PILOT SCALE COLUMN TESTING OF THE WILLIAMS CREEK OXIDE DEPOSIT

February 1996

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February 19, 1996

Western Copper Holdings Ltd.
1180 - 999 West Hastings Street
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Attention: Mr. Ken McNaughton

Dear Ken,

Enclosed is the summary report on the pilot scale testwork for the Williams Creek (Carmacks Copper) oxide copper project. The report includes all the test details for the columns, including the multiple lift testwork as well as the results of neutralization testwork conducted on the leach tailings.

It has been a pleasure working with you on this project and we look forward to seeing the project proceed to production.

Yours sincerely,
BEATTIE CONSULTING LTD

MBeattie

Dr. M.J.V. Beattie, P. Eng.

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1.0 INTRODUCTION

Over the period from 1990 to early 1993, various leaching tests were conducted on samples from the Williams Creek deposit. These tests included bottle roll tests, small-scale (mini) column tests and various flood and percolation column tests. The results from that testwork has been compiled and summarized in a previous report dated April 1994.

Subsequent to the previous report, additional testwork has been conducted consisting of column tests having a height similar to that proposed for the commercial operation. The initial column test (FH) in this series utilized similar sample material as was used for the preliminary testwork. The subsequent two tests (PC1 and PC2) used a portion of a bulk sample which was also used for a 200 ton test in Carmacks, Y.T. Test FH consisted of a single lift test while PC1 and PC2 were done in two stages in series in order to model a multiple lift leaching operation.

Following the acid copper leach, both columns PC1 and PC2 were subjected to neutralization testwork for an extended period of time.

The present report summarizes the procedures for and results obtained from the full height column tests for both the acid leaching and neutralization studies. The work included in the report was conducted at the laboratories of Process Research Associates Ltd, of Vancouver, under the direction of M.J.V. Beattie, P.Eng.

2.0 SUMMARY

Three column tests having a height comparable to that proposed for a lift in the commercial operation have been conducted. One column utilized a composite sample from drill core while the other two samples used a portion of a bulk sample prepared for a bulk test in Yukon.

The results of these tests have demonstrated that a copper extraction of 80% can be achieved over a leach period of about 180 days. The results of column PC1 demonstrate that when a second lift is placed on a partially leached first lift, the first lift continues to leach to completion once the top lift is being leached. The results of column PC2 demonstrate that the use of lower concentrations of acid during the initial part of the leach cycle do not affect the ultimate copper extraction or the time to achieve this extraction.

The acid consumption is sensitive to the concentration of acid in the feed to the leach. Increasing acid concentration in the feed results in an increase in the acid consumption without any benefit to copper extraction. An acid consumption of 25 kg/tonne is indicated by the test results when the acid addition to the feed is controlled by adjusting the feed pH to 1.5.

Neutralization of the rock once the acid leaching is completed has proven to be very difficult. Testwork including both immersion as well as percolation tests indicate that the rock appears to be buffered at about pH 4. When the precipitates formed during neutralization of the final solutions were returned to the column, they proved to be impervious. The formation of such an impermeable cap on the depleted leach pile may prove to be a preferred alternative to neutralization of the leach residue.

3.0 SAMPLE DESCRIPTION

3.1 FH column

The sample used for this test consisted of a composite sample of drill core material which had been prepared previously. The make-up of the FH composite is summarized in Table 3.1 and the analysis of the individual samples is summarized in Table 3.2. The material shown as HG composite in Table 3.1 consists of equal portions of composites 2, 4 and 6. All the material included in the FH composite is from the high grade section of the deposit. A detailed description of the samples used for preparing the composites is contained in the April 1994 report.

Table 3.1

Make-up of composite used for FH column test

Material	Weight, kg
Composite 4	20.1
Composite 6	90.7
HG composite	91.3

The core had all been crushed to nominally passing 2 cm prior to being composited. It had been noted during previous testwork that the crushing of the core resulted in a much greater proportion of -2 cm + 1.3 cm material (approximately 38% by weight) than would be expected from a crusher which was operating in closed circuit with a screen (15 to 20%). The top size material was therefore passed through the jaw crusher a second time, resulting in the final distribution for the test. The size distribution of the feed to the column together with the copper assay of each size fraction is summarized in Table 3.3

Table 3.2

Analyses of composite samples

Comp. No.	Description	Cu_T %	Cu_{ox} %	Fe_T %	Fe_{ox} %	S^{-2} %
2	+2700 H	1.44	1.43	3.60	3.68	0.12
4	2500-2700 H	1.36	1.24	3.74	3.76	0.12
6	2300-2500 H	1.31	1.30	3.46	3.46	<0.01

Table 3.3

FH sample feed size - assay

FRACTION	WEIGHT	Cu_{total}	Cu_{ox}	DISTRIBUTION	
cm	%	%	%	Cu_{total}	Cu_{ox}
- 2 + 1.5	15.4	1.06	0.98	12.4	12.3
- 1.5 + 1	27.8	1.14	1.04	24.2	23.5
- 1 + 0.6	19.4	1.22	1.16	18.0	18.3
- 0.6 + 6m	13.4	1.28	1.24	13.1	13.5
- 6m	24.0	1.76	1.66	32.2	32.4
Total		1.31	1.23		

3.2 PC1 and PC2 Columns

The sample used for the two pilot column tests was the same material as was used for a pilot heap test in Carmacks, Y. T. This bulk sample consisted of a composite of material taken from three trenches as summarized in Table 3.4.

Table 3.4

Description of trench samples

Composite	Location	Length feet	Approx. wt. tons
1	1700 N	100	90
2	1200 N	150	135
3	800 N	100	90

Each composite was screened into a series of size fractions and the fractions were assayed for total and acid soluble copper. The difference between these two values was taken as the sulphide copper. The results of these analyses are tabulated in Table 3.5. All three composites can be seen to be more than 90% oxidized and all show increasing copper content from the coarse to fine material. Acid base accounting results for the three samples are included in Appendix B.

The minus 6 mesh portions of each composite were screened further to evaluate the proportion of very fine material (which could migrate during leaching) present in each composite. The size distribution of minus 6 mesh material present in each composite is summarized in Table 3.6.

Table 3.5

Trench composites size assays

FRACTION	WEIGHT	ASSAYS, %			% DISTRIBUTION		
cm	%	Cu_T	Cu_{ox}	Cu_{sulph}	Cu_T	Cu_{ox}	Cu_{sulph}
			Composite 1				
- 2 + 1.3	22.7	0.92	0.78	0.14	15.4	14.2	29.4
- 1.3 + 1	14.8	0.96	0.86	0.10	10.5	10.2	13.7
- 1 + 0.6	14.4	1.02	0.92	0.10	10.8	10.6	13.3
- 0.6+6m	14.4	1.12	0.98	0.14	11.9	11.3	18.6
-6m	33.7	2.06	1.98	0.08	51.3	53.6	25.0
Total		1.35	1.25	0.11			
			Composite 2				
- 2 + 1.3	23.0	0.80	0.70	0.10	15.0	14.4	20.9
- 1.3 + 1	15.7	0.86	0.78	0.08	10.9	10.9	11.4
- 1 + 0.6	13.9	0.93	0.82	0.11	10.5	10.2	13.9
- 0.6+6m	14.1	1.05	0.96	0.09	12.0	12.0	11.5
- 6m	33.3	1.91	1.77	0.14	51.6	52.5	42.3
Total		1.23	1.12	0.11			
			Composite 3				
- 2 + 1.3	17.9	0.68	0.66	0.02	11.3	11.3	11.5
- 1.3 + 1	12.3	0.78	0.74	0.04	8.9	8.7	15.8
- 1 + 0.6	13.4	0.86	0.82	0.04	10.7	10.5	17.2
- 0.6+6m	14.4	1.06	0.94	0.12	14.1	12.9	55.5
- 6m	41.9	1.42	1.42	0.0	55.0	56.7	0.0
Total		1.08	1.05	0.03			

Table 3.6

Size distribution of minus 6 mesh fraction of trench samples.

Mesh	Cumulative % Passing		
	Composite 1	Composite 2	Composite 3
10	78.4	80.0	81.1
20	56.9	59.7	61.4
35	39.1	40.8	42.8
65	23.8	24.0	25.9
100	17.3	17.1	18.7

The proportions of material from the three trenches used to prepare the samples for PC1 and PC2 are tabulated in Table 3.7.

Table 3.7

Make - up of bulk sample

SIZE FRACTION	COMPOSITE		
cm	1	2	3
- 2 + 1.5	125	195	100
- 1.5 + 1	82	134	68
- 1 + 0.6	80	120	75
- 0.6 + 6m	80	120	80
- 6m	185	283	230

The weighted size distribution and total copper assay by fraction for the overall bulk sample is summarized in Table 3.8.

Table 3.8

Size distribution and assay by fraction of bulk sample.

SIZE FRACTION	WEIGHT %	Cu_T %
- 2 + 1.3	21.7	0.81
- 1.3 + 1	14.6	0.87
- 1 + 0.6	13.9	0.94
- 0.6 + 6m	14.3	1.07
-6m	36.2	1.79

4.0 PROCEDURE

4.1 FH column

The crushed feed material was agglomerated with a sulphuric acid solution prior to being placed in a 15 cm diameter by 5.5m tall column. Agglomeration was accomplished by spraying 5 kg/tonne H_2SO_4 as a 150 g/L solution on the ore and then mixing the ore by rolling it back and forth on a sheet of plastic.

Leaching was initiated by pumping a fresh solution containing 15 g/L H_2SO_4 onto the top of the column at a rate of approximately 0.010 gal/ft^2/min. Fresh acid solution was used as feed to the column for the first four days of the test and after this time the feed became the raffinate from solvent extraction. For the first 59 days of the test an addition of 15 g/L H_2SO_4 was made to the raffinate regardless of the pH. From day 60 on, only sufficient acid was added to the raffinate to adjust the pH to 1.5 before the solution was recycled.

On day 24, the flowrate to the column was reduced to 0.005 gal/ft^2/min and was maintained at this rate for the duration of the test.

The test was continued until a copper extraction of approximately 80%, based on the head assay calculated from the analysis of the size fractions of the feed, was achieved. At this point the column was washed and allowed to drain.

The leached solids were removed from the column by continuously withdrawing material from the bottom of the column so that the material could be analyzed in sections. The column tails were divided into three approximately equal sections designated as top, middle and bottom. Each section was screened into the same size fractions as had been used for the feed and each fraction was analyzed.

4.2 PC1 and PC2 columns

For test PC1, the composite ore sample was agglomerated with 10 kg/tonne H_2SO_4 added as a 300 g/L solution. Agglomeration was accomplished by placing charges of the ore in a cement mixer, adding the acid solution and rotating the mixer until the ore was uniformly wetted, about 2 minutes. At the completion of agglomeration the coarse particles were uniformly coated with fines but considerable additional fines were still evident due to the fine size distribution of the ore sample.

The agglomerated material was placed in a 25 cm diameter by 5.5 meter tall column. Leaching was initiated by pumping a fresh acid solution containing 15 g/L H_2SO_4 onto the column at a rate of 0.010 gal/ft^2/min. The feed rate was maintained at this flowrate for the first 12 days of leaching and was then decreased to half this rate. The discharge from the column was at a point approximately 30 cm from the bottom so that approximately 20 litres of pregnant solution remained in the bottom of the column at all times and the bottom section of ore was immersed in solution.

The feed solution for the first four days consisted of the fresh acid solution. From day 5 through day 12 the feed solution consisted of raffinate to which an acid addition of 10 g/L was made regardless of pH or acid content. From day 12 to day 80 the feed to PC1 consisted of raffinate adjusted to pH 1.5. Solvent extraction was conducted with a 20% by volume solution of Acorga M 5460 in Shell Sol DMS. For the first few cycles, up to 5 stages of solvent extraction were required to remove all the copper from solution while after this initial stage, solvent extraction was accomplished in two and later one stage.

From day 80 until the end of the test the feed to PC1 consisted of the pregnant solution from PC2 without any adjustment. A three day operating cycle was established where the PLS from PC2 was collected for a three day period and then became the feed for PC1 for the following three days. At the same time the PLS from PC1 was subjected to solvent extraction, the pH was

adjusted to 1.5 and it became the feed to PC2 for the second three day period. In this way, both columns were operated continuously while samples could be taken, and volumes measured of the intermediate samples.

A second batch of the ore composite was prepared for column PC2 by agglomerating with 15 kg/tonne acid. The procedure used for the agglomeration was the same as for PC1.

The flowrate to PC2 was constant at 0.005 gal/ft^2/min for the duration of the test. The feed solution to PC2 for the first 80 days of leaching consisted of raffinate from PC1 adjusted to pH 1.5. After 80 days of operating PC2, column PC1 was finished leaching. At this point the PLS from PC2 was subjected to solvent extraction, the pH was adjusted to 1.5 and the solution was recycled to the feed.

When the feed to PC1 was stopped, the solution contained in the bottom of the column was drained out and the column was allowed to drain for a period of several weeks. After this drainage period the column was washed with two batches of water before a neutralization study was commenced. Following the completion of the neutralization work, the column was emptied and the contents were analyzed in three sections by size fraction.

The operation of PC2 with solvent extraction of the PLS and adjustment of the recycle solution to pH 1.5 was continued until day 182, at which time a copper extraction of 80.6% had been achieved. From this point on the PLS was subjected to solvent extraction but the raffinate was then recycled to the feed without pH adjustment so that the feed and PLS pH gradually increase. This mode of operation was continued with occasional rest periods until day 289 at which time the test was ended. The column was then subjected to neutralization studies, at the completion of which the column was emptied and the contents analyzed by size fraction.

4.3 Neutralization tests.

Upon the completion of acid leaching of column PC1, it was subjected to several washing steps, followed by neutralization testwork. The neutralization work consisted primarily of pumping neutral or alkaline solutions onto the column and then analyzing and neutralizing the column effluent. The operating parameters were varied as the testwork progressed and are therefore discussed together with the results in Section 5.4. Similarly, column PC2 was washed and neutralized following copper leaching although while PC1 was washed and tested arbitrarily when approximately 80% copper had been achieved, the raffinate from column PC2 was recirculated without acid addition for 100 days following the 160 day active leaching period to observe any natural neutralization which would occur as the rock components consumed the residual acid in the solution. The detailed test conditions for PC2 are also included with the discussion of results in Section 5.4.

5.0 RESULTS AND DISCUSSION

5.1 FH column

The detailed test results are included in tabular form in Appendix A. The copper extraction as a function of time is shown in Figures 5.1 and 5.2 and can be seen to follow a fairly standard profile. The extraction is also plotted in Figure 5.3, together with the extraction profile predicted by the model prepared by Brown & Root Braun. The model was based on data developed from previous column testwork on Williams Creek samples.

A copper extraction of 79.6% was achieved over a leach period of 186 days. The semi-log plot presented as Figure 5.2 shows a change in slope at 20 days. This change corresponds to the decrease in flow rate which took effect at this time.

While a higher leaching rate could have been maintained by continuing the test at the faster initial feed rate, the decrease in flow was effected in an attempt to decrease the unit acid consumption. Figures 5.4 and 5.5 summarize the acid consumption per unit of copper as a function of copper extraction and time respectively. While the unit acid consumption decreased during the first two weeks of leaching due to the amount of acid soluble copper available, after this time it started to increase significantly as can be seen in Figure 5.5. It is apparent that while the decrease in feed rate from day 20 onward resulted in a slight inflection in the curve in Figure 5.5, the unit acid consumption was still increasing rapidly until the rate of acid addition was decreased on day 60.

The change in acid addition strategy from day 60 on, resulted in a minor decrease in the copper leaching rate as is evident in Figure 5.2. However, as acid consumption is a major contributor to operating expense, a longer leaching period with reduced acid consumption is believed to be a preferred operating strategy. The acid consumption of 50.7 kg/tonne experienced in this test is not considered to be meaningful in terms of the consumption to be expected in commercial

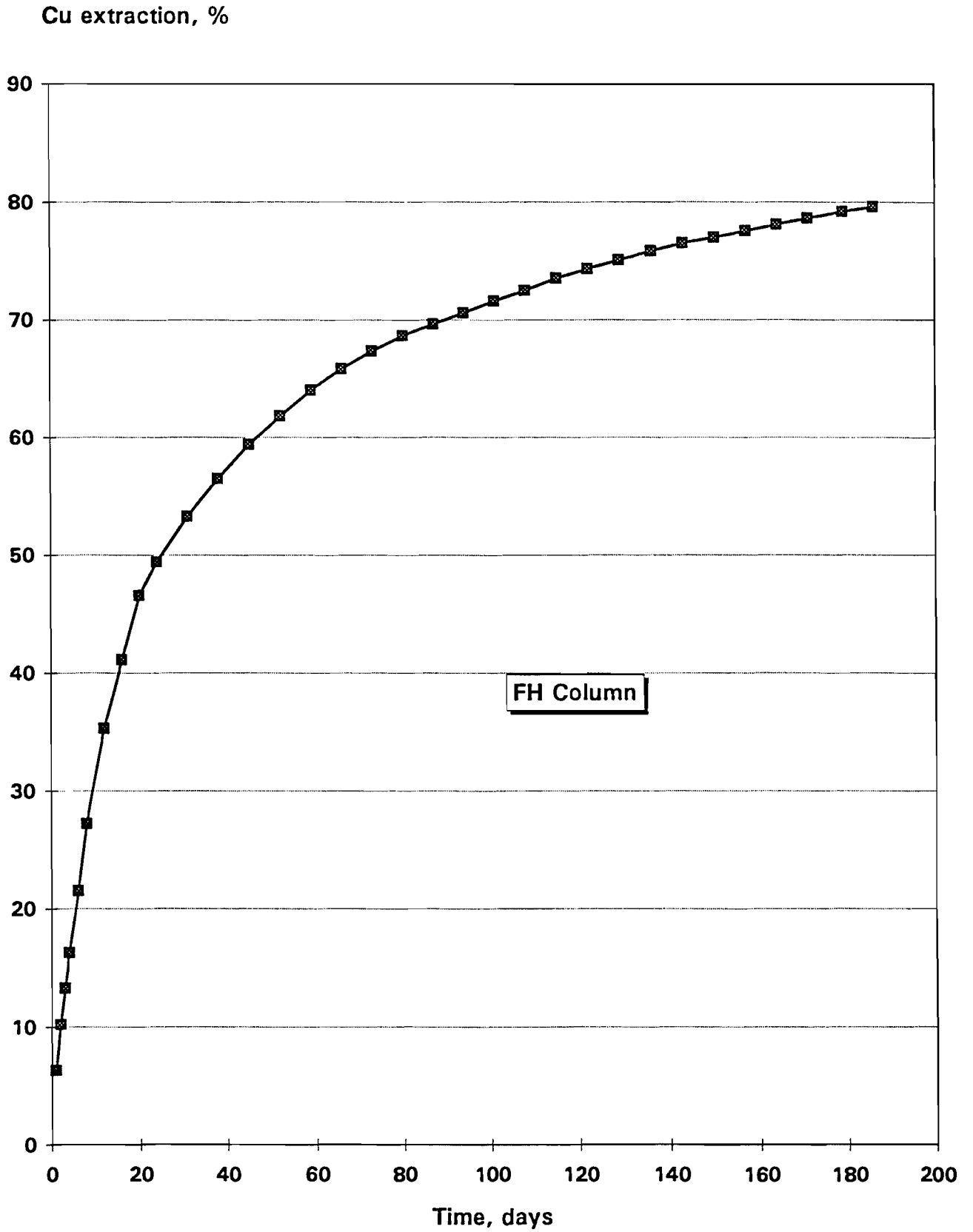

Cu extraction, %
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
Time, days
FH Column

Figure 5.1

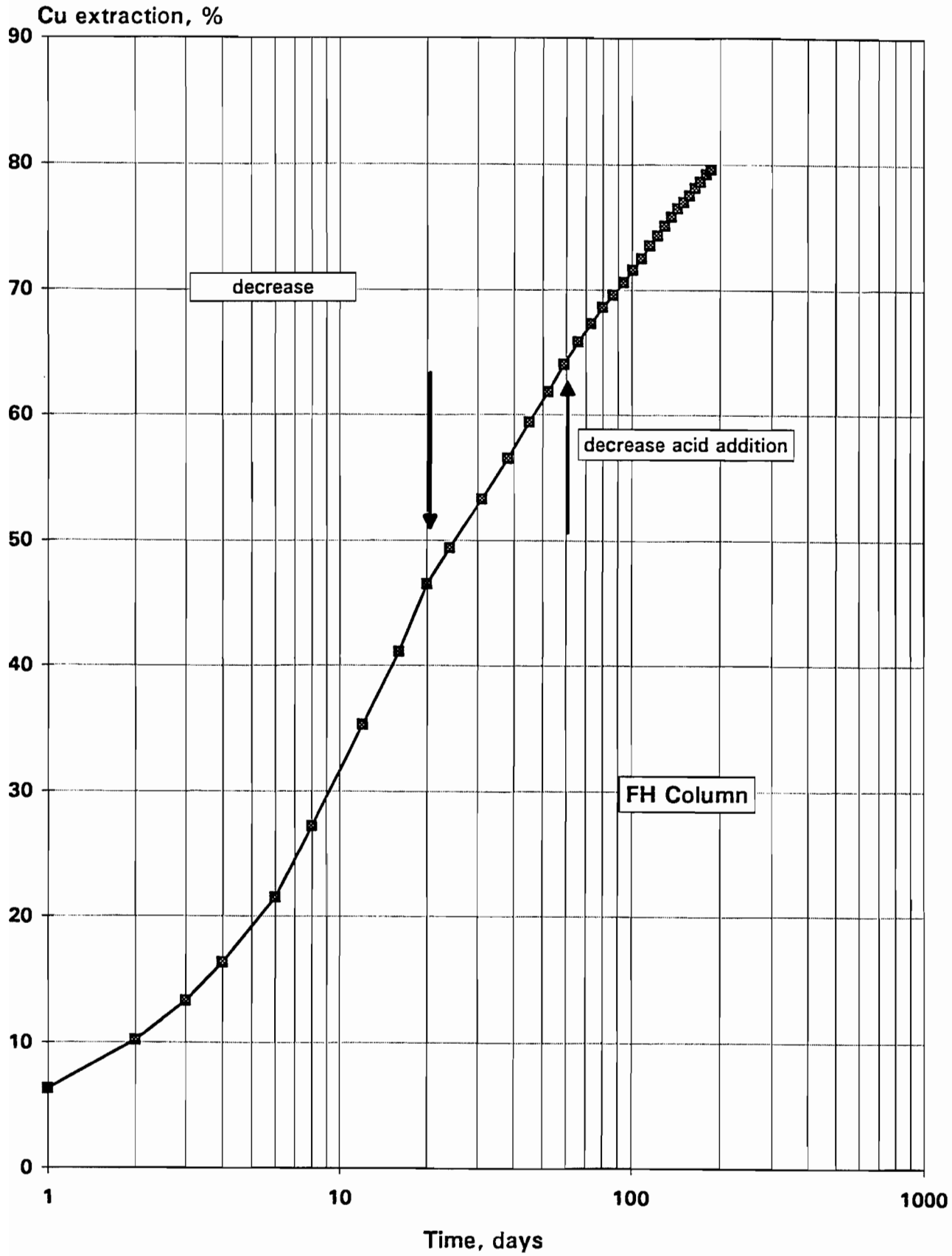

Cu extraction, %
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Time, days
decrease
decrease acid addition
FH Column

Figure 5.2

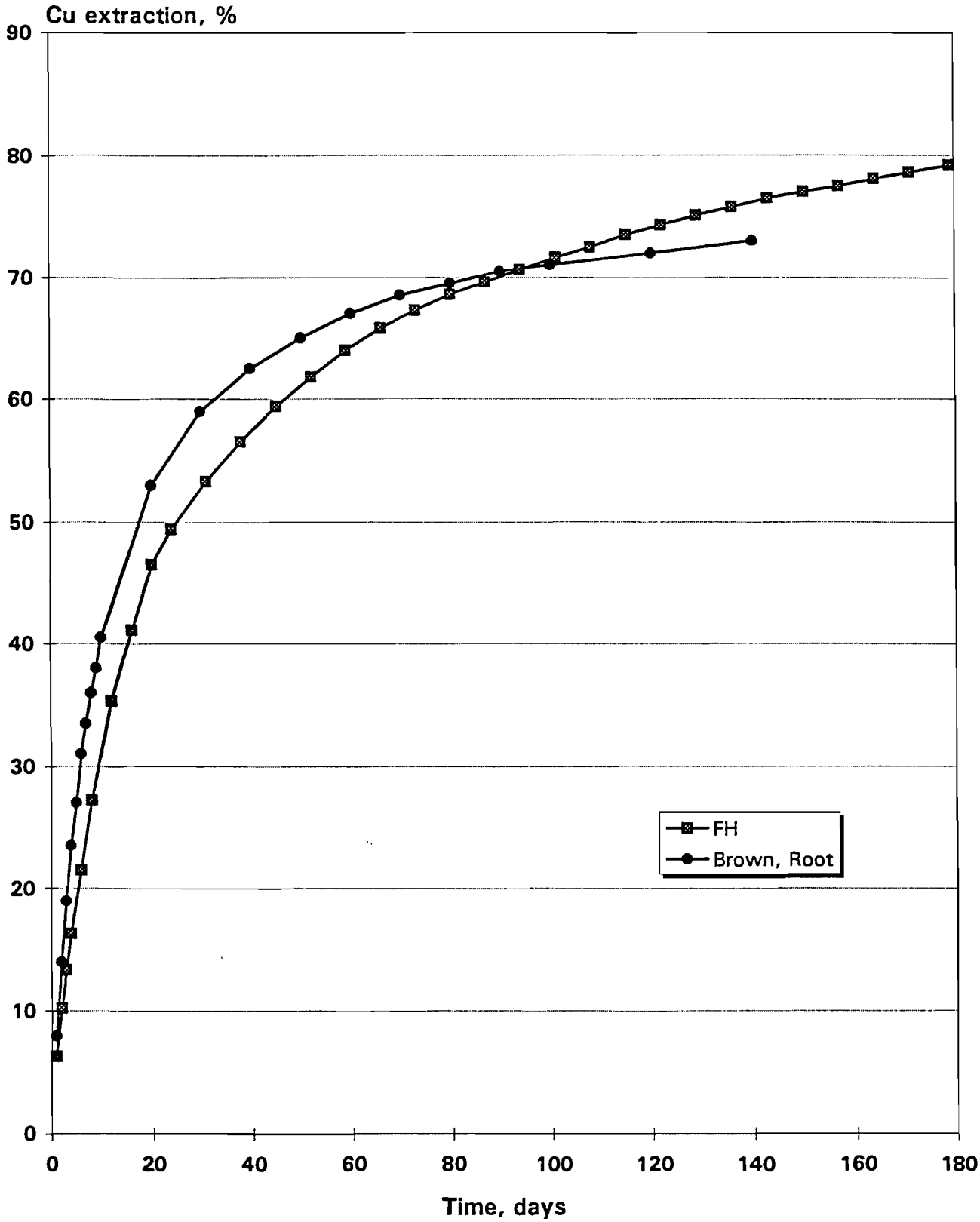

Cu extraction, %
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
Time, days
FH
Brown, Root

Figure 5.3

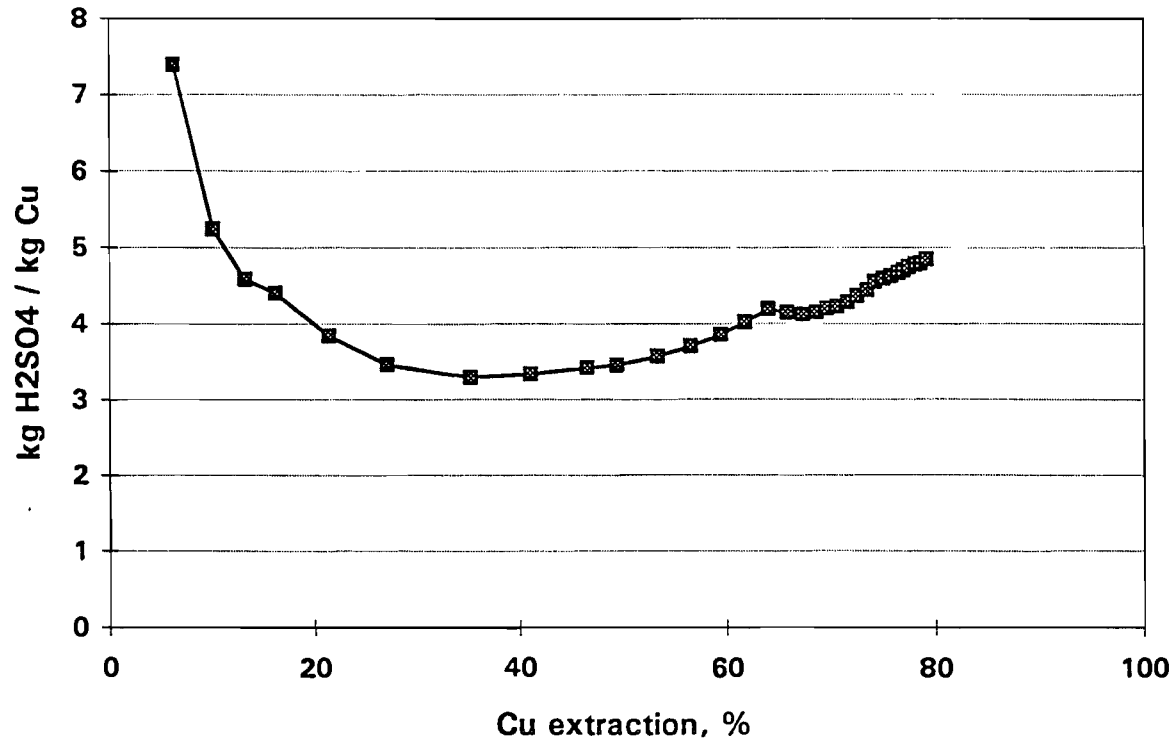


Figure 5.4 Acid consumption vs extraction for FH column.

