

**SUBAQUEOUS DEPOSITION OF
TAILINGS IN THE STRATHCONA
TAILINGS TREATMENT SYSTEM**

MEND Project PCA-2

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**SUBAQUEOUS DEPOSITION OF TAILINGS
IN THE
STRATHCONA TAILINGS TREATMENT SYSTEM**

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Prepared for:

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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY <i>Sommaire</i>	i
1.0 INTRODUCTION	1
1.1 Background	1
1.2 Objective and Scope	3
2.0 EXPERIMENTAL DESIGN	4
2.1 Characterization of Upper Strathcona Tailings Treatment System Water, Process Water, Pyrrhotite Tailings and Strathcona Mill Tailings	4
2.2 Column Leach Tests	5
2.3 Pilot Column Tests	7
2.3.1 Pilot Column Construction and Set-up	8
2.3.2 Pilot Column Filling	11
2.3.3 Sampling and Monitoring	15
2.3.3.1 Water Sample Collection	15
2.3.3.2 In-situ Measurement	16
3.0 RESULTS	18
3.1 Characteristics of Strathcona Tailings Treatment System Water and Process Water	18
3.2 Characteristics of Pyrrhotite Tailings and Strathcona Mill Tailings	19
3.3 Column Leach Test Results	24

3.4	Pilot Column Test Results	26
3.4.1	Conductivity Changes in the Columns	26
3.4.2	Eh Changes in the Columns	28
3.4.3	pH Changes in the Columns	31
3.4.4	Changes in Sulphate Concentrations	32
3.4.5	Changes in Iron Concentrations	36
3.4.6	Changes in Nickel Concentrations	41
3.4.7	Changes in Thiosulphate Concentrations in the Water Cover and Pore Water of Tailings	43
3.4.8	Changes in Concentrations of Other Elements	44
3.4.9	Visual Observations	45
4.0	SUMMARY AND DISCUSSION	46
5.0	CONCLUSIONS	52
6.0	RECOMMENDATIONS	53

LIST OF TABLES

Table 1. Characteristics of Upper Moose Lake Water and Process Water	19
Table 2. A Multi-elemental ICP-ES Scan of Tailings Solids	20
Table 3. Characteristics of the Liquid Portions of the Pyrrhotite Tailings and Strathcona Mill Tailings	21
Table 4. The Thiosulphate Concentrations in the Pore Waters of the Water Cover, Interface and the Tailings Layer After 6 and 13 Months of Column Test	44

LIST OF FIGURES

Figure 1. Pilot Column Set-up	9
Figure 2. Pyrrhotite and Strathcona Mill Tailings Grain Size Distribution	22
Figure 3. Viscosity Test at Pulp Density of 62% Solids	23
Figure 4. Conductivity vs. Time	27
Figure 5. In-situ Eh vs. Time	29
Figure 6. Water pH vs. Time	33
Figure 7. Water SO ₄ Concentrations vs. Time	34
Figure 8. Water Fe Concentrations vs. Time	37
Figure 9. Water Fe ³⁺ Concentrations vs. Time	39
Figure 10. Water Fe ²⁺ Concentrations vs. Time	40
Figure 11. Water Ni Concentrations vs. Time	42

LIST OF PLATES

- Plate #1: Subaqueous Columns Prior to Filling
- Plate #2: Subaqueous Columns #1 (pyrrhotite) and #2 (thickened SM tailings), January 30, 1995
- Plate #3: Subaqueous Columns #3 (pyrrhotite and substrate) and #4 (thickened pyrrhotite), January 30, 1995
- Plate #4: Subaqueous Column #5 (SM tailings), January 30, 1995
- Plate #5: Subaqueous Column #5 (SM tailings), January 22, 1996
- Plate #6: Subaqueous Column #2 (thickened SM tailings), January 22, 1996
- Plate #7: Subaqueous Column #1 (pyrrhotite), January 22, 1996
- Plate #8: Subaqueous Column #4 (thickened pyrrhotite), January 22, 1996
- Plate #9: Subaqueous Column #3 (pyrrhotite and substrate), January 22, 1996
- Plate #10: Subaqueous Columns #1 to #5, January 22, 1996

LIST OF APPENDICES

Appendix A Analytical Procedure

Appendix B Analytical Results

Appendix C In-situ Redox (Eh) and Conductivity Results

Appendix D Column Leach Test Results from Noranda Technology Centre

1.0 INTRODUCTION

1.1 Background

The deposition of tailings under water is one of the most promising and cost effective methods to reduce or prevent acid mine drainage from tailings. However, the environmental consequences of depositing potentially acid generating tailings into acidic water have not yet been determined.

The majority of the Falconbridge Limited (Falconbridge) mining and milling operations in the Sudbury area are in the Strathcona and Fecunis areas. Strathcona tailings treatment system covers an area of approximately 200 hectares with a maximum depth of approximately 55 meters. The water in the tailings treatment system generally has a pH of approximately 3 due to leachate from tailings and waste rock in the area, and from the oxidation of process water containing sulphides and thiosalts.

Drainage from the Strathcona and Fecunis tailings areas introduces acid and metal sulphide oxidation products to Upper Strathcona tailings treatment system. This section of the Strathcona tailings treatment system is characterized by low pH and high metals concentrations. Treatment by Falconbridge of the lower Strathcona tailings treatment system has consisted primarily of pH adjustment through lime addition. This has resulted in the production of a neutral water with lower metals concentrations which is used by the Strathcona Mill (SM) as Process Water.

Falconbridge mines operating in Strathcona area include: Onaping Mine, Strathcona Mine, Fraser Mine and Craig Mine. The Strathcona Mill processes approximately 10,000 tonnes per day (tpd) of ore, which typically produces approximately: 1,500 tpd

of pyrrhotite tailings, 5,000 tpd of sand tailings for backfill, 1,500 tpd tailings slimes, and 2,000 tpd of concentrate. The pyrrhotite tailings contains high concentrations of sulphide, while the slimes contain low concentrations of sulphide. Both the pyrrhotite tailings and tailings slimes have net acid producing potential.

Previous studies by Falconbridge of the Strathcona area identified three options as having excellent potential for the cost effective disposal of tailings. Two of the three options relied largely or partially on flooding existing tailings areas to reduce the generation of acid from the oxidation of sulphide tailings. One of the concerns of subaqueous deposition has been that metals, including nickel, may leach into the cover waters, thereby increasing the metal concentration to higher than acceptable limits. Another concern has been that thiosulphate concentrations in the Strathcona tailings treatment system may increase to levels which would result in thiosulphate discharge from the tailings treatment system. This could lead to increased treatment requirements at the discharge point, which may result in increased sludge volumes requiring disposal and the discharge of thiosalts may also result in the acidification of receiver streams following the oxidation of thiosalts. Since subaqueous deposition in non-acidic waters has shown that the overlying water quality remains unchanged, it is anticipated that treatment requirements will decrease at the discharge point over time as the water in treatment system approaches pH 7.

The deposition of tailings in the Strathcona tailings treatment system is previously unstudied, however, it was considered possible that the Strathcona tailings treatment system could provide a suitable and cost effective location for the disposal of potentially acid generating tailings.

1.2 Objective and Scope

The purpose of the subaqueous program was to determine the feasibility of depositing the Strathcona Mill sulphide tailings into the Strathcona tailings treatment system as a method of acid generation control. During the research program, data has been collected to: assist with the feasibility assessment, establish baseline conditions and provide data for future modeling studies.

This research program was divided into three main components:

1. Tailings Characterization and Subaqueous Column Test Work

This work was conducted by Lakefield Research Limited (LRL) to characterize the unoxidized tailings from the Strathcona Mill circuit and to determine the effects of the subaqueous deposition of tailings on the Strathcona tailings treatment system water and on the pore water in the tailings. The two types of tailings tested were high sulphide tailings (pyrrhotite concentrate), and low sulphide tailings (end of pipe slime tailings). In addition to chemical, physical and mineralogical testing on the tailings, pilot columns were constructed to observe physical and chemical changes in the water cover and pore water of subaqueously deposited tailings.

2. Strathcona Tailings Treatment System Characterization

This characterization work was performed by Rescan Environmental Services Limited to obtain information on the bathymetry, physical limnology, water quality and sediment geochemistry of the tailings treatment system. An interim report by Rescan ESL was included as an appendix in the March, 1995, Progress Report.

3. Strathcona and Fecunis Tailings Area Characterization

This work was performed by the University of Waterloo Centre for Groundwater Research to determine the hydrogeology, geochemistry and mineralogy of the Strathcona tailings disposal site located near the Strathcona Mine site. A summary report was submitted directly to Falconbridge Limited, Sudbury Operations, in February 1996.

The following report focuses on the results obtained from the tailings characterization and subaqueous column test work conducted by LRL from November 1994 to January 1996.

2.0 EXPERIMENTAL DESIGN

2.1 Characterization of Upper Strathcona Tailings Treatment System Water, Process Water, Pyrrhotite Tailings and Strathcona Mill Tailings

Upper Strathcona tailings treatment system water and process water were collected and analyzed for pH, conductivity, total inorganic carbon, total cyanide and thiosulphate. An anion scan (NO₂, NO₃, F, Cl, Br, SO₄, PO₄) and a 24 element metals scan using inductively coupled plasma emission spectrophotometry (ICP-ES) were also conducted.

Samples of the pyrrhotite tailings and slime tailings collected from the Strathcona Mill were decanted and filtered through a 0.45 µm filter. The liquid portion of the tailings slurry was analyzed for pH, conductivity, total dissolved solids, turbidity, total alkalinity, total acidity, total hardness, ammonia, total Kjeldahl nitrogen, cyanide, and thiosulphate. An anion scan and a 24 element metals scan using ICP-ES were also conducted. The solid portion of the tailings was digested in a hydrofluoric and

perchloric acid solution and a multi-element scan was conducted using ICP-ES. Total sulfur was determined using a LECO Furnace. One sample of each type of solid tailings was characterized physically for particle size distribution using sieve series, cyclosizer analyses and hygrometric analyses. Hygrometric analyses included slurry viscosity (Rheology), specific gravity determination and settling density. The hydraulic conductivity and porosity of the tailings were calculated using the results of the physical tests.

Mineralogical examinations were conducted on the high and low sulphide tailings solids samples by X-Ray Diffraction (XRD). Polished sections of the samples were also examined under incident and transmitted light using the ore microscope at 56x to 500x magnifications.

2.2 Column Leach Tests

Representative head samples of each type of solid tailings were forwarded to Noranda Technology Centre (NTC) for Column Leach Tests. The objective of the test was to determine the release or uptake rates and the concentrations of major cations in a tailings sample permeated with a leachant solution. The leach tests were performed on two samples and were run in duplicate. The first sample analyzed was the pyrrhotite tailings and the second was the SM tailings. While ASTM standards which relate specifically to this test were unavailable, there was an ASTM standard which applied to certain sections of this test. The ASTM standard was ASTM 2434-68 (Standard Test Method for Permeability of Granular Soils (Constant Head)).

