.35	0.10	0.033	3.8	4.1	3.4	6.9	2.9
20 Ro Tail E	1794.9	14.92	0.17	0.17	2.24	0.11	0.032	4.4	4.5	3.3	7.7	2.9
21 Ro Tail F	1758.1	14.61	0.16	0.15	2.18	0.10	0.030	4.0	3.9	3.1	6.8	2.7
Head (calc)	12029.5	100.00	0.58	0.57	10.3	0.21	0.17	100.0	100.0	100.0	100.0	100.0
(direct)			0.42	0.59	9.87	0.24	0.18					
Combined Products												
3rd Cl Conc A-F		3.00	12.9	12.1	240	3.14	4.19	66.6	64.2	70.0	43.9	76.1
1st Cl Sc Tail A-F		7.72	0.39	0.53	9.70	0.27	0.10	5.2	7.3	7.3	9.6	4.7
Ro Tail A-F		88.30	0.17	0.17	2.28	0.11	0.032	26.4	25.7	19.6	43.3	17.3

Projected Results Cycles D, E and F (Based on 2 product formula and Cu assays)

Test: 54

Product	Weight	Assays, %, g/t					% Distribution				
	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
3rd Cl Conc	3.32	12.1	11.6	229	3.04	3.88	69.5	67.3	73.0	47.1	78.0
1st Cl Sc Tail	8.27	0.42	0.56	9.91	0.27	0.10	6.0	8.0	7.9	10.3	5.0
Ro Tail	88.41	0.16	0.16	2.26	0.10	0.032	24.5	24.7	19.1	42.6	16.9
Head(calc)	100.00	0.58	0.57	10.4	0.21	0.17	100.0	100.0	100.0	100.0	100.0
Comb Tail	96.68	0.18	0.19	2.91	0.12	0.038	30.5	32.7	27.0	52.9	22.0



4255-54 Cycle Test Flowsheet

Project No: 4255 MB

Product: Cu Ni 1st Cl. Sc. Tail D-F Test No: 54 S.G.- 3.00

Mesh	Weight Grams	% Weight		
		Ind.	Cum.	Passing
200	1.33	1.8	1.8	98.2
34.4µ	6.95	9.3	11.0	89.0
26.6	6.54	8.7	19.8	80.2
18.6	10.46	13.9	33.7	66.3
12.8	10.26	13.7	47.4	52.6
9.9	3.71	4.9	52.3	47.7
-9.9	35.75	47.7	100.0	-
Total	75.00	100.0	-	-

Product: Cu Ni 3rd Cl Conc. D-F Test No: 54 S.G.- 3.47

Mesh	Weight Grams	% Weight		
		Ind.	Cum.	Passing
270	3.02	4.0	4.0	96.0
30.8µ	6.96	9.3	13.3	86.7
23.9	6.15	8.2	21.5	78.5
16.6	10.23	13.6	35.1	64.9
11.4	10.15	13.5	48.7	51.3
8.8	4.15	5.5	54.2	45.8
-8.8	34.34	45.8	100.0	-
Total	75.00	100.0	-	-

Project No: 4255 MB

Product: Cu Ni Ro Tail D-F Test No: 54

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
208	65	3.6	3.6	3.6	96.4
147	100	6.2	6.2	9.8	90.2
104	150	12.5	12.5	22.3	77.7
74	200	11.7	11.7	34.0	66.0
53	270	11.7	11.7	45.7	54.3
38	400	9.8	9.8	55.5	44.5
-38	-400	44.5	44.5	100.0	-
	Total	100.0	100.0	-	-

Project No. 4255 Cyanidation Test Report Date: Aug 31,'92
Test No. 54C Operator: BW

Purpose: To conduct a 48 hour cyanidation test on combined cl scav tailing from Test 54.

Procedure : The sample was pulped with water in a 2.5 liter bottle. NaCN and lime were added and the cyanidation was carried out on the rolls in 1 x 48 hour stage.
The residue was washed three times with water.

Feed: 250 g of combined 1st cl scav tailings.

Solution Volume: 500 mL Pulp Density: 33 % Solids

Sol'n Composition: 2.0 g/L NaCN

pH Range: 10.5 with Ca(OH)2

Reagent Consumption (kg/t of cyanide feed) NaCN: 5.16 CaO: 0.97

Time	Added, Grams				Residual		Consumed		
	Actual		Equivalent		Grams		Grams		pH
Hours	NaCN	Ca(OH)2	NaCN	CaO	NaCN	CaO	NaCN	CaO	4.4
0 - 18	1.05	0.30	1.00	0.23	0.35	-	0.65	-	7.0 - 10.6
18 - 42	0.68	0.05	0.65	0.04	0.53	-	0.47	-	10.3 - 10.6
42 - 48	0.49	0	0.47	0	0.84	0.03	0.16	0.24	10.6 - 10.6
Total	2.22	0.35	2.12	0.27	0.84	0.03	1.28	0.24	

Results

Product	Amount (g, mL)	Assays, mg/L, g/t Au	Pt	Pd	% Distribution Au	Pt	Pd
1. 48 Hr P&W	960	0.12	0.02	1.68	88.6	13.2	65.3
2. 48 Hr cyn Residue	248.2	0.06	0.51	3.46	11.4	86.8	34.7
Head (calc.)	248.2	0.52	0.59	10.0	100.0	100.0	100.0
direct		0.42	0.56	9.91			

Test No. 1C Project No. 4255 Operator: B.W. Date: Oct. 5th/92

Purpose: To conduct a cyanidation test on Test 54 combined 1st Cl Scav. Tails A - F.

Procedure : The sample was pulped with water in a 1L bottle and agitated on *mechanical rolls. Lime, NaCN were added and maintained as per* conditions described below, for a 96h retention time. A solution sample was taken at 72 hours. The pulp was filtered and washed, with all products being submitted for analysis.

Feed: 125g of Test 54 Combined 1st Cl Scav. Tails A to F

Solution Volume: 250 mL Pulp Density: 33 % Solids

Solution Composition: 2.0g/L

pH Range: 10.5 with Ca(OH)2

Grind: No Grind

Reagent Consumption (kg/t of cyanide feed)	NaCN:	5.91
	Ca(OH)2	1.78

Time	Added, Grams				Residual		Consumed		pH
	Actual		Equivalent		Grams		Grams		
Hours	NaCN	Ca(OH)2	NaCN	CaO	NaCN	CaO	NaCN	CaO	
0 - 2	0.53	0.17	0.50	0.13	0.33	-	0.18	-	10.7- 10.0
2-24	0.19	0.09	0.18	0.07	0.30	-	0.20	-	10.6-10.2
24-48	0.21	0.04	0.20	0.03	0.36	-	0.14	-	10.5-10.5
48-72	0.15	0	0.14	0	0.36	-	0.14	-	10.5-10.5
72-96	0.15	0	0.14	0	0.43	0.01	0.07	0.22	10.5-10.5
Total	1.22	0.30	1.16	0.22	0.43	0.01	0.73	0.218	

Metallurgical Balance

	Product	Amount	Assays %,g/t,mg/L			% Distribution		
		g,ml	Au	Pt	Pd	Au	Pt	Pd
1	72 hr. Preg sol'n	25.0	0.135	0.02	2.40	51.1	6.1	51.2
2	96 hr. Preg &Wash sol'n	860.0	0.060	0.020	0.764	83.3	21.6	61.2
3	96 hr. Residue	122.7	0.09	0.53	3.7	16.7	78.4	38.8
	Head (calc.)	122.7	0.54	0.67	9.54	100.0	100.0	100.0

Test No. 2C Project No. 4255 Operator: B.W. Date: Oct. 5th/92

Purpose: To conduct a cyanidation test on the reground combined 1st Cl Scav. Tails A from Test 54

Procedure : The sample was pulped with water in a 1L bottle and agitated on mechanical rolls. Lime, NaCN were added and maintained as per conditions described below, for a 96h retention time. Solution samples were taken at 48 and 72 hours and submitted for analysis. The pulp was filtered and washed with all products being submitted for analysis.

Feed: 125g of Test 54 Combined 1st Cl Scav. Tails A to F

Solution Volume: 250 mL Pulp Density: 33 % Solids

Solution Composition: 2.0g/L

pH Range: 10.5 with Ca(OH)2

Grind: The sample was ground at 50 % solids, for 10 minutes, in a laboratory pebble mill.

Reagent Consumption (kg/t of cyanide feed)		
	NaCN:	7.96
	Ca(OH)2	1.25

Time	Added, Grams				Residual		Consumed		pH
	Actual		Equivalent		Grams		Grams		
Hours	NaCN	Ca(OH)2	NaCN	CaO	NaCN	CaO	NaCN	CaO	
0 - 2	0.53	0.20	0.50	0.15	0.29	-	0.21	-	10.9-10.4
2-24	0.22	0.05	0.21	0.04	0.23	-	0.27	-	10.6-10.5
24-48	0.28	0	0.27	0	0.33	-	0.17	-	10.5-10.5
48-72	0.18	0	0.17	0	0.33	-	0.17	-	10.5-10.5
72-96	0.18	0	0.17	0	0.35	0.03	0.15	-	10.5-10.5
Total	1.39	0.25	1.32	0.19	0.35	0.03	0.97	0.153	

Metallurgical Balance

	Product	Amount	Assays %,g/t,mg/L			% Distribution		
		g,ml	Au	Pt	Pd	Au	Pt	Pd
1	48 hr. Preg sol'n	25.0	0.180	0.02	2.66	59.3	6.3	60.2
2	72 hr. Preg sol'n	25.0	0.166	0.02	2.62	60.6	6.9	65.3
3	96 hr. Preg &Wash sol'n	795.0	0.063	0.02	0.744	77.4	21.3	65.5
4	96 hr. Residue	122.4	0.14	0.51	3.12	22.6	78.7	34.5
	Head (calc.)	122.4	0.62	0.65	9.03	100.0	100.0	100.0

Test: 55 Project: 4255 Date: July 28/92 Operator: GC

Purpose: Conduct a batch test using low density conditions on group 1 ore.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh group 1 ore.

Grind: 11 minutes at 50% solids in the yellow ball mill.

Conditions:

	Reagents, g/t							Time, minutes			
Stage	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	pH
Primary Grind	*125		*400		*25	*50		11			8.7
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	
PM Regrind			*100		*5	*20		7.5			
1st Cleaner							5		1	7	
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	3	8.8
2nd Cleaner			50						1	3.5	8.5
						10	5	7.5	1	2	
									1	3	
3rd Cleaner			10					5	1	3	
						5	2.5			2	
						5				3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 55

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 2nd Cl Conc	8.5	0.9	12.9	19.1	373	1.27	3.78	46.2	38.4	54.6	11.8	82.6
2 2nd Cl Tail	10.6	1.1	1.01	3.07	35.8	0.22	0.27	4.5	7.7	6.5	2.5	7.4
3 1st Cl Sc Conc	3.3	0.3	0.95	1.61	16.5	0.18	0.13	1.3	1.3	0.9	0.6	1.1
4 1st Cl Sc Tail	28.3	2.9	0.36	1.22	12.7	0.12	0.090	4.3	8.2	6.2	3.7	6.5
5 Scav Tail	941.2	94.9	0.11	0.20	1.96	0.079	0.001	43.6	44.5	31.8	81.3	2.4
Head (calc)	991.9	100.0	0.24	0.43	5.86	0.092	0.039	100.0	100.0	100.0	100.0	100.0
Head (direct)			0.23	0.49	6.47	0.091	0.045					
Combined Products												
1st Cl Conc (1 & 2)		1.9	6.30	10.2	186	0.69	1.83	50.7	46.1	61.1	14.4	89.9
Ro Conc (1 to 4)		5.1	2.64	4.63	78.2	0.34	0.75	56.4	55.5	68.2	18.7	97.6

Test: 56 Project: 4255 Date: July 28/92 Operator: GC

Purpose: As per Test 55, but on group 2 ore.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh group 2 ore.

Grind: 11 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		11			8.7
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	8.8
PM Regrind			*100		*5	*20		7.5			
1st Cleaner							5		1	7	8.3
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	
2nd Cleaner			50						1	3.5	
					5	10	7.5		1	2	
									1	3	
3rd Cleaner			10						1	3	
					2.5	5	5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 56

Metallurgical Balance

Product	Weight			Assays, %, g/t				% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 2nd Cl Conc	4.7	0.5	30.3	21.3	261	5.94	10.9	37.7	37.8	49.4	21.9	57.2
2 2nd Cl Tail	7.1	0.7	0.55	0.48	5.98	1.45	0.53	1.0	1.3	1.7	8.1	4.2
3 1st Cl Sc Conc	3.1	0.3	4.06	5.78	66.2	0.87	0.27	3.3	6.8	8.3	2.1	0.9
4 1st Cl Sc Tail	26.4	2.7	0.42	0.42	3.79	0.23	0.092	2.9	4.2	4.0	4.8	2.7
5 Scav Tail	946.4	95.8	0.22	0.14	0.96	0.085	0.033	55.1	50.0	36.6	63.1	34.9
Head (calc)	987.7	100.0	0.38	0.27	2.51	0.13	0.091	100.0	100.0	100.0	100.0	100.0
Head (direct)			0.27	0.30	2.90	0.15	0.11					
Combined Products												
1st Cl Conc (1 & 2)		1.2	12.4	8.77	108	3.24	4.66	38.7	39.1	51.1	30.0	61.5
Ro Conc (1 to 5)		4.2	4.12	3.21	38.1	1.14	1.41	44.9	50.0	63.4	36.9	65.1

Test: 57 Project: 4255 Date: July 28/92 Operator: GC

Purpose: As per Test 55, but on group 3 ore.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh group 3 ore.

Grind: 11 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		11			
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	
PM Regrind			*100		*5	*20		7.5			
1st Cleaner							5		1	7	
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	
2nd Cleaner			50						1	3.5	
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner			10						1	3	
					2.5	5	5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 57

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 2nd Cl Conc	8.0	0.8	45.7	23.0	305	6.37	10.7	63.2	57.3	60.8	30.5	64.4
2 2nd Cl Tail	7.5	0.8	1.81	2.28	60.6	2.96	0.59	2.3	5.3	11.3	13.3	3.3
3 1st Cl Sc Conc	1.7	0.2	2.06	1.47	35.1	1.60	0.34	0.6	0.8	1.5	1.6	0.4
4 1st Cl Sc Tail	21.4	2.2	0.73	0.62	11.3	0.58	0.16	2.7	4.1	6.0	7.4	2.6
5 Scav Tail	946.8	96.1	0.19	0.11	0.86	0.083	0.041	31.1	32.4	20.3	47.1	29.2
Head (calc)	985.4	100.0	0.59	0.33	4.07	0.17	0.13	100.0	100.0	100.0	100.0	100.0
Head (direct)			0.68	0.35	4.35	0.20	0.16					
Combined Products												
1st Cl Conc (1 & 2)		1.6	24.5	13.0	187	4.72	5.81	65.6	62.6	72.2	43.8	67.8
Ro Conc (1 to 5)		3.9	10.3	5.62	82.8	2.29	2.44	68.9	67.6	79.7	52.9	70.8

Test: 58 Project: 4255 Date: July 28/92 Operator: GC

Purpose: As per Test 55, but on group 4 ore.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh group 4 ore.

Grind: 11 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		11			
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	
PM Regrind			*100		*5	*20		7.5			
1st Cleaner							5		1	7	
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	
2nd Cleaner			50						1	3.5	
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner									1	3	
					2.5	5	5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 58

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 2nd Cl Conc	10.1	1.0	41.9	26.6	401	7.22	10.6	59.0	65.3	61.0	39.9	71.0
2 2nd Cl Tail	8.5	0.9	2.25	1.84	76.1	2.19	0.61	2.7	3.8	9.7	10.2	3.4
3 1st Cl Sc Conc	2.8	0.3	2.10	1.19	88.7	2.72	0.35	0.8	0.8	3.7	4.2	0.7
4 1st Cl Sc Tail	25.7	2.6	1.24	0.75	26.5	0.75	0.24	4.4	4.7	10.3	10.5	4.1
5 Scav Tail	948.2	95.3	0.25	0.11	1.07	0.068	0.033	33.1	25.4	15.3	35.3	20.8
Head (calc)	995.3	100.0	0.72	0.41	6.67	0.18	0.15	100.0	100.0	100.0	100.0	100.0
(direct)			0.94	0.40	7.54	0.28	0.17					
Combined Products												
1st Cl Conc (1 & 2)		1.9	23.8	15.3	253	4.92	6.03	61.7	69.1	70.7	50.0	74.5
Ro Conc (1 to 5)		4.7	10.2	6.52	119	2.51	2.53	66.9	74.6	84.7	64.7	79.2

Test: 59 Project: 4255 Date: July 28/92 Operator: GC

Purpose: As per Test 55, but on group 5 ore.

Procedure: As shown below.

Feed: 1000 grams minus 10 mesh group 5 ore.

Grind: 11 minutes at 50% solids in the yellow ball mill.

Conditions:

Stage	Reagents, g/t							Time, minutes			pH
	Na2S		PA MED	CuSO4	3501	PAX	MIBC	Grind	Cond.	Froth	
Primary Grind	*125		*400		*25	*50		11			
Rougher 1							25		1	3	
2									1	5	
Scavenger 1	50			50		25			1	7	
2						25			1	5	
						25	7.5		1	5	
						25	7.5		1	5	
PM Regrind			*100		*5	*20		7.5			
1st Cleaner							5		1	7	
						10			1	5	
						5			1	3	
1st Cl Scav	50					20			2	10	
2nd Cleaner			50						1	3.5	
					5	10	7.5		1	2	
						5			1	3	
3rd Cleaner			10						1	3	
					2.5	5	5		1	2	
						5			1	3	

* Indicates that the reagent was added for the last 5 minutes of the corresponding grinding stage

Circuit	Cell	RPM
Ro/Scav	D-1 , 1000g	1750

Test: 59

Metallurgical Balance

Product	Weight		Assays, %, g/t					% Distribution				
	g	%	Au	Pt	Pd	Ni	Cu	Au	Pt	Pd	Ni	Cu
1 1st Cl Conc	6.8	0.7	24.9	44.6	1023	2.72	3.63	50.7	60.6	61.5	6.6	69.6
2 1st Cl Sc Conc	1.5	0.2	2.57	5.91	176	1.26	0.28	1.2	1.8	2.3	0.7	1.2
3 1st Cl Sc Tail	27.6	2.8	0.63	1.29	34.7	0.36	0.098	5.2	7.1	8.5	3.6	7.6
4 Scav Tail	954.7	96.4	0.15	0.16	3.29	0.26	0.008	42.9	30.5	27.7	89.1	21.5
Head (calc)	990.6	100.0	0.34	0.51	11.4	0.28	0.036	100.0	100.0	100.0	100.0	100.0
(direct)			0.23	0.67	17.2	0.11	0.039					
Combined Products												
1st Cl+Cl Sc Conc (1 & 2)		0.8	20.9	37.6	870	2.46	3.02	51.9	62.4	63.8	7.3	70.8
Ro Conc (1 to 3)		3.6	5.31	9.69	228	0.84	0.77	57.1	69.5	72.3	10.9	78.5

APPENDIX 1

Mineralogical Examination of a PGM Leach Residue

submitted by

George W. Reschke

(Lac des Iles)

Project LR4255

SUMMARY

The samples appeared to have been solids held in suspension which, given enough time, have settled and formed a residue.

It appeared to consist of silicates and sulphides, mostly chalcopyrite and pyrite.

INTRODUCTION

A sample identified as "LAN #7, Sept. 7th, 80% salt 20% PGM + Au: Sample H" was received in the Mineralogy laboratory for examination. The purpose of the examination was to confirm the composition as salts plus PGM plus Au.

pr Greg Davison
R.W. Deane
Mineralogist

PREPARATION AND PROCEDURE

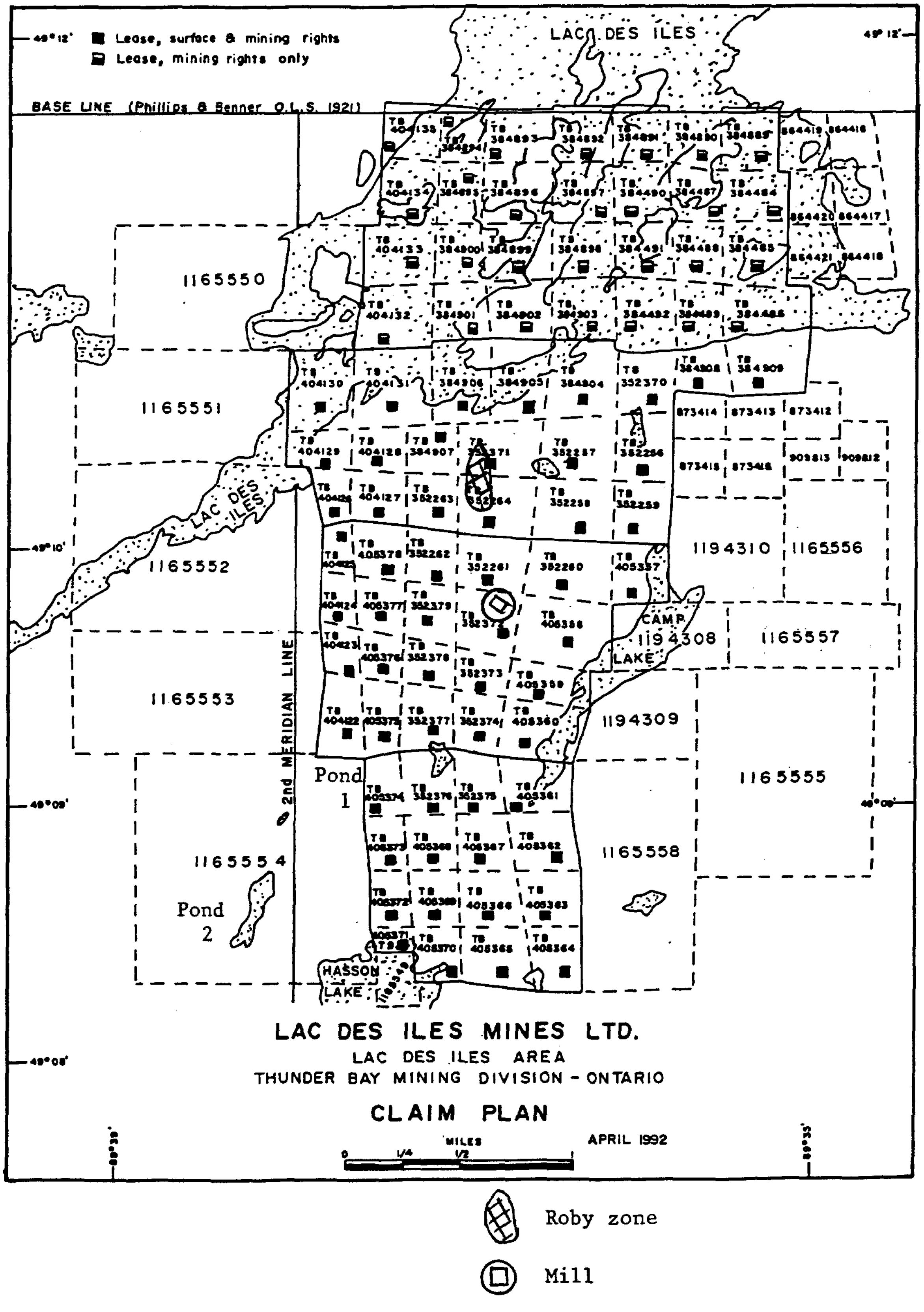
A portion of the sample was briquetted and polished for incident light microscopy. The reject was submitted for powder x-ray diffractometry.

RESULTS

The sample consisted of rock-forming silicates plus fine-grained sulphides, notably chalcopyrite and pyrite. From the history of the sample, as supplied by Mr. Reschke, we have deduced the following:

- A concentrate containing Platinum Group Metals was leached with hydrochloric acid and a little nitric acid under 100 psi oxygen pressure. Following the leaching period, the liquor was separated from the residue and set aside. A day following the leaching, the liquor was observed to have a sediment. The liquor plus sediment were filtered and the filter paper plus sediment were submitted to Lakefield Research as the sample identified above.

- We concluded that the sample consists of fine-grained particles held in suspension at the time of the original separation of liquor and residue; particles which, given time to do so, settled out to form more residue.



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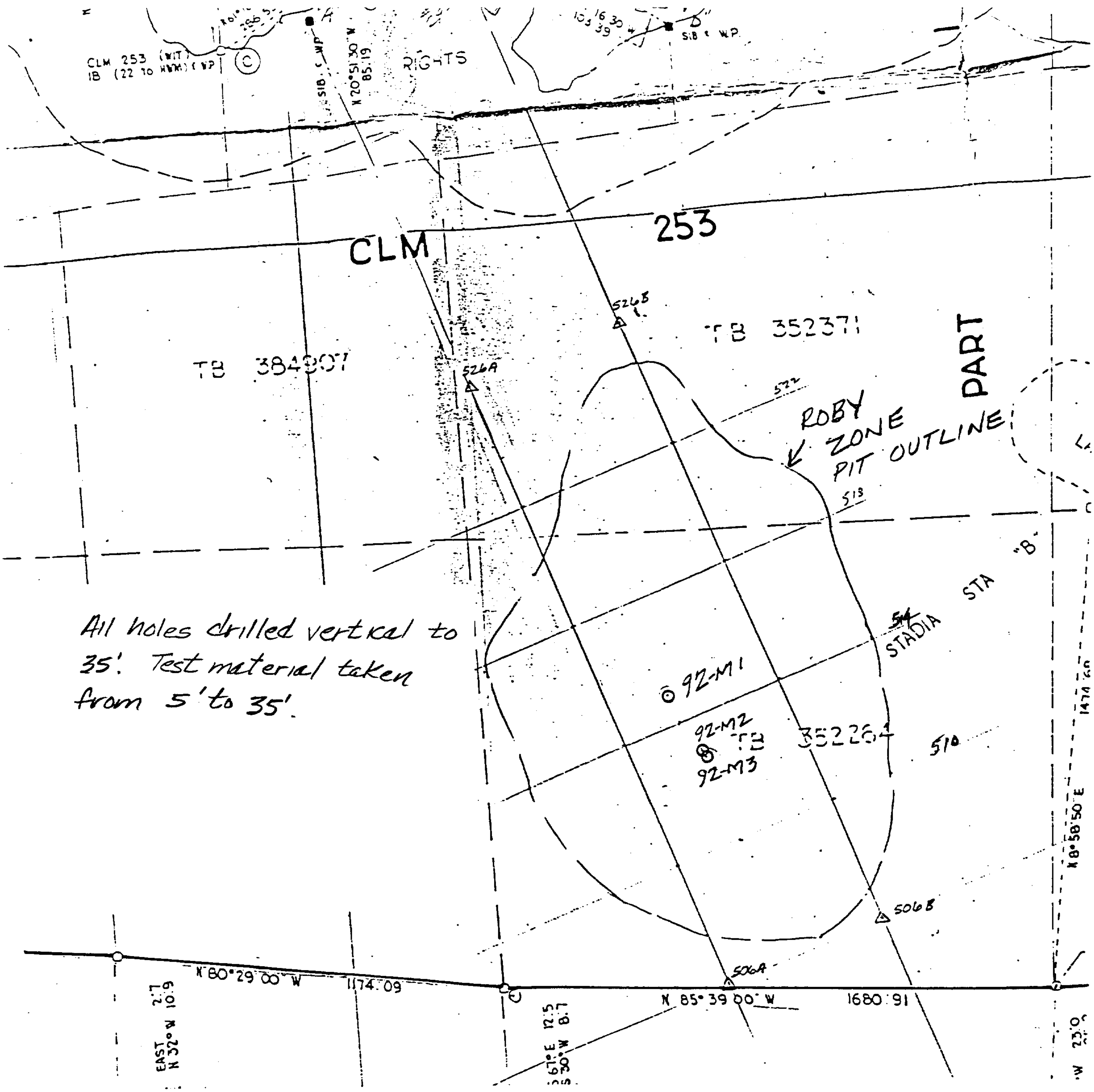

All holes drilled vertical to 35'. Test material taken from 5' to 35'.

LAC DES ILES MINES LTD.

PERCUSSION DRILL HOLE PLAN
(Lakefield Research M92 test material obtained from 92M-1, 2 + 3)

Jan. 1994

0 300 600
Feet

52H04NE0013 2.15334 LAC DES ILES

030

2.15334

INCO

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

J Roy Gordon Research Laboratory
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Subject
Lac des Iles Mines-
ROCK (MgO) REJECTION

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1 Summary

Testwork was initiated to prove the applicability of the sodium sulfide/nitrogen gas flotation procedure for reducing the MgO content of freshly prepared Lac des Iles bulk copper nickel concentrate. The aim of this phase was the adaptation of the laboratory bulk copper/nickel flowsheet developed at Lakefield Research to JRGRL practices.

The adapted flowsheet consisted of a primary grind of 15 min/kg (90% -75 μm) with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.2 g/kg creosote. Rougher flotation was conducted at pH 9.5 with 0.5 g/kg CMC (Finnfix-300) as rock depressant and a further addition of 0.04 g/kg PAX. A scavenger stage was performed after a 0.05 g/kg copper sulfate pentahydrate and a 0.04 g/kg PAX conditioning.

The combined rougher and scavenger concentrate graded 0.76% Cu, 0.76% Ni, 4.1% S with 86.9% Cu, 60.3% Ni, and 83.4% S. The weight recovery to this combined concentrate is 18.0% with a Mg content is 17.7% (29.4% MgO).

Regrinding the rougher concentrate to 90.2% -21 μm yielded a cleaner concentrate with 59.0% sulfur and 16.0% rock stage recoveries respectively. The cleaner concentrate graded 5.2% Cu, 3.5% Ni, 17.4% S with 64.7% Cu, 30.5% Ni, and 38.7% S recoveries. The Mg content was 5.4% (9.0% MgO). These grades are comparable to those of the old bulk concentrate for which the sodium sulfide/nitrogen gas flotation procedure was developed.

Distribution: G.E. Agar, R.A. Alcock, ~~R.E. Butler (2)~~, B.R. Conard, Library

2 Introduction

The project was initiated when Lac des Iles Mines (then called Madeleine Mines) offered its stock pile of bulk copper/nickel concentrate to INCO for smelting and refining. The high content in Platinum Group Metals (PGMs) of the concentrate was interesting. However, the MgO content (around 10%) was above the acceptable limit of 5.0%.

Testwork for MgO rejection from the concentrate sample indicated that the most effective approach was to perform a reverse flotation of the highly hydrophobic silicate minerals. Potential controlled sodium sulfide addition (with nitrogen as flotation gas) or sodium trithiocarbonate (Orfom D-8) were used to depress the copper and nickel sulfides (Progress Report #1, December 1991).

With sodium sulfide, a sulfide product grading 10.0% Cu, 6.3% Ni and 3.3% MgO was achieved at -400 mV vs SCE with 94% copper and nickel recoveries. Also, around 95% of the platinum, palladium and gold were recovered into this product. The Pt, Pd, and Au assays of the sulfide product were 15.0, 180, and 26.3 ppm respectively. Sodium trithiocarbonate gave similar results with the exceptions of lower copper recoveries to the sulfide product (89% vs 94%) and as such was less efficient than the sodium sulfide/nitrogen flotation gas approach.

These results prompted negotiations between INCO and Lac des Iles Mines as to a possible smelter contract. During these discussion, it was determined that additional testwork would be required to prove the proposed processing scheme on fresh bulk copper/nickel concentrate.

A technological exchange agreement was drafted on August 19th, 1992. The agreement consisted of the exchange of technical reports (bulk copper/nickel flowsheet development at Lakefield Research vs MgO rejection from the old bulk concentrate), the definition of the ore sample to be used, and the plan for the additional testwork to be performed at JRGRL.

The agreement was eventually signed and the reports exchanged. A 25 kg of ore sample, composite M92 used for flowsheet development at Lakefield Research, was received on October 2nd. Testwork was then initiated on the first part of the development plan: the adaptation of the laboratory bulk copper/nickel flowsheet to achieve a rougher concentrate of grades and metal recoveries similar to those obtained at Lakefield Research with the JRGRL practices.

3 Material and Procedure

The analyses of the Lac des Iles samples can be found table 1. Also shown are the analyses of the residues of bromine alcohol leaches. The precious metal analyses of all feed samples can be found in table 2. For reference, the analyses of the previous samples (bulk concentrate (527) and ore (528)) are included with those of the present ore sample (555; Composite M92) which is used for this testwork. The analyses of the original Composite M92, as given by Lakefield Research are also provided in tables 1 and 2. The analyses of the fresh ore sample (555) agree well with those given for the original Composite M92 of which it is a sub-sample.

The fresh Lac des Iles ore sample (555) contains slightly less copper and nickel than the previous one. However, it contains more iron and sulfur and hence there is more pyrrhotite than chalcopyrite and pentlandite in the sample (table 2). The chemical assays of the ore do not yield pyrite in the estimated mineral composition although pyrite was estimated in some flotation test products.

Table 1 Analyses of the Lac des Iles Mines samples.

Sample	Product	Analysis (%)								Distribution (%)	
		Cu	Ni	Fe	S	MgO	SiO_2	Al_2O_3	CaO	Wt	Ni
Conc. (527)	Feed	6.27	3.77	17.1	16.9	9.7	27.6	4.8	3.2	100.0	100.0
Ore (528)	Feed	0.25	0.26	5.3	0.77	10.1	47.3	16.1	9.8	100.0	100.0
	BAL Residues	0.05	0.08	4.7	0.33	10.2	47.7	17.5	9.7	97.6	30.0
Ore (555)	Feed	0.18	0.22	7.9	0.97	12.2	47.7	13.5	6.9	100.0	100.0
	BAL Residues	0.01	0.09	7.3	0.32	12.5	48.8	14.1	7.3	97.6	39.5
M92	Feed	0.18	0.24	7.9	1.03	N.A.	N.A.	N.A.	N.A.	-	-

Bromine alcohol leach assays indicates that 61.1% of the nickel in the ore (sample 555) would be recoverable by flotation. This estimate is lower than the 70.0% flotation recovery predicted for the previous ore sample. The difference between the two ore samples lies mostly in the lower nickel assay for the fresh ore sample (0.22% Ni vs 0.26% Ni); the bromine alcohol leach residue contains nearly the same amount of nickel in both cases (0.09% Ni vs 0.08% Ni). The sulfur assay in the bromine alcohol leach residues is higher than one would expect even though two bromine alcohol leaches were performed consecutively to minimize passivation of the sulfur. It is possible that very fine grained pyrrhotite is still fully enclosed in silicates at the product size (-75 um) normally used for assaying purposes.

Table 2 Precious metal assays and mineral compositions of the Madeleine Mines samples.

Sample	Analysis (% or ppm)								
	Cp	Pn	Po	Rk	Pt	Pd	Au	Rh	Ir
Conc. (527)	18.1	10.2	13.1	58.6	7.8	109	12.8	0.2	0.5
Ore (528)	0.7	0.7	0.7	97.9	0.6	4.9	0.5	0.02	0.09
Ore (555)	0.5	0.6	1.5	97.4	0.6	10.1	0.6	N.A.	N.A.
M92	N.A.	N.A.	N.A.	N.A.	0.59	9.87	0.42	N.A.	N.A.

It might be coincidental but there appears to be a correlation between the pyrrhotite and palladium contents of the ore samples. Both Po and Pd assays for the fresh ore sample (555) are approximately twice those of the previous one (528).

X-Ray Diffraction analyses indicated that chlorite and tremolite are the major non-sulfide minerals in the ore sample. Minor amounts of talc, quartz, and feldspar were also detected. The pyrrhotite and pyrite contents were high enough to be detected (trace amounts) but this was not the case for chalcopyrite and pentlandite.

Size analysis indicated that the ore sample is much finer (96.4% -1.18 mm) than what normally used for testwork at JRGRL (100% -3.35 mm). In view of this, half of the 1 kg representative test charges were stored in the freezer to minimize oxidation. The other half of the test charges were kept in the store room and are being used first.

Since this part of the testwork is an adaptation of an existing laboratory flowsheet, targets were defined from the locked cycle tests performed in the original development work (1):

-Primary grind to 90% -75 μm

-Rougher plus scavenger recoveries:
    ≈ 85% for copper, ≈ 65% for nickel, and ≈ 90% for sulfur
    ≈ 85% for palladium (to be assessed sporadically)
    ≈ 80% for gold and platinum (to be assessed sporadically)

-Rougher plus scavenger concentrate grades:
    approximately 1.0% Cu, 1.0% Ni, 7.0% S

-Regrind to approximately 95% -45 um (optimum recoveries?)

-First cleaner grades and recoveries:
    approximately 3.0% Cu (80% rec.), 2.5% Ni (45% rec.), 16.0% S

-Second cleaner grades and recoveries:
    approximately 5.0% Cu (75% rec.), 3.5% Ni (40% rec.), 24.0% S

These targets are not to be taken in absolute terms but rather to ensure that the bulk copper/nickel concentrate eventually subjected to the sodium sulfide/nitrogen gas flotation procedure for MgO rejection would be of comparable quality to that expected in the Lac des Iles concentrator.

Three tests were initially planned with a simplified version of the reagent scheme used at Lakefield Research. The selected collector was Potassium Amyl Xanthate (PAX) with sodium carboxyl methyl cellulose (CMC; Finnfix-300) as the rock depressant. From past experience with ultramafic ores, a flotation pH of 9.5 using soda ash and a CMC dosage of 0.5 g/kg were chosen.

A base addition of PAX (0.01 g/kg) to the grinding stage was deemed necessary to help recoveries. Previous experience indicated that a PAX dosage to the scavenger of half that to the rougher would be sufficient. To enhance the recovery of the sulfide minerals during scavenging, a 0.05 g/kg addition of copper sulfate was selected.

The total PAX requirement for the rougher stage was determined using the incremental collector dosage procedure. This dosage was confirmed using the standard rougher rate test which was also used to determine the optimum rougher flotation time. Finally, a scavenger rate flotation test was performed following rougher flotation to the optimum time.

As a starting point, a 10 min./kg grind (65% solids) was used in the first test. Adjustments to this grind time, as needed, were performed in the subsequent tests. The test procedures are described below.

Incremental collector dosage test (rougher)

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #1 at 65% solids with 2.0 g/kg soda ash and 0.01 g/kg PAX for 10 min/kg

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute
-1.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 2 minutes

-PAX conditioning (0.01 g/kg) for 1 minute

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 2 minutes

-Repeat 0.01 g/kg PAX conditioning and 2 minute flotation steps until the froth is barren

Rougher rate test (rougher)

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #1 at 65% solids with 1.75 g/kg soda ash, 0.01 g/kg PAX, and 0.10 g/kg creosote for 15 min/kg

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute

-PAX conditioning (0.04 g/kg) for 1 minute

-2.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

Scavenger rate test with optimized rougher

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #1 at 65% solids with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.10 g/kg creosote for 15 min/kg

ROUGHER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute

-PAX conditioning (0.04 g/kg) for 1 minute

-2.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 9.3 minutes (558 seconds)

SCAVENGER

-Copper sulfate pentahydrate conditioning (0.05 g/kg) for 5 minutes; maintain pH 9.5

-PAX conditioning (0.02 g/kg) for 1 minute

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

Poor froth quality during the rougher rate test required the addition of creosote to the grinding stage to counter-balance the poor froth quality in laboratory flotation cells resulting from the addition of CMC. Past experience indicates that the addition of creosote is only a requirement for laboratory flotation test and will not be needed in the concentrator.

The test products from the rougher rate test performed without creosote (T12908) were not sent for analysis but they have been kept if it is required in the future. All subsequent tests used creosote.

To determine if a higher creosote dosage (0.2 g/kg) would be needed, and that this higher dosage would not have negative downstream impact on the optimum rougher flotation time or the cleaning of the rougher/scavenger concentrate, an additional test was performed. For this test, the rougher concentrate collected after 9.3 minutes of flotation was reground and cleaned. Prior to scavenging, two additional "rougher" increments of 1 minute of flotation each were collected. Also, due to lower than expected sulfur recoveries, the PAX dosage to the scavenger was increased to 0.04 g/kg (i.e. same as that added just prior to rougher flotation). The actual procedure used is described below.

First cleaner rate test with optimized rougher

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #2 at 65% solids with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.20 g/kg creosote for 15 min/kg

ROUGHER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute

-PAX conditioning (0.04 g/kg) for 1 minute

-2.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 9.3 minutes (558 seconds)

EXTENDED ROUGHER

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 1 minute

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 1 minute

SCAVENGER

-Copper sulfate pentahydrate conditioning (0.05 g/kg) for 5 minutes. Maintain pH 9.5

-PAX conditioning (0.04 g/kg) for 1 minute

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

1ST CLEANER

-Regrinding the rougher concentrate for 20 minutes in the laboratory regrind ball mill at 60% solids and with 0.05 g/kg soda ash

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.25 g/kg rougher concentrate; Finnfix-300) for 1 minute

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

4 Results and discussion

The results of the tests conducted are summarized in figures 1 to 7 and in tables 1 to 4. The size distributions can be found in appendix 1 while the material balances can be found in appendix 2.

The first test performed with a 10 min/kg grind achieved a flotation feed of 74% -75 μm (T12907). The initial concentrate increment (after the 0.01 g/kg PAX addition to the grind) graded 3.3% Ni (figure 1) at 41.0% recovery (figure 2).

As the amount of PAX added to the flotation pulp, the nickel grade decreased rapidly and would probably reach 1.0% Ni at excessive amounts of PAX (figure 1). The nickel recovery does increase with increasing cumulative PAX dosage (figure 2) but it does not look likely that it will exceed 60% even at excessively high PAX dosages. This estimate of the ultimate nickel recovery which can be achieved by flotation is in line with the one predicted from the Bromine Alcohol Leach.

In this case, the plots of nickel grade and recovery as functions of cumulative PAX dosage do not yield an obvious optimum collector dosage. Plots of the separation efficiencies for pentlandite against rock and pentlandite against pyrrhotite (figure 3) are more effective for this task.

The separation efficiency (Pn/Rk) levels off rather quickly at 0.46 after a cumulative PAX dosage of only 0.04 g/kg (figure 3). As expected, the SE (Pn/Po) becomes more negative as the PAX dosage increases). These curves indicate that the rougher stage should primarily recover pentlandite while the scavenger stage should primarily recover pyrrhotite. Attempting to recover both in the rougher stage would likely waste collector even though a low xanthate residual would be observed (3.9 μM after the last flotation in T12907).

An examination of the curves of total sulfur recovery and SE (S/Rk) vs PAX dosage, figures 4 and 5 respectively, does not yield a definite optimum collector dosage. Since the SE (Pn/Rk) vs PAX dosage curves reaches a definite plateau, it is relatively easy to use it to obtain a conservative estimate of the optimum PAX dosage for the rougher stage. In this case, 0.05 g/kg PAX, of which 0.01 g/kg is added to the grinding stage, is appropriate.

The first attempt to optimize the rougher flotation (T12908) was aborted due to extremely poor froth quality. Subsequently, creosote was added to the grinding stage to counter-balance the poor froth quality in laboratory flotation cells resulting from the addition of CMC. It should be noted that the addition of creosote is only a requirement for laboratory flotation tests and will not be needed in the concentrator.

A second attempt to optimize the rougher flotation was performed with 0.10 g/kg creosote added to the grind and a grind time of 15 min/kg (T12913). The flotation feed was 90% -75 μm. The rate data (first order model modified for limited infinite recovery and time zero correction) is summarized in table 1.

Table 1 Optimization of rougher stage

Component	RI	k (x10^{3} sec^{-1})	$t_{cor.}$	Calculated		Observed	
				Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
Sulfur	0.714	6.85	14.3	70.0	0.65	71.1	0.63
Rock	1.000	0.10	-6.6	5.0	(559 secs)	8.2	(720 secs)

The most striking feature of the data in table 1 is that the infinite recovery of the rock component is 1.000 (100%) and as such is higher than the sulfur bearing minerals. This is an extremely rare observation and probably indicates that increasing flotation time will allow the recovery of more rock than the sulfide minerals. Separation is nevertheless possible due to the higher flotation rate constant for the sulfur bearing minerals than for the rock minerals.

The cumulative rougher concentrate collected at the 720 seconds observed optimum flotation time grades 1.5% Cu, 1.3% Ni and 6.9% S; rather low but nonetheless expected from such a low grade ore. The recoveries into this concentrate are 86.2% for copper, 53.6% for nickel and 71.1% for sulfur.

The scavenger rate test was performed essentially with the same conditions using the calculated optimum flotation time for the rougher stage (T12909). The rate data for the scavenging stage is summarized in table 2.

No optimum flotation time could be calculated for the scavenger stage mostly due to the large time correction for the rock component (-22.7 seconds). The sign and the magnitude of the correction indicates that the rock minerals had a head start in the flotation against the sulfide minerals.

Table 2 Optimization of scavenger stage

Component	RI	k (x10^{3} sec^{-1})	$t_{cor.}$	Calculated		Observed	
				Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
Sulfur	0.535	2.11	-3.7	N.A.	N.A.	79.5	0.61
Rock	0.163	0.97	-22.7	N.A.	(no optime)	15.3	(720 secs)

For the observed scavenger optimum flotation time, the grades of the combined rougher plus scavenger concentrates were 0.88% Cu, 0.80% Ni, and 4.6% S with 87.8% Cu, 59.9% Ni, and 79.5% S recoveries.

These grades and recoveries are slightly below the desired levels but are not too far off the "target" 1.0% Cu, 1.0% Ni, 7.0% S with 85% Cu, 65% Ni, and 90% S recoveries. This is acceptable given that these results were achieved after only three flotation tests and that the "target" was defined from a locked cycle test result!

Performing a fair comparison on the basis of batch tests (table 3) shows that the simplified flowsheet used at JRGRL is nearly equivalent to the more complex one used at Lakefield Research with the exception of the lower nickel and sulfur recoveries.

The lower nickel and sulfur recoveries obtained at JRGRL are likely to be due to the use of a rod mill (narrow product size distribution) rather than a ball mill (wide product size distribution). The narrower size distribution yields a lower proportion of fines for a given product size specification (e.g. 90% -75 μm) as shown in appendix 1. Hence, a lower degree of liberation of the sulfide minerals is expected from a laboratory rod mill compared to a laboratory ball mill for the same product specification.

In fact, the recoveries achieved at JRGRL are probably better estimates of those which can be achieved in the concentrator since a laboratory rod mill closely simulates a closed-circuit industrial ball mill with hydrocyclone size classification.

Table 3 Comparison of Lakefield Research and JRGRL Batch Test Performances

Grind Size (%-75 μm)	Rougher Concentrate						Combined Concentrate					
	Grade (%)			Rec. (%)			Grade (%)			Rec. (%)		
	Ni	Cu	S	Ni	Cu	S	Ni	Cu	S	Ni	Cu	S
* 47	1.1	1.1	6.7	55	65	82	0.8	0.8	4.6	63	71	89
* 68	-	-	-	-	-	-	0.6	0.7	N.A.	66	87	N.A.
* 90	1.2	1.3	7.3	60	85	92	0.8	0.8	4.7	66	88	96
74	1.5	1.8	8.9	54	82	79	-	-	-	-	-	-
90	1.3	1.5	6.7	52	83	65	0.8	0.9	4.6	60	88	80

* Lakefield Research test results

On the basis that the froth quality was still below the desired one, a fourth test was performed. In this test (T12924), a higher amount of creosote (0.20 g/kg) was added to the grind. To ensure that the higher amount of creosote would not distort the test results, separate additional one minute rougher concentrate increments were collected. Furthermore, to increase the recovery of the sulfide minerals, the collector dosage to the scavenger was increased from 0.02 to 0.04 g/kg. Finally, the initial rougher concentrate was reground for 20 minutes in a laboratory regrind ball mill and cleaned. The results for this test are summarized in figures 6 and 7 and in table 4

From figure 6, it can be observed that the calculated optimum flotation time slightly over-estimated the sulfur recovery achieved with 0.1 g/kg creosote added to the grind. However, it appears that the addition of 0.2 g/kg creosote decreases the sulfur recovery achieved at the rougher stage compared with the lower addition of creosote.

The over-estimation of the sulfur recovery translates into an over-estimation of the achieved separation efficiency (S/Rk) for the 0.1 g/kg addition of creosote (figure 7). Although no plateau was observed for the lower creosote addition, it appears that the separation efficiency will not increase with a rougher flotation longer than 600 seconds for the 0.2 g/kg addition. This means that the rougher flotation time will be increased to 600 seconds for the subsequent tests.

The rate data for the scavenger stage (table 4) is as unusual as that originally obtained for the rougher stage with an infinite recovery for the rock component is 1.000 (100%). A very long (1334 seconds or 22.2 minutes) optimum flotation time is calculated. Given the small difference between the calculated SE (S/Rk) of 0.45 and the observed SE of 0.40 (at 720 seconds or 12 minutes), it would be more practical to perform a first scavenger with a 720 seconds flotation time and, if necessary for higher recoveries, add a second scavenger with a stronger collector than PAX (e.g. dodecyl mercaptan?).

The combined rougher and scavenger concentrate graded 0.76% Cu, 0.76% Ni, 4.1% S with 86.9% Cu, 60.3% Ni, and 83.4% S. The weight recovery to this combined concentrate is 18.0% and the Mg content is 17.7% (29.4% MgO).

Table 4 Optimization of the scavenger and the first cleaner stages

Stage/ Component	RI	k $(x10^3 sec^{-1})$	$t_{cor.}$	Calculated		Observed	
				Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
Scavenger							
Sulfur	0.675	1.77	13.0	61.0	0.45	49.4	0.40
Rock	1.000	0.01	-2.8	16.0	(1334 secs)	9.1	(720 secs)
Cleaner							
Sulfur	0.61	5.74	14.8	59.0	0.43	59.8	0.43
Rock	0.19	2.75	14.9	16.0	(619 secs)	16.8	(720 secs)

Regrinding only the rougher concentrate for 20 minutes gave a product which is 90.2% -21 μm. Cleaning of the reground concentrate gave a stage SE (S/Rk) of 0.43 for 59.0% and 16.0% stage sulfur and rock recoveries respectively. The calculated optimum flotation time (619 seconds) is acceptable although slightly longer than for the rougher stage.

Furthermore, the cleaner stage ultimate recovery of the sulfur component is only 0.61. This is much lower than the 0.95 or higher which is expected from a re-flotation of a rougher concentrate. Regrinding of the rougher concentrate before cleaning can decrease the RI of the sulfide minerals but not to the extent observed in this case.

Both a cleaning time longer than the rougher time and a RI less than 0.90 for the sulfide minerals normally suggest that an addition of a minute amount of collector will be required to maintain floatability of the sulfide minerals during the cleaning stages. This will be verified during the optimization of the first and second cleaner stages.

At the observed optimum cleaning flotation time, the first cleaner concentrate graded 5.2% Cu, 3.5% Ni, 17.4% S with 64.7% Cu, 30.5% Ni, and 38.7% S recoveries. The Mg content was 5.4% (9.0% MgO). These grades are slightly lower than those of the old bulk concentrate with which the sodium sulfide/nitrogen gas flotation procedure was developed.

It is still too early to say if one cleaning stage is sufficient for cleaning the combined rougher plus scavenger concentrate. However, there is no doubt that the overall recoveries will be improved.

In passing, it was observed that the flotation products took an extremely long time to filter using the usual laboratory vacuum filters compared to the products of other ultramafic ores. The problem was particularly acute for the flotation tailings. A pressure filter has been used since the second test with a dramatic reduction of the time required to filter the test products. The filtration characteristics of the final bulk copper/nickel concentrate will be qualitatively monitored for the cleaner tests.

6 Conclusions

Testwork was initiated on the first part of a development plan for proving the sodium sulfide/nitrogen gas flotation procedure for reduction of the MgO content of fresh Lac des Iles bulk copper/nickel concentrate. The aim of this phase was the adaptation of the laboratory bulk copper/nickel flowsheet to achieve a rougher concentrate of grades and metal recoveries similar to those obtained at Lakefield Research with the JRGRL practices.

The adapted flowsheet consisted of a primary grinding for 15 min/kg (90% -75 μm) with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.2 g/kg creosote. Rougher flotation (600 seconds) was conducted at pH 9.5 with 0.5 g/kg CMC (Finnfix-300) as rock depressant and an addition 0.04 g/kg PAX. A scavenger stage (720 seconds) was performed after a 0.05 g/kg copper sulfate pentahydrate and a 0.04 g/kg PAX conditioning.

The combined rougher and scavenger concentrate graded 0.76% Cu, 0.76% Ni, 4.1% S with 86.9% Cu, 60.3% Ni, and 83.4% S. The weight recovery to this combined concentrate is 18.0% with a Mg content of 17.7% (29.4% MgO).

Regrinding only the rougher concentrate to 90.2% -21 μm yielded a cleaner concentrate with a stage SE (S/Rk) of 0.43 for 59.0% and 16.0% stage sulfur and rock recoveries respectively. At the observed optimum cleaning flotation time (720 seconds), the cleaner concentrate graded 5.2% Cu, 3.5% Ni, 17.4% S with 64.7% Cu, 30.5% Ni, and 38.7% S recoveries. The Mg content was 5.4% (9.0% MgO).

These grades are slightly lower than those of the old bulk concentrate with which the sodium sulfide/nitrogen gas flotation procedure was developed. It is still too early to say if only one cleaning stage is required for cleaning the combined rougher plus scavenger concentrate. However, there is no doubt that the overall recoveries will be improved.

Records

The original records are in ERB 2159 and 2174.

Reference

1) Parker, S.J, K.W. Sarbutt, S.R. Williams, An Investigation of the Recovery of Copper, Nickel and PG Metals from Roby Zone Project Samples Submitted by Lac des Iles Mines Ltd, Progress Report No. 1, June 17th, 1992, Lakefield Research.

Appendices

1 Size Distributions

2 Material Balances

Figure 1

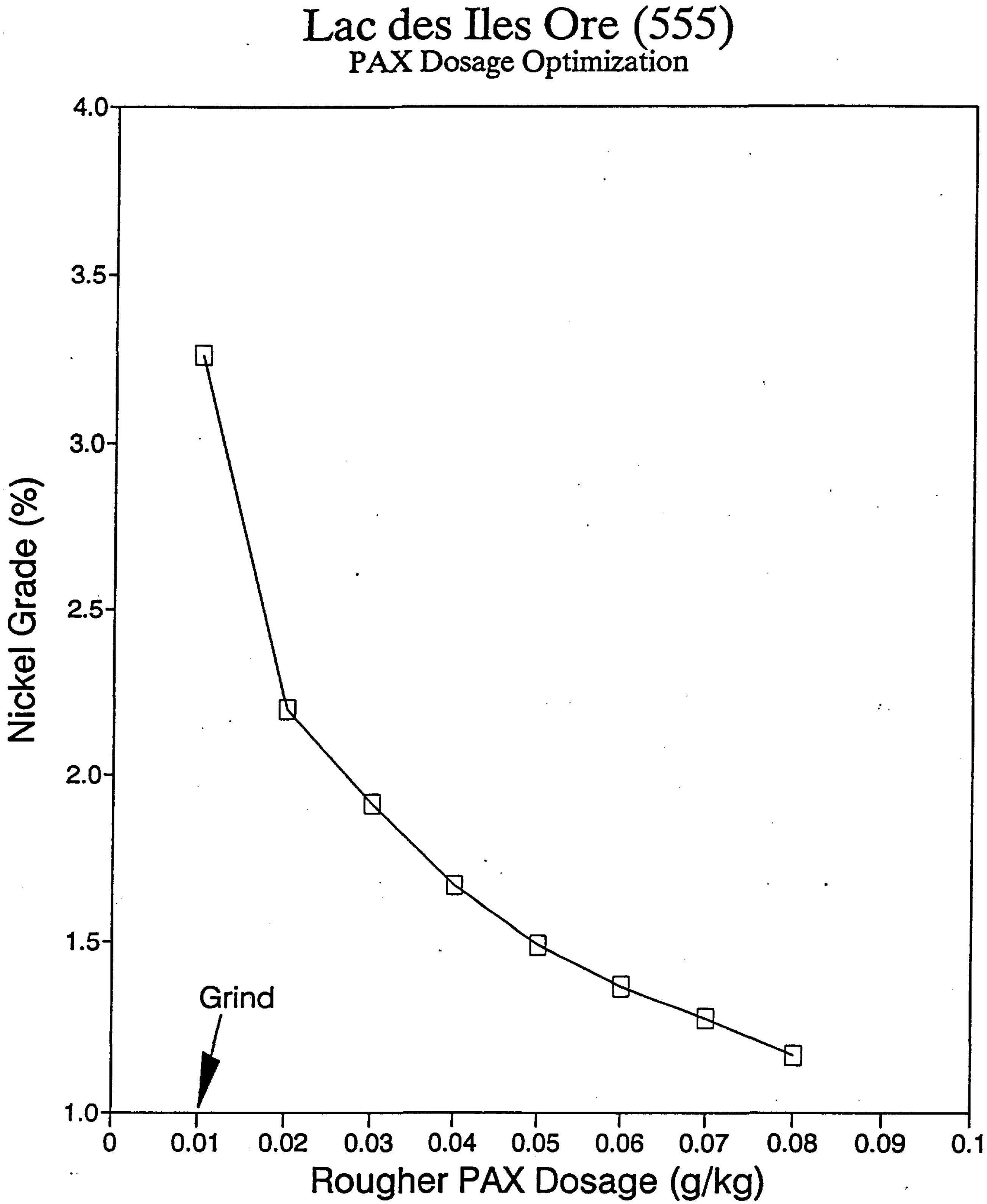

Lac des Iles Ore (555)
PAX Dosage Optimization
Nickel Grade (%)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Grind
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Rougher PAX Dosage (g/kg)

Figure 2

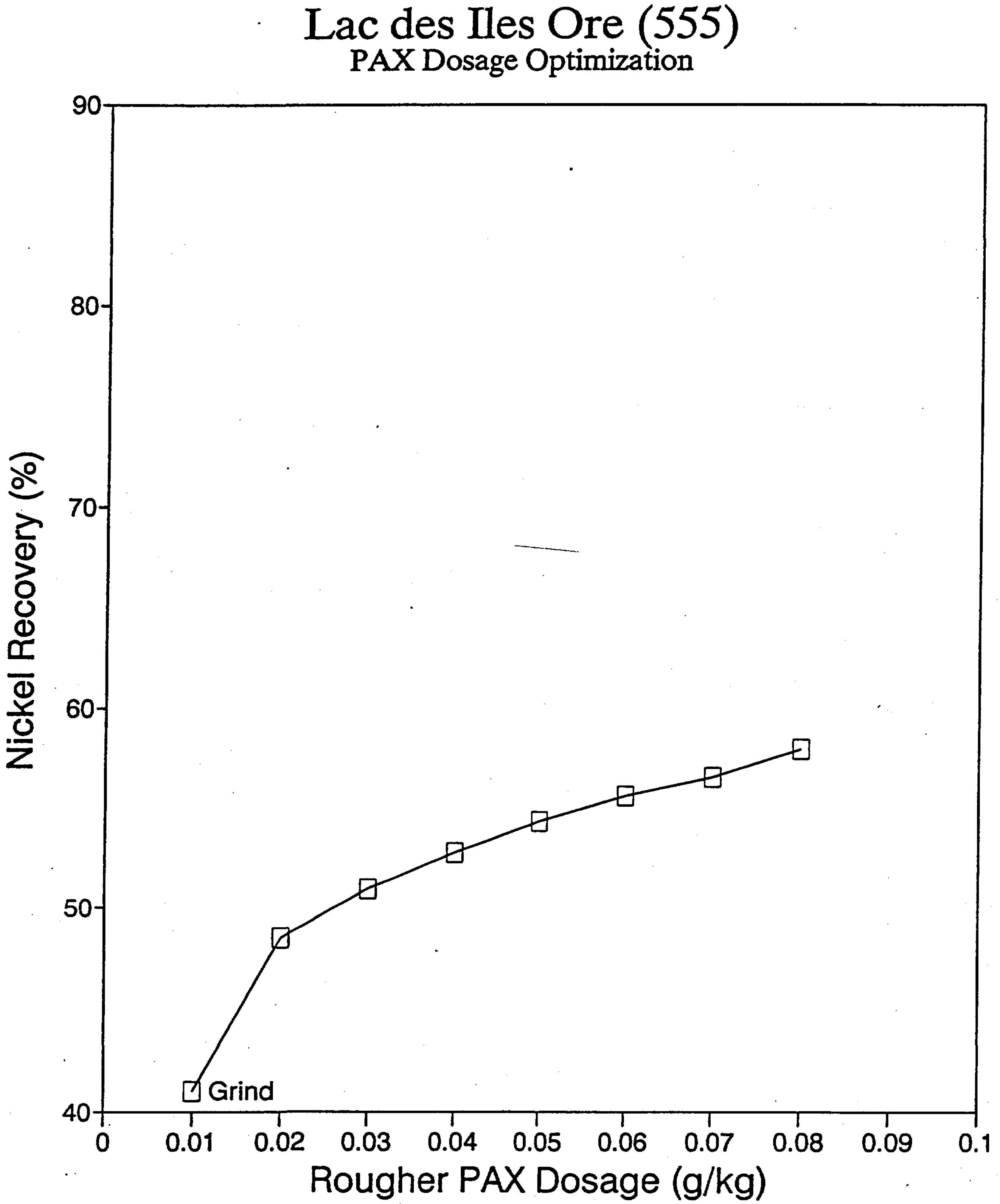
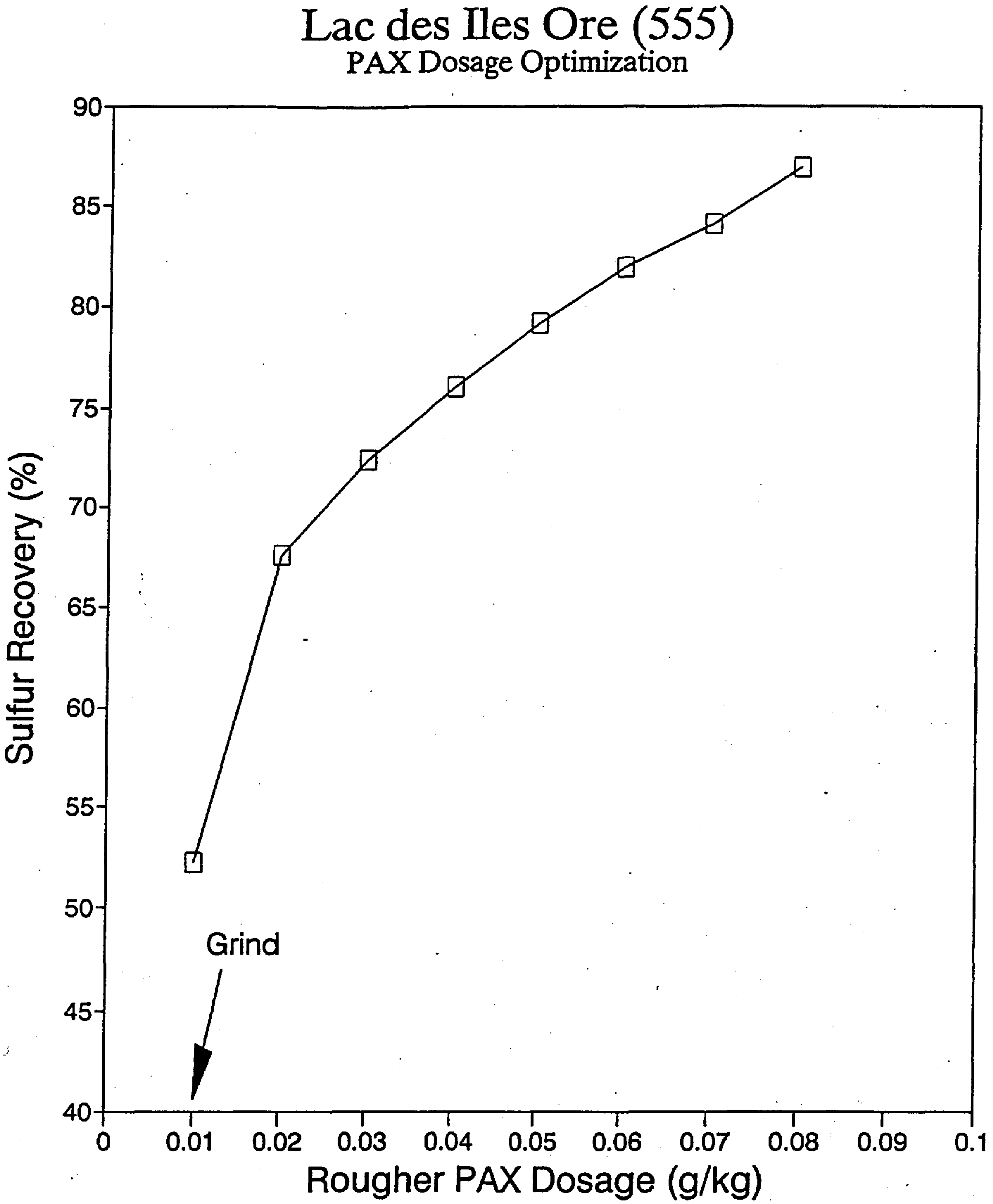

Lac des Iles Ore (555)
PAX Dosage Optimization
Nickel Recovery (%)
90
80
70
60
50
40
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Rougher PAX Dosage (g/kg)
Grind

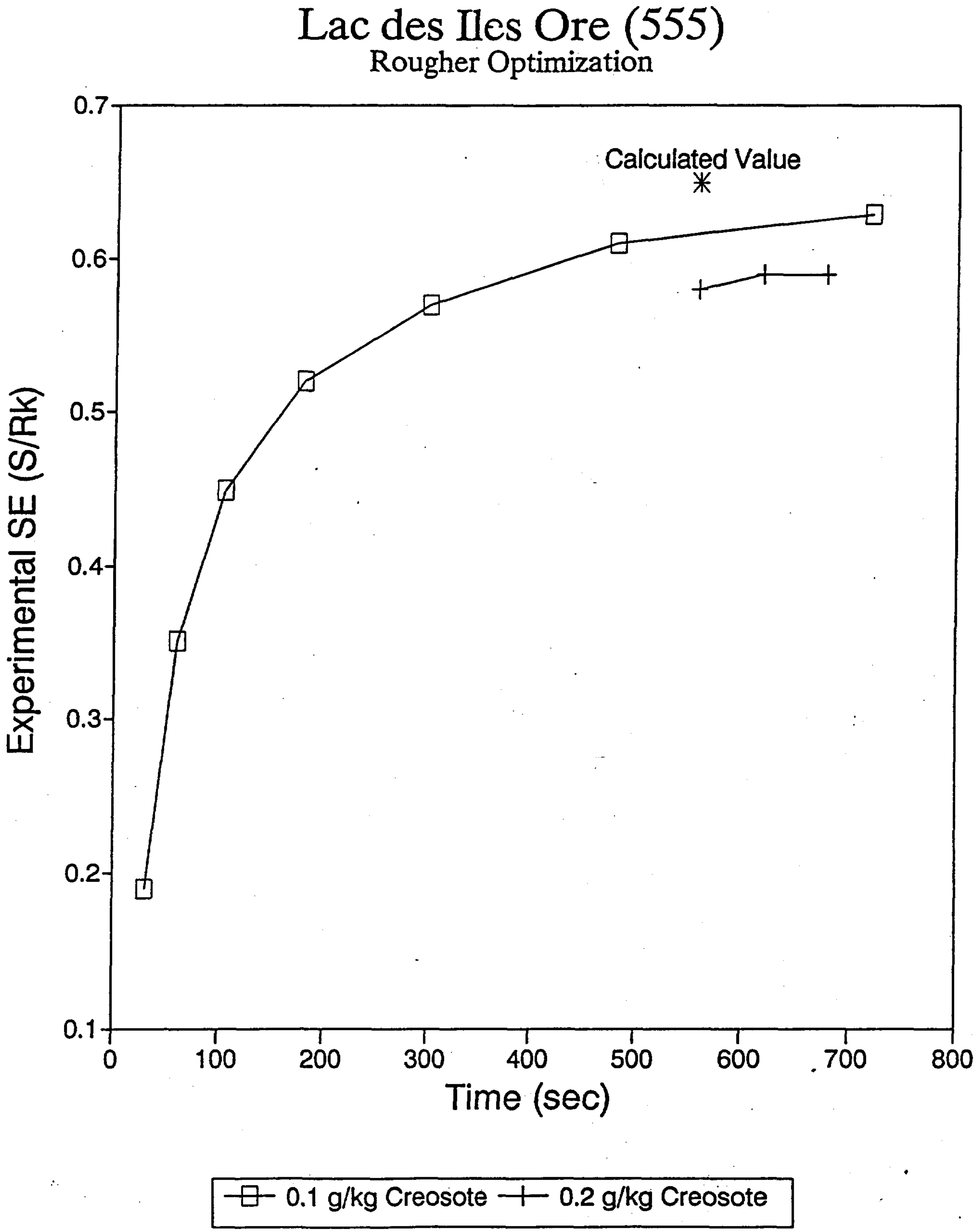
Figure 4


Lac des Iles Ore (555)
PAX Dosage Optimization
Sulfur Recovery (%)
90
85
80
75
70
65
60
55
50
45
40
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Rougher PAX Dosage (g/kg)
Grind

APPENDIX 1

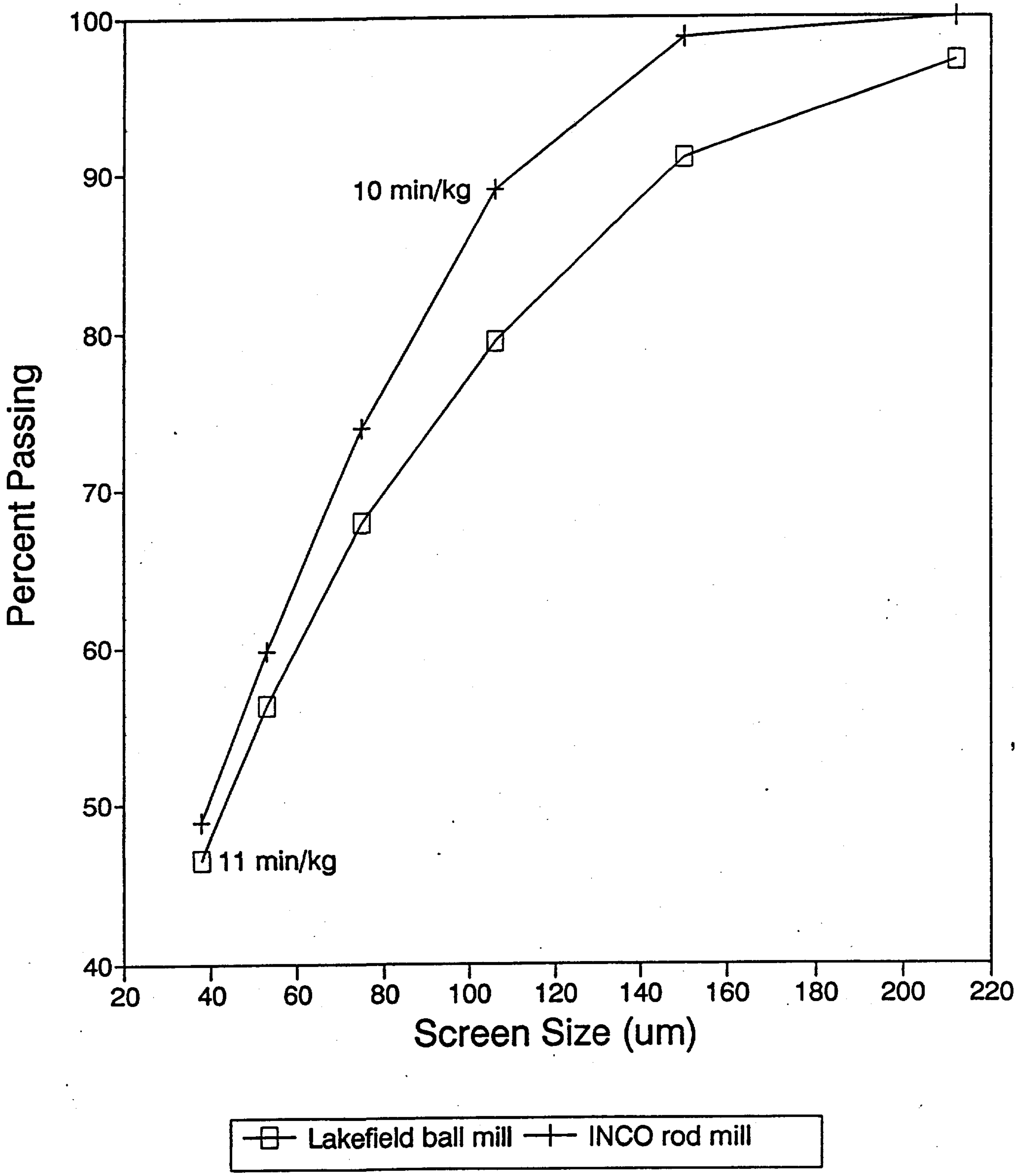
Size Distributions

Figure 7


Lac des Iles Ore (555)
Rougher Optimization
Calculated Value
Experimental SE (S/Rk)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
100
200
300
400
500
600
700
800
Time (sec)
0.1 g/kg Creosote
0.2 g/kg Creosote

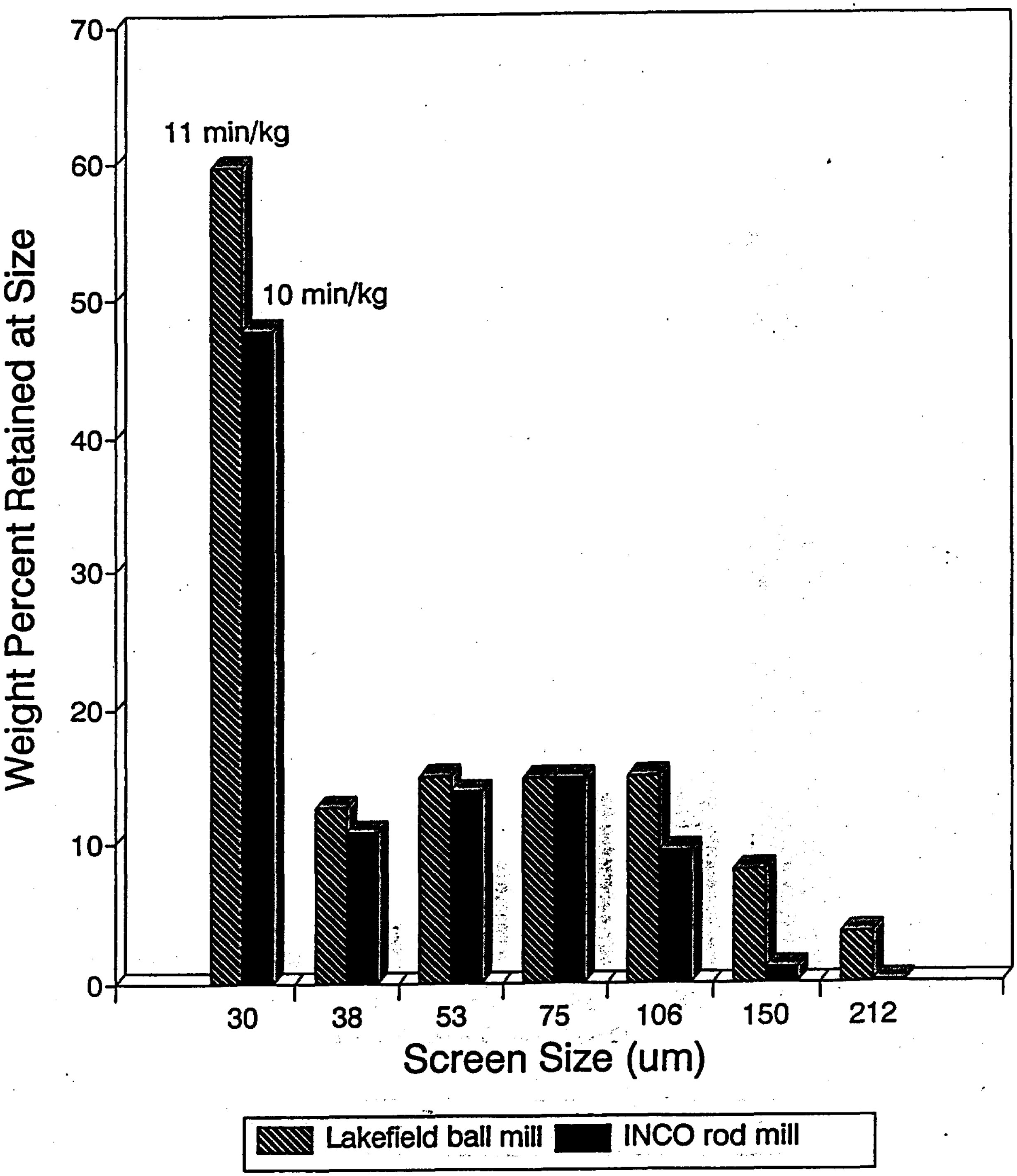
Lac des Iles Ore (555)

Grind Comparison (Target 90 % -75 um)



Lac des Iles Ore (555)

Grind Comparison (Short Grinds)



APPENDIX 2

Material Balances

T12907: Lac Des Iles Ore (555); 10 min/kg grind 2.0 2/kg Na2CO3,
0.5 g/kg CMC, 0.01 g/kg incremental PAX addition
ERB # 2159

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	29.0	4.37	3.26	20.2	16.9	4.95	12.6	8.62	21.7	1.34	55.7
Rghr conc 2	21.8	0.540	0.790	14.1	6.61	6.97	1.56	1.90	13.7	0.000E+0	82.8
Rghr conc 3	10.9	0.390	0.520	12.4	4.07	8.10	1.13	1.27	8.22	0.000E+0	89.4
Rghr conc 4	11.0	0.260	0.380	11.6	3.13	8.28	0.751	0.917	6.47	0.000E+0	91.9
Rghr conc 5	11.3	0.190	0.320	11.0	2.59	8.36	0.549	0.773	5.41	0.000E+0	93.3
Rghr conc 6	9.76	0.170	0.300	11.1	2.68	8.38	0.491	0.710	5.74	0.000E+0	93.1
Rghr conc 7	7.89	0.150	0.290	11.0	2.55	8.42	0.433	0.686	5.48	0.000E+0	93.4
Rghr conc 8	12.9	0.120	0.250	10.3	2.03	8.26	0.347	0.602	4.32	0.000E+0	94.7
Rghr tls	880.	0.330E-1	0.110	7.23	0.140	7.46	0.953E-1	0.307	0.120E-1	0.000E+0	99.6
TOTAL	994.91	0.182	0.232	8.014	0.942	7.430	0.526	0.618	1.321	0.039	97.496

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	2.92	70.0	41.0	7.35	52.3	1.94	70.0	40.7	47.9	100.	1.67
Rghr conc 2	2.19	6.48	7.46	3.85	15.3	2.05	6.48	6.73	22.7	0.000E+0	1.86
Rghr conc 3	1.09	2.34	2.45	1.59	4.72	1.19	2.34	2.24	6.80	0.000E+0	1.00
Rghr conc 4	1.10	1.57	1.81	1.59	3.66	1.23	1.57	1.64	5.40	0.000E+0	1.04
Rghr conc 5	1.13	1.18	1.56	1.55	3.11	1.27	1.18	1.42	4.63	0.000E+0	1.08
Rghr conc 6	0.981	0.915	1.27	1.36	2.79	1.11	0.915	1.13	4.26	0.000E+0	0.936
Rghr conc 7	0.793	0.653	0.993	1.09	2.15	0.899	0.653	0.883	3.29	0.000E+0	0.760
Rghr conc 8	1.30	0.853	1.40	1.67	2.79	1.44	0.853	1.26	4.23	0.000E+0	1.26
Rghr tls	88.5	16.0	42.0	79.8	13.1	88.9	16.0	44.0	0.805	0.000E+0	90.4

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	29.0	4.37	3.26	20.2	16.9	4.95	12.6	8.62	21.7	1.34	55.7
Rghr conc 2	50.8	2.73	2.20	17.6	12.5	5.82	7.88	5.74	18.3	0.764	67.3
Rghr conc 3	61.6	2.32	1.91	16.7	11.0	6.22	6.69	4.95	16.5	0.629	71.2
Rghr conc 4	72.6	2.01	1.67	15.9	9.82	6.53	5.79	4.34	15.0	0.534	74.3
Rghr conc 5	83.9	1.76	1.49	15.2	8.85	6.73	5.09	3.86	13.7	0.463	76.9
Rghr conc 6	93.6	1.60	1.37	14.8	8.20	6.94	4.61	3.54	12.9	0.414	78.6
Rghr conc 7	102.	1.48	1.28	14.5	7.76	7.06	4.29	3.31	12.3	0.382	79.7
Rghr conc 8	114.	1.33	1.17	14.0	7.12	7.20	3.84	3.01	11.4	0.339	81.4
Rghr tls	995.	0.182	0.232	8.01	0.942	7.43	0.526	0.618	1.32	0.390E-1	97.5

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk	Pn/Po
Rghr conc 1	2.92	70.0	41.0	7.35	52.3	1.94	70.0	40.7	47.9	100.	1.67	-0.0
Rghr conc 2	5.10	76.5	48.5	11.2	67.6	4.00	76.5	47.4	70.6	100.	3.53	-0.2
Rghr conc 3	6.20	78.8	51.0	12.9	72.4	5.19	78.8	49.7	77.4	100.	4.53	-0.29
Rghr conc 4	7.30	80.4	52.8	14.5	76.0	6.41	80.4	51.3	82.8	100.	5.56	-0.3
Rghr conc 5	8.43	81.5	54.3	16.0	79.1	7.69	81.5	52.7	87.4	100.	6.65	-0.3
Rghr conc 6	9.41	82.5	55.6	17.4	81.9	8.79	82.5	53.9	91.7	100.	7.58	-0.31
Rghr conc 7	10.2	83.1	56.6	18.5	84.1	9.69	83.1	54.7	95.0	100.	8.34	-0.4
Rghr conc 8	11.5	84.0	58.0	20.2	86.9	11.1	84.0	56.0	99.2	100.	9.60	-0.4
Rghr tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.	

Mineral calculations based on 0.800% Ni in Po

```
JT12907 Lac Deas Iles Ore (555) 10 min/kg grind 2.0 2/kg Na2CO3,
0.5 g/kg CMC, 0.01 g/kg incremental PAX addition
ERB # 2159

   - ASSAYS

              Wt       Cu       Ni      Fe      S       Mg      Cp      Pn      Po      Py        Rk
Rghr conc 1   29.0     4.37     3.26    20.2    16.9    4.95    12.6    8.62    21.7    1.34      55.7
Rghr conc 2   21.8     0.540    0.790   14.1    6.61    6.97    1.56    1.90    13.7    0.000E+0  82.8
Rghr conc 3   10.9     0.390    0.520   12.4    4.07    8.10    1.13    1.27    8.22    0.000E+0  89.4
Rghr conc 4   11.0     0.260    0.380   11.6    3.13    8.28    0.751   0.917   6.47    0.000E+0  91.9
Rghr conc 5   11.3     0.190    0.320   11.0    2.59    8.36    0.549   0.773   5.41    0.000E+0  93.3
Rghr tls      911.     0.370E-1 0.116   7.35    0.220   7.49    0.107   0.320   0.193   0.000E+0  99.4
TOTAL         994.91   0.182    0.232   8.016   0.947   7.430   0.527   0.618   1.332   0.039     97.484

   - DISTRIBUTIONS

              Wt       Cu       Ni      Fe      S       Mg      Cp      Pn      Po      Py        Rk
Rghr conc 1   2.92     69.9     41.0    7.35    52.0    1.94    69.9    40.7    47.5    100.      1.67
Rghr conc 2   2.19     6.47     7.45    3.85    15.3    2.05    6.47    6.72    22.5    0.000E+0  1.86
Rghr conc 3   1.09     2.34     2.45    1.69    4.69    1.19    2.34    2.24    6.74    0.000E+0  1.00
Rghr conc 4   1.10     1.57     1.80    1.59    3.64    1.23    1.57    1.63    5.35    0.000E+0  1.04
Rghr conc 5   1.13     1.18     1.56    1.55    3.09    1.27    1.18    1.41    4.59    0.000E+0  1.08
Rghr tls      91.6     18.6     45.8    84.0    21.3    92.3    18.6    47.3    13.3    0.000E+0  93.4

   - CUMULATIVE ASSAYS

              Wt       Cu       Ni      Fe      S       Mg      Cp      Pn      Po      Py        Rk
Rghr conc 1   29.0     4.37     3.26    20.2    16.9    4.95    12.6    8.62    21.7    1.34      55.7
Rghr conc 2   50.8     2.73     2.20    17.6    12.5    5.82    7.88    5.74    18.3    0.764     67.3
Rghr conc 3   61.6     2.32     1.91    16.7    11.0    6.22    6.69    4.95    16.5    0.629     71.2
Rghr conc 4   72.6     2.01     1.67    15.9    9.82    6.53    5.79    4.34    15.0    0.534     74.3
Rghr conc 5   83.9     1.76     1.49    15.2    8.85    6.78    5.09    3.86    13.7    0.463     76.9
Rghr tls      995.     0.182    0.232   8.02    0.947   7.43    0.527   0.618   1.33    0.390E-1  97.5

   - CUMULATIVE DISTRIBUTIONS

              Wt       Cu       Ni      Fe      S       Mg      Cp      Pn      Po      Py        Rk
Rghr conc 1   2.92     69.9     41.0    7.35    52.0    1.94    69.9    40.7    47.5    100.      1.67
Rghr conc 2   5.10     76.3     48.4    11.2    67.3    4.00    76.3    47.4    70.0    100.      3.53
Rghr conc 3   6.20     78.7     50.9    12.9    72.0    5.19    78.7    49.6    76.8    100.      4.53
Rghr conc 4   7.30     80.2     52.7    14.5    75.6    6.41    80.2    51.3    82.1    100.      5.57
Rghr conc 5   8.43     81.4     54.2    16.0    78.7    7.69    81.4    52.7    86.7    100.      6.65
Rghr tls      100.     100.0    100.    100.    100.    100.    100.0   100.    100.0   100.      100.

Mineral calculations based on  0.800% Ni in Po
```

```
JT12907: Lac Des Iles Ore (555); 10 min/kg grind 2.0 2/kg Na2CO3,
0.5 g/kg CMC, 0.01 g/kg incremental PAX addition
ERB # 2159

     - ASSAYS

               Wt       Cu       Ni       Fe       S        As       Cp       Pn       Po       Py       Rk
Rghr conc 6   9.76     0.170    0.300    11.1     2.68     8.38     0.491    0.710    5.74     0.000E+0 93.1
Rghr conc 7   7.89     0.150    0.290    11.0     2.55     8.42     0.433    0.688    5.48     0.000E+0 93.4
Rghr conc 8   12.9     0.120    0.250    10.3     2.03     8.28     0.347    0.602    4.32     0.000E+0 94.7
Rghr tls      880.     0.330E-1 0.110    7.23     0.140    7.46     0.953E-1 0.307    0.120E-1 0.000E+0 99.6
TOTAL         911.04   0.037    0.116    7.348    0.215    7.490    0.106    0.319    0.182    0.000    99.394

     - DISTRIBUTIONS

               Wt       Cu       Ni       Fe       S        As       Cp       Pn       Po       Py       Rk
Rghr conc 6   1.07     4.96     2.78     1.62     13.4     1.20     4.96     2.39     33.9     0.000E+0 1.00
Rghr conc 7   0.866    3.54     2.17     1.30     10.3     0.974    3.54     1.87     26.1     0.000E+0 0.814
Rghr conc 8   1.41     4.62     3.06     1.98     13.4     1.56     4.62     2.67     33.6     0.000E+0 1.35
Rghr tls      96.6     86.9     92.0     95.1     63.0     96.3     86.9     93.1     6.40     0.000E+0 96.8

     - CUMULATIVE ASSAYS

               Wt       Cu       Ni       Fe       S        As       Cp       Pn       Po       Py       Rk
Rghr conc 6   9.76     0.170    0.300    11.1     2.68     8.38     0.491    0.710    5.74     0.000E+0 93.1
Rghr conc 7   17.6     0.161    0.296    11.1     2.62     8.40     0.465    0.700    5.62     0.000E+0 93.2
Rghr conc 8   30.5     0.144    0.276    10.7     2.37     8.35     0.415    0.658    5.07     0.000E+0 93.9
Rghr tls      911.     0.367E-1 0.116    7.35     0.215    7.49     0.106    0.319    0.182    0.000E+0 99.4

     - CUMULATIVE DISTRIBUTIONS

               Wt.      Cu       Ni       Fe       S        As       Cp       Pn       Po       Py       Rk
Rghr conc 6   1.07     4.96     2.78     1.62     13.4     1.20     4.96     2.39     33.9     0.000E+0 1.00
Rghr conc 7   1.94     8.50     4.95     2.91     23.6     2.17     8.50     4.25     60.0     0.000E+0 1.82
Rghr conc 8   3.35     13.1     8.01     4.90     37.0     3.74     13.1     6.92     93.6     0.000E+0 3.17
Rghr tls      100.     100.     100.     100.0    100.     100.     100.     100.     100.0    0.000E+0 100.

Mineral calculations based on  0.800% Ni in Po
```

T12913: Lac Des Iles Ore (555); 15 min/kg grind 1.7 g/kg Na2CO3
0.01 g/kg PAX, 0.5 g/kg CMC, 0.04 g/kg PAX, incremental rougher
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Co	Pn	Po	Py	Rk
Rghr conc 1-2	6.40	8.96	4.13	27.1	27.9	2.69	25.9	11.3	11.1	19.7	32.0
Rghr conc 3	7.60	4.51	3.66	22.4	20.2	4.33	13.0	9.80	19.0	8.61	49.6
Rghr conc 4	7.60	2.57	2.86	18.1	13.9	5.85	7.42	7.49	22.3	0.000E+0	62.8
Rghr conc 5	6.50	1.64	2.10	15.2	9.66	7.00	4.74	5.52	15.6	0.000E+0	74.2
Rghr conc 6	15.9	0.610	1.01	11.7	4.30	8.17	1.76	2.66	7.07	0.000E+0	88.5
Rghr conc 7	23.5	0.260	0.460	10.2	2.43	8.59	0.751	1.18	4.48	0.000E+0	93.6
Rghr conc 8	29.6	0.140	0.300	9.67	1.46	8.56	0.404	0.778	2.68	0.000E+0	96.1
Rghr tls	905.	0.250E-1	0.120	7.77	0.300	7.52	0.722E-1	0.326	0.421	0.000E+0	99.2
TOTAL	1002.50	0.164	0.233	8.306	0.938	7.515	0.474	0.626	1.161	0.191	97.548

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Co	Pn	Po	Py	Rk
Rghr conc 1-2	0.638	34.9	11.3	2.08	19.0	0.229	34.9	11.5	6.10	65.9	0.209
Rghr conc 3	0.758	20.8	11.9	2.04	16.3	0.437	20.8	11.9	12.4	34.1	0.385
Rghr conc 4	0.758	11.9	9.29	1.65	11.2	0.591	11.9	9.07	14.5	0.000E+0	0.488
Rghr conc 5	0.648	6.48	5.83	1.19	6.67	0.604	6.48	5.71	8.71	0.000E+0	0.493
Rghr conc 6	1.59	5.90	6.86	2.23	7.27	1.72	5.90	6.75	9.66	0.000E+0	1.44
Rghr conc 7	2.34	3.72	4.62	2.88	6.07	2.68	3.72	4.44	9.05	0.000E+0	2.25
Rghr conc 8	2.95	2.52	3.79	3.44	4.59	3.36	2.52	3.67	6.81	0.000E+0	2.91
Rghr tls	90.3	13.8	46.4	84.5	28.9	90.4	13.8	47.0	32.7	0.000E+0	91.8

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Co	Pn	Po	Py	Rk
Rghr conc 1-2	6.40	8.96	4.13	27.1	27.9	2.69	25.9	11.3	11.1	19.7	32.0
Rghr conc 3	14.0	6.54	3.87	24.5	23.7	3.58	18.9	10.5	15.4	13.7	41.6
Rghr conc 4	21.6	5.15	3.52	22.3	20.3	4.38	14.9	9.43	17.8	8.87	49.0
Rghr conc 5	28.1	4.33	3.19	20.6	17.8	4.99	12.5	8.52	17.3	6.82	54.8
Rghr conc 6	44.0	2.99	2.40	17.4	12.9	6.14	8.63	6.41	13.6	4.36	67.0
Rghr conc 7	67.5	2.04	1.73	14.9	9.27	6.99	5.89	4.59	10.4	2.84	76.3
Rghr conc 8	97.1	1.46	1.29	13.3	6.89	7.47	4.22	3.43	8.06	1.97	82.3
Rghr tls	0.100E+4	0.164	0.233	8.31	0.938	7.52	0.474	0.626	1.16	0.191	97.5

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Co	Pn	Po	Py	Rk
Rghr conc 1-2	0.638	34.9	11.3	2.08	19.0	0.229	34.9	11.5	6.10	65.9	0.209
Rghr conc 3	1.40	55.7	23.2	4.13	35.3	0.665	55.7	23.4	18.5	100.0	0.595
Rghr conc 4	2.15	67.6	32.5	5.78	46.5	1.26	67.6	32.4	33.0	100.0	1.08
Rghr conc 5	2.80	74.1	38.3	6.97	53.2	1.86	74.1	38.2	41.7	100.0	1.58
Rghr conc 6	4.39	80.0	45.2	9.20	60.5	3.58	80.0	44.9	51.4	100.0	3.01
Rghr conc 7	6.73	83.7	49.8	12.1	66.5	6.26	83.7	49.3	60.5	100.0	5.26
Rghr conc 8	9.69	86.2	53.6	15.5	71.1	9.63	86.2	53.0	67.3	100.0	8.17
Rghr tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.0	100.

Mineral calculations based on 0.800% Ni in Po

112909: Lac Des Iles Ore (555); 15 min/kg grind 1.75 g/kg Na2CO3
0.01 g/kg PAX, 0.1 g/kg Creosote, 0.5 g/kg CMC, 0.04 g/kg PAX Rghr
0.02 g/kg PAX, Scav. ERB # 2159

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc	95.0	1.49	1.26	13.1	6.70	7.21	4.30	3.29	10.4	0.000E+0	82.0
Scav conc 1-2	1.20	0.370	0.420	15.4	6.62	5.31	1.07	0.836	15.1	0.000E+0	83.0
Scav conc 3	5.00	0.180	0.300	11.7	3.00	7.23	0.520	0.692	6.54	0.000E+0	92.3
Scav conc 4	4.60	0.140	0.270	11.4	2.57	7.70	0.404	0.629	5.61	0.000E+0	93.4
Scav conc 5	12.8	0.110	0.230	10.7	1.96	7.78	0.318	0.548	4.21	0.000E+0	94.9
Scav conc 6	13.6	0.120	0.240	10.5	1.90	8.08	0.347	0.581	4.00	0.000E+0	95.1
Scav conc 7	17.6	0.960E-1	0.230	10.3	1.65	8.12	0.277	0.565	3.45	0.000E+0	95.7
Scav conc 8	21.6	0.890E-1	0.210	9.90	1.39	8.16	0.257	0.523	2.84	0.000E+0	96.4
Scav tls	837.	0.250E-1	0.110	7.43	0.240	7.47	0.722E-1	0.301	0.290	0.000E+0	99.3
TOTAL	1008.60	0.170	0.228	8.199	0.974	7.481	0.490	0.603	1.521	0.000	97.386

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc	9.42	82.7	52.1	15.0	64.8	9.08	82.7	51.4	64.2	0.000E+0	7.94
Scav conc 1-2	0.119	0.259	0.219	0.223	0.809	0.844E-1	0.259	0.165	1.18	0.000E+0	0.101
Scav conc 3	0.496	0.526	0.653	0.707	1.53	0.479	0.526	0.569	2.13	0.000E+0	0.470
Scav conc 4	0.456	0.376	0.540	0.634	1.20	0.469	0.376	0.476	1.68	0.000E+0	0.437
Scav conc 5	1.27	0.823	1.28	1.66	2.55	1.32	0.823	1.16	3.51	0.000E+0	1.24
Scav conc 6	1.35	0.954	1.42	1.73	2.63	1.46	0.954	1.30	3.55	0.000E+0	1.32
Scav conc 7	1.74	0.987	1.76	2.19	2.96	1.89	0.987	1.64	3.95	0.000E+0	1.71
Scav conc 8	2.14	1.12	1.97	2.59	3.06	2.34	1.12	1.86	4.00	0.000E+0	2.12
Scav tls	83.0	12.2	40.1	75.2	20.5	82.9	12.2	41.4	15.8	0.000E+0	84.7

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc	95.0	1.49	1.26	13.1	6.70	7.21	4.30	3.29	10.4	0.000E+0	82.0
Scav conc 1-2	96.2	1.48	1.25	13.1	6.70	7.19	4.26	3.26	10.4	0.000E+0	82.1
Scav conc 3	101.	1.41	1.20	13.1	6.52	7.19	4.08	3.13	10.2	0.000E+0	82.6
Scav conc 4	106.	1.36	1.16	13.0	6.34	7.21	3.92	3.02	10.0	0.000E+0	83.0
Scav conc 5	119.	1.22	1.06	12.7	5.87	7.27	3.53	2.75	9.40	0.000E+0	84.3
Scav conc 6	132.	1.11	0.977	12.5	5.46	7.36	3.20	2.53	8.85	0.000E+0	85.4
Scav conc 7	150.	0.990	0.889	12.2	5.01	7.45	2.86	2.30	8.21	0.000E+0	86.6
Scav conc 8	171.	0.876	0.804	12.0	4.56	7.54	2.53	2.08	7.54	0.000E+0	87.9
Scav tls	0.101E+4	0.170	0.226	8.20	0.974	7.48	0.490	0.603	1.52	0.000E+0	97.4

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc	9.42	82.7	52.1	15.0	64.8	9.08	82.7	51.4	64.2	0.000E+0	7.94
Scav conc 1-2	9.54	83.0	52.3	15.3	65.6	9.16	83.0	51.6	65.3	0.000E+0	8.04
Scav conc 3	10.0	83.5	53.0	16.0	67.1	9.64	83.5	52.1	67.5	0.000E+0	8.51
Scav conc 4	10.5	83.9	53.5	16.6	68.3	10.1	83.9	52.6	69.2	0.000E+0	8.94
Scav conc 5	11.8	84.7	54.8	18.3	70.9	11.4	84.7	53.8	72.7	0.000E+0	10.2
Scav conc 6	13.1	85.7	56.2	20.0	73.5	12.9	85.7	55.1	76.2	0.000E+0	11.5
Scav conc 7	14.9	86.6	58.0	22.2	76.5	14.8	86.6	56.7	80.2	0.000E+0	13.2
Scav conc 8	17.0	87.8	59.9	24.8	79.5	17.1	87.8	58.6	84.2	0.000E+0	15.3
Scav tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	0.000E+0	100.

Mineral calculations based on 0.800% Ni in Po

T12909: Lac Des Iles Ore (SSS); 15 min/kg grind 1.75 g/kg Na2CO3
0.01 g/kg PAX, 0.1 g/kg Creosote, 0.5 g/kg CMC, 0.04 g/kg PAX Rghr
0.02 g/kg PAX, Scav. ERB # 2159

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-2	1.20	0.370	0.420	15.4	6.62	5.31	1.07	0.836	15.1	0.000E+0	83.0
Scav conc 3	5.00	0.180	0.300	11.7	3.00	7.23	0.520	0.692	6.54	0.000E+0	92.3
Scav conc 4	4.60	0.140	0.270	11.4	2.57	7.70	0.404	0.629	5.61	0.000E+0	93.4
Scav conc 5	12.8	0.110	0.230	10.7	1.95	7.78	0.318	0.548	4.21	0.000E+0	94.9
Scav conc 6	13.6	0.120	0.240	10.5	1.90	8.08	0.347	0.581	4.00	0.000E+0	95.1
Scav conc 7	17.6	0.960E-1	0.230	10.3	1.65	8.12	0.277	0.565	3.45	0.000E+0	95.7
Scav conc 8	21.6	0.890E-1	0.210	9.90	1.39	8.16	0.257	0.523	2.84	0.000E+0	96.4
Scav tls	837.	0.250E-1	0.110	7.43	0.240	7.47	0.722E-1	0.301	0.290	0.000E+0	99.3
TOTAL	913.60	0.032	0.121	7.689	0.378	7.509	0.093	0.323	0.602	0.000	98.981

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-2	0.131	1.50	0.458	0.263	2.30	0.929E-1	1.50	0.340	3.29	0.000E+0	0.110
Scav conc 3	0.547	3.04	1.36	0.833	4.34	0.527	3.04	1.17	5.94	0.000E+0	0.510
Scav conc 4	0.504	2.18	1.13	0.747	3.42	0.516	2.18	0.980	4.69	0.000E+0	0.475
Scav conc 5	1.40	4.76	2.67	1.95	7.26	1.45	4.76	2.38	9.80	0.000E+0	1.34
Scav conc 6	1.49	5.52	2.96	2.03	7.47	1.60	5.52	2.67	9.90	0.000E+0	1.43
Scav conc 7	1.93	5.71	3.68	2.58	8.40	2.08	5.71	3.37	11.0	0.000E+0	1.86
Scav conc 8	2.36	6.50	4.12	3.04	8.69	2.57	6.50	3.83	11.2	0.000E+0	2.30
Scav tls	91.6	70.8	83.6	88.6	58.1	91.2	70.8	85.3	44.2	0.000E+0	92.0

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-2	1.20	0.370	0.420	15.4	6.62	5.31	1.07	0.836	15.1	0.000E+0	83.0
Scav conc 3	6.20	0.217	0.323	12.4	3.70	6.86	0.626	0.720	8.19	0.000E+0	90.5
Scav conc 4	10.8	0.184	0.301	12.0	3.22	7.22	0.532	0.681	7.09	0.000E+0	91.7
Scav conc 5	23.6	0.144	0.262	11.3	2.54	7.52	0.416	0.609	5.53	0.000E+0	93.4
Scav conc 6	37.2	0.135	0.254	11.0	2.30	7.73	0.390	0.599	4.97	0.000E+0	94.0
Scav conc 7	54.8	0.123	0.246	10.8	2.09	7.85	0.354	0.588	4.48	0.000E+0	94.6
Scav conc 8	76.4	0.113	0.236	10.5	1.89	7.94	0.327	0.570	4.02	0.000E+0	95.1
Scav tls	914.	0.324E-1	0.121	7.69	0.378	7.51	0.935E-1	0.323	0.602	0.000E+0	99.0

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-2	0.131	1.50	0.458	0.263	2.30	0.929E-1	1.50	0.340	3.29	0.000E+0	0.110
Scav conc 3	0.679	4.55	1.82	1.10	6.64	0.620	4.55	1.51	9.23	0.000E+0	0.620
Scav conc 4	1.18	6.72	2.95	1.84	10.1	1.14	6.72	2.49	13.9	0.000E+0	1.10
Scav conc 5	2.58	11.5	5.62	3.79	17.3	2.59	11.5	4.87	23.7	0.000E+0	2.44
Scav conc 6	4.07	17.0	8.58	5.82	24.8	4.19	17.0	7.54	33.6	0.000E+0	3.87
Scav conc 7	6.00	22.7	12.3	8.41	33.2	6.27	22.7	10.9	44.7	0.000E+0	5.73
Scav conc 8	8.36	29.2	16.4	11.4	41.9	8.84	29.2	14.7	55.8	0.000E+0	8.03
Scav tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	0.000E+0	100.0

Mineral calculations based on 0.800% Ni in Po

T12924: Lac Des Iles Ore (555); 15 min/kg grind,1.85 g/kg Na2CO3,
0.01 g/kg PAX, 0.2 g/kg Creosote, 0.5 g/kg CMC, 0.04 g/kg PAX Rghr
0.04 g/kg PAX scav inc., 20 min regrind, 0.025 g/kg CMC Clnr inc.

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	3.50	6.66	3.57	21.6	19.8	4.37	19.2	9.59	17.3	5.24	48.7
Clnr conc 3	2.80	7.69	4.65	24.4	24.3	3.78	22.2	12.7	12.7	13.3	39.1
Clnr conc 4	1.60	7.91	4.82	25.0	25.4	3.81	22.8	13.2	11.3	15.7	37.0
Clnr conc 5	2.70	5.77	4.15	21.3	19.9	5.07	16.7	11.2	15.6	7.34	49.1
Clnr conc 6	3.50	3.81	3.25	18.0	14.7	6.30	11.0	8.63	20.2	0.000E+0	60.2
Clnr conc 7	2.60	2.78	2.64	16.0	11.2	6.57	8.03	7.03	15.3	0.000E+0	69.6
Clnr conc 8	2.60	2.19	2.03	14.8	9.18	7.43	6.33	5.38	13.1	0.000E+0	75.2
Clnr tls	58.3	0.410	0.740	12.1	3.87	7.28	1.18	1.91	7.13	0.000E+0	89.8
Rghr conc 2	7.50	0.170	0.300	9.60	1.55	8.25	0.491	0.775	2.83	0.000E+0	95.9
Rghr conc 3	7.00	0.150	0.280	9.50	1.46	8.22	0.433	0.722	2.70	0.000E+0	96.1
Scav conc 1-4	12.3	0.140	0.300	11.8	2.88	7.49	0.404	0.696	6.33	0.000E+0	92.6
Scav conc 5	8.90	0.120	0.260	11.2	2.36	7.77	0.347	0.611	5.14	0.000E+0	93.9
Scav conc 6	17.8	0.930E-1	0.220	10.1	1.63	7.79	0.269	0.538	3.43	0.000E+0	95.8
Scav conc 7	14.3	0.880E-1	0.220	10.0	1.59	7.98	0.254	0.540	3.34	0.000E+0	95.9
Scav conc 8	30.5	0.680E-1	0.190	9.31	1.08	7.93	0.196	0.483	2.15	0.000E+0	97.2
Scav tls	803.	0.250E-1	0.110	7.48	0.180	7.52	0.722E-1	0.304	0.136	0.000E+0	99.5
TOTAL	979.40	0.157	0.227	8.260	0.888	7.501	0.452	0.608	1.188	0.102	97.649

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	0.357	15.2	5.61	0.934	7.97	0.208	15.2	5.63	5.19	18.3	0.178
Clnr conc 3	0.286	14.0	5.85	0.844	7.83	0.144	14.0	5.97	3.06	37.0	0.114
Clnr conc 4	0.163	8.25	3.47	0.494	4.67	0.830E-1	8.25	3.55	1.55	25.0	0.618E-1
Clnr conc 5	0.276	10.2	5.03	0.711	6.18	0.186	10.2	5.10	3.63	19.7	0.139
Clnr conc 6	0.357	8.69	5.11	0.773	5.92	0.300	8.69	5.07	6.07	0.000E+0	0.220
Clnr conc 7	0.265	4.71	3.08	0.514	3.35	0.233	4.71	3.07	3.42	0.000E+0	0.189
Clnr conc 8	0.265	3.71	2.37	0.476	2.75	0.263	3.71	2.35	2.93	0.000E+0	0.204
Clnr tls	5.95	15.6	19.4	8.72	26.0	5.78	15.6	18.7	35.7	0.000E+0	5.47
Rghr conc 2	0.766	0.831	1.01	0.890	1.34	0.842	0.831	0.975	1.83	0.000E+0	0.752
Rghr conc 3	0.715	0.684	0.881	0.822	1.18	0.783	0.684	0.848	1.62	0.000E+0	0.704
Scav conc 1-4	1.26	1.12	1.66	1.79	4.07	1.25	1.12	1.44	6.69	0.000E+0	1.19
Scav conc 5	0.909	0.696	1.04	1.23	2.42	0.941	0.696	0.914	3.93	0.000E+0	0.874
Scav conc 6	1.82	1.08	1.76	2.22	3.34	1.89	1.08	1.61	5.24	0.000E+0	1.78
Scav conc 7	1.46	0.820	1.41	1.77	2.62	1.55	0.820	1.30	4.10	0.000E+0	1.43
Scav conc 8	3.11	1.35	2.60	3.51	3.79	3.29	1.35	2.47	5.63	0.000E+0	3.10
Scav tls	82.0	13.1	39.7	74.3	16.6	82.3	13.1	41.0	9.37	0.000E+0	83.6

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	3.50	6.66	3.57	21.6	19.8	4.37	19.2	9.59	17.3	5.24	48.7
Clnr conc 3	6.30	7.12	4.05	22.8	21.8	4.11	20.6	11.0	15.2	8.81	44.4
Clnr conc 4	7.90	7.28	4.21	23.3	22.5	4.05	21.0	11.4	14.4	10.2	42.9
Clnr conc 5	10.6	6.89	4.19	22.8	21.9	4.31	19.9	11.4	14.7	9.47	44.5
Clnr conc 6	14.1	6.13	3.96	21.6	20.1	4.80	17.7	10.7	16.1	7.12	48.4
Clnr conc 7	16.7	5.61	3.75	20.7	18.7	5.08	16.2	10.1	16.0	6.01	51.7
Clnr conc 8	19.3	5.15	3.52	19.9	17.4	5.39	14.9	9.49	15.6	5.20	54.9
Clnr tls	77.6	1.59	1.43	14.0	7.24	6.81	4.59	3.79	9.23	1.29	81.1
Rghr conc 2	85.1	1.46	1.33	13.7	6.74	6.94	4.23	3.53	8.67	1.18	82.4
Rghr conc 3	92.1	1.36	1.25	13.3	6.34	7.04	3.94	3.31	8.21	1.09	83.4
Scav conc 1-4	104.	1.22	1.14	13.2	5.93	7.09	3.52	3.01	7.99	0.962	84.5
Scav conc 5	113.	1.13	1.07	13.0	5.65	7.14	3.27	2.82	7.77	0.886	85.3
Scav conc 6	131.	0.992	0.955	12.6	5.10	7.23	2.86	2.51	7.18	0.766	86.7
Scav conc 7	145.	0.903	0.883	12.4	4.76	7.30	2.61	2.31	6.80	0.690	87.6
Scav conc 8	176.	0.758	0.763	11.9	4.12	7.41	2.19	2.00	5.99	0.571	89.2
Scav tls	979.	0.157	0.227	8.26	0.888	7.50	0.452	0.608	1.19	0.102	97.6

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	0.357	15.2	5.61	0.934	7.97	0.208	15.2	5.63	5.19	18.3	0.178
Clnr conc 3	0.643	29.2	11.5	1.78	15.8	0.352	29.2	11.6	8.26	55.3	0.293
Clnr conc 4	0.807	37.5	14.9	2.27	20.5	0.435	37.5	15.2	9.81	80.3	0.354
Clnr conc 5	1.08	47.6	20.0	2.98	26.7	0.622	47.6	20.3	13.4	100.0	0.493
Clnr conc 6	1.44	56.3	25.1	3.76	32.6	0.922	56.3	25.3	19.5	100.0	0.713
Clnr conc 7	1.71	61.0	28.2	4.28	35.9	1.15	61.0	28.4	22.9	100.0	0.903
Clnr conc 8	1.97	64.7	30.5	4.75	38.7	1.42	64.7	30.7	25.9	100.0	1.11
Clnr tls	7.92	80.3	49.9	13.5	64.6	7.19	80.3	49.4	61.6	100.0	6.58
Rghr conc 2	8.69	81.2	50.9	14.4	66.0	8.04	81.2	50.4	63.4	100.0	7.33
Rghr conc 3	9.40	81.8	51.8	15.2	67.1	8.82	81.8	51.2	65.0	100.0	8.04
Scav conc 1-4	10.7	83.0	53.5	17.0	71.2	10.1	83.0	52.7	71.7	100.0	9.23
Scav conc 5	11.6	83.7	54.5	18.2	73.6	11.0	83.7	53.6	75.6	100.0	10.1
Scav conc 6	13.4	84.7	56.3	20.4	77.0	12.9	84.7	55.2	80.9	100.0	11.9
Scav conc 7	14.8	85.6	57.7	22.2	79.6	14.5	85.6	56.5	85.0	100.0	13.3
Scav conc 8	18.0	86.9	60.3	25.7	83.4	17.7	86.9	59.0	90.6	100.0	16.4
Scav tls	100.	100.	100.	100.	100.	100.0	100.0	100.	100.	100.0	100.

T12924: Lac Des Iles Ore (555); 15 min/kg grind, 1.85g/kg Na2CO3,
0.01 g/kg PAI, 0.2 g/kg Creosote, 0.5 g/kg CMC, 0.04 g/kg PAI Rghr
0.04 g/kg PAI scav inc., 20 min regrind, 0.025 g/kg CMC Clnr inc.

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	3.50	6.66	3.57	21.6	19.8	4.37	19.2	9.59	17.3	5.24	48.7
Clnr conc 3	2.80	7.69	4.65	24.4	24.3	3.78	22.2	12.7	12.7	13.3	39.1
Clnr conc 4	1.60	7.91	4.82	25.0	25.4	3.81	22.8	13.2	11.3	15.7	37.0
Clnr conc 5	2.70	5.77	4.15	21.3	19.9	5.07	16.7	11.2	15.6	7.34	49.1
Clnr conc 6	3.50	3.81	3.25	18.0	14.7	6.30	11.0	8.63	20.2	0.000E+0	60.2
Clnr conc 7	2.60	2.78	2.64	16.0	11.2	6.57	8.03	7.03	15.3	0.000E+0	69.6
Clnr conc 8	2.60	2.19	2.03	14.8	9.18	7.43	6.33	5.38	13.1	0.000E+0	75.2
Clnr tls	58.3	0.410	0.740	12.1	3.87	7.28	1.18	1.91	7.13	0.000E+0	89.8
TOTAL	77.60	1.588	1.432	14.046	7.239	6.811	4.587	3.793	9.231	1.294	81.096

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.51	18.9	11.2	6.94	12.3	2.89	18.9	11.4	8.43	18.3	2.71
Clnr conc 3	3.61	17.5	11.7	6.27	12.1	2.00	17.5	12.1	4.98	37.0	1.74
Clnr conc 4	2.06	10.3	6.94	3.67	7.23	1.15	10.3	7.18	2.52	25.0	0.939
Clnr conc 5	3.48	12.6	10.1	5.28	9.56	2.59	12.6	10.3	5.89	19.7	2.11
Clnr conc 6	4.51	10.8	10.2	5.78	9.16	4.17	10.8	10.3	9.86	0.000E+0	3.35
Clnr conc 7	3.35	5.87	6.18	3.82	5.18	3.23	5.87	6.21	5.55	0.000E+0	2.88
Clnr conc 8	3.35	4.62	4.75	3.53	4.25	3.65	4.62	4.75	4.75	0.000E+0	3.11
Clnr tls	75.1	19.4	38.8	64.7	40.2	80.3	19.4	37.8	58.0	0.000E+0	83.2

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	3.50	6.66	3.57	21.6	19.8	4.37	19.2	9.59	17.3	5.24	48.7
Clnr conc 3	6.30	7.12	4.05	22.8	21.8	4.11	20.6	11.0	15.2	8.81	44.4
Clnr conc 4	7.90	7.28	4.21	23.3	22.5	4.05	21.0	11.4	14.4	10.2	42.9
Clnr conc 5	10.6	6.89	4.19	22.8	21.9	4.31	19.9	11.4	14.7	9.47	44.5
Clnr conc 6	14.1	6.13	3.96	21.6	20.1	4.80	17.7	10.7	16.1	7.12	48.4
Clnr conc 7	16.7	5.61	3.75	20.7	18.7	5.08	16.2	10.1	16.0	6.01	51.7
Clnr conc 8	19.3	5.15	3.52	19.9	17.4	5.39	14.9	9.49	15.6	5.20	54.9
Clnr tls	77.6	1.59	1.43	14.0	7.24	6.81	4.59	3.79	9.23	1.29	81.1

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.51	18.9	11.2	6.94	12.3	2.89	18.9	11.4	8.43	18.3	2.71
Clnr conc 3	8.12	36.4	23.0	13.2	24.4	4.90	36.4	23.5	13.4	55.3	4.45
Clnr conc 4	10.2	46.7	29.9	16.9	31.7	6.05	46.7	30.7	15.9	80.3	5.39
Clnr conc 5	13.7	59.3	40.0	22.2	41.2	8.64	59.3	41.0	21.8	100.0	7.49
Clnr conc 6	18.2	70.1	50.2	27.9	50.4	12.8	70.1	51.2	31.7	100.0	10.8
Clnr conc 7	21.5	76.0	56.4	31.7	55.6	16.0	76.0	57.5	37.2	100.0	13.7
Clnr conc 8	24.9	80.6	61.2	35.3	59.8	19.7	80.6	62.2	42.0	100.0	16.8
Clnr tls	100.	100.0	100.	100.	100.	100.	100.0	100.	100.	100.0	100.

Mineral calculations based on 0.800% Ni in Po

T12924: Lac Des Iles Ore (555); optimization of rougher [illegible]

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	77.6	1.59	1.43	14.0	7.24	6.81	4.59	3.75	11.1	0.000E+0	80.6
Rghr conc 2	7.50	0.170	0.300	9.60	1.55	8.25	0.491	0.775	2.83	0.000E+0	95.9
Rghr conc 3	7.00	0.150	0.280	9.50	1.46	8.22	0.433	0.722	2.70	0.000E+0	96.1
Rghr tls	887.	0.310E-1	0.120	7.73	0.320	7.55	0.895E-1	0.325	0.457	0.000E+0	99.1
TOTAL	979.40	0.156	0.226	8.254	0.886	7.502	0.452	0.602	1.333	0.000	97.613

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	7.92	80.5	50.1	13.4	64.8	7.19	80.5	49.3	65.9	0.000E+0	6.54
Rghr conc 2	0.766	0.832	1.02	0.891	1.34	0.842	0.832	0.985	1.63	0.000E+0	0.752
Rghr conc 3	0.715	0.685	0.884	0.823	1.18	0.783	0.685	0.856	1.45	0.000E+0	0.704
Rghr tls	90.6	18.0	48.0	84.8	32.7	91.2	18.0	48.9	31.0	0.000E+0	92.0

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	77.6	1.59	1.43	14.0	7.24	6.81	4.59	3.75	11.1	0.000E+0	80.6
Rghr conc 2	85.1	1.46	1.33	13.6	6.74	6.94	4.23	3.48	10.4	0.000E+0	81.9
Rghr conc 3	92.1	1.36	1.25	13.3	6.34	7.03	3.94	3.27	9.78	0.000E+0	83.0
Rghr tls	979.	0.156	0.226	8.25	0.886	7.50	0.452	0.602	1.33	0.000E+0	97.6

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Rghr conc 1	7.92	80.5	50.1	13.4	64.8	7.19	80.5	49.3	65.9	0.000E+0	6.54
Rghr conc 2	8.69	81.4	51.1	14.3	66.1	8.04	81.4	50.3	67.5	0.000E+0	7.29
Rghr conc 3	9.40	82.0	52.0	15.2	67.3	8.82	82.0	51.1	69.0	0.000E+0	8.00
Rghr tls	100.	100.	100.	100.	100.	100.0	100.	100.	100.	0.000E+0	100.

Mineral calculations based on 0.800% Ni in Po

T12924; Lac Des Iles Ore (555); 15 min/kg grind, 1.85 g/kg Na2CO3,
0.01 g/kg PAX, 0.2 g/kg Creosote, 0.5 g/kg CMC, 0.04 g/kg PAX Rghr
0.04 g/kg PAX scav inc.; 20 min regrind, 0.025 g/kg CMC Clnr inc.

- ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-4	12.3	0.140	0.300	11.8	2.88	7.49	0.404	0.696	6.33	0.000E+0	92.6
Scav conc 5	8.90	0.120	0.260	11.2	2.36	7.77	0.347	0.611	5.14	0.000E+0	93.9
Scav conc 6	17.8	0.930E-1	0.220	10.1	1.63	7.79	0.269	0.538	3.43	0.000E+0	95.8
Scav conc 7	14.3	0.880E-1	0.220	10.0	1.59	7.98	0.254	0.540	3.34	0.000E+0	95.9
Scav conc 8	30.5	0.680E-1	0.190	9.31	1.08	7.93	0.196	0.483	2.15	0.000E+0	97.2
Scav tls	803.	0.250E-1	0.110	7.48	0.180	7.52	0.722E-1	0.304	0.136	0.000E+0	99.5
TOTAL	887.30	0.031	0.121	7.733	0.322	7.549	0.091	0.327	0.459	0.000	99.123

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-4	1.39	6.18	3.44	2.12	12.4	1.38	6.18	2.95	19.1	0.000E+0	1.29
Scav conc 5	1.00	3.83	2.16	1.45	7.35	1.03	3.83	1.87	11.2	0.000E+0	0.950
Scav conc 6	2.01	5.94	3.65	2.62	10.2	2.07	5.94	3.30	15.0	0.000E+0	1.94
Scav conc 7	1.61	4.52	2.93	2.08	7.96	1.70	4.52	2.66	11.7	0.000E+0	1.56
Scav conc 8	3.44	7.44	5.40	4.14	11.5	3.61	7.44	5.07	16.1	0.000E+0	3.37
Scav tls	90.6	72.1	82.4	87.6	50.6	90.2	72.1	84.2	26.8	0.000E+0	90.9

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-4	12.3	0.140	0.300	11.8	2.88	7.49	0.404	0.696	6.33	0.000E+0	92.6
Scav conc 5	21.2	0.132	0.283	11.5	2.66	7.61	0.380	0.661	5.83	0.000E+0	93.1
Scav conc 6	39.0	0.114	0.254	10.9	2.19	7.69	0.329	0.605	4.73	0.000E+0	94.3
Scav conc 7	53.3	0.107	0.245	10.6	2.03	7.77	0.309	0.587	4.36	0.000E+0	94.7
Scav conc 8	83.8	0.928E-1	0.225	10.2	1.68	7.83	0.268	0.549	3.56	0.000E+0	95.6
Scav tls	887.	0.314E-1	0.121	7.73	0.322	7.55	0.907E-1	0.327	0.459	0.000E+0	99.1

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	Mg	Cp	Pn	Po	Py	Rk
Scav conc 1-4	1.39	6.18	3.44	2.12	12.4	1.38	6.18	2.95	19.1	0.000E+0	1.29
Scav conc 5	2.39	10.0	5.60	3.57	19.7	2.41	10.0	4.82	30.4	0.000E+0	2.24
Scav conc 6	4.40	16.0	9.25	6.19	29.9	4.48	16.0	8.12	45.4	0.000E+0	4.18
Scav conc 7	6.01	20.5	12.2	8.27	37.9	6.18	20.5	10.8	57.1	0.000E+0	5.74
Scav conc 8	9.44	27.9	17.6	12.4	49.4	9.79	27.9	15.8	73.2	0.000E+0	9.11
Scav tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	0.000E+0	100.

Mineral calculations based on 0.800% Ni in Po

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Subject
Lac des Iles Mines-
ROCK (MgO) REJECTION

Report Number: Progress Report #3 - December 1992
Project Number: 96-R410-04
Date: 5 February 1993

Author
Germain Labonté and Kevin Stewart

Author / Approved / Approved
RSC

1 Summary

Testwork for proving the applicability of the sodium sulfide/nitrogen gas flotation procedure for MgO rejection on fresh bulk concentrate from the Lac des Iles ore continued.

With a concentrate regrind to around 80% - 11 μm, a first cleaner flotation was conducted at pH 9.5 (soda ash) with 0.075 g/kg ore of CMC (Finnfix-300) and 0.04 g/kg ore of PAX. The concentrate graded 4.5% Cu, 3.4% Ni, 18% S and 9.2% MgO with recoveries of 76% for Cu, 41% for Ni, and 58% for S.

A second cleaning stage brought the MgO content to 4.3% and increased the grades of the values to 7% Cu, 5% Ni, 30% S, 23 ppm Pt, 386 ppm Pd and 28 ppm Au. The recoveries of the values were 70% for Cu, 36% for Ni, 46% for S, 55% for Pt and Pd, and 67% for Au.

Nearly linear relationships were established between the precious metals recoveries and the sulfur recovery. Using these relationships, test results, and numerical simulations, it was determined that not only a first cleaner-scavenger stage is required but its concentrate should be combined with that of the first cleaner for feeding the second cleaner stage.

The third and last part of the test program will focus on the application of the sodium suflide/nitrogen gas flotation scheme on the first cleaner concentrate and the combined first cleaner and first cleaner-scavenger concentrates. Given the grades achieved in the two first cleaner stages, it appears that it will not be necessary to perform a second cleaner prior to application of the scheme.

Distribution: R.A. Alcock, R.E. Butler (2), B.R. Conard, R. Stratton-Crawley, Library

2 Introduction

The project was initiated when Lac des Iles Mines (then called Madeleine Mines) offered its stock pile of bulk copper/nickel concentrate to INCO for smelting and refining. The high content in Platinum Group Metals (PGMs) of the concentrate was interesting. However, the MgO content (around 10%) was above the acceptable limit of 5.0%.

Testwork for MgO rejection from the concentrate sample indicated that the most effective approach was to perform a reverse flotation of the highly hydrophobic silicate minerals. Potential controlled sodium sulfide addition (with nitrogen as flotation gas) or fixed dosage addition of sodium trithiocarbonate (Orfom D-8) were used to depress the copper and nickel sulfides (Progress Report #1, December 1991).

Either of these schemes could bring down the MgO content of the sulfide product to 4.0% or less with around 95% recoveries of the base and precious metals. These results prompted negotiations between INCO and Lac des Iles Mines as to a possible smelter contract. During these discussions, it was determined that additional testwork would be required to prove the proposed processing scheme on fresh bulk copper/nickel concentrate.

A technological exchange agreement was drafted on August 19th, 1992, and testwork commenced at the end of October 1992 on Lac des Iles Ore Composite M92. The first part of the testwork (Progress Report #2, November 1992) dealt with the rougher and scavenger section of the flowsheet to achieve a bulk concentrate of grades and metal recoveries similar to those obtained at Lakefield Research with the JRGRL practices.

This report addresses the second part of the project, namely the cleaning of the bulk concentrate prior to application of the sodium sulfide/nitrogen gas flotation scheme for ultimate MgO rejection.

3 Material and Procedure

The analyses of the Lac des Iles samples can be found table 1. Also shown are the analyses of the residues of bromine alcohol leaches. The precious metal analyses of all feed samples can be found in table 2. For reference, the analyses of the previous samples (bulk concentrate (527) and ore (528)) are included with those of the present ore sample (555; Composite M92) which is used for this testwork. The analyses of the original Composite M92, as given by Lakefield Research are also provided in tables 1 and 2. The analyses of the fresh ore sample (555) agree well with those given for the original Composite M92 of which it is a sub-sample.

The fresh Lac des Iles ore sample (555) contains slightly less copper and nickel than the previous one. However, it contains more iron and sulfur and hence there is more pyrrhotite than chalcopyrite and pentlandite in the sample (table 2). The chemical assays of the ore do not yield pyrite in the estimated mineral composition although pyrite was estimated in some flotation test products.

Table 1 Analyses of the Lac des Iles Mines samples.

Sample	Product	Analysis (%)								Distribution (%)	
		Cu	Ni	Fe	S	MgO	SiO_2	Al_2O_3	CaO	Wt	Ni
Conc. (527)	Feed	6.27	3.77	17.1	16.9	9.7	27.6	4.8	3.2	100.0	100.0
Ore (528)	Feed	0.25	0.26	5.3	0.77	10.1	47.3	16.1	9.8	100.0	100.0
	BAL Residues	0.05	0.08	4.7	0.33	10.2	47.7	17.5	9.7	97.6	30.0
Ore (555)	Feed	0.18	0.22	7.9	0.97	12.2	47.7	13.5	6.9	100.0	100.0
	BAL Residues	0.01	0.09	7.3	0.32	12.5	48.8	14.1	7.3	97.6	39.5
M92	Feed	0.18	0.24	7.9	1.03	N.A.	N.A.	N.A.	N.A.	-	-

Bromine alcohol leach assays indicates that 61.1% of the nickel in the ore (sample 555) would be recoverable by flotation. This estimate is lower than the 70.0% flotation recovery predicted for the previous ore sample. The difference between the two ore samples lies mostly in the lower nickel assay for the fresh ore sample (0.22% Ni vs 0.26% Ni); the bromine alcohol leach residue contains nearly the same amount of nickel in both cases (0.09% Ni vs 0.08% Ni).

The sulfur assay in the bromine alcohol leach residues is higher than one would expect even though two bromine alcohol leaches were performed consecutively to minimize passivation of the sulfur. It is possible that very fine grained pyrrhotite is still fully enclosed in silicates at the product size (-75 μm) normally used for assaying purposes.

Table 2 Precious metal assays and mineral compositions of the Lac des Iles Mines samples.

Sample	Analysis (% or ppm)								
	Cp	Pn	Po	Rk	Pt	Pd	Au	Rh	Ir
Conc. (527)	18.1	10.2	13.1	58.6	7.8	109	12.8	0.2	0.5
Ore (528)	0.7	0.7	0.7	97.9	0.6	4.9	0.5	0.02	0.09
Ore (555)	0.5	0.6	1.5	97.4	0.6	10.1	0.6	N.A.	N.A.
M92	N.A.	N.A.	N.A.	N.A.	0.59	9.87	0.42	N.A.	N.A.

X-Ray Diffraction analyses indicated that chlorite and tremolite are the major non-sulfide minerals in the ore sample. Minor amounts of talc, quartz, and feldspar were also detected. The pyrrhotite and pyrite contents were high enough to be detected (trace amounts) but this was not the case for chalcopyrite and pentlandite.

Since one part of the testwork is an adaptation of an existing laboratory flowsheet, targets were defined from the locked cycle tests performed in the original development work (1):

-Primary grind to 90% -75 μm

-Rougher plus scavenger recoveries:
  ≈ 85% for copper, ≈ 65% for nickel, and ≈ 90% for sulfur
  ≈ 85% for palladium (to be assessed sporadically)
  ≈ 80% for gold and platinum (to be assessed sporadically)

-Rougher plus scavenger concentrate grades:
  approximately 1.0% Cu, 1.0% Ni, 7.0% S

-Regrind to approximately 95% -45 μm (optimum recoveries?)

-First cleaner grades and recoveries:
  approximately 3.0% Cu (80% rec.), 2.5% Ni (45% rec.), 16.0% S

-Second cleaner grades and recoveries:
  approximately 5.0% Cu (75% rec.), 3.5% Ni (40% rec.), 24.0% S

These targets were not taken in absolute terms but rather were used to ensure that the bulk copper/nickel concentrate which would eventually be subjected to the sodium sulfide/nitrogen gas flotation scheme would be of comparable quality to that expected in the Lac des Iles plant.

As defined in previous tests (Progress Report #2; November 1992), the adapted flowsheet consists of a primary grind of 15 min/kg (90% -75 μm) with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.2 g/kg creosote. Rougher flotation is conducted at pH 9.5 with 0.5 g/kg CMC (Finnfix-300) as rock depressant and a further addition of 0.04 g/kg PAX. A scavenger stage is also performed after a 0.05 g/kg copper sulfate pentahydrate and a 0.04 g/kg PAX conditioning stages.

These rougher and scavenger conditions were kept constant while the regrind time and cleaning conditions (one or two stages) were investigated. Also, the possible improvements in recoveries through the use of a second scavenger stage and/or a first cleaner scavenger stage were examined in some tests.

Two rougher/scavenger tests are used (total of 2 kg of feed) to produce the concentrate for cleaning to avoid inherent scale-up mishaps with either using a larger rougher/scavenger flotation cell or a higher pulp density in the same cell size.

An Attritor (also known as stirred ball mill) was used as the concentrate regrind unit rather than the laboratory ball mill. This was for convenience as the Attritor achieves equivalent product size to a ball mill in about a fifth of the time required in the ball mill.

The actual test procedures are described below.

First cleaner rate test with optimized rougher/scavenger

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #2 at 65% solids with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.20 g/kg creosote for 15 min/kg

ROUGHER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute

-PAX conditioning (0.04 g/kg) for 1 minute

-2.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 10 minutes (600 seconds)

SCAVENGER

-Copper sulfate pentahydrate conditioning (0.05 g/kg) for 5 minutes. Maintain pH 9.5

-PAX conditioning (0.04 g/kg) for 1 minute

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 12 minutes (780 seconds)

CONCENTRATE REGRIND

-Repeat the primary grind, rougher, and scavenger and combine all concentrates

-Filter the concentrates (keep the filtrate for washing and initial pulp level adjustment)

-Regrind the rougher for 5 minutes in the Attritor at approximately 60% solids with 0.5 g/kg soda ash (80% stainless steel and 20% mild steel ball charge; 2 kg)

1ST CLEANER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.25 g/kg concentrate (0.075 g/kg ore); Finnfix-300) for 1 minute

-PAX conditioning (0.35 g/kg concentrate (0.04 g/kg ore)) for 1 minute

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

VARIATIONS

-Incremental second scavenger with 0.02 g/kg ore dodecyl mercaptan (DDM)
-Attritor regrind time of 10 minutes
-No PAX added to 1st cleaner

Second cleaner rate test with optimized rougher/scavenger/1st cleaner

-Primary grinding of 1.0 kg Lac Des Iles Ore (555) sample in Rod Mill #2 at 65% solids with 1.85 g/kg soda ash, 0.01 g/kg PAX, and 0.20 g/kg creosote for 15 min/kg

ROUGHER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.5 g/kg; Finnfix-300) for 1 minute
-PAX conditioning (0.04 g/kg) for 1 minute

-2.0 ml of frother (1.0% MIBC solution) at 30 seconds prior to flotation

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 10 minutes (600 seconds)

SCAVENGER

-Copper sulfate pentahydrate conditioning (0.05 g/kg) for 5 minutes. Maintain pH 9.5

-PAX conditioning (0.04 g/kg) for 1 minute

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 12 minutes (780 seconds)

CONCENTRATE REGRIND

-Repeat the primary grind, rougher, and scavenger and combine all concentrates

-Filter the concentrates (keep the filtrate for washing and initial pulp level adjustment)

-Regrind the rougher for 5 minutes in the Attritor at approximately 60% solids with 0.5 g/kg soda ash (80% stainless steel and 20% mild steel ball charge; 2 kg)

1ST CLEANER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-CMC conditioning (0.25 g/kg concentrate (0.075 g/kg ore); Finnfix-300) for 1 minute
-PAX conditioning (0.35 g/kg concentrate (0.04 g/kg ore)) for 1 minute

-Flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) for 6.5 minutes (390 seconds)

2ND CLEANER

-2.2 l cell, 22 Hertz, pulp level at 70 mm from top of cell (room tempered pH 9.5 soda ash water as make-up water). Finalize pH to 9.5 with soda ash if required (5 minutes)

-Incremental flotation at 0.2 sec^{-1} froth skimming frequency, 3.0 l/min air and 0.1% frother (MIBC) as required (12 minutes)

VARIATION

-Incremental 1st cleaner scavenger with 0.035 g/kg concentrate (0.04 g/kg ore) PAX

4 Results and discussion

The results of the tests conducted are summarized in figures 1 to 6 and in tables 3 to 13. The size distributions of the reground concentrates can be found in appendix 1 while the material balances (including precious metal balances when determined) can be found in appendix 2.

One attempt at cleaning the rougher concentrate had been performed previously (T12924; Progress Report #2; November 1992) using only one kg of feed and the laboratory ball mill for regrinding (76.4% -10 μm). This test yielded a cleaner concentrate with 59.0% sulfur and 16.0% rock stage recoveries respectively from the rougher concentrate. The cleaner concentrate graded 5.2% Cu, 3.5% Ni, 17.4% S with 64.7% Cu, 30.5% Ni, and 38.7% S recoveries.

1st CLEANER OPTIMIZATION

Three tests were performed to optimize the concentrate regrind and first cleaner flotation stages. A five minute Attritor regrind was used in test T12934 (82.3% -11 μm). Low cleaner stage recoveries and an optimum flotation time longer than that for the rougher indicated that some of the collector was disappearing before cleaning. In test T12940 (92.2% - 11 μm), a ten minute Attritor regrind was used and PAX (0.04 g/kg ore) was added prior to cleaner flotation. Finally, T12945 (78.6% - 11 μm) was performed with a five minute Attritor regrind and also a PAX addition prior to cleaning.

Table 3 summarizes the results. As a reminder, the optimum rougher flotation time is 10 minutes (600 seconds). Only for tests T12940 and T12945, for which 0.04 g/kg PAX was added, that the optimum flotation times for the cleaner are shorter than for the rougher stage.

Table 3 Optimization of regrind and 1st cleaner stages

Test	Regrind (min.)	PAX (g/kg)	Component	RI	k (10^{-3} sec^{-1})	Calculated		Observed	
						Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
12924	20	0.00	Sulfur	0.605	5.73	61.0	0.43	59.8	0.43
	BM		Rock	0.191	2.75	19.0	(619 secs)	16.9	(720 secs)
12934	5	0.00	Sulfur	0.818	5.14	81.3	0.71	79.9	0.57
	At.		Rock	0.115	2.40	10.4	(983 secs)	22.9	(720 secs)
12940	10	0.04	Sulfur	0.784	5.70	73.9	0.61	71.9	0.55
	At.		Rock	1.000	0.29	13.4	(502 secs)	16.8	(480 secs)
12945	5	0.04	Sulfur	0.779	7.72	77.0	0.61	69.3	0.59
	At.		Rock	0.365	1.23	14.5	(390 secs)	10.7	(300 secs)

The fact that both tests without PAX addition prior to cleaning, T12924 (ball mill regrind) and T12934 (Attritor regrind) gave longer optimum flotation times at the cleaner than the rougher flotation time indirectly suggests that the cause of the problem is not some strange pulp chemistry arising from the use of the Attritor. Furthermore, disappearance of the collector between the rougher and cleaning flotation stages has been observed at JRGRL for other ultramafic ores.

A comparison of the rate data (table 3) for the two tests with PAX addition prior to cleaning indicates that the 5 minute Attritor regrind is the best. Namely, T12945 (5 minutes regrind; 78.6% -11 μm) is metallurgically more efficient than T12940 (10 minutes regrind; 92.2% - 11 μm) with a higher flotation rate constant for sulfur (7.72 vs 5.70 $x10^{-3}$ sec^{-1}) and sulfur recovery (77.0% vs 73.9%) at the separation efficiency (SE (S/Rk) of 0.61 in both cases).

An examination of the nickel grade-recovery relationships obtained for the three cleaner tests with the Attritor as regrind unit (figure 1) shows that both tests with additional PAX at the cleaning stage gave higher nickel grades at equivalent recovery than the test without PAX. The 10 minutes regrind yielded a higher nickel grade initially than the 5 minutes one but there was virtually no difference between the two grinds at high nickel recoveries.

In terms of overall separation efficiency between the sulfide minerals and the "rock" (figure 2), the test with the 5 minute regrind (with additional PAX) consistently gives slightly higher separation efficiencies than the 10 minute regrind one.

Plots of the nickel and sulfur recoveries vs flotation time (figure 3) indicate that the 5 minutes Attritor regrind (with additional PAX) yields recoveries vs time curves which tend to plateau after 300 seconds, especially for sulfur. For the other two test conditions, plateaus are not reached before 480 seconds or even 720 seconds of flotation.