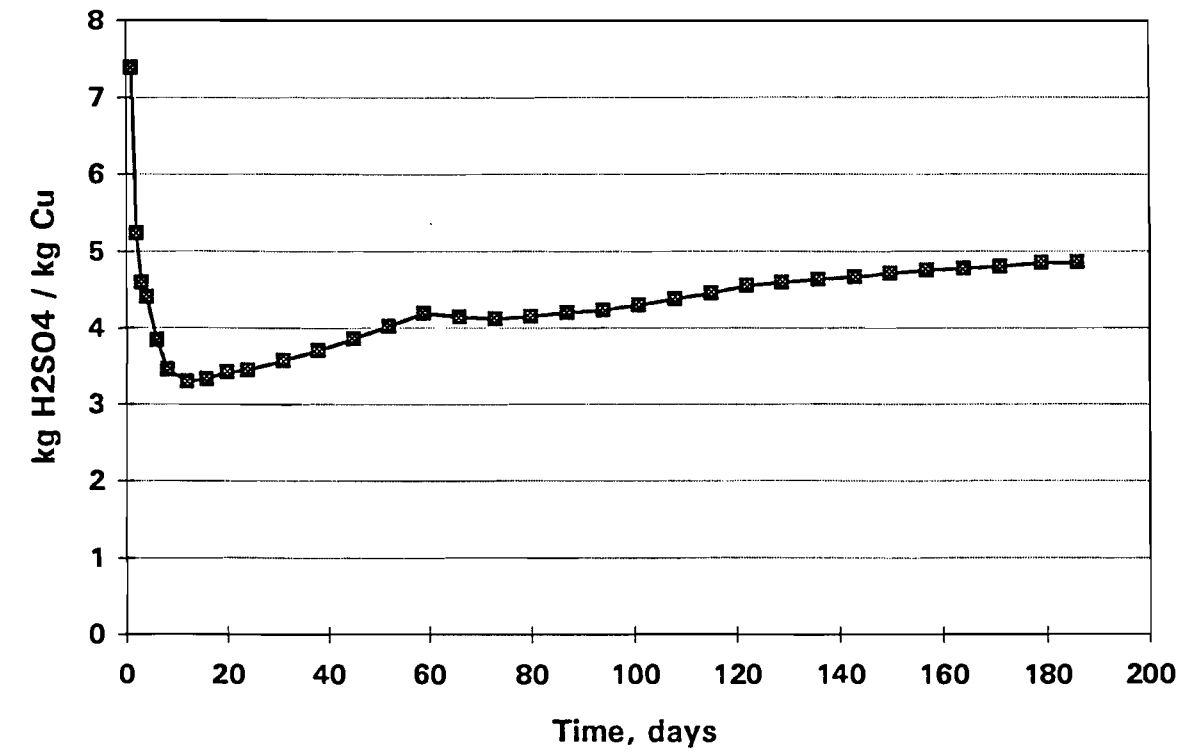


Figure 5.5 Acid consumption vs time for FH column.

production. When excessive acid is added, as it was for the first part of this test, it results in the acid being consumed by the rock components rather than for dissolving copper. A more detailed analysis of acid consumption, including a comparison of the consumption in the three tests included in this report is included as Appendix C.

The tailings from the column were analyzed in three approximately equal sections from the top of the column to the bottom. The results which are summarized in Table 5.1 indicate that based on a head assay of 1.33% Cu approximately 90% of the copper has been leached from the top section of the column but only about 70% of the copper has been leached from the bottom section. The results indicate that even with the high acid concentrations utilized in the test, the acid was not available for leaching near the bottom of the column. These results suggest that a high solution flowrate with low acid concentration may be the optimum condition for leaching. There is also evidence that due to the high acid conditions which prevailed for much of this test, iron was being leached from the top of the column and precipitated towards the bottom, which is consistent with observations made during unloading of the column. The top material was light grey in colour while the bottom material had a slight yellow tinge. The agglomerates at the bottom of the column were easily broken by hand and appeared to be porous. The entire column length appeared to be well drained so that the precipitation of the iron near the bottom of the column did not appear to have resulted in any percolation problems.

Selected fragments of the FH column residue were submitted to Vancouver Petrographics for microscopic analysis. Their report is included as Appendix D.

Table 5.1

Assay of FH column tailings

PRODUCT	WEIGHT	ASSAYS			DISTRIBUTION		
	%	Cu, T %	Cu, ox %	Fe %	Cu, T	Cu, ox	Fe
Top	33.4	0.14	0.08	2.38	17.4	13.7	23.9
Middle	35.3	0.31	0.23	3.62	38.8	39.5	38.5
Bottom	31.3	0.39	0.30	3.98	43.8	46.8	37.5
Total		0.28	0.20	3.32	100	100	100

The column contents were screened into a series of size fractions and each fraction was assayed. The results are summarized in Table 5.2. As would be expected, for each section of the column the copper content of the fines is significantly lower than that of the coarser fractions. Due to the weight distribution however, the losses are spread across the size fractions. It is evident from the results that the iron precipitation towards the bottom of the column is in the form of very fine precipitates. It is expected that such migration of iron from the top of the leach pile to the bottom will be minimized as the acid concentration in the feed is controlled to the recommended levels as was subsequently tested in column PC2.

It appears that the strong acid concentration of the column feed resulted in particle degradation at the top of the column. The percent passing 6 mesh in the column residue was 30.3% at the top, 24.2% in the middle and 20.9% at the bottom of the column. The results also confirm that migration of the fines down through the column will not be a problem.

The moisture content following the cure acid plus water addition was 3.5%. In addition, the solution hold-up in the column on the first day of leaching amounted to an additional 2.9% moisture by weight for a total of 6.4%.

Table 5.2

Size-assay of FH column tailings

FRACTION	WEIGHT	ASSAY			DISTRIBUTION, %		
cm	%	Cu_T	Cu_{ox}	Fe	Cu_T	Cu_{ox}	Fe
TOP							
+ 2	0.2	0.20	0.18	3.48	0.2	0.4	0.2
- 2 + 1.3	15.5	0.25	0.19	2.53	26.6	35.1	16.5
- 1.3 + 1	22.9	0.16	0.11	2.36	25.8	30.2	22.7
- 1 + 0.6	17.2	0.15	0.07	2.18	18.1	15.0	15.8
- 0.6 + 6m	13.8	0.09	0.05	2.26	9.0	7.7	13.1
- 6 m	30.3	0.10	0.03	2.48	20.3	11.7	31.6
Total		0.14	0.08	2.38			
MIDDLE							
+ 2	0.1	0.41	0.35	3.42	0.2	0.2	0.1
- 2 + 1.3	19.4	0.46	0.38	3.14	29.4	32.3	16.8
- 1.3 + 1	25.3	0.37	0.29	3.40	30.6	32.5	23.7
- 1 + 0.6	17.4	0.28	0.20	3.34	15.8	15.2	16.0
- 0.6 + 6m	13.6	0.21	0.14	3.52	9.1	8.4	13.2
- 6 m	24.2	0.19	0.11	4.50	14.9	11.4	30.1
Total		0.31	0.23	3.62			
BOTTOM							
+ 1.3	17.3	0.55	0.44	3.01	24.3	25.4	13.1
- 1.3 + 1	28.0	0.45	0.38	3.22	32.6	34.9	22.6
- 1 + 0.6	19.3	0.38	0.29	3.92	18.6	18.7	19.0
- 0.6 + 6m	14.5	0.30	0.21	4.28	11.0	10.2	15.5
- 6m	20.9	0.25	0.16	5.66	13.4	10.8	29.8
Total		0.39	0.30	3.98			

5.2 PC1 and PC2 columns

The detailed test results for PC1 and PC2 are tabulated in Appendix B. The copper extraction as a function of time is summarized in Figures 5.6 and 5.7. It is readily apparent that in spite of the increased acid addition made during the agglomeration of the PC2 feed, the initial leaching rate of PC1 was considerably faster. PC1 operated with higher initial flowrate and acid concentration. Since the results of the FH column indicate that high acid concentrations are not beneficial to copper leaching, the high initial extraction rate observed for PC1 compared to PC2 apparently results from the higher flowrate.

The copper extraction for PC1 shows an apparent decrease at day 80, when PC2 came on line. This apparent decrease was due to the hold-up of high grade solution in column PC1 plus the reservoir of solution held in the bottom of the PC1 column. By day 80 the PLS grade of column PC1 had decreased to less than 1 gpl Cu. When PC2 was started, the feed to PC1 contained over 5 gpl Cu but this was diluted by the solution in the bottom of the column to about 1 gpl. Since the extraction calculation is based on the difference in copper content between the feed and PLS, the apparent extraction decreases. This apparent loss in recovery is partially regained over the next few weeks of leaching as the PLS grade from PC2 decreases but the final recovery is only made when the column is drained at the end of the test. The inventory of copper in the leach pile must be taken into account when production schedules are prepared and this inventory will increase when additional lifts are added.

While PC1 had a faster initial leaching rate so that it achieved an extraction of 70% in 80 days leaching and PC2 achieved an extraction of just under 50% in the same period, the rate of PC2 continued at a more constant rate so that the total leaching time required for the two columns to achieve 80% extraction appears similar.

The unit acid consumption as a function of time and copper extraction is summarized in Figures 5.8 and 5.9 respectively. Both figures include the acid consumption over the duration of the test

and an expanded view of the region of lowered unit consumption. The results for both tests indicate that the acid consumption based on a feed assay of the ore of 1.22% Cu will be in the order of 2.5 kg H_2SO_4 per tonne. It should be noted that during the period of 80 days when the two columns were running in series, all acid additions were assumed to be to PC2 since it represented the top lift being leached. It should also be noted that unlike the FH column where the excessive acid additions resulted in the unit acid consumption increasing after an initial period of decreasing consumption, for both PC1 and PC2 the unit consumption continuously decreased with time. This decreasing trend indicates that acid additions were being made in an efficient manner with respect to copper leaching. The effect of feed acid concentration on acid consumption is discussed more fully in Appendix C.

As can be seen from Figures 5.10 and 5.11 the iron concentration in the PLS from both columns PC1 and PC2 decreased dramatically when the two columns had been in series for about 30 days (day 110 for PC1). The decrease in iron concentration was accompanied by an increase in solution potential in the order of 100 mV. Examination of the PLS confirmed the presence of bacteria. Apparently a viable population of bacteria became established in the columns, oxidizing the iron to the ferric state and accounting for both the increase in potential and the precipitation of the iron. There was no evidence that the iron precipitation resulted in any loss in permeability in the column.

The copper extraction from PC2 continued at a somewhat slower rate after the acid addition to the feed was discontinued but was proceeding even with a feed pH greater than 2 and PLS pH of 2.7. The test was ended after 289 days of leaching at which time an extraction of 87% had been achieved with a total acid consumption of 22.9 kg/t.

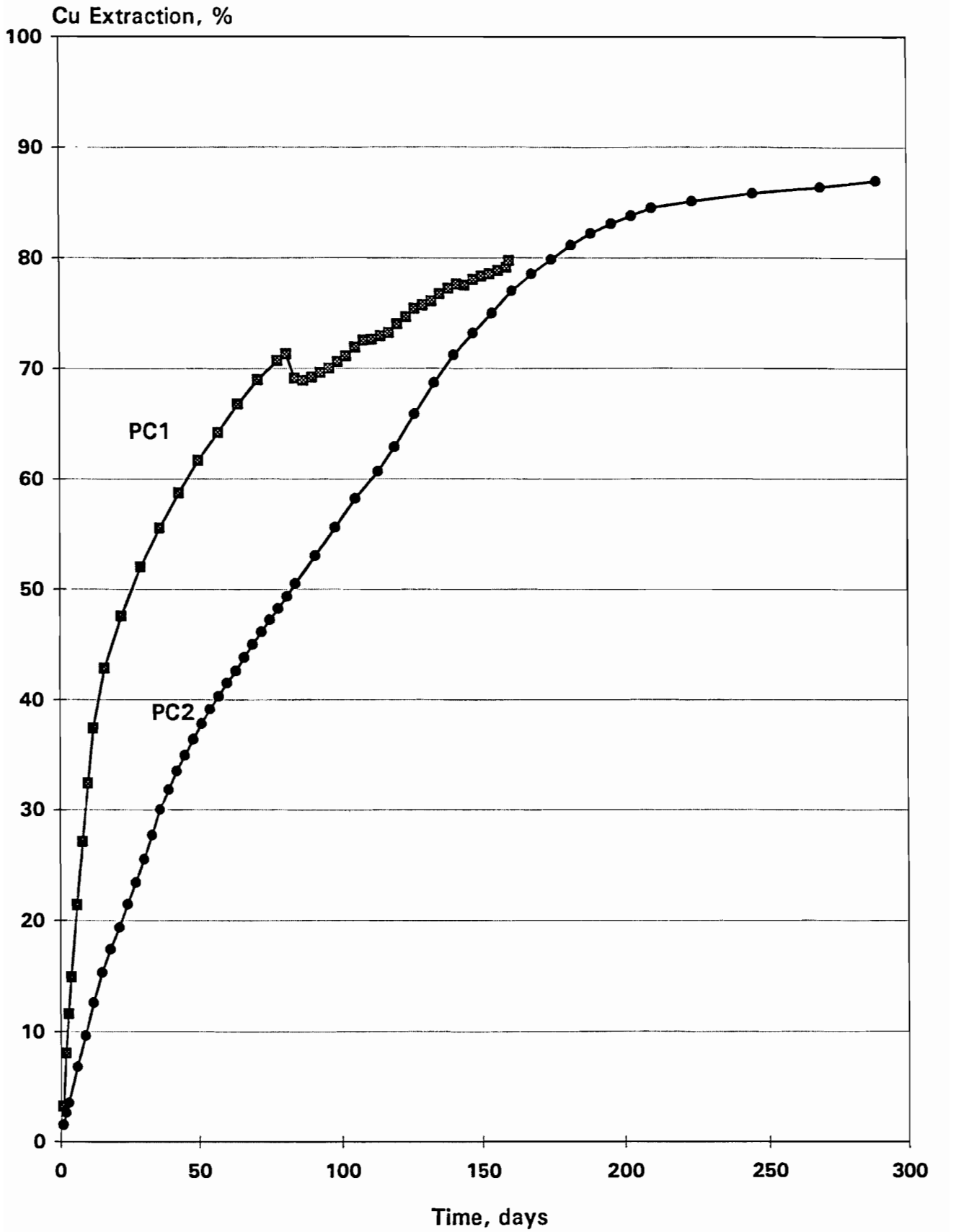

Cu Extraction, %
100
90
80
70
60
50
40
30
20
10
0
PC1
PC2
0
50
100
150
200
250
300
Time, days

Figure 5.6

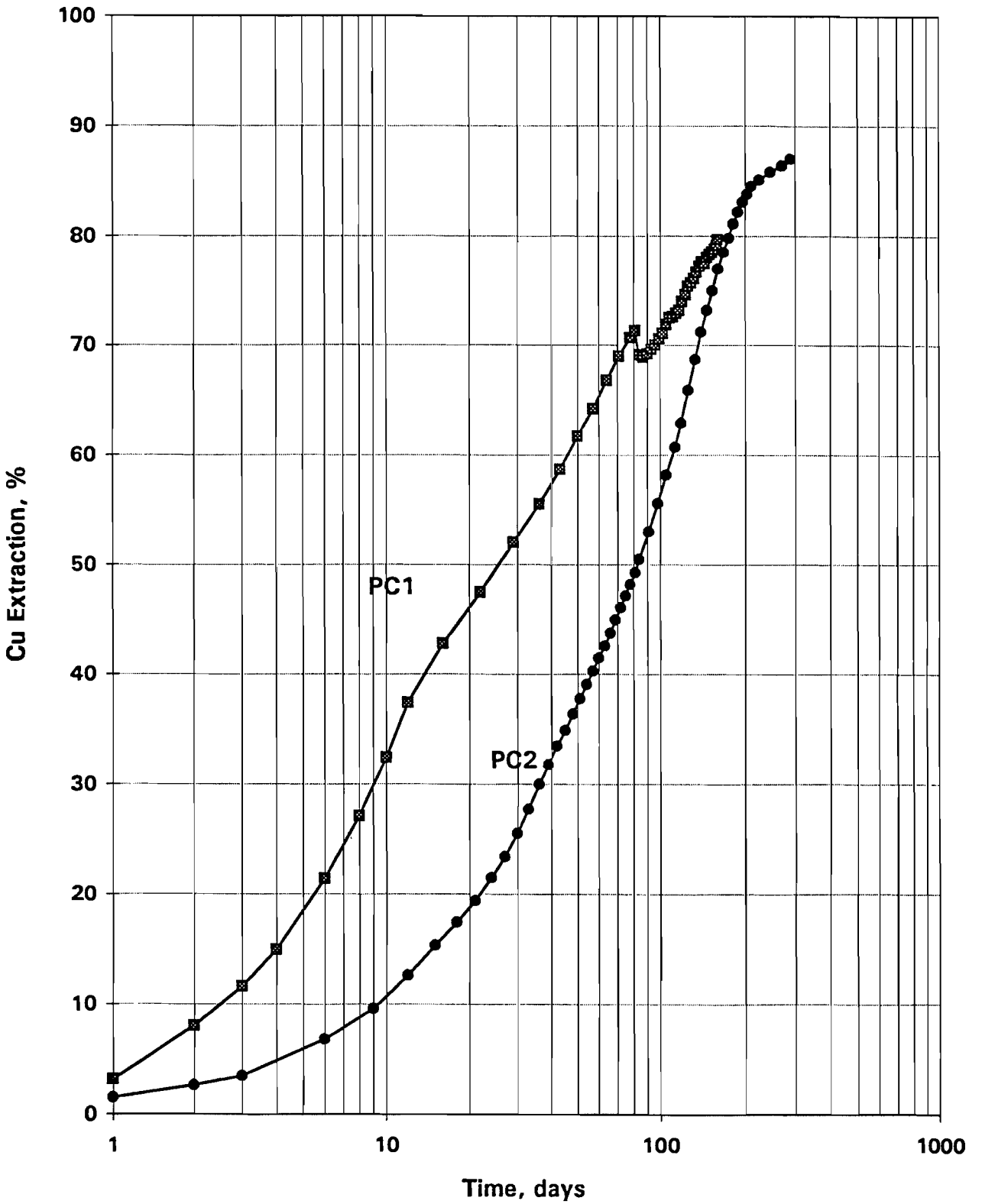
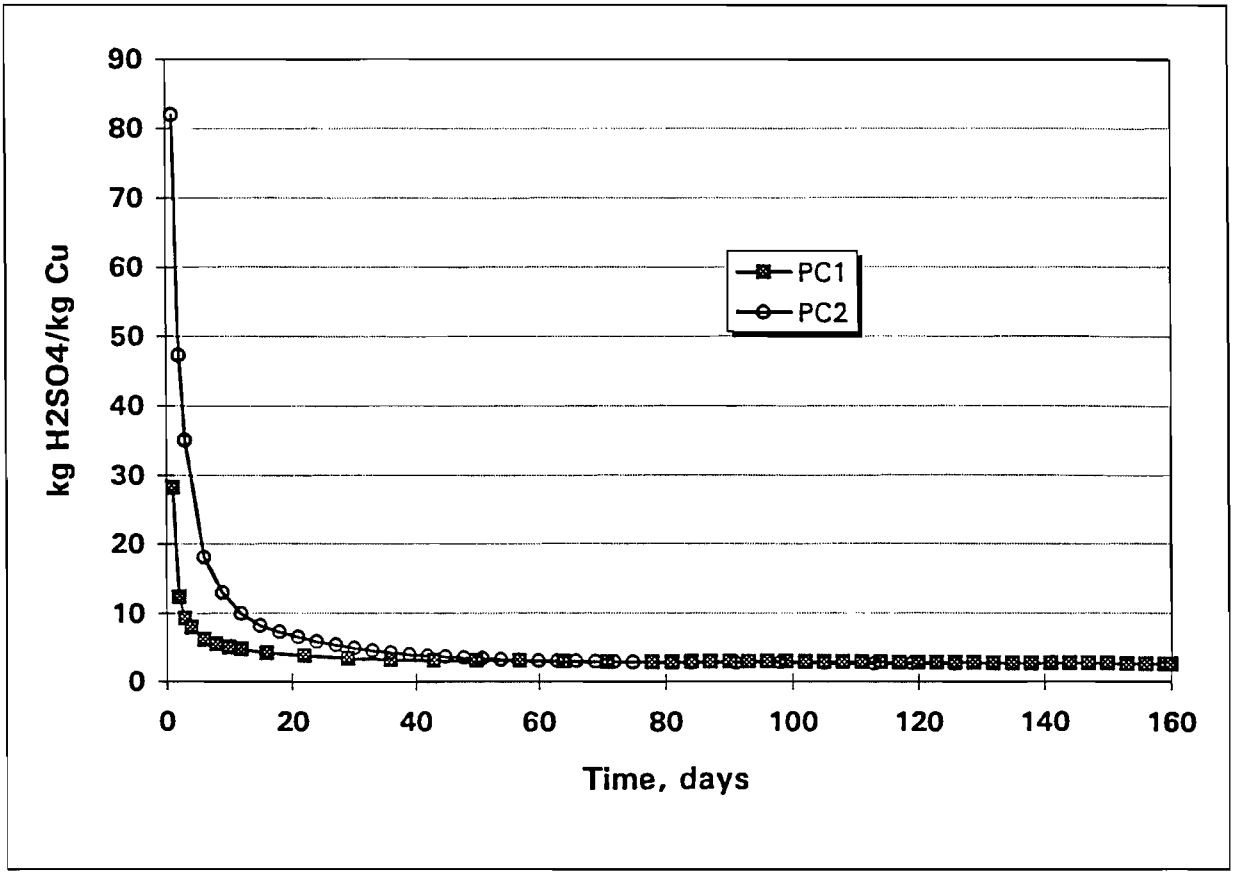

100
90
80
70
60
50
40
30
20
10
0
Cu Extraction, %
PC1
PC2
1
10
100
1000
Time, days

Figure 5.7



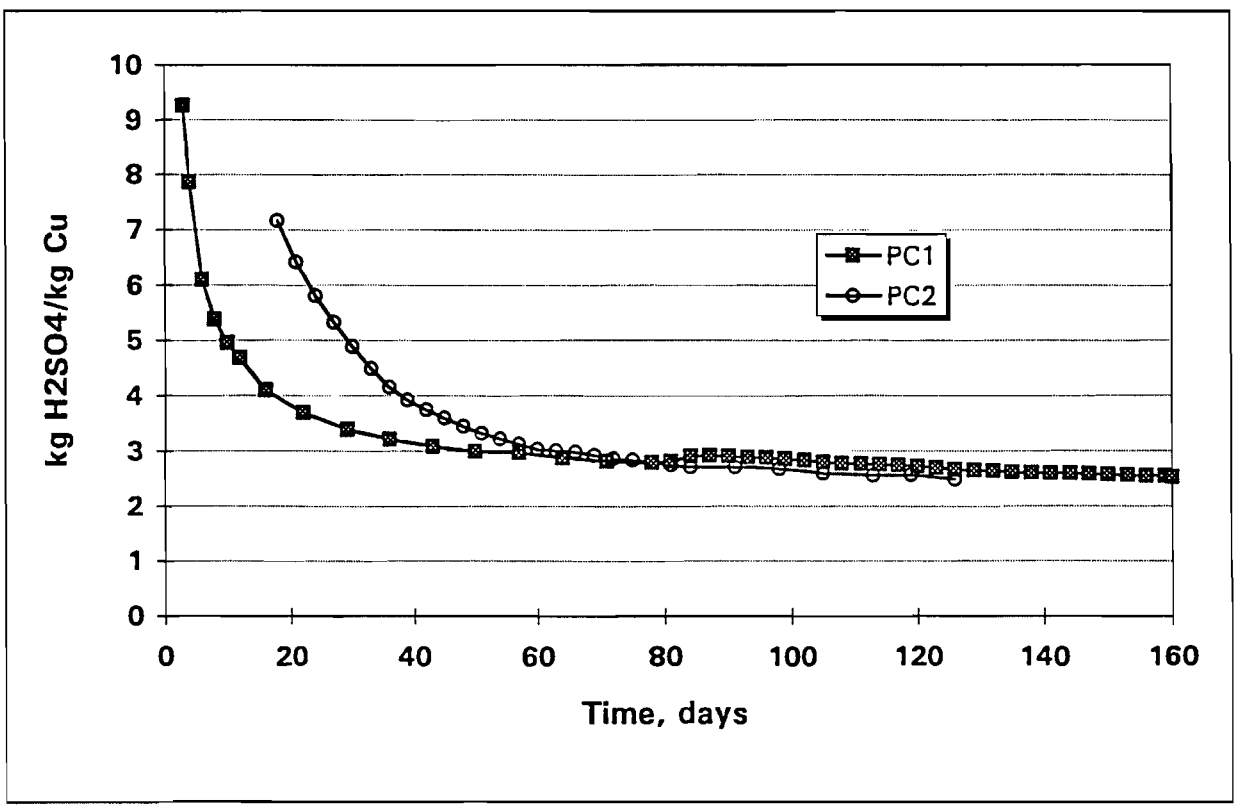
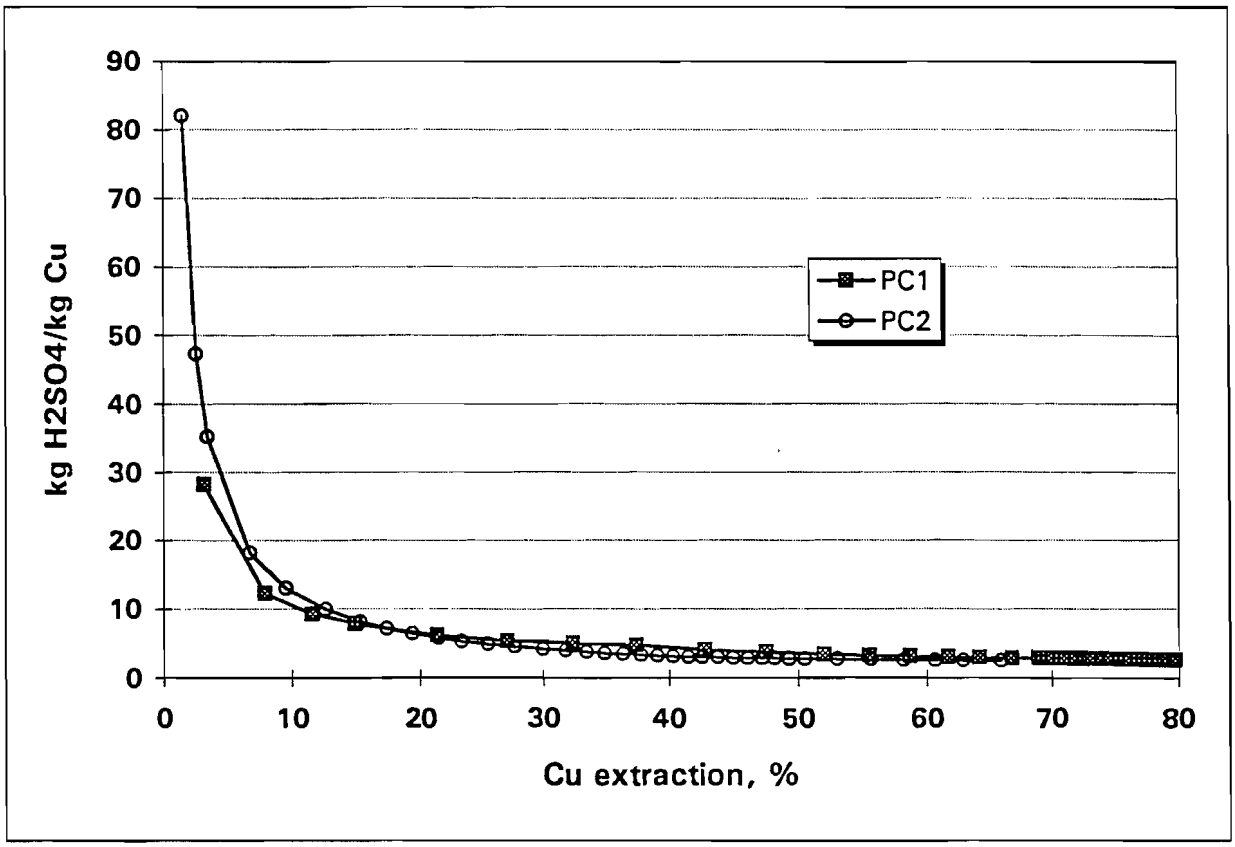


Figure 5.8 Pilot column acid consumption vs time.