For all tests, the samples were blended into a slurry, to ensure a homogeneous mixture, and poured into the cell used for one-dimensional consolidation/hydraulic conductivity tests. Using this cell to produce samples proved to be more effective

than drying and compacting into Proctor molds which was initially considered. Once the samples were poured into the cells, a piston was placed on the cell and brought into contact with the sample surface. The cell was then moved to the modified triaxial load frame and the sample was consolidated with vertical stress and a vacuum, which was slightly greater than the air entry value, to ensure complete drainage. When most of the water had been removed (drainage had slowed) the cell was disassembled and the sample was removed. Using the consolidation-hydraulic conductivity cell ensured that the diameter of the sample would be constant and that the ends would be parallel to each other.

All pertinent data were then collected (weight, diameter and height) and recorded. The samples were then coated with a uniform layer of high vacuum grease and placed on the pedestal base of the permeability or triaxial cell. The sample was then covered with a rubber membrane. The top cap was then seated on the top of the sample and the rubber membrane was sealed with several o-rings. Then the tubes were connected to the top cap. These tubes would carry the effluent leachate from the samples to the effluent collection bottles. Once the fittings were secure, the permeability or triaxial cell was assembled and the chamber was filled with water. The water in the chamber would be used to evenly distribute the confining stress. This confining stress was necessary to maintain contact between the rubber membrane and the sample, to prevent side wall leakage.

Once the cell was filled, it was moved to the permeability setup where the chamber pressure or confining stress was applied. Due to the low gradient that was anticipated for the testing program, the confining stress was equally low, at less than 70 kPa (10 psi). The tubes were then connected from the permeability cell to the reservoir and from the cell to the collection bottle. The inflow of effluent was supplied at the base of the sample and the outflow of effluent was collected from the top of the sample.

The level in the reservoir was maintained constant, thus ensuring a constant inflow pressure. The outflow exited at a constant height to maintain a constant outflow pressure.

The inflow leachant used was Upper Strathcona tailings treatment system water. It was agreed by personnel at LRL and NTC that this leachant would produce the most representative results since the tailings deposition scheme being investigated was Strathcona Mill tailings deposited subaqueously. The samples were permeated for a minimum of 50 pore volumes with the Upper Strathcona tailings treatment system water. The outflow from the permeability cell was collected in flasks and the volume was recorded as a function of time for hydraulic conductivity calculations. The pH of the effluent was recorded, and a sample of the effluent was filtered through a 0.45 µm filter and submitted to the NTC analytical laboratory for ICP analysis.

2.3 Pilot Column Tests

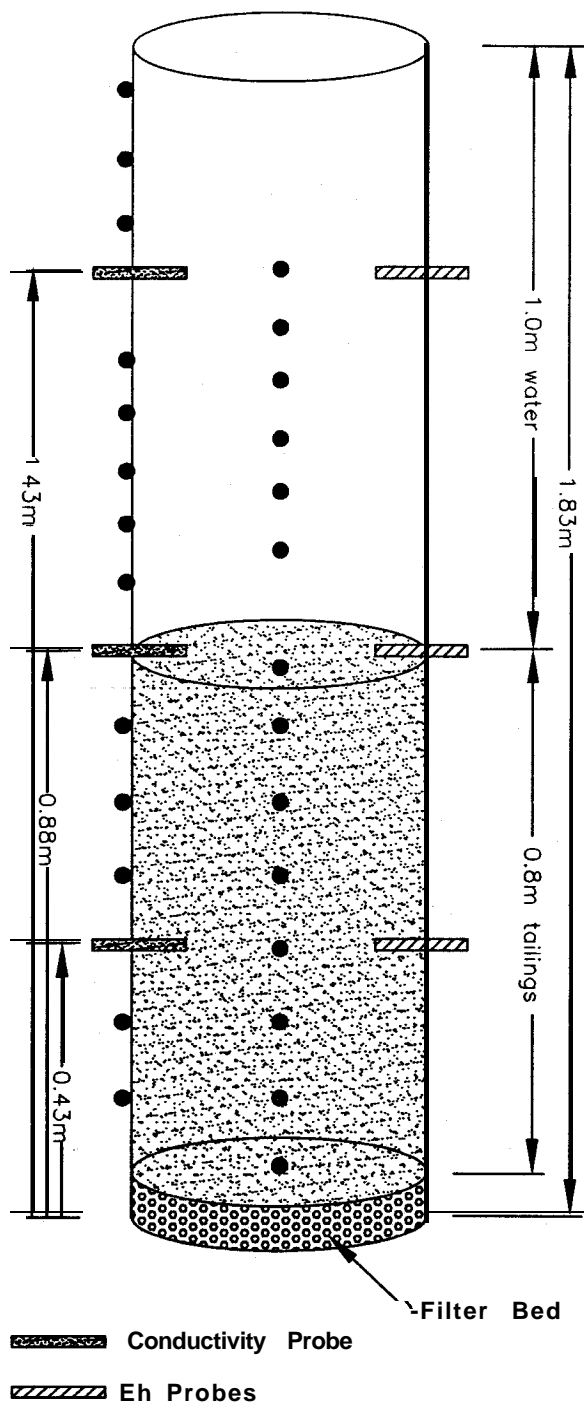
Laboratory simulations of tailings deposited subaqueously in the Strathcona tailings treatment system were conducted using Pilot Column Tests. Five different deposition scenarios were modeled using five different types of tailings in one subaqueous environment. The five tailings used included: Strathcona Mill (SM) tailings blend, thickened SM tailings blend, pyrrhotite tailings, thickened pyrrhotite tailings and pyrrhotite tailings with 100 mm of sediment substrate collected from the Strathcona tailings treatment system. Each type of tailings was deposited subaqueously in Upper Strathcona tailings treatment system water, which was at pH 3.0. The water was collected from above the chemocline and thermocline in the system. The pilot column tests were used to study the chemical and physical impact of subaqueous tailings deposition of tailings on the water cover and on the tailings pore water.

2.3.1 Pilot Column Construction and Set-up

The design of the pilot columns was reviewed by LRL and NTC personnel prior to construction. A total of five columns were constructed for the program. The subaqueous test columns were constructed of PlexiglasTM with a solid polyvinyl chloride (PVC) base and a PVC lid. The pilot columns were constructed 1830 mm high and 300 mm in diameter (Figure 1). Fourteen septum ports were installed vertically in the bottom section of each column for the collection of pore water from the tailings. Fourteen septum ports were also installed vertically in the top section, to allow the collection of water from above the tailings (Figure 1). One sampling port was installed at the tailings/water interface. Monitoring ports were also installed at three depth levels in each column. One monitoring level was located at the middle of the water column, another was located just above the interface between the water and the tailings, and the third was located midway in the tailings column. The monitoring ports were constructed with a porous cap solution sampler, a conductivity and temperature probe and an Eh probe. This provided a total of 29 sampling ports in each column.

An interlayered system of geomembrane, identified as Geotex AMOCO woven geosynthetic M1198 (425 opening) from Terrafix Environmental Technology Inc. of Rexdale, Ontario, and glass marbles was placed at the bottom of the columns to comprise a bottom filter. This system was installed to permit sampling from the base of the columns. A spigot was installed at the base of the columns to permit sample collection from the bottom of the system (Figure 1). Column construction and modifications resulting from the use of specific probe types were completed in November, 1994.

Figure 1. Pilot Column Set-up



Prior to filling the columns were rinsed with the treated Strathcona mill process water. The water had been collected from the discharge point of the lower Strathcona tailings treatment system and shipped to LRL by Falconbridge. Marbles, similarly rinsed, were poured into the columns to a thickness of 60-80 mm, to cover the spigot at the base. A double layer of geomembrane was placed on top of the marbles to minimize the influx of tailings to the marble layer. The placement and sealing of the Eh and conductivity probes and solution samplers began following placement of the marble base layer.

The Eh probes consisted of 6.35 mm outside diameter (OD) acrylic tubing, 22 gauge copper wire and 0.254 mm diameter platinum wire. The platinum wire was soldered to the copper wire and placed in the tubing, so that the platinum wire would be exposed on one end. The tubing was filled with silicone sealant. Epoxy was applied at both ends to physically separate the wire inside the tubing from the water. The electrodes used were not platinized because, when platinized, Eh electrodes can be contaminated with lead from the trace amounts of lead acetate in the platinizing solution. The difference in redox potentials between any two Eh probes was determined to be less than 50 mV. Probes were installed through the column walls and silicon was used to seal around the exterior of the probes. The probe sensor was extended approximately 130 mm from the wall of the columns (i.e. inside the column).

Several suppliers were contacted to determine the appropriate conductivity probe for use in a long term, sealed, continuously submerged system. The probe selected was the ESD 01-35-COND-1 Conductivity Probe and the ESD Model 73 Conductivity Meter with temperature display. Each probe had a separate temperature sensor. The conductivity probes and temperature sensors were installed in the columns and silicone was used to seal around the exterior of the probe. The conductivity probe sensor was extended approximately 40 mm from the inside of the column. The

temperature sensor was extended 10 mm from the inside of the column. The in-situ conductivity probes and Eh electrodes were located opposite the sampling ports at the three monitoring levels (i.e. midway through the water column, at the tailings/water interface and midway down the tailings).

To protect the probes and solution samplers extending from the outside walls of the columns, the columns were surrounded by a protective wood frame. This frame also supports a black plastic cover, which was installed over the columns in January, 1995. This was used to reduce the effects of light and the potential biological growth on the subaqueous system.

Each sample port in the water columns was constructed of a black HDPE compression fitting and a rubber septum. Sample collection was performed using VACUTAINER brand multiple sample needles. As the extraction of pore water was not possible using a syringe from the tailings sample port, this port was modified by inserting a polyethylene (PE) porous cup with a small diameter tube into the tailings. The insertion was completed very quickly and only a 50-mL volume of tailings escaped from the columns.

2.3.2 Pilot Column Filling

Pyrrhotite concentrate and end of pipe slime tailings samples from the Strathcona Mill, and surface and process water from the Strathcona tailings treatment system, were collected and shipped to LRL for the subaqueous column test program.

Because the slimes had a low pulp density when discharged from the Strathcona Mill, Falconbridge reduced the water content and thickened the overflow slimes prior to shipment to LRL. The slimes were initially shipped to LRL in a pump truck outfitted

with a screw auger. The tailings solids settled during the trip from the Strathcona Mill to LRL and, upon unloading, only the lighter fraction of the slimes could be removed from the truck. The heavier fraction had compacted on the bottom of the truck and could not be removed using available equipment. The slimes which had been unloaded were considered unrepresentative and were disposed of in the settling pond at LRL. The pump truck returned to Falconbridge for cleaning. The cyclone overflow slimes were subsequently shipped to LRL in drums after they were collected and settled in a collection tank at the Strathcona Mill (SM).