In table 4, the results (at the observed optimum flotation time) of the three cleaner tests performed with the Attritor as regrind unit are compared to those obtained at Lakefield Research.

Table 4 Comparison of Lakefield Research and JRGRL test performances

Regrind Size (%-11 μm)	Rougher/Scavenger Concentrate						1st Cleaner Concentrate						
	Grade (%)			Rec. (%)			Grade (%)				Rec. (%)		
	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S	MgO	Cu	Ni	S
* ?	1.3	1.1	7.2	83	54	45	3.3	2.5	16	?	78	45	38
82.3	0.7	0.7	4.0	88	62	84	2.5	2.0	11	12.0	83	50	67
! 78.6	0.9	0.8	4.6	85	60	83	4.5	3.4	18	9.2	76	41	58
! 92.2	1.1	1.0	5.5	85	57	81	4.0	3.1	16	9.4	79	44	58

* Lakefield Research test results (test 53a)
! With PAX at the cleaner stage

From table 4, the rougher/scavenger concentrate fed to the first cleaner stage in the tests performed at JRGRL had slightly lower grades but higher recoveries than for test 53a performed at Lakefield Research. Given this, it is not surprising to observe that the JRGRL first cleaner concentrate obtained without additional collector had also slightly lower grades but with higher recoveries than for the Lakefield Research test.

The first cleaner concentrates obtained with additional PAX had higher grades and equivalent or higher recoveries than for the Lakefield Research test. With grades in the range of 4.0-4.5% Cu, 3.1-3.4% Ni, 16-18% S and 9.2-9.4% MgO, the first cleaner concentrate approaches the quality of the bulk concentrate used previously to define the sodium sulfide/nitrogen gas scheme (6.3% Cu, 3.8% Ni, 16.9% S and 9.7% MgO; table 1). Hence, it is probable that a second bulk sulfide cleaning stage will not be required prior to application of the Na_2S/N_2 approach.

The grades and recoveries of the precious metals are shown in table 5 for only two of the cleaner tests performed at JRGRL (5 min. regrind without PAX and 10 min. regrind with PAX). Again, these results are compared to those obtained in test 53a at Lakefield Research.

It can be observed in table 5 that the precious metal recoveries into the combined rougher/scavenger concentrate for the tests performed at JRGRL are equivalent to those obtained at Lakefield Research. However, the gold recovery appears to fluctuate more than the platinum and palladium recoveries. More precious metals balances will be required to determine if the observed fluctuation is due to slight variations in experimental conditions or that a "nugget" effect is present.

Table 5 Comparison of Lakefield Research and JRGRL test performances (precious metals)

Regrind Size (%-11 μm)	Rougher/Scavenger Concentrate						1st Cleaner Concentrate					
	Grade (ppm)			Rec. (%)			Grade (ppm)			Rec. (%)		
	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au
* ?	3.8	80	3.6	72	79	71	8.9	190	8.7	64	71	65
82.3	2.5	43	2.5	75	84	55	8.0	140	7.7	69	77	47
! 92.2	3.1	48	2.5	70	83	83	9.9	175	9.1	54	73	72

* Lakefield Research test results (test 53a)
! With PAX at the cleaner stage

With respect to the first cleaner stage, the addition of PAX prior to cleaning appears as beneficial to the precious metal grades into the concentrate as it is for the base metal grades (table 4). However, the finer regrind (92.2% vs 82.3% -11 μm) could also be a conjunct cause in the grade increase.

Assuming that the precious metals behave in the same way as the base metals, it is expected that higher recoveries will be achieved with a regrind of the order of 80% -11 μm than at 90% -11 μm when an addition of PAX is made prior to cleaning. Hence, the optimum conditions for the regrind and first cleaner stages are a regrind of 5 minutes in the Attritor (80% -11 μm) and a 0.04 g/kg addition of PAX prior to the first cleaner flotation for 390 seconds.

Since the curve of sulfur recovery vs flotation time (figure 3) is essentially a plateau for flotation times greater than the optimum of 390 seconds, performing a first cleaner-scavenger flotation would be more efficient than extending the first cleaner flotation time to improve the recoveries. This possibility will be examined at a later stage in the testwork.

IMPACT OF A SECOND SCAVENGING STAGE

In two tests, T12940 and T12945, a second scavenging stage was added when processing one of the two one kg test charges. Dodecyl mercaptan (DDM; 0.02 g/kg ore) was used as the collector to increase base and precious metals recoveries. Tables 6 to 8 summarize these results. It should be noted that only one of the two rougher/scavenger flotation charges performed for each cleaning test was subjected to the second scavenging stage.

From table 6, it can be observed that the ultimate recovery of the sulfides (indicated by RI for sulfur) in the scavenger tailings is around 0.50. This means that only 50% of the sulfides present in the rougher/scavenger tailings have exposed surfaces and are recoverable by flotation while the remainder are totally encapsulated in rock minerals.

The flotation rate constants for the sulfides are acceptable although on the low side. However, in only one case, T12945, can an optimum flotation time be calculated from the rate data. This optimum flotation time, 861 seconds (14.4 minutes) is too long for being practical for a plant.

Probably a higher collector dosage would be required to achieve the same recoveries within 8 to 10 minutes. However, given the low stage sulfur recovery, only high recoveries of the precious metals in the second scavenger would justify such a stage.

Table 6 Optimization of the second scavenger stage

Test	DDM (g/kg)	Component	RI	k (x10^3 sec^{-1})	Calculated		Observed	
					Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
12940	0.02	Sulfur	0.535	1.79	N.D.	N.D.	39.5	0.32
		Rock	1.000	0.10	N.D.	(None)	7.9	(720 secs)
12945	0.02	Sulfur	0.430	4.05	41.8	0.35	41.1	0.36
		Rock	0.118	0.92	6.4	(861 secs)	5.6	(720 secs)

The grades and recoveries of the feed and concentrate (at the observed optimum time of 720 seconds) of the second scavenger stage are shown in table 7 (base metals) and table 8 (precious metals).

In terms of copper and nickel grades (table 7), the second scavenger concentrate is barely better than the feed to the stage (rougher/scavenger tailings). However, at around 0.1% Cu, 0.2% Ni, and 1.4% S this concentrate is near ore grade (0.18% Cu, 0.22% Ni, 0.97% S; table 1). As such, it could be recycled to the rougher/scavenger stage if the content in precious metals makes it valuable.

Table 7 Comparison of second scavenger performances

Test	Rougher/Scavenger Tailings						2nd Scavenger Concentrate					
	Grade (%)			Overall Rec. (%)			Grade (%)			Stage Rec. (%)		
	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S
T12940	0.03	0.12	0.26	14.9	42.7	18.7	0.09	0.20	1.26	23.8	13.9	39.5
T12945	0.03	0.11	0.21	15.0	40.5	16.8	0.10	0.23	1.48	16.6	12.2	41.1

An examination of the precious metal balances around the second scavenger stage (table 8) shows that the second scavenger concentrate grades around 0.5 ppm Pt, 5.0 ppm Pd, and 0.2 ppm Au which is almost the same as the ore (0.6 ppm Pt, 10.1 ppm Pd, 0.6 ppm Au; table 2). However, the second scavenger stage recovers only between 10 and 25% of the precious metals present in the rougher/scavenger tailings. This gives, at best, gains of around 4-5% in overall precious metals recoveries from the ore.

The logistic of handling a large recirculating load of floatable silicate minerals might prove more costly than the value of the 4-5% additional precious metals recoveries associated with that load. Hence, further examination of secondary scavenging of the rougher/scavenger tailings by flotation will not be performed within the scope of this test program.

Table 8 Comparison of second scavenger performances (precious metals)

Test	Rougher/Scavenger Tailings						2nd Scavenger Concentrate					
	Grade (ppm)			Overall Rec. (%)			Grade (ppm)			Stage Rec. (%)		
	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au
T12940	0.22	1.82	0.11	30.3	16.9	17.5	0.50	5.50	0.20	18.0	24.4	14.9
T12945	0.21	2.16	0.29	N.D.	N.D.	N.D.	0.40	4.70	0.20	10.9	12.6	3.9

2nd CLEANER OPTIMIZATION

Only one test for optimization of the second cleaner stage was done. In this test, T12958, the rougher/scavenger, regrind, and first cleaner stages were performed under the optimum best conditions as discussed earlier. In addition to the second cleaner stage optimization, the possible benefits of having a first cleaner-scavenger stage were examined.

The results of this test are summarized in tables 9 to 11, including comparison with the results of test 53a performed at Lakefield Research.

In table 9, the rate data for both the second cleaner and the first cleaner-scavenger stage are summarized. It can be observed that the ultimate recovery for the sulfides (RI for sulfur) is above 0.90 which is typical for a second cleaning stage. Namely, nearly all of the sulfides which floated previously in the first cleaner stage are floatable again. Disappearance of collector between the first and second cleaning stages does not occur.

The optimum flotation time for the second cleaner is acceptable (334 seconds or 5.6 minutes) and is shorter than that used for the first cleaner (390 seconds or 6.5 minutes). The good agreements between the calculated and observed values for the recoveries, separation efficiencies and flotation times indicate that the second cleaning stage behaves in a straight forward fashion.

The rate data for the first cleaner-scavenger stage shows that there would be little advantage in doing the stage as performed. An extremely long flotation time (1221 seconds or 20.4 minutes) would be required to achieve the maximum separation efficiency for the stage. This is due to small differentials in ultimate recoveries of the sulfide and rock minerals (RI of 0.574 vs RI of 0.495 respectively) and in flotation rate constants (k of 1.40 x 10^{-3} vs 0.62 x 10^{-3} sec^{-1} respectively).

Table 9 Optimization of the second cleaner and first cleaner-scavenger stages

Stage	Component	RI	k (x10^3 sec^{-1})	Calculated		Observed	
				Rec.(%)	SE (S/Rk)	Rec.(%)	SE (S/Rk)
2nd Cleaner	Sulfur	0.918	8.56	86.6	0.66	83.0	0.65
	Rock	0.431	1.97	20.3	(334)	18.4	(300 secs)
1st Cleaner-Scavenger	Sulfur	0.574	1.40	47.1	0.21	36.7	0.19
	Rock	0.495	0.62	25.8	(1221 secs)	17.3	(720 secs)

Ideally, the first cleaner-scavenger stage would warrant further examination (e.g. copper sulfate activation prior to collector addition or a scavenging collector other than PAX). Such a work would be outside of the scope of the agreed test program. Hence, if a first cleaner-scavenger stage is performed in future tests, it will be floated up to the observed optimum time of 720 seconds (12 minutes).

The second cleaner performance achieved in T12958 is compared to that of the Lakefield Research test 53a for the base metals (table 10) and the precious metals (table 11).

With grades of 7.1% Cu, 5.1% Ni and 30% S, the second cleaner stage of T12958 out-performed the one of test 53a (5.2% Cu, 3.6% Ni and 24% S) for equal or better metal recoveries. Interestingly, the achieved MgO content of 4.3% is close to the target of 4.0% for the test program.

Table 10 Comparison of Lakefield Research and JRGRL test performances (2nd Cleaner)

Test	1st Cleaner Concentrate						2nd Cleaner Concentrate						
	Grade (%)			Rec. (%)			Grade (%)				Rec. (%)		
	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S	MgO	Cu	Ni	S
T53a; LR	3.3	2.5	16	78	45	38	5.2	3.6	24	?	74	38	33
T12958	4.0	3.1	16	79	44	58	7.1	5.1	30	4.3	70	36	46

With respect to the precious metals (table 11), the second cleaner stage of T12958 again out-performs the one of test 53a in terms of grades. The higher grades of the first cleaner concentrate of T12958 were certainly a contributing factor. On the other hand, the precious metal recoveries obtained in T12958 are slightly lower than those achieved in test 53a. This could be a consequence of estimating the overall precious metals recoveries for T12958; only the second cleaner concentrate and tailings were assayed for the precious metals.

Table 11 Comparison of Lakefield Research and JRGRL test performances (precious metals)

Test	1st Cleaner Concentrate						2nd Cleaner Concentrate					
	Grade (ppm)			Rec. (%) *			Grade (ppm)			Rec. (%) *		
	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au	Pt	Pd	Au
T53a; LR	8.9	190	8.7	64	71	65	13.6	293	13.9	57	65	62
T12958	10.7	187	12.4	54	66	63	22.7	386	28.3	46	55	58

* For test T12958, the overall recoveries were estimated using the average feed grades

In view of the lower precious metal recoveries in the cleaning stages, especially for palladium, it is worth examining more closely the performance of the first cleaner-scavenger stage (table 12).

Table 12 Summary of 1st cleaner-scavenger results

Test	1st Cleaner Tailings						1st Cleaner-Scavenger Concentrate					
	Grade (%)			Overall Rec. (%)			Grade (%)			Stage Rec. (%)		
	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S	Cu	Ni	S
T12958	0.09	0.24	1.59	8.9	16.6	24.1	0.24	0.50	3.22	47.8	38.2	36.7

With stage recoveries of nearly 50% for copper and 40% for both nickel and sulfur, the first cleaner-scavenger stage appears capable of boosting the overall base and precious metals recoveries to the desired levels. However, the concentrate grades only 0.24% Cu, 0.50% Ni and 3.22% S.

The cleaner-scavenger concentrate is of comparable quality to the scavenger concentrate and it could be recycled to the concentrate regrind stage. Alternatively, the first cleaner and cleaner-scavenger concentrates could be combined together for the second cleaning stage or the first cleaner-scavenger concentrate could be recycled to the first cleaner stage. Numerical simulations have been performed to evaluate the last two possibilities and the results obtained will be discussed later.

PRECIOUS METALS RECOVERIES AND SULFUR RECOVERY

Since precious metal assays are more expensive to perform than base metal assays, it was desired to establish relationships between the precious metals recoveries and sulfur recovery. For this purpose, plots of the overall platinum, palladium and gold recoveries against sulfur recovery were made for the tests performed at JRGRL. These plots can be seen in figure 4.

From figure 4, it can be observed that the palladium recovery is nearly equal to that of the sulfur recovery for the rougher and scavenger stages. For the cleaning stages, it appears that the recovery of Pd is roughly 10% higher than that of S.

In the case of platinum, its recovery lags that of sulfur by about 10% in the rougher and scavenger stages. However, it is approximately equals to that of sulfur in the cleaning stages.

Establishing a relationship between the gold and sulfur recoveries is problematic since two of the six data points appear to be completely out of line (one rougher/scavenger point and one first cleaner point). Excluding these two "strange" points, the relationship between gold and sulfur recoveries seems similar to that between palladium and sulfur. Namely, the Au recovery is roughly equal to that of S in the rougher and scavenger stages while it is about 10% higher than that of S in the cleaning stages.

The two "strange" points in the plot of gold vs sulfur recoveries could easily be due to a "nugget" effect. More data would be required to fully assess the extent of a "nugget" effect.

The existence of relationships, even as crude as shown in figure 4, between the precious metals recoveries and sulfur recovery is reassuring. Namely, an optimization of the flowsheet for sulfur recovery should give nearly optimum precious metal recoveries.

NUMERICAL SIMULATIONS- 1st CLEANER-SCAVENGER CONCENTRATE

Numerical simulations were performed to define where would be the most appropriate location for recycling the first cleaner-scavenger concentrate into the flowsheet. The outputs of the simulations can be found in appendix 4 and the results are summarized in figures 5 and 6.

Prior to performing these simulations, it was felt that attempting to prove the validity of the approach for prediction of locked cycle test results would be an excellent exercise. The results obtained at Lakefield Research appeared ideal for this purpose. The results of the batch test 53a (1) were used as raw data for a predication of the outcome of the locked cycle test 54 (1) using the numerical simulation. The raw data and outputs for this simulation can be found in appendix 3. The results are summarized in table 13.

It can be observed in table 13 that the numerical simulation predicted well the metal recoveries achieved in the actual locked cycle test. In fact, the simulation appears slightly pessimistic with respect to achieved metal recoveries.

On the other hand, the simulation over-estimates the grades of the third cleaner concentrate (final concentrate). A comparison of the simulated and actual grades of the rougher/scavenger concentrate indicates that the simulation also over-estimates the grades achieved in the locked cycle test. The rougher/scavenger stages were performed in open-circuit in the batch test serving as raw data for the simulation and in the locked cycle test. Hence, the only possible cause for the discrepancy is that the rougher/scavenger stages were pulled harder in the locked cycle test (test 54) than in the preparatory batch test (test 53a).

Table 13 Comparison of predicted and actual locked cycle test results (Lakefield Research data)

Method	Rougher/Scavenger Concentrate						3rd Cleaner Concentrate					
	Grade (%, ppm)			Rec. (%)			Grade (%, ppm)			Rec. (%)		
	Cu	Ni	Pd	Cu	Ni	Pd	Cu	Ni	Pd	Cu	Ni	Pd
Simulation	1.3	1.2	80	83.3	54.3	78.9	4.9	3.8	290	79.3	45.8	73.2
Test (54)	1.18	1.06	72.6	83.1	57.4	80.9	3.9	3.0	229	78.0	47.1	73.0

With this comparison in mind, the results of the simulations for location of the recycle point for the first cleaner-scavenger concentrate can be examined with confidence. It should be noted that these simulations were performed using mineral assays rather than metal assays. This allowed a closer look at the expected distribution of MgO in a continuous circuit.

The final concentrate obtained when the first cleaner and first cleaner-scavenger concentrates are combined (figure 5) recovers 81.7% of the chalcopyrite, 48.1% of the pentlandite, 38.5% of the pyrrhotite and 1.5% of the MgO. The MgO content of the concentrate is 5.4%.

When recycling the first cleaner-scavenger concentrate to the first cleaner stage (figure 6), the final concentrate recovers 81.4% of the chalcopyrite, 47.0% of the pentlandite, 29.2% of the pyrrhotite and 0.8% of the MgO at a MgO grade of 4.9%.

The two most significant differences between the two flowsheets are the higher pyrrhotite recovery (38.5% vs 29.2%) and higher MgO content (5.4% vs 4.9%) when the two first cleaner concentrates are combined for cleaning in the second cleaner stage rather than recycling the first cleaner-scavenger concentrate to the first cleaner stage. Hence, the former flowsheet is to be preferred over the latter one as increasing the sulfur recovery (i.e. pyrrhotite) would increase the overall precious metal recoveries.

Attempts to apply the sodium sulfide/nitrogen flotation gas procedure will be made on both the first cleaner concentrate and on the combined first cleaner and first cleaner-scavenger concentrates. From the information gathered so far, the second option appears to be the one with the greatest promises in terms of overall precious metals recoveries. Also, it appears that a second bulk sulfide cleaning stage will not be necessary prior to application of the Na_2S/N_2 scheme.

6 Conclusions

Testwork for proving the applicability of the sodium sulfide/nitrogen gas flotation procedure for MgO rejection on freshly prepared bulk concentrate from the Lac des Iles ore continued. In this second part of the test program, the cleaning of the rougher/scavenger concentrate was addressed.

It was found that the rougher/scavenger concentrate could be easily cleaned after regrinding to around 80% - 11 μm. This required a regrind time of only 5 minutes in the Attritor. The first cleaner flotation was conducted at pH 9.5 (soda ash) with 0.075 g/kg ore of CMC (Finnfix-300) and 0.04 g/kg ore of PAX. The addition of PAX prior to cleaning was found necessary to maximize concentrate grades and recoveries.

The first cleaner concentrate graded 4.5% Cu, 3.4% Ni, 18% S and 9.2% MgO with recoveries of 76%, 41%, and 58% for copper, nickel and sulfur respectively. The precious metals grades were 8 ppm Pt, 140 Pd and 7.7 ppm Au with recoveries of 69%, 77%, and 47% respectively.

A second cleaning stage brought the MgO content down to 4.3% and increased the grades of the values to 7.1% Cu, 5.1% Ni, 30% S, 22.7 ppm Pt, 386 ppm Pd and 28.3 ppm Au. The recoveries of the values were 70% for Cu, 36% for Ni, 46% for S, 55% of Pt, 55% for Pd, and 67% for Au.

Higher recoveries of the values in the cleaning stages can be achieved by performing a first cleaner-scavenger stage. Numerical simulations indicated that the best way to utilize the concentrate produced by this stage is to combine it with the first cleaner concentrate prior to cleaning in the second cleaner. Unfortunately, this would cause the MgO content of the second cleaner concentrate to rise to 5.4%.

Nearly linear relationships were established between the precious metals recoveries and the sulfur recovery. The existence of such relationships allows to confidently use the sulfur recovery to maximize precious metals recoveries.

The third and last part of the test program will focus on the application of the sodium suflide/nitrogen gas flotation scheme (reverse flotation) on the first cleaner concentrate and the combined first cleaner and first cleaner-scavenger concentrates. Given the grades achieved in the two first cleaner stages, it appears that it will not be necessary to perform a second cleaner prior to application of the reverse flotation procedure.

Records

The original records are in ERB 2174.

Reference

1) Parker, S.J, K.W. Sarbutt, S.R. Williams, An Investigation of the Recovery of Copper, Nickel and PG Metals from Roby Zone Project Samples Submitted by Lac des Iles Mines Ltd, Progress Report No. 1, June 17th, 1992, Lakefield Research.

Appendices

1 Size Distributions

2 Material Balances

3 Numerical Simulation of Lakefield Research Test 54

4 Numerical Simulations of Options for the 1st Cleaner Scavenger Concentrate

Figure 1

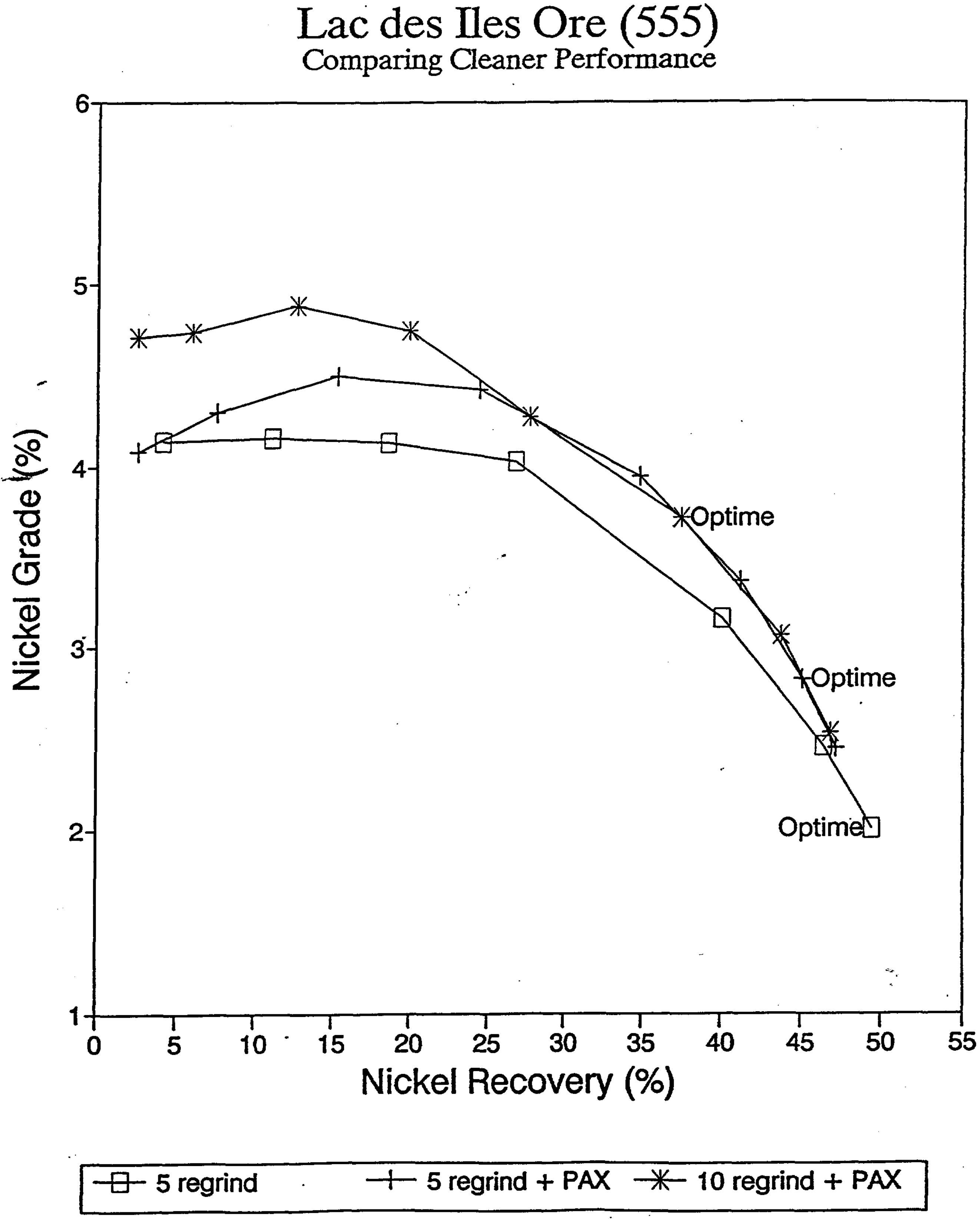

Lac des Iles Ore (555)
Comparing Cleaner Performance
Nickel Grade (%)
6
5
4
3
2
1
0
5
10
15
20
25
30
35
40
45
50
55
Nickel Recovery (%)
Optime
Optime
Optime
5 regrind
5 regrind + PAX
10 regrind + PAX

Figure 2

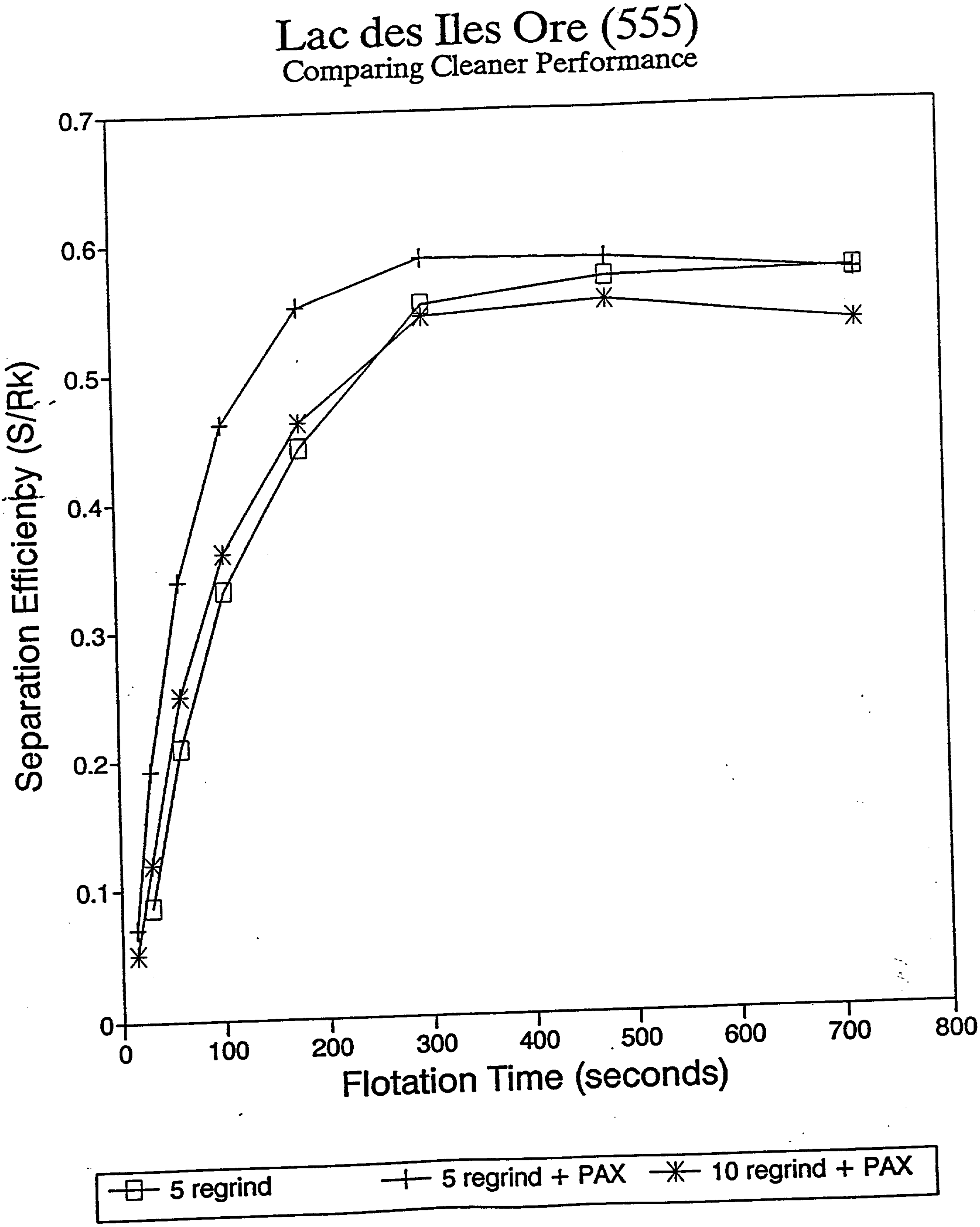

Lac des Iles Ore (555)
Comparing Cleaner Performance
Separation Efficiency (S/Rk)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
700
800
Flotation Time (seconds)
5 regrind
5 regrind + PAX
10 regrind + PAX

Figure 3

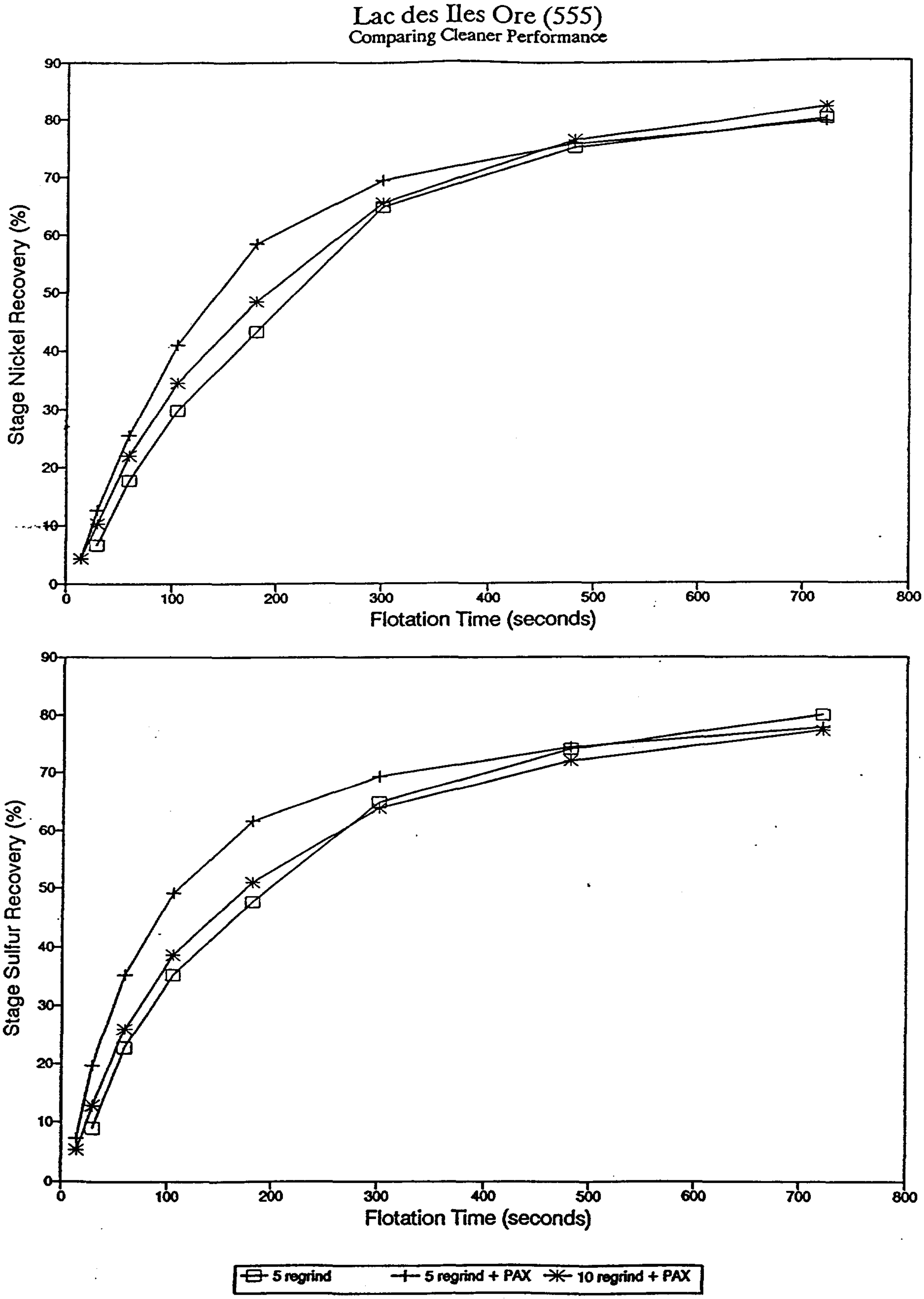

Lac des Iles Ore (555)
Comparing Cleaner Performance
Stage Nickel Recovery (%)
0
10
20
30
40
50
60
70
80
90
0
100
200
300
400
500
600
700
800
Flotation Time (seconds)
Stage Sulfur Recovery (%)
0
10
20
30
40
50
60
70
80
90
0
100
200
300
400
500
600
700
800
Flotation Time (seconds)
5 regrind
5 regrind + PAX
10 regrind + PAX

Figure 4

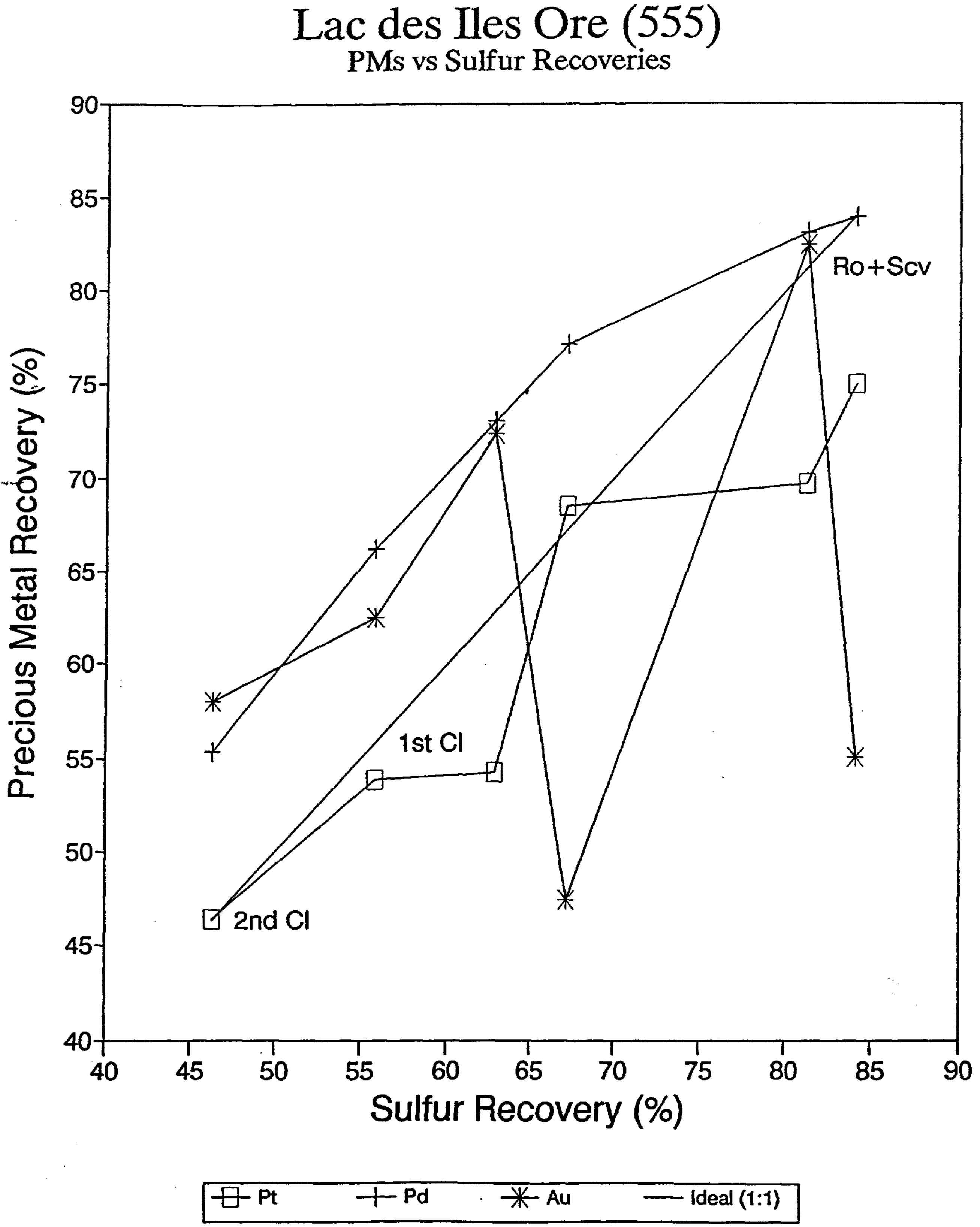

Lac des Iles Ore (555)
PMs vs Sulfur Recoveries
Precious Metal Recovery (%)
90
85
80
75
70
65
60
55
50
45
40
Sulfur Recovery (%)
40
45
50
55
60
65
70
75
80
85
90
Ro+Scv
1st Cl
2nd Cl
Pt
Pd
Au
Ideal (1:1)

Figure 5

Lac des Iles Ore (555); Simulation #1

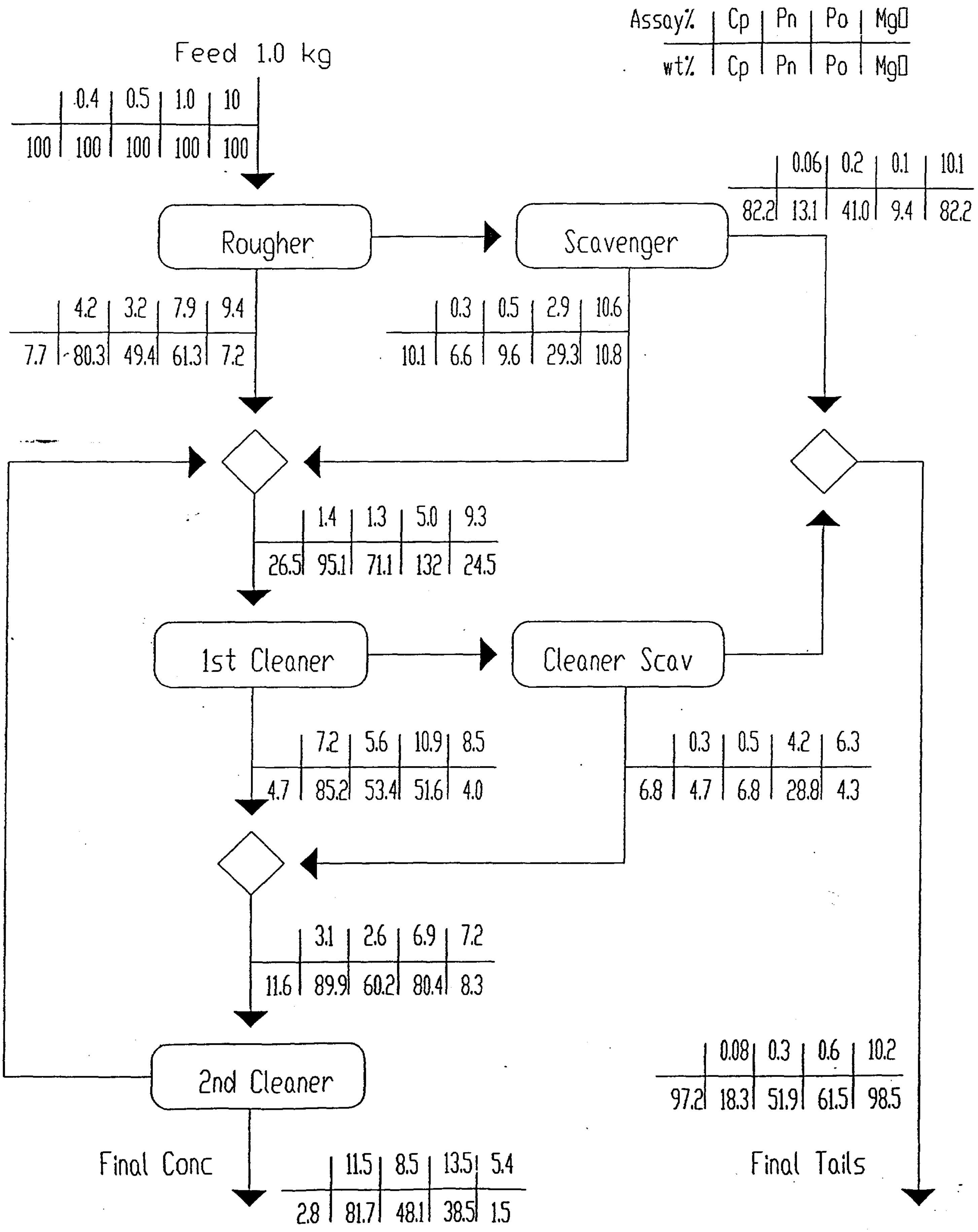
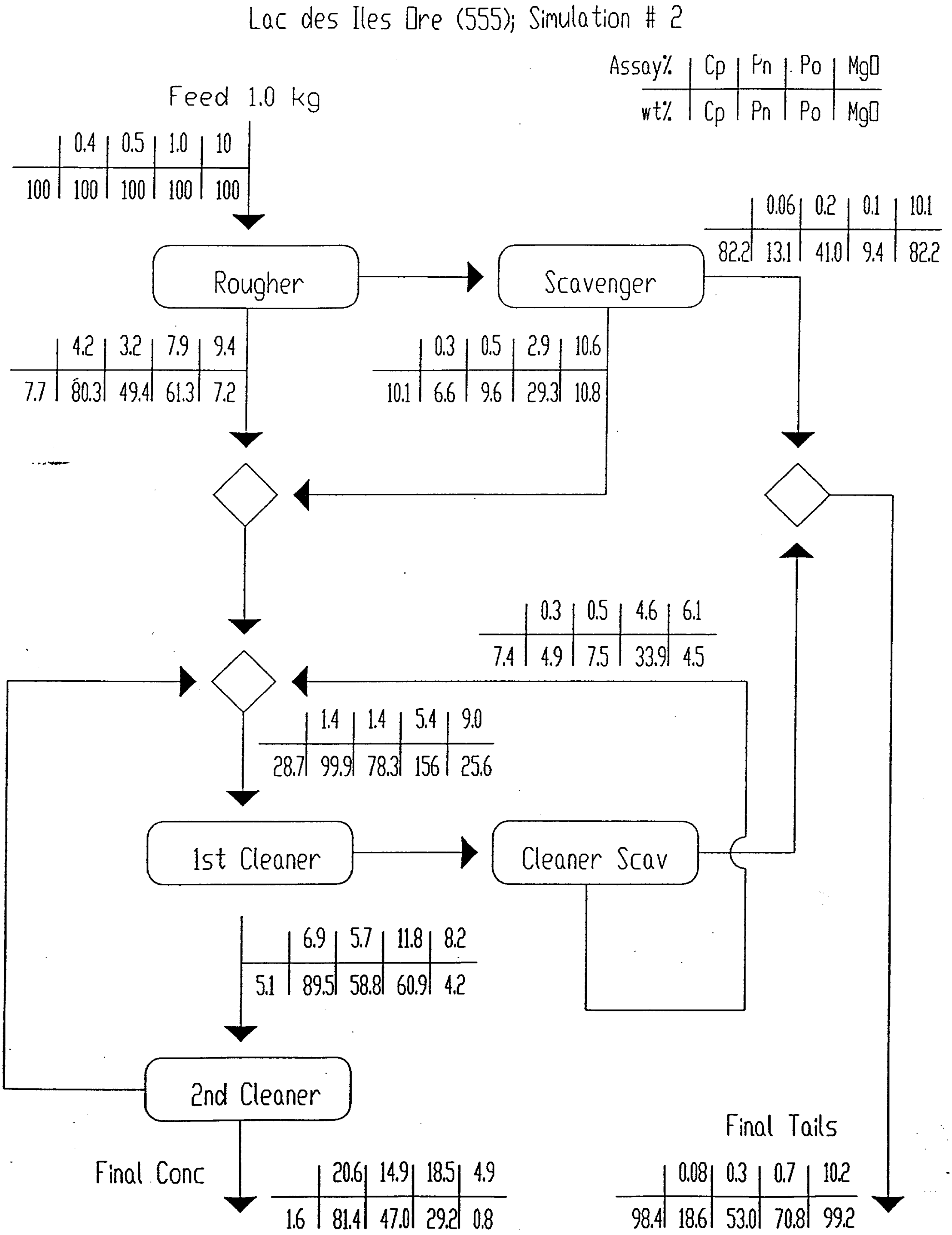


Figure 6

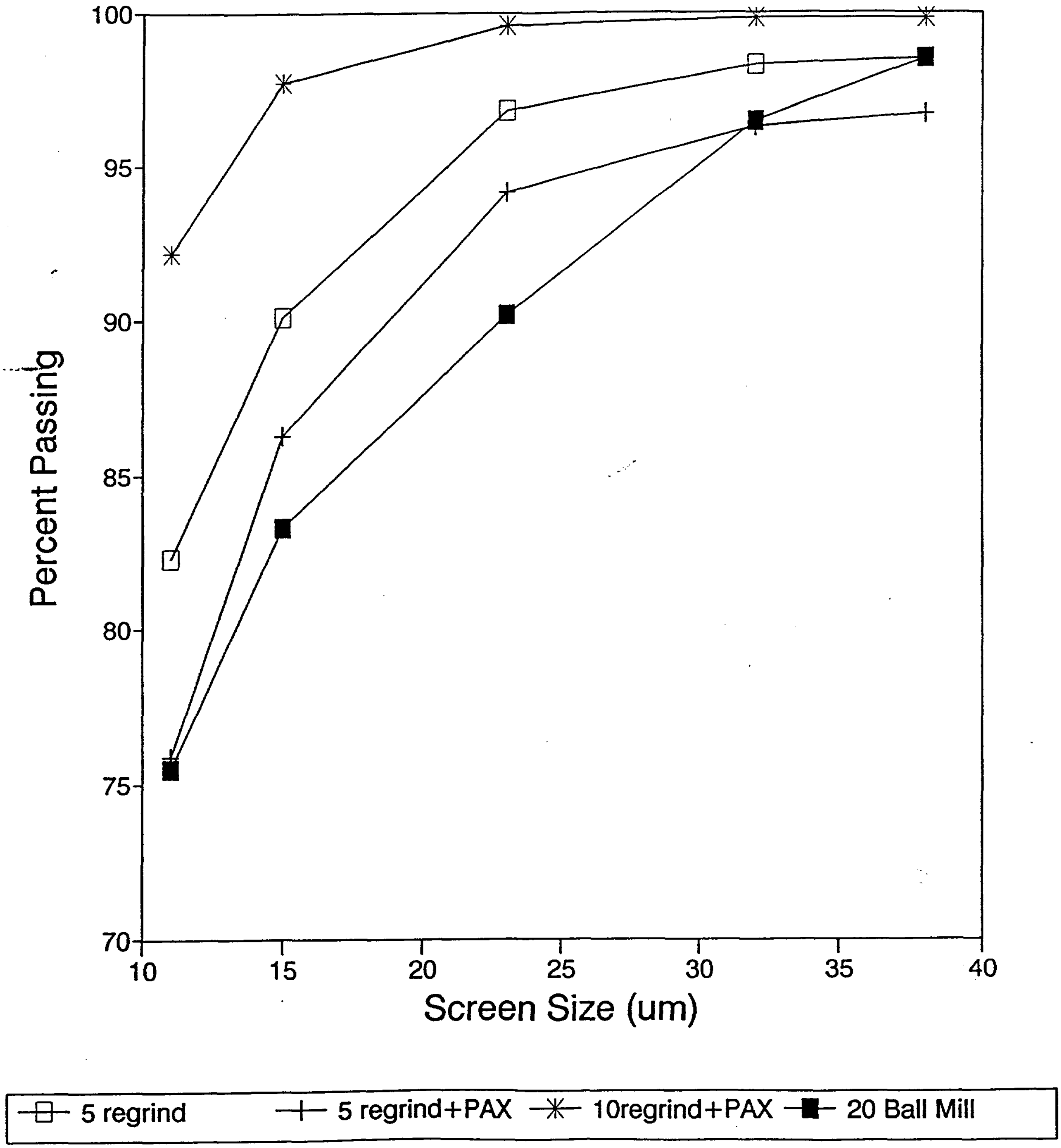

Lac des Iles Ore (555); Simulation # 2
Assay% | Cp | Pn | Po | MgO
wt% | Cp | Pn | Po | MgO
Feed 1.0 kg
0.4 | 0.5 | 1.0 | 10
100 | 100 | 100 | 100 | 100
Rougher
Scavenger
0.06 | 0.2 | 0.1 | 10.1
82.2 | 13.1 | 41.0 | 9.4 | 82.2
4.2 | 3.2 | 7.9 | 9.4
7.7 | 80.3 | 49.4 | 61.3 | 7.2
0.3 | 0.5 | 2.9 | 10.6
10.1 | 6.6 | 9.6 | 29.3 | 10.8
0.3 | 0.5 | 4.6 | 6.1
7.4 | 4.9 | 7.5 | 33.9 | 4.5
1.4 | 1.4 | 5.4 | 9.0
28.7 | 99.9 | 78.3 | 156 | 25.6
1st Cleaner
Cleaner Scav
6.9 | 5.7 | 11.8 | 8.2
5.1 | 89.5 | 58.8 | 60.9 | 4.2
2nd Cleaner
Final Tails
Final Conc
20.6 | 14.9 | 18.5 | 4.9
1.6 | 81.4 | 47.0 | 29.2 | 0.8
0.08 | 0.3 | 0.7 | 10.2
98.4 | 18.6 | 53.0 | 70.8 | 99.2

APPENDIX 1

Size Distributions

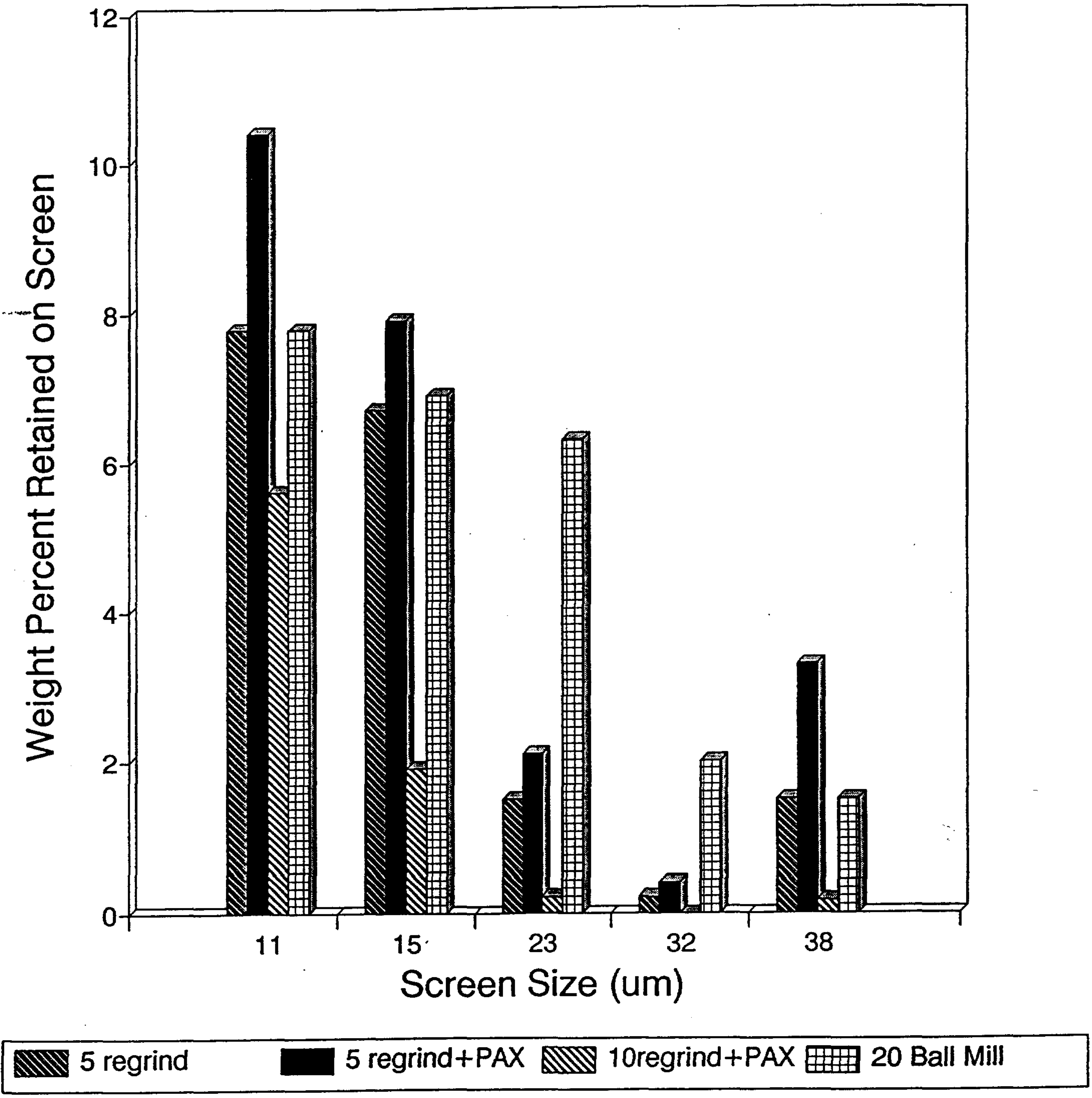
Lac des Iles Ore (555)

Comparing Regrind Methods



Lac des Iles Ore (555)

Comparing Regrind Methods



APPENDIX 2

Material Balances

T12934: Lac des Iles Ore (555); optimizing the regrind in the attritor
and 1st cleaner. 5 minute regrind, 0.5 g/kg Na2CO3, 0.025 g/kg CMC
incremental cleaner   ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.40	8.36	4.14	28.7	31.6	4.70	24.1	10.5	4.64	32.1	28.6
Clnr conc 3	7.30	7.47	4.17	26.5	28.2	5.80	21.6	9.94	7.66	24.7	36.1
Clnr conc 4	8.10	6.03	4.08	23.7	24.0	7.50	17.4	8.93	11.1	16.7	45.9
Clnr conc 5	9.50	4.75	3.82	21.0	19.8	9.30	13.7	7.35	14.9	8.36	55.7
Clnr conc 6	26.6	1.96	2.20	15.1	9.88	12.6	5.66	2.08	18.2	0.000E+0	74.1
Clnr conc 7	27.3	0.750	1.03	12.4	5.15	14.5	2.17	0.490	10.7	0.000E+0	86.7
Clnr conc 8	25.4	0.310	0.520	11.9	3.55	14.5	0.895	-.460	8.56	0.000E+0	91.0
Clnr tls	275.	0.570E-1	0.200	9.32	1.12	12.9	0.165	-.503E-1	2.73	0.000E+0	97.2
Scav tls 1	770.	0.250E-1	0.100	7.14	0.140	11.9	0.722E-1	0.264	0.684E-1	0.000E+0	99.6
Scav tls 2	819.	0.250E-1	0.110	7.34	0.220	12.2	0.722E-1	0.243	0.288	0.000E+0	99.4
TOTAL	1972.80	0.163	0.223	8.023	0.921	12.174	0.470	0.358	1.185	0.272	97.715

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	0.223	11.5	4.14	0.798	7.65	0.861E-1	11.5	6.56	0.873	26.3	0.653E-1
Clnr conc 3	0.370	17.0	6.92	1.22	11.3	0.176	17.0	10.3	2.39	33.6	0.137
Clnr conc 4	0.411	15.2	7.51	1.21	10.7	0.253	15.2	10.2	3.83	25.3	0.193
Clnr conc 5	0.482	14.1	8.25	1.26	10.4	0.368	14.1	9.88	6.04	14.8	0.274
Clnr conc 6	1.35	16.2	13.3	2.54	14.5	1.40	16.2	7.82	20.7	0.000E+0	1.02
Clnr conc 7	1.38	6.38	6.39	2.14	7.74	1.65	6.38	1.89	12.5	0.000E+0	1.23
Clnr conc 8	1.29	2.45	3.00	1.91	4.96	1.53	2.45	-1.66	9.30	0.000E+0	1.20
Clnr tls	13.9	4.88	12.5	16.2	16.9	14.8	4.88	-1.96	32.0	0.000E+0	13.9
Scav tls 1	39.0	5.99	17.5	34.7	5.93	38.1	5.99	28.8	2.25	0.000E+0	39.8
Scav tls 2	41.5	6.38	20.5	38.0	9.92	41.6	6.38	28.2	10.1	0.000E+0	42.2

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.40	8.36	4.14	28.7	31.6	4.70	24.1	10.5	4.64	32.1	28.6
Clnr conc 3	11.7	7.80	4.16	27.3	29.5	5.39	22.5	10.2	6.53	27.5	33.3
Clnr conc 4	19.8	7.08	4.13	25.8	27.2	6.25	20.4	9.65	8.38	23.1	38.5
Clnr conc 5	29.3	6.32	4.03	24.3	24.8	7.24	18.3	8.91	10.5	18.3	44.1
Clnr conc 6	55.9	4.25	3.16	19.9	17.7	9.79	12.3	5.66	14.2	9.59	58.3
Clnr conc 7	83.2	3.10	2.46	17.4	13.6	11.3	8.95	3.96	13.0	6.44	67.6
Clnr conc 8	109.	2.45	2.01	16.1	11.2	12.1	7.07	2.93	12.0	4.93	73.1
Clnr tls	383.	0.734	0.711	11.3	3.99	12.7	2.12	0.793	5.35	1.40	90.3
Scav tls 1	0.115E+4	0.261	0.303	8.51	1.42	12.2	0.753	0.440	1.82	0.465	96.5
Scav tls 2	0.197E+4	0.163	0.223	8.02	0.921	12.2	0.470	0.358	1.19	0.272	97.7

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	0.223	11.5	4.14	0.798	7.65	0.861E-1	11.5	6.56	0.873	26.3	0.653E-1
Clnr conc 3	0.593	28.4	11.1	2.02	19.0	0.262	28.4	16.8	3.26	59.9	0.202
Clnr conc 4	1.00	43.6	18.6	3.23	29.7	0.515	43.6	27.1	7.09	85.2	0.395
Clnr conc 5	1.49	57.7	26.8	4.49	40.0	0.883	57.7	36.9	13.1	100.	0.670
Clnr conc 6	2.83	73.9	40.1	7.03	54.5	2.28	73.9	44.8	33.9	100.	1.69
Clnr conc 7	4.22	80.3	46.5	9.17	62.2	3.93	80.3	46.7	46.3	100.	2.92
Clnr conc 8	5.50	82.7	49.5	11.1	67.2	5.46	82.7	45.0	55.6	100.	4.12
Clnr tls	19.4	87.6	62.0	27.3	84.1	20.2	87.6	43.0	87.6	100.	18.0
Scav tls 1	58.5	93.6	79.5	62.0	90.1	58.4	93.6	71.8	89.9	100.	57.8
Scav tls 2	100.	100.0	100.0	100.	100.	100.	100.0	100.	100.	100.	100.

Mineral calculations based on 8.000% Ni in Po

T12934: Lac des Iles Ore (555); optimizing the regrind in the attritor and 1st cleaner. 5 minute regrind, 0.5 g/kg Na2CO3, 0.025 g/kg CMC incremental cleaner   ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.40	8.36	4.14	28.7	31.6	4.70	24.1	10.5	4.64	32.1	28.6
Clnr conc 3	7.30	7.47	4.17	26.5	28.2	5.80	21.6	9.94	7.66	24.7	36.1
Clnr conc 4	8.10	6.03	4.08	23.7	24.0	7.50	17.4	8.93	11.1	16.7	45.9
Clnr conc 5	9.50	4.75	3.82	21.0	19.8	9.30	13.7	7.35	14.9	8.36	55.7
Clnr conc 6	26.6	1.96	2.20	15.1	9.88	12.6	5.66	2.08	18.2	0.000E+0	74.1
Clnr conc 7	27.3	0.750	1.03	12.4	5.15	14.5	2.17	0.490	10.7	0.000E+0	86.7
Clnr conc 8	25.4	0.310	0.520	11.9	3.55	14.5	0.895	-.460	8.56	0.000E+0	91.0
Clnr tls	275.	0.570E-1	0.200	9.32	1.12	12.9	0.165	-.503E-1	2.73	0.000E+0	97.2
TOTAL	383.50	0.734	0.711	11.253	3.987	12.667	2.120	0.793	5.345	1.397	90.345

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	1.15	13.1	6.68	2.93	9.09	0.426	13.1	15.2	0.997	26.3	0.363
Clnr conc 3	1.90	19.4	11.2	4.48	13.5	0.872	19.4	23.9	2.73	33.6	0.762
Clnr conc 4	2.11	17.4	12.1	4.45	12.7	1.25	17.4	23.8	4.37	25.3	1.07
Clnr conc 5	2.48	16.0	13.3	4.62	12.3	1.82	16.0	23.0	6.90	14.8	1.53
Clnr conc 6	6.94	18.5	21.4	9.31	17.2	6.90	18.5	18.2	23.6	0.000E+0	5.69
Clnr conc 7	7.12	7.28	10.3	7.84	9.20	8.15	7.28	4.40	14.2	0.000E+0	6.83
Clnr conc 8	6.62	2.80	4.84	7.00	5.90	7.58	2.80	-3.85	10.6	0.000E+0	6.67
Clnr tls	71.7	5.57	20.2	59.4	20.1	73.0	5.57	-4.55	36.5	0.000E+0	77.1

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	4.40	8.36	4.14	28.7	31.6	4.70	24.1	10.5	4.64	32.1	28.6
Clnr conc 3	11.7	7.80	4.16	27.3	29.5	5.39	22.5	10.2	6.53	27.5	33.3
Clnr conc 4	19.8	7.08	4.13	25.8	27.2	6.25	20.4	9.65	8.38	23.1	38.5
Clnr conc 5	29.3	6.32	4.03	24.3	24.8	7.24	18.3	8.91	10.5	18.3	44.1
Clnr conc 6	55.9	4.25	3.16	19.9	17.7	9.79	12.3	5.66	14.2	9.59	58.3
Clnr conc 7	83.2	3.10	2.46	17.4	13.6	11.3	8.95	3.96	13.0	6.44	67.6
Clnr conc 8	109.	2.45	2.01	16.1	11.2	12.1	7.07	2.93	12.0	4.93	73.1
Clnr tls	383.	0.734	0.711	11.3	3.99	12.7	2.12	0.793	5.35	1.40	90.3

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1-2	1.15	13.1	6.68	2.93	9.09	0.426	13.1	15.2	0.997	26.3	0.363
Clnr conc 3	3.05	32.4	17.8	7.41	22.6	1.30	32.4	39.1	3.72	59.9	1.13
Clnr conc 4	5.16	49.8	29.9	11.9	35.3	2.55	49.8	62.9	8.09	85.2	2.20
Clnr conc 5	7.64	65.8	43.2	16.5	47.6	4.37	65.8	85.8	15.0	100.	3.73
Clnr conc 6	14.6	84.4	64.7	25.8	64.8	11.3	84.4	104.	38.6	100.	9.41
Clnr conc 7	21.7	91.6	75.0	33.6	74.0	19.4	91.6	108.	52.8	100.	16.2
Clnr conc 8	28.3	94.4	79.8	40.6	79.9	27.0	94.4	105.	63.5	100.	22.9
Clnr tls	100.	100.	100.0	100.	100.	100.	100.	100.0	100.	100.	100.0

Mineral calculations based on 8.000% Ni in Po

T12934: Lac des Iles Ore (555), Precious metal balance

- ASSAYS

	Wt	Pt	Pd	Au
Clnr Conc	109.	8.00	140.	7.70
Clnr tls	275.	0.300	4.90	0.500
Scav tls 1	770.	0.200	1.90	0.500
Scav tls 2	819.	0.200	2.10	0.500
TOTAL	1973.00	0.645	10.058	0.898

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
Clnr Conc	5.52	68.5	77.2	47.4
Clnr tls	13.9	6.48	6.79	7.76
Scav tls 1	39.0	12.1	7.37	21.7
Scav tls 2	41.5	12.9	8.67	23.1

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
Clnr Conc	109.	8.00	140.	7.70
Clnr tls	384.	2.49	43.4	2.54
Scav tls 1	0.115E+4	0.961	15.7	1.18
Scav tls 2	0.197E+4	0.645	10.1	0.898

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
Clnr Conc	5.52	68.5	77.2	47.4
Clnr tls	19.5	75.0	84.0	55.1
Scav tls 1	58.5	87.1	91.3	76.9
Scav tls 2	100.	100.	100.	100.

T12940: Lac des Iles Ore (555): Optimizing 1st clnr with 0.04 g/kg PAX
an 2nd scav with 0.02 g/kg DOM
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Co	Pn	Po	Py	Rk
Clnr Conc 1	2.35	9.18	4.71	30.2	32.8	2.94	25.5	13.0	6.40	31.0	23.0
Clnr Conc 2	3.24	9.16	4.77	29.6	32.3	3.02	26.5	13.2	5.74	30.5	24.1
Clnr Conc 3	5.90	9.00	5.02	29.3	32.0	3.77	26.0	13.9	5.55	30.0	24.6
Clnr Conc 4	7.07	7.11	4.52	25.4	26.1	5.80	20.5	12.4	10.5	19.7	36.9
Clnr Conc 5	10.3	4.33	3.40	19.9	17.1	8.79	12.5	9.06	19.8	2.98	55.7
Clnr Conc 6	15.9	2.49	2.72	16.3	11.6	11.1	7.19	7.22	16.9	0.000E+0	68.7
Clnr Conc 7	18.6	0.900	1.50	13.4	6.21	13.4	2.60	3.97	10.1	0.000E+0	83.4
Clnr Conc 8	18.8	0.350	0.740	12.3	4.17	14.1	1.01	1.89	8.06	0.000E+0	89.0
Clnr tls	178.	0.740E-1	0.260	10.3	1.83	12.7	0.214	0.639	3.30	0.000E+0	95.3
2nd sc tls 2	856.	0.250E-1	0.100	7.10	0.120	11.8	0.722E-1	0.279	0.520E-2	0.000E+0	99.6
2ndsc con 1-2	1.80	0.210	0.340	11.5	3.31	12.0	0.607	0.790	7.16	0.000E+0	91.4
2nd sc conc 3	1.82	0.310	0.350	13.8	4.56	11.4	0.895	0.752	10.1	0.000E+0	88.3
2nd sc conc 4	5.41	0.150	0.250	11.0	2.32	12.5	0.433	0.587	4.98	0.000E+0	94.0
2nd sc conc 5	6.46	0.130	0.240	10.0	1.78	13.1	0.376	0.588	3.67	0.000E+0	95.4
2nd sc conc 6	8.95	0.950E-1	0.210	9.44	1.29	13.3	0.274	0.529	2.57	0.000E+0	96.6
2nd sc conc 7	19.2	0.690E-1	0.190	9.02	0.990	12.9	0.199	0.488	1.91	0.000E+0	97.4
2nd sc conc 8	27.6	0.570E-1	0.170	8.70	0.770	13.0	0.165	0.443	1.43	0.000E+0	98.0
2nd sc tls 1	812.	0.250E-1	0.110	6.98	0.170	11.7	0.722E-1	0.305	0.110	0.000E+0	99.5
TOTAL	1999.91	0.162	0.222	7.857	0.883	11.825	0.467	0.599	0.960	0.259	97.715

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	0.118	6.67	2.49	0.452	4.37	0.292E-1	6.67	2.56	0.784	14.1	0.277E-1
Clnr Conc 2	0.162	9.18	3.48	0.611	5.93	0.414E-1	9.18	3.57	0.968	19.1	0.400E-1
Clnr Conc 3	0.295	16.4	6.68	1.10	10.7	0.941E-1	16.4	6.85	1.71	34.1	0.743E-1
Clnr Conc 4	0.354	15.5	7.20	1.14	10.5	0.173	15.5	7.32	3.85	26.8	0.134
Clnr Conc 5	0.515	13.8	7.89	1.31	9.97	0.383	13.8	7.80	10.6	5.92	0.294
Clnr Conc 6	0.797	12.3	9.77	1.65	10.5	0.748	12.3	9.61	14.0	0.000E+0	0.560
Clnr Conc 7	0.929	5.17	6.27	1.58	6.53	1.05	5.17	6.15	9.73	0.000E+0	0.792
Clnr Conc 8	0.942	2.04	3.14	1.47	4.45	1.12	2.04	2.97	7.91	0.000E+0	0.858
Clnr tls	8.89	4.07	10.4	11.7	18.4	9.55	4.07	9.49	36.1	0.000E+0	8.66
2nd sc tls 2	42.8	6.62	19.3	38.7	5.82	42.7	6.62	20.0	0.232	0.000E+0	43.7
2ndsc con 1-2	0.900E-1	0.117	0.138	0.132	0.337	0.914E-1	0.117	0.119	0.672	0.000E+0	0.843E-1
2nd sc conc 3	0.910E-1	0.174	0.144	0.160	0.470	0.878E-1	0.174	0.114	0.957	0.000E+0	0.822E-1
2nd sc conc 4	0.271	0.251	0.305	0.379	0.711	0.286	0.251	0.265	1.41	0.000E+0	0.260
2nd sc conc 5	0.323	0.260	0.349	0.411	0.651	0.358	0.260	0.318	1.24	0.000E+0	0.315
2nd sc conc 6	0.448	0.263	0.424	0.538	0.654	0.504	0.263	0.396	1.20	0.000E+0	0.443
2nd sc conc 7	0.961	0.410	0.823	1.10	1.08	1.05	0.410	0.783	1.92	0.000E+0	0.958
2nd sc conc 8	1.38	0.487	1.06	1.53	1.20	1.52	0.487	1.02	2.05	0.000E+0	1.38
2nd sc tls 1	[illegible]	[illegible]	20.1	36.1	7.82	40.2	6.28	20.7	4.65	0.000E+0	41.4

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	2.35	9.18	4.71	30.2	32.8	2.94	26.5	13.0	6.40	31.0	23.0
Clnr Conc 2	5.59	9.17	4.74	29.9	32.5	2.99	26.5	13.1	6.01	30.7	23.6
Clnr Conc 3	11.5	9.08	4.89	29.6	32.2	3.39	26.2	13.5	5.78	30.3	24.1
Clnr Conc 4	18.6	8.33	4.75	28.0	29.9	4.31	24.1	13.1	7.56	26.3	29.0
Clnr Conc 5	28.9	6.90	4.27	25.1	25.3	5.91	19.9	11.6	11.9	16.0	38.5
Clnr Conc 6	44.8	5.33	3.72	22.0	20.5	7.75	15.4	10.1	13.7	11.6	49.3
Clnr Conc 7	63.3	4.03	3.07	19.5	16.3	9.41	11.7	8.28	12.6	8.18	59.3
Clnr Conc 8	82.2	3.19	2.53	17.6	13.5	10.5	9.22	6.82	11.6	6.31	66.1
Clnr tls	260.	1.05	0.979	12.7	5.52	12.0	3.06	2.59	6.33	1.99	86.0
2nd sc tls 2	0.112E+4	0.266	0.305	8.40	1.38	11.8	0.768	0.818	1.48	0.465	96.5
2ndsc con 1-2	0.112E+4	0.266	0.305	8.40	1.38	11.8	0.768	0.818	1.49	0.464	96.5
2nd sc conc 3	0.112E+4	0.266	0.305	8.41	1.39	11.8	0.768	0.818	1.50	0.463	96.5
2nd sc conc 4	0.112E+4	0.265	0.305	8.43	1.39	11.8	0.766	0.817	1.52	0.461	96.4
2nd sc conc 5	0.113E+4	0.265	0.304	8.43	1.39	11.9	0.764	0.816	1.53	0.458	96.4
2nd sc conc 6	0.114E+4	0.263	0.303	8.44	1.39	11.9	0.760	0.813	1.54	0.455	96.4
2nd sc conc 7	0.116E+4	0.260	0.302	8.45	1.39	11.9	0.751	0.808	1.54	0.447	96.5
2nd sc conc 8	0.119E+4	0.255	0.299	8.46	1.37	11.9	0.737	0.799	1.54	0.437	96.5
2nd sc tls 1	0.200E+4	0.162	0.222	7.86	0.883	11.8	0.467	0.599	0.960	0.259	97.7

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	0.118	6.67	2.49	0.452	4.37	0.292E-1	6.67	2.56	0.784	14.1	0.277E-1
Clnr Conc 2	0.280	15.8	5.98	1.06	10.3	0.706E-1	15.8	6.13	1.75	33.1	0.677E-1
Clnr Conc 3	0.575	32.3	12.7	2.16	21.0	0.165	32.3	13.0	3.46	67.3	0.142
Clnr Conc 4	0.929	47.8	19.9	3.31	31.4	0.338	47.8	20.3	7.31	94.1	0.276
Clnr Conc 5	1.44	61.6	27.7	4.61	41.4	0.721	61.6	28.1	17.9	100.	0.569
Clnr Conc 6	2.24	73.9	37.5	6.26	51.9	1.47	73.9	37.7	32.0	100.	1.13
Clnr Conc 7	3.17	79.0	43.8	7.85	58.4	2.52	79.0	43.9	41.7	100.	1.92
Clnr Conc 8	4.11	81.1	46.9	9.32	62.8	3.64	81.1	46.8	49.6	100.	2.78
Clnr tls	13.0	85.1	57.3	21.0	81.3	13.2	85.1	56.3	85.7	100.	11.4
2nd sc tls 2	55.8	91.8	76.6	59.7	87.1	55.9	91.8	76.3	85.9	100.	55.1
2ndsc con 1-2	55.9	91.9	76.8	59.8	87.4	56.0	91.9	76.4	86.6	100.	55.2
2nd sc conc 3	56.0	92.1	76.9	60.0	87.9	56.1	92.1	76.5	87.5	100.	55.3
2nd sc conc 4	56.3	92.3	77.2	60.3	88.6	56.4	92.3	76.8	88.9	100.	55.5
2nd sc conc 5	56.6	92.6	77.6	60.8	89.2	56.7	92.6	77.1	90.2	100.	55.9
2nd sc conc 6	57.0	92.8	78.0	61.3	89.9	57.3	92.8	77.5	91.4	100.	56.3
2nd sc conc 7	58.0	93.2	78.8	62.4	91.0	58.3	93.2	78.3	93.3	100.	57.3
2nd sc conc 8	59.4	93.7	79.9	63.9	92.2	59.8	93.7	79.3	95.3	100.	58.6
2nd sc tls 1	100.	100.	100.	100.	100.	100.0	100.0	100.0	100.	100.	100.

T12940: Lac des Iles Ore (555): Optimizing 1st clnr with 0.04 g/kg PAX
an 2nd scav with 0.02 g/kg DDM
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	2.35	9.18	4.71	30.2	32.8	2.94	26.5	13.0	6.40	31.0	23.0
Clnr Conc 2	3.24	9.16	4.77	29.6	32.3	3.02	26.5	13.2	5.74	30.5	24.1
Clnr Conc 3	5.90	9.00	5.02	29.3	32.0	3.77	26.0	13.9	5.55	30.0	24.6
Clnr Conc 4	7.07	7.11	4.52	25.4	26.1	5.80	20.5	12.4	10.5	19.7	36.9
Clnr Conc 5	10.3	4.33	3.40	19.9	17.1	8.79	12.5	9.06	19.8	2.98	55.7
Clnr Conc 6	15.9	2.49	2.72	16.3	11.6	11.1	7.19	7.22	16.9	0.000E+0	68.7
Clnr Conc 7	18.6	0.900	1.50	13.4	6.21	13.4	2.60	3.97	10.1	0.000E+0	83.4
Clnr Conc 8	18.8	0.350	0.740	12.3	4.17	14.1	1.01	1.89	8.06	0.000E+0	89.0
Clnr tls	178.	0.740E-1	0.260	10.3	1.83	12.7	0.214	0.639	3.90	0.000E+0	95.3
TOTAL	259.85	1.060	0.979	12.678	5.522	11.999	3.061	2.593	6.327	1.995	86.024

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	0.904	7.84	4.35	2.15	5.37	0.222	7.84	4.54	0.915	14.1	0.242
Clnr Conc 2	1.25	10.8	6.07	2.91	7.29	0.314	10.8	6.34	1.13	19.1	0.349
Clnr Conc 3	2.27	19.3	11.6	5.25	13.2	0.713	19.3	12.2	1.99	34.1	0.649
Clnr Conc 4	2.72	18.3	12.6	5.45	12.9	1.32	18.3	13.0	4.50	26.8	1.17
Clnr Conc 5	3.96	16.2	13.8	6.22	12.3	2.90	16.2	13.8	12.4	5.92	2.57
Clnr Conc 6	6.13	14.4	17.0	7.88	12.9	5.67	14.4	17.1	16.4	0.000E+0	4.90
Clnr Conc 7	7.14	6.07	10.9	7.55	8.03	7.98	6.07	10.9	11.4	0.000E+0	6.92
Clnr Conc 8	7.25	2.39	5.48	7.03	5.47	8.52	2.39	5.27	9.23	0.000E+0	7.50
Clnr tls	68.4	4.78	18.2	55.6	22.7	72.4	4.78	16.9	42.1	0.000E+0	75.7

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	2.35	9.18	4.71	30.2	32.8	2.94	26.5	13.0	6.40	31.0	23.0
Clnr Conc 2	5.59	9.17	4.74	29.9	32.5	2.99	26.5	13.1	6.01	30.7	23.6
Clnr Conc 3	11.5	9.08	4.89	29.6	32.2	3.39	26.2	13.5	5.78	30.3	24.1
Clnr Conc 4	18.6	8.33	4.75	28.0	29.9	4.31	24.1	13.1	7.56	26.3	29.0
Clnr Conc 5	28.9	6.90	4.27	25.1	25.3	5.91	19.9	11.6	11.9	18.0	38.5
Clnr Conc 6	44.8	5.33	3.72	22.0	20.5	7.75	15.4	10.1	13.7	11.6	49.3
Clnr Conc 7	63.3	4.03	3.07	19.5	16.3	9.41	11.7	8.28	12.6	8.18	59.3
Clnr Conc 8	82.2	3.19	2.53	17.8	13.5	10.5	9.22	6.82	11.6	6.31	66.1
Clnr tls	260.	1.06	0.979	12.7	5.52	12.0	3.06	2.59	6.33	1.99	86.0

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr Conc 1	0.904	7.84	4.35	2.15	5.37	0.222	7.84	4.54	0.915	14.1	0.242
Clnr Conc 2	2.15	18.6	10.4	5.07	12.7	0.535	18.6	10.9	2.04	33.1	0.591
Clnr Conc 3	4.42	37.9	22.1	10.3	25.8	1.25	37.9	23.0	4.04	67.3	1.24
Clnr Conc 4	7.14	56.2	34.6	15.8	38.7	2.56	56.2	36.0	8.54	94.1	2.41
Clnr Conc 5	11.1	72.4	48.4	22.0	51.0	5.47	72.4	49.9	20.9	100.	4.97
Clnr Conc 6	17.2	86.8	65.4	29.9	63.8	11.1	86.8	67.0	37.3	100.	9.87
Clnr Conc 7	24.4	92.8	76.4	37.4	71.9	19.1	92.8	77.9	48.7	100.	16.8
Clnr Conc 8	31.6	95.2	81.8	44.4	77.3	27.6	95.2	83.1	57.9	100.	24.3
Clnr tls	100.	100.	100.	100.	100.	100.	100.	100.0	100.	100.	100.0

Mineral calculations based on 0.800% Ni in Po

T12940: Lac des Iles Ore (555): Optimizing 1st clnr with 0.04 g/kg PAX
an 2nd scav with 0.02 g/kg DDM
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndsc con 1-2	1.80	0.210	0.340	11.5	3.31	12.0	0.607	0.790	7.16	0.000E+0	91.4
2nd sc conc 3	1.82	0.310	0.350	13.8	4.56	11.4	0.895	0.752	10.1	0.000E+0	88.3
2nd sc conc 4	5.41	0.150	0.250	11.0	2.32	12.5	0.433	0.587	4.98	0.000E+0	94.0
2nd sc conc 5	6.46	0.130	0.240	10.0	1.78	13.1	0.376	0.588	3.67	0.000E+0	95.4
2nd sc conc 6	8.95	0.950E-1	0.210	9.44	1.29	13.3	0.274	0.529	2.57	0.000E+0	96.6
2nd sc conc 7	19.2	0.690E-1	0.190	9.02	0.990	12.9	0.199	0.488	1.91	0.000E+0	97.4
2nd sc conc 8	27.6	0.570E-1	0.170	8.70	0.770	13.0	0.165	0.443	1.43	0.000E+0	98.0
2nd sc tls 1	812.	0.250E-1	0.110	6.98	0.170	11.7	0.722E-1	0.305	0.110	0.000E+0	99.5
TOTAL	883.06	0.030	0.117	7.173	0.258	11.798	0.087	0.321	0.306	0.000	99.285

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndsc con 1-2	0.204	1.42	0.590	0.327	2.61	0.207	1.42	0.501	4.77	0.000E+0	0.188
2nd sc conc 3	0.206	2.12	0.614	0.397	3.64	0.199	2.12	0.483	6.79	0.000E+0	0.183
2nd sc conc 4	0.613	3.05	1.30	0.939	5.50	0.649	3.05	1.12	9.97	0.000E+0	0.580
2nd sc conc 5	0.732	3.15	1.50	1.02	5.04	0.812	3.15	1.34	8.77	0.000E+0	0.703
2nd sc conc 6	1.01	3.19	1.81	1.33	5.06	1.14	3.19	1.67	8.51	0.000E+0	0.986
2nd sc conc 7	2.18	4.98	3.52	2.74	8.34	2.38	4.98	3.31	13.6	0.000E+0	2.13
2nd sc conc 8	3.13	5.91	4.53	3.79	9.32	3.45	5.91	4.31	14.6	0.000E+0	3.09
2nd sc tls 1	91.9	76.2	86.1	89.5	60.5	91.2	76.2	87.3	33.0	0.000E+0	92.1

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndsc con 1-2	1.80	0.210	0.340	11.5	3.31	12.0	0.607	0.790	7.16	0.000E+0	91.4
2nd sc conc 3	3.62	0.260	0.345	12.7	3.94	11.7	0.752	0.771	8.64	0.000E+0	89.8
2nd sc conc 4	9.03	0.194	0.288	11.7	2.97	12.2	0.561	0.661	6.45	0.000E+0	92.3
2nd sc conc 5	15.5	0.167	0.268	11.0	2.47	12.6	0.484	0.631	5.29	0.000E+0	93.6
2nd sc conc 6	24.4	0.141	0.247	10.4	2.04	12.8	0.407	0.593	4.29	0.000E+0	94.7
2nd sc conc 7	43.6	0.109	0.222	9.80	1.58	12.9	0.316	0.547	3.25	0.000E+0	95.9
2nd sc conc 8	71.3	0.890E-1	0.202	9.37	1.26	12.9	0.257	0.507	2.54	0.000E+0	96.7
2nd sc tls 1	883.	0.302E-1	0.117	7.17	0.258	11.8	0.871E-1	0.321	0.306	0.000E+0	99.3

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndsc con 1-2	0.204	1.42	0.590	0.327	2.61	0.207	1.42	0.501	4.77	0.000E+0	0.188
2nd sc conc 3	0.410	3.54	1.20	0.723	6.25	0.406	3.54	0.984	11.6	0.000E+0	0.371
2nd sc conc 4	1.02	6.58	2.51	1.66	11.8	1.06	6.58	2.10	21.5	0.000E+0	0.951
2nd sc conc 5	1.75	9.74	4.00	2.68	16.8	1.87	9.74	3.44	30.3	0.000E+0	1.65
2nd sc conc 6	2.77	12.9	5.82	4.02	21.9	3.01	12.9	5.11	38.8	0.000E+0	2.64
2nd sc conc 7	4.94	17.9	9.34	6.75	30.2	5.39	17.9	8.42	52.4	0.000E+0	4.77
2nd sc conc 8	8.07	23.8	13.9	10.5	39.5	8.83	23.8	12.7	67.0	0.000E+0	7.86
2nd sc tls 1	100.	100.	100.	100.	100.	100.	100.	100.	100.	0.000E+0	100.

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T12940: Lac dea Iles Ore (555): precious metal balance



          - ASSAYS

                    Wt        Pt        Pd        Au
Clnr conc          82.2      9.90      175.      9.10
Clnr tls           260.      0.900     7.70      0.400
Scav tls 2         856.      0.300     2.00      0.100
2 Scav conc 1      71.3      0.500     5.50      0.200
2 Scav tls 1       812.      0.200     1.50      0.100
TOTAL           2081.50      0.722     9.469     0.496


          - DISTRIBUTIONS

                    Wt        Pt        Pd        Au
Clnr conc          3.95      54.2      73.0      72.4
Clnr tls           12.5      15.6      10.2      10.1
Scav tls 2         41.1      17.1      8.69      8.29
2 Scav conc 1      3.43      2.37      1.99      1.38
2 Scav tls 1       39.0      10.8      6.18      7.86


          - CUMULATIVE ASSAYS

                    Wt        Pt        Pd        Au
Clnr conc          82.2      9.90      175.      9.10
Clnr tls           342.      3.06      47.9      2.49
Scav tls 2      0.120E+4     1.09      15.1      0.783
2 Scav conc 1   0.127E+4     1.06      14.6      0.750
2 Scav tls 1    0.208E+4     0.722     9.47      0.496


          - CUMULATIVE DISTRIBUTIONS

                    Wt        Pt        Pd        Au
Clnr conc          3.95      54.2      73.0      72.4
Clnr tls           16.4      69.7      83.1      82.5
Scav tls 2         57.6      86.8      91.8      90.8
2 Scav conc 1      61.0      89.2      93.8      92.1
2 Scav tls 1       100.      100.      100.      100.
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T12940: Lac dea Iles Ore (555): precious metal balance

- ASSAYS

	Wt	Pt	Pd	Au
2 Scav conc 1	71.3	0.500	5.50	0.200
2 Scav tls 1	812.	0.200	1.50	0.100
TOTAL	883.30	0.224	1.823	0.108

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
2 Scav conc 1	8.07	18.0	24.4	14.9
2 Scav tls 1	91.9	82.0	75.6	85.1

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
2 Scav conc 1	71.3	0.500	5.50	0.200
2 Scav tls 1	883.	0.224	1.82	0.108

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
2 Scav conc 1	8.07	18.0	24.4	14.9
2 Scav tls 1	100.	100.	100.	100.

T12945: Lac des Iles (555): 5 minute regrind, 0.075 g/kg CMC,
0.[illegible] g/kg PAX Cleaner inc.
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	2.96	9.83	4.08	33.0	37.3	2.69	28.4	11.4	2.02	42.6	15.6
Clnr conc 2	5.26	9.48	4.43	31.8	35.3	3.45	27.4	12.3	4.14	37.3	18.9
Clnr conc 3	7.53	8.36	4.70	29.0	30.9	4.66	24.1	12.9	8.18	27.7	27.0
Clnr conc 4	9.88	5.44	4.31	22.8	21.3	7.93	15.7	11.7	16.7	9.48	46.4
Clnr conc 5	15.3	2.73	3.14	17.0	12.3	11.0	7.89	8.39	17.1	0.000E+0	66.7
Clnr conc 6	15.9	1.28	1.90	13.9	7.08	13.4	3.70	5.08	10.4	0.000E+0	80.9
Clnr conc 7	17.4	0.570	1.01	12.3	4.36	14.2	1.65	2.66	7.33	0.000E+0	88.4
Clnr conc 8	15.1	0.310	0.660	11.9	3.38	14.7	0.895	1.70	6.32	0.000E+0	91.1
Clnr tls	238.	0.700E-1	0.240	10.3	1.41	13.4	0.202	0.606	2.87	0.000E+0	96.3
1 Scav tls 1	826.	0.280E-1	0.120	7.62	0.160	12.7	0.809E-1	0.334	0.526E-1	0.000E+0	99.5
2 Scav conc 1	0.450	0.490	0.640	27.8	14.6	5.47	1.42	1.01	34.8	0.000E+0	62.8
2 Scav conc 2	1.20	0.240	0.580	16.9	6.39	10.2	0.693	1.30	14.4	0.000E+0	83.6
2 Scav conc 3	1.42	0.260	0.380	16.5	6.11	10.7	0.751	0.745	14.1	0.000E+0	84.4
2 Scav conc 4	5.15	0.120	0.230	10.3	1.71	13.1	0.347	0.563	3.54	0.000E+0	95.6
2 Scav conc 5	6.32	0.120	0.220	9.59	1.39	13.4	0.347	0.553	2.74	0.000E+0	96.4
2 Scav conc 6	8.40	0.900E-1	0.210	9.45	1.19	13.6	0.260	0.535	2.33	0.000E+0	96.9
2 Scav conc 7	13.1	0.720E-1	0.210	9.19	0.900	13.7	0.208	0.550	1.63	0.000E+0	97.6
2 Scav conc 8	11.7	0.600E-1	0.190	8.81	0.730	13.7	0.173	0.502	1.27	0.000E+0	98.1
2 Scav tls	779.	0.300E-1	0.100	7.33	0.130	12.4	0.867E-1	0.279	0.179E-1	0.000E+0	99.6
TOTAL	1979.67	0.172	0.234	8.339	0.912	12.608	0.496	0.635	0.903	0.316	97.650

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	0.150	8.55	2.60	0.592	6.11	0.319E-1	8.55	2.67	0.335	20.2	0.239E-1
Clnr conc 2	0.266	14.7	5.02	1.01	10.3	0.727E-1	14.7	5.14	1.22	31.4	0.513E-1
Clnr conc 3	0.380	18.5	7.63	1.32	12.9	0.141	18.5	7.76	3.44	33.4	0.105
Clnr conc 4	0.499	15.8	9.18	1.36	11.7	0.314	15.8	9.18	9.24	15.0	0.237
Clnr conc 5	0.772	12.3	10.3	1.57	10.4	0.674	12.3	10.2	14.6	0.000E+0	0.527
Clnr conc 6	0.801	5.97	6.49	1.34	6.22	0.851	5.97	6.41	9.19	0.000E+0	0.663
Clnr conc 7	0.881	2.92	3.80	1.30	4.21	0.992	2.92	3.[illegible]	7.15	0.000E+0	0.797
Clnr conc 8	0.762	1.38	2.15	1.09	2.82	0.889	1.38	2.05	5.33	0.000E+0	0.711
Clnr tls	12.0	4.90	12.3	14.8	18.6	12.8	4.90	11.5	38.2	0.000E+0	11.9
1 Scav tls 1	41.7	6.80	21.4	38.1	7.32	42.0	6.80	22.0	2.43	0.000E+0	42.5
2 Scav conc 1	0.227E-1	0.648E-1	0.621E-1	0.758E-1	0.364	0.936E-2	0.648E-1	0.362E-1	0.875	0.000E+0	0.146E-1
2 Scav conc 2	0.606E-1	0.847E-1	0.150	0.123	0.425	0.490E-1	0.847E-1	0.124	0.969	0.000E+0	0.519E-1
2 Scav conc 3	0.717E-1	0.109	0.116	0.142	0.480	0.609E-1	0.109	0.843E-1	1.12	0.000E+0	0.620E-1
2 Scav conc 4	0.260	0.182	0.255	0.321	0.488	0.270	0.182	0.231	1.02	0.000E+0	0.255
2 Scav conc 5	0.319	0.223	0.300	0.367	0.486	0.339	0.223	0.278	0.968	0.000E+0	0.315
2 Scav conc 6	0.424	0.222	0.380	0.481	0.553	0.458	0.222	0.357	1.09	0.000E+0	0.421
2 Scav conc 7	0.659	0.276	0.591	0.726	0.650	0.716	0.276	0.572	1.19	0.000E+0	0.659
2 Scav conc 8	0.589	0.206	0.478	0.623	0.472	0.641	0.206	0.467	0.828	0.000E+0	0.592
2 Scav tls	39.3	6.87	16.8	34.6	5.60	38.7	6.87	17.3	0.782	0.000E+0	40.1

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	2.96	9.83	4.08	33.0	37.3	2.69	28.4	11.4	2.02	42.6	15.6
Clnr conc 2	8.22	9.61	4.30	32.2	36.0	3.18	27.7	11.9	3.38	39.2	17.7
Clnr conc 3	15.7	9.01	4.49	30.7	33.6	3.89	26.0	12.4	5.67	33.7	22.2
Clnr conc 4	25.6	7.63	4.42	27.6	28.8	5.44	22.1	12.1	9.93	24.4	31.5
Clnr conc 5	40.9	5.80	3.94	23.7	22.7	7.52	16.8	10.7	12.6	15.3	44.6
Clnr conc 6	56.8	4.54	3.37	20.9	18.3	9.16	13.1	9.15	12.0	11.0	54.8
Clnr conc 7	74.2	3.61	2.82	18.9	15.0	10.3	10.4	7.63	10.9	8.42	62.7
Clnr conc 8	89.3	3.05	2.45	17.7	13.1	11.1	8.81	6.63	10.1	6.99	67.5
Clnr tls	327.	0.893	0.844	12.3	4.59	12.8	2.55	2.25	4.85	1.91	88.4
1 Scav tls 1	0.115E+4	0.271	0.325	8.96	1.42	12.7	0.782	0.877	1.41	0.542	96.4
2 Scav conc 1	0.115E+4	0.271	0.326	8.96	1.42	12.7	0.782	0.878	1.43	0.541	96.4
2 Scav conc 2	0.115E+4	0.271	0.326	8.97	1.43	12.7	0.782	0.878	1.44	0.541	96.4
2 Scav conc 3	0.116E+4	0.271	0.326	8.98	1.43	12.7	0.782	0.878	1.46	0.540	96.3
2 Scav conc 4	0.116E+4	0.270	0.325	8.99	1.43	12.7	0.780	0.876	1.47	0.538	96.3
2 Scav conc 5	0.117E+4	0.269	0.325	8.99	1.43	12.7	0.778	0.875	1.47	0.535	96.3
2 Scav conc 6	0.118E+4	0.268	0.324	8.99	1.43	12.7	0.774	0.872	1.48	0.531	96.3
2 Scav conc 7	0.119E+4	0.266	0.323	9.00	1.43	12.7	0.768	0.869	1.48	0.525	96.4
2 Scav conc 8	0.120E+4	0.264	0.322	8.99	1.42	12.7	0.762	0.865	1.48	0.520	96.4
2 Scav tls	0.198E+4	0.172	0.234	8.34	0.912	12.6	0.496	0.635	0.903	0.316	97.7

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	0.150	8.55	2.60	0.592	6.11	0.319E-1	8.55	2.67	0.335	20.2	0.239E-1
Clnr conc 2	0.415	23.2	7.62	1.60	16.4	0.105	23.2	7.82	1.55	51.6	0.753E-1
Clnr conc 3	0.796	41.7	15.3	2.93	29.3	0.245	41.7	15.6	5.00	85.0	0.181
Clnr conc 4	1.29	57.5	24.4	4.29	40.9	0.559	57.5	24.8	14.2	100.	0.418
Clnr conc 5	2.07	69.8	34.8	5.87	51.3	1.23	69.8	35.0	28.8	100.	0.945
Clnr conc 6	2.87	75.8	41.3	7.20	57.6	2.08	75.8	41.4	38.0	100.	1.61
Clnr conc 7	3.75	78.7	45.1	8.50	61.8	3.08	78.7	45.1	45.2	100.	2.41
Clnr conc 8	4.51	80.1	47.2	9.59	64.6	3.97	80.1	47.1	50.5	100.	3.12
Clnr tls	16.5	85.0	59.5	24.4	83.2	16.7	85.0	58.6	88.7	100.	15.0
1 Scav tls 1	58.3	91.8	80.9	62.6	90.5	58.8	91.8	80.6	91.2	100.	57.5
2 Scav conc 1	58.3	91.8	80.9	62.6	90.8	58.8	91.8	80.6	92.0	100.	57.5
2 Scav conc 2	58.3	91.9	81.1	62.8	91.3	58.8	91.9	80.7	93.0	100.	57.6
2 Scav conc 3	58.4	92.0	81.2	62.9	91.7	58.9	92.0	80.8	94.1	100.	57.6
2 Scav conc 4	58.7	92.2	81.5	63.2	92.2	59.2	92.2	81.0	95.1	100.	57.9
2 Scav conc 5	59.0	92.4	81.8	63.6	92.7	59.5	92.4	81.3	96.1	100.	58.2
2 Scav conc 6	59.4	92.6	82.1	64.1	93.3	60.0	92.6	81.7	97.2	100.	58.6
2 Scav conc 7	60.1	92.9	82.7	64.8	93.9	60.7	92.9	82.2	98.4	100.	59.3
2 Scav conc 8	60.7	93.1	83.2	65.4	94.4	61.3	93.1	82.7	99.2	100.	59.9
2 Scav tls	100.	100.	100.	100.	100.0	100.0	100.	100.0	100.	100.	100.

T12945: Lac des Iles (555): 5 minute regrind, 0.075 g/kg CMC,
0.04 g/kg PAX Cleaner inc.
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	2.96	9.83	4.08	33.0	37.3	2.69	28.4	11.4	2.02	42.6	15.6
Clnr conc 2	5.26	9.48	4.43	31.8	35.3	3.45	27.4	12.3	4.14	37.3	18.9
Clnr conc 3	7.53	8.36	4.70	29.0	30.9	4.66	24.1	12.9	8.18	27.7	27.0
Clnr conc 4	9.88	5.44	4.31	22.8	21.3	7.93	15.7	11.7	16.7	9.48	46.4
Clnr conc 5	15.3	2.73	3.14	17.0	12.3	11.0	7.89	8.39	17.1	0.000E+0	66.7
Clnr conc 6	15.9	1.28	1.90	13.9	7.08	13.4	3.70	5.08	10.4	0.000E+0	80.9
Clnr conc 7	17.4	0.570	1.01	12.3	4.36	14.2	1.65	2.66	7.33	0.000E+0	88.4
Clnr conc 8	15.1	0.310	0.660	11.9	3.38	14.7	0.895	1.70	6.32	0.000E+0	91.1
Clnr tls	238.	0.700E-1	0.240	10.3	1.41	13.4	0.202	0.606	2.87	0.000E+0	96.3
TOTAL	327.31	0.883	0.844	12.326	4.589	12.768	2.550	2.249	4.848	1.908	88.444

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	0.904	10.1	4.37	2.42	7.35	0.191	10.1	4.57	0.378	20.2	0.160
Clnr conc 2	1.61	17.3	8.44	4.15	12.4	0.434	17.3	8.78	1.37	31.4	0.343
Clnr conc 3	2.30	21.8	12.8	5.41	15.5	0.840	21.8	13.2	3.88	33.4	0.703
Clnr conc 4	3.02	18.6	15.4	5.58	14.0	1.87	18.6	15.7	10.4	15.0	1.58
Clnr conc 5	4.67	14.4	17.4	6.44	12.5	4.02	14.4	17.4	16.4	0.000E+0	3.52
Clnr conc 6	4.85	7.02	10.9	5.46	7.48	5.09	7.02	10.9	10.4	0.000E+0	4.43
Clnr conc 7	5.33	3.44	6.38	5.32	5.06	5.93	3.44	6.30	8.05	0.000E+0	5.32
Clnr conc 8	4.61	1.62	3.61	4.45	3.40	5.31	1.62	3.49	6.01	0.000E+0	4.75
Clnr tls	72.7	5.77	20.7	60.8	22.3	76.3	5.77	19.6	43.1	0.000E+0	79.2

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	2.96	9.83	4.08	33.0	37.3	2.69	28.4	11.4	2.02	42.6	15.6
Clnr conc 2	8.22	9.61	4.30	32.2	36.0	3.18	27.7	11.9	3.38	39.2	17.7
Clnr conc 3	15.7	9.01	4.49	30.7	33.6	3.89	26.0	12.4	5.67	33.7	22.2
Clnr conc 4	25.6	7.63	4.42	27.6	28.8	5.44	22.1	12.1	9.93	24.4	31.5
Clnr conc 5	40.9	5.80	3.94	23.7	22.7	7.52	16.8	10.7	12.6	15.3	44.6
Clnr conc 6	56.8	4.54	3.37	20.9	18.3	9.16	13.1	9.15	12.0	11.0	54.8
Clnr conc 7	74.2	3.61	2.82	18.9	15.0	10.3	10.4	7.63	10.9	8.42	62.7
Clnr conc 8	89.3	3.05	2.45	17.7	13.1	11.1	8.81	6.63	10.1	6.99	67.5
Clnr tls	327.	0.883	0.844	12.3	4.59	12.8	2.55	2.25	4.85	1.91	88.4

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
Clnr conc 1	0.904	10.1	4.37	2.42	7.35	0.191	10.1	4.57	0.378	20.2	0.160
Clnr conc 2	2.51	27.3	12.8	6.57	19.7	0.625	27.3	13.3	1.75	51.6	0.503
Clnr conc 3	4.81	49.1	25.6	12.0	35.2	1.46	49.1	26.6	5.63	85.0	1.21
Clnr conc 4	7.83	67.7	41.0	17.6	49.2	3.34	67.7	42.2	16.0	100.	2.79
Clnr conc 5	12.5	82.2	58.4	24.0	61.7	7.36	82.2	59.7	32.5	100.	6.31
Clnr conc 6	17.3	89.2	69.3	29.5	69.2	12.4	89.2	70.6	42.8	100.	10.7
Clnr conc 7	22.7	92.6	75.7	34.9	74.3	18.4	92.6	76.9	50.9	100.	16.1
Clnr conc 8	27.3	94.2	79.3	39.2	77.7	23.7	94.2	80.4	56.9	100.	20.8
Clnr tls	100.	100.	100.	100.	100.	100.	100.0	100.0	100.	100.	100.

Mineral calculations based on 0.800% Ni in Pn

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              T12945: Lac des Iles (555): 5 minute  regrind, 0.075 g/kg CMC,
              0.04 g/kg PAX Cleaner inc.
              ERB # 2174


                 - ASSAYS

                     Wt        Cu        Ni       Fe        S         MgO       Cp        Pn        Po        Py         Rk
 2 Scav conc 1 0.450     0.490     0.640     27.8      14.6      5.47      1.42      1.01      34.8      0.000E+0  62.8
 2 Scav conc 2  1.20     0.240     0.580     16.9      6.39      10.2      0.693     1.30      14.4      0.000E+0  83.6
 2 Scav conc 3  1.42     0.260     0.380     16.5      6.11      10.7      0.751     0.745     14.1      0.000E+0  84.4
 2 Scav conc 4  5.15     0.120     0.230     10.3      1.71      13.1      0.347     0.563     3.54      0.000E+0  95.6
 2 Scav conc 5  6.32     0.120     0.220     9.59      1.39      13.4      0.347     0.553     2.74      0.000E+0  96.4
 2 Scav conc 6  8.40     0.900E-1  0.210     9.45      1.19      13.6      0.260     0.535     2.33      0.000E+0  96.9
 2 Scav conc 7  13.1     0.720E-1  0.210     9.19      0.900     13.7      0.208     0.550     1.63      0.000E+0  97.6
 2 Scav conc 8  11.7     0.600E-1  0.190     8.81      0.730     13.7      0.173     0.502     1.27      0.000E+0  98.1
 2 Scav tls     779.     0.300E-1  0.100     7.33      0.130     12.4      0.867E-1  0.279     0.179E-1  0.000E+0  99.6
 TOTAL         826.46     0.034     0.107     7.478     0.208    12.453     0.098     0.296     0.191     0.000     99.415


                 - DISTRIBUTIONS

                     Wt        Cu        Ni       Fe        S         MgO       Cp        Pn        Po        Py         Rk
 2 Scav conc 1 0.544E-1  0.787     0.325     0.202     3.82      0.239E-1  0.787     0.186     9.89      0.000E+0  0.344E-1
 2 Scav conc 2 0.145     1.03      0.785     0.328     4.46      0.119     1.03      0.638     11.0      0.000E+0  0.122
 2 Scav conc 3 0.172     1.32      0.608     0.379     5.04      0.148     1.32      0.433     12.7      0.000E+0  0.146
 2 Scav conc 4 0.623     2.21      1.34      0.858     5.12      0.656     2.21      1.19      11.5      0.000E+0  0.599
 2 Scav conc 5 0.765     2.71      1.57      0.981     5.11      0.823     2.71      1.43      10.9      0.000E+0  0.741
 2 Scav conc 6  1.02     2.70      1.99      1.28      5.81      1.11      2.70      1.84      12.4      0.000E+0  0.990
 2 Scav conc 7  1.58     3.35      3.09      1.94      6.83      1.74      3.35      2.94      13.4      0.000E+0  1.55
 2 Scav conc 8  1.41     2.50      2.50      1.66      4.95      1.55      2.50      2.40      9.36      0.000E+0  1.39
 2 Scav tls     94.2     83.4      87.8      92.4      58.9      93.8      83.4      88.9      8.84      0.000E+0  94.4


                 - CUMULATIVE ASSAYS

                     Wt        Cu        Ni       Fe        S         MgO       Cp        Pn        Po        Py         Rk
 2 Scav conc 1 0.450     0.490     0.640     27.8      14.6      5.47      1.42      1.01      34.8      0.000E+0  62.8
 2 Scav conc 2  1.65     0.308     0.596     19.9      8.63      8.91      0.890     1.22      20.0      0.000E+0  77.9
 2 Scav conc 3  3.07     0.286     0.496     18.3      7.46      9.74      0.826     1.00      17.3      0.000E+0  80.9
 2 Scav conc 4  8.22     0.182     0.329     13.3      3.86      11.8      0.526     0.726     8.67      0.000E+0  90.1
 2 Scav conc 5  14.5     0.155     0.282     11.7      2.79      12.5      0.448     0.651     6.09      0.000E+0  92.8
 2 Scav conc 6  22.9     0.131     0.256     10.9      2.20      12.9      0.379     0.608     4.71      0.000E+0  94.3
 2 Scav conc 7  36.0     0.110     0.239     10.3      1.73      13.2      0.317     0.587     3.60      0.000E+0  95.5
 2 Scav conc 8  47.7     0.976E-1  0.227     9.90      1.48      13.3      0.282     0.567     3.03      0.000E+0  96.1
 2 Scav tls     826.     0.339E-1  0.107     7.48      0.208     12.5      0.979E-1  0.296     0.191     0.000E+0  99.4


                 - CUMULATIVE DISTRIBUTIONS

                     Wt        Cu        Ni       Fe        S         MgO       Cp        Pn        Po        Py         Rk
 2 Scav conc 1 0.544E-1  0.787     0.325     0.202     3.82      0.239E-1  0.787     0.186     9.89      0.000E+0  0.344E-1
 2 Scav conc 2 0.200     1.82      1.11      0.531     8.28      0.143     1.82      0.824     20.8      0.000E+0  0.156
 2 Scav conc 3 0.371     3.13      1.72      0.910     13.3      0.290     3.13      1.26      33.5      0.000E+0  0.302
 2 Scav conc 4 0.995     5.34      3.05      1.77      18.4      0.946     5.34      2.45      45.1      0.000E+0  0.901
 2 Scav conc 5  1.76     8.05      4.62      2.75      23.5      1.77      8.05      3.88      56.0      0.000E+0  1.64
 2 Scav conc 6  2.78     10.7      6.61      4.03      29.4      2.88      10.7      5.72      68.4      0.000E+0  2.63
 2 Scav conc 7  4.35     14.1      9.70      5.97      36.2      4.62      14.1      8.66      81.8      0.000E+0  4.18
 2 Scav conc 8  5.77     16.6      12.2      7.64      41.1      6.17      16.6      11.1      91.2      0.000E+0  5.58
 2 Scav tls     100.     100.      100.      100.      100.      100.      100.      100.      100.      0.000E+0  100.


 Mineral calculations based on  0.800% Ni in Po
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T12945: Lac des Iles Ore (555); Precious metals balance
of 2nd scavenger (on 2nd 1st scvavenger tls)

- ASSAYS

	Wt	Pt	Pd	Au
2 scav conc	47.7	0.400	4.70	0.200
s scav tls	779.	0.200	2.00	0.300
TOTAL	826.70	0.212	2.156	0.294

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
2 scav conc	5.77	10.9	12.6	3.92
s scav tls	94.2	89.1	87.4	96.1

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
2 scav conc	47.7	0.400	4.70	0.200
s scav tls	827.	0.212	2.16	0.294

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
2 scav conc	5.77	10.9	12.6	3.92
s scav tls	100.	100.	100.	100.

T12959: Lac des Iles Ore (555): Optimizing the 2nd cleaner and
1st clnt sacv (0.04 g/kg PAX)
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.30	9.29	4.06	36.2	40.4	0.760	26.8	11.3	4.00	48.0	9.94
2ndcl conc 2	5.20	9.78	4.70	34.8	39.3	1.12	28.2	13.1	2.19	45.2	11.2
2ndcl conc 3	5.60	8.61	4.86	31.5	34.4	2.48	24.9	13.4	5.99	35.1	20.6
2ndcl conc 4	5.40	7.79	5.46	29.4	31.5	3.57	22.5	15.1	7.59	29.0	25.8
2ndcl conc 5	5.70	5.46	5.58	24.4	23.8	6.38	15.8	15.3	14.3	13.7	40.9
2ndcl conc 6	5.30	3.28	5.09	20.6	17.8	8.86	9.47	13.8	19.9	3.23	53.6
2ndcl conc 7	5.30	1.65	3.27	17.8	11.9	11.6	4.79	8.72	18.5	0.000E+0	68.0
2ndcl conc 8	3.40	0.960	1.72	15.4	7.54	13.4	2.77	4.52	12.8	0.000E+0	79.9
2ndcl tls	33.2	0.240	0.460	10.8	2.57	12.2	0.693	1.18	4.89	0.000E+0	93.2
1stcl scav 12	1.60	0.730	1.31	14.7	6.52	13.2	2.11	3.40	11.8	0.000E+0	82.7
1stcl scav 3	1.80	0.510	0.980	13.5	5.13	13.5	1.47	2.52	9.54	0.000E+0	85.5
1stcl scav 4	3.70	0.360	0.730	12.2	4.10	13.7	1.04	1.86	7.87	0.000E+0	89.2
1stcl scav 5	5.90	0.300	0.610	15.4	3.67	14.0	0.867	1.54	7.21	0.000E+0	90.4
1stcl scav 6	11.3	0.220	0.450	11.7	2.95	14.1	0.635	1.12	5.95	0.000E+0	92.3
1stcl scav 7	10.9	0.200	0.420	11.3	2.86	14.1	0.578	1.04	5.84	0.000E+0	92.5
1stcl scav 8	15.1	0.160	0.360	11.1	2.72	13.8	0.462	0.878	5.72	0.000E+0	92.9
1stclsvca tls	227.	0.590E-1	0.180	9.87	1.23	11.9	0.170	0.445	2.58	0.000E+0	96.8
Scav tls 2	792.	0.250E-1	0.900E-1	7.19	0.220	7.23	0.722E-1	0.245	0.286	0.000E+0	99.4
Scav tls 1	846.	0.250E-1	0.930E-1	7.31	0.230	12.0	0.722E-1	0.253	0.305	0.000E+0	99.4
TOTAL	1995.10	0.145	0.201	8.080	0.924	10.046	0.419	0.540	0.997	0.376	97.668

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	0.655E-1	4.19	1.32	0.293	2.86	0.495E-2	4.19	1.36	0.263	8.35	0.666E-2
2ndcl conc 2	0.262	17.6	6.11	1.13	11.1	0.292E-1	17.6	6.34	0.576	31.5	0.301E-1
2ndcl conc 3	0.282	16.7	6.81	1.10	10.5	0.696E-1	16.7	7.02	1.69	26.4	0.593E-1
2ndcl conc 4	0.272	14.6	7.37	0.989	9.27	0.966E-1	14.6	7.59	2.07	21.0	0.718E-1
2ndcl conc 5	0.287	10.8	7.96	0.867	7.40	0.182	10.8	8.11	4.12	10.5	0.120
2ndcl conc 6	0.257	6.03	6.75	0.680	5.14	0.235	6.03	6.81	5.34	2.29	0.146
2ndcl conc 7	0.267	3.05	4.33	0.588	3.44	0.308	3.05	4.31	4.95	0.000E+0	0.186
2ndcl conc 8	0.171	1.13	1.46	0.226	1.40	0.228	1.13	1.43	2.20	0.000E+0	0.140
2ndcl tls	1.67	2.76	3.82	2.23	4.65	2.20	2.76	3.64	8.21	0.000E+0	1.60
1stcl scav 12	0.806E-1	0.405	0.524	0.147	0.569	0.106	0.405	0.507	0.950	0.000E+0	0.682E-1
1stcl scav 3	0.906E-1	0.318	0.441	0.151	0.503	0.122	0.318	0.424	0.867	0.000E+0	0.802E-1
1stcl scav 4	0.186	0.462	0.676	0.281	0.827	0.254	0.462	0.643	1.47	0.000E+0	0.170
1stcl scav 5	0.297	0.614	0.900	0.566	1.18	0.414	0.614	0.849	2.15	0.000E+0	0.275
1stcl scav 6	0.566	0.862	1.27	0.824	1.82	0.799	0.862	1.18	3.39	0.000E+0	0.538
1stcl scav 7	0.549	0.756	1.15	0.768	1.70	0.770	0.756	1.06	3.21	0.000E+0	0.520
1stcl scav 8	0.760	0.838	1.36	1.04	2.24	1.04	0.838	1.24	4.37	0.000E+0	0.723
1stclsvca tls	11.5	4.65	10.2	14.0	15.3	13.6	4.65	9.44	29.7	0.000E+0	11.4
Scav tls 2	39.9	6.87	17.8	35.5	9.50	28.7	6.87	18.1	11.5	0.000E+0	40.6
Scav tls 1	42.5	7.33	19.7	38.5	10.6	50.9	7.33	19.9	13.0	0.000E+0	43.3

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.30	9.29	4.06	36.2	40.4	0.760	26.8	11.3	4.00	48.0	9.94
2ndcl conc 2	6.50	9.68	4.57	35.1	39.5	1.05	28.0	12.7	2.55	45.8	11.0
2ndcl conc 3	12.1	9.19	4.71	33.4	37.2	1.71	26.5	13.1	4.14	40.9	15.4
2ndcl conc 4	17.5	8.76	4.94	32.2	35.4	2.28	25.2	13.7	5.21	37.2	18.6
2ndcl conc 5	23.2	7.95	5.10	30.3	32.6	3.29	23.0	14.1	7.44	31.4	24.1
2ndcl conc 6	28.5	7.08	5.09	28.5	29.8	4.33	20.4	14.0	9.77	26.2	29.6
2ndcl conc 7	33.8	6.23	4.81	26.6	27.0	5.47	18.0	13.2	11.1	22.1	35.6
2ndcl conc 8	37.2	5.75	4.53	25.6	25.2	6.19	16.6	12.4	11.3	20.1	39.7
2ndcl tls	70.4	3.15	2.61	18.7	14.5	9.50	9.10	7.10	8.27	10.6	64.9
1stcl scav 12	72.0	3.10	2.58	18.6	14.4	9.59	8.94	7.02	8.35	10.4	65.3
1stcl scav 3	73.8	3.03	2.54	18.5	14.1	9.67	8.76	6.91	8.38	10.1	65.8
1stcl scav 4	77.5	2.91	2.45	18.2	13.7	9.87	8.39	6.67	8.35	9.63	67.0
1stcl scav 5	83.4	2.72	2.32	18.0	13.0	10.2	7.86	6.31	8.27	8.95	68.6
1stcl scav 6	94.7	2.42	2.10	17.2	11.8	10.6	7.00	5.69	8.00	7.88	71.4
1stcl scav 7	105.	2.19	1.93	16.6	10.8	11.0	6.34	5.21	7.77	7.07	73.6
1stcl scav 8	121.	1.94	1.73	15.9	9.82	11.3	5.60	4.67	7.52	6.19	76.0
1stclsvca tls	348.	0.711	0.719	12.0	4.21	11.7	2.05	1.91	4.29	2.14	89.6
Scav tls 2	0.114E+4	0.234	0.282	8.65	1.44	8.60	0.677	0.753	1.51	0.655	96.4
Scav tls 1	0.199E+4	0.145	0.201	8.08	0.924	10.0	0.419	0.540	0.997	0.376	97.7

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	0.655E-1	4.19	1.32	0.293	2.86	0.495E-2	4.19	1.36	0.263	8.35	0.666E-2
2ndcl conc 2	0.327	21.8	7.43	1.42	14.0	0.341E-1	21.8	7.70	0.839	39.9	0.368E-1
2ndcl conc 3	0.609	38.5	14.2	2.52	24.5	0.104	38.5	14.7	2.53	66.2	0.961E-1
2ndcl conc 4	0.881	53.1	21.6	3.51	33.8	0.200	53.1	22.3	4.60	87.2	0.168
2ndcl conc 5	1.17	63.9	29.6	4.38	41.2	0.383	63.9	30.4	8.72	97.7	0.288
2ndcl conc 6	1.43	69.9	36.3	5.06	46.3	0.618	69.9	37.2	14.1	100.0	0.435
2ndcl conc 7	1.70	73.0	40.7	5.64	49.8	0.926	73.0	41.5	19.0	100.0	0.620
2ndcl conc 8	1.87	74.1	42.1	5.97	51.2	1.15	74.1	43.0	21.2	100.0	0.760
2ndcl tls	3.54	76.9	45.9	8.21	55.8	3.35	76.9	46.6	29.4	100.0	2.36
1stcl scav 12	3.62	77.3	46.5	8.35	56.4	3.46	77.3	47.1	30.4	100.0	2.42
1stcl scav 3	3.72	77.6	46.9	8.50	56.9	3.58	77.6	47.5	31.2	100.0	2.50
1stcl scav 4	3.90	78.1	47.6	8.78	57.7	3.83	78.1	48.2	32.7	100.0	2.67
1stcl scav 5	4.20	78.7	48.5	9.35	58.9	4.25	78.7	49.0	34.9	100.0	2.95
1stcl scav 6	4.77	79.6	49.7	10.2	60.7	5.05	79.6	50.2	38.2	100.0	3.49
1stcl scav 7	5.32	80.3	50.9	10.9	62.4	5.82	80.3	51.3	41.5	100.0	4.01
1stcl scav 8	6.08	81.1	52.3	12.0	64.6	6.86	81.1	52.5	45.8	100.0	4.73
1stclsvca tls	17.5	85.8	62.5	26.0	79.9	20.4	85.8	62.0	75.5	100.0	16.1
Scav tls 2	57.4	92.7	80.3	61.5	89.4	49.1	92.7	80.1	87.0	100.0	56.7
Scav tls 1	100.0	100.	100.	100.	100.	100.	100.	100.	100.0	100.0	100.

T12958: Lac des Iles Ore (555): Optimizing the 2nd cleaner and 1st clnt sacv (0.04 g/kg PAX)
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.30	9.29	4.06	36.2	40.4	0.760	26.8	11.3	4.00	48.0	9.94
2ndcl conc 2	5.20	9.78	4.70	34.8	39.3	1.12	28.2	13.1	2.19	45.2	11.2
2ndcl conc 3	5.60	8.61	4.86	31.5	34.4	2.48	24.9	13.4	5.99	35.1	20.6
2ndcl conc 4	5.40	7.79	5.46	29.4	31.5	3.57	22.5	15.1	7.59	29.0	25.8
2ndcl conc 5	5.70	5.46	5.58	24.4	23.8	6.38	15.8	15.3	14.3	13.7	40.9
2ndcl conc 6	5.30	3.28	5.09	20.6	17.8	8.86	9.47	13.8	19.9	3.23	53.6
2ndcl conc 7	5.30	1.66	3.27	17.8	11.9	11.6	4.79	8.72	18.5	0.000E+0	68.0
2ndcl conc 8	3.40	0.960	1.72	15.4	7.54	13.4	2.77	4.52	12.8	0.000E+0	79.9
2ndcl tls	33.2	0.240	0.460	10.8	2.57	13.2	0.693	1.18	4.89	0.000E+0	93.2
TOTAL	70.40	3.150	2.609	18.703	14.540	9.497	9.098	7.102	8.272	10.605	64.923

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.85	5.45	2.87	3.57	5.13	0.148	5.45	2.93	0.893	8.35	0.283
2ndcl conc 2	7.39	22.9	13.3	13.7	20.0	0.871	22.9	13.6	1.96	31.5	1.28
2ndcl conc 3	7.95	21.7	14.8	13.4	18.8	2.08	21.7	15.1	5.76	26.4	2.52
2ndcl conc 4	7.67	19.0	16.1	12.1	16.6	2.88	19.0	16.3	7.04	21.0	3.05
2ndcl conc 5	8.10	14.0	17.3	10.6	13.3	5.44	14.0	17.4	14.0	10.5	5.10
2ndcl conc 6	7.53	7.84	14.7	8.29	9.22	7.02	7.84	14.6	18.1	2.29	6.21
2ndcl conc 7	7.53	3.97	9.44	7.16	6.16	9.20	3.97	9.24	16.8	0.000E+0	7.88
2ndcl conc 8	4.83	1.47	3.18	3.98	2.50	6.81	1.47	3.07	7.48	0.000E+0	5.94
2ndcl tls	47.2	3.59	8.32	27.2	8.34	65.5	3.59	7.81	27.9	0.000E+0	67.7

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.30	9.29	4.06	36.2	40.4	0.760	26.8	11.3	4.00	48.0	9.94
2ndcl conc 2	6.50	9.68	4.57	35.1	39.5	1.05	28.0	12.7	2.55	45.8	11.0
2ndcl conc 3	12.1	9.19	4.71	33.4	37.2	1.71	26.5	13.1	4.14	40.9	15.4
2ndcl conc 4	17.5	8.76	4.94	22.2	35.4	2.28	25.3	13.7	5.21	37.2	18.6
2ndcl conc 5	23.2	7.95	5.10	30.3	32.6	3.29	23.0	14.1	7.44	31.4	24.1
2ndcl conc 6	28.5	7.08	5.09	28.5	29.8	4.33	20.4	14.0	9.77	26.2	29.6
2ndcl conc 7	33.8	6.23	4.81	26.8	27.0	5.47	18.0	13.2	11.1	22.1	35.6
2ndcl conc 8	37.2	5.75	4.53	25.8	25.2	6.19	16.6	12.4	11.3	20.1	39.7
2ndcl tls	70.4	3.15	2.61	18.7	14.5	9.50	9.10	7.10	8.27	10.6	64.9

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
2ndcl conc 1	1.85	5.45	2.87	3.57	5.13	0.148	5.45	2.93	0.893	8.35	0.283
2ndcl conc 2	9.23	28.4	16.2	17.3	25.1	1.02	28.4	16.5	2.85	39.9	1.56
2ndcl conc 3	17.2	50.1	31.0	30.7	43.9	3.10	50.1	31.6	8.61	65.2	4.08
2ndcl conc 4	24.9	69.1	47.1	42.8	60.5	5.98	69.1	47.9	15.7	87.2	7.13
2ndcl conc 5	33.0	83.1	64.4	53.3	73.8	11.4	83.1	65.3	29.6	97.7	12.2
2ndcl conc 6	40.5	91.0	79.1	61.6	83.0	18.4	91.0	79.9	47.8	100.	18.4
2ndcl conc 7	48.0	94.9	88.5	68.8	89.2	27.6	94.9	89.1	64.6	100.	26.3
2ndcl conc 8	52.8	96.4	91.7	72.8	91.7	34.5	96.4	92.2	72.1	100.	32.3
2ndcl tls	100.0	100.	100.0	100.	100.	100.	100.	100.	100.	100.	100.

T12958: Lac des Iles Ore (555): Optimizing the 2nd cleaner and
1st clnt sacv (0.04 g/kg PAX)
ERB # 2174

- ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
1stcl scav 12	1.60	0.730	1.31	14.7	6.52	13.2	2.11	3.40	11.8	0.000E+0	82.7
1stcl scav 3	1.80	0.510	0.980	13.5	5.13	13.5	1.47	2.52	9.54	0.000E+0	86.5
1stcl scav 4	3.70	0.360	0.730	12.2	4.10	13.7	1.04	1.86	7.87	0.000E+0	89.2
1stcl scav 5	5.90	0.300	0.610	15.4	3.67	14.0	0.867	1.54	7.21	0.000E+0	90.4
1stcl scav 6	11.3	0.220	0.450	11.7	2.95	14.1	0.635	1.12	5.95	0.000E+0	92.3
1stcl scav 7	10.9	0.200	0.420	11.3	2.86	14.1	0.578	1.04	5.84	0.000E+0	92.5
1stcl scav 8	15.1	0.160	0.360	11.1	2.72	13.8	0.462	0.878	5.72	0.000E+0	92.9
1stclsvca tls	227.	0.590E-1	0.180	9.87	1.23	11.9	0.170	0.445	2.58	0.000E+0	96.8
TOTAL	277.80	0.092	0.238	10.267	1.591	12.266	0.267	0.592	3.284	0.000	95.856

- DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
1stcl scav 12	0.576	4.55	3.17	0.825	2.36	0.620	4.55	3.30	2.06	0.000E+0	0.497
1stcl scav 3	0.648	3.57	2.66	0.852	2.09	0.713	3.57	2.76	1.88	0.000E+0	0.584
1stcl scav 4	1.33	5.18	4.08	1.58	3.43	1.49	5.18	4.19	3.19	0.000E+0	1.24
1stcl scav 5	2.12	6.89	5.44	3.19	4.90	2.42	6.89	5.53	4.66	0.000E+0	2.00
1stcl scav 6	4.07	9.68	7.68	4.64	7.54	4.68	9.68	7.72	7.36	0.000E+0	3.92
1stcl scav 7	3.92	8.48	6.91	4.32	7.05	4.51	8.48	6.91	6.97	0.000E+0	3.79
1stcl scav 8	5.44	9.40	8.21	5.88	9.29	6.12	9.40	8.05	9.47	0.000E+0	5.27
1stclsvca tls	81.9	52.2	61.8	78.7	63.3	79.5	52.2	61.5	64.4	0.000E+0	82.7

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
1stcl scav 12	1.60	0.730	1.31	14.7	6.52	13.2	2.11	3.40	11.8	0.000E+0	82.7
1stcl scav 3	3.40	0.614	1.14	14.1	5.78	13.4	1.77	2.93	10.6	0.000E+0	84.7
1stcl scav 4	7.10	0.481	0.924	13.1	4.91	13.5	1.39	2.38	9.17	0.000E+0	87.1
1stcl scav 5	13.0	0.399	0.782	14.1	4.35	13.7	1.15	2.00	8.28	0.000E+0	88.6
1stcl scav 6	24.3	0.316	0.627	13.0	3.70	13.9	0.912	1.59	7.19	0.000E+0	90.3
1stcl scav 7	35.2	0.280	0.563	12.5	3.44	14.0	0.809	1.42	6.77	0.000E+0	91.0
1stcl scav 8	50.3	0.244	0.502	12.1	3.22	13.9	0.705	1.26	6.46	0.000E+0	91.6
1stclsvca tls	278.	0.925E-1	0.238	10.3	1.59	12.3	0.267	0.592	3.28	0.000E+0	95.9

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	Fe	S	MgO	Cp	Pn	Po	Py	Rk
1stcl scav 12	0.576	4.55	3.17	0.825	2.36	0.620	4.55	3.30	2.06	0.000E+0	0.497
1stcl scav 3	1.22	8.12	5.83	1.68	4.45	1.33	8.12	6.06	3.94	0.000E+0	1.08
1stcl scav 4	2.56	13.3	9.91	3.26	7.88	2.82	13.3	10.3	7.14	0.000E+0	2.32
1stcl scav 5	4.68	20.2	15.3	6.44	12.8	5.24	20.2	15.8	11.8	0.000E+0	4.32
1stcl scav 6	8.75	29.9	23.0	11.1	20.3	9.92	29.9	23.5	19.2	0.000E+0	8.24
1stcl scav 7	12.7	38.4	29.9	15.4	27.4	14.4	38.4	30.4	26.1	0.000E+0	12.0
1stcl scav 8	18.1	47.8	38.2	21.3	36.7	20.5	47.8	38.5	35.6	0.000E+0	17.3
1stclsvca tls	100.	100.	100.	100.	100.	100.	100.	100.	100.	0.000E+0	100.

Mineral calculations based on 0.000% Ni in Po

T12958: Lac des Iles Ore (S55); Optimizing the 2nd cleaner and
1st cleaner scavenger (0.04 g/kg PAX)
ERB # 2174

- ASSAYS

	Wt	Pt	Pd	Au
2nd Cl Con	28.5	22.6	385.	28.3
2nd Cl Tails	41.9	2.50	51.6	1.50
TOTAL	70.40	10.657	186.773	12.349

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
2nd Cl Con	40.5	86.0	83.6	92.8
2nd Cl Tails	59.5	14.0	16.4	7.23

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
2nd Cl Con	28.5	22.6	385.	28.3
2nd Cl Tails	70.4	10.7	187.	12.3

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
2nd Cl Con	40.5	86.0	83.6	92.8
2nd Cl Tails	100.	100.	100.	100.

APPENDIX 3

Numerical Simulation of the Lakefield Research Test 54

Lac des Iles; Lakefield Research Test 53a
For numerical simulation of locked cycle test 54

- ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	5.20	0.740	1.28	7.33	90.7
2nd Cl Tails	31.6	0.460	0.850	4.77	93.9
1st Cl Scv C.	10.8	0.380	1.10	8.93	89.6
1st Cl Scv T.	114.	0.100	0.260	1.04	98.6
Scv Tails	0.177E+4	0.300E-1	0.110	1.01	98.9
TOTAL	1973.00	0.162	0.216	1.640	98.028

- DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	1.96	72.7	36.7	32.2	1.26
3rd Cl Tails	0.264	1.21	1.56	1.18	0.244
2nd Cl Tails	1.60	4.56	6.30	4.66	1.53
1st Cl Scv C.	0.547	1.29	2.79	2.98	0.500
1st Cl Scv T.	5.80	3.59	6.98	3.68	5.84
Scv Tails	89.8	16.7	45.7	55.3	90.6

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	43.8	5.38	3.72	24.7	66.3
2nd Cl Tails	75.4	3.32	2.52	16.3	77.9
1st Cl Scv C.	86.2	2.95	2.34	15.4	79.3
1st Cl Scv T.	201.	1.32	1.15	7.21	90.3
Scv Tails	0.197E+4	0.162	0.216	1.64	98.0

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	1.96	72.7	36.7	32.2	1.26
3rd Cl Tails	2.22	73.9	38.2	33.4	1.50
2nd Cl Tails	3.82	78.4	44.5	38.0	3.04
1st Cl Scv C.	4.37	79.7	47.3	41.0	3.54
1st Cl Scv T.	10.2	83.3	54.3	44.7	9.37
Scv Tails	100.	100.	100.	100.	100.

Lac des Iles; Lakefield Research Test 5
For numerical simulation of locked cyc

- ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	5.20	3.31	66.3	2.00
2nd Cl Tails	31.6	2.17	42.0	1.12
1st Cl Scv C.	10.8	2.48	50.0	1.02
1st Cl Scv T.	114.	0.530	8.94	0.370
Scv Tails	0.177E+4	0.170	2.45	0.170
TOTAL	1973.00	0.544	10.414	0.51

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	1.96	55.8	63.1	60.8
3rd Cl Tails	0.264	1.60	1.68	1.02
2nd Cl Tails	1.60	6.39	6.46	3.46
1st Cl Scv C.	0.547	2.50	2.63	1.08
1st Cl Scv T.	5.80	5.66	4.98	4.15
Scv Tails	89.8	28.1	21.1	29.5

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	43.8	14.1	304.	14.4
2nd Cl Tails	75.4	9.07	194.	8.85
1st Cl Scv C.	86.2	8.25	176.	7.87
1st Cl Scv T.	201.	3.84	80.7	3.59
Scv Tails	0.197E+4	0.544	10.4	0.518

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	1.96	55.8	63.1	60.8
3rd Cl Tails	2.22	57.4	64.8	61.8
2nd Cl Tails	3.82	63.8	71.3	65.3
1st Cl Scv C.	4.37	66.3	73.9	66.4
1st Cl Scv T.	10.2	71.9	78.9	70.5
Scv Tails	100.	100.	100.	100.0

Lac des Iles; Lakefield Research Test 53a
For numerical simulation of locked cycle test 54

- ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	5.20	0.740	1.28	7.33	90.7
2nd Cl Tails	31.6	0.460	0.850	4.77	93.9
1st Cl Scv C.	10.8	0.380	1.10	8.93	89.6
1st Cl Scv T.	114.	0.100	0.260	1.04	98.6
TOTAL	200.70	1.323	1.153	7.208	90.324

- DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	19.2	87.2	67.5	72.0	13.4
3rd Cl Tails	2.59	1.45	2.88	2.63	2.60
2nd Cl Tails	15.7	5.47	11.6	10.4	16.4
1st Cl Scv C.	5.38	1.55	5.13	6.67	5.34
1st Cl Scv T.	57.1	4.31	12.9	8.23	62.3

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	43.8	5.38	3.72	24.7	66.3
2nd Cl Tails	75.4	3.32	2.52	16.3	77.9
1st Cl Scv C.	86.2	2.95	2.34	15.4	79.3
1st Cl Scv T.	201.	1.32	1.15	7.21	90.3

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	19.2	87.2	67.5	72.0	13.4
3rd Cl Tails	21.8	88.7	70.4	74.7	16.0
2nd Cl Tails	37.6	94.1	82.0	85.1	32.4
1st Cl Scv C.	42.9	95.7	87.1	91.8	37.7
1st Cl Scv T.	100.0	100.	100.	100.	100.

Lac des Iles; Lakefield Research Test 53
For numerical simulation of locked cycle

- ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	5.20	3.31	66.3	2.00
2nd Cl Tails	31.6	2.17	42.0	1.12
1st Cl Scv C.	10.8	2.48	50.0	1.02
1st Cl Scv T.	114.	0.530	8.94	0.370
TOTAL	200.70	3.844	80.743	3.591

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	19.2	77.5	80.0	86.2
3rd Cl Tails	2.59	2.23	2.13	1.44
2nd Cl Tails	15.7	8.89	8.19	4.91
1st Cl Scv C.	5.38	3.47	3.33	1.53
1st Cl Scv T.	57.1	7.87	6.32	5.88

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	43.8	14.1	304.	14.4
2nd Cl Tails	75.4	9.07	194.	8.85
1st Cl Scv C.	86.2	8.25	176.	7.87
1st Cl Scv T.	201.	3.84	80.7	3.59

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	19.2	77.5	80.0	86.2
3rd Cl Tails	21.8	79.8	82.2	87.7
2nd Cl Tails	37.6	88.7	90.4	92.6
1st Cl Scv C.	42.9	92.1	93.7	94.1
1st Cl Scv T.	100.0	100.	100.	100.

Lac des Iles; Lakefield Research Test 53a
For numerical simulation of locked cycle test 54

- ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	5.20	0.740	1.28	7.33	90.7
2nd Cl Tails	31.6	0.460	0.850	4.77	93.9
TOTAL	75.40	3.315	2.518	16.327	77.860

- DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	51.2	92.6	82.3	84.7	41.4
3rd Cl Tails	6.90	1.54	3.51	3.10	8.03
2nd Cl Tails	41.9	5.81	14.1	12.2	50.5

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	43.8	5.38	3.72	24.7	66.3
2nd Cl Tails	75.4	3.32	2.52	16.3	77.9

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	51.2	92.6	82.3	84.7	41.4
3rd Cl Tails	58.1	94.2	85.9	87.8	49.5
2nd Cl Tails	100.	100.	100.	100.0	100.

Lac des Iles; Lakefield Research Test
For numerical simulation of locked c

- ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.
3rd Cl Tails	5.20	3.31	66.3	2.0
2nd Cl Tails	31.6	2.17	42.0	1.12
TOTAL	75.40	9.073	194.185	8.

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	51.2	87.5	88.6	93.1
3rd Cl Tails	6.90	2.52	2.35	1.5
2nd Cl Tails	41.9	10.0	9.06	5.3

- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	43.8	14.1	304.	14.
2nd Cl Tails	75.4	9.07	194.	8.85

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	51.2	87.5	88.6	93.1
3rd Cl Tails	58.1	90.0	90.9	94.7
2nd Cl Tails	100.	100.	100.	100.

Lac des Iles; Lakefield Research Test 53a
For numerical simulation of locked cycle test 54

- ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	5.20	0.740	1.28	7.33	90.7
TOTAL	43.80	5.376	3.721	24.665	66.289

- DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	88.1	98.4	95.9	96.5	83.8
3rd Cl Tails	11.9	1.63	4.08	3.53	16.2

- CUMULATIVE ASSAYS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	38.6	6.00	4.05	27.0	63.0
3rd Cl Tails	43.8	5.38	3.72	24.7	66.3

- CUMULATIVE DISTRIBUTIONS

	Wt	Cu	Ni	S	RkFe
3rd Cl Con.	88.1	98.4	95.9	96.5	83.8
3rd Cl Tails	100.	100.	100.	100.	100.