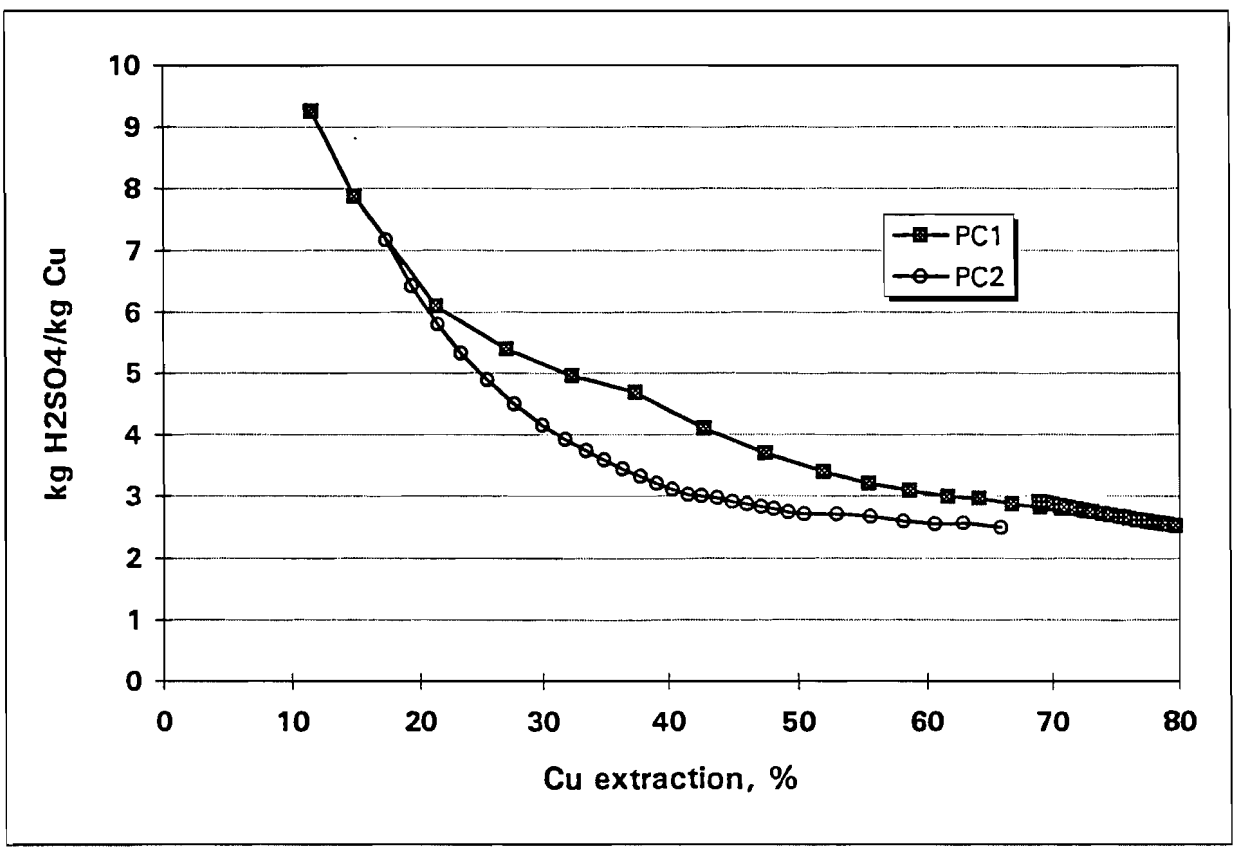


Figure 5.9 Pilot column acid consumption vs Cu extraction.

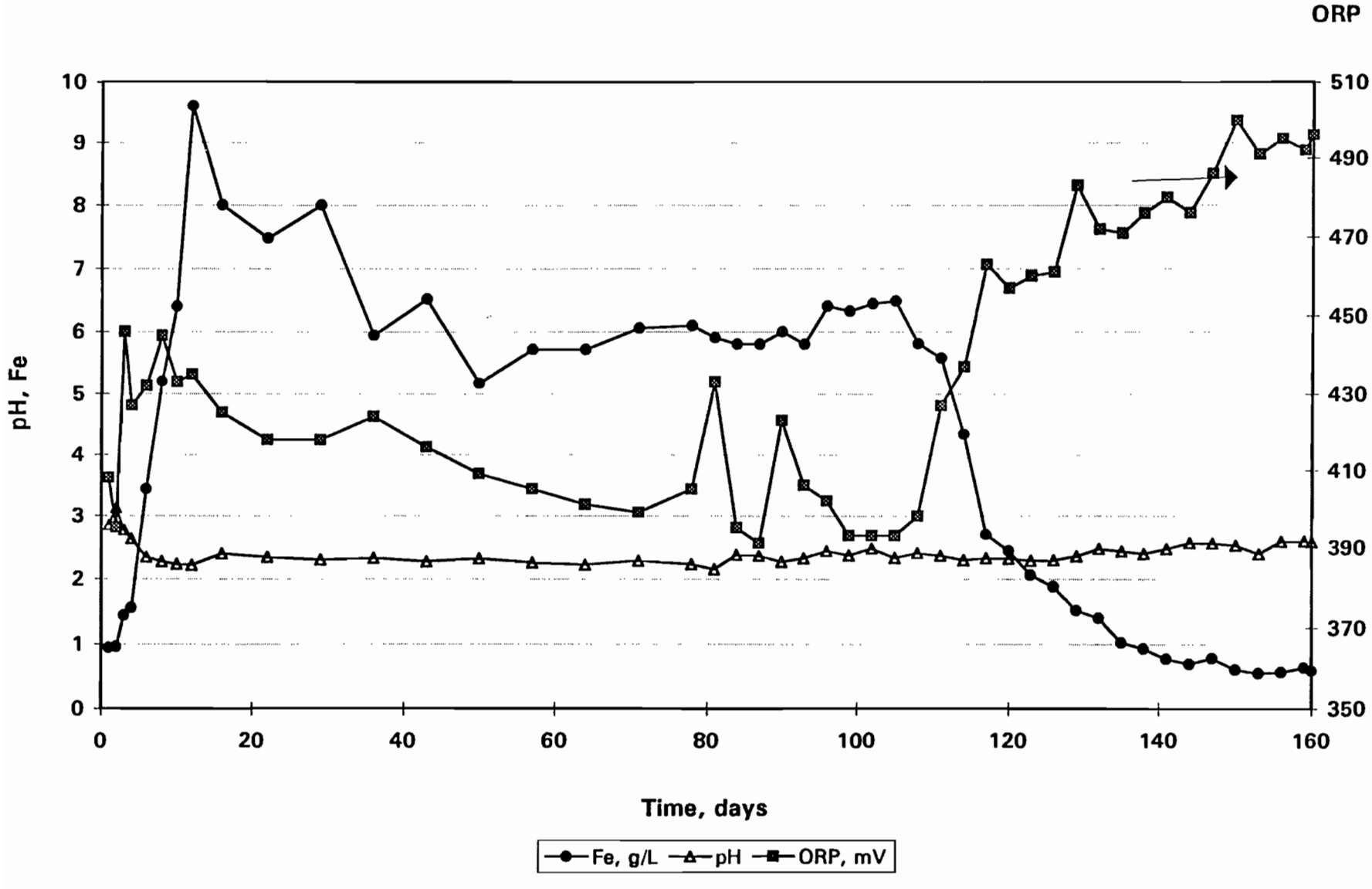


Figure 5.10 Potential, pH and iron vs time for PC1.

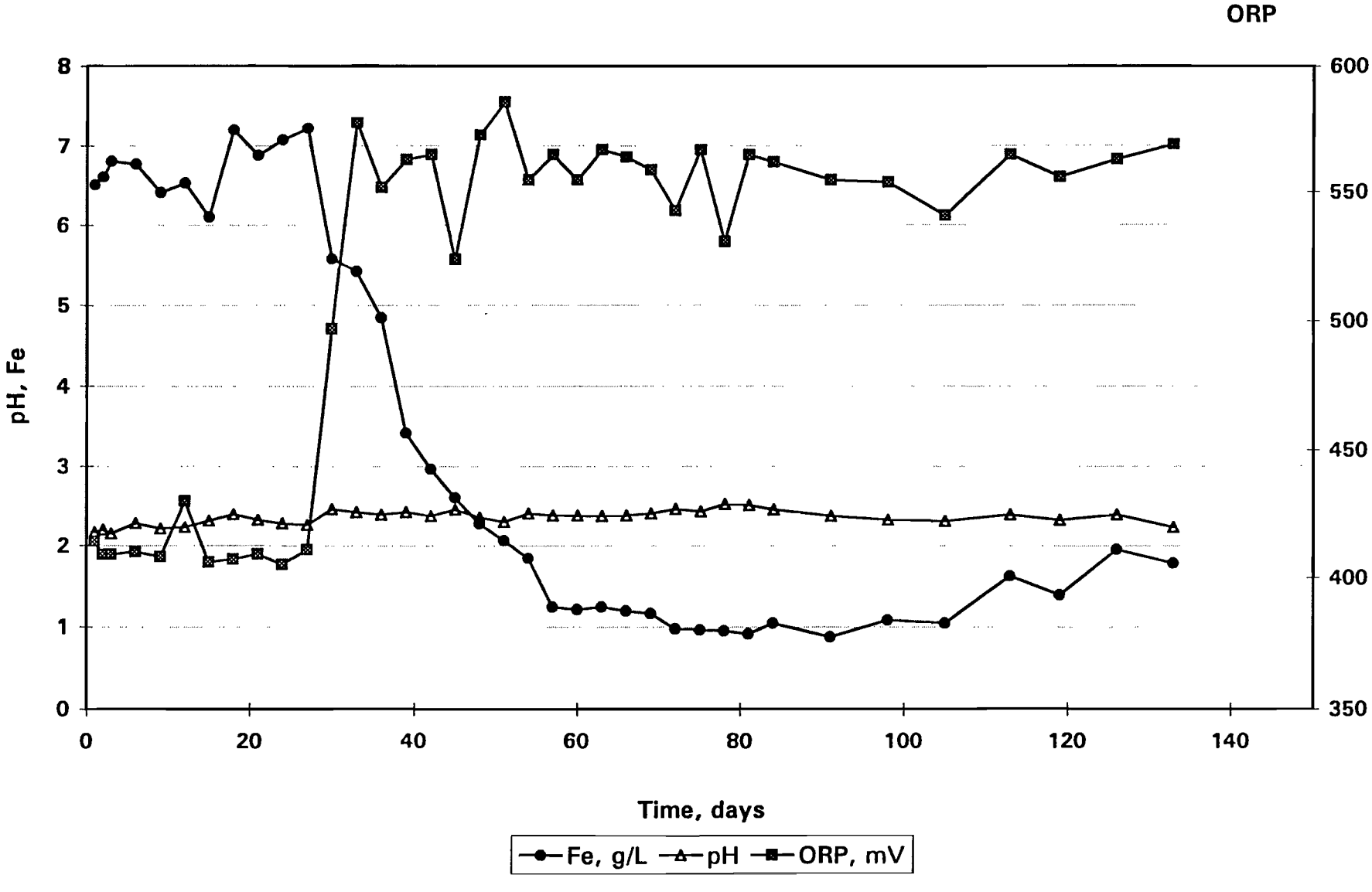


Figure 5.11 Potential, pH and iron vs time for PC2 to day 133.

5.2.1 Moisture determinations.

The feed to PC1 was cured with an addition of 10 kg/t acid, added as a 300 g/l solution. This addition is equivalent to 3.3% moisture. In addition, the solution holdup during the first day of leaching was equivalent to an additional moisture content of 4.1% so that the total moisture was 7.4%.

The feed to PC2 was cured with an addition of 15 kg/t acid added as a 300 g/l solution plus some additional water for a total moisture addition of 5.9%. The first day solution holdup in this column was equivalent to 0.5% moisture so that the total moisture content was 6.4%.

The moisture content of the column residues was determined in sections when the columns were emptied. In evaluating these results it must be noted that these column had been exposed to long term neutralization experiments following the acid leaching. The neutralization conditions appeared to result in considerable particle degradation and this may have resulted in higher residual moisture contents than would be experienced with acid leaching of the ore alone. The measured residual moistures are as follows:

Column PC1	Top	8.0%
	Middle	7.7%
	Bottom	8.3%
Column PC2	Top	7.1%
	Bottom	8.1%

5.2.2 Residue analyses

Upon completion of the neutralization studies for each column, the residues were removed from the column and were dried and analyzed. The residue from column PC1 was separated into top, middle and bottom sections while the residue from column PC2 was analyzed as one overall sample. In each case the samples were screened into the same size fractions as the feed had been and each fraction was analyzed for total and acid soluble copper as well as iron. The complete analyses for these samples are included in Appendix B and are summarized in Table 5.3. The results indicate that leaching has progressed throughout the column with much less gradation in copper content from the top of the column to the bottom than was observed in the FH column tailings. The migration of iron from the top of the column to the bottom is also considerably less than for FH. Comparing the size distribution of the residues with that of the feed as presented in Table 3.8 indicates that some particle degradation has occurred. This degradation cannot be concluded as resulting from the acid leaching step however since the neutralization testwork as discussed in Section 5.4 apparently was actively attacking the gangue minerals.

The residue from test PC2 was analyzed as one sample for the entire column length. The weight distribution and assay by size fraction for the PC2 residue are summarized in Table 5.4. The table includes data for degradation and copper recovery for each size fraction. The degradation index is the percentage change in weight for that size fraction with a negative number indicating a weight loss and a positive number a weight gain. As for the PC1 column, considerable particle degradation has occurred but much of this likely occurred during the neutralization testwork. The recovery figures are based on the simple determination of the difference between the feed assay and residue assay for each fraction, ignoring the change in weight. As would be expected, the copper extraction was the maximum for the finest size fraction.

Table 5.4

Analysis of PC2 column residue.

Fraction	Feed		Residue		Decrep.	Cu Recov.
	Weight %	Assay Cu, %	Weight %	Assay Cu, %	Index	%
- 2 + 1.3	21.7	0.81	14.7	0.20	-32.2	75.2
- 1.3 + 1	14.6	0.87	10.4	0.18	-28.9	79.3
- 1 + 0.6	13.9	0.94	10.8	0.16	-22.4	82.9
- 0.6 + 6m	14.3	1.07	12.5	0.15	-12.4	86.0
-6m	36.2	1.79	51.4	0.17	41.8	90.5

Table 5.3

Size-assay of PC1 column tailings

FRACTION	WEIGHT	ASSAY			DISTRIBUTION, %		
cm	%	Cu_T	Cu_{ox}	Fe	Cu_T	Cu_{ox}	Fe
TOP							
+ 2	0.6	0.15	0.11	2.70	0.4	0.5	0.4
- 2 + 1.3	14.3	0.23	0.15	3.10	16.9	17.1	10.7
- 1.3 + 1	11.2	0.20	0.13	3.00	11.6	11.9	8.1
- 1 + 0.6	11.3	0.19	0.12	3.00	11.1	11.5	8.2
- 0.6 + 6m	12.9	0.17	0.11	3.20	11.6	11.6	10.0
- 6 m	49.8	0.19	0.12	5.20	48.3	47.4	62.6
Total		0.19	0.12	4.13			
MIDDLE							
+ 2	0.6	0.17	0.14	2.60	0.5	0.6	0.4
- 2 + 1.3	15.1	0.25	0.18	3.10	17.3	18.1	10.7
- 1.3 + 1	12.3	0.23	0.15	3.40	13.3	12.7	9.67
- 1 + 0.6	12.7	0.22	0.15	3.40	12.8	12.5	9.9
- 0.6 + 6m	14.1	0.20	0.13	3.60	12.9	12.0	11.6
- 6 m	45.2	0.20	0.15	5.60	43.1	44.0	57.9
Total		0.21	0.15	4.37			
BOTTOM							
+ 2	0.7	0.14	0.11	2.60	0.5	0.6	0.4
- 2 + 1.3	17.3	0.27	0.19	3.20	23.0	23.7	12.2
- 1.3 + 1	12.3	0.22	0.15	3.20	13.1	13.4	8.6
- 1 + 0.6	10.9	0.20	0.12	3.40	10.5	9.60	8.1
- 0.6 + 6m	12.8	0.19	0.11	3.60	11.7	10.5	10.1
- 6m	46.0	0.19	0.13	6.00	41.4	42.3	60.5
Total		0.21	0.14	4.56			

5.3 Trace element and environmental analyses

Solutions from the FH and PC2 column were analyzed for rare earth elements. The results of these analyses are summarized in Table 5.5 with all value expressed as ppb. Note that the PC2 day 189 and final pregnant solutions were analyzed by two different analytical laboratories.

Table 5.5

Rare earth element analyses of leach solutions.

Element	FH column Final preg.	PC2 column day 189 preg.	PC2 column Final preg.
Scandium	2100		980
Yttrium	2100	7545	4440
Lanthanum	460	735	151
Cerium	1700	2636	1120
Praseodymium	280	630	366
Neodymium	1800	3865	2250
Europium	120	286	265
Samarium	470	933	764
Gadolinium	620	1279	900
Terbium	62	213	153
Dysprosium	450	1248	830
Holmium	74	232	190
Erbium	270	571	525
Thulium	32	79	73.3
Ytterbium	250	576	466
Lutetium	34	59	70.1

The final pregnant solution from column FH was analyzed for trace elements. The results of this analysis are summarized in Table 5.6 The solution can be seen to be elevated in the rock forming elements.

Table 5.6

Trace element analysis of final FH column pregnant solution.

Element	ppm	Element	ppm
Ag	<.1	Hg	<1
Al	9675	La	0.7
As	2.6	Mg	4851
Au	<1	Mn	254.5
B	455.8	Mo	1.6
Ba	3.2	Na	0.03
Be	0.7	Ni	4.8
Bi	<1	P	312
Ca	410	Pb	0.8
Cd	1.6	Sb	<1
Co	8.0	Si	385.4
Cr	3.7	Sr	0.7
Cu	349	Ti	25.7
Fe	6965	V	22.5
W	1.4	Zn	91.7

Samples of final raffinate from FH and PC1 column as well as from the pilot test conducted at Carmacks were neutralized with lime. The test conditions are summarized in Table 5.7, together with the solution analyses expressed as ppm.

Table 5.7
Analyses of raffinates and neutralized raffinates.

	FH		PC1		Pilot Test	
Initial pH/ final pH	1.78/7.05		1.75/7.01		1.15/6.98	
Sample vol, L	23		0.5		0.5	
Lime, g	1013		19		33	
Lime, g/L	44		38		65	
	Raffinate	**Neut. raff.**	**Raffinate**	**Neut. raff.**	**Raffinate**	**Neut. raff.**
Ag	0.1	0.1	0.1	<.1	0.1	<.1
Al	4388	<100	8474	<100	6045	<100
As	0.2	1.2	1.5	0.8	0.9	0.5
Au	<.1	<.1	<.1	<.1	<.1	<.1
B	131.2		278.3	42.4	249.5	59.3
Ba	1	0.4	3.1	0.5	2.8	0.6
Be	0.2	0	0.2	0	0.2	0
Bi	<1	<1	<1	<1	<1	<1
Ca	445	420	419	484	412	448
Cd	0.5	0.1	0.6	<.1	0.5	<.1
Co	5.1	0.1	5.1	0.4	10.1	0.3
Cr	1.2	0.1	2.4	<.1	2.1	<.1
Cu	10.2	0.4	7.7	0.1	155.3	0.4
Fe	533	149	7397	10	5593	19
Hg	<.5	<.5	<.5	<.5	<.5	<.5
La	0.6	<.1	0.5	<.1	0.6	<.1
Mg	3071	2946	3842	3214	4130	4383
Mn	398.5	67.1	260.6	110.5	665	179.4
Mo	<.1	0.1	0.1	0	<.1	0
Na	73	96	180	55	103	73
Ni	3.6	0.5	4.2	0.2	7.4	0.1
P	53	5	270	2	150	2
Pb	0.2	0.3	0.9	0.4	0.3	0.1
Sb	<.1	1	0.3	0.3	0.2	0.2
Si	114.2	0.2	299.9	0.6	55.9	0.2
Sr	<.1	2.9	0.3	4.3	0.4	5.1
Ti	<.1	0.1	17.8	<.1	2.9	<.1
V	0.1	<.1	17.7	<.1	7	<.1
W	<.1	0.3	0.8	0.4	0.5	0.3
Zn	55.3	0.5	93.9	0.3	68.5	0.3

The neutralized raffinate from FH column was submitted for a rainbow trout toxicity test. The results of this test are included as Appendix E. The solid precipitate formed during neutralization of the FH raffinate was analyzed by means of whole rock and ICP analysis and the results are summarized in Table 5.8. The high calcium content of this precipitate is consistent with the formation of calcium sulphate which comprised the majority of the product.

Table 5.8

Analysis of precipitate formed by neutralization of final FH raffinate.

Whole rock analysis		ICP analysis	
Element	**%**	**Element**	**ppm**
SiO_2	0.35	Ag	0.7
Al_2O_3	9.79	As	14
Fe_2O_3	7.06	B	2035
MgO	2.08	Be	1
CaO	32.74	Bi	1
Na_2O	0.01	Cd	8
K_2O	0.03	Co	45
P_2O_5	0.37	Cu	45
TiO_2	0.02	Hg	<3
MnO	0.179	La	4
BaO	0.004	Mo	4
Cr_2O_3	0.023	Ni	37
SrO	0.031	Pb	19
LOI	18.5	Sb	6
Total	71.2	V	146
		Zn	570

5.4 Column neutralization results

The leaching of column PC1 was ended after 160 days, at which time it was allowed to drain. After the draining was complete, it was washed with two 20 litre batches of water. The composition of the final PLS and the wash solutions are summarized in Table 5.9. It is apparent from the results that although the solution pH had increased significantly through the washing, the copper content of the solution was still very high and additional washing would be warranted before neutralization was started.

Table 5.9

Column PC1 washing results.

Product	pH	Cu, g/L
Final day PLS	2.58	1.60
Drain solution	2.69	1.81
Wash 1	2.81	1.75
Wash 2	2.90	1.58

Neutralization of PC1 was started by pumping water adjusted to pH 7 with NaOH onto the top of the column at the rate of 0.2 $L/m^2/min$. The pH of the effluent from the column was measured and was then adjusted to 7 with NaOH before being recycled back to the column. At first, the precipitate which formed when the effluent was neutralized was pumped back to the column with the neutralized solution. It was soon found that the volume of precipitate was so great that the top of the column was filling up and the solution would not pass through the precipitate. At this point, the accumulation of precipitate was removed from the top of the column and additional precipitate was settled from the solution before it was returned to the column. An analysis of the precipitate formed at the start of the neutralization is summarized in Table 5.10. Also included in this table is the analysis for a precipitate formed by neutralizing a sample of the day 119

raffinate from PC2 to pH 7 with NaOH.

Table 5.10

Analysis of precipitate formed by NaOH neutralization of column effluent.

Element	ppm unless otherwise noted	
	PC1	PC2
Ag	3.1	1.0
Al	7.32 %	9.44%
As	50	26
B	478	702
Ba	16	16
Be	2.2	5
Bi	<5	<5
Ca	0.84%	0.20%
Cd	10.8	10.2
Co	148	174
Cr	16	36
Cu	61,660	206
Fe	0.34	2.90
Hg	<5	<5
La	<2	24
1.38	4.08%	1.38%
Mn	8558	3344
Mo	10	8
Na	1.88%	4.14%
Ni	16	74
P	44	2650
Pb	22	14
Sb	8	10
Si	0.12%	0.10
Sr	<2	<2
Ti	0.02	0.02
V	<2	16
W	<5	<5
Zn	1212	974

The detailed neutralization results for column PC1, including feed and effluent pH, are included in Appendix F. The effluent pH as a function of time is summarized in Figure 5.12. Changes which were made to the procedure as the test progressed are as follows:

- On day 15 the feed pH was increased from 7 to 9
- From day 34 on the pH was adjusted with lime instead of NaOH
- On day 61 the feed pH was increased to 10.5
- From day 120 on, the flowrate was doubled
- From days 134 to 145 and 155 to 169, the column was allowed to rest
- From day 256 through day 260 and days 309 through 330, the feed pH was decreased to 7 and 100 mg/L Si was added as sodium silicate
- From day 260 to 306 the column was allowed to rest
- From day 306 on, the feed pH was maintained at 7

The objective of the various changes was to achieve the maximum neutralization rate and to achieve a neutral effluent pH. It can be seen from Figure 5.12 that none of the changes had a profound effect on the neutralization rate. It is also apparent that there is a marked resistance to achieving an effluent pH greater than about 4. Over the course of the neutralization, 1.7 kg/t of NaOH and 3.7 kg/t lime were added to the feed solutions. Based on the assumption that the leach residue contained 10% moisture at 10 g/L acid, the NaOH required for acid neutralization would be 0.8 kg/t.