Discussions with Mr. M. Romaniuk and Mr. M. Wiebe of Falconbridge determined the appropriate ratio of pyrrhotite concentrate to cyclone overflow slimes that should be blended to produce a representative sample of SM unoxidized tailings for use in this study. A blended mixture (50 to 30 ratio by volume) of pyrrhotite to slimes was recommended by Falconbridge and this was prepared for pumping into the two columns designated as “SM Tailings” and “Thickened SM Tailings” (columns 5 and 2, respectively).

On November 28, 1994, the construction and leak proofing of the columns was completed. Plate #1 illustrates the set-up of the columns prior to filling. The columns were filled with acidic Upper Strathcona tailings treatment system water on November 29, 1994. Initial measurements of the conductivity were taken from the in-situ probes prior to tailings addition.

Tailings were reslurried in their respective 200 litre storage drums and then pumped into the bottom of the water-filled columns to simulate subaqueous disposal conditions. Slurrying of the contents of the individual drums was completed using drum mixers. The revolutions of the variable speed (SP25) pump were set at 10% speed. During filling, samples of overflow water were collected and placed in freezer

storage. Due to the suspension of the tailings slurry in the water column, the filling of the columns had to be conducted in several stages. The observed suspension was considered to be largely a result of boundary effects caused by the column walls.

The pyrrhotite concentrate from the Strathcona Mill (Mill) had been thickened by settling and decanting, prior to shipment to LRL and had a measured pulp density of 2000 g/L. This pyrrhotite was designated as the thickened pyrrhotite. On November 30, 1994, the thickened pyrrhotite was slurried and pumped into Column 4. Filling the column to the desired depth of tailings (800-900 mm) required that the tailings be pumped into the column and allowed to settle nine times. Conductivity measurements in Column 4 were recorded on December 2, 1994.

Column 3 was filled with a diluted blend of the thickened pyrrhotite. The thickened pyrrhotite was diluted to produce a slurry density similar to current discharge slurry densities at the Mill through the addition of sufficient volumes of Strathcona tailings treatment system process water (pH 7). The resultant slurry density was 1090 g/L. On December 1, this diluted pyrrhotite slurry was tremied into Column 3, filled to the overflow level, and allowed to settle overnight. Conductivity measurements of the partially filled column were taken on December 2, 1994. It took eleven cycles of filling and settling to reach the required depth of tailings. After Column 3 was topped up to the required level, the sediment substrate was poured in from the top of the column onto the top of the pyrrhotite to provide a 100 mm substrate thickness.

Filling of Column 1 began on December 2, and was completed on December 5, 1994. Column 1 was filled with a diluted pyrrhotite tailings similar to that of Column 3, however, no substrate was added to this column. The deposition density of the diluted pyrrhotite tailings closely resembled the subaqueous deposition density of pyrrhotite tailings discharged from the Mill.

Column 2 and Column 5 were filled during the week of December 5, 1994. Both were filled with a 50:30 tailings blend, by volume, of pyrrhotite tailings to SM slimes. Column 2 was filled with the thickened (65% solids) blended tailings, which exhibited a slurry density of 2000 g/L. Column 5 was filled with a diluted tailings slurry made from the combination of the 50:30 thickened tailings blend and the treated process water. Sufficient volumes of the treated process water were added to the thickened blend to produce a tailings slurry with a density of 1090 g/L (10% solids). This diluted tailings slurry density was similar to end of pipe tailings densities at the Strathcona Mill.

The various materials within the columns are summarized below:

Height (mm)	Column 1	Column 2	Column 3	Column 4	Column 5
1800	Acidic Water	Acidic Water	Acidic Water	Acidic Water	Acidic Water
800	Pyrrhotite Tailings	Thickened SM Tailings	Substrate	Thickened Pyrrhotite Tailings	SM Tailings
700			Pyrrhotite Tailings		
60	Filter Bed	Filter Bed	Filter Bed	Filter Bed	Filter Bed

Visual inspection of the columns showed a varved, or stratified, effect of the intermittent method of column filling. Alternate bands of darker, coarser materials

were separated by thinner bands of lighter coloured, fine materials. This layering was very apparent in the 50:30 pyrrhotite:slimes mix tailings.

Filling the columns resulted in the displacement of the acidic water from Upper Strathcona tailings treatment system by neutral process water from the tailings slurry. Therefore, after settling, the remaining water on top of the tailings was decanted off and replaced with the same acidic water. Tailings which had adhered to the interior surface of the columns and the surfaces of the probes were cleaned with a dry cloth on an extension arm before the acidic water was added. Columns 1, 2 and 3 were completed on December 16, and Columns 4 and 5 were completed on December 19, 1994. The pH of the Upper Strathcona tailings treatment system water that was added to Columns 1, 2 and 3, was recorded at pH 4.3 on December 16, 1994.

Photographic Plate #1 and #2 show the columns before filling and the filling of Column #4, respectively. Plates #3, #4 and #5 show the columns in January, 1995, 6 weeks after filling.

2.3.3 Sampling and Monitoring

2.3.3.1 Water Sample Collection

Water samples were collected from the columns, using dedicated, sterilized, double sided blood collection needles that were inserted into the column through the septa, allowed to discharge two milliliters (purging), and then inserted into vacuum sample tubes. Samples were collected carefully to minimize disturbance of the water column. The collected water samples were stored in the vacuum sample tubes and transferred directly to the Lakefield Research Limited, Environmental Analytical Laboratory

(LRLEAL) for analysis. Samples were collected for analyses from each of the three sample collection ports, in each column, at two month intervals.

Every two months, the water samples collected were analyzed for pH, conductivity, EMF (Eh), iron, nickel, sulphate, total sulphur, dissolved oxygen (DO), carbon dioxide (CO₂) and dissolved inorganic carbon (DIC). Laboratory measurements of EMF, DO and CO₂ in the water samples were discontinued after the first six months of monitoring due to possible exposure of samples to the air during sample preparation and the effect on the sample of this exposure. In addition, at the start and at the end of six months of testing water samples collected from the columns were analyzed for: pH, conductivity, dissolved oxygen, CO₂, total inorganic carbon, total cyanide and thiosulphate. An anion scan (NO₂, NO₃, F, Cl, Br, SO₄, PO₄) and a 24-element scan using ICP-ES were also conducted. At the end of 13 months of testing, water samples were collected from the columns and analyzed for pH, conductivity, total inorganic carbon, sulphate and thiosulphate, and a 24-element scan was conducted using ICP-ES.

2.3.3.2 In-situ Measurements

A dedicated Eh probe system was constructed specifically for use in the subaqueous pilot columns. The probe system consisted of a dedicated probe and non-dedicated reference electrode connected through a coaxial connector. The probe system was used to collect in-situ Eh data in the columns. Since the Eh reference electrode will, by the nature of its operation, leach AgCl into the column over time it was dedicated. The reference electrode was inserted into the top of each column to provide the electrical connection required prior to taking readings.

Conductivity probes were permanently installed into the columns and measurements were collected by connecting a conductivity meter to each probe. Measurements were taken following calibration of the meter at each monitoring interval. The meter was calibrated using a standard solution and external probe. The calibration procedure, developed through consultation with the manufacturers of the meter and probe system and the LRLEAL, is contained in Appendix A. Temperature readings were also recorded at the time of conductivity measurement. For the second six months of testing, a new conductivity meter and a new probe (manufactured by Oakton) were used to directly measure the conductivity in water samples collected from the column. This Oakton meter had the advantage of multi-range calibration and temperature compensation.

Conductivity and Eh measurements at each monitoring port in each of the five columns were recorded on December 9, 14, and again on December 19, 1994, after replacement of the standing water column with fresh Upper Strathcona tailings treatment system water. Conductivity and Eh measurements were collected again on December 23, 1994, and measurements were also collected weekly during January, 1995. The conductivity and Eh results indicated that only very slow changes in these parameter readings were occurring, therefore, the monitoring frequency was decreased to once every two weeks for the first six months of the test program. Conductivity, Eh and pH measurements at each monitoring port in each of the five columns were conducted on a monthly interval during the latter seven months of the program.

Conductivity measurements from the dedicated in-situ probes, collected during the first six months of the program, were considered to be representative of relative changes and differences in the columns. These readings were compared with laboratory measurements taken on the samples collected bi-monthly to calibrate or relate in-situ readings to laboratory equivalents and are discussed in detail in Section

3.4.1. During the second six months of testing a solution sample was collected from the sampling port and the conductivity was measured with the new conductivity meter, which was calibrated and temperature compensated at each sampling time interval.

3.0 RESULTS

3.1 Characteristics of Upper Strathcona Tailings Treatment System Water and Process Water

The characteristics of the Upper Strathcona tailings treatment system water and the treated process water are presented in Table 1. The Upper Strathcona tailings treatment system water was characterized by a pH of 2.91. A pH of 7.36 was measured in the treated process water (Table 1). Of the two waters, the Upper Strathcona tailings treatment system water exhibited the higher conductivity (2270 vs. 1631 $\mu\text{mhos/cm}$), and higher concentrations of: S (597 vs. 199 mg/L), SO_4^{2-} (941 vs. 542 mg/L) , Fe (6.9 vs. <0.02 mg/L) and Ni (2.08 vs. 0.17 mg/L). In the Upper Strathcona tailings treatment system water, SO_4^{2-} accounts for 53% of the total S, whereas in the process water, SO_4^{2-} accounted for 91% of the total S. For both waters, the concentrations of S^{2-} , total cyanide (CN) and thiosulphates ($\text{S}_2\text{O}_3^{2-}$) were below the detection limits of 0.5, 0.01 and 10 mg/L, respectively.

Table 1: Characteristics of Upper Strathcona Tailings Treatment System Water and Process Water

Parameter	Upper Strathcona Tailings Treatment System Water	Process Water
pH	2.91	7.36
Conductivity (µmhos/cm)	2270	1631
Fe (mg/L)	6.90	<0.02
Ni (mg/L)	2.08	0.17
Total S (mg/L)	597	199
SO ₄ ²⁻ (mg/L)	941	542
S ²⁻ (mg/L)	<0.5	<0.5
Total CN ⁻ (mg/L)	<0.01	<0.01
Thiosulphate (S ₂ O ₃ ²⁻) as SO ₄ ²⁻ (mg/L)	<10	<10

3.2 Characteristics of Pyrrhotite Tailings and Strathcona Mill Tailings

Polished sections of the pyrrhotite tailings and the slime tailings were examined by mineralogists on staff at LRL. The pyrrhotite tailings were observed to consist predominantly of liberated, irregularly shaped, angular pyrrhotite (92-95%) with lesser amounts of magnetite and non-opaque minerals. Trace amounts of chalcopyrite, goethite, ilmenite and pentlandite were also identified. The slime tailings consisted predominantly of liberated, irregularly shaped, angular non-opaque minerals (85-90%) such as quartz, albite, actinolite and white mica. The remaining opaque minerals of the slime tailings consisted of pyrrhotite, chalcopyrite and magnetite. The mineralogy suggests that the pyrrhotite tailings are more reactive than the slimes.