Lac des Iles; Lakefield Research Test
For numerical simulation of locked cyc

- ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	5.20	3.31	66.3	2.00
TOTAL	43.80	14.053	303.981	14.42

- DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	88.1	97.2	97.4	98.4
3rd Cl Tails	11.9	2.80	2.59	1.65

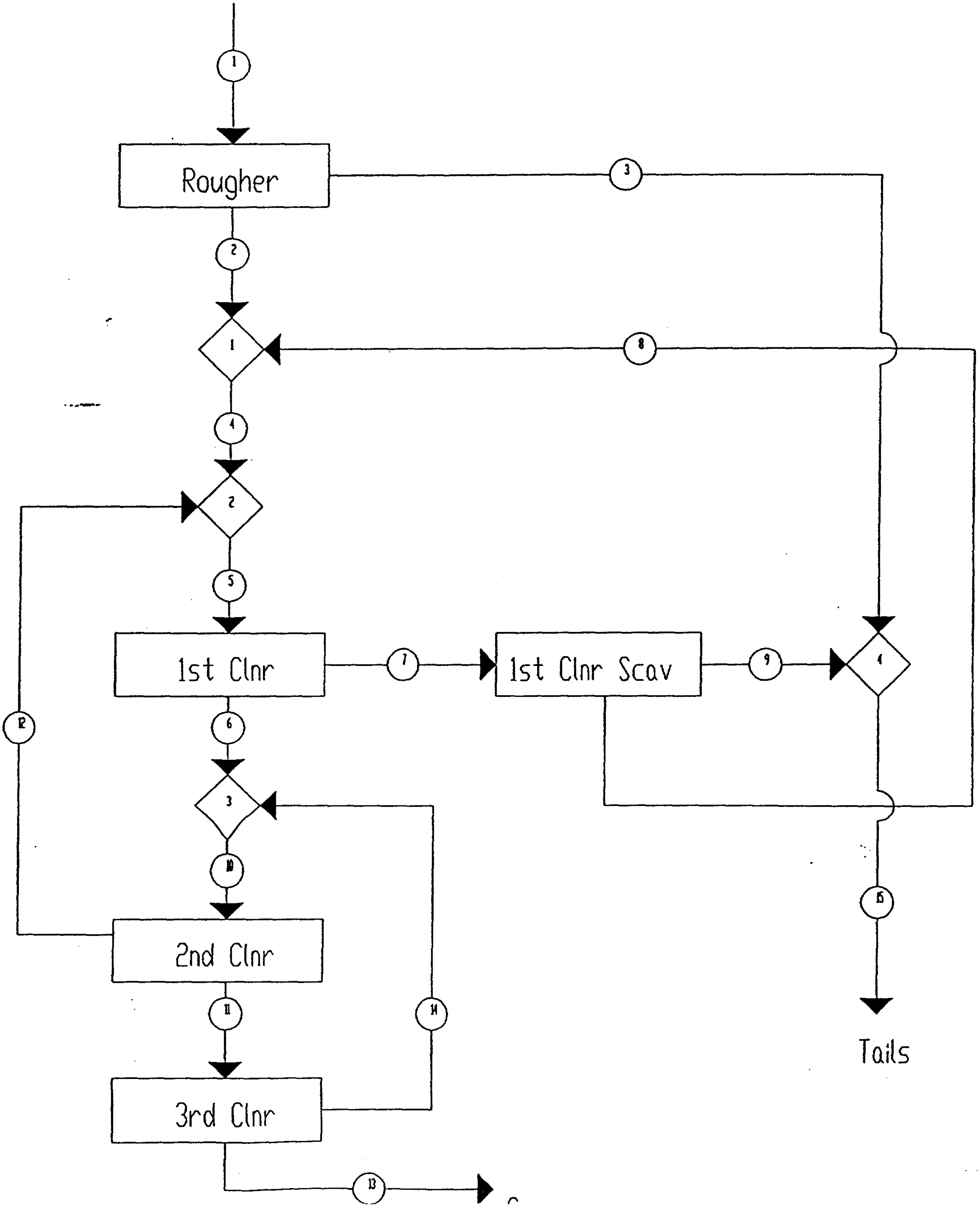
- CUMULATIVE ASSAYS

	Wt	Pt	Pd	Au
3rd Cl Con.	38.6	15.5	336.	16.1
3rd Cl Tails	43.8	14.1	304.	14.4

- CUMULATIVE DISTRIBUTIONS

	Wt	Pt	Pd	Au
3rd Cl Con.	88.1	97.2	97.4	98.4
3rd Cl Tails	100.	100.	100.	100.

Locked Cycle Test Simulation of Test 53A



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           7           1           5           15           9
      OPEN
Lac des Iles; Lakefield Research Test 53a
Simulation of Locked Cycle Test 54

          Cu        Ni        S          Pt         Pd         Au         Rk
          OVERALL      100.00
F.ASSAY   .16200    .21600    1.6400    .54000E-4.10400E-2.52000E-498.028
SF1       0.1670    0.4570    0.5530    0.2810     0.2110    0.2950     0.9063
SF2       0.5900E-10.1800     0.1490    0.1127     0.9630E-10.7380E-10.6760
SF3       0.7355    0.7155    0.5523    0.6940     0.6549    0.7935     0.9211
SF4       0.5740E-10.1416     0.1211    0.1003     0.9120E-10.5360E-10.5060
SF5       0.1620E-10.3930E-10.3590E-10.2790E-10.2620E-10.1620E-10.1630
         1         1         1         3         2
         1         2         2         8         4
         2         2         4        12         5
         2         1         5         7         6
         3         1         7         9         8
         3         2         6        14        10
         4         1        10        12        11
         5         1        11        14        13
         4         2         3         9        15


 Calculated Assay
Stream no.  Cu        Ni         S          Pt         Pd         Au         Rk
     1      .16192    .21590    1.6392    .53975E-4.10395E-2.51975E-497.982
     2      1.3267    1.1531    7.2072    .38172E-3.80673E-2.36042E-390.304
     3      .30102E-1.10983     1.0091    .16883E-4.24416E-3.17068E-498.851
     4      1.3267    1.1531    7.2072    .38172E-3.80673E-2.36042E-390.304
     5      1.3267    1.1531    7.2072    .38172E-3.80673E-2.36042E-390.304
     6      3.3209    2.5152    16.315    .90094E-3.19393E-1.88797E-377.828
     7      .12543    .33260    1.7208    .68935E-4.12449E-2.42623E-497.820
     8      .38503    1.0981    8.9408    .24481E-3.49858E-2.10215E-389.571
     9      .10095    .26041    1.0400    .52352E-4.89214E-3.37010E-498.598
    10      3.3209    2.5152    16.315    .90094E-3.19393E-1.88797E-377.828
    11      5.3882    3.7164    24.682    .13953E-2.30337E-1.14466E-266.180
    12      .45488    .84989    4.7147    .21564E-3.42205E-2.11358E-393.976
    13      6.0174    4.0530    27.013    .15397E-2.33535E-1.16155E-262.880
    14      .73305    1.2266    7.4414    .32691E-3.66749E-2.19680E-390.592
    15      .34397E-1.11896     1.0110    .19034E-4.28345E-3.18277E-498.835
 Calculated Recovery
Stream no.  Weight    Cu        Ni        S         Pt        Pd        Au        Rk
     1      100.05    100.00    100.00    100.00    100.00    100.00    100.00    100.00
     2      10.171    83.300    54.300    44.700    71.900    78.900    70.500    9.3700
     3      89.876    16.700    45.700    55.300    28.100    21.100    29.500    90.630
     4      10.171    83.300    54.300    44.700    71.900    78.900    70.500    9.3700
     5      10.171    83.300    54.300    44.700    71.900    78.900    70.500    9.3700
     6      3.8238    78.385    44.526    38.040    63.797    71.302    65.297    3.0359
     7      6.3476    4.9147    9.7740    6.6603    8.1031    7.5981    5.2029    6.3341
     8      .54695    1.2999    2.7807    2.9818    2.4796    2.6221    1.0744    .49976
     9      5.8006    3.6148    6.9933    3.6785    5.6236    4.9760    4.1285    5.8344
    10      3.8238    78.385    44.526    38.040    63.797    71.302    65.297    3.0359
    11      2.2214    73.886    38.221    33.433    57.398    64.799    61.797    1.4997
    12      1.6024    4.4993    6.3049    4.6066    6.3988    6.5027    3.4999    1.5362
    13      1.9569    72.689    36.719    32.233    55.797    63.101    60.796    1.2553
    14      .26452    1.1970    1.5021    1.2002    1.6014    1.6977    1.0011    .24446
    15      95.676    20.315    52.693    58.978    33.724    26.076    33.628    96.464
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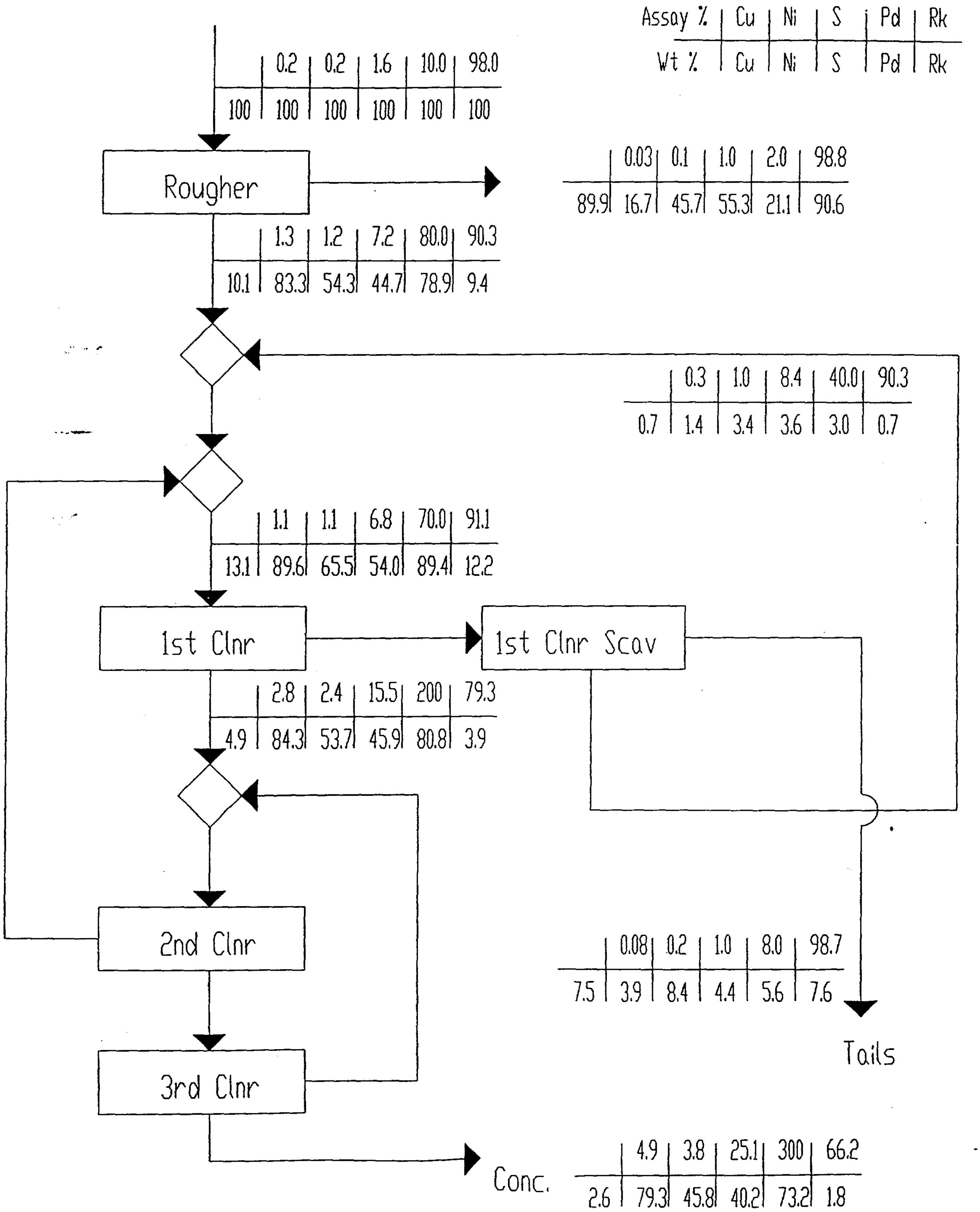
           7          1           5          15           9
   LOCKED
Lac des Iles; Lakefield Research Test 53a
Simulation of Locked Cycle Test 54

         Cu       Ni        S          Pt        Pd        Au        Rk
         OVERALL     100.00
F.ASSAY  .16200   .21600   1.6400   .54000E-4.10400E-2.52000E-498.028
SF1      0.1670   0.4570   0.5530   0.2810   0.2110   0.2950   0.9063
SF2      0.5900E-10.1800   0.1490   0.1127   0.9630E-10.7380E-10.6760
SF3      0.7355   0.7155   0.5523   0.6940   0.6549   0.7935   0.9211
SF4      0.5740E-10.1416   0.1211   0.1003   0.9120E-10.5360E-10.5060
SF5      0.1620E-10.3930E-10.3590E-10.2790E-10.2620E-10.1620E-10.1630
        1        1        1        3        2
        1        2        2        8        4
        2        2        4       12        5
        2        1        5        7        6
        3        1        7        9        8
        3        2        6       14       10
        4        1       10       12       11
        5        1       11       14       13
        4        2        3        9       15


 Calculated Assay
Stream no.  Cu       Ni       S        Pt        Pd        Au        Rk
     1      .16192   .21590   1.6392   .53975E-4.10395E-2.51975E-497.982
     2      1.3267   1.1531   7.2072   .38172E-3.80673E-2.36042E-390.304
     3      .30102E-1.10983   1.0091   .16883E-4.24416E-3.17068E-498.851
     4      1.2617   1.1449   7.2821   .37110E-3.78297E-2.34261E-390.303
     5      1.1068   1.0784   6.7546   .33864E-3.70918E-2.29917E-391.052
     6      2.8012   2.3782   15.459   .80813E-3.17236E-1.74523E-379.342
     7      .10396   .30900   1.6021   .60755E-4.10872E-2.35147E-497.984
     8      .32107   1.0265   8.3755   .21708E-3.43809E-2.84749E-490.272
     9      .83622E-1.24180   .96773   .46113E-4.77867E-3.30502E-498.706
    10      2.6450   2.2882   14.841   .77078E-3.16418E-1.70372E-380.208
    11      4.3632   3.4376   22.828   .12136E-2.26113E-1.11655E-269.343
    12      .35423   .75599   4.1934   .18038E-3.34936E-2.88006E-494.693
    13      4.8962   3.7669   25.103   .13457E-2.29005E-1.13079E-266.202
    14      .57332   1.0958   6.6472   .27464E-3.55492E-2.15315E-391.678
    15      .34239E-1.12003   1.0059   .19143E-4.28548E-3.18107E-498.840
 Calculated Recovery
Stream no.  Weight   Cu       Ni       S        Pt       Pd       Au       Rk
     1      100.05   100.00   100.00   100.00   100.00   100.00   100.00   100.00  Feed
     2      10.171   83.300   54.300   44.700   71.900   78.900   70.500   9.3700  Ro/Scav. Con.
     3      89.876   16.700   45.700   55.300   28.100   21.100   29.500   90.630  Scav. Tails
     4      10.874   84.690   57.635   48.284   74.729   81.866   71.644   10.017  Ro/Scav. + 1st Cl Scav. Con.
     5      13.110   89.572   65.451   53.995   82.214   89.396   75.425   12.177  1st Cl Feed
     6      4.8745   84.287   53.670   45.949   72.949   80.788   69.858   3.9453  1st Cl Con.
     7      8.2354   5.2847   11.781   8.0452   9.2656   8.6089   5.5663   8.2316  1st Cl Tails
     8      .70528   1.3978   3.3518   3.6018   2.8353   2.9709   1.1495   .64948  1st Cl Scav. Con.
     9      7.5301   3.8869   8.4295   4.4434   6.4303   5.6380   4.4169   7.5822  1st Cl Scav. Tails
    10      5.2420   85.586   55.532   47.437   74.822   82.754   70.940   4.2891  2nd Cl Feed
    11      2.9953   80.673   47.669   41.693   67.317   75.207   67.137   2.1188  2nd Cl Con.
    12      2.2467   4.9126   7.8634   5.7447   7.5047   7.5471   3.8024   2.1703  2nd Cl Tails
    13      2.6260   79.366   45.795   40.196   65.439   73.236   66.050   1.7734  3rd Cl Con.
    14      .36929   1.3069   1.8734   1.4968   1.8782   1.9704   1.0876   .34536  3rd Cl Tails
    15      97.406   20.587   54.129   59.743   34.530   26.738   33.917   98.212  Final Tails (Scav + 1st Cl. Sca

 No. of iterations for :  Cu        =    3
 No. of iterations for :  Ni        =    4
 No. of iterations for :  S         =    4
 No. of iterations for :  Pt        =    4
 No. of iterations for :  Pd        =    4
 No. of iterations for :  Au        =    3
```

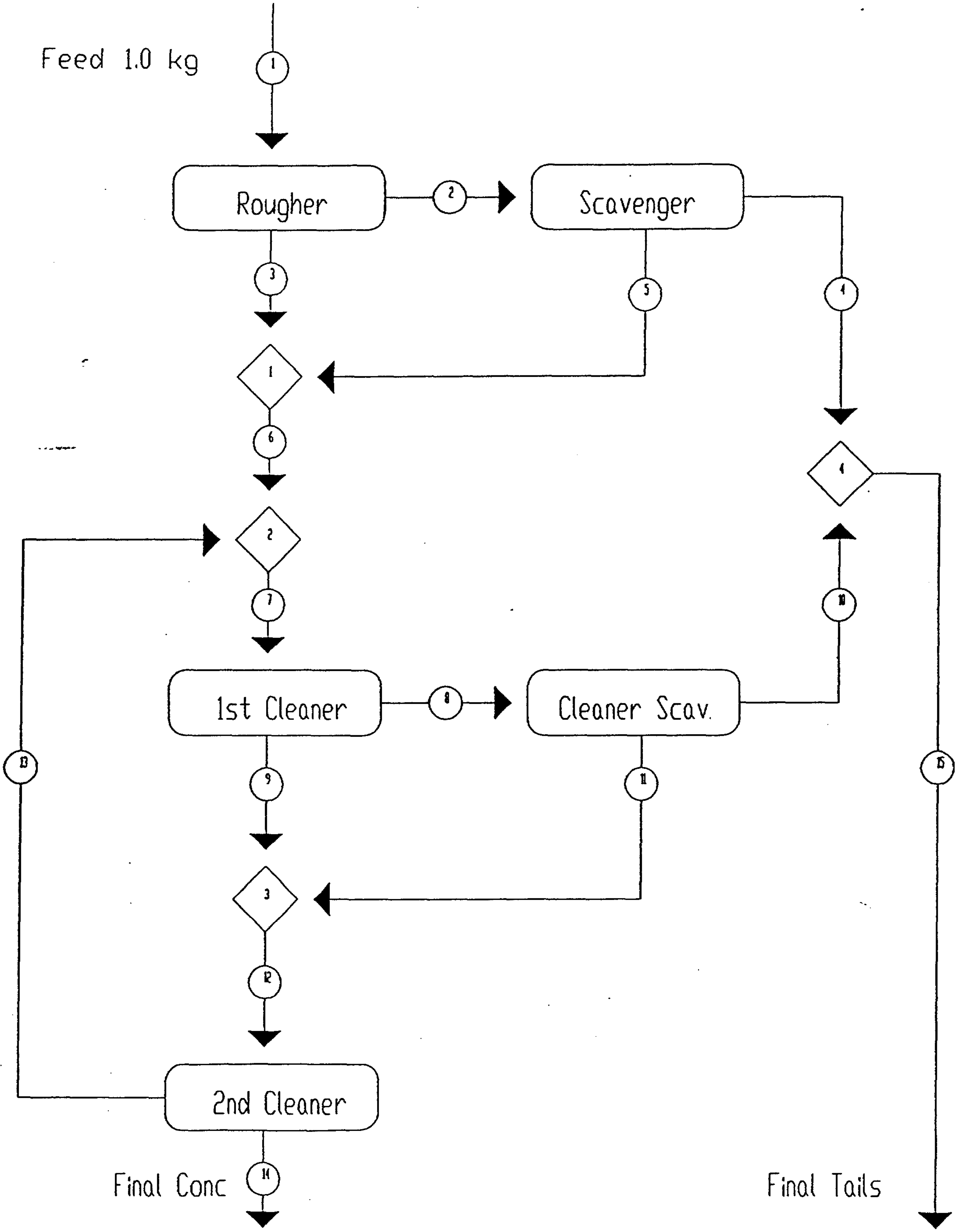
Locked Cycle Test Simulation of Test 53A



APPENDIX 4

Numerical Simulations of Options for the 1st Cleaner Scavenger Concentrate

Lac des Iles Ore (555); Simulation #1



SIM #1

```
        5           1           5          15          9
    OPEN
T12958 & T12924 Simulation; Lac des Iles Ore (555); 2nd Cleaning
2nd cleaner tails recycle to 1st cleaner feed, 1st cleaner scavenger
conc. combined with 1st cleaner conc for 2nd cleaning.  ERB # 2174
         Cp        Pn        Po        MgO       Gn
         OVERALL     100.00
F.ASSAY  .40000    .50000    1.0000    10.100    88.000
SF1      0.1970    0.5060    0.3870    0.9280    0.9340
SF2      0.6650    0.8100    0.2440    0.8860    0.8950
SF3      0.1040    0.2490    0.6100    0.8370    0.8540
SF4      0.5280    0.6140    0.6440    0.7920    0.6760
SF5      0.9100E-10.2010   0.5210    0.8150    0.8130
         1         1         1         2         3
         2         1         2         4         5
         1         2         3         5         6
         2         2         6        13         7
         3         1         7         8         9
         4         1         8        10        11
         3         2         9        11        12
         5         1        12        13        14
         4         2         4        10        15

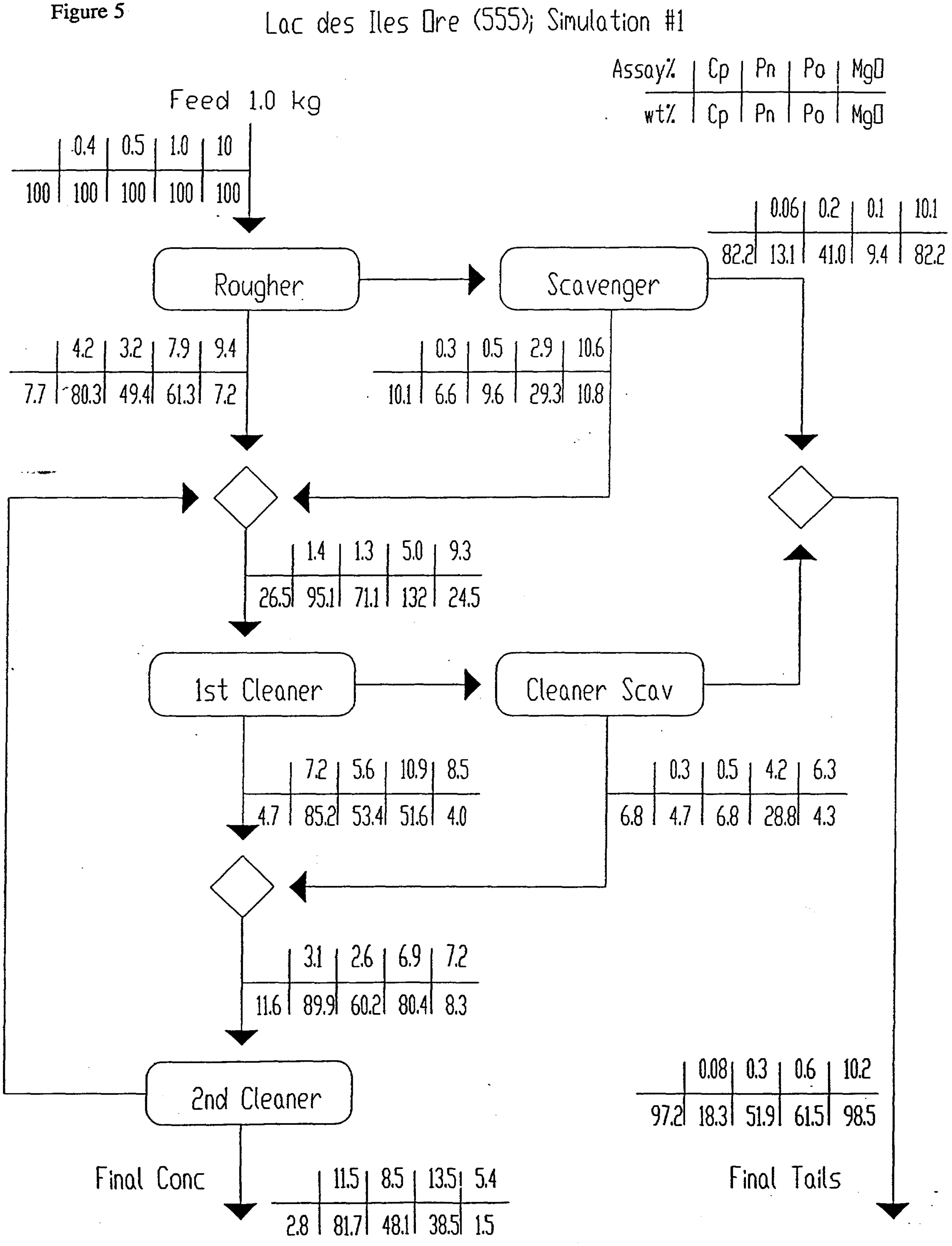

 Calculated Assay
Stream no.  Cp        Pn        Po        MgO       Gn
      1     .40000    .50000    1.0000    10.100    88.000
      2     .85389E-1.27415     .41936    10.157    89.065
      3     4.1626    3.2010    7.9441    9.4241    75.268
      4     .63736E-1.24925     .11485    10.100    89.472
      5     .26226    .47756    2.9066    10.615    85.738
      6     1.9548    1.6594    5.0926    10.098    81.195
      7     1.9548    1.6594    5.0926    10.098    81.195
      8     .24939    .50687    3.8109    10.369    85.064
      9     9.4755    6.7419    10.745    8.9050    64.133
     10     .19192    .45359    3.5769    11.969    83.809
     11     .37503    .62335    4.3224    6.8713    87.808
     12     4.1920    3.1896    7.0162    7.7243    77.878
     13     .51351    .86301    4.9206    8.4742    85.229
     14     14.820    9.9118    13.071    5.5577    56.640
     15     .77568E-1.27130     .48845    10.302    88.861
 Calculated Recovery
Stream no.  Weight    Cp        Pn        Po        MgO       Gn
      1     100.00    100.00    100.00    100.00    100.00    100.00
      2     92.284    19.700    50.600    38.700    92.800    93.400
      3     7.7164    80.300    49.400    61.300    7.2000    6.6000
      4     82.218    13.101    40.986    9.4428    82.221    83.593
      5     10.066    6.5995    9.6140    29.257    10.579    9.8070
      6     17.782    86.900    59.014    90.557    17.779    16.407
      7     17.782    86.900    59.014    90.557    17.779    16.407
      8     14.495    9.0375    14.694    55.240    14.881    14.012
      9     3.2869    77.862    44.320    35.317    2.8980    2.3954
     10     9.9455    4.7718    9.0224    35.574    11.786    9.4718
     11     4.5497    4.2657    5.6721    19.665    3.0953    4.5398
     12     7.8366    82.128    49.992    54.983    5.9933    6.9352
     13     5.8216    7.4736    10.048    28.646    4.8845    5.6383
     14     2.0149    74.654    39.943    26.337    1.1088    1.2969
     15     92.163    17.872    50.008    45.017    94.007    93.065
```

```
              SIM #1
          5           1           5          15          9
   LOCKED
T12958 & T12924 Simulation; Lac des Iles Ore (555); 2nd Cleaning
2nd cleaner tails recycle to 1st cleaner feed, 1st cleaner scavenger
conc. combined with 1st cleaner conc for 2nd cleaning.  ERB # 2174
         Cp        Pn        Po        MgO       Gn
         OVERALL      100.00
F.ASSAY  .40000    .50000    1.0000    10.100    88.000
SF1      0.1970    0.5060    0.3870    0.9280    0.9340
SF2      0.6650    0.8100    0.2440    0.8860    0.8950
SF3      0.1040    0.2490    0.6100    0.8370    0.8540
SF4      0.5280    0.6140    0.6440    0.7920    0.6760
SF5      0.9100E-10.2010   0.5210    0.8150    0.8130
        1         1         1         2         3
        2         1         2         4         5
        1         2         3         5         6
        2         2         6        13         7
        3         1         7         8         9
        4         1         8        10        11
        3         2         9        11        12
        5         1        12        13        14
        4         2    .    4        10        15


 Calculated Assay
Stream no.   Cp        Pn        Po        MgO       Gn
      1      .40000    .50000    1.0000    10.100    88.000
      2      .85389E-1.27415     .41936    10.157    89.065
      3      4.1626    3.2010    7.9441    9.4241    75.268
      4      .63736E-1.24925     .11485    10.100    89.472
      5      .25226    .47756    2.9066    10.615    85.738
      6      1.9548    1.6594    5.0926    10.098    81.195
      7      1.4354    1.3412    4.9981    9.3308    82.895
      8      .18175    .40660    3.7120    9.5087    86.191
      9      7.1986    5.6376    10.910    8.5129    67.741
     10      .14003    .36428    3.4882    10.969    85.019
     11      .27262    .49875    4.1995    6.2852    88.744
     12      3.1035    2.5991    6.9423    7.1957    80.159
     13      .37428    .69236    4.7935    7.7721    86.368
     14      11.494    8.4611    13.549    5.4237    61.073
     15      .75449E-1.26691     .63277    10.237    88.788
 Calculated Recovery
Stream no.   Weight    Cp        Pn        Po        MgO       Gn
      1      100.00    100.00    100.00    100.00    100.00    100.00 feed
      2      92.284    19.700    50.600    38.700    92.800    93.400 Rghr tls
      3      7.7164    80.300    49.400    61.300    7.2000    6.6000 Rghr conc
      4      82.218    13.101    40.986    9.4428    82.221    83.593 Scav tls
      5      10.066    6.5995    9.6140    29.257    10.579    9.8070 Scav Conc
      6      17.782    86.900    59.014    90.557    17.779    16.407 Rghr + Scav Conc
      7      26.493    95.071    71.065    132.42    24.476    24.956 Rghr + Scav + 2nd clnr tls.
      8      21.760    9.8874    17.695    80.773    20.486    21.313 1st clnr tls
      9      4.7333    85.184    53.369    51.642    3.9855    3.6436 1st clnr Conc
     10      14.913    5.2205    10.865    52.018    16.225    14.407 1st clnr scav tls
     11      6.8474    4.6669    6.8303    28.755    4.2611    6.9053 1st clnr Scav Conc
     12      11.581    89.851    60.200    80.397    8.2506    10.549 1st clnr Scav Conc + 1st clnr conc
     13      8.7283    8.1764    12.100    41.887    6.7243    8.5763 2nd clnr tls
     14      2.8424    81.674    48.100    38.510    1.5264    1.9726 2nd clnr conc
     15      97.130    18.321    51.851    61.461    98.446    98.000 Scav tls + 1st clnr Scav tls.

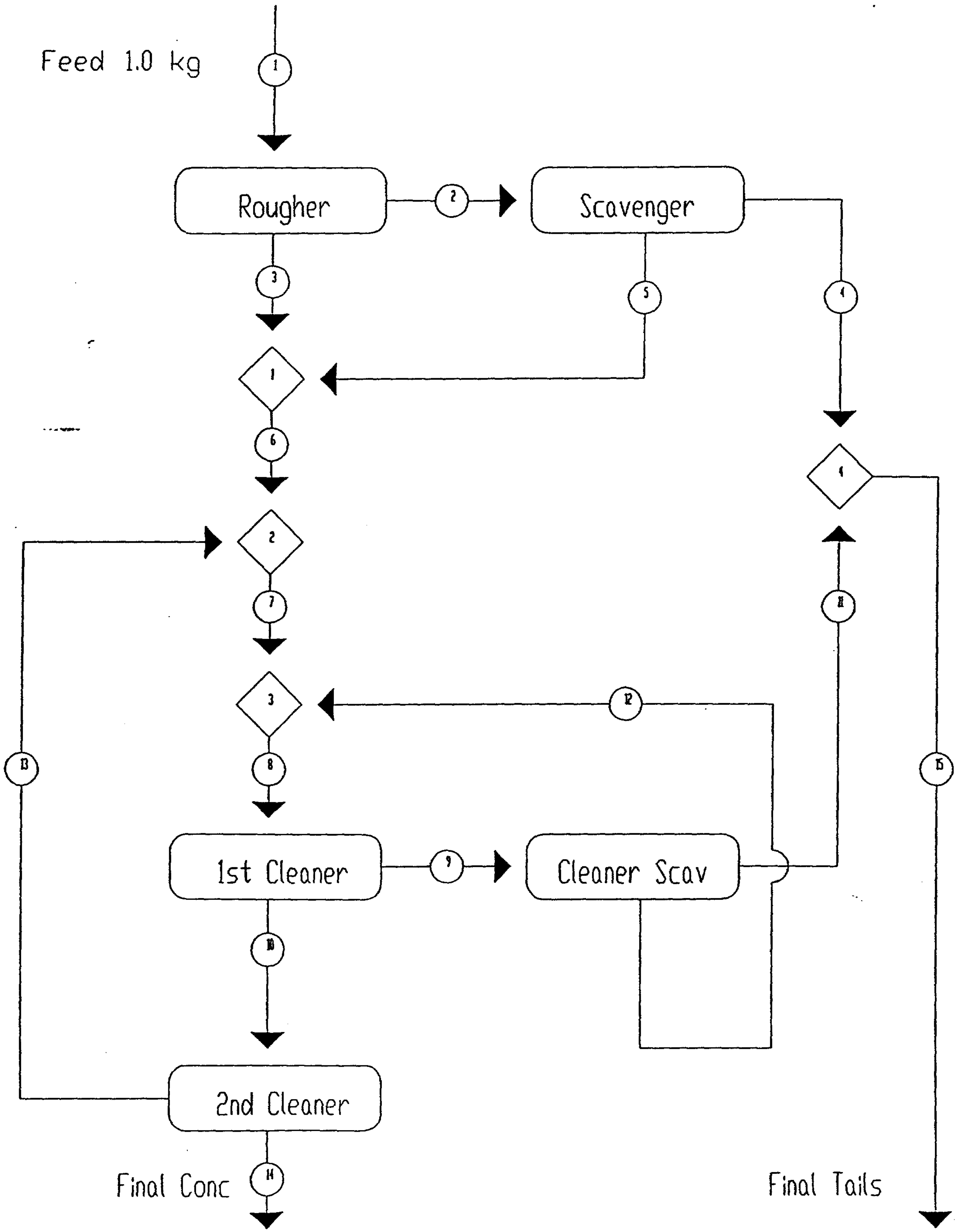
 No. of iterations for :  Cp        =   4
 No. of iterations for :  Pn        =   4
 No. of iterations for :  Po        =   7
 No. of iterations for :  MgO       =   5
```

Figure 5



Lac des Iles Ore (555); Simulation #1

Lac des Iles Ore (555); Simulation #2



SIM #2

```
          5           1           5          15          9
    OPEN
T12958 & T12924 Simulation; Lac des Iles,Ore (555); 2nd Cleaning
2nd cleaner tails and 1st cleaner scavenger conc. recycle to
1st cleaner feed.  ERB # 2174
         Cp        Pn        Po        MgO       Gn
         OVERALL     100.00
F.ASSAY  .40000    .50000    1.0000    10.100    88.000
SF1      0.1970    0.5060    0.3870    0.9280    0.9340
SF2      0.6650    0.8100    0.2440    0.8860    0.8950
SF3      0.1040    0.2490    0.6100    0.8370    0.8540
SF4      0.5280    0.6140    0.6440    0.7920    0.6760
SF5      0.9100E-10.2010    0.5210    0.8150    0.8130
        1         1         1         2         3
        2         1         2         4         5
        1         2         3         5         6
        2         2         6        13         7
        3         2         7        12         8
        3         1         8         9        10
        4         1         9        11        12
        5         1        10        13        14
        4         2         4        11        15


 Calculated Assay
Stream no.  Cp        Pn        Po        MgO       Gn
     1      .40000    .50000    1.0000    10.100    88.000
     2      .85389E-1.27415    .41936    10.157    89.065
     3      4.1626    3.2010    7.9441    9.4241    75.268
     4      .63736E-1.24925    .11485    10.100    89.472
     5      .26226    .47756    2.9066    10.615    85.738
     6      1.9548    1.6594    5.0926    10.098    81.195
     7      1.9548    1.6594    5.0926    10.098    81.195
     8      1.9548    1.6594    5.0926    10.098    81.195
     9      .24939    .50687    3.8109    10.369    85.064
    10      9.4755    6.7419    10.745    8.9050    64.133
    11      .19192    .45359    3.5769    11.969    83.809
    12      .37503    .62335    4.3224    6.8713    87.808
    13      1.2829    2.0161    8.3289    10.798    77.574
    14      26.270    16.430    15.698    5.0247    36.578
    15      .77568E-1.27130    .48845    10.302    88.861
 Calculated Recovery
Stream no.  Weight    Cp        Pn        Po        MgO       Gn
     1      100.00    100.00    100.00    100.00    100.00    100.00
     2      92.284    19.700    50.600    38.700    92.800    93.400
     3      7.7164    80.300    49.400    61.300    7.2000    6.6000
     4      82.218    13.101    40.986    9.4428    82.221    83.593
     5      10.066    6.5995    9.6140    29.257    10.579    9.8070
     6      17.782    86.900    59.014    90.557    17.779    16.407
     7      17.782    86.900    59.014    90.557    17.779    16.407
     8      17.782    86.900    59.014    90.557    17.779    16.407
     9      14.495    9.0375    14.694    55.240    14.881    14.012
    10      3.2869    77.862    44.320    35.317    2.8980    2.3954
    11      9.9455    4.7718    9.0224    35.574    11.785    9.4718
    12      4.5497    4.2657    5.6721    19.665    3.0953    4.5398
    13      2.2092    7.0854    8.9082    18.400    2.3619    1.9475
    14      1.0777    70.777    35.411    16.917    .53613    .44794
    15      92.163    17.872    50.008    45.017    94.007    93.065
```

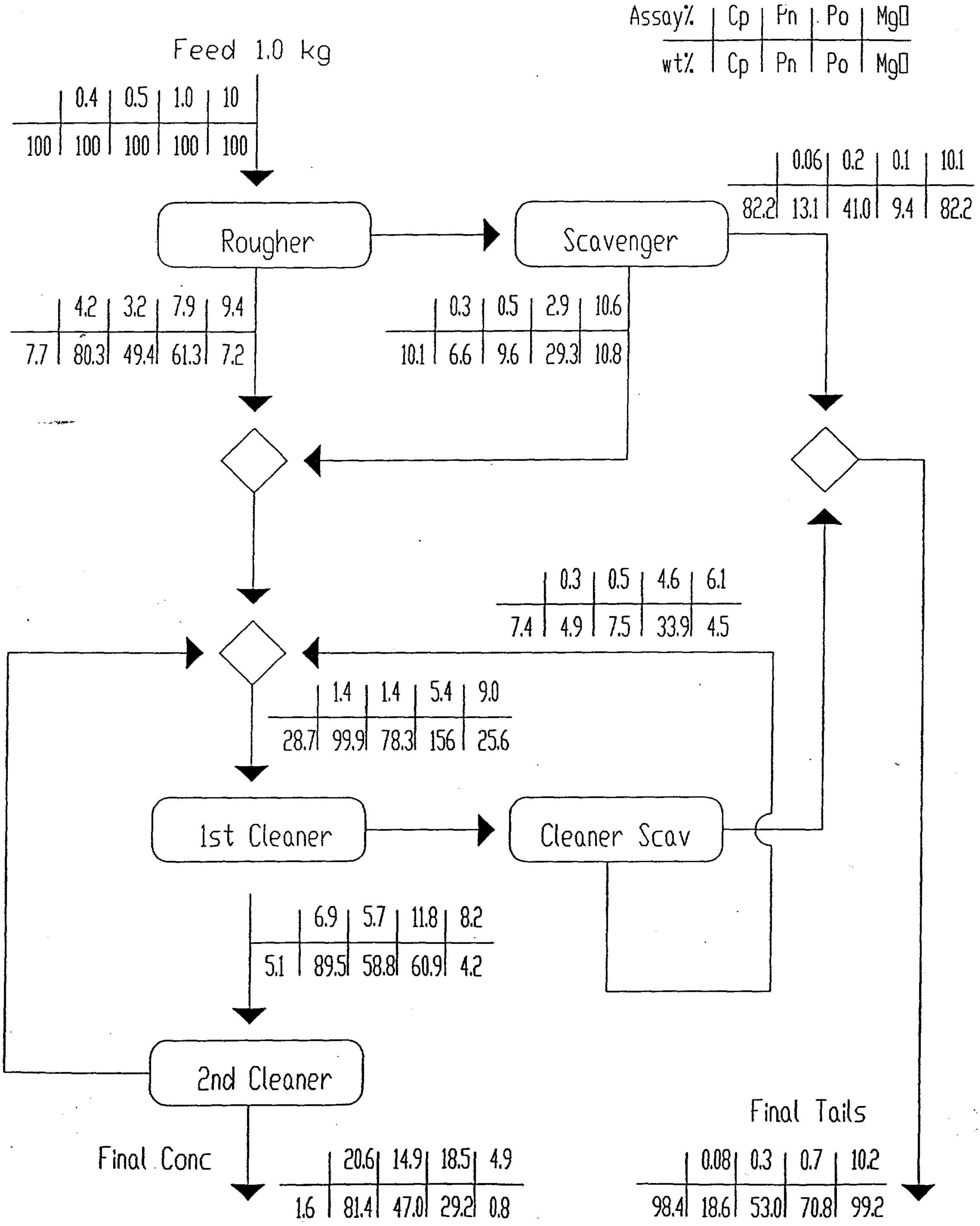
```
          5           1           5           15          9
   LOCKED
T12958 & T12924 Simulation; Lac des Iles Ore (555); 2nd Cleaning
2nd cleaner tails and 1st cleaner scavenger conc. recycle to
1st cleaner feed.  ERB # 2174
         Cp        Pn        Po        MgO       Gn
         OVERALL     100.00
F.ASSAY  .40000    .50000    1.0000    10.100    88.000
SF1      0.1970    0.5060    0.3870    0.9280    0.9340
SF2      0.6650    0.8100    0.2440    0.8860    0.8950
SF3      0.1040    0.2490    0.6100    0.8370    0.8540
SF4      0.5280    0.6140    0.6440    0.7920    0.6760
SF5      0.9100E-10.2010   0.5210    0.8150    0.8130
        1         1         1         2         3
        2         1         2         4         5
        1         2         3         5         6
        2         2         6         13        7
        3         2         7         12        8
        3         1         8         9         10
        4         1         9         11        12
        5         1         10        13        14
        4         2         4         11        15


 Calculated Assay
Stream no.  Cp        Pn         Po         MgO       Gn
     1      .40000    .50000     1.0000     10.100    88.000
     2      .85389E-1.27415      .41936     10.157    89.065
     3      4.1626    3.2010     7.9441     9.4241    75.268
     4      .63736E-1.24925      .11485     10.100    89.472
     5      .26226    .47756     2.9066     10.615    85.738
     6      1.9548    1.6594     5.0926     10.098    81.195
     7      1.7812    1.6588     5.7293     10.023    80.808
     8      1.3912    1.3628     5.4354     9.0106    82.800
     9      .17633    .41355     4.0408     9.1915    86.178
    10      6.9455    5.7025     11.811     8.1836    67.357
    11      .13595    .37077     3.7998     10.630    85.064
    12      .26410    .50652     4.5646     6.0665    88.598
    13      .91121    1.6525     8.8717     9.6155    78.949
    14      20.607    14.872     18.467     4.9416    41.113
    15      .75588E-1.26920      .71968     10.187    88.748
 Calculated Recovery
Stream no.  Weight    Cp        Pn        Po        MgO       Gn
     1      100.00    100.00    100.00    100.00    100.00    100.00  Feed
     2      92.284    19.700    50.600    38.700    92.800    93.400  Rghr tls
     3      7.7164    80.300    49.400    61.300    7.2000    6.6000  Rghr Conc
     4      82.218    13.101    40.986    9.4428    82.221    83.593  Scav tls
     5      10.066    6.5995    9.6140    29.257    10.579    9.8070  Scav Conc
     6      17.782    86.900    59.014    90.557    17.779    16.407  Combined Rghr + Scav Conc
     7      21.341    95.031    70.801    122.27    21.178    19.597  Rghr + Scav Conc + 2nd clnr tls
     8      28.731    99.927    78.306    156.16    25.632    27.033  1st clnr feed.
     9      23.574    10.392    19.498    95.260    21.454    23.085  1st clnr tls
    10      5.1564    89.535    58.808    60.904    4.1780    3.9468  1st clnr Conc
    11      16.145    5.4872    11.972    61.347    16.991    15.606  1st clnr scav tls
    12      7.4294    4.9052    7.5263    33.912    4.4624    7.4799  1st clnr Scav Conc
    13      3.5766    8.1477    11.820    31.731    3.4051    3.2088  2nd clnr tls
    14      1.5798    81.387    46.988    29.173    .77293    .73805  2nd clnr Conc
    15      98.363    18.588    52.958    70.790    99.212    99.199  Final tls