To determine whether there was a significant variation in the condition of material from the top of the column to the bottom, samples representative of the top, middle and bottom sections of the column were tested once the column was taken down. A 5 kg portion from each column section was covered with water which had been adjusted to pH 7 with lime. The solids were stirred for 5 minutes and then the pH and solution potential were measured. The solids were then allowed to sit in the solution for 24 hours following which period the solids were again stirred and the solution pH and potential were measured. The results of this testwork are summarized in Table

5.11. While there has been somewhat greater neutralization of the top solids compared to the bottom, after the 24 hour immersion it is apparent that all the material is still exerting a buffering action on the solution to result in an effluent pH near pH 4. Also note that in each case the solution potential is increasing with time.

Table 5.11

Results of batch neutralization tests on PC1 residues.

Sample	Time	pH	ORP mV vs Ag/AgCl
top	5 min.	4.6	278
top	24 hr	4.4	312
middle	5 min.	4.4	319
middle	24 hr	4.3	344
bottom	5 min.	4.2	342
bottom	24 hr	4.2	372

The effluent solution on day 7 was analyzed by means of multiple element ICP analysis. The results are included in Appendix F, together with other ICP analyses for both PC1 and PC2 discharges. Since the effluents were elevated in aluminum and silica, additions of sodium silicate were made to the solutions as indicated above to determine whether the decrepitation of the rock could be suppressed. Both the ICP analyses of solutions and the pH vs time results in Figure 5.12 indicate that the silicate additions did not have any beneficial effects.

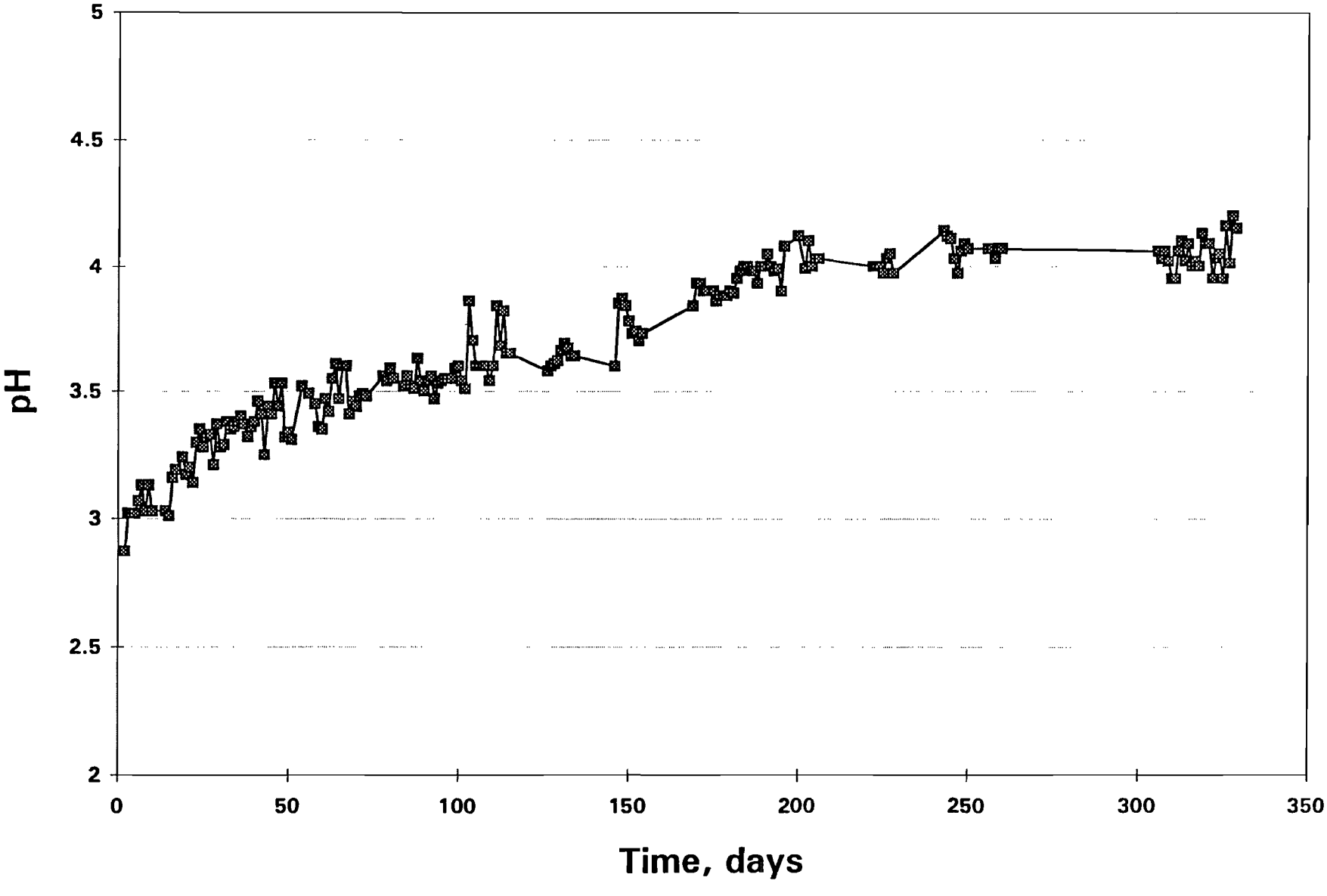


Figure 5.12 Neutralization results for PC1 column.

The neutralization of column PC2 had some differences to the procedure followed for PC1. While PC1 was washed twice and then neutralized while the PLS still contained abundant copper, the raffinate from PC2 was returned to the feed without acid addition until the PLS pH had increased to 2.78. At this point the solution was neutralized to pH 11 with lime before being returned to the column. Additional variations included in the PC2 neutralization are as follows:

- On day 30 the solution flowrate was doubled
- The column was allowed to rest from day 14 to 28, 33 to 50, 56 to 75, and 81 to 137
- On day 137 the feed pH was decreased to pH 7

The results for PC2 are included with those of PC1 in Figure 5.13. In spite of the different conditions which prevailed at the start of PC2 compared to PC1, the effluent pH as a function of time is essentially the same for the two columns.

Following the active neutralization period, the bottom 6 feet of column PC2 was flooded with water adjusted to pH 7 with NaOH. The pH of the solution was measured at several locations within the flooded zone and the results are summarized in Table 5.12.

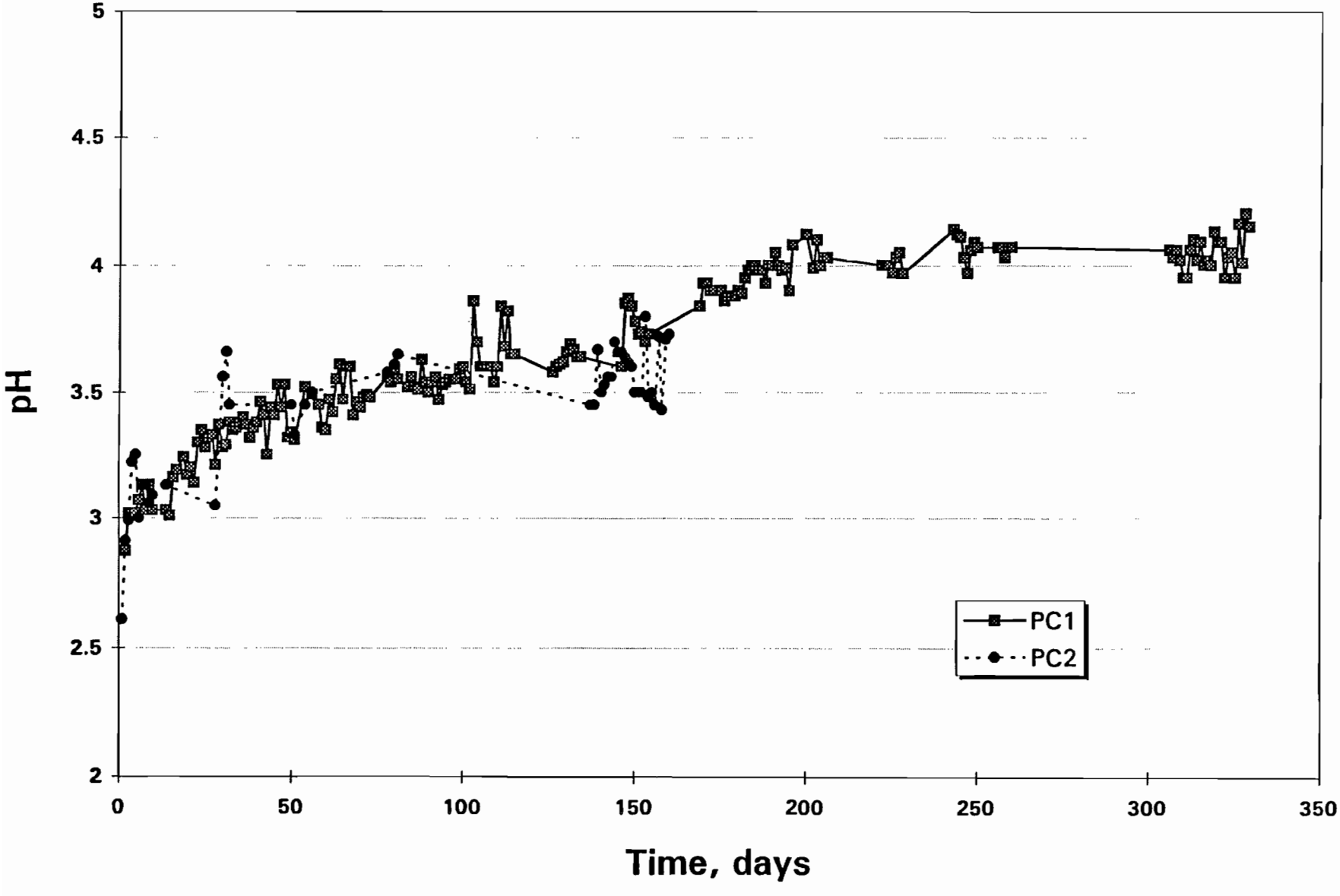


Figure 5.13 Neutralization results for PC1 and PC2 columns.

Table 5.12

Variation of solution pH with time in flooded leach residue.

Date 1995	Day	Port location from bottom (ft)	pH
26-Sep	7	2	3.43
		4	3.48
		6	3.48
3-Oct	14	2	3.63
		4	4.30
		6	4.43
11-Oct	22	2	3.71
		4	3.85
		6	3.80
17-Oct	28	2	3.73
		4	3.81
		6	3.77
25-Oct	36	2	3.83
		4	3.80
		6	3.77
1-Nov	44	2	3.88
		4	3.88
		6	3.83

APPENDIX A

Test details for columns

WILLIAMS CREEK - FH COLUMN LEACH TEST DATA

Project #: 92-006
Column #: FH
Column Size: 6 inch x 18 feet
Ore Sample: High Grade Composite

Sample Weight 155 kg
Copper Grade: 1.33 %
Charge Height: 5.52 m
Bulk S.G. 1.54 tonne/m^3

Agglomeration Acid Concentration: 150 g H2SO4/L
Agglomeration Acid Consumption: 5.00 kg/tonne
Sample Moisture: 3.46 % by weight
Initial H2SO4 Solution Concentration: 15.1 g/L

Date	Time on	Time off	Days	FEED SOLUTION						LEACHATE							RAFFINATE							Free	Cu	H2SO4
				Start Wt.	End Wt	s.g.	pH	H2SO4	Flow	Wt.	s.g.	Vol.	pH	ORP	Cu	Fe	Wt.	s.g.	Vol.	pH	Cu	Fe	H2SO4	Extr.	Add'n
1993				g	g			g	mL/min	g		L		mV*	g/L	g/L	g		L		g/L	g/L	g/L	%	kg/t
	10:15					1.005																				
May-26		11:00	1					164	7.30		1.061	6.36	3.70	344	20.50	0.37									6.3	6.1
	11:05					1.005																				
May-27		10:40	2					153	7.15		1.025	9.89	3.70	343	8.08										10.2	7.0
	10:45					1.005																				
May-28		10:45	3					156	7.16		1.020	9.91	3.72	329	6.48										13.3	8.0
	10:50					1.005																				
May-29		12:35	4					209	8.97		1.019	13.43	3.73	317	4.68			1.017	39.15	0.89	0.136		16.9	16.3	9.4
	15:03					1.013	0.93																			
May-31		13:55	6					227	7.35		1.028	20.32	3.71	315	5.44						0.136			21.5	10.8
	13:58					1.013	0.93																			
Jun-02		11:10	8					233	7.81		1.038	20.62	3.66	315	5.84			1.024	41.04	1.16	0.090		17.5	27.2	12.3
	12:23					1.029	0.78																			
Jun-06		13:00	12					442	6.93		1.043	39.76	3.41	343	4.32			1.035	39.82	1.40	0.063		16.8	35.3	15.2
	14:45					1.040	0.88																			
Jun-10		08:00	16					422	7.17		1.049	37.54	3.42	363	3.28			1.043	37.01	1.49	0.030		15.7	41.1	17 9
	11:45					1.051	0.93																			
Jun-14		08:56	20					449	7.29		1.060	40.45	2.86	388	2.76	4.20		1.053	40.51	1.61	0.037		9.1	46.5	20.8
	11:10					1.058	0.95																			
Jun-18		08:35	24					240	3.89		1.063	22.03	2.83	385	2.78	5.00		1.061	21.93	1.60	0.034		17.9	49.4	22.3
	09:10					1.071	1.02																			
Jun-25		09:35	31					400	3.60		1.069	35.80	2.86	393	2.32	5.20		1.066	34.40	1.68	0.013		18.1	53.3	24.9
	11:40					1.071	1.00																			
Jul-02		10:55	38					390	3.54		1.077	34.84	2.78	403	1.90	6.00		1.073	34.80	1.79	0.013		18.8	56.5	27.4
	12:50					1.074	0.97																			
Jul-09		08:20	45					405	3.75		1.086	36.11	2.62	391	1.64	6.60		1.084	35.90	1.79	0.006		19.8	59.4	30.0
	10:45					1.088	1.11																			
Jul-16		11:08	52					380	3.42		1.09	34.02	2.56	388	1.48	7.40		1.092	33.99	1.81	0.009		21.8	61 8	32.5
	13:07					1.095	1.01																			
Jul-23		10:40	59					402	3.68		1.104	35.94	2.48	393	1.28	8.20		1.101	35.91	1.81	0.005		13.5	64.0	35.1

* vs Ag/AgCl reference

WILLIAMS CREEK - FH COLUMN LEACH TEST DATA

Project #: 92-006
Column #: FH
Column Size: 6 inch x 18 feet
Ore Sample: High Grade Composite

Sample Weight 155 kg
Copper Grade: 1.33 %
Charge Height: 5.52 m
Bulk S.G. 1.54 tonne/m^3

Agglomeration Acid Concentration: 150 g H2SO4/L
Agglomeration Acid Consumption: 5.00 kg/tonne
Sample Moisture: 3.46 % by weight
Initial H2SO4 Solution Concentration: 15.1 g/L

Date	Time on	Time off	Days	FEED SOLUTION						LEACHATE							RAFFINATE						Free	Cu	H2SO4
				Start Wt.	End Wt	s.g.	pH	H2SO4	Flow	Wt.	s.g.	Vol.	pH	ORP	Cu	Fe	Wt.	s.g.	Vol.	pH	Cu	Fe	H2SO4	Extr.	Add'n
1993				g	g			g	mL/min	g		L		mV*	g/L	g/L	g		L		g/L	g/L	g/L	%	kg/t
	12:40					1.104	1.50																		
Jul-30		09:00	66					106	3.58		1.106	35.04	2.46	390	1.08	8.40		1.101	34.90	1.85	0.006		13.9	65.8	35.7
	10:30					1.104	1.50																		
Aug-06		09:35	73					94	3.53		1.106	36.49	2.50	408	0.88	8.60		1.103	36.54	1.92	0.004		14.1	67.3	36.3
	11:25					1.104	1.50																		
Aug-13		10:35	80					142	3.76		1.105	36.07	2.56	391	0.72	8.60		1.11	36.01	2.03	0.003		14.1	68.6	37.3
	12:30					1.104	1.50																		
Aug-20		08:45	87					168	3.80		1.110	36.71	2.41	381	0.60	8.80		1.109	36.48	1.99	0.002		14.5	69.6	38.3
	09:53					1.113	1.50																		
Aug-27		08:00	94					122	3.57		1.109	34.51	2.54	409	0.56	8.40		1.108	33.91	2.05	0.002		13.4	70.6	39.1
	11:05					1.110	1.50																		
Sep-03		09:14	101					161	3.71		1.113	38.62	2.46	415	0.54	9.00		1.113	38.06	2.06	0.002		11.2	71.6	40.2
	11:16					1.110	1.50																		
Sep-10		08:08	108					204	4.09		1.103	37.52	2.36	381	0.52	8.40		1.101	37.45	2.00	0.002		12.4	72.5	41.5
	10:45					1.101	1.50																		
Sep-17		09:55	115					214	3.71		1.104	38.57	2.35	388	0.51	8.50		1.106	37.91	2.00	0.002		14.5	73.5	42.8
	11:45					1.110	1.50																		
Sep-24		08:20	122					220	4.16		1.140	39.15	2.24	388	0.44	8.80		1.112	34.17	1.96	0.003		7.4	74.3	44.3
	10:20					1.113	1.50																		
Oct-01		08:40	129					144	3.67		1.116	36.73	2.34	388	0.45	9.30		1.114	36.35	1.91	0.003		14.8	75.1	45.2
	11:40					1.114	1.50																		
Oct-08		08:27	136					128	3.77		1.104	36.88	2.30	389	0.40	8.50		1.105	36.44	1.94	0.001		13.7	75.8	46.0
	10:39					1.103	1.50																		
Oct-15		10:50	143					122	3.65		1.110	37.42	2.24	389	0.38	8.43		1.109	37.19	1.91	0.006			76.5	46.8
	16:35					1.113	1.50																		
Oct-22		08:25	150					113	3.66		1.112	33.11	2.20	390	0.35	8.62		1.112	32.87	1.79	0.004			77.0	47.5
	11:15					1.103	1.50																		
Oct-29		10:22	157					103	3.21		1.110	31.91	2.13	392	0.34	8.70		1.108	31.81	1.93	0.002			77.5	48.2
	12:55					1.107	1.50																		
Nov-08		10:43	164					115	3.12		1.111	30.96	2.22	389	0.36	8.77		1.108	30.89	1.83	0.007			78.1	48.9

* vs Ag/AgCl reference

WILLIAMS CREEK - FH COLUMN LEACH TEST DATA

Project #: 92-006
Column #: FH
Column Size: 6 inch x 18 feet
Ore Sample: High Grade Composite

Sample Weight 155 kg
Copper Grade: 1.33 %
Charge Height: 5.52 m
Bulk S.G. 1.54 tonne/m^3

Agglomeration Acid Concentration: 150 g H2SO4/L
Agglomeration Acid Consumption: 5.00 kg/tonne
Sample Moisture: 3.46 % by weight
Initial H2SO4 Solution Concentration: 15.1 g/L

Date	Time on	Time off	Days	FEED SOLUTION						LEACHATE							RAFFINATE						Free	Cu	H2SO4
1993				Start Wt. g	End Wt g	s.g.	pH	H2SO4 g	Flow mL/min	Wt. g	s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	Wt. g	s.g.	Vol. L	pH	Cu g/L	Fe g/L	H2SO4 g/L	Extr. %	Add'n kg/t
	13:20					1.109	1.50																		
Nov-12		10:00	171					77	3.92		1.115	37.80	2.23	392	0.30	8.76		1.112	37.14	1.84	0.004			78.6	49.4
	13:11					1.117	1.50																		
Nov-19		09:24	179					140	3.64		1.116	35.11	2.16	391	0.31	9.57		1.115	35.05	1.73	0.008			79.2	50.3
	12:45					1.111	1.50																		
Nov-24		17:00	186					59	3.58		1.120	28.86	2.08	393	0.32	9.71								79.6	50.7
									Wash solution		1.054	16.54			0.19	4.00								79.7	50.7

* vs Ag/AgCl reference

MATERIAL BALANCE

Project no : 92-006
Test no : FH

Date : December 12, 1995

Sample description : Column residue

Products	Weight		Assays			% Distribution		
	(kg)	(%)	Cu (T) (%)	Cu (ox) (%)	Fe (%)	Cu (T)	Cu (ox)	Fe
+3/4"	50.1	33.4	0.14	0.08	2.38	17.4	13.7	23.9
-3/4" +1/2"	53.1	35.3	0.31	0.23	3.62	38.8	39.5	38.5
-1/2" +3/8"	47.0	31.3	0.39	0.30	3.98	43.8	46.8	37.5
Calculated head	**150.2**	**100.0**	**0.28**	**0.20**	**3.32**	**100.0**	**100.0**	**100.0**
Assay head								

MATERIAL BALANCE

Project no : 92-006
Test no : FH

Date : December 12, 1995

Sample description : Top column residue

Products	Weight		Assays			% Distribution		
	(kg)	(%)	Cu (T) (%)	Cu (ox) (%)	Fe (%)	Cu (T)	Cu (ox)	Fe
+3/4"	0.1	0.2	0.20	0.18	3.48	0.2	0.4	0.2
-3/4" +1/2"	7.8	15.5	0.25	0.19	2.53	26.6	35.1	16.5
-1/2" +3/8"	11.5	22.9	0.16	0.11	2.36	25.8	30.2	22.7
-3/8" +1/4"	8.6	17.2	0.15	0.07	2.18	18.1	15.0	15.8
1/4" +6 mesh	6.9	13.8	0.09	0.05	2.26	9.0	7.7	13.1
- 6 mesh	15.2	30.3	0.10	0.03	2.48	20.3	11.7	31.6
Calculated head	**50.1**	**100.0**	**0.14**	**0.08**	**2.38**	**100.0**	**100.0**	**100.0**
Assay head								

MATERIAL BALANCE

Project no : 92-006
Test no : FH

Date : December 12, 1995

Sample description : Mid column residue

Products	Weight		Assays			% Distribution		
	(kg)	(%)	Cu (T) (%)	Cu (ox) (%)	Fe (%)	Cu (T)	Cu (ox)	Fe
+3/4"	0.1	0.1	0.41	0.35	3.42	0.2	0.2	0.1
-3/4" +1/2"	10.3	19.4	0.46	0.38	3.14	29.4	32.3	16.8
-1/2" +3/8"	13.4	25.3	0.37	0.29	3.40	30.6	32.5	23.7
-3/8" +1/4"	9.2	17.4	0.28	0.20	3.34	15.8	15.2	16.0
1/4" +6 mesh	7.2	13.6	0.21	0.14	3.52	9.1	8.4	13.2
- 6 mesh	12.8	24.2	0.19	0.11	4.50	14.9	11.4	30.1
Calculated head	**53.1**	**100.0**	**0.31**	**0.23**	**3.62**	**100.0**	**100.0**	**100.0**
Assay head								

MATERIAL BALANCE

Project no : 92-006
Test no : FH

Date : December 12, 1995

Sample description : Bottom column residue

Products	Weight		Assays			% Distribution		
	(kg)	(%)	Cu (T) (%)	Cu (ox) (%)	Fe (%)	Cu (T)	Cu (ox)	Fe
+3/4"								
-3/4" +1/2"	8.1	17.3	0.55	0.44	3.01	24.3	25.4	13.1
-1/2" +3/8"	13.2	28.0	0.45	0.38	3.22	32.6	34.9	22.6
-3/8" +1/4"	9.1	19.3	0.38	0.29	3.92	18.6	18.7	19.0
1/4" +6 mesh	6.8	14.5	0.30	0.21	4.28	11.0	10.2	15.5
- 6 mesh	9.8	20.9	0.25	0.16	5.66	13.4	10.8	29.8
Calculated head	**47.0**	**100.0**	**0.39**	**0.30**	**3.98**	**100.0**	**100.0**	**100.0**
Assay head								

MATERIAL BALANCE

Project no : 92-006
Test no : FH

Date : May 28, 1993

Sample description : Column Head

Products	Weight		Cu (T)	Cu (ox)	Cu (T)	Cu (ox)
	(kg)	(%)	(%)	(%)		
-3/4" +1/2"	23.9	15.4	1.06	0.98	12.4	12.3
-1/2" +3/8"	43.2	27.8	1.14	1.04	24.2	23.5
-3/8" +1/4"	30.1	19.4	1.22	1.16	18.0	18.3
1/4" +6 mesh	20.8	13.4	1.28	1.24	13.1	13.5
- 6 mesh	37.3	24.0	1.76	1.66	32.2	32.4
Calculated head	**155.3**	**100.0**	**1.31**	**1.23**	**100.0**	**100.0**
Assay head						

APPENDIX B

Test details for PC1 and PC2 columns

WILLIAMS CREEK - PC1 COLUMN LEACH TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench sample composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density : 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 10.00 kg/tonne
Sample Moisture: 3.9 % by weight
Initial H2SO4 Solution Concentration: 15.2 g/L

Date	Time	Time	Days	FEED SOLUTION				LEACHATE						RAFFINATE					Free	Cu	H2SO4
	on	off		s.g.	pH	H2SO4	Flow	s.g.	Vol.	pH	ORP	Cu	Fe	s.g.	Vol.	pH	Cu	Fe	H2SO4	Extr.	Add'n
1993						g	mL/min		L		mV*	g/L	g/L		L		g/L	g/L	g/L	%	kg/t
	09:00			1.007	0.89																
Sep-14		08:50	1			588	27.11	1.051	14.94	2.85	408	15.70	0.94	1.032	14.89	0.76	1.460		24.7	3.2	11.0
	08:50			1.007	0.89																
Sep-15		08:15	2			573	26.88	1.034	36.71	3.13	395	9.44	0.96	1.021	36.64	1.06	0.245		16.3	8.0	12.0
	08:15			1.007	0.89																
Sep-16		08:00	3			689	31.87	1.029	40.78	2.77	446	6.40	1.44	1.02	40.85	1.30	0.795		10.0	11.6	13.1
	08:00			1.007	0.89																
Sep-17		08:09	4			684	31.13	1.029	42.17	2.63	427	5.60	1.56	1.021	41.89	1.34	0.705		9.5	14.9	14.3
	09:47			1.029	0.87																
Sep-19		06:53	6			986	30.72	1.043	80.70	2.34	432	6.56	3.44	1.036	80.46	1.27	0.900		11.3	21.4	15.9
	10:45			1.044	0.93																
Sep-21		08:00	8			1142	28.34	1.057	72.91	2.27	445	6.64	5.20	1.049	72.76	1.25	0.700		12.8	27.1	17.8
	08:05			1.055	0.98																
Sep-23		08:04	10			1051	26.85	1.064	73.99	2.23	433	5.92	6.40	1.055	73.84	1.47	0.620		12.8	32.4	19.6
	08:15			1.059	1.18																
Sep-25		08:01	12			1056	27.70	1.074	76.48	2.21	435	5.44	9.60	1.067	76.29	1.34	0.350		12.6	37.4	21.4
	11:05			1.053	1.14																
Sep-29		09:07	16			0	14.41	1.069	81.57	2.39	425	5.12	8.00	1.060	81.63	1.38	0.340		10.8	42.8	21.4
	12:20			1.060	1.38																
Oct-05		07:48	22			0	14.05	1.066	113.04	2.34	418	3.36	7.48	1.058	112.84	1.55	0.070		9.1	47.5	21.4
	12:03			1.058	1.50																
Oct-12		08:22	29			69	16.71	1.065	138.32	2.30	418	2.44	8.00	1.062	137.73	1.60	0.056		7.8	52.0	21.5
	13:07			1.061	1.50																
Oct-19		08:15	36			147	17.01	1.055	139.50	2.32	424	1.88	5.94	1.054	136.39	1.59	0.023			55.5	21.7
	12:58			1.057	1.50																
Oct-26		08:22	43			198	17.07	1.057	138.28	2.27	416	1.68	6.51	1.052	137.22	1.64	0.025			58.7	22.1
	13:25			1.055	1.50																
Nov-02		10:00	50			239	16.84	1.056	139.34	2.31	409	1.60	5.17	1.052	139.29	1.75	0.019			61.7	22.5
	15:00			1.056	1.50																
Nov-09		11:00	57			440	15.84	1.060	125.08	2.25	405	1.44	5.71	1.058	125.24	1.61	0.026			64.2	23.2