The results of a multi-elemental scan by ICP-ES indicated a similar occurrence of metals in the pyrrhotite tailings and SM tailings (Table 2). The concentrations of Al,

Ca, Cu, Mg, Mn, Na, P and Pb were two to three times higher in the SM tailings than in the pyrrhotite tailings (Table 2). Both types of tailings contained similar concentrations of Co and Zn. The pyrrhotite tailings contained 30.2% S and 56% Fe, whereas the Strathcona Mill tailings contained 19.0% S and 37% Fe.

Table 2: A Multi-Elemental ICP-ES Scan of Tailings Solids

Element	Pyrrhotite Tailings	SM Tailings
Al (g/t)	7100	31000
Ca (g/t)	5900	20000
Co (g/t)	170	140
Cu (g/t)	720	1600
Fe (g/t)	560000	370000
Mg (g/t)	3000	10000
Mn (g/t)	380	650
Na (g/t)	3000	12000
Ni (g/t)	7620	5600
P (g/t)	82	470
Pb (g/t)	76	140
Zn (g/t)	190	160
S (%)	30.2	19.0

The concentrations of metals present in the liquid portions of the tailings slurry are presented in Table 3. Concentrations of Al, Co, Cu, Fe, Pb and Zn were not detected above method detection limits (Table 3). The liquid portion of the pyrrhotite tailings had a pH value of 7.9, while the liquid portion of the SM tailings had a pH value of 6.8. The liquid portion of both tailings types were characterized by high hardness (3430-3790 mg/L), high conductivity (5354-5550 μ mhos/cm), total dissolved solids (5180-5410 mg/L), high concentrations of Cl⁻ (156-203 mg/L), SO₄²⁻ (991-1129

mg/L), S (2810-3180 mg/L), thiosulphate (1882-2761 mg/L), Ca (1290-1480 mg/L) and Na (162-183 mg/L). Generally, for these parameters, higher values were observed in the liquid portion of the pyrrhotite tailings than in the liquid portion of the SM tailings.

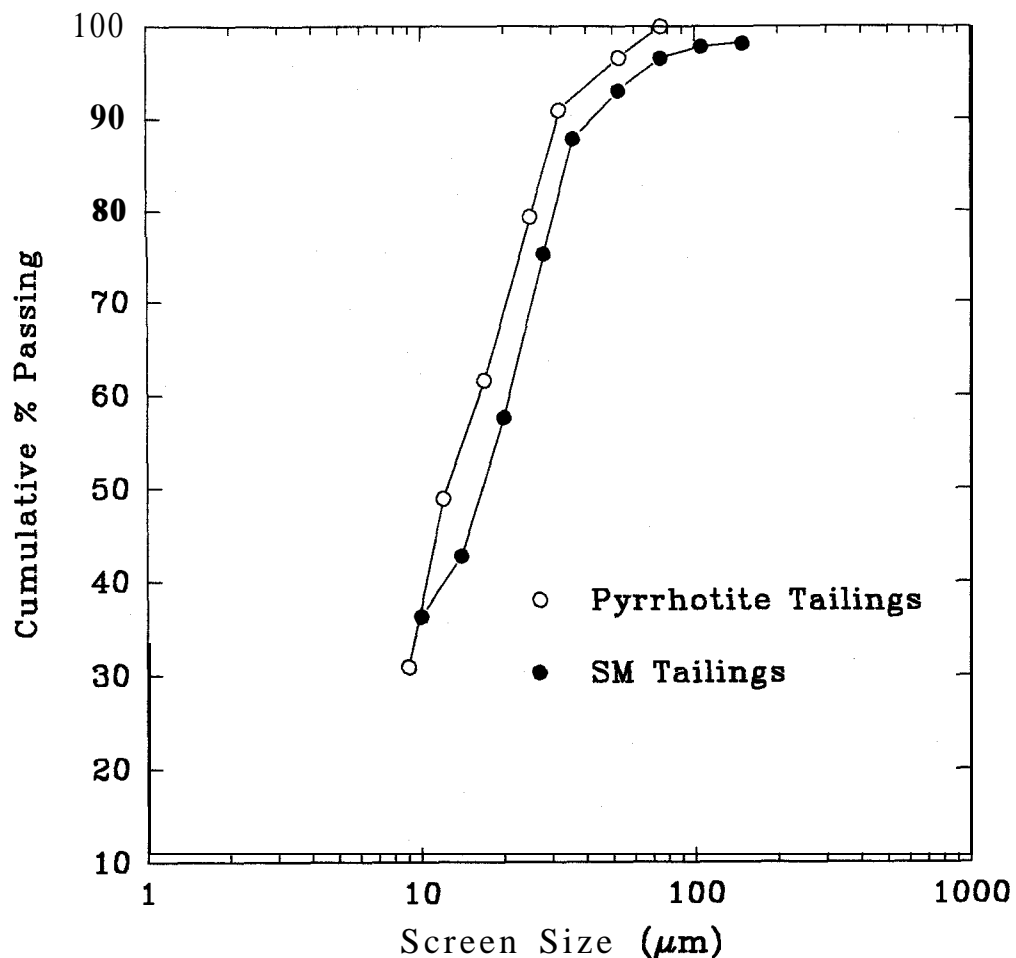
Table 3: Characteristics of the Liquid Portions of Pyrrhotite Tailings and Strathcona Mill Tailings

Element	Pyrrhotite Tailings	SM Tailings
Al (mg/L)	<0.10	<0.10
Ca (mg/L)	1480	1290
Co (mg/L)	<0.01	0.01
Cu (mg/L)	<0.02	<0.02
Fe (mg/L)	<0.02	<0.02
Mg (mg/L)	22.9	50.7
Mn (mg/L)	0.02	0.05
Na (mg/L)	162	183
Ni (mg/L)	0.05	0.21
P (mg/L)	0.20	0.14
Pb (mg/L)	<0.05	<0.05
Zn (mg/L)	<0.01	<0.01
S (mg/L)	3180	2810
pH	7.88	6.83
Conductivity (µmhos/cm)	5550	5354
TDS (mg/L)	5410	5180
Hardness (mg/L)	3790	3430
Cl ⁻	156	203
SO ₄ ²⁻	991	1129
Total CN (mg/L)	<0.01	<0.01
Thiosulphate (mg/L)	2761	1882
(NH ₃ +NH ₄)-N (mg/L)	3.87	4.37
NO ₃ -N (mg/L)	<0.005	<0.005
TKN (mg/L)	4.92	5.37

The liquid portions were also low in nutrients ($P < 0.20$ mg/L; total Kjeldahl nitrogen, 4.9-5.4 mg/L; $\text{NO}_3\text{-N} < 0.005$ mg/L; $\text{NH}_4\text{-N}$ 3.9-4.4 mg/L). Total cyanide was not detectable in the liquid portions of both tailings types.

The pyrrhotite tailings showed a finer particle size distribution than the SM tailings (Figure 2). The 80% passing sizes for the pyrrhotite tailings and the Strathcona Mill tailings were 26 and 31 μm , respectively.

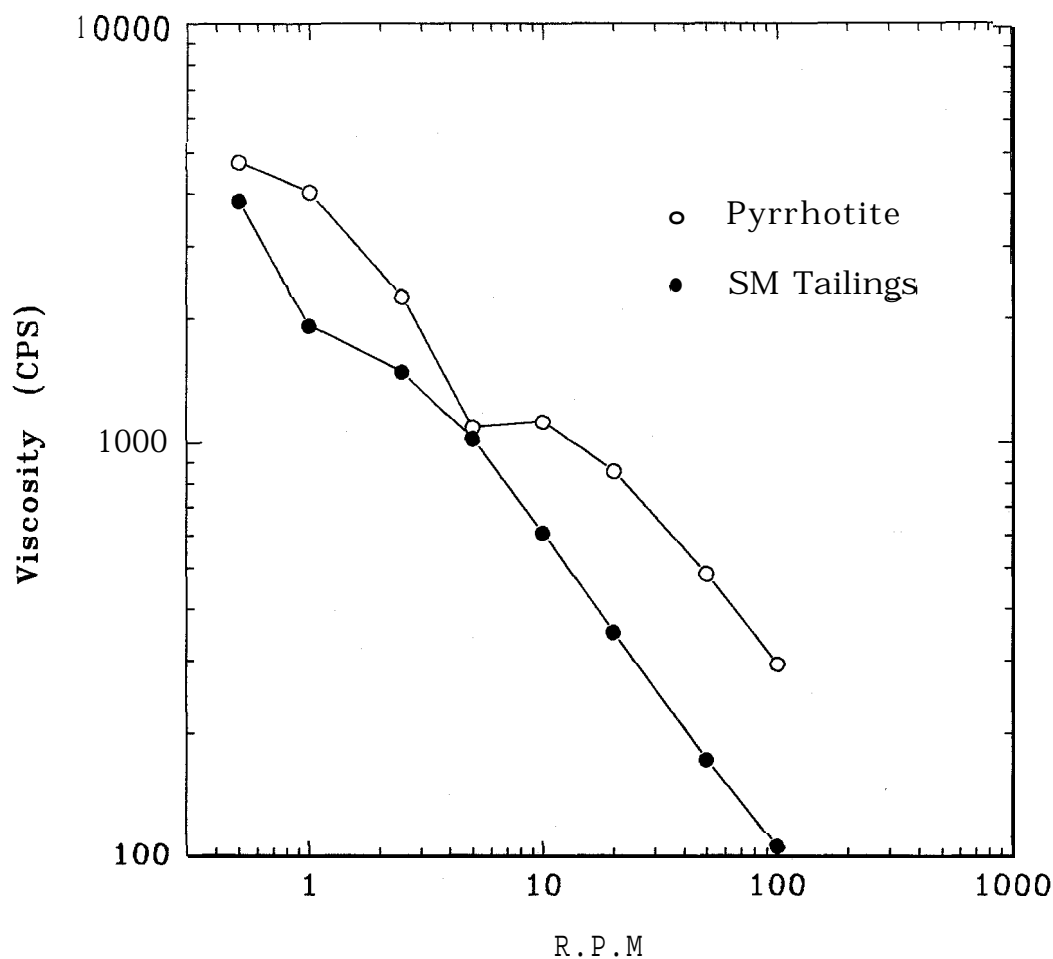
Figure 2: Pyrrhotite and Strathcona Mill Tailings Grain Size Distributions



The pyrrhotite tailings had a specific gravity of 4.32 g/cm^3 and the SM tailings had a specific gravity of 3.66 g/cm^3 .