 No. of iterations for :  Cp          =   4
 No. of iterations for :  Pn          =   5
 No. of iterations for :  Po          =   9
 No. of iterations for :  MgO         =   6
 No. of iterations for :  Gn          =   6
```

Figure 6

Lac des Iles Ore (555); Simulation # 2



050

DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

PROJECT No. 0786-001

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LAC DES ILES MINES LTD

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REPORT ON BEDROCK PERMEABILITY TESTING AT SOUTH END OF EXISTING TAILINGS AREA, LAC DES ILES, ONTARIO

P.O. BOX 10
NORTH BAY, ONTARIO P1B 8G8
PHONE (705) 476-2165
OFFICES AT 885 JET AVENUE
FAX (705) 474-8095

DENNIS NETHERTON ENGINEERING
(742963 ONTARIO LTD.)
ENGINEERING FOR THE RESOURCE INDUSTRIES

P.O. Box 10, North Bay, Ont. P1B 8G8
Offices at 885 Jet Ave.
Phone: (705) 476-2165 Fax: (705) 474-8095

14 April 1992

Lac des Iles Mines Ltd.
Suite 916
111 Richmond St. W.
Toronto, Ontario
M5H 2G4

ATTN: Glenn Clark, Project Manager
RE: Bedrock Permeability Testing at the South end of the Existing Tailings Area, Lac des Iles.

Dear Sir:

This report presents the findings of the bedrock permeability testing conducted at the Lac des Iles Project from March 6, to March 13, 1992. The testing was conducted in four BQ size diamond drill holes located along the south perimeter of the existing tailings area (see Figure 1, Appendix I). All diamond drill holes were drilled at 60 degrees from the horizontal with casing placed in the overburden. Overburden thickness (true) ranged from 10 to 35 feet and was interpreted by Norex's drillers to contain numerous boulders.

Temperature conditions were initially around the freezing mark (0 degrees Celsius) but fell to about -20 degrees celsius after two days of testing. A plastic shelter heated with a tiger torch was required during the low temperatures to prevent water freezing in the flow meter and to prevent the pressure gauge from getting too cold to operate accurately (see Photo 2, Appendix II). This shelter was constructed by the client at short notice and greatly expedited the testing.

TEST RESULTS

The testing consisted of isolating a 1.2 meter (4 ft) section of the diamond drill hole with a double pneumatic packer system. Water was then pumped down rods connected to the packer system and injected into the isolated section of drill hole. The water pressure for each test was set at a predetermined value and the flow of water into the rockmass was measured (see Photo 3, Appendix II). A pressure gauge connected to the system downstream of the flow meter was used to monitor the water pressure (see Figure 2, Appendix I and Photo 3, Appendix II). The water take was measured using a flow meter (capable of measuring flows in the range of 0.4 to 20 gal/min) or by measuring the drop in the water level in the water reserve tank and calculating the volume of water used during the test when the flow was less than 0.4 gal/min.

The water takes for the test sections of all drill holes were generally less than what could be accurately recorded by the flow meter (<.4 gal/min) and thus the method of measuring the water reserve level was used.

The relationship between water pressure, water take and coefficient of permeability is as follows:

$$K=(1.16E-6 \times Cp \times Q)/H$$

where K is the permeability in cm/s, Cp is a constant related to the borehole diameter and the test interval length, Q is the water flow, and H is determined from the following relationship:

$$H=H_1+H_2+(Pg \times 2.308\ \text{ft/psi})-H_L$$

where H_1 is the vertical depth to the midpoint of the test interval, H_2 is the vertical height of the pressure gauge from the drill hole collar, Pg is the pressure gauge reading and H_L is the predetermined head loss of the system for the average flow range of the test and the particular rod string employed.

Tables 1 to 4 of Appendix I list the test interval and the associated permeability as calculated from the test data and the above relationship for diamond drill holes 92-02 through 92-05. The values range from a high of 5.89E-4 cm/sec to a low of 1.31E-6 cm/sec. The following statistics are obtained from the tests for which it was possible to measure the water flow.

		Permeability (cm/sec)			
Drill hole	mean	sdev	var	max	min
92-02	4.8E-5	5.6E-5	3.2E-9	1.3E-4	5.9E-6
92-03	2.1E-5	1.5E-5	2.1E-10	3.6E-5	3.2E-6
92-04	1.5E-5	1.7E-5	2.9E-10	5.9E-4	1.4E-6
92-05	1.2E-5	5.1E-6	2.6E-11	1.9E-5	5.3E-6

Based on the statistics, a reasonable value for the **rockmass** coefficient of permeability would be in the range of 2 to 5 E-5 cm/sec for the tests in which it was possible to measure the water flow.

Permeabilities of 1.93E-3 and 2.70E-3 cm/sec were observed in the top test interval of diamond drill holes 92-02 and 92-05 respectively. These values are not representative of the rockmass as water bypassed the upper packer and flowed to the surface via the casing string.

During most of the testing, no measurable drop in water reserve level or flow through the gauges occurred. Therefore for these tests, the permeability is determined to be 0.0 cm/sec by the above relationship. However, a more reasonable approach is to use a value of 1E-6 cm/sec as this is the lower limit of testing with the equipment. Incorporating 1E-6 into the permeabilities for the tested rockmass results in the following statistics:

	Permeability (cm/sec)				
Drill hole	mean	sdev	var	max	min
92-02	8.2E-6	2.6E-5	6.8E-10	1.3E-4	1.0E-6
92-03	4.0E-6	8.9E-5	7.9E-11	3.6E-5	1.0E-6
92-04	1.0E-5	1.5E-5	2.3E-10	5.9E-5	1.0E-6
92-05	1.2E-5	5.1E-6	2.6E-11	1.9E-5	5.3E-6

Based upon the revised statistics, the coeffieient of permeability of the **rockmass** has a mean ranging from 4.0E-6 to 1.2E-5 cm/sec.

Drill core

The upper 80 feet of the drill core retrieved from the diamond drill holes was examined to determine the Rock Quality Determination (RQD) of the bedrock and to determine the physical characteristics of fracture surfaces. Overall the bedrock has a RQD ranging from 50 to 100 with the majority of the core having a RQD greater than 80 (good to excellent) (Table 5, Appendix 1). With the exception of the upper 10 feet of bedrock in drill hole 92-04 where the RQD was found to be 50 (poor-fair), the lower values were the result of a fracture plane running sub-parallel to the axis of the diamond drill hole resulting in long sections (11 inches plus) of highly fractured core.

Most fracture surfaces were rough planar to irregular rough with chlorite, carbonate and amphibole mineralization. Weak to moderate slickensides were common. Extensive weathering of fractures was uncommon. Most weathering consisted of light iron or manganese staining. Healed fracture surfaces were common.

Closure

Based on the tight rock conditions observed in the above noted drill holes and the earlier observations by Mr. Netherton during his inspection of the open pit in, October of 1991, it does not appear that bedrock grouting is not warranted at this site. However, due to the length of the Dams required for the proposed Stage 1, it is recommended that further permeability testing be carried out along the remaining alignments. This can be carried out with your airtrack drill and the packer equipment during the course of other field investigations planned for this site.

We trust that the information presented is sufficient for your requirements. If you have any questions or require additional information please call.

Yours very truly,
DNE Dennis Netherton Engineering

David Orava, M.Eng, P.Eng
Manager, Engineering

David Machin
Project Engineer

File 0786-001

APPENDIX 1

TABLES AND FIGURES

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APR 1 4 1992

APPENDIX I

TABLE 1

DATE: APRIL, 1992 MADE BY: D. MACHIN PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-02	24	20.78	4	5	10	7.9	10300	1.93E-03	WATER BY PASS
92-02	29	25.11	4	5	15	0	10300	0.00E+00	
92-02	29	25.11	4	5	20	0	10300	0.00E+00	
92-02	29	25.11	4	5	28	0	10300	0.00E+00	
92-02	34	29.44	4	5	15	0	10300	0.00E+00	
92-02	34	29.44	4	5	25	0	10300	0.00E+00	
92-02	34	29.44	4	5	30	0	10300	0.00E+00	
92-02	39	33.77	4	5	15	0	10300	0.00E+00	
92-02	39	33.77	4	5	25	0	10300	0.00E+00	
92-02	39	33.77	4	5	30	0	10300	0.00E+00	
92-02	42	36.37	4	5	16	0	10300	0.00E+00	
92-02	42	36.37	4	5	25	0	10300	0.00E+00	
92-02	42	36.37	4	5	30	0	10300	0.00E+00	
92-02	46	39.84	4	5	15	0	10300	0.00E+00	
92-02	46	39.84	4	5	25	0	10300	0.00E+00	
92-02	46	39.84	4	5	30	0	10300	0.00E+00	
92-02	54	46.77	4	5	16	0	10300	0.00E+00	
92-02	54	46.77	4	5	20	0	10300	0.00E+00	
92-02	54	46.77	4	5	30	0	10300	0.00E+00	
92-02	59	51.10	4	5	25	0	10300	0.00E+00	
92-02	59	51.10	4	5	35	1.5	10300	1.31E-04	
92-02	64	55.43	4	5	25	0	10300	0.00E+00	
92-02	64	55.43	4	5	35	0.07	10300	5.92E-06	
92-02	69	59.76	4	5	25	0.24	10300	2.34E-05	
92-02	69	59.76	4	5	35	0.38	10300	3.12E-05	
92-02	74	64.09	4	5	25	0	10300	0.00E+00	
92-02	74	64.09	4	5	35	0	10300	0.00E+00	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APR 1 4 1992

APPENDIX I

TABLE 2

DATE: APRIL, 1992   MADE BY: D. MACHIN   PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-03	24	20.78	4	5	8	0	10300	0.00E+00	
92-03	24	20.78	4	5	15.5	0	10300	0.00E+00	
92-03	29	25.11	4	5	10	0	10300	0.00E+00	
92-03	29	25.11	4	5	15	0	10300	0.00E+00	
92-03	29	25.11	4	5	20	0.05	10300	7.83E-06	
92-03	34	29.44	4	5	10	0	10300	0.00E+00	
92-03	34	29.44	4	5	18	0	10300	0.00E+00	
92-03	34	29.44	4	5	25	0	10300	0.00E+00	
92-03	39	33.77	4	5	15	0	10300	0.00E+00	
92-03	39	33.77	4	5	23	0	10300	0.00E+00	
92-03	39	33.77	4	5	30	0	10300	0.00E+00	
92-03	44	38.11	4	5	16	0	10300	0.00E+00	
92-03	44	38.11	4	5	25	0	10300	0.00E+00	
92-03	44	38.11	4	5	30	0.03	10300	3.19E-06	
92-03	49	42.44	4	5	15	0	10300	0.00E+00	
92-03	49	42.44	4	5	25	0	10300	0.00E+00	
92-03	49	42.44	4	5	30	0	10300	0.00E+00	
92-03	54	46.77	4	7	15	0	10300	0.00E+00	
92-03	54	46.77	4	7	25	0	10300	0.00E+00	
92-03	54	46.77	4	7	35	0	10300	0.00E+00	
92-03	59	51.10	4	7	18	0.19	10300	2.28E-05	
92-03	59	51.10	4	7	26	0.32	10300	3.24E-05	
92-03	59	51.10	4	7	35	0.42	10300	3.61E-05	
92-03	64	55.43	4	7	15	0	10300	0.00E+00	
92-03	64	55.43	4	7	25	0	10300	0.00E+00	
92-03	64	55.43	4	7	35	0	10300	0.00E+00	
92-03	69	59.76	4	7	15	0	10300	0.00E+00	
92-03	69	59.76	4	7	25	0	10300	0.00E+00	
92-03	69	59.76	4	7	35	0	10300	0.00E+00	
92-03	74	64.09	4	7	15	0	10300	0.00E+00	
92-03	74	64.09	4	7	25	0	10300	0.00E+00	
92-03	74	64.09	4	7	35	0	10300	0.00E+00	

APR 1 ^ 1992

APPENDIX I

TABLE 3

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

DATE: APRIL, 1992

MADE BY: D.MACHIN

PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-04	34	29.44	4	5	10	0.18	10300	3.74E-05	
92-04	34	29.44	4	5	15	0.09	10300	1.56E-05	
92-04	34	29.44	4	5	25	0.27	10300	3.50E-05	
92-04	39	33.77	4	5	10	0	10300	0.00E+00	
92-04	39	33.77	4	5	15	0	10300	0.00E+00	
92-04	39	33.77	4	5	25	0	10300	0.00E+00	
92-04	44	38.11	4	5	15	0.015	10300	2.31E-06	
92-04	44	38.11	4	5	25	0.07	10300	8.30E-06	
92-04	44	38.11	4	5	30	0.03	10300	3.19E-06	
92-04	49	42.44	4	5	15	0	10300	0.00E+00	
92-04	49	42.44	4	5	25	0.012	10300	1.36E-06	
92-04	49	42.44	4	5	36	0.017	10300	1.56E-06	
92-04	54	46.77	4	5	15	0.05	10300	6.92E-06	
92-04	54	46.77	4	5	25	0.54	10300	5.89E-05	
92-04	54	46.77	4	5	35	0.38	10300	3.43E-05	
92-04	59	51.10	4	5	18	0	10300	0.00E+00	
92-04	59	51.10	4	5	26	0.04	10300	4.12E-06	
92-04	59	51.10	4	5	36	0.05	10300	4.29E-06	
92-04	64	55.43	4	5	15	0	10300	0.00E+00	
92-04	64	55.43	4	5	25	0	10300	0.00E+00	
92-04	64	55.43	4	5	35	0.2	10300	1.69E-05	
92-04	69	59.76	4	5	15	0	10300	0.00E+00	
92-04	69	59.76	4	5	25	0	10300	0.00E+00	
92-04	69	59.76	4	5	35	0	10300	0.00E+00	
92-04	74	64.09	4	5	15	0.04	10300	4.61E-06	
92-04	74	64.09	4	5	25	0	10300	0.00E+00	
92-04	74	64.09	4	5	35	0.08	10300	6.38E-06	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APR 1 4 1992

APPENDIX I

TABLE 4

DATE: APRIL, 1992 MADE BY: D. MACHIN PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-05	44	38.11	4	5	0.5	10	10300	2.70E-03	LEAK, LOST ALL WATER
92-05	49	42.44	4	5	25	0.11	10300	1.25E-05	
92-05	49	42.44	4	5	36	0.21	10300	1.92E-05	
92-05	54	46.77	4	5	25	0.15	10300	1.64E-05	
92-05	54	46.77	4	5	35	0.18	10300	1.62E-05	
92-05	59	51.10	4	5	25	0.05	10300	5.25E-06	
92-05	59	51.10	4	5	35	0.08	10300	6.98E-06	
92-05	64	55.43	4	5	25	0.18	10300	1.82E-05	
92-05	64	55.43	4	5	35	0.22	10300	1.86E-05	
92-05	69	59.76	4	5	15	0.06	10300	7.21E-06	
92-05	69	59.76	4	5	25	0.07	10300	6.83E-06	
92-05	69	59.76	4	5	35	0.08	10300	6.57E-06	
92-05	74	64.09	4	5	15	0.07	10300	8.06E-06	
92-05	74	64.09	4	5	25	0.13	10300	1.23E-05	
92-05	74	64.09	4	5	35	0.16	10300	1.28E-05	

RQD VALUES DETERMINED FOR THE UPPER 80 FEET
OF DIAMOND DRILL CORE RECOVERED

APR 1 4 1992

APPENDIX I

TABLE 5

DATE:
APRIL, 1992

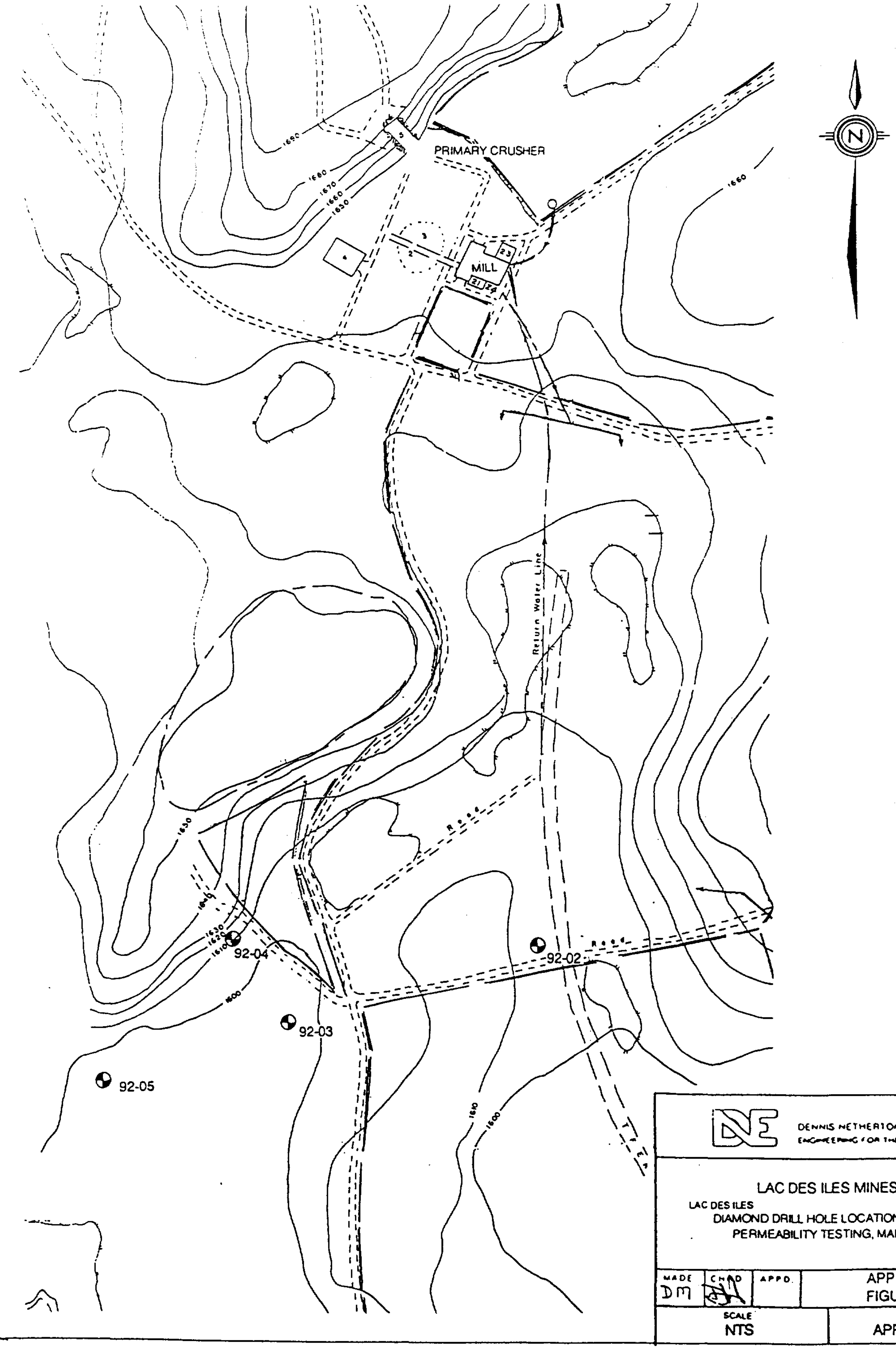
MADE BY:
D. MACHIN

PROJECT NO.:
0786-001

DEPTH TO BOTTOM OF RUN	RQD DRILL NO. 92-02	DEPTH TO BOTTOM OF RUN	RQD DRILL NO. 92-03	DEPTH TO BOTTOM OF RUN	RQD DRILL NO. 92-04	DEPTH TO BOTTOM OF RUN	RQD DRILL NO. 92-05
0		0		0		0	
17	O/B	12	O/B	28	O/B	38	O/B
23	74	17	97	33	50	43	88
28	93	22	97	38	50	48	100
33	50	27	100	43	77	53	100
38	95	32	92	48	80	58	100
43	100	37	87	53	50	63	82
48	83	42	80	58	93	68	87
53	97	47	62	63	90	73	95
58	100	52	87	68	93	78	90
63	100	57	92	73	94	83	100
68	100	62	100	78	100	88	100
73	100	67	100	83	100	93	83
78	100	72	93	88	93	98	80
83	100	77	90	93	90	103	95
88	100	82	80	98	97	108	95
		87	100	103	93	113	75
		92	92				

NOTE: DEPTHS HAVE NOT BEEN CORRECTED FOR DRILL HOLE DIP OF 60 DEGREES.

NOTE: RQD DESCRIPTIONS (from CANADIAN MANUAL ON FOUNDATION ENGINEERING)
0 - 25 VERY POOR; 25 - 50 POOR; 50 - 75 FAIR; 75 - 90 GOOD; 90 - 100 EXCELLENT.

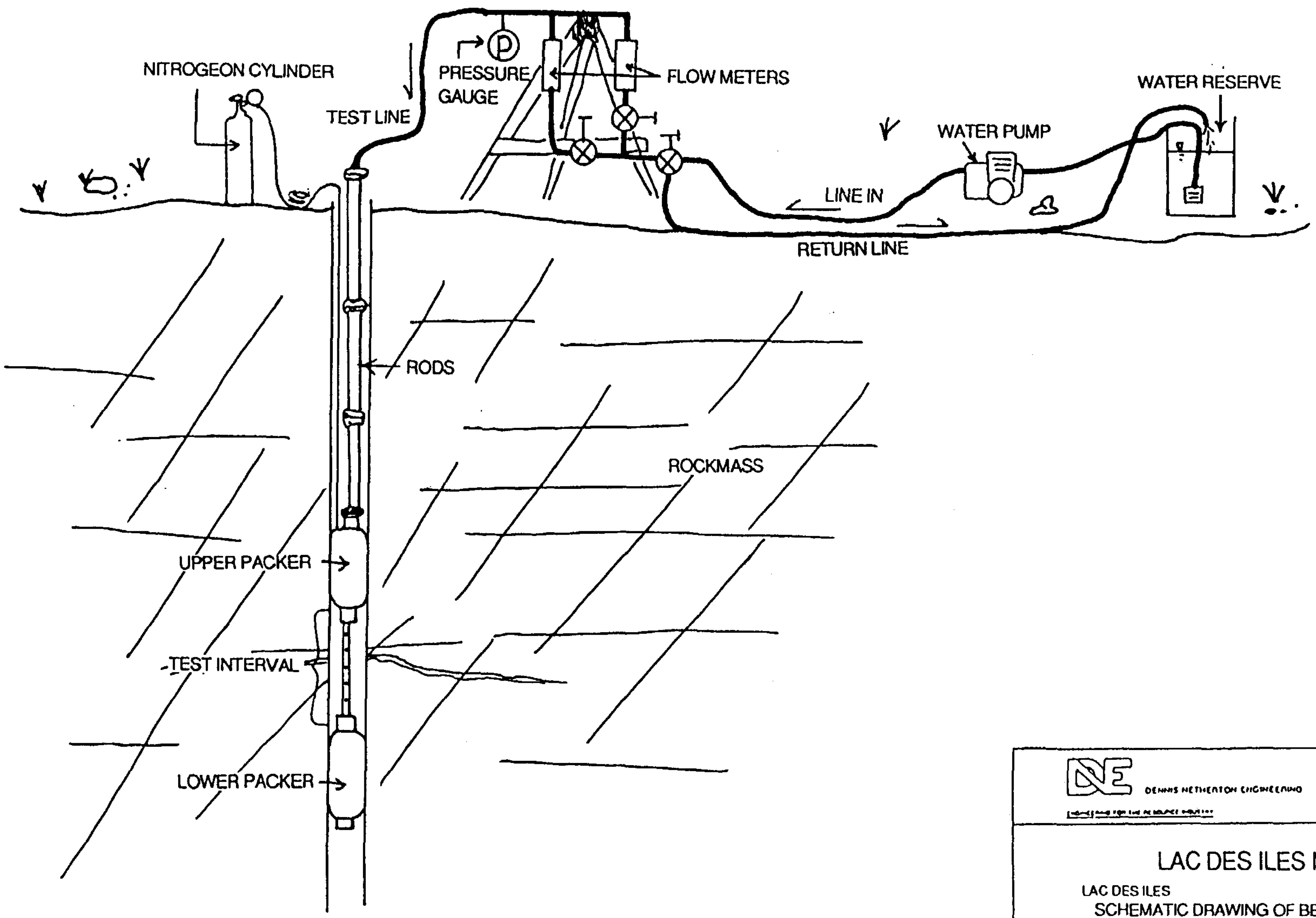


DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

LAC DES ILES MINES LTD
LAC DES ILES ONTARIO
DIAMOND DRILL HOLE LOCATIONS USED FOR PERMEABILITY TESTING, MARCH 1992.

MADE	CHKD	APPD.	
DM			APPENDIX I FIGURE 1

SCALE	DATE
NTS	APRIL, 1992



DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRY

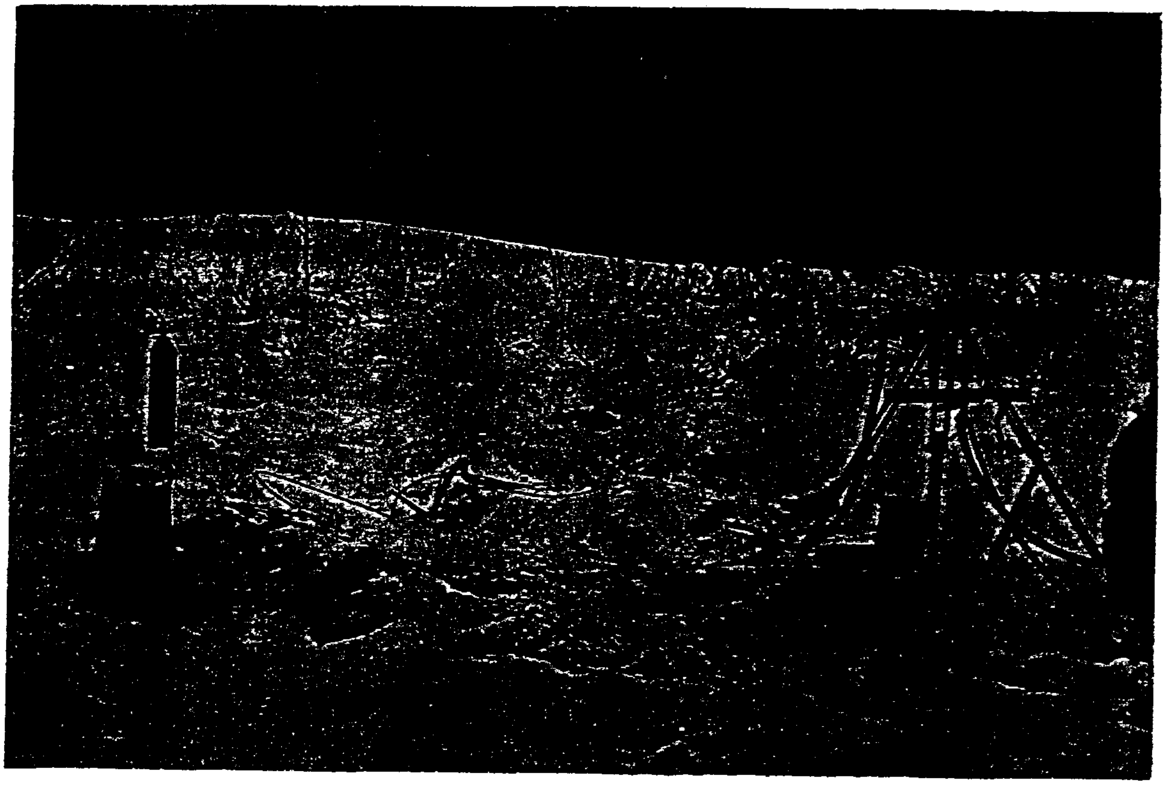
LAC DES ILES MINES LTD
LAC DES ILES ONTARIO
SCHEMATIC DRAWING OF BEDROCK PERMEABILTY
TESTING EQUIPMENT

DATE: APRIL 1992	MADE: DM	SCALE: NTS	APPENDIX I FIGURE 2

APPENDIX 2

PHOTOGRAPHS

Photo 1



View showing equipment set up prior to cold weather. Gas cylinder to left contains the nitrogen used to pressurize the packer assembly down the hole. The collar is visible on the water line attached to the end of the steel rod. The pipe wrench is attached to the rod for safety for when the packers are deflated. The flow meter, water valve and pressure gauge set-up are mounted on the tripod and permit the adjustment of water flow to the test zone. (March 8, 1992)

View showing equipment set-up at 92-04. Water reserve is a plastic 2051 container with the lid cut off. It is mounted on the sled to allow the snow mobile to move it. The water pump is in front of the water reserve and pumps the water to the plastic covered shelter where the flow meters pressure gauges and water valves are used to regulate the flow during the test. The plastic shelter has extended over the collar to prevent freezing of the water line and drill hole rod (March 13, 1992)

Photo 3

View showing flow meters, pressure gauge, water valves and water lines set-up inside plastic shelter. Tiger torch (at bottom of photo) provides heat to prevent freezing of water and to permit proper operation of the pressure gauge. (March 13, 1992)

LAC DES ILES PROJECT
TAILINGS MANAGEMENT FACILITY
INFORMATION PACKAGE

2.15334

Prepared For

LAC DES ILES MINES LTD

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

File number: 0786

August 6, 1992

DENNIS NETHERTON ENGINEERING

DENNIS NETHERTON ENGINEERING
(743963 ONTARIO LTD.)
ENGINEERING FOR THE RESOURCE INDUSTRIES

P.O. Box 10, North Bay, Ont. P1B 8G8
Offices at 885 Jet Ave.
Phone: (705) 476-2165 Fax: (705) 474-8095

August 6, 1992

Mr. Glenn Clark, P.Eng.
Lac des Iles Mines Ltd.
Suite 916
111 Richmond St. W.
Toronto, Ontario
M5H 2G4

Dear Mr. Clark:

Dennis Netherton Engineering (**DNE**) is pleased to provide you with the attached Information Package which outlines the Tailings Management Facility proposed for the Lac des Iles Project. .

The Information Package has been prepared to serve as both a progress report and discussion document for meetings to be held next week with the Ministries involved.

We would be pleased to provide supplementary information at your request.

Sincerely,
DNE Dennis Netherton Engineering

D. Orava.

David Orava, M.Eng., P.Eng.
Manager of Engineering

Reference file: 0786
DO:lb

TABLE OF CONTENTS

1.0 INTRODUCTION

This document summarizes the work carried out to date by Lac des Iles Mines Ltd., in developing an environmental and operational solution for the storage of mill tailings at the Lac des Iles Project in northwestern Ontario. It also outlines the Tailings Management Facility proposed for the Lac des Iles Project.

1.1 Background

The project is located approximately 100 kilometres due north of Thunder, Bay, Ontario and consists of an open pit, mill and supporting infrastructure. The mine product will be predominately palladium and platinum with gold, copper and nickel. The deposit contains reserves of approximately 5.9 million tonnes, in the Roby zone open pit, located within a gabbroic complex. The project location is indicated on drawing number 0786-099.

The work performed to date for Lac des Iles Mines Ltd. has been carried out by Dennis Netherton Engineering (**DNE**), geotechnical engineering investigations and evaluations; Senes Consultants Ltd (**SENES**), environmental impact and assessment, and Lakefield Research (**Lakefield**), effluent properties. The work of all the consultants has been coordinated by Mr. Glenn Clark of Lac des Iles Mines Ltd.

DNE personnel first visited the site in the fall of 1991. Based on the information obtained from that site visit, 1:20,000 scale Ontario base maps and information provided by Madeline Mines Ltd (the previous owner), **DNE** developed four options for tailings storage. One of the options incorporated the existing tailings area while the other three examined other areas for their suitability as a tailings storage area.

1.1.1 Conceptual Stage 1 Tailings Management Facility

Following the review of the four tailings storage options, the various Government Ministries involved with the project expressed the desire that any Tailings Management Facility should incorporate the existing tailings area. This resulted in the conceptual design for the Stage 1 Tailings Management Facility (TMF).

The conceptual Stage 1 TMF was based on utilizing the existing tailings area and developing a new water retention pond immediately downstream of the tailings area. Calculations based on preliminary topographic information indicated that the conceptual Stage 1 TMF could provide storage for up to 1.8 million tonnes of tailings along with a water retention pond with a 740,000 cubic metre capacity. This approach required that perimeter dams be constructed around the existing tailings area. It also required that a new water retention pond dam be constructed in the area between the southern limit of the tailings area and Pond No. 1.

It was envisaged that once the Stage 1 tailings impoundment area was filled, additional tailings would be placed in a new Stage 2 area located in the same valley as Stage 1 but downstream of Pond No. 1. The Stage 1 tailings area would be reclaimed once it was filled.

Field investigations were subsequently carried out in the conceptual Stage 1 TMF area. In March 1992, **DNE** personnel carried out bedrock permeability testing in the upper 25 metres of four exploratory diamond drill holes located along the southern boundary of the existing tailings area. **SENES** personnel concurrently undertook environmental water quality and sediment sampling work.

Further on-site investigations of the conceptual Stage 1 TMF area were carried out in May 1992, when a test pitting and bedrock permeability program was conducted along the proposed dam alignments. Till deposits located on the mine property were also evaluated as borrow sources for the proposed dams. The test pitting program indicated that the site contained shallow depths of glacial till throughout the area with the exception of the downstream valley that acts as a drainage basin for Pond No.1. Test pitting in the area to the north of Pond No. 1 using a Caterpillar 235 excavator determined that muskeg was present to a depth of three metres. The center of the valley could not be accessed by the excavator. Diamond drilling of hole No. 92-05 in March 1992 indicated that there was approximately 10 metres of overburden in the center of the valley consisting of muskeg and bouldery till with the water table at or near the ground surface. The May 1992 bedrock permeability testing work concentrated on the north and east sides of the existing tailings area as the southern area had been evaluated earlier during the March, 1992 program. Environmental studies continued to be carried out concurrently.

1.1.2 Revised Stage 1 TMF

Upon the review of geotechnical and environmental data and analyses, new topographic information, and hydrologic information the conceptual Stage 1 TMF was revised. Revisions were based on key criteria which included:

- Making use of the existing tailings area in Stage 1.
- Providing a Stage 2 tailings area with sufficient storage capacity for the balance of anticipated tailings tonnage.

- Providing a water retention pond system to collect and store tailings transport water so that it could be recycled back to the mill.
- Providing a sufficient watershed area so that precipitation input to the water retention pond system would, on average, counterbalance the normal losses of tailings transport water. This would allow water to be recycled back to the mill and reduce the quantity of make-up fresh water required.
- Ensuring that there would be no net loss of Fisheries when Pond No. 1 becomes part of the Stage 1 TMF. Lac des Iles Mines Ltd. could provide compensation by improving fishery habitat in another nearby location (this arrangement has yet to be finalized).

The new topographic information was in the form of maps at 1:2,500 scale with a contour interval of one metre. The maps were developed by Airquest Resource Surveys Ltd. using aerial photographs taken in late May, 1992. The hydrological evaluation used historical information obtained from Environment Canada for Thunder Bay, Armstrong and Abitibi Camp No. 228.

2.0 PROPOSED TMF

Please refer to drawing numbers:

- 0786-101 Plan
- 0786-102 Stage 1 Profiles
- 0786-103 Stage 2 Profiles

The proposed Tailings Management Facility (TMF) would be developed in three stages. The first stage would use the existing tailings area for tailings storage (approximately 936,000 metric tonnes) and the downstream valley that contains Pond No.1 for the water pond. Stage 2 would combine the tailings area and water retention pond of Stage 1 into a combined tails and water pond. This would be achieved by raising and extending the Stage 1 Dams as well as constructing additional perimeter Dams. Stage 2 could provide up to 9,000,000 tonnes of tailings storage. In Stage 3, a replacement water retention pond would be constructed along the southeastern side of the Phase 2 area, if required.

2.1 Stage 1 Tailings Management Facility

The Stage 1 Tailings Management Facility is located immediately south of the mill building in a shallow valley, part of which has previously been used for tailings disposal. The valley is bounded on the north and west sides by bedrock ridges that are covered with shallow depths of silty sand till. The east side of the valley consists of a number of bedrock ridges that are separated by flat stretches of low lying ground. The south end of the Stage 1 area is a narrow valley, approximately 150 metres wide. A small shallow pond (Pond No.1) is located within the southern part of the valley and receives the surface water drainage from the northern part. The pond drains, via a small stream, south into Hasson Lake.

The Stage 1, TMF would consist of two separate parts, a tailings storage area and a water retention pond. The tailings storage area would consist of the area containing the existing tailings. The water pond would be located to the south of the tailings area. A spillway, blasted into the bedrock would allow clarified water overflow from the tailings area to flow down to the water retention pond.

The tailings area would be contained on the west, east and north sides by the height of land. The tailings would be deposited from an end spill along the north side of area, at or below the 3040 metre elevation. Based upon a beach slope of 0.5 percent, the ultimate Stage 1 beach would be at 3037.5 elevation at the south end of the tailings area. An earth fill dam, 520 metres long and constructed to an elevation of 3038.5, would be required along the south side of the tailings area.

The dam would consist of a low permeability core constructed from 150 mm minus till with either 150 mm plus till or pit waste rock for the upstream and downstream shells. A crushed stone filter would be used to separate the downstream shell and the core in order to prevent washing of fines from the core into the shell. The east half of the dam would contain a low permeability till cut off constructed to bedrock in order to minimize seepage to Camp Lake. Such a feature may not be required along the west half of the dam as the water pond lies immediately downstream of this part of the dam. The Dam would be constructed to a maximum height of eight metres above the present ground surface. It would require approximately 20,000 cubic metres of minus 150 mm till for the core and 70,000 cubic metres of shell material.

The tailings area would have a surface area of approximately 320,000 square metres and would be able to store approximately 650,000 cubic metres (936,000 dry tonnes) of tailings. This translates into about one year of storage at the anticipated mill rate of 2,730 tonnes per day.

The water retention pond would be located to the south of the tailings area, within the same shallow valley. The water pond would be contained by the height of land along the west, north and north east sides. An earth fill perimeter dam would be required along the south east and the south sides of the proposed area. A saddle dam would also be required in a topographic low on the west side.

The dam along the south west side of the water pond would be constructed to an elevation of 3031 metres and would be approximately 760 metres long. The dam would be constructed to a maximum height of five metres above the existing ground surface. The dam would have a similar cross-section to that of the tails area dam, having a low permeability core constructed of 150 mm minus till and upstream and downstream shells of 150 mm plus till and or pit waste rock. The design would vary from the tailings dam in that a filter zone would be required between the upstream shell as well as the downstream shell. A total of 15,000 cubic metres of 150 mm minus till fill and 30,700 cubic metres of shell material would be required. The low permeability core would be extended to bedrock along the full length of the dam in order to minimize seepage losses.

The dam along the south side of the water pond would also be constructed to an elevation of 3031 metres, with a length of approximately 180 metres, and to a maximum height of five metres above the existing ground. The dam would be constructed in the same manner as the south east water pond dam and would require 3,600 cubic metres of 150 mm minus till fill and 9,500 cubic metres of shell material. The low permeability core would be extended to bedrock for the full length of the dam.

A saddle dam would be required in the low ground along the west side of the water pond in an area where the height of land is approximately one metre below the maximum water elevation of 3,030 metres. The dam would be about 125 metres long and would be constructed similar to the other water retention pond dams.

A spillway would be blasted into the bedrock on the east abutment of the south water retention pond dam. Initial studies have indicated that water quality will not be a problem, and a treatment plant will not be required.

The water pond surface would rise to a maximum elevation of 3,030 metres with a surface area of 320,000 square metres. The pond would have the capacity to 604,000 cubic metres of water.

2.2 Stage 2 Tailings Management System

The Stage 2 TMF would occupy the same area as the Stage 1 TMF. The perimeter dams of Stage 1 would be extended and raised and additional dams would be constructed along topographic lows. This would result in the formation of a combined water and tails pond. Raised dams would be tied into existing structures and stepped downstream. A total of 3,680 metres of dam length would be required for the Stage 2 TMF.

The north end of the Stage 2 TMF would be contained by an earth fill dam constructed to an elevation of 3045 metres. The dam would abut against the bedrock ridges that contained the Stage 1 Tails. Dams would be constructed on the south east and south west boundaries to an elevation of 3,045 metres. From the position of the Stage 1 tailings dam, to the south water pond dam, the crest of the perimeter dams would be graded from an elevation of 3,045 metres to 3,039 metres, reflecting the ultimate tailings beach slope.

A total of 144,000 cubic metres of 150 mm minus till core fill would be required for the dams and 574,000 cubic metres of 150 mm plus till or pit waste rock would be required for the shells.

Excess water would be decanted from the Stage 2 TMF via a spillway blasted into the bedrock. The spillway would be located in the west abutment of the south dam and would release water into the present downstream drainage system that drains to Hasson Lake.

The total storage capacity of the Stage 2 TMF is approximately 6,650,000 cubic metres or 9,000,000 tonnes of dry tails. This storage capacity, in addition to that of Stage 1, provides more than sufficient storage capacity for the anticipated life of the mine.

2.3 Stage 3 Tailings Management Facility

The Stage 3 TMF consists of the continued use of the Stage 2 TMF for tailings storage and the construction of a new water pond. The new water pond would be located in the valley to the east of the Stage 2 TMF and would require the construction of a 330 metre long perimeter dam. The height of land would form the remaining perimeter of the water pond. The water level would remain approximately 1.5 metres below the height of land to insure that the (assumed) ground water flow continues to be directed in a westward direction, i.e. away from Camp Lake.

The dam would be constructed to an elevation of 3,030 metres providing for a maximum water level of 3,029 metres. The east end of the Dam would abut against the bedrock ridge on the east side and would tie into Stage 2 perimeter dam on the west side. Approximately 8,000 cubic metres of 150 mm plus till would be required for the core zone along with 20,000 cubic metres of either waste rock or 150 mm plus till for the shells.

The Stage 3 water retention pond would provide storage for approximately 525,000 cubic metres of water. Excess water would be decanted via a spillway blasted into the bedrock of the east abutment. Currently there is no surface drainage course, but topography and visual examination indicate that water from the valley drains into Hasson Lake.

3.0 ENVIRONMENTAL ISSUES

3.1 Environmental Studies

In March 1992, SENES Consultants Limited (**SENES**) conducted the first of three surveys in the planned baseline surface water and sediment quality monitoring program at the Lac des Iles mine site. The program was designed to collect data on those water bodies most likely to be impacted by the development and operation of the proposed palladium/platinum/gold/copper/nickel mine and mill complex. In late May 1992, a second sampling program was carried out by Niblett Environmental Associates Inc. (NEA), subconsultants retained to perform biological studies. In addition to collection of water samples, the May program included benthic sampling, fish netting and habitat investigations. A third water quality survey is to be undertaken in August 1992 to augment the database on local surface water quality.

3.1.1 Surface Water and Sediment Quality

The sampling program is described in detail in a report submitted in April (**SENES**, 1992a) and is briefly discussed below.

Sampling Methods

Many facilities already exist on the Lac des Iles mine site from past exploration and mining activities. The water bodies identified for inclusion in the sampling program are:

- Camp Lake, which is located to the east and south of the surface facilities and may be used as a source of fresh water for the mill;
- Hasson Lake, which is located to the south of the surface facilities and receives runoff from a small volume of tailings deposited from past mining activities in a low-lying area in the lake watershed; and
- two ponds (first pond and second pond), which are located on the drainage course between the tailings area and Hasson Lake.

The program has included measurement of field pH, temperature and dissolved oxygen for each of the water bodies and collection of lake water (both surveys) and sediment (March survey only) samples. In addition, water samples were obtained from the existing tailings management facility (TMF) for chemical analyses. For each survey, a total of nine (9) surface water samples were collected: 2 from Camp Lake, 3 from Hasson Lake, 1 from each of the two ponds, 1 from the tailings secondary sedimentation pond and 1 from the tailings decant pond. Seven (7) sediment samples were collected during the March survey: 2 from Camp Lake, 3 from Hasson Lake and 1 from each of the ponds. The sampling locations are shown on Figures 2.1, 2.2 and 2.3 of the SENES report (1992a). The sampling stations on Camp Lake were located to sample in the vicinity of the deepest points. No bathymetry mapping was available on Hasson Lake or the two ponds downstream of the TMF. Consequently, Hasson Lake was sampled at three locations to obtain an appreciation of the characteristics of this water body. Only one water sample was taken from each of the ponds for chemical analyses.

The samples were stored in coolers with ice packs and shipped via air to Barringer Laboratories in Mississauga for analysis. The water samples were analyzed for trace metals, major anions and cations and nutrients as well as for ammonia, total and ortho-phosphorus, dissolved organic carbon (DOC) and colour. The sediment samples were analyzed for metals and loss on ignition (LOI). The field measurements and analytical data for the surface water and sediment samples are discussed below. The data for the tailings facility water samples are included for comparison and are further discussed in Section 3.2.

Field Measurements

During the initial March survey, the water bodies were under ice. As a result, the measured dissolved oxygen levels were significantly less than the solubility limit for oxygen in water (at the field temperatures) for all monitoring stations. The measured dissolved oxygen level in Camp Lake was acceptable for sustaining aquatic life in the upper portion of the water column. In contrast, Hasson Lake and the two ponds had low dissolved oxygen levels even in the upper layers of the water column. This observation was attributed to the shallowness of the lake and ponds.

The Ontario Ministry of Natural Resources (OMNR), Thunder Bay District, has also provided some baseline data for Camp Lake (OMNR, 1987a). The results of the March survey, the second survey in late May and the OMNR data indicate that for all of the water bodies sampled, the hypolimnetic oxygen concentrations approach anoxic conditions during the winter months and may also approach anoxic conditions during the summer months.

The pH values recorded in the field ranged from 6.7 to 7.4 during both surveys and are typical of values usually reported for Precambrian Shield waters. Camp Lake, First Pond and Second Pond were all found to be very slightly acidic while Hasson Lake was very slightly alkaline.

Analytical Results for Water Samples

The analytical results for key constituents in the surface water and tailings facility samples are summarized in Table 3.1.1. The complete data sets are presented in SENES (1992a and 1992b). In general, the data for Camp Lake, Hasson Lake and the two ponds downstream of the existing tailings basin indicate that the concentrations of many of the trace metals (not shown) were quite low and generally less than the detection limits of the analytical techniques (e.g. silver, boron, barium, beryllium, cobalt, chromium, molybdenum, nickel, lead, strontium, titanium, vanadium and zinc). The concentrations (not shown) of the major cations (i.e. calcium, potassium, magnesium, sodium and silica) and anions (i.e. chloride, carbonate, bicarbonate and sulphate) were also low.

The theoretical total dissolved solids levels were calculated to vary between 25 and 41 mg/L, with the exception of the first pond values (96 mg/L in March and 53 mg/L in May), which apparently reflect the influence of the discharge from the existing tailings basin. The generally low concentrations of the major and trace elements is typical of many Precambrian Shield waters.

The alkalinity of Camp Lake and Hasson Lake waters varied between 14.1 and 15.4 mg/L $CaCO_3$ during the May survey and between 20.3 to 21.3 mg/L $CaCO_3$ during the March survey. The limited buffering capacity of these waters is typical of surface runoff on much of the Precambrian Shield. The average alkalinity of the water samples taken from the first pond below the TMF is higher than observed in the other water bodies and apparently reflects the influence of the tailings discharge water which had an alkalinity of 84 mg/L $CaCO_3$ in May and a much higher alkalinity of 250 mg/L $CaCO_3$ in March.

The lake and pond water samples have a distinctive dark brown colour typical of waters affected by the by-products of organic matter decay. These waters have various descriptors: "swamp water", "humus water" or "coloured water". The observed range of the colour readings, between 124 and 379 TCU, are characteristic of waters with a high organic acid content.

The presence of organic matter in the Lac Des Iles area waters is also confirmed by the dissolved organic carbon (DOC) measurements. The measured levels generally range from 14.3 mg/L to 22.0 mg/L, with the exception of an unusually low value of 4.9 mg/L measured in March for the first pond. Typical concentrations of organic carbon in surface waters are reported by the CCME (1987) to range from 1 to 3 mg/L in pristine streams, 2 to 10 mg/L in rivers and lakes, and 10 to 60 mg/L in swamps, marshes and bogs. Comparing the measured levels to the classification range quoted above, the water quality in Camp Lake, Hasson Lake and the two ponds would fall into the latter group.

The presence of organic acids can dramatically increase the solubility of metals as most metals form complexes with humic substances in water (CCME, 1987). At low pH, those metals which complex with fulvic acid, in order of decreasing stability, are reported to be: iron (III); aluminum (III); copper (II); nickel (II); cobalt (II); lead (II); calcium (II); zinc (II); cadmium (II); iron (II); manganese (II); and magnesium (II). This factor would explain the elevated iron levels reported in Table 3.1.1 which varied from a low of 0.29 mg/L to a high of 1.46 mg/L and from a low of 0.31 mg/L to a high of 0.52 mg/L in Camp Lake. The unusually high levels of iron recorded in the two ponds and in the west bay of Hasson Lake during the March survey was not repeated for the May survey. However the measured iron levels consistently exceed the provincial surface water quality of 0.30 mg/L for protection of aquatic life (MOE, 1984). The presence of organic acids may have also influenced the observed levels of aluminum which were generally equal to or marginally greater than the federal guideline of 0.10 mg/L for protection of aquatic life in fresh waters with pH $\geq$ 6.5, calcium concentration $\geq$ 4.0 mg/L and dissolved organic carbon concentration (DOC) $\geq$ 2.0 mg/L. The Province of Ontario has not as yet published an objective for aluminum. Unlike the March survey result, the copper levels measured during the May survey did not exceed the provincial objective of 0.005 mg/L for protection of aquatic life (MOE, 1984) for any of the samples.

The measured concentrations of the nutrients (i.e. nitrogen and phosphorus compounds) were generally found to be present in fairly low concentrations. The total phosphorus levels measured in Camp Lake and Hasson Lake were generally less than the guideline of 0.020 mg/L to protect against nuisance aquatic plant growth in lake systems. The total phosphorus levels measured in the first pond (0.080 and 0.033 mg/L in March and May, respectively) were higher than the guideline but were still considerably lower than the levels reported on Table 3.1.1 for the tailings pond water for each survey. The ammonia-nitrogen concentrations were found to be elevated for most samples during the March survey but were still well below the surface water quality objective. In contrast to the March survey, the May tailings pond water samples did not contain elevated ammonia-nitrogen levels.

Analytical Results for Sediment Samples

The sediment samples collected in March were analyzed for 24 metals and percent loss on ignition (LOI). The results of the analyses for key constituents are summarized in Table 3.1.2. The complete data set is presented in SENES (1992a). In addition, typical background levels of several of the metals in sediments from the Great Lakes are included in the table for comparison purposes.

The three sediment samples collected from Camp Lake are seen to have a very consistent quality. The duplicate samples taken from the north basin of Camp Lake (denoted north basin #1 and north basin #2) showed essentially no difference in most of the parameters measured (i.e. the levels fall within the expected range of natural variability). The measured levels of several of the metals (i.e. cadmium, chromium, manganese, nickel, lead and zinc) are characteristic of the reported typical background levels. The measured iron levels were approximately one-half the typical value reported on Great Lakes sediment. In contrast, the copper levels were more than twice the background values. This observation is not surprising as Camp Lake is located in an area of mineralization. The organic content of the sediments in Camp Lake is high, ranging from 29.1% to 35.8%.

The sediment sample taken from the north basin of Hasson Lake is seen to have very similar characteristics to the sediment in Camp Lake. The sediment samples from the west basin and mid lake station on Hasson Lake however, had quite different chemical characteristics. These sediment samples were found to have a much higher silt content and corresponding lower organic content (i.e. low LOI values). Accordingly, the metals content of these samples differed from the north basin sample and the Camp Lake samples.

The sediments in the two ponds downstream of the TMF are seen from Table 3.1.2 to have a high organic content (i.e. high LOI), similar to that measured on the sediments from Camp Lake. The metals content of the sediment from the second pond is also comparable to the metal levels found on Camp Lake. Interestingly, the metal levels measured in the sediment sample from the first pond are generally lower than the levels found in the sediments from the second pond, the north basin of Hasson Lake and Camp Lake. It is possible that the sediment quality has been altered by tailings deposition in the watershed although this is strictly a speculative conclusion.

Summary of Results

In summary, the waters of Camp Lake, Hasson Lake and the ponds downstream of the TMF are characterized by strong dark brown colour indicative of the presence of humic acids. As a consequence, the waters also contain elevated levels of aluminum and iron in particular, as these metals tend to most readily form organic metal complexes. The waters have a neutral pH and modest buffering capacity against pH change.

The sediments from the lakes and ponds sampled in the March survey were found to have typical sediment quality characteristics in most respects. Several of the sediment samples had a high organic carbon content and an elevated copper level. These attributes are indicative of the effects of local forestation and mineralization.

3.1.2 Biological Program

The objectives of the biological program, carried out by NEA in late May 1992, were to document the existing natural biological features of the proposed receiving waters for the mine effluent and to identify and evaluate the general potential impacts from the proposed mining operation on the identified natural resources.

The following is a brief summary of the methodology and results of the biological program. A more detailed description of the sampling techniques employed in the field survey program is given in NEA (1992) along with detailed results and discussions.

Sampling Methods

The biological field program included collection of fish tissue samples for analysis of mercury and benthic samples for sorting as well as habitat investigations. The aquatic biological resources were assessed through observations and the use of various sampling techniques.

Incidental observations of birds and mammals were recorded during the fisheries surveys. Observations included direct sightings, tracks, browse, scats and nests.

The study area for the fisheries inventory included Camp Lake, Hasson Lake, two unnamed ponds and associated creeks within this drainage basin. Prior to the field survey, background information obtained from OMNR were reviewed. Background information included a 1987 lake survey of Camp Lake (OMNR, 1987a).

Biophysical habitat characteristics were initially assessed through aerial photographs and confirmed by ground-truthing. Major biophysical characteristics were mapped, photographed and details recorded. All fish habitat characteristics were made by visual observations and followed techniques outlined in OMNR (1987b).

Fish collection gear included seine nets, gill nets and minnow traps. All large fish were sampled for fork length, total length and weight. Flesh samples were also retained from northern pike for mercury analysis. Representative samples of small fish were retained for species verification. All net setting procedures followed OMNR (1987b).

Benthos samples were collected from riffles using a Surber sampler. The collection methods follow those outlined by OMNR (1987b). At each sampling location, a minimum of three replicates were collected. Samples were labelled and preserved in 10% buffered formalin in the field and returned to the lab for sorting. Three replicate samples from each site were sorted to major taxonomic groups with one of the three identified to species level, where possible.

Depth profiles of Hasson Lake were made with the aid of a Micronar ME 203 chart recording depth sounder while travelling transects. Depths of the two unnamed ponds were recorded with the use of a calibrated line and sinker. The depth profiles for Camp Lake were provided by OMNR, Thunder Bay District.

Biophysical Habitat Characteristics

The physical characteristics, measured by NEA, of the two lakes and two ponds are given in Table 3.1.3.

Based on the biophysical characteristics of Camp Lake, the NEA field crew identified the inflow at the northeast arm of the lake as the most probably location for northern pike spawning. No ideal sucker spawning locations were found, but may be expected to occur at the inflow at the north end of the lake.

Several locations in Hasson Lake were identified as potential northern pike spawning habitat, based on biophysical habitat characteristics. The Hasson Lake inflow from Camp Lake was confirmed to be a white sucker spawning area (sucker eggs were collected in Surber sampler).

No aquatic macrophytes were observed in either of the two ponds downstream of the TMF.

Fisheries Investigations

The NEA field crew identified four fish species within Camp Lake. These species included northern pike, yellow perch, blacknose shiner and white sucker. The OMNR survey (OMNR, 1987a) found two additional species, Iowa darter and burbot. The gill netting program found northern pike to be the most abundant large fish (28 fish) followed by white sucker (4 fish) and yellow perch (1 fish). Minnow traps, utilized to collect small fish within Camp Lake, failed to collect any fish. Seine net catches were more productive and a total of 1,249 fish were caught. Blacknose shiners were by far the most abundant forage fish with 1,229 being caught. Nineteen yellow perch and one 1^+ northern pike were collected. The catch of the 1^+ northern pike indicates that the Camp Lake pike population is viable and naturally reproducing.

The Hasson Lake fisheries investigation identified five species of fish: northern pike, white sucker, blacknose shiner, yellow perch and lake chub. Gill nets captured only two species, northern pike (13 fish) and white sucker (11 fish). The minnow traps failed to catch any small fish. A single seine haul netted 493 fish from 4 species. Once again blacknose shiners were the most abundant (364 fish) followed by yellow perch (122 fish), 1^+ northern pike (5 fish) and lake chub (2 fish). The capture of five 1^+ northern pike indicates that the Hasson Lake pike population is viable and naturally reproducing.

In the first pond downstream of the TMF, the gill net failed to capture any large fish. This was not unexpected considering the low dissolved oxygen levels measured in the pond and the fact that the maximum depth was recorded as being 1.9 metres; the majority of this pond would likely freeze solid during the winter months. The first pond minnow traps were by far the most successful at catching small fish. A total of 365 fish from three species, northern redbelly dace, finescale dace and Johnny darter, were caught. The success of the minnow traps in this pond can be linked to the absence of northern pike. With no large predatory fish, the minnow populations are not kept in check.

Only two species of fish were found in the second pond downstream of the TMF, northern pike and yellow perch. The gill nets captured only 10 northern pike and yellow perch were found in the stomach contents of the sacrificed northern pike. The minnow traps failed to capture any small fish.

Benthic Resources

Benthic resource investigations focused on seven sampling locations: two control locations where no tailings effluent has entered that portion of the system and five locations starting at the existing tailings effluent discharge point and working downstream to the major discharge stream of Hasson Lake.

The collected data show that generally the benthic invertebrate fauna is dominated by midges (chironomids) and blackflies (simulidae). At the station immediately below the tailings pond, very few different kinds of organisms (Taxa) were collected. This decrease in species diversity may, however, be related to physical differences in the substrata, rather than the quality of water in the tailings pond discharge. The presence of blackflies near the tailings pond discharge indicates that the water is not toxic, as this species is sensitive to adverse changes in water quality. All other stations showed variability in numbers and kinds of benthic organisms present. Mayflies (Ephemeroptera) and caddisflies (Tricoptera) were found at all stations and are indicative of moderately good water quality.

Mercury Levels

Ten northern pike specimens taken form each of Camp Lake, Hasson Lake and the second pond downstream of the TMF were submitted to the laboratory for mercury analyses. Camp Lake fish were found to have the highest mercury concentrations followed by Hasson Lake and Second Pond. Regression analyses of total length (cm) versus mercury concentration (mg/g) yielded the following relationships:

- Camp Lake - Hg (mg/g) = 0.023 (Length) + 0.404, $r^2 = 0.505$
- Hasson Lake - Hg (mg/g) = 0.041 (Length) - 1.279, $r^2 = 0.656$
- Second Pond - Hg (mg/g) = 0.038 (Length) - 1.331, $r^2 = 0.505$

The Camp Lake northern pike were found to have mercury concentrations above the MOE guideline for no consumption (1.5 mg/g). The pike from Hasson Lake and the majority of the pike from the second pond fall within the MOE guidelines of restrictive consumption, while the small pike from second pond (less than 50 cm total length) have no consumption restrictions (MOE, 1991b).

High concentrations of mercury within northern pike flesh are typical for Northern Ontario fish populations. Nearby Dog Lake and Muskeg Lake also have restrictive guidelines for pike consumption (MOE, 1991b).

Summary of Results

All fish species captured within the study are typical species for northwestern Ontario. Scott and Crossman (1973) report all captured species as having population ranges within the study site. No captured species are found on the list of rare and/or endangered fish published by Environment Canada (1992). The fisheries data collected to date provide a substantial database from which future environmental conditions can be evaluated.

Mercury concentrations in northern pike within the study area were found to be elevated. This was found to be consistent with observations made by the MOE for this general area (MOE, 1991b).

The northeast inflow for Camp Lake was found to have ideal biophysical conditions for successful northern pike spawning. Several potential northern pike spawning areas were identified within Hasson Lake. The Hasson Lake inflow from Camp Lake was positively identified (eggs) as a white sucker spawning location. Important fisheries areas were not identified in the two ponds within the study area.

The benthic invertebrate data exhibited high variability. The variation appears to be related to substrate type and stream flow conditions.

The presence of pollution intolerant organisms such as blackflies, stoneflies, mayflies and caddisflies suggests that operation of the Lac des Iles mine has not had an adverse impact to date on water quality or the benthic fauna. The stations sampled during this study will serve as monitoring points for future assessments of the impacts of mine operation on the aquatic environment.

3.2 TMF Effluent Quality

3.2.1 Existing TMF Pond Water Quality

During the period from December 1990 to July 1991, the mill at the Lac des Iles mine site was operated sporadically and the tailings were discharged to an impoundment created in the Hasson Lake watershed to the south of the mill. During October 1991, March 1992 and May 1992, water samples were collected from the main pond (tailings decant water) and from the secondary sedimentation pond for chemical analyses. The results of the analyses of total analyte concentrations are summarized on Table 3.2.1.

In general, the data show that most trace elements were present in very low or non-detectable levels (e.g. silver, boron, barium, beryllium, cadmium, cobalt, chromium, molybdenum, lead, strontium, titanium, vanadium, zinc, fluoride and bromide) in all three sets of samples. Those trace elements which were present at elevated levels (i.e. aluminum, iron and manganese) are believed to be associated mainly with suspended matter.

The main elements in the tailings pond water samples were calcium, potassium, magnesium sodium, silica, chloride, sulphate and bicarbonate alkalinity. The concentrations of these elements were not unusually high since the milling process involves only physical separation of concentrate from the tailings (i.e. gangue material). The total dissolved solids content of the samples collected in October was estimated to be in the order of 500 to 700 mg/L.

The data for the three sampling dates indicate a general decrease in the concentration of the major elements between October 1991 and May 1992. This observation is undoubtedly due to the diluting effect of runoff water entering the watershed over the intervening months since milling was stopped in July 1991. The water samples collected from the existing tailings impoundment, therefore, may not be completely representative of the effluent quality from a full scale operation.

3.2.2 Tailings Settability Test Work

To establish the level of treatment required for the tailings decant water and the expected quality of the treated effluent, a series of tailings settling tests were carried out at Lakefield Research using flotation rougher tailings produced during metallurgical investigations. The milling process will involve flotation of a sulphide concentrate containing palladium/platinum/gold/copper/nickel. The ore will be ground to less than 200 mesh size to liberate the sulphide minerals. Standard chemical reagents will be added to the mill circuit to aid in the separation of sulphide minerals from the gangue material. The reagents include sodium sulphide, PA MED (guar gum), copper sulphate, potassium amyl xanthate, Aerofloat 3501, Dowfroth 250C, flocculant and possibly soda ash.

Initial tailings settling tests were carried out to determine the effect of pH adjustment and/or polyelectrolyte addition on the clarity of supernatant produced after 24 hours settling time. The results of this early work indicated that supernatant clarity improved at pH $\geq$ 10 with or without flocculant addition. With the addition of Percol 156, however, the supernatant was found to clear more rapidly at the elevated pH level.

Adjustment of the tailings pH to a value > 10 in order to enhance effluent clarification is not particularly desirable since it would most likely be necessary to readjust the effluent pH prior to effluent release to the environment. Accordingly, additional test work was undertaken to evaluate the effects of various milling chemicals without pH adjustment of the tailings samples. These investigations showed that supernatant clarity noticeably improved with a reduction in the amount of soda ash added to the milling circuit. (It is now believed that it will not be necessary to use this reagent in the milling process.) Subsequently, two sets of tests were performed, one on an untreated tailings sample and one on a tailings sample to which 15 g/t of Percol 156 was added. Supernatant samples were removed from both sets of test samples after 24 hours and 72 hours and analyzed for total and dissolved metals, as well as total suspended solids and total dissolved solids. The dissolved metals analyses were performed on supernatant samples which were filtered through 0.45 μ fibreglass filter paper. The analytical results are presented on Table 3.2.2.

A review of the data presented in Table 3.2.2 and comparison to the results summarized in Table 3.2.1 led to the following principal observations:

1. The chemical quality of the supernatant samples taken from test S1 (no flocculant addition) and test S2 (with flocculant addition) after 24 hours of settling time were essentially identical. The concentrations of the dissolved metals were quite low in both sets of results. Similarly, the total metal concentrations were generally low with the exception of aluminium and iron. As previously noted, the concentrations of these elements are dependant on the total suspended solids concentration. After 24 hours and 72 hours of settling time, the concentrations of aluminum and iron in sample S1 are seen to decrease from 1.61 to 0.30 mg/L and from 1.74 to 0.39 mg/L, respectively. The total suspended solids content of the samples taken from test sample S1 similarly decreased from 39 mg/L at the end of 24 hours of settling time to 10 mg/L after 72 hours of settling time.

2. The concentrations of most elements in the supernatant samples derived from the laboratory test programs (Table 3.2.2) are seen to be reasonably comparable to the element concentrations measured on the tailings pond water samples collected in the field (Table 3.2.1). The data present in Table 3.2.2 therefore may be considered to be representative of the quality of the effluent which will be produced from the milling of ore at the Lac des Iles mine.

3.2.3 Effluent Treatment and Expected Quality

Based on the results of tailings settling test work carried out at Lakefield Research and the results of chemical analyses performed on water samples collected from the existing tailings impoundment at the Lac des Iles mine site, it has been concluded that the provision of an effluent sedimentation pond is the only form of treatment which will be required to produce a high quality final effluent. Accordingly, it is proposed to construct a reclaim water pond at the site with several weeks storage capacity to provide a high quality water for reuse in the mill and a high quality effluent for release during the spring high flow period. Should experience show that chemical treatment is required to enhance effluent clarification then the addition of a polyelectrolyte is all that is likely to be required to improve solids coagulation and sedimentation. It is fully expected that this treatment step will not be necessary with the provision of the proposed water reclaim pond.

The effluent quality from the proposed tailings management facility is expected to be comparable to that produced in the test work carried out at Lakefield Research (Table 3.2.2) and to be characterized by low concentrations of most elements. Because the concentrations of most heavy metals in the final effluent will be less than the surface water quality objectives established by the province for protection of aquatic life, the discharge of treated effluent into the Hasson Lake watershed is expected to have little impact on aquatic biota.

3.3 AQUATIC ENVIRONMENT IMPACT ASSESSMENT

3.3.1 Water Management Plan

Water management at the Lac des Iles mine site will maximize water reuse in the mill to minimize both fresh water requirements and the volume of treated effluent to be released to the environment. Mine water will be pumped to the mill where it will be introduced into the milling circuit. Tailings pond water will also be recycled from the proposed reclaim pond for reuse in the mill. It is expected that these measures will reduce the fresh water requirement to approximately 909 m^3/d (200,000 Igpd) or less than 10% of the total mill process water requirements.

At the tailings management facility (TMF), the tailings decant water will be collected in a water reclaim pond for recycle to the mill. As discussed elsewhere, the water reclaim pond has been sized to provide several weeks retention capacity such that:

- the tailings solids have ample opportunity to settle, thus producing a high quality water for recycle to the mill or for discharge to the environment;
- a large reservoir of water is available for recycle to the mill, thus ensuring a continuous supply of recycle water; and
- excess water can be stored for several months per year and released during the spring high-flow period.

Effluent from the reclaim pond will be released into a stream which flows southward from the TMF through the Second Pond and hence into the west basin of Hasson Lake.

Fresh water for use in the mill will be obtained from Camp Lake which is also located in the Hasson Lake watershed. As previously noted, the average daily fresh water requirement is estimated to equal approximately 909 m^3/d once recycle of process water from the reclaim pond is established. Initially, the fresh water withdrawal rate from Camp Lake may approach 9,990 m^3/d while the water level in the reclaim pond is allowed to rise. However, the time required to establish the reclaim pond is estimated to take no more than one to two weeks. The requirement to pump at 9,990 m^3/d from Camp Lake could even be eliminated if the outlet dam on the reclaim pond is constructed early this fall, to allow runoff from the TMF watershed to be collected and stored over the next several months, prior to start up of the mill in early 1993.

The objectives in this subsection therefore are:

1. To assess the effect of the effluent discharge from the Lac des Iles TMF on the downstream receiving waters; and
2. To assess the potential water balance in Camp Lake if it is used as a source of fresh water for the mill.

3.3.2 Runoff Flow Estimates

In order to achieve the above objectives, it was first necessary to estimate the flows through the lake - river systems in the Lac Des Iles project area. Preliminary flow estimates for Camp and Hasson Lakes were carried out as discussed below. First, the drainage areas of the watersheds of the two lakes were estimated from 1:50,000 contour mapping as follows:

• Drainage area to outlet of Hasson Lake	~18 km^2
• Drainage area of Camp Lake subwatershed	~ 5 km^2

Next, net precipitation data was obtained for the nearest two stations for which such data is available - Armstrong, 135 km to the north and Thunder Bay, 90 km to the south of the mine site. The data was taken from Environment Canada's "Canadian Climate Normals, Volume 3: Precipitation, 1951-1980" (1982). The data, averaged for the years 1951 to 1980, are given in Table 3.3.1. In addition, precipitation data from the Abitibi Camp, approximately 26 km southeast of the Lac des Iles mine site are also available for the period from December 1969 to May 1978. Comparison of the Abitibi Camp station data to the data from the Armstrong and Thunder Bay stations for the comparable period of record, suggested that precipitation at the Abitibi Camp site equals about the average of the other two sites. Because the Lac des Iles and Abitibi Camp sites are in close proximity, it was assumed that net precipitation at Lac des Iles is approximately the average of the data for Armstrong & Thunder Bay.

Finally, Environment Canada's "Historical Streamflow Summary - Ontario - To 1986" was consulted in order to establish streamflows in the Lac des Iles area so that runoff factors could be calculated. No streamflow data in the immediate vicinity of Lac des Iles are available. However, eight monitoring stations are located within a 150 km radius of the mine site. The drainage areas associated with these stations are generally large and range from 2,560 to 7,740 km^2. One station (02AB012) is located on a drainage basin with a 174 km^2 area. All of the streams are regulated. The location, drainage area and streamflow data for each station are given in Table 3.3.2. For comparison, Lac des Iles is located at a latitude of about 49°10' and a longitude of about 89°37'.

The streamflows and drainage areas were used to calculate runoffs in metres per month. The means and standard deviation of the data for the larger drainage area stations are shown in Table 3.3.3. The data for Station 02AB012 is given separately. It can be seen that the monthly runoff factors for station 02AB012 do not compare well with the average runoffs for the other stations. However, the annual runoff of 0.24 m is comparable to the mean of 0.25 m for the larger drainage areas. The discrepancy for the monthly runoffs is probably related to the fact that all of the streams are regulated to varying degrees.

Based on the estimated drainage areas and the annual runoff of 0.25 m the outflows from Camp and Hasson lakes were estimated to be:

• Camp Lake	1.25 x 10^6 m^3/y
• Hasson Lake	4.5 x 10^6 m^3/y

3.3.3 Impact Assessment

Camp Lake

Withdrawal of water from Camp Lake for fresh water makeup in the mill will affect the water balance on the lake. Based on a daily withdrawal rate of 909 M^3/d, the total volume of water which would be taken annually equals approximately 332,000 m^3/y. This volume equals approximately 26% of the total estimated runoff into Camp Lake and, therefore, should not have a negative effect on the lake level. Based on a lake volume of 1.79 x 10^6 m^3, the average retention time in the lake would increase from about 1.43 y to 1.93 y. The result of this change in the retention time would not be expected to have a significant effect on the lake water quality.

During start-up of the mill and the TMF, it is probable that the water supply to the mill would be taken entirely from Camp Lake for a one to two week period. For the two week scenario, the total volume of water which would be withdrawn would equal approximately 140,000 m^3. This volume represents only about 7.8% of the total volume of water stored in the lake and, assuming no inflow to the lake over the two week period, would lower the water level by approximately 0.3 m. As the lake level would be expected to recover fairly quickly, the effect of lowering lake level on shoreline biota and fish habitat would be minor.

First Pond

The proposed concept for development of an expanded TMF will incorporate the first pond downstream of the existing tailings area within the boundaries of the TMF. Initially this pond will be incorporated in the water reclaim pond although it will eventually be filled with tailings. The physical and ecological characteristics of First Pond were investigated during the environmental baseline studies and are discussed in detail in the report by NEA (1992). A summary of the findings of the field investigations is presented below.

Briefly, First Pond has a surface area of 1.87 ha, a mean depth of 0.86 metres and a maximum recorded depth of 1.9 metres. A large percent of the shoreline is composed of floating bog with little to no tree cover. It is locate din the headwaters of its drainage basin, thus it is low in nutrients and has a low flushing rate.

First Pond was found to sustain poor quality fisheries. This is due to the existing natural water quality of the area as well as lack of viable fish habitat. A preliminary calculation of the morphoedaphic index reveals that this pond has the productive capacity of only 12.8 kg of fish flesh per year. The morphoedaphic index is a very simplistic calculation but it does give a general measure of the pond's productivity. The low flushing rate also restricts the productivity of this pond as it becomes almost stagnant in the winter. This causes the dissolved oxygen to drop to low levels. Dissolved oxygen values as low as 0.3 ppm were recorded during a March survey. This low level of oxygen would be inadequate for the survival of most species of fish.

Additional fish habitat constraints found during the field investigations included the lack of overhead cover, the shallowness of the pond, the lack of varied substrata, the predicted high summer water temperatures and a beaver dam preventing recruitment from downstream reaches.

The poor fish habitat of First Pond was evident in the fisheries results. A total of 150 metres of gill net of varying sizes (1.5" to 5.0") were set for 21.5 hours with no catch. The minnow traps were more successful with the catch of the three minnow species: finescale dace, northern redbelly dace and Johnny darter. These fish all have very short life spans, thus are able to invade into and survive in areas with restrictive fish habitat.

The loss of First Pond, therefore, does not represent a significant loss and can be compensated easily by improvement in fish habitat in one of the nearby lakes.

Hasson Lake

The water management plan for the TMF has been developed around the concept of storing excess process and runoff water in the reclaim pond for release during the spring (i.e. the April to June period) when flows in the receiving waters are at their highest. As previously discussed, the long retention time provided in the reclaim pond will ensure that a high quality effluent, low in suspended solids and trace metals, is available for discharge. The excess water will be released to the drainage course connecting the First Pond to the Second Pond which ultimately drains into Hasson Lake.

A preliminary estimate of the amount of excess process and runoff water which will accumulate in the reclaim pond over a twelve month period suggests that approximately 200,000 m,^{3} would have to be released each spring. The concept plans for the reclaim pond suggest that sufficient capacity can be developed to store the excess water, in addition to runoff from major storm events.

On an annual basin, the effluent would be diluted by a factor of greater than 20:1 at a the outlet of Hasson Lake (i.e. the ratio of the estimated average annual flow at the outlet of Hasson Lake of 4.5 x 10^6 m^3 to the estimated effluent flow of 0.2 x 10^6 m^3 equals 22.5:1). Since the effluent would be released over only a portion of the year (between April and June), the dilution received during this period would be less than the 20:1 ration quoted above. The runoff flow records summarized in Tables 3.3.2 and 3.3.3 suggest that between 25 and 35% of the annual runoff occurs during the April to June period. Effluent discharged over this period therefore, would be diluted by a factor of 5:1 to 8:1. Given the excellent quality of the effluent expected from the proposed tailings management facility, the impact on receiving water quality and aquatic biota is expected to be negligible.

3.3.4 Proposed Monitoring Program

To ensure that the proposed tailings and water management systems operates as predicted, it will be necessary to routinely monitor the effluent quality and the quality of the receiving waters. Accordingly, the following surface water monitoring program is proposed:

- Monthly sampling of the contents of the reclaim pond during those months when there is no effluent release to ensure that the systems is performing as expected.

- Weekly sampling of the effluent from the reclaim pond over the duration of the discharge period to determine whether the effluent quality changes as the reclaim pond is drawn down.

- Quarterly sampling of Camp Lake, Second Pond and Hasson Lake.

- Monthly sampling at the outlets of Second Pond and Hasson Lake over the duration of the effluent discharge period.

It is intended that all samples collected would be analyzed for those elements included in the baseline monitoring and effluent sampling programs discussed in Sections 3.1 and 3.2, subject to periodic review.

4.0 TMF PLANNING CONSIDERATIONS

This section highlights the key environmental and operational considerations that have been incorporated into the proposed multi-stage TMF.

- The existing tailings impoundment area would become the Stage 1 tailings area. This addresses the need to: contain existing tailings; provide for the closure of the existing tailings area; and make effective use of an already disturbed area.
- Pond No. 1 would become part of the Stage 1 water retention pond and would be filled with tailings in Stage 2. This assumes that Lac des Iles Mines Ltd can compensate for any loss by improving the fishery habitat at another nearby location. It should be noted that this important consideration has yet to be finalized.
- In Stage 2, tailings would continue to be deposited in the same valley system used in Stage 1. The watersheds for all three stages drain to Hasson Lake. This approach would limit tailings deposition to one valley system and limit any impact to one watershed.
- In Stage 2, tailings pipelines and water reclaim pipelines would be positioned on the upstream side of access roads on perimeter dams. This would ensure that spills caused by pipeline breaks are contained within the TMF.
- In Stage 3, groundwater flows to Camp Lake are assumed to be prevented by maintaining the water retention pond water level below that of Camp Lake.
- The proposed multi-stage TMF would allow rehabilitation and other closure activities to be done on a progressive basis.
- In each stage, spillways would be constructed by excavating in bedrock. These spillways could be incorporated into the closure plan.
- In each stage, the water retention pond provides sufficient storage capacity to provide a high degree of water recycling to the mill. This would reduce the requirements for fresh make-up water to the mill.

APPENDIX A - ATTACHMENTS

INDEX

Table 3.1.1

CHEMICAL QUALITY OF SURFACE AND TMF WATER SAMPLES

	Aluminum (Al) (mg/L)	Copper (Cu) (mg/L)	Iron (Fe) (mg/L)	Nitrite (NO_2-N) (mg/L)	Nitrate (NO_3-N) (mg/L)	Alkalinity 4.2 (mg/L CO_3)	Ammonia Nitrogen (NH_3-N) (mg/L)	Ortho-Phosphorus (mg/L)	Total Phosphorus (mg/L)	Dissolved Organic Carbon (mg/L)	Theoretical Tot. Diss. Solids (mg/L)	Colour (TCU)
Provincial Water Quality Objective[a]		0.005	0.30				1.67[b]		0.020			
Camp Lake North Basin												
• March 1992	0.08	0.009	0.47	<0.02	0.15	21.2	0.02	<0.01	0.011	18.9	33	130
• May 1992	0.09	<0.002	0.31	<0.02	0.16	14.9	0.05	<0.02	0.011	15.5	29	124
Camp Lake Mid Lake												
• March 1992	0.10	0.006	0.52	<0.02	0.16	21.3	<0.02	<0.01	0.011	15.6	34	130
• May 1992	0.10	<0.002	0.36	<0.02	0.18	15.4	<0.02	<0.02	0.016	14.3	28	130
First Pond South of TMF												
• March 1992	0.32	0.007	1.27	<0.02	0.06	64.9	0.18	<0.01	0.080	4.9	96	379
• May 1992	0.11	0.003	0.22	<0.02	<0.02	34.6	<0.02	<0.02	0.033	22.0	53	216
Second Pond South of TMF												
• March 1992	0.24	0.004	6.51	<0.02	0.07	22.9	0.18	<0.01	0.060	17.2	33	210
• May 1992	0.15	<0.002	0.25	<0.02	0.05	14.3	<0.02	<0.02	0.016	17.8	25	128
Hasson Lake North Basin												
• March 1992	0.12	0.003	0.56	<0.02	0.20	20.3	0.02	<0.01	0.012	18.8	33	135
• May 1992	0.10	<0.002	0.30	<0.02	0.15	14.8	<0.02	<0.02	0.008	14.1	27	128
Hasson Lake West Bay												
• March 1992	0.20	0.002	1.46	<0.02	0.10	26.6	0.11	<0.01	0.022	15.5	41	227
• May 1992	0.10	<0.002	0.29	<0.02	0.12	14.5	<0.02	<0.02	0.013	14.4	26	136
Hasson Lake Mid Lake												
• March 1992	0.11	0.003	0.51	<0.02	0.19	20.3	<0.02	<0.01	0.012	18.7	32	139
• May 1992	0.11	<0.002	0.34	<0.02	0.16	14.1	<0.02	<0.02	0.011	14.4	26	138
Tailings Decant Water												
• March 1992	0.57	0.015	4.75	<0.02	<0.02	309.	2.60	0.05	0.240	28.0	401	285
• May 1992	0.73	0.037	0.93	<0.02	<0.02	83.8	<0.02	<0.02	0.059	15.8	124	120
Tailings Secondary Pond												
• March 1992	0.47	0.014	6.57	<0.02	<0.02	250.	1.91	0.06	0.290	16.3	335	352
• May 1992	0.10	0.013	1.00	<0.02	<0.02	88.8	<0.02	<0.02	0.088	18.2	127	126

Notes:
a) Provincial Water Quality Objectives for Protection of Aquatic Life and Recreation (MOE, 1984).
b) Ammonia nitrogen objective given applies at a pH of 7.5 and temperature of 20°C and is based on an un-ionized ammonia objective of 0.02 mg/L.

Table 3.1.2

CHEMICAL QUALITY OF SEDIMENTS SAMPLED DURING MARCH 1992 SURVEY
(units are in µg/g dry weight except for LOI in percent)

Analyte	Typical Background Levels[a]	Camp Lake North Basin #1	Camp Lake North Basin #2	Camp Lake Mid Lake	First Pond South of TMF	Second Pond South of TMF	Hasson Lake North Basin	Hasson Lake Mid Lake	Hasson Lake West Basin
Aluminum (Al)	-	15700	16700	17100	5400	14300	13400	10200	6920
Cadmium (Cd)	1.1	0.9	0.7	0.8	1.3	0.7	0.8	<0.3	<0.3
Chromium (Cr)	31	23.2	26.1	24.5	13.8	22.6	22.8	13.9	11.5
Copper (Cu)	25	63.6	67.4	61.5	36.0	50.9	56.9	11.2	10.9
Iron (Fe)	31200.	12600.	12300.	19700.	4150.	21100.	13400.	17600.	9380.
Manganese (Mn)	400.	233.	240.	410.	102.	146.	179.	226.	112.
Nickel (Ni)	31	23	24	30	23	31	22	17	15
Phosphorus (P)	-	1230	1320	1360	510	700	950	440	320
Lead (Pb)	23	21	16	20	7	9	32	3	6
Zinc (Zn)	65	64.7	53.2	86.3	29.0	87.4	74.7	57.6	53.4
LOI	-	34.8	35.8	29.1	34.5	36.7	35.8	4.30	7.17

Note:

a) Typical background levels for metals are based on analyses of Great Lakes pre-colonial sediment horizon (MOE, 1991a).

Table 3.1.3

PHYSICAL CHARACTERISTICS OF KEY WATER BODIES NEAR THE LAC DES ILES MINE

	Surface Area (ha)	**Volume (m^3)**	**Average Depth (m)**	**Maximum Depth (m)**
Camp Lake	45.2	1.79×10^6	3.9	15.8
Hasson Lake	41.7	8.63×10^4	2.1	7.0
First Pond	1.87	1.6×10^4	0.86	1.9
Second Pond	5.14	9.4×10^4	1.8	4.0

Table 3.2.1

CHEMICAL CHARACTERISTICS OF TAILINGS MANAGEMENT FACILITY (TMF) WATER SAMPLES

Analyte	October 1991 Samples		March 1992 Samples		May 1992 Samples	
	Tailings Decant Water	TMF Secondary Pond	Tailings Decant Water	TMF Secondary Pond	Tailings Decant Water	TMF Secondary Pond
Silver (Ag^{*})	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001
Aluminum (Al)	2.59	0.49	0.57	0.47	0.73	0.10
Boron (B)	0.015	0.011	0.011	0.012	<0.01	<0.01
Barium (Ba)	-	-	0.016	0.021	<0.005	<0.005
Beryllium (Be)	0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium (Ca)	19.8	15.3	32.2	21.9	12.8	10.7
Cadmium (Cd)	<0.005	<0.005	0.0002	0.0004	0.0001	0.0002
Cobalt (Co)	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01
Chromium (Cr)	<0.01	<0.01	0.01	0.01	<0.01	<0.01
Copper (Cu)	0.05	0.02	0.015	0.014	0.037	0.013
Iron (Fe)	2.34	3.12	4.75	6.57	0.93	1.00
Potassium (K)	5.6	6.7	6.2	6.1	2.3	2.9
Magnesium (Mg)	10.6	8.64	16.1	11.6	6.1	5.6
Manganese (Mn)	0.09	0.27	1.68	2.65	0.03	0.01
Molybdenum (Mo)	<0.2	<0.2	<0.2	<0.2	<0.1	<0.1
Sodium (Na)	81.6	65.7	74.5	72.1	20.1	23.8
Nickel (Ni)	0.05	<0.05	0.04	0.06	0.04	0.01
Phosphorus (P)	<0.5	<0.5	<0.5	<0.5	0.059	0.088
Lead (Pb)	<0.05	<0.05	<0.01	<0.01	<0.01	0.01
Silica (Si)	11.1	9.44	14.5	10.4	3.85	4.25
Strontium (Sr)	0.045	0.034	0.072	0.052	0.025	0.022
Titanium (Ti)	0.020	0.012	0.011	0.011	0.005	<0.005

Table 3.2.1, Continued

Analyte	October 1991 Samples		March 1992 Samples		May 1992 Samples	
	Tailings Decant Water	TMF Secondary Pond	Tailings Decant Water	TMF Secondary Pond	Tailings Decant Water	TMF Secondary Pond
Vanadium (V)	0.005	0.006	<0.005	0.008	<0.005	<0.005
Zinc (Zn)	0.01	0.02	<0.01	<0.01	<0.01	<0.01
Fluoride (F)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride (Cl)	8.78	8.57	10.8	11.2	2.48	3.70
Nitrite (NO_2-N)	0.016	0.023	<0.02	<0.02	<0.02	<0.02
Phosphate (PO_4-3)	<0.1	<0.1	0.2	0.3	<0.1	<0.1
Bromide (Br)	0.11	0.11	0.10	0.11	<0.05	<0.05
Nitrate (NO_3-N)	0.17	0.13	<0.02	<0.02	<0.02	<0.02
Sulphate (SO_4)	5.85	0.61	1.24	1.44	5.82	2.90
pH	8.06	7.75	7.36	7.34	7.74	7.06
Alk 8.3 (mg $CaCO_3$/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Alk 4.2 (mg $CaCO_3$/L)	214	177	309	250	83.8	88.8
Ammonia (NH_3-N)	0.04	0.27	2.60	1.91	<0.02	<0.02
Ortho Phosphorus	0.04	0.04	0.05	0.06	<0.02	<0.02
Diss. Organic Carbon (DOC)	27.0	46.0	28.0	16.3	15.8	18.2
Th. Cond. (µmhos/cm)	1029	845.4	616.5	515	191.1	195.3
Th. TDS	669	550	401	335	124	127
Turb. Fluor. (FTU)	35.0	19.5	-	-	-	-
Tot. Susp. Solids (TSS)	10.9	15.2	-	-	-	-
Colour (TCU)	-	-	-	-	120	126

<u>Note:</u>

* All units mg/L unless otherwise specified.

Table 3.2.2

TAILINGS SETTLING TEST RESULTS - SUPERNATANT QUALITY

Analyte	Units	Sample S1 - No Flocculant Addition				Sample S2 - With Flocculant Addition		
		Total Metals		Dissolved Metals		Total Metals		Dissolved Metals
		24 Hours	72 Hours	24 Hours	72 Hours	24 Hours	72 Hours	24 Hours
Aluminum (Al)	mg/L	1.61	0.30	<0.1	<0.1	1.34	-	<0.1
Arsenic (As)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05
Barium (Ba)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02
Beryllium (Be)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005
Calcium (Ca)	mg/L	39.2	38.4	37.2	38.4	37.2	-	37.2
Cadmium (Cd)	mg/L	0.0003	<0.0002	0.0002	<0.0002	<0.0002	-	<0.0002
Cobalt (Co)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01
Chromium (Cr)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02
Copper (Cu)	mg/L	0.021	0.010	0.007	<0.003	0.022	-	0.004
Iron (Fe)	mg/L	1.74	0.39	<0.02	<0.02	1.29	-	<0.02
Magnesium (Mg)	mg/L	13.0	17.3	17.0	17.3	17.0	-	17.0
Manganese (Mn)	mg/L	0.04	0.02	0.02	0.02	0.03	-	0.01
Molybdenum (Mo)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05
Sodium (Na)	mg/L	29.0	29.3	29.0	29.3	29.0	-	30.0
Nickel (Ni)	mg/L	0.08	0.03	0.02	0.02	0.07	-	0.02
Phosphorus (P)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1
Lead (Pb)	mg/L	0.017	0.010	0.006	<0.005	0.008	-	<0.005
Antimony (Sb)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05

Table 3.2.2, Continued

Analyte	Units	Sample S1 - No Flocculant Addition				Sample S2 - With Flocculant Addition		
		Total Metals		Dissolved Metals		Total Metals		Dissolved Metals
		24 Hours	72 Hours	24 Hours	72 Hours	24 Hours	72 Hours	24 Hours
Selenium (Se)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10
Silica (Si)	mg/L	3.95	3.60	3.40	3.60	3.61	-	3.30
Tin (Sn)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1
Tellurium (Te)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05
Zinc (Zn)	mg/L	0.14	0.24	<0.01	0.02	0.05	-	<0.01
Tot. Susp. Sol. (TSS)	mg/L	39	10	-	-	20	15	-
Tot. Diss. Sol. (TDS)	mg/L	346	384	-	-	340	404	-

Table 3.3.1

SUMMARY OF MONTHLY PRECIPITATION DATA AT ARMSTRONG AND THUNDER BAY, ONTARIO

Month	Measured Data		Estimated Data
	Armstrong	Thunder Bay	Lac des Iles
Jan	35.8	40.9	38.4
Feb	29.6	28.3	29.0
Mar	37.5	45.0	41.3
Apr	46.5	50.7	48.6
May	63.4	73.3	68.4
Jun	89.5	76.6	83.1
Jul	93.7	75.4	84.6
Aug	91.2	83.1	87.2
Sep	86.4	89.1	87.8
Oct	68.6	54.8	61.7
Nov	57.2	52.9	55.1
Dec	39.0	41.7	40.4
TOTAL	738.4	711.8	725.1

Source: Environment Canada, 1982. "Canadian Climate Normals. Volume 3: Precipitation, 1951-1980".

Table 3.3.2

SUMMARY OF MONTHLY STREAMFLOW DATA FOR STATIONS NEAR THE LAC DES ILES SITE

Station	02AB001	02AB004	02AB005	02AB006	02AB007	02AB009	02AB010	02AB012
LATITUDE	48 33 20	48 42 30	48 32 36	48 31 58	48 22 05	48 33 20	48 24 56	48 36 23
LONGITUDE	89 35 19	89 38 00	89 47 00	89 35 39	89 33 55	89 40 55	89 37 51	90 27 21
Drainage area (km^2)	3630	3760	2560	6480	7740	2800	6710	174
Streamflow (m^3/s)								
Jan	27.5	30.6	9.9	50.4	29.9	12.3	40.4	1.23
Feb	28.4	32.5	9.8	47.8	27.4	11.6	41.4	1.45
Mar	28.8	32.1	11.5	49.0	28.4	15.1	43.8	1.36
Apr	24.4	19.4	29.2	71.9	38.5	45.6	72.3	1.14
May	39.7	25.6	58.2	99.2	54.9	56.3	91.7	1.33
Jun	37.8	35.1	44.3	91.0	49.8	43.2	81.2	1.57
Jul	31.1	28.3	27.2	65.3	63.6	27.3	55.5	1.70
Aug	28.0	25.0	15.8	47.4	42.0	14.6	39.6	1.52
Sep	27.2	23.2	13.6	46.4	43.1	20.6	41.4	0.993
Oct	26.1	24.4	14.8	49.4	44.6	21.8	44.7	0.999
Nov	26.2	27.4	14.0	50.4	46.1	20.1	45.8	1.09
Dec	27.1	29.0	11.5	50.3	38.6	14.9	41.5	1.20
Annual ave.	29.5	27.7	22.4	61.1	42.0	25.4	53.5	1.33

<u>Source:</u> Environment Canada, 1986. "Historical Streamflow Summary - Ontario - to 1986".

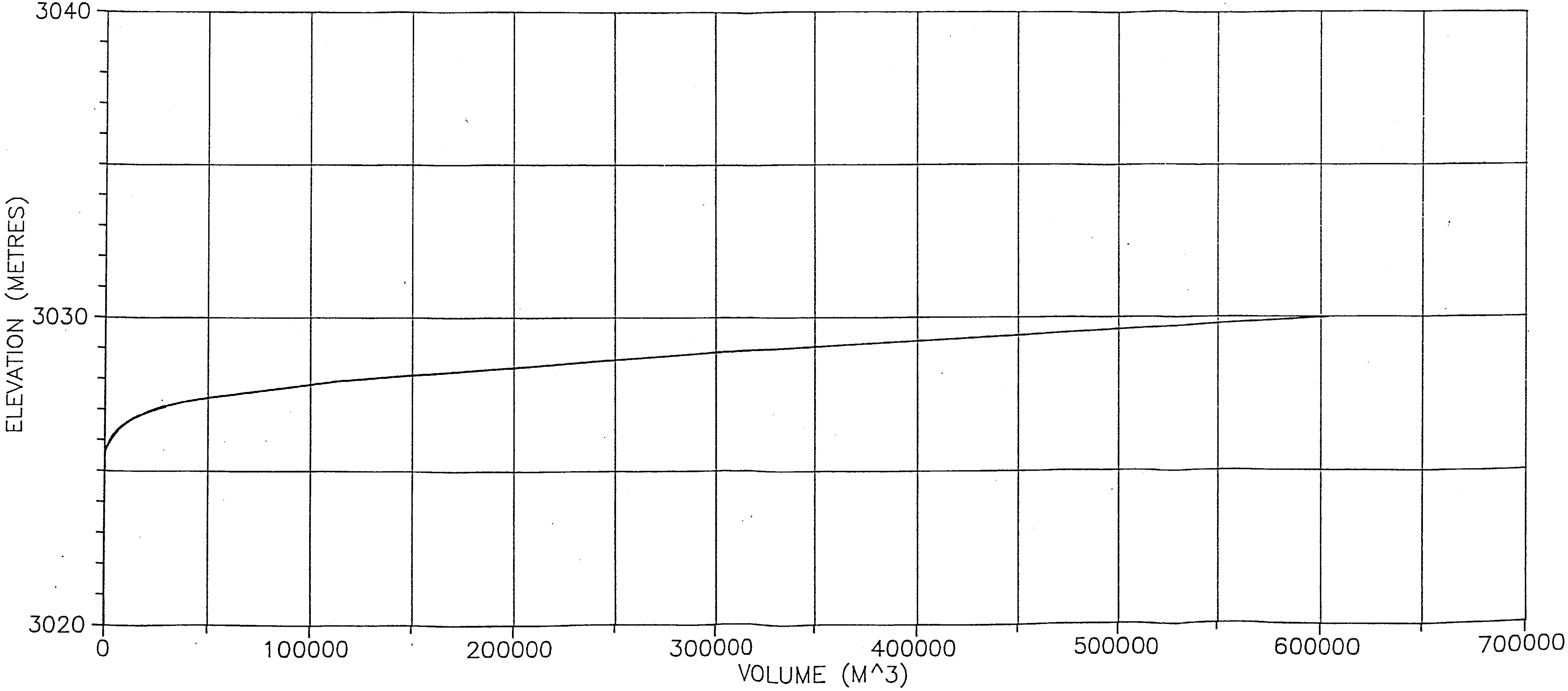
Table 3.3.3

ESTIMATED MONTHLY RUNOFF RATES (m^3/mth.m^2)

	Others		02AB012
	Mean	Std dev	
Jan	0.016	0.004	0.0197
Feb	0.014	0.004	0.0202
Mar	0.017	0.004	0.0209
Apr	0.025	0.008	0.0170
May	0.037	0.013	0.0205
Jun	0.031	0.008	0.0234
Jul	0.024	0.002	0.0262
Aug	0.017	0.002	0.0234
Sep	0.017	0.002	0.0148
Oct	0.018	0.002	0.0154
Nov	0.018	0.002	0.0162
Dec	0.017	0.003	0.0185
Annual total	0.253	0.034	0.24

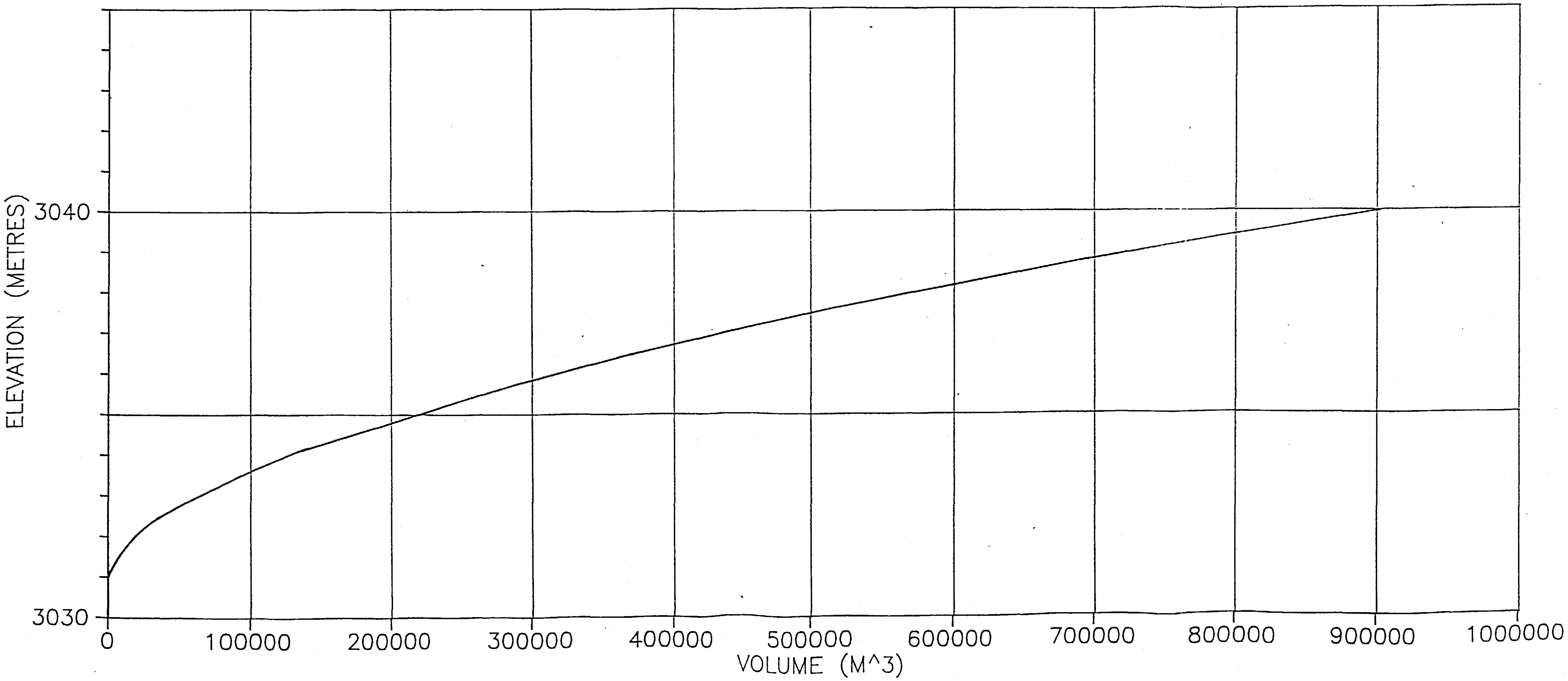
STORAGE VOLUME CURVE

PROPOSED STAGE 1 WATER POND



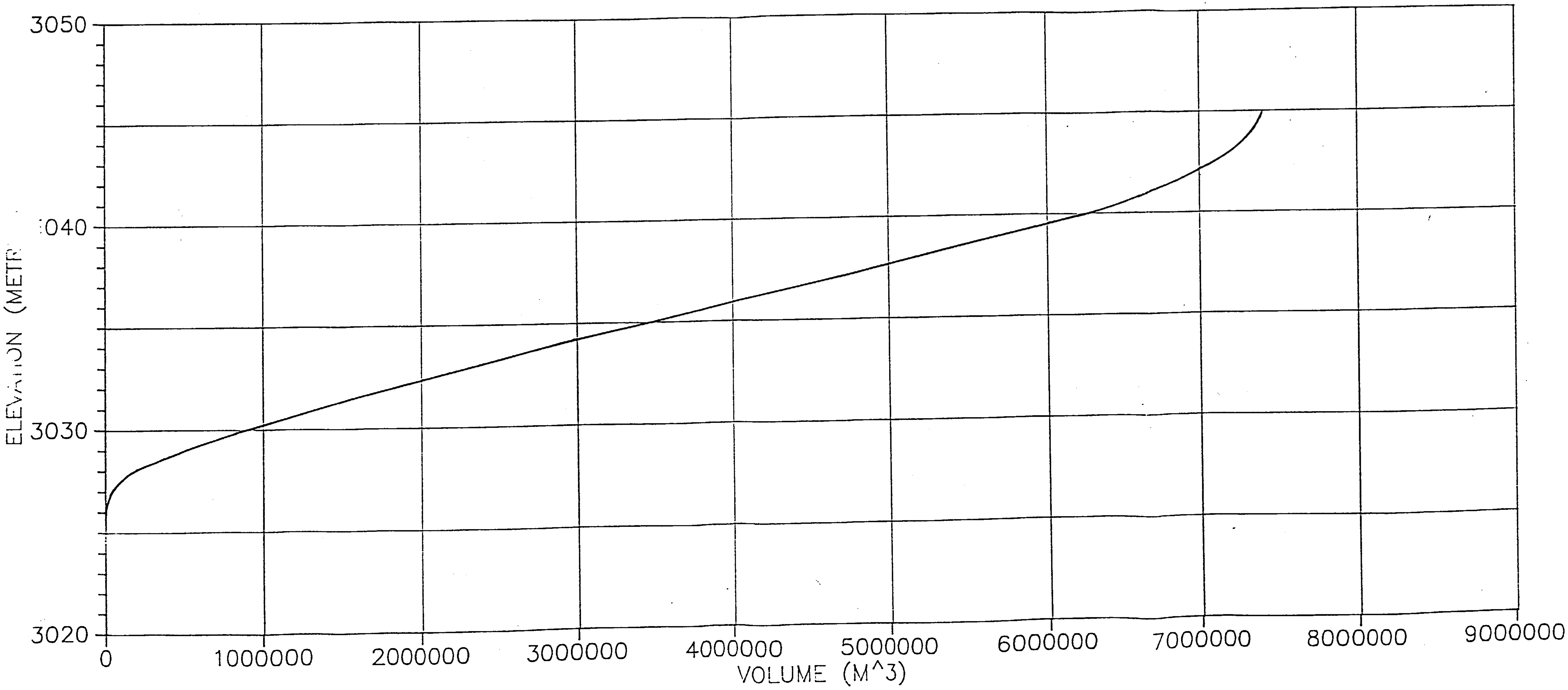
STORAGE VOLUME CURVE

PROPOSED STAGE 1 TAILINGS POND



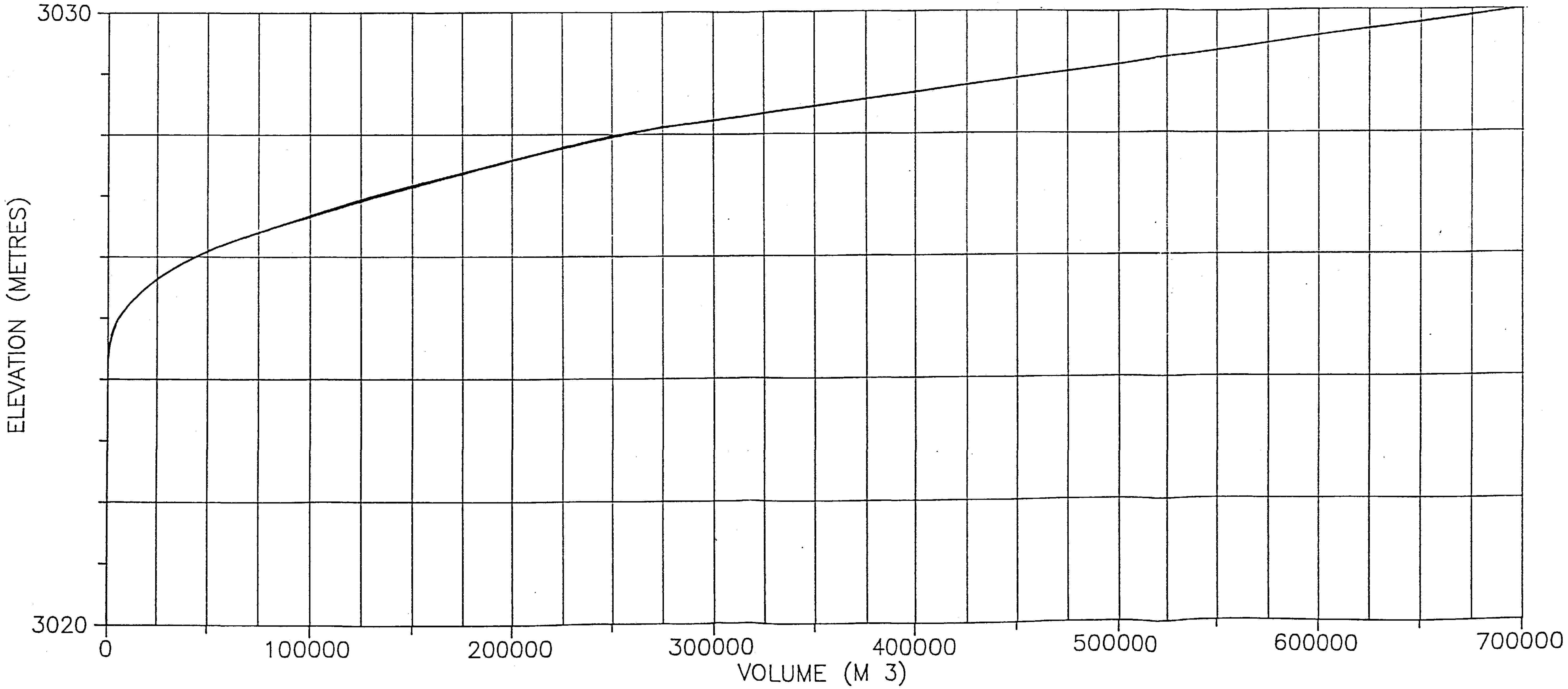
STORAGE VOLUME CURVE

PROPOSED STAGE 2 TAILINGS AND WATER POND



STORAGE VOLUME CURVE

PROPOSED STAGE 3 WATER POND



LAC DES ILES PROJECT
1992 FACTUAL SOILS REPORT

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

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DNE - 1

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DNE DENNIS NETHERTON ENGINEERING

TABLE OF CONTENTS

1.0 INTRODUCTION

This report details the findings of a field investigation program conducted by Dennis Netherton Engineering (**DNE**) personnel from May 14, 1992 to May 25, 1992 at the Lac des Iles mine site. The purposes of the investigation were to determine the subsurface conditions along the alignments of the proposed Phase 1 Tailings Management Facility (TMF) Retention Structures and to locate a source of fill material for the construction of the proposed Tailings and Water Retention Structures.

The subsurface investigation along the alignments consisted of test pitting of the overburden with a Cat 235 excavator, provided by Lac des Iles Mines Ltd., as well as conducting a number of pump-in bedrock permeability tests in bedrock along the north, west and east parts of the proposed alignments. A total of 22 test pits were excavated and five boreholes were drilled for permeability testing.

The test pits were logged by **DNE**'s field staff as they were excavated and representative soil samples were collected from each test pit for later testing. The information logged consisted of a field identification of the soil type, depth to bedrock as well as depth to the water table (if encountered). The soil samples were returned to our laboratory in North Bay and tested to assist in soil classification and to determine their engineering properties.

The pump-in permeability tests in bedrock were performed in the same manner as those conducted along the south end of the existing tailings area in March, 1992 (see **DNE**'s Report on Bedrock Permeability Testing at South End of Existing Tailings Area, Lac des Iles, Ontario). The testing was conducted along the west, north and east ends of the proposed Stage 1 tailings alignments, at locations where the head of water within the proposed tailings impoundments was anticipated to be the maximum. The tests were conducted in 15 metre deep, 75mm (3 inches) diameter, vertical boreholes drilled by Lac des Iles Mines Ltd. at locations selected by **DNE**'s field project leader.

The procedure used for the permeability testing consisted of isolating a section of the diamond drill hole with a double pneumatic packer system. Water was then pumped down rods connected to the packer system and injected into the isolated section of drill hole. The water pressure for each test was set at a predetermined value and the flow of water into the rockmass was measured. A pressure gauge connected to the system behind the flow meter was used to monitor the water pressure. The water take was measured using a flow meter (able to measure flows in the range of 0.4 to 20 gal/min) or by measuring the drop in the water level in the water reserve tank and calculating the volume of water used during the test when the flow was below 0.4 gal/min.

The water takes for the test sections of all drill holes were generally less than what could be accurately recorded by the flow meter, (less than .4 gal/min) and thus the method of measuring the water reserve level was used.