* vs Ag/AgCl reference

WILLIAMS CREEK - PC1 COLUMN LEACH TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench sample composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density : 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 10.00 kg/tonne
Sample Moisture: 3.9 % by weight
Initial H2SO4 Solution Concentration: 15.2 g/L

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	H2SO4 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	RAFFINATE s.g.	Vol. L	pH	Cu g/L	Fe g/L	Free H2SO4 g/L	Cu Extr. %	H2SO4 Add'n kg/t
1993																					
	15:00			1.060	1.50																
Nov-16		09:15	64			84	16.52	1.058	140.25	2.22	401	1.40	5.71	1.059	140.23	1.61	0.021		8.0	66.8	23.4
	14:15			1.058	1.50																
Nov-23		09:15	71			216	16.53	1.061	134.47	2.28	399	1.16	6.05	1.060	134.64	1.66	0.013		8.7	69.0	23.7
	13:40			1.060	1.50																
Nov-30		08:12	78			222	16.08	1.065	129.30	2.23	405	1.00	6.09	1.06	129.46	1.78	0.007		7.7	70.7	24.1
	13:15			1.060	1.50																
Dec-02		08:20	81			264	14.13	1.064	44.38	2.15	433	0.92	5.90	1.062	43.86	1.65	0.005		7.8	71.3	24.5
Dec-06	10:17			1.077	2.20																
Dec-09		13:45	84			0	11.33	1.066	48.50	2.38	395	1.80	5.80	1.062	48.48	1.69	0.016		8.8	69.1	24.5
	16:14			1.074	2.28																
Dec-12		10:15	87			0	12.95	1.071	46.77	2.36	391	4.00	5.80	1.064	46.67	1.43	0.014		11.7	68.9	24.5
	12:27			1.074	2.21																
Dec-15		08:07	90			0	13.31	1.070	55.32	2.27	423	4.20	6.00	1.064	55.10	1.33	0.202		11.8	69.2	24.5
	10:37			1.077	2.23																
Dec-18		08:43	93			0	11.45	1.072	56.72	2.32	406	3.92	5.80	1.066	56.80	1.42	0.303		11.0	69.6	24.5
	11:00			1.075	2.23																
Dec-21		08:30	96			0	13.88	1.074	53.76	2.44	402	4.20	6.40	1.064	56.24	1.42	0.176		11.6	70.0	24.5
	11:30			1.074	2.44																
Dec-24		08:10	99			0	13.72	1.074	57.60	2.37	393	3.88	6.32	1.070	57.36	1.46	0.184		11.7	70.6	24.5
	10:13			1.077	2.33																
Dec-27		09:25	102			0	14.19	1.076	56.83	2.48	393	3.60	6.44	1.070	57.68	1.48	0.142		11.1	71.1	24.5
	12:00			1.075	2.28																
Dec-30		08:05	105			0	12.05	1.074	56.00	2.33	393	3.36	6.48	1.069	55.85	1.40	0.090		12.3	71.9	24.5
1994	13:00			1.076	2.26																
Jan-02		10:00	108			0	13.49	1.076	57.48	2.41	398	3.20	5.81	1.069	57.44	1.50	0.150		12.3	72.5	24.5
	11:35			1.075	2.46																
Jan-05		08:40	111			0	13.63	1.074	53.40	2.36	427	3.08	5.58	1.069	53.44	1.70	0.124		12.6	72.6	24.5
	10:30			1.067	2.53																
Jan-08		08:50	114			0	14.38	1.075	55.34	2.29	437	3.20	4.34	1.066	53.82	1.47	0.146		12.7	72.9	24.5

* vs Ag/AgCl reference

WILLIAMS CREEK - PC1 COLUMN LEACH TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench sample composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density : 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 10.00 kg/tonne
Sample Moisture: 3.9 % by weight
Initial H2SO4 Solution Concentration: 15.2 g/L

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE						RAFFINATE					Free	Cu	H2SO4
				s.g.	pH	H2SO4	Flow	s.g.	Vol.	pH	ORP	Cu	Fe	s.g.	Vol.	pH	Cu	Fe	H2SO4	Extr.	Add'n
1994						g	mL/min		L		mV*	g/L	g/L		L		g/L	g/L	g/L	%	kg/t
	10:50			1.069	2.39																
Jan-11		08:30	117			0	13.32	1.068	56.56	2.32	463	3.24	2.70	1.062	56.57	1.50	0.078		11.4	73.2	24.5
	10:30			1.061	2.43																
Jan-14		08:15	120			0	14.10	1.065	55.83	2.31	457	3.24	2.44	1.062	55.61	1.59	0.080		11.5	74.0	24.5
	10:10			1.064	2.38																
Jan-17		08:15	123			0	14.41	1.063	59.81	2.28	460	2.80	2.06	1.060	59.93	1.45	0.062		12.2	74.6	24.5
	10:25			1.059	2.29																
Jan-20		08:15	126			0	14.45	1.063	59.50	2.29	461	2.64	1.88	1.059	58.91	1.46	0.056		10.8	75.4	24.5
	10:10			1.064	2.35																
Jan-23		10:05	129			0	13.76	1.062	58.60	2.35	483	2.24	1.52	1.058	58.58	1.45	0.044		10.5	75.7	24.5
	12:15			1.061	2.30																
Jan-26		08:15	132			0	13.83	1.061	55.88	2.47	472	2.32	1.40	1.057	55.62	1.47	0.034		10.8	76.1	24.5
	10:30			1.060	2.28																
Jan-29		08:45	135			0	14.19	1.060	59.14	2.43	471	2.23	1.02	1.056	59.08	1.61	0.026		11.3	76.7	24.5
	10:45			1.060	2.35																
Feb-01		08:20	138			0	14.55	1.059	60.44	2.39	476	2.02	0.93	1.059	59.89	1.73	0.024		10.5	77.2	24.5
	10:30			1.058	21.36																
Feb-04		08:20	141			0	14.21	1.059	59.33	2.47	480	1.86	0.77	1.056	58.14	1.66	0.017		10.1	77.6	24.5
	10:20			1.062	2.38																
Feb-07		08:25	144			0	14.75	1.058	60.94	2.57	476	1.76	0.69	1.057	60.66	1.59	0.014		10.2	77.5	24.5
	10:25			1.059	2.40																
Feb-10		08:15	147			0	14.73	1.060	61.07	2.56	486	1.88	0.78	1.058	60.60	1.54	0.016		10.4	78.0	24.5
	10:20			1.057	2.46																
Feb-13		10:30	150			0	14.28	1.060	62.16	2.53	500	1.73	0.60	1.056	62.24	1.61	0.016		10.3	78.3	24.5
	12:10			1.064	2.44																
Feb-16		08:15	153			0	14.51	1.060	56.84	2.39	491	1.67	0.55	1.057	56.59	1.54	0.011		10.1	78.5	24.5
	10:05			1.061	2.52																
Feb-19		08:15	156			0	13.96	1.060	58.14	2.59	495	1.65	0.56	1.058	58.40	1.65	0.023		9.3	78.8	24.5
	10:00			1.060	2.52																
Feb-22		08:35	159				14.17	1.062	58.39	2.60	492	1.63	0.63	1.060	58.29	1.65	0.015		10.4	79.1	24.5
	08:40			1.060																	
Feb-23			160					1.061	43.12	2.58	496	1.60	0.59	1.058	42.31	1.70	0.012			79.7	24.5
Mar-17						Column drained PLs		1.064	7.47	2.69	525	1.81	0.34							79.9	24.5
							Wash 1	1.061	13.52	2.81		1.00								80.1	24.5
							Wash 2	1.033	23.25	2.90		0.95								80.4	24.5

* vs Ag/AgCl reference

WILLIAMS CREEK - PC1 COLUMN LEACH TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench sample composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density : 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 10.00 kg/tonne
Sample Moisture: 3.9 % by weight
Initial H2SO4 Solution Concentration: 15.2 g/L

Date 1994	Time on	Time off	Days	FEED SOLUTION s.g.	pH	H2SO4 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	RAFFINATE s.g.	Vol. L	pH	Cu g/L	Fe g/L	Free H2SO4 g/L	Cu Extr. %	H2SO4 Add'n kg/t

	Weight (kg)	Assay (%) Cu(T)	Cu(ox)	Fe
Residue	587.0	0.20	0.14	4.33

Cu distribution	grams	%
Solution	**6192**	**84.9**
Residue	**1103**	**15.1**
Total	**7295**	**100.0**

Calculated head 1.23%
Measured head 1.22%

* vs Ag/AgCl reference

ACID BASE ACCOUNTING TEST REPORT

Western Copper Holdings
900 - 850 West Hastings Street
Vancouver, B.C.
V6C 1E1

File No. : 92-006

Report No. : 1

Date Reported : 25-Jan-94

Attention : Mr. Ken McNaughton

Project : Williams Creek

	Sample I.D.	S (tot) %	Paste pH	NP	MPA	Net NP
1.	Comp 1	0.10	8.1	8.20	3.13	5.1
2.	Comp 2	0.12	8.0	13.3	3.75	9.6
3.	Comp 3	0.03	8.1	13.2	0.94	12.3

Peter Tse
Chemical Technologist

Notes :

1. Analytical methods employed according to procedures described in "Field and Laboratory Methods Applicable to Overburden and Minesoils", EPA 600/2-78-054, pp. 45-55, 1978
2. NP = Neutralization Potential as determined by acid consumption test
   MPA = Maximum Potential Acidity (%S (tot) x 31.25)
   Net NP = NP - MPA
3. NP, MPA and Net NP are expressed in tonnes CaCO3 equiv. per 1000 tonnes sample
4. Samples with negative Net NP are potential acid producers

WILLIAMS CREEK - PC2 LEACH TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 573 kg
Copper Grade: 1.23 %
Charge Height: 5.3 m
Bulk Density 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4
Agglomeration Acid Consumption: 15.00 kg/tonne
Sample Moisture: 5.86 % by weight
Initial H2SO4 Solution Concentration: 9.4 g/L

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	H2SO4 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	FEED s.g.	Vol. L	pH	Cu g/L	Fe g/L	Free H2SO4 g/L	Cu Extr. %	H2SO4 Add'n kg/t
1993																					
	11:17			1.062	1.50																
Dec-04		12:52	1				14.48	1.078	19.36	2.17	414	5.44	6.50				0.005		6.0	1.5	15.0
	12:52			1.062	1.50																
Dec-05		12:19	2				12.50	1.073	16.64	2.20	409	4.80	6.60				0.005		6.0	2.6	15.0
	12:19			1.062	1.50																
Dec-06		9:20	3				13.06	1.075	15.72	2.15	409	4.00	6.80				0.005		5.7	3.5	15.0
	9:00			1.062	1.50																
Dec-09		13:45	6				13.11	1.074	57.96	2.28	410	3.92	6.76				0.005		5.9	6.8	15.0
	17:15			1.061	1.50																
Dec-12		10:15	9			88	15.40	1.074	58.11	2.21	408	3.44	6.40				0.016		5.0	9.6	15.2
	12:27			1.064	1.49																
Dec-15		8:07	12			0	14.00	1.077	54.54	2.23	430	3.96	6.52				0.100			12.6	15.2
	10:37			1.064	1.33																
Dec-18		8:43	15			0	13.17	1.074	54.91	2.31	406	3.40	6.10				0.014		6.8	15.2	15.2
	11:00			1.066	1.42																
Dec-21		8:30	18			0	13.62	1.073	54.25	2.39	407	3.00	7.20				0.308		6.8	17.3	15.2
	11:30			1.064	1.47																
Dec-24		8:10	21			0	14.76	1.075	55.60	2.32	409	2.72	6.87				0.160		7.0	19.3	15.2
	10:13			1.070	1.46																
Dec-27		9:25	24			0	13.88	1.075	59.01	2.28	405	2.68	7.07				0.180			21.4	15.2
	12:00			1.070	1.48																
Dec-30		8:05	27			0	14.12	1.076	55.26	2.26	411	2.48	7.22				0.142		4.6	23.2	15.2
	13:00			1.069	1.40																
Jan-02		10:00	30			0	13.49	1.075	56.51	2.46	497	2.72	5.57				0.090		5.9	25.3	15.2
	11:35			1.069	1.50																
Jan-05		8:40	33			0	13.96	1.075	55.78	2.42	578	2.84	5.42				0.124		6.4	27.5	15.2
	10:30			1.061	1.50																
Jan-08		8:50	36			25	14.55	1.07	57.44	2.39	552	2.96	4.84				0.112		6.2	29.8	15.2
1994	10:50			1.066	1.47																
Jan-11		8:30	39			0	12.88	1.070	55.15	2.42	563	2.48	3.42				0.156		6.8	31.6	15.2

* vs Ag/AgCl reference

9.4 g/L H2SO4 in day 0 feed solution, all free acid results in the table are for pregnent solution

WILLIAMS CREEK - PC2 LEACH TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench Composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 15.00 kg/tonne
Sample Moisture: 5.86 % by weight
Initial H2SO4 Solution Concentration: 9.4 g/L

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	H2SO4 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	FEED s.g.	Vol. L	pH	Cu g/L	Fe g/L	Free H2SO4 g/L	Cu Extr. %	H2SO4 Add'n kg/t
1994																					
	10:30			1.054	1.50																
Jan-14		8:15	42			33	14.58	1.066	56.65	2.37	565	2.12	2.96				0.076		7.1	33.3	15.3
	10:01			1.060	1.50																
Jan-17		8:15	45			7	13.55	1.065	58.39	2.45	524	1.84	2.60				0.114		7.1	34.7	15.3
	10:25			1.054	1.45																
Jan-20		8:15	48			13	14.43	1.066	57.19	2.35	573	1.92	2.27				0.064		7.1	36.2	15.3
	10:10			1.059	1.43																
Jan-23		10:05	51			0	14.27	1.061	59.24	2.30	586	1.72	2.06				0.052		7.1	37.6	15.3
	12:15			1.058	1.45																
Jan-26		8:15	54			0	14.13	1.062	56.86	2.40	555	1.56	1.84				0.044		7.4	38.9	15.3
	10:30			1.052	1.50																
Jan-29		8:45	57			9	14.34	1.059	59.61	2.38	565	1.51	1.24				0.030		7.1	40.1	15.3
	10:45			1.057	1.47																
Feb-01		8:20	60			0	14.34	1.063	58.69	2.38	555	1.36	1.21				0.026		7.5	41.2	15.3
	10:30			1.058	1.50																
Feb-04		8:20	63			157	14.49	1.063	59.79	2.37	567	1.39	1.24				0.034		7.6	42.4	15.6
	10:20			1.054	1.50																
Feb-07		8:25	66			168	14.52	1.063	59.92	2.38	564	1.37	1.19				0.018		7.4	43.5	15.9
	10:25			1.056	1.50																
Feb-10		8:15	69			56	14.72	1.059	60.39	2.40	559	1.42	1.16				0.014		7.4	44.7	16.0
	8:20			1.058	1.50																
Feb-13		10:30	72			91	13.46	1.064	60.52	2.46	543	1.33	0.97				0.018		7.9	45.9	16.1
	12:10			1.056	1.50																
Feb-16		8:15	75			95	14.24	1.062	56.64	2.43	567	1.28	0.96				0.011		7.7	46.9	16.3
	10:05			1.053	1.50																
Feb-19		8:15	78			66	14.36	1.060	59.76	2.52	531	1.26	0.95				0.014		7.7	48.0	16.4
	10:00			1.056	1.50																
Feb-22		8:35	81			66	14.34	1.06	59.95	2.51	565	1.30	0.91				0.023		7.8	49.0	16.5
	10:30			1.054	1.50																
Feb-25		8:35	84			123	14.22	1.062	59.63	2.45	562	1.39	1.04				0.022		8.6	50.2	16.7

* vs Ag/AgCl reference

WILLIAMS CREEK - PC2 LEACH TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench Composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density 1.54

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 15.00 kg/tonne
Sample Moisture: 5.86 % by weight
Initial H2SO4 Solution Concentration: 9.4 g/L

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE						RAFFINATE					Free	Cu	H2SO4
				s.g.	pH	H2SO4	Flow	s.g.	Vol.	pH	ORP	Cu	Fe	s.g.	Vol.	pH	Cu	Fe	H2SO4	Extr.	Add'n
1994						g	mL/min		L		mV*	g/L	g/L		L		g/L	g/L	g/L	%	kg/t
	13:15			1.061	1.50																
Mar-04		8:25	91			416	14.20	1.066	134.52	2.37	555	1.32	0.87	1.063	133.53	1.73	0.013		9.3	52.7	17.5
	12:30			1.065	1.50																
Mar-11		8:20	98			375	13.86	1.069	133.74	2.32	554	1.35	1.08	1.065	133.88	1.68	0.015		11.1	55.2	18.1
	12:35			1.065	1.50																
Mar-18		8:30	105			160	13.80	1.071	134.62	2.31	541	1.38	1.04	1.07	133.00	1.66	0.017		11.4	57.8	18.4
	13:15			1.072	1.50																
Mar-25		8:40	113			259	13.59	1.070	133.07	2.39	565	1.33	1.62	1.072	131.92	1.80	0.016		11.7	60.3	18.9
	13:15			1.069	1.50																
Mar-31		8:30	119			480	13.91	1.071	112.86	2.32	556	1.40	1.39	1.070	112.28	1.67	0.054		11.3	62.5	19.7
	12:10			1.072	1.50																
Apr-07		8:50	126			199	13.53	1.076	133.00	2.39	563	1.60	1.95	1.077	132.19	1.69	0.017		12.1	65.5	20.0
	12:50			1.072	1.50																
Apr-14		8:45	133			234	13.35	1.076	132.85	2.23	569	1.48	1.78	1.076	132.71	1.62	0.015		12.1	68.3	20.4
	12:40			1.077	1.50																
Apr-21		8:40	140			159	13.91	1.080	130.95	2.22	551	1.37	1.61	1.076	130.35	1.66	0.015		12.9	70.8	20.7
	13:05			1.067	1.50																
Apr-28		8:15	147			325	14.00	1.074	133.83	2.29	565	1.06		1.072	132.79	1.59	0.009		12.1	72.8	21.3
	12:50			1.071	1.50																
May-05		8:20	154			107	12.46	1.073	120.62	2.19	566	1.05	1.51	1.071	120.37	1.72	0.008		11.7	74.6	21.5
	12:25			1.071	1.50																
May-12		8:30	161			253	14.66	1.073	146.97	2.16	571	0.94	1.47	1.072	145.24	1.70	0.005		16.1	76.5	21.9
	13:50			1.071	1.50																
May-19		8:25	168			287	13.59	1.075	125.24	2.13	583	0.88	1.22	1.075	124.06	1.72	0.011		16.2	78.1	22.4
	12:25			1.071	1.50																
May-26		8:30	175			260	14.64	1.070	142.68	2.16	548	0.72	1.06	1.072	141.00	1.68	0.070		11.5	79.4	22.9
	13:00			1.071	1.50																
Jun-02		8:25	182			0	14.39	1.07	138.01	2.22	553	0.64	0.94	1.073	137.44	1.73	0.006		11.7	80.6	22.9
	12:50			1.073	1.73																
Jun-09		8:27	189			0	13.89	1.074	134.30	2.23	562	0.56	0.80	1.073	133.00	1.82	0.006		11.0	81.7	22.9

* vs Ag/AgCl reference

WILLIAMS CREEK - PC2 LEACH TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench Composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk Density 1.54 tonne/m3

Agglomeration Acid Concentration: 297 g H2SO4/L
Agglomeration Acid Consumption: 15.00 kg/tonne
Sample Moisture: 5.86 % by weight
Initial H2SO4 Solution Concentration: 9.4 g/L

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	H2SO4 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L	RAFFINATE s.g.	Vol. L	pH	Cu g/L	Fe g/L	Free H2SO4 g/L	Cu Extr. %	H2SO4 Add'n kg/t
1994																					
	12:25			1.073	1.82																
Jun-16		8:15	196			0	14.75	1.073	149.59	2.28	564	0.46	0.80	1.073	149.26	1.84	0.005		11.5	82.7	22.9
	12:23			1.073	1.84																
Jun-23		8:23	203			0	14.58	1.071	136.04	2.21	543	0.36	0.62	1.069	135.69	1.76	0.003		11.5	83.3	22.9
	12:42			1.066	1.77																
Jun-30		8:30	210			0	14.12	1.071	135.34	2.32	543	0.36	0.48	1.070	134.08	2.01	0.002		10.3	84.0	22.9
	12:15			1.070	2.01																
Jul-07		8:30	217			0	13.59	1.067	132.10	2.38	516	0.32	0.52	1.062	131.74	2.02	0.003		10.6	84.6	22.9
	15:00			1.062	2.02																
Jul-14		8:00	224			0	13.64	1.070	139.22	2.31	506	0.26	0.32	1.068	139.24	2.02	0.002		10.4	85.1	22.9
Jul-28	8:17			1.068	2.02																
Aug-08		8:35	245			0	14.55	1.069	139.62	2.70	458	0.34	0.18	1.070	151.08	2.05	0.001		10.2	85.8	22.9
Aug-25	11:45			1.070	2.05																
Sep-01		8:45	269			0	14.01	1.069	145.09	2.70	530	0.30	0.25	1.066	144.78	2.20	0.001		10.5	86.4	22.9
Sep-15	9:12			1.060	2.01																
Sep-21		8:25	289			0	14.80	1.068	137.45	2.78	471	0.28	0.20	1.067	137.29	2.08	0.001		10.0	87.0	22.9

	Weight (kg)	Assay (%) Cu(T)	Cu(ox)	Cu(=)	Fe
Residue	539.8	0.17	0.08	0.09	3.87

Cu distribution	grams	%
Solution	6114	86.9
Residue	918	13.1
Total	7031	100.0

Calculated head	1.23%
Measured head	1.22%

* vs Ag/AgCl reference

APPENDIX C

Analysis of acid consumption

BEATTIE CONSULTING LTD.

2955 WEST 38th AVENUE
VANCOUVER, B.C.
V6N 2X2

TEL.(604) 263 0695
FAX.(604) 263 0695

MEMO

TO: Art Winckers, Teck
Ken McNaughton, Silver Standard

FROM: Morris Beattie

DATE: January 20, 1995

RE: Acid Consumption for Williams Creek Project

The following summary has been prepared at the request of Art Winckers in order to give a degree of comfort to the acid consumption projected for the Williams Creek project with multiple lift leaching. The summary will attempt to explain the reason for differences in the acid consumption displayed by the various columns, particularly the FH column which used drill core as feed versus the PC columns which used surface trench material as feed. The column test which is believed to most closely resemble commercial operation is column PC2. The results from this column test will therefore be discussed first and the results and conditions of the other columns will be compared against PC2.

PC2

Day	Cu Extraction		Feed avg.	Acid consumption			
	%	%/day	acid, g/l	g	kg/t	kg/t/day	kg/kg Cu
9 - 84	40.9	0.55	11.1	7146	12.5	.17	2.5
98 - 175	24.2	0.31	14.3	5736	10.0	.13	3.39
182 - 245	5.2	0.08	11.0	877.5	1.53	.02	2.41

This column operated from day 9 through 84 with raffinate from PC1 as feed solution, acid being

experienced with a feed containing on average 11 g/l acid. The projected acid consumption of 25 kg/tonne is therefore a reasonable figure, provided that the acid concentrations are minimized in the operation.

PC1

Column PC1 was operated as the first lift of a two lift sequence. For the first 81 days it was operated as a single closed circuit column with the PLS being treated by SX before having acid added and being recycled to the feed. The flowrate to the column varied during this initial period from double the rate of column PC2 to approximately the same rate. An excess of acid was added during this period with the average acid concentration over the period being 16.9 g/l, resulting in a consumption of 2.92 kg acid per kg Cu or a rate of 0.26 kg/tonne/day. The consumption was directly proportional to the feed acid concentration as shown in figure 3. The copper extraction rate was quite high at 0.73% per day.

From day 81 on, the feed to this column was the PLS from column PC2. The feed acid concentration during this period was less than 8 g/l. The resulting copper extraction rate was quite low at 0.13% per day. The tabulated data for feed and PLS acid concentration during this period indicate that there was a net gain in acid of 1.17 kg/tonne. Although some bacterial activity was noted in the column, it is not certain that acid equivalent to the oxidation of 0.038%S was in fact generated. The results do give comfort however that acid consumption at these low acid concentrations must have been very low (figure 4).

FH

The FH column was started at double the standard flowrate and this rate was continued for the first 20 days of operation. An excess of acid was added for the first 59 days of operation so that the average feed acid was 29.3 g/l, resulting in very high acid consumption. After day 59 the control strategy for this column was changed so that the feed pH was controlled to 1.5. However,

the acid concentration in the feed remained quite high so that the consumption was also quite high. The results for this column under the two control regimes are summarized as follows:

Day	Cu Extraction		Feed avg.	Acid consumption			
	%	%/day	acid, g/l	g	kg/t	kg/t/day	kg/kg Cu
12 - 59	28.7	0.61	29.3	4917	31.6	0.67	8.3
66 - 136	10	0.14	18.0	2115	13.6	0.19	10.2

Due to the high acid concentrations in this test it is not possible to compare the acid consumptions and consumption rates under what appear to be identical control conditions, ie feed pH = 1.5. The overall results, figures 5 and 6, do indicate that this column behaved in the same manner as the PC columns and that if the feed acid had been maintained at lower levels, the acid consumption as well as the copper leaching rate would have been lower for this test as well. Since the acid concentration under a control strategy of feed = pH 1.5 was still excessive, the acid concentration in solution should be monitored for the purpose of control and the acid addition controlled accordingly.