The viscosity tests indicated that there was a negative correlation between viscosity and mixing speed (rpm) for both types of tailings and that the pyrrhotite tailings were more viscous than the SM tailings at 62% solids (Figure 3). The settling densities during a 24-hour period for the **pyrrhotite** tailings and the SM tailings were 234 1.1 and 2142.5 g/L , respectively. This indicated that the pyrrhotite tailings settled faster than the SM tailings, which correlates with the higher specific gravity measured for the pyrrhotite tailings.

Figure 3: Viscosity Test at Pulp Density of 62% Solids



3.3 Column Leach Test Results

The column leach tests were conducted in duplicate on Strathcona pyrrhotite tailings (SL1 and SL2) and on Strathcona Mill tailings (SL3 and SL4). The Upper Strathcona tailings treatment system water was used as the leachant. The inflow and outflow water chemistry was monitored. The column leach test results are attached in Appendix D. The main results of this test are summarized below.

Leach test results for pyrrhotite tailings (SL1 and SL2) follow:

- The initial paste pH of the pyrrhotite tailings was 6.47.
- The duration of the SL1 test for 172 pore volumes was approximately 161 days to complete. The SL2 test was 71 days in duration, with 136 pore volumes being flushed through the sample. The duration of the test depended on the hydraulic conductivity of the material (i.e., the lower the hydraulic conductivity, the longer the test duration).
- The hydraulic conductivity (K) decreased from an initial value of 2.1×10^{-5} cm/s to 4.3×10^{-7} cm/s at the termination of the test. The reduction in the K values may be attributed to the anaerobic bacterial growth, which caused plugging of the pores within the sample, and, to a lesser extent, the consolidation of the sample. Evidence of bacterial growth was noted on the tube walls carrying the leach fluid and the sample, which had a blackened surface. As well, there was some algae growth on the bottom of the reservoirs and on the walls of the tubing.
- Concentrations of Cu, Co, Zn, Pb, Ni and Al were higher in the inflow water than in the outflow water.
- Concentrations of Mn, Fe, Si, Ca, K, Mg and Na were higher in the outflow water than in the inflow water.

Leach test results for Strathcona Mill (SM) tailings blend (SL3 and SL4) follow:

- The hydraulic conductivity of the test SL3 maintained a constant average of 4.1×10^{-6} cm/s. The hydraulic conductivity of the SL4 test was initially 2.1×10^{-6} cm/s and dropped to 1.3×10^{-6} cm/s at approximately 25 pore volumes. The hydraulic conductivity then remained constant at 1.4×10^{-6} cm/s until the termination of the test. The duration of both tests was 43 days.
- The pH of outflow water increased from an initial inflow water pH of 3.0 to about 8.0, and decreased slightly after about 50 pore volumes.
- Concentrations of Zn, Ni, Cu, Co, Pb and Al were higher in the inflow water than in the outflow water.
- Concentrations of Fe, Mn, Si, Ca, K, Mg and Na were higher in the outflow water than in the inflow water.

The results observed in tests SL1 and SL2 were similar to those observed in SL3 and SL4. The rise in pH indicated that both tailings types had pH buffering capacities. This buffering can normally be associated with the dissolution of carbonate and silicate minerals. Release of alkali metals and silica confirm the dissolution of carbonate and silicate minerals.

The dissolution of heavy metals from the pyrrhotite tailings and SM tailings blend were not evident. To the contrary, metals concentrations decreased in the outflow water, suggesting retention of these metals by the tailings. Iron and Mn may have been released from carbonate dissolution or reductive dissolution of hydroxides. Since both types of tailings were fresh and oxidation were limited, carbonate dissolution is likely the controlling mechanism.

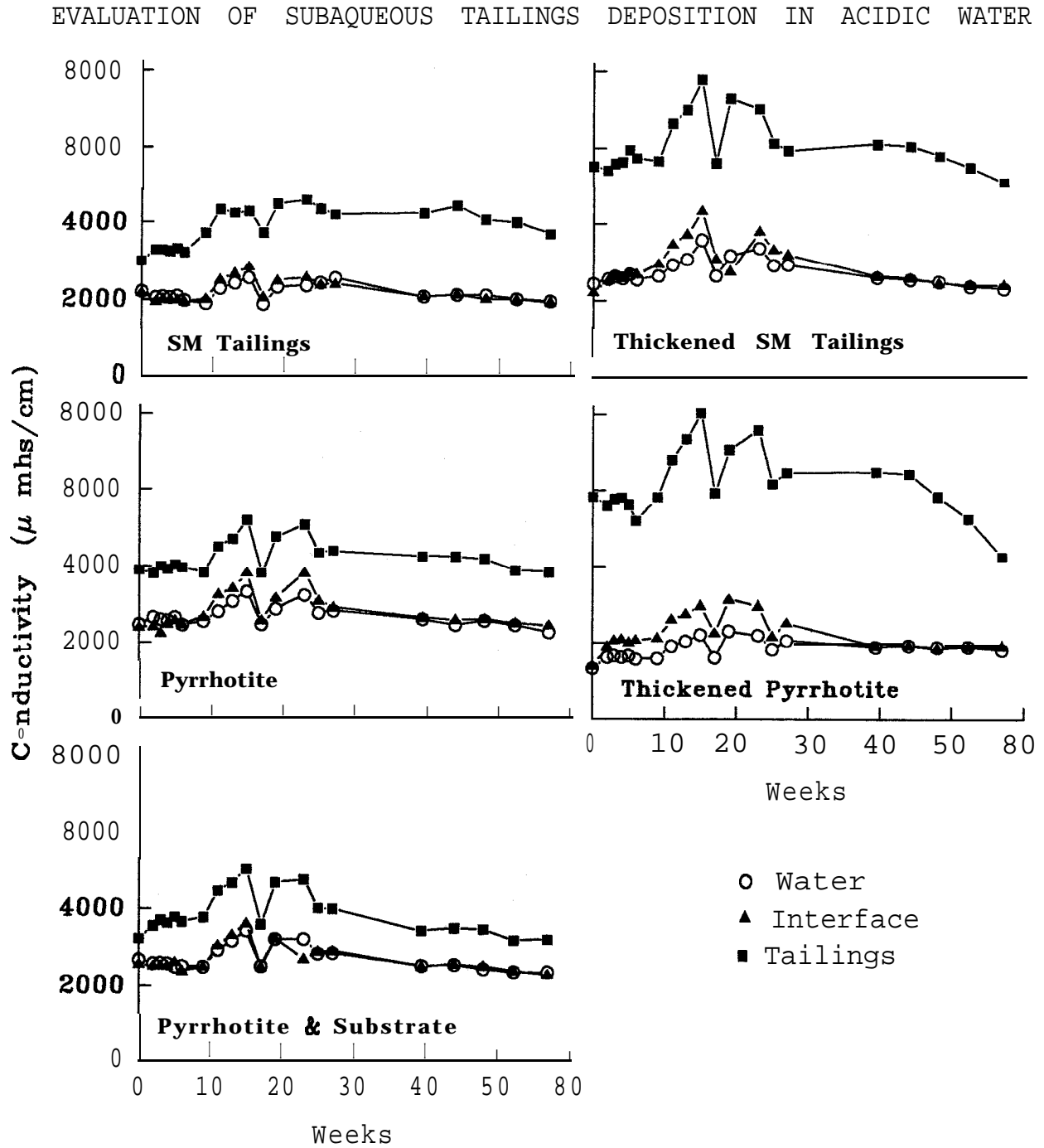
3.4 Pilot Column Test Results

Monitoring and sampling of the five pilot columns was initiated in December, 1994. During the first six months of the monitoring program in-situ monitoring for conductivity and the Eh was conducted on a bi-weekly basis. Samples were extracted from the columns for analysis on a bi-monthly basis. During the later six months of the monitoring program in-situ monitoring of Eh and measurements of conductivity and pH on solution samples were conducted monthly. Samples were also extracted from the columns for analyses bi-monthly. The results of the monitoring, sampling and analysis program are discussed in the following sections.

3.4.1 Conductivity Changes in the Columns

Both laboratory and in-situ conductivity measurements were collected during the first six months of the test program. The laboratory measurements correlated better with the in-situ measurements for the water cover and the interface than with the in-situ measurements for the tailings layer. The in-situ conductivity measurements were only one third to one half of the laboratory values. Therefore, the in-situ conductivity measurements from the three sampling ports were corrected using a ratio factor based on the bi-monthly laboratory measurements. The corrected conductivities from the first six month period, and the direct conductivity measurements collected during the second seven months of testing period, are presented in Figure 4.