The relationship between water pressure, water take and permeability is as follows:

- K=(1.6E-6 x Cp x Q)/H

where K is the permeability in cm/s, Cp is a constant related to the borehole diameter and the test interval length, Q is the water flow, and H is determined from the following relationship:

- $H=H_1+H_2+(Pg \times 2.308 \text{ ft/psi})-H_L$

where H_1 is the vertical depth to the midpoint of the test interval less natural water level above the test interval, H_2 is the vertical height of the pressure gauge from the drill hole collar, Pg is the pressure gauge reading and H_L is the predetermined head loss of the system for the average flow range of the test and the particular rod string employed. For flows less than 1 l/s H_L can be neglected as laminar flow occurs within the test string.

Upon completion of the permeability testing, piezometers were installed in the boreholes to permit later monitoring of the ground water levels and quality. The piezometers consisted of a 1.5 metre length of 50mm inside diameter pvc well pipe screen with 10 micron slots, connected to 1.5 metre lengths of 50mm inside diameter pvc well pipe riser with the screen installed at the bottom of the borehole. A 600 mm thick cement seal was installed at the collar of the bore hole to prevent surface runoff from contaminating the subsurface water. Appendix V, Tables 1 to 5 contain the installation logs for each piezometer installation.

Concurrent to the permeability testing, test pitting of possible borrow sites were conducted in order to assess the suitability of the sites as a source of fill for the construction of the Retention structures. The borrow sites selected and examined were all located within 1.6 km of the Tailings Management Facility (see DWG 0786-301). **DNE**'s soil technician logged and sampled each of the test pits following the same criteria used for the Tailings Management Facility alignment.

The sites that were examined lie either south of the proposed tailings facility or to the north east. To the west there was very little visual evidence of any significant volume of fill material. All the access roads in the area had been built by scratching for fill or by using the open pit strippings.

A total of four areas were examined to the south of the proposed tailings facility, the Southwest site, the West Camp lake site, the Southeast site, and the South Camp Lake site (see DWG 0786-301). The Southwest site consists of a 600 metre long ridge that runs southwest from the bottom of Camp Lake towards Hasson Lake. The West Camp Lake site occupies a cut over area south of the proposed tailings facility and immediately west of the south end of Camp Lake. This area has been called the "G" zone by Lac des Iles Mines Ltd. The Southeast Camp Lake site was located along a 400 metre long ridge located immediately to the east of the south end of the Camp Lake. The mid-southern end of the ridge had previously been used for borrow during the construction of a road across the outlet of Camp Lake in order to construct an explosives storage area. The South Camp Lake site extends to the northeast of the explosive storage area for a distance of 550 metres.

Two areas were examined to the northeast of the proposed tailings area, the North Camp Lake site and the Main Gate site. The North Camp Lake site consists of 500 metre long ridge located along the northeast side of Camp Lake and south of the mine access road. The Main Gate site occurs along the west side of a bedrock ridge located north of the North Camp Lake site and the north side of the mine access road and approximately 300 metres east of the main gate entrance to the mine site.

The topography and test pit locations along the south end of the existing tailings area, the locations of the test pits at the Explosives Storage clearing, the "G" zone and to the northeast of the main gate were surveyed in using a Wild RDS. The RDS is an instrument capable of measuring distances and orientations so that it was possible to use the survey information to generate topographic contours and location plans of the test pits. A compass and hip chain were used to locate the test pits within forested areas where the RDS would have been slow and inefficient. All the test pit locations as surveyed were checked against the aerial photographs and topographic mapping that were available after the field investigation was completed. This information was used to calculate preliminary volume estimates.

2.0 SITE AND GEOLOGY

2.1 Site Description

The Lac des Iles Mine site is located approximately 70 km due north of Thunder Bay, Ontario. The site is accessed by a 25 km gravel road leading off the west side of the Armstrong Highway (Highway 527).

The terrain is of moderate relief (ridged) with a ground moraine lying as a shallow veneer over bedrock (OGS Northern Ontario Engineering Geology Terrain Study 41, Heaven Lake Area, NTS 52H/SW, 1981). A low relief peat organic terrain exists as a subordinate landform in low lying areas. Drainage conditions for the ground moraine are indicated as dry while for the peat terrain, wet. On-site observations agree with the OGS terrain study. Bedrock was noted to outcrop frequently, especially along sides of the ridges. Observations made during test pitting and inspection of exposures, indicated the bedrock to be very irregular in relief.

The mine site occupies the height of land between the water bodies Lac des Iles and Hassen Lake (see DWG 0786-001). Camp Lake lies to the immediate east side of the mine-site and drains southward into Hasson Lake via a small stream. Surface drainage consists of several small streams. Ponding of water on surface was common throughout the area of the mine-site. Test pitting revealed that these areas are underlain by silt and clay.

2.2 Geology

Surficial (Pleistocene) deposits are comprised of glacial ground moraine deposits that have been locally modified by glacio-fluvial action. Recent deposits consisted of organic material or muskeg which has accumulated in swamps or low lying areas.

Archean bedrock underlies the Pleistocene deposits with numerous outcrops throughout the area. The bedrock consisted of a gabbro complex intruded into a gneissic to foliated tonalite suite (MNDM Map 2542). Examination of the gabbro complex indicates that it is competent with only minor faulting and shearing evident.

3.0 SUBSURFACE CONDITIONS

Subsurface conditions were determined for both the Proposed Stage One Tailings Management Facility Retention Structure Alignments and for possible fill borrow sites (see DWG 0786-301). The test pits were located, logged and sampled by **DNE**'s field staff. Bedrock conditions in the north half of the Tailings Dam Alignments were evaluated with five bore holes that were drilled using an air track percussion drill supplied by Lac des Iles Mines Ltd. **DNE**'s previous experience testing of air track boreholes has determined that the hydrogeological results from such boreholes compare favorably with holes drilled by a rotary diamond drill bit. **DNE**'s field staff conducted pump-in permeability tests in the boreholes and installed piezometers in the bore holes upon completion of the tests.

3.1 Proposed Phase One TMF Retention Structure Alignments

The subsurface conditions along the Proposed Phase One TMF Tailings alignments was investigated by a total of 22 test pits and 5 bedrock boreholes during the May, 1992, investigation. Prior to this testing, **DNE** carried out bedrock permeability testing in 4 exploration diamond drill holes located in the southern part of the proposed Phase One TMF alignments. Locations of the test pits and boreholes are indicated on DWG-0786-301 at the back of this report. The results of the Laboratory testing is presented in Appendix II, along with the test pit logs.

It should be noted that soils and bedrock investigations use point sources of stratigraphic information and that "methods of grouping" are used to delineate the various strata. Variations in strength, colour or consistency may occur within a specific stratum. It is recommended that site specific information be obtained from the description and pertinent in situ and lab testing of the nearest investigation points. Laboratory testing samples were collected usually from the minus 50mm size fraction of the material and the fraction of the material that was greater was estimated in the field.

SOILS

Topsoil/organics (Pt)

A surficial deposit of topsoil and/or organics was found throughout the vicinity of the proposed tailings area. The deposit was generally thin, less than 0.3 metres with the exception of the valley immediately downstream of the existing secondary water pond Test Pit No. 24, encountered muskeg was excavated to a depth of 3.0 metres. The center of the valley was not excavated as it was not possible to cross the intervening muskeg and creek with the Cat 235. It is suspected that muskeg depths on the order of 5 metres may be present based upon the diamond drilling conducted in March 1992 (DD-92-05). Boulders in this area ranged from 0.15 to 1.2 metres and locally comprised up to 60 percent of the deposit.

Silt Till

A cobble silt till deposit, which ranged from silty sand, with some gravel, to silt and sand, with trace gravel, overlay the bedrock along the proposed Phase One TMF alignments. Test Pit No. 19 was the exception to the above range and contained coarser material that classified as sand and gravel with some silt. Boulders ranged from 0.15 to 1.2 metres in size and comprised up to 35 percent of the deposit. The depth of the deposit varied greatly, ranging from 0.3 to 3.0 metres. The range in thickness was due in part to the uneven nature of the bedrock and to the lodgment of till against the glaciated sides of bedrock faces (Test Pit No.1 and No. 20). Test pitting revealed that wet, boggy areas are underlain by a silt layer that was localized in extent and becomes silty sand with depth. The deposit was identified as ground moraine with some silt deposited locally on top, probably a result of ponding of melt waters against the retreating Pleistocene ice mass.

A total of 22 sieves and 6 hydrometers were performed on samples collected from the stratum in order to determine the grain size distribution (Figures 1 to 6, Appendix II). The grain size distributions indicated that the deposit was relatively consistent throughout the proposed Phase One TMF tailings area and was predominately a silty sand with some gravel to a silt and sand with some gravel. The deposit contained approximately 20 to 35 percent cobbles and boulders. The material from test pit No. 16 was more sandy and was classified as a sand with some gravel and trace silt.

Water contents for the samples collected ranged from 6.6 to 15.5 percent for those collected above the water table and from 8.6 to 16.1 for those collected below the water table. Samples collected from test pits No. 2 and No. 3 were collected from below a perched water table and had water contents of 8.4 and 9.6 percent, respectively. Test pit No. 14 also encountered a perched water table with a water content of 20.7 percent for a sample collected within the perched water table and a value of 6.8 for a sample collected below. Including the values from the perched samples the average natural moisture content of the samples collected above the water table was 9.8 percent and for those collected below it was 13.7 percent.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel and the side slopes commonly stood to 3m or more during backhoe excavation. DNE conducted one standard proctor density test on the material from test pit No. 4 and obtained a maximum dry density of 2130 $kg.m^{-3}$ at an optimum water content of 7.3 percent, which is quite typical of silt till deposits.

The permeability of the deposit was quite variable. Observations made in the field indicate that ground water flow was through discrete high permeability zones of sand and gravel. Perched water tables were observed to occur when ever silt rich horizons overlay the silty sand to sand and silt strata. The siltier zones of higher silt content were not laterally extensive and seemed to be restricted to topographic lows. The coefficient of permeability was determined for the samples collected from test pits No. 4 and No. 16 by using a constant head permeameter test at DNE's Laboratory. The value obtained from test pit No. 4 was 1.26 E-05 cm/s and from test pit No.16 was 5.7 E-06 cm/s (average was 8.5 E-06 cm/s). The coefficient of permeability was also estimated for all the samples by using Hazens empirical relationship:

- $k = 10^{-2} D_{10}^{2}$ (m/s)

where D_{10} is the effective grain size in mm obtained from the grain size distribution curve. They ranged from 7.9 E-03 to 1.7 E-04 cm/s with a log-normal average of 7.3 E-04 cm/s.

Bedrock

The bedrock underlying the proposed Phase One TMF alignment consists of massive to foliated gabbroic intrusive complex. An overall RQD of 80+ was determined from the diamond drill core during the March, 1992, site visit for the upper 24 metres of the rockmass along the southern edge of the proposed Phase One South Tailings Dam. Examination of the bedrock exposures throughout the TMF area indicated that there were no apparent significant differences in the type and extent of the discontinuities and thus the entire area was assumed to have an RQD similar to that determined for the diamond drill core.

Bedrock permeability testing along the perimeter of the proposed tailings retention area has been conducted on two separate occasions. In March, 1992, four exploratory BQ diamond drill holes were tested to provide preliminary hydrogeological data for the proposed Phase One TMF, South Tailings Dam. During the May, 1992, field investigation program, 5 additional NX air track boreholes were drilled specifically for the hydrogeological testing of the northern part of the proposed tailings area in order to provide information for the TMF structures. These boreholes were located at points where the maximum head of water would exist for the proposed Phase Two retention structures.

Tables 1 to 9, Appendix IV, list the test interval, test data and the associated permeability value determined by the above relationship for each location as determined in the March and May, 1992, tests. Tables 10 and 11, Appendix IV, contain the summaries and statistics of the tests with Table 10 containing the permeabilities determined by the above relationship without any correction applied for the limitations of the equipment and Table 11 containing the permeabilities obtained after a correction factor was applied to reflect the limitations of the equipment. Permeability values below 1E-06 cm/s as calculated by the above relationship were corrected to equal 1E-06 cm/s as this value represents the lower most limit of the test equipment.

The values obtained for the Proposed Tailings Management Facility ranged from an overall high of 2.7E-03 cm/s (DD-92-05) to a low of 1E-06 cm/s (calculated for test intervals in all holes except DD-92-05) for all tests completed. An average permeability of all the tests as determined by a log-normal statistical analysis was 1.8E-06 cm/s for the corrected values.

In the report issued in April, 1992, **DNE** reported that a reasonable value for the rockmass coefficient of permeability would be in the range of 2 to 5 E-5 cm/s for those tests for which it was possible to measure water flow. If the tests which were corrected are excluded from the log-normal statistics, a value of 1.6 E-5 cm/s was obtained. The rockmass along the proposed tailings facility was therefore characterized by a coefficient of permeability of 2 E-06 to 2 E-05 cm/s. Grouting of the bedrock is therefore not warranted.

Water Conditions

Water levels were observed and recorded for all test pits and bore holes along the proposed Phase One TMF alignments. The water levels are indicated on the logs for the test pits (Tables 1 to 8, Appendix II) and on the piezometer installation logs (Figures 1 to 5, Appendix V).

In general, the water table was close to or at the surface. This was due in part to the recent spring thaw and in part to the heavy rain encountered during the field investigation. The water table was found to be at or just above the bedrock in test pits that were dug away from surface drainage paths. Perched water tables were encountered throughout the proposed tailings facility area as a result of silty horizons overlying the till. Preferential ground water flow was found to occur along discrete zones of sands and gravels having a low silt content. These zones were found to occur at random throughout the proposed Tailings Management Facility area.

3.2 Borrow Investigations

Borrow searches were carried out at the south and north ends of Camp Lake as these areas were considered to have the best potential for supplying the fill material required for the proposed Phase One Tailings Management Facility Retention Structures (see Drawing 0786-301). The area immediately west of the Mill and the open pit were discounted due to the amount of bedrock exposed and the obvious difficult search for material used in construction of the existing roads. Further west, access was prevented by a locked gate and this area was reported by Lac des Iles Mines Ltd. personnel to have little material. With the exception of an existing borrow site, 8 km from the main camp gate and which has a 800 metre long road exposure, there was little indication of a possible borrow site east of the fuelling station located immediately outside the mine site gate. Bedrock exposures were common along the road and it appears the sourcing of material for the road was quite difficult as well.

3.2.1 Southwest Camp Lake Site

A rounded ridge located to the south west of Camp Lake was examined by 11 test pits to determine its potential as a source of borrow material (see Drawing 0786-301). It was hoped that till had lodged against the side of the ridge as it had else where (borrow pit outside of main gate). With the exception of a small pocket of till occupying a bedrock depression, the till was only 0.3 to 1.5 metres thick. The pocket contains approximately 7 000 cubic metres of till with an average depth of 4 metres.

SOILS

Topsoil/Organics (Pt)

A surficial deposit of topsoil and/or organics was found along the ridge. The deposit was generally thin, less than 0.3 metres and consisted of oxidized sandy loam. Boulders ranged from 0.15 to 1.2 metres in size and locally comprised up to 30 percent of the deposit.

Silt Till

A cobble silt till deposit ranging from silty sand, with some gravel, to sand and gravel, with some silt, overlies bedrock in the Southwest Camp Lake site. The grain size envelope derived from the 50 mm minus fraction collected in the field was found to have has a maximum of 26% gravel, 57% sand, I7% silt and 0% clay, and a minimum of 3% gravel, 58% sand, 38% silt and 1% clay. Following the convention of describing tills on the basis of the binder material or matrix, the deposit is described as a silt till. Boulders ranging from 0.15 to 1.20 metres were common and comprised up to 35 percent of the deposit. The depth of the deposit varied widely, ranging from 0.3 to 6 metres. The range in thickness was due in part to the uneven nature of the bedrock and to the lodgment of till in a bedrock hollow between the two high points of the ridge (Test Pit No. 3, 4, 6 and 8).

A total of 6 sieves and 1 hydrometer were performed on samples collected from the stratum in order to determine the grain size distribution (Figures 1 and 2, Appendix III). The grain size distributions indicated that the deposit was consistent within the area and was predominately a silty sand with some gravel. The deposit contained approximately 20 to 35 percent cobbles and boulders. The material from test pit No. 6 was slightly less silty and was classified as a sand with some silt and gravel.

Water contents for the samples collected ranged from 7.4 to 7.8 percent for those collected from above the water table and from 9.3 to 12.0 for those collected below the water table. The average for all samples was 8.5 percent.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel, and the banks stood vertically to heights of 2 to 4 m. The Cat 235 did not have any problems while digging in the till. **DNE** conducted one standard proctor density test on the material from test pit No. 4 and obtained a maximum dry density of 2162 kg/m^3 at an optimum water content of 7.4 percent (Figure 3, Appendix III), which is quite typical for a predominantly silt till.

The permeability of the deposit was found to be quite variable. Observations made in the field indicate that ground water flow occurred through discrete high permeability zones of sand and gravel. The coefficient of permeability was determined for the samples collected from test pits No. 4 by using a constant head permeameter test at **DNE**'s Laboratory. The value obtained from test pit No. 4 was 2.04 E-05 cm/s. The coefficient of permeability was also determined for all the samples by using Hazens empirical relationship. They ranged from 1.02E-03 to 3.2 E-04 cm/s with a log-normal average of 7.5 E-04 cm/s.

Bedrock

The bedrock underlying the Southwest Camp Lake site consisted of the gabbroic complex found in the tailing retention area. It had a rough relief and rose rapidly towards the crest of the ridge. A bedrock notch occurred between the two high points of the ridge.

Water Conditions

Water levels were observed and recorded for Test Pits No. 4, 5, 6 and 8 and are indicated on the test pit logs (Tables 1 to 4, Appendix III). Perched water tables were observed to occur whenever sand and gravel rich horizons occurred in the silty sand till.

3.2.2 West Camp Lake Site

The area to the west of Camp Lake and south of the proposed Phase One Tailings Management Facility area (also known as the "G" zone) was test pitted at the suggestion of Lac des Iles Mines Ltd. A total of 15 test pits were dug using the Cat 235 excavator. The northwest corner of the area contained an old borrow pit that was used for the construction of the logging access road that runs along the north side of the site. The area was quite wet as it lies only one meter higher, than the water level in Camp Lake. Overburden in the area was also quite shallow, ranging from 0.3 to 1.8 metres depth, with an average 0.82 metres. There was no significant volume of borrow material in the area.

3.2.3 Southeast Camp Lake Site

This site consists of a ridge that runs north-south along the edge of Camp Lake (see DWG 0786-301). An existing borrow site was present at the southwest end of the ridge and was used for the construction of the access road to the explosives storage clearing. A total of fifteen test pits were excavated with the Cat 235 in order to determine the extent of the existing burrow site. Access to the test pit locations required cutting a trail through a mature poplar forest for Test Pits No. 6 to 12 including B and C.

A 3.7 metre high face of granular till was exposed at the existing borrow site. Bedrock forms the floor of the excavation and rose rapidly toward the crest of the ridge where test pit No. 5 determined the depth of till to be 0.76 metres. The test pitting determined that a narrow wedge of till occurs along the west central part of the ridge. It was found to contain approximately 19 000 m^3 of till. Elsewhere the till was only 0.9 to 1.8 metres in thickness and is not judged a viable source of fill material.

SOILS

Topsoil/Organics (Pt)

A surficial deposit of topsoil and/or organics was present throughout the site. The deposit was generally thin, 0.3 to 0.6 metres in depth. Boulders ranged from a size of 0.15 to 1.2 metres and comprised up to 40 percent of the deposit.

Silt Till

A granular till deposit underlies the topsoil/organic stratum and was found to overlie bedrock at all of the test pit locations. The till was predominately a silty sand with some gravel. Local variations were present with the sampled material being either coarser or finer (i.e. more gravelly or silty). The grain size envelope derived from the 50 mm minus fraction has a maximum gradation of 45% gravel, 48% sand, 7% silt and 0% clay, and a minimum of 0% gravel, 47% sand, 51% silt and 2% clay. Following the convention of describing tills on the basis of the binder material, the deposit is a silt till. Boulders ranging from 0.15 to 1.2 metres were common and comprised up to 35 percent of the deposit. The depth of the deposit ranged from 0.46 to 6.1 metres. The greatest depths occurred in a band along the west central side of the ridge (see DWG 0786-301).

A total of 11 sieves and 3 hydrometer tests were performed on samples collected from the stratum in order to determine the grain size distribution (Figures 4 to 6, Appendix III). The grain size distributions indicated that the deposit was fairly consistent throughout and was predominately a silty sand with some gravel. Variation in the till was evident as samples collected from three test pits classified either slightly coarser or finer. Coarser till was sampled at Test Pits No. B, sand and gravel with some silt, and Test Pit No. 5, gravelly sand with some silt. Test Pit No. 2 contained finer material which classified as a silt and sand, with trace gravel.

Water contents for the samples collected ranged from 6.5 to 12.6 percent for those collected above the water table. Two samples were collected from below and at the water table (Test Pit No. 2) and had values of 12.6 and 14.8 percent respectively. The average for all samples was 10.4 percent.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel, and test pit walls of 4 m were maintained in a near vertical configuration. A Proctor Density test on the material from Test Pit No. 1 and obtained a maximum dry density of 2169 kg/m^3 at an optimum water content of 7.4 percent (Figure 7, Appendix III).

A constant head coefficient of permeability test determined to a value of 4.22 E-6 cm/s for a sample collected from Test Pit No. A. The coefficient of permeability was also determined for all the samples by using Hazens empirical relationship. They range from 6.25 E-03 to 2.0 E-04 cm/s with a log-normal average of 8.3 E-04 cm/s, however, Hazen's test is more applicable to clear well rounded sand sizes.

Bedrock

The bedrock underlying the Southeast Camp Lake site consists of the gabbroic complex found in the proposed tailings facility area. It has a moderate to high relief and rose approximately 16.8 metres between Test Pits No. 1 and No. 5 (146 metres apart). Vertical bedrock outcrops were found to occur along the west edge of the ridge. The exposed vertical faces were up to 2 metres in height.

Water Conditions

Water levels were observed and recorded in 3 of the Test Pits (No. A, 2 and 8). The water levels are indicated on the logs for the test pits (Tables 15 to 18, Appendix III). Test Pits No. A and 1 were located adjacent to the stream flowing out of Camp Lake and had water levels at 4.57 and 3.05 metres below ground surface respectively. This translated into an elevation difference of less than 1 metre between the stream surface and the ground water levels. Test Pit No. 6 had a water level that was 0.91 metres below the ground surface.

3.2.4 South Camp Lake Site

The area investigated is located to the east of the Southeast Camp Lake site. It consists of a low relief terrain that was void of any bedrock outcrops. Surface water was absent and it seemed to be well drained. The area was forested by mature popular trees and this in combination with the low relief and the absence of any bedrock outcrops, indicated the possibility of sufficient overburden depth for a borrow site. A total of twelve test pits were excavated with the Cat 235 in order to determine the nature of the overburden (see DWG 0786-301). With the exception of three test pits, No. 6, 8 and 10, the overburden averaged only 0.88 metres. Test Pits No. 6 and 8 had 2 metres of overburden while Test Pit No. 10 had 3 metres of overburden.

SOILS

Topsoil/Organics (Pt)

A surficial deposit of topsoil and/or organics was present throughout the site. The deposit was generally thin, 0.3 to 0.6 metres in depth. It consisted of an oxidized sandy loam with boulders ranging from 0.15 to 1.2 metres that comprised up to 35 percent of the deposit.

Silt Till

A granular till deposit underlies the topsoil/organic strata and overlies the bedrock at all the test pits. The till was a gravelly sand with some silt to a silty sand with some gravel. Local variations were present within the sampled material, coarser or finer (i.e. more gravelly or silty). The grain size envelope derived from the 25 mm minus fraction collected has a maximum of 30% gravel, 60% sand, 10% silt and 0% clay, and a minimum of 0% gravel, 35% sand, 64% silt and 1% clay. Following the convention of describing tills on the basis of the binder material, the deposit is a silt till. Boulders ranging from 0.15 to 1.2 metres comprised up to 35 percent of the deposit. The depth of the deposit ranged from 0.5 to 1.8 metres. Test Pits No. 6, 8 and 10 had the thickest depths, 1.4, 1.4 and 1.8 metres respectively. Elsewhere the deposit was quite thin, 0.15 to 0.5 metres in depth.

A total of 1 hydrometer and 3 sieves were performed on samples collected from Test Pits No. 6, 8 and 10 in order to determine the grain size distributions (Figure 8, Appendix III). The grain size distributions indicated that the deposit was relatively consistent and ranged from a gravelly sand with silt to a silty sand with gravel.

Water contents for the samples collected ranged from 7.5 to 13.4 percent, with all samples collected from above the water table. The average of the samples was 10.7 percent.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel, and test pit walls of 3 metres were maintained in a near vertical configuration.

The coefficient of permeability was determined for the samples collected from Test Pits No. 6, 8 and 10 by using Hazens empirical relationship. Values of 9.0 E-04, 3.6 E-04 and 2.6 E-03 cm/s were determined for test pits No. 6, 8 and 10 respectively. The log-normal average of the coefficient of permeability was 9.5 E-04 cm/s.

Bedrock

The bedrock underlying the South Camp Lake site consists of the Archean foliated tonalite suite. It was assumed to have a low to moderate relief based upon the information from the test pitting and the absence of bedrock ridges.

Water Conditions

Water levels occurring within the overburden stratum were observed and recorded in 1 of the test pits (No. 8). This test pit was located in a topographic low that acts as a local drainage zone. Water levels in the other test pits occurred at the bedrock surface.

3.2.5 North Camp Lake Site

This area lies to the south of the Lac des Iles Mines Ltd. access road along the northeast side of Camp Lake (see DWG 0786-301). It consists of a north-south oriented ridge that rises 20 metres above Camp Lake. The ridge is smoothly rounded and has a mature growth of popular and birch trees. The rational for examining the ridge was the presence of the borrow site approximately 91 metres north of the beginning of the ridge as well as the smoothly rounded nature of the ridge and the mature growth of popular.

A total of eight test pits were excavated with the Cat 235 in order to determine the nature and depth of the overburden. With the exception of test pit No. 7, the overburden averaged only 0.9 metres in depth (see Tables 19 to 21, Appendix III). Test pit No. 7 was located in an eroded east-west fault zone that had 4.3 metres of overburden.

SOILS

Topsoil/Organics (Pt)

A surficial deposit of topsoil and/or organics was present throughout the site. The deposit was generally thin, 0.3 to 0.6 metres in depth and consisted of oxidized sandy loam. The exception was Test Pit No. 1 which had 1.22 metres of muskeg and boulders overlying the bedrock at the north base of the ridge. Boulders ranged from 0.15 to 1.2 metres and comprised up to 35 percent of the deposit.

Silt Till

A cobble silt till deposit underlies the topsoil/organic strata and overlies the bedrock at Test Pits No. 2, 3, 4 and 7. The till ranged from a gravelly sand with some silt to a silty sand with some gravel. Boulders ranged from 0.15 to 1.2 metres and comprised up to 35 percent of the deposit. Test Pits No. 3 and 7 had the thickest depths, 1.5 and 3.7 metres respectively. Elsewhere the deposit was quite thin, 0.15 to 0.5 metres thick.

One sieve size analysis was performed on the sample collected from Test Pit No. 7 in order to compare the grain size distribution with those obtained from the other sites (Figure 9, Appendix III). The grain size distribution indicated that the deposit was relatively similar with the till examined at the other borrow site locations and that the material was a sand with some gravel and trace silt.

The water content for the sample collected was found to be 10.8 percent which was similar to other locations.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel, with near vertical walls to depths of 4.2 m.

The coefficient of permeability as determined by Hazens empirical relationship was 6.4 E-02 cm/s which was significantly higher than previous values but was reasonable based on the observations of discrete zones of high permeability in other test pits.

Bedrock

The bedrock underlying the North Camp Lake site consisted of an Archean foliated tonalite suite (MNDM Map 2542, Bedrock Geology of Ontario, west-central sheet). It was assumed to have a low to moderate relief based upon the information from the test pitting.

Water Conditions

Water levels were observed and recorded for test pits No. 1 and 7 at depths of l0.3 m and 2.4 m respectively. Both test pits were located in topographic lows that are part of the local drainage.

3.2.6 Main Gate Site

The Main Gate site was located on the north side of the mine access road and approximately 335 metres east of the Lac des Iles mine site gate (see DWG 0786-301). The site has been clear cut in the past and now had a regrowth of 1.5 to 3.0 metre birch and popular saplings. It consisted of a wedge of granular till that lay against the west side of a north-south trending bedrock ridge. Preliminary evaluation of the site indicated that the till extended north of an existing borrow site. It is bounded to the west by a muskeg deposit and to the east by bedrock outcrops that occurred along the ridge crest. The top of the muskeg deposit is approximately 4.4 metres below the top of the till wedge and has a stream, flowing south in to Camp Lake, located in the center.

The existing borrow has a 4.6 metre high face exposed (see Photograph No. 17, Appendix I). Test pitting by Lac des Iles personnel on the mid-west side of the borrow determined that approximately 3 metres of till underlay the existing bench.

A total of nineteen test pits were excavated with the Cat 235 in order to determine how far along the ridge the till ledge extended along with the subsurface conditions (see DWG 0786-301). The test pitting indicated that there was approximately 60 000 m^3 of granular till present in the wedge lying against the ridge that extended approximately 380 metres north with an average depth of 3.5 metres.

SOILS

Topsoil/Organics (Pt)

A surficial deposit of topsoil and/or organics was present through out the site. The deposit was generally thin, 0.3 - 0.6 metres in depth. Boulders ranged from 0.15 to 1.2 metres and comprised up to 35 percent of the deposit.

Muskeg to depths of 3.1 metres was found to occur along the western side of the till deposit. It was not possible to dig Test Pits No. 3 and 4 as the muskeg did not support the weight of the Cat 235 excavator when it tried to reach the planned test pit locations in the bottom of the valley.

Silt Till

A granular deposit underlies the topsoil/organic strata and overlays the bedrock at all of the test pits. It was predominately a silty sand to sand and silt, but ranged from a gravelly sand, with trace silt to a sandy silt, with trace gravel. The grain size envelope derived from the 50 mm minus fraction has a maximum gradation of 30% gravel, 60% sand, 10% silt and 0% clay, and a minimum of 0% gravel, 33% sand, 66% silt and <1% clay. Following the convention of describing tills on the basis of the binder material, the deposit is a silt till. Boulders ranged from 0.15 to 1.2 metres and comprised up to 35 percent of the deposit. The depth of the deposit ranged from 0.6 to 9.5 metres, the thickest depths occurred in a band along the west central side of the ridge.

A total of 15 sieves and 4 hydrometers were performed on samples collected from the stratum in order to determine the grain size distributions (Figures 10 to 13, Appendix III). The grain size distributions indicated that the deposit was fairly consistent throughout and was predominately a silty sand with some gravel to a sand and silt with some gravel. Some variation in the till stratum was observed, and samples collected from the test pits range from gravelly sand with some silt (Test Pit No. 12) to sandy silt with trace gravel (Test Pit No. 1). There was no discernable pattern in the variation of the grain size distribution and as in Photograph No. 17, Appendix I, the transition between grain size distributions is abrupt. The envelope of the grain size distributions for the Main Gate site corresponded to those from other areas at the Lac des Iles mine site.

Water contents for the samples collected ranged from 7.4 to 18.3 percent for those from above the water table and from 6.8 to 19.8 for samples from below the water table. The average for all samples was 10.5 percent.

The till deposit was considered to be "compact" as it was dug with some difficulty with a hand shovel, and test pits stood with near vertical walls to heights of 10 m. The Cat 235 did not have any problems with digging in the till. DNE conducted standard proctor density tests on the material collected from Test Pits No. 2, 10, and 15 with results of 2103 kg.m^{-3} at 9.4% water, 2150 kg.m^{-3} at 8.9% water, and 2100 kg.m^{-3} at 9.5% water respectively (Figures 14 to 16, Appendix III). The average of the tests was 2118 kg.m^{-3} at an optimum water content 9.3%.

The coefficient of permeability as determined by a constant head permeability test was found to be 4.38 E-5 cm/s for a sample collected from Test Pit No. 1. The coefficient of permeability was also determined for all the samples by Hazens empirical relationship. They ranged from 6.4 E-03 to 6.7 E-05 cm/s with a log-normal average of 1.0 E-03 cm/s.

Bedrock

The bedrock that underlies the Main Gate site consists of an Archean foliated tonalite suite. The bedrock rises eastward from a depth of 9.5 metres at Test Pit No. 10 to a depth of 0.15 metres at Test Pit No. 15, over a distance of 82 metres. The bedrock has a low relief along the western side of the borrow area but changes to a moderate to high relief on the east side of the burrow area. Test Pit No. 15 on the east side had a sloping bedrock surface that rose from 0.15 to 1.8 metres depth towards the ridge crest. The east side of the ridge as well as the ridge bounding the west side of the muskeg deposit has vertical rock faces in excess of 20 metres.

Water Conditions

Water levels were observed and recorded in 10 of the Test Pits (No. 2, 5, 6, 7, 8, 10, 12, 13, 15 and 16). The water levels are indicated on the logs for the test pits (Tables 22 to 27, Appendix III). The water tables that observed in Test Pits No. 2, 5, 6, 7, 8, and 16 were perched and restricted to localized zones of coarser, sand and gravel located within the till. These zones were commonly less than 0.3 metres in thickness. Test Pits No. 5 and 6 had a second perched water table that was approximately 0.3 metres below the ground surface and was considered to be connected to surface water. This occurred within the upper part of the muskeg deposit which was vegetated by loose grass and moss vegetation.

APPENDIX I

PHOTOGRAPHIC SUMMARY

Photographs 1 to 17

Dm

Photo 1. View looking south of Test Pit No. 2. Bedrock was a smooth hump with the high point located at the edge of the ponded water. The ponded water originated in the upper 0.30 m of the strata in the south end of the pit where it was perched above a silty horizon. (May 15, 1992)

Photo 2. View of Test Pit No. 5, Proposed Phase 1 tailings alignment. Note the boulders and oxided layer overlying the grey silt till. Bedrock was uneven and sloped from a depth of 0.8 m to a depth of 1.2 m. (May 15, 1992)

Photo 3. View of Test Pit No. 6, Proposed Phase 1 TMF alignment. Test pit was dug in the bottom of a seasonal drainage course. The upper 0.3 m of the strata contained organics and boulders from which the fines had been washed out from. Water table was close to the surface and was a result of the recent spring thaw. (May 15, 1992)

Dm

Photo 4. View of Test Pit No. 10, Proposed Phase 1 TMF alignment, showing irregular nature of bedrock, which ranged from 0.15 to 2.29m depth. (May 15, 1992)

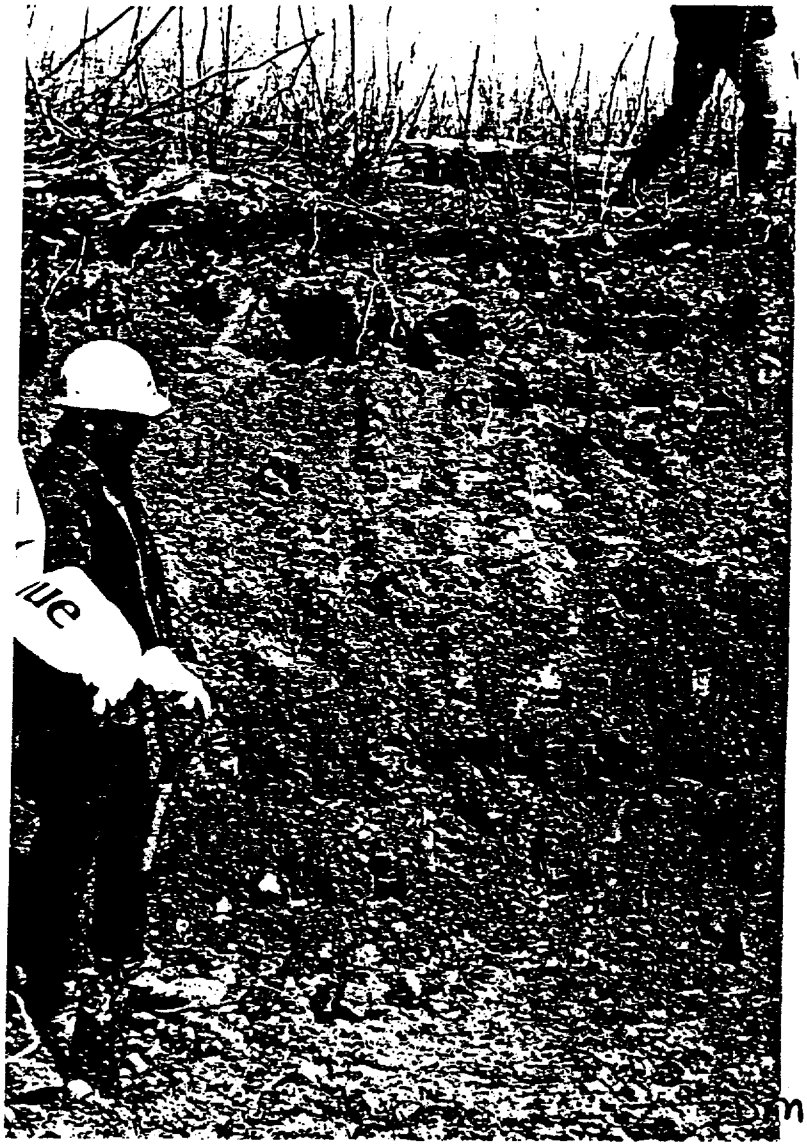


Photo 5. View of Test Pit No. 17, Proposed Phase 1 TMF alignment. Note oxidized layer of till overlying the grey till. The till is competent as is evident by the stable test pit wall and the imprints of the backhoe bucket teeth. (May 15, 1992)

Photo 6. View of Test Pit No. 19, Proposed Phase 1 TMF alignment. Note the wet conditions present. The disturbed material flowed readily, while the test pit walls were relatively stable. (May 23, 1992)

Photo 7. View, looking south, of Test Pit No. 4, South West Camp Lake borrow investigation site, showing the compact nature of the till. Note the oxidized till in the upper 0.20 m of the test pit as well as the localized inflow of water at the mid left point of the far test pit wall. (May 16, 1992)

Photo 8. View showing close-up of grey silty sand with some gravel excavated from Test Pit No. 4, Southwest Camp Lake borrow investigation site. Cobbles and boulders account for approximately 25+ % of material. (May 16, 1992)

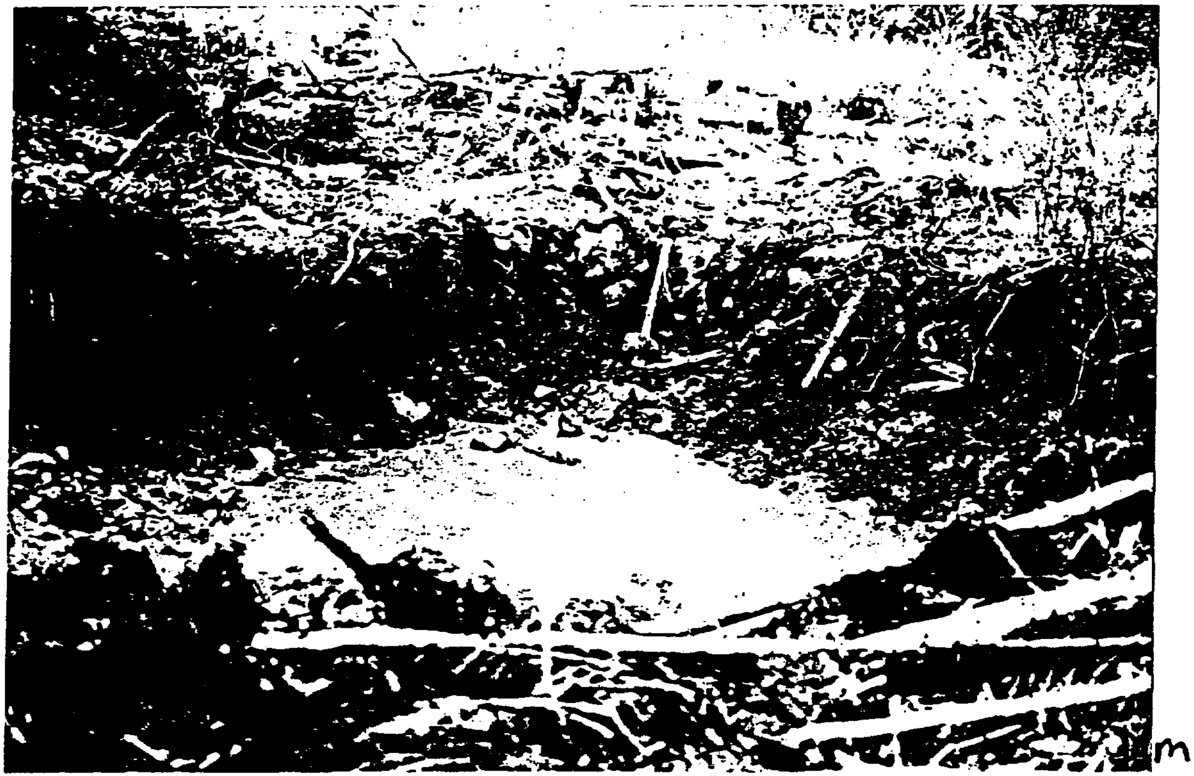


Photo 9. View of Test Pit No. 12, West Camp Lake borrow investigation site, showing the wet conditions encountered there. (May 22, 1992)

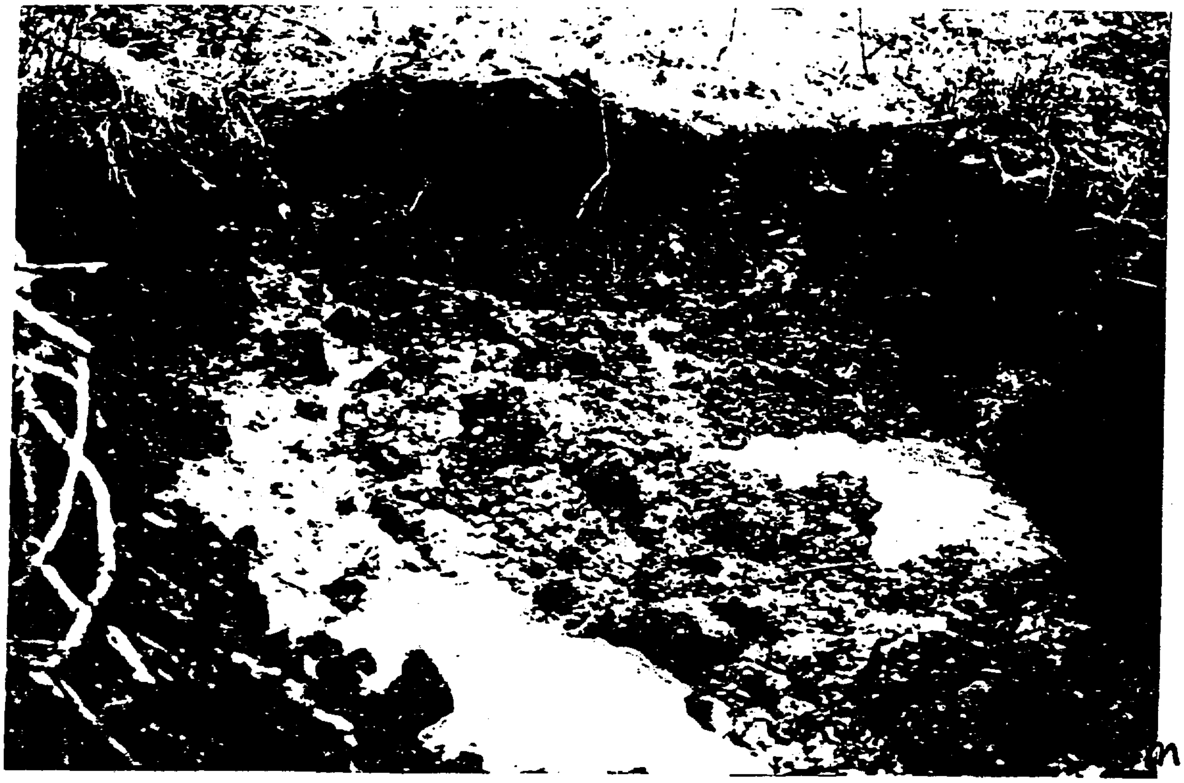


Photo 10. View of Test Pit No. 14, West Camp Lake borrow investigation site. Water table was located at 0.30m and was concentrated in the cobble and boulders visible in the left side of the photography. (May 22, 1992)

Photo 11. View of Test Pit No. 5, Southeast Camp Lake borrow investigation site, showing the shallow nature of the till on the ridge top. (May 17, 1992)

Photo 12. View showing terrain and forest cover at the Southeast Camp Lake borrow investigation site. The two people are standing on a trail cleared through the forest to permit access by the backhoe which is visible behind the trees just left of center. This type of terrain and cover was also typical of the South Camp Lake borrow investigation site. (May 18, 1992)

Photo 13. View of Test Pit No. 4, South Camp Lake borrow investigation site. Shallow depth was typical of the South Camp Lake site. (May 21, 1992)

Photo 14. View of Test Pit No. 3, North Camp Lake borrow investigation site. Stratigraphy and depth was typical of the North Camp Lake borrow search site. (May 25, 1992)

Photo 15. View of Test Pit No. 8, Main Gate borrow investigation site, showing 4.5 m near vertical test pit walls indicating competent till. (May 23, 1992)

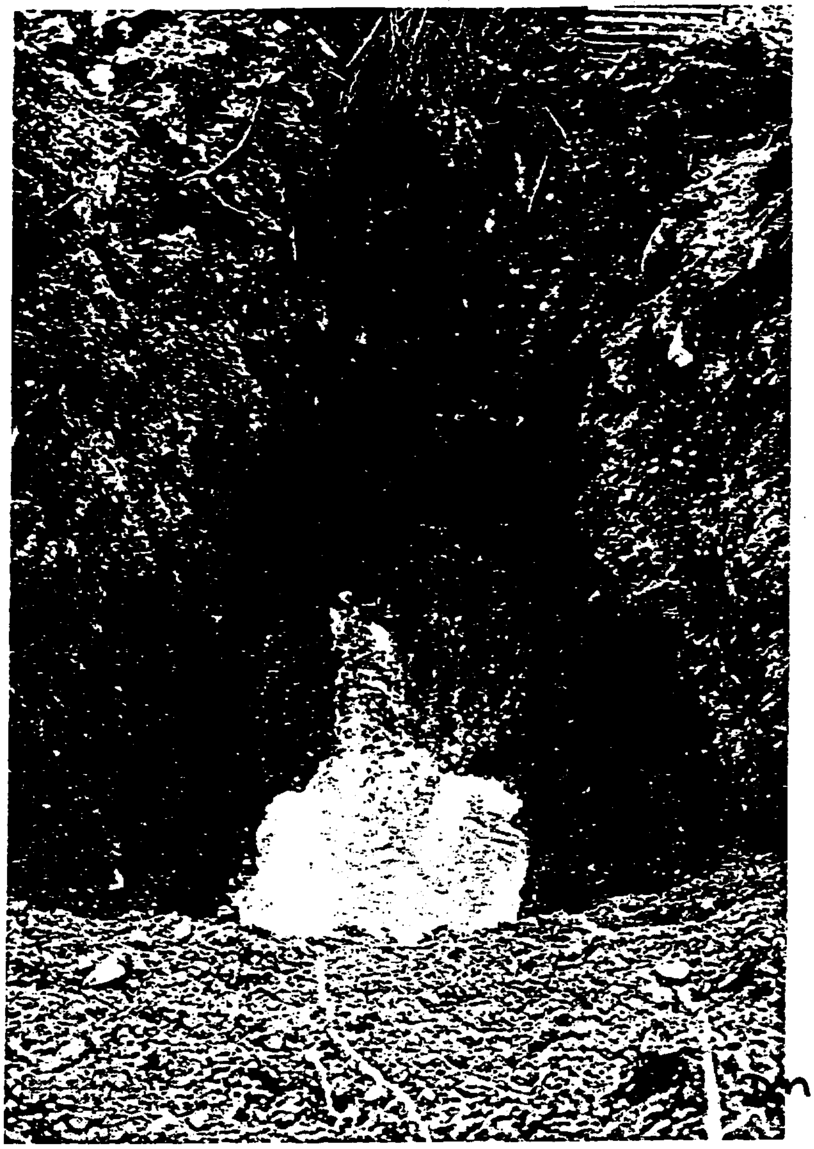


Photo 16. View of Test Pit No. 16, Main Gate borrow investigation site. Water table was encountered at 3.66m and as can be seen in the above photography, significant flow occurred through a coarse (gravel-boulder) zone. Such zones were encountered throughout the Lac des Iles investigation area. (May 23, 1992)

Photo 17. View of working face in existing borrow located at the south end of the Main Gate borrow investigation site. Notice the juxtaposition of strata with differing grain size distributions. This lack of homogeneity was common throughout the Lac des Iles investigation area. (October 17, 1992)

APPENDIX II

PROPOSED PHASE ONE TMF, RETENTION STRUCTURE ALIGNMENTS
TEST PIT LOGS AND SOIL TESTING RESULTS

(Tables 1 through 8)

(Lab Test figures 1 through 7)

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 1

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	ORGANICS	
.15-.76	BROWN, SILTY SAND WITH 10% BOULDERS	BROWN COLOUR MAY BE RESULT OF OXIDIZATION
.76-1.52	GREY, SILTY SAND WITH SOME GRAVEL, 15 % COBBLES. LARGE BOULDERS PRESENT W.C.=8.5%, HAZEN k=5.5E-4 cm/s (SAMPLE No.1)	
1.52-3.05	GREY SILTY SAND, FEW BOULDERS, COBBLES COMMON W.C.=7.2%, HAZEN k=1.6E-3 cm/s (SAMPLE No2)	WATER TABLE @ BEDROCK SURFACE
3.05	BEDROCK, GABBROIC COMPLEX, UNDULATORY SURFACE END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	ORGANICS	
.15-.46	YELLOW SILTY SAND, PEPPLES ARE COMMON	PERCHED W.L. AT .15M OVERLIES SILT SILT AND SAND HORIZEN PINCH OUT SOUTHWARD AND IS REPLACED BY THE SILTY SAND
.46-1.22	GREY SILTY SAND WITH SOME GRAVEL. W.C.=8.4%, HAZEN k=5.8E-4 cm/s (SAMPLE No.1)	
.92-1.22	BEDROCK, GABBROIC COMPLEX, UNDULATORY SURFACE END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	ORGANICS AND BOULDERS (25%)	
.30-1.22	YELLOW SILTY SAND, PEBBLES COMMON W.C.=9.6%, HAZEN k=3.4E-4 cm/s (SAMPLE No.1)	
1.22-1.52	GREY SILTY SAND, PEBBLES COMMON	COMPACTED AS BREAKING IN TO LUMPS
1.52-1.83	BROWN SILTY SAND, CONTAINS SOME SILT SEAMS	WATER SEEPING THROUGH
1.83	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 2

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	ORGANICS	
.15-.61	RED BROWN SANDY LOAM WITH .61-1.22M BOULDERS	RED BROWN COLOUR MAY BE RESULT OF OXIDIZATION
.61-1.22	GREY, SILTY SAND WITH SOME GRAVEL, 10 % COBBLES. LARGE BOULDERS PRESENT W.C.=12.2%, HAZEN k=4.8E-4 cm/s, PERMEAMETER k=1.26E-5 cm/s (SAMPLE No.1) PROCTOR MAX DENSITY = 2135 kg/m^3 @7.2% w.c.	
.61-1.22	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	ORGANICS	
.15-.30	TOPSOIL AND 20% BOULDERS UPTO .92M IN SIZE	
.30-1.22	GREY SILT AND SAND WITH TRACE GRAVEL. W.C.=10.0%, HAZEN k=3.0E-4 cm/s (sample nO.1)	
.76-1.07	BEDROCK, GABBROIC COMPLEX, UNDULATORY SURFACE	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	ORGANICS	A ZONE FROM .30-1.22M DEPTH CONTAINED NOTHING BUT SHATTERED ROCK, POSSIBLY AN OLD DRAINAGE COURSE THAT WASHED OUT THE FINES. WATER WAS FLOWING THROUGH THE BOULDERS.
.30-1.22	SILTY SAND WITH TRACE GRAVEL. W.C.=12.6%, HAZEN k=3.2E-4 cm/s (sample nO.1)	
1.22	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 3

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	ORGANICS	
.30-.76	BROWN SILTY SAND TILL WITH .30-.92M BOULDERS	BROWN COLOUR MAY BE RESULT
.76-1.83	GREY, SILTY SAND WITH SOME GRAVEL, 20 % COBBLES. LARGE BOULDERS PRESENT	OF OXIDIZATION
	W.C.=6.6%, HAZEN k=1.5E-3 cm/s (SAMPLE No.1)	
.61-1.83	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.06	ORGANICS	
.06-.23	RED GRAVELLY SILTY SAND, 5% BOULDERS	RED COLOUR DUE TO OXIDIZATION
.23-.61	RED TO GREY GRAVELLY SILTY SAND WITH 5% BOULDERS	
	W.C.=15.5%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
.61	BEDROCK, GABBROIC COMPLEX, SMOOTH SURFACE	
	END OF TEST PIT	

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.08	ORGANICS	
.08-.61	BROWN SILTY SAND WITH SOME GRAVEL, 8% COBBLES AND BOULDERS	
.61-2.29	GREY SILTY SAND WITH SOME GRAVEL, 8% COBBLES AND BOULDERS	
	W.C.=10.7%, HAZEN k=1.65E-3 cm/s (SAMPLE No.1)	
.15-2.29	BEDROCK, GABBROIC COMPLEX, IRREGULAR SURFACE	WATER FLOWING ALONG BEDROCK
	END OF TEST PIT	/ TILL CONTACT

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 4

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	BROWN SILTY GRAVELLY SAND, 15% BOULDERS	BROWN COLOUR MAY BE RESULT OF OXIDIZATION
.61-1.83	GREY SILTY GRAVELLY SAND, 15% BOULDERS W.C.=13.6%, HAZEN k=5.2E-4 cm/s (SAMPLE No.1)	
.61-1.83	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE END OF TEST PIT	

TEST PIT NO. 12

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.76	BROWN SILTY SAND WITH SOME GRAVEL, 20% COBBLES AND BOULDERS	BROWN COLOUR MAY BE RESULT OF OXIDIZATION
.76-1.68	GREY SILTY SAND WITH SOME GRAVEL, 20% COBBLES AND BOULDERS W.C.=10.3%, HAZEN k=1.0E-3 cm/s (SAMPLE No.1)	
1.68	BEDROCK, GABBROIC COMPLEX END OF TEST PIT	

TEST PIT NO. 13

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.46	BROWN SILTY SAND TRACE GRAVEL, BOULDERY	
.46-2.74	GREY SILTY SAND TRACE GRAVEL, BOULDERY W.C.=8.6%, HAZEN k=1.6E-3 cm/s (SAMPLE No.1)	TILL IS MOIST AND SIDES OF EXCAVATION CAVED EASILY
.46-2.74	BEDROCK, GABBROIC COMPLEX, IRREGULAR SURFACE END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 5

TEST PIT NO. 14

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.92	75% 0.2-0.5m BOULDERS WITH AN ORGANIC MATRIX, 5% OF BOULDERS WERE 0.5-1.5m IN SIZE.	W.T. @ .15M
.92-1.68	BLACK SAND AND SILT, SOME GRAVEL.	BLACK COLOUR MAY BE RESULT
	W.C.=20.7%, HAZEN k=2.1E-4 cm/s (SAMPLE No.1)	OF ORGANICS, ROTTEN VEGETATION SMELL
1.68-2.74	SILTY SAND WITH TRACE GRAVEL, COBBLES AND BOULDERS PRESENT	
	W.C.=6.8%, HAZEN k=1.3E-3 cm/s (SAMPLE No.2)	
2.74	BEDROCK	UNABLE TO SEE BEDROCK DUE TO WATER
	END OF TEST PIT	IN EXCAVATION

TEST PIT NO. 15

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.23	ORGANICS WITH 30% BOULDERS	BOULDERS LARGE, 1.5M AVERAGE SIZE
.23-.53	BROWN SILT AND SAND WITH TRACE GRAVEL, 20% COBBLES AND BOULDERS	BROWN COLOUR RESULT
.53-1.52	GREY SILT AND SAND WITH TRACE GRAVEL, 20% COBBLES AND BOULDERS	OF OXIDIZATION
	W.C.=11.2%, HAZEN k=2.1E-4 cm/s (SAMPLE No.1)	WATER FLOWING IN SIDE, ABOVE BEDROCK
1.37-1.52	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	/ TILL CONTACT
	END OF TEST PIT	

TEST PIT NO. 16

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.08	ORGANICS WITH 8% BOULDERS UP TO 1.5M IN SIZE	
.08-.61	BROWN SAND WITH SOME GRAVEL AND TRACE SILT, 10% COBBLES AND BOULDERS	W.T. @ .46M, LOCALLIZED ZONE
.61-3.05	GREY SAND WITH SOME GRAVEL AND TRACE SILT, 10% COBBLES AND BOULDERS	CAUSED CAVING OF EXCAVATION SIDE
	W.C.=9.1%, HAZEN k=7.9E-3 cm/s (SAMPLE No.1)	
1.83-3.05	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

APPENDIX II

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

TABLE 6

TEST PIT NO. 17

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	
.09-.46	BROWN SILTY SAND WITH SOME GRAVEL. COBBLES AND BOULDERS UPTO 0.4M.	
.46-2.44	GREY SILTY SAND WITH SOME GRAVEL. COBBLES AND BOULDERS PRESENT.	
	W.C.=6.6%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
1.98-2.44	BEDROCK, GABBROIC COMPLEX, ROUNDED SURFACE	
	END OF TEST PIT	

TEST PIT NO. 18

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND MUSKEG WITH BOULDERS	W.T. @ .30M
.30-.92	BROWN SILT AND SAND WITH SOME GRAVEL, COBBLES AND BOULDERS PRESENT.	BROWN COLOUR MAY BE RESULT
.92-1.98	BROWN TO GREY SILT AND SAND WITH SOME GRAVEL, COBBLES AND BOULDERS PRESENT.	OF OXIDIZATION
	W.C.=14.8%, HAZEN k=1.7E-4 cm/s (SAMPLE No.1)	
1.83-1.98	BEDROCK, GABBROIC COMPLEX	
	END OF TEST PIT	

TEST PIT NO. 19

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .76M
.30-.61	BROWN SAND AND GRAVEL WITH SOME SILT.	BROWN COLOUR MAY BE RESULT
.61-1.22	FIRM BROWN TO GREY SAND AND GRAVEL WITH SOME SILT.	OF OXIDIZATION
	W.C.=16.1%, HAZEN k=7.3E-4 cm/s (SAMPLE No.1)	
1.07-1.22	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 7

TEST PIT NO. 20

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.92	BROWN SILTY SAND WITH SOME GRAVEL.	W.T. @ 1.52M
.92-3.35	GREY SILTY SAND WITH SOME GRAVEL.	
	W.C.=16.0%, HAZEN k=1.7E-4 cm/s (SAMPLE No.1)	
3.35	BEDROCK, GABBROIC COMPLEX	
	END OF TEST PIT	

TEST PIT NO. 23

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	BROWN SILT AND SAND WITH TRACE GRAVEL, COBBLES AND BOULDERS PRESENT.	BROWN COLOUR MAY BE RESULT
	W.C.=19.2%, HAZEN k=1.7E-4 cm/s (SAMPLE No.1)	OF OXIDIZATION
.61	BEDROCK, GABBROIC COMPLEX	
	END OF TEST PIT	

TEST PIT NO. 24

DEPTH (METRES)	DESCRIPTION	REMARKS
0-3.05	MUSKEG	W.T. @ .30M
3.05	BEDROCK	NOT SAMPLED
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
PROPOSED PHASE ONE TMF AREA

APPENDIX II

TABLE 8

TEST PIT NO. 25

DEPTH (METRES)	DESCRIPTION	REMARKS
0-?	MUSKEG	W.T. @ SURFACE NOT DUG DUE TO ACESS PROBLEMS

TEST PIT NO. 26

DEPTH (METRES)	DESCRIPTION	REMARKS
0-1.83	MUSKEG AND BOULDERS	W.T. @ .15M
1.83	BEDROCK	NOT SAMPLED
	END OF TEST PIT	

TEST PIT NO.

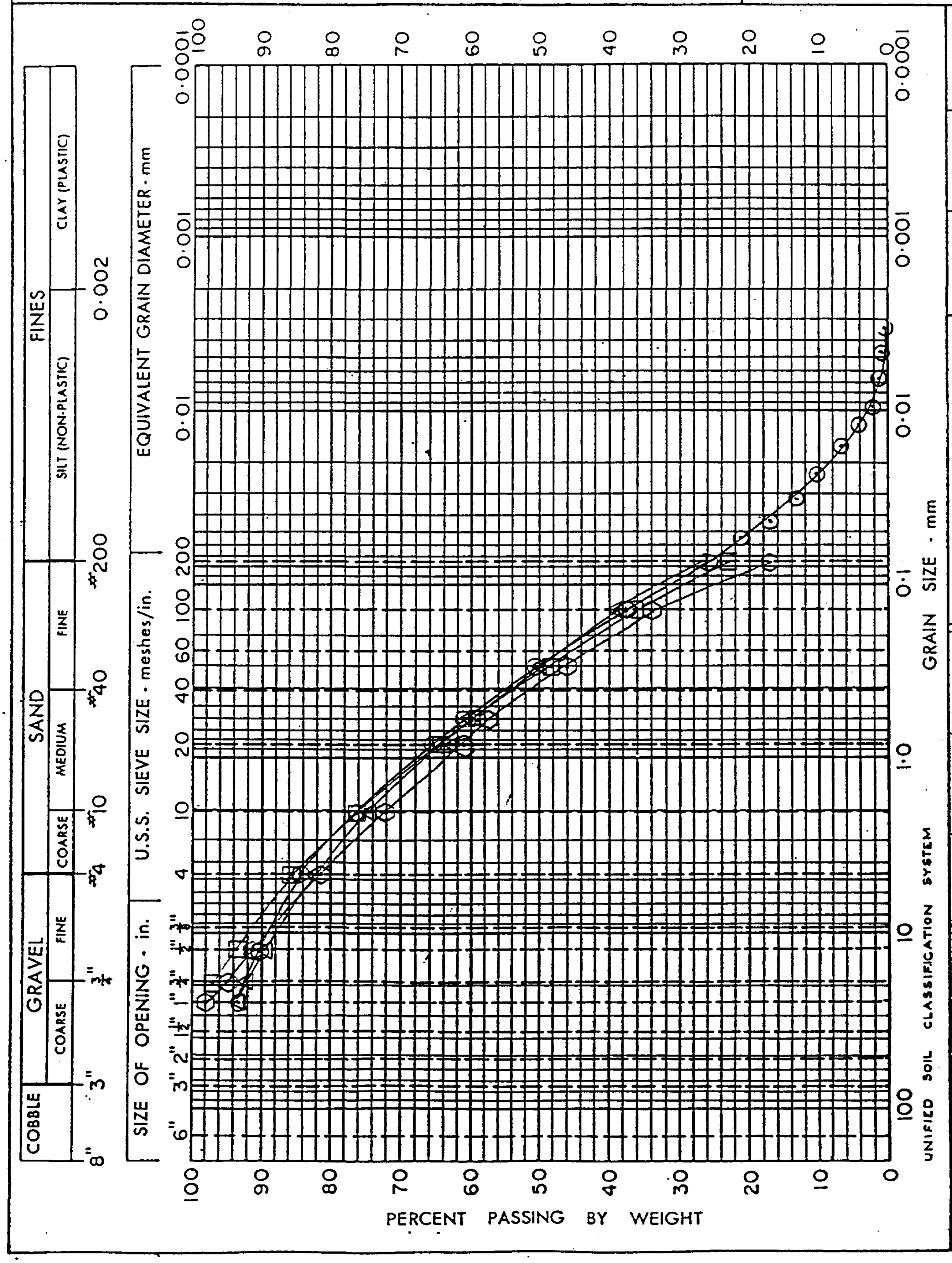
DEPTH (METRES)	DESCRIPTION	REMARKS

LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION

PROPOSED PHASE 1 TMF RETENTION STRUCTURES

APPENDIX II
FIG. NO. 1



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL No.1	TP1	0.8-0.9m	⊙
SILTY SAND SOME GRAVEL No.2	TP1	2.1-2.3m	⊡
SILTY SAND SOME GRAVEL	TP 2 No.1	0.9-1.2m	△
SAND SOME SILT SOME GRAVEL	TP 3 No.1	1.2-1.4m	⊙

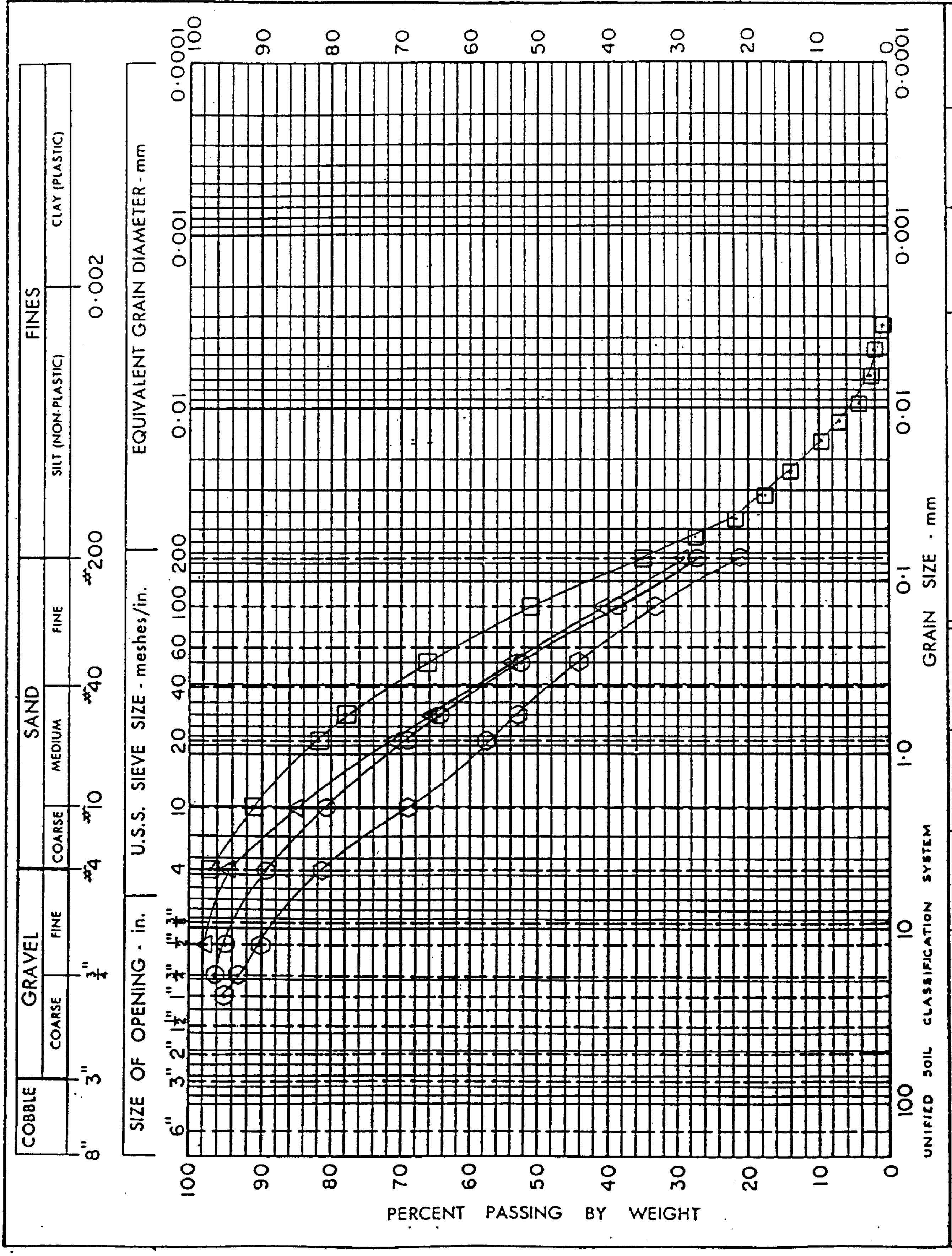
LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION

PROPOSED PHASE 1 TMF RETENTION STRUCTURES

APPENDIX II

FIG. NO. 2



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 4 No.1	0.6-1.2m	⊙
SILTY SAND TRACE GRAVEL	TP 5 No.1	0.9-1.2m	⊡
SILTY SAND TRACE GRAVEL	TP 6 No.1	0.6-1.2m	△
SILTY SAND SOME GRAVEL	TP 7 No.1	0.9-1.2m	⊙

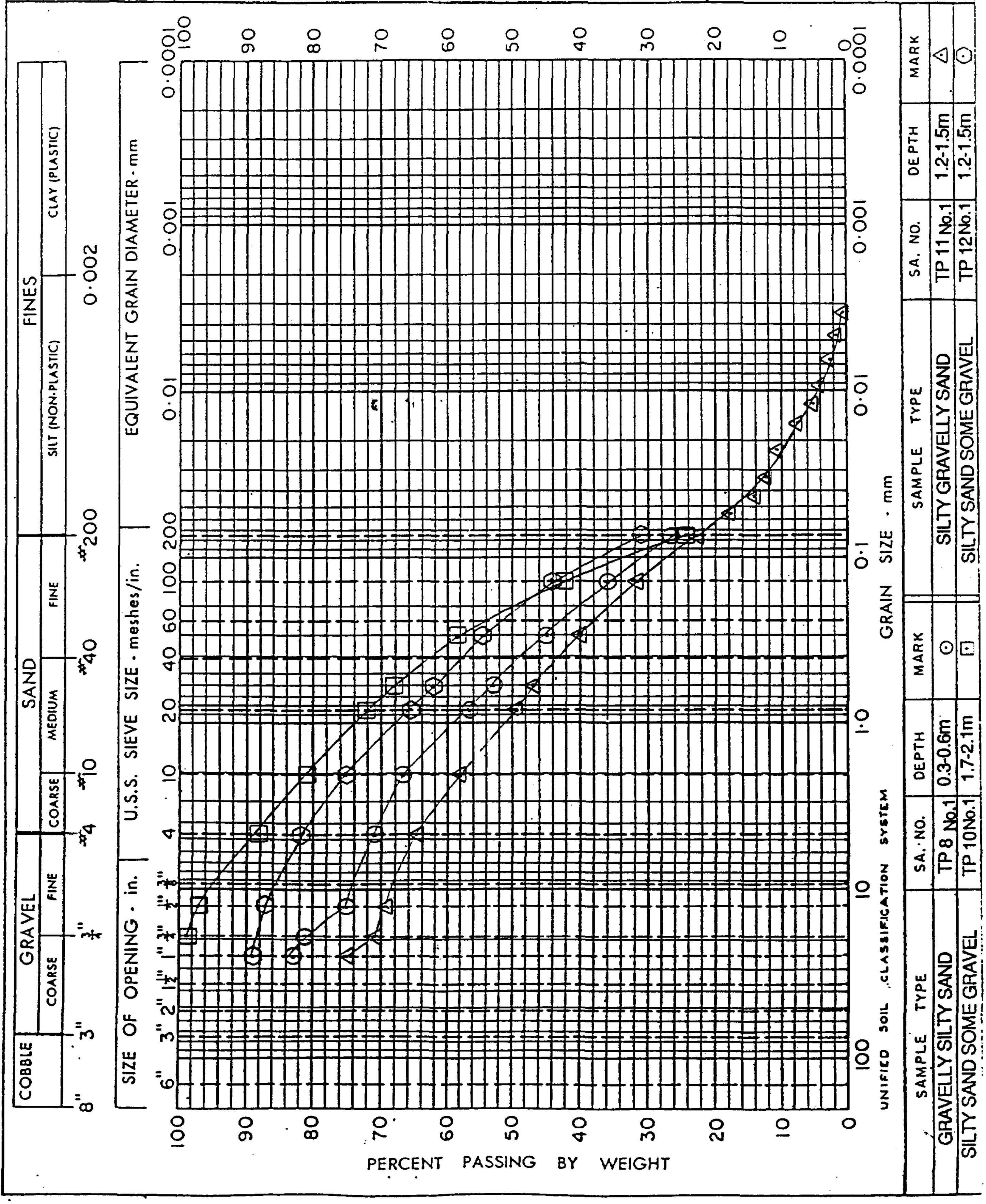
LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION

PROPOSED PHASE 1 TMF RETENTION STRUCTURES

APPENDIX II

FIG. NO. 3



SAMPLE TYPE	SA. NO.	DEPTH	MARK
GRAVELLY SILTY SAND	TP 8 No.1	0.3-0.6m	⊙
SILTY SAND SOME GRAVEL	TP 10No.1	1.7-2.1m	⊡

SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY GRAVELLY SAND	TP 11 No.1	1.2-1.5m	△
SILTY SAND SOME GRAVEL	TP 12 No.1	1.2-1.5m	⬡

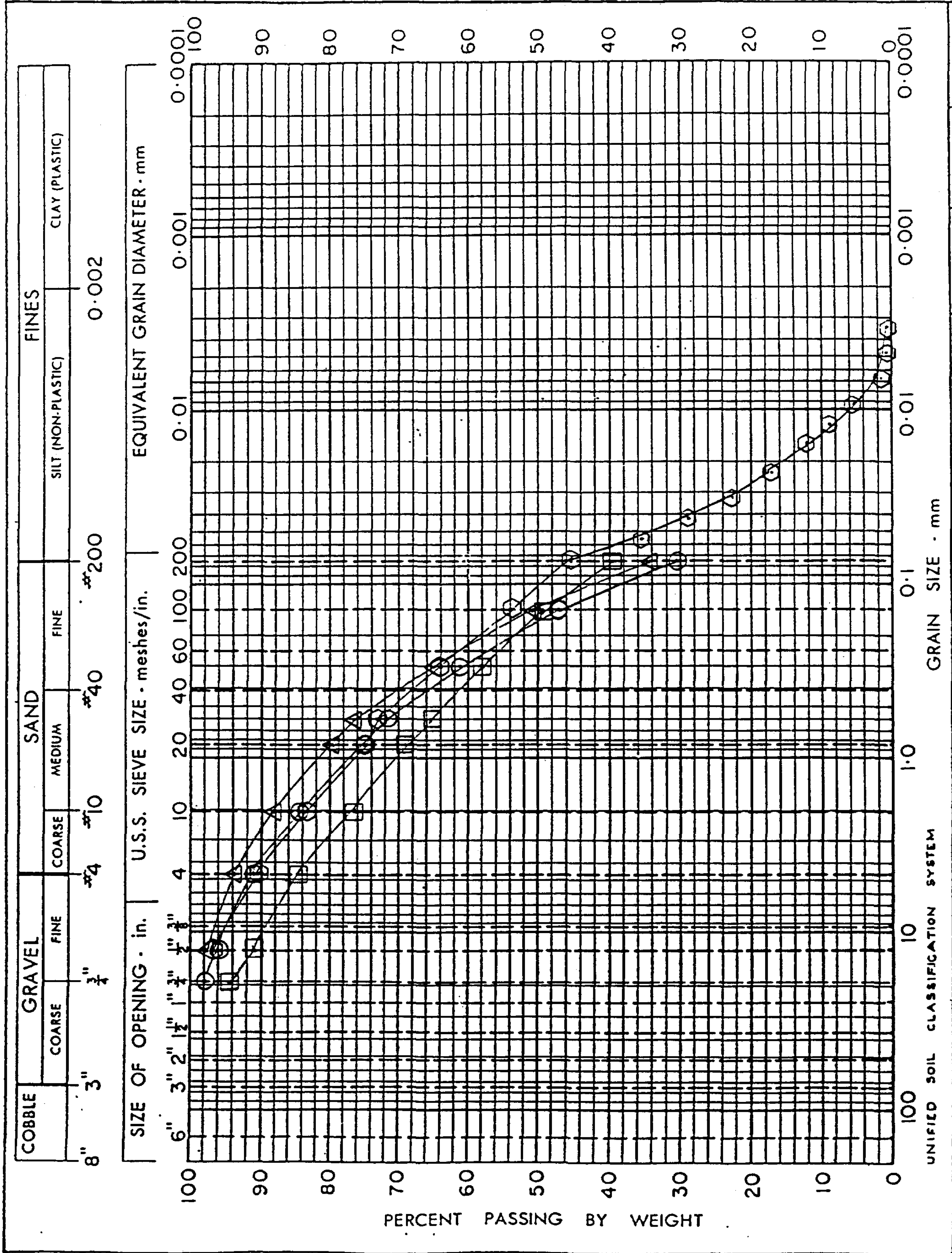
LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION

PROPOSED PHASE 1 TMF RETENTION STRUCTURES

APPENDIX II

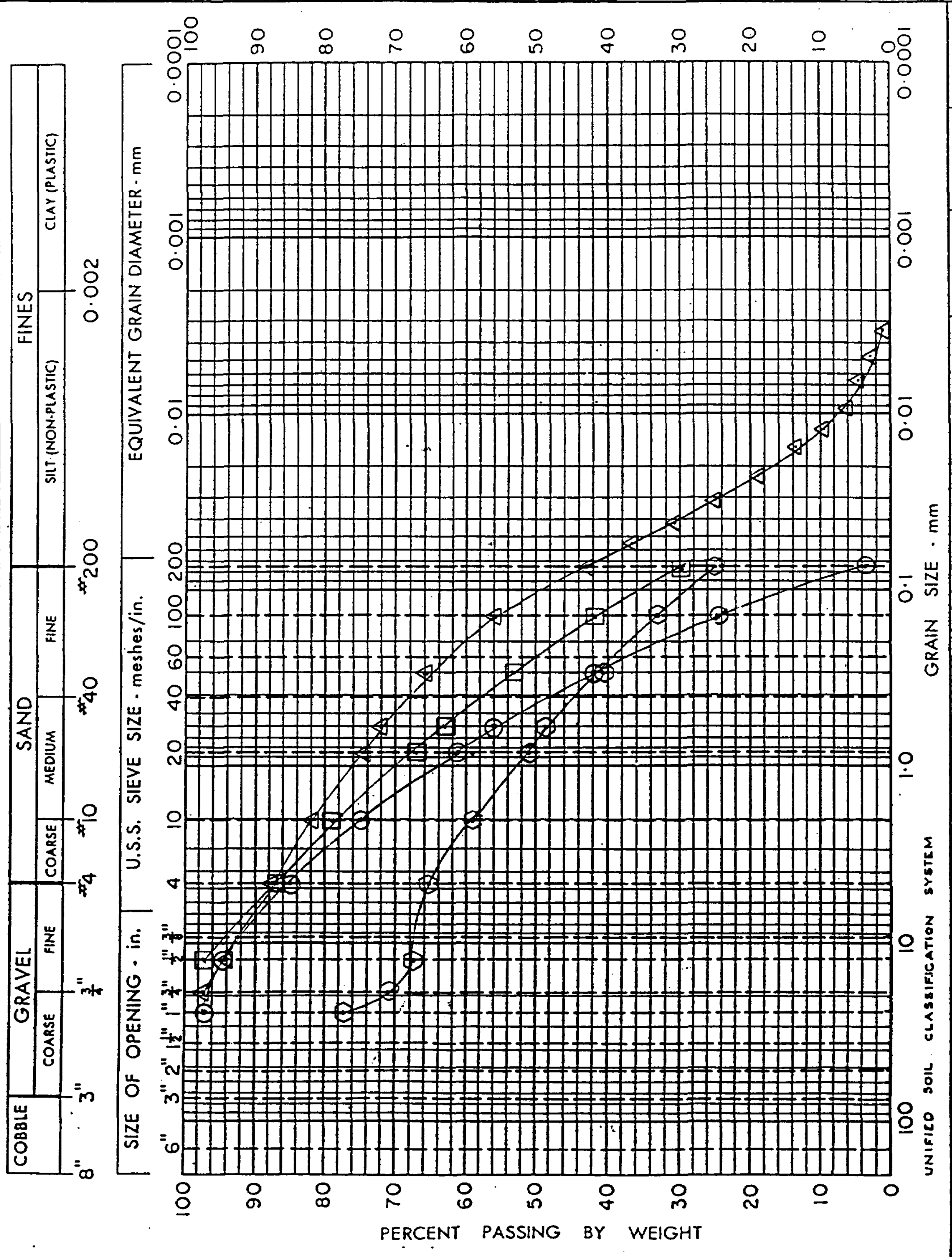
FIG. NO. 4



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND TRACE GRAVEL	TP 13 No.1	1.5-1.8m	⊙
SAND AND SILT SOME GRAVEL	TP 14 No.1	1.1-1.4m	□
SILTY SAND TRACE GRAVEL	TP 14 No.2	2.1-2.4m	△
SILT AND SAND TRACE GRAVEL	TP 15 No.1	1.2-1.5m	⬡

LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION	APPENDIX II
PROPOSED PHASE 1 TMF RETENTION STRUCTURES	FIG. NO. 5



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND SOME GRAVEL TRACE SILT	TP 16 No.1	1.8-2.1m	⊙
SILTY SAND SOME GRAVEL	TP 17 No.1	1.5-1.8m	⊡
SAND AND SILT SOME GRAVEL	TP 18 No.1	0.3-0.6m	△
SILTY SAND AND GRAVEL	TP 19 No.1	0.3-0.6m	⊙

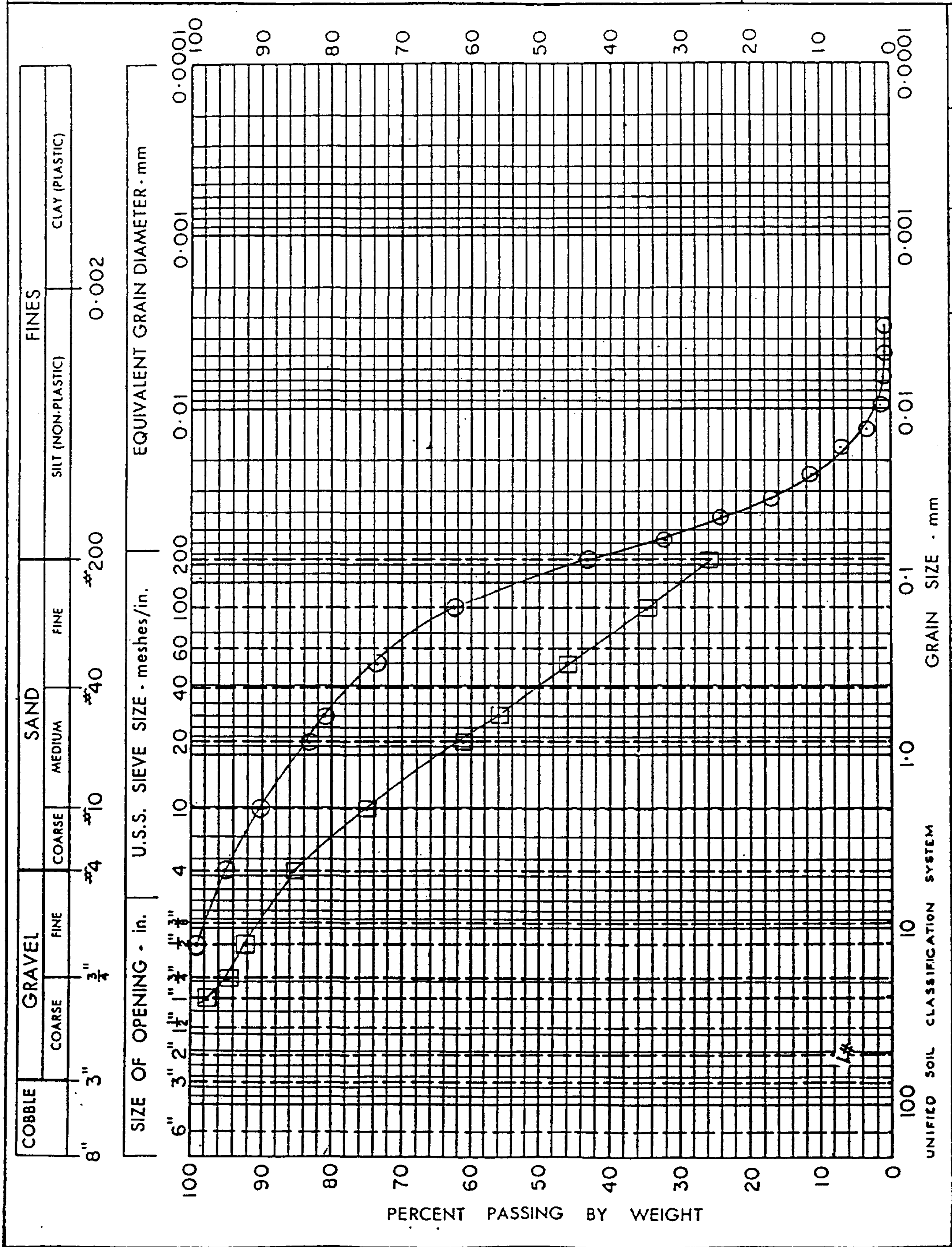
LAC DES ILES FOUNDATION SOILS

GRAIN SIZE DISTRIBUTION

PROPOSED PHASE 1 TMF RETENTION STRUCTURES

APPENDIX II

FIG. NO. 6

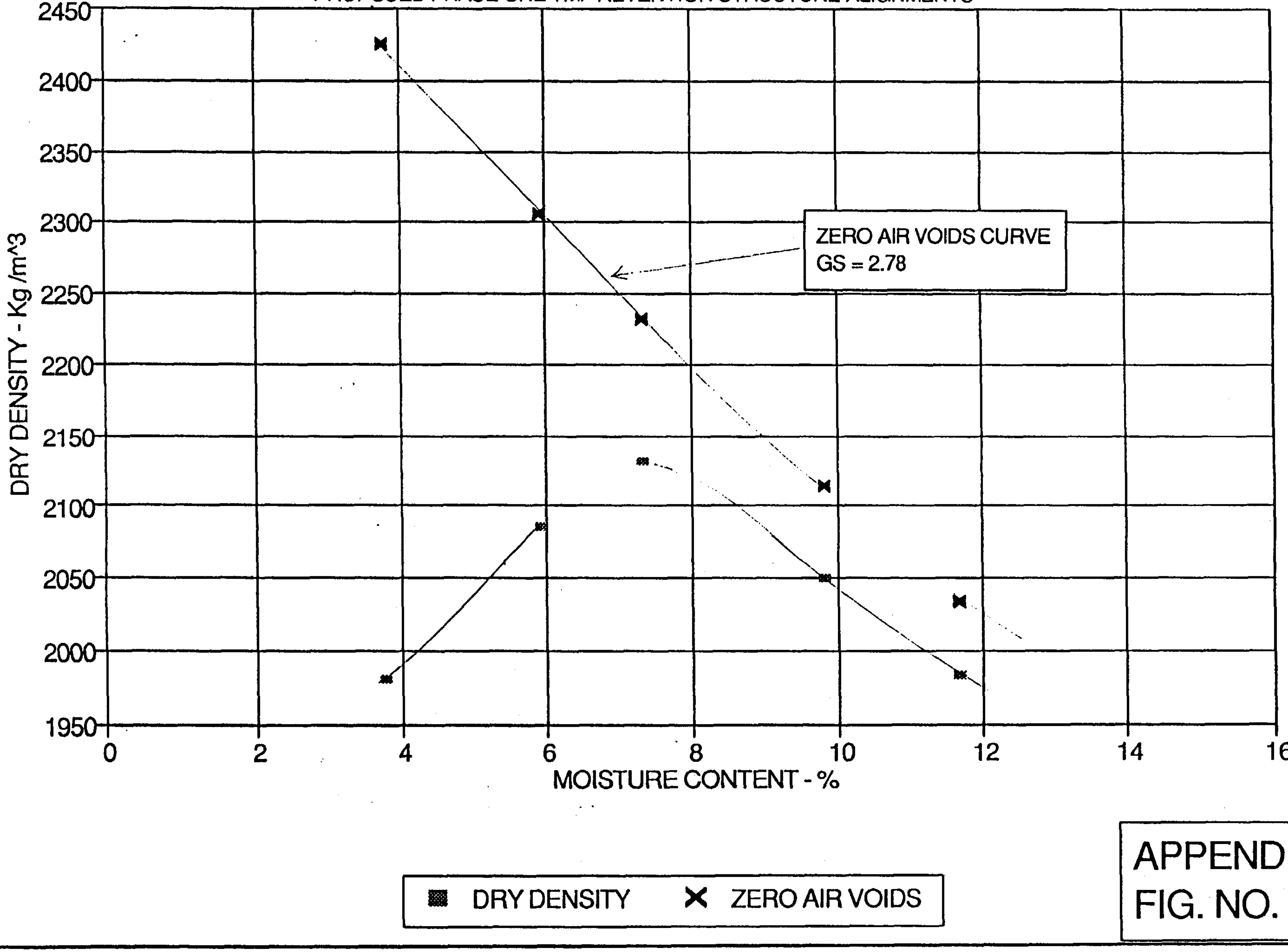


SAMPLE TYPE	SA. NO.	DEPTH	MARK
			△
			⊙

SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND AND SILT TRACE GRAVEL	TP 20, No.1	1.8-2.1m	⊙
SILTY SAND SOME GRAVEL	TP 23, No.1	0.3-0.6m	◻

STANDARD PROCTOR COMPACTION CURVE
SILTY SAND TRACE GRAVEL TP4 #1

PROPOSED PHASE ONE TMF RETENTION STRUCTURE ALIGNMENTS



APPENDIX II
FIG. NO. 7

APPENDIX III

BORROW INVESTIGATIONS
TEST PIT LOGS AND SOIL TESTING RESULTS

(Tables 1 through 28)

(Figures 1 through 16)

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH WEST CAMP LAKE SITE

APPENDIX III

TABLE 1

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	
.09-.46	RED BROWN SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	RED BROWN COLOUR DUE TO OXIDIZATION
.46-.76	GREY SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	
.76	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	W.T. @ .15M
.09-.46	RED BROWN SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	RED BROWN COLOUR DUE TO OXIDIZATION
.46-.61	GREY SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	
.61	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	
.09-.52	RED BROWN SILTY SAND WITH SOME GRAVEL. 40% COBBLES AND BOULDERS	RED BROWN COLOUR DUE TO OXIDIZATION
.52-2.13	GREY SILTY SAND WITH SOME GRAVEL. 40% COBBLES AND BOULDERS W.C.=7.8%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
1.37-2.13	BEDROCK, GABBROIC COMPLEX, SMOOTH SLOPING SURFACE	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH WEST CAMP LAKE SITE

APPENDIX III

TABLE 2

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	
.09-.46	RED BROWN SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	RED BROWN COLOUR DUE TO OXIDIZATION
.46-6.10	GREY SILTY SAND, SOME GRAVEL. 25% COBBLES AND BOULDERS	LOCALIZED PERCHED W.T.s @4.42 & 5.49 M
	W.C.=7.6% &8.5%,HAZEN k=9.0E-4cm/s.PERMEABILITY k=2.0E-5cm/s (SAMPLES No.1 and No.2)	SAMPLE No.1: 2.4-3.0M DEPTH
	PROCTOR MAX DENSITY = 2160 kg/m^3 @ 7% w.c. (SAMPLE No.1)	SAMPLE No.2: 4.5-4.9M DEPTH
6.10	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.09	ORGANICS	W.T. @ .76M
.09-.61	RED BROWN GRAVELLY SILTY SAND. 25% COBBLES AND BOULDERS	RED BROWN COLOUR DUE TO OXIDIZATION
.61-1.68	GREY GRAVELLY SILTY SAND. 25% COBBLES AND BOULDERS	
	W.C.=12.0%,HAZENk=1.0-3cm/s (SAMPLE No.1)	
1.68	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.3	TOPSOIL AND BOULDERS	
.3-5.49	GREY SAND WITH SOME GRAVEL AND SILT. BOULDERS PRESENT	W.T.@1.52M
	W.C.=7.4%, HAZEN k=1.0E-3 cm/s (SAMPLE No.1)	
5.49	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH WEST CAMP LAKE SITE

APPENDIX III

TABLE 3

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.46	RED BROWN GRAVELLY SILTY SAND.	
.46-.61	GREY GRAVELLY SILTY SAND.	
.61	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 5.79M
.30-6.10	GREY SILTY SAND WITH TRACE GRAVEL. 25% BOULDERS	
	W.C.=7.4%, HAZEN k=3.2E-4 cm/s (SAMPLE No.1)	
6.10	BEDROCK, GABBROIC COMPLEX, UNEVEN SURFACE	
	END OF TEST PIT	

TEST PIT NO. 9

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH TRACE GRAVEL. 25% BOULDERS	
.61-1.22	GREY MOIST SILTY SAND WITH TRACE GRAVEL. 25% BOULDERS	
1.22	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH WEST CAMP LAKE SITE

APPENDIX III

TABLE 4

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.76	RED BROWN TO GREY MOIST SILTY SAND WITH TRACE GRAVEL.	
.76	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL, SOME BOULDERS	
.30-.76	RED BROWN TO GREY SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
.76	BEDROCK	
	END OF TEST PIT	

TEST PIT NO.

DEPTH (FEET)	DESCRIPTION	REMARKS

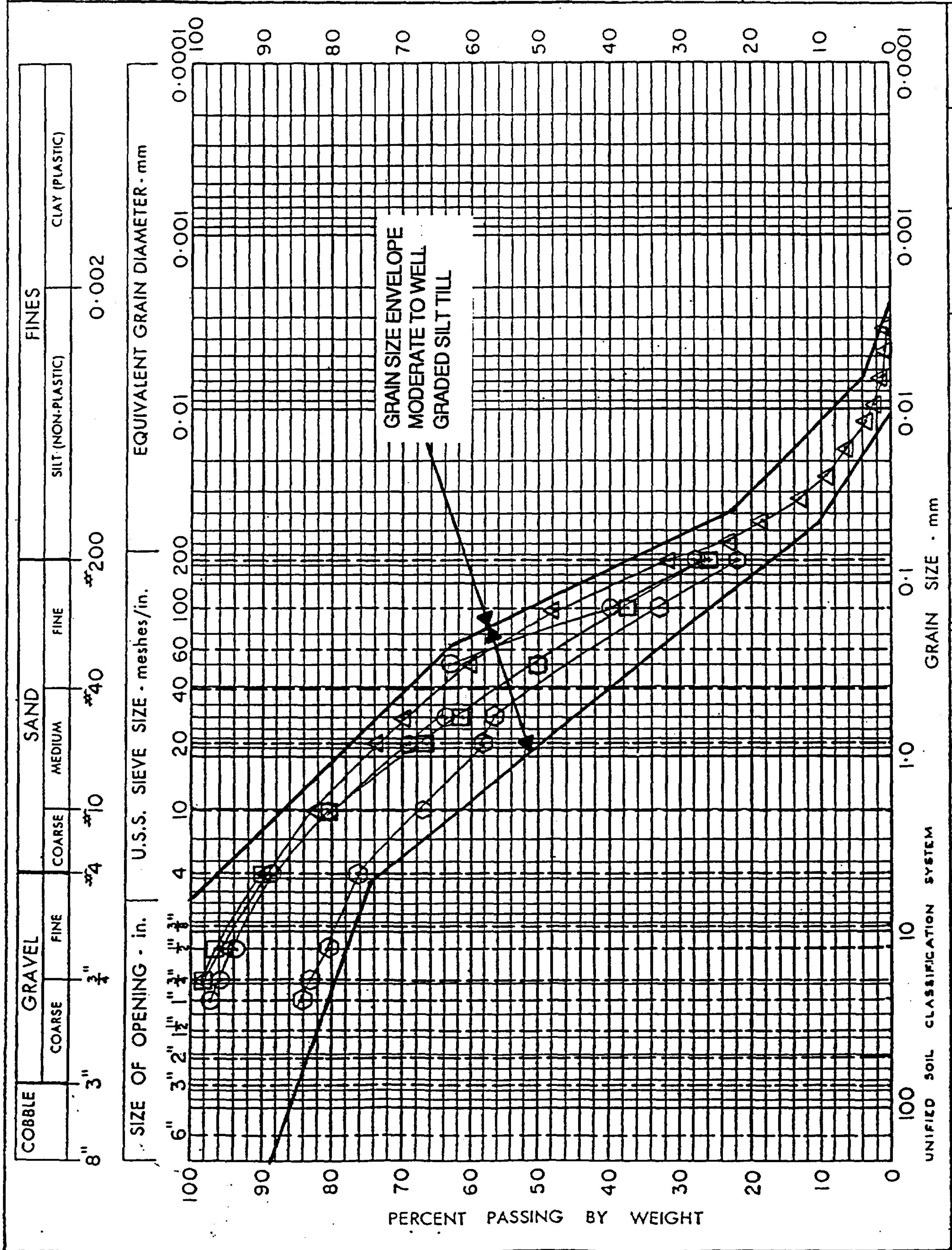
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH WEST CAMP LAKE SITE

APPENDIX III

FIG. NO. 1



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 4 No.2	4.5-4.9m	△
GRAVELLY SILTY SAND	TP 5 No.1	1.2-1.5m	⊙

SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 3 No.1	1.5-1.8m	⊙
SILTY SAND SOME GRAVEL	TP 4 No.1	2.4-3.0m	⊡

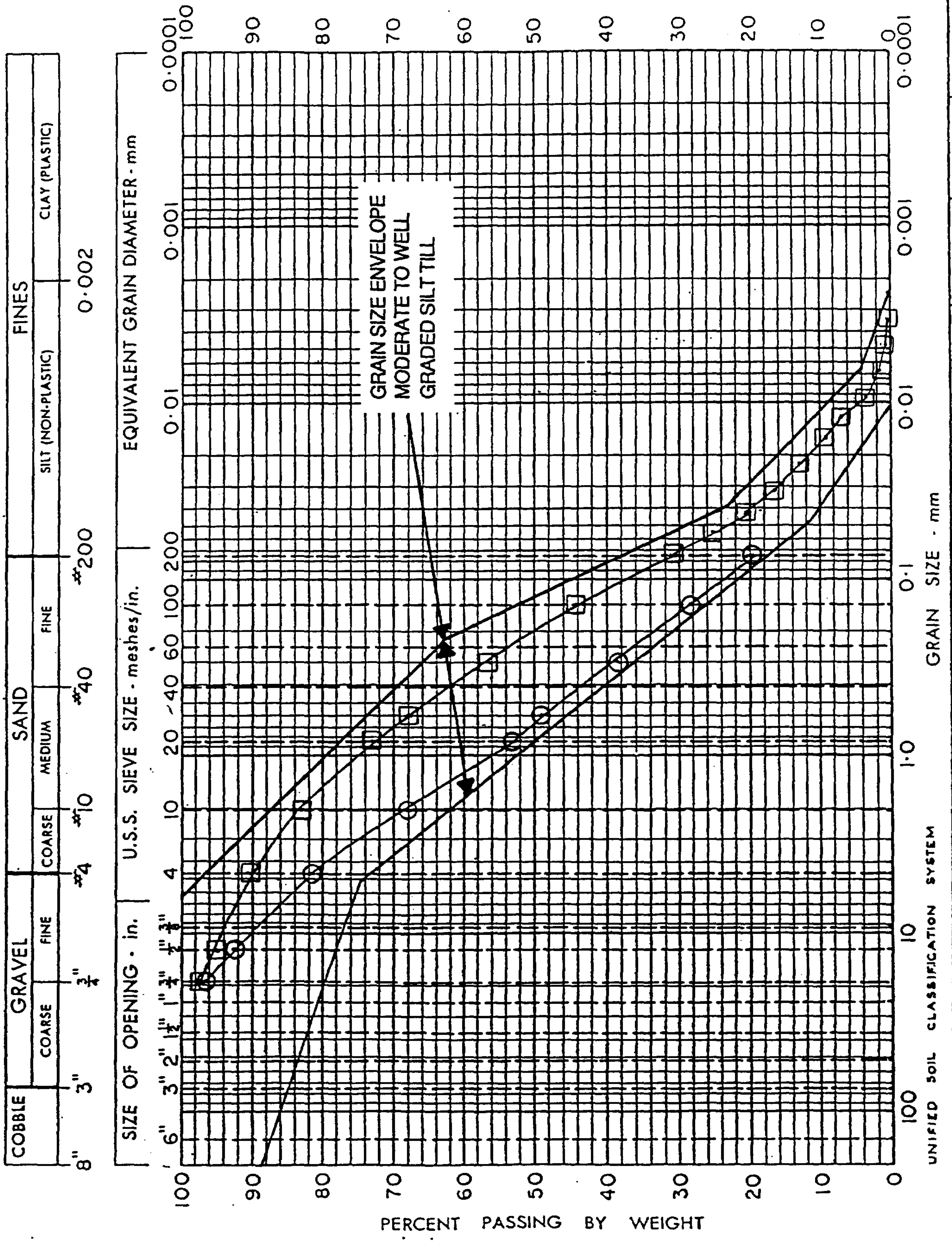
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH WEST CAMP LAKE SITE

APPENDIX III

FIG. NO. 2



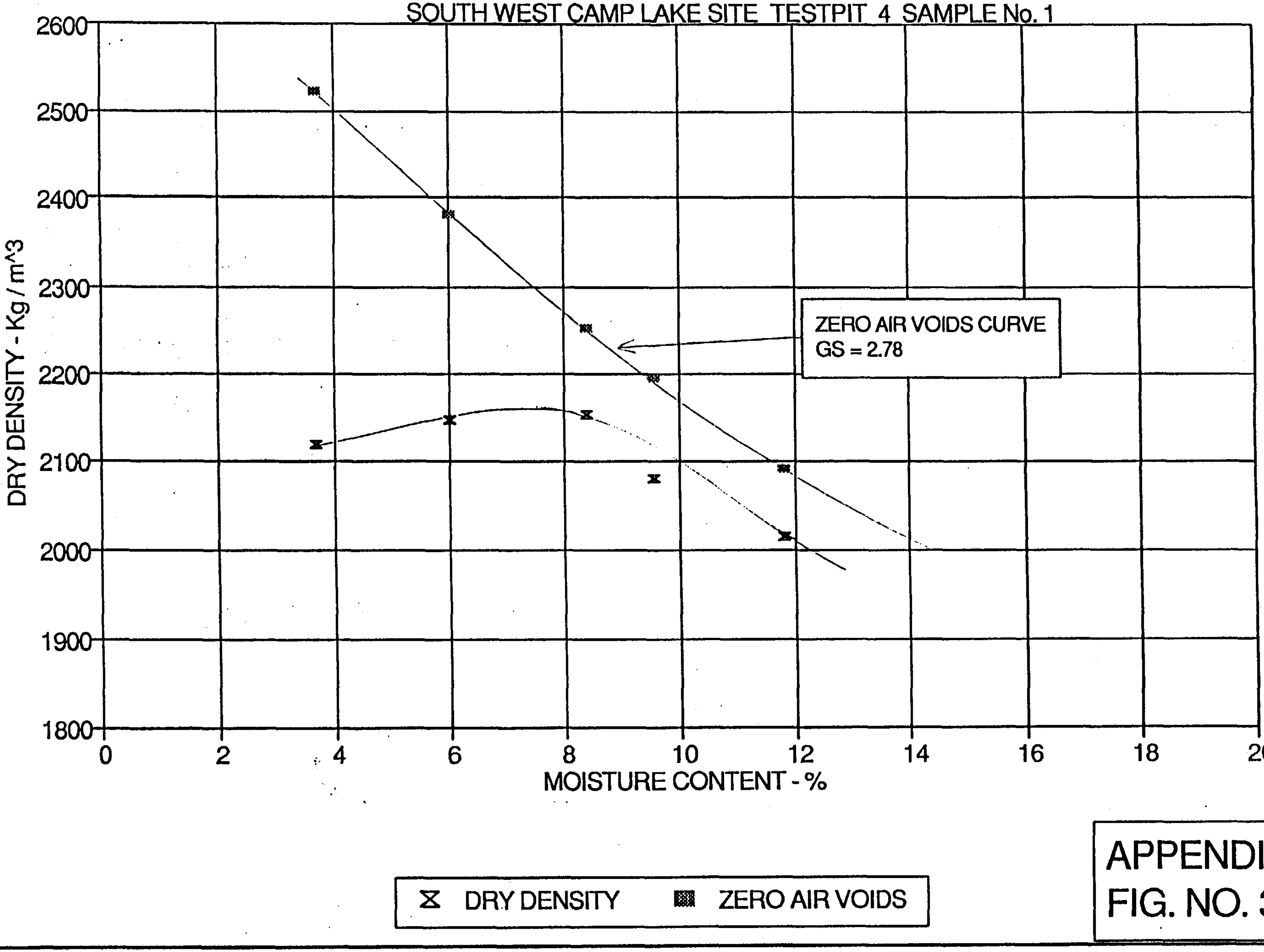
SAMPLE TYPE	SA. NO.	DEPTH	MARK
			△
			⊙

SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 6 No.1	2.7-3.0m	⊙
SILTY SAND TRACE GRAVEL	TP 8 No.1	2.7-3.0m	□

STANDARD PROCTOR COMPACTION CURVE

SILTY SAND SOME GRAVEL

SOUTH WEST CAMP LAKE SITE TESTPIT 4 SAMPLE No. 1



APPENDIX III
FIG. NO. 3

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
WEST CAMP LAKE SITE

APPENDIX III

TABLE 5

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.76	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.76	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.61	TOPSOIL AND BOULDERS	W.T. @ .76M
.61-.92	RED BROWN SILTY GRAVELLY SAND. BOULDERS PRESENT	
.92-1.98	WET DENSE GREY SILTY SAND WITH SOME GRAVEL.	
1.83-1.92	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.92	TOPSOIL AND MUSKEG	W.T. @ .76M
.92-1.22	MOIST DENSE GREY SILTY SAND WITH TRACE GRAVEL.	
1.22	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
WEST CAMP LAKE SITE

APPENDIX III

TABLE 6

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND MUSKEG	W.T. @ .61M
.30-1.07	MOIST GREY SILTY SAND AND TRACE GRAVEL.	
.92-1.07	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .76M
.30-.61	RED BROWN SILTY GRAVELLY SAND. BOULDERS PRESENT	
.61-1.22	FIRM GREY SILTY SAND WITH SOME GRAVEL.	
.76-1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .61M
.30-.61	BOULDERS	
.61	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
WEST CAMP LAKE SITE

APPENDIX III

TABLE 7

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .61M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.52	MOIST GREY SILTY SAND WITH SOME GRAVEL.	
1.52	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	TOPSOIL	
.15	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 9

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.46	TOPSOIL AND BOULDERS	
.46	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
WEST CAMP LAKE SITE

APPENDIX III

TABLE 8

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 12

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .46M
.30-.76	RED BROWN SILTY SAND WITH TRACE GRAVEL.	
.76	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
WEST CAMP LAKE SITE

APPENDIX III

TABLE 9

TEST PIT NO. 13

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND MUSKEG	W.T. @ .46M
.30-.92	BOULDERS AND WET BLACK MUSKEG	
.92	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 14

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ .30M
.30-.61	RED BROWN SILTY SAND WITH TRACE GRAVEL	
.61	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 15

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ .30M
.30-.46	RED BROWN SILTY SAND WITH TRACE GRAVEL.	
.46	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH EAST CAMP LAKE SITE

APPENDIX III

TABLE 10

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.61-4.57	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	SAMPLE No.1: 2.4 - 3.0M DEPTH
	W.C.=6.5% & 12.6, HAZEN k=7.8E-4 & 6.3E-4 cm/s (SAMPLES No.1 and No.2)	SAMPLE No.2: 3.4 - 3.7M DEPTH
4.57	BEDROCK	
	END OFTEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 3.05M
.30-.92	RED BROWN SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
.92-6.40	MOIST GREY SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	SAMPLE No.1: 2.7 - 3.0M DEPTH
	W.C.=14.8% & 12.6%, HAZEN k=2.0E-4 &7.8E-4 cm/s (SAMPLES No.1 AND No.2)	SAMPLE No.2: 6.1 - 6.4M DEPTH
6.40	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND AND GRAVEL. BOULDERS PRESENT	
.61-1.83	GREY SILTY SAND AND GRAVEL. BOULDERS PRESENT	
	W.C.=9.0%, HAZEN k=6.2E-3 cm/s (SAMPLE No.1)	
1.83	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH EAST CAMP LAKE SITE

APPENDIX III

TABLE 11

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-2.13	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
	W.C.=9.2%, HAZEN k=5.8E-4 cm/s (SAMPLE No.1)	
2.13	BEDROCK	
	END OFTEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.61	RED BROWN GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT	
.61-1.07	BROWN TO GREY GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT	
	W.C.=11.0%, HAZEN k=2.5E-4 cm/s (SAMPLE No.1)	
.92-1.07	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.83	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
	W.C.=9.0%, HAZEN k=4.0E-4 cm/s (SAMPLE No.1)	
1.83	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH EAST CAMP LAKE SITE

APPENDIX III

TABLE 12

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.52	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT W.C.=9.3%, HAZEN k=5.8E-4cm/s (SAMPLE No.1)	
1.22-1.52	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ .92M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.22	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.92-1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 9

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.22	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
1.22	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH EAST CAMP LAKE SITE

APPENDIX III

TABLE 13

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.22	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
61-1.22	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.92-1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 12

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.22	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
1.22	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH EAST CAMP LAKE SITE

APPENDIX III

TABLE 14

TEST PIT NO. A

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 4.57M
.30-.92	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.92-6.71	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT W.C.=8.9%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
6.71	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. B

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.92	RED BROWN SAND AND GRAVEL WITH SOME SILT. BOULDERS PRESENT	
.92-2.13	BROWN TO GREY SAND AND GRAVEL WITH SOME SILT. BOULDERS PRESENT W.C.=11.2%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
1.98-2.13	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. C

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.31	TOPSOIL AND BOULDERS	
.31-1.37	RED BROWN TO GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.31-1.37	BEDROCK	
	END OF TEST PIT	

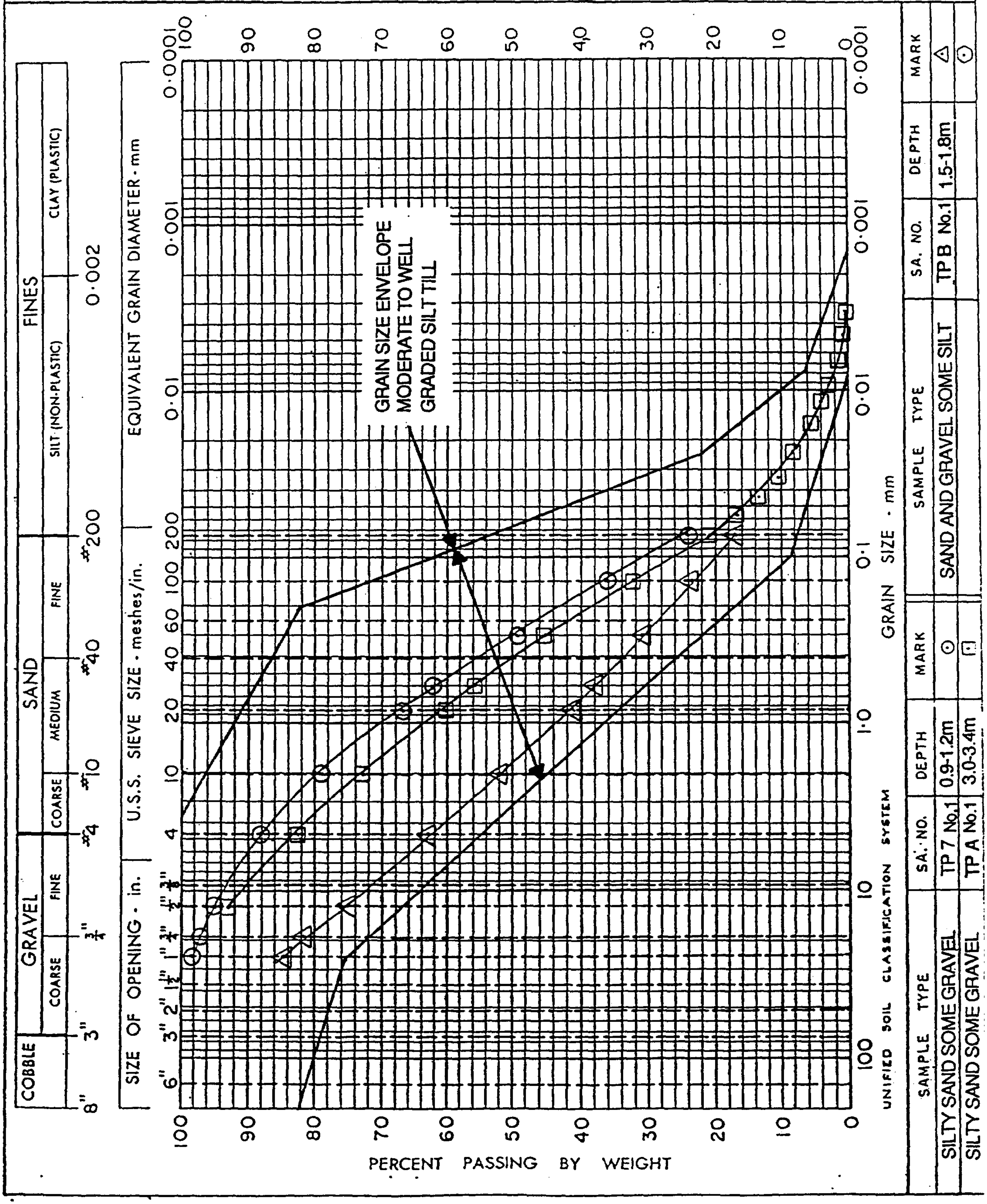
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH EAST CAMP LAKE SITE

APPENDIX III

FIG. NO. 4



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 7 No.1	0.9-1.2m	⊙
SILTY SAND SOME GRAVEL	TP A No.1	3.0-3.4m	▵
SAND AND GRAVEL SOME SILT	TP B No.1	1.5-1.8m	☐

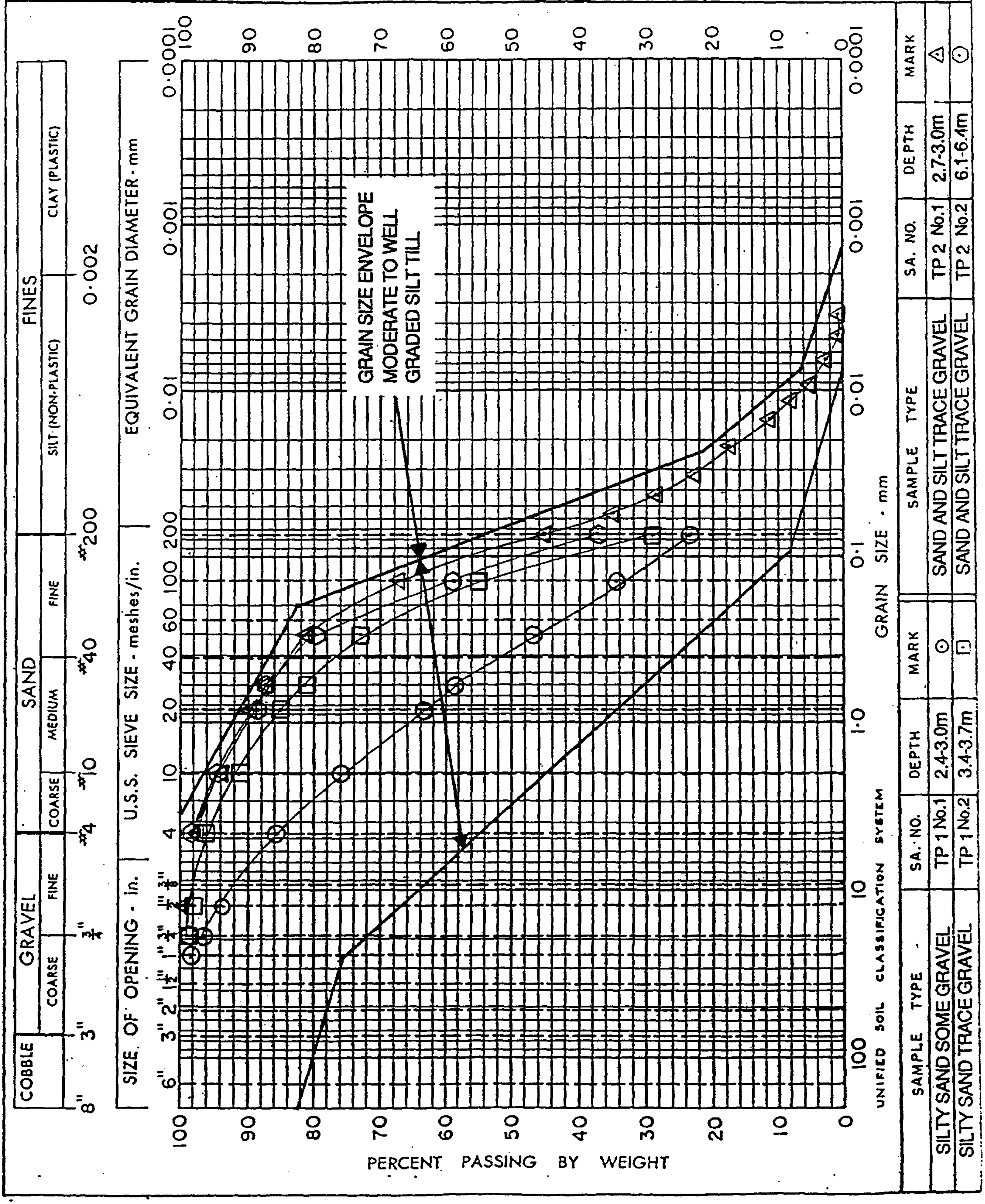
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH EAST CAMP LAKE SITE

APPENDIX III

FIG. NO. 5



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND AND SILT TRACE GRAVEL	TP 2 No.1	2.7-3.0m	△
SAND AND SILT TRACE GRAVEL	TP 2 No.2	6.1-6.4m	⊙

SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND SOME GRAVEL	TP 1 No.1	2.4-3.0m	⊙
SILTY SAND TRACE GRAVEL	TP 1 No.2	3.4-3.7m	□

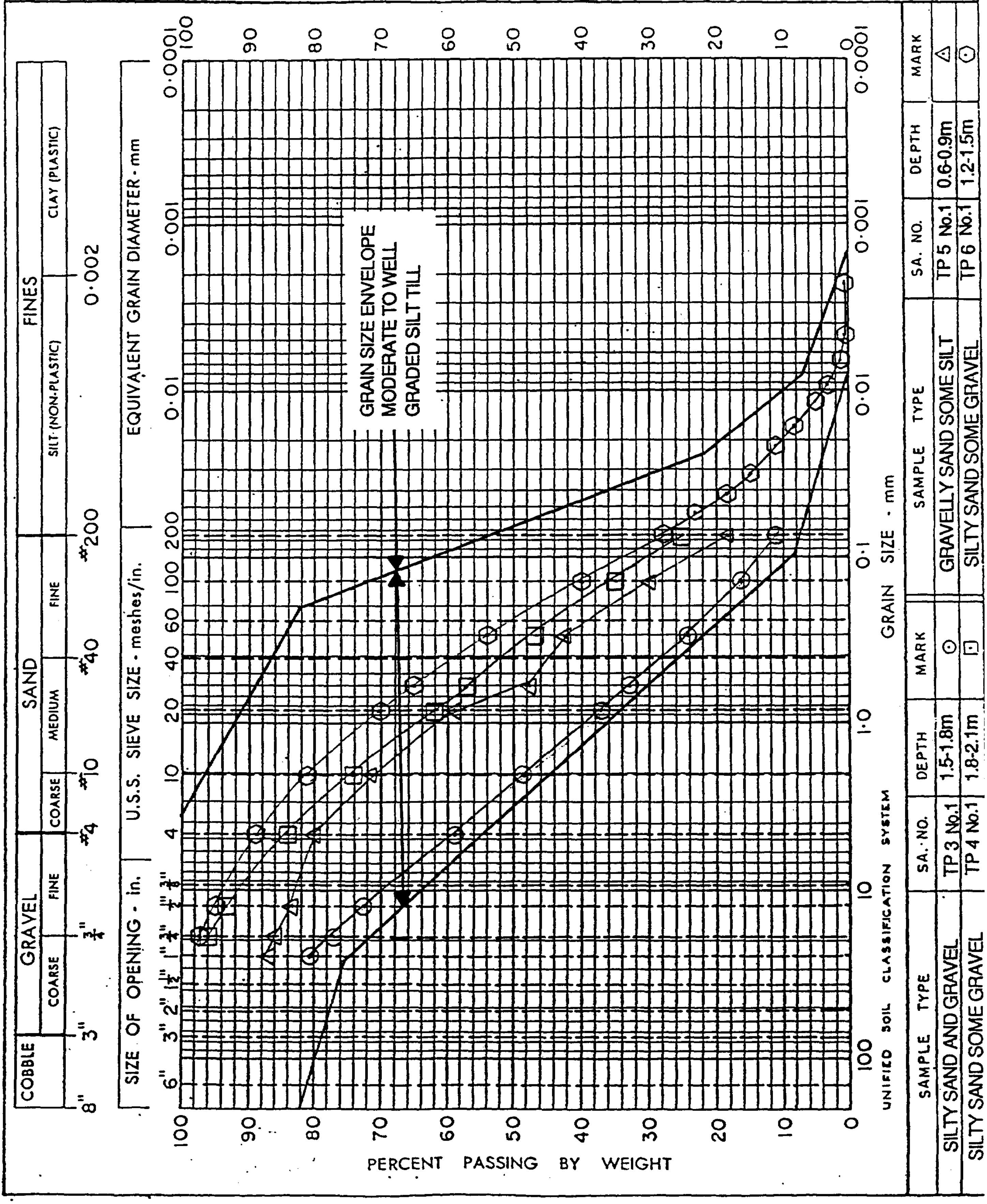
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH EAST CAMP LAKE SITE

APPENDIX III

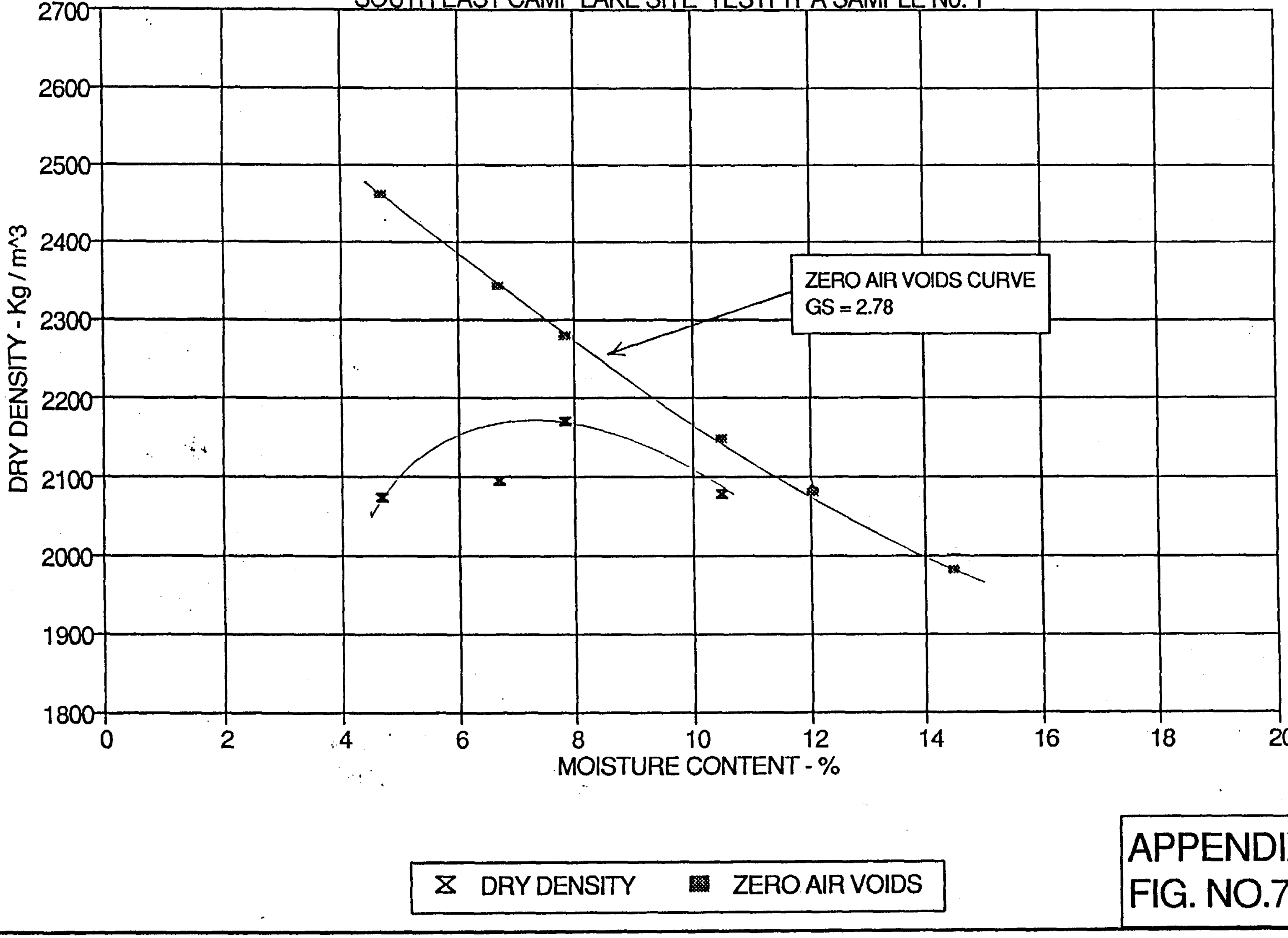
FIG. NO. 6



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILTY SAND AND GRAVEL	TP 3 No.1	1.5-1.8m	⊙
SILTY SAND SOME GRAVEL	TP 4 No.1	1.8-2.1m	⊡
GRAVELLY SAND SOME SILT	TP 5 No.1	0.6-0.9m	△
SILTY SAND SOME GRAVEL	TP 6 No.1	1.2-1.5m	⬡

STANDARD PROCTOR COMPACTION CURVE
SILTY SAND SOME GRAVEL

SOUTH EAST CAMP LAKE SITE TESTPIT A SAMPLE No. 1



APPENDIX III
FIG. NO.7

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH CAMP LAKE SITE

APPENDIX III

TABLE 15

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL.	SURFACE OXIDIZATION ABOVE
.61-1.07	MOIST GREY SILTY SAND WITH SOME GRAVEL.	WATER TABLE
1.07	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-61	RED BROWN SILTY SAND WITH SOME GRAVEL.	SURFACE OXIDIZATION ABOVE
.61-1.07	MOIST GREY SILTY SAND WITH SOME GRAVEL.	WATER TABLE
1.07	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.06	TOPSOIL	
.06	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH CAMP LAKE SITE

APPENDIX III

TABLE 16

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.92	RED BROWN TO GREY SILTY SAND WITH SOME GRAVEL.	
.92	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.76	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.76	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.92	RED BROWN GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT	
.92-1.98	MOIST GREY GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT W.C.=7.5%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	
1.83-1.98	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH CAMP LAKE SITE

APPENDIX III

TABLE 17

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.76	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.76-1.07	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.92-1.07	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ 1.88M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.61-1.98	MOIST GREY SILTY SAND WITH SOME GRAVEL. W.C.=13.4%, HAZEN k=3.6E-4 cm/s (SAMPLE No.1)	
.76-1.98	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 9

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.92	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.92	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
SOUTH CAMP LAKE SITE

APPENDIX III

TABLE 18

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.76	RED BROWN GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT	
.76-3.05	MOIST GREY GRAVELLY SAND WITH SOME SILT. BOULDERS PRESENT W.C.=11.2%, HAZEN k=2.6E-3 cm/s (SAMPLE No.1)	
3.05	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.76	RED BROWN SILTY SAND WITH SOME GRAVEL.	
.76	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 12

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.76	RED BROWN TO GREY SILTY SAND WITH SOME GRAVEL.	
.76	BEDROCK	
	END OF TEST PIT	

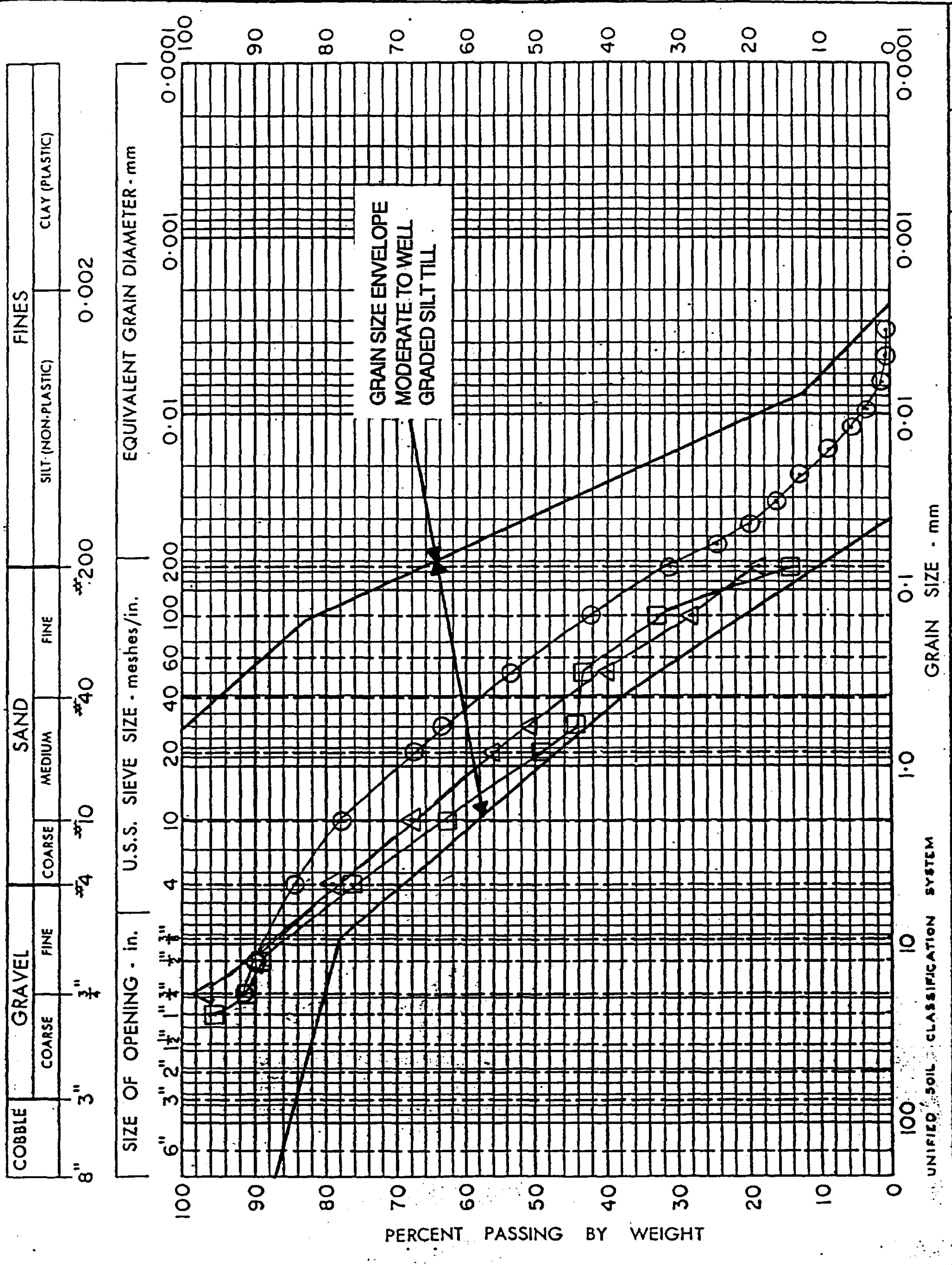
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

SOUTH CAMP LAKE SITE

APPENDIX III

FIG. NO. 8



SAMPLE TYPE	SA. NO.	DEPTH	MARK
GRAVELLY SAND SOME SILT	TP.6 No.1	1.5-1.8m	△
SILTY SAND SOME GRAVEL No.1	TP 8	0.8-2.0m	⊙
GRAVELLY SAND SOME SILT No.1	TP 10	1.8-2.1m	□

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
NORTH CAMP LAKE SITE

APPENDIX III

TABLE 19

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ .31M
.30-1.22	MUSKEG AND BOULDERS	
1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.92	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.92-1.22	GREY GRAVELLY SAND WITH SOME SILT.	
1.22	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.83	GREY GRAVELLY SAND WITH SOME SILT.	
1.83	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
NORTH CAMP LAKE SITE

APPENDIX III

TABLE 20

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-1.52	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
1.22-1.52	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
NORTH CAMP LAKE SITE

APPENDIX III

TABLE 21

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 2.44M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-4.27	MOIST GREY SAND WITH SOME GRAVEL AND TRACE SILT. BOULDERS PRESENT W.C.=10.8%, HAZEN k=6.4E-2 cm/s (SAMPLE No.1)	
3.96-4.27	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.15	TOPSOIL	
.15	BEDROCK	
	END OF TEST PIT	

TEST PIT NO.

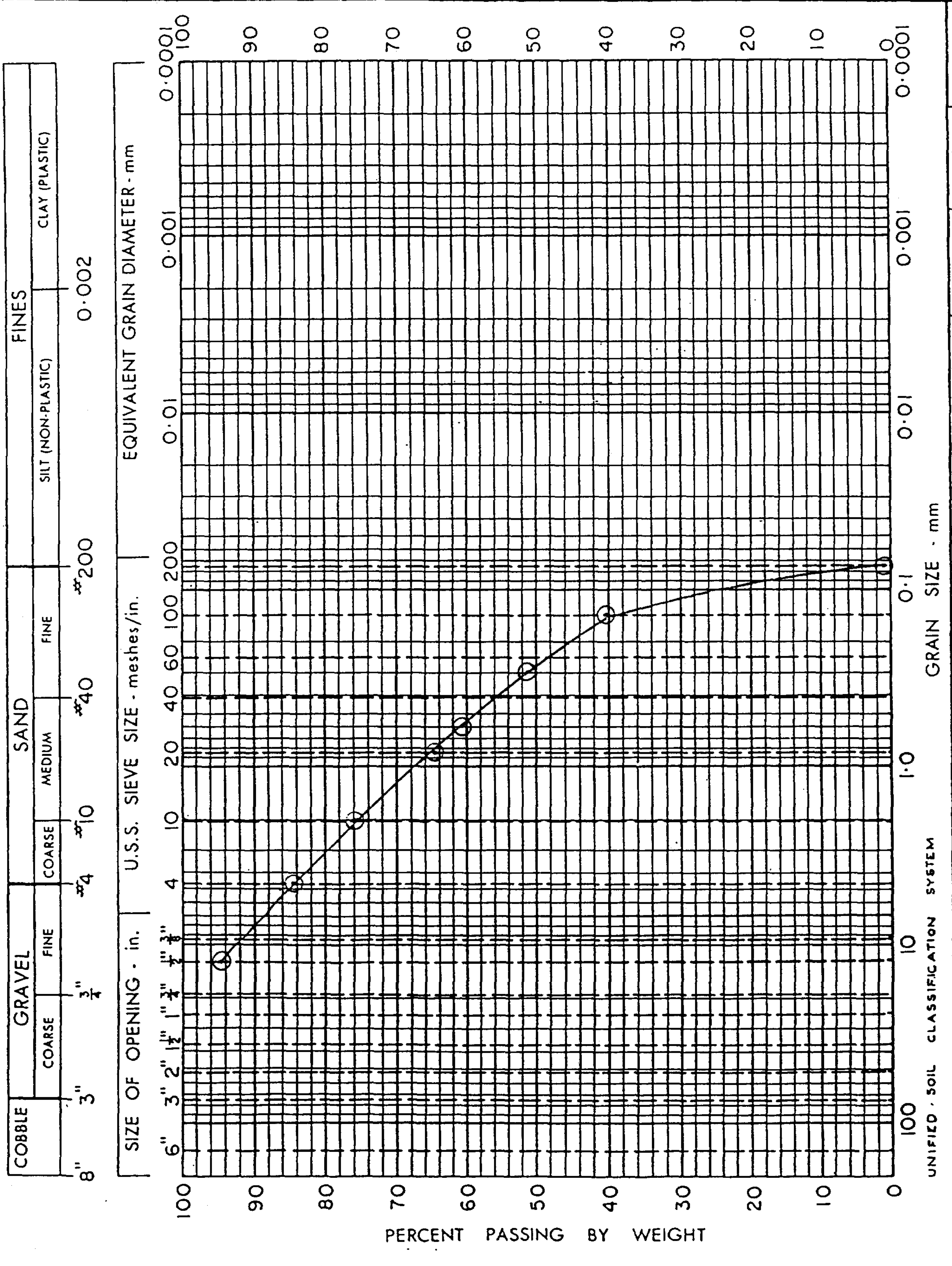
DEPTH (METRES)	DESCRIPTION	REMARKS

GRAIN SIZE DISTRIBUTION

NORTH CAMP LAKE SITE

APPENDIX III

FIG. NO. 9



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND SOME GRAVEL TRACE SILT	TP 7 No.1	1.8-2.1m	⊙
			⊡
			△
			⊙

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 22

TEST PIT NO. 1

DEPTH (METRES)	DESCRIPTION	REMARKS
0-1.98	GREY SANDY SILT WITH TRACE GRAVEL. SOME BOULDERS PRESENT	
	W.C.=13.8, HAZEN k=6.7E-5 cm/s, PERMEAMETER k=4.38E-5 cm/s (SAMPLE No. 1)	
1.98	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 2

DEPTH (METRES)	DESCRIPTION	REMARKS
0-1.52	FIBROUS MUSKEG	W.T. @ 1.37M
1.52-3.05	WET GREY SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	WATER FLOWED IN STRONGLY AT
	W.C.=13.6%, HAZEN k=6.4E-3 cm/s (SAMPLE No. 1)	BOULDER LAYER
3.05	BOULDERS	
	END OF TEST PIT	

TEST PIT NO. 3

DEPTH (METRES)	DESCRIPTION	REMARKS
0-?	MUSKEG	NOT DUG DUE TO ACCESS PROBLEMS

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 23

TEST PIT NO. 4

DEPTH (METRES)	DESCRIPTION	REMARKS
0-?	MUSKEG	NOT DUG DUE TO ACESS PROBLEMS

TEST PIT NO. 5

DEPTH (METRES)	DESCRIPTION	REMARKS
0-0.3	TOPSOIL AND MUSKEG	PERCHED W.T. @ .30 & 1.52M SIDES OF EXCAVATION UNSTABLE AND COLLAPSED WHILE OPEN
0.3-0.76	RED BROWN GRAVELLY SAND WITH SOME SILT	
.76-3.81	MOIST GREY GRAVELLY SAND WITH SOME SILT W.C.=6.8%, HAZEN k=2.2E-3 cm/s (SAMPLE No. 1)	
3.81	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 6

DEPTH (METRES)	DESCRIPTION	REMARKS
0-3.05	MUSKEG	PERCHED W.T. @ .30 & 1.68M SIDES OF EXCAVATION UNSTABLE AND DIGGING HAD TO BE HALTED
3.05-3.66	BOULDERS	
3.66-4.12	WET GREY SAND	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD
MAIN GATE SITE

APPENDIX III
TABLE 24

TEST PIT NO. 7

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ 1.83M
.30-.61	RED BROWN SAND WITH SOME SILT AND SOME GRAVEL. BOULDERS PRESENT	
.61-3.05	MOIST GREY SAND WITH SOME SILT AND SOME GRAVEL. BOULDERS PRESENT W.C.=7.0%, HAZEN k=2.3E-4 cm/s (SAMPLE No.1)	
3.05	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 8

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 2.13M
.30-.61	RED BROWN SILT AND SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-4.57	MOIST GREY SILT AND SAND WITH SOME GRAVEL. BOULDERS PRESENT W.C.=11.4%, HAZEN k=1.7E-4 cm/s (SAMPLE No.1)	
4.57	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 9

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-4.73	MOIST GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT. W.C.=10.2%, HAZEN k=1.1E-3 cm/s (SAMPLE No.1)	
4.42-4.73	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 25

TEST PIT NO. 10

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ 8.08M
0.3-0.61	RED BROWN SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
0.61-9.45	GREY SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
	W.C.=7.4%, HAZEN k=2.5E-3 cm/s (SAMPLE No.1)	
9.15-9.45	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 11

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-.61	RED BROWN SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
.61-1.98	MOIST GREY SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
	W.C.=18.3%, HAZEN k=4.4E-4 cm/s (SAMPLE No.1)	
1.83-1.98	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 12

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 3.81M
.30-.76	RED BROWN GRAVELLY SILTY SAND. BOULDERS PRESENT	BEDROCK SLOPING DOWNHILL
.76-4.57	MOIST GREY GRAVELLY SILTY SAND. BOULDERS PRESENT.	
	W.C.=7.8%, HAZEN k=1.3E-3 cm/s (SAMPLE No.1)	
4.12-4.57	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 26

TEST PIT NO. 13		
DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 1.98M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
.61-3.81	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	
	W.C.=12.0%, HAZEN k=1.7E-3 cm/s (SAMPLE No.1)	
3.66-3.81	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 14		
DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	
.30-1.37	RED BROWN TO GREY SAND WITH SOME SILT AND SOME GRAVEL. BOULDERS PRESENT	
	W.C.=15.2%, HAZEN k=4.9E-3 cm/s (SAMPLE No.1)	
1.22-1.37	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 15		
DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 1.68M
.30-.61	RED BROWN SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
.61-1.83	MOIST GREY SILT AND SAND WITH TRACE GRAVEL. BOULDERS PRESENT.	
	W.C.=19.8%, HAZEN k=7.3E-4 cm/s (SAMPLE No.1)	
.15-1.83	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 27

TEST PIT NO. 16

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	W.T. @ 3.66M
.30-.61	RED BROWN SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	W.T. ASSUMED TO BE HIGHER AS WATER
.61-4.88	GREY SILTY SAND WITH SOME GRAVEL. BOULDERS PRESENT	GUSHED IN" TO EXCAVATION AT
	W.C.=9.6%, HAZEN k=9.0E-4 cm/s (SAMPLE No.1)	THIS ELEVATION.
4.57-4.88	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 17

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL	
.30-.61	RED BROWN SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
.61-2.59	GREY SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
	W.C.=9.2%, HAZEN k=3.6E-4 cm/s (SAMPLE No.1)	
2.44-2.59	BEDROCK	
	END OF TEST PIT	

TEST PIT NO. 18

DEPTH (METRES)	DESCRIPTION	REMARKS
0-3.96	GREY SILTY SAND WITH TRACE GRAVEL. BOULDERS PRESENT	
3.66-3.96	BEDROCK	
	END OF TEST PIT	

SUMMARY OF TEST PITTING AND SAMPLE INFORMATION
LAC DES ILES MINES LTD.
MAIN GATE SITE

APPENDIX III

TABLE 28

TEST PIT NO. A

DEPTH (METRES)	DESCRIPTION	REMARKS
0-.30	TOPSOIL AND BOULDERS	W.T. @ 1.83M
.30-.76	RED BROWN SILTY GRAVELLY SAND. BOULDERS PRESENT	BEDROCK SLOPING DOWNHILL
.61-2.74	MOIST GREY SILTY GRAVELLY SAND. BOULDERS PRESENT	
	W.C.=9.5%, HAZEN k=1.6E-4 cm/s (SAMPLE No.1)	
2.44-2.74	BEDROCK	
	END OF TEST PIT	

TEST PIT NO.

DEPTH (METRES)	DESCRIPTION	REMARKS

TEST PIT NO.

DEPTH (METRES)	DESCRIPTION	REMARKS

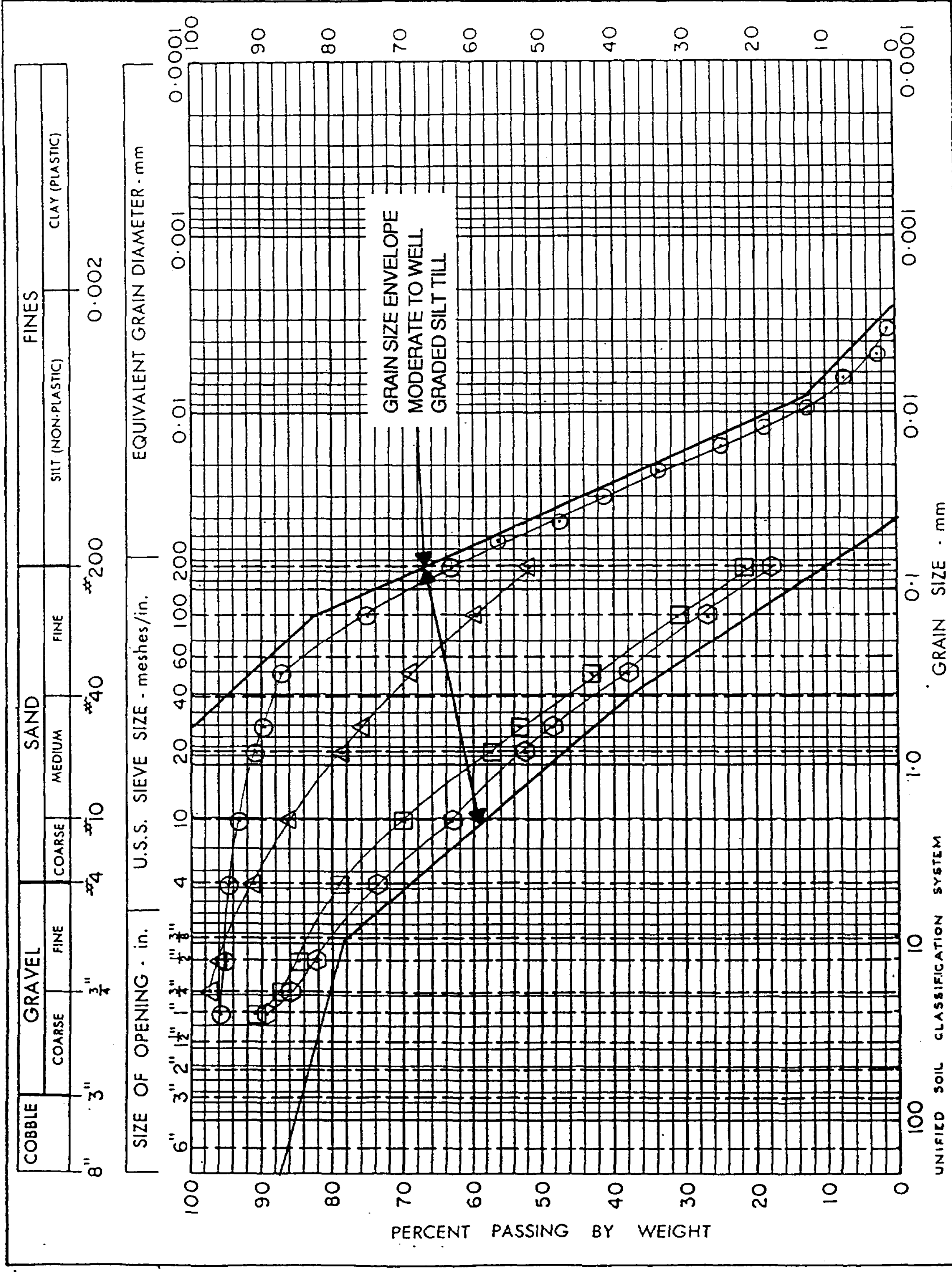
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

MAIN GATE SITE

APPENDIX III

FIG. NO. 10



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SANDY SILT TRACE GRAVEL	TP 1 No.1	1.5-1.8m	⊙
SILTY GRAVELLY SAND	TP A No.1	1.5-1.8m	⊡
SILT AND SAND TRACE GRAVEL	TP 2 No.1	2.1-2.4m	△
GRAVELLY SAND SOME SILT	TP 5 No.1	2.1-2.4m	⊙

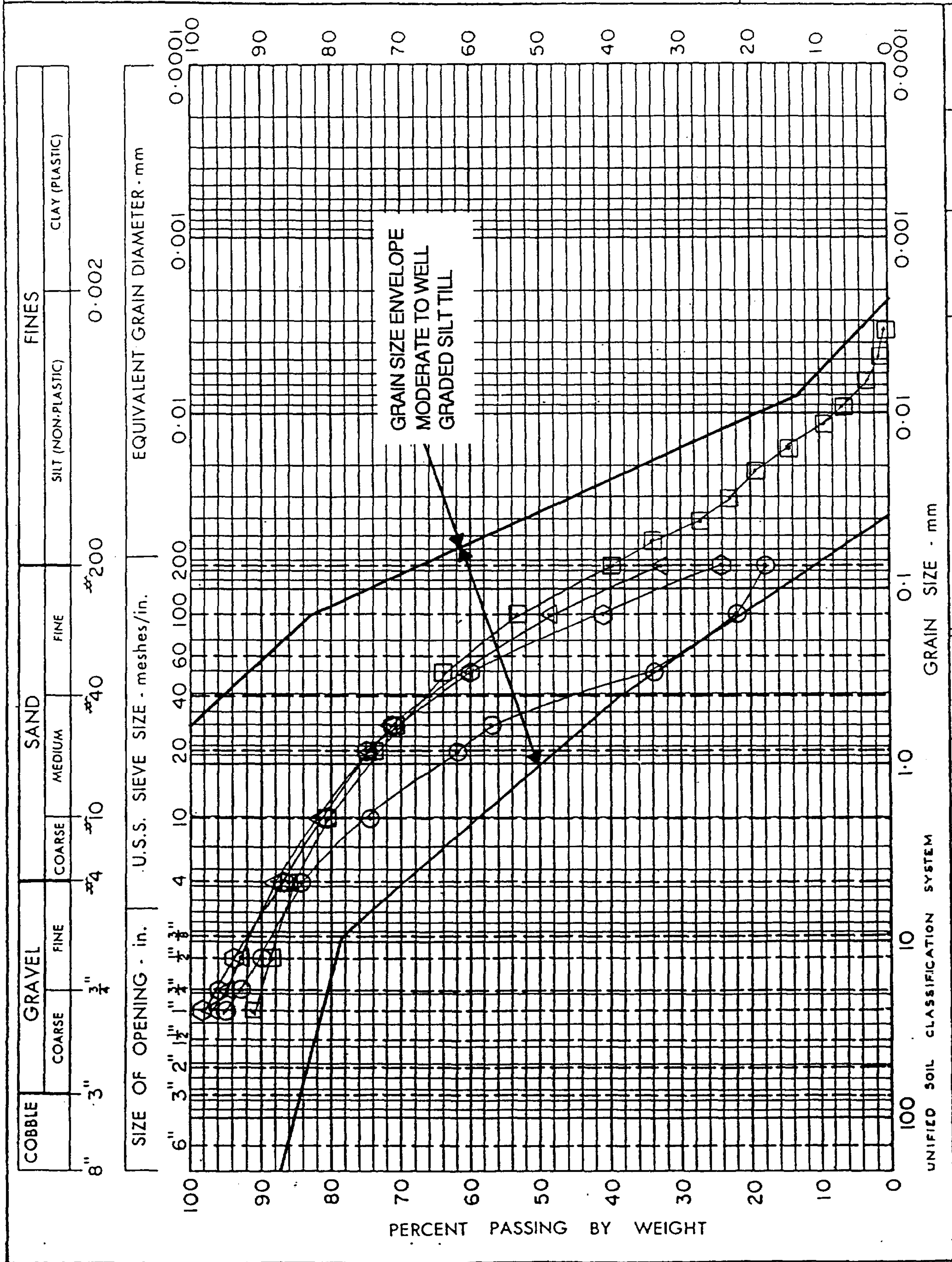
DENNIS NETHERTON ENGINEERING

GRAIN SIZE DISTRIBUTION

MAIN GATE SITE

APPENDIX III

FIG. NO. 11



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND SOME SILT SOME GRAVEL	TP 7 No.1	2.1-2.4m	⊙
SAND AND SILT SOME GRAVEL	TP 8 No.1	3.0-3.4m	⊡
SILTY SAND SOME GRAVEL	TP 9 No.1	2.4-2.7m	△
SILTY SAND TRACE GRAVEL	TP 10 No.1	3.0-3.4m	⊙

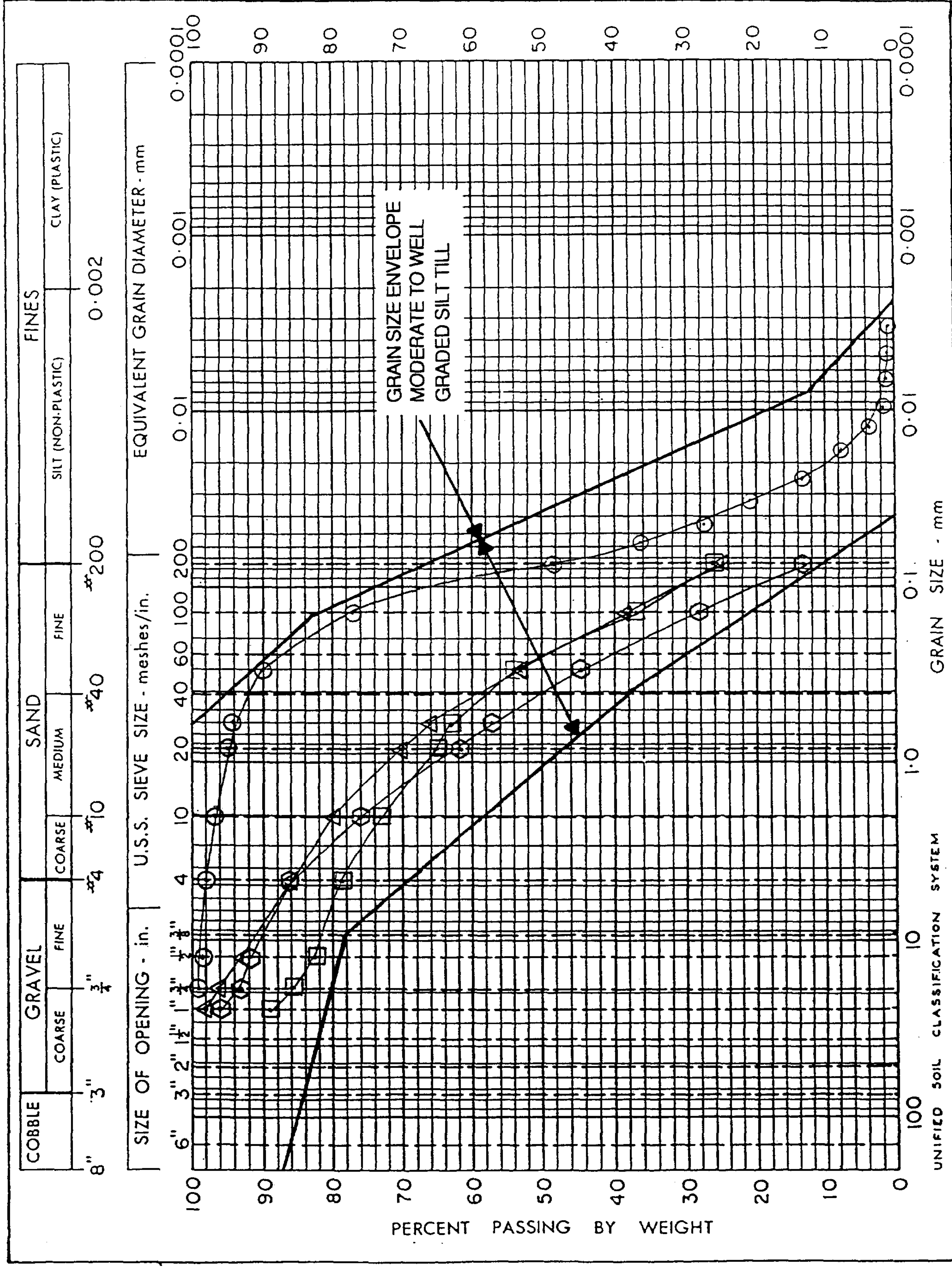
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

MAIN GATE SITE

APPENDIX III

FIG. NO. 12



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SILT AND SAND TRACE GRAVEL	TP 11 No.1	1.2-1.5m	⊙
GRAVELLY SILTY SAND	TP 12 No.1	3.4-3.7m	⊡
SILTY SAND SOME GRAVEL	TP 13 No.1	2.1-2.4m	△
SAND SOME SILT SOME GRAVEL	TP 14 No.1	0.9-1.2m	⊙

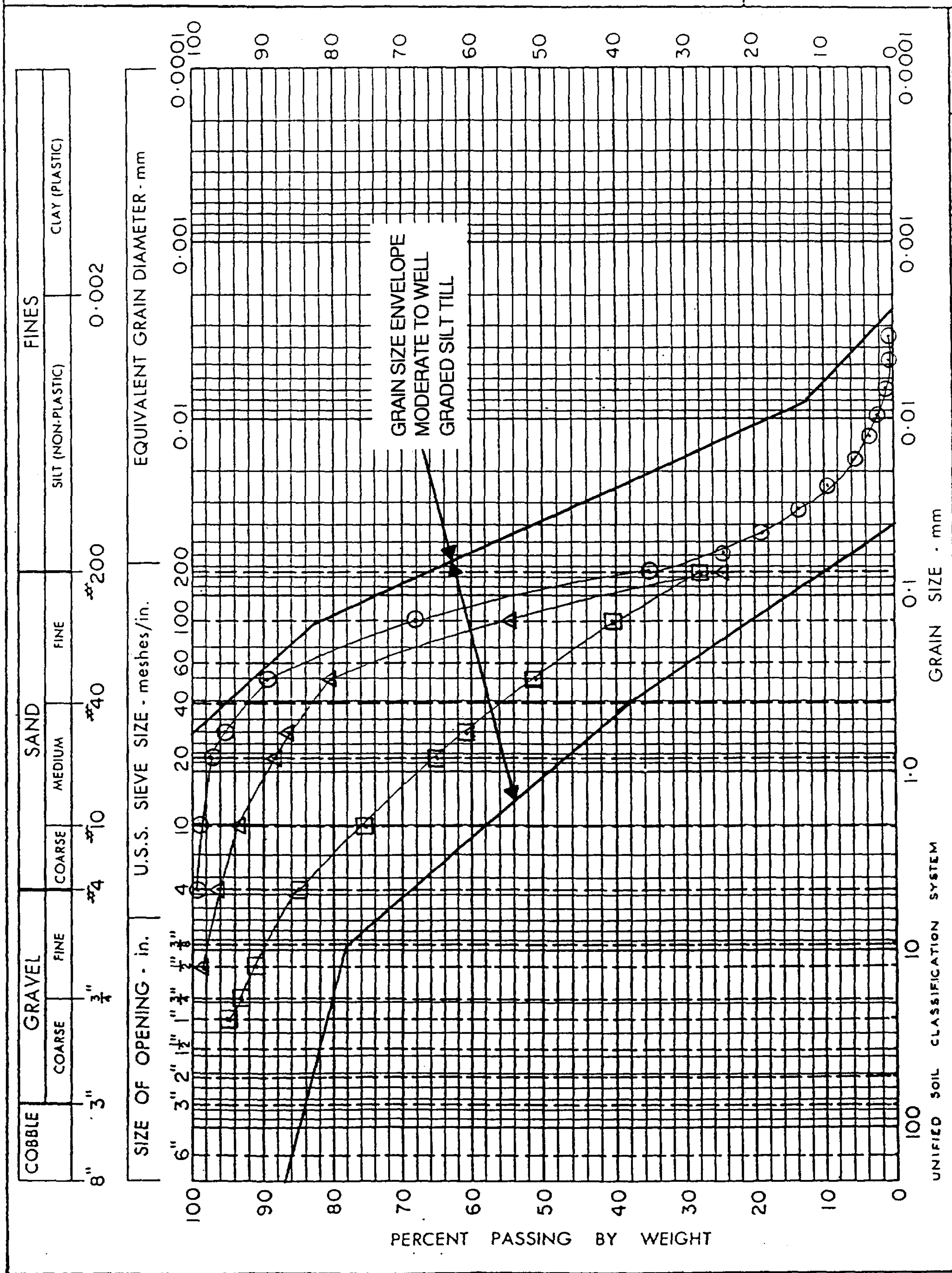
LAC DES ILES BORROW SEARCH INVESTIGATION

GRAIN SIZE DISTRIBUTION

MAIN GATE SITE

APPENDIX III

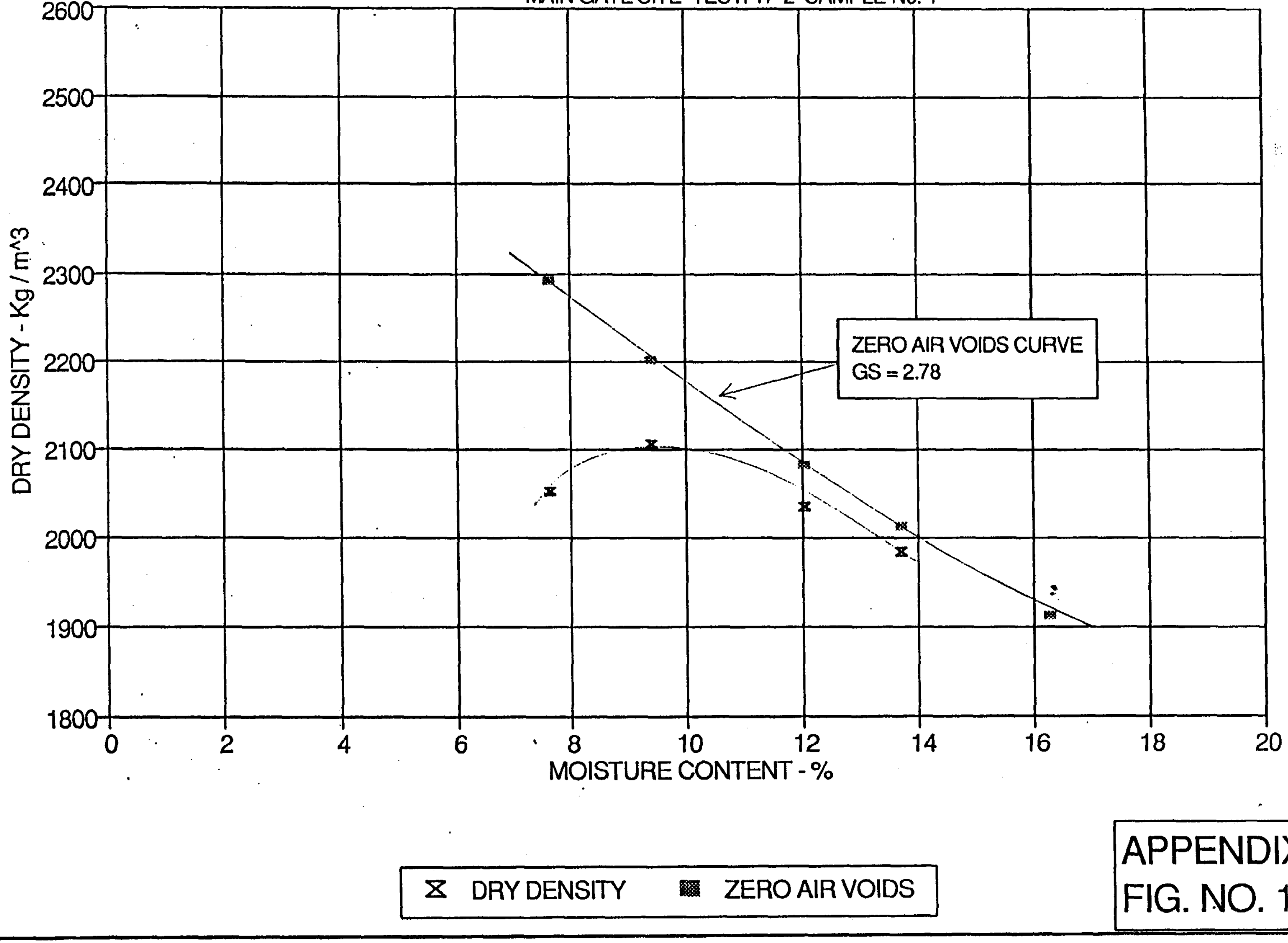
FIG. NO. 13



SAMPLE TYPE	SA. NO.	DEPTH	MARK
SAND AND SILT TRACE GRAVEL	TP 15 No.1	1.5-1.8m	⊙
SILTY SAND SOME GRAVEL	TP 16 No.1	2.7-3.0m	⊡
SILTY SAND TRACE GRAVEL	TP 17 No.1	1.5-1.8m	△

STANDARD PROCTOR COMPACTION CURVE
SILT AND SAND WITH TRACE GRAVEL

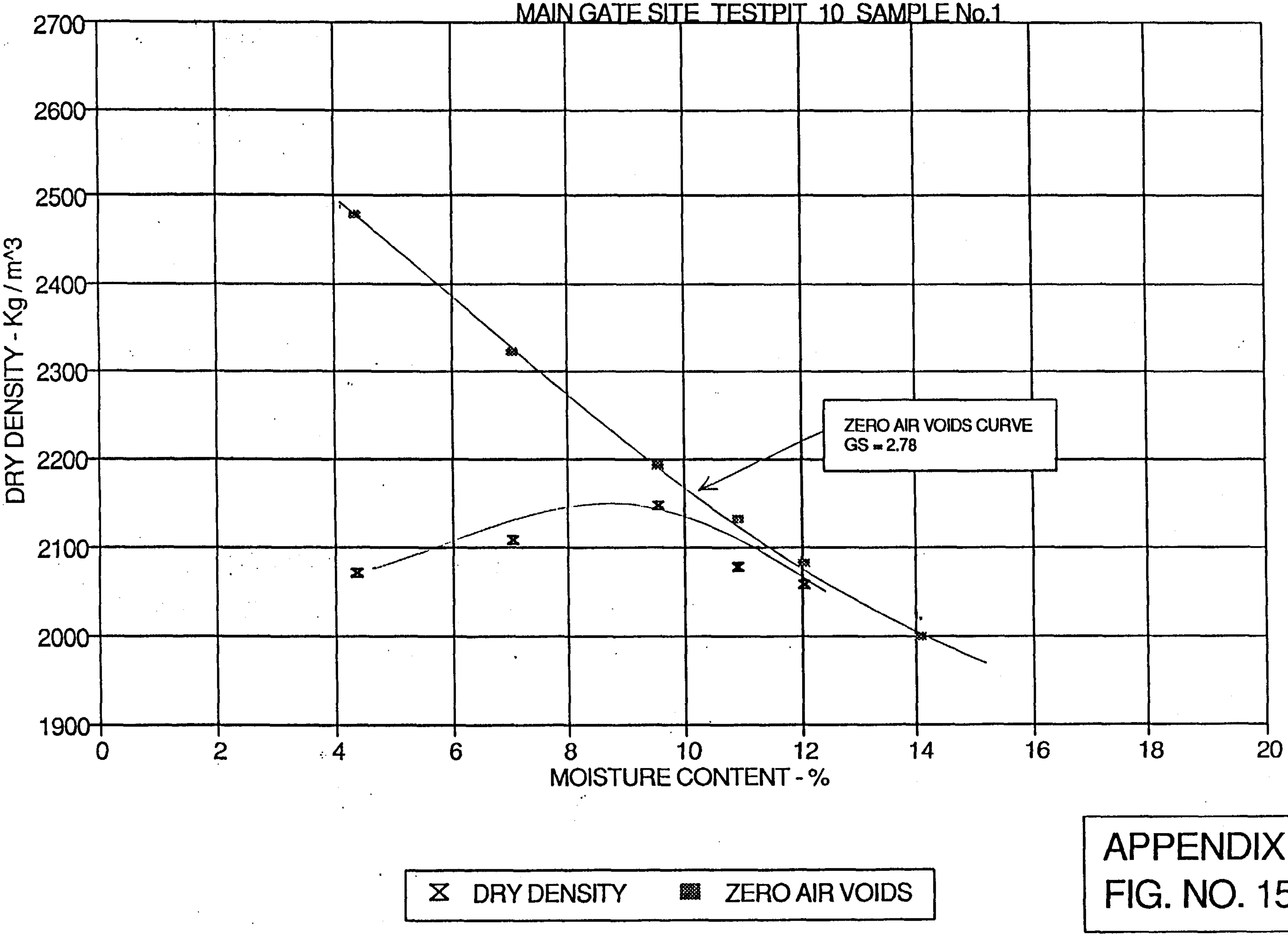
MAIN GATE SITE TESTPIT 2 SAMPLE No. 1



APPENDIX III
FIG. NO. 14

STANDARD PROCTOR COMPACTION CURVE
SILTY SAND TRACE GRAVEL

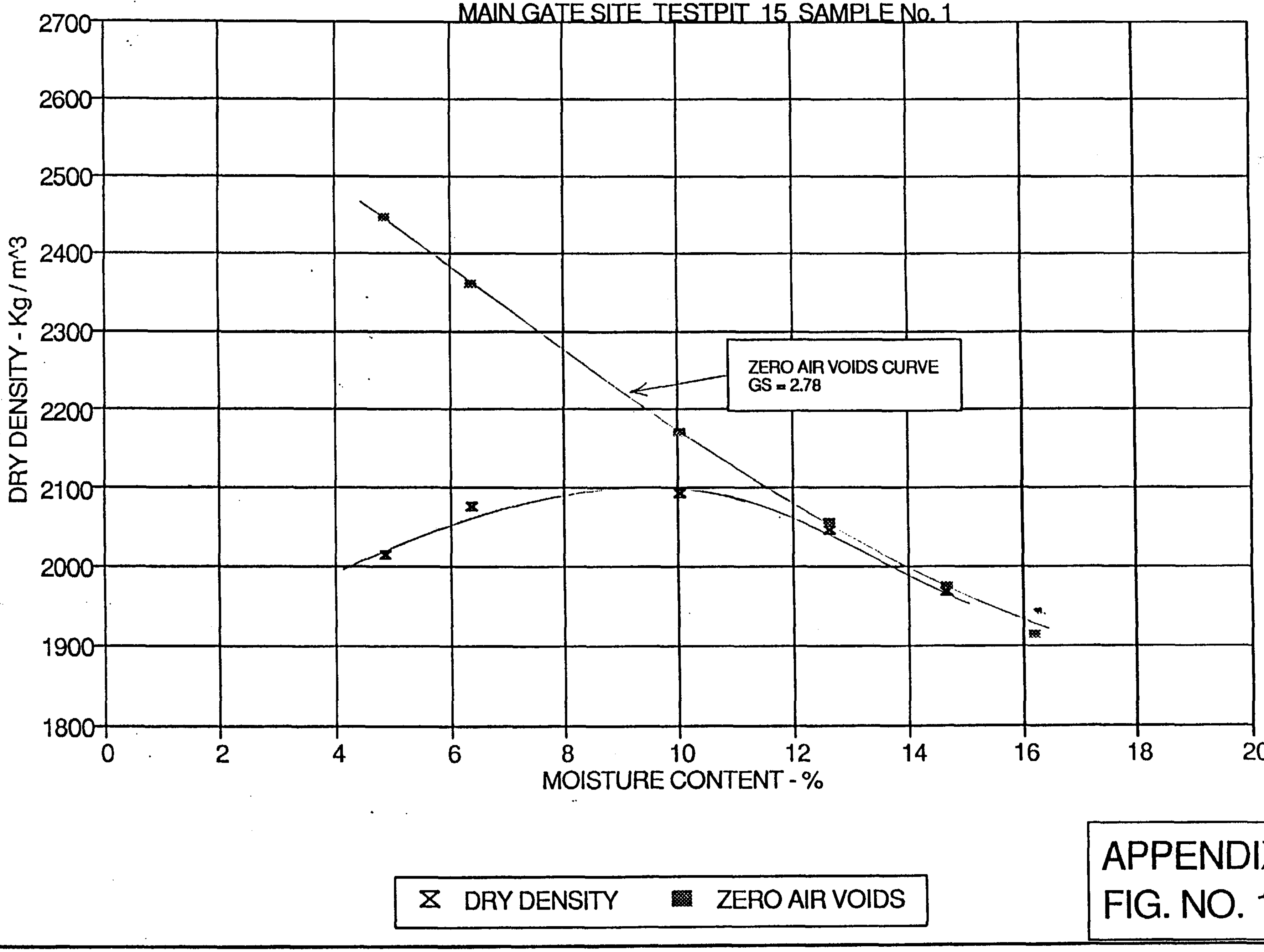
MAIN GATE SITE TESTPIT 10 SAMPLE No.1



APPENDIX III
FIG. NO. 15

STANDARD PROCTOR DENSITY CURVE
SILT AND SAND WITH TRACE GRAVEL

MAIN GATE SITE TESTPIT 15 SAMPLE No. 1



APPENDIX III
FIG. NO. 16

APPENDIX IV

BEDROCK PERMEABILITY RESULTS

(Tables 1 through 11)

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 1

DATE: MAY, 1992

MADE BY: D. MACHIN

PROJECT NO.: 0786-002

AIRTRACK DRILLHOLE #	TEST INTERVAL (ft)	TEST DEPTH MIDPOINT (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	DROP W. L. (mm/min)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
MW-92-01	2 - 8.5	5.30	6.5	1.93	5	0.2	0.0002	6800	8.01E-08	
MW-92-01	2 - 8.5	5.30	6.5	0.83	10	0.25	0.0002	6800	6.43E-08	
MW-92-01	7 - 13.5	10.30	6.5	0.83	8	1	0.0010	6800	2.54E-07	
MW-92-01	7 - 13.5	10.30	6.5	0.83	13	1.2	0.0011	6800	2.19E-07	
MW-92-01	7 - 13.5	10.30	6.5	0.83	18	1.8	0.0017	6800	2.57E-07	
MW-92-01	12 - 18.5	15.30	6.5	0.83	10	0.2	0.0002	6800	3.83E-08	
MW-92-01	12 - 18.5	15.30	6.5	0.83	15	0.35	0.0003	6800	5.18E-08	
MW-92-01	12 - 18.5	15.30	6.5	0.83	20	0.4	0.0004	6800	4.82E-08	
MW-92-01	17 - 23.5	20.30	6.5	0.83	10	0.2	0.0002	6800	3.40E-08	
MW-92-01	17 - 23.5	20.30	6.5	0.83	18	0.3	0.0003	6800	3.60E-08	
MW-92-01	17 - 23.5	20.30	6.5	0.83	25	0.4	0.0004	6800	3.81E-08	
MW-92-01	22 - 28.5	25.30	6.5	0.83	13	4.4	0.0042	6800	5.89E-07	
MW-92-01	22 - 28.5	25.30	6.5	0.83	23	5.6	0.0053	6800	5.31E-07	
MW-92-01	22 - 28.5	25.30	6.5	0.83	30	2.4	0.0023	6800	1.89E-07	
MW-92-01	27 - 33.5	30.30	6.5	0.83	13	3.4	0.0032	6800	4.18E-07	
MW-92-01	27 - 33.5	30.30	6.5	0.83	23	4.8	0.0046	6800	4.28E-07	
MW-92-01	27 - 33.5	30.30	6.5	0.83	30	5.3	0.0050	6800	3.97E-07	
MW-92-01	32 - 38.5	35.30	6.5	0.83	13	0.7	0.0007	6800	7.95E-08	
MW-92-01	32 - 38.5	35.30	6.5	0.83	23	0.8	0.0008	6800	6.74E-08	
MW-92-01	32 - 38.5	35.30	6.5	0.83	30	1.1	0.0010	6800	7.84E-08	
MW-92-01	37 - 43.5	40.30	6.5	0.83	15	0.2	0.0002	6800	1.98E-08	
MW-92-01	37 - 43.5	40.30	6.5	0.83	25	0.25	0.0002	6800	1.90E-08	
MW-92-01	37 - 43.5	40.30	6.5	0.83	33	0.2	0.0002	6800	1.28E-08	
MW-92-01	42 - 48.5	45.30	6.5	0.83	15	0.5	0.0005	6800	4.65E-08	
MW-92-01	42 - 48.5	45.30	6.5	0.83	25	0.3	0.0003	6800	2.17E-08	
MW-92-01	42 - 48.6	45.30	6.5	0.83	33	0.9	0.0009	6800	5.53E-08	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 2

DATE: MAY, 1992
MADE BY: D. MACHIN
PROJECT NO.: 0786-002

AIRTRACK DRILLHOLE #	TEST INTERVAL (ft)	TEST DEPTH MIDPOINT (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	DROP W.L. (mm/min)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
MW-92-02	2 - 8.5	5.30	6.5	1.83	8	0.35	0.0003	6800	1.03E-07	
MW-92-02	2 - 8.5	5.30	6.5	1.83	13	0.35	0.0003	6800	7.08E-08	
MW-92-02	7 - 13.5	10.30	6.5	1.83	8	0.1	0.0001	6800	2.46E-08	
MW-92-02	7 - 13.5	10.30	6.5	1.83	15	0.3	0.0003	6800	4.82E-08	
MW-92-02	12 - 18.5	15.30	6.5	1.83	10	1	0.0010	6800	1.87E-07	
MW-92-02	12 - 18.5	15.30	6.5	1.83	20	7	0.0067	6800	8.31E-07	
MW-92-02	17 - 23.5	20.30	6.5	1.83	10	0.1	0.0001	6800	1.66E-08	
MW-92-02	17 - 23.5	20.30	6.5	1.83	23	0.3	0.0003	6800	3.00E-08	
MW-92-02	22 - 28.5	25.30	6.5	1.83	10	0.15	0.0001	6800	2.24E-08	
MW-92-02	22 - 28.5	25.30	6.5	1.83	20	0.1	0.0001	6800	1.03E-08	
MW-92-02	22 - 28.5	25.30	6.5	1.83	30	0.1	0.0001	6800	7.80E-09	
MW-92-02	27 - 33.5	30.30	6.5	1.83	10	0.15	0.0001	6800	2.04E-08	
MW-92-02	27 - 33.5	30.30	6.5	1.83	20	0.2	0.0002	6800	1.92E-08	
MW-92-02	27 - 33.5	30.30	6.5	1.83	32	0.35	0.0003	6800	2.48E-08	
MW-92-02	32 - 38.5	35.30	6.5	1.83	10	0.1	0.0001	6800	1.25E-08	
MW-92-02	32 - 38.5	35.30	6.5	1.83	20	0.1	0.0001	6800	9.02E-09	
MW-92-02	32 - 38.5	35.30	6.5	1.83	32	0.35	0.0003	6800	2.37E-08	
MW-92-02	37 - 43.5	40.30	6.5	1.83	10	0.3	0.0003	6800	3.46E-08	
MW-92-02	37 - 43.5	40.30	6.5	1.83	20	0.5	0.0005	6800	4.25E-08	
MW-92-02	37 - 43.5	40.30	6.5	1.83	32	0.5	0.0005	6800	3.24E-08	
MW-92-02	42 - 48.5	45.30	6.5	1.83	10	0.05	0.0000	6800	5.35E-09	
MW-92-02	42 - 48.5	45.30	6.5	1.83	20	0.3	0.0003	6800	2.42E-08	
MW-92-02	42 - 48.6	45.30	6.5	1.83	32	0.3	0.0003	6800	1.86E-08	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 3

DATE: MAY, 1992
MADE BY: D. MACHIN
PROJECT NO.: 0786-002

AIRTRACK DRILLHOLE #	TEST INTERVAL (ft)	TEST DEPTH MIDPOINT (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	DROP W.L. (mm/min)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
MW-92-03	2 - 8.5	5.30	6.5	3.41	5		0.0000	6800	0.00E+00	
MW-92-03	2 - 8.5	5.30	6.5	3.41	10	12.7	0.0121	6800	3.00E-06	
MW-92-03	7 - 13.5	10.30	6.5	3.41	8		2.9000	6800	7.11E-04	
MW-92-03	7 - 13.5	10.30	6.5	3.41	15		9.6300	6800	1.57E-03	
MW-92-03	12 - 18.5	15.30	6.5				0.0000	6800	0.00E+00	NOT TESTED AS PACKER STUCK
MW-92-03	12 - 18.5	15.30	6.5				0.0000	6800	0.00E+00	
MW-92-03	17 - 23.5	20.30	6.5	0.91	10	0.1	0.0001	6800	1.70E-08	
MW-92-03	17 - 23.5	20.30	6.5	0.91	18	0.2	0.0002	6800	2.39E-08	
MW-92-03	17 - 23.5	20.30	6.5	0.91	25	0.3	0.0003	6800	2.86E-08	
MW-92-03	22 - 28.5	25.30	6.5	0.91	10	0.2	0.0002	6800	3.05E-08	
MW-92-03	22 - 28.5	25.30	6.5	0.91	20	0.7	0.0007	6800	7.27E-08	
MW-92-03	22 - 28.5	25.30	6.5	0.91	30	0.9	0.0009	6800	7.08E-08	
MW-92-03	27 - 33.5	30.30	6.5	0.91	10	0.1	0.0001	6800	1.38E-08	
MW-92-03	27 - 33.5	30.30	6.5	0.91	20	0.2	0.0002	6800	1.94E-08	
MW-92-03	27 - 33.5	30.30	6.5	0.91	30	0.2	0.0002	6800	1.50E-08	
MW-92-03	32 - 38.5	35.30	6.5	0.91	10	0.2	0.0002	6800	2.53E-08	
MW-92-03	32 - 38.5	35.30	6.5	0.91	20	0.2	0.0002	6800	1.82E-08	
MW-92-03	32 - 38.5	35.30	6.5	0.91	33	0.3	0.0003	6800	2.01E-08	
MW-92-03	37 - 43.5	40.30	6.5	0.91	10	0.15	0.0001	6800	1.75E-08	
MW-92-03	37 - 43.5	40.30	6.5	0.91	20	0.15	0.0001	6800	1.29E-08	
MW-92-03	37 - 43.5	40.30	6.5	0.91	33	0.1	0.0001	6800	6.40E-09	
MW-92-03	42 - 48.5	45.30	6.5	0.91	10	0.1	0.0001	6800	1.08E-08	
MW-92-03	42 - 48.5	45.30	6.5	0.91	20	0.2	0.0002	6800	1.63E-08	
MW-92-03	42 - 48.6	45.30	6.5	0.91	33	0.6	0.0006	6800	3.68E-08	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 4

DATE: MAY, 1992

MADE BY: D. MACHIN

PROJECT NO.: 0786-002

AIRTRACK DRILLHOLE #	TEST INTERVAL (ft)	TEST DEPTH MIDPOINT (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	DROP W.L. (mm/min)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
MW-92-04	2 - 8.5	5.30	6.5	0.5	8	27	0.0257	6800	8.36E-06	
MW-92-04	2 - 8.5	5.30	6.5	0.5	13		4.4333	6800	9.77E-04	
MW-92-04	7 - 13.5	10.30	6.5	0.5	8	0.2	0.0002	6800	5.13E-08	
MW-92-04	7 - 13.5	10.30	6.5	0.5	15	0.1	0.0001	6800	1.65E-08	
MW-92-04	12 - 18.5	15.30	6.5	0.5	10	0.1	0.0001	6800	1.93E-08	
MW-92-04	12 - 18.5	15.30	6.5	0.5	20	0.1	0.0001	6800	1.21E-08	
MW-92-04	17 - 23.5	20.30	6.5	0.5	10	0.1	0.0001	6800	1.71E-08	
MW-92-04	17 - 23.5	20.30	6.5	0.5	20	0.15	0.0001	6800	1.68E-08	
MW-92-04	22 - 28.5	25.30	6.5	0.5	10	0.1	0.0001	6800	1.54E-08	
MW-92-04	22 - 28.5	25.30	6.5	0.5	20	0.1	0.0001	6800	1.04E-08	
MW-92-04	22 - 28.5	25.30	6.5	0.5	29	0.1	0.0001	6800	8.10E-09	
MW-92-04	27 - 33.5	30.30	6.5	0.5	10	0.1	0.0001	6800	1.39E-08	
MW-92-04	27 - 33.5	30.30	6.5	0.5	20	0.1	0.0001	6800	9.76E-09	
MW-92-04	27 - 33.5	30.30	6.5	0.5	29	0.1	0.0001	6800	7.69E-09	
MW-92-04	32 - 38.5	35.30	6.5	0.5	10	0.1	0.0001	6800	1.28E-08	
MW-92-04	32 - 38.5	35.30	6.5	0.5	20	0.1	0.0001	6800	9.17E-09	
MW-92-04	32 - 38.5	35.30	6.5	0.5	29	0.1	0.0001	6800	7.31E-09	
MW-92-04	37 - 43.5	40.30	6.5	0.5	10	0.1	0.0001	6800	1.18E-08	
MW-92-04	37 - 43.5	40.30	6.5	0.5	20	0.1	0.0001	6800	8.64E-09	
MW-92-04	37 - 43.5	40.30	6.5	0.5	29	0.1	0.0001	6800	6.97E-09	
MW-92-04	42 - 48.5	45.30	6.5	0.5	10	0.1	0.0001	6800	1.09E-08	
MW-92-04	42 - 48.5	45.30	6.5	0.5	20	0.1	0.0001	6800	8.17E-09	
MW-92-04	42 - 48.6	45.30	6.5	0.5	29	0.1	0.0001	6800	6.66E-09	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 5

DATE: MAY, 1992 | MADE BY: D. MACHIN | PROJECT NO.: 0786-002

AIRTRACK DRILLHOLE #	TEST INTERVAL (ft)	TEST DEPTH MIDPOINT (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	DROP W.L. (mm/min)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
MW-92-05	2 - 8.5	5.30	6.5	2.5	10	0.6	0.0006	6800	1.46E-07	
MW-92-05	2 - 8.5	5.30	6.5	2.5	15	0.8	0.0008	6800	1.42E-07	
MW-92-05	7 - 13.5	10.30	6.5	1.5	13	0.5	0.0005	6800	8.99E-08	
MW-92-05	7 - 13.5	10.30	6.5	1.5	27	0.1	0.0001	6800	1.01E-08	
MW-92-05	12 - 18.5	15.30	6.5	1.5	8	0.2	0.0002	6800	4.26E-08	
MW-92-05	12 - 18.5	15.30	6.5	1.5	15	0.3	0.0003	6800	4.38E-08	
MW-92-05	17 - 23.5	20.30	6.5	1.5	14	0.2	0.0002	6800	2.78E-08	
MW-92-05	17 - 23.5	20.30	6.5	1.5	20	0.1	0.0001	6800	1.11E-08	
MW-92-05	22 - 28.5	25.30	6.5	1.5	10	0.3	0.0003	6800	4.52E-08	
MW-92-05	22 - 28.5	25.30	6.5	1.5	20	0.4	0.0004	6800	4.12E-08	
MW-92-05	22 - 28.5	25.30	6.5	1.5	25	0.3	0.0003	6800	2.67E-08	
MW-92-05	27 - 33.5	30.30	6.5	1.5	10	0.1	0.0001	6800	1.37E-08	
MW-92-05	27 - 33.5	30.30	6.5	1.5	20	0.1	0.0001	6800	9.64E-09	
MW-92-05	27 - 33.5	30.30	6.5	1.5	30	0.15	0.0001	6800	1.12E-08	
MW-92-05	32 - 38.5	35.30	6.5	1.5	10	0.1	0.0001	6800	1.25E-08	
MW-92-05	32 - 38.5	35.30	6.5	1.5	20	0.1	0.0001	6800	9.06E-09	
MW-92-05	32 - 38.5	35.30	6.5	1.5	30	0.1	0.0001	6800	7.08E-09	
MW-92-05	37 - 43.5	40.30	6.5	1.5	10	0.2	0.0002	6800	2.32E-08	
MW-92-05	37 - 43.5	40.30	6.5	1.5	20	0.2	0.0002	6800	1.71E-08	
MW-92-05	37 - 43.5	40.30	6.5	1.5	30	0.3	0.0003	6800	2.03E-08	
MW-92-05	42 - 48.5	45.30	6.5	1.5	10	0.1	0.0001	6800	1.08E-08	
MW-92-05	42 - 48.5	45.30	6.5	1.5	20	0.1	0.0001	6800	8.08E-09	
MW-92-05	42 - 48.6	45.30	6.5	1.5	30	0.1	0.0001	6800	6.47E-09	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 6

DATE: APRIL, 1992

MADE BY: D. MACHIN

PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW Q (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-02	24	20.78	4	5	10	7.9	10300	1.93E-03	WATER BY PASS
92-02	29	25.11	4	5	15	0	10300	0.00E+00	
92-02	29	25.11	4	5	20	0	10300	0.00E+00	
92-02	29	25.11	4	5	28	0	10300	0.00E+00	
92-02	34	29.44	4	5	15	0	10300	0.00E+00	
92-02	34	29.44	4	5	25	0	10300	0.00E+00	
92-02	34	29.44	4	5	30	0	10300	0.00E+00	
92-02	39	33.77	4	5	15	0	10300	0.00E+00	
92-02	39	33.77	4	5	25	0	10300	0.00E+00	
92-02	39	33.77	4	5	30	0	10300	0.00E+00	
92-02	42	36.37	4	5	16	0	10300	0.00E+00	
92-02	42	36.37	4	5	25	0	10300	0.00E+00	
92-02	42	36.37	4	5	30	0	10300	0.00E+00	
92-02	46	39.84	4	5	15	0	10300	0.00E+00	
92-02	46	39.84	4	5	25	0	10300	0.00E+00	
92-02	46	39.84	4	5	30	0	10300	0.00E+00	
92-02	54	46.77	4	5	16	0	10300	0.00E+00	
92-02	54	46.77	4	5	20	0	10300	0.00E+00	
92-02	54	46.77	4	5	30	0	10300	0.00E+00	
92-02	59	51.10	4	5	25	0	10300	0.00E+00	
92-02	59	51.10	4	5	35	1.5	10300	1.31E-04	
92-02	64	55.43	4	5	25	0	10300	0.00E+00	
92-02	64	55.43	4	5	35	0.07	10300	5.92E-06	
92-02	69	59.76	4	5	25	0.24	10300	2.34E-05	
92-02	69	59.76	4	5	35	0.38	10300	3.12E-05	
92-02	74	64.09	4	5	25	0	10300	0.00E+00	
92-02	74	64.09	4	5	35	0	10300	0.00E+00	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 7

DATE: APRIL, 1992 MADE BY: D. MACHIN PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-03	24	20.78	4	5	8	0	10300	0.00E+00	
92-03	24	20.78	4	5	15.5	0	10300	0.00E+00	
92-03	29	25.11	4	5	10	0	10300	0.00E+00	
92-03	29	25.11	4	5	15	0	10300	0.00E+00	
92-03	29	25.11	4	5	20	0.05	10300	7.83E-06	
92-03	34	29.44	4	5	10	0	10300	0.00E+00	
92-03	34	29.44	4	5	18	0	10300	0.00E+00	
92-03	34	29.44	4	5	25	0	10300	0.00E+00	
92-03	39	33.77	4	5	15	0	10300	0.00E+00	
92-03	39	33.77	4	5	23	0	10300	0.00E+00	
92-03	39	33.77	4	5	30	0	10300	0.00E+00	
92-03	44	38.11	4	5	16	0	10300	0.00E+00	
92-03	44	38.11	4	5	25	0	10300	0.00E+00	
92-03	44	38.11	4	5	30	0.03	10300	3.19E-06	
92-03	49	42.44	4	5	15	0	10300	0.00E+00	
92-03	49	42.44	4	5	25	0	10300	0.00E+00	
92-03	49	42.44	4	5	30	0	10300	0.00E+00	
92-03	54	46.77	4	7	15	0	10300	0.00E+00	
92-03	54	46.77	4	7	25	0	10300	0.00E+00	
92-03	54	46.77	4	7	35	0	10300	0.00E+00	
92-03	59	51.10	4	7	18	0.19	10300	2.28E-05	
92-03	59	51.10	4	7	26	0.32	10300	3.24E-05	
92-03	59	51.10	4	7	35	0.42	10300	3.61E-05	
92-03	64	55.43	4	7	15	0	10300	0.00E+00	
92-03	64	55.43	4	7	25	0	10300	0.00E+00	
92-03	64	55.43	4	7	35	0	10300	0.00E+00	
92-03	69	59.76	4	7	15	0	10300	0.00E+00	
92-03	69	59.76	4	7	25	0	10300	0.00E+00	
92-03	69	59.76	4	7	35	0	10300	0.00E+00	
92-03	74	64.09	4	7	15	0	10300	0.00E+00	
92-03	74	64.09	4	7	25	0	10300	0.00E+00	
92-03	74	64.09	4	7	35	0	10300	0.00E+00	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 8

DATE: APRIL, 1992 MADE BY: D. MACHIN PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-04	34	29.44	4	5	10	0.18	10300	3.74E-05	
92-04	34	29.44	4	5	15	0.09	10300	1.56E-05	
92-04	34	29.44	4	5	25	0.27	10300	3.50E-05	
92-04	39	33.77	4	5	10	0	10300	0.00E+00	
92-04	39	33.77	4	5	15	0	10300	0.00E+00	
92-04	39	33.77	4	5	25	0	10300	0.00E+00	
92-04	44	38.11	4	5	15	0.015	10300	2.31E-06	
92-04	44	38.11	4	5	25	0.07	10300	8.30E-06	
92-04	44	38.11	4	5	30	0.03	10300	3.19E-06	
92-04	49	42.44	4	5	15	0	10300	0.00E+00	
92-04	49	42.44	4	5	25	0.012	10300	1.36E-06	