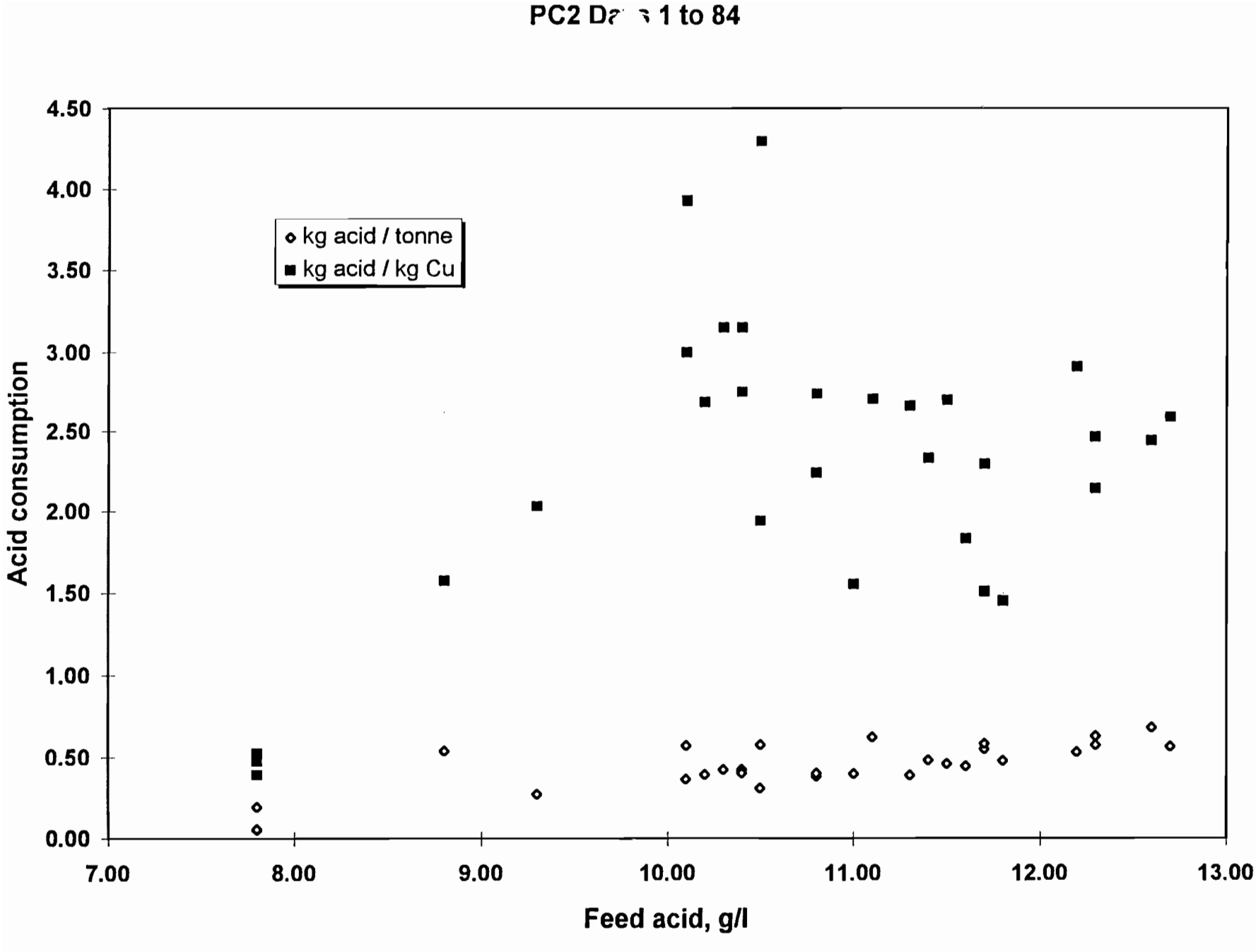

PC2 Data 1 to 84
kg acid / tonne
kg acid / kg Cu
Acid consumption
Feed acid, g/l
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00

Figure 1

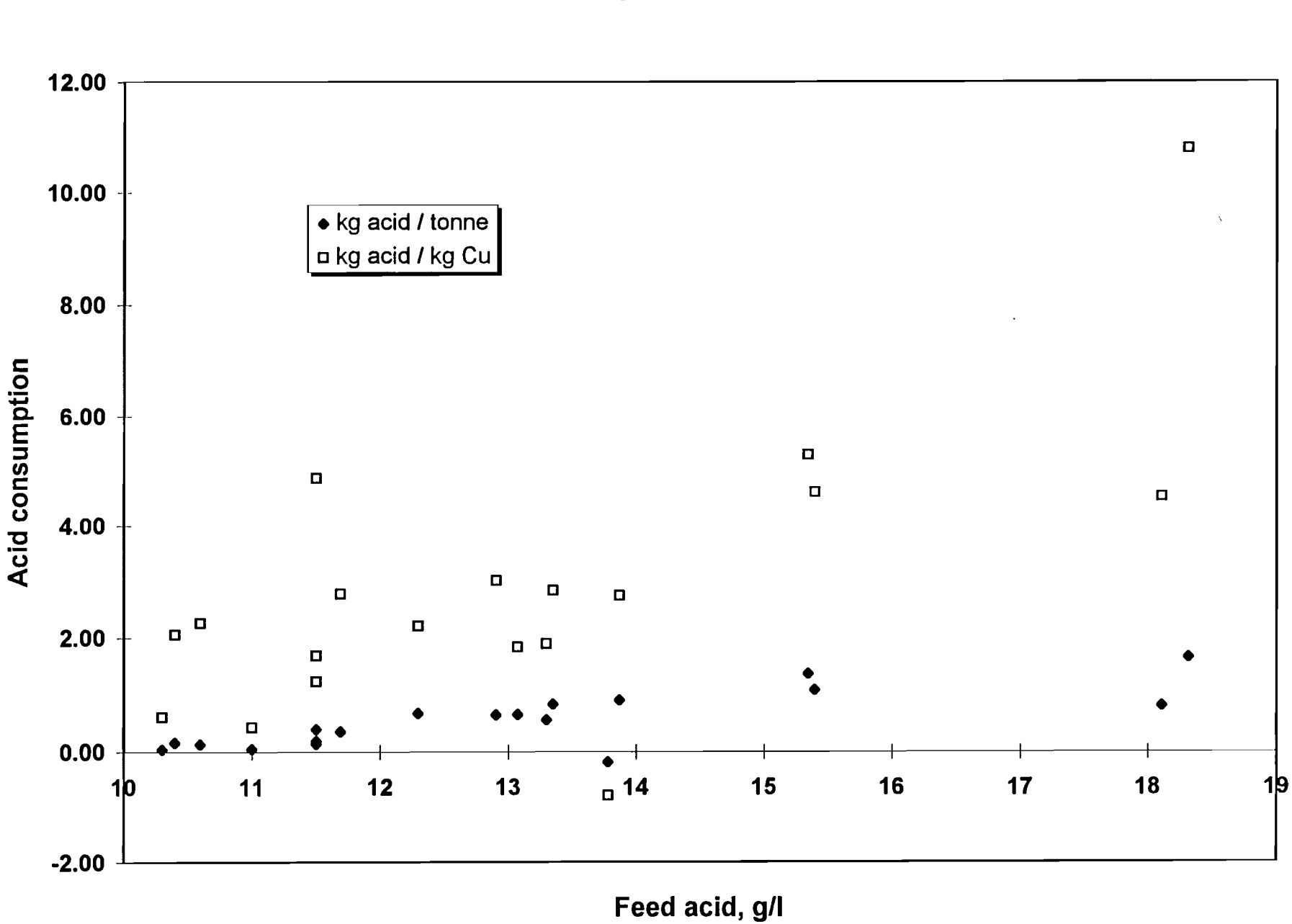

PC2 Day 98 to 245
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Acid consumption
kg acid / tonne
kg acid / kg Cu
10
11
12
13
14
15
16
17
18
19
Feed acid, g/l

Figure 2

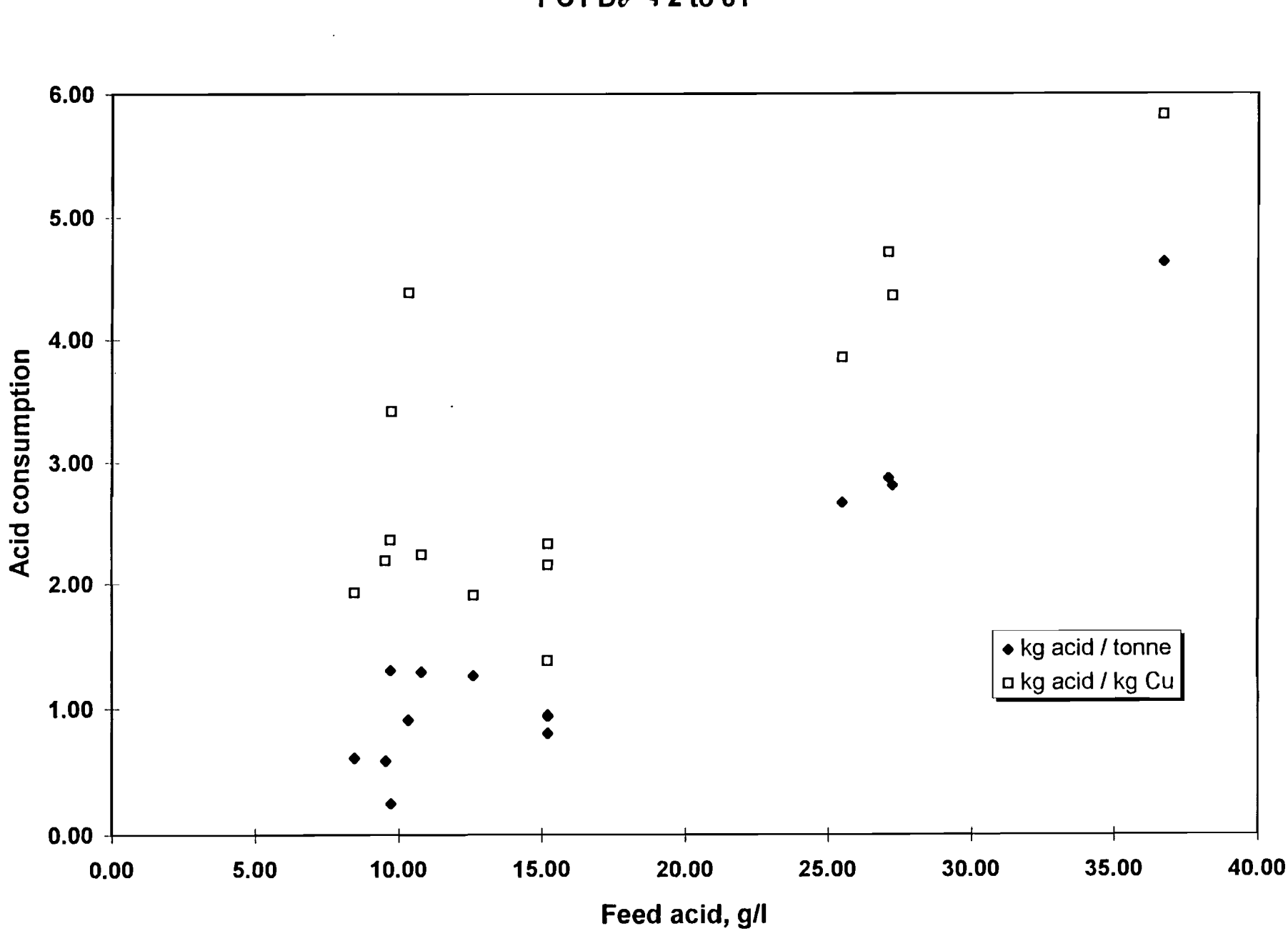

PC1 Days 2 to 81
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Acid consumption
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
Feed acid, g/l
kg acid / tonne
kg acid / kg Cu

Figure 3

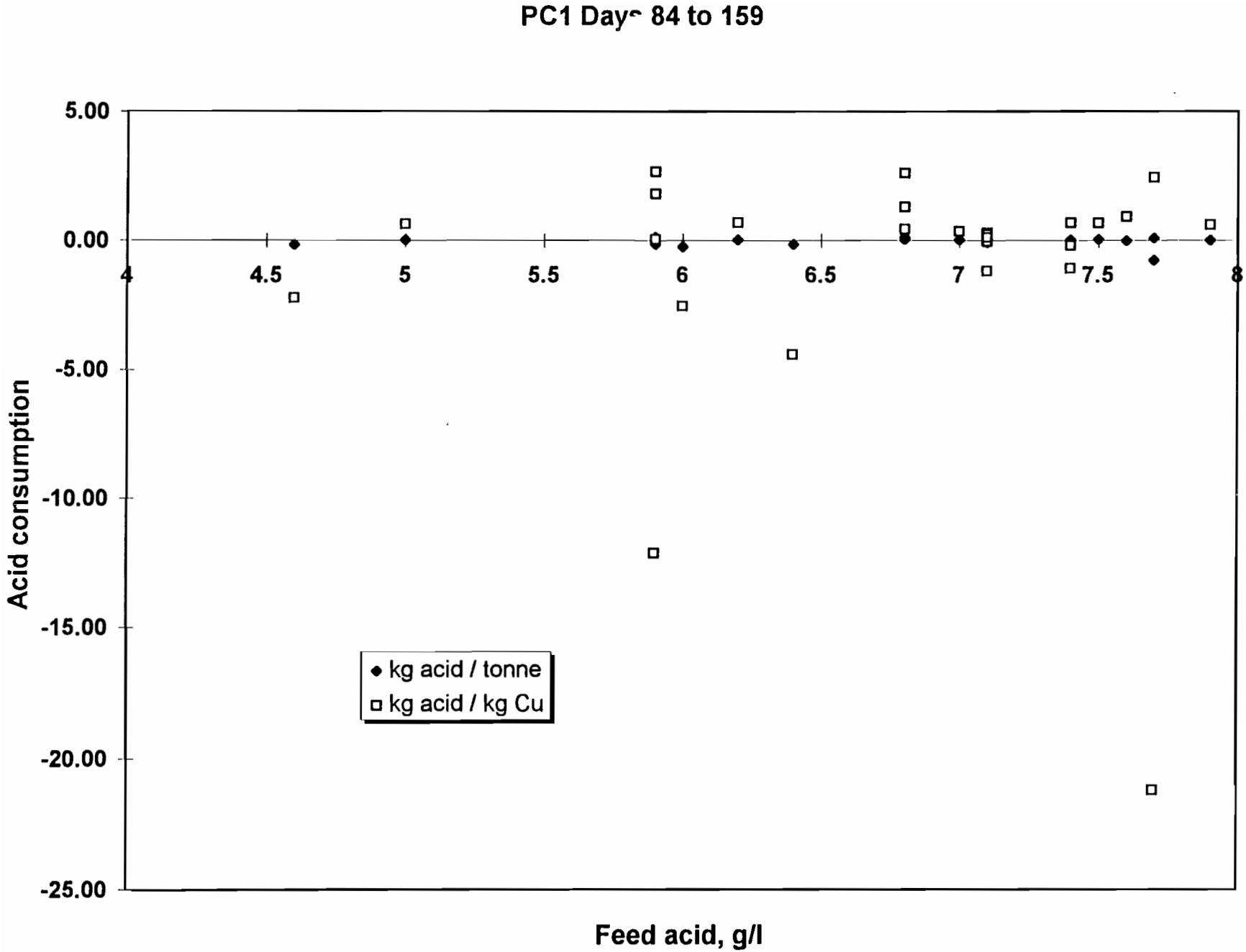

PC1 Days 84 to 159
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
4
4.5
5
5.5
6
6.5
7
7.5
8
Acid consumption
Feed acid, g/l
kg acid / tonne
kg acid / kg Cu

Figure 4

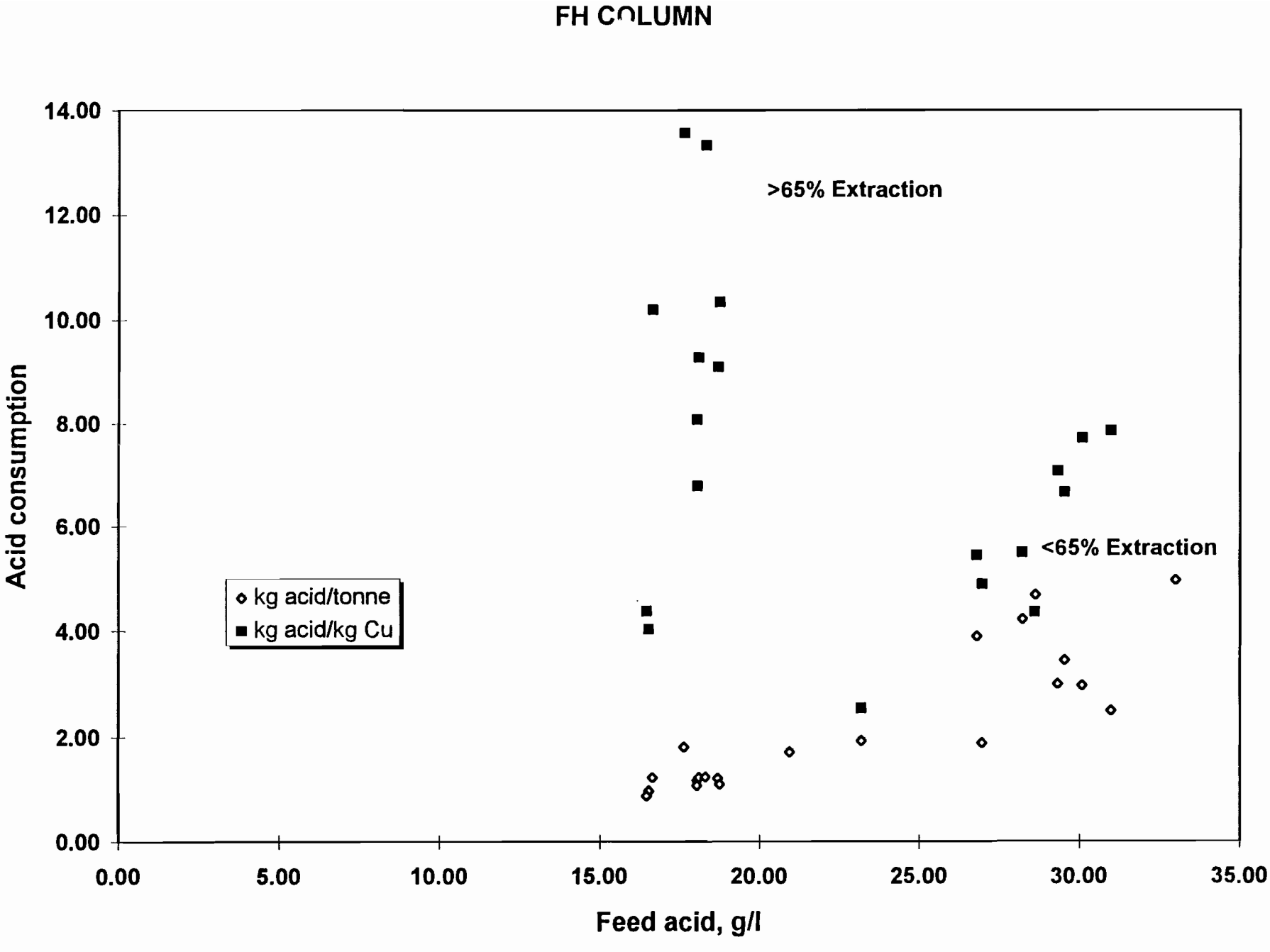

FH COLUMN
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Acid consumption
>65% Extraction
<65% Extraction
kg acid/tonne
kg acid/kg Cu
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Feed acid, g/l

Figure 5

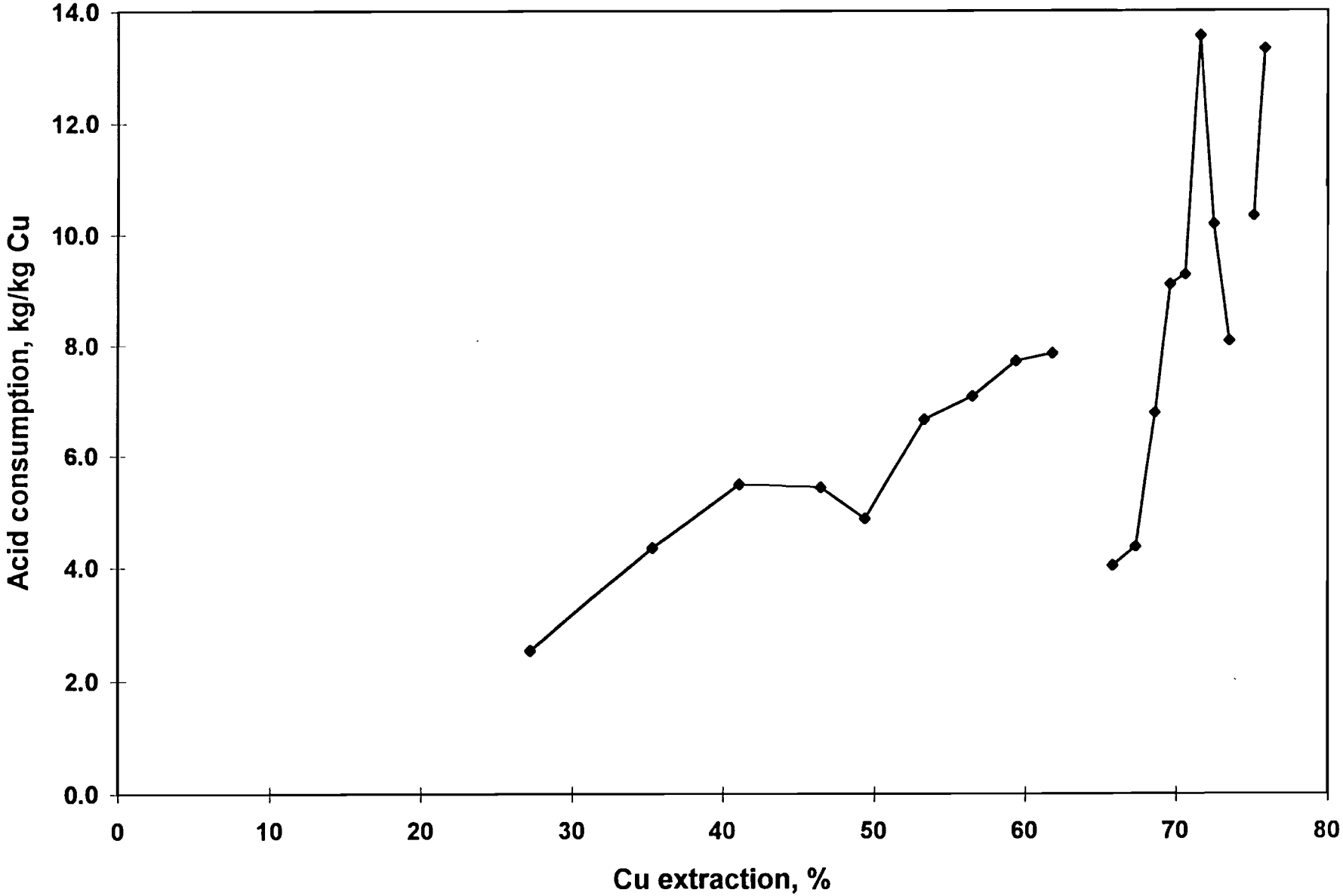

FH COLUMN
Acid consumption, kg/kg Cu
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
70
80
Cu extraction, %

Figure 6

Appendix D

Microscopy of FH column tailing

Vancouver Petrographics Ltd.

8080 GLOVER ROAD, LANGLEY, B.C. V3A 4P9
PHONE (604) 888-1323 • **FAX** (604) 888-3642

Dr. Morris Beattie P.Eng.

Beattie Consulting Ltd.
2955 West 38 Avenue
Vancouver, B.C. V6N 2X2
Tel & Fax 263-0695

JOBS 940065
February 22/94

Dear Morris,

RE: Williams Creek Project BCL 007

Samples submitted by client for petrographic description

Williams Creek Project BCL 007
The polished thin sections show wide variations in abundance of mineralization, intensity of leaching. Leaching intensity appears to be a function of fragment size, abundance of microfractures and abundance of primary mineralization.

One polished thin section containing two fragments of samples B, M and T were examined and each fragment (in most cases) was treated separately) Comments are illustrated by photomicrographs.

Primary mineralization consists of
Bornite
Chalcopyrite
Digenite
Covellite
Chalcocite
Magnetite/hematite
Gold [trace] two minute grains

Where leached, primary copper minerals are generally totally leached, very minor small remnant grains of chalcopyrite may remain. See photomicrographs.

Leach solutions follow microfracture systems some of which contain iron oxides/hydroxides(?) staining; others appear unaffected. See photomicrographs.

Microfracture systems have a random distribution. Unleached fragments appear "tight". May require finer crushing or induced fracture patterns. No measure of the relative percentage of leached and unleached fragments.

Yours very truly,

K.E. Northcote, Ph.D., P.Eng.

Williams Creek project #BCL007
Sample B (Two mounted grains (1) and (2))

[1] Altered and leached.

Host rock fine/medium grained biotite (hornblende) diorite/monzodiorite. Feldspar (plagioclase and K-feldspar?) show uniform "clay" dusting alteration throughout with associated weakly disseminated microcrystalline sericite. Quartz not conspicuous. Mafic biotite > hornblende, near complete alteration to chlorite, with very minor associated sphene and epidote. Accessory apatite (<0.5%) traces zircon. Alteration deuteric/ hydrothermal not a result of leaching.

There is an irregular microfracture network among and connecting mafic clusters. Localized iron stain in this fracture system but generally tight with no evidence of having served as leachate channelways.

Leaching effects
Leached sulphides, 1-1.5%, isolated and microfracture connected "pods" of orange-red and orange iron oxides/hydroxides(?), (<.02 to 0.5 mm). Although these may occur in feldspar groundmass they show strong affinity for altered mafic clusters. Commonly containing clusters of fine acicular to bladed hematite. See photomicrographs.

Note: The outer margin of the fragment has adhering minute crystal grains subsequently cemented in place with epoxy. A few unleached, very small grains of chalcopyrite were noted in this rind.

Cut surface of rock fragments show no marked bleached margins affected by leaching solutions. Leaching solutions appear to have permeated the sample completely. No original sulphides were noted in the rock groundmass.

[2] Weakly altered

Host rock as for [1] fine/medium grained biotite > hornblende diorite/monzodiorite. Less intense but patchy alteration of feldspars (plagioclase and K-feldspar(?)) than in [1]. Hornblende relatively fresh; biotite partially alterated to chlorite with iron-stained(?) alteration lensoids along biotite cleavage traces. Very minor amounts of associated sphene and epidote with mafics. Accessory apatite, traces zircon.

Mineralized by scattered metallic hematite lensoids along biotite cleavage traces. No primary copper mineralization in leached "pods" was noted in B-[2].

Surfaces of fragment show a thin coating of adhering very fine mineral grains subsequently cemented in place by epoxy.

Sample M (Two fragments [1] and [2]

The two fragments are similar so the description apples to both fragments except as noted.

Composition similar to B, composed of interlocking fine to medium-grained feldspars (plagioclase and K-feldspar(?)) showing patchy weak to moderate alteration dusting, very weak disseminated microcrystalline sericite. Medium to coarser grained biotite intergrown with lesser hornblende in [1] whereas [2] shows little hornblende and more intense chloritic alteration of biotite.

Irregular microfracture networks similar to B, locally iron-stained, particularly in proximity to leached pods.

Leaching effects

Both fragments contain irregular pods/pseudomorphous outlines of leached sulphides (<0.5 to 1% in [1], less in [2]) (<0.2 to 0.6 mm), iron oxides, hydroxides. Numerous plucked voids (during preparation of section?). Traces of secondary copper minerals (blue-green) associated with one leached pod in [1]. Associated small clusters of metallic hematite in some leached pods. See photomicrographs.

Leaching solution appears to have penetrated both fragments. No primary copper sulphides noted; leached pods occur throughout.

Surfaces of fragments have a coating of very fine mineral fragments adhering to them. Subsequently cemented by epoxy. There are no noticeable effects of leaching on the small adhering mineral grains or on the margins of the rock fragments.

Sample T (Two fragments 1 and 2)

The two fragments show quite different intensity of leaching. Sample [1] has been leached throughout; sample [2] virtually unleached except locally near margin. Both fragments have a bleached envelope about 0.3 to 0.5 cm at their margins.

Fragment [1] Host/medium grained biotite > hornblende diorite/ monzodiorite as for B and M. Has patchy deuteric clay > sericite alteration dusting of feldspars and chloritic alteration of biotite > hornblende.

Leached throughout Unevenly distributed patches of leached sulphides (<.05 to 0.1 mm) leave oxides/hydroxide(?) remnants. More intensely brecciated zones coincide with leached sulphide-rich zones. Shows a crackle pattern filled with leached "residue" with colloform and zoned patterns which may represent outlines of former chalcopyrite an bornite(?) grains. Small remnant grains of chalcopyrite occur in some of these. See photomicrographs Disseminated metallic hematite, <0.5%, grains (<.01 to .05 mm) occurs in clusters in association with mafics and locally with pods of leached sulphides. One isolated grain of unleached chalcopyrite, (0.25 mm), was noted in a void in groundmass.

Fragments [2] Virtually unleached. The bleached margin of this fragment shows only patchy leaching of sulphides near fragment margin with primary sulphides, 4-5%, occurring throughout the fragment including the margin.