Figure 4. Conductivity vs. Time



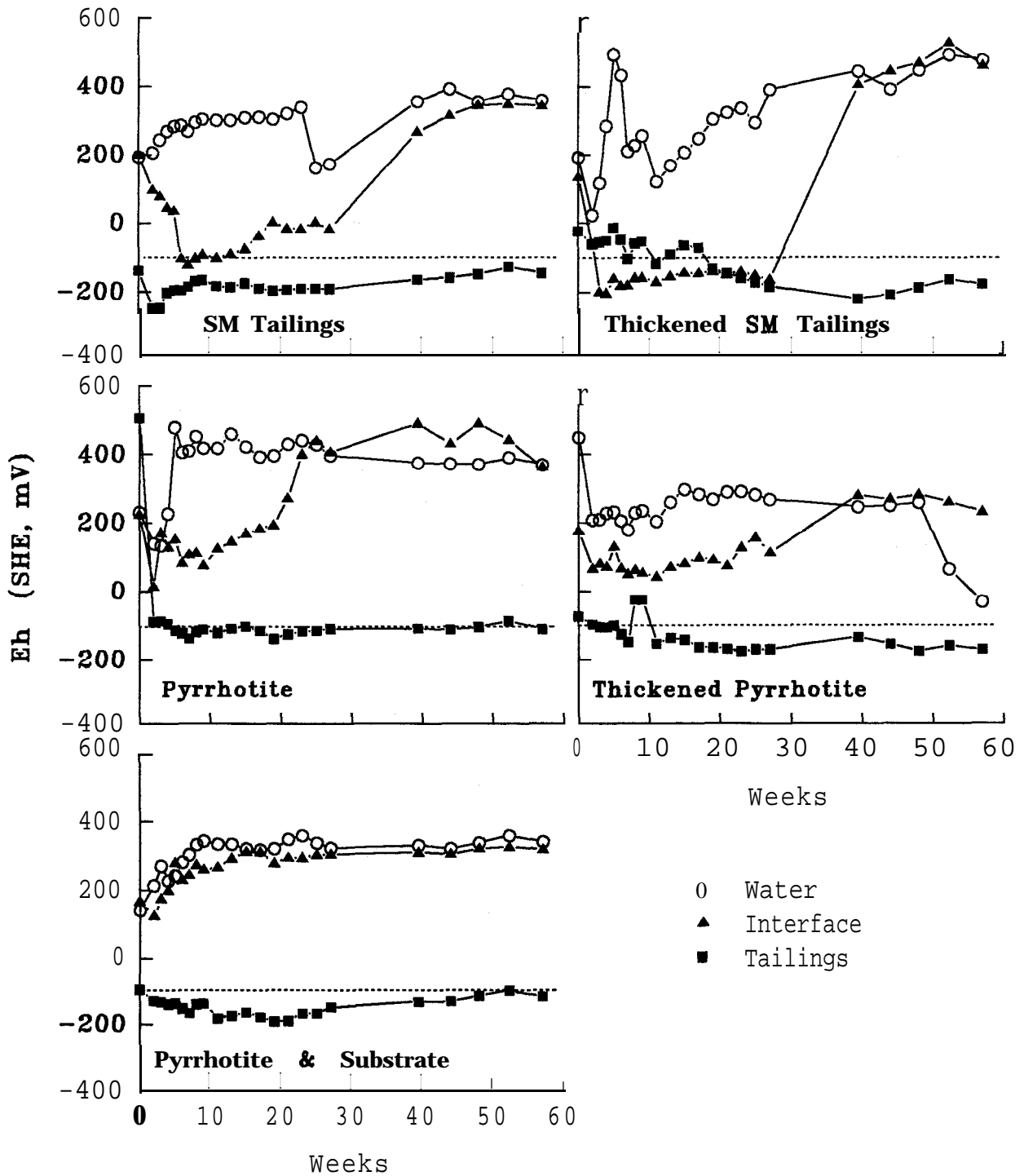
As shown in Figure 4, the pore water collected from the tailings layer consistently exhibited higher conductivity values than the water samples collected at the water cover and the interface. Higher conductivity values were also detected in the pore water collected from the thickened SM tailings (5130-7793 $\mu\text{mhos/cm}$) and thickened pyrrhotite tailings (4280-8031 $\mu\text{mhos/cm}$) than from the SM tailings (2993-4597 $\mu\text{mhos/cm}$) or pyrrhotite tailings (3803-5098 $\mu\text{mhos/cm}$) (Figure 4). During the first six months of testing, slightly higher conductivity values were recorded at the interface than in the water cover. This suggests that a conductivity gradient had developed between the tailings and the water cover, resulting in the diffusion of salts from the tailings to the water. During the second seven months of testing, the conductivities from all three sampling ports of all the columns decreased to their initial values, and similar conductivity values were observed at the water cover and at the interface (Figure 4).

3.4.2 Eh Changes in the Columns

The laboratory Eh measurements for the water samples collected from the pilot columns were extremely high ($> +500$ mV). It is possible that the water samples may have been exposed to the air in the laboratory and, therefore, the laboratory Eh measurements may not be representative of the in-situ redox potentials in the columns. Thus, only the in-situ Eh measurements have been plotted for the various column configurations (Figure 5). The Eh values plotted are standard hydrogen electrode (SHE) potentials, which have been converted from the direct measurements. The 200 mV were added to the direct measurement because of the use of an Ag/AgCl reference electrode.

Figure 5: In-situ Eh vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER



Eh is a measure of the oxidation-reduction potential of a solution. A positive Eh indicates an oxidizing potential and a negative Eh indicates a reducing potential. As illustrated in Figure 5, consistently positive and negative Eh values were observed in the water cover ($> +200$ mV) and in the tailings layer (< -100 mV), respectively, and the Eh values at the interface were between the values of water covers and the tailings. The results suggest that, after 13 month of testing, even though the water column had oxidizing potential, the underlying tailings remained anoxic. Biological sulphate reduction could, therefore, take place in the Tailings (Eh < -100 mV and pH > 4.5).

During the first six months of testing, the Eh of the interface in the SM tailings column decreased from an initial $+200$ mV to ~ -100 mV, whereas the Eh in the thickened SM tailings column decreased from an initial $+200$ mV to -150 mV. However, during the second seven months of testing, the Eh values at both interfaces increased to $+400$ mV, which was similar to the Eh values observed in the water cover.

During the first six months of testing the Eh at the interface of the pyrrhotite tailings column increased from $+200$ mV to $+400$ mV, which was similar to the water cover Eh of $+400$ mV in the same column. The Eh values at both the water cover and the interface remained at $+400$ mV over the remaining seven months of testing. In the thickened pyrrhotite tailings column, the Eh was $+100$ mV at the interface and $+200$ mV in the water cover during the first six months of testing. During the following seven months, the Eh values at the interface initially increased to $>+200$ mV and then decreased towards the end of the testing. The Eh values at the water cover also decreased from $+200$ mV after 10 months of testing to below 0 mV at the end of the testing.

The Eh values were similar in both the water cover and at the interface for the column containing pyrrhotite and 100 mm sediment substrate. The Eh values at both sampling ports increased from an initial value of +140 mV to a value of +350 mV about 10 weeks after initiation of the testing. The Eh remained at +350 mV.

3.4.3 pH Changes in the Columns

The changes in the pH of the water samples collected over time for the water cover, the interface, and the tailings layer are shown in Figure 6. The pH of the pore waters collected from each type of tailings remained relatively constant over time (pH 6.6-7.7) (Figure 6).

In the unthickened SM tailings column, the pH of the water samples collected from the water cover and the interface increased from an initial pH of 3.2 to about 4.0 during the first two months of the testing. The pH was then observed to decrease to the initial pH value (3.2). This pH values recorded for the water cover and the interface remained over the remainder of the program.

The pH of waters collected from both the water cover and the interface in the thickened SM tailings column was constant over time. The pH values at the two sampling ports fluctuated around 3.4 (Figure 6).

An abrupt increase in the pH of water occurred at the interface of the thickened pyrrhotite tailings after two months of testing. The pH increased from 3.4 to 7.3 during the first two months of the testing and remained above 7.0 until the end of six months (Figure 6). The pH then dropped to 5, and, at the end of 13 months, increased to 6.8. The pH of the water cover in the same column increased steadily with time from 3.3 to 5.7 (Figure 6). In comparison, little change in the pH of waters collected from the interface and the water cover was observed in the unthickened pyrrhotite

tailings column (pH around 3.2) (Figure 6). The difference in the pH of the overlying water cover for the pyrrhotite tailings and the thickened pyrrhotite tailings may have been caused by a 1-cm thick layer of filamentous material that formed at the interface in the thickened pyrrhotite tailings column.

The pH values in the waters collected from the water cover and at the interface in the column containing pyrrhotite tailings with 100 mm sediment substrate were approximately the same. The pH at both sampling ports increased gradually with time from 3.0 to 5.7 after 13 months of testing (Figure 6).

3.4.4 Changes in Sulphate Concentrations

The concentrations of SO_4^{2-} in the water samples collected over time are presented in Figure 7. In the Strathcona Mill (SM) tailings column, the water collected from the water cover had an initial SO_4^{2-} concentration of 1400 mg/L. This SO_4^{2-} concentration was substantially higher than the SO_4^{2-} concentration in the water cover of the other four columns. The SO_4^{2-} concentration decreased to about 600 mg/L after the first four months of the testing, then increased to 900 mg/L at the 6 months sampling date and remained at 900 mg/L until the end of the program (Figure 7). The concentrations of SO_4^{2-} in the water samples collected from the interface increased from 620 mg/L to 954 mg/L after the first four months of testing, and then decreased slightly to 855 mg/L at the end of the program. The concentrations of SO_4^{2-} in the pore water collected from the SM tailings layer increased with time from 934 mg/L to as high as 2363 mg/L, at the ten month sampling (Figure 7). A slight decrease was then observed at the 13 month sampling. The high concentrations of SO_4^{2-} in the tailings pore water may be associated with high concentrations of Fe^{3+} present in the tailings pore water (see Section 3.4.5).