92-04	49	42.44	4	5	36	0.017	10300	1.56E-06	
92-04	54	46.77	4	5	15	0.05	10300	6.92E-06	
92-04	54	46.77	4	5	25	0.54	10300	5.89E-05	
92-04	54	46.77	4	5	35	0.38	10300	3.43E-05	
92-04	59	51.10	4	5	18	0	10300	0.00E+00	
92-04	59	51.10	4	5	26	0.04	10300	4.12E-06	
92-04	59	51.10	4	5	36	0.05	10300	4.29E-06	
92-04	64	55.43	4	5	15	0	10300	0.00E+00	
92-04	64	55.43	4	5	25	0	10300	0.00E+00	
92-04	64	55.43	4	5	35	0.2	10300	1.69E-05	
92-04	69	59.76	4	5	15	0	10300	0.00E+00	
92-04	69	59.76	4	5	25	0	10300	0.00E+00	
92-04	69	59.76	4	5	35	0	10300	0.00E+00	
92-04	74	64.09	4	5	15	0.04	10300	4.61E-06	
92-04	74	64.09	4	5	25	0	10300	0.00E+00	
92-04	74	64.09	4	5	35	0.08	10300	6.38E-06	

BEDROCK PERMEABILITY VALUES DETERMINED BY PACKER TESTING.

APPENDIX IV

TABLE 9

DATE: APRIL, 1992

MADE BY: D. MACHIN

PROJECT NO.: 0786-001

DIAMOND DRILLHOLE #	TEST DEPTH (INCLINED) (ft)	TEST DEPTH (VERTICAL) (ft)	TEST INTERVAL (ft)	HEIGHT GAUGE (ft)	GAUGE PRESSURE (psi)	FLOW (gal/min)	Cp CONSTANT	PERMEABILITY (cm/sec)	COMMENTS
92-05	44	38.11	4	5	0.5	10	10300	2.70E-03	LEAK, LOST ALL WATER
92-05	49	42.44	4	5	25	0.11	10300	1.25E-05	
92-05	49	42.44	4	5	36	0.21	10300	1.92E-05	
92-05	54	46.77	4	5	25	0.15	10300	1.64E-05	
92-05	54	46.77	4	5	35	0.18	10300	1.62E-05	
92-05	59	51.10	4	5	25	0.05	10300	5.25E-06	
92-05	59	51.10	4	5	35	0.08	10300	6.98E-06	
92-05	64	55.43	4	5	25	0.18	10300	1.82E-05	
92-05	64	55.43	4	5	35	0.22	10300	1.86E-05	
92-05	69	59.76	4	5	15	0.06	10300	7.21E-06	
92-05	69	59.76	4	5	25	0.07	10300	6.83E-06	
92-05	69	59.76	4	5	35	0.08	10300	6.57E-06	
92-05	74	64.09	4	5	15	0.07	10300	8.06E-06	
92-05	74	64.09	4	5	25	0.13	10300	1.23E-05	
92-05	74	64.09	4	5	35	0.16	10300	1.28E-05	

APPENDIX IV
TABLE 10

BEDROCK PERMEABILTIY STATISTICS

(BEFORE CORRECTION FOR EQUIPMENT LIMITATIONS)

DATE: JUNE, 1992
MADE BY: D. MACHIN
PROJECT NO.: 0786

BOREHOLE NO.	DRILL RIG TYPE	PERMEABILITY (cm/s)				
		MEAN	SDEV	VAR	MAX	MIN
MW-92-01	AIRTRACK	1.6E-07	1.7E-07	3.0E-14	5.9E-07	1.3E-08
MW-92-02	AIRTRACK	7.0E-08	1.7E-07	2.9E-14	8.3E-07	5.4E-09
MW-92-03	AIRTRACK	1.8E-07	6.8E-07	4.7E-13	3.0E-06	6.4E-09
MW-92-04	AIRTRACK	4.3E-05	2.0E-04	4.1E-08	9.8E-04	6.7E-09
MW-92-05	AIRTRACK	3.4E-08	4.0E-08	1.6E-15	1.5E-07	6.5E-09
92-02	DIAMOND	4.8E-05	5.6E-05	3.2E-09	1.3E-04	5.9E-06
92-03	DIAMOND	2.1E-05	1.5E-05	2.1E-10	3.6E-05	3.2E-06
92-04	DIAMOND	1.5E-05	1.7E-05	2.9E-10	5.9E-04	1.4E-06
92-05	DIAMOND	1.2E-05	5.1E-06	2.6E-11	1.9E-05	5.3E-06

BEDROCK PERMEABILTIY STATISTICS

(AFTER CORRECTION FOR EQUIPMENT LIMITATIONS)

APPENDIX IV
TABLE 11

DATE: JUNE, 1992

MADE BY: D. MACHIN

PROJECT NO.: 0786

BOREHOLE NO.	DRILL RIG TYPE	PERMEABILITY (cm/s)				
		MEAN	SDEV	VAR	MAX	MIN
MW-92-01	AIRTRACK	1.0E-06	0.0E+00	0.0E+00	1.0E-06	1.0E-06
MW-92-02	AIRTRACK	1.0E-06	0.0E+00	0.0E+00	1.0E-06	1.0E-06
MW-92-03	AIRTRACK	1.1E-06	4.6E-07	2.1E-13	3.0E-06	1.0E-06
MW-92-04	AIRTRACK	4.4E-05	2.0E-04	4.1E-08	9.8E-04	1.0E-06
MW-92-05	AIRTRACK	1.0E-06	0.0E+00	0.0E+00	1.0E-06	1.0E-06
92-02	DIAMOND	8.2E-06	2.6E-05	6.8E-10	1.3E-04	1.0E-06
92-03	DIAMOND	4.0E-06	8.9E-05	7.9E-11	3.6E-05	1.0E-06
92-04	DIAMOND	1.0E-05	1.5E-05	2.3E-10	5.9E-05	1.0E-06
92-05	DIAMOND	1.2E-05	5.1E-06	2.6E-11	1.9E-05	5.3E-06

NOTE: SEE SECTION 1.0 OF FACTUAL SOILS REPORT FOR DISCUSSION ON EQUIPMENT LIMITATIONS.

APPENDIX V

MONITORING WELL INSTALLATIONS
(MW92-01 through MW92-05)

PIEZOMETER NUMBER

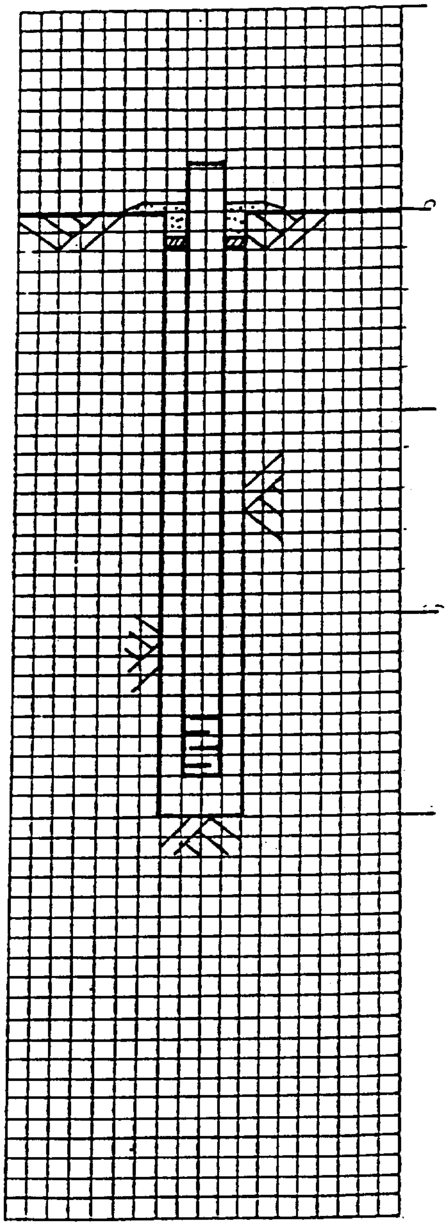
APPENDIX V
MW-92-01

LOCATION: LAC DES ILES MINES, NORTHWEST SIDE OF PROPOSED PHASE 1 TMF AREA.

DESCRIPTION: 3cm STANDPIPE WITH 1.5M, 10 MICRON SLOTTED SCREEN INSTALLED IN A 7.5cm AIRTRACK DRILLED VERTICAL BOREHOLE. A 0.6M CEMENT CAP OVERLIES A PLASTIC SEAL. 1.2M STICK-UP. ONE 1.25cm STEEL ROD, 1.5M LONG, LOST AT BOTTOM OF HOLE.

DATE	WATER LEVEL	DATE	WATER LEVEL
D/M/YR.	—	D/M/YR.	—

INSTALLATION SKETCH



FOR PETUR PIEZOMETER

PIEZOMETRIC HEAD =
TIP ELEVATION IN FT. + (GAUGE READING IN PSI) x 2.31

PIEZOMETER NUMBER

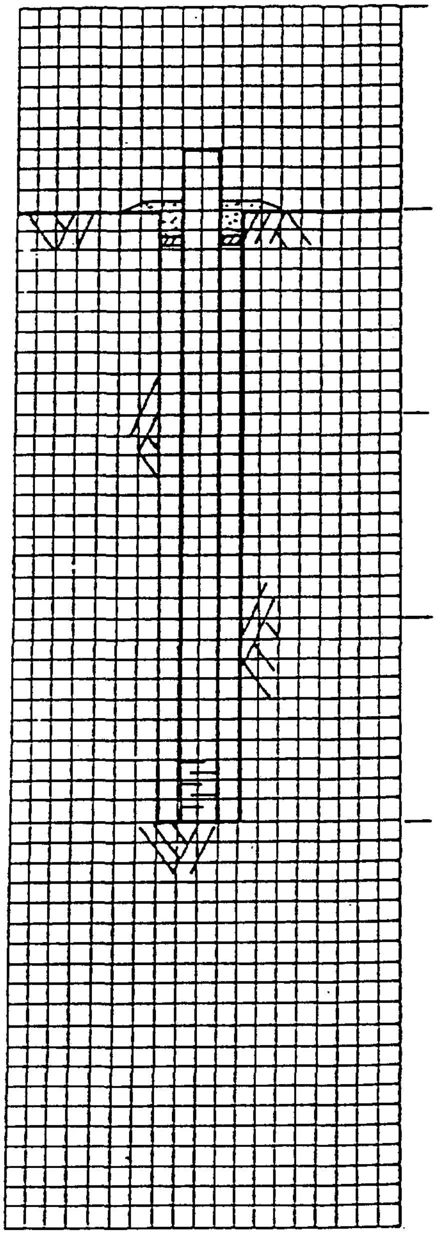
APPENDIX V
MW-92-02

LOCATION: LAC DES ILES MINES, NORTHEAST SIDE OF PROPOSED PHASE 1 TMF AREA.

DESCRIPTION: 3cm STANDPIPE WITH 1.5M, 10 MICRON SLOTTED SCREEN INSTALLED IN A 7.5cm AIRTRACK DRILLED VERTICAL BOREHOLE. A 0.6M CEMENT CAP OVERLIES A PLASTIC SEAL. 1.5M STICK-UP.

DATE	WATER LEVEL	DATE	WATER LEVEL
D/M/YR.	—	D/M/YR.	—

INSTALLATION SKETCH



FOR PETUR PIEZOMETER

PIEZOMETRIC HEAD =
TIP ELEVATION IN FT. +
(GAUGE READING IN PSI) x
2.31

PIEZOMETER NUMBER

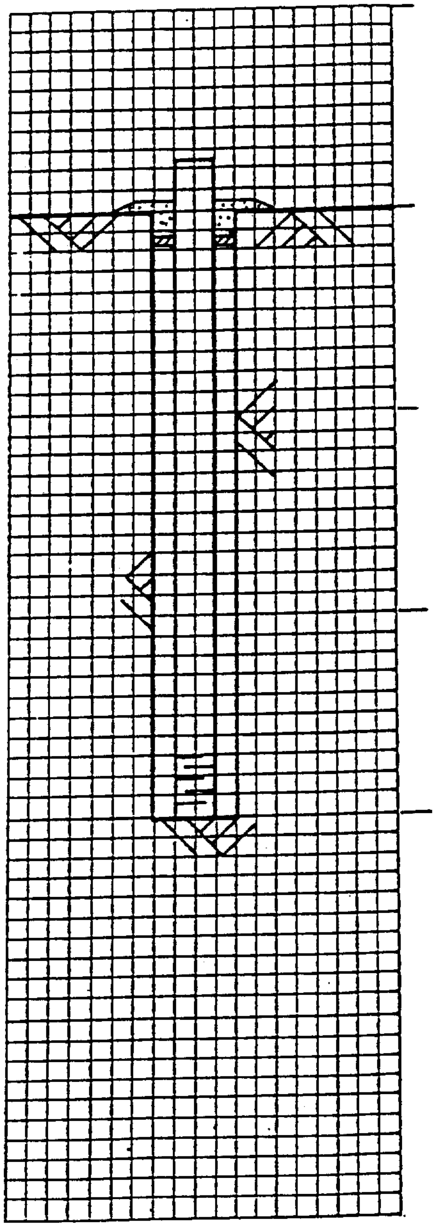
APPENDIX V
MW-92-03

LOCATION: LAC DES ILES MINES, NORTHEAST SIDE OF PROPOSED PHASE 1 TMF AREA.

DESCRIPTION: 3cm STANDPIPE WITH 1.5M, 10 MICRON SLOTTED SCREEN INSTALLED IN A 7.5cm AIRTRACK DRILLED VERTICAL BOREHOLE. A 0.6M CEMENT CAP OVERLIES A PLASTIC SEAL. 1.2M STICK-UP.

DATE	WATER LEVEL	DATE	WATER LEVEL
D/M/YR.	—	D/M/YR.	—

INSTALLATION SKETCH



FOR PETUR PIEZOMETER

PIEZOMETRIC HEAD =
TIP ELEVATION IN FT. +
(GAUGE READING IN PSI) x
2.31

PIEZOMETER NUMBER

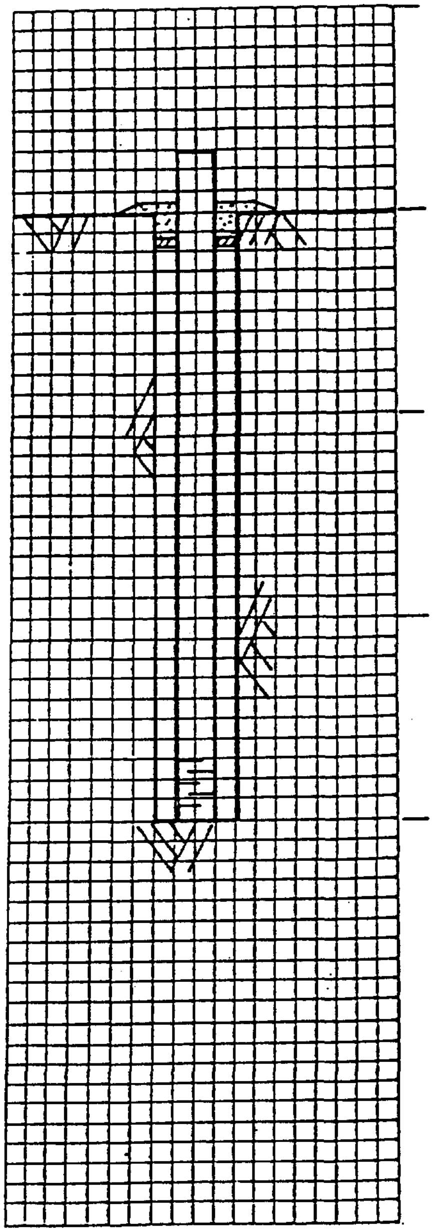
APPENDIX V
MW-92-04

LOCATION: LAC DES ILES MINES, NORTHWEST SIDE OF PROPOSED PHASE 1 TMF AREA.

DESCRIPTION: 3cm STANDPIPE WITH 1.5M, 10 MICRON SLOTTED SCREEN INSTALLED IN A 7.5cm AIRTRACK DRILLED VERTICAL BOREHOLE. A 0.6M CEMENT CAP OVERLIES A PLASTIC SEAL. 1.5M STICK-UP.

DATE D/M/YR.	WATER LEVEL —	DATE D/M/YR.	WATER LEVEL —

INSTALLATION SKETCH



FOR PETUR PIEZOMETER

PIEZOMETRIC HEAD =
TIP ELEVATION IN FT. + (GAUGE READING IN PSI) x 2.31

PIEZOMETER NUMBER

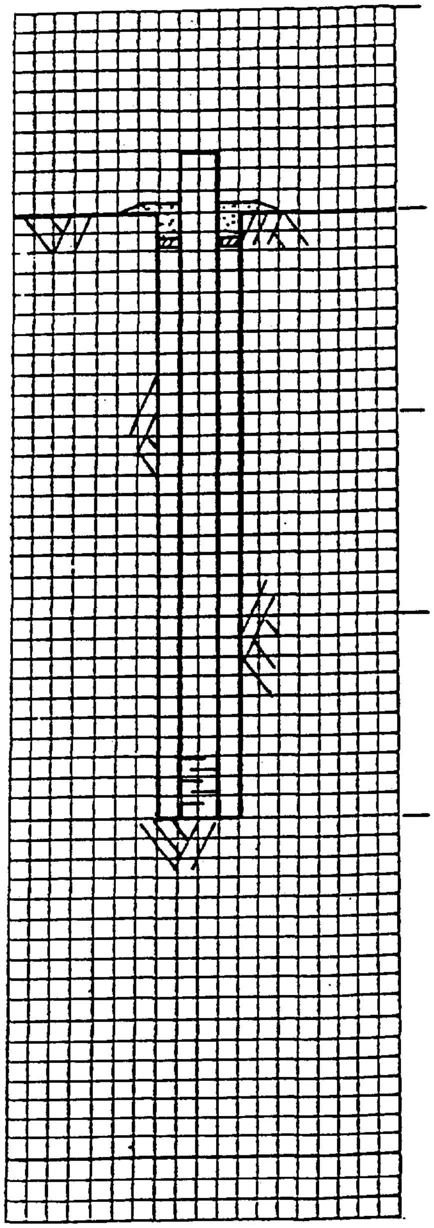
APPENDIX V
MW-92-05

LOCATION: LAC DES ILES MINES, NORTHEAST SIDE OF PROPOSED PHASE 1 TMF AREA.

DESCRIPTION: 3cm STANDPIPE WITH 1.5M, 10 MICRON SLOTTED SCREEN INSTALLED IN A 7.5cm AIRTRACK DRILLED VERTICAL BOREHOLE. A 0.6M CEMENT CAP OVERLIES A PLASTIC SEAL. 1.5M STICK-UP.

DATE	WATER LEVEL	DATE	WATER LEVEL
D/M/YR.	—	D/M/YR.	—

INSTALLATION SKETCH



FOR PETUR PIEZOMETER

PIEZOMETRIC HEAD =
TIP ELEVATION IN FT. +
(GAUGE READING IN PSI) x
2.31

APPENDIX VI

DRAWINGS

0786-099

0786-301

Baseline Biological Survey
at the
Lac Des Iles Mine Site

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

2.15334

A Report for:
Lac Des Iles Mine Ltd.

By:
Niblett Environmental Associates Inc.

July 1992

nea
NIBLETT ENVIRONMENTAL ASSOCIATES INC.

92 07 10 PN 92-023

Lac des Iles Mines Limited
111 Richmond Street West
Suite 916
Toronto, Ontario
M5H 2G4

Attention : Mr. Glen R. Clark
General Manager

Re : Lac des Iles Mines Limited : Biological Survey

Dear Mr. Clark

We are pleased to present this report on the biological conditions in the vicinity of the Lac des Iles Mine, north of Thunder Bay, Ontario.

As outlined in our work program, we collected physical, biological and chemical samples from two lakes, two ponds and connecting tributaries in the vicinity of the mine site.

Our general findings are that operation of the mine to date has had no perceptible impact on the natural environment. Levels of mercury in the northern pike appear to be quite high. These levels do not, however, appear to be related to the operation of the mine. The data collected during this study will provide a solid baseline for future monitoring programs.

We hope that this report addresses all the concerns identified by both the Ministry of the Environment and the Ministry of Natural Resources. We believe that this report will address all the requirements for obtaining a Certificate of Approval for the mine. If there is anything else we can do to elaborate upon our findings, please call.

Yours very truly

Philip Niblett

Philip Niblett

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encl.

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1.0 Introduction

SENES Consultants Limited was contracted by Lac Des Iles Mine Ltd to initiate a baseline environmental monitoring program at the Lac Des Iles mine site. A portion of this monitoring program included the collection and synthesis of baseline aquatic biology data adjacent to the mine site. Niblett Environmental Associates Inc. (NEA) was retained to provide this aspect of the monitoring program.

The mine site is located approximately 90 km north of Thunder Bay (Figure 1). The existing mine facilities are located adjacent to Camp Lake (Figure 2), with the old tailing facilities discharging through two unnamed ponds and eventually to Hasson Lake (Figure 2). The biological study focussed around these four water bodies; Camp Lake, Hasson Lake, Pond 1 and Pond 2.

The Ontario Ministry of Natural Resources (OMNR), Thunder Bay District provided baseline data for Camp Lake (OMNR, 1987). NEA biologists collected additional information for Camp Lake as well as the initial surveys for Hasson Lake, Pond 1 and Pond 2.

This report documents the results of the 1992 NEA spring survey and includes water quality and fish mercury data provided by SENES Consultants Ltd.

2.0 Study Rationale

The overall objective of the NEA study was to document the existing natural biological features in the proposed area of the receiving water(s) within and beyond the anticipated area of mixing. A secondary objective was the identification and evaluation of the general potential impacts from the proposed mining operation on the identified natural resources.

This rationale was adopted to satisfy requirement 3 of D. Hollinger's letter (dated February 22, 1990) concerning the Lac Des Iles Mine application for a C. of A. (Appendix 1). The details of this requirement are " **A description of the aquatic biology in the area of the receiving water(s) within and beyond the anticipated area of mixing which focusses principally on the benthic macroinvertebrate and the fish community**".

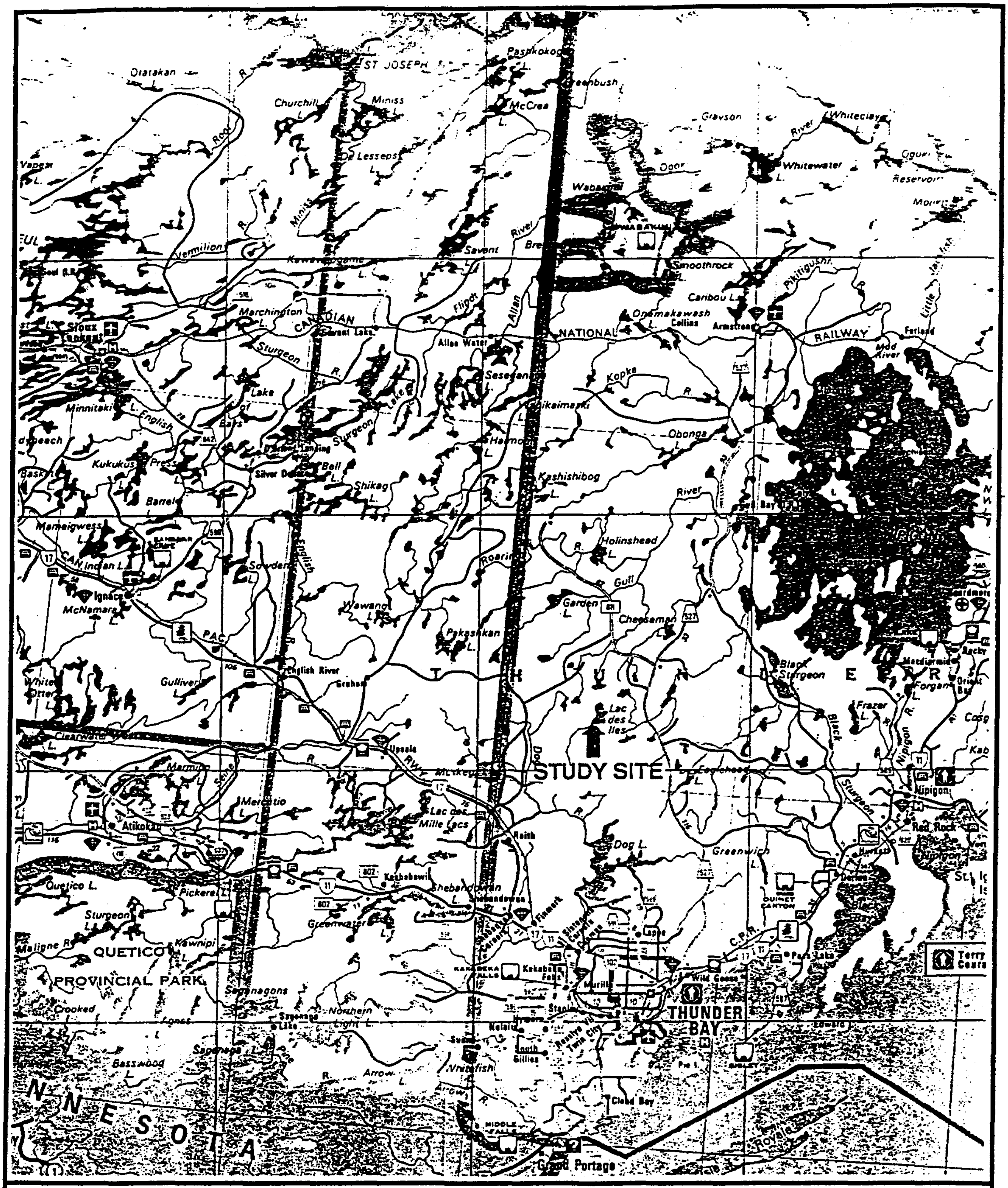

Figure 1: Study Site Location
Lac des Isles Mine

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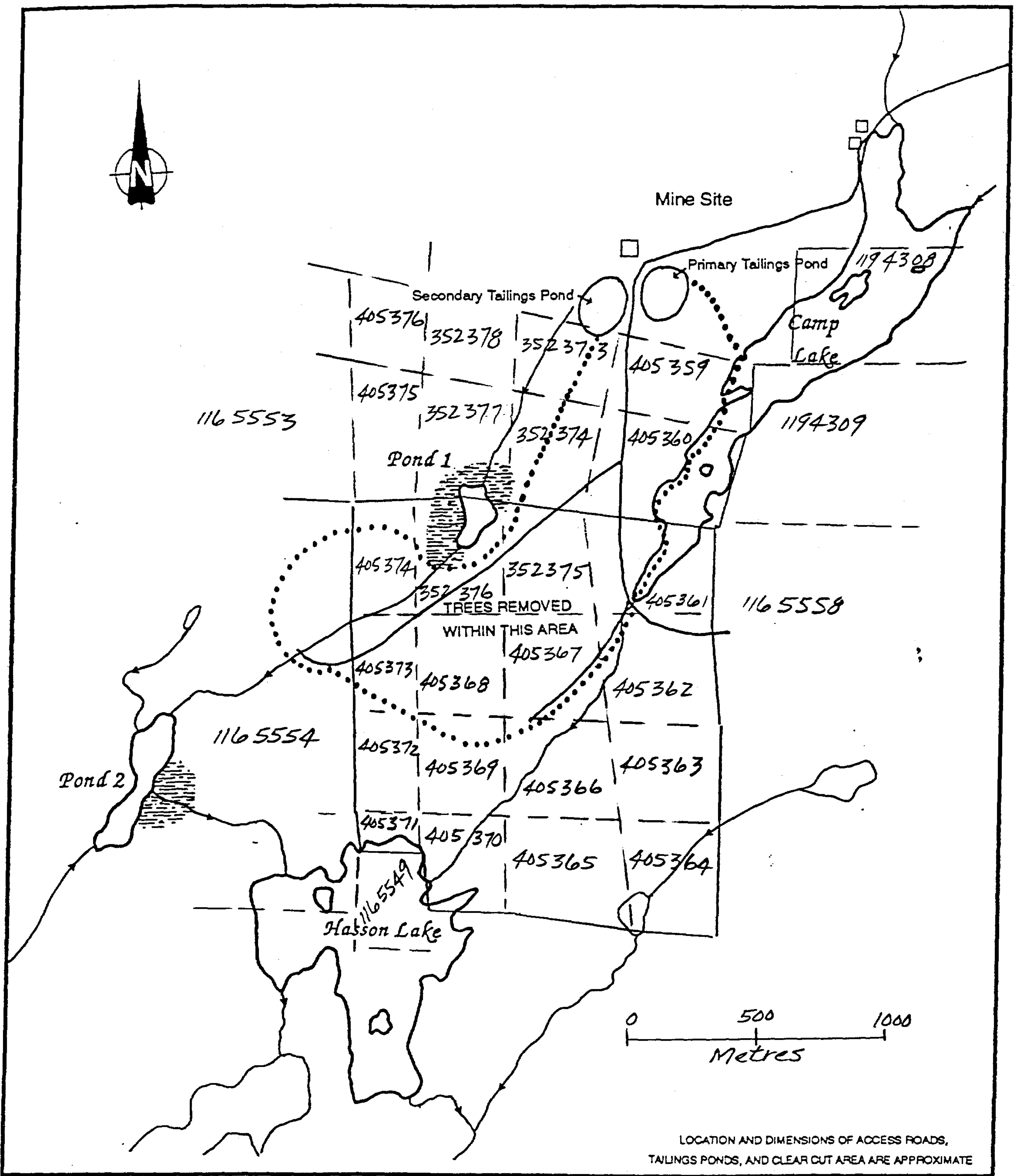

LOCATION AND DIMENSIONS OF ACCESS ROADS, TAILINGS PONDS, AND CLEAR CUT AREA ARE APPROXIMATE

Figure 2: Study Area
Lac des Isles Mine

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3.0 Study Approach

A four phased approach was adopted by NEA to accomplish the environmental objectives :

Phase I involved a review of background information from the files of the Ontario Ministry of Natural Resources (OMNR) and the Ministry of the Environment. In addition discussions were held with OMNR staff to solicit their concerns and comments about the proposed work plan.

Phase II of the study was a field survey program. The purpose of the field program was to characterize the biophysical and biological features in Camp Lake, Hasson Lake and the two unnamed ponds. The aquatic biological resources were assessed through observations and the use of various sampling techniques. A more detailed description of the sampling techniques employed in the field survey program follows.

Phase III consisted of the analysis and assessment of the general impacts of the proposed tailing facilities.

Phase IV of the study was the consolidation of the background literature review, field survey program data and impact assessment into report form.

Wildlife

Incidental observations of birds and mammals were recorded during the fisheries surveys. Observations included direct sightings, tracks, browse, scats, and nests.

Fisheries

The study area for the fisheries inventory included Camp Lake, Hasson Lake, two unnamed ponds and associated creeks within this drainage basin.

Prior to the field survey, background information obtained from OMNR were reviewed. Background information included a 1987 lake survey of Camp Lake.

Biophysical habitat characteristics were initially assessed through aerial photographs and confirmed by ground-truthing. Major biophysical characteristics were mapped, photographed and details recorded. All fish habitat characteristics were made by visual observations and followed techniques outlined in Dodge et al (1987).

Fish collection gear included beach seine nets, gill nets and minnow traps. All large fish were sampled for fork length, total length and weight. Flesh samples were also retained from northern pike for mercury analysis. Representative samples of small fish were retained for species verification.

Gill nets of varying mesh sizes were utilized to collect large fish samples. Within Hasson Lake and Camp Lake three experimental gangs of nets were utilized. Two of these nets consisted of eight 15 meter panels while one net consisted of four 15 meter panels. The stretched mesh sizes varied from 1.5" to 5.0" in 0.5" intervals. The full gangs were set in the order (shore to deep water) 2.5", 4.5", 1.5", 3.5", 2.0", 4.0", 3.0" and 5.0", while the half gang was in the order 1.5", 3.0", 4.0" and 5.". The gill net sets in the two unnamed ponds were composed of ten 15 meter panels. They were set in the order 2.0", 2.5", 3.5", 4.5", 2.5", 4.5", 1.5", 3.5", 2.0" and 4.0".

All gill nets utilized were multifilament nylon nets with 3/8" float line and #30 lead line. The panels of net were 15 meters long and 2 meters deep.

A 15 by 2 meter beach seine was utilized for small fish collections.

All net setting procedures followed Dodge et. al. (1987).

The significance status of fish species was determined from published sources such as COSEWIC (1992).

Benthos

Benthos samples were collected from riffles using a Surber sampler. The collection methods follow those outlined by Dodge et al (1987). At each sampling location a minimum of three replicates were collected. Samples were labelled and preserved in 10 % buffered formalin in the field and returned to the lab for sorting. Three replicate samples from each site were sorted to major taxonomic groups with one of the three identified to species level, where possible.

Water Quality

Water quality was measured in the field using various meters and a HACH Ecological Combination Test Kit Model AL 36DT. Dissolved oxygen and temperature were measured with a YSI meter (Model 58). A portable HACH One pH meter (Model 43800-00) was used to measure pH. Conductivity was measured with a HACH Conductivity/TDS meter (Model 44600) and alkalinity, acidity and hardness with a HACH kit.

Depth profiles of Hasson Lake were made with the aid of a Micronar ME 203 chart recording depth sounder while travelling transects. Depths of the two unnamed ponds were recorded with the use of a calibrated line and sinker. The depth profiles for Camp Lake were provided by OMNR, Thunder bay District.

4.0 Resource Inventory

4.1 Biophysical Habitat

4.1.1 Camp Lake

Figure 3 summarizes the information collected from the shoreline cruise. The majority of this data was supplied by a previous OMNR survey (MNR, 1987). Changes were made where environmental conditions had changed between the two surveys e.g. location of timber cutting.

Camp Lake had a surface area of 45.2 ha. with a total volume of 1,793,000 m^3. The maximum depth was recorded as being 15.8 meters with the average being calculated at 3.9 meters. These physical characteristics result in a relatively slow flushing rate of 0.65 times per year.

The lake is made up of 3 basins, south, middle and north (Figure 4). The south basin was the shallowest with a maximum depth of 2.0 meters. This basin had the only outflow for Camp Lake. The middle basin was the deepest, with the maximum depth being recorded at 15.8 meters. The northern basin had a maximum depth of 5 meters. This basin had two inflows, one within each arm (Figure 3).

The two inflows as well as the outflow had perceptible flows during the spring 1991 survey. No perceptible flows were observed within the inflows or outflow, during the OMNR 1987 survey.

The shoreline cruise determined substrata composition to be 60 percent rock, 10 percent boulder, 10 percent rubble, 5 percent gravel, 10 percent muck and 5 percent detritus. Lake bottom consisted mainly of muck and detritus.

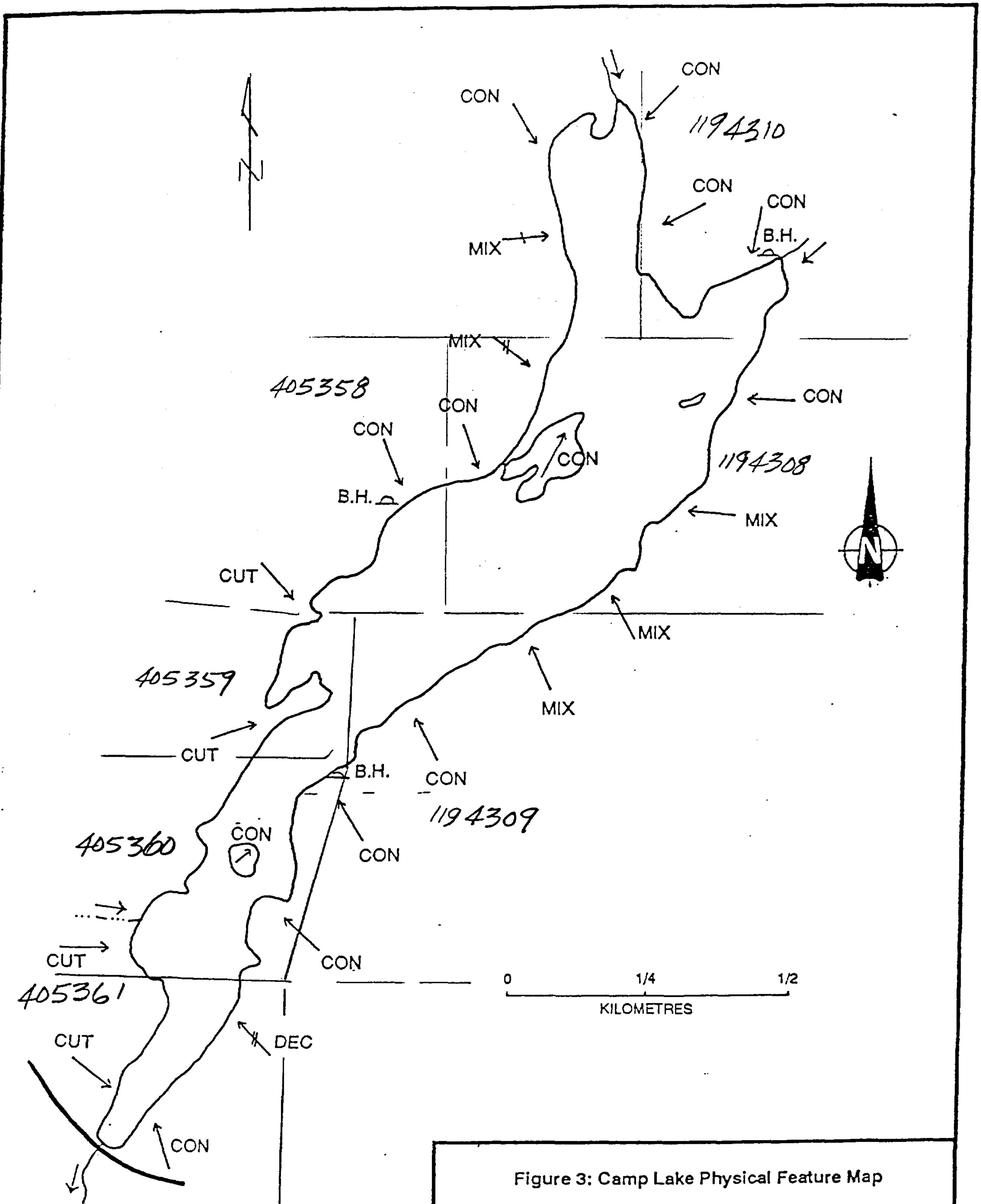

Figure 3: Camp Lake Physical Feature Map

(Base Map From O.M.N.R. Lake Survey 1987. See Appendix for Legend)

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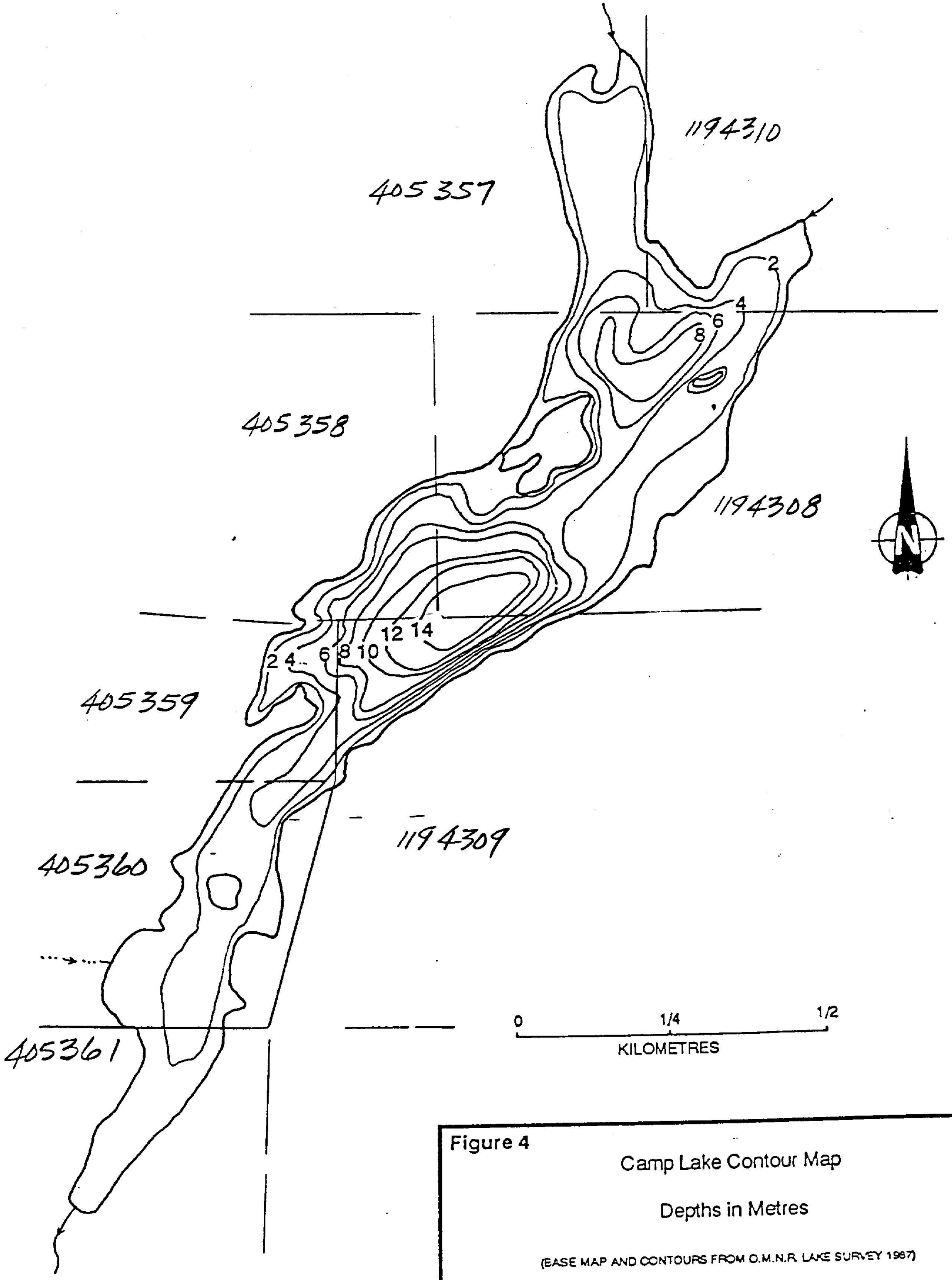

Figure 4

Camp Lake Contour Map

Depths in Metres

(BASE MAP AND CONTOURS FROM O.M.N.R. LAKE SURVEY 1987)

NIBLETT ENVIRONMENTAL ASSOCIATES INC. 1992 SCALE AS SHOWN

The main difference between biophysical observations recorded by OMNR (OMNR, 1987) and the NEA field crew was the percentage of upland forest cover. Recent logging adjacent to Camp Lake has changed the upland forest composition along the south west shoreline (Figure 3). This shoreline is no longer vegetated with coniferous trees (OMNR, 1987) but instead it has been logged, leaving open cut areas. This cut area comprised approximately 25 percent of the Camp Lake shoreline. The remaining shoreline was similar to that recorded by OMNR (1987).

Based on biophisical characteristics the NEA field crew identified the inflow at the north east arm of the lake (Figure 3), as the most probable location for northern pike spawning. No ideal sucker spawning locations were found, but it is expected to occur at the inflow at the north end of the lake (Figure 3).

Dissolved oxygen and temperature profiles (Figure 5 through 7) indicate that the Camp Lake hypolimnion becomes anoxic during summer months (Figures 5 and 6) and approaches anoxic conditions during winter months (Figure 7). The May (NEA survey) and the June (OMNR survey) field trips found Camp Lake to become stratified with the thermocline being found between 4.0 and 8.0 meters.

Table 1 provides general surface water quality results recorded during the NEA field survey. The pH indicated that Camp Lake is slightly acidic. The low alkalinity and acidity results indicate the low buffering capacity (acidic as well as basic) of Camp Lake. This is found to be typical for areas draining swampy lands (MOE, 1979). The shallow Secchi depth (1.2 meters) was a result of the brown coloured water, resulting from tannic and humic acids.

4.1.2 Hasson Lake

The surface area for Hasson Lake was recorded as being 41.7 ha., with the volume being calculated at 86.3 X $10^4 m^3$. The maximum depth was found to be 7.0 meters while the average depth was calculated to be 2.1 meters Figure 8). These physical characteristics result in a moderately high flushing rate of five times per year for this lake.

Hasson Lake was made up of 3 basins, north, south and west. The west basin was found to have a maximum depth of 2.0 meters. This basin contained an inflow as well as outflow. The west basin inflow was discharge from Pond 2. The north basin was found to be the deepest with a recorded depth of approximately 7.0 meters. This basin had an inflow which was from the Camp Lake discharge. The south basin was the smallest of all basins. Its maximum depth was recorded as being 2.0 meters. This basin had one outflow (Figure 8).

Figure 5 - Camp Lake Oxygen Profile (NEA survey)

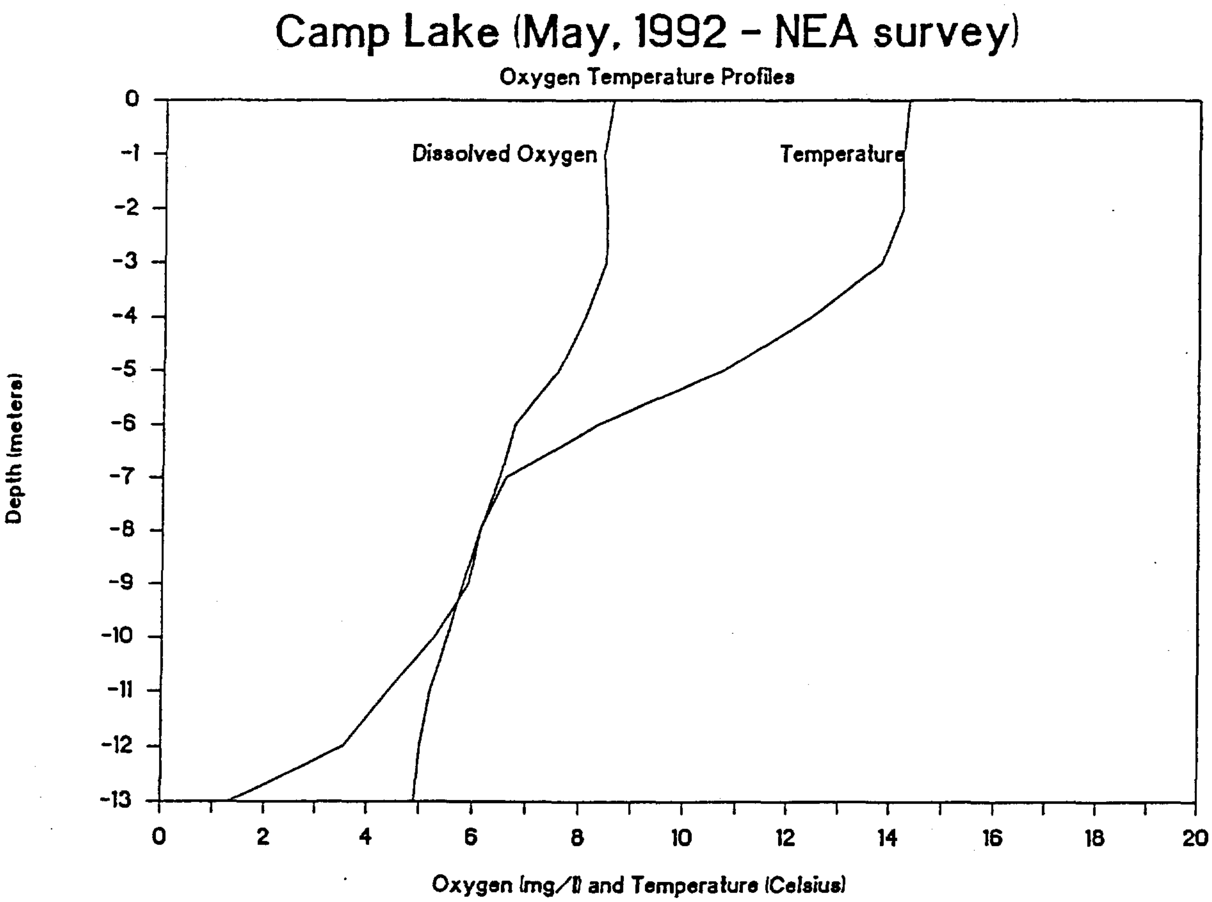

Figure 6 - Camp Lake Oxygen Profile (MNR survey)

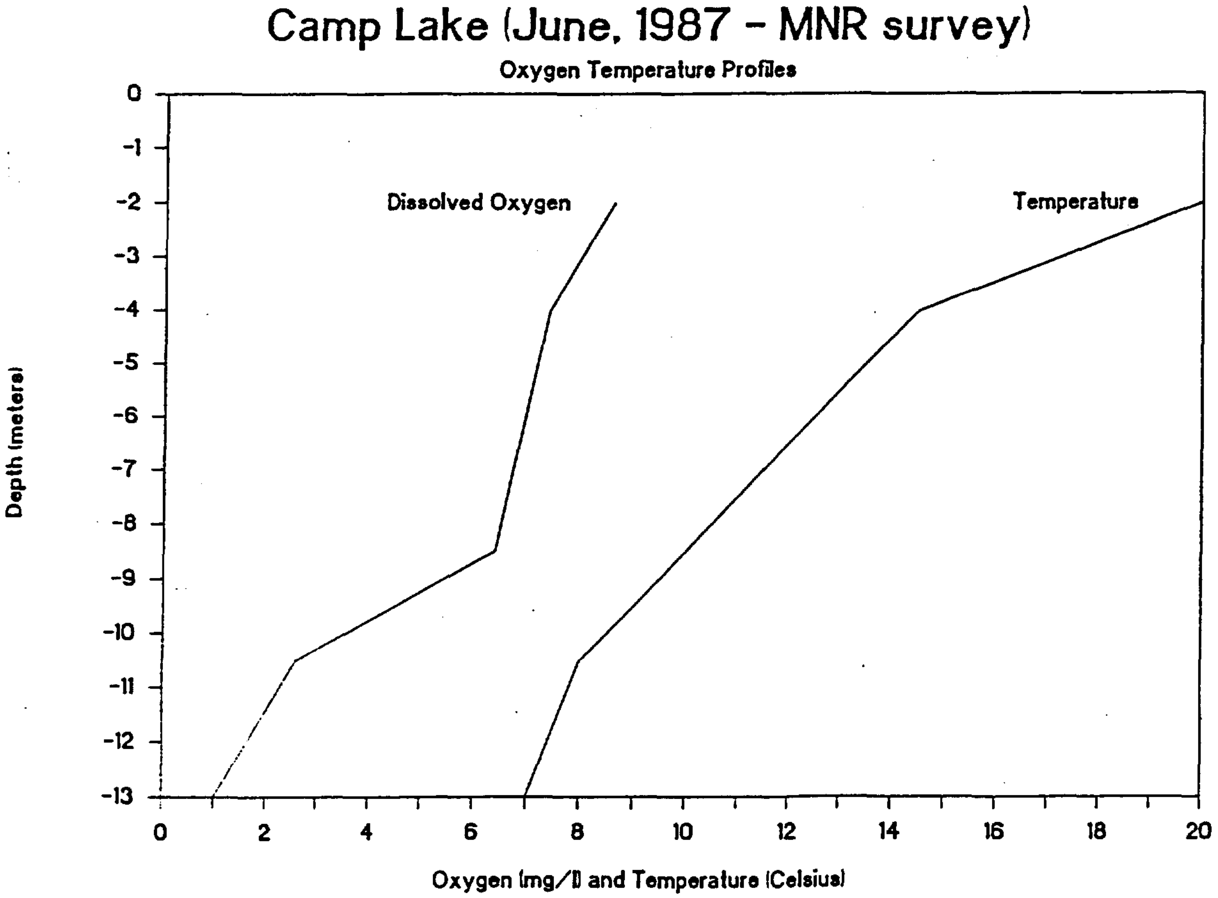

Figure 7 - Camp Lake Oxygen Profile (SENES survey)

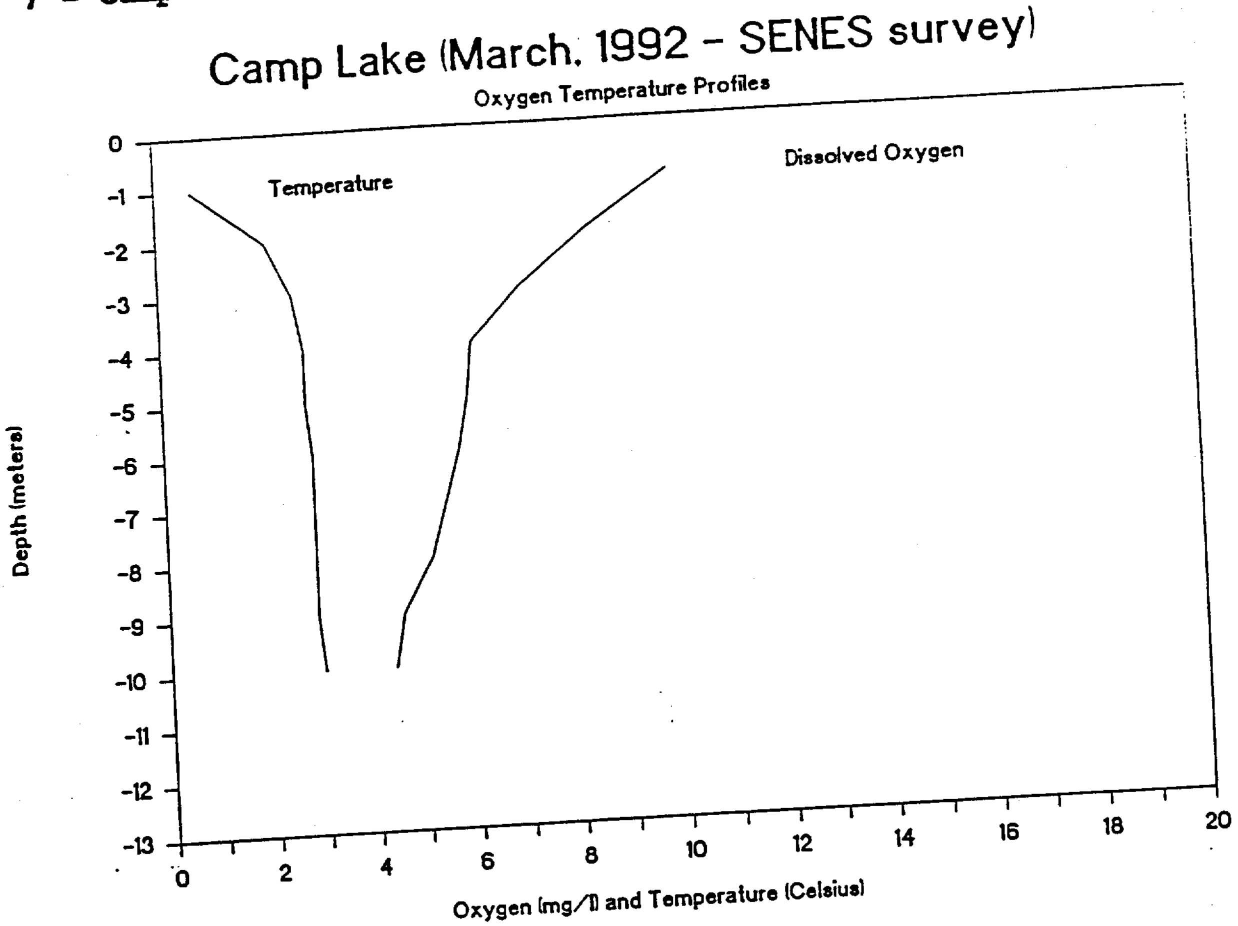

Table 1: Basic Surface Water Chemistry Results

Parameter	Units	Hasson Lake	Camp Lake	1st Pond	2nd Pond
Conductivity	mS/cm	0.05	0.05	0.08	0.05
Total Dissolved Solids	g/l	0.025	0.03	0.04	0.03
Alkalinity	mg/l	13.0	8.0	29.0	11.0
Hardness	mg/l	14.0	19.0	16.0	7.0
Acidity	mg/l	3.0	14.0	19.4	5.0
pH		7.1	6.9	7.4	6.8
Secchi depth	meters	1.4	1.2	0.6	1.1

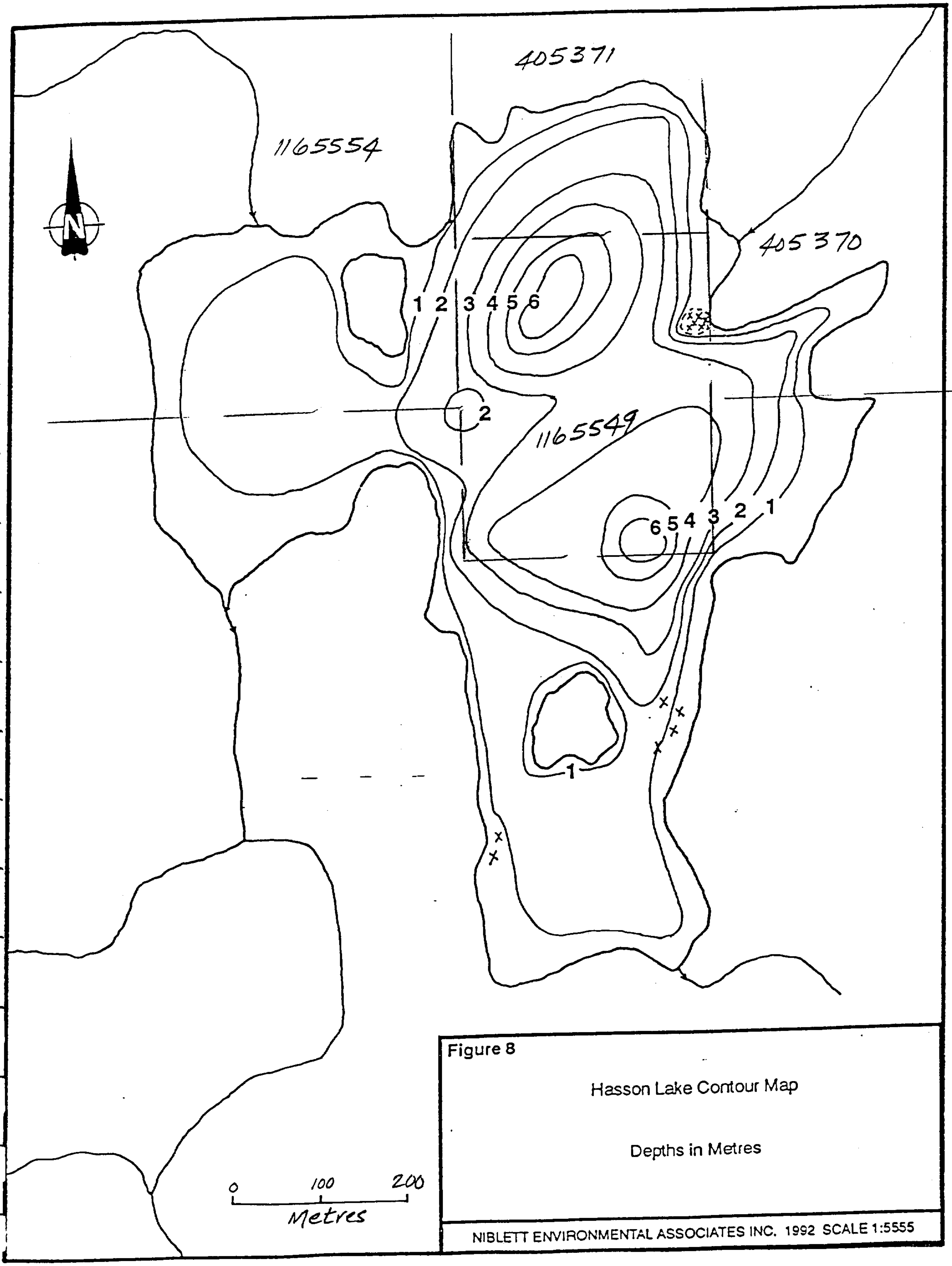

Figure 8

Hasson Lake Contour Map

Depths in Metres

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During our field reconnaissance all Hasson Lake inlets and outlets had perceptible flows. The outflow in the west basin was deemed to contain the greatest flow.

The shoreline substrata was determined to be 5 percent bedrock, 30 percent boulder, 10 percent rubble, 5 percent gravel, 30 percent sand, 15 percent muck and 5 percent detritus. Offshore substrata was almost 100 percent muck and detritus. A small percentage of boulder was found.

The main forest type surrounding Hasson Lake was coniferous, with the south shore of the south basin having a deciduous stand. The main tree species observed were black spruce, Jack pine, tamarack, cedar, white birch and poplar (Figure 8).

Since our survey took place immediately following ice-out, aquatic plant species were found to be sparse. It is expected that thick mats of yellow water lily, ribbonleaf pondweed, horse tails and bulrush will develop along the shoreline of the west basin, later in the season. These species are also expected to be found in the small bays of the north basin.

Several locations were identified as potential northern pike spawning habitat (Figure 9). This analysis was based on biophysical habitat characteristics. The Hasson Lake inflow from Camp Lake was confirmed to be a white sucker spawning area (sucker eggs were collected in Surber sampler)(Figure 9).

The dissolved oxygen profiles for Hasson Lake (Figures 10 and 11) indicate that the hypolimnetic oxygen concentration dropped to critical levels, eventually reaching anoxic conditions in the bottom meter (SENES winter survey) (Figure 10). Sampling later in the year (July) may also show that Hasson Lake becomes anoxic in the summer months as well. The May, 1992 survey indicated that the north basin will likely stratify during the summer months, as partial stratification was already apparent (Figure 11).

The general surface water quality indicates that Hasson Lake is slightly alkaline with a pH of 7.1 (Table 1). The low alkalinity results indicated that Hasson Lake has low capacity to buffer acids, while the acidity test indicates that Hasson Lake has an even lower capacity to buffer bases. Hasson Lake had the deepest Secchi reading at 1.4 meters (Table 1).

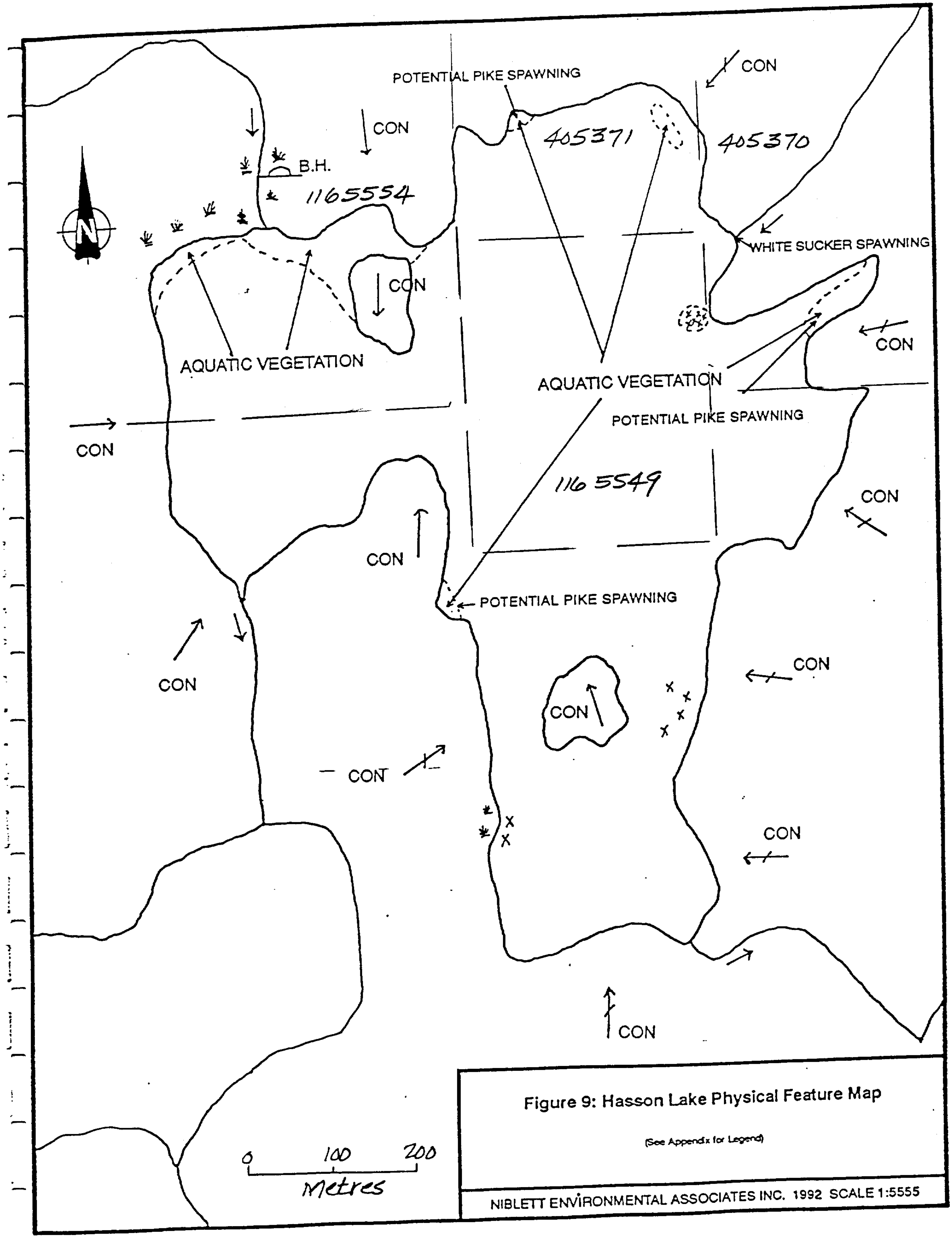

Figure 9: Hasson Lake Physical Feature Map

(See Appendix for Legend)

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Figure 10 - Hasson Lake Oxygen Profile (NEA survey)

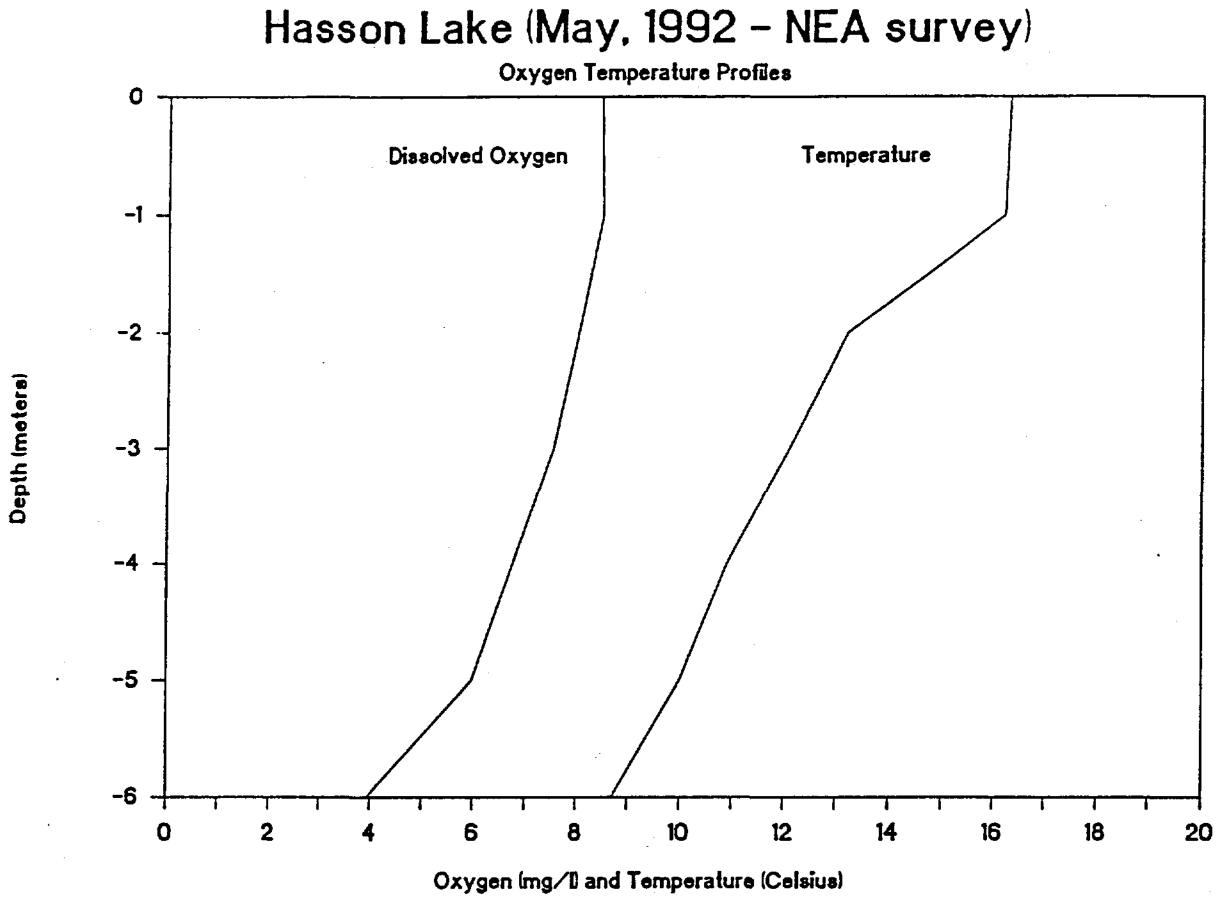
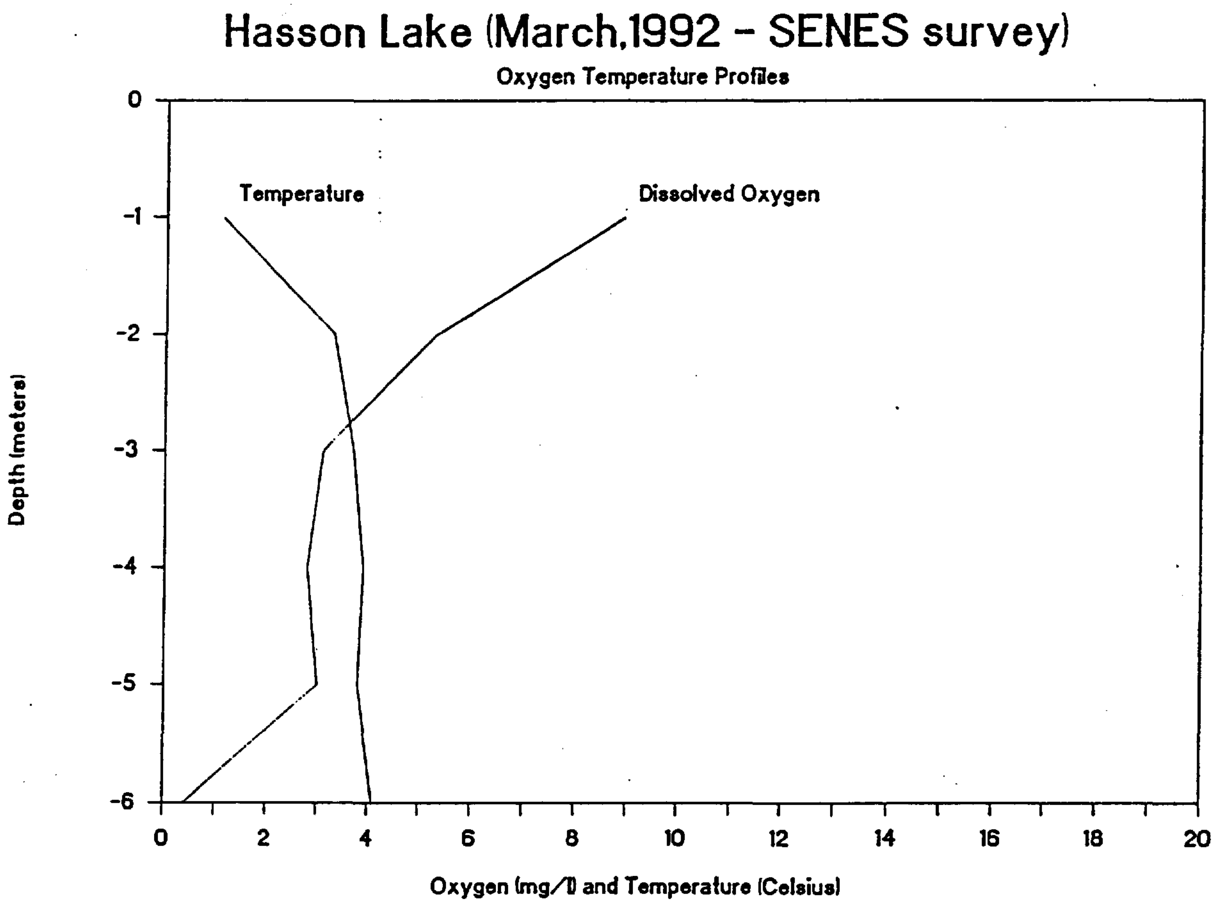


Figure 11 - Hasson Lake Oxygen Profile (SENES survey)



4.1.3 Pond 1

Pond 1 was an extremely small water body with a surface area of 1.87 ha. and a volume of 1.6 X $10^4 m^3$. The average depth was calculated to be 0.86 meters while the maximum depth was recorded as 1.9 meters (Figure 12). Due to the small volume of water within this pond, the flushing rate was a very high fifteen times per year. This calculation was based on runoff from the immediate watershed only.

One inflow and one outflow were found for Pond 1. The inflow receives discharge from the Lac des Iles Mine tailing ponds, with the outflow going to Pond 2. The water level of the pond was controlled by a beaver dam across the outflow (Figure 13).

The shoreline substrata consisted of 100 percent muck and detritus.

The shoreline of Pond 1 consists of 75 percent open water bog and 15 percent cut over and 10 percent conifers. The coniferous stands were composed of black spruce and tamarack (Figure 13).

No submergent or floating aquatic plants were observed. The floating bog surrounding Pond 1 was populated by sweet gale, Labrador tea, pitcher plant, sundew, grasses and sedges.

The oxygen and temperature profiles (Figure 14) indicate that the dissolved oxygen drops from 9.5 ppm at the surface to 2.9 ppm at 1.5 meters. The shallowness of this pond likely prevents the formation of a stable thermocline but slight top to bottom differences likely occur on calm days. Pond 1 was found to go anoxic during the winter months. SENES field personnel recorded oxygen levels at 0.3 ppm during their March, 1992 survey.

Table 1 provides general surface water quality results recorded during the NEA field survey. The pH indicated that Pond 1 was slightly acidic. The low alkalinity and acidity results indicate a low buffering capacity for acids as well as bases. This is found to be typical for areas draining swampy lands (MOE, 1979). The strongly tea coloured water resulted in a low Secchi depth of 0.6 meters.

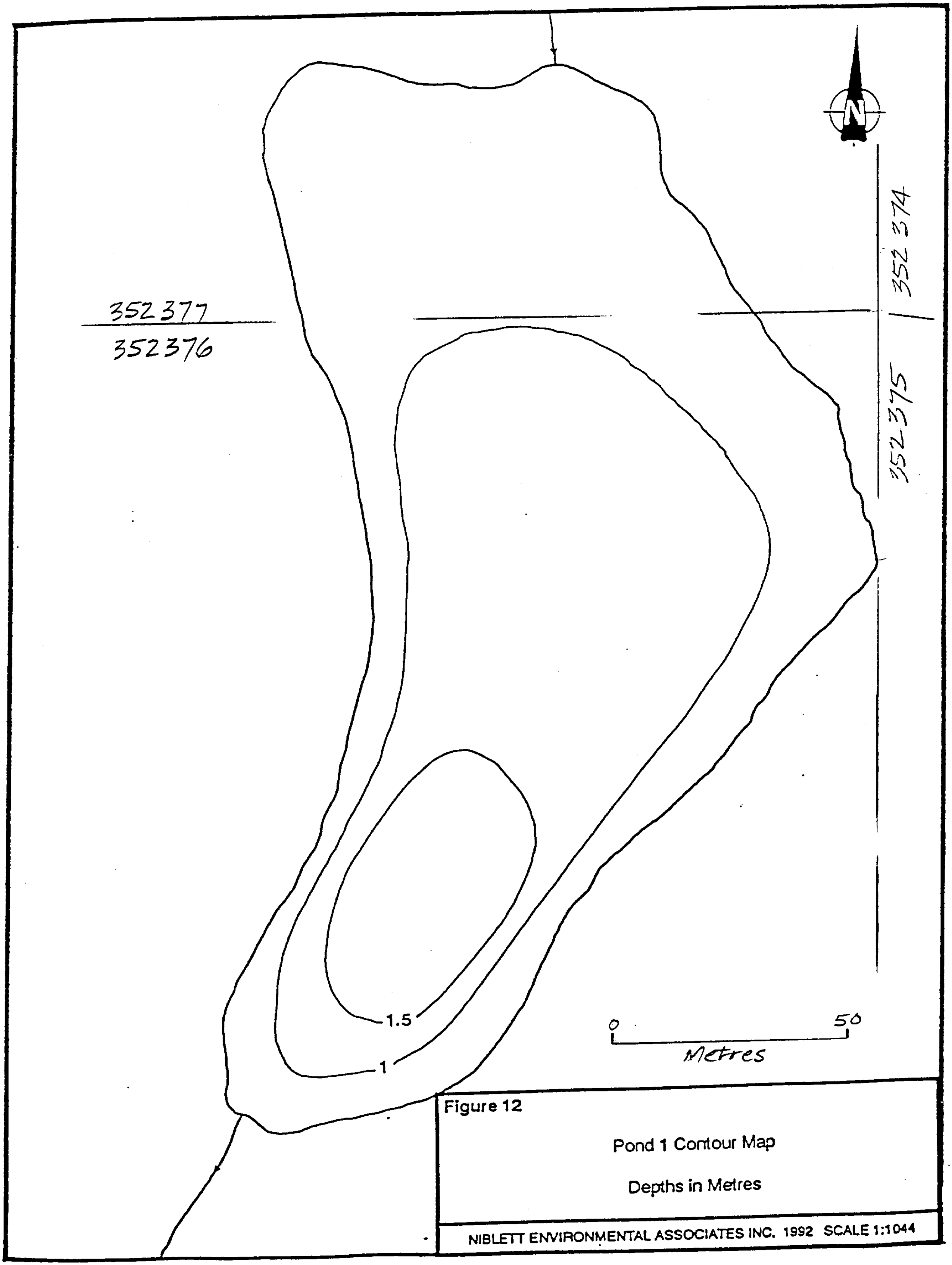


Figure 12

Pond 1 Contour Map

Depths in Metres

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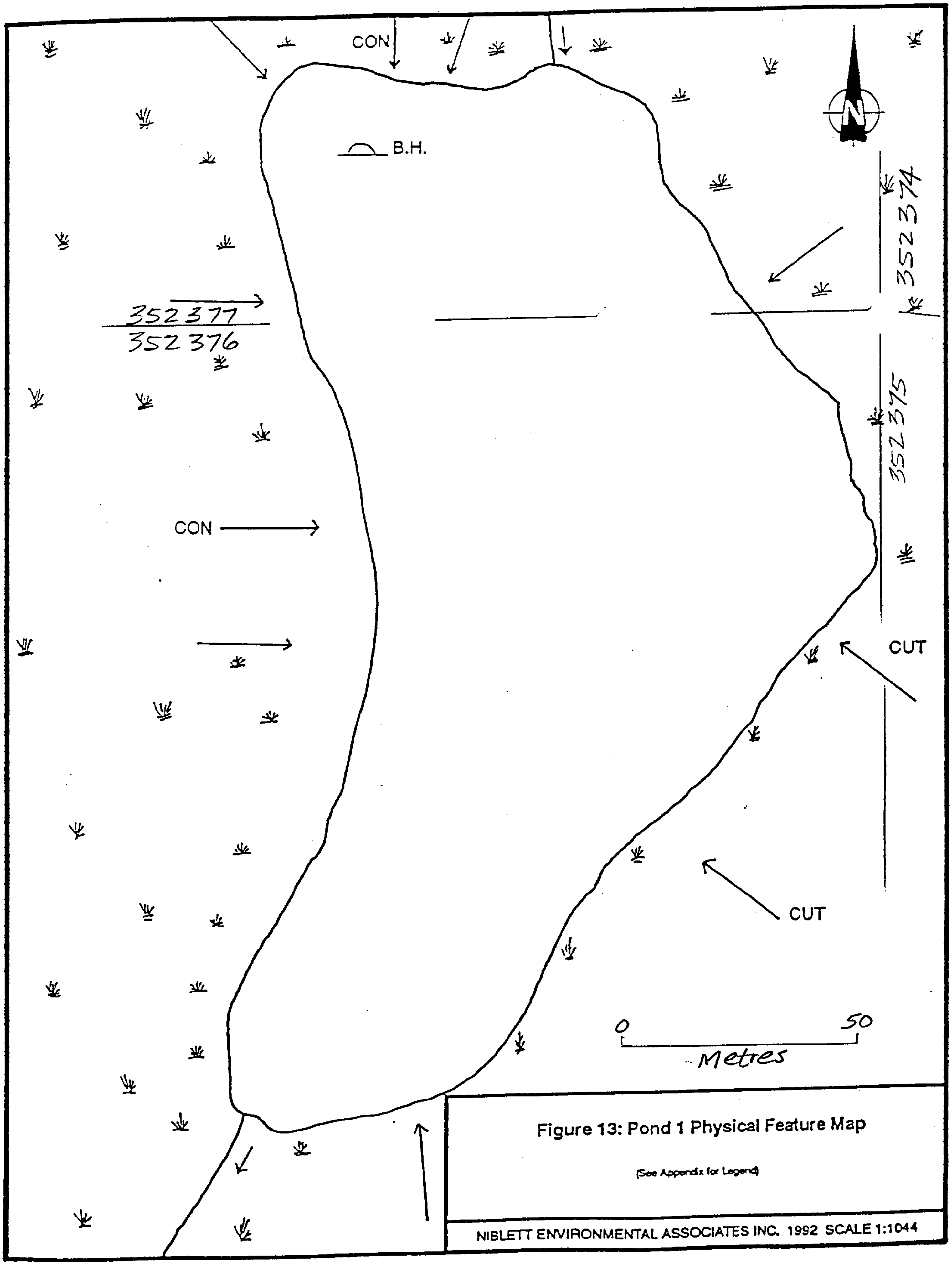

Figure 13: Pond 1 Physical Feature Map

(See Appendix for Legend)

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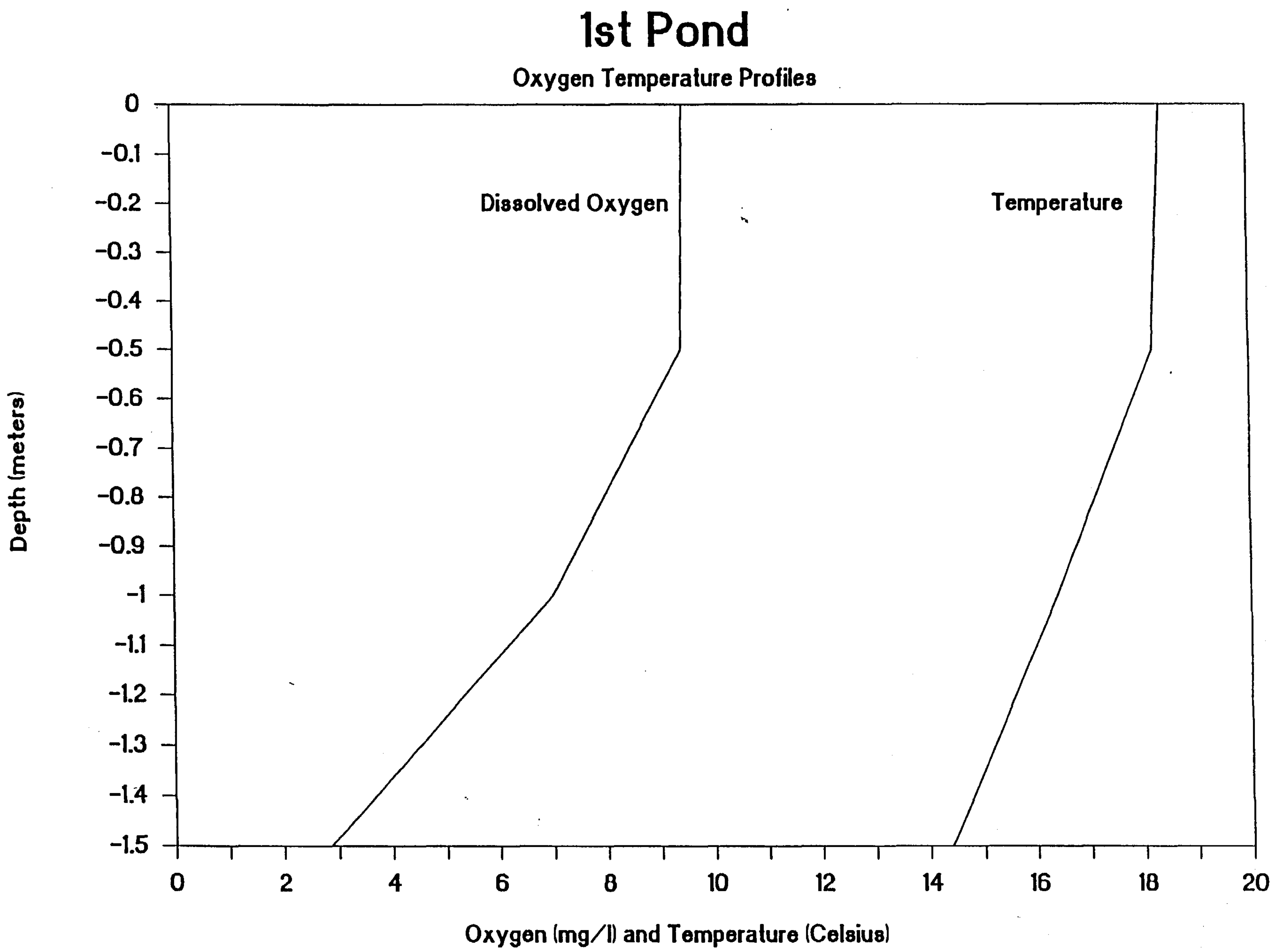

Figure 14 - Pond 1 Oxygen Profile (NEA survey)

4.1.4 Pond 2

Pond 2 was a small water body with a surface area of 5.14 ha. and a volume of 9.4 X 10^4m^3. The average depth was calculated to be 1.8 meters while the maximum depth was found to be 4.0 meters (Figure 15). These physical conditions result in a very high flushing rate of twenty-three times per year.

Pond 2 was found to have three inflows. The south inlet and north west inlet had no perceptible flow. The outlet had perceptible flow over a beaver dam (Figure 16).

The vegetation along the shoreline was composed of 60 percent coniferous stand and 40 percent open water bog. Large stands of dead conifers were observed within the littoral zone of this pond (Figure 16). No aquatic macrophytes were observed.

The shoreline substrata was composed of 75 percent muck and detritus, 15 percent bedrock and 5 percent boulder and 5 percent rubble.

The dissolved oxygen profile found saturated water from the surface to 2.5 meters (Figure 17). Below 2.5 meters the oxygen drops from 7.7 ppm to 1.5 ppm. This indicates that Pond 2 likely becomes anoxic during summer months. The March, 1992 water sampling program (SENES, 1992) found oxygen values as low as 1.3 ppm.

The pH indicates that Pond 2 was slightly acidic. This water body was found to have the lowest alkalinity and acidity results of the four tested. This indicates it's low capacity to buffer acids as well as bases. The Secchi depth was 1.1 meters.

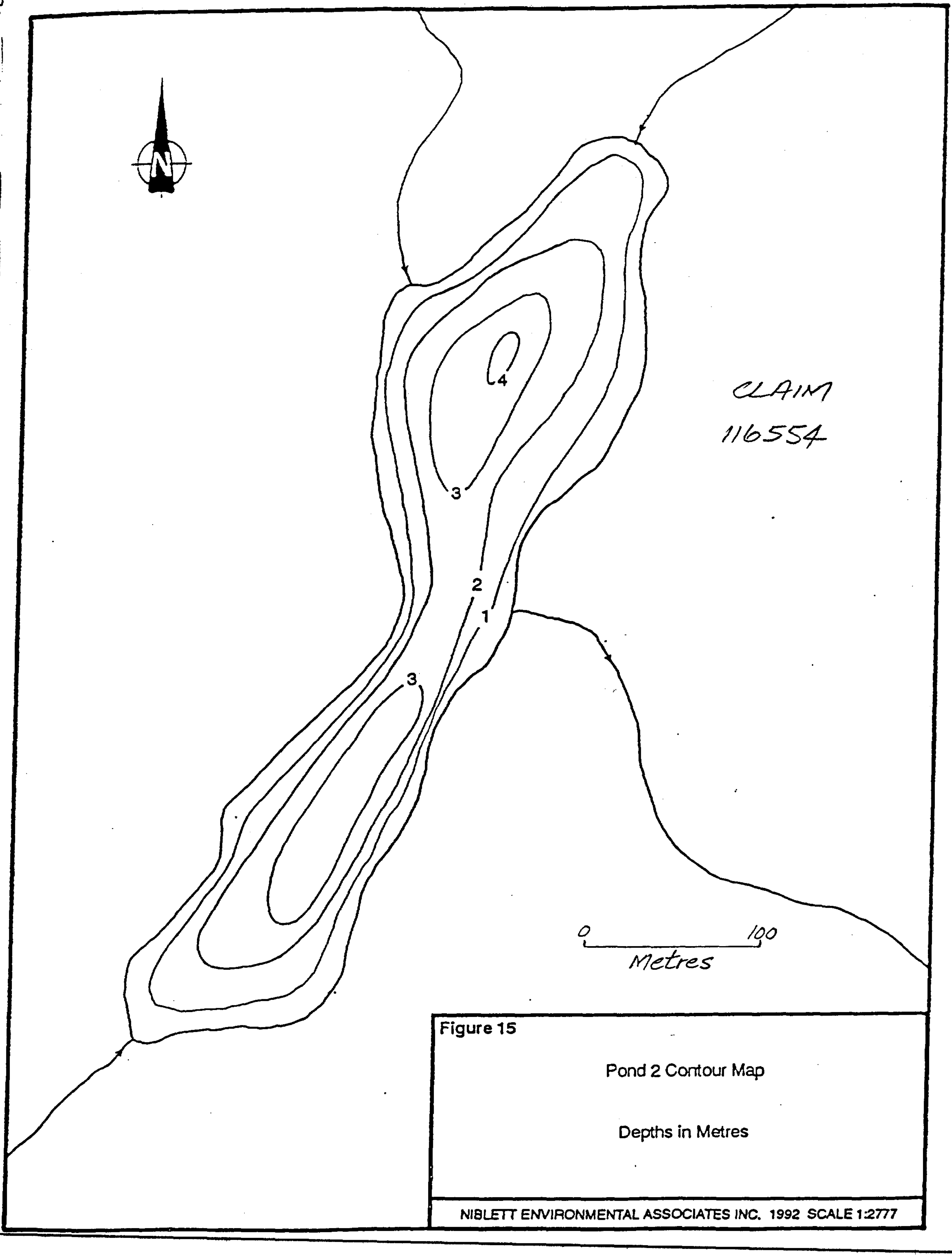

Figure 15

Pond 2 Contour Map

Depths in Metres

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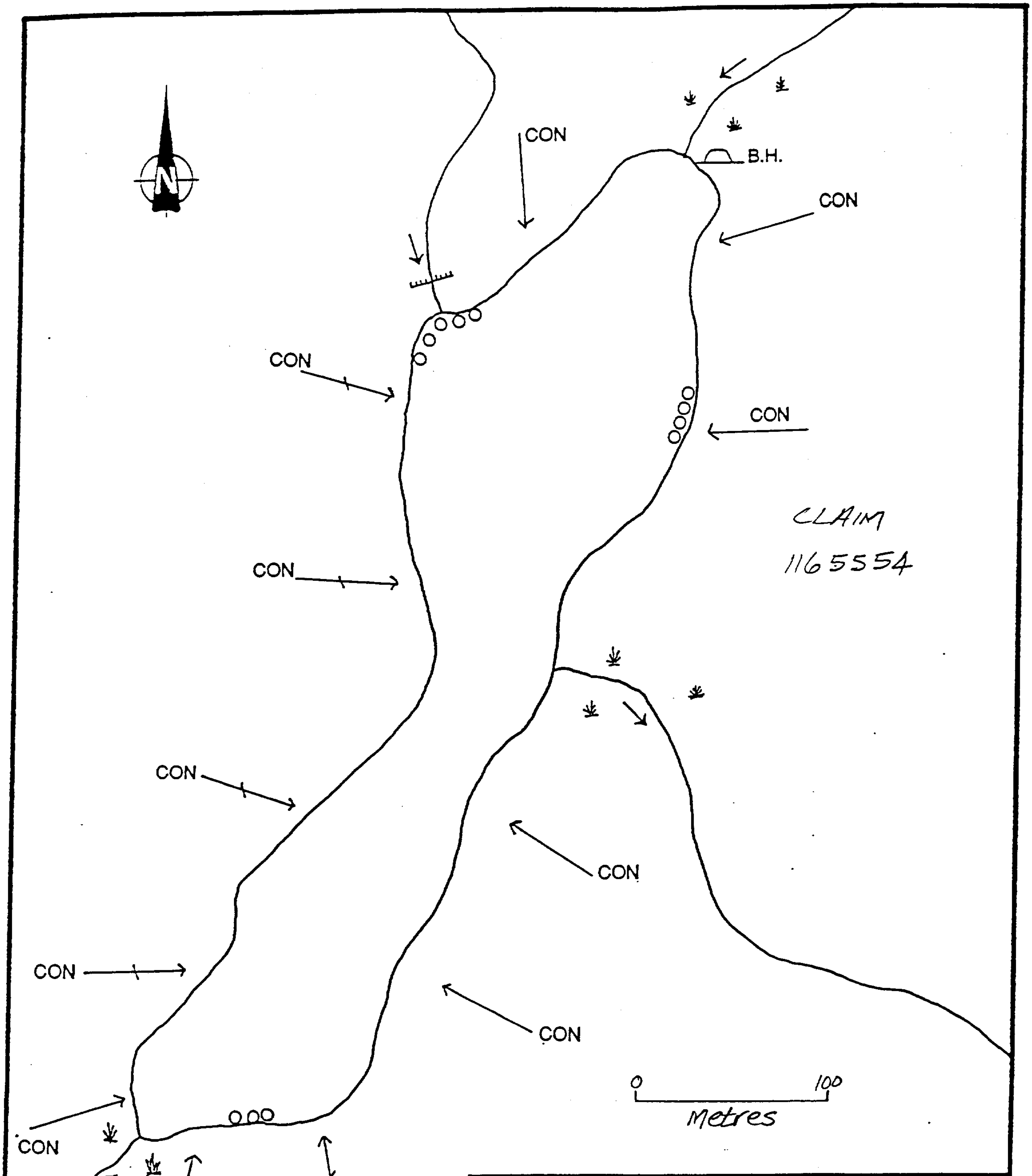

Figure 16: Pond 2 Physical Feature Map

(See Appendix for Legend)

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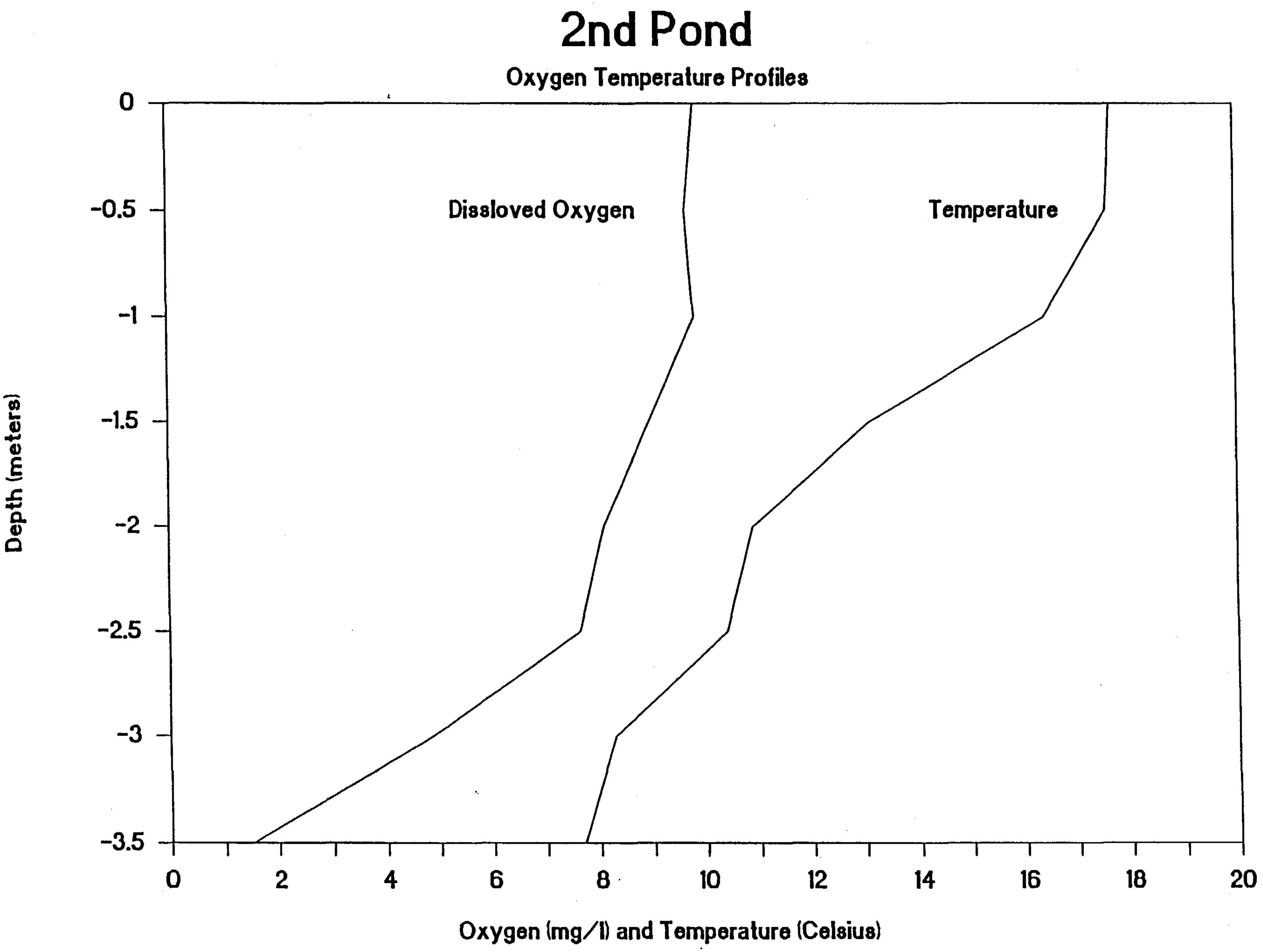


Figure 17 - Pond 2 Oxygen Profile (NEA survey)

4.2 Fisheries

A total of 10 species of fish were recorded within the study area (Table 2). Eight species were recorded by the NEA field personnel while six were reported by the OMNR field crew (OMNR, 1987). Both studies reported northern pike, yellow perch, blacknose shiner and northern redbelly dace. Additional species captured by the NEA crew were white sucker, finescale dace, Johnny darter and lake chub. All of these fish were caught in other water bodies not surveyed by OMNR, except the white sucker. The OMNR crew captured Iowa darter and burbot in Camp Lake. These species were absent from the NEA catch records.

The fish within the study area can be separated into the 3 general categories of sport fish, forage fish and coarse fish (Table 2).

Table 2: Study Site Fish Species List

Common Name	Scientific Name	NEA	MNR
Sport Fish			
Northern pike	*Esox lucius*	X	X
Yellow perch	*Perca flavescens*	X	X
Forage Fish			
Finescale dace	*Phoxinus neogaeus*	X	
Northern redbelly dace	*Phoxinus eos*	X	X
Johnny darter	*Etheostoma nigrum*	X	
Iowa darter	*Etheostoma exile*		X
Blacknose shiner	*Notropis heterolepsis*	X	X
Lake chub	*Couesius plumbeus*	X	
Burbot	*Lota lota*		X
Coarse Fish			
White sucker	*Catostomus commersoni*	X	
Total	10	8	6

4.2.1 Camp Lake

The NEA field crew identified four fish species within Camp Lake. They included northern pike, yellow perch, blacknose shiner and white sucker. The OMNR survey (OMNR, 1987) found two additional species, Iowa darter and burbot.

The NEA netting efforts are located on Tables 3 through 5, with all net locations on Figure 18 and all recorded meristic data being presented in Appendix 2.

The gill netting program (Table 3) found northern pike to be the most abundant large fish, followed by white sucker and yellow perch. The combined C.U.E. calculations per species was 0.511, 0.088 and 0.015 (fish/hour/120 meters of net) for northern pike, white sucker and yellow perch respectively.

Table 3: Camp Lake Gill Net Catch Records

Net	In (day/hour)	Out (day/hour)	Total (hours)	Catch	C.U.E.
1	27/0930	28/0800	22.5	14 Northern pike	0.622
				2 White sucker	0.089
2	27/1000	28/0900	23.0	7 Northern pike	0.304
				1 Yellow perch	0.043
3	27/1030	28/0930	23.0	7 Northern pike	0.609
				2 White sucker	0.174
Total			**68.5**	**33 Fish**	**0.613**

C.U.E. - The number of fish caught per hour per 120 meters of net
Gill net 1: 8, 15 meter panels from 1.5 to 5.0" at 0.5" intervals
Gill net 2: 8, 15 meter panels from 1.5 to 5.0" at 0.5" intervals
Gill Net 3: 4, 15 meter panels - 1.5", 3.0", 4.0" and 5.0"

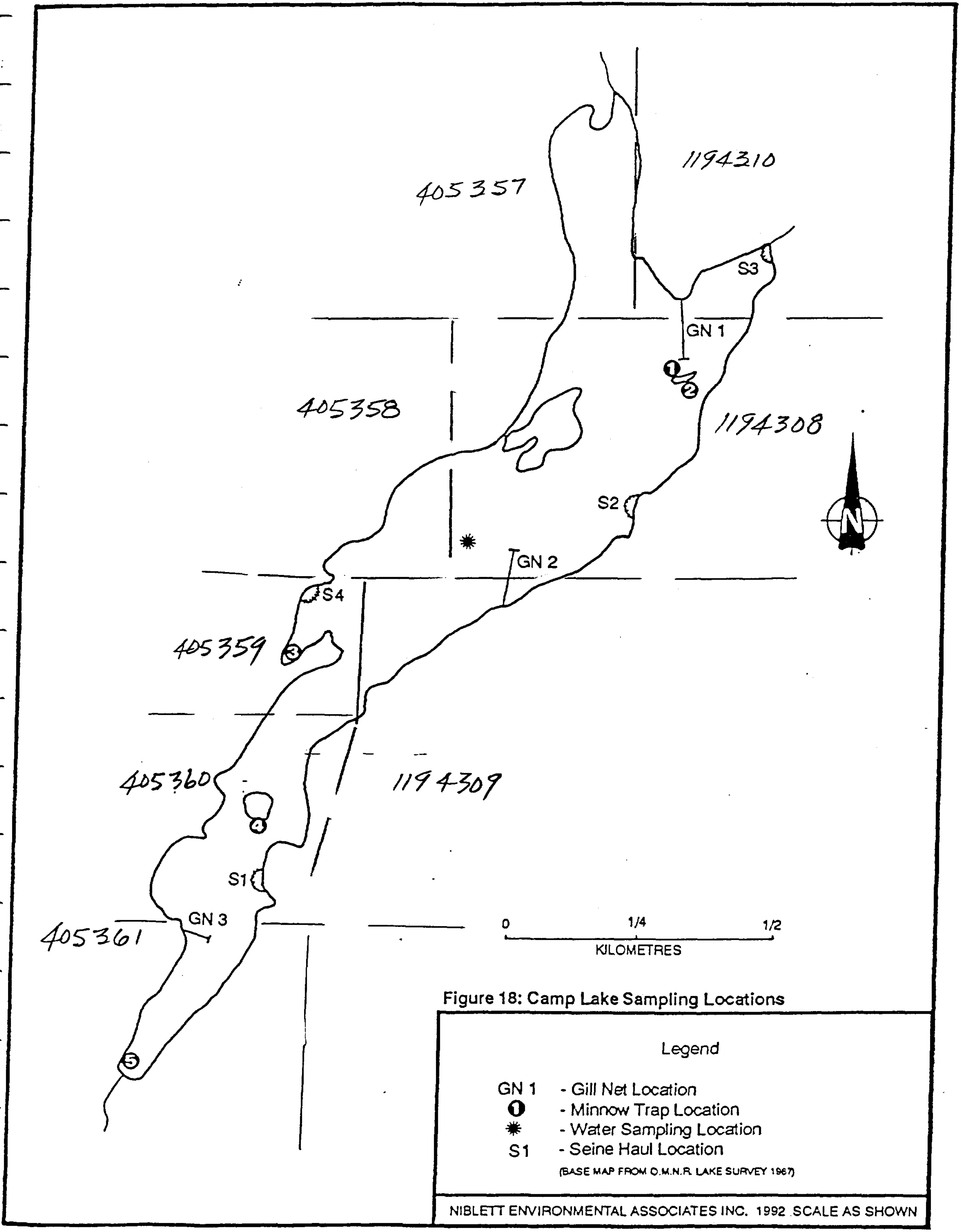


Figure 18: Camp Lake Sampling Locations

The OMNR gill netting program (OMNR, 1987) captured only four northern pike, for a calculated C.U.E. of 0.828 (pike/hour/120 meters of net). The difference in pike C.U.E. between the two programs may only be due to the timing of the surveys. During the OMNR survey, Camp Lake had stratified with an anoxic hypolimnion thus, the pike had less usable habitat which would lead to a relatively higher density of fish near shore as well as to a higher C.U.E. Differences in type and size of gear used can also lead to different reported C.U.E.s.

Minnow traps and seine hauls were utilized for the small fish collections within Camp Lake. The minnow traps (Table 4) failed to catch any fish. These results are similar to the OMNR (1987) results. They captured one blacknose shiner with five overnight minnow trap sets. The lack of forage fish in the minnow traps is likely due to the presence of northern pike. They would keep all small fish populations in check.

Table 4: Camp Lake Minnow Trap Catch Records.

Set	In (day/hour)	Out (day/hour)	Total (hours)	Trap	Catch	C.U.E.
1	27/0945	28/0845	23.0	1	0 Fish	0.000
				2	0 Fish	0.000
2	27/1000	28/0900	23.0	1	0 Fish	0.000
				2	0 Fish	0.000
3	27/1015	28/0915	23.0	1	0 Fish	0.000
				2	0 Fish	0.000
4	27/1030	28/0930	23.0	1	0 Fish	0.000
				2	0 Fish	0.000
5	27/1045	28/1000	23.3	1	0 Fish	0.000
				2	0 Fish	0.000

C.U.E. - The number of fish caught per hour per trap

The seine net catches (Table 5) were slightly more productive than the minnow traps. A total of 1249 fish, from three species were captured in 4 seine hauls. Blacknose shiners were by far the most abundant forage fish with 1227 being caught in one seine haul. The catch of a 1^+ northern pike confirms that the Camp Lake pike population is viable and naturally reproducing.

Table 5: Camp Lake Seine Net Catch Records

Location	Catch
1	1227 Blacknose shiner 19 Yellow perch
2	2 Blacknose shiner
3	1 Northern pike 1+
4	0 Fish

OMNR (1987) reported the capture of 129 fish from four species in 4 seine hauls. They also found blacknose shiner to be the most abundant forage fish. They captured two additional species, Iowa darter and finescale dace, that were not captured by the NEA crew.

Stomach contents examination of the 10 pike sacrificed for metal analysis found yellow perch and unidentified cyprinids as the major food source. OMNR (1987) identified yellow perch and burbot as forage for northern pike.

4.2.2 Hasson Lake

The Hasson Lake fisheries investigation identified five species of fish: northern pike, white sucker, blacknose shiner, yellow perch and lake chub. The netting catch records are found in Table 6 through 8 with Figure 19 showing sampling locations and Appendix 2 containing all the meristic data.

The gill nets (Table 6) captured only the two species, northern pike and white sucker. The overall C.U.E. for pike and white sucker was found to be 0.300 and 0.344 respectively.

Table 6: Hasson Lake Gill Net Catch Records

Net	In (day/hour)	Out (day/hour)	Total (hours)	Catch	C.U.E.
1	28/1445	29/0900	18.3	4 Northern pike	0.438
				8 White sucker	0.877
2	28/1500	29/1015	19.3	5 Northern pike	0.260
				2 White sucker	0.104
3	28/1545	29/1130	19.8	4 Northern pike	0.203
				1 White sucker	0.051
Total			**57.3**	**24 Fish**	**0.629**

C.U.E. - The number of fish caught per hour per 120 meters of net
Gill net 2: 8, 15 meter panels from 1.5 to 5.0" at 0.5" intervals
Gill net 3: 8, 15 meter panels from 1.5 to 5.0" at 0.5" intervals
Gill Net 1: 4, 15 meter panels - 1.5", 3.0", 4.0" and 5.0"

The northern pike C.U.E indicates that the relative population of pike in Hasson Lake is almost half of that found in Camp Lake. The relative population of white suckers is considerably higher in Hasson Lake than that found in Camp Lake.

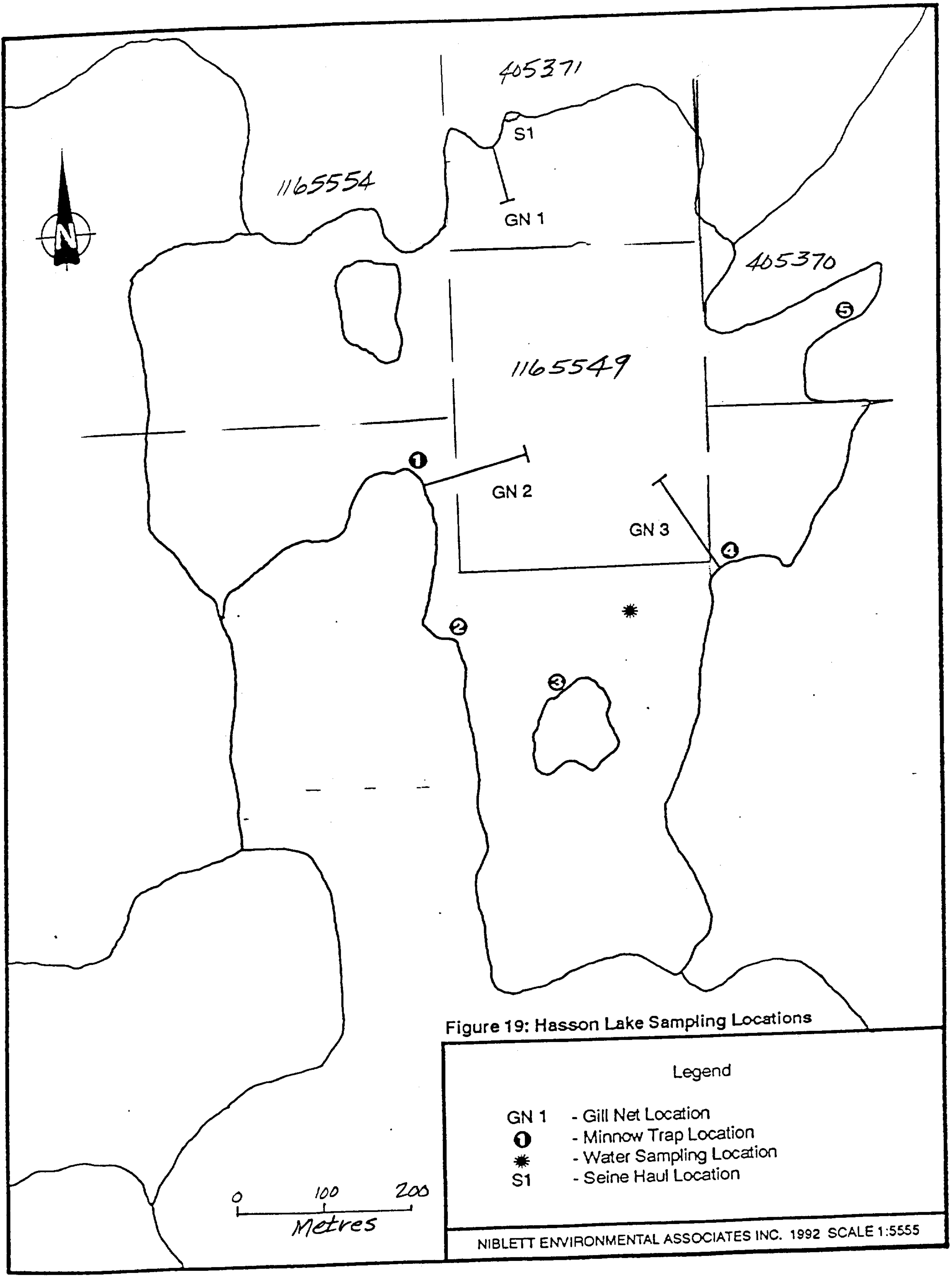


Figure 19: Hasson Lake Sampling Locations

Environmental conditions within Hasson Lake may contribute to the differences in relative populations between the two lakes. The winter dissolved oxygen conditions within Hasson Lake would limit the pike production. Oxygen values were found to be within the 3 ppm range below 2 meters throughout Hasson Lake (SENES, 1992). The Camp Lake winter oxygen values were found to remain above 5 ppm from the surface to 8.0 meters. Therefore there is more winter habitat within Camp Lake than Hasson Lake. It should therefore be able to support a larger population of fish. The larger white sucker population would be due to the increased amount of suitable spawning habitat within Hasson Lake. No ideal white sucker spawning habitat was found within Camp Lake, while one of the inflows to Hasson Lake (Figure 9) provides suitable spawning habitat. Eggs were found at this location during our study.

The minnow traps failed to catch any small fish (Table 7). The lack of small fish in the minnow traps may be due to the presence of northern pike, as in Camp Lake.

Table 7: Hasson Lake Minnow Trap Catch Records

Set	In (day/hour)	Out (day/hour)	Total (hours)	Trap	Catch	C.U.E.
1	28/1500	29/1045	19.8	1	0 Fish	0.000
				2	0 Fish	0.000
2	28/1515	29/1115	20.0	1	0 Fish	0.000
				2	0 Fish	0.000
3	28/1530	29/1115	19.8	1	0 Fish	0.000
				2	0 Fish	0.000
4	28/1545	29/1200	20.3	1	0 Fish	0.000
				2	0 Fish	0.000
5	28/1600	29/1215	20.3	1	0 Fish	0.000
				2	0 Fish	0.000

C.U.E. - The number of fish caught per hour per trap

The seine net catches (Table 8) were more successful at catching small fish. With a single seine haul 493 fish from 4 species were captured. As in Camp Lake the blacknose shiner was the most abundant forage fish. Yellow perch and lake chub were additional forage species captured. The capture of five 1^+ northern pike indicates that the Hasson Lake pike population is viable and naturally reproducing.

Table 8: Hasson Lake Seine Net Catch Records

Location	Catch
1	364 Blacknose shiner 122 Yellow perch 5 Northern pike 1^+ 2 Lake chub

4.2.3 Pond 1

The gill net set (Table 9, Figure 20) failed to capture any large fish. This was not unexpected as the maximum depth was recorded as being 1.9 meters, thus the majority of this pond would likely freeze solid during winter months. The SENES report (1992) found that the oxygen levels were all below 1.0 ppm at the depth of 1 meter. Thus fish habitat would be severely limited during winter months.

Table 9: Pond 1 Gill Net Catch Records

Net	In (day/hour)	Out (day/hour)	Total (hours)	Catch	C.U.E.
1	27/1500	28/1230	21.5	0 Fish	0.000

C.U.E. - The number of fish caught per hour per 120 meters of net
Gill net - A total of 10, 15 meter panels.
1.5", 2.0", 2.0", 2.5", 2.5", 3.0", 3.5", 4.0", 4.5" and 4.5"

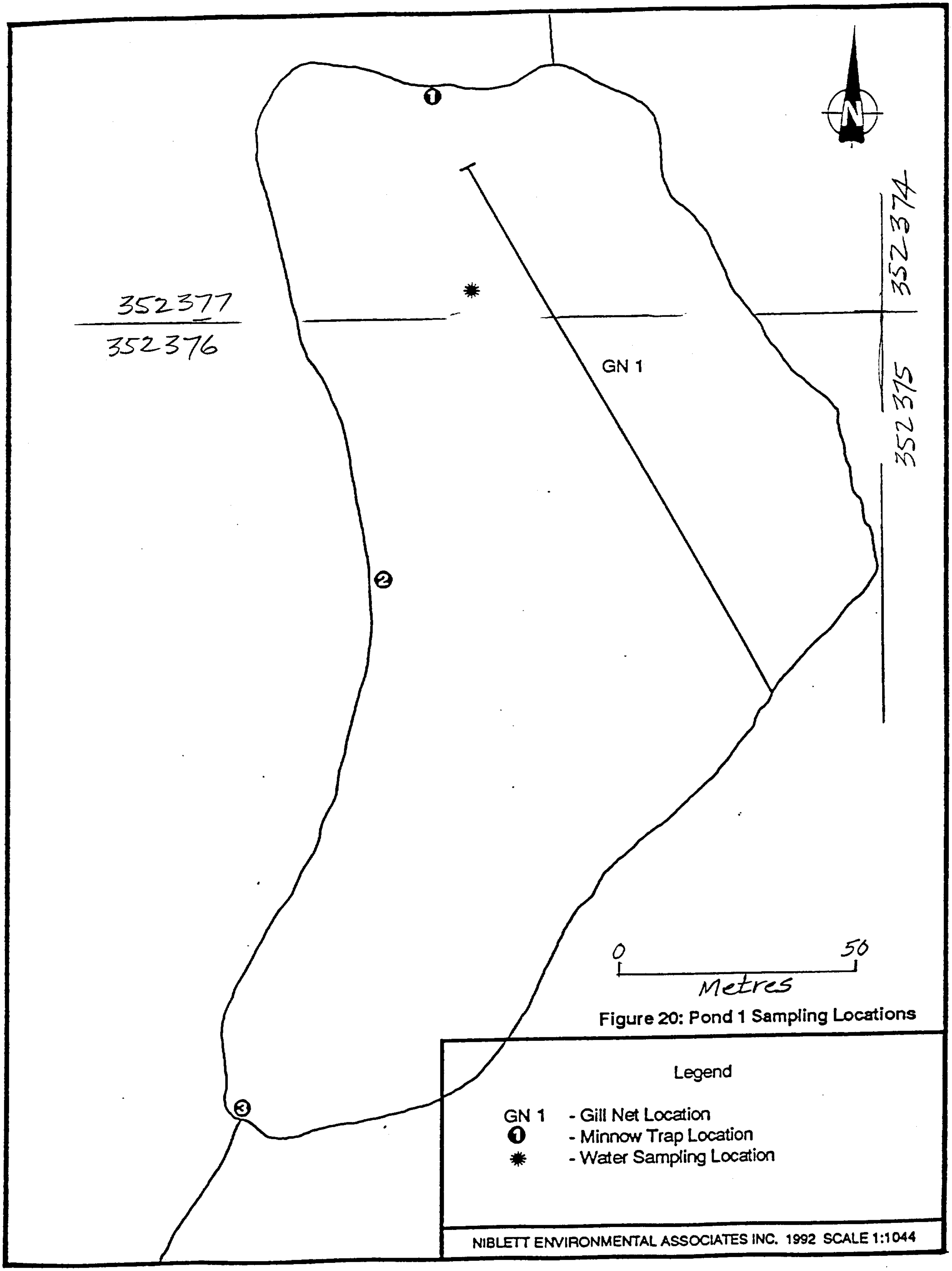


Figure 20: Pond 1 Sampling Locations

The Pond 1 minnow traps (Table 10) were by far the most successful at catching small fish. A total of 365 fish from three species were captured in six minnow traps. The species found were northern redbelly dace, finescale dace and Johnny darter.

Table 10: Pond 1 Minnow Trap Catch Records

Set	In (day/hour)	Out (day/hour)	Total (hours)	Trap	Catch	C.U.E.
1	27/1530	28/1115	19.8	1	32 Finescale dace	1.620
					19 N.redbelly dace	0.962
				2	34 Finescale dace	1.722
					5 N.redbelly dace	0.253
Total					**90 Fish**	**2.278**
2	27/1545	28/1130	19.8	1	41 Finescale dace	2.076
					1 Johnny darter	0.051
				2	107 Finescale dace	5.418
					1 N.redbelly dace	0.051
					1 Johnny darter	0.051
Total					**151 Fish**	**3.823**
3	27/1600	28/1200	20.0	1	31 Finescale dace	1.550
				2	89 Finescale dace	4.450
					3 N.redbelly dace	0.150
					1 Johnny darter	0.050
Total					**124 Fish**	**3.100**
Total			**59.5**		**365 Fish**	**3.067**

C.U.E. - The number of fish caught per hour per trap

The success of the minnow traps within Pond 1 can be linked to the absence of northern pike. With no large predatory fish, the minnow populations in Pond 1 are not kept in check.

4.2.3 Pond 2

Only two species of fish were found within Pond 2. These include northern pike and yellow perch. Other forage species such as finescale dace and northern redbelly dace are also expected to be found within Pond 2.

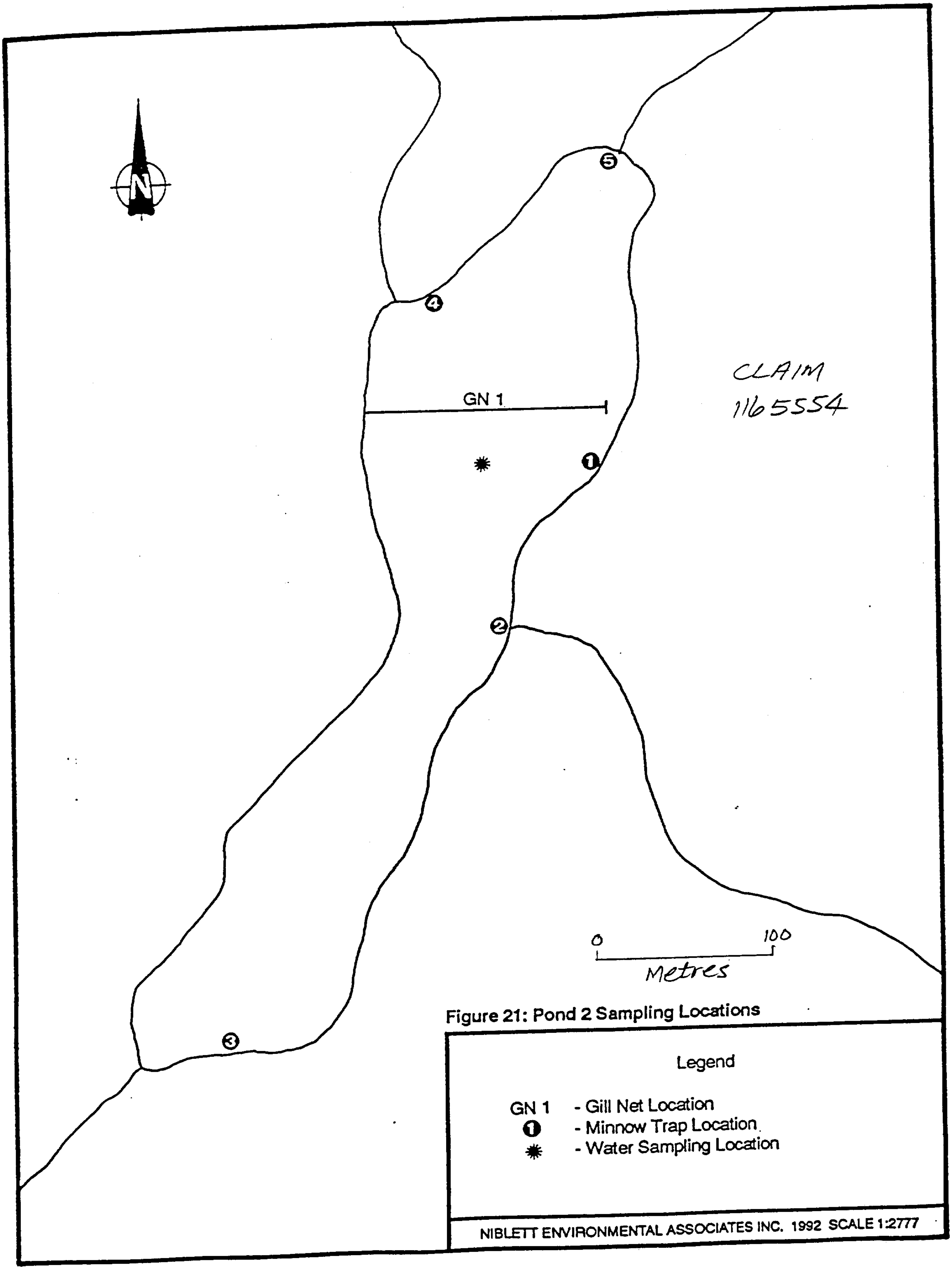
The gill net set (Table 11, Figure 21) only captured 10 northern pike. The C.U.E. was calculated to be 0.432 (fish/hour/120 meters of net). This was found to be slightly higher then that found for Hasson Lake but lower than that found for Camp Lake.

Table 11: Pond 2 Gill Net Catch Records

Net	In (day/hour)	Out (day/hour)	Total (hours)	Catch	C.U.E.
1	30/1400	31/0830	18.5	10 Northern pike	0.432

C.U.E. - The number of fish caught per hour per 120 meters of net
Gill net - A total of 10, 15 meter panels.
1.5", 2.0", 2.0", 2.5", 2.5", 3.0", 3.5", 4.0", 4.5" and 4.5"

The minnow traps (Table 12) failed to catch any small fish. This is considered to be due to the presence of northern pike. Yellow perch were found in the stomach contents of the sacrificed northern pike.



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1165554

Figure 21: Pond 2 Sampling Locations

Table 12: Pond 2 Minnow Trap Catch Records

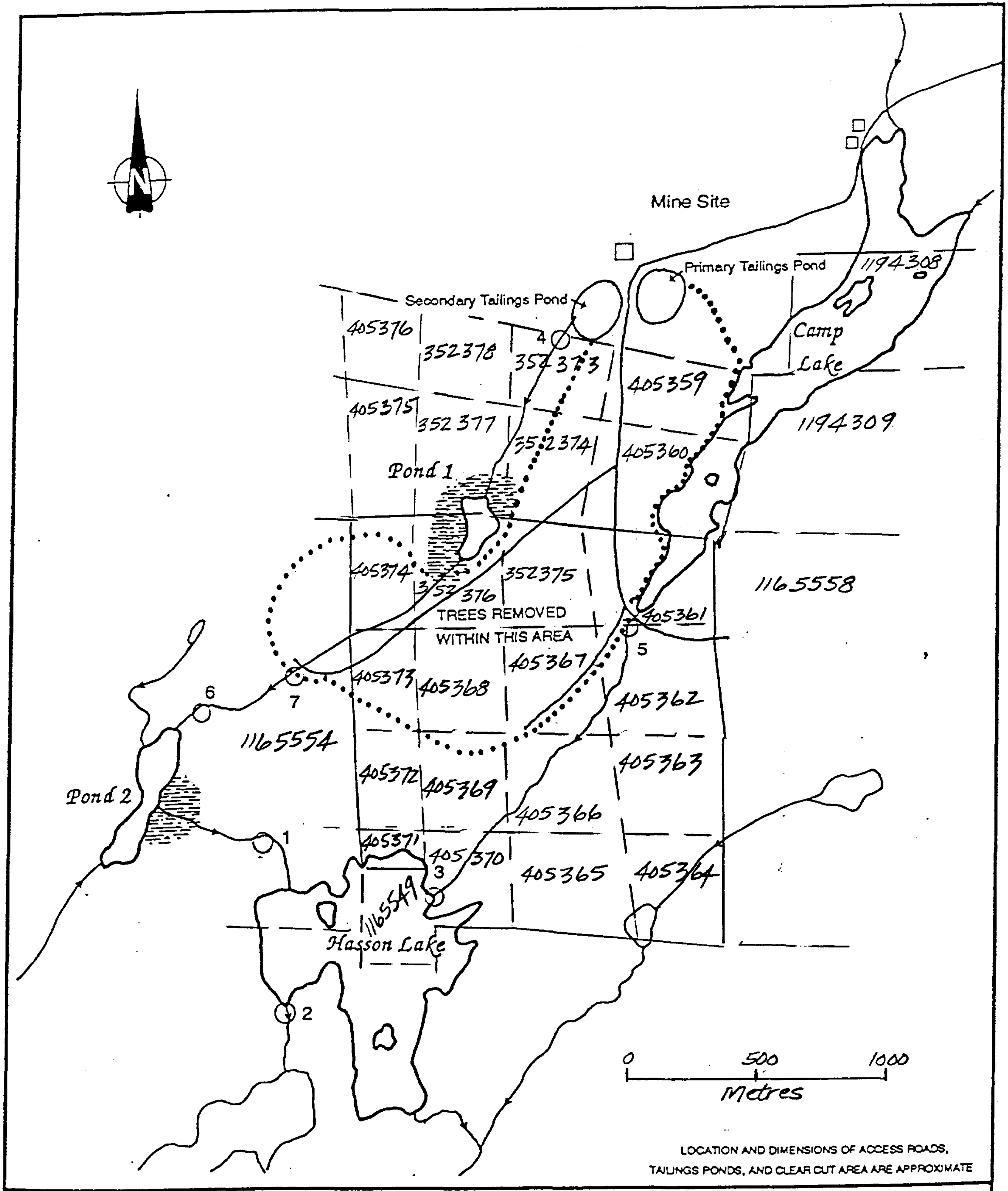
Set	In (day/hour)	Out (day/hour)	Total (hours)	Trap	Catch	C.U.E.
1	30/1415	31/0930	18.8	1	0 Fish	0.000
				2	0 Fish	0.000
2	30/1430	31/0930	19.0	1	0 Fish	0.000
				2	0 Fish	0.000
3	30/1430	31/0945	19.3	1	0 Fish	0.000
				2	0 Fish	0.000
4	30/1500	31/1000	19.0	1	0 Fish	0.000
				2	0 Fish	0.000
5	30/1530	31/1015	18.8	1	0 Fish	0.000
				2	0 Fish	0.000

C.U.E. - The number of fish caught per hour per trap

4.3 Benthic Resources

A total of 7 sampling locations (Figure 22) were examined with the use of a Surber sampler for benthic analysis. Sample sites 3 and 5 are control stations as no tailing effluent has entered this portion of the system. Sample sites 4, 7, 6, 1 and 2 start at the existing tailings effluent and work downstream to the major discharge stream of Hasson Lake (Figure 22).

Table 13 presents the primary taxonomic identification of all samples with Table 14 having the detailed speciation of selected samples. Physical descriptions of each station are given in Table 15.



LOCATION AND DIMENSIONS OF ACCESS ROADS, TAILINGS PONDS, AND CLEAR CUT AREA ARE APPROXIMATE

Figure 22: Benthos Sampling Locations

NIBLETT ENVIRONMENTAL ASSOCIATES INC. 1992 SCALE 1:20,000

Table 13 Lac des Iles Mine : Benthos

	Station 1			Station 2		
	R1	R2	R3	R1	R2	R3
INSECTA						
Diptera						
Chironomidae	8	14	64	26	10	52
Simulidae	11	337	48	751	149	423
Ceratopogonidae			1			
Other Diptera	1		1		1	1
Ephemeroptera	10	1	5	12	9	20
Plecoptera				2	1	2
Coleoptera	10	1	37			
Tricoptera	6	19	56	42	33	194
Odonata						1
AMPHIPODA			5	1		
MOLLUSCA						
Pelecypoda				11		
ANNELIDA						
Hirudinea			1	2	9	15
Oligochaeta			3			
No.of Taxa	6	5	10	8	7	8
No.of Animals	46	372	221	847	212	708

	Station 3			Station 4		
	R1	R2	R3	R1	R2	R3
INSECTA						
Diptera						
Chironomidae	16	5	6	185	316	138
Simulidae	8	1	6	50	37	28
Ceratopogonidae	3					
Ephemeroptera	2		2	1		1
Tricoptera	1					5
AMPHIPODA					1	
ANNELIDA						
Hirudinea			1		1	
No. of Taxa	5	2	4	3	4	4
No. of Animals	30	6	15	236	355	172

Table 13 Lac des Iles Mine : Benthos (Continued)

	Station 5			Station 6		
	R1	R2	R3	R1	R2	R3
INSECTA						
Diptera						
Chironomidae	58	42	82	41	10	26
Simulidae	3692	927	3472	41	17	4
Ceratopogonidae		2	4	2	1	1
Ephemeroptera		1	2	2	1	
Coleoptera	24	43	4			
Tricoptera	70	6	26	9	4	
Odonata				2	3	1
AMPHIPODA	10	4	4			
MOLLUSCA						
Pelecypoda		3			3	4
ANNELIDA						
Hirudinea	10	2	2		3	4
Oligochaeta				1	3	8
No. of Taxa	6	9	8	7	9	7
No. of Animals	3864	1030	3596	98	45	48

	Station 7		
	R1	R2	R3
INSECTA			
Diptera			
Chironomidae	4	33	65
Simulidae	333	37	209
Ceratopogonidae	1	3	3
Ephemeroptera		1	7
Tricoptera			16
Odonata		4	2
MOLLUSCA			
Pelecypoda		3	4
ANNELIDA			
Hirudinea	2	9	15
No. of Taxa	4	6	7
No. of Animals	340	87	317

Table 14 Benthic Macroinvertebrate Identification

	Station 1	Station 2	Station 3	Station 4
INSECTA				
Diptera				
Chironomidae				
Chironomus sp				15
Tanytarsus sp.	55	9	2	
Cricotopus sp.		22	8	116
Orthocladius sp.		15	5	
Cardiocladius sp.				7
Thienemannimiya grp.	9	7	2	
Simulidae				
Simulium sp.	31	423	8	48
Ephemeroptera				
Ephemerellidae				
Ephemerella sp.		4		1
Heptagenidae				
Stenonema sp.	2	16	4	
Plecoptera				
Perlidae				
Acroneuria sp.		1		
Perloididae				
Isoperla sp.		1		
Tricoptera				
Leptoceridae				
Oecetis sp.		17		3
Hydropsychidae				
Hydropsyche sp.	55	148	1	2
Philopotamidae				
Chimarra sp.		4		
Phryganeidae				
Agrypnia sp.		1		
Polycentropododae				
Nyctiophylax sp.			3	
Odonata				
Libellulidae				
Somatochlora sp.			1	
Coleoptera				
Elmidae				
Optioservus sp.		11		
Stenelimis sp.		28	1	

Table 14 Continued

	Station 1	Station 2	Station 3	Station 4
CRUSTACEA				
Amphipoda				
Talitridae				
Hyalella azteca		5		
MOLLUSCA				
Pelecypoda				
Sphaeriidae				
Pisidium sp.			13	
ANNELIDA				
Hirudinea				
Dina sp.		1		
Oligiochaeta				
Tubificidae				
imm-non-capilliform		1		
Total Number of Taxa	11	16	7	7
Total Number of Organisms	199	685	30	192
Shannon Diversity	2.59	1.85	NC	1.60
Evenness	0.75	0.47	NC	0.57

NC Not Calculated due to too few organisms collected

Table 14 Benthic Macroinvertebrate Identification
(Continued)

	Station 5	Station 6	Station 7
INSECTA			
Diptera			
Chironomidae			
Microtendipes sp.	24		
Polypedilium sp	16		
Dicrotendipes sp.	8		
Tanytarsus sp.		5	
Cricotopus sp.		3	36
Psectrocladius sp.			16
Orthocladius sp.			2
Thienemannimiya grp.	10		13
Simulidae			
Simulium sp.	3640	17	259
Ephemeroptera			
Leptophlebidae			
Leptophlebia sp.		1	3
Tricoptera			
Leptoceridae			
Oecetis sp.	18		
Limnephilidae			
Pycnopsyche sp.	4		
Limnephilus sp.		1	16
Hydropsychidae			
Hydropsyche sp.	40	3	
Cheumatopsyche sp.	8		
Lepidostomatidae			
Lepidostoma sp.	2		
Philopotamidae			
Chimarra sp.	2		
Odonata			
Libellulidae			
Somatochlora sp.		3	2
Hemiptera			
Notonectidae			
Notonecta sp.	2		
Coleoptera			
Elmidae			
Optioservus sp.	8		
Stenelimis sp.	16		

Table 14 Benthic Macroinvertebrate Identification (Continued)

	Station 5	Station 6	Station 7
CRUSTACEA			
Amphipoda			
Talitridae			
Hyalella azteca	12		
MOLLUSCA			
Pelecypoda			
Sphaeriidae			
Pisidium sp.	4	4	
ANNELIDA			
Hirudinea			
Helobdella stagnalis	4		
Dina sp.	6	2	14
Glossiphonia complanata		1	1
Oligiochaeta			
Tubificidae			
imm-non-capilliform		3	
Total Number of Taxa	18	12	9
Total Number of Organisms	3824	45	360
Shannon Diversity	0.45	NC	1.55
Evenness	0.11	NC	0.49

NC Not Calculated due to too few organisms collected

Table 15 Physical Characteristics of Benthic Sampling Areas

Station 1 - Located Downstream of Pond 2 and Upstream of Hasson Lake
- boulder riffle not a great spot for Surber sampling
- qualitative sample only

Station 2 - Outflow from Hasson Lake
- rubble and boulder riffle

Station 3 - Hasson Lake - Inflow from Camp Lake
- boulder and rubble riffle
- slow moving water at lake
- white sucker spawning area

Station 4 - Downstream of second tailings pond
- silt, clay, sand, rubble riffle
- shallow with slow moving current

Station 5 - Outflow from Camp Lake
- rubble, gravel and sand riffle
- deeper, fast flowing water

Station 6 - Upstream of Pond 2
- boulder and rubble riffle
- narrow and shallow creek, bordered by alder thicket

Station 7 - Downstream of Pond 1
- 1st sample in sand runoff from road
- other two samples in boulder and rubble riffle

Table 13 shows that generally the benthic invertebrate fauna is dominated by chironomids (midges) and blackflies (Simulidae). At Station 4, immediately below the tailings pond outflow, very few different kinds of organisms (Taxa) were collected. This decrease in species diversity may however be related to physical differences in the substrata, rather than the quality of water in the tailings pond discharge. The presence of blackflies within the tailings pond discharge indicates that the water is not toxic, as these species are sensitive to even temporary adverse changes in water quality.

All other stations showed variability in numbers and kinds of benthic organisms present. All this variation may however be attributed to differences in flows and physical conditions of the substrata. Mayflies (Ephemeroptera) and caddisflies (Tricoptera) were found at all stations. These groups are also indicative of moderately good water quality. Only station 2,the discharge from

Hasson Lake had stoneflies (Plecoptera). These organisms are generally the most sensitive of all benthic organisms. Their presence at this station is indicative of very good water quality conditions. The reason for their absence at all other station is not readily apparent.

The results of the detailed benthic identification is presented in Table 14. The largest number of taxa was found at Station 5, the outflow from Camp Lake. Due to the presence of an extremely large number of blackflies, diversity at this stations was the lowest measured at 0.45. Generally diversity values less than 1 are indicative of severely stressed benthic communities. In this case however, the low diversity is a result of an overabundance of a pollution sensitive organisms. Without the blackflies, the diversity of this sample would have been 3.6, the highest of all stations. Evenness indicies at this station were also extremely low at 0.11. Generally values less than 0.5 are indicative of degraded conditions, while values between 0.6 and 0.8 are indicative of background values.

Diversity indices could not be calculated for stations 3 and 6 due to too few specimens being collected. Since diversity indices are a measure of community structure it is important that enough organisms are collected to enable accurate estimates can be made. Generally samples with less than 100 organisms should be evaluated cautiously, if at all. Samples with less than 50 organisms should not be used for calculation of diversity indices.

Station 1, between Pond 2 and Hasson Lake had the highest diversity of any station sampled. This index of 2.59 is indicative of moderate to very good water quality conditions. This information appears to confirm the suggestion that discharges from the upstream tailings pond is not toxic to the benthic fauna. Evenness indicies at this station were the highest of all stations analysed, at 0.75. This index value is indicative of very good water quality conditions.

Station 2 had the second highest number of taxa of all stations sampled, and was the only area where the very pollution sensitive stoneflies (Plecoptera) were found. Diversity at this station was 1.85, indicative of only moderately good water quality conditions, while the evenness index suggests slightly degraded conditions.

Station 4 was located immediately below the tailings pond outflow. The benthic fauna at this location was dominated by chironomids, especially *Tanytarsus* sp. and blackflies. Neither of these genera are usually associated with degraded water quality. Diversity at this station was 1.6, and evenness was 0.57. Both these indices are associated with moderately good water quality.

Station 7 is located upstream of station 6, where too few organisms were collected to enable calculation of diversity indices. The better benthic fauna at this station may therefore reflect sampling variability and not water quality changes in this stream. Diversity and evenness indices are typical of areas with moderately good water quality.

4.4 Fish Mercury Concentration

Figure 23 illustrates the northern pike flesh mercury concentration results.

Camp Lake fish were found to have the highest mercury concentration followed by Hasson Lake and Second Pond. The total length (cm) versus mercury concentration (mg/g) were found to be:

Camp Lake - $Hg(mg/g) = 0.023(Length)+0.404$, $r^2=0.505$

Hasson Lake - $Hg\ (mg/g) = 0.041(Length)-1.279$, $r^2=0.656$

Second Pond - $Hg=0.038(Length)-1.331$, $r^2=0.505$

The Camp Lake northern pike were found to have mercury concentrations above the MOE guideline for no consumption (1.5 mg/g). The pike from Hasson Lake and the majority of the pike from Second Pond fall within the MOE guidelines of restrictive consumption, while the small pike from Second Pond (less than 50 cm total length) have no consumption restrictions (MOE, 1991).

High concentrations of mercury within northern pike flesh are typical for Northern Ontario fish populations. Nearby Dog Lake and Muskeg Lake also have restrictive guidelines for pike consumption (MOE, 1991).

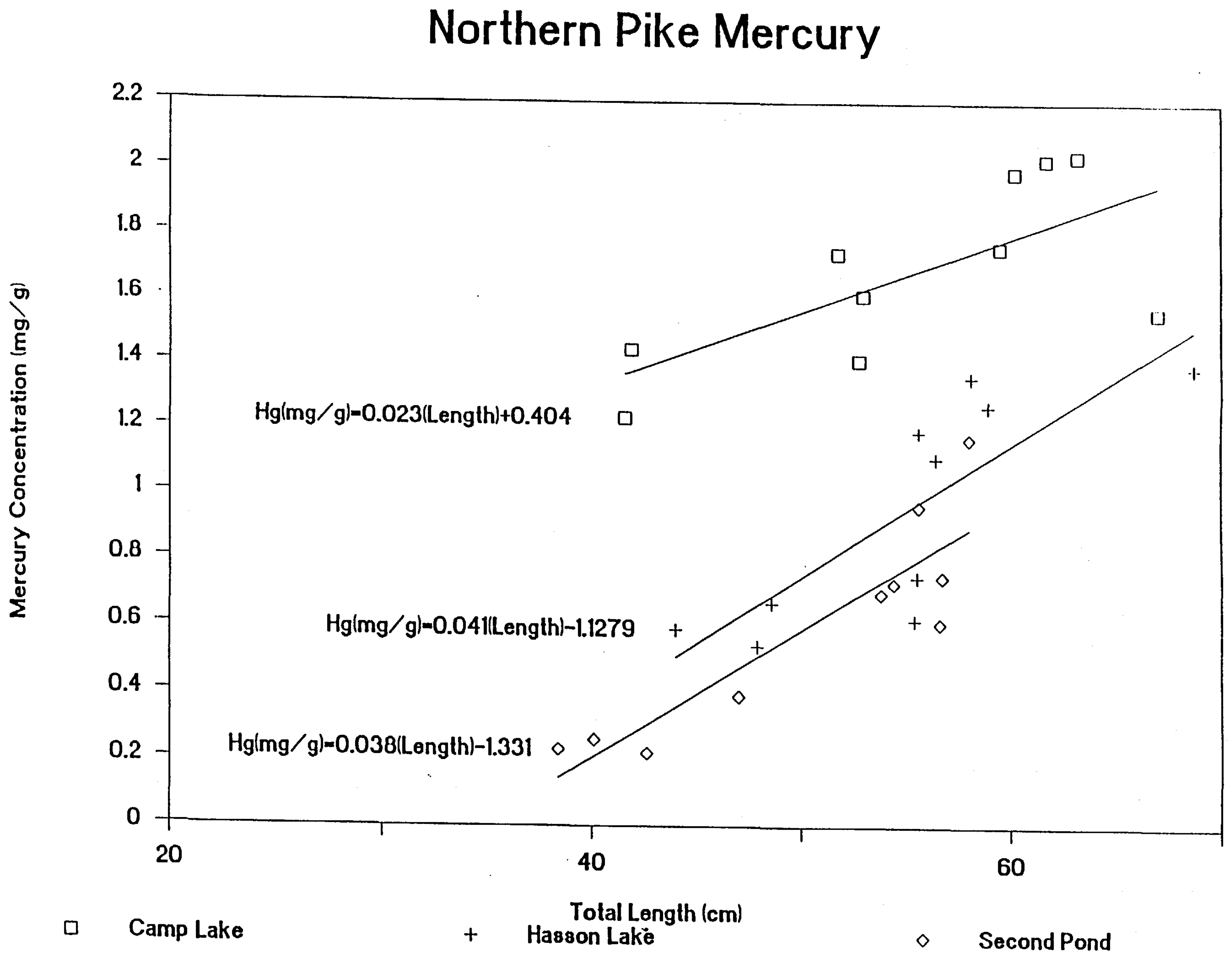


Figure 23 - Northern Pike Mercury Concentrations

5.0 Resource Evaluation

All fish species captured within the study are typical species for north western Ontario. Scott and Crossman (1973) report all captured species as having population ranges within the study site.

No captured species are found on the list of rare and/or endangered fish published by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 1992).

The north east inflow for Camp Lake (Figure 3) was found to have ideal biophysical conditions for successful northern pike spawning. Several potential northern pike spawning areas were identified within Hasson Lake (Figure 9). The Hasson Lake inflow from Camp Lake was positively identified (eggs) as a white sucker spawning location. Important fisheries areas were not identified for the two ponds within the study area.

The fisheries data collected to date provides a substantial data base from which future environmental conditions can be evaluated.

The benthic invertebrate data exhibited a high variability. All this variation appears to be related to substrate and flow conditions and not to water quality changes that may be associated with the mine tailings pond discharges.

The presence of pollution intolerant organisms such as blackflies, stoneflies, mayflies, and caddisflies suggests that operation of the Lac des Iles mine is not having an adverse impact on water quality or the benthic fauna. The stations sampled during this study will serve as monitoring points for future assessments of the impacts of mine operation on the aquatic environment.

Mercury concentrations within study site northern pike were found to be elevated. This was found to be consistent with observations made by MOE for this general area (MOE, 1991).

6.0 References

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SENES, 1992. Baseline Surface Water and Sediment Quality Survey at the Lac Des Iles Mine Site. A report prepared by SENES Consultants Ltd for Lac Des Iles Mine Ltd.

Appendix 1

MOE Letter

Ministry of the Environment
Ministère de l'Environnement
Ontario

Northwestern Region
Région du Nord-Ouest

435 James St South
PO Box 5000
Thunder Bay Ontario
P7C 5G6
807/475-1205

435, rue James sud
C.P. 5000
Thunder Bay (Ontario)
P7C 5G6
807/475-1205

February 22, 1990

MEMORANDUM:

TO: Mr. Howard Mortfield
Environmental Officer
Abatement Section

FROM: D. Hollinger
Biologist
Technical Support Section

RE: MADELINE MINES LIMITED,
LAC DES ILES PROJECT -
REVIEW OF ENVIRONMENTAL
INFORMATION PROVIDED BY THE COMPANY

I have reviewed the environmental information, which was submitted by the company regarding the potential water quality impact of the proposed platinum/palladium mine near Lac des Iles.

The four documents which were submitted previously by the company and formed the basis of my review are:

1) Madeline Mines, Tailings Disposal Alternatives. (prepared by company consultant, M. Oosterveld).

2) Summary of Lake Survey and Aquatic Habitat Inventory of Camp Lake (Field data collected by MNR - Summary report written by company consultant, M. Oosterveld).

3) Mineral Industries Information Sheet

4) Geochemical Analyses of Ore Rock - Ontario Geological Survey.

Generally, I find that the information provided by the company is inadequate to accurately predict the water quality impact of the three tailings disposal alternatives. In comparing the three tailings alternatives, the selection of the preferred option by the company, was based solely on financial considerations. The Ministry of the Environment requires that each tailings disposal alternative be evaluated from an environmental impact perspective. For the company to provide that perspective, the following information for each tailings alternative is required.

1) A quantitative projection of the chemical quality and the quantity of mine effluent to be discharged.

2) An evaluation of background water and sediment quality in the proposed receiving water(s) which focuses on chemical characteristics.

3) A description of the aquatic biology in the area of the receiving water(s) within and beyond the anticipated area of mixing which focuses principally on the benthic macroinvertebrate and the fish community.

4) A hydrological examination of the proposed receiving stream(s) including a low flow analyses based on the best available information from gauged systems where rivers or streams are involved; or a plume dispersion analysis including thermal and other physical properties of the receiving water where a lake is involved.

5) Having provided the above information for each alternative, calculate the receiving water mixing zone(s) required to comply with the Provincial Water Quality Objectives (for the protection of aquatic life) and assess the potential impact to the downstream aquatic community.

Once a tailings disposal alternative has been approved, a Certificate of Approval (C of A) will be issued, which will contain conditions that will require the company to conduct a more intensive pre-operational hydrological, chemical and biological receiving water assessment. Much of the information which will have been provided to evaluate the tailings disposal alternatives will form the basis for the company's intensive pre-operational study.

The C of A will also require the company to conduct a post-operational receiving water assessment to document the actual impact of mining operations to the aquatic environment. For both the pre and post-operational intensive studies, the company will be required to submit detailed interpretive reports. The Ministry will liaise with the company's consultant in the planning of these intensive studies and, in addition, conduct its own assessment for audit purposes.

DH:ag

c.c.: D. Vitone
J. Vander Wal
Regional File TS 42-02,
Lac des Iles

Appendix 2

Meristic Data - Madeline Mines, Lac des Isle Project

Appendix 2
Meristic Data - Madeline Mines, Lac des Isle Project

Camp Lake

	Length (cm)					
Species	Fork	Total	Wght (g)	Sex	Mesh (inches)	Net
Northern pike	62.4	66.2	1325		4.0	1
Northern pike	48.5	51.8	775	F	3.0	1
Northern pike	45.6	49.2	675		4.0	1
Northern pike	60.9	65.5	1325		4.0	1
Northern pike	65.0	70.2	1775		4.5	1
Northern pike	38.8	41.6	450	M	2.5	1
Northern pike	59.2	63.2	1375	F	3.0	1
Northern pike	37.1	39.9	400		2.5	1
Northern pike	57.7	61.7	1350	SM	3.0	1
Northern pike	30.1	32.3	200		2.0	1
Northern pike	56.7	60.2	1150	SF	2.5	1
Northern pike	39.0	41.9	450	M	2.0	1
Northern pike	49.2	52.8	850	M	3.0	1
Northern pike	60.2	64.8	1550		3.5	1
White sucker	44.8	48.0	1650	RF	4.0	1
White sucker	38.0	40.1	900	RM	3.5	1
Northern pike	56.0	59.0	1325		4.0	2
Northern pike	53.7	56.7	1000		2.0	2
Northern pike	40.7	43.6	500		2.5	2
Northern pike	55.4	59.5	1200	M	3.0	2
Northern pike	48.7	52.1	850		1.5	2
Northern pike	48.0	51.4	825		2.0	2
Yellow perch	14.5	15.3	25		1.5	2
Northern pike	48.3	53.0	775	M	3.0	3
Northern pike	51.8	55.3	1025		3.0	3
Northern pike	58.5	62.7	1525	RM	3.0	3
Northern pike	63.0	67.0	1700	F	3.0	3
Northern pike	53.2	56.5	1375		1.5	3
Northern pike	46.0	49.1	950		5.0	3
Northern pike	49.5	52.9	875		3.0	3
White sucker	53.7	57.4	3250	RF	5.0	3
White sucker	36.1	39.2	900	RF	3.0	3

F-Female, M-Male, S-Spent, R-Ripe, RA-Reabsorbing eggs

Appendix 2:
Meristic Data continued....

Hasson Lake

Species	Length (cm) Fork	Length (cm) Total	Wght (g)	Sex	Mesh (inches)	Net
Northern pike	65.3	68.7	1875	SF	4.0	1
Northern pike	26.3	28.2	130		1.5	1
Northern pike	54.9	58.1	825	SF	3.0	1
Northern pike	45.6	48.6	600	SF	3.0	1
Northern pike	43.4	46.9	1250	RM	3.0	1
Northern pike	43.0	46.7	1175	SM	3.0	1
White sucker	48.8	52.7	1650	RAF	4.0	1
White sucker	40.9	43.4	1125	RM	4.0	1
White sucker	39.2	43.2	925	SF	4.0	1
White sucker	42.5	45.3	1125	RAF	4.0	1
White sucker	45.9	49.1	1325	SF	4.0	1
White sucker	45.4	48.3	1450	RM	4.0	1
Northern pike	45.1	47.9	700	M	3.0	2
Northern pike	52.4	55.6	800	M	4.0	2
Northern pike	55.0	58.9	775	SF	4.0	2
Northern pike	45.4	44.0	700	M	4.0	2
Northern pike	51.5	55.4	950	SF	4.0	2
White sucker	28.4	30.6	425	F	2.0	2
White sucker	48.3	51.7	1875	RM	3.5	2
Northern pike	47.5	51.5	725		2.5	3
Northern pike	35.9	38.2	350	IF	2.0	3
Northern pike	52.8	56.4	750	SF	3.5	3
Northern pike	52.0	55.5	1075	SM	3.5	3
White sucker	37.9	39.3	850	RM	3.5	3

F-Female, M-Male, S-Spent, R-Ripe, RA-Reabsorbing eggs

Appendix 2:
Meristic Data continued....

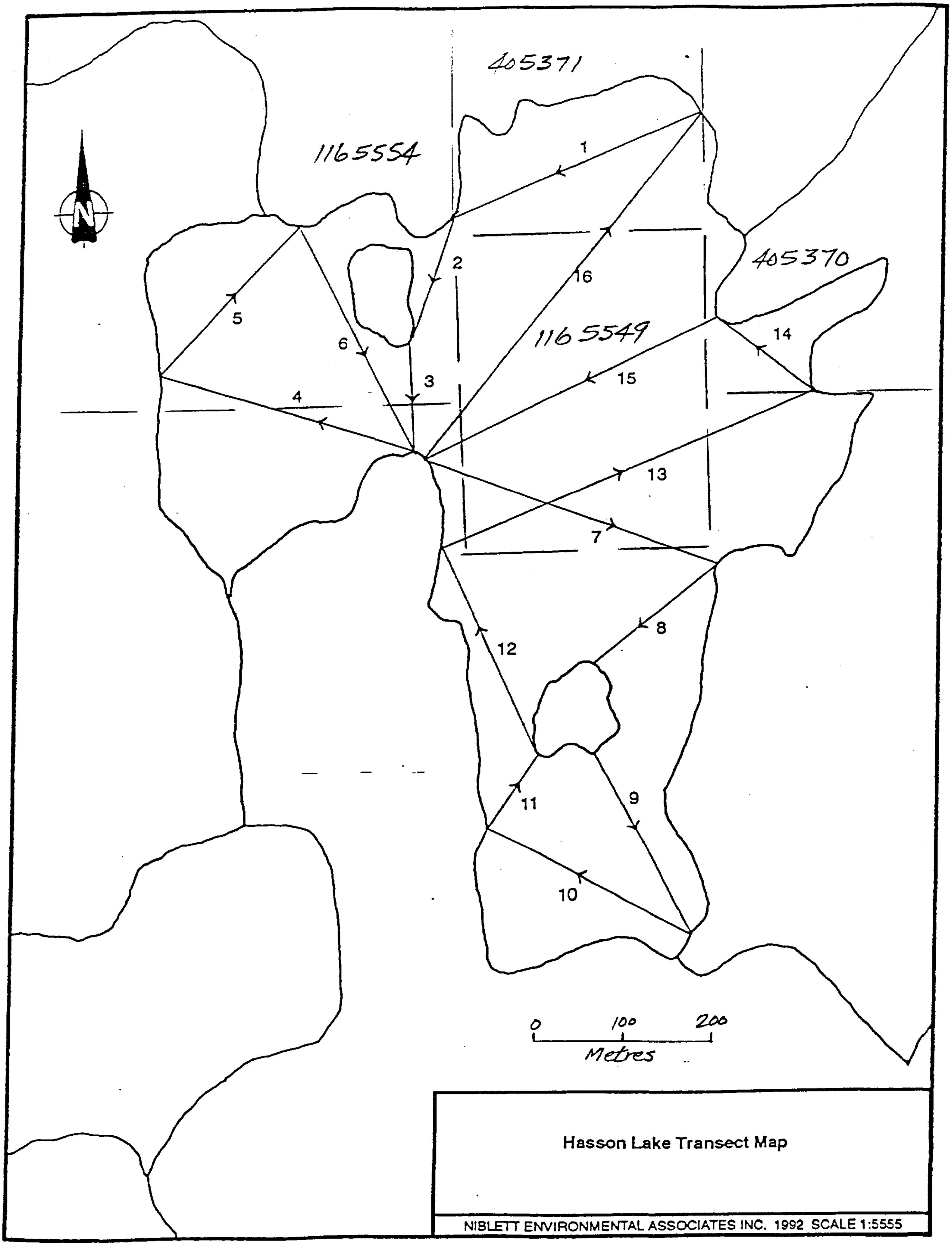
2nd Pond

Species	Length (cm) Fork	Total	Wght (g)	Sex	Mesh (inches)	Net
Northern pike	52.5	55.6	900	SF	3.0	1
Northern pike	54.5	58.0	925	F	2.0	1
Northern pike	53.0	56.7	1125	F	2.0	1
Northern pike	52.5	56.6	1075	F	2.0	1
Northern pike	39.9	42.6	475	F	2.0	1
Northern pike	36.0	38.4	400	F	2.0	1
Northern pike	37.8	40.1	450	M	2.0	1
Northern pike	50.7	53.8	850	F	2.5	1
Northern pike	51.4	54.4	875	F	2.5	1
Northern pike	44.1	47.0	600	F	2.5	1

F-Female, M-Male, S-Spent, R-Ripe, RA-Reabsorbing eggs

Appendix 3

Hasson Lake Transect Map



Hasson Lake Transect Map

NIBLETT ENVIRONMENTAL ASSOCIATES INC. 1992 SCALE 1:5555

Appendix 4

Legend for Physical Feature Maps

Legend For Physical Feature Maps

——→	0 - 10% Slope
—/→	11 - 30% Slope
—//→	31 - 70% Slope
B.H. ⌓	Beaver House
ɯɯɯ	Beaver Dam
CON	>75% Coniferous
DEC	>75% Deciduous
MIX	Coniferous/Deciduous Mixed
– – – –	Intermittent Inflow/Outflow
ψ ψ	Muskeg
x X	Scattered Rocks
(×××)	Rocky Shoal
○○○	Standing Dead Trees

Appendix 5

NEA Field Notes

27/May/92 Madeleine Mills

Carp Lake

Gill Net #1 set 0930

Minnow trap 1 T1 0950
2 T2 0950

Minnow trap 2 T1 1001
T2 1001

Gill net #2 set 1000

Minnow trap 3 T1 1015
T2 1015

Gill net #3 1030
4 panels only

Minnow Trap #4 T1 1045
T2 1045

Madeline Mills 27/Aug/92

1st Pond

Gill Net set 1500 hrs

M 1 1530 }
M 2 1545 } Two Traps Each.
M 3 1600 }

Depths

1	1.2	7	1.2
2	1.9	8	1.1
3	1.6	9	0.9
4	1.3		
5	1.2		
6	1.3		

Gill Net #3 Cmp Lake / 1630 (1.5, 3.0 4.0, 5.0)

	RQ	FL	TL	Wght	Mesh	Sample	
WS		53.7	57.4	3250	5.0"	WS1	
NP		48.3	53.0	775	3.0"	NP1	♂
NP		63.0	67.0	1700	3.0"	NP2	♀

Cmp Lak

Gill net #1 1830

	FL	TL	Wght	Mesh	Sample	Sex
NP	38.8	41.6	450	2.5"	WP3	♂
NP	56.7	60.2	1150	2.5"	NP4	S ♀
WP	59.2	63.2	1375	3.0"	WP5	♀
WP	49.2	52.8	850	3.0"	NP6	♂
NP	57.2	61.7	1350	3.0"	WP7	B ♂
WP	39.0	41.9	450	2.0"	WP8	♂
NP	48.5	51.8	775	3.0"	NP9	♀
WS	44.8	48.0	1650	4.0	WS 2	R ~~♂~~ ♀

Cmp Lake

Gill Net #2 1930

NP	40.7	43.6	500	2.5"		
WP	56.0	59.0	1325	4.0"		
NP	48.0	51.4	825	2.0"		
NP	33.0			1.5"		
NP	55.4	59.5	1200	3.0	NP10	♂

Camp Lake 28/May/92

Gill net #1 0815 · rocky shoreline
· organic bottom
· 0 to 3m depth.

Fs	FL	TL	wght	Mat.	Sample
NP	60.9	65.5	1326	4.0	
NP	62.4	66.2	1325	4.0	
NP	45.6	49.2	675	9.0	
NP	65.0	70.2	1775	4.5	
NP	60.2	64.8	1550	3.5	
NP	30.1	32.3	200	2.0	
NP	37.1	39.9	400	2.5	
WS	38.0	40.1	900	3.5 RO?	WS 3

Minnow set #1 0845
T1 - 0 fish
T2 - 0 fish

Minnow set #2 0900
T1 - 0 fish
T2 - 0 fish

Camp Lake – 28/May/92

Gill net #2 0900 · rocky shore
· organic bottom
· 0–8m.

	FL	TL	wght	mat
NP	53.7	56.7	1000	2.0
WP	48.7	52.1	850	1.5
YP	14.5	15.3	25	1.5

Minnow set #3 0915
T1 - no fish
T2 - no fish

Minnow set #4 0930
T1 - no fish
T2 - out of water
racoon ?

Minnow set #5

Cray Lake 28/Aug/92

Gill net #3 0930 rock shore organic [illegible] 0-2 m.

Fish	FL	TL	wgt		
NP	46.0	49.1	950	5.0"	
NP	51.8	55.3	1025	3.0"	
NP	58.5	62.7	1525	3.0"	RO♂
NP	49.5	52.9	825	3.0"	
NP	53.2	56.5	1375	1.5"	
WS	36.1	39.2	900	3.0"	WS4 RQ

1st Pond
minnow Trap set #1 1115
T1 - 32 FSD
19 NRD

T2 - 34 FSD
- 5 NRD

Minnow trap set #2 1130
partially out of water (uncom.)
T1 - 41 FSD
- 1 JD
T2 - 107 FSD
- 1 NRD
- 1 JD

1st Pond 28/Aug/92 1200 hrs

Minnow Trap set 3 T1 - 31 FSD
T2 - 89 FSD
3 NRD
1 JD

Gill Net 10 panels 1230 hrs
→ no fish

Hansen Lake

Gill net #1 (4 panels) 1445

Gill net #2 1500
Minnow set #1 1500
Minnow set #2 1815
Minnow set #3 1530
Minnow set #4 1545
Gill net #3 1545
Minnow set #5 1600

HUDSON MIKE
WS SAMPLES - NO WS9
∴ ONLY 9 SAMPLES

Camp Lake 28/Aug/92

Seine #1	1227	BNS		
	19	YP		
Seine #2	2	BNS		
Seine #3	1	NP		
Seine #4	0	fish		

Husson Lake 29/Aug/92 Gill Net 1 0900

Spc	FL	TL	wt	Sex	Sample	
WS	45.9	49.1	1325	S♀	WS1	4."
WS	48.8	52.7	1650	♀RA	WS2	4"
WS	39.2	43.2	925	S♀	WS3	4"
WS	45.4	48.3	1450	R♂	WS4	4"
WS	40.9	43.4	1125	R♂	WS5	4"
WS	42.5	45.3	1125	♀RA	WS6	4"
NP	65.3	68.7	1875	S♀	NP1	4"
WP	26.3	28.2	130			1.5"
WS	43.4	46.9	1250	R♂	WS7	3.0"
WS	43.0	46.7	1175	S♂	WS8	3.0"
NP	54.9	58.1	825	S♀	NP2	3.0"
NP	45.6	48.6	600	S♀	NP3	3.0"

4, 3.0 5.0 2.0 3.5 .5, 4.5 2.0

Gill net #1 - gravel rubble slow
- organic buffer
- 2.0 m deep

Minnow Trap set #1 1045
T1 - 0 fish
T2 0 fish

Gill Net #2 1015 hrs

Spc	FL	TL	wt	Sex	Sample	
NP	48.1	47.9	700	♂	NP4	3.0"
WS	48.3	51.7	1875	♂R		3.5"
WS	28.4	30.6	425	♀	WS10	3.0
NP	45.4	440	700	♂	NP5	4.0
NP	51.5	55.4	950	S♀	NP6	4.0
NP	55.0	58.9	725	S♀	NP7	4.0
NP	52.4	55.6	800	♂	NP8	4.0

Minnow Trap Set #2 1115
T1 - 0 fish
T2 - 0 fish

Minnow Trap set #3 1115
T1 - 0 fish
T2 - 0 fish

29/May/92 Hasson Lake

Minnow trap set #~~4~~ 1200
T1 - 0 fish
T2 - 0 fish

Gill Net #3
1130 hrs

Spec.	FL	TL	wgt	sex	Net	Sample
NP	47.5	51.5	725		2.5"	
NP	35.9	38.2	350	I ♀	2.0	
NP	52.8	56.4	750	S ♀	3.5"	NP9
NP	54.0	55.5	1075	S ♂	3.5"	NP10
WS	37.9	39.3	850	R ♂	3.5"	

Minnow trap set #5 1215
T1 0 fish
T2 0 fish

1530 hrs
Hasson Lake 3 water samples taken for Senes

Conduct 0.08 / TDS - 0.025
pH meter 7.14 kit 7.0
Secchi 1.4 m.
Alkalinity 13
Acidity 3
Hardness 14

Hassen Lake 29/May/92

Depth	DO.	Temp.	Hach test
Surface	8.45	16.3	8.38
1m	8.48	16.2	
2.0	8.01	13.2	
3.0	7.53	12.1	
4.0	6.75	10.9	
5.0	5.97	10.0	
6.0	3.94	8.7	
6.3	Bottom		

Camp Lake water Quality
1930 hrs 2 samples taken for Senes

Conduct 0.05
TDS 0.03
pH 6.in 6.5H
Secchi 1.2m
Alkal. 8
Acidity 14
Hardness 19

Depth	D.O.	Temp			
Surface	8.56	14.3	11	4.40	5.2
1.0	9.4	14.2	12	3.53	5.0
2.0	8.45	14.2	13	1.3	4.9
3.0	8.45	13.8	13.5 bottom		
4.0	8.05	12.4			
5.0	7.56	10.7			
6.0	6.75	8.3	Hach		
7.0	6.48	6.6	Surface		
8.0	6.11	6.1	7.92		
9.0	5.90	5.8			
10.	5.27	5.5			

30/May/92 Husson Hatch

Seine Haul 364 BNS
122 YP
5 1+ NP
2 unknown [illegible]

Husson Lake Suckers

① Upstream Husson Lake
- outflow 2nd pond
· three samples taken
- boulder riffle not a great spot for suckers.
qualitative samples.

② Husson Lake Outflow #1

- rubble boulder riffle
- better samples than Sta. 1
- 3 suckers taken

30/May/92

③ Husson Lake Inflow from Camp.

- boulder rubble riffle
slower moving than 2.
- at lake.
- white sucker spawning area.

2nd Panel all 5x and 5.0 + 3.5
2, 2.5, 3.5, 4.5,

Gill net set 1400 hrs 10 panel

Minnow trap set 1 1415 hrs
Minnow trap set #2 1430
Minnow trap set #3 1435
Minnow trap set #4 1500
Minnow trap set #5 1530

2nd Pond 30/may/92

Dept	0.0.	Temp
Surface	9.85	17.7
0.5	9.60	17.6
1.0	9.83	16.4
1.5	9.95	13.1
2.0	8.11	10.9
2.5	7.65	10.4
3.0	4.86	8.3
3.5	01.5	7.7

→ Kit 0.0 → 9.42

One water sample taken for Seres.

Bitten

Acidity	5	
Conducty	0.05	
TDS	0.03	
Alkalinity	11	
pH	6.82 m.	6.5 kit.
Hardness	7	
Secchi	1.1 m	

30/May/92

Sites collection.

④ Downstream 2nd tailings pond

- slow moving current
- silt, clay, sand rubble
- shallow 5 cm

⑤ Out flow Camp Lake

- fast flowing water
- 30 cm deep
- rubble, gravel, sand
- alot of Blackflies

⑥ Upstream of Pond Two

- narrow shallow creek
- boulder rubble substrate
- dense alder thicket

2nd Pond 31/Aug/92
Gill Net 0830

Species	FL	TL	wght	Sex	Sample	
NP	52.5	55.6	900	♀	NP1	3.0"
NP	54.5	58.0	925	♀	NP2	2.0"
NP	53.0	56.7	1125	♀	NP3	2.0"
NP	52.5	56.6	1075	♀	NP4	2.0
NP	39.9	42.6	475	♀	NP5	2.0
NP	36.0	38.4	400	♀	NP6	2.0
NP	37.8	40.1	450	♂	NP7	2.0
NP	50.7	53.8	850	♀	NP8	~~3.0~~ 2.5
NP	51.4	54.4	875	♀	NP9	2.5
NP	44.1	47.0	600	♀	NP10	2.5

Stomachs

Fish	contents
NP4	YP.
NP8	YP.

Minnow Trap set #1 0930
T1: 0 fish
T2: 0 fish

Minnow trap set #2 0930
T1 - 0 fish
T2 - 0 fish

2nd Pond 31/Aug/92

Minnow Trap set #3 0945
T1 - 0 fish
T2 - 0 fish

Minnow Trap set #4 1000
T1 0 fish
T2 0 fish

Minnow Trap set #5 1015
T1 0 fish
T2 0 fish

Depths

Sta	Depth	Sta	Depth
1	1.6	11	3.2
2	2.5	12	4.0
3	1.8	13	2.0
4	3.4	14	2.2
5	1.8	15	1.5
6	2.4		
7	1.7		
8	2.0		
9	3.8		
10	2.0		

Surbeam 30/my/92

⑦ Downstream of 1st Pond

- immediately downstream of road crossing
- 1st sample in gravel sand of fr road
- 2nd & third in boulder rubble riffle.

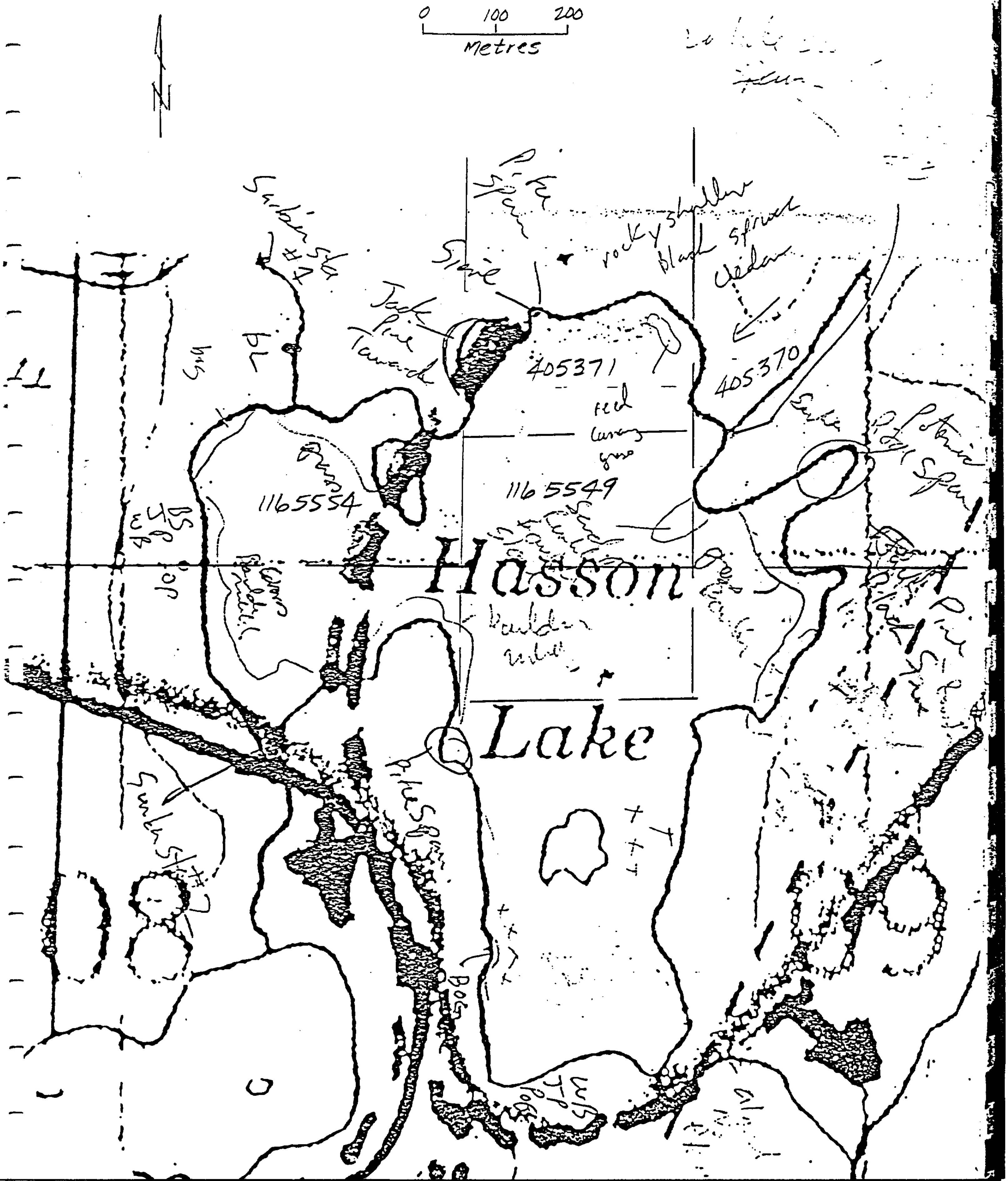
-

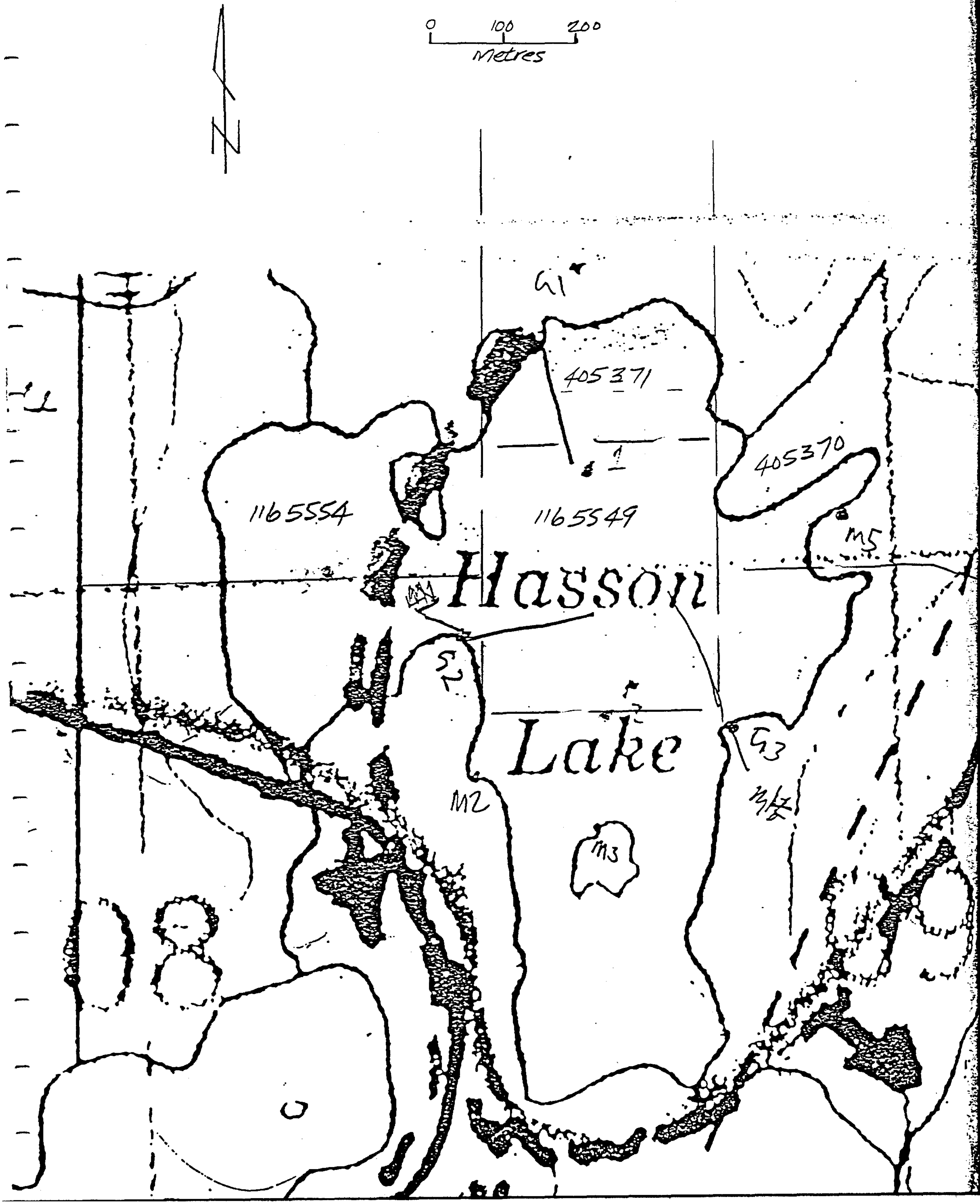
1st Pond water chemistry

1 sample taken for Series.

Depth	D.O.	Temp	
Surface	9.50	18.4	7.6 Hach.
0.5	9.42	18.2	
1.0	7.00	16.4	
1.5	2.85	14.4	- 1.6 bottom

Conduct	0.08	Secchi 0.6m
TDS	0.04	
Hardness	16	
Alkalinity	29	
Ph	7.41 M	7.0 Hach.
Acidity	19	

0
100
200
Metres
N
Hasson
Lake
405371
405370
1165549
1165554
rocky shallow
black spruce
Cedar
Pike Spawn
Stave
Jack Pine
Tamarack
Sunken Site #4
red
canary
grass
Swamp
Pike Spawn
Bog
Sunken Site #7
BS
Boulder
Bog


0
100
200
Metres
N
G1
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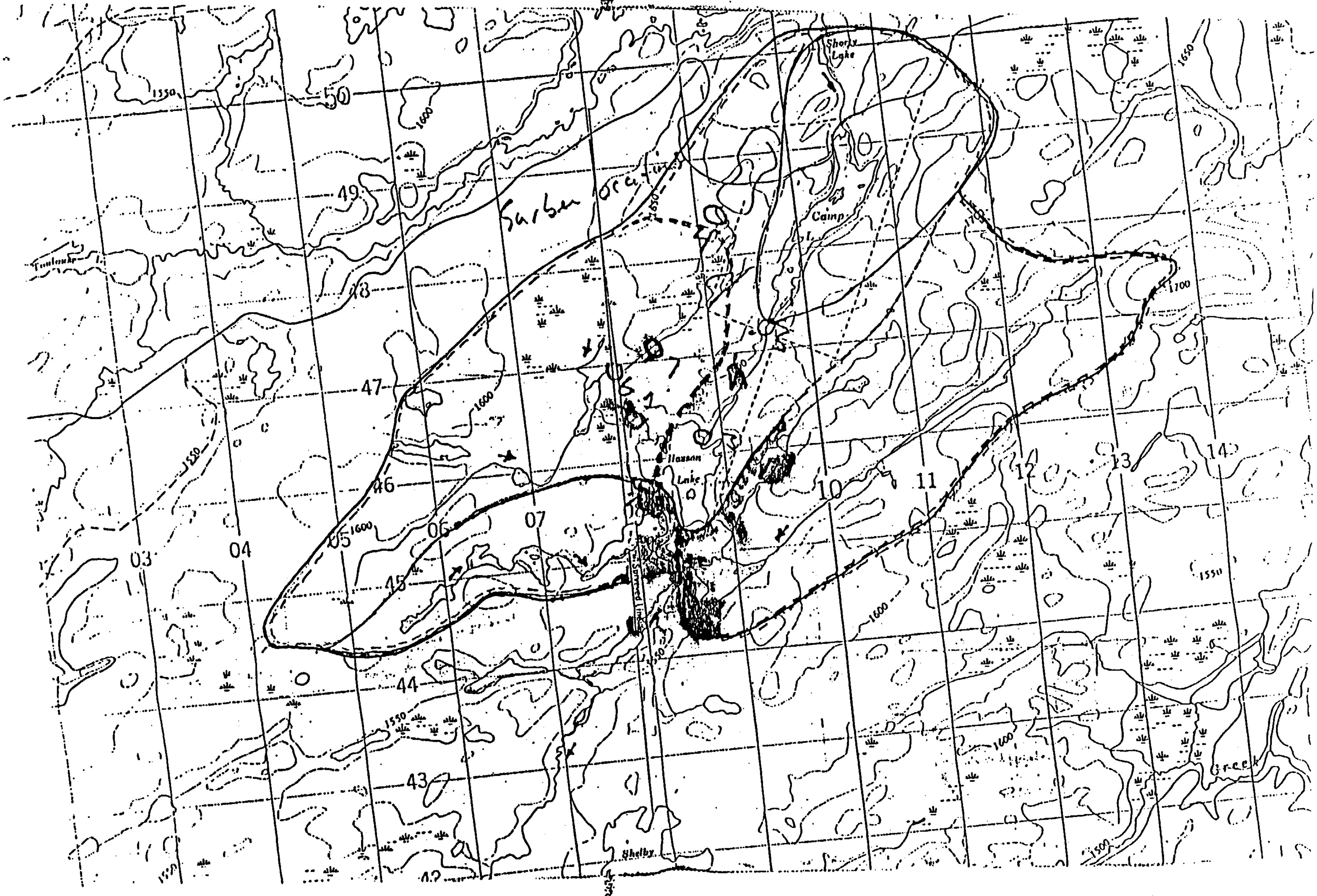
1
405370
1165554
1165549
M5
Hasson
M1
G2
Lake
M2
G3
M4
M3



Surban area
Shorty Lake
Camp L.
Hansen Lake
Surveyed Line
Shelby
Creek
Toulouse L.
50
49
48
47
46
45
44
43
42
03
04
05
06
07
10
11
12
13
14
1550
1600
1650
1700
1500

REPORT ON

BASELINE SURFACE WATER AND SEDIMENT QUALITY SURVEY AT THE LAC DES ILES MINE SITE

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

2.15334

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April 1992

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LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

In March 1992, SENES Consultants Limited was contracted by Lac Des Iles Mines Ltd. to initiate a baseline surface water and sediment quality monitoring program at the Lac Des Iles mine site some 90 km north of Thunder Bay, Ontario. The program was designed to collect an initial set of data on those surface water bodies which are most likely to be impacted by development and operation of a copper/nickel/palladium/platinum mine and mill complex. Since many of the facilities already exist on-site from past exploration and mining activities the water bodies identified for inclusion in the initial round of sampling were:

- Camp Lake which is located to the east and south of the surface facilities and may be used as a source of fresh water for the mill;
- Hasson Lake which is located to the south of the surface facilities and receives runoff from a small volume of tailings deposited from past mining activities in a low lying area in the lake watershed; and
- two ponds which are located on the drainage course between the tailings and Hasson Lake.

While development plans for the mine site have not been completed, it was felt that sampling of water bodies more remote to the site was not justified at this time. As the plans evolve it is possible that adjustment of the sampling station locations may be warranted in future campaigns. It is intended that the program will be reviewed prior to future sampling.

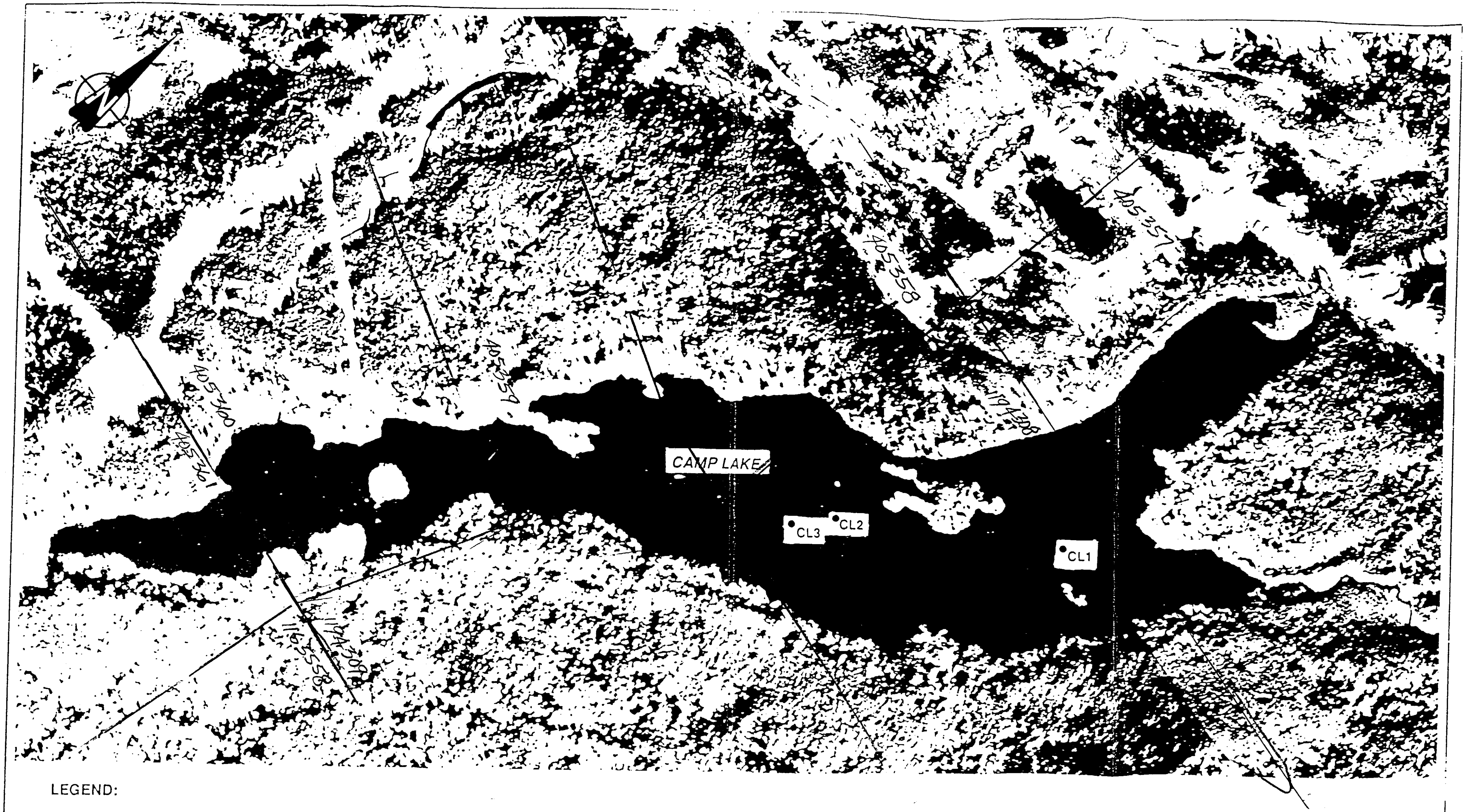
The details of the sampling program and results of the field and laboratory measurements are discussed in the following sections. Copies of the field report and laboratories analyses are provided in the appendices.

2.0 MONITORING PROGRAM

The sampling program was carried out on 4 and 5 March, 1992 under ideal weather conditions. Access to the water bodies was difficult, however, as the lakes were covered with up to a foot of snow and slush. To obtain the water and sediment samples it was necessary to auger through more than a half metre of ice. The details of the field program are recorded in Appendix A.

The program included measurement of field pH, temperature and dissolved oxygen for each of the water bodies and collection of lake water and bottom sediment samples for chemical analyses. In addition, water samples were obtained from the existing tailings management facility (TMF) for chemical analyses. The water and sediment samples were stored in a cooler with ice packs and shipped via air to Barringer Laboratories in Mississauga for chemical analyses.

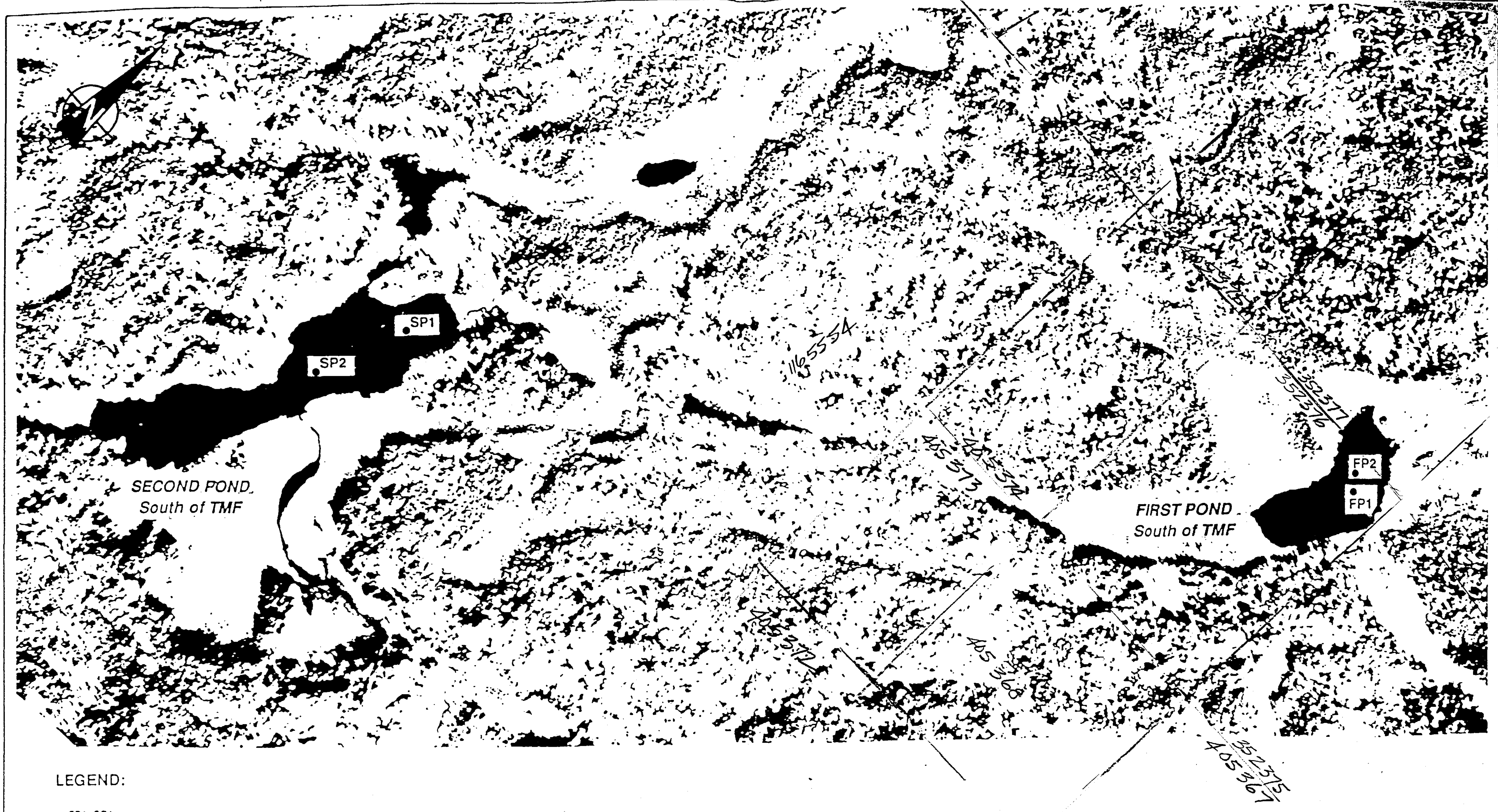
In total, nine (9) surface water samples (2 from Camp Lake, 3 from Hasson Lake, 1 from each of the ponds downstream of the TMF, 1 from the tailings secondary sedimentation pond and 1 from the tailings decant pond) and seven (7) sediment samples (2 from Camp Lake, 3 from Hasson Lake and 1 from each of the ponds downstream of the TMF) were collected. The locations of the sampling stations are shown on Figures 2.1, 2.2 and 2.3. Bathymetry mapping on Camp Lake indicates that the lake is deepest in the north basin and in the mid lake basin and is quite shallow in the south arm. The sampling stations on Camp Lake were located to sample in the vicinity of the deepest points. No bathymetry mapping was available on Hasson Lake or the two ponds downstream of the TMF. Consequently, Hasson Lake was sampled at three locations to obtain an appreciation of the characteristics of this water body. Two auger holes were also cut in each of the ponds to measure depth, dissolved oxygen, etc., although only one water sample and one sediment sample was taken from each water body for chemical analyses.



LEGEND:

● CL1 MONITORING STATION LOCATION

FIGURE 2.1
CAMP LAKE



LEGEND:

- ● FP1, SP1 MONITORING STATION LOCATION

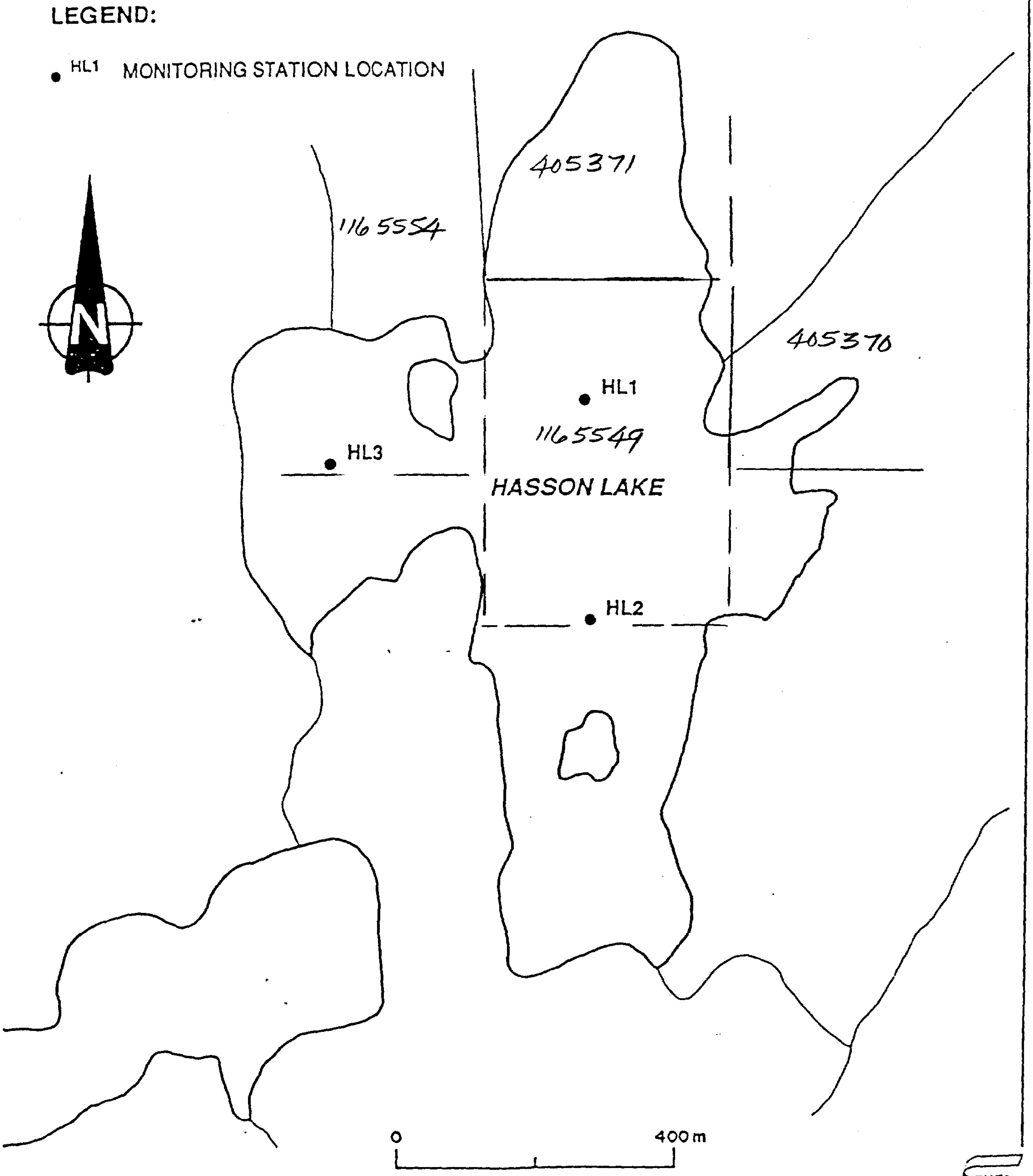
FIGURE 2.3

FIRST AND SECOND POND

ENE

FIGURE 2.2

HASSON LAKE



3.0 MONITORING RESULTS

3.1 FIELD MEASUREMENTS

The water temperature was observed to vary from a low of 0.2°C just below the ice surface to a high of 4.1°C near the bottom of the water column. Temperature profiles were measured generally at 1 m intervals and are recorded on the field note reports included in Appendix A. The pH values recorded in the field ranged between 6.7 to 7.3 and are typical of the values usually reported on Precambrian Shield waters.

The dissolved oxygen measurements are summarized on Table 3.1 for each of the water bodies surveyed. For comparison, the solubility of oxygen in water, with a chloride content near zero and a temperature of between 0 to 4°C, ranges from 13.1 mg/L (at 4°C) to 14.6 mg/L (at 0°C). As seen from Table 3.1, the measured dissolved oxygen levels were all less than the solubility limits. This observation is not surprising, however, as the water bodies had been under ice cover for several months at the time of the survey.

At most of the monitoring stations, the dissolved oxygen profile showed decreasing concentration from top to bottom. This is a common observation and reflects the effect of the oxygen demand exerted by bottom sediments which undergo degradation, albeit slowly, even in the winter months.

In Camp Lake, the oxygen concentrations were found to drop below 5 mg/L only in the bottom 2 to 3 m of the water column. The dissolved oxygen level in Camp Lake is considered to be good, considering the samples were collected late in the winter season, and is acceptable for sustaining aquatic life.

In contrast, the dissolved oxygen level in Hasson Lake was greater than 5 mg/L only in the upper 1 m of the water column. This observation is attributed to the shallowness of the lake at the survey locations. The significance of lake depth is that the shallower the lake, the smaller the volume of water contained in the lake and hence the smaller the oxygen source available to satisfy the oxygen demand exerted by the bottom sediments.

The observation made above for Hasson Lake was also very evident in the dissolved oxygen profiles measured on the two ponds south of the existing tailings area. These ponds are very shallow (measured depths of <1.5 m in the first pond and <2.5 m in the second pond) and the dissolved oxygen levels in the water column were found to be quite low. As noted in a subsequent section, the organic content of the sediments in these ponds is high which may explain why the dissolved oxygen levels in the ponds are so low.

3.2 SURFACE WATER CHEMICAL QUALITY

The analytical results on the mine water samples collected for analyses of trace metals, major cations and anions and nutrients are summarized on Table 3.2. The data on Camp Lake, Hasson Lake and the two ponds downstream of the existing tailings basin indicate that the concentrations of many of the trace metals are quite low and generally less than the detection limits of the analytical techniques (e.g. silver, boron, barium, beryllium, cobalt, chromium, molybdenum, nickel, lead, strontium, titanium, vanadium and zinc). The concentrations of the major cations (i.e. calcium, potassium, magnesium, sodium and silica) and anions (i.e. chloride, carbonate, bicarbonate and sulphate) are also low. The theoretical total dissolved solids levels were calculated to vary between 33 and 41 mg/L, with the exception of the first pond value of 96 mg/L which has apparently been influenced by the discharge from the existing tailings basin. The generally low concentrations of the major and trace elements is typical of many Precambrian Shield waters.

The pH of Camp Lake and Hasson Lake waters was found to range between 6.91 and 7.14 and the alkalinity varied between 20.3 and 21.3 mg/L $CaCO_3$. The limited buffering capacity of these waters is typical of surface runoff on much of the Precambrian Shield. The alkalinity of the water samples from the first pond below the TMF measured 64.9 mg/L $CaCO_3$. The fact that this value is higher than observed in the other water bodies apparently reflects the influence of the tailings discharge water which had an alkalinity of 250 mg/L $CaCO_3$.

The most significant characteristic of the lake and pond water samples was the distinctive dark brown colour typical of waters affected by the by-products of organic matter decay. These waters have various descriptors: "swamp water", "humus water" or "coloured water" (Faust and Aly, 1981). The observed range of the colour readings, between 130 and 379 TCU, are characteristic of waters with a high organic acid content. Faust and Aly (1981) indicate that dark brown waters from bogs may have colour in excess of 1,000 units. The Canadian Council of Ministers of the Environment (CCME, 1987) report a typical range of colour for surface waters in central Canada of 5 to 200 TCU. The observed levels at the Lac Des Iles site fall within the range of values cited from these reference sources.

The presence of organic matter in the Lac Des Iles area waters is also confirmed by the dissolved organic carbon (DOC) measurements. The measured levels range from 4.9 mg/L in the first pond to 18.9 mg/L in Camp Lake. Typical concentrations of organic carbon in surface waters are reported by the CCME (1987) to range from 1 to 3 mg/L in pristine streams, 2 to 10 mg/L in rivers and lakes, and 10 to 60 mg/L in swamps, marshes and bogs. Comparing the measured levels to the classification range quoted above, the water quality in Camp Lake, Hasson Lake and the second pond would fall into the latter group.

The presence of organic acids can dramatically increase the solubility of metals as most metals form complexes with humic substances in water (CCME, 1987). At low pH, the best known metal complexes with fulvic acid, in order of decreasing stability, are reported to be: iron (III); aluminum (III); copper (II); nickel (II); cobalt (II); lead (II); calcium (II); zinc (II); cadmium (II); iron (II); manganese (II); and magnesium (II). This factor would explain the elevated iron levels reported in Table 3.2 which vary from a low of 0.47 mg/L in Camp Lake to a high of 6.51 mg/L in the second pond. Iron, in particular, was observed to consistently exceed the provincial surface water quality of 0.30 mg/L for protection of aquatic life (MOE, 1984). Similarly, the copper levels marginally exceeded the provincial objective of 0.005 mg/L for protection of aquatic life (MOE, 1984) in some of the samples, most notably in Camp Lake. As noted in subsequent sections, the copper level in the sediments of Camp Lake is also elevated which suggests that this water body is more affected by exposed mineralization within its watershed than Hasson Lake. Finally, the presence of organic acids may have also influenced the observed levels of aluminum which generally were greater than the federal guideline of 0.10 mg/L for protection of aquatic life in fresh waters with a pH $\geq$ 6.5, a calcium concentration $\geq$ 4.0 mg/L and a dissolved organic carbon concentration (DOC) $\geq$ 2.0 mg/L. The Province of Ontario has not as yet published an objective for aluminum.

The measured concentrations of the nutrients (i.e. nitrogen and phosphorus compounds) were generally found to be present in fairly low concentrations. The total phosphorus levels measured in Camp Lake and Hasson Lake were, with the exception of one measurement on Hasson Lake, less than the guideline of 0.020 mg/L to protect against nuisance aquatic plant growth in lake systems. The total phosphorus levels in the two ponds were higher than the objective but were considerably lower than the levels reported on Table 3.2 for the tailings pond water. Similarly, the ammonia-nitrogen concentrations were found to be low in Camp Lake and Hasson Lake with the exception of the west bay sample. The concentrations in the two ponds were slightly higher but were well below the surface water quality objective. The tailings pond water samples contained elevated ammonia-nitrogen levels which presumably is attributable to the blasting agents used in mining the ore body.

In summary, the waters of Camp Lake, Hasson Lake and the ponds downstream of the TMF are characterized by strong dark brown colour indicative of the presence of humic acids. As a consequence, the waters also contain elevated levels of aluminum, copper and iron in particular, as these metals tend to most readily form organic metal complexes. The waters have a neutral pH and modest buffering capacity against pH change.

3.3 SEDIMENT CHEMICAL QUALITY

The sediment samples were analyzed for 24 metals and percent loss on ignition (LOI). The results of the analyses are summarized in Table 3.3. In addition, typical background levels of several of the metals in sediments from the Great Lakes are included in the table for comparison purposes.

The three sediment samples collected on Camp Lake are seen to have a very consistent quality.

The duplicate samples taken from the north basin of Camp Lake (denoted north basin #1 and north basin #2) showed essentially no difference in most of the parameters measured (i.e. the levels fall within the expected range of natural variability). The measured levels of several of the metals (i.e. cadmium, chromium, manganese, nickel, lead and zinc) are characteristic of the reported typical background levels. The measured iron levels were approximately one-half the typical value reported on Great Lakes sediment. In contrast, the copper levels were more than twice the background values. This observation is not surprising as Camp Lake is located in an area of mineralization. The organic content of the sediments in Camp Lake is high, ranging from 29.1% to 35.8%, and is consistent with expectations based on visual observations (see Field Notes in Appendix A).

The sediment sample taken from the north basin of Hasson Lake is seen to have very similar characteristics to the sediment in Camp Lake. The sediment samples from the west basin and mid lake station on Hasson Lake however, had quite different chemical characteristics. These sediment samples were found to have a much higher silt content and corresponding lower organic content (i.e. low LOI values). Accordingly, the metals content of these samples differed from the north basin sample and the Camp Lake samples.

The sediments in the two ponds downstream of the TMF are seen from Table 3.3 to have a high organic content (i.e. high LOI), similar to that measured on the sediments from Camp Lake. The metals content of the sediment from the second pond is also comparable to the metal levels found on Camp Lake. Interestingly, the metal levels measured in the sediment sample from the first pond are generally lower than the levels found in the sediments from the second pond, the north basin of Hasson Lake and Camp Lake. It is possible that the sediment quality has been altered by tailings deposition in the watershed although this is strictly a speculative conclusion.

In summary, the sediments from the lakes and ponds sampled in this initial survey were found to have typical sediment quality characteristics in most respects. Several of the sediment samples had a high organic carbon content and an elevated copper level. These attributes are indicative of the effects of local forestation and mineralization.

Table 3.1

DISSOLVED OXYGEN LEVELS (mg/L) OBSERVED DURING MARCH 1992 SURVEY

	Camp Lake			First Pond South of TMF		Second Pond South of TMF		Hasson Lake		
Depth from Surface (m)	North Basin Station CL1	Mid Lake Station CL2	Mid Lake Station CL3	Station FP1	Station FP2	Station SP1	Station SP2	North Basin Station HL1	Mid Lake Station HL2	West Basin Station HL3
0.3	-	-	-	1.4	2.5	2.2	1.3	-	9.0	5.0
1	10.7	9.5	10.0	0.3	0.4	4.5	4.2	8.9	7.4	3.4
2	9.0	8.4	8.4	0.17^{a,b}	-	4.8	0.2^{a}	5.3	4.7	2.4^{b}
3	7.5	7.1	7.1	-	-	0.2^{a,c}	-	3.1	3.5^{c}	-
4	6.7	6.4	6.1	-	-	-	-	2.8	-	-
5	6.2	6.3	6.0	-	-	-	-	3.0	-	-
6	3.4	0.4^{a}	5.8	-	-	-	-	0.4	-	-
7	2.1	-	5.5	-	-	-	-	-	-	-
8	0.5	-	5.2	-	-	-	-	-	-	-
9	0.2^{a}	-	4.6	-	-	-	-	-	-	-
10	-	-	4.4	-	-	-	-	-	-	-
11	-	-	0.2^{a}	-	-	-	-	-	-	-

Notes:

a) Dissolved oxygen measured in bottom sediment.
b) Dissolved oxygen measured at depth of 1.5 m.
c) Dissolved oxygen measured at depth of 2.5 m.

Table 3.2

CHEMICAL QUALITY OF SURFACE WATERS SAMPLED DURING MARCH 1992 SURVEY

Analyte	Units	Prov. Water Quality Objective[a]	Camp Lake North Basin	Camp Lake Mid Lake	First Pond South of TMF	Second Pond South of TMF	Hasson Lake North Basin	Hasson Lake West Bay	Hasson Lake Mid Lake	Tailings Decant Water	Tailings Secondary Pond
Ag	mg/L	0.0001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Al	mg/L	-	0.08	0.10	0.32	0.24	0.12	0.20	0.11	0.57	0.47
B	mg/L	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	0.012
Ba	mg/L	-	<0.005	<0.005	0.007	0.006	0.005	0.006	0.005	0.016	0.021
Be	mg/L	0.011[c]	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Ca	mg/L	-	5.27	5.41	5.96	4.98	5.31	5.28	5.11	32.2	21.9
Cd	mg/L	0.0002	0.0010	0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0004
Co	mg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cr	mg/L	0.10	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01
Cu	mg/L	0.005	0.009	0.006	0.007	0.004	0.003	0.002	0.003	0.015	0.014
Fe	mg/L	0.30	0.47	0.52	1.27	6.51	0.56	1.46	0.51	4.75	6.57
K	mg/L	-	<1.0	<1.0	2.4	<1.0	<1.0	<1.0	<1.0	6.2	6.1
Mg	mg/L	-	2.48	2.56	3.11	2.23	2.35	2.23	2.19	16.1	11.6
Mn	mg/L	-	0.01	0.01	0.18	0.15	0.02	0.11	0.02	1.68	2.65
Mo	mg/L	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Na	mg/L	-	1.1	1.1	23.2	1.9	1.3	4.6	1.4	74.5	72.1
Ni	mg/L	0.025	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.06
P	mg/L	0.02	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pb	mg/L	0.010[d]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/L	-	3.04	3.23	9.45	7.96	3.38	6.21	3.26	14.5	10.4
Sr	mg/L	-	0.011	0.012	0.013	0.012	0.012	0.013	0.012	0.072	0.052
Ti	mg/L	-	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.011	0.011
V	mg/L	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008
Zn	mg/L	0.03	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
F	mg/L	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<1.00	<0.10
Cl	mg/L	-	0.61	0.54	3.39	0.35	0.51	0.96	0.52	10.8	11.2
NO2-N	mg/L	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
PO4-3	mg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.3

Table 3.2, cont'd.

Analyte	Units	Prov. Water Quality Objective[a]	Camp Lake North Basin	Camp Lake Mid Lake	First Pond South of TMF	Second Pond South of TMF	Hasson Lake North Basin	Hasson Lake West Bay	Hasson Lake Mid Lake	Tailings Decant Water	Tailings Secondary Pond
Br	mg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.10	0.11
NO3-N	mg/L	-	0.15	0.16	0.06	0.07	0.20	0.10	0.19	<0.02	<0.02
SO4	mg/L		2.11	2.03	1.46	1.27	2.12	1.68	2.06	1.44	1.24
pH	pH Units	6.5 to 8.5	7.14	7.00	7.18	6.93	6.94	6.91	6.91	7.36	7.34
Alk 8.3	mg CaCO3/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Alk 4.2	mg CaCO3/L	-	21.2	21.3	64.9	22.9	20.3	26.6	20.3	309.	250.
NH3-N	mg/L	1.67[b]	0.02	<0.02	0.18	0.18	0.02	0.11	<0.02	2.60	1.91
Ortho P	mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.06
Total P	mg/L	0.020	0.011	0.011	0.080	0.060	0.012	0.022	0.012	0.240	0.290
DOC	mg/L	-	18.9	15.6	4.9	17.2	18.8	15.5	18.7	28.0	16.3
Colour	TCU		130.	130.	379.	210.	135.	227.	139.	285.	352.
Th. Cond.	µmhos/cm	-	51.4	51.9	148.1	50.9	50.6	62.7	49.6	616.5	515.0
Th. TDS	mg/L	-	33	34	96	33	33	41	32	401	335
pHs	pH Units	-	9.28	9.27	8.79	9.29	9.31	9.19	9.32	7.48	7.73
CAB	%	-	-4.02	-5.28	-6.64	-4.48	-5.68	-5.89	-4.15	0.29	-1.17
Hard(Calc)	mg CaCO3/L	-	23.4	24.1	27.7	21.6	23.0	22.4	21.8	147.1	102.6
CO3	mg/L	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HCO3	mg/L	-	25.6	25.7	78.9	27.7	24.5	32.2	24.5	376.5	304.6

Notes:

a) Provincial Water Quality Objectives for Protection of Aquatic Life and Recreation (MOE, 1984).
b) Ammonia nitrogen objective given applies at a pH of 7.5 and temperature of 20°C and is based on an un-ionized ammonia objective of 0.02 mg/L.
c) Objective applies to waters with hardness of <75 mg/L $CaCO_3$.
d) Objective applies to waters with alkalinity of between 20 and 40 mg/L $CaCO_3$.

See Table B.1 for list of abbreviations and descriptors.

Table 3.3

CHEMICAL QUALITY OF SEDIMENTS SAMPLED DURING MARCH 1992 SURVEY
(units are in µg/g dry weight except for LOI in percent)

Analyte	Typical Background Sediment Levels*	Camp Lake North Basin #1	Camp Lake North Basin #2	Camp Lake Mid Lake	First Pond South of TMA	Second Pond South of TMA	Hasson Lake North Basin	Hasson Lake Mid Lake	Hasson Lake West Basin
Ag	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Al	-	15700	16700	17100	5400	14300	13400	10200	6920
Ba	-	72.6	75.1	71.1	32.5	117.	62.5	24.4	25.4
Be	-	0.39	0.40	0.48	0.13	0.61	0.39	0.37	0.19
Ca	-	6150	6710	5230	5630	11800	5310	5020	3810
Cd	1.1	0.9	0.7	0.8	1.3	0.7	0.8	<0.3	<0.3
Co	-	5	4	12	2	13	6	8	5
Cr	31	23.2	26.1	24.5	13.8	22.6	22.8	13.9	11.5
Cu	25	63.6	67.4	61.5	36.0	50.9	56.9	11.2	10.9
Fe	31200.	12600.	12300.	19700.	4150.	21100.	13400.	17600.	9380.
K	-	410	410	420	340	370	400	320	290
Mg	-	2590.	2670.	2380.	1720.	2890.	1920	2290.	2120.
Mn	400.	233.	240.	410.	102.	146.	179.	226.	112.
Mo	-	<3	<3	<3	<3	<3	<3	<3	<3
Na	-	340	300	260	570	300	110	940	520
Ni	31	23	24	30	23	31	22	17	15
P	-	1230	1320	1360	510	700	950	440	320
Pb	23	21	16	20	7	9	32	3	6
Sr	-	16.9	17.8	14.7	12.7	21.2	14.1	14.6	10.7
Th	-	4	4	4	<2	6	3	4	3
Ti	-	169.	199.	216.	82.1	361.	139.	486.	436.
V	-	49.9	51.7	65.0	9.8	105.	54.4	75.1	38.4

Analyte	Typical Background Sediment Levels[a]	Camp Lake North Basin #1	Camp Lake North Basin #2	Camp Lake Mid Lake	First Pond South of TMA	Second Pond South of TMA	Hasson Lake North Basin	Hasson Lake Mid Lake	Hasson Lake West Basin
Zn	65	64.7	53.2	86.3	29.0	87.4	74.7	57.6	53.4
Zr	-	5	5	6	<2	9	4	3	2
LOI	-	34.8	35.8	29.1	34.5	36.7	35.8	4.30	7.17

Note:

a) Typical background levels for metals are based on analyses of Great Lakes pre-colonial sediment horizon (MOE, 1991).

See Table B.1 for list of abbreviations and descriptors.

4.0 RECOMMENDATIONS

The results of an initial survey of surface water and sediment quality in the vicinity of the Lac Des Iles mine site are presented in this report. In addition, a biological survey of Camp Lake, Hasson Lake and two ponds in the proposed tailings management facility watershed is planned for early spring. The biological program will include benthic sampling, fish netting and habitat investigations.

To augment the data base on local surface water quality, it is proposed that two additional sets of surface water samples be collected during 1992 from the monitoring stations sampled in March 1992. It is recommended that the first of these surveys be carried out at the same time as the biological survey planned for late April/early May. It is suggested that the second water quality survey be undertaken in August 1992.

5.0 REFERENCES

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APPENDIX A: FIELD NOTES: LAC DES ILES MINE SITE BASELINE MONITORING SURVEY 4 AND 5 MARCH 1992

Program Scope

Mr. Bruce E. Halbert of SENES Consultants Limited travelled to the Lac Des Iles Mine Site approximately 90 km north of Thunder Bay to collect water and sediment samples from ponds and lakes in the vicinity of the existing mine facilities. The purpose of the program was to establish baseline conditions under winter conditions. The program included the collection of water and sediment samples for chemical analyses and measurement of field pH, temperature and dissolved oxygen. The program was carried out on 4 and 5 March 1992 and included sampling of:

- Camp Lake to the south east of the mine camp facilities as this lake may be used as a source of process water;
- Hasson Lake to the south of the mine site as this lake may receive the effluent from the proposed tailings management facility (TMF);