Mineralization in approximate order of abundance is as follows:

Bornite; 2%, anhedral (<.01 to >2.0 mm). Irregular grains larger amoeboid outlines. Commonly containing smaller chalcopyrite grains. Irregular replacement by narrow envelopes of covellite and/or digenite at grain margins and in microfractures. Interstitial to rock forming minerals as if filling voids.??? Finer disseminated grains largely replaced by covellite/digenite with few remnant bornite flecks.

Chalcopyrite; 1%, anhedral (<.01 to 1.0 mm). Irregular shaped grains are intergrown, included within larger bornite grains. Minute crystallographic controlled laminae (exsolution?) in bornite.

Covellite; 0.5-1%, anhedral (<.01 to 0.1 mm) with digenite, replacing margins and in microfractures in bornite. Disseminated minute grains (after bornite) in groundmass.

Digenite; 0.5%, anhedral (<.01 to 0.2 mm). With covellite, replacing margins of bornite grains and microfractures in bornite. Disseminated minute grains (after bornite) in groundmass.

Sample T [2] Continued

Chalcocite; <<<<0.5%, anhedral (<.01 to <.05 mm) Suspected. Intricate intergrowths of minute grains with covellite/digenite.

Undetermined [a] and [b]; <<0.5%, semiopaque microgranular material associated with covellite/digenite microveinlets in bornite. See photomicrographs.

Hematite; <<0.5%, anhedral/subhedral (<.01 to >0.7 mm). Clusters of small laths/blades associated with (engulfed by bornite etc). Also associated with magnetite and as intricate intergrowths replacing magnetite. Small clusters of fine grains in leached pods.

Magnetite; traces (+), subhedral/anhedral (<.01 to 0.1 mm). Widely scattered grains, intricate intergrowths with hematite.

Leached primary sulphides; <<0.5%, anhedral, (microgranular to >0.3 mm). Semitranslucent infilling colloform banding, red orange and orange colour and internal reflections. Pseudomorphous after sulphides.

Gold; trace, anhedral (.0050 to .0075 mm). Two grains isolated in feldspar groundmass. See photomicrographs.

94 R III-0A Reflected light
Scale 0.1 mm

94 R III-1A Reflected light
Scale 0.1 mm

Williams Creek T-[1]

Photomicrograph 0A Bornite purplish pink, containing irregular chalcopyrite grains. Bornite rimmed and bornite and chalcopyrite veined by digenite, very minor chalcocite. Note skeletal metallic hematite [left centre margin]

Photomicrograph 1A Detail of 0A under higher magnification. Paler patterns within digenite probably chalcocite. Note very fine exsolution (?) patterns of minute chalcopyrite laminae, lesser digenite in bornite. Dark blue grey core of veinlet not identified, nonreflective, appears opaque in transmitted light.

94 R III-2A Plane light

94 R III-3A Reflected light
Scale 0.1 mm

Williams Creek T-[1]

Photomicrograph 2A Leached copper sulphides leaving iron oxide/ hydroxides(?) with small irregular chalcopyrite remnants [opaque] see 3A] Note partially iron-stained microfracture systems.

Photomicrograph 3A As for 2A but showing chalcopyrite remnants in leached residue [top centre]. Note the two minute gold grains in feldspar at centre of photograph. Deeper gold colour than chalcopyrite and brighter reflectance,[arrow]. Also grainy polish.

94 R III-5A Reflected light
Scale 0.1 mm

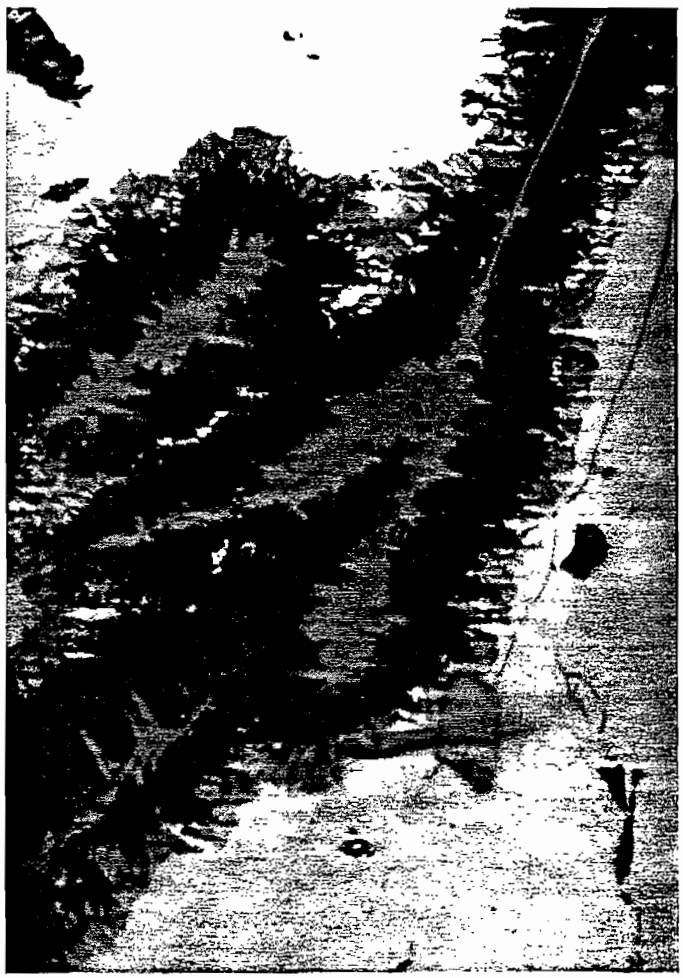
94 R III-6A Reflected light
Scale 0.1 mm

Williams Creek T-[1]

Photomicrograph 5A intergrowth of skeletal hematite [pale blue-grey] and subhedral magnetite [pale brown-grey]

Photomicrograph 6A Intergrowth of magnetite with intricate replacement by hematite [bottom right] Bornite containing chalcopyrite; rimmed by digenite [pale blue] and covellite [dark blue]

94 R III-8A Reflected light
Scale 0.1 mm



94 R III-9A Reflected light
Scale 0.1 mm

Williams Creek T-[1]

Photomicrograph 8A Amoeboid bornite [pinkish brown] with included chalcopyrite grain. Veinlets with envelope of covellite [blue] with infilling of hematite [grey] and (?) [black]

Photomicrograph 9A Veinlet detail as for 8A under higher magnification.

94 R III-10A Reflected polarized light 94 R III-11A Plane light
Scale 0.1 mm

Williams Creek T-[1]

Photomicrographs 10A and 11A Showing detail of microveinlets as for 9A. Note orange-red hematitic core rimmed by unidentified mineral.

94 R III-12A Plane light

94 R III-13A Reflected light
Scale 0.1 mm

Williams Creek T-[2]

Photomicrographs 12A and 13A. Showing detail of leached sulphide zone. Mainly hematite of massive and colloform varieties. Note small chalcopyrite remnants in massive hematite. The two habits of "hematite" may reflect results of leaching of bornite(?) and chalcopyrite(?).

94 R III 15A Plane light

94 R III-16A Reflected light
Scale 0.1 mm

Williams Creek T-[2]

Photomicrograph 15A and 16A. Showing detail of pattern of leaching of primary sulphides. Note voids in centre of leached area.

94 R III-17A Plane light

94 R III-18A Reflected light
Scale 0.1 mm

Williams Creek B-[1]

Photomicrographs 17A and 18A. Leached sulphides in microfracture system. Associated minute metallic hematite clusters [18A]

94 R III-19A Plane light

94 R III-20A Reflected light
Scale 0.1 mm

Williams Creek M-[1]

Photomicrographs 19A and 20A. Leached sulphides in microfractures in groundmass and connecting mineralized mafic clusters. Leached showing trail in microfractures. Note minor associated green and blue-green secondary sulphides [19A] and metallic hematite clusters [20A]

Appendix E

Toxicity test on neutralized raffinate

EVS ENVIRONMENT CONSULTANTS

Our File: 9/315-02
W.O.: 940059

February 28, 1994

Mr. Bern Klein
Process Research Associates Ltd.
9145 Shaughnessy St.
Vancouver, B.C.
V6P 6R9

Dear Mr. Klein:

Re: Toxicity Testing on a Sample Identified as 92-006 FH Neutralized Filtrate (Collected February 14, 1994)

We have completed one (1) Rainbow Trout 96-h Pass/Fail Toxicity Test on a sample identified as 92-006 FH Neutralized Filtrate, received February 14, 1994.

Standard toxicity test procedures were followed in accordance with A.P.H.A. Standard Methods, 17th Edition (1989) and Environment Canada's "Biological Test Method: Acute Lethality Test Using Rainbow Trout" EPS 1/RM/9 (1990).

The results, summarized below for your convenience, are based on data from the following pages.

Summary of Results:

Sample I.D./ Collection Date	No. Deaths/ Fish Exposed	Environment Canada Classification[1]
92-006 FH Neutralized Filtrate/ February 14, 1994	1/10	Pass

[1] Environment Canada specifies that more than 50% of fish exposed must survive a 96-h exposure to be considered a pass.

195 Pemberton Avenue
North Vancouver, B.C.
Canada V7P 2R4
Tel: (604) 986-4331
Fax: (604) 662-8548
evs_consultants@mindlink.bc.ca

200 West Mercer Street
Suite 403
Seattle, WA 98119
Tel: (206) 217-9337
Fax: (206) 217-9343
evswa@halcyon.com

Should you have any questions or comments, please do not hesitate to contact the undersigned at 986-4331.

Yours truly,

E.V.S. CONSULTANTS

for Edmund C. Canaria, B.Sc.
Biologist

Certified By:

QA/QC Committee:
Hugh Hamilton, Ph.D.
Judy Crane, Ph.D.
Iain Watson, M.A.
Cathy McPherson, B.Sc.

ECC/cjm

EVS CONSULTANTS

ACUTE TOXICITY TEST DATA SUMMARY

Client: Process Research
EVS Project #: 9/315-02
EVS Work Order #: 940059.

EVS Analysts: ECC CJM CEB ERS MEL
Test Type: 96-h Pass/Fail
Test Initiation Date: February 15, 1994

SAMPLE

Identification	92-006 FH Neutralized Filtrate			
Amount Received	20L			
Date Collected	February 14, 1994			
Date Received	February 14, 1994			
pH	7.1 - 7.3	after	30	minutes of aeration
Dissolved Oxygen (mg/L)	9.3 - 9.8	after	30	minutes of aeration
Conductivity (µmhos/cm)	12000			
Other	salinity = 8.5 °/oo			

DILUTION AND CONTROL MEDIUM

Fresh Water (dechlorinated)	✓
Salt Water (Burrard Inlet)	
pH	7.1
Dissolved Oxygen (mg/L)	10.1
Conductivity (µmhos/cm)	25
Hardness (mg/L as $CaCO_3$)	15
Alkalinity (mg/L as $CaCO_3$)	14
Salinity (ppt)	
Other	

TEST SPECIES INFORMATION

Organism: Rainbow Trout *(Oncorhynchus mykiss)*
Source: Sun Valley Trout Farm
Collection Date/Batch: 020494
Reference Toxicant: Sodium Dodecyl Sulphate
Current Reference Toxicant Result: LC50 value (mg/L) = 36
Laboratory Range for Reference Toxicant (mean ± 2SD): 34 ± 15

TEST CONDITIONS

Temperature Range (°C)	14.5-15
pH Range	6.8-8.0
Dissolved Oxygen Range (mg/L)	9.8-10.1
Conductivity Range (µmhos/cm)	25-12000
Aeration (7.5 cc/min/L)	✓
Photoperiod (L:D h)	16:8
No. Organisms/Volume	10/10 L
Loading Density (g/L)	0.44
Other	

Toxicity Test Results: The Environment Canada classification is a "Pass", 90 % survival)

Certified By: Judy L Crane
Date: 2/28/94

EVS ENVIRONMENT CONSULTANTS

EVS CONSULTANTS

SAMPLE I.D. 92-006FH Neutralized Filtrate **ACUTE LETHALITY TOXICITY TESTING DATA**

DATE COLLECTED February 14, 1994

TEST DATE February 15, 1994 1500h

NO. FISH/VOLUME 10/10L

PROJECT NAME Process Research

EVS PROJECT NO. 9315-02

WORK ORDER NO. 940059

TEST SPECIES Rainbow Trout

BATCH # 020494

CONC. %(vol/vol)	PERCENT SURVIVAL (1 to 96 hours)							DISSOLVED OXYGEN (mg/L)					TEMPERATURE (°C)					pH					COND. (µmhos/cm)	
	1	2	4	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
100				100 ①	100 ①	80	90	9.8	10.0	10.1	10.0	10.0	15	15	15	15	14.5	7.3	7.9	7.9	7.9	8.0	12000	12000
Control				100	100	90	90	10.1	10.1	10.1	10.0	10.1	15	15	15	15	14.5	7.1	6.8	6.9	6.9	7.5	25	80
Technician				CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	CMM	ETTS	CMM	CMM	CMM	CMM	ETTS	CMM	ETTS

SAMPLE DESCRIPTION Neon orange, turbid @ 24h - orange solid has settled out of clear supernatant.

COMMENTS ① All fish very dark in colour (stressed) All at or near tank bottom. Some fish losing equilibria.

MEAN FISH LENGTH (mm) 37 RANGE 34-39

MEAN FISH WEIGHT (g) 0.44 RANGE 0.34-0.56

TEST SET UP BY CMM

DATA VERIFIED BY Julie C. Crane

DATE VERIFIED 2/28/94

EVS CONSULTANTS

h:\user\Bob\data\bpt\bbpt.fw

Appendix F

Neutralization test results

WILLIAMS CREEK - PC1 NEUTRALIZATION TE

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time	Time	Days	FEED SOLUTION				LEACHATE					
	on	off		s.g.	pH	NaOH	Flow	s.g.	Vol.	pH	ORP	Cu	Fe
1994						g	mL/min		L		mV*	g/L	g/L
	18:00			1.000	7.00								
Mar-31		16:00	1			1.1	12.07						
	16:00			1.000	7.00								
Apr-01		9:00	2			0.8	11.17	1.021	12.54	2.87		0.88	0.032
	9:00			1.000	7.00								
Apr-02		13:50	3			1.3	11.20	1.013	19.04	3.02		0.65	0.019
	13:50			1.000	7.00								
Apr-03		9:45	4			0.9	11.51	1.010	13.70	3.02		0.53	0.015
	9:45			1.000	7.00								
Apr-04		11:24	5			1.0	10.17	1.007	15.62	3.02		0.45	0.012
	12:50			1.015	7.00								
Apr-05		8:52	6			132.8	10.99	1.010	11.61	3.07		0.43	0.009
	9:00			1.015	7.00								
Apr-06		8:40	7				14.19	1.007	14.46	3.13		0.39	0.009
	8:45			1.015	7.00								
Apr-07		9:00	8				11.07	1.006	20.04	3.03		0.36	0.009
	9:02			1.051	7.00								
Apr-08		11:00	9			166.3	5.91	1.006	10.03	3.13		0.43	0.013
	12:15			1.051	7.00								
Apr-09		14:00	10				*	1.011	17.11	3.03	Pump line plugged		
	14:20												
Apr-13		16:45	14			187.7	*	1.013	11.16	3.03		0.38	0.016
	17:17			1.013	9.00								
Apr-14		9:56	15				*	1.010	13.08	3.01		0.32	0.009
	10:00				9.00								
Apr-15		8:30	16				*	1.013	15.59	3.16			
	8:30				9.00								
Apr-16			17			52.0	*	1.007	17.65	3.19		0.28	0.005
	15:00			1.011	9.00								
Apr-18			19				*	1.009	16.11	3.24			

*Precipitates cumulated on top of the column, restricting solution flow, feed pump constantly plugged up.

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	NaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
	13:60			0.996	9.00								
Apr-19		16:05	20			11.7	*	1.014	15.71	3.17		0.29	0.008
	16:28			0.996	9.00								
Apr-20		10:55	21			108.9	*	1.009	16.79	3.20			
	11:05			1.007	9.00								
Apr-21		8:15	22			37.7	13.70	1.009	19.41	3.14		0.24	0.007
	8:35			1.009	9.00								
Apr-22		8:27	23			27.6	14.12	1.006	17.87	3.30		0.20	0.005
	8:35			1.009	9.00								
Apr-23		14:15	24			40.6	13.28	1.007	24.71	3.35		0.21	0.005
	15:00			1.000	9.00								
Apr-24		12:15	25			30.6	13.34	1.009	15.45	3.28		0.22	0.006
	12:16			1.007	9.00								
Apr-25		10:37	26			45.9	13.39	1.008	17.66	3.32		0.21	0.005
	10:50			1.011	9.00								
Apr-26		9:21	27			25.7	14.11	1.008	18.52	3.33		0.19	0.004
	9:42			1.009	9.00								
Apr-27		8:30	28			20.0	13.68	1.007	19.03	3.21		0.15	0.004
	8:37			1.009	9.00								
Apr-28		9:45	29			21.5	11.74	1.007	19.48	3.37		0.14	
	9:49			1.009	9.00								
Apr-29		9:00	30			24.8	13.84	1.013	16.54	3.28		0.15	
	14:30			1.009	9.00								
Apr-30		14:30	31			27.0	16.92	1.009	22.02	3.29			
	12:05			1.002	9.00								
May-01		12:05	32			15.2	12.06	1.007	12.03	3.38			
	9:37			1.006	9.00								
May-02		9:35	33			26.6	12.11	1.007	18.54	3.35		0.14	
	9:15			1.009	9.00	CaOH							
May-03		8:53	34			33.0	13.60	1.009	19.38	3.36		0.11	

*Precipitates cumulated on top of the column, restricting solution flow , feed pump constantly plugged up.

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
	9:15			1.002	9.00								
May-04		8:50	35			51.8	13.76	1.010	20.77	3.38		0.11	
	8:53			1.003	9.00								
May-05		9:40	36			38.5	13.56	1.007	14.42	3.40		0.10	
	9:50			1.007	9.00								
May-06		9:40	37			41.9	13.73	1.006	19.16	3.37			
	9:40			1.006	9.00								
May-07		14:15	38			62.8	13.95	1.006	23.39	3.32			
	14:30			1.007	9.00								
May-08		11:30	39			26.2	13.71	1.005	17.11	3.36			
	11:33			1.007	9.00								
May-09		9:35	40			34.5	14.77	1.005	17.95	3.38		0.08	
	9:35			1.008	9.00								
May-10		8:55	41			31.7	11.68	1.007	19.12	3.46			
	8:57			1.007	9.00								
May-11		9:22	42			12.0	10.64	1.008	17.46	3.41			
	9:30			1.006	9.00								
May-12		9:30	43			22.3	12.44	1.009	15.91	3.25			
	9:30			1.006	9.00								
May-13		9:50	44			14.2	10.50	1.007	18.88	3.44		0.08	
	9:50			1.006	9.00								
May-14		14:30	45			11.2	13.06	1.004	18.31	3.41			
	14:40			1.004	9.00								
May-15		11:40	46			9.5	12.96	1.005	15.73	3.53			
	11:45			1.003	9.00								
May-16		8:30	47				0.00	1.006	8.67	3.44			
	8:40			1.003	9.00								
May-17		8:10	48			13.3	14.63	1.007	11.37	3.53			
	8:10			1.006	9.00								

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
May-18		8:15	49			19.1	13.76	1.005	20.32	3.32		0.08	
	8:17			1.006	9.00								
May-19		8:30	50			10.6	14.58	1.009	17.44	3.34			
	8:35			1.005	9.00								
May-20		8:15	51			12.7	5.53	1.005	18.51	3.31		0.08	
	8:20			1.005	9.00								
May-21		15:00	54			9.1	11.12	1.005	18.60	3.52			
	15:00												
May-22		12:00	55										
	12:00			1.005	9.00								
May-23		12:30	56			8.7	14.44	1.005	16.12	3.49			
	12:30			1.005	9.00								
May-24			57										
	8:35			1.005	9.00								
May-25		8:25	58			15.0	12.74	1.004	17.62	3.45			
	8:30			1.005	9.00								
May-26		8:45	59			11.0	15.05	1.004	18.99	3.36		0.07	
	8:45			1.005	9.00								
May-27		8:25	60			15.2	15.14	1.005	20.31	3.35			
	8:25			1.005	10.50								
May-28		14:30	61			17.2	13.37	1.006	23.85	3.47			
	14:30			1.006	10.50								
May-29		9:05	62			9.8	12.78	1.006	13.97	3.42		0.06	
	9:05			1.005	10.50								
May-30		8:30	63			11.9	13.07	1.005	18.02	3.55			
	8:30			1.005	10.50								
May-31		8:45	64			13.1	17.85	1.007	20.74	3.61			
	8:45			1.004	10.50								
Jun-01		9:30	65			11.4	13.98	1.006	18.60	3.47			

WILLIAMS CREEK - PC1 I JTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE					
1994				s.g.	pH	CaOH g	Flow mL/min	s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
	9:30			1.005	10.50								
Jun-02		8:32	66			13.3	13.69	1.005	19.42	3.60			
	8:32			1.003	10.50								
Jun-03		8:15	67			12.1	13.30	1.004	19.70	3.6		0.05	
	8:19			1.004	10.50								
Jun-04		9:00	68			17.7	14.32	1.004	20.61	3.41			
	9:00			1.005	10.50								
Jun-05		8:45	69			13.8	12.87	1.004	18.88	3.46			
	8:45			1.004	10.50								
Jun-06		8:00	70			16.3	13.90	1.005	15.05	3.44		0.05	
	8:50			1.005	10.50								
Jun-07		8:20	71			14.5	14.78	1.005	17.99	3.48			
	8:20			1.005	10.50								
Jun-08		8:00	72			15.0	14.66	1.005	19.20	3.49			
	8:40			1.006	10.50								
Jun-09		8:45	73				13.95	1.005	15.25	3.48			
	8:45			1.004	10.50								
Jun-10		8:20	74					1.003	10.86				
	8:20	15:15											
Jun-14			78			14.9		1.004	19.35	3.56		0.05	
	9:40			1.005	10.50								
Jun-15		8:15	79			10.9	15.38	1.005	16.48	3.54			
	8:30			1.003	10.50								
Jun-16		8:43	80			15.9	14.32	1.004	22.34	3.59			
	8:43			1.004	10.50								
Jun-17		8:18	81			15.3	14.67	1.003	21.98	3.55		0.05	
	8:18			1.004	10.50								
Jun-18		15:36	82			16.2	10.41	1.004	22.57	3.56			
	14:15			1.004	10.50								

WILLIAMS CREEK - PC1 ' UTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Jun-19		12:45				15.5	13.82	1.004	15.99	3.55			
	12:45			1.004	10.50								
Jun-20		8:35	84			10.8	14.66	1.005	16.69	3.52			
	8:35			1.004	10.50								
Jun-21		10:15	85			11.9	14.09	1.003	21.14	3.56			
	10:15			1.003	10.50								
Jun-22		9:00	86			10.8	11.70	1.002	19.67	3.52			
	9:00			1.003	10.50								
Jun-23		8:45	87			11.4	14.36	1.004	20.46	3.51			
	8:45			1.002	10.50								
Jun-24		9:53	88			10.8	13.89	1.003	19.97	3.63			
	9:53			1.004	10.50								
Jun-25		13:30	89			12.0	12.62	1.002	21.37	3.54			
	13:30			1.003	10.50								
Jun-26		13:30	90			10.6	12.56	1.003	18.18	3.50			
	13:30			1.004	10.50								
Jun-27		8:25	91			8.1	12.33	1.004	13.11	3.54			
	8:25			1.004	10.50								
Jun-28		10:42	92			13.4	15.32	1.003	23.11	3.56			
	10:42			1.003	10.50								
Jun-29		9:15	93			11.2	15.31	1.003	20.43	3.47			
	9:15			1.002	10.50								
Jun-30		8:30	94			11.1	13.64	1.002	20.44	3.53			
	8:30			1.002	10.50								
Jul-01		10:45	95			10.1	12.73	1.003	20.01	3.54			
	10:45			1.002	10.50								
Jul-02		13:55	96			10.8	13.61	1.003	20.22	3.55			
	13:55			1.002	10.50								
Jul-03		10:40	97			9.1	14.59	1.003	16.51	3.55			
	10:40			1.002	10.50								

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Jul-04		8:00	98			10.8	10.80	1.003	18.60	3.55			
	8:00			1.002	10.50								
Jul-05		8:00	99			16.1	15.37	1.003	24.46	3.59			
	8:00			1.002	10.50								
Jul-07		8:15	100			24.3	15.80	1.002	25.24	3.60			
	8:15			1.002	10.50								
Jul-08		9:00	101			15.9	15.01	1.002	20.63	3.54			
	9:00			1.002	10.50								
Jul-09		7:30	102			14.8	15.85	1.002	27.50	3.51			
	7:30			1.002	10.50								
Jul-10		12:45	103			8.1	15.96	1.001	13.67	3.86			
	12:45			1.002	10.50								
Jul-11		9:15	104			4.0	18.08	1.002	12.32	3.70			
	9:15			1.002	10.50								
Jul-12		11:12	105			8.4	13.31	1.004	15.37	3.60			
	11:12			1.003	10.50								
Jul-13		8:50	106			8.2	14.38	1.003	17.27	3.60			
	8:50			1.002	10.50								
Jul-14		10:05	107			10.2	14.19	1.002	21.34	3.60			
	10:05			1.002	10.50								
Jul-15		8:20	108			10.1	14.14	1.003	18.59	3.60			
	8:20			1.001	10.50								
Jul-16		14:20	109			24.2	14.63	1.002	25.86	3.54			
	14:20			1.002	10.50								
Jul-17		14:20	110			8.2	12.57	1.002	17.92	3.60			
	14:20			1.002	10.50								
Jul-18		8:25	111			9.8	17.22	1.003	18.25	3.84			
	8:25			1.002	10.50								

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Jul-19		13:45	112			13.7	14.80	1.003	25.01	3.68			
	13:45			1.003	10.50								
Jul-20		9:15	113			8.2	14.46	1.001	17.01	3.82			
	9:15			1.003	10.50								
Jul-21		15:50	114			9.5	8.68	1.000	16.17	3.65		Line plugged	
	15:50			1.000	10.50								
Jul-22		8:31	115			8.1	15.15	1.003	15.50	3.65		0.04	
	8:31			1.001	10.50								
Jul-23		15:00	116			20.7	10.95	1.002	27.09	3.64			
	15:00			1.001	10.50								
Jul-24		9:40	117			9.1	15.18	1.003	14.72	3.65			
	9:40			1.000	10.50								
Jul-25		8:25	118			10.9	15.33	1.002	20.40	3.64			
	8:25			1.001	10.50								
Jul-26		8:30	119			15.2	14.90	1.002	20.94	3.62			
	8:30			1.002	10.50								
Jul-27		8:50	120			31.4	28.73	1.002	40.66	3.62	Increased flow rate		
	8:50			1.001	10.50								
Jul-28		8:40	121			29.5	29.55	1.003	39.75	3.59			
	8:40			1.001	10.50								
Jul-29		9:25	122			30.8	28.87	1.003	37.78	3.58			
	9:35			1.002	10.50								
Jul-30		13:45	123			31.8	28.09	1.003	50.04	3.62			
	13:45			1.002	10.50								
Jul-31		12:00	124			18.6	28.54	1.003	36.46	3.56			
	12:00			1.002	10.50								
Aug-01		12:15	125			20.2	27.60	1.001	43.55	3.57			
	12:15			1.002	10.50								