Figure 6. Water pH vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER

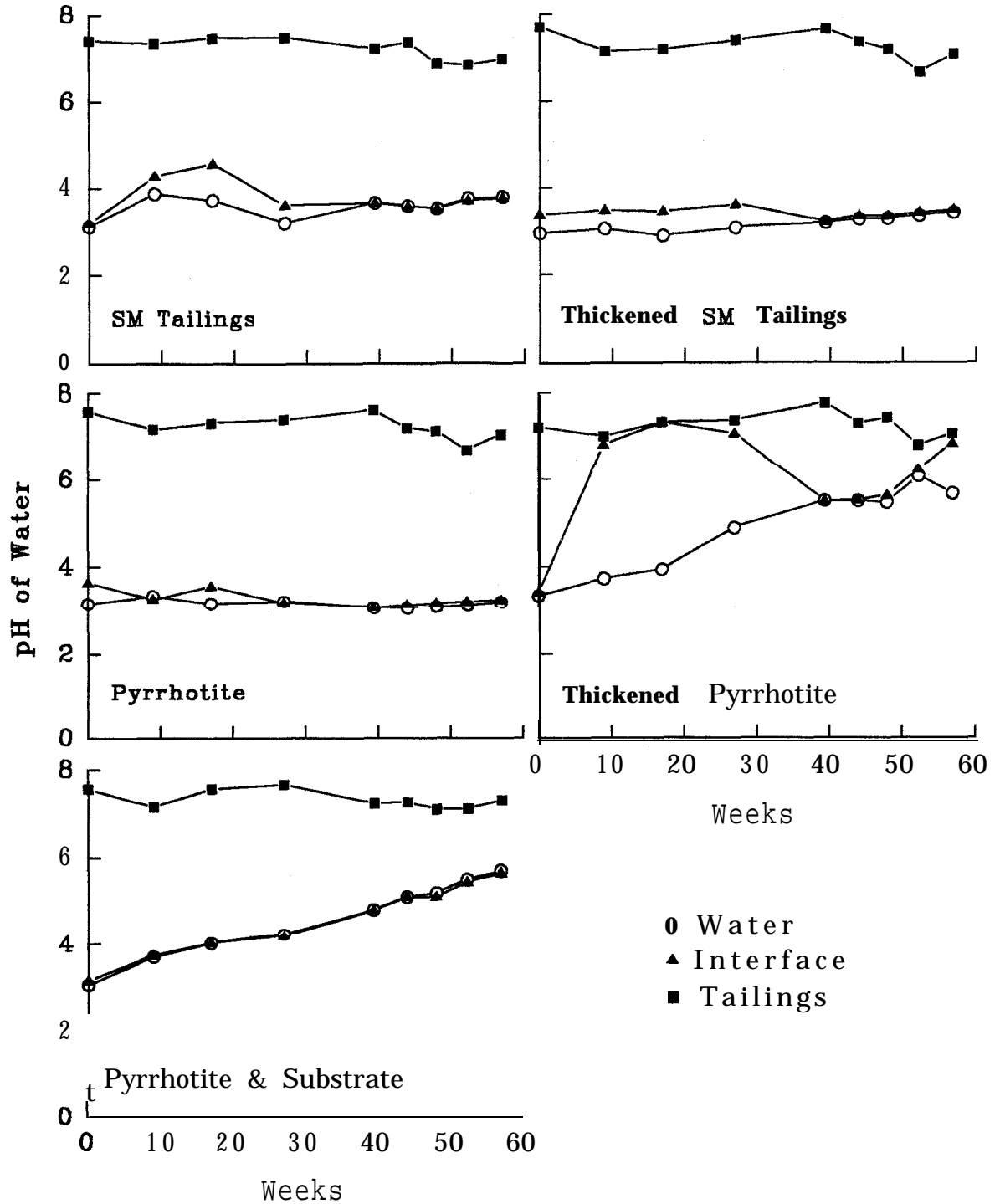
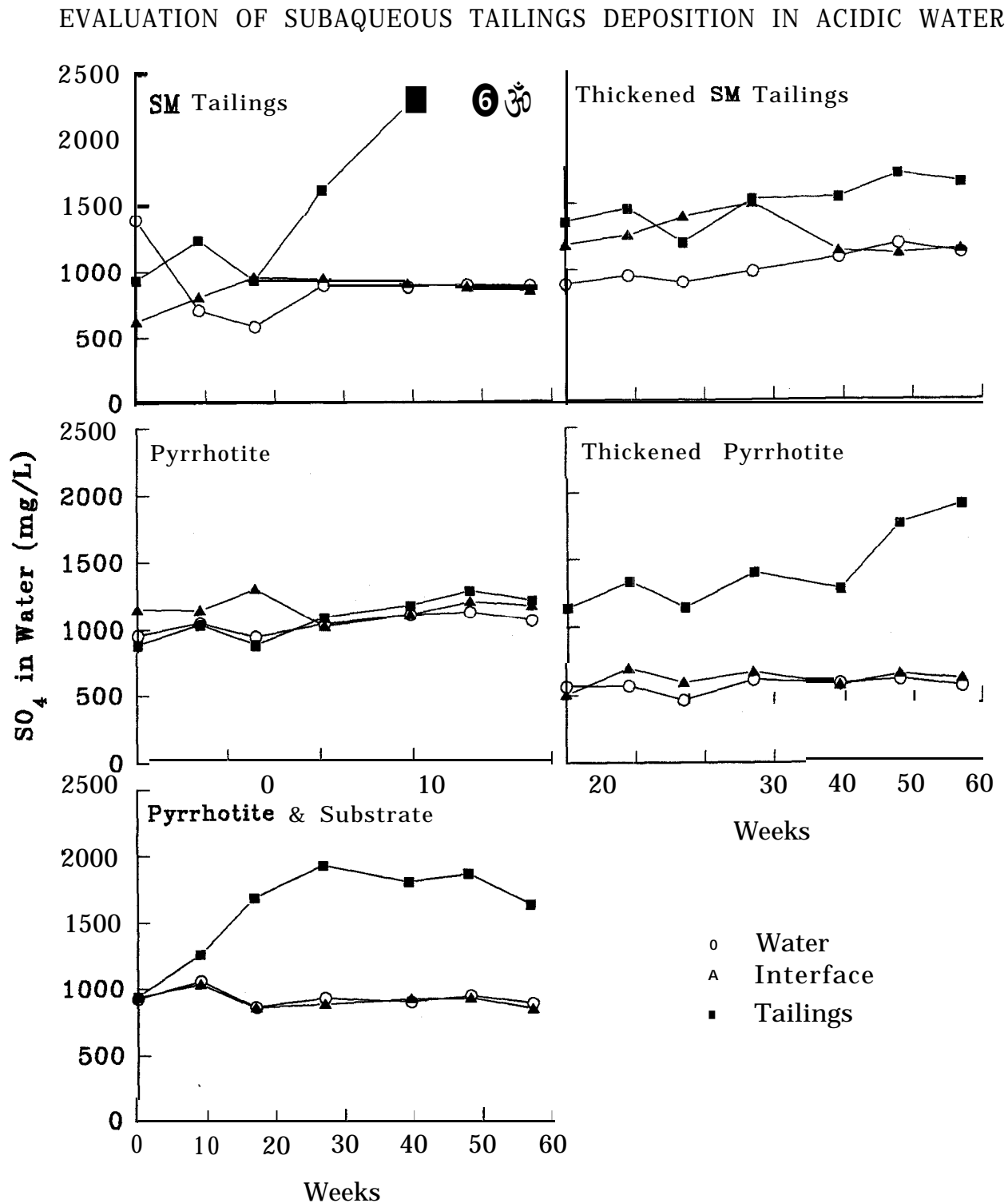


Figure 7: Water SO₄ Concentrations vs. Time



In the column with thickened SM tailings the concentrations of SO_4^{2-} in the water cover and in the pore waters of the tailings layer increased from 894 to 1129 mg/L and from 1359 to 1653 mg/L, respectively (Figure 7). The concentrations of SO_4^{2-} in the water samples collected from the interface increased from 1180 to 1500 mg/L during the first six months of testing, and then decreased and remained at 1150 mg/L for the remainder of the program (Figure 7).

In the unthickened pyrrhotite tailings column, the concentrations of SO_4^{2-} in the water samples collected from the three sampling ports remained relatively constant with time (Figure 7). The concentrations of SO_4^{2-} fluctuated around 1000 mg/L in the water cover, around 1100 mg/L at the interface and around 1200 mg/L in the tailings layer.

In the thickened pyrrhotite tailings column, the concentrations of SO_4^{2-} in the water cover and at the interface remained below 600 mg/L and below 700 mg/L, respectively. These were the lowest SO_4^{2-} concentrations found in all the columns. The concentrations of SO_4^{2-} in the pore waters collected from the thickened pyrrhotite tailings layer increased from 1100 to 1900 mg/L during the program (Figure 7).

In the column containing pyrrhotite tailings covered with 100 mm sediment substrate, the concentrations of SO_4^{2-} were similar in both the water cover and the interface, and remained relatively constant at 900 mg/L (Figure 7). However, the concentrations of SO_4^{2-} in the pore waters collected from the underlying pyrrhotite tailings layer increased steadily with time from 940 to 1930 mg/L during the first six months of testing, and then exhibited a decreasing trend to 1650 mg/L during the later part of the program (Figure 7).

3.4.5 Changes in Iron Concentrations

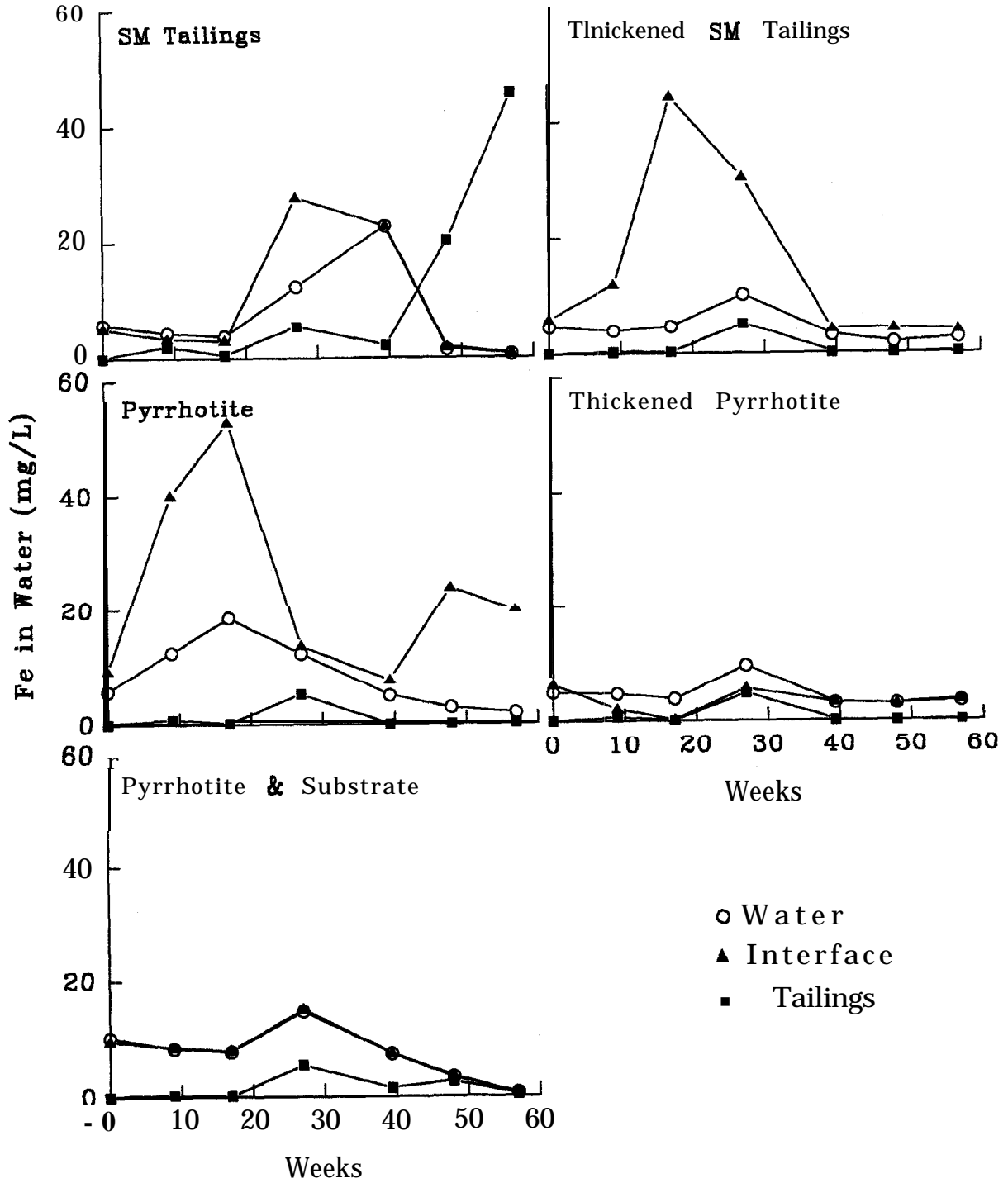
The temporal changes in dissolved Fe concentrations in water samples collected from the various columns are presented in Figure 8. The Fe concentrations were generally low in the pore waters collected from the tailings layers of all the columns, ranging from below the method detection limit to approximately 5 mg/L at the 6 month sampling. The one exception to this was the SM tailings column, where the Fe concentrations of the tailings pore water increased to 45.5 mg/L (Figure 8).