- two ponds downstream of the proposed TMF; and,
- pond water in the area which currently contains tailings from past operations.

Field Conditions

Weather conditions at the time of sample collection were excellent with the temperature ranging from about -5°C to +5°C.

Working conditions on the lakes were difficult as they were covered with approximately 15 cm of snow, underlain with several centimetres of slush and 60 cm or more of solid ice. The conditions were unsuitable for use of a snowmobile thus all equipment had to be back-packed out to the sampling station locations. The General Manager for the mine, Mr. Glen Clark, kindly assisted with the field program and provided the services of mine workers to haul the field equipment onto and off of the lakes and to cut the access holes through the ice.

shipment to the laboratory for chemical analyses. These samples were also packed in the cooler to keep them cold and shipped overnight by air to the laboratory.

Observations made in the field about the characteristics of the sediments are summarized on the "Lake Survey Field Notes" forms attached hereto. In general, the sediment samples were found to have a high consistency, a dark brown, mucky appearance and a uniform texture. Most of the samples appeared to have a high organic content and were generally odorous.

LAKE SURVEY FIELD NOTES

1 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Sub-watershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 Survey Time: 10^{30} AM

Survey Team: R.E. Halbert and Two Mine Staff.

Air Temperature: 3°C Precipitation: [✓ none] ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Camp Lake

Location Sampled: North Basin - Station CL1

Water Sample(s) Taken: [✓ YES] ______ NO

Water Sample Type: ______ Top Metre ______ Mid Depth ______ Bottom Metre
[✓ Composite (top, mid depth, bottom)]
______ Other (specify) ______

Water Colour: ______ Clear ______ Turbid ______ Blue/Green
[✓ Brown] ______ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1	0.6	10.7	7.3	–
2	2.1	9.0	–	–
3	2.6	7.5	–	–
4	2.8	6.7	–	–
5	2.9	6.2	–	–
6	2.9	3.4	–	–
7	3.0	2.1	–	–
8	3.3	0.5	–	–
9 *	3.6	0.2	–	–

* D.O. probe was into sediment at 9 m depth.

Sediment Sample Taken: [✓ YES] NO

Sediment Sample Characteristics: Clay Gravel [✓ Muck] Sand Silt Other (specify)

Sediment Sample Colour: Black [✓ Brown] Grey Other (specify)

Sediment Sample Odour: Not odourous Slightly Odourous

Vegetation: Emergent Floating Submergent None Other

Other Observations: Sediment sample had a dark brown colour and a very consistent texture. Sediment appeared to have a high organic content and was quite thick.

Surveyors Signature

LAKE SURVEY FIELD NOTES

2 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 – Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 Survey Time: 11^{15} AM

Survey Team: B. E. Hulbert and Two Mine Staff

Air Temperature: 3°C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Camp Lake

Location Sampled: Mid Lake – Station CL2

Water Sample(s) Taken: ______ YES ✓ NO

Water Sample Type: ______ Top Metre ______ Mid Depth ______ Bottom Metre

______ Composite (top, mid depth, bottom)

______ Other (specify) ______________

Water Colour: ______ Clear ______ Turbid ______ Blue/Green

✓ Brown ______ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1	0.7	9.5	7.3	–
2	2.1	8.4	–	–
3	2.6	7.1	–	–
4	2.8	6.4	–	–
5	2.9	6.3	–	–
6*	2.9	8.4	–	–

* D.O. probe was into sediment at 6 m depth.

Sediment Sample Taken: ______ YES ✓ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck ______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent None Other

Other Observations: Temperature and dissolved oxygen only were measured at this station. Another attempt was made to find a deeper station to sample in the mid lake basin.

Surveyors Signature

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

3 of 8

Project Number: 31121 – Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed.

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 Survey Time: 12^{20} PM.

Survey Team: B. Halbert and Two Mine Staff

Air Temperature: 4°C Precipitation: ✓ none ____ rain ____ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Camp Lake

Location Sampled: Mid Lake – Station CL3

Water Sample(s) Taken: ✓ YES ____ NO

Water Sample Type: ____ Top Metre ____ Mid Depth ____ Bottom Metre
✓ Composite (top, mid depth, bottom)
____ Other (specify) ____

Water Colour: ____ Clear ____ Turbid ____ Blue/Green
✓ Brown ____ Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)
1	0.7	10.0	7.2	—
2	2.1	8.4	—	—
3	2.6	7.1	—	—
4	2.7	6.1	—	—
5	2.8	6.0	—	—
6	2.9	5.7	—	—
7	2.9	5.5	—	—
8	2.9	5.2	—	—
9	2.9	4.6	—	—
10	3.0	4.4	—	—
11*	—	0.2	—	—

* D.O. probe was into sediment at 11m depth.

Sediment Sample Taken: [✓ YES] ______ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel [✓ Muck]
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black [✓ Brown] ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous Slightly Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent None Other

Other Observations: Sediment was thick, had a dark brown appearance and uniform consistency.

Surveyors Signature ______

LAKE SURVEY FIELD NOTES

4 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 – Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 Survey Time: 2^{45} P.M.

Survey Team: B.E. Halbert and Four Mine Staff

Air Temperature: 4°C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100%

Waterbody Surveyed: First Pond Southwest of Tailings Management Area.

Location Sampled: Two Mid Pond Stations – FP1 at Narrows
– FP2 North of Narrows.

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ Top Metre ___ Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ___ Turbid ___ Blue/Green
Dark Brown & Turbid Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Station FP1				
0.3	0.2	1.4	6.8	–
1.0	1.8	0.3	–	–
1.5 *	2.4	0.17	–	–
* D.O. probe went into sediment at 1.5 m depth				
Station FP2				
0.3	0.4	2.5	–	–
1.0	1.4	0.4	–	–

Sediment Sample Taken: ✓ YES ____ NO

Sediment Sample Characteristics: ____ Clay ____ Gravel Organic Muck
____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black Dark Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous Very Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent None Other

Other Observations: Sediment Sample was taken at Station FP1 and had a strong anaerobic odour. Water sample was taken at Station FP2, had a deep brown colour and contained a noticeable level of suspended solids.

Surveyors Signature ____

LAKE SURVEY FIELD NOTES

5 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site.

Watershed Name: Dog River Subwatershed.

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 Survey Time: 4^{30} p.m.

Survey Team: R. E. Hallbert and Four Mine Staff

Air Temperature: 4 °C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Second Pond Southwest of Tailings Mgt. Area.

Location Sampled: Two stations: SP1 - North End of North Basin
SP2 - South End of North Basin

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓(SP1) Top Metre ___ Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ___ Turbid ___ Blue/Green
Dark Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
STATION SP1				
0.3	0.3	2.1/2.3 (confirmed)	6.7	—
1.0	0.8	4.5	—	—
2.0	2.6	4.8	—	—
2.5*	2.9	0.2	—	—
* D.O. probe was into sediment at 2.5m depth!				
STATION SP2				
0.3	0.2	1.3 (confirmed)	—	—
1.0	1.0	4.2	—	—
2.0*	2.5	0.2	—	—

Sediment Sample Taken: ✓ (SP2) YES ______ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel Organic Muck
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous Strong Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent None Other

Other Observations: Sediment Sample, taken from Station SP2, had a deep dark brown colour, was odourous and had a uniform texture and consistency.

Surveyors Signature Bruce E [illegible]

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

6 of 8

Project Number: 31121 – Lac Des Iles Mine Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 Survey Time: 9^{00} AM.

Survey Team: B.E. Halbert and Three Mine Staff

Air Temperature: < 0°C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Hasson Lake

Location Sampled: Entrance to North Basin – Station HL1

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ___ Top Metre ___ Mid Depth ___ Bottom Metre

___ Composite (top, mid depth, bottom)

Composite Other (specify) Top & bottom waters.

Water Colour: ___ Clear ___ Turbid ___ Blue/Green

✓ Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1.0	1.1	8.9	6.9	–
2.0	3.3	5.3	–	–
3.0	3.7	3.1	–	–
4.0	3.9	0.8	–	–
5.0	3.8	3.0	–	–
6.0	4.1	0.4	–	–

Sediment Sample Taken: ✓ YES ____ NO

Sediment Sample Characteristics: ____ Clay ____ Gravel ✓ Muck ____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black ✓ Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous Slightly Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent None Other

Other Observations: Sediment had higher silt content than other lakes and ponds sampled during survey

Surveyors Signature Bruce E Holt

31132 - March 1992

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

7 of 8

Project Number: 31121 - Lac Des Iles Mines Ltd

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 Survey Time: 9^{45} to 10^{45} AM

Survey Team: B. E. Halbert and Three Mine Staff

Air Temperature: <0°C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100%

Waterbody Surveyed: Hasson Lake

Location Sampled: Station HL2 - Mid Lake
HL3 - Centre of West Basin

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ HL3 Top Metre ✓ HL2 Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ___ Turbid ___ Blue/Green
✓ Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
STATION HL2 - MID LAKE				
0.3	0.2	9.0	6.9	—
1.0	1.3	7.4	—	—
2.0	3.0	4.7	—	—
2.5	3.6	3.5	—	—
STATION HL3 - Centre of West Basin				
0.3	0.2	5.0	6.9	—
1.0	0.7	3.4	—	—
1.5	1.1	2.4	—	—

Sediment Sample Taken: ✓ HL2 & HL3 YES ________ NO

Sediment Sample Characteristics: ________ Clay ________ Gravel Silty Muck ✓
________ Sand ________ Silt ________ Other (specify)

Sediment Sample Colour: ________ Black ✓ Brown ________ Grey ________ Other (specify)

Sediment Sample Odour: ________ Not odourous Slightly Odourous

Vegetation: ________ Emergent ________ Floating ________ Submergent NONE. Other

Other Observations: Sediment samples had higher silt content than other lakes and ponds sampled, particularly the sediment from the mid lake station. Very little sediment was obtained using the clam in each attempt.

Surveyors Signature ________

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

8 of 8

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Sub-watershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 Survey Time: 11^{30} AM.

Survey Team: BE Hubbard and Three Mine Staff

Air Temperature: < 0°C Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Tailing Management Facility Ponds

Location Sampled: TMF1 - Tailings Pond Decant Water.
TMF2 - Tailings Secondary Sedimentation Pond

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ Top Metre ___ Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ✓ Turbid ___ Blue/Green
___ Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (umhos/cm)

Sediment Sample Taken: ______ YES ✓ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent None Other

Other Observations: Both tailings water samples had a grey/green colour and were quite turbid and odourous. The auger holes through the ice only partially filled with water making it difficult to obtain ice free samples.

Surveyors Signature B E. H

APPENDIX B

ANALYTICAL REPORTS PREPARED BY BARRINGER LABORATORIES

Table B.1
LIST OF ABBREVIATIONS AND DESCRIPTORS

Measured Parameters	
Abbreviations	Field Descriptor
Ag	Silver
Al	Aluminum
Alk 4.2	Alkalinity to pH 4.2
Alk 8.3	Alkalinity to pH 8.3
B	Boron
Ba	Barium
Be	Berrylium
Br	Bromide
Ca	Calcium
Cd	Cadmium
Cl	Chloride
Co	Cobalt
Cr	Chromium
Cu	Copper
DOC	Dissolved Organic Carbon
F	Fluoride
Fe	Iron
K	Potassium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
Na	Sodium
NH3-N	Ammonia-Nitrogen
Ni	Nickel
NO2-N	Nitrite-Nitrogen
NO3-N	Nitrate-Nitrogen
Ortho P	Ortho Phosphate
P	Phosphorus
Pb	Lead
pH	pH
PO4	Phosphate
Si	Silica
SO4	Sulphate
Sr	Strontium
Th	Thallium
Ti	Titanium
V	Vanadium
Zn	Zinc
Zr	Zirconium

Calculated Parameters	
Abbreviations	Field Descriptor
Th Cond.	Theoretical Conductivity
Th TDS	Theoretical Total Dissolved Solids
Turb	Turbidity
CAB	Cation/Anion Balance
Hard (Calc)	Hardness - Calculated
CO3	Carbonate - Calculated
HCO3	Bicarbonate - Calculated
L.I.	Langelier Index
A.I.	Aggressive Index
R.S.I.	Ryzner Stability Index
Colour	Colour
Total P	Total Phosphorus

BARRINGER LABORATORIES

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25-Mar-92

SENES CONSULTANTS LIMITED
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Unit #4
Richmond Hill, ON
L4B 1G5

Page: 1
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Set : 1

Attn: Ms. Trudi Collins
Received: 6-Mar-92 11:25
Project:
PO #:

Job: 924617
Status: Final

Sediment Samples

Sample Id	Ag ICAP ppm	Al ICAP ppm	Ba ICAP ppm	Be ICAP ppm	Ca ICAP ppm	Cd ICAP ppm	Co ICAP ppm
FIRST POND SOUTH OF TMA SEDIMENT	<0.2	5400	32.5	0.13	5630	1.3	2
SECOND POND SOUTH OF TMA SEDIMENT	<0.2	14300	117.	0.61	11800	0.7	13
HASSON LAKE NORTH SEDIMENT	<0.2	13400	62.5	0.39	5310	0.8	6
HASSON MID LAKE SEDIMENT	<0.2	10200	24.4	0.37	5020	<0.3	8
HASSON LAKE WEST SEDIMENT	<0.2	6920	25.4	0.19	3810	<0.3	5
CAMP LAKE NORTH #1 SEDIMENT	<0.2	15700	72.6	0.39	6150	0.9	5
CAMP LAKE NORTH #2 SEDIMENT	<0.2	16700	75.1	0.40	6710	0.7	4
CAMP LAKE MID STATION SEDIMENT	<0.2	17100	71.1	0.48	5230	0.8	12
Blank	<0.2	<10	<0.3	<0.02	<20	<0.3	<2
QC Standard (actual)	1.1	17100	149.	0.68	5820	0.5	28
QC Standard (expected)	1.5	16500	149.	0.73	5920	0.5	26
Repeat FIRST POND	<0.2	5320	32.6	0.13	5460	2.4	2

BARRINGER LABORATORIES

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Sediment Samples

Sample Id	Cr ICAP ppm	Cu ICAP ppm	Fe ICAP ppm	K ICAP ppm	Mg ICAP ppm	Mn ICAP ppm	Mo ICAP ppm
FIRST POND SOUTH OF TMA SEDIMENT	13.8	36.0	4150.	340	1720.	102.	<3
SECOND POND SOUTH OF TMA SEDIMENT	22.6	50.9	21100.	370	2890.	146.	<3
HASSON LAKE NORTH SEDIMENT	22.8	56.9	13400.	400	1920.	179.	<3
HASSON MID LAKE SEDIMENT	13.9	11.2	17600.	320	2290.	226.	<3
HASSON LAKE WEST SEDIMENT	11.5	10.9	9380.	290	2120.	112.	<3
CAMP LAKE NORTH #1 SEDIMENT	23.2	63.6	12600.	410	2590.	233.	<3
CAMP LAKE NORTH #2 SEDIMENT	26.1	67.4	12300.	410	2670.	240.	<3
CAMP LAKE MID STATION SEDIMENT	24.5	61.5	19700.	420	2380.	410.	<3
Blank	<0.3	<0.3	<10.0	<20	<0.3	<0.3	<3
QC Standard (actual)	39.4	33.9	32100.	2580	7880.	1170.	<3
QC Standard (expected)	39.5	29.9	29500.	2480	7600.	1040.	<3
Repeat FIRST POND	14.0	37.1	3770.	320	1720.	102.	<3

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Sediment Samples

Sample Id	Na ICAP ppm	Ni ICAP ppm	P ICAP ppm	Pb ICAP ppm	Sr ICAP ppm	Th ICAP ppm	Ti ICAP ppm
FIRST POND SOUTH OF TMA SEDIMENT	570	23	510	7	12.7	<2	82.1
SECOND POND SOUTH OF TMA SEDIMENT	300	31	700	9	21.2	6	361.
HASSON LAKE NORTH SEDIMENT	110	22	950	32	14.1	3	139.
HASSON MID LAKE SEDIMENT	940	17	440	3	14.6	4	486.
HASSON LAKE WEST SEDIMENT	520	15	320	6	10.7	3	436.
CAMP LAKE NORTH #1 SEDIMENT	340	23	1230	21	16.9	4	169.
CAMP LAKE NORTH #2 SEDIMENT	300	24	1320	16	17.8	4	199.
CAMP LAKE MID STATION SEDIMENT	260	30	1360	20	14.7	4	216.
Blank	<20	<2	<20	<2	<0.3	<2	<0.3
QC Standard (actual)	360	41	810	22	28.7	10	727.
QC Standard (expected)	350	39	700	23	26.8	11	732.
Repeat FIRST POND	580	24	500	7	12.8	2	78.0

BARRINGER LABORATORIES

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Sediment Samples

Sample Id	V ICAP ppm	Zn ICAP ppm	Zr ICAP ppm	LOI Grav. %
FIRST POND SOUTH OF TMA SEDIMENT	9.8	29.0	<2	34.5
SECOND POND SOUTH OF TMA SEDIMENT	105.	87.4	9	36.7
HASSON LAKE NORTH SEDIMENT	54.4	74.7	4	35.8
HASSON MID LAKE SEDIMENT	75.1	57.6	3	4.30
HASSON LAKE WEST SEDIMENT	38.4	53.4	2	7.17
CAMP LAKE NORTH #1 SEDIMENT	49.9	64.7	5	34.8
CAMP LAKE NORTH #2 SEDIMENT	51.7	53.2	5	35.8
CAMP LAKE MID STATION SEDIMENT	65.0	86.3	6	29.1
Blank	<0.3	<0.5	<2	<0.01
QC Standard (actual)	43.1	123.	11	8.92
QC Standard (expected)	43.8	112.	13	9.13
Repeat FIRST POND	9.8	29.2	<2	36.2

BARRINGER LABORATORIES

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Water Samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.005	0.08	<0.010	<0.005	<0.0005	5.27	<0.005
#2-CAMP LAKE MID LAKE COMPOSITE	<0.005	0.10	<0.010	<0.005	<0.0005	5.41	<0.005
#3-FIRST POND SOUTH OF TMA	<0.005	0.32	<0.010	0.007	<0.0005	5.96	<0.005
#4-SECOND POND SOUTH OF TMA	<0.005	0.24	<0.010	0.006	<0.0005	4.98	<0.005
#5-HASSON LAKE NORTH SAMPLE	<0.005	0.12	<0.010	0.005	<0.0005	5.31	<0.005
#6-HASSON LAKE WEST BAY SAMPLE	<0.005	0.20	<0.010	0.006	<0.0005	5.28	<0.005
#7-HASSON LAKE MID LAKE SAMPLE	<0.005	0.11	<0.010	0.005	<0.0005	5.11	<0.005
#8-TAILINGS SECONDARY POND	<0.005	0.47	0.012	0.021	<0.0005	21.9	<0.005
#9-TAILINGS DECANT WATER	<0.005	0.57	0.011	0.016	<0.0005	32.2	<0.005
Blank	<0.005	<0.05	<0.010	<0.005	<0.0005	<0.05	<0.005
QC Standard (actual)	<0.005	10.0	0.193	0.998	0.0187	50.0	0.191
QC Standard (expected)	<0.005	10.0	0.200	1.00	0.0200	50.0	0.200
Repeat #1-CAMP LAKE NORTH	<0.005	0.09	<0.010	<0.005	<0.0005	5.21	<0.005

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25-Mar-92

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Water Samples

Sample Id	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.05	<0.01	<0.01	0.47	<1.0	2.48	0.01
#2-CAMP LAKE MID LAKE COMPOSITE	<0.05	<0.01	<0.01	0.52	<1.0	2.56	0.01
#3-FIRST POND SOUTH OF TMA	<0.05	<0.01	<0.01	1.27	2.4	3.11	0.18
#4-SECOND POND SOUTH OF TMA	<0.05	0.01	<0.01	6.51	<1.0	2.23	0.15
#5-HASSON LAKE NORTH SAMPLE	<0.05	0.01	<0.01	0.56	<1.0	2.35	0.02
#6-HASSON LAKE WEST BAY SAMPLE	<0.05	<0.01	<0.01	1.46	<1.0	2.23	0.11
#7-HASSON LAKE MID LAKE SAMPLE	<0.05	0.01	<0.01	0.51	<1.0	2.19	0.02
#8-TAILINGS SECONDARY POND	<0.05	0.01	0.01	6.57	6.1	11.6	2.65
#9-TAILINGS DECANT WATER	<0.05	0.01	0.01	4.75	6.2	16.1	1.68
Blank	<0.05	<0.01	<0.01	<0.01	<1.0	<0.05	<0.01
QC Standard (actual)	0.19	0.20	0.20	9.71	50.5	9.93	0.19
QC Standard (expected)	0.20	0.20	0.20	10.0	50.0	10.0	0.20
Repeat #1-CAMP LAKE NORTH	<0.05	<0.01	<0.01	0.46	<1.0	2.46	0.01

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Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.2	1.1	<0.05	<0.5	<0.05	3.04	0.011
#2-CAMP LAKE MID LAKE COMPOSITE	<0.2	1.1	<0.05	<0.5	<0.05	3.23	0.012
#3-FIRST POND SOUTH OF TMA	<0.2	23.2	<0.05	<0.5	<0.05	9.45	0.013
#4-SECOND POND SOUTH OF TMA	<0.2	1.9	<0.05	<0.5	<0.05	7.96	0.012
#5-HASSON LAKE NORTH SAMPLE	<0.2	1.3	<0.05	<0.5	<0.05	3.38	0.012
#6-HASSON LAKE WEST BAY SAMPLE	<0.2	4.6	<0.05	<0.5	<0.05	6.21	0.013
#7-HASSON LAKE MID LAKE SAMPLE	<0.2	1.4	<0.05	<0.5	<0.05	3.26	0.012
#8-TAILINGS SECONDARY POND	<0.2	72.1	<0.05	<0.5	<0.05	10.4	0.052
#9-TAILINGS DECANT WATER	<0.2	74.5	<0.05	<0.5	<0.05	14.5	0.072
Blank	<0.2	<0.5	<0.05	<0.5	<0.05	<0.05	<0.001
QC Standard (actual)	0.5	50.8	0.20	9.9	0.19	10.0	0.197
QC Standard (expected)	0.5	50.0	0.20	10.0	0.20	10.0	0.200
Repeat #1-CAMP LAKE NORTH	<0.2	1.1	<0.05	<0.5	<0.05	3.03	0.011

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Water Samples

Sample Id	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L
#1-CAMP LAKE NORTH BASIN	<0.005	<0.005	<0.01	<0.10	0.61	<0.02	<0.1
#2-CAMP LAKE MID LAKE COMPOSITE	<0.005	<0.005	<0.01	<0.10	0.54	<0.02	<0.1
#3-FIRST POND SOUTH OF TMA	0.005	<0.005	<0.01	<0.10	3.39	<0.02	<0.1
#4-SECOND POND SOUTH OF TMA	<0.005	<0.005	0.02	<0.10	0.35	<0.02	<0.1
#5-HASSON LAKE NORTH SAMPLE	<0.005	<0.005	<0.01	<0.10	0.51	<0.02	<0.1
#6-HASSON LAKE WEST BAY SAMPLE	<0.005	<0.005	<0.01	<0.10	0.96	<0.02	<0.1
#7-HASSON LAKE MID LAKE SAMPLE	<0.005	<0.005	<0.01	<0.10	0.52	<0.02	<0.1
#8-TAILINGS SECONDARY POND	0.011	0.008	<0.01	<0.10	11.2	<0.02	0.3
#9-TAILINGS DECANT WATER	0.011	<0.005	<0.01	<1.00	10.8	<0.02	0.2
Blank	<0.005	<0.005	<0.01	<0.10	<0.01	<0.02	<0.1
QC Standard (actual)	0.196	0.198	0.19	0.44	2.01	0.99	2.0
QC Standard (expected)	0.200	0.200	0.20	0.46	2.00	1.00	2.0
Repeat #1-CAMP LAKE NORTH	<0.005	<0.005	<0.01	<0.10	0.63	<0.02	<0.1

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Water Samples

Sample Id	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	pH pH Elec. pH Units	Alk 8.3 Titr. 1 mg CaCO3/L	Alk 4.2 Titr. 1 mg CaCO3/L
#1-CAMP LAKE NORTH BASIN	<0.05	0.15	2.11	7.14	<0.1	21.2
#2-CAMP LAKE MID LAKE COMPOSITE	<0.05	0.16	2.03	7.00	<0.1	21.3
#3-FIRST POND SOUTH OF TMA	<0.05	0.06	1.46	7.18	<0.1	64.9
#4-SECOND POND SOUTH OF TMA	<0.05	0.07	1.27	6.93	<0.1	22.9
#5-HASSON LAKE NORTH SAMPLE	<0.05	0.20	2.12	6.94	<0.1	20.3
#6-HASSON LAKE WEST BAY SAMPLE	<0.05	0.10	1.68	6.91	<0.1	26.6
#7-HASSON LAKE MID LAKE SAMPLE	<0.05	0.19	2.06	6.91	<0.1	20.3
#8-TAILINGS SECONDARY POND	0.11	<0.02	1.44	7.34	<0.1	250.
#9-TAILINGS DECANT WATER	0.10	<0.02	1.24	7.36	<0.1	309.
Blank	<0.05	<0.02	<0.05	5.68	<0.1	<0.1
QC Standard (actual)	1.88	0.45	2.00	4.47	<0.1	244.
QC Standard (expected)	2.00	0.44	2.00	4.45	<0.1	250.
Repeat #1-CAMP LAKE NORTH	<0.05	0.16	2.04	7.11	<0.1	21.0

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Water Samples

Sample Id	NH3-N A. Col. mg/L	Ortho P A. Col. mg/L	DOC A. Col. mg/L	Th. Cond. Calc. umhos/cm	Th. TDS Calc. mg/L	pHs Calc. pH Units	CAB Calc. %
#1-CAMP LAKE NORTH BASIN	0.02	<0.01	18.9	51.4	33	9.28	-4.02
#2-CAMP LAKE MID LAKE COMPOSITE	<0.02	<0.01	15.6	51.9	34	9.27	-5.28
#3-FIRST POND SOUTH OF TMA	0.18	<0.01	4.9	148.1	96	8.79	-6.64
#4-SECOND POND SOUTH OF TMA	0.18	<0.01	17.2	50.9	33	9.29	-4.48
#5-HASSON LAKE NORTH SAMPLE	0.02	<0.01	18.8	50.6	33	9.31	-5.68
#6-HASSON LAKE WEST BAY SAMPLE	0.11	<0.01	15.5	62.7	41	9.19	-5.89
#7-HASSON LAKE MID LAKE SAMPLE	<0.02	<0.01	18.7	49.6	32	9.32	-4.15
#8-TAILINGS SECONDARY POND	1.91	0.06	16.3	515.0	335	7.73	-1.17
#9-TAILINGS DECANT WATER	2.60	0.05	28.0	616.5	401	7.48	0.29
Blank	<0.02	<0.01	<0.2	3.8	2	13.64	-64.40
QC Standard (actual)	0.11	0.38	10.1	592.0	385	7.41	-15.09
QC Standard (expected)	0.10	0.40	10.0	594.6	386	7.37	-13.64
Repeat #1-CAMP LAKE NORTH	0.02	<0.01	18.2	50.8	33	9.28	-3.82

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Water Samples

Sample Id	Hard(Calc) Calc. mg CaCO3/L	CO3= Calc. mg/L	HCO3- Calc. mg/L	L.I. Calc. None	A.I. Calc. None	R.S.I. Calc. None	Colour M. Col. TCU
#1-CAMP LAKE NORTH BASIN	23.4	0.1	25.6	-2.1	9.84	11.4	130.
#2-CAMP LAKE MID LAKE COMPOSITE	24.1	0.1	25.7	-2.3	9.71	11.5	130.
#3-FIRST POND SOUTH OF TMA	27.7	0.1	78.9	-1.6	10.43	10.4	379.
#4-SECOND POND SOUTH OF TMA	21.6	0.1	27.7	-2.4	9.62	11.6	210.
#5-HASSON LAKE NORTH SAMPLE	23.0	0.1	24.5	-2.4	9.61	11.7	135.
#6-HASSON LAKE WEST BAY SAMPLE	22.4	0.1	32.2	-2.3	9.68	11.5	227.
#7-HASSON LAKE MID LAKE SAMPLE	21.8	0.1	24.5	-2.4	9.56	11.7	139.
#8-TAILINGS SECONDARY POND	102.6	0.1	304.6	-0.4	11.75	8.1	352.
#9-TAILINGS DECANT WATER	147.1	0.1	376.5	-0.1	12.02	7.6	285.
Blank	0.3	0.1	0.0	-8.0	4.20	21.6	---
QC Standard (actual)	166.0	0.1	297.4	-2.9	9.08	10.3	50.0
QC Standard (expected)	166.0	0.1	304.6	-2.9	9.07	10.3	50.0
Repeat #1-CAMP LAKE NORTH	23.1	0.1	25.4	-2.2	9.80	11.5	130.

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Water Samples

Sample Id	Cd GFAAS mg/L	Cu ICAP mg/L	Ni ICAP mg/L	Pb ICAP mg/L	Total P A. Col. mg/L
#1-CAMP LAKE NORTH BASIN	0.0010	0.009	<0.01	<0.01	0.011
#2-CAMP LAKE MID LAKE COMPOSITE	0.0001	0.006	<0.01	<0.01	0.011
#3-FIRST POND SOUTH OF TMA	0.0001	0.007	0.01	<0.01	0.080
#4-SECOND POND SOUTH OF TMA	0.0001	0.004	<0.01	<0.01	0.060
#5-HASSON LAKE NORTH SAMPLE	<0.0001	0.003	<0.01	<0.01	0.012
#6-HASSON LAKE WEST BAY SAMPLE	<0.0001	0.002	<0.01	<0.01	0.022
#7-HASSON LAKE MID LAKE SAMPLE	<0.0001	0.003	<0.01	<0.01	0.012
#8-TAILINGS SECONDARY POND	0.0004	0.014	0.06	<0.01	0.290
#9-TAILINGS DECANT WATER	0.0002	0.015	0.04	<0.01	0.240
Blank	<0.0001	<0.002	<0.01	<0.01	<0.002
QC Standard (actual)	0.0024	0.197	0.20	0.20	0.081
QC Standard (expected)	0.0025	0.200	0.20	0.20	0.084
Repeat #1-CAMP LAKE NORTH	0.0010	---	---	---	0.011

Job approved by:

Signed: ....
Mike Muneswar
Senior Supervisor, Environmental Analytical Services

100

REPORT ON

BASELINE SURFACE WATER AND SEDIMENT QUALITY MONITORING PROGRAM AT THE LAC DES ILES MINE SITE

2.15334

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MAR 7 - 1994
MINING LANDS BRANCH

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November 1992

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1.0 INTRODUCTION

In March 1992, SENES Consultants Limited (SENES) was contracted by Lac des Iles Mines Ltd. to initiate baseline aquatic environment studies at the Lac des Iles mine site some 90 km north of Thunder Bay, Ontario (see Figure 1.1). The first of three surveys in the planned program was conducted in March 1992. Both surface water and bottom sediment samples were collected in this survey. In late May 1992, a second sampling program was carried out by Niblett Environmental Associates Inc. (NEA), subconsultants retained to perform biological studies. In addition to collection of water samples, the May program included benthic sampling, fish netting and habitat investigations. To augment the database on local surface water quality, a third water quality survey was undertaken in August 1992.

The program was designed to collect data on those surface water bodies which are most likely to be impacted by the development and operation of a proposed palladium/platinum/gold/copper/nickel mine and mill complex.

Existing facilities on the Lac des Iles mine site from past exploration and mining activities, and proposed future development is contained primarily within the Hasson Lake watershed which flows southward into the Dog River. The water bodies identified for inclusion in the sampling program are located in the immediate vicinity of the mine site (see Figure 1.2):

- Camp Lake - located to the east and south of the surface facilities which may be used as a source of fresh water for the mill;
- Hasson Lake - located to the south of the surface facilities. It receives runoff from a small volume of tailings deposited in a low-lying area in the lake watershed; and
- two ponds (First Pond and Second Pond) - located on the drainage course between the tailings area and Hasson Lake.

The details of the sampling program and results of the field and laboratory measurements are discussed in the following sections. Copies of the field reports and laboratory analyses are provided in the appendices.

FIGURE 1.1

Study Site Location for Lac des Iles Mine

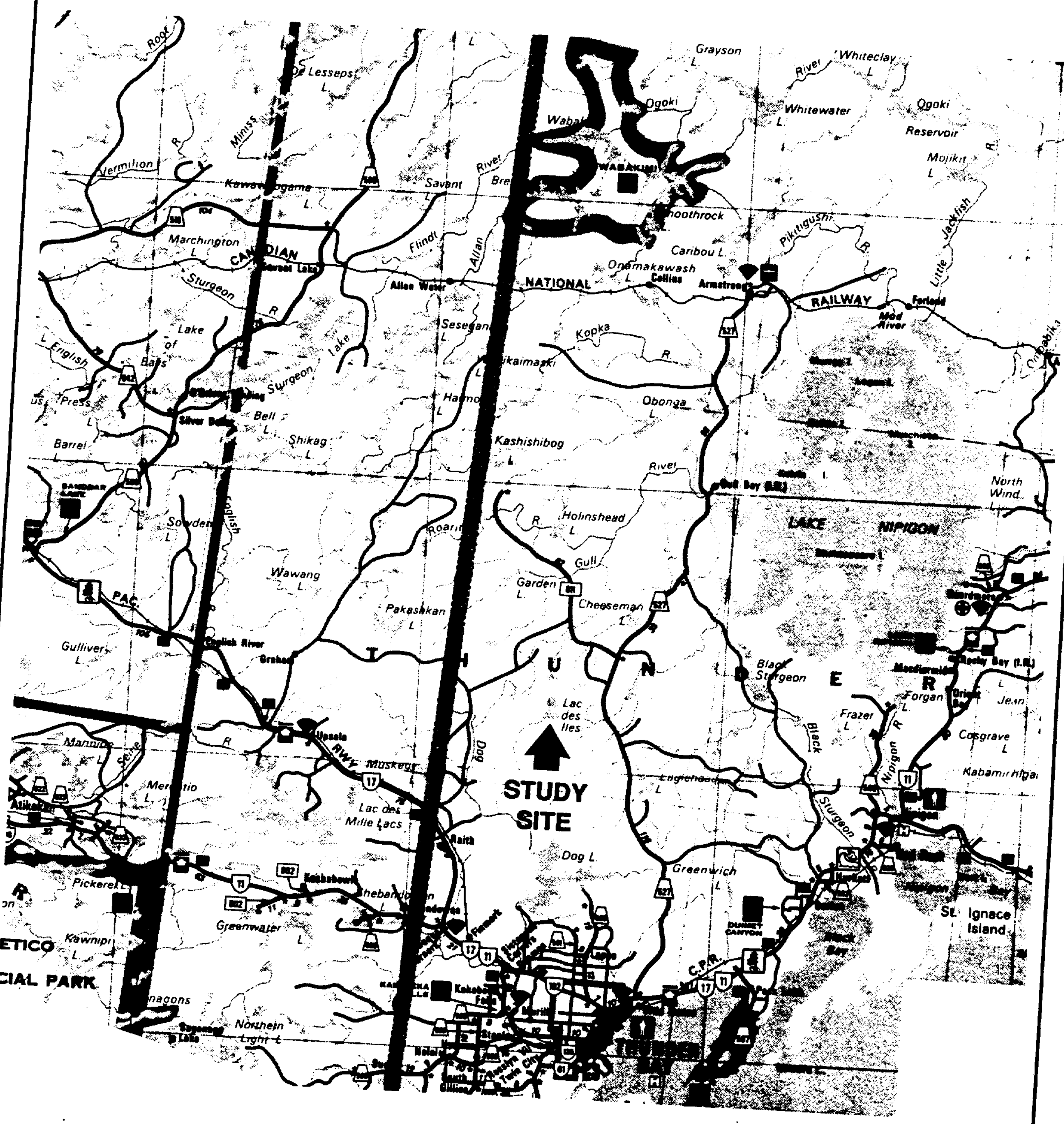
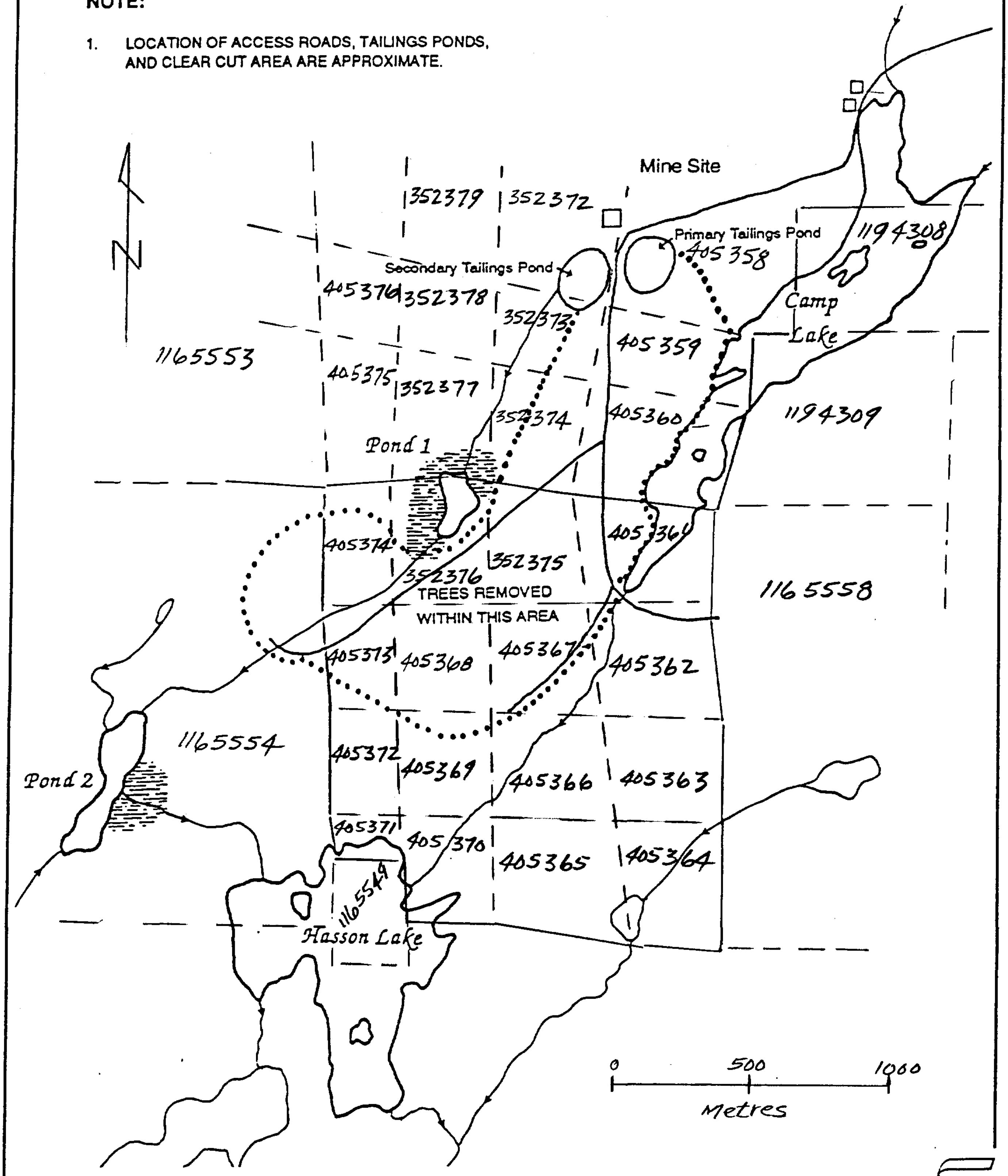


FIGURE 1.2

Study Area at Lac des Iles Mine

NOTE:

1. LOCATION OF ACCESS ROADS, TAILINGS PONDS, AND CLEAR CUT AREA ARE APPROXIMATE.



SOURCE: NIBLETT ENVIRONMENTAL ASSOCIATES INC., 1992

2.0 MONITORING PROGRAM

The baseline monitoring program included measurements of field pH, temperature and dissolved oxygen for each of the water bodies. Lake water samples were collected for chemical analyses during all surveys. Bottom sediment samples were only collected during the March survey. In addition, water samples were obtained from the existing tailings management facility (TMF) for chemical analyses. In each survey, a total of nine (9) surface water samples were collected: two (2) from Camp Lake, three (3) from Hasson Lake, one (1) from each of the two ponds, one (1) from the tailings secondary sedimentation pond and one (1) from the tailings decant pond. Seven (7) sediment samples were collected during the March survey: two (2) from Camp Lake, three (3) from Hasson Lake and one (1) from each of the two ponds. In addition to the above, a water sample was collected from Lac des Iles during the August survey for comparison purposes.

A summary of the program sampling frequencies and locations is provided on Table 2.1. Field dissolved oxygen and temperature measurements were taken over the depth of the water columns at a minimum of two stations on each pond and lake during the March and August surveys and at a single location during the May survey. The locations of the monitoring stations are shown on Figures 2.1 to 2.5.

Bathymetry mapping on Camp Lake indicates that the lake is deepest in the north and mid-lake basins and is quite shallow in the south arm. The sampling stations on Camp Lake were chosen to allow for sampling in the vicinity of the deepest points. Field pH, dissolved oxygen and temperature measurements were also taken at a station in the south basin during the August survey.

No bathymetry mapping was available on Hasson Lake or the two ponds downstream of the TMF at the time of the March 1992 survey. Consequently, Hasson Lake was sampled at three locations to obtain an appreciation of the characteristics of this water body. Only one (1) water sample was taken from each of the ponds for chemical analyses; however, field dissolved oxygen and temperature measurements were performed at two locations as shown on Figure 2.3. Subsequently, during the May field survey, the bathymetry of Hasson Lake and the two ponds

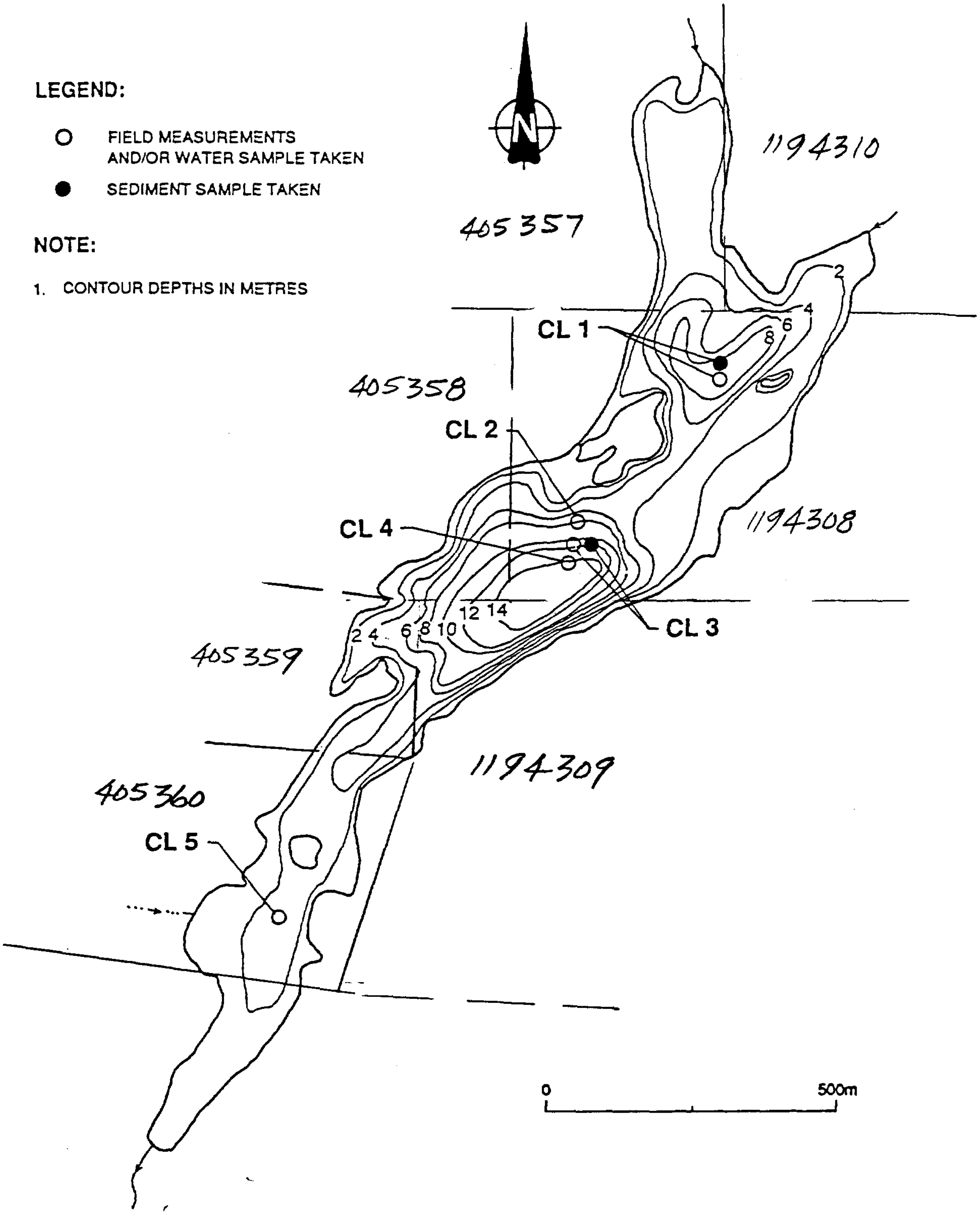
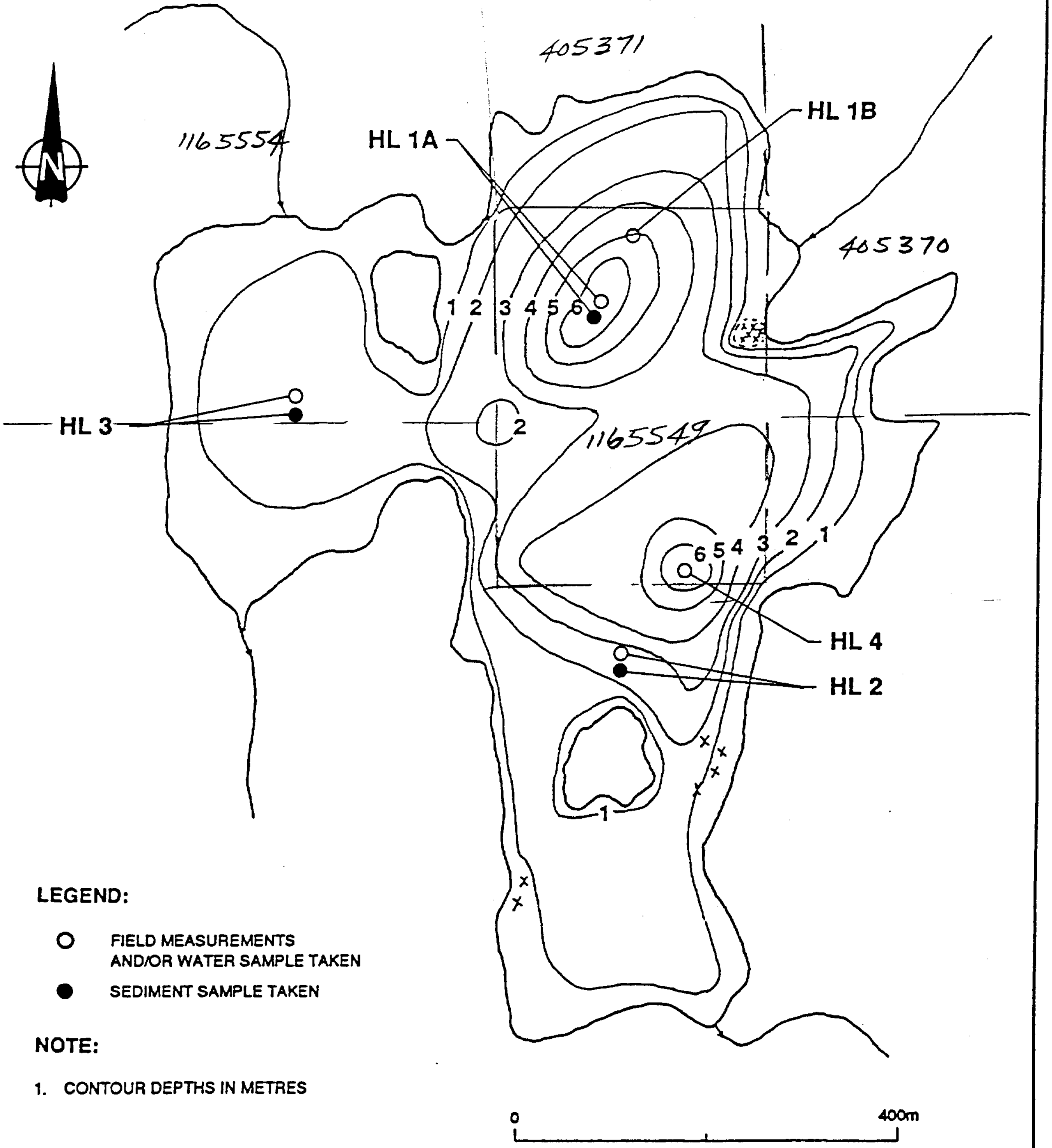


FIGURE 2.1

Camp Lake
Sampling Station Locations

SOURCE: ADAPTED FROM NIBLETT ASSOCIATES INC., 1992



LEGEND:

○ FIELD MEASUREMENTS AND/OR WATER SAMPLE TAKEN

● SEDIMENT SAMPLE TAKEN

NOTE:

1. CONTOUR DEPTHS IN METRES

FIGURE 2.2

Hasson Lake
Sampling Station Locations

SOURCE: ADAPTED FROM NIBLETT ASSOCIATES INC., 1992

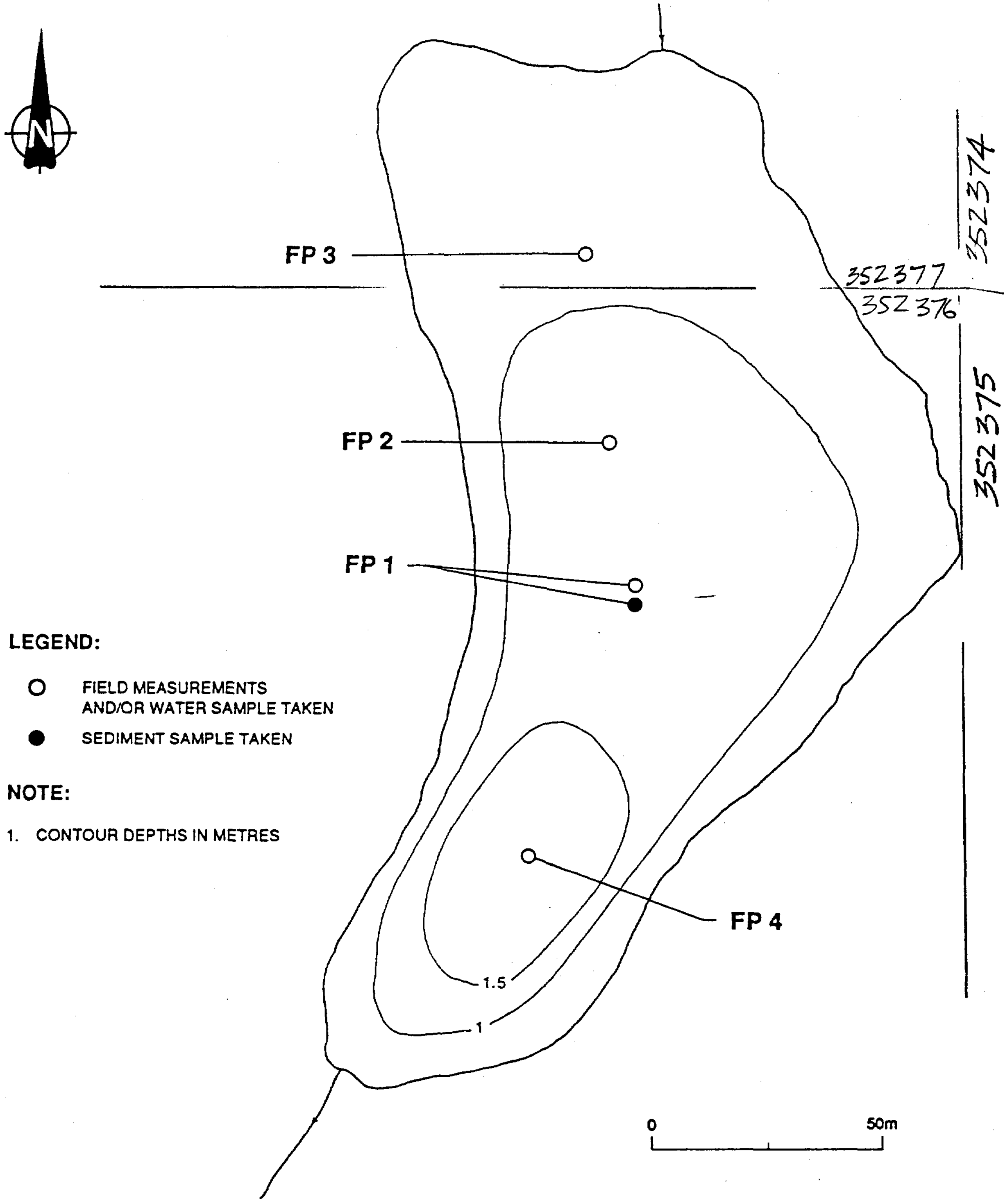
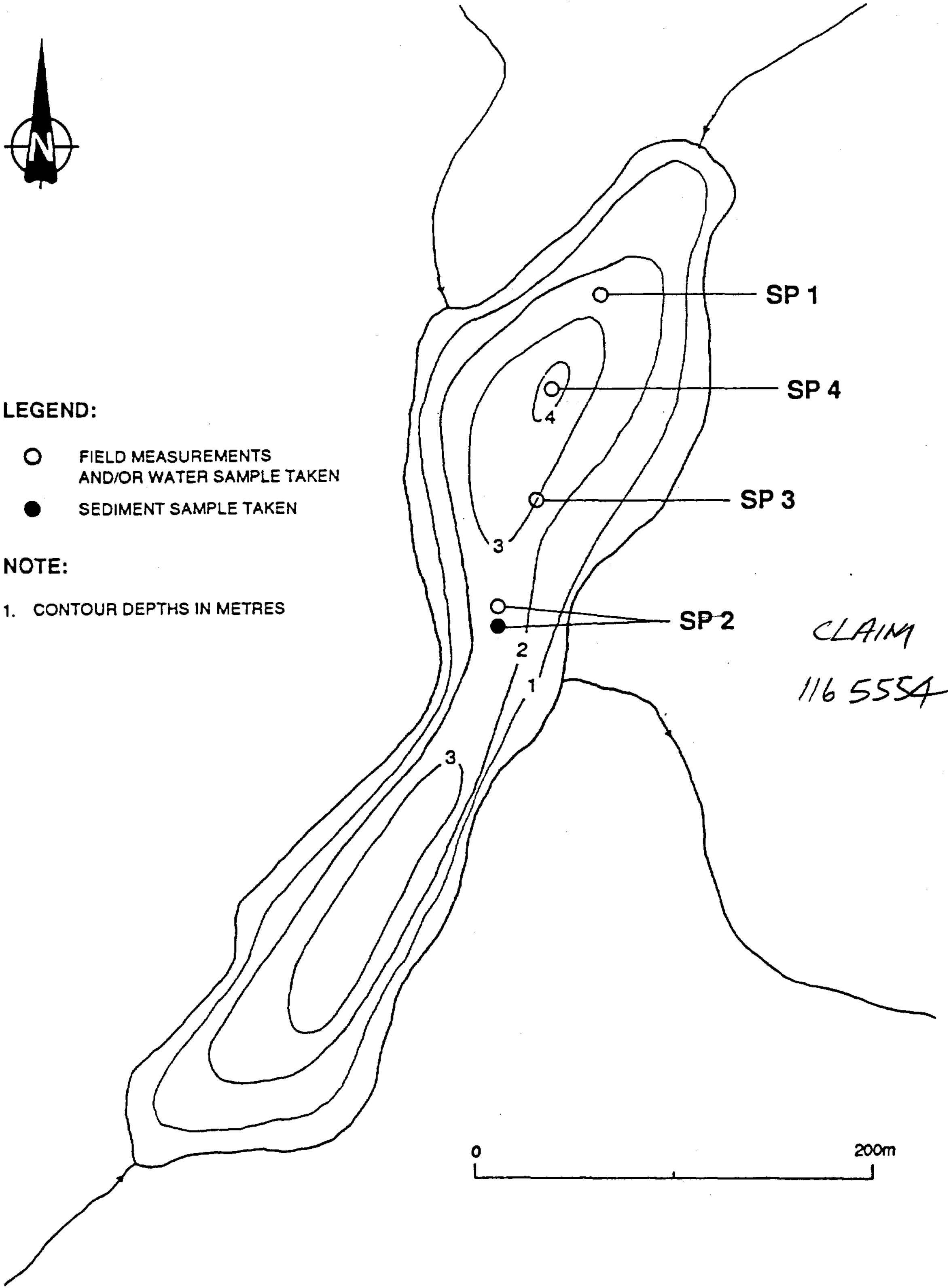


FIGURE 2.3

First Pond
Sampling Station Locations

SOURCE: ADAPTED FROM NIBLETT ASSOCIATES INC., 1992



LEGEND:

○ FIELD MEASUREMENTS AND/OR WATER SAMPLE TAKEN

● SEDIMENT SAMPLE TAKEN

NOTE:

1. CONTOUR DEPTHS IN METRES

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FIGURE 2.4

Second Pond
Sampling Station Locations

SOURCE: ADAPTED FROM NIBLETT ASSOCIATES INC., 1992

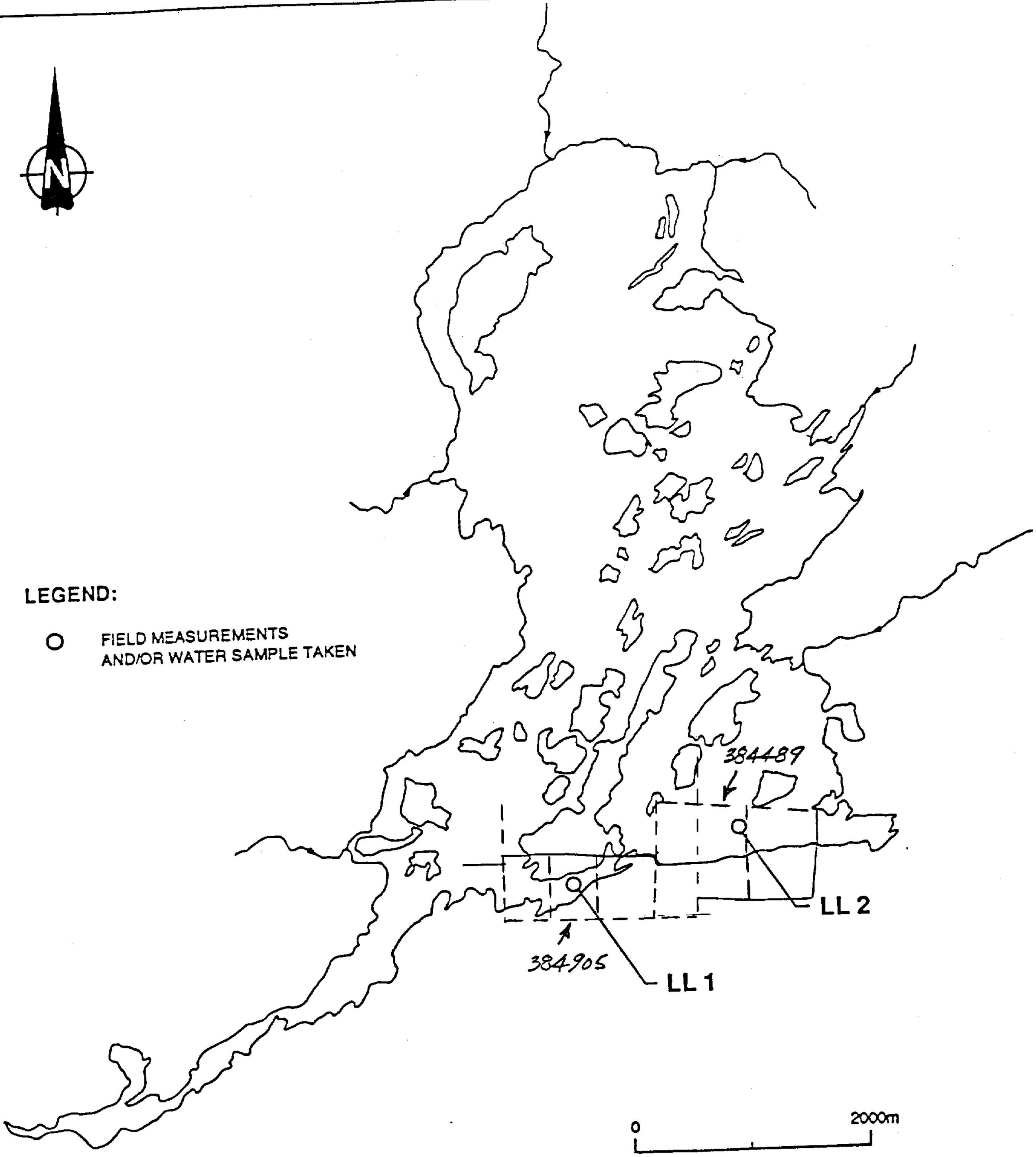

FIGURE 2.5

Lac des Iles
Sampling Station Locations

SOURCE: ADAPTED FROM NIBLETT ASSOCIATES INC., 1992

was determined by Niblett Environmental Associates Inc., (NEA, 1992). The locations of the monitoring stations were adjusted, where appropriate, to include the deepest points in the water bodies.

The water and sediment samples were stored in coolers with ice packs and shipped, via air, to Barringer Laboratories in Mississauga, Ontario, for chemical analyses. The water samples were analyzed for trace metals, major anions and cations and nutrients, as well as for ammonia, total and ortho-phosphorus, dissolved organic carbon (DOC) and colour. The sediment samples were analyzed for metals and loss on ignition (LOI).

The first sampling program was carried out on 4-5 March, 1992 under ideal weather conditions. Access to the water bodies was difficult; however, as the lakes were covered with up to 30 cm of snow and slush. To obtain the water and sediment samples it was necessary to auger through more than a half metre of ice. The second and third programs took place under ideal weather conditions on 29-31 May 1992, and 12-13 August 1992, respectively. The details of the March and August field programs are recorded in Appendices A and B, respectively. The May survey was carried out as part of the biological survey and is documented in the report by NEA (1992).

Table 2.1

WATER AND SEDIMENT SURVEY LOCATIONS AND FREQUENCY

Lake Name	Reference Figure #	Station Number	Period Sampled or Measurements Taken		
			Field Measurements	Water Sample Collected	Sediment Sample Collected
Camp Lake	2.1	CL1	March, August	March, May, August	March
		CL2	March	-	-
		CL3	March	March	March
		CL4	May, August	May, August	-
		CL5	August	-	-
Hasson Lake	2.2	HL1A	March, August	March, May, August	March
		HL1B	March, August	-	-
		HL2	March	March	March
		HL3	March, August	March, May, August	March
		HL4	May, August	May, August	-
First Pond	2.3	FP1	March, August	-	March
		FP2	March	March	-
		FP3	May	May	-
		FP4	August	August	-
Second Pond	2.4	SP1	March	March	-
		SP2	March	-	March
		SP3	May	May	-
		SP4	August	August	-
Lac des Iles	2.5	LL1	August	August	-
		LL2	August	-	-
TMF Decant Pond	-	TMF1	-	March, May, August	-
TMF Secondary Pond	-	TMF2	-	March, May, August	-

3.0 MONITORING RESULTS

3.1 FIELD MEASUREMENTS

3.1.1 March Survey

For the March survey, the water temperature was observed to vary from a low of 0.2°C just below the ice surface to a high of 4.1°C near the bottom of the water column. Temperature profiles were measured generally at 1 m intervals and are recorded on the field note reports included in Appendix A and on Table 3.1.

The dissolved oxygen measurements are summarized on Table 3.1 for each of the water bodies surveyed. For comparison, the solubility of oxygen in water, with a chloride content near zero and a temperature of between 0 to 4°C, ranges from 13.1 mg/L (at 4°C) to 14.6 mg/L (at 0°C). As seen from Table 3.1, the measured dissolved oxygen levels were all less than the solubility limits. This observation is not surprising; however, as the water bodies had been under ice cover for several months at the time of the survey.

At most of the monitoring stations the dissolved oxygen profile showed decreasing concentrations from top to bottom. This is a common observation and reflects the effect of the oxygen demand exerted by bottom sediments which undergo degradation, albeit slowly, even in the winter months.

In Camp Lake, the oxygen concentrations were found to drop below 5 mg/L only in the bottom 2 to 3 m of the water column. The dissolved oxygen level in Camp Lake is considered to be good, considering the survey was carried out late in the winter season, and is acceptable for sustaining aquatic life.

In contrast, the dissolved oxygen level in Hasson Lake was greater than 5 mg/L only in the upper 1 m of the water column. This observation is attributed to the shallowness of the lake at the survey locations. The significance of lake depth is that the shallower the lake, the smaller the volume of water contained in the lake, and hence, the smaller the oxygen source available to satisfy the oxygen demand exerted by the bottom sediments.

The observation made above for Hasson Lake was also very evident in the dissolved oxygen profiles measured on the two ponds south of the existing tailings area. These ponds are very shallow (measured depths of <1.5 m in the first pond and <2.5 m in the second pond) and the dissolved oxygen levels in the water column were found to be quite low. As noted in a subsequent section, the organic content of the sediments in these ponds is high which may explain why the dissolved oxygen levels in the ponds are so low.

The pH values recorded in the field ranged from 6.7 to 7.4 during all surveys and are typical of values usually reported for precambrian shield waters. Camp Lake, First Pond and Second Pond were all found to be very slightly acidic while Hasson Lake was very slightly alkaline.

3.1.2 May Survey

At the time of the lake surveys on 29-31 May 1992, the water temperature in the surface layer on Camp Lake ranged from 14.2 to 14.3 °C whereas the surface temperature in Hasson Lake varied between 16.2 °C and 16.3 °C (see Table 3.2). The difference in the surface water temperatures in these lakes may be attributed to the fact that Camp Lake has a greater volume (1.79×10^6 m^3 in Camp Lake versus 0.86×10^6 m^3 in Hasson Lake) and greater depth (mean depth of 3.9 m in Camp Lake versus 2.1 m in Hasson Lake). As a consequence of these factors, the water temperature in Camp Lake will take longer to react to the sun's energy than Hasson Lake. For the converse reason the water temperatures in First Pond and Second Pond were higher (>18 °C in First Pond and >17.5 °C in Second Pond). The water volume in these ponds have been estimated to be an order of magnitude or more smaller than Hasson Lake and Camp Lake (i.e. volume of First Pond and Second Pond equals 1.6×10^4 m^3 and 9.4×10^4 m^3, respectively).

The temperature data on Table 3.2 for Camp Lake indicate that the water column was thermally stratified at the time of the survey with the thermocline extending from about 3 m to 7 m below

Table 3.1

DISSOLVED OXYGEN AND TEMPERATURE LEVELS OBSERVED DURING MARCH 1992 SURVEY

Depth from Surface (m)	Camp Lake						First Pond South of TMF				Second Pond South of TMF				Hasson Lake					
	North Basin Station CL1		Mid Lake Station CL2		Mid Lake Station CL3		Station FP1		Station FP2		Station SP1		Station SP2		North Basin Station HL1		Mid Lake Station HL2		West Basin Station HL3	
	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)
0.3	-	-	-	-	-	-	1.4	0.2	2.5	0.4	2.2	0.3	1.3	0.2	-	-	9.0	0.2	5.0	0.2
1.0	10.7	0.6	9.5	0.7	10.0	0.7	0.3	1.8	0.4	1.4	4.5	0.8	4.2	1.0	8.9	1.1	7.4	1.3	3.4	0.7
1.5	-	-	-	-	-	-	0.17[a]	2.4	-	-	-	-	-	-	-	-	-	-	2.4	1.1
2.0	9.0	2.1	8.4	2.1	8.4	2.1	-	-	-	-	4.8	2.6	0.2[a]	2.5	5.3	3.3	4.7	3.0	-	-
2.5	-	-	-	-	-	-	-	-	-	-	0.2[a]	2.9	-	-	-	-	3.5	3.6	-	-
3.0	7.5	2.6	7.1	2.6	7.1	2.6	-	-	-	-	-	-	-	-	3.1	3.7	-	-	-	
3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.0	6.7	2.8	6.4	2.8	6.1	2.8	-	-	-	-	-	-	-	-	2.8	3.9	-	-	-	
4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.0	6.2	2.9	6.3	2.9	6.0	2.8	-	-	-	-	-	-	-	-	3.0	3.8	-	-	-	
5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.0	3.4	2.9	0.4[a]	2.9	5.8	2.9	-	-	-	-	-	-	-	-	0.4	4.1	-	-	-	
6.5	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
7.0	2.1	3.0	-	-	5.5	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
7.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.0	0.5	3.3	-	-	5.2	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.0	0.2[a]	3.6	-	-	4.6	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.0	-	-	-	-	4.4	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	
10.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11.0	-	-	-	-	0.2[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
11.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

a) Dissolved oxygen measured in bottom sediment.

Table 3.2

DISSOLVED OXYGEN AND TEMPERATURE LEVELS OBSERVED DURING MAY 1992 SURVEY

Depth from Surface (m)	Camp Lake Mid Lake Station CL4		First Pond South of TMF Station FP3		Second Pond South of TMF Station SP3		Hasson Lake Mid Lake Station HL4	
	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)
Surface	8.56	14.3	9.50	18.4	9.85	17.7	8.45	16.3
0.5	-	-	9.42	18.2	9.60	17.6	-	-
1.0	8.40	14.2	7.00	16.4	9.83	16.4	8.48	16.2
1.5	-	-	2.85	14.4	8.95	13.1	-	-
2.0	8.45	14.2	-	-	8.11	10.9	8.01	13.2
2.5	-	-	-	-	7.65	10.4	-	-
3.0	8.45	13.8	-	-	4.80	8.3	7.53	12.1
3.5	-	-	-	-	1.50	7.7	-	-
4.0	8.05	12.4	-	-	-	-	6.75	10.9
4.5	-	-	-	-	-	-	-	-
5.0	7.56	10.7	-	-	-	-	5.97	10.0
5.5	-	-	-	-	-	-	-	-
6.0	6.75	8.3	-	-	-	-	3.94	8.7
6.5	-	-	-	-	-	-	-	-
7.0	6.48	6.6	-	-	-	-	-	-
7.5	-	-	-	-	-	-	-	-
8.0	6.11	6.1	-	-	-	-	-	-
8.5	-	-	-	-	-	-	-	-
9.0	5.90	5.8	-	-	-	-	-	-
9.5	-	-	-	-	-	-	-	-
10.0	5.27	5.5	-	-	-	-	-	-
10.5	-	-	-	-	-	-	-	-
11.0	4.40	5.2	-	-	-	-	-	-
11.5	-	-	-	-	-	-	-	-
12.0	3.53	5.0	-	-	-	-	-	-
12.5	-	-	-	-	-	-	-	-
13.0	1.30	4.9	-	-	-	-	-	-

the lake surface. The bottom water temperature ranged between 4.9 and 6.6 °C. By contrast, because First Pond, Second Pond and Hasson Lake are all quite shallow, the water temperature was typically higher near the bottom of these water bodies. This observation was even more evident during the August survey discussed below (see Table 3.3).

The dissolved oxygen levels in Camp Lake were found to be more uniform over the column depth in the May survey than during the March survey. This observation suggests that the lake water had turned over during the spring snow melt introducing oxygenated water to the lake bottom. However, the dissolved oxygen level was observed to decrease sharply near the bottom indicating that the bottom sediments were exerting an oxygen demand on the water column.

Dissolved oxygen levels throughout the Camp Lake water column were below saturation levels which are estimated to range between 12.8 mg/L at 5 °C to 10.3 mg/L at 14 °C. A similar observation can be made about the dissolved oxygen levels in Hasson Lake. In the First and Second Ponds; however, the measured surface water dissolved oxygen levels were near saturation (i.e. the solubility of oxygen in water at 18.4 °C equals 9.39 mg/L and at 17.6 °C equals 9.55 mg/L). In all four water bodies, the dissolved oxygen levels were generally satisfactory for the protection of aquatic life. The provincial surface water quality objectives for dissolved oxygen, at a temperature of 15 °C, are >6 mg/L for cold water biota and >5 mg/L for warm water biota. These objectives were met except in the very deepest waters.

The pH values measured in the field during the survey varied between 6.8 and 7.4. The pH range was very close to that observed in March.

3.1.3 August Survey

The results of field measurements of dissolved oxygen and temperature made during the survey on 12-13 August 1992 are summarized on Table 3.3. The field notes from the survey are included as Appendix B.

Surface water temperatures were slightly higher in Camp Lake and Hasson Lake than observed

Table 3.3

DISSOLVED OXYGEN AND TEMPERATURE LEVELS OBSERVED DURING AUGUST 1992 SURVEY

Depth from Surface (m)	Camp Lake						First Pond South of TMF				Second Pond South of TMF	
	North Basin Station CL1		Mid Lake Basin Station CL4		South Basin Station CL5		Station FP1		Station FP4		Station SP4	
	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O (mg/L)	Temp (°C)
Surface	7.80	18.1	7.95	18.3	8.80	18.5	6.47	17.9	6.50	18.2	6.69	16.9
0.5	7.80	17.9	7.98	18.4	8.72	18.5	-	-	-	-	6.65	16.5
1.0	7.80	17.5	8.03	18.2	8.60	18.5	5.61	16.1	4.63	15.4	6.05	16.3
1.5	-	-	-	-	5.10	17.8	4.22	15.7	-	-	-	-
2.0	7.52	17.2	7.85	17.4	-	-	-	-	3.40	15.4	5.60	14.5
2.5	-	-	-	-	-	-	-	-	-	-	-	-
3.0	7.15	16.9	7.70	17.2	-	-	-	-	-	-	0.22	11.8
3.5	-	-	-	-	-	-	-	-	-	-	-	-
4.0	6.40	16.4	3.95	14.9	-	-	-	-	-	-	0.12	10.0
4.5	-	-	-	-	-	-	-	-	-	-	-	-
5.0	3.10	14.7	2.32	12.8	-	-	-	-	-	-	-	-
5.5	-	-	-	-	-	-	-	-	-	-	-	-
6.0	1.79	12.2	1.38	10.7	-	-	-	-	-	-	-	-
6.5	-	-	-	-	-	-	-	-	-	-	-	-
7.0	1.00	10.6	1.76	8.5	-	-	-	-	-	-	-	-
7.5	-	-	-	-	-	-	-	-	-	-	-	-
8.0	0.07	9.6	1.60	7.0	-	-	-	-	-	-	-	-
8.5	-	-	-	-	-	-	-	-	-	-	-	-
9.0	8.5	-	0.70	6.1	-	-	-	-	-	-	-	-
9.5	-	-	-	-	-	-	-	-	-	-	-	-
10.0	-	-	0.06	5.7	-	-	-	-	-	-	-	-
10.5	-	-	-	-	-	-	-	-	-	-	-	-
11.0	-	-	0.02	5.4	-	-	-	-	-	-	-	-
11.5	-	-	-	-	-	-	-	-	-	-	-	-
12.0	-	-	0.02	5.3	-	-	-	-	-	-	-	-
12.5	-	–	–	–	–	–	–	–	–	–	–	–
13.0	-	-	0.02	5.2	-	-	-	-	-	-	-	-

Table 3.3, Cont'd

	Hasson Lake								Lac des Iles			
Depth from Surface (m)	North Basin Station HL1A		North Basin Station HL1B		Mid Lake Basin Station HL4		West Basin Station HL3		Bay Near Lodge Station LL1		Angle Bay Station LL2	
	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)
Surface	7.68	16.8	7.58	16.9	7.66	17.0	7.81	17.1	8.38	18.9	8.43	18.5
0.5	7.68	16.8	7.58	16.9	7.66	17.0	7.83	16.9	-	-	-	-
1.0	7.70	16.8	7.62	16.9	7.66	17.0	7.66	16.7	8.52	18.0	8.47	18.4
1.5	-	-	-	-	-	-	7.10	16.1	-	-	-	-
2.0	7.70	16.8	7.62	16.9	7.32	16.9	-	-	8.50	17.6	8.47	18.1
2.5	-	-	-	-	-	-	-	-	-	-	-	-
3.0	7.26	16.5	7.16	16.5	7.27	16.8	-	-	8.08	15.5	8.37	17.3
3.5	5.87	15.7	5.82	15.7	7.16	-	-	-	-	-	-	-
4.0	0.55	13.7	0.62	13.6	5.64	16.7	-	-	5.00	11.2	8.00	17.2
4.5	0.09	12.2	0.13	11.9	0.82	-	-	-	-	-	-	-
5.0	-	-	0.09	11.0	0.10	15.8	-	-	0.24	9.0	7.75	17.0
5.5	-	-	-	-	0.07	-	-	-	-	-	-	-
6.0	-	-	-	-	0.05	14.1	-	-	0.13	8.7	7.75	16.7
6.5	-	-	-	-	-	-	-	-	-	-	-	-
7.0	-	-	-	-	-	12.8	-	-	-	-	5.56	14.1
7.5	-	-	-	-	-	-	-	-	-	-	-	-
8.0	-	-	-	-	-	12.0	-	-	-	-	2.40	11.0
8.5	-	-	-	-	-	-	-	-	-	-	-	-
9.0	-	-	-	-	-	11.9	-	-	-	-	-	-
9.5	-	-	-	-	-	-	-	-	-	-	-	-
10.0	-	-	-	-	-	-	-	-	-	-	-	-
10.5	-	-	-	-	-	-	-	-	-	-	-	-
11.0	-	-	-	-	-	-	-	-	-	-	-	-
11.5	-	-	-	-	-	-	-	-	-	-	-	-
12.0	-	-	-	-	-	-	-	-	-	-	-	-
12.5	-	-	-	-	-	-	-	-	-	-	-	-
13.0	-	-	-	-	-	-	-	-	-	-	-	-

in late May. The temperature in the top 1 m of the water columns ranged from 17.5 to 18.5 °C in Camp Lake (surveyed in the late afternoon) to 16.7 to 17.1 °C in Hasson Lake (surveyed in the early morning). The water temperature in First and Second Ponds fell within the range of values recorded in Camp Lake and Hasson Lake.

The bottom waters of Camp Lake, below about 5 m, were found to be essentially devoid of oxygen. This finding is similar to that noted in March and unquestionably reflects the oxygen demand of the naturally high organic sediments found in all water bodies (discussed further in Section 3.3). The dissolved oxygen level is the water columns of Hasson Lake and the two ponds were found to drop below 5 mg/L only in the immediate vicinity of the bottom sediments as none of these water bodies stratify due to these shallow depths.

For comparison purposes, dissolved oxygen and temperature measurements were performed at two locations in Lac des Iles which is a huge water body compared to those discussed above. Interestingly, the depth of Lac des Iles at the two monitoring stations was less than the deepest parts of Camp Lake. The water temperature and dissolved oxygen profiles in Lac des Iles were found to be very similar to those observed in Camp Lake. Lac des Iles generally had a slightly higher dissolved oxygen level than found in Camp Lake. As observed in Camp Lake, the dissolved oxygen level dropped below 5 mg/L in the bottom water.

The measured dissolved oxygen levels in all water bodies were below saturation levels, which for temperatures of 18 to 19 °C, varies between 9.28 and 9.47 mg/L. This observation suggests that none of the water bodies are highly productive (i.e. phytoplankton levels are presumably fairly low).

The pH values measured in the field were generally found to be marginally lower than observed in the earlier surveys and varied from 6.22 on Camp Lake to 6.64 on Hasson Lake. The pH level measured on Lac des Iles was somewhat higher at 7.35. This observation is not surprising as the waters of Camp Lake, Hasson Lake and the two ponds had a much browner colour and, by inference, a higher organic acid content than Lac des Iles.

3.2 SURFACE WATER CHEMICAL QUALITY

The analytical results for key constituents in the surface water and tailings water samples are summarized in Tables 3.4 and 3.5, respectively. The complete data sets are presented in Appendix C. In general, the data for Camp Lake, Hasson Lake and the two ponds downstream of the existing tailings basin indicate that the concentrations of many of the trace metals (not shown) were quite low and generally less than the detection limits of the analytical techniques (i.e. silver, boron, barium, beryllium, cobalt, chromium, molybdenum, nickel, lead, strontium, titanium, vanadium and zinc). The concentrations (not shown) of the major cations (i.e. calcium, potassium, magnesium, sodium and silica) and anions (i.e. chloride, carbonate, bicarbonate and sulphate) were also low.

The theoretical total dissolved solids level in the surface water samples were calculated to vary between 25 and 41 mg/L, with the exception of the first pond values (96 mg/L in March, 53 mg/L in May and 58 mg/L in August), which apparently reflect the influence of the discharge from the existing tailings basin. The generally low concentrations of the major and trace elements is typical of many precambrian shield waters.

The alkalinity of Camp Lake and Hasson Lake waters varied between 14.9 and 21.2 mg/L $CaCO_3$ and between 14.1 to 26.6 mg/L $CaCO_3$, respectively, over the three surveys. The alkalinity of the Lac des Iles sample taken in August measured 22.6 mg/L $CaCO_3$. The limited buffering capacity of these waters is typical of surface runoff on much of the precambrian shield. The average alkalinity of the water samples taken from the first pond below the TMF (i.e. between 34.6 and 64.9 mg/L $CaCO_3$) is higher than observed in the other water bodies and apparently reflects the influence of the tailings discharge water which had an alkalinity of between 89 mg/L $CaCO_3$ and 250 mg/L $CaCO_3$ during the survey period (see Table 3.5). The alkalinity of the Second Pond was similar to that observed in Camp Lake and Hasson Lake, and apparently, was not measurably affected by the outflow from the First Pond.

The lake and pond water samples had a distinctive dark brown colour typical of waters affected by the by-products of organic matter decay. These waters have various descriptors: "swamp water", "humus water" or "coloured water". The observed range of the colour readings, between 108 TCU on Hasson Lake North Basin during the August survey and 379 TCU on First Pond during the March survey, are characteristic of waters with a high organic acid content. The sample taken during August from Lac des Iles had a colour of 49 TCU which concurs with the visual observation that the sample had a light yellowish appearance compared to the other samples which had a light to dark yellowish brown appearance. Because Lac des Iles is vastly larger than the other water bodies, this finding was expected.

The presence of organic matter in the Lac Des Iles area waters is also confirmed by the dissolved organic carbon (DOC) measurements. The measured levels generally range from 14.3 mg/L to 29.0 mg/L, with the exception of an unusually low value of 4.9 mg/L measured in March for the First Pond. Typical concentrations of organic carbon in surface waters are reported by the Canadian Council of Ministers of the Environment (CCME, 1987) to range from 1 to 3 mg/L in pristine streams, 2 to 10 mg/L in rivers and lakes, and 10 to 60 mg/L in swamps, marshes and bogs. Comparing the measured levels to the classification range quoted above, the water quality in Camp Lake, Hasson Lake, Lac des Iles and the two ponds would fall into the latter group.

The presence of organic acids can dramatically increase the solubility of metals as most metals form complexes with humic substances in water (CCME, 1987). At low pH, those metals which complex with fulvic acid, in order of decreasing stability, are reported to be: iron (III); aluminum (III); copper (II); nickel (II); cobalt (II); lead (II); calcium (II); zinc (II); cadmium (II); iron (II); manganese (II); and magnesium (II).

This factor would explain the elevated iron levels reported in Table 3.4 which varied from a low of 0.29 mg/L to a high of 1.46 mg/L in Hasson Lake and from a low of 0.31 mg/L to a high of 0.52 mg/L in Camp Lake. The unusually high levels of iron recorded in the two ponds and in the west bay of Hasson Lake during the March survey were not repeated in the May or August surveys. However, the measured iron levels consistently exceed the provincial surface water quality objective of 0.30 mg/L for protection of aquatic life (MOE, 1984).

The presence of organic acids may have also influenced the observed levels of aluminum which were generally marginally greater than the provincial objective for total aluminum of 0.075 mg/L for protection of aquatic life in fresh waters with pH $\geq$ 6.5 and $\leq$ 9.0. The only sample with an aluminum level below the guideline was taken from Lac des Iles.

The copper levels measured on samples taken during the March survey from Camp Lake and First Pond were found to be slightly above the provincial objective of 0.005 mg/L for protection of aquatic life (MOE, 1984). However, the copper levels measured on all samples collected during the May and August surveys were found to be consistently below the objective.

The measured concentrations of the nutrients (i.e. nitrogen and phosphorus compounds) were generally found to be present in fairly low concentrations. The total phosphorus levels measured in Camp Lake and Hasson Lake were generally less than the guideline of 0.020 mg/L to protect against nuisance aquatic plant growth in lake systems. The total phosphorus levels measured in the First Pond (0.080, 0.033 and 0.027 mg/L in March, May and August, respectively) were higher than the guideline, but were still considerably lower than the levels reported on Table 3.5 for the tailings pond water during each survey. The ammonia-nitrogen concentrations were found to be elevated for most samples during the March survey, but were still well below the surface water quality objective. In contrast to the March survey, the May tailings pond water samples did not contain elevated ammonia-nitrogen levels, although it was elevated in the tailings secondary pond at the time of the August survey. None of the measured ammonia and nitrogen levels posed an environmental concern.

In summary, the waters of Camp Lake, Hasson Lake and the ponds downstream of the TMF are typically characterized by strong, dark brown colour indicative of the presence of humic acids. As a consequence, the waters also contain elevated levels of aluminum, copper and iron, as these metals tend to most readily form organic metal complexes. The waters have a neutral pH and modest buffering capacity against pH change.

3.3 SEDIMENT CHEMICAL QUALITY

The sediment samples were analyzed for 24 metals and percent loss on ignition (LOI). The

Table 3.4

CHEMICAL QUALITY OF SURFACE WATER SAMPLES

	Aluminum (Al) (mg/L)	Copper (Cu) (mg/L)	Iron (Fe) (mg/L)	Nitrite (NO_2-N) (mg/L)	Nitrate (NO_3-N) (mg/L)	Alkalinity 4.2 (mg $CaCO_3$/L)	Ammonia Nitrogen (NH_3-N) (mg/L)	Ortho-Phosphorus (mg/L)	Total Phosphorus (mg/L)	Dissolved Organic Carbon (mg/L)	Theoretical Tot. Diss. Solids (mg/L)	Colour (TCU)
Provincial Water Quality Objective or Guideline[a]	0.075	0.005	0.30				1.67[b]		0.020			
Camp Lake North Basin												
• March 1992	0.08	0.009	0.47	<0.02	0.15	21.2	0.02	<0.01	0.011	18.9	33	130.
• May 1992	0.09	<0.002	0.31	<0.02	0.16	14.9	0.05	<0.02	0.011	15.5	29	124
• August 1992	0.10	0.003	0.35	<0.020	0.05	16.6	<0.02	0.004	0.019	15.3	28	139
Camp Lake Mid Lake												
• March 1992	0.10	0.006	0.52	<0.02	0.16	21.3	<0.02	<0.01	0.011	15.6	34	130.
• May 1992	0.10	<0.002	0.36	<0.02	0.18	15.4	<0.02	<0.02	0.016	14.3	28	130
• August 1992	0.11	0.003	0.43	<0.020	0.07	16.4	<0.02	0.004	0.016	15.3	28	131
First Pond South of TMF												
• March 1992	0.32	0.007	1.27	<0.02	0.06	64.9	0.18	<0.01	0.080	4.9	96	379.
• May 1992	0.11	0.003	0.22	<0.02	<0.02	34.6	<0.02	<0.02	0.033	22.0	53	216
• August 1992	0.15	0.002	0.68	<0.020	0.03	40.6	0.04	0.008	0.027	29.0	58	275
Second Pond South of TMF												
• March 1992	0.24	0.004	6.51	<0.02	0.07	22.9	0.18	<0.01	0.060	17.2	33	210.
• May 1992	0.15	<0.002	0.25	<0.02	0.05	14.3	<0.02	<0.02	0.016	17.8	25	128
• August 1992	0.15	0.002	0.55	<0.020	<0.02	20.2	0.05	0.016	0.022	23.0	31	230
Hasson Lake North Basin												
• March 1992	0.12	0.003	0.56	<0.02	0.20	20.3	0.02	<0.01	0.012	18.8	33	135.
• May 1992	0.10	<0.002	0.30	<0.02	0.15	14.8	<0.02	<0.02	0.008	14.1	27	128
• August 1992	0.10	0.003	0.38	<0.020	<0.02	16.2	<0.02	0.004	0.014	15.1	26	108
Hasson Lake West Bay												
• March 1992	0.20	0.002	1.46	<0.02	0.10	26.6	0.11	<0.01	0.022	15.5	41	227.
• May 1992	0.10	<0.002	0.29	<0.02	0.12	14.5	<0.02	<0.02	0.013	14.4	26	136
• August 1992	0.11	0.002	0.40	<0.020	<0.02	16.4	<0.02	0.004	0.014	16.5	27	140
Hasson Lake Mid Lake												
• March 1992	0.11	0.003	0.51	<0.02	0.19	20.3	<0.02	<0.01	0.012	18.7	32	139.
• May 1992	0.11	<0.002	0.34	<0.02	0.16	14.1	<0.02	<0.02	0.011	14.4	26	138
• August 1992	0.10	0.002	0.39	<0.020	<0.02	15.8	<0.02	0.008	0.015	15.1	26	125
Lac des Iles Bay near Lodge												
• August 1992	<0.05	0.002	0.10	<0.020	<0.02	22.6	<0.02	<0.002	0.017	15.3	33	49

Notes:
a) Provincial Water Quality Objectives for Protection of Aquatic Life and Recreation (MOE, 1984 and 1991).
b) Ammonia nitrogen objective given applies at a pH of 7.5 and temperature of 20°C and is based on an un-ionized ammonia objective of 0.02 mg/L.

Table 3.5

CHEMICAL QUALITY OF TMF WATER SAMPLES

	Aluminum (Al) (mg/L)	Copper (Cu) (mg/L)	Iron (Fe) (mg/L)	Nitrite (NO_2-N) (mg/L)	Nitrate (NO_3-N) (mg/L)	Alkalinity 4.2 (mg $CaCO_3$/L)	Ammonia Nitrogen (NH_3-N) (mg/L)	Ortho-Phosphorus (mg/L)	Total Phosphorus (mg/L)	Dissolved Organic Carbon (mg/L)	Theoretical Tot. Diss. Solids (mg/L)	Colour (TCU)
Provincial Water Quality Objective or Guideline[a]	0.075	0.005	0.30	-	-	-	1.67[b]	-	0.020	-	-	-
Tailings Decant Water												
• March 1992	0.57	0.015	4.75	<0.02	<0.02	309.	2.60	0.05	0.240	28.0	401	285
• May 1992	0.73	0.037	0.93	<0.02	<0.02	83.8	<0.02	<0.02	0.059	15.8	124	120
• August 1992	0.67	0.025	1.34	<0.020	<0.02	135.	<0.02	0.006	0.044	21.4	181	132
Tailings Secondary Pond												
• March 1992	0.47	0.014	6.57	<0.02	<0.02	250.	1.91	0.06	0.290	16.3	335	352
• May 1992	0.10	0.013	1.00	<0.02	<0.02	88.8	<0.02	<0.02	0.088	18.2	127	126
• August 1992	0.13	0.006	4.03	<0.020	<0.02	125.	0.80	0.036	0.124	57.0	167	270

<u>Notes:</u>

a) Provincial Water Quality Objectives for Protection of Aquatic Life and Recreation (MOE, 1984 and 1991).

b) Ammonia nitrogen objective given applies at a pH of 7.5 and temperature of 20°C and is based on an un-ionized ammonia objective of 0.02 mg/L.

results of the analyses for key constituents are summarized in Table 3.6. Full analytical results are given in Appendix C. In addition, typical background levels of several of the metals in sediments from the Great Lakes are included in the table for comparison purposes.

The three sediment samples collected from Camp Lake are seen to have a very consistent quality. The duplicate samples taken from the north basin of Camp Lake (denoted North Basin #1 and North Basin #2) showed essentially no difference in most of the parameters measured (i.e. the levels fall within the expected range of natural variability). The measured levels of several of the metals (i.e. cadmium, chromium, manganese, nickel, lead and zinc) are characteristic of the reported typical background levels. The measured iron levels were approximately one-half the typical value reported on Great Lakes sediment. In contrast, the copper levels were more than twice the background values. This observation is not surprising as Camp Lake is located in an area of mineralization. The organic content of the sediments in Camp Lake is high. This is reflected by the loss on ignition measurements which ranged from 29.1% to 35.8%. This finding is consistent with expectations based on visual observations (see Field Notes in Appendix A).

The sediment sample taken from the north basin of Hasson Lake is seen to have very similar characteristics to the sediment in Camp Lake. However, the sediment samples from the west basin and mid lake basin station on Hasson Lake had quite different chemical characteristics. These sediment samples were found to have a much higher silt content and corresponding lower organic content (i.e. low LOI values). Accordingly, the metals content of these samples differed from the north basin sample and the Camp Lake samples.

The sediments in the two ponds downstream of the TMF are seen from Table 3.6 to have a high organic content (i.e. high LOI), similar to that measured on the sediments from Camp Lake. The metals content of the sediment from the Second Pond is also comparable to the metal levels found in Camp Lake. Interestingly, the metal levels measured in the sediment sample from the First Pond are generally lower than the levels found in the sediments from the Second Pond, the north basin of Hasson Lake and Camp Lake. It is possible that the sediment quality has been altered by tailings deposition in the watershed, although this is strictly speculation.

Table 3.6

CHEMICAL QUALITY OF SEDIMENTS SAMPLED DURING MARCH 1992 SURVEY

(units are in µg/g dry weight except for LOI in percent)

Analyte	Typical Background Levels[a]	Camp Lake North Basin #1	Camp Lake North Basin #2	Camp Lake Mid Lake	First Pond South of TMF	Second Pond South of TMF	Hasson Lake North Basin	Hasson Lake Mid Lake	Hasson Lake West Basin
Aluminum (Al)	-	15700	16700	17100	5400	14300	13400	10200	6920
Cadmium (Cd)	1.1	0.9	0.7	0.8	1.3	0.7	0.8	<0.3	<0.3
Chromium (Cr)	31	23.2	26.1	24.5	13.8	22.6	22.8	13.9	11.5
Copper (Cu)	25	63.6	67.4	61.5	36.0	50.9	56.9	11.2	10.9
Iron (Fe)	31200.	12600.	12300.	19700.	4150.	21100.	13400.	17600.	9380.
Manganese (Mn)	400.	233.	240.	410.	102.	146.	179.	226.	112.
Nickel (Ni)	31	23	24	30	23	31	22	17	15
Phosphorus (P)	-	1230	1320	1360	510	700	950	440	320
Lead (Pb)	23	21	16	20	7	9	32	3	6
Zinc (Zn)	65	64.7	53.2	86.3	29.0	87.4	74.7	57.6	53.4
LOI	-	34.8	35.8	29.1	34.5	36.7	35.8	4.30	7.17

<u>Note:</u>

a) Typical background levels for metals are based on analyses of Great Lakes pre-colonial sediment horizon (MOE, 1991a).

In summary, the sediments from the lakes and ponds sampled in this initial survey were found to have typical sediment quality characteristics, in most respects. Several of the sediment samples had a high organic carbon content and an elevated copper level. These attributes are indicative of the effects of local forestation and mineralization.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The results of three surveys of surface water and sediment quality in the vicinity of the Lac des Iles mine site are presented in this report. The water bodies sampled included Camp Lake, Hasson Lake and two ponds downstream of the existing TMFs; those which are most apt to be impacted by the mining activities and the proposed tailings management facility. In addition, benthic sampling, fish netting and habitat investigations were carried out on these water bodies. The results of these investigations are discussed in a separate report (NEA, 1992).

The results of the surface water monitoring program indicate that the waters of Camp Lake, Hasson Lake and the two ponds are characterized by strong, dark brown colour indicative of the presence of humic acids. As a consequence, the waters also contain elevated levels of aluminum and iron, as these metals tend to most readily form organic complexes. The surface waters have a neutral pH and modest buffering capacity against pH change. The dissolved oxygen level in the lakes and ponds showed evidence of stress due to the oxygen demand exerted by the sediments. All four water bodies had naturally low dissolved oxygen levels throughout the depth of the water columns after several months of ice cover. Also, the bottom waters of Camp Lake, which stratifies during the summer months, were found to contain low dissolved oxygen levels. The dissolved oxygen levels in the upper portion of all the water bodies surveyed were found to be acceptable to sustain aquatic life.

The sediments from the lakes and ponds sampled in the March survey were found to have typical sediment quality characteristics in most respects. Several of the sediment samples had a high organic carbon content and an elevated copper level. These attributes are indicative of the effects of local forestation and mineralization.

In conclusion, the data presented in this report and the biological survey report prepared by NEA (1992), provide a baseline against which the potential impact of the proposed mining operation at the Lac des Iles site can be assessed and future change can be measured. If it is intended to proceed with the project, then it is recommended that each of the water bodies be monitored quarterly to augment the existing database. The monitoring program should include measurements of field pH, dissolved oxygen and temperature and the collection of water samples for analyses of those parameters included in the program discussed in this report. An additional set of sediment samples should be collected for measurements and organic carbon analyses. These recommendations do not consider the requirements for effluent monitoring, nor for additional sampling which may be required downstream of the point of effluent discharge.

5.0 REFERENCES

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APPENDIX A

FIELD NOTES - 4-5 MARCH 1992

APPENDIX A: FIELD NOTES: LAC DES ILES MINE SITE BASELINE MONITORING SURVEY 4 AND 5 MARCH 1992

Program Scope

Mr. Bruce E. Halbert of SENES Consultants Limited travelled to the Lac Des Iles Mine Site approximately 90 km north of Thunder Bay to collect water and sediment samples from ponds and lakes in the vicinity of the existing mine facilities. The purpose of the program was to establish baseline conditions under winter conditions. The program included the collection of water and sediment samples for chemical analyses and measurement of field pH, temperature and dissolved oxygen. The program was carried out on 4 and 5 March 1992 and included sampling of:

- Camp Lake to the south east of the mine camp facilities as this lake may be used as a source of process water;
- Hasson Lake to the south of the mine site as this lake may receive the effluent from the proposed tailings management facility (TMF);
- two ponds downstream of the proposed TMF; and,
- pond water in the area which currently contains tailings from past operations.

Field Conditions

Weather conditions at the time of sample collection were excellent with the temperature ranging from about -5°C to +5°C.

Working conditions on the lakes were difficult as they were covered with approximately 15 cm of snow, underlain with several centimetres of slush and 60 cm or more of solid ice. The conditions were unsuitable for use of a snowmobile thus all equipment had to be back-packed out to the sampling station locations. The General Manager for the mine, Mr. Glen Clark, kindly assisted with the field program and provided the services of mine workers to haul the field equipment onto and off of the lakes and to cut the access holes through the ice.

Field Measurements

In situ measurements of water temperature and dissolved oxygen were made using a YSI Model 58 dissolved oxygen meter equipped with a 50 m probe extension. Measurements were made generally at 1 m intervals over the depth of the water column by lowering the probe progressively downward from the top to the bottom. The meter was calibrated at each station location using a sample of lake water by partially filling a sample bottle and shaking the bottle for several minutes to saturate the water with dissolved oxygen.

Field pH measurements were made using a Solinat pen pH meter. The pH of the surface water was recorded at each site.

The results of the field program are recorded on the "Lake Survey Field Notes" forms attached to this report.

Sample Collection

Water samples were collected from the pond and lake monitoring stations using a Kemmerer acrylic water sampler. At the shallow monitoring stations (generally < 3 m deep) the water samples were taken approximately 1 m below the surface. At the deep monitoring stations (generally > 6 m), water samples were taken from the top meter, mid-depth and bottom meter and composited to obtain one sample for chemical analyses. At the intermediate depth stations (generally between 2 and 6 m deep), a composite water sample was obtained for submission to the laboratory by compositing samples taken from the top and bottom waters.

One litre samples were taken from each station and stored in a cooler with ice packs to keep the samples cold. The samples were not filtered in the field and no preservatives were added. The samples were shipped by air to Barringer Laboratories in Mississauga for chemical analyses.

Sediment samples were taken with a Wildco Instrument 6 inch scoop (dredge) sampler. In general, the top 5 cm of the bottom sediments were removed and placed in glass jars for shipment to the laboratory for chemical analyses. These samples were also packed in the cooler to keep them cold and shipped overnight by air to the laboratory.

Observations made in the field about the characteristics of the sediments are summarized on the "Lake Survey Field Notes" forms attached hereto. In general, the sediment samples were found to have a high consistency, a dark brown, mucky appearance and a uniform texture. Most of the samples appeared to have a high organic content and were generally odorous.

APPENDIX C

SURFACE WATER CHEMICAL QUALITY DATA SETS

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Attn: Ms. Trudi Collins
Project:
PO #:
Received: 6-Mar-92 11:25

Job: 924617
Status: Final

Sediment Samples

Sample Id	Ag ICAP ppm	Al ICAP ppm	Ba ICAP ppm	Be ICAP ppm	Ca ICAP ppm	Cd ICAP ppm	Co ICAP ppm
FIRST POND SOUTH OF TMA SEDIMENT	<0.2	5400	32.5	0.13	5630	1.3	2
SECOND POND SOUTH OF TMA SEDIMENT	<0.2	14300	117.	0.61	11800	0.7	13
HASSON LAKE NORTH SEDIMENT	<0.2	13400	62.5	0.39	5310	0.8	6
HASSON MID LAKE SEDIMENT	<0.2	10200	24.4	0.37	5020	<0.3	8
HASSON LAKE WEST SEDIMENT	<0.2	6920	25.4	0.19	3810	<0.3	5
CAMP LAKE NORTH #1 SEDIMENT	<0.2	15700	72.6	0.39	6150	0.9	5
CAMP LAKE NORTH #2 SEDIMENT	<0.2	16700	75.1	0.40	6710	0.7	4
CAMP LAKE MID STATION SEDIMENT	<0.2	17100	71.1	0.48	5230	0.8	12
Blank	<0.2	<10	<0.3	<0.02	<20	<0.3	<2
QC Standard (actual)	1.1	17100	149.	0.68	5820	0.5	28
QC Standard (expected)	1.5	16500	149.	0.73	5920	0.5	26
Repeat FIRST POND	<0.2	5320	32.6	0.13	5460	2.4	2

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Sediment Samples

Sample Id	Na ICAP ppm	Ni ICAP ppm	P ICAP ppm	Pb ICAP ppm	Sr ICAP ppm	Th ICAP ppm	Ti ICAP ppm
FIRST POND SOUTH OF TMA SEDIMENT	570	23	510	7	12.7	<2	82.1
SECOND POND SOUTH OF TMA SEDIMENT	300	31	700	9	21.2	6	361.
HASSON LAKE NORTH SEDIMENT	110	22	950	32	14.1	3	139.
HASSON MID LAKE SEDIMENT	940	17	440	3	14.6	4	486.
HASSON LAKE WEST SEDIMENT	520	15	320	6	10.7	3	436.
CAMP LAKE NORTH #1 SEDIMENT	340	23	1230	21	16.9	4	169.
CAMP LAKE NORTH #2 SEDIMENT	300	24	1320	16	17.8	4	199.
CAMP LAKE MID STATION SEDIMENT	260	30	1360	20	14.7	4	216.
Blank	<20	<2	<20	<2	<0.3	<2	<0.3
QC Standard (actual)	360	41	810	22	28.7	10	727.
QC Standard (expected)	350	39	700	23	26.8	11	732.
Repeat FIRST POND	580	24	500	7	12.8	2	78.0

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Status: Final

Sediment Samples

Sample Id	V ICAP ppm	Zn ICAP ppm	Zr ICAP ppm	LOI Grav. %
FIRST POND SOUTH OF TMA SEDIMENT	9.8	29.0	<2	34.5
SECOND POND SOUTH OF TMA SEDIMENT	105.	87.4	9	36.7
HASSON LAKE NORTH SEDIMENT	54.4	74.7	4	35.8
HASSON MID LAKE SEDIMENT	75.1	57.6	3	4.30
HASSON LAKE WEST SEDIMENT	38.4	53.4	2	7.17
CAMP LAKE NORTH #1 SEDIMENT	49.9	64.7	5	34.8
CAMP LAKE NORTH #2 SEDIMENT	51.7	53.2	5	35.8
CAMP LAKE MID STATION SEDIMENT	65.0	86.3	6	29.1
Blank	<0.3	<0.5	<2	<0.01
QC Standard (actual)	43.1	123.	11	8.92
QC Standard (expected)	43.8	112.	13	9.13
Repeat FIRST POND	9.8	29.2	<2	36.2

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Project:
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Status: Final

Water Samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.005	0.08	<0.010	<0.005	<0.0005	5.27	<0.005
#2-CAMP LAKE MID LAKE COMPOSITE	<0.005	0.10	<0.010	<0.005	<0.0005	5.41	<0.005
#3-FIRST POND SOUTH OF TMA	<0.005	0.32	<0.010	0.007	<0.0005	5.96	<0.005
#4-SECOND POND SOUTH OF TMA	<0.005	0.24	<0.010	0.006	<0.0005	4.98	<0.005
#5-HASSON LAKE NORTH SAMPLE	<0.005	0.12	<0.010	0.005	<0.0005	5.31	<0.005
#6-HASSON LAKE WEST BAY SAMPLE	<0.005	0.20	<0.010	0.006	<0.0005	5.28	<0.005
#7-HASSON LAKE MID LAKE SAMPLE	<0.005	0.11	<0.010	0.005	<0.0005	5.11	<0.005
#8-TAILINGS SECONDARY POND	<0.005	0.47	0.012	0.021	<0.0005	21.9	<0.005
#9-TAILINGS DECANT WATER	<0.005	0.57	0.011	0.016	<0.0005	32.2	<0.005
Blank	<0.005	<0.05	<0.010	<0.005	<0.0005	<0.05	<0.005
QC Standard (actual)	<0.005	10.0	0.193	0.998	0.0187	50.0	0.191
QC Standard (expected)	<0.005	10.0	0.200	1.00	0.0200	50.0	0.200
Repeat #1-CAMP LAKE NORTH	<0.005	0.09	<0.010	<0.005	<0.0005	5.21	<0.005

BARRINGER LABORATORIES

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25-Mar-92

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Water Samples

Sample Id	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.05	<0.01	<0.01	0.47	<1.0	2.48	0.01
#2-CAMP LAKE MID LAKE COMPOSITE	<0.05	<0.01	<0.01	0.52	<1.0	2.56	0.01
#3-FIRST POND SOUTH OF TMA	<0.05	<0.01	<0.01	1.27	2.4	3.11	0.18
#4-SECOND POND SOUTH OF TMA	<0.05	0.01	<0.01	6.51	<1.0	2.23	0.15
#5-HASSON LAKE NORTH SAMPLE	<0.05	0.01	<0.01	0.56	<1.0	2.35	0.02
#6-HASSON LAKE WEST BAY SAMPLE	<0.05	<0.01	<0.01	1.46	<1.0	2.23	0.11
#7-HASSON LAKE MID LAKE SAMPLE	<0.05	0.01	<0.01	0.51	<1.0	2.19	0.02
#8-TAILINGS SECONDARY POND	<0.05	0.01	0.01	6.57	6.1	11.6	2.65
#9-TAILINGS DECANT WATER	<0.05	0.01	0.01	4.75	6.2	16.1	1.68
Blank	<0.05	<0.01	<0.01	<0.01	<1.0	<0.05	<0.01
QC Standard (actual)	0.19	0.20	0.20	9.71	50.5	9.93	0.19
QC Standard (expected)	0.20	0.20	0.20	10.0	50.0	10.0	0.20
Repeat #1-CAMP LAKE NORTH	<0.05	<0.01	<0.01	0.46	<1.0	2.46	0.01

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Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L
#1-CAMP LAKE NORTH BASIN	<0.2	1.1	<0.05	<0.5	<0.05	3.04	0.011
#2-CAMP LAKE MID LAKE COMPOSITE	<0.2	1.1	<0.05	<0.5	<0.05	3.23	0.012
#3-FIRST POND SOUTH OF TMA	<0.2	23.2	<0.05	<0.5	<0.05	9.45	0.013
#4-SECOND POND SOUTH OF TMA	<0.2	1.9	<0.05	<0.5	<0.05	7.96	0.012
#5-HASSON LAKE NORTH SAMPLE	<0.2	1.3	<0.05	<0.5	<0.05	3.38	0.012
#6-HASSON LAKE WEST BAY SAMPLE	<0.2	4.6	<0.05	<0.5	<0.05	6.21	0.013
#7-HASSON LAKE MID LAKE SAMPLE	<0.2	1.4	<0.05	<0.5	<0.05	3.26	0.012
#8-TAILINGS SECONDARY POND	<0.2	72.1	<0.05	<0.5	<0.05	10.4	0.052
#9-TAILINGS DECANT WATER	<0.2	74.5	<0.05	<0.5	<0.05	14.5	0.072
Blank	<0.2	<0.5	<0.05	<0.5	<0.05	<0.05	<0.001
QC Standard (actual)	0.5	50.8	0.20	9.9	0.19	10.0	0.197
QC Standard (expected)	0.5	50.0	0.20	10.0	0.20	10.0	0.200
Repeat #1-CAMP LAKE NORTH	<0.2	1.1	<0.05	<0.5	<0.05	3.03	0.011

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Water Samples

Sample Id	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L
#1-CAMP LAKE NORTH BASIN	<0.005	<0.005	<0.01	<0.10	0.61	<0.02	<0.1
#2-CAMP LAKE MID LAKE COMPOSITE	<0.005	<0.005	<0.01	<0.10	0.54	<0.02	<0.1
#3-FIRST POND SOUTH OF TMA	0.005	<0.005	<0.01	<0.10	3.39	<0.02	<0.1
#4-SECOND POND SOUTH OF TMA	<0.005	<0.005	0.02	<0.10	0.35	<0.02	<0.1
#5-HASSON LAKE NORTH SAMPLE	<0.005	<0.005	<0.01	<0.10	0.51	<0.02	<0.1
#6-HASSON LAKE WEST BAY SAMPLE	<0.005	<0.005	<0.01	<0.10	0.96	<0.02	<0.1
#7-HASSON LAKE MID LAKE SAMPLE	<0.005	<0.005	<0.01	<0.10	0.52	<0.02	<0.1
#8-TAILINGS SECONDARY POND	0.011	0.008	<0.01	<0.10	11.2	<0.02	0.3
#9-TAILINGS DECANT WATER	0.011	<0.005	<0.01	<1.00	10.8	<0.02	0.2
Blank	<0.005	<0.005	<0.01	<0.10	<0.01	<0.02	<0.1
QC Standard (actual)	0.196	0.198	0.19	0.44	2.01	0.99	2.0
QC Standard (expected)	0.200	0.200	0.20	0.46	2.00	1.00	2.0
Repeat #1-CAMP LAKE NORTH	<0.005	<0.005	<0.01	<0.10	0.63	<0.02	<0.1

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Water Samples

Sample Id	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	pH pH Elec. pH Units	Alk 8.3 Titr. 1 mg CaCO3/L	Alk 4.2 Titr. 1 mg CaCO3/L
#1-CAMP LAKE NORTH BASIN	<0.05	0.15	2.11	7.14	<0.1	21.2
#2-CAMP LAKE MID LAKE COMPOSITE	<0.05	0.16	2.03	7.00	<0.1	21.3
#3-FIRST POND SOUTH OF TMA	<0.05	0.06	1.46	7.18	<0.1	64.9
#4-SECOND POND SOUTH OF TMA	<0.05	0.07	1.27	6.93	<0.1	22.9
#5-HASSON LAKE NORTH SAMPLE	<0.05	0.20	2.12	6.94	<0.1	20.3
#6-HASSON LAKE WEST BAY SAMPLE	<0.05	0.10	1.68	6.91	<0.1	26.6
#7-HASSON LAKE MID LAKE SAMPLE	<0.05	0.19	2.06	6.91	<0.1	20.3
#8-TAILINGS SECONDARY POND	0.11	<0.02	1.44	7.34	<0.1	250.
#9-TAILINGS DECANT WATER	0.10	<0.02	1.24	7.36	<0.1	309.
Blank	<0.05	<0.02	<0.05	5.68	<0.1	<0.1
QC Standard (actual)	1.88	0.45	2.00	4.47	<0.1	244.
QC Standard (expected)	2.00	0.44	2.00	4.45	<0.1	250.
Repeat #1-CAMP LAKE NORTH	<0.05	0.16	2.04	7.11	<0.1	21.0

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Water Samples

Sample Id	NH3-N A. Col. mg/L	Ortho P A. Col. mg/L	DOC A. Col. mg/L	Th. Cond. Calc. umhos/cm	Th. TDS Calc. mg/L	pHs Calc. pH Units	CAB Calc. %
#1-CAMP LAKE NORTH BASIN	0.02	<0.01	18.9	51.4	33	9.28	-4.02
#2-CAMP LAKE MID LAKE COMPOSITE	<0.02	<0.01	15.6	51.9	34	9.27	-5.28
#3-FIRST POND SOUTH OF TMA	0.18	<0.01	4.9	148.1	96	8.79	-6.64
#4-SECOND POND SOUTH OF TMA	0.18	<0.01	17.2	50.9	33	9.29	-4.48
#5-HASSON LAKE NORTH SAMPLE	0.02	<0.01	18.8	50.6	33	9.31	-5.68
#6-HASSON LAKE WEST BAY SAMPLE	0.11	<0.01	15.5	62.7	41	9.19	-5.89
#7-HASSON LAKE MID LAKE SAMPLE	<0.02	<0.01	18.7	49.6	32	9.32	-4.15
#8-TAILINGS SECONDARY POND	1.91	0.06	16.3	515.0	335	7.73	-1.17
#9-TAILINGS DECANT WATER	2.60	0.05	28.0	616.5	401	7.48	0.29
Blank	<0.02	<0.01	<0.2	3.8	2	13.64	-64.40
QC Standard (actual)	0.11	0.38	10.1	592.0	385	7.41	-15.09
QC Standard (expected)	0.10	0.40	10.0	594.6	386	7.37	-13.64
Repeat #1-CAMP LAKE NORTH	0.02	<0.01	18.2	50.8	33	9.28	-3.82

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Water Samples

Sample Id	Hard(Calc) Calc. mg CaCO3/L	CO3= Calc. mg/L	HCO3- Calc. mg/L	L.I. Calc. None	A.I. Calc. None	R.S.I. Calc. None	Colour M. Col. TCU
#1-CAMP LAKE NORTH BASIN	23.4	0.1	25.6	-2.1	9.84	11.4	130.
#2-CAMP LAKE MID LAKE COMPOSITE	24.1	0.1	25.7	-2.3	9.71	11.5	130.
#3-FIRST POND SOUTH OF TMA	27.7	0.1	78.9	-1.6	10.43	10.4	379.
#4-SECOND POND SOUTH OF TMA	21.6	0.1	27.7	-2.4	9.62	11.6	210.
#5-HASSON LAKE NORTH SAMPLE	23.0	0.1	24.5	-2.4	9.61	11.7	135.
#6-HASSON LAKE WEST BAY SAMPLE	22.4	0.1	32.2	-2.3	9.68	11.5	227.
#7-HASSON LAKE MID LAKE SAMPLE	21.8	0.1	24.5	-2.4	9.56	11.7	139.
#8-TAILINGS SECONDARY POND	102.6	0.1	304.6	-0.4	11.75	8.1	352.
#9-TAILINGS DECANT WATER	147.1	0.1	376.5	-0.1	12.02	7.6	285.
Blank	0.3	0.1	0.0	-8.0	4.20	21.6	---
QC Standard (actual)	166.0	0.1	297.4	-2.9	9.08	10.3	50.0
QC Standard (expected)	166.0	0.1	304.6	-2.9	9.07	10.3	50.0
Repeat #1-CAMP LAKE NORTH	23.1	0.1	25.4	-2.2	9.80	11.5	130.

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Water Samples

Sample Id	Cd GFAAS mg/L	Cu ICAP mg/L	Ni ICAP mg/L	Pb ICAP mg/L	Total P A. Col. mg/L
#1-CAMP LAKE NORTH BASIN	0.0010	0.009	<0.01	<0.01	0.011
#2-CAMP LAKE MID LAKE COMPOSITE	0.0001	0.006	<0.01	<0.01	0.011
#3-FIRST POND SOUTH OF TMA	0.0001	0.007	0.01	<0.01	0.080
#4-SECOND POND SOUTH OF TMA	0.0001	0.004	<0.01	<0.01	0.060
#5-HASSON LAKE NORTH SAMPLE	<0.0001	0.003	<0.01	<0.01	0.012
#6-HASSON LAKE WEST BAY SAMPLE	<0.0001	0.002	<0.01	<0.01	0.022
#7-HASSON LAKE MID LAKE SAMPLE	<0.0001	0.003	<0.01	<0.01	0.012
#8-TAILINGS SECONDARY POND	0.0004	0.014	0.06	<0.01	0.290
#9-TAILINGS DECANT WATER	0.0002	0.015	0.04	<0.01	0.240
Blank	<0,0001	<0.002	<0.01	<0.01	<0.002
QC Standard (actual)	0.0024	0.197	0.20	0.20	0.081
QC Standard (expected)	0.0025	0.200	0.20	0.20	0.084
Repeat #1-CAMP LAKE NORTH	0.0010	---	---	---	0.011

Job approved by:

Signed: ....

Mike Muneswar
Senior Supervisor, Environmental Analytical Services

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26-Jun-92

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Job: 925572

Status: Final

Water Samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L
CAMP LAKE STA.1 MAY 29/92	<0.001	0.09	<0.01	<0.005	<0.0005	4.56	<0.005
CAMP LAKE STA.2 MAY 29/92	<0.001	0.10	<0.01	<0.005	<0.0005	4.55	<0.005
HASSON LAKE STA.1 MAY 29/92	<0.001	0.10	<0.01	<0.005	<0.0005	4.37	<0.005
HASSON LAKE STA.2 MAY 29/92	<0.001	0.11	<0.01	<0.005	<0.0005	4.18	<0.005
HASSON LAKE STA.3 MAY 29/92	<0.001	0.10	<0.01	<0.005	<0.0005	4.08	<0.005
FIRST POND-LAC DES ISLE MAY 31/92	<0.001	0.11	<0.01	<0.005	<0.0005	4.28	<0.005
SECOND POND MAY 30/92	<0.001	0.15	<0.01	<0.005	<0.0005	3.17	<0.005
TAILINGS DECANT WATER MAY 29/92	<0.001	0.73	<0.01	<0.005	<0.0005	12.8	<0.005
TAILINGS SECONDARY POND MAY 29/92	<0.001	0.10	<0.01	<0.005	<0.0005	10.7	<0.005
Blank	<0.001	<0.05	<0.01	<0.005	<0.0005	<0.05	<0.005
QC Standard (actual)	0.812	10.1	0.20	0.983	0.0183	50.4	0.212
QC Standard (expected)	1.00	10.0	0.20	1.00	0.0200	50.0	0.200
Repeat CAMP LAKE STA.1	<0.001	0.09	<0.01	<0.005	<0.0005	4.46	<0.005

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Water Samples

Sample Id	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
CAMP LAKE STA.1 MAY 29/92	<0.01	<0.01	<0.002	0.31	<1.0	2.30	0.01
CAMP LAKE STA.2 MAY 29/92	<0.01	<0.01	<0.002	0.36	<1.0	2.30	0.02
HASSON LAKE STA.1 MAY 29/92	<0.01	<0.01	<0.002	0.30	<1.0	1.96	<0.01
HASSON LAKE STA.2 MAY 29/92	<0.01	<0.01	<0.002	0.34	<1.0	1.84	<0.01
HASSON LAKE STA.3 MAY 29/92	<0.01	<0.01	<0.002	0.29	<1.0	1.80	<0.01
FIRST POND-LAC DES ISLE MAY 31/92	<0.01	<0.01	0.003	0.22	1.8	2.37	<0.01
SECOND POND MAY 30/92	<0.01	<0.01	<0.002	0.25	<1.0	1.56	<0.01
TAILINGS DECANT WATER MAY 29/92	<0.01	<0.01	0.037	0.93	2.3	6.10	0.03
TAILINGS SECONDARY POND MAY 29/92	<0.01	<0.01	0.013	1.00	2.9	5.60	0.01
Blank	<0.01	<0.01	<0.002	<0.01	<1.0	<0.05	<0.01
QC Standard (actual)	0.20	0.20	0.201	9.53	9.7	8.02	0.20
QC Standard (expected)	0.20	0.20	0.200	10.0	10.0	8.00	0.20
Repeat CAMP LAKE STA.1	<0.01	<0.01	<0.002	0.30	<1.0	2.26	0.01

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Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L
CAMP LAKE STA.1 MAY 29/92	<0.1	1.4	<0.01	<0.1	<0.01	3.76	0.008
CAMP LAKE STA.2 MAY 29/92	<0.1	1.0	<0.01	<0.1	<0.01	3.77	0.008
HASSON LAKE STA.1 MAY 29/92	<0.1	1.7	<0.01	<0.1	<0.01	3.37	0.008
HASSON LAKE STA.2 MAY 29/92	<0.1	1.5	<0.01	<0.1	<0.01	3.47	0.008
HASSON LAKE STA.3 MAY 29/92	<0.1	1.6	<0.01	<0.1	<0.01	3.20	0.007
FIRST POND-LAC DES ISLE MAY 31/92	<0.1	10.4	<0.01	<0.1	<0.01	2.22	0.008
SECOND POND MAY 30/92	<0.1	3.2	<0.01	<0.1	<0.01	2.33	0.006
TAILINGS DECANT WATER MAY 29/92	<0.1	20.1	0.04	<0.1	<0.01	3.85	0.025
TAILINGS SECONDARY POND MAY 29/92	<0.1	23.8	0.01	<0.1	0.01	4.25	0.022
Blank	<0.1	<0.1	<0.01	<0.1	<0.01	<0.05	<0.001
QC Standard (actual)	0.5	51.2	0.19	9.9	0.22	10.0	0.199
QC Standard (expected)	0.5	50.0	0.20	10.0	0.20	10.0	0.200
Repeat CAMP LAKE STA.1	<0.1	1.1	<0.01	<0.1	<0.01	3.64	0.008

BARRINGER LABORATORIES

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26-Jun-92

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Water Samples

Sample Id	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L
CAMP LAKE STA.1 MAY 29/92	<0.005	<0.005	<0.01	<0.1	0.66	<0.02	<0.1
CAMP LAKE STA.2 MAY 29/92	<0.005	<0.005	<0.01	<0.1	0.64	<0.02	<0.1
HASSON LAKE STA.1 MAY 29/92	<0.005	<0.005	<0.01	<0.1	0.54	<0.02	<0.1
HASSON LAKE STA.2 MAY 29/92	<0.005	<0.005	<0.01	<0.1	0.51	<0.02	<0.1
HASSON LAKE STA.3 MAY 29/92	<0.005	<0.005	<0.01	<0.1	0.54	<0.02	<0.1
FIRST POND-LAC DES ISLE MAY 31/92	<0.005	<0.005	<0.01	<0.1	1.43	<0.02	<0.1
SECOND POND MAY 30/92	<0.005	<0.005	<0.01	<0.1	0.49	<0.02	<0.1
TAILINGS DECANT WATER MAY 29/92	0.005	<0.005	<0.01	<0.1	2.48	<0.02	<0.1
TAILINGS SECONDARY POND MAY 29/92	<0.005	<0.005	<0.01	<0.1	3.70	<0.02	<0.1
Blank	<0.005	<0.005	<0.01	<0.1	<0.01	<0.02	<0.1
QC Standard (actual)	0.200	0.201	0.21	0.6	2.11	1.07	2.0
QC Standard (expected)	0.200	0.200	0.20	0.6	2.00	1.00	2.0
Repeat CAMP LAKE STA.1	<0.005	<0.005	<0.01	<0.1	0.67	<0.02	<0.1

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Water Samples

Sample Id	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	pH pH Elec. pH Units	Alk 8.3 Titr. 1 mg CaCO3/L	Alk 4.2 Titr. 1 mg CaCO3/L
CAMP LAKE STA.1 MAY 29/92	<0.05	0.16	2.59	6.55	<0.1	14.9
CAMP LAKE STA.2 MAY 29/92	<0.05	0.18	2.03	6.68	<0.1	15.4
HASSON LAKE STA.1 MAY 29/92	<0.05	0.15	1.91	6.64	<0.1	14.8
HASSON LAKE STA.2 MAY 29/92	<0.05	0.16	1.80	6.51	<0.1	14.1
HASSON LAKE STA.3 MAY 29/92	<0.05	0.12	1.78	6.82	<0.1	14.5
FIRST POND-LAC DES ISLE MAY 31/92	<0.05	<0.02	1.33	6.94	<0.1	34.6
SECOND POND MAY 30/92	<0.05	0.05	1.32	6.68	<0.1	14.3
TAILINGS DECANT WATER MAY 29/92	<0.05	<0.02	5.82	7.74	<0.1	83.8
TAILINGS SECONDARY POND MAY 29/92	<0.05	<0.02	2.90	7.06	<0.1	88.8
Blank	<0.05	<0.02	<0.05	5.20	<0.1	1.0
QC Standard (actual)	2.00	0.44	2.05	4.45	<0.1	49.9
QC Standard (expected)	2.00	0.44	2.00	4.45	<0.1	50.0
Repeat CAMP LAKE STA.1	<0.05	0.17	2.50	6.63	<0.1	15.2

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Water Samples

Sample Id	NH3-N A. Col. mg/L	Ortho P A. Col. mg/L	DOC A. Col. mg/L	Th. Cond. Calc. umhos/cm	Th. TDS Calc. mg/L	pHs Calc. pH Units	CAB Calc. %
CAMP LAKE STA.1 MAY 29/92	0.05	<0.02	15.5	44.8	29	9.50	-13.26
CAMP LAKE STA.2 MAY 29/92	<0.02	<0.02	14.3	43.5	28	9.48	-11.38
HASSON LAKE STA.1 MAY 29/92	<0.02	<0.02	14.1	42.2	27	9.52	-13.38
HASSON LAKE STA.2 MAY 29/92	<0.02	<0.02	14.4	40.2	26	9.56	-12.91
HASSON LAKE STA.3 MAY 29/92	<0.02	<0.02	14.4	40.2	26	9.56	-11.72
FIRST POND-LAC DES ISLE MAY 31/92	<0.02	<0.02	22.0	81.1	53	9.17	-8.38
SECOND POND MAY 30/92	<0.02	<0.02	17.8	38.8	25	9.67	-14.74
TAILINGS DECANT WATER MAY 29/92	<0.02	<0.02	15.8	191.1	124	8.36	-5.28
TAILINGS SECONDARY POND MAY 29/92	<0.02	<0.02	18.2	195.3	127	8.41	-3.90
Blank	<0.02	<0.02	<0.2	3.7	2	12.61	-15.14
QC Standard (actual)	0.09	0.12	9.7	342.5	223	8.05	-65.94
QC Standard (expected)	0.10	0.12	10.0	339.0	220	8.05	-65.62
Repeat CAMP LAKE STA.1	0.05	<0.02	15.2	44.1	29	9.50	-10.72

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Water Samples

Sample Id	Hard(Calc) Calc. mg CaCO3/L	CO3= Calc. mg/L	HCO3- Calc. mg/L	L.I. Calc. None	A.I. Calc. None	R.S.I. Calc. None
CAMP LAKE STA.1 MAY 29/92	20.8	0.1	17.9	-2.9	9.04	12.4
CAMP LAKE STA.2 MAY 29/92	20.8	0.1	18.5	-2.8	9.19	12.3
HASSON LAKE STA.1 MAY 29/92	19.0	0.1	17.8	-2.9	9.09	12.4
HASSON LAKE STA.2 MAY 29/92	18.0	0.1	16.9	-3.0	8.92	12.6
HASSON LAKE STA.3 MAY 29/92	17.6	0.1	17.4	-2.7	9.23	12.3
FIRST POND-LAC DES ISLE MAY 31/92	20.4	0.1	41.9	-2.2	9.79	11.4
SECOND POND MAY 30/92	14.3	0.1	17.2	-3.0	8.99	12.7
TAILINGS DECANT WATER MAY 29/92	57.2	0.0	102.0	-0.6	11.42	9.0
TAILINGS SECONDARY POND MAY 29/92	49.8	0.1	108.0	-1.4	10.71	9.8
Blank	0.3	0.1	1.0	-7.4	4.72	20.0
QC Standard (actual)	159.1	0.1	60.6	-3.6	8.35	11.6
QC Standard (expected)	157.8	0.1	60.7	-3.6	8.35	11.7
Repeat CAMP LAKE STA.1	20.5	0.1	18.3	-2.9	9.12	12.4

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Water Samples

Sample Id	Cd-GFAAS GFAAS mg/L	Total P A. Col. mg/L	Colour M. Col. TCU
CAMP LAKE STA.1 MAY 29/92	0.0002	0.011	124
CAMP LAKE STA.2 MAY 29/92	0.0001	0.016	130
HASSON LAKE STA.1 MAY 29/92	0.0001	0.008	128
HASSON LAKE STA.2 MAY 29/92	0.0001	0.011	138
HASSON LAKE STA.3 MAY 29/92	0.0001	0.013	136
FIRST POND-LAC DES ISLE MAY 31/92	0.0001	0.033	216
SECOND POND MAY 30/92	0.0001	0.016	128
TAILINGS DECANT WATER MAY 29/92	0.0001	0.059	120
TAILINGS SECONDARY POND MAY 29/92	0.0002	0.088	126
Blank	<0.0001	<0.002	<1
QC Standard (actual)	0.0026	0.085	50
QC Standard (expected)	0.0025	0.084	50
Repeat CAMP LAKE STA.1	0.0001	0.012	124

Job approved by:

Signed:
....
Agnes Love, B.Sc.
Manager, Environmental Inorganic Services

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fish

Sample Id	Hg CVAAS ppb
CAMP LAKE NP1	1610
CAMP LAKE NP2	1560
CAMP LAKE NP3	1230
CAMP LAKE NP4	1990
CAMP LAKE NP5	2040
CAMP LAKE NP6	1410
CAMP LAKE NP7	2030
CAMP LAKE NP8	1440
CAMP LAKE NP9	1740
CAMP LAKE NP10	1760
HASSON LAKE NP1	1390
HASSON LAKE NP2	1360
HASSON LAKE NP3	670
HASSON LAKE NP4	540
HASSON LAKE NP5	590
HASSON LAKE NP6	620
HASSON LAKE NP7	1270
HASSON LAKE NP8	1190
HASSON LAKE NP9	1110
HASSON LAKE NP10	750

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fish

Sample Id	Hg CVAAS ppb
SECOND POND NP1	960
SECOND POND NP2	1170
SECOND POND NP3	750
SECOND POND NP4	610
SECOND POND NP5	220
SECOND POND NP6	230
SECOND POND NP7	260
SECOND POND NP8	700
SECOND POND NP9	730
SECOND POND NP10	390
Blank	<10
QC Standard (actual)	54
QC Standard (expected)	57
Repeat CAMP LAKE NP1	1580

Job approved by:

Signed: ....

Agnes Love, B.Sc.

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Water Samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L
STN# FP1	<0.005	0.15	<0.010	0.006	<0.0005	5.85	<0.005
STN# CL1	<0.005	0.10	<0.010	<0.005	<0.0005	4.38	<0.005
STN# CL2	<0.005	0.11	<0.010	<0.005	<0.0005	4.37	<0.005
STN# HL1	<0.005	0.10	0.017	<0.005	<0.0005	4.05	<0.005
STN# HL2	<0.005	0.10	<0.010	<0.005	<0.0005	4.00	<0.005
STN# HL3	<0.005	0.11	<0.010	<0.005	<0.0005	4.10	<0.005
TAILINGS DECANT POND	<0.005	0.67	0.021	0.007	<0.0005	18.5	<0.005
TAILINGS SEDIMENTATION POND	<0.005	0.13	0.020	0.014	<0.0005	14.4	<0.005
BY NEAR LODGE COMPOSITE	<0.005	<0.05	0.015	0.007	<0.0005	5.29	<0.005
STN# SP1	<0.005	0.15	<0.010	<0.005	<0.0005	4.02	<0.005
Blank	<0.005	<0.05	<0.010	<0.005	<0.0005	<0.05	<0.005
QC Standard (actual)	0.026	10.1	0.215	1.01	0.0184	50.6	0.196
QC Standard (expected)	0.020	10.0	0.200	1.00	0.0190	50.0	0.200
Repeat STN# FP1	<0.005	0.15	0.012	0.006	<0.0005	5.90	<0.005

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Water Samples

Sample Id	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
STN# FP1	<0.01	<0.01	<0.01	0.68	1.4	3.28	0.13
STN# CL1	<0.01	<0.01	<0.01	0.35	<1.0	2.26	0.02
STN# CL2	<0.01	<0.01	<0.01	0.43	<1.0	2.24	0.04
STN# HL1	<0.01	<0.01	<0.01	0.38	<1.0	1.82	0.01
STN# HL2	<0.01	<0.01	<0.01	0.39	<1.0	1.81	0.01
STN# HL3	<0.01	<0.01	<0.01	0.40	<1.0	1.86	0.01
TAILINGS DECANT POND	<0.01	<0.01	0.02	1.34	3.7	9.17	0.05
TAILINGS SEDIMENTATION POND	<0.01	<0.01	<0.01	4.03	4.2	7.83	1.15
BY NEAR LODGE COMPOSITE	<0.01	<0.01	<0.01	0.10	<1.0	2.77	<0.01
STN# SP1	<0.01	<0.01	<0.01	0.55	<1.0	1.93	0.02
Blank	<0.01	<0.01	<0.01	<0.01	<1.0	<0.05	<0.01
QC Standard (actual)	0.20	0.20	0.20	9.95	10.1	8.03	0.20
QC Standard (expected)	0.20	0.20	0.20	10.0	10.0	8.00	0.20
Repeat STN# FP1	<0.01	<0.01	<0.01	0.67	1.4	3.26	0.13

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Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L
STN# FP1	<0.1	9.9	<0.05	<0.1	<0.05	2.60	0.012
STN# CL1	<0.1	1.0	<0.05	<0.1	<0.05	2.74	0.009
STN# CL2	<0.1	1.0	<0.05	<0.1	<0.05	2.86	0.009
STN# HL1	<0.1	1.6	<0.05	<0.1	<0.05	1.67	0.008
STN# HL2	<0.1	1.6	<0.05	<0.1	<0.05	1.62	0.008
STN# HL3	<0.1	1.8	<0.05	<0.1	<0.05	1.63	0.008
TAILINGS DECANT POND	<0.1	28.0	<0.05	<0.1	<0.05	2.93	0.042
TAILINGS SEDIMENTATION POND	<0.1	29.0	<0.05	0.1	<0.05	3.93	0.035
BY NEAR LODGE COMPOSITE	<0.1	0.7	<0.05	<0.1	<0.05	1.95	0.008
STN# SP1	<0.1	3.6	<0.05	<0.1	<0.05	2.23	0.009
Blank	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05	<0.001
QC Standard (actual)	0.5	51.0	0.20	10.3	0.20	10.6	0.976
QC Standard (expected)	0.5	50.0	0.20	10.0	0.20	10.0	1.00
Repeat STN# FP1	<0.1	10.0	<0.05	<0.1	<0.05	2.64	0.012

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Water Samples

Sample Id	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- IC mg/L	Cl- IC mg/L	NO2-N A. Col. mg/L	PO4-3 IC mg/L
STN# FP1	<0.005	<0.005	<0.01	<0.10	0.77	<0.020	<0.1
STN# CL1	<0.005	<0.005	<0.01	<0.10	0.58	<0.020	<0.1
STN# CL2	<0.005	<0.005	<0.01	<0.10	0.58	<0.020	<0.1
STN# HL1	<0.005	<0.005	<0.01	<0.10	0.38	<0.020	<0.1
STN# HL2	<0.005	<0.005	<0.01	<0.10	0.41	<0.020	<0.1
STN# HL3	<0.005	<0.005	<0.01	<0.10	0.40	<0.020	<0.1
TAILINGS DECANT POND	0.006	<0.005	<0.01	<0.10	2.65	<0.020	<0.1
TAILINGS SEDIMENTATION POND	<0.005	<0.005	0.03	<0.10	3.24	<0.020	<0.1
BY NEAR LODGE COMPOSITE	<0.005	<0.005	0.02	<0.10	0.29	<0.020	<0.1
STN# SP1	<0.005	<0.005	<0.01	<0.10	0.40	<0.020	<0.1
Blank	<0.005	<0.005	<0.01	<0.10	<0.01	<0.020	<0.1
QC Standard (actual)	0.202	0.206	0.20	0.60	2.08	1.07	1.9
QC Standard (expected)	0.200	0.200	0.20	0.60	2.00	1.00	2.0
Repeat STN# FP1	<0.005	<0.005	<0.01	<0.10	0.76	<0.020	<0.1

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Water Samples