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE					
				s.g.	pH	Ca(OH)2	Flow	s.g.	Vol.	pH	ORP	Cu	Fe
1994						g	mL/min		L		mV*	g/L	g/L
Aug-02		8:27	126			18.4	16.91	1.001	32.93	3.58			
	8:27			1.003	10.50								
Aug-03		8:20	127			19.8	28.35	1.001	40.62	3.60			
	8:20			1.002	10.50								
Aug-04		9:32	128			22.2	28.68	1.002	43.37	3.61			
	9:32			1.002	10.50								
Aug-05		9:05	129			22.4	27.67	1.002	39.10	3.62		0.02	
	9:05			1.001	10.50								
Aug-06		14:30	130			21.1	20.31	1.001	35.84	3.66			
	14:30			1.001	10.50								
Aug-07		11:00	131			15.6	28.99	0.999	35.66	3.69			
	11:00			1.000	10.50								
Aug-08		8:40	132			18.7	28.35	1.002	36.86	3.67			
	8:40			1.003	10.50								
Aug-09		12:30	133			19.8	26.56	1.002	44.36	3.64			
	12:30			1.002	10.50								
Aug-10		9:30	134			7.7	17.10	1.001	21.54	3.64	Line plugged overnight		
	9:30			1.002	10.50								
Aug-22		9:30	146			6.9	15.80	1.001	22.75	3.60	Drain solution		
	8:15			1.002	10.50								
Aug-23		16:20	147			9.5	12.77	1.001	24.58	3.85			
	16:20			1.001	10.50								
Aug-24		18:00	148			11.3	20.20	1.002	31.11	3.87			
	18:00			1.002	10.50								
Aug-25		13:25	149			9.9	23.76	1.002	27.68	3.84			
	13:25			1.001	10.50								
Aug-26		15:20	150			19.2	29.95	1.002	46.57	3.78			

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	Ca(OH)2 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
	15:20			1.002	10.50								
Aug-27		15:00	151			16.4	27.25	1.002	38.69	3.73			
	15:00			1.001	10.50								
Aug-28		9:15	152			10.0	24.70	1.002	27.04	3.74			
	9:15			1.001	10.50								
Aug-29		10:15	153			12.6	29.51	1.002	44.27	3.70			
	10:15			1.002	10.50								
Aug-30		9:15	154			24.1	33.14	0.999	45.74	3.73			
	9:15			1.002	10.50								
Sep-13		8:25	168						Start up				
	8:25			1.002	10.50								
Sep-14		8:54	169			10.9	22.14	1.002	32.53	3.84			
	8:54			1.003	10.50								
Sep-15		8:50	170			7.1	23.47	1.003	33.70	3.93			
	8:50			1.003	10.50								
Sep-16		9:05	171			11.6	27.55	1.002	40.08	3.93			
	9:05			1.001	10.50								
Sep-17		14:45	172			27.0	27.98	1.001	49.81	3.90			
	14:45			1.002	10.50								
Sep-18		11:15	173			14.7	23.43	1.002	28.81	3.90			
	11:15			1.002	10.50								
Sep-19			174						Hose plugged				
Sep-20		8:50	175			25.4	23.00	1.001	45.31	3.86			
	8:50			1.002	10.50								
Sep-21		12:07	176			12.2	20.12	1.003	32.94	3.88			

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE					
1994				s.g.	pH	Ca(OH)2 g	Flow mL/min	s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
	12:07			1.002	10.50								
Sep-22		9:25	177			13.2	31.97	1.002	40.86	3.88			
	9:25			1.002	10.50								
Sep-23		10:25	178			14.3	28.12	1.001	42.19	3.88			
	10:25			1.002	10.50								
Sep-24		17:00	179			8.3	14.29	1.002	26.22	3.88			
	17:00			1.002	10.50								
Sep-25		11:15	180			14.5	43.40	1.002	47.52	3.90			
	11:15			1.002	10.50								
Sep-26		10:17	181			19.4	30.92	1.002	42.73	3.89			
	10:17			1.002	10.50								
Sep-27		12:45	182			7.9	20.24	1.002	32.14	3.95			
	12:45			1.002	10.50								
Sep-28		9:15	183			8.8	30.72	1.001	37.78	3.98			
	9:15			1.001	10.50								
Sep-29		9:45	184			10.1	25.07	1.002	36.85	4.00			
	9:45			1.002	10.50								
Sep-30		9:50	185			7.1	19.57	1.002	28.27	4.00			
	9:50			1.002	10.50								
Oct-01		15:00	186			8.6	15.50	1.002	27.12	3.98			
	15:00			1.002	10.50								
Oct-02		12:00	187			9.1	31.66	1.003	39.89	3.98			
	12:00			1.002	10.50								
Oct-03		11:00	188			6.4	27.99	1.002	38.63	3.93			
	11:00			1.001	10.50								
Oct-04		13:30	189			4.5	15.67	1.002	24.92	4.00			

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	Ca(OH)2 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
	13:30			1.002	10.50								
Oct-05		9:15	190			4.5	21.03	1.002	24.92	4.00			
	9:15			1.002	10.50								
Oct-06		10:45	191			10.4	28.35	1.003	43.38	4.05			
	10:45			1.002	10.50								
Oct-07		9:48	192			9.1	26.80	1.003	37.06	4.00			
	9:48			1.002	10.50								
Oct-08		10:00	193			10.4	28.63	1.003	41.57	3.98			
	10:00			1.003	10.50								
Oct-09		12:25	194			9.8	28.87	1.002	45.76	3.99			
	12:25			1.003	10.50								
Oct-10		15:00	195			11.6	26.97	1.002	43.01	3.9			
	15:00			1.003	10.50								
Oct-11		8:25	196			4.4	30.96	1.003	32.36	4.08			
	8:25			1.002	10.50								
Oct-25		8:15	200			11.0	29.02	1.003	41.50	4.12			
	8:15			1.002	10.50								
Oct-27		8:45	202			6.2	13.86	1.002	20.37	3.99	Line plugged		
	8:45			1.003	10.50								
Oct-28		9:45	203			9.7	27.28	1.002	40.93	4.10			
	9:45			1.002	10.50								
Oct-29		11:00	204			11.2	29.73	1.003	45.05	4.00			
	11:00			1.002	10.50								
Oct-30		13:00	205			7.3	23.87	1.002	37.23	4.03			
	13:00			1.002	10.50								
Oct-31		12:45	206			11.3	30.61	1.003	43.63	4.03			
	12:45			1.002	10.50								

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	Ca(OH)2 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
15-Nov			221			12.2		1.001	63.48	4.03	Drain solution		
	9:03			1.0014	10.5								
Nov-16		11:20	222			6.6	18.28	1.002	28.83	4.00			
	11:20			1.000	7.00								
Nov-17		9:30	223			8.7	30.71	1.003	40.85	4.00			
	9:30			1.001	10.50								
Nov-18		10:30	224			10.6	30.16	1.002	45.24	4.00			
	10:30			1.002	10.50								
Nov-19		16:20	225			11.8	24.57	1.002	43.99	3.97			
	16:20			1.003	10.50								
Nov-20		14:10	226			7.5	29.64	1.002	38.83	4.03			
	14:10			1.003	10.50								
Nov-21		14:20	227			10.4	29.36	1.003	42.58	4.05			
	14:20			1.002	10.50								
Nov-22		8:15	228			9.9	49.77	1.002	53.50	3.97			
Dec-06	8:25			1.0027	10.50								
Dec-07		9:30	243			5.4	14.66	1.002	22.07	4.14			
	9:30			0.997	10.50								
Dec-08		9:10	244			8.8	27.85	1.002	39.54	4.12			
	9:10			1.003	10.50								
Dec-09		12:02	245			9.1	28.61	1.002	46.11	4.11			
	12:02			1.001	10.50								
Dec-10		12:45	246			11.5	28.67	1.003	42.51	4.03			
	12:45			1.002	10.50								
Dec-11		11:15	247			8.4	28.07	1.004	37.90	3.97			
	11:15			1.002	10.50								
Dec-12		12:50	248			8.9	28.40	1.002	43.59	4.06			
	12:50			1.002	10.50								
Dec-13		9:30	249			8.0	28.43	1.002	35.25	4.09			

WILLIAMS CREEK - PC1 [JTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE					
				s.g.	pH	Ca(OH)2 g	Flow mL/min	s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Dec-14		12:00	250				29.02	1.000	48.53	4.07			
Dec-18						4.0							
	17:00			1.000	7.00								
Dec-19		16:30	256*			1.6	29.02	1.003	17.62	4.07			
	16:30			1.000	7.00								
Dec-20		13:25	257*			3.0	27.90	1.002	32.25	4.07			
	13:25			1.002	7.00								
Dec-21		10:11	258*			2.4	29.00	1.001	27.95	4.03			
	10:11			1.002	7.00								
Dec-22		8:17	259*			3.4	28.19	1.002	37.38	4.07			
	8:17			1.003	7.00								
Dec-23		11:00	260*					1.003		4.07			
1995													
Feb-06								1.002	59.88	3.99			
	11:55			1.003	7.00								
Feb-07		10:30	306			1.4	10.07	1.002	13.64	4.06			
	10:30			1.003	7.00								
Feb-08		8:55	307			4.3	28.96	1.002	38.95	4.03			
	8:55			1.003	7.00								
Feb-09		15:00	308			6.6	27.41	1.002	49.47	4.06			
	15:00			1.003	7.00								
Feb-10		9:15	309			3.8	27.78	1.002	30.42	4.02			
	9:15			1.003	7.00								
Feb-11		14:30	310			5.1	26.36	1.002	46.27	3.95			
	14:30			1.003	7.00								
Feb-12		14:35	311			2.7	28.80	1.002	41.61	3.95			
	14:35			1.003	7.00								
Feb-13		9:15	312			2.0	33.80	1.002	37.86	4.06			
	9:15			1.003	7.00								
Feb-14		13:15	313			2.2	29.27	1.002	49.18	4.10			

*100mg Si/L added to the feed solution as Na2SiO3

WILLIAMS CREEK - PC1 UTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	Ca(OH)2 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1995													
	13:15			1.003	7.00								
Feb-15		8:45	314			1.5	25.31	1.002	29.61	4.02			
	8:45			1.003	7.00								
Feb-16		9:34	315			2.0	27.65	1.002	41.17	4.09			
	9:34			1.003	7.00								
Feb-17		11:00	316			2.0	26.70	1.002	40.74	4.00			
	11:00			1.003	7.00								
Feb-18		11:30	317			2.0	29.35	1.002	43.14	4.02			
	11:30			1.003	7.00								
Feb-19		13:00	318			1.7	28.91	1.002	44.23	4.00			
	13:00			1.003	7.00								
Feb-20		10:00	319			1.6	30.56	1.002	38.50	4.13			
	10:00			1.003	7.00								
Feb-21		10:40	320			1.8	27.60	1.002	40.85	4.09			
	10:40			1.003	7.00								
Feb-22		11:00	321			1.8	30.37	1.002	44.34	4.09			
	11:00			1.003	7.00								
Feb-23		8:40	322			1.2	24.95	1.002	32.44	3.95			
	8:40			1.003	7.00								
Feb-24		9:30	323			1.2	29.67	1.002	44.21	4.03			
	9:30			1.003	7.00								
Feb-25		18:00	324			2.0	26.68	1.002	52.02	4.05			
	18:00			1.003	7.00								
Feb-26		13:00	325			0.6	23.89	1.002	27.23	3.95			
	13:00			1.003	7.00								
Feb-27		18:30	326			1.7	26.19	1.002	46.35	4.16			
	18:30			1.003	7.00								
Feb-28		8:45	327			0.9	24.69	1.002	21.11	4.01			
	8:45			1.003	7.00								
Mar-01		8:35	328			1.0	26.35	1.002	37.68	4.20			

*100mg Si/L added to the feed solution as Na2SiO3

WILLIAMS CREEK - PC1 NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC1
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 594.5 kg
Copper Grade: 1.22 %
Charge Height: 5.3 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	Ca(OH)2 g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1995													
	8:35			1.003	7.00								
Mar-02		8:35	329			1.56	29.41	1.002	42.36	4.15			
	8:35			1.003	7.00								
Mar-03		8:15	330										

*100mg Si/L added to the feed solution as Na2SiO3

WILLIAMS CREEK - PC2 COLUMN NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 1.54 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Sep-26													
	14:00			1.001	11.00								
Sep-27		14:30	1				15.08	1.065	9.18	2.61			
	14:30			1.001	11.00								
Sep-28		17:16	2				10.50	1.049	23.99	2.91			
	17:16			1.000	11.00								
Sep-29													
				Not enough solution to feed the column									
Sep-30		8:35	3					1.037	12.91	2.99			
	11:15			1.000	11.00								
Oct-01		14:40	4				9.39	1.027	12.33	3.22			
	14:40			1.000	11.00								
Oct-02		12:00	5				12.41	1.022	12.57	3.25			
	12:00			1.000	11.00								
Oct-03		11:00	6				11.82	1.013	17.43	3.00			
	15:15			0.998	11.00								
Oct-04		13:00	7				14.84	1.009	15.77	3.13			
	13:00			0.997	11.00								
Oct-05		8:25	8				16.48	1.008	17.15	3.13			
	8:25			0.998	11.00								
Oct-06		9:55	9			490.0	11.71	1.005	21.90	3.06			
	9:55			0.997	11.00								
Oct-07		8:30	10				17.27	1.006	17.94	3.09			
	8:30			0.997	11.00								
Oct-08		9:37	11			453.7	15.36	1.003	23.84	3.08			
	9:37			1.000	11.00								
Oct-09		12:02	12				13.58	1.004	23.74	3.07			
	12:02			1.000	11.00								

WILLIAMS CREEK - PC2 COLUMN NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 1.54 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
Oct-10		14:45	13			698.7	13.26	1.003	21.77	3.30			
	14:45			0.999	11.00								
Oct-11		8:45	14				21.29	1.003	13.64	3.13			
	8:45			1.000	11.00								
Oct-25		8:15	28				14.20	1.003	37.62	3.05			
	8:15			1.000	11.00								
Oct-27		9:20	30			117.3	28.63	1.004	36.65	3.56			
	9:20			1.001	11.00								
Oct-28		10:25	31			126.3	29.85	1.003	39.93	3.66			
	10:25			1.001	11.00								
Oct-29		11:20	32			138.0	27.91	1.003	42.21	3.45			
	11:20			1.004	11.00								
Oct-30		12:30	33			55.3		Line plugged by precipitates,					
	12:30			1.003	11.00			no feed solution into the column.					
Nov-15		8:30				75.4	35.19	1.002	54.67	3.35	Drain solution		
	9:15			1.002	11.00								
Nov-16		10:35	50			29.3	28.77	0.999	27.14	3.45			
	10:35			1.003	11.00								
Nov-17		9:00	51			41.4	34.15	1.001	37.11	3.33			
	9:00			1.001	11.00								
Nov-18		9:50	52			41.5	29.32	1.001	44.49	3.42			
	9:50			1.002	11.00								
Nov-19		16:00	53			35.2	23.96	1.001	42.78	3.41			
	16:00			1.002	11.00								
Nov-20		8:15	54			36.2	39.38	1.000	44.51	3.45			
	8:15			1.001	11.00								
Nov-21		8:50	55			32.3	29.93	1.000	41.83	3.47			
	8:50			1.001	11.00								
Nov-22		8:43	56			29.1	32.10	1.000	49.54	3.50			
Dec-06	8:43			0.999	11.00								

WILLIAMS CREEK - PC2 COLU N NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 1.54 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION				LEACHATE					
1994				s.g.	pH	CaOH g	Flow mL/min	s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
Dec-07		8:50	75			20.8	30.40	1	25.23	3.64			
	8:50			1.002	11.00								
Dec-08		8:43	76			32.4	30.73	1.000	39.33	3.64			
	8:43			1.001	11.00								
Dec-09		11:40	77			29.5	23.48	1.000	46.74	3.63			
	11:40			1.001	11.00								
Dec-10		13:20	78			41.7	27.94	1.002	46.43	3.58			
	13:20			1.001	11.00								
Dec-11		11:30	79				Line plugged						
	11:30			1.001	11.00								
Dec-12		14:50	80			32.4	26.31	1.001	46.14	3.61			
	14:50			1.001	11.00								
Dec-13		10:00	81			20.3	28.40	1.001	32.67	3.65			
1995													
Feb-06	12:15			1.000	7.00								
Feb-07		10:00	137			7.5	27.90	1.001	15.63	3.45			
	10:00			1.000	7.00								
Feb-08		8:35	138			14.6	42.58	1.000	38.85	3.45			
	8:35			1.000	7.00								
Feb-09		14:36	139			18.2	21.57	1.000	48.76	3.67			
	14:36			1.000	7.00								
Feb-10		9:05	140			10.1	43.96	1.000	26.51	3.50	Feed line broke		
	9:05			1.000	7.00								
Feb-11		14:00	141			19.7	20.51	1.000	43.62	3.53			
	15:00			1.000	7.00								
Feb-12		14:15	142			5.7	31.27	1.000	32.31	3.56			
	14:30			1.000	7.00								
Feb-13		9:30	143			5.2	28.34	1.000	40.40	3.56			
	9:30			1.000	7.00								
Feb-14		8:15	144			15.1	29.60	1.000	38.97	3.70			

WILLIAMS CREEK - PC2 COLUMN NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 1.54 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1995													
	8:15			1.000	7.00								
15-Feb		8:15	145			7.6	27.06	1.000	37.75	3.66			
	8:15			1.000	7.00								
Feb-16		9:15	146			8.4	25.18	1.000	41.33	3.66			
	9:15			1.000	7.00								
Feb-17		10:00	147			7.8	27.81	1.000	43.48	3.64			
	10:00			1.000	7.00								
Feb-18		11:15	148			8.6	28.71	1.000	43.76	3.62			
	11:15			1.000	7.00								
Feb-19		12:30	149			7.3	27.70	1.000	36.33	3.60			
	12:30			1.000	7.00								
Feb-20		9:30	150			6.6	36.12	1.000	34.24	3.50			
	9:30			1.000	7.00								
Feb-21		9:50	151			8.6	23.46	1.000	41.88	3.5			
	9:50			1.000	7.00								
Feb-22		10:40	152			7.5	28.11	1.000	40.93	3.50			
	10:40			1.000	7.00								
Feb-23		8:20	153			7.0	31.49	1.000	35.80	3.80			
	8:20			1.000	7.00								
Feb-24		8:45	154			8.0	24.44	1.000	42.74	3.48			
	8:45			1.000	7.00								
Feb-25		18:30	155			9.3	21.11	1.000	55.06	3.50			
	18:30			1.000	7.00								
Feb-26		13:00	156			5.3	49.61	1.000	30.84	3.45			
	13:00			1.000	7.00								
Feb-27		18:30	157			8.8	17.43	1.000	51.68	3.72			
	18:30			1.000	7.00								
Feb-28		8:30	158			4.3	61.52	1.000	22.60	3.43			

WILLIAMS CREEK - PC2 COLUMN NEUTRALIZATION TEST DATA

Project #: 92-006
Column #: PC2
Column Size: 12 inch x 18 feet
Ore Sample: Trench composite

Sample Weight 595 kg
Copper Grade: 1.22 %
Charge Height: 1.54 m
Bulk S.G. 1.54 tonne/m3

Date	Time on	Time off	Days	FEED SOLUTION s.g.	pH	CaOH g	Flow mL/min	LEACHATE s.g.	Vol. L	pH	ORP mV*	Cu g/L	Fe g/L
1994													
	8:30			1.000	7.00								
1-Mar		8:15	159			6.8	47.70	1.000	41.03	3.71			
	8:15			1.000	7.00								
Mar-02		8:15	160			6.0	28.50	1.000	42.40	3.73			
	8:15			1.000	7.00								
Mar-03		8:15	161										

CAVENDISH LABORATORY LTD.

CERTIFICATE OF ANALYSIS

2225 Springer Ave., Burnaby,
British Columbia, Can. V5B 3N1
Ph:(604)299-2560 Fax:299-6252

To : PROCESS RESEARCH ASSOCIATES
9141 SHAUGHNESSY ST. VANCOUVER
B.C. V6P 3R9 FAX: 322-0181

Project: 94006
Type of Analysis: ICP

Certificate: 940412B
Invoice: 0412B.PRA
Date Entered: 94-04-12
File Name: PRA0412B.1
Page No.: 1

PRE FIX	SAMPLE NAME	PPM LA	PPM MG	PPM MN	PPM MO	PPM NA	PPM NI	PPM P	PPM PB	PPM SB	PPM SI	PPM SR	PPM TI	PPM V	PPM W	PPM ZN
N	NAOH WASH DAY7	<.01	604	15.1	0.01	2764	<.01	0.9	<.02	0.03	<.01	<.01	<.01	0.02	0.15	0.1

COLUMN PC1 - DAY 7 DISCHARGE

CERTIFIED BY : W. Reeves

CAVENDISH LABORATORY LTD.

CERTIFICATE OF ANALYSIS

2225 Springer Ave., Burnaby,
British Columbia, Can. V5B 3N1
Ph:(604)299-2560 Fax:299-6252

To : PROCESS RESEARCH ASSOCIATES
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Project: 94006
Type of Analysis: ICP

Certificate: 940412B
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Page No.: 1

PRE FIX	SAMPLE NAME	PPM AG	PPM AL	PPM AS	PPM AU	PPM B	PPM BA	PPM BE	PPM BI	PPM CA	PPM CD	PPM CO	PPM CR	PPM CU	PPM FE	PPM HG	PPM AA-K
N	NAOH WASH DAY7	<.01	<1	0.05	<.01	42.16	0.11	0.01	<.05	456	<.01	0.01	<.01	0.31	1	<.02	N/A

COLUMN PC 1 - DAY 7 DISCHARGE

CERTIFIED BY : W. Peng

Morris: Williams Creek Column

RESULTS OF ANALYSIS. - Water File No. E6055

			PC1 Dischrge	Feed PC1 Neutral	PC2 Dischrge	Feed PC2 Neutral
			94 11 23	94 11 23	94 11 23	94 11 23
Nutrients						
Nitrate Nitrogen		N	0.677	IP	IP	IP
Nitrite Nitrogen		N	0.027	IP	IP	IP
Total Metals						
Aluminum	T-Al		5.73	0.27	64.9	1.29
Antimony	T-Sb		<0.20	<0.20	<0.20	<0.20
Arsenic	T-As		<0.20	<0.20	<0.20	<0.20
Barium	T-Ba		<0.010	<0.010	<0.010	<0.010
Beryllium	T-Be		<0.005	<0.005	0.006	<0.005
Bismuth	T-Bi		<0.10	<0.10	<0.10	<0.10
Boron	T-B		0.19	0.12	0.17	<0.10
Cadmium	T-Cd		<0.010	<0.010	<0.010	<0.010
Calcium	T-Ca		407	456	510	664
Chromium	T-Cr		<0.015	<0.015	<0.015	<0.015
Cobalt	T-Co		<0.015	<0.015	0.079	<0.015
Copper	T-Cu		11.5	0.574	16.1	0.191
Iron	T-Fe		0.233	<0.030	0.408	<0.030
Lead	T-Pb		<0.050	<0.050	<0.050	<0.050
Lithium	T-Li		<0.015	<0.015	0.196	0.168
Magnesium	T-Mg		12.3	5.07	67.8	18.7
Manganese	T-Mn		0.158	0.010	2.95	0.105
Molybdenum	T-Mo		<0.030	<0.030	<0.030	<0.030
Nickel	T-Ni		<0.020	<0.020	0.059	<0.020
Phosphorus	T-P		<0.30	<0.30	<0.30	<0.30
Potassium	T-K		12.6	11.2	8.1	7.1
Selenium	T-Se		<0.20	<0.20	<0.20	<0.20
Silicon	T-Si		46.8	24.4	55.3	7.02
Silver	T-Ag		<0.015	<0.015	<0.015	<0.015
Sodium	T-Na		942	879	29.8	27.2
Strontium	T-Sr		0.130	0.186	1.27	1.40
Thallium	T-Tl		<0.10	<0.10	<0.10	<0.10
Tin	T-Sn		<0.30	<0.30	<0.30	<0.30
Titanium	T-Ti		<0.010	<0.010	<0.010	<0.010
Tungsten	T-W		<0.10	<0.10	<0.10	<0.10
Vanadium	T-V		<0.030	<0.030	<0.030	<0.030
Zinc	T-Zn		0.041	0.009	0.765	0.014

IP = In Progress.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

WILLIAMS CREEK COLUMN NEUTRALIZATION ICP REPORT

Project no : 92-006 **Date :** 3-Jan-95

Test description

100 mg/L Si as sodium silicate was added to the feed solution.
Column discharged solution was analyzed for multi-elements ICP.

Test results Discharges - all

Metals	PC1 Day 309	PC1 Day 317	PC1 Day 324	PC1 Day 330	PC2 Day 140	PC2 Day 148	PC2 Day 155	PC2 Day 161
Al	4.30	3.69	3.89	3.57	37.8	31.8	27.6	24.8
Sb	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ba	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Be	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bi	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
B	0.15	0.12	0.12	0.12	0.11	<0.10	0.10	0.11
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ca	393	371	423	415	504	555	545	548
Cr	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.027	<0.015
Co	<0.015	<0.015	<0.015	<0.015	0.051	0.029	0.017	<0.015
Cu	12.0	7.86	6.10	5.77	22.50	16.00	11.80	9.82
Fe	0.167	0.081	0.107	0.102	0.273	0.218	0.464	0.197
Pb	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Li	<0.015	<0.015	<0.015	<0.015	0.122	0.111	0.102	0.095
Mg	8.96	7.57	8.73	8.77	44.5	35.6	35.6	35.4
Mn	0.232	0.148	0.117	0.111	1.96	1.16	0.886	0.775
Mo	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Ni	<0.020	<0.020	<0.020	<0.020	0.027	<0.020	<0.020	<0.020
P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
K	11.0	9.5	10.9	11.1	8.8	8.8	7.8	7.4
Se	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Si	41.5	37.7	43.9	43.2	50.1	53.3	52.2	51.8
Ag	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Na	788	721	833	835	17.1	32.1	29.7	30.4
Sr	0.095	0.087	0.105	0.103	0.793	0.857	0.822	0.823
Tl	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
W	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zn	0.062	0.027	0.023	0.025	0.650	0.401	0.250	0.178

WILLIAMS CREEK COLUMN NEUTRALIZATION REPORT

Project no : 92-006 **Date :** 12-Apr-95

Test description

Different concentrations of Sodium Tripolyphosphate were added to the PC1 discharged solution
Solutions were mixed for 1 hour
Analyzed treated solution for multi-element ICP

Test results

Metals	Sodium Tripolyphosphate (mg/L)					
	Blank	10	100	500	1000	5000
Al	3.77	3.73	3.74	3.27	3.03	3.7
Sb	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
As	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ba	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Be	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bi	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
B	0.14	0.14	0.17	0.15	<0.20	<0.10
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ca	443	435	435	378	278	443
Cr	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Co	<0.015	<0.015	<0.015	<0.015	0.032	0.029
Cu	6.1	6.07	6.00	3.63	2.66	6.05
Fe	0.123	0.140	0.147	0.133	0.186	0.27
Pb	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Li	<0.015	<0.015	<0.015	<0.015	<0.030	<0.075
Mg	9.09	8.95	9.34	8.53	7.93	9.49
Mn	0.119	0.119	0.124	0.077	0.06	0.14
Mo	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Ni	<0.020	<0.020	<0.020	<0.020	<0.040	<0.020
P	<0.30	4.89	24.0	65.3	83.2	<0.30
K	11.2	11.0	11.8	11.4	11.8	15.0
Se	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Si	45.8	45.1	45.2	44.9	44.9	45.8
Ag	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Na	884	877	897	993	1130	2250
Sr	0.111	0.109	0.109	0.090	0.066	0.130
Tl	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sn	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
W	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zn	0.034	0.123	0.045	0.026	0.020	0.10

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

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CHEMICAL ANALYSIS REPORT

Date: January 3, 1995

ASL File No. E6580

Report On: Project 92-006
Water Analysis

Report To: **Process Research Associates Ltd.**
9141 Shaughnessy Street
Vancouver, BC
V6P 6R9

Attention: **Mr. Peter Tse**, Laboratory Manager

Received: December 28, 1994

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Cameron McLean, B.Sc
Project Chemist

Frederick Chen, B.Sc.
Supervisor, Trace Metals Lab

METHODOLOGY File No. E6580

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

End of Report