Sample Id	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	pH pH Elec. pH Units	Alk 8.3 Titr. 1 mg CaCO3/L	Alk 4.2 Titr. 1 mg CaCO3/L	NH3-N A. Col. mg/L
STN# FP1	<0.05	0.03	0.49	6.48	<0.1	40.6	0.04
STN# CL1	<0.05	0.05	1.97	6.41	<0.1	16.6	<0.02
STN# CL2	<0.05	0.07	1.95	6.22	<0.1	16.4	<0.02
STN# HL1	<0.05	<0.02	1.67	6.26	<0.1	16.2	<0.02
STN# HL2	<0.05	<0.02	1.72	6.24	<0.1	15.8	<0.02
STN# HL3	<0.05	<0.02	1.54	6.12	<0.1	16.4	<0.02
TAILINGS DECANT POND	<0.05	<0.02	2.82	7.29	<0.1	135.	<0.02
TAILINGS SEDIMENTATION POND	<0.05	<0.02	0.48	7.07	<0.1	125.	0.80
BY NEAR LODGE COMPOSITE	<0.05	<0.02	2.07	6.38	<0.1	22.6	<0.02
STN# SP1	<0.05	<0.02	0.74	6.35	<0.1	20.2	0.05
Blank	<0.05	<0.02	<0.05	4.97	<0.1	1.8	<0.02
QC Standard (actual)	1.96	0.44	2.06	4.46	<0.1	49.5	0.53
QC Standard (expected)	2.00	0.44	2.00	4.45	<0.1	50.0	0.50
Repeat STN# FP1	<0.05	0.03	0.42	6.52	<0.1	39.9	0.06

BARRINGER LABORATORIES

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9-Nov-92

SENES CONSULTANTS LIMITED
52 West Beaver Creek
Unit #4
Richmond Hill, ON
L4B 1G5

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Attn: Ms. Protibha Gupta
Project: 31121-0
PO #:
Received: 14-Aug-92 13:38

Job: 926442
Status: Final

Water Samples

Sample Id	Ortho P A. Col. mg/L	DOC A. Col. mg/L	Th. Cond. Calc. umhos/cm	Th. TDS Calc. mg/L	pHs Calc. pH Units	CAB Calc. %	Hard(Calc) Calc. mg CaCO3/L
STN# FP1	0.008	29.0	89.6	58	8.94	-9.58	28.1
STN# CL1	0.004	15.3	43.1	28	9.44	-8.64	20.2
STN# CL2	0.004	15.3	42.9	28	9.44	-8.76	20.1
STN# HL1	0.004	15.1	40.5	26	9.48	-8.78	17.6
STN# HL2	0.008	15.1	40.2	26	9.50	-9.19	17.5
STN# HL3	0.004	16.5	41.3	27	9.47	-10.28	17.9
TAILINGS DECANT POND	0.006	21.4	278.3	181	8.00	-2.53	84.2
TAILINGS SEDIMENTATION POND	0.036	57.0	256.2	167	8.13	-3.28	68.4
BY NEAR LODGE COMPOSITE	<0.002	15.3	51.5	33	9.23	-3.82	24.6
STN# SP1	0.016	23.0	47.4	31	9.39	-11.17	18.0
Blank	<0.002	<0.2	4.4	3	12.33	7.33	0.3
QC Standard (actual)	0.024	10.0	343.8	223	8.02	-66.33	159.5
QC Standard (expected)	0.024	10.0	339.9	221	8.02	-65.76	157.8
Repeat STN# FP1	0.008	28.0	89.3	58	8.95	-10.91	28.2

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9-Nov-92

SENES CONSULTANTS LIMITED
52 West Beaver Creek
Unit #4
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Attn: Ms. Protibha Gupta
Project: 31121-0
PO #:
Received: 14-Aug-92 13:38

Job: 926442
Status: Final

Water Samples

Sample Id	CO3= Calc. mg/L	HCO3- Calc. mg/L	L.I. Calc. None	A.I. Calc. None	R.S.I. Calc. None	Total P A. Col. mg/L	Colour M. Col. TCU
STN# FP1	0.1	49.3	-2.5	9.54	11.4	0.027	275
STN# CL1	0.1	20.0	-3.0	8.94	12.5	0.019	139
STN# CL2	0.1	19.8	-3.2	8.74	12.7	0.016	131
STN# HL1	0.1	19.5	-3.2	8.72	12.7	0.014	108
STN# HL2	0.1	19.0	-3.3	8.68	12.8	0.015	125
STN# HL3	0.1	19.8	-3.4	8.59	12.8	0.014	140
TAILINGS DECANT POND	0.1	165.0	-0.7	11.35	8.7	0.044	132
TAILINGS SEDIMENTATION POND	0.1	152.7	-1.1	11.00	9.2	0.124	270
BY NEAR LODGE COMPOSITE	0.1	27.3	-2.8	9.13	12.1	0.017	49
STN# SP1	0.1	24.4	-3.0	8.91	12.4	0.022	230
Blank	0.1	2.0	-7.4	4.74	19.7	<0.002	<1
QC Standard (actual)	0.1	60.1	-3.6	8.36	11.6	0.140	50
QC Standard (expected)	0.1	60.7	-3.6	8.35	11.6	0.140	50
Repeat STN# FP1	0.1	48.4	-2.4	9.57	11.4	0.026	275

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9-Nov-92

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Attn: Ms. Protibha Gupta
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PO #:
Received: 14-Aug-92 13:38

Job: 926442
Status: Final

Water Samples

Sample Id	Cd-GFAAS GFAAS mg/L	Cu ICAP mg/L	Ni ICAP mg/L	Pb ICAP mg/L	Ag ICAP mg/L
STN# FP1	<0.0001	0.002	<0.01	<0.01	<0.001
STN# CL1	<0.0001	0.003	<0.01	<0.01	<0.001
STN# CL2	<0.0001	0.003	<0.01	<0.01	<0.001
STN# HL1	<0.0001	0.003	<0.01	<0.01	<0.001
STN# HL2	<0.0001	0.002	<0.01	<0.01	<0.001
STN# HL3	<0.0001	0.002	<0.01	<0.01	<0.001
TAILINGS DECANT POND	<0.0001	0.025	0.02	<0.01	<0.001
TAILINGS SEDIMENTATION POND	<0.0001	0.006	<0.01	<0.01	<0.001
BY NEAR LODGE COMPOSITE	<0.0001	0.002	<0.01	<0.01	<0.001
STN# SP1	<0.0001	0.002	<0.01	<0.01	<0.001
Blank	<0.0001	<0.002	<0.01	<0.01	<0.001
QC Standard (actual)	0.0023	0.198	0.20	0.21	<0.001
QC Standard (expected)	0.0025	0.200	0.20	0.20	<0.001
Repeat STN# FP1	<0.0001	---	---	---	---

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9-Nov-92

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Attn: Ms. Protibha Gupta
Project: 31121-0
PO #:
Received: 14-Aug-92 13:38

Job: 926442
Status: Final

Job approved by:

Signed:
....
Agnes Love, B.Sc.
Manager, Environmental Inorganic Services

LAKE SURVEY FIELD NOTES

1 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Sub-watershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 **Survey Time:** 10^{30} AM

Survey Team: B.E. Halbert **and** Two Mine Staff.

Air Temperature: 3°C **Precipitation:** [✓ none] rain snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Camp Lake

Location Sampled: North Basin - Station CL1

Water Sample(s) Taken: [✓ YES] NO

Water Sample Type: Top Metre Mid Depth Bottom Metre
[✓ Composite (top, mid depth, bottom)]
Other (specify)

Water Colour: Clear Turbid Blue/Green
[✓ Brown] Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1	0.6	10.7	7.3	-
2	2.1	9.0	-	-
3	2.6	7.5	-	-
4	2.8	6.7	-	-
5	2.9	6.2	-	-
6	2.9	3.4	-	-
7	3.0	2.1	-	-
8	3.3	0.5	-	-
9 *	3.6	0.2	-	-

* D.O. probe was into sediment at 9 m depth.

Sediment Sample Taken: [✓ YES] NO

Sediment Sample Characteristics: Clay Gravel [✓ Muck] Sand Silt Other (specify)

Sediment Sample Colour: Black [✓ Brown] Grey Other (specify)

Sediment Sample Odour: Not odourous Slightly Odourous

Vegetation: Emergent Floating Submergent None Other

Other Observations: Sediment sample had a dark brown colour and a very consistent texture. Sediment appeared to have a high organic content and was quite thick.

Surveyors Signature

31132 - March 1992

LAKE SURVEY FIELD NOTES

2 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 **Survey Time:** 11^{15} AM

Survey Team: B.E. Halbert **and** Two Mine Staff

Air Temperature: 3°C **Precipitation:** ✓ none ____ rain ____ snow

Overcast Conditions (percent cloud cover): 100%

Waterbody Surveyed: Camp Lake

Location Sampled: Mid Lake - Station CL2

Water Sample(s) Taken: ________ YES ✓ NO

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre

________ Composite (top, mid depth, bottom)

________ Other (specify) ________________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

✓ Brown ________ Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1	0.7	9.5	7.3	—
2	2.1	8.4	—	—
3	2.6	7.1	—	—
4	2.8	6.4	—	—
5	2.9	6.3	—	—
6*	2.9	0.4	—	—

* D.O. probe was into sediments at 6 m depth.

Sediment Sample Taken: ______ YES __✓__ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck ______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent __None__ Other

Other Observations: Temperature and dissolved oxygen only were measured at this station. Another attempt was made to find a deeper station to sample in the mid lake basin.

Surveyors Signature ______

31132 - March 1992

LAKE SURVEY FIELD NOTES

3 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed.

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 **Survey Time:** 12^{20} PM.

Survey Team: B. Halbert and Two Mine Staff

Air Temperature: 4°C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Camp Lake

Location Sampled: Mid Lake - Station CL3

Water Sample(s) Taken: ✓ YES ________ NO

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre

✓ Composite (top, mid depth, bottom)

________ Other (specify) ________________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

✓ Brown ________ Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)
1	0.7	10.0	7.2	–
2	2.1	8.4	–	–
3	2.6	7.1	–	–
4	2.8	6.1	–	–
5	2.8	6.0	–	–
6	2.9	5.8	–	–
7	2.9	5.5	–	–
8	2.9	5.2	–	–
9	2.9	4.6	–	–
10	3.0	4.4	–	–
11*	–	0.2	–	–

* D.O. probe was into sediment at 11m depth.

Sediment Sample Taken: ✓ YES ____ NO

Sediment Sample Characteristics: ____ Clay ____ Gravel ✓ Muck
____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black ✓ Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous Slightly Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent None Other

Other Observations: Sediment was thick, had a dark brown appearance and uniform consistency.

Surveyors Signature Bruce E Hatton

31132 - March 1992

LAKE SURVEY FIELD NOTES

4 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 – Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 **Survey Time:** 2^{45} p.m.

Survey Team: B.E. Halbert and Four Mine Staff

Air Temperature: 4°C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100%

Waterbody Surveyed: First Pond Southwest of Tailings Management Area.

Location Sampled: Two Mid Pond Stations – FP1 at Narrows
– FP2 North of Narrows.

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ Top Metre ___ Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ___ Turbid ___ Blue/Green
Dark Brown & Turbid Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Station FP1				
0.3	0.2	1.4	6.8	—
1.0	1.8	0.3	—	—
1.5 *	2.4	0.17	—	—
* D.O. probe was into sediment at 1.5 m depth				
Station FP2				
0.3	0.4	2.5	—	—
1.0	1.4	0.4	—	—

Sediment Sample Taken: ✓ YES ______ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel Organic Muck
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black Dark Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous Very Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent NONE Other

Other Observations: Sediment Sample was taken at Station FP1 and had a strong anaerobic odour. Water sample was taken at Station FP2, had a deep brown colour and contained a noticeable level of suspended solids.

Surveyors Signature ______

LAKE SURVEY FIELD NOTES

5 of 8

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site.

Watershed Name: Dog River Subwatershed.

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 4 March 92 **Survey Time:** 4^{30} p.m.

Survey Team: R E. Hallbert **and** Four Mine Staff

Air Temperature: 4 °C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Second Pond Southwest of Tailings Mgt. Area

Location Sampled: Two stations: SP1 - North End of North Basin
SP2 - South End of North Basin

Water Sample(s) Taken: ✓ **YES** ________ **NO**

Water Sample Type: ✓(SP1) **Top Metre** ________ **Mid Depth** ________ **Bottom Metre**
________ **Composite (top, mid depth, bottom)**
________ **Other (specify)** ________

Water Colour: ________ **Clear** ________ **Turbid** ________ **Blue/Green**
Dark **Brown** ________ **Other (Specify)**

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
STATION SP1				
0.3	0.3	2.1/2.3 (confirmed)	6.7	—
1.0	0.8	4.5	—	—
2.0	2.6	4.8	—	—
2.5 *	2.9	0.2	—	—
* D.O. probe was into sediment at 2.5m depth!				
STATION SP2				
0.3	0.2	1.3 (confirmed)	—	—
1.0	1.0	4.2	—	—
2.0*	2.5	0.2	—	—

Sediment Sample Taken: ✓ (SP2) YES ________ NO

Sediment Sample Characteristics: ________ Clay ________ Gravel Organic Muck
________ Sand ________ Silt ________ Other (specify)

Sediment Sample Colour: ________ Black ________ Brown ________ Grey ________ Other (specify)

Sediment Sample Odour: ________ Not odourous Strong Odourous

Vegetation: ________ Emergent ________ Floating ________ Submergent None Other

Other Observations: Sediment Sample, taken from Station SP2, had a deep dark brown colour, was odourous and had a uniform texture and consistency.

Surveyors Signature Bruce E Holtke

31132 - March 1992

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

6 of 8

Project Number: 31121 – Lac Des Iles Mine Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 **Survey Time:** $9^{\underline{00}}$ AM.

Survey Team: B.E. Halbert **and** Three Mine Staff

Air Temperature: < 0°C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Hasson Lake

Location Sampled: Entrance to North Basin – Station HL1

Water Sample(s) Taken: ✓ **YES** ________ **NO**

Water Sample Type: ________ **Top Metre** ________ **Mid Depth** ________ **Bottom Metre**

________ **Composite (top, mid depth, bottom)**

Composite **Other (specify)** Top & bottom waters.

Water Colour: ________ **Clear** ________ **Turbid** ________ **Blue/Green**

✓ **Brown** ________ **Other (Specify)**

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
1.0	1.1	8.9	6.9	—
2.0	3.3	5.3	—	—
3.0	3.7	3.1	—	—
4.0	3.9	2.8	—	—
5.0	3.8	3.0	—	—
6.0	4.1	0.4	—	—

Sediment Sample Taken: ✓ YES ____ NO

Sediment Sample Characteristics: ____ Clay ____ Gravel ✓ Muck
____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black ✓ Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous Slightly Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent None Other

Other Observations: Sediment had higher silt content than other lakes and ponds sampled during survey

Surveyors Signature Bruce E. Holte

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

7 of 8

Project Number: 31121 - Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 **Survey Time:** 9^{45} to 10^{45} AM

Survey Team: B. E. Halbert **and** Three Mine Staff

Air Temperature: <0°C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100%

Waterbody Surveyed: Hasson Lake

Location Sampled: Station HL2 - Mid Lake
HL3 - Centre of West Basin

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ HL3 Top Metre ✓ HL2 Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ___ Turbid ___ Blue/Green
✓ Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
STATION HL2 – MID LAKE				
0.3	0.2	9.0	6.9	–
1.0	1.3	7.4	–	–
2.0	3.0	4.7	–	–
2.5	3.6	3.5	–	–
STATION HL3 – Centre of West Basin				
0.3	0.2	5.0	6.9	–
1.0	0.7	3.4	–	–
1.5	1.1	2.4	–	–

Sediment Sample Taken: ✓ HL2 & HL3 YES ________ NO

Sediment Sample Characteristics: ________ Clay ________ Gravel Silty Muck ✓
________ Sand ________ Silt ________ Other (specify)

Sediment Sample Colour: ________ Black ✓ Brown ________ Grey ________ Other (specify)

Sediment Sample Odour: ________ Not odourous Slightly Odourous

Vegetation: ________ Emergent ________ Floating ________ Submergent NONE. Other

Other Observations: Sediment samples had higher silt content than other lakes and ponds sampled, particularly the sediment from the mid lake station. Very little sediment was obtained using the clam in each attempt.

Surveyors Signature ____________

LAKE SURVEY FIELD NOTES

PART A: GENERAL INFORMATION

8 of 8

Project Number: 31121 – Lac Des Iles Mines Ltd.

Project Name: Baseline Monitoring – Lac Des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay

PART B: SURVEY INFORMATION

Survey Date: 5 March 92 **Survey Time:** 11^{30} AM.

Survey Team: BE Halbert **and** Three Mine Staff

Air Temperature: < 0°C **Precipitation:** ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): 100 %

Waterbody Surveyed: Tailing Management Facility Ponds

Location Sampled: TMF1 – Tailings Pond Decant Water.
TMF2 – Tailings Secondary Sedimentation Pond

Water Sample(s) Taken: ✓ YES ___ NO

Water Sample Type: ✓ Top Metre ___ Mid Depth ___ Bottom Metre
___ Composite (top, mid depth, bottom)
___ Other (specify) ___

Water Colour: ___ Clear ✓ Turbid ___ Blue/Green
___ Brown ___ Other (Specify)

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)

Sediment Sample Taken: ______ YES ✓ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent None Other

Other Observations: Both tailings water samples had a grey/green colour and were quite turbid and odourous. The auger holes through the ice only partially filled with water making it difficult to obtain ice free samples.

Surveyors Signature

APPENDIX B

FIELD NOTES: LAC DES ILES MINE SITE BASELINE MONITORING SURVEY 12-13 AUGUST 1992

APPENDIX B: FIELD NOTES: LAC DES ILES MINE SITE, BASELINE MONITORING SURVEY 12 AND 13 AUGUST 1992

Program Scope

Mr. Bruce E. Halbert of SENES Consultants Limited travelled to the Lac Des Iles Mine Site approximately 90 km north of Thunder Bay to collect water samples from ponds and lakes in the vicinity of the existing mine facilities on 12 and 13 August 1992. The purpose of the program was to establish baseline conditions during the period to complement data collected previously during the winter and spring periods. The program included the collection of water samples for chemical analyses and measurement of field pH, temperature and dissolved oxygen. Water samples were collected for chemical analyses from:

- Camp Lake to the south east of the mine camp facilities as this lake may be used as a source of process water;
- Hasson Lake to the south of the mine site as this lake may receive the effluent from the proposed tailings management facility (TMF);
- two ponds downstream of the proposed TMF (i.e. designated First Pond and Second Pond);
- pond water in the area which currently contains tailings from past operations; and
- Lac des Iles to the north of the mine facilities and which could potentially be used as a water supply source.

Field Conditions

Weather conditions at the time of sample collection were excellent. Mr. Mike Michaud, mine site geologist kindly assisted with the field program.

Field Measurements

In situ measurements of water temperature and dissolved oxygen were made using a YSI Model

58 dissolved oxygen meter equipped with a 15 m probe extension. Measurements were made generally at 1 m intervals over the depth of the water column by lowering the probe progressively downward from the top to the bottom. The meter was calibrated in the field using a sample of lake water by partially filling a sample bottle and shaking the bottle for several minutes to saturate the water with dissolved oxygen.

Field pH measurements were made using a Cole-Parme Model 05669-00 Digital Handheld pH meter. The pH of the surface water was recorded at each site.

The results of the field program are recorded on the "Lake Survey Field Notes" forms attached to this report.

Sample Collection

Water samples were collected from the pond and lake monitoring stations using a Kemmerer acrylic water sampler. At the shallow monitoring stations (generally < 3 m deep) the water samples were taken approximately 1 m below the surface. At the deep monitoring stations (generally > 6 m), water samples were taken from the top meter, mid-depth and bottom meter and composited to obtain one sample for chemical analyses. At the intermediate depth stations (generally between 2 and 6 m deep), a composite water sample was obtained for submission to the laboratory by compositing samples taken from the top and bottom waters.

One litre samples were taken from each station and stored in a cooler with ice packs to keep the samples cold. The samples were not filtered in the field and no preservatives were added. The samples were shipped by air to Barringer Laboratories in Mississauga for chemical analyses.

LAKE SURVEY FIELD NOTES

1 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT.

PART B: SURVEY INFORMATION

Survey Date: 12 Aug 92 Survey Time: 7:30 p.m.

Survey Team: B. E. Halbert and M. Michaud

Air Temperature: ____________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ____________

Waterbody Surveyed: Camp Lake.

Location Sampled: South Basin - Stn CL5

Water Sample(s) Taken: ________ YES ✓ NO

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre

________ Composite (top, mid depth, bottom)

________ Other (specify) ____________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

________ Brown Slightly Yellow Other (Specify)

31132 - March 1992

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Surface	18.5	8.80	6.60	
0.5	18.5	8.72		
1.0	18.5	8.60		
1.5	17.8	5.10		

Sediment Sample Taken: ____YES [✓ NO]

Sediment Sample Characteristics: ____Clay ____Gravel ____Muck ____Sand ____Silt ____Other (specify)

Sediment Sample Colour: ____Black ____Brown ____Grey ____Other (specify)

Sediment Sample Odour: ____Not odourous ____Odourous

Vegetation: ____Emergent ____Floating ____Submergent ____Other

Other Observations: ____

Surveyors Signature B. E. Halbert

LAKE SURVEY FIELD NOTES

2 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT

PART B: SURVEY INFORMATION

Survey Date: 12 Aug 92 Survey Time: 8:00 p.m.

Survey Team: B.E. Halbert and M. Michaud.

Air Temperature: ______ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ______

Waterbody Surveyed: Camp Lake

Location Sampled: Mid Lake - Stn CL4

Water Sample(s) Taken: ✓ YES ______ NO

Water Sample Type: ______ Top Metre ______ Mid Depth ______ Bottom Metre

✓ Composite (top, mid depth, bottom)

______ Other (specify) ______

Water Colour: ______ Clear ______ Turbid ______ Blue/Green

______ Brown Slightly Yellow Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)
Surface	18.3	7.95	6.22	
0.5	18.4	7.98		
1	18.2	8.03		
2	17.4	7.85		
3	17.2	7.70		
4	14.9	3.95		
5	12.8	2.32		
6	10.7	1.38		
7	8.5	1.76		
8	7.0	1.60		
9	6.1	0.70		
10	5.7	0.06		
11	5.4	0.02		
12	5.3	0.02		
13	5.2	0.02		

Sediment Sample Taken: ______ YES [✓ NO]

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck ______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent ______ Other

Other Observations: ______________________________

Surveyors Signature B. E. [illegible]

31132 - March 1992

LAKE SURVEY FIELD NOTES

3 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT

PART B: SURVEY INFORMATION

Survey Date: 12 Aug 92 Survey Time: 8:30 p.m.

Survey Team: B.E. Halbert and M. Michaud

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ________

Waterbody Surveyed: Camp Lake

Location Sampled: North Basin - Stn CL1

Water Sample(s) Taken: ✓ YES ________ NO

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre

✓ Composite (top, ~~mid depth~~, bottom)

________ Other (specify) ________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

________ Brown Slightly Yellow Other (Specify)

31132 - March 1992

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Surface	18.1	7.80	6.35	
0.5	17.9	7.80		
1	17.5	7.80		
2	17.2	7.52		
3	16.9	7.15		
4	16.4	6.40		
5	14.7	3.10		
6	12.2	1.79		
7	10.6	1.00		
8	9.6	0.07		
9 *	8.5	–		
* Bottom				

Sediment Sample Taken: ____ YES [✓ NO]

Sediment Sample Characteristics: ____ Clay ____ Gravel ____ Muck
____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black ____ Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous ____ Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent ____ Other

Other Observations: ____

Surveyors Signature B. E. Holbert

LAKE SURVEY FIELD NOTES

4 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT

PART B: SURVEY INFORMATION

Survey Date: 12 Aug 92. Survey Time: 6:50 pm.

Survey Team: B.E. Walbert and M. Michaud

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ________________

Waterbody Surveyed: First Pond Southwest of Tailings Management Facility

Location Sampled: Stn FP4 - South Bay
Stn FP1 - Near Narrows

Water Sample(s) Taken: ✓ YES ________ NO
from FP4

Water Sample Type: ✓ Top Metre ______ Mid Depth ______ Bottom Metre
________ Composite (top, mid depth, bottom)
________ Other (specify) ____________________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green
Yellowish Brown ________ Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Station RP1				
Surface	17.9	6.47	6.48	
1.0	16.1	5.61		
1.5	15.7	4.22		
Station RP4				
Surface	18.2	6.50	6.43	
1.0	15.4	4.63		
1.5	15.4	3.40		

Sediment Sample Taken: ________YES [✓ NO]

Sediment Sample Characteristics: ________Clay ________Gravel ________Muck ________Sand ________Silt ________Other (specify)

Sediment Sample Colour: ________Black ________Brown ________Grey ________Other (specify)

Sediment Sample Odour: ________Not odourous ________Odourous

Vegetation: ________Emergent ________Floating ________Submergent ________Other

Other Observations: ________________________________

Surveyors Signature B. E. Holben

LAKE SURVEY FIELD NOTES

5 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT

PART B: SURVEY INFORMATION

Survey Date: 13 Aug 92 Survey Time: 9:00 A.M.

Survey Team: B.E. Halbert and M. Michaud

Air Temperature: ______ Precipitation: [✓ none] ___ rain ___ snow

Overcast Conditions (percent cloud cover): clear, bright day with partial cloud cover.

Waterbody Surveyed: Hasson Lake

Location Sampled: North Basin - Stn HL1A & Stn HL1B

Water Sample(s) Taken: [✓ YES] ______ NO
from Stn. HL1B

Water Sample Type: ______ Top Metre ______ Mid Depth ______ Bottom Metre
[✓ Composite (top, ~~mid depth,~~ bottom)]
______ Other (specify) ______

Water Colour: ______ Clear ______ Turbid ______ Blue/Green
______ Brown Yellowish Tint Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (umhos/cm)
Stn. HL1A				
Surface	16.8	7.68	—	
0.5	16.8	7.68		
1.0	16.8	7.70		
2.0	16.8	7.70		
3.0	16.5	7.26		
3.5	15.7	5.87		
4.0	13.7	0.65		
4.5	12.2	0.09		
Stn HL1B Surface	16.9	7.58	6.64	
0.5	16.9	7.58		
1.0	16.9	7.62		
2.0	16.9	7.62		
3.0	16.5	7.16		
3.5	15.7	5.82		
4.0	13.6	0.62		
4.5	11.9	0.13		
5.0	11.0	0.09		

Sediment Sample Taken: ____ YES [✓ NO]

Sediment Sample Characteristics: ____ Clay ____ Gravel ____ Muck ____ Sand ____ Silt ____ Other (specify)

Sediment Sample Colour: ____ Black ____ Brown ____ Grey ____ Other (specify)

Sediment Sample Odour: ____ Not odourous ____ Odourous

Vegetation: ____ Emergent ____ Floating ____ Submergent ____ Other

Other Observations: ____

Surveyors Signature B. E. Holbert

31132 - March 1992

LAKE SURVEY FIELD NOTES

6 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT.

PART B: SURVEY INFORMATION

Survey Date: 13 Aug 92 Survey Time: 10:00 A.M.

Survey Team: B. E. Halbert and M. Mrchant

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): bright, partial cover

Waterbody Surveyed: Hasson Lake

Location Sampled: Mid Lake Deep Basin - Stn HL4

Water Sample(s) Taken: ✓ YES ________ NO

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre

✓ Composite (top, ~~mid depth~~, bottom)

________ Other (specify) ________________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

________ Brown Yellowish Tint Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)
Surface	17.0	7.66	6.64	
0.5	17.0	7.66		
1.0	17.0	7.66		
2.0	16.9	7.32		
3.0	16.8	7.27		
3.5	16.7	7.16		
4.0	15.8	5.64		
4.5	14.1	3.82		
5.0	12.8	0.10		
5.5	12.0	0.07		
6.0 *	11.9	0.05		
* Bottom				

Sediment Sample Taken: ______ YES [✓ NO]

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck ______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent ______ Other

Other Observations: ______

Surveyors Signature B. S. Walbert.

LAKE SURVEY FIELD NOTES

7 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mines Site

Watershed Name: Dog River Subwatershed.

Municipality: Thunder Bay, ONT

PART B: SURVEY INFORMATION

Survey Date: 13 Aug 92 Survey Time: 11:00 A.m.

Survey Team: B. C. Hallant and M. Mrchand

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): bright partial cover.

Waterbody Surveyed: Hasson Lake

Location Sampled: West Basin - Stn HL3 ; Inlet from Second Pond; outlet from West Basin

Water Sample(s) Taken: ✓ YES ________ NO
Stn HL3

Water Sample Type: ________ Top Metre ✓ Mid Depth ________ Bottom Metre
________ Composite (top, mid depth, bottom)
________ Other (specify) ________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green
________ Brown Yellowish Tint Other (Specify)

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Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (μmhos/cm)
Stn HL3				
Surface	17.1	7.81	6.64	
0.5	16.9	7.83		
1.0	16.7	7.66		
1.5	16.1	7.10		
Inflow from Second Pond (Below Rapids near Second Pond Outlet).				
	16.1	7.10	6,22	
Outflow from West Basin				
	16.9	7.84	6.59	

Sediment Sample Taken: ______YES ______NO

Sediment Sample Characteristics: ______Clay ______Gravel ______Muck ______Sand ______Silt ______Other (specify)

Sediment Sample Colour: ______Black ______Brown ______Grey ______Other (specify)

Sediment Sample Odour: ______Not odourous ______Odourous

Vegetation: ______Emergent ______Floating ______Submergent ______Other

Other Observations: Outlet from Hasson Lake in West Basin Measured ~ 2 m wide × 0.2 m deep and was flowing rapidly.

Surveyors Signature B. E. Holbert.

31132 - March 1992

LAKE SURVEY FIELD NOTES

8 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT.

PART B: SURVEY INFORMATION

Survey Date: 13 Aug 92 Survey Time: 1:45 P.M.

Survey Team: B.E. Halbert and M. Michaud

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ____________

Waterbody Surveyed: Second Pond Southwest of Tailings Management Facility.

Location Sampled: Stn SP4 - North Basin

Water Sample(s) Taken: ✓ YES ________ NO

Water Sample Type: ________ Top Metre ✓ Mid Depth ________ Bottom Metre

________ Composite (top, mid depth, bottom)

________ Other (specify) ____________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green

Yellowish Brown ________ Other (Specify)

Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Surface	16.9	6.69	6.40	
0.5	16.5	6.65		
1.0	16.3	6.05		
2.0	14.5	5.60		
3.0	11.8	0.22		
4.0	10.0	0.12		

Sediment Sample Taken: ______YES ✓ NO

Sediment Sample Characteristics: ______Clay ______Gravel ______Muck ______Sand ______Silt ______Other (specify)

Sediment Sample Colour: ______Black ______Brown ______Grey ______Other (specify)

Sediment Sample Odour: ______Not odourous ______Odourous

Vegetation: ______Emergent ______Floating ______Submergent ______Other

Other Observations: ______________________

Surveyors Signature B E Holt

LAKE SURVEY FIELD NOTES

9 of 9

PART A: GENERAL INFORMATION

Project Number: 31121 - Lac des Iles Mines Ltd.

Project Name: Baseline Monitoring - Lac des Iles Mine Site

Watershed Name: Dog River Subwatershed

Municipality: Thunder Bay, ONT.

PART B: SURVEY INFORMATION

Survey Date: 13 Aug 92 Survey Time: 3:30 p.m.

Survey Team: B. E. Halbert and M. Michaud

Air Temperature: ________ Precipitation: ✓ none ___ rain ___ snow

Overcast Conditions (percent cloud cover): ________

Waterbody Surveyed: Lac des Iles

Location Sampled: LL1 - Bay North of Mine Lodge
LL2 - Angle Bay

Water Sample(s) Taken: ✓ YES ________ NO
from LL1

Water Sample Type: ________ Top Metre ________ Mid Depth ________ Bottom Metre
✓ Composite (top, ~~mid depth~~, bottom)
________ Other (specify) ________

Water Colour: ________ Clear ________ Turbid ________ Blue/Green
________ Brown Light Yellowish Ting. Other (Specify)

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Lake Survey Field Notes, cont'd.

PART C: FIELD OBSERVATIONS AND NOTES

Depth (m)	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Field pH	Conductivity (µmhos/cm)
Station LL1 Surface	18.9	8.38	7.33	
1.0	18.0	8.52		
2.0	17.6	8.50		
3.0	17.2	8.08		
4.0	15.5	5.00		
5.0	11.2	0.24		
6.0	9.0	0.13		
Station LL2 Surface	18.5	8.43	7.35	
1.0	18.4	8.47		
2.0	18.1	8.47		
3.0	17.3	8.37		
4.0	17.2	8.00		
5.0	17.0	7.75		
6.0	16.7	7.75		
7.0	14.1	5.56		
8.0	11.0	2.40		

Sediment Sample Taken: ______ YES ___✓___ NO

Sediment Sample Characteristics: ______ Clay ______ Gravel ______ Muck
______ Sand ______ Silt ______ Other (specify)

Sediment Sample Colour: ______ Black ______ Brown ______ Grey ______ Other (specify)

Sediment Sample Odour: ______ Not odourous ______ Odourous

Vegetation: ______ Emergent ______ Floating ______ Submergent ______ Other

Other Observations: ______________________________

Surveyors Signature B. E. Halbert

31132 - March 1992

Ministry of
thern Develo
Mines
Ontario

52H04NE0013 2.15334 LAC DES ILES

900

Transaction Number
W9440-67

MINING LANDS

ersonal information collected on this form is obtained under the authority of the Mining Act. This information will be used for correspondence. Questions about is collection should be directed to the Provincial Manager, Mining Lands, Ministry of Northern Development and Mines, Fourth Floor, 159 Cedar Street, udbury, Ontario, P3E 6A5, telephone (705) 670-7264.

2.15334

nstructions:
- Please type or print and submit in duplicate.
- Refer to the Mining Act and Regulations for requirements of filing assessment work or consult the Mining Recorder.
- A separate copy of this form must be completed for each Work Group.
- Technical reports and maps must accompany this form in duplicate.
- A sketch, showing the claims the work is assigned to, must accompany this form.

ecorded Holder(s): Lac des Iles Mines Ltd.
Client No.: 217699
Address: 916-111 Richmond Street West Toronto, Ontario M5H 2G4
Telephone No.: (416) 867-3072
ining Division: Thunder Bay
Township/Area: Lac des Iles
M or G Plan No.: G 739
Dates Work Performed From: 16th Feb 1992 To: Oct 5 ~~Sept~~ 1992 (Lakefield)
2nd Oct 1992 5th Feb 1993 (J. Roy Gordon)

Work Performed (Check One Work Group Only)

	Work Group	Type
☐	Geotechnical Survey	
☐	Physical Work, Including Drilling	
☐	Rehabilitation	
☐	Other Authorized Work	Metallurgical Testing
☐	Assays	
☐	Assignment from Reserve	

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Total Assessment Work Claimed on the Attached Statement of Costs $ 95,389.88

Note: The Minister may reject for assessment work credit all or part of the assessment work submitted if the recorded holder cannot verify expenditures claimed in the statement of costs within 30 days of a request for verification.

Persons and Survey Company Who Performed the Work (Give Name and Address of Author of Report)

Name	Address
Lakefield Research	- Recovery of Cu, Ni, & PG Metals - Report #1
- Lakefield, Ontario	- Recovery of Cu, Ni, & PG Metals - Report #2
J. Roy Gordon Research Lab.	- Rock (MgO) Rejection - Report #2
- Mississauga, Ontario	- Rock (MgO) Rejection - Report #3

(attach a schedule if necessary)

Certification of Beneficial Interest * See Note No. 1 on reverse side

I certify that at the time the work was performed, the claims covered in this work report were recorded in the current holder's name or held under a beneficial interest by the current recorded holder.	Date Feb 8, 1994	Recorded Holder or Agent (Signature) W.B. Murphy

Certification of Work Report

I certify that I have a personal knowledge of the facts set forth in this Work report, having performed the work or witnessed same during and/or after its completion and annexed report is true.

Name and Address of Person Certifying: W.B. Murphy
Telepone No.: (416) 867-3072
Date: February 8, 1994
Certified By (Signature): W.B. Murphy

For Office Use Only

Total Value Cr. Recorded: $95,390
Date Recorded:
Deemed Approval Date: May 17/94
Date Notice for Amendments Sent:
Mining Recorder: for
Date Approved:

RECEIVED
THUNDER BAY MINING DIVISION
FEB 16 1994
A.M. 7 8 9 10 11 12 1 2 3 4 5 P.M.

0241 (03/91)

METALLURGICAL LAC DES ILES MINES LTD.

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
2.15334	(L) Lease No. 104409 352 264	1	$95,390.—	—	12000.—	83,390.—
	194308	2		$800.—		
	309	4		1600.—		
	310	4		1600.—		
	1165554	16		6400.—		
	1165556	4		1600.—		
			$ [illegible]	$ [illegible]	[illegible]	83 390.—

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MAR 7 - 1994
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dits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from ch claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

☐ Credits are to be cut back starting with the claim listed last, working backwards.
☑ Credits are to be cut back equally over all claims contained in this report of work.
☐ Credits are to be cut back as priorized on the attached appendix.

he event that you have not specified your choice of priority, option one will be implemented.

1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

2: If work has been performed on patented or leased land, please complete the following:

ertify that the recorded holder had a beneficial interest in the patented .eased land at the time the work was performed.	Signature W. B. Murphy	Date Feb. 24/94

Ministry of Northern Development an( )es

Mi( )re du Développement du Nord et des mines

ntario

Statement of Costs for Assessment Credit

État des coûts aux fins du crédit d'évaluation

Mining Act/Loi sur les mines

Transaction No./N° de transaction
W9440-067

2.15334

ersonal information collected on this form is obtained under the authority ' the Mining Act. This information will be used to maintain a record and 1going status of the mining claim(s). Questions about this collection should 3 directed to the Provincial Manager, Minings Lands, Ministry of Northern evelopment and Mines, 4th Floor, 159 Cedar Street, Sudbury, Ontario 3E 6A5, telephone (705) 670-7264.

Les renseignements personnels contenus dans la présente formule sont recueillis en vertu de la Loi sur les mines et serviront à tenir à jour un registre des concessions minières. Adresser toute question sur la collecte de ces renseignements au chef provincial des terrains miniers, ministère du Développement du Nord et des Mines, 159, rue Cedar, 4e étage, Sudbury (Ontario) P3E 6A5, téléphone (705) 670-7264.

Direct Costs/Coûts directs

Type	Description	Amount Montant	Totals Total global
Vages Salaires	Labour Main-d'oeuvre		
	Field Supervision Supervision sur le terrain		
:ontractor's and Consultant's Fees)roits de 'entrepreneur :t de l'expert-:onseil	Type Metallurgical	95,389.88	
	Environmental	90,995.37	
			186,385.25
upplies Used ournitures ıtilisées	Type		
:quipment ental .ocation de ıatériel	Type		
		Total Direct Costs Total des coûts directs	186,385.25

2. Indirect Costs/Coûts indirects

** Note: When claiming Rehabilitation work Indirect costs are not allowable as assessment work.
Pour le remboursement des travaux de réhabilitation, les coûts indirects ne sont pas admissibles en tant que travaux d'évaluation.

Type	Description	Amount Montant	Totals Total global
Transportation Transport	Type		
Food and Lodging Nourriture et hébergement			
Mobilization and Demobilization Mobilisation et démobilisation			
		Sub Total of Indirect Costs Total partiel des coûts indirects	
		Amount Allowable (not greater than 20% of Direct Costs) Montant admissible (n'excédant pas 20 % des coûts directs)	
		Total Value of Assessment Credit (Total of Direct and Allowable Indirect costs) Valeur totale du crédit d'évaluation (Total des coûts directs et indirects admissibles)	

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MINING DIVISION

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ɔte: The recorded holder will be required to verify expenditures claimed in this statement of costs within 30 days of a request for verification. If verification is not made, the Minister may reject for assessment work all or part of the assessment work submitted.

Note : Le titulaire enregistré sera tenu de vérifier les dépenses demandées dans le présent état des coûts dans les 30 jours suivant une demande à cet effet. Si la vérification n'est pas effectuée, le ministre peut rejeter tout ou une partie des travaux d'évaluation présentés.

ling Discounts

Work filed within two years of completion is claimed at 100% of the above Total Value of Assessment Credit.

Work filed three, four or five years after completion is claimed at 50% of the above Total Value of Assessment Credit. See calculations below:

otal Value of Assessment Credit		Total Assessment Claimed
	x 0.50 =	

Remises pour dépôt

1. Les travaux déposés dans les deux ans suivant leur achèvement sont remboursés à 100 % de la valeur totale susmentionnée du crédit d'évaluation.
2. Les travaux déposés trois, quatre ou cinq ans après leur achèvement sont remboursés à 50 % de la valeur totale du crédit d'évaluation susmentionné. Voir les calculs ci-dessous.

Valeur totale du crédit d'évaluation		Évaluation totale demandée
	x 0,50 =	

ɜrtification Verifying Statement of Costs

ɛreby certify:
at the amounts shown are as accurate as possible and these costs ɛre incurred while conducting assessment work on the lands shown 1 the accompanying Report of Work form.

ıt as Agent I am authorized
(Recorded Holder, Agent, Position in Company)

make this certification

Attestation de l'état des coûts

J'atteste par la présente :
que les montants indiqués sont le plus exact possible et que ces dépenses ont été engagées pour effectuer les travaux d'évaluation sur les terrains indiqués dans la formule de rapport de travail ci-joint.

Et qu'à titre de ______ je suis autorisé
(titulaire enregistré, représentant, poste occupé dans la compagnie)

à faire cette attestation.

Signature	Date
W. B. Murphy	Feb

ı2 (04/91)

Nota : Dans cette formule, lorsqu'il désigne des personnes, le masculin est utilisé au sens neutre.

Ministry of Northern Development and Mines
Ontario

Report of Work Conducted After Recording Claim

Mining Act

Transaction Number
W9440-68

MINING LANDS

Personal information collected on this form is obtained under the authority of the Mining Act. This information will be used for correspondence. Questions about this collection should be directed to the Provincial Manager, Mining Lands, Ministry of Northern Development and Mines, Fourth Floor, 159 Cedar Street, Sudbury, Ontario, P3E 6A5, telephone (705) 670-7264.

2.15334

Instructions:
- Please type or print and submit in duplicate.
- Refer to the Mining Act and Regulations for requirements of filing assessment work or consult the Mining Recorder.
- A separate copy of this form must be completed for each Work Group.
- Technical reports and maps must accompany this form in duplicate.
- A sketch, showing the claims the work is assigned to, must accompany this form.

Recorded Holder(s) Lac des Iles Mines Ltd.		Client No. 217699
Address 916-111 Richmond Street West, Toronto, Ontario M5H 2G4		Telephone No. (416) 867-3072
Mining Division Thunder Bay	Township/Area Lac des Iles	M or G Plan No. G 739
Dates Work Performed From: 4th March 1992	To: 19th November 1992	

Work Performed (Check One Work Group Only)

Work Group	Type
Geotechnical Survey	
Physical Work, Including Drilling	
Rehabilitation	
Other Authorized Work	Environmental Studies
Assays	
Assignment from Reserve	

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Total Assessment Work Claimed on the Attached Statement of Costs $ 90,995.~~37~~ 60
see attached sheet "A"

Note: The Minister may reject for assessment work credit all or part of the assessment work submitted if the recorded holder cannot verify expenditures claimed in the statement of costs within 30 days of a request for verification.

Persons and Survey Company Who Performed the Work (Give Name and Address of Author of Report)

Name	~~Address~~ Report
Dennis Netherton Eng.	Apr 14, 1992 - Bedrock Permeability Testing
- North Bay, Ontario	Aug 6, 1992 - Tailings Management Facility
	Oct 9, 1992 - Factual Soils Report
	- see attached Sheet "B"

(attach a schedule if necessary)

Certification of Beneficial Interest * See Note No. 1 on reverse side

I certify that at the time the work was performed, the claims covered in this work report were recorded in the current holder's name or held under a beneficial interest by the current recorded holder.	Date Feb 8, 1994	Recorded Holder or Agent (Signature) W B Murphy

Certification of Work Report

I certify that I have a personal knowledge of the facts set forth in this Work report, having performed the work or witnessed same during and/or after its completion and annexed report is true.

Name and Address of Person Certifying
W.B. Murphy

Telepone No. (416) 867-3072	Date February 8, 1994	Certified By (Signature) W B Murphy

For Office Use Only

Total Value Cr. Recorded $ 90,995	Date Recorded	Mining Recorder	Received Stamp
	Deemed Approval Date May 17/94	Date Approved	
	Date Notice for Amendments Sent		

THUNDER BAY
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ENVIRONMENTAL LAC DES ILES MINES LTD

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
2.15334	352 259	1	$ 2904.		$ 2904.	
	372	1	2904.		2904.	
	373	1	3621.		3621	
	374	1	3621.		3621.	
	375	1	3621.		3621	
	376	1	6121.		6121.	
	377	1	6121.		6121.	
	378	1	2904.		2904.	
	384489	1	2500.		2500.	
	384905	1	2499.		2499.	
	405 357	1	717.		717.	
	358	1	3621.		3621.	
	359	1	3622.		3622.	
	360	1	3216.		3216.	
	361	1	3622		3622.	
	362	1	3622.		3622.	
	367	1	2905.		2905.	
	Total Number		Total Value Work	Total Value Work Applied	Total Assigned From	Total Reserve

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
2. ☑ Credits are to be cut back equally over all claims contained in this report of work.
3. ☐ Credits are to be cut back as priorized on the attached appendix.

In the event that you have not specified your choice of priority, option one will be implemented.

Note 1: **Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.**

Note 2: **If work has been performed on patented or leased land, please complete the following:**

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature W. B Murphy	Date Feb 24/94

ENVIRON MENTAL

LAC DES ILES MINES LTD

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
2.15334	405 368		$ 2905.		$ 2905.	
	370		717.		717	
	371		717.		717.	
	373		2905.		2905.	
	374		2905.		2905.	
	375		2905.		2905.	
	873415		2905.	400.—	2505	
	116 5549	1	3217.	953.-	2264	
	5554	16	3217.	15,252.—		
	5558	8	2905.	7,627.—		
	1194308	2	3217.	1,906.—		
	309	4	717.	3,813.—		
	310	4	3622	3,813.—		
	30 Total Number		Total Value Work	Total Value Work Applied	Total Assigned From	— Total Reserve

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
2. ☑ Credits are to be cut back equally over all claims contained in this report of work.
3. ☐ Credits are to be cut back as priorized on the attached appendix.

In the event that you have not specified your choice of priority, option one will be implemented.

Note 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

Note 2: If work has been performed on patented or leased land, please complete the following:

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature W. B. Murphy	Date Feb. 21/94

ENVIRONMENTAL LAC DES ILES MINES LTD.

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
2.15334	864416	1		$ 400.		
	417	1		400.		
	418	1		400.		
	419	1		400.		
	420	1		400		
	421	1		400.		
	873412	1		400.		
	413	1		400.		
	414	1		400.		
	416	1		400.		
	909812	1		400.		
	813	1		400.		
	1165550	8		7626.		
	5551	8		7626.		
	5552	12		11,439.		
	5553	8		7,627.		
	5555	12		11,440.		

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edits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from ich claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

☐ Credits are to be cut back starting with the claim listed last, working backwards.

☑ Credits are to be cut back equally over all claims contained in this report of work.

☐ Credits are to be cut back as priorized on the attached appendix.

the event that you have not specified your choice of priority, option one will be implemented.

: 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

: 2: If work has been performed on patented or leased land, please complete the following:

ertify that the recorded holder had a beneficial interest in the patented leased land at the time the work was performed.	Signature W. B. Murphy	Date Feb. 24/94

ENVIRONMENTAL

LAC DES ILES MINES LTD

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
2.15334	1165556	4		3813.		
	5557	3		2860.		
			90,995.-	90,995.-	75,964.-	—

redits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from hich claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

- ☐ Credits are to be cut back starting with the claim listed last, working backwards.
- ☑ Credits are to be cut back equally over all claims contained in this report of work.
- ☐ Credits are to be cut back as priorized on the attached appendix.

the event that you have not specified your choice of priority, option one will be implemented.

e 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

e 2: If work has been performed on patented or leased land, please complete the following:

certify that the recorded holder had a beneficial interest in the patented leased land at the time the work was performed.	Signature	Date

Ministry of Northern Development and Mines
Ontario

Ministère du Développement du Nord et des mines

Statement of Costs for Assessment Credit
État des coûts aux fins du crédit d'évaluation

Mining Act/Loi sur les mines

Transaction No./N° de transaction
W9440-06763

2.15334

Personal information collected on this form is obtained under the authority of the Mining Act. This information will be used to maintain a record and ongoing status of the mining claim(s). Questions about this collection should be directed to the Provincial Manager, Minings Lands, Ministry of Northern Development and Mines, 4th Floor, 159 Cedar Street, Sudbury, Ontario P3E 6A5, telephone (705) 670-7264.

Les renseignements personnels contenus dans la présente formule sont recueillis en vertu de la Loi sur les mines et serviront à tenir à jour un registre des concessions minières. Adresser toute question sur la collece de ces renseignements au chef provincial des terrains miniers, ministère du Développement du Nord et des Mines, 159, rue Cedar, 4e étage, Sudbury (Ontario) P3E 6A5, téléphone (705) 670-7264.

1. Direct Costs/Coûts directs

Type	Description	Amount Montant	Totals Total global
Wages Salaires	Labour Main-d'oeuvre		
	Field Supervision Supervision sur le terrain		
Contractor's and Consultant's Fees Droits de l'entrepreneur et de l'expert-conseil	Type Metallurgical	95,389.88	
	Environmental	90,995.37	
			186,385.25
Supplies Used Fournitures utilisées	Type		
Equipment Rental Location de matériel	Type		
Total Direct Costs Total des coûts directs			186,385.25

2. Indirect Costs/Coûts indirects

** Note: When claiming Rehabilitation work Indirect costs are not allowable as assessment work.
Pour le remboursement des travaux de réhabilitation, les coûts indirects ne sont pas admissibles en tant que travaux d'évaluation.

Type	Description	Amount Montant	Totals Total global
Transportation Transport	Type		
Food and Lodging Nourriture et hébergement			
Mobilization and Demobilization Mobilisation et démobilisation			
Sub Total of Indirect Costs Total partiel des coûts indirects			
Amount Allowable (not greater than 20% of Direct Costs) Montant admissible (n'excédant pas 20 % des coûts directs)			
Total Value of Assessment Credit (Total of Direct and Allowable Indirect costs) Valeur totale du crédit d'évaluation (Total des coûts directs et indirects admissibles)			

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Note: The recorded holder will be required to verify expenditures claimed in this statement of costs within 30 days of a request for verification. If verification is not made, the Minister may reject for assessment work all or part of the assessment work submitted.

Note : Le titulaire enregistré sera tenu de vérifier les dépenses demandées dans le présent état des coûts dans les 30 jours suivant une demande à cet effet. Si la vérification n'est pas effectuée, le ministre peut rejeter tout ou une partie des travaux d'évaluation présentés.

Filing Discounts

1. Work filed within two years of completion is claimed at 100% of the above Total Value of Assessment Credit.
2. Work filed three, four or five years after completion is claimed at 50% of the above Total Value of Assessment Credit. See calculations below:

Total Value of Assessment Credit		Total Assessment Claimed
	× 0.50 =	

Remises pour dépôt

1. Les travaux déposés dans les deux ans suivant leur achèvement sont remboursés à 100 % de la valeur totale susmentionnée du crédit d'évaluation.
2. Les travaux déposés trois, quatre ou cinq ans après leur achèvement sont remboursés à 50 % de la valeur totale du crédit d'évaluation susmentionné. Voir les calculs ci-dessous.

Valeur totale du crédit d'évaluation		Évaluation totale demandée
	× 0,50 =	

Certification Verifying Statement of Costs

I hereby certify:
that the amounts shown are as accurate as possible and these costs were incurred while conducting assessment work on the lands shown on the accompanying Report of Work form.

that as Agent (Recorded Holder, Agent, Position in Company) I am authorized

to make this certification

Attestation de l'état des coûts

J'atteste par la présente :
que les montants indiqués sont le plus exact possible et que ces dépenses ont été engagées pour effectuer les travaux d'évaluation sur les terrains indiqués dans la formule de rapport de travail ci-joint.

Et qu'à titre de ______ (titulaire enregistré, représentant, poste occupé dans la compagnie) je suis autorisé

à faire cette attestation.

Signature	Date

212 (04/91)

Nota : Dans cette formule, lorsqu'il désigne des personnes, le masculin est utilisé au sens neutre.

Ontario

Ministry of
Northern Development
and Mines

Ministère du
Développement du Nord
et des Mines

Mining Lands Section
Geoscience Approvals Office
933 Ramsey Lake Road
6th Floor
Sudbury, Ontario
P3E 6B5

Telephone: (705) 670-5853
Fax: (705) 670-5863

Our File: 2.15334
Transaction #: W9440.67
.68

May 13, 1994

Mining Recorder
Ministry of Northern
Development and Mines
435 James Street South
Suite B003
Thunder Bay, Ontario
P7E 6E3

Dear Sir:

Subject: APPROVAL OF ASSESSMENT WORK ON MINING CLAIMS TB 1194308 ET AL. IN THE LAC DES ILES AREA.

The assessment credits for OTHER AUTHORISED WORK, Section 18 of the Mining Act Regulations, as listed on the original submission, have been approved as of May 13, 1994.

Please indicate this approval on the claim record sheets.

If you have any questions, please contact Clive Stephenson at (705) 670-5856.

Yours sincerely,

Ron C. Gashinski
Senior Manager, Mining Lands Section
Mining and Land Management Branch
Mines and Minerals Division

CDS/ls

cc: Resident Geologist
Thunder Bay, Ontario

√Assessment Files Library
Toronto, Ontario

W 9440-067

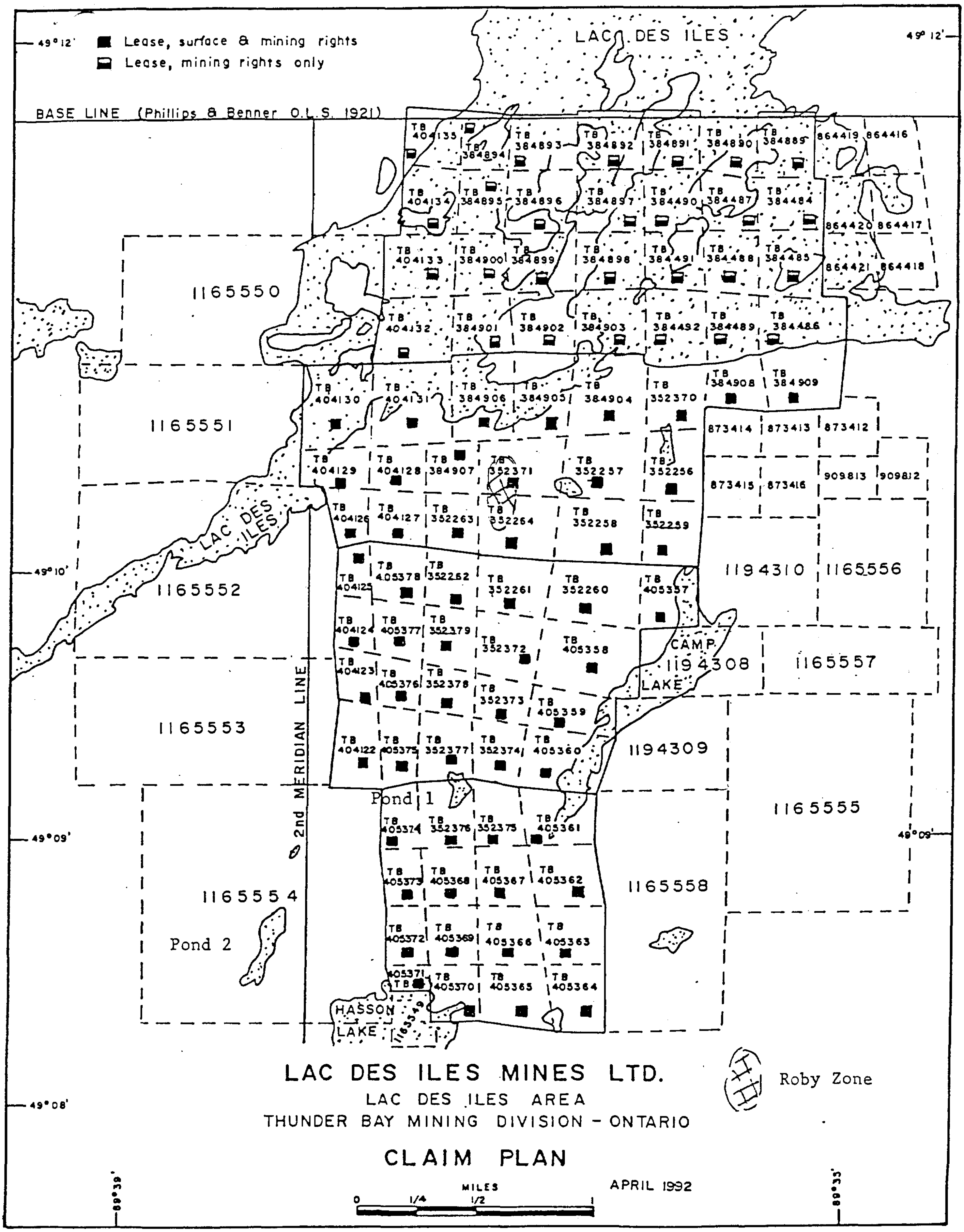
LAC DES ILES MINES LTD.

Lakefield Research

February 1992	$ 12,082.21	
March	15,024.05	
April	11,836.14	
May	10,192.46	
June	15,421.97	
July	13,416.56	
August	5,459.58	
September	1,456.91	$ 84,889.88

Inco - J. Roy Gordon Research Lab.

Progress Report #2 November 30, 1992	4,500.00	
Progress Report #3 February 5, 1993	6,000.00	10,500.00
		$ 95,389.88



LAC DES ILES MINES LTD.

LAC DES ILES AREA

THUNDER BAY MINING DIVISION - ONTARIO

CLAIM PLAN

APRIL 1992

LAC DES ILES MINES LTD. TORONTO, ONTARIO M5H 2G4

916 - 111 Richmond Street West
Tel: (416) 867-3072
Fax: (416) 867-9438

2.15334

February 24,1994

Mining Recorder
Ministry of Northern Development
& Mines
435 James Street South
Thunder Bay, Ontario
P7C 5G9

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Dear Sirs:

Attached are revised "Reports of Work" covering environmental and metallurgical studies, sent to your office earlier this month. Would you please add this to our previous submission.

Also attached are the qualifications of the authors of the reports.

Sincerely,

W.B. Murphy

W.B. Murphy Qual. # 2.5460.

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NIBLETT ENVIRONMENTAL ASSOCIATES INC.

Niblett Environmental Associates Inc. was founded in 1985 as an independent consulting firm, offering services to both industry and government. As an independent contractor, NEA offers confidential advice to private and public sector clients to assist in environmental decision making. The experienced personnel of NEA have represented clients' interests at various public and legal forums, from open houses and public meetings to regulatory hearings and criminal prosecutions.

NEA's special expertise is in water quality management of both freshwater and marine environments. In addition, we offer a full range of terrestrial services including woodlot surveys and wildlife assessments. We are particularly proud of our record in evaluating potential impacts affecting provincially significant wetlands.

Principals

Philip. D. Niblett

Founder and president of NEA, Mr. Niblett has seventeen years experience in environmental consulting. Four of these years were spent as head of the environmental group of a large Toronto based engineering firm. Mr. Niblett graduated from Trent University in 1973 with a B.Sc. in Biology and Psychology, and from the University of Guelph in 1975 with an M.Sc. in Environmental Physiology. His major area of expertise lies in the evaluation of organic and inorganic compounds on aquatic resources.

Janis. A. Speel

Dr. Speel graduated from Radcliffe College in 1967 with an A.B. in Biology. In 1976 she earned a Ph.D. in Zoology with a speciality in marine biology from the University of Maine. In 1982 she was appointed a Research Associate at the Royal Ontario Museum in Toronto. Dr. Speel is a vice-president of NEA and a director of the company.

David G. Cunningham

David Cunningham has worked with NEA since its inception. He is now a full time member of the firm. David brings a specialist expertise in vegetation and wetland inventories and analyses. He also directs most of the wildlife studies conducted by NEA.

C. Thomas Hoggarth

Tom Hoggarth is the NEA fisheries biologist. Since joining the firm in 1990, Tom has participated in or directed the majority of the aquatic survey programs.

Curriculum Vitae for all staff members are available.

P.O. BOX 160, BETHANY, ONTARIO L0A 1A0
(705) 277-1020 FAX (705) 277-1951

POSITION

Vice President and Secretary-Treasurer
Director of Water Quality Management Studies

EDUCATION

B.A.Sc., Civil Engineering, 1968, University of Waterloo
M.Sc., Environmental Health Engineering, 1970, University of Texas at Austin

PROFESSIONAL AFFILIATIONS

American Water Works Association
Pollution Control Association of Ontario
Water Pollution Control Federation

EXPERIENCE

1980-date SENES Consultants Limited. Corporate responsibility for management of the firm's financial affairs. Project responsibilities include management and coordination of water quality monitoring and modelling investigations, sanitary engineering studies and research projects.

Coordinator of a multi-disciplinary team in the development of the uranium tailings assessment program - UTAP, a probabilistic assessment code for predicting the long-term effects of uranium mine tailings. Lead investigator in the development of mathematical models to describe the source term and receiving water components and in the determination of model parameter values and their associated statistical distributions. Project manager on a study of uncertainty analysis in probabilistic modelling and on investigations into the application and interpretation of sensitivity and uncertainty analysis techniques.

Project director in the development of the reactive acid tailings assessment program - RATAP, a comprehensive model of the processes controlling acid generation in sulphidic mine tailings. Team leader on a subsequent assignment to adapt RATAP to model acid generation from high sulphide bearing base metal tailings. Also, lead researcher in an assessment of the role of bacteria in the oxidation of pyritic tailings. These studies considered in-depth the mechanisms of microbial oxidation, the environmental factors controlling the rate of oxidation and the applicability of tailings management technologies in limiting acid generation.

Project manager on studies of the change in trophic status of recreational lakes in northern Ontario due to shoreline development proposals. Project director on an investigation into the effects of

Bruce E. Halbert

nuclear generating station emissions on water quality in the Great Lakes to support an application to the National Energy Board for the export of power.

Technical specialist on several environmental baseline studies including: a long-term investigation of the effects of acidic precipitation on a forested watershed; an intensive one-year study to characterize tailings and the surrounding environs at a uranium tailings disposal site; a two-phase study on the distribution of naturally-occurring radionuclides in freshwater benthos and their environment; a pre-operational baseline monitoring program of ground water, surface water, fish, vegetation, soil and sediment at the site of a new uranium refinery on the North Channel of Lake Huron; and a pre-operational investigation of baseline conditions at the site of a beryllium and rare earth deposit on the north shore of Great Slave Lake in the NWT.

Project manager on a study to assess the applicability of underwater tailings disposal for the management of uranium mine tailings. The project included the development of a water quality model to predict downstream effects on chemical and radiological quality. Also assessed the environmental implications of sub-surface flow at uranium tailings facilities on receiving water quality. These studies included estimation of tailings seepage characteristics, evaluation of receiving water quality impacts and development of environmental monitoring and contingency response plans.

Senior investigator in the evaluation of acid generation sources from uranium mining operations in northern Ontario. The study included laboratory investigations of pyrite and ammonia oxidation rates and assessment of the relative acid contributions from pyrite oxidation at numerous tailings and waste rock sources, ammonia oxidation in the river system and deposition of acid precipitation.

Environmental engineer on the feasibility study of potential concepts for decommissioning and reclamation of a uranium mine/mill facility in northern Saskatchewan. The engineering requirements and environmental implications of applying various concepts to each of the facility components were addressed in this first ever close-out report prepared for a Canadian uranium mine operator.

Project director on a study to assess alternative concepts for decommissioning open pits at a uranium mining property in northern Saskatchewan including modelling of water quality changes in Wollaston Lake and of incremental doses to local residents. Also, acted as the principal reviewer of a study of management options for the disposal of low-level radioactive wastes.

Contributing author in the development of derived release limits for uranium refinery operations in three separate studies including evaluation of process wastewater characteristics and the resultant incremental increases in receiving water concentrations.

Specialist advisor on a study of alternative management concepts for the treatment and disposal of sewage sludge from several small scale municipal wastewater treatment facilities on Vancouver Island.

1970-1980 James F. MacLaren Limited. Assistant Manager, Water Treatment and Waste Disposal Division, 1974. Manager, Municipal Treatment, 1978.

Project manager for reports on industrial wastewater treatment for a meat packer, hardboard mill, refinery and petrochemical complexes, railway yard facilities, and fruit and vegetable processors. Study on in-plant water use, wastewater treatment and reuse for a large manufacturing company. Design of central treatment works for several industries in Ikeja, Nigeria.

Lead author and coordinator of water quality investigations on several environmental assessments including proposed uranium mines expansion, an investigation of alternative sewerage schemes, three site selection studies for a new uranium refinery in Ontario, and evaluation of the effects of Ontario pulp and paper mills on Great Lakes water quality. Advised on the development of receiving water criteria for a large petroleum based complex in Jubail, Saudi Arabia.

Prime sanitary engineering role in the evaluation and design of large municipal sewage treatment systems including plants for the cities of Toronto, Winnipeg, and Regina. Assistance in the design of treatment systems for a number of other domestic cities as well as municipal developments in Nigeria, Cyprus and Saudi Arabia. Participant in regional sewerage studies with responsibility for evaluation of alternative treatment systems and their environmental implications for several municipalities in Ontario.

Project manager on several wastewater and sewage sludge treatability investigations including both laboratory and pilot scale studies. Contributing author on several studies at airports involving the characterization of industrial wastewaters, sanitary sewage and stormwater runoff and the conceptual design of industrial and sanitary wastewater treatment systems. Project manager on a stormwater runoff monitoring investigation at Toronto International Airport.

Project engineer and manager for several inventory studies including: sources and emissions of asbestos, beryllium, lead, and mercury; hazardous pollutants in the Lower Great Lakes; and several industrial waste characterization studies.

TECHNICAL PAPERS

"Application of the Reactive Acid Tailings Assessment Program to Pyritic Mine Tailings." To be presented at the 28th Annual CIM Conference of Metallurgists, Halifax, Nova Scotia, 20 to 24 August, 1989 (with R.A. Knapp, J.W. Maltby and A.J. Vivyurka).

"Reactive Acid Tailings Assessment Program (RATAP): The Concepts and Application." To be presented at the Joint Annual Meeting of the Geological Association of Canada and the Mineralogical Association of Canada, Montreal, Quebec, 15 to 17 May, 1989 (with R.V. Nicholson, J.M. Scharer, W.J. Snodgrass and J.D. Phyper).

"Environmental Assessment Modelling." Section 8.1 of the IAEA Monograph on the Environmental Behaviour of Radium, 1988 (with D.B. Chambers, V.J. Cassaday and F.O. Hoffman).

"Probabilistic Assessment of the Long-Term Effects of Uranium Mill Tailings." Presented at the Second International Conference on Radioactive Waste Management, Winnipeg, Manitoba, September 1986 (with R.W. Holmes, D.B. Chambers, M.L. Murray and D.I. Beals).

"Probabilistic Analysis of the Environmental Behaviour of Uranium Mill Tailings." Presented to the Society for Computer Simulation, San Diego, January 1986 (with D.B. Chambers, M.L. Murray and D.I. Beals).

"Safety Assessment of Uranium Mill Tailings: The National Uranium Tailings Program." Presented at the annual meeting of the Canadian Nuclear Society, Ottawa, ON, June 1985 (with W.C. Harrison and D.B. Chambers).

"Determination of Acid Generation Rates in Pyritic Mine Tailings." Presented at the 56th Annual Conference of the Water Pollution Control Federation, Atlanta, GA, October 1983 (with J.M. Scharer, R.A. Knapp and D.M. Gorber).

"Modelling of the Underwater Disposal of Uranium Mine Tailings in Elliot Lake." Presented at the International Symposium on Management of Waste from Uranium Mining and Milling, Albuqerque, NM, May 1982 (with J.M. Scharer, E. Barnes and J.L. Chakravatti).

"Development and Application of a Water Quality Model for Use in an Environmental Assessment." Water Pollution Research Journal of Canada, Vol. 15, pp. 59-79, 1980 (with J.M. Scharer and B.G. Ibbotson).

"The Use of Peaking Factors in Equalization Basin Design." Paper presented at the Third National Conference on Environmental Research, Development and Design, Seattle, WA, 1976 (with D.M. Gorber and J.M. Scharer).

"Application of Flow Equalization." Presented at the Technology Transfer Seminar on High Quality Effluents sponsored under Canada-Ontario Agreement on Great Lakes Water Quality, Toronto, ON, 1975 (with D.M. Gorber and J.M. Scharer).

"Equalization Basin Design: Methodology and Benefits." Presented at the Twenty-fifth Canadian Chemical Engineering Conference, Montreal, PQ. 1975 (with D.M. Gorber and J.M. Scharer).

"To Establish Viable Methods of Maintaining Waste Treatment Facility Efficiencies with Reference to Waste Variations." Presented at the Fourth Joint Chemical Engineering Conference, Vancouver, British Columbia, 1973; Published by the American Institute of Chemical Engineers in New York, 1974 (with C.J. Edmonds and D.M. Gorber).

DAVID A. ORAVA, P.ENG.

EDUCATION AND AFFILIATIONS

EDUCATION:	McGill University, 1981 - Master of Engineering McGill University, 1979 - Bachelor of Engineering - Mining Dawson College (C.E.G.E.P.) - Pure and Applied Science
SCHOLARSHIPS:	Dawson Porter Engineering Prize McGill University Scholarship McGill University Bursary C.M.I.E.F. University Scholarship Secondary School Scholarships
AFFILIATIONS:	Association of Professional Engineers of Ontario Canadian Institute of Mining, Metallurgy, Petroleum
TECHNICAL PAPERS:	Innovations in Mining - Presented to A.P.E.O. Mechanized Excavation - Presented to C.I.M. Mine Development - Presented to C.I.M.

EXPERIENCE RECORD

1992 to present — DENNIS NETHERTON ENGINEERING, North Bay

Mr. Orava joined DNE on January 1, 1992 in the capacity of Principal and Manager of Engineering. He has since been involved in all DNE projects.

He is currently the DNE Project Manager for the following projects:

1. Placer Dome Inc., Dome Mine - Summer '92 Construction Program
2. Minnova Inc., Winston Lake - Closure Planning
3. Lac des Iles Mines Ltd. - New Tailings Area Field Investigations, Planning and Design.

1991 — UMA ENGINEERING LTD., Sudbury

Mr. Orava was the Head of the Environment and Mining Group. He was involved with providing project management and technical input for both civil and mineral industry projects. He was the UMA Project Manager for several projects including:

1. Falconbridge Gold - Tailings and Water Retention Dam Inspections and Recommendations.

2. Teck Corona - Bulk Fuel Plant, Safety Audit and Planning.
3. Confidential - Resolution of disputes between Owner and Contractor on a major civil project.

Mr. Orava also provided extensive technical input to hydrological, hydrogeological, and environmental projects either undertaken or proposed by UMA for Falconbridge Limited and INCO Limited.

1990 EAGLE MINING CONTRACTORS INC., Sudbury

Mr. Orava was the Vice-President of this General Contract firm. His responsiblities included most aspects of operating the business such as administration, supervision, budgeting and cost control, safety, technical evaluations, estimating and scheduling, design, and negotiations.

On occasion he acted as project manager for several engineering, procurement, and installation projects. He also provided supervision to surface construction crews which typically included millwrights or riggers, welders, electricians, crane operator, and general labourers.

1986 - 1990 DYNATEC MINING LIMITED, Richmond Hill

Mr. Orava joined Dynatec as a senior engineer and was soon promoted to Manager of Contract Development reporting to the President.

His primary duties in this fast growing and innovative company included:

1. Supervision of technical and administration and field personnel.
2. Assisting area managers in dealings with clients.
3. Tendering.
4. Contract Administration and Project Management.

From time to time, Mr. Orava was asked to provide input on special projects such as the INCO Thompson I-D, and the Manitoba Potash projects.

Mr. Orava was occasionally directly involved in field work which ranged from initial site clearing through to the custom milling of ore.

1981 - 1986 J.S. REDPATH LIMITED, North Bay

Mr. Orava was a Mining Engineer/Assistant Superintendent involved in field and engineering consulting work, marketing, new equipment selection, supervision, tendering, budgeting and cost control, uranium mining, mine ventilation, mine planning, mine closures, design work and feasibility studies. He also acted as the Redpath Project Manager on numerous consulting engineering projects.

1979 - 1980	IRON ORE COMPANY OF CANADA, Labrador City Mining engineer involved in mine engineering and open pit operations.

DAVID MACHIN

EDUCATION

University:	Memorial University, B.Science - Geology 1987 Queen's University, B. Science - Geological Engineering, Geotechnical Option, 1991
PROFESSIONAL	Graduate Engineering in Training, APEO

EXPERIENCE RECORD

March 1991 to Present	DNE - Project Engineer, involved with geo-environmental site assessments, including landfills, hydrocarbon, and metals contamination, report writing and remediation. Supervision of large Earth Dam construction projects, involving grouting, design and site evaluations, rock and earth work. Structural and formational mapping of and geotechnical evaluation of subsurface formations by test pitting, auger and diamond drilling, and supervision of technical and construction work crews
Summer 1990	ASARCO - Exploration and Structural Geologist, supervised field crews and responsible for final mapping of Northern Ontario claims.
Summer 1989	Len Corcoran Exc. - Surveying
Summer 1988	Iron Ore Company - Exploration and Structural Geologist, responsible for several field mapping projects in Labrador.
Winter 1988	G.S.C., Ottawa - Preparation of final Geological mapping projects.
Summer 1983 to 1987	G.S.C., Western Newfoundland - Assisted in numerous geological field exploration and mapping programs.
Summer 1982	G.S.C., Northern Labrador, assisted in geological mapping program.

LAKEFIELD RESEARCH

SUE PARKER
Project Manager

SUMMARY OF EXPERIENCE

	Lakefield Research
1992 to 1993	Project Manager
1989 to 1992	Senior Project Metallurgist
1986 to 1989	Project Metallurgist
1976 to 1986	Senior Technician

1975 to 1976
H.R. Oldale, Consulting Geologist
Assistant

EDUCATION
Mining Technology Diploma, College of Cape Breton, 1976

PROJECT EXPERIENCE

Ore Type or Description	Project Name & Location	Company	Area of Involvement
Cu	Bald Mountain	Chevron Resources	Flotation
	Carajas Copper	CVRD/Bechtel	Flotation
Cu-Ni	Amax	Amax	Flotation
	Kelly Lake	Moneta	Flotation - MSP
	Mt. Keith	FNML	Flotation
	Matte Samples	FNML	Flotation
	Wellgreen	Galactic Resources	Flotation
	Dunka Road	Nerco Explorations	Flotation
Cu-Zn	B.C.	Sumitomo/Kutcho Creek	Flotation
	Bald Mountain	Chevron Resources	Flotation
Cu-Zn, Ag	Mobrun Mine	Selbaie Mines	Flotation - PP
Cu-Pb-Zn	Silver Queen	Houston Metals	Flotation
	Lynne, Wisc.	Noranda Mines	Flotation
	Heath Steele	Noranda Mines	Flotation
	J and L Deposit, B.C.	Equinox	Flotation - PP
Cu-Mo	Cerro Colorado	Bechtel -RTZ	Flotation
Pb-Zn	B.C.	Equinox	Flotation
Au	Kirkland Lake	Eastmaque	Flotation - CN
	Timmins Tailings	Energy & Resources	Flotation - CN
		Nortek Minerals	Cyanidation
	Detour Lake	Campbell Red Lake	Flotation - CN
	Ghana	Ashanti Gold	Grav. Flo-CIL
Au-Ag	Bald Mtn Gossan	Chevron Resources	Flotation
	Eskay Creek	Corona Corp.	Gravity - Flo
Zn-Ag	Logan Deposit	Strathcona	Flotation

Ore Type or Description	Project Name & Location	Company	Area of Involvement
Sb		Durham Resources	Flo - Leach
Potash	New Brunswick	Denison Mines	Flotation
Diamonds		Falconbridge	
SrSO4	N.S.	Chromasco	Flo - Leach
REO	Greenland	Highwood	Flotation
		Strathcona	Flo - Leach
AsPy	J and L Deposit, B.C.	Cheni Gold	Flotation

EXPERIENCE LIST

Company / Deposit	Location	Type
Amax		Cu - Ni
20th Century Energy		Cu - Mo
Sumitomo	Kutcho Creek	Cu - Zn
Eastmaque	Kirkland Lake	Au
Energy and Resources	Timmins Tailings	Au
Bechtel RTZ	Cerro Colorado	Cu - Mo
Durham Resourecs		Sb
Denison Mines	New Brunswick	Potash
Falconbridge	various matte samples	Cu - Ni
Falconbridge		Diamonds
Campbell Red Lake	Detour Lake	Au
Chromasco	Nova Scotia	SrSO4
Chervon Resources	Bald Mountain	Cu
Highwood	Greenland	REO
Houston Metals	Silver Queen	Cu, Pb, Zn, Au, Ag
Chervon Resources	Bald Mountain Gossan	Au, Ag
Galactic Resources	Wellgreen	Cu - Ni, Pt, Pd
Nortek Minerals		Au
CVRD/ Bechtel	Carajas Copper	Cu
Strathcona	Logan Deposit	Zn, Ag
Moneta Porcupine Mines	Kelly Lake	Cu - Ni
Prime Exploration	Eskay Creek	Au - Ag, Pb, Zn
Echo Bay Lupin Mill Tails	NWT	Au - As
Noranda Mines - Tundra	NWT	Refractory Au
Congress Mines		Au
Comsur Mine	Bolivia	Pb, Zn, Ag
Rio Algom	East Kemptville	Sn
J and L / Equinox	B.C.	Pb, Zn, Au, Ag
Mt Milligan	B.C.	Au, Cu
Echo Bay AJ	Alaska	Au
Selbaie Mines	Mobrun	Cu, Zn, Au
Prime / Corona	Eskay Creek	Au, Ag, Pb,Zn,Sb,As
Servicios Industriales Penoles	Mexico	Oxide Zn
Noranda Mines	Lynne	Cu - Pb , Zn , Ag
Noranda Mines	Heath Steele	Cu - Pb, Zn
Noranda Mines	Snod Grass	Au
J and L / Cheni Gold	British Columbia	AsPy - Au
Nerco/ Zundel	Dunka Road	Cu-Ni, Pt, Pd
Ashanti/Kilborn	Ghana	Au

LAKEFIELD RESEARCH

Steven R. Williams, B.App.Sc.
Manager - Mineral Processing (Interim)

PERSONAL DATA
Born: 1955, in Fremantle, Australia
Came to Canada in 1987

PROFESSIONAL ASSOCIATIONS
CIMM

EDUCATION
Bachelor of Applied Science (Extractive Metallurgy)
W.A. Schools of Mines, Kalgoorlie, Western Australia - 1976

OTHER LANGUAGES
French

SUMMARY OF EXPERIENCE

Lakefield Research

Jan - June 1994 :	Manager - Mineral Processing (Interim)
1992 to 1994:	Senior Project Manager
1989 to 1991:	Senior Metallurgist

1987-1989
East West Caribou Mining Ltd., Bathurst, NB
Lead Zinc Mine
Concentrator Manager (1987-1989)
Metallurgy Research and Development Manager, 1989

1986-1987
East West Minerals, Sydney, Australia
Lucky Break Gold Mine
Project Manager/Metallurgist

1979-1986
Woodlawn Mines, Goulburn, NSW, Australia
Copper Lead Zinc Mine
Senior Operations Metallurgist

1977-1978
Agnew Mining, Leinster, WA, Australia
Nickel Operation
Metallurgist

1976-1977
Australian Selection Pty Ltd., Perth, WA, Austalia
Teutonic Core Copper Zinc Operation
Metallurgist

PUBLICATIONS

"Process Development and Control at Woodlawn Mines"
C. J. Burns, P. J. Duke and S. R. Williams,
XIV International Mineral Processing Conference, Toronto - 1982

"Process Development at Woodlawn Mines"
S. R. Williams and J. M. Phelan
Complex Sulfides Processing of Ores, Concentrates and By-Products Conference
The Metallurgical Society, AIME, San Diego - 1985

"Autogenous Grinding Practise at the Caribou Concentrator"
L. P. Taggart and S. R. Williams
International SAG Milling Conference, Vancouver, 1989

"A New On-Stream Size Indicator: PSI 200"
M.Falutsu and S. Williams
CMP Conference, Ottawa, 1993

"Falconbridge's Raglan Project: A Development Update and Description of the Concentrator Circuit Design"
D. Hyma and S. Williams
CMP Conference, Ottawa, 1993

"Limitations in the Application of Column Flotation"
B.J. Huls and S. Williams
XVIII IMPC, Sydney, Australia, May 1993

PROJECT EXPERIENCE

Ore Type or Description	Project Name & Location	Company	Area of Involvement
Cu/Zn	Teutonic Bore, WA, Australia	Australian Selection Pty	Metallurgist
Ni	Agnew Mining, Austalia	Agnew Mining	Metallurgist
Cu/Pb/Zn	Woodlawn Mines, Austalia	Woodlawn Mines	Sr. Ops. Metallurgist
Au	Lucky Break, Queensland, Aust.	East West Minerals	Project Manager
	Columns, Kirkland Lake, Can.	Eastmaque Gold	Sr. Metallurgist
	Lac, Toqui, Chile	Lac Chile	Project Manager
	Giant Yellowknife Mine, NWT	Giant Yellowknife Mines	Sr. Metallurgist
	Juneau, Alaska	Echo Bay Mines	Project Manager
	Chapais, Quebec	Metall Mining Corp.	Sr. Project Manager
Pb/Zn	Caribou Mines, NB	East West Caribou Mining	Met. & Dev. Mgr
	Brunswick Mining & Smelting,NB	BM&S	Project Manager
	Ganesh Himal, Nepal	United Nations	Sr. Project Manager
Cu/Ni	Manitoba, Can. & Maine, USA	Black Hawk Mining	Sr. Metallurgist
	Raglan, Que.	Falconbridge Ltd.	Project Manager
Graphite	Sweden	ANRO Graphit AB	Sr. Metallurgist
	Ontario, Canada	Cal Graphite	Sr. Project Manager
Cu	Gecamines, Zaire	Gecamines	Project Manager
	Freeport, Indonesia	Freeport Res. & Dev.	Project Manager

LAKEFIELD RESEARCH

K. W. SARBUTT
B. Sc., Minerals Engineering
Manager - Mineral Processing

SUMMARY OF EXPERIENCE

	LAKEFIELD RESEARCH
1981 to date:	Manager - Mineral Processing
1973 to 1981	Senior Project Engineer
	LAKEFIELD RESEARCH CHILE S.A.
Jan.-June 1994	Acting Manager
	A.R. MacPHERSON CONSULTANTS LTD.
1990 to date:	Manager
1970 to 1972	UNION CORPORATION Metallurgist

PROFESSIONAL ASSOCIATIONS

EDUCATION

B. Sc., University of Birmingham, England, 1969

PUBLICATIONS AND PATENTS

The Carbon-in-Pulp Process
K.W. Sarbutt, D.M. Wyslouzil
Lecture and Seminar, Laval University, Quebec, 1982

Principles of Cyanidation
K.W. Sarbutt
Lecture and Seminar, McGill University, Montreal, 1983

The Recovery of Gold From a Telluride Concentrate
I. Jackman and K.W. Sarbutt
Presented at Randol Gold Forum '90, Squaw Valley, California, Sept. 1990

Developments in Flotation at Lakefield Research
K.W. Sarbutt
Presented at the Northwest Mining Association Conference, Spokane, Dec. 1990

US 4283017 Selective Flotation of Cubanite and Chalcopyrite from Copper/Nickel Mineralized Rock
R.D. Coale, K.W. Sarbutt, D.B. Smith, 1979

MAJOR PROJECTS

Mineral Processing

A. Gold Ores

Union Corporation, South Africa
- Mill Metallurgist, Operation
- Shut down of mills

Detour Lake Mines Limited
- Process development
- Pilot plant investigation
- Grinding, flotation, CIP

Comp. Min. El Indio, Chile
- Process study
- CIP, pressure desorption
- Design of laboratory equipment

Lurgi Corporation, Western Division
- Flowsheet design
- Pilot plant design
- Cyanidation, CIP

Noranda Golden Giant
- Flowsheet design
- Pilot plant study
- Cyanidation, CIP

Kiena Gold Mines
- Flowsheet design
- Pilot plant design
- SAG milling, cyanidation, CIP

Kennecott, Lihir Island
- Flowsheet design
- Pilot plant study
- POX, roasting, flotation

Star Lake, SMDC
- Process development
- Process review
- On site testwork

Campbell Red Lake Mines
- In plant CIP testwork
- Flotation, roasting

ERG Resources
- Pilot plant testwork
- Flowsheet development

Eastmaque Gold Mines
- Flowsheet development
- Pilot plant study
- Process review
- In plant testing

Placer (PNG) Proprietary Ltd.
- Bench scale flowsheet development including gravity and flotation
- Pilot plant operation for production of concentrate from bulk samples

B. Copper-Lead-Zinc Ores

Sumitomo Mining Company
- Pilot plant supervision
- Process evaluation

C. Copper-Nickel Ores

Amax Exploration
- Minnimax Project development
- Pilot plant autogenous grinding
- Flotation (patent)

New Quebec Raglan Mines Ltd.
- Flowsheet design
- Extensive laboratory research

D. Miscellaneous Ores

Iron, phosphate, pyrochlore, potash, tin
Extensive pilot plant, flowsheet development experience

Hydrometallurgy

Consolidated Rexspar Minerals and Chemicals Ltd.

Low pressure autoclave leach, column leaching, ferric sulphate autogenous leaching. Cycle tests under various conditions, equipment design for column leaching, sampling and temperature control.

The Anschutz Corporation

Pressure leaching of tungsten concentrates, solution purification, preparation of tungsten acid and ammonium paratungstate, crystallization of APT.

Uranium Ores

Acid leaching, solution purification, ion exchange and precipitation on a great variety of domestic and foreign ores.

Inco

Dr. Bruce R. Conard
Director
Process Research

21 February 1994

Mr. Bern Murphy
North American Palladium
111 Richmond St., West
Suite 916
Toronto, Ontario M5H 2G4

Dear Mr. Murphy,

Following your verbal request, this letter will clarify the authorship of the Progress Reports issued by us on the Lac des Iles project between mid-1992 and mid-1993.

The authors of the reports are:

Mr. Germain Labonté - Senior Research Engineer, who has nearly completed his Ph.D. degree at McGill University;

Mr. Kevin Stewart - Technologist, who received a Chemical Engineering technology diploma from Sheridan College.

They are both employed within the Mineral Processing Section of Inco's J. Roy Gordon Laboratory. The reports have been approved by either Dr. Gordon Agar (now retired) or Dr. Ric Stratton-Crawley, Section Head of Mineral Processing.

I hope this is the information you require.

Sincerely yours,

BRConard.

BRC/bc

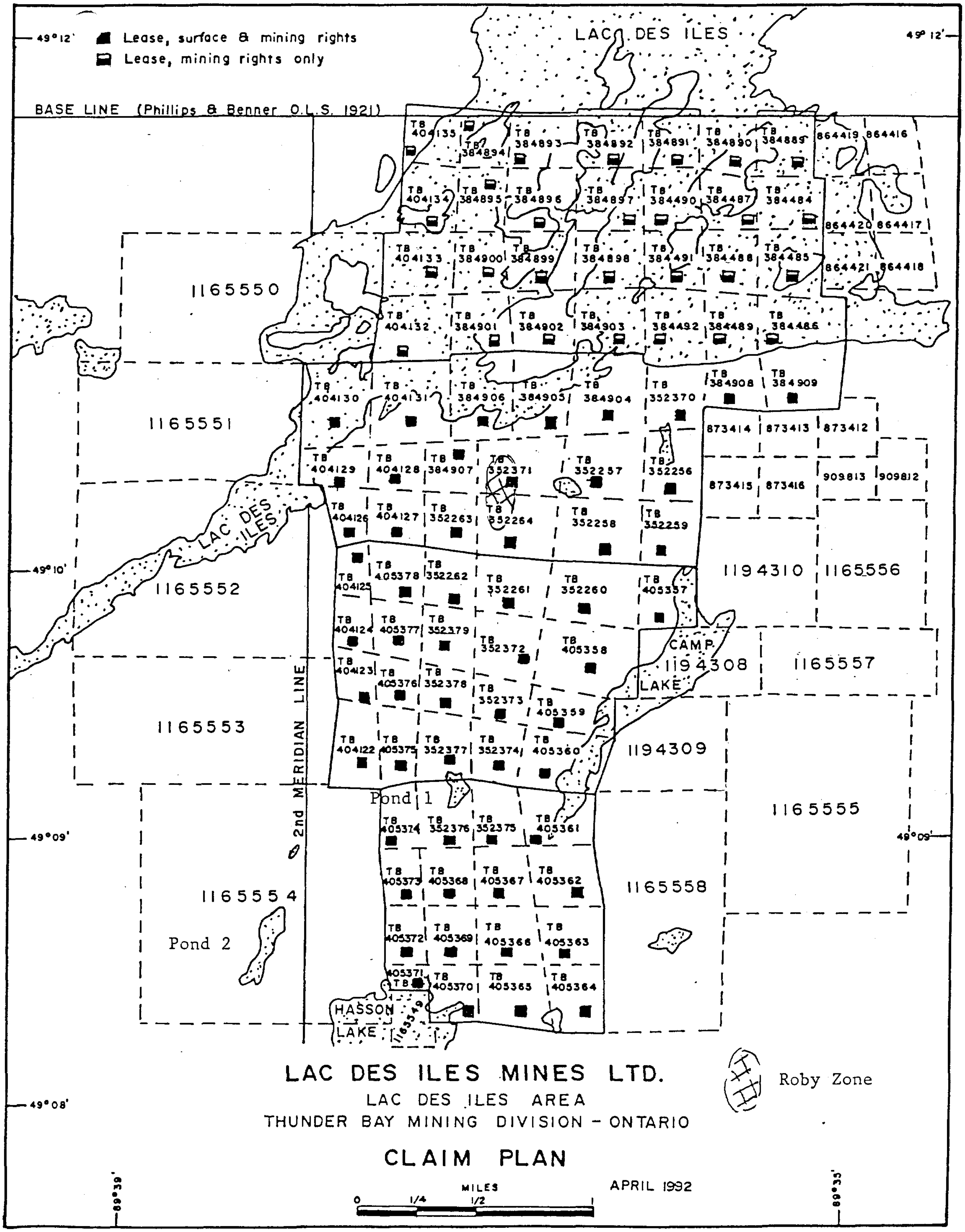
xc R.E. Butler

Inco Limited, J Roy Gordon Research Laboratory, 2060 Flavelle Boulevard, Mississauga, Ontario, Canada L5K 1Z9
Telephone (905) 403-2460 • Facsimile (905) 403-2530

LAC DES ILES MINES LTD. 2.15334

Name	**Report**
Senes Consultants Ltd. Richmond Hill, Ontario	April 1992 B.L. Surface Water & Sed. Quality Survey
	November 1992 B.L. Surface Water & Sed. Quality Monitor Program
Niblett Environmental Assoc. Inc. Bethany, Ontario	July 1992 B.L. Biological Survay

SHEET "B"



LAC DES ILES MINES LTD.

LAC DES ILES AREA
THUNDER BAY MINING DIVISION – ONTARIO

CLAIM PLAN

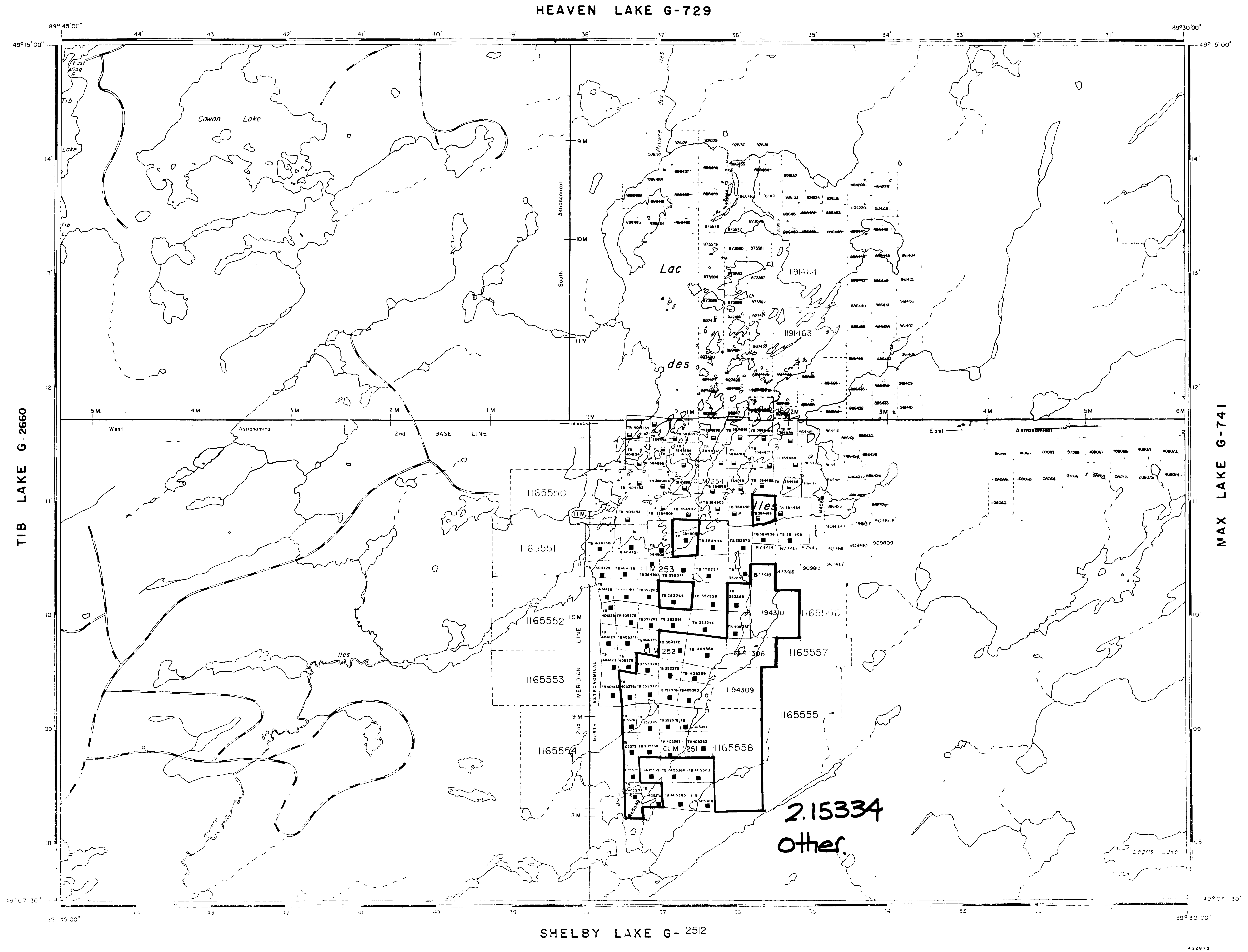
APRIL 1992

REFERENCES

AREAS WITHDRAWN FROM DISPOSITION

M.R.O. – MINING RIGHTS ONLY
S.R.O. – SURFACE RIGHTS ONLY
M.+ S. – MINING AND SURFACE RIGHTS

Description	Order No	Date	Disposition	File
Summer Resort Locations Not Open For Staking Sec 3(c)				



2.15334
Other.

REFERENCES

TOPOGRAPHY

LAKES, RIVERS, ETC, FROM FOREST RESOURCES INVENTORY SHEET Nº 492 893

THE INFORMATION THAT APPEARS ON THIS MAP HAS BEEN COMPILED FROM VARIOUS SOURCES, AND ACCURACY IS NOT GUARANTEED THOSE WISHING TO STAKE MINING CLAIMS SHOULD CONSULT WITH THE MINING RECORDER, MINISTRY OF NORTHERN DEVELOPMENT AND MINES FOR ADDITIONAL INFORMATION ON THE STATUS OF THE LANDS SHOWN HEREON

LEGEND

HIGHWAY AND ROUTE No
OTHER ROADS
TRAILS
SURVEYED LINES
  TOWNSHIPS BASE LINES, ETC
  LOTS, MINING CLAIMS, PARCELS ETC
UNSURVEYED LINES
  LOT LINES
  PARCEL BOUNDARY
  MINING CLAIMS ETC
RAILWAY AND RIGHT OF WAY
UTILITY LINES
NON-PERENNIAL STREAM
FLOODING OR FLOODING RIGHTS
SUBDIVISION OR COMPOSITE PLAN
RESERVATIONS
ORIGINAL SHORELINE
MARSH OR MUSKEG
MINES ⚒
TRAVERSE MONUMENT ✦

DISPOSITION OF CROWN LANDS

TYPE OF DOCUMENT	SYMBOL
PATENT, SURFACE & MINING RIGHTS	●
" , SURFACE RIGHTS ONLY	⊖
" , MINING RIGHTS ONLY	◒
LEASE, SURFACE & MINING RIGHTS	■
" , SURFACE RIGHTS ONLY	⬒
" , MINING RIGHTS ONLY	⬓
LICENCE OF OCCUPATION	▼
ORDER IN-COUNCIL	OC
RESERVATION	Ⓡ
CANCELLED	⊗
SAND & GRAVEL	⊙
LAND USE PERMITS FOR COMMERCIAL TOURISM OUTPOST CAMPS	✓

NOTE MINING RIGHTS IN PARCELS PATENTED PRIOR TO MAY 6 1913 VESTED IN ORIGINAL PATENTEE BY THE PUBLIC LANDS ACT R S O 1970, CHAP 380, SEC 63, SUBSEC 1

SCALE 1 INCH = 40 CHAINS

FEET 0 1000 2000 4000 6000 8000
0 200 1000 (1 KM) 2000 (2 KM)
METRES

INTO SERVICE Feb 16, 1983

AREA

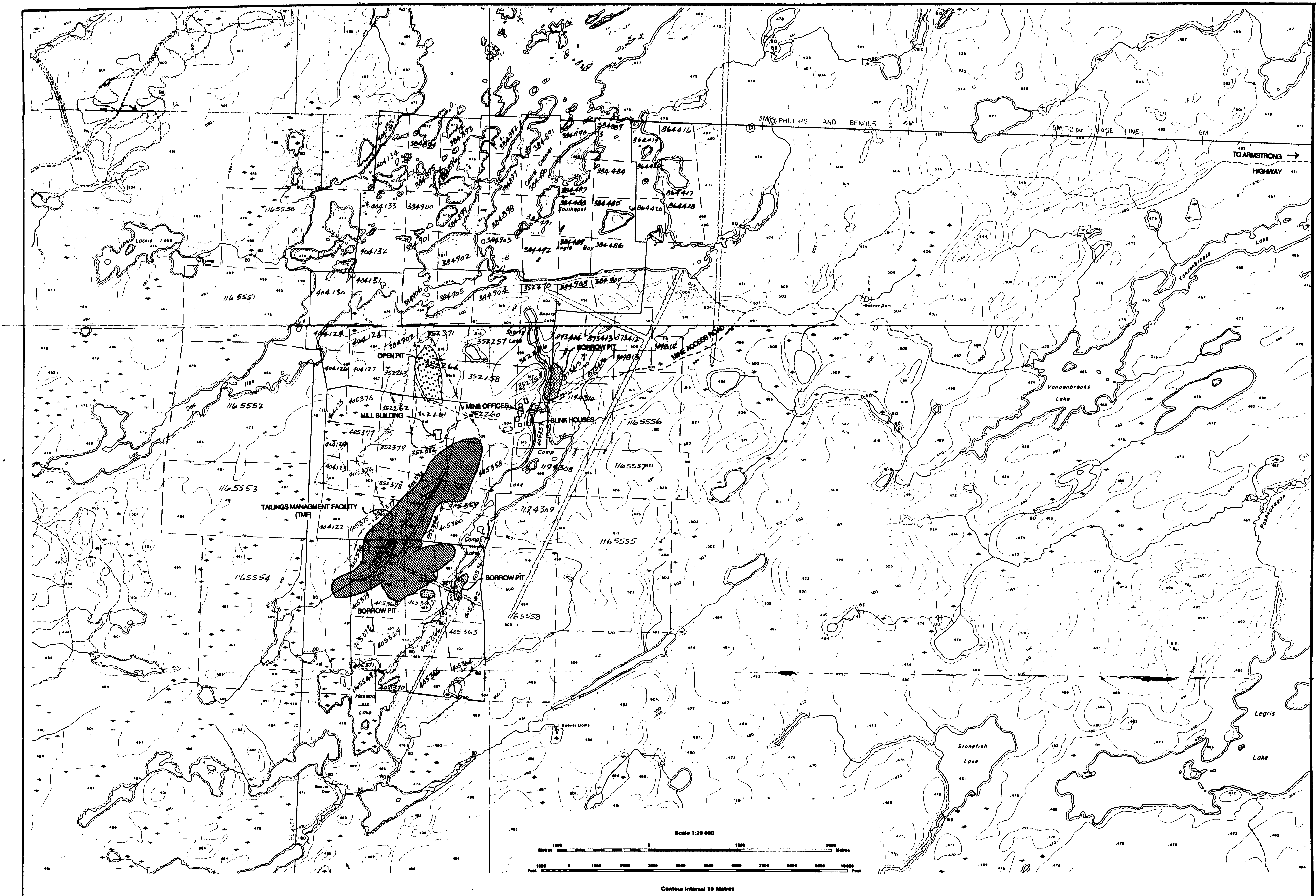
LAC DES ILES

M N R ADMINISTRATIVE DISTRICT
THUNDER BAY
MINING DIVISION
THUNDER BAY
LAND TITLES / REGISTRY DIVISION
THUNDER BAY

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

Ministry of Natural Resources
Land Management Branch
Ontario

Date JANUARY, 1983
Number G-739



Contour Interval 10 Metres

LEGEND

-·-Y-·-Y-	WATERSHED BOUNDRY
▨	TAILINGS MANAGENT AREA (TMF)
▒	.BORROW PIT AREAS

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

2 15334

REVISIONS		
MARK	DATE	DESCRIPTION

SECTION No.
DWG. No. WHERE SECTION IS SHOWN. BLANK IF SAME DRAWING.

DETAIL No.
DWG. No. WHERE DETAIL IS SHOWN. BLANK IF SAME DRAWING.

REFERENCE	
DWG. NO.	DESCRIPTION
20 16 3000 54400	ONTARIO BASE MAP
20 16 3100 54400	ONTARIO BASE MAP
20 16 3100 54500	ONTARIO BASE MAP
20 16 3000 54500	ONTARIO BASE MAP

REFERENCE	
DWG. NO.	DESCRIPTION
0786-301	LOCATION PLAN FOR SUBSURFACE TESTING - MAY 1992

LAC DES ILES MINES LTD
LAC DES ILES ONTARIO
SITE LOCATION PLAN

DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

DATE AUG 1, 1992 SCALE : 1 : 20,000

MADE DM CHKD. JC APPD. DWG. NO. 0786-099

STAGE 1

STAGE 2

STAGE 3

RECEIVED
MAR 7 - 1994
MINING LANDS BRANCH

0 500 1000
metres

2.15334

MARK	DATE	REVISIONS DESCRIPTION

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DWG. NO.	REFERENCE DESCRIPTION	DWG. NO.	REFERENCE DESCRIPTION

LAC DES ILES MINES LTD.

LAC DES ILES ONTARIO

PROPOSED MULTISTAGE TMF

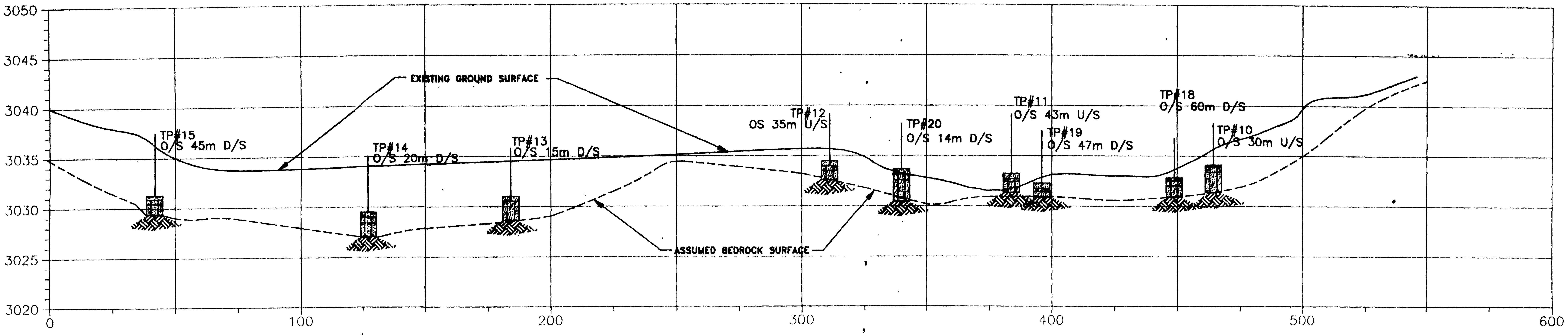
DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

DATE : AUGUST, 1992 SCALE : 1:15000

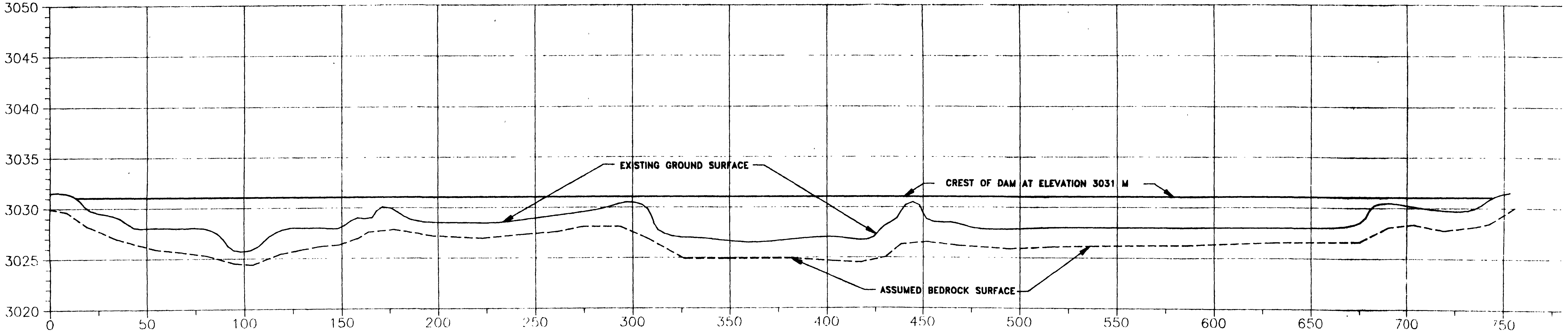
MADE DNS CHKD. APPD. DWG. NO. 0786-101

52H04NE0013 2 15334 LAC DES ILES

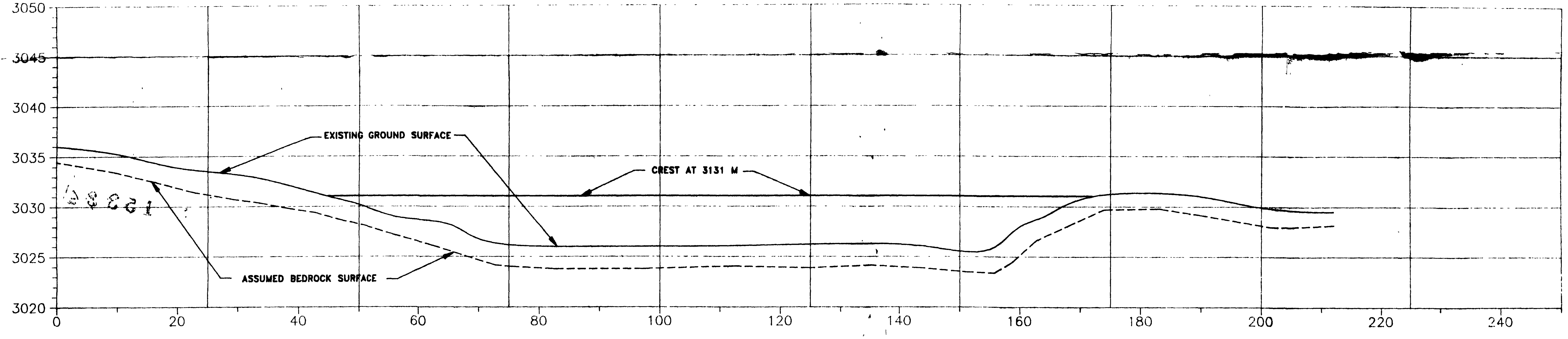
220



PROFILE THROUGH STAGE 1 TAILINGS DAM



PROFILE THROUGH STAGE 1 EAST WATER POND DAM



PROFILE THROUGH STAGE 1 SOUTH WATER POND DAM

2.15334

MARK	DATE	REVISIONS DESCRIPTION

SECTION No.
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DETAIL No.
DWG No. WHERE DETAIL IS SHOWN. BLANK IF SAME DRAWING.

DWG. NO.	REFERENCE DESCRIPTION

DWG. NO.	REFERENCE DESCRIPTION

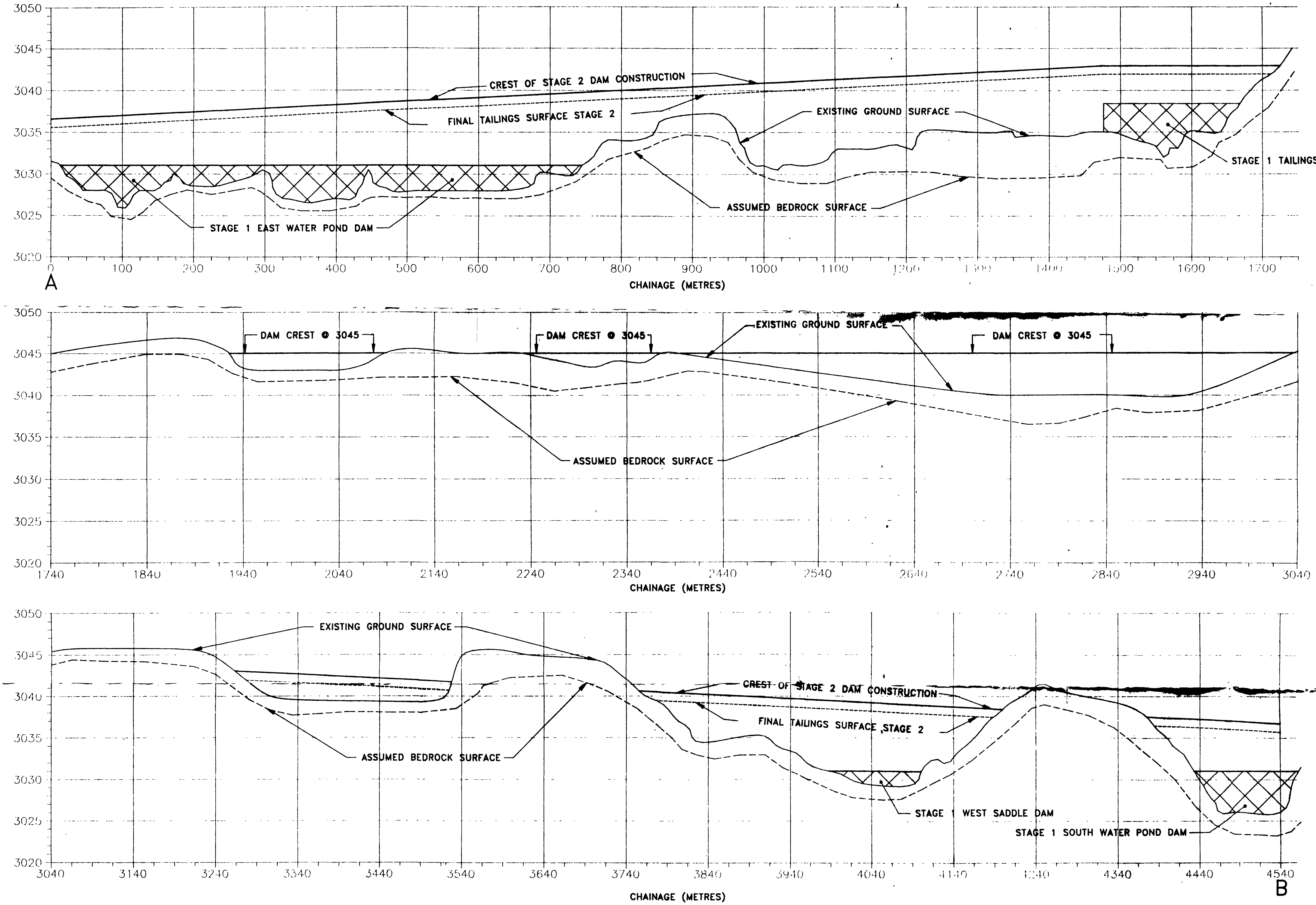
LAC DES ILES MINING LTD.

LAC DES ILES ONTARIO

STAGE 1 PROFILES

DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

DATE : AUGUST, 1992
SCALE : AS SHOWN
MADE DKS
CHKD.
APPD.
DWG. NO. 0796-102



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MAR 7 - 1994
MINING LANDS BRANCH

2.15334

MARK	DATE	REVISIONS DESCRIPTION

SECTION No.
DWG. No. WHERE SECTION IS SHOWN. BLANK IF SAME DRAWING

DETAIL No.
DWG No. WHERE DETAIL IS SHOWN. BLANK IF SAME DRAWING.

DWG. NO.	REFERENCE DESCRIPTION	DWG. NO.	REFERENCE DESCRIPTION

LAC DES ILES MINES LTD

LAC DES ILES ONTARIO

STAGE 2 TMF DAM PROFILES

DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

DATE : AUGUST, 1992 SCALE : AS SHOWN

MADE DRG. CHKD. APPD. DWG. NO. 8786-103

52H04NE0013 2.15334 LAC DES ILES

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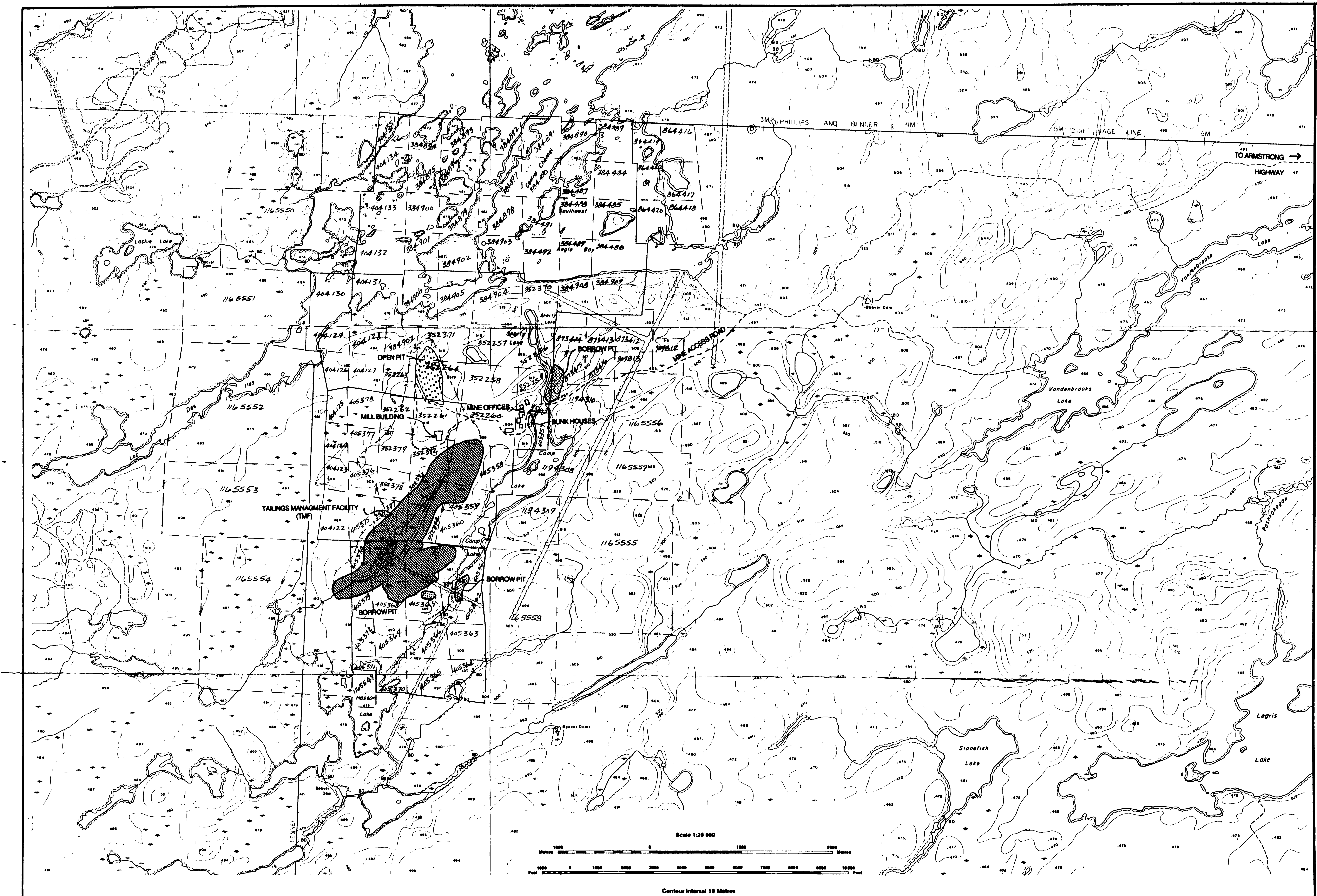

N

LEGEND

- - - - WATERSHED BOUNDRY

▨ TAILINGS MANAGENT AREA (TMF)

▨ BORROW PIT AREAS

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REVISIONS		
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DWG. No. WHERE DETAIL IS SHOWN. BLANK IF SAME DRAWING.

REFERENCE	
DWG. NO.	DESCRIPTION
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20 16 3100 54400	ONTARIO BASE MAP
20 16 3100 54500	ONTARIO BASE MAP
20 16 3000 54500	ONTARIO BASE MAP

REFERENCE	
DWG. NO.	DESCRIPTION
0786-301	LOCATION PLAN FOR SUBSURFACE TESTING - MAY 1992

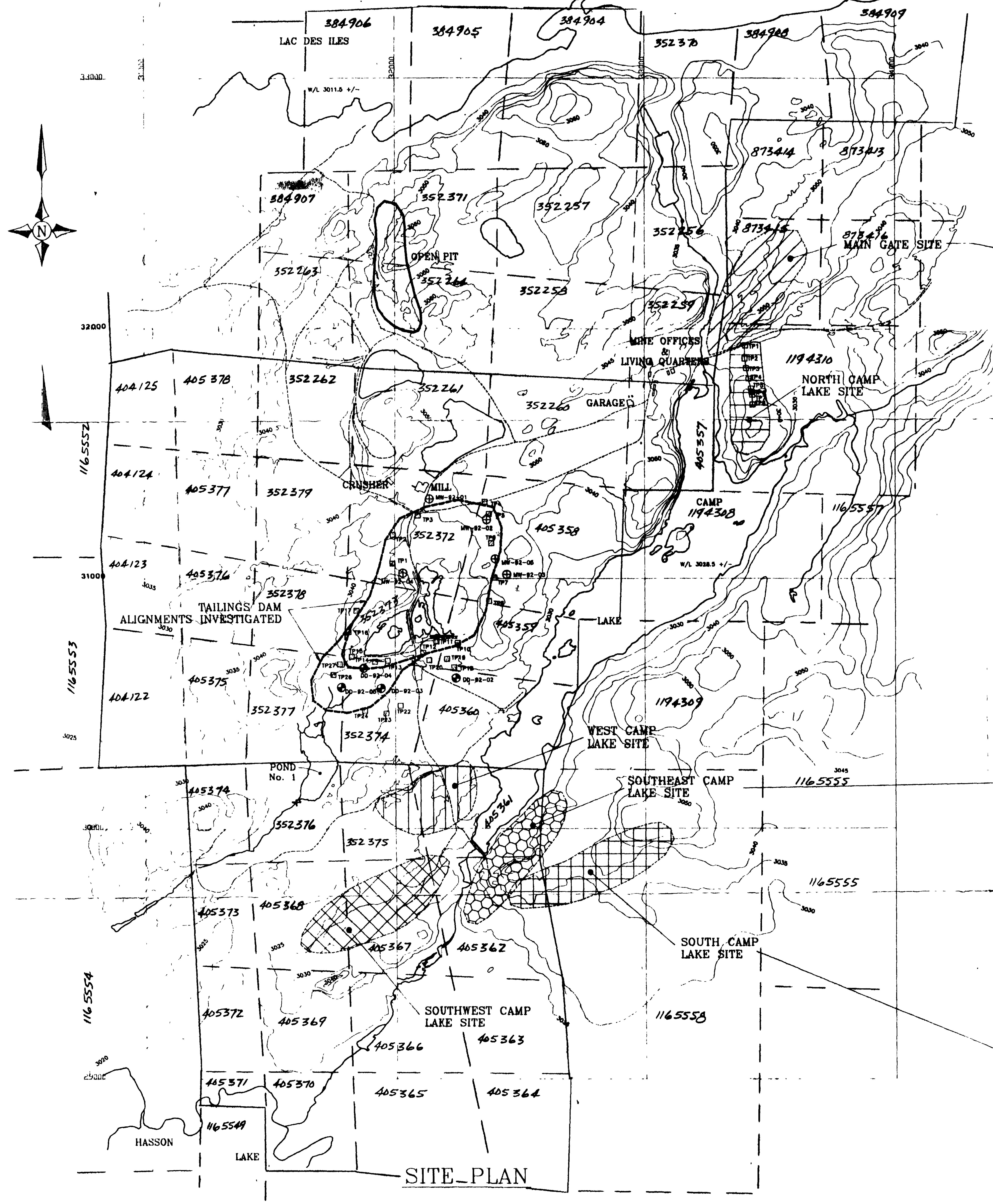
LAC DES ILES MINES LTD

LAC DES ILES ONTARIO
SITE LOCATION PLAN

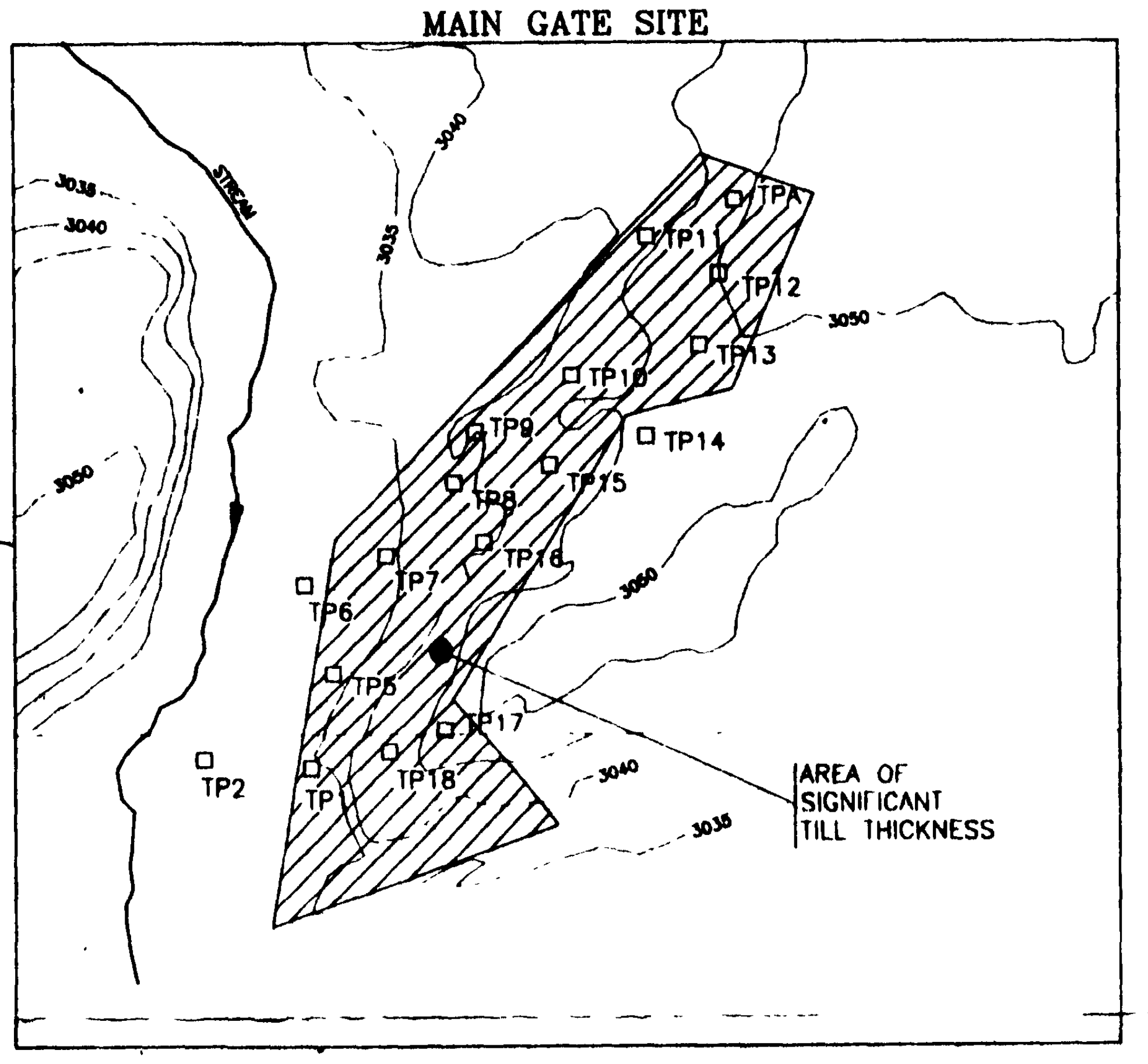
DNE DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

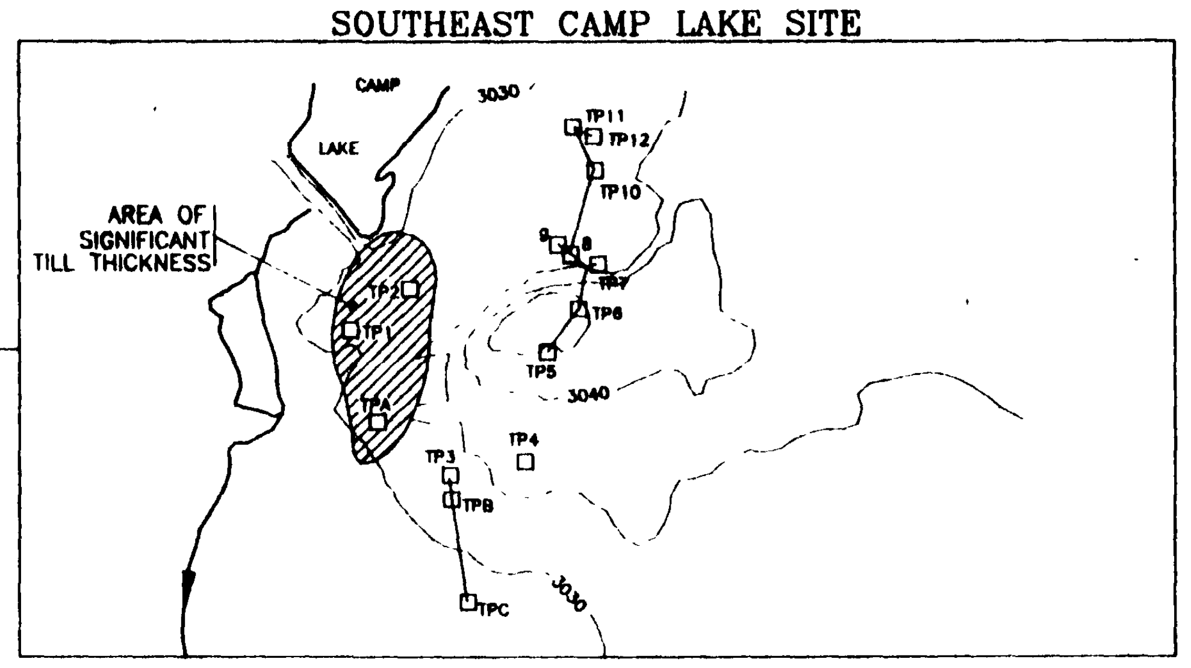
DATE AUG 1, 1992 SCALE : 1 : 20,000

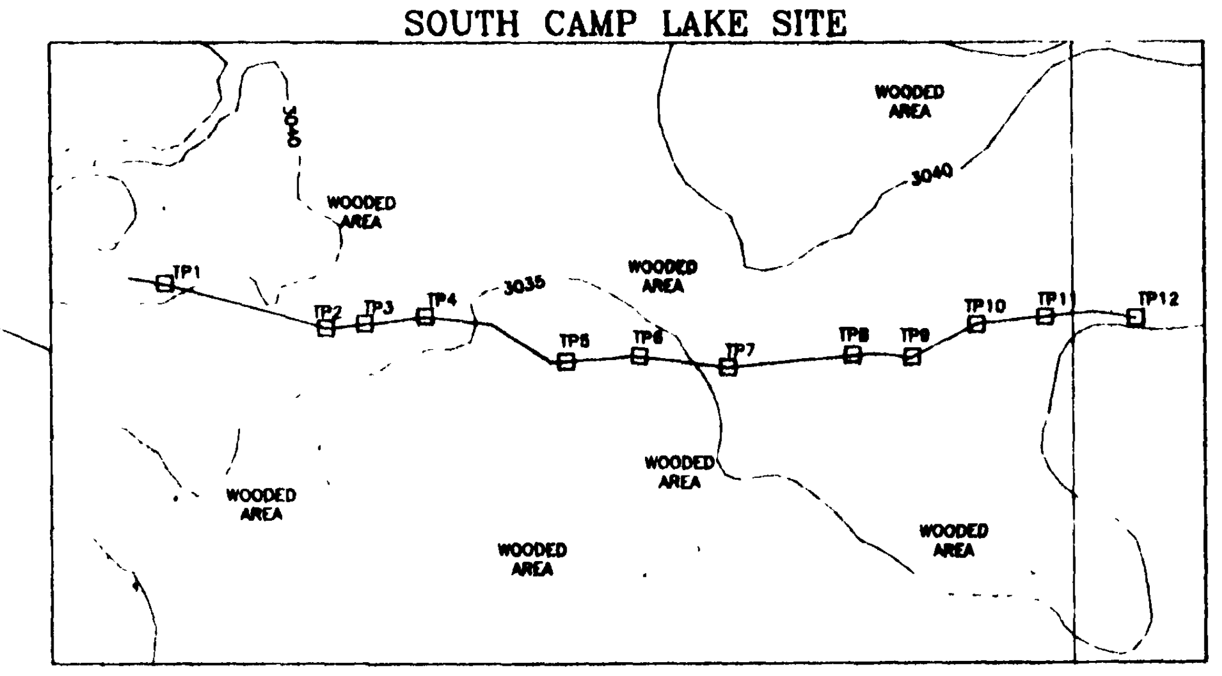
MADE CHKD. APPD. DWG. NO. 0786-099



SITE_PLAN


MAIN GATE SITE


SOUTHEAST CAMP LAKE SITE


SOUTH CAMP LAKE SITE

KEY

▭ OPEN PIT

⬭ PHASE 1 TAILINGS MANAGEMENT FACILITY ALIGNMENT INVESTIGATED

BORROW INVESTIGATIONS

▩ SOUTHWEST CAMP LAKE SITE (SWCL)

▥ WEST CAMP LAKE SITE (WCL)

⬡ SOUTHEAST CAMP LAKE SITE (SECL)

▦ SOUTH CAMP LAKE SITE (SCL)

▤ NORTH CAMP LAKE SITE (NCL)

▨ MAIN GATE SITE (MGS)

◐ DD-92-xx DIAMOND DRILL HOLE

⊕ MW-92-xx MONITORING WELL INSTALLATION

☐ TPx TEST PIT LOCATION

2.15334

NOTES

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING DOCUMENT No. 0786-07.
2. CONTOUR INTERVAL IS 5 METRES.
3. ELEVATIONS ARE REFERENCED TO MINE DATUM.
4. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES.

0 250 500
Metres

REVISIONS		
MARK	DATE	DESCRIPTION

SECTION No.
DWG. No. WHERE SECTION IS SHOWN. BLANK IF SAME DRAWING

DETAIL No
DWG No. WHERE DETAIL IS SHOWN. BLANK IF SAME DRAWING.

DWG. NO.	REFERENCE DESCRIPTION
0786-099	SITE LOCATION PLAN

DWG. NO.	REFERENCE DESCRIPTION

LAC DES ILES MINES LTD.

LAC DES ILES ONTARIO

LOCATION PLAN FOR SUBSURFACE TESTING–MAY 1992

DENNIS NETHERTON ENGINEERING
ENGINEERING FOR THE RESOURCE INDUSTRIES

DATE : SEPT., 1992 SCALE : 1:10000
MADE DWG CHKD DWG. NO. 0786-301

260