In the SM tailings column, the Fe concentrations in the water cover and at the interface decreased slightly over the first four months of testing, increased at the 6 month sampling date, and then decreased again during the remainder of the program (Figure 8). The total dissolved Fe concentrations increased during the first six months of testing from 4 to 23 mg/L in the water cover and from 3 to 28 mg/L at the interface. Then the dissolved Fe concentrations decreased at the end of the testing to 0.5 mg/L in the water cover and to 0.6 mg/L at the interface. The pore water Fe concentrations in the tailings layer increased with time from 0.03 to 45.5 mg/L.

In the thickened SM tailings column, the Fe concentrations in the water cover remained at 4.5 mg/L over the first four months, then increased to 10 mg/L at the 6 month sampling, and then decreased to 1.9 mg/L at the 13 month sampling (Figure 8). The Fe concentrations of water samples collected from the interface increased from 5.8 to 44 mg/L for the first four months of the testing, and decreased with time to 3.9 mg/L at the end of 13 month testing (Figure 8).

Figure 8: Water Fe Concentrations vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER



The total dissolved Fe concentrations in the water cover in the unthickened pyrrhotite tailings column increased from 5.7 to 19 mg/L over the first four months of the testing, and decreased with time to 2.0 mg/L at the end of 13 months of testing (Figure 8). The Fe concentrations of waters sampled at the interface fluctuated between 7.7 and 53 mg/L, with the highest concentration recorded after four months and the lowest concentration after nine months.

The Fe concentrations in the water samples collected from the water cover and the interface of the thickened pyrrhotite tailings column showed minor decreases for the first four months of the testing, and minor increases at the 6 month sampling date. The Fe concentrations in both the water cover and interface then remained relatively constant at approximately 3.0 mg/L during the remainder of the program (Figure 8).

The Fe concentrations in the water cover and at the interface of the column containing pyrrhotite and 100 mm sediment substrate decreased from 10 to 8 mg/L after the first four months of the testing, then increased to 15 mg/L at the 6 month sampling date, and decreased with time to 0.6 mg/L (Figure 8).

Starting at the 6 month sampling date, the concentrations of the individual iron species (Fe^{2+} and Fe^{3+}) were determined for the pore water and water column samples collected. The data indicated that the Fe present in the water samples collected from the water cover and the interface in both the thickened SM tailings column and the pyrrhotite tailings column, was primarily in the form of Fe^{3+} (Figure 9). However, the Fe present in the water samples collected from the water cover and the interface of the column containing pyrrhotite and 100 mm sediment substrate was primarily in the form of Fe^{2+} (Figure 10). Both the Fe^{2+} and Fe^{3+} concentrations showed a decreasing trend with time on the column containing pyrrhotite and 100 mm sediment substrate.

Figure 9: Water Fe³⁺ Concentrations vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER

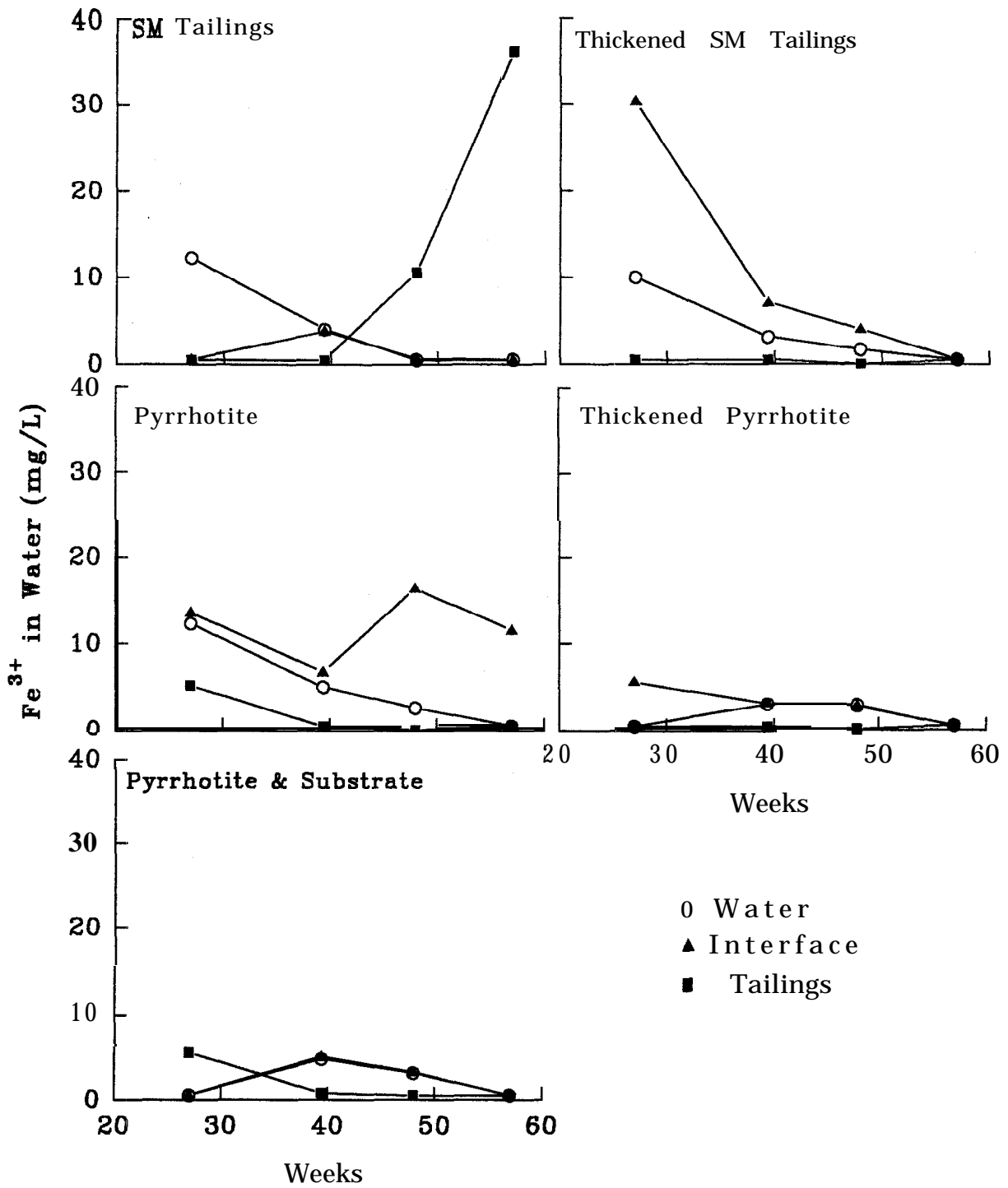
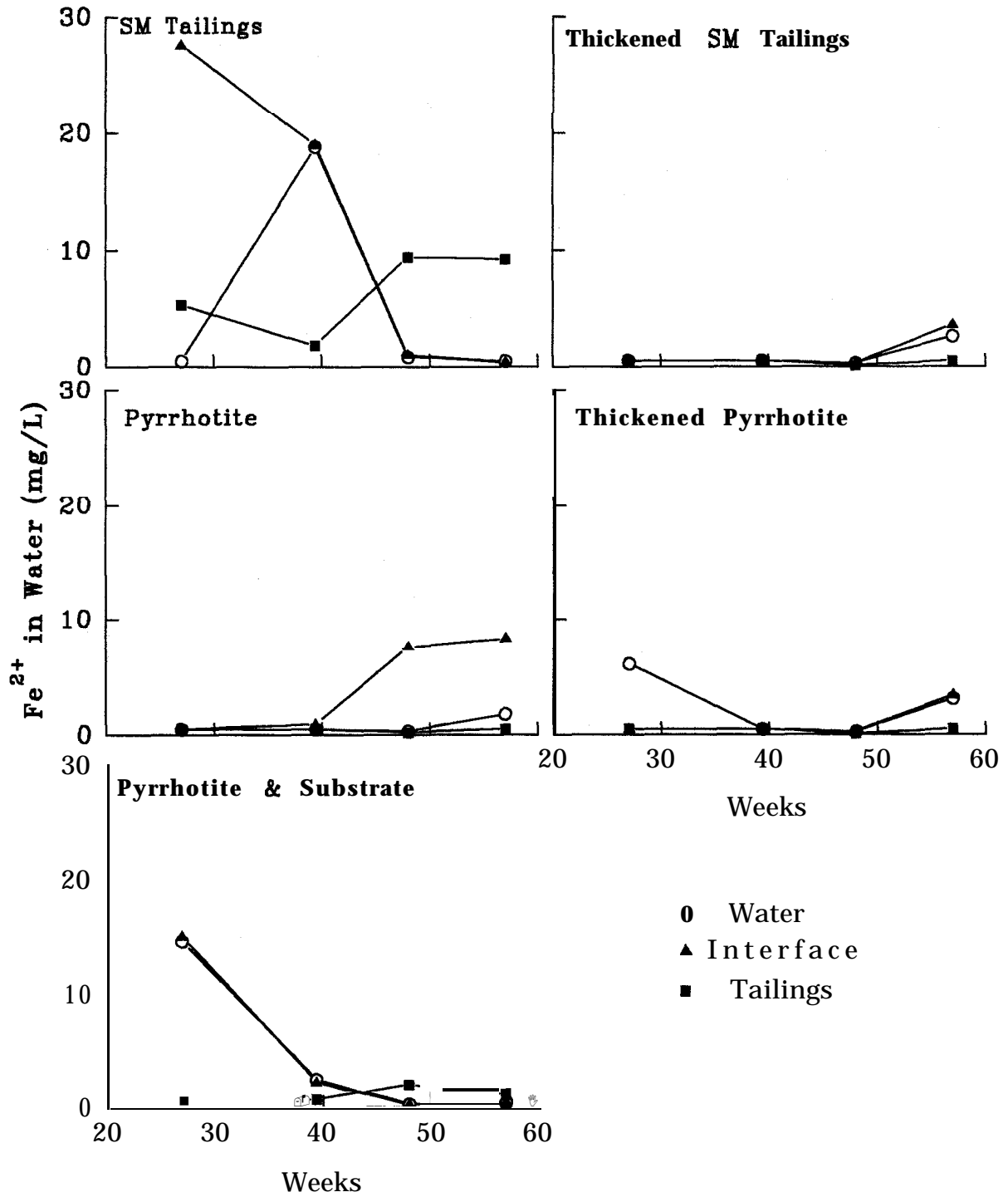


Figure 10: Water Fe^{2+} Concentrations vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER



In the thickened pyrrhotite column, the Fe^{3+} concentrations were higher than Fe^{2+} concentrations during nine and 11 months of testing, but at the 13 month sampling date, almost all the Fe in the water cover and at the interface was present as Fe^{2+} . This may have been caused by the observed decrease in Eh.

The Fe present in the water cover and the interface in the SM tailings column primarily occurred as Fe^{2+} . Both the Fe^{2+} and Fe^{3+} concentrations in these two sampling ports decreased with time, but they increased with time in the tailings layer, with a greater increase in Fe^{3+} than in Fe^{2+} (Figures 9 and 10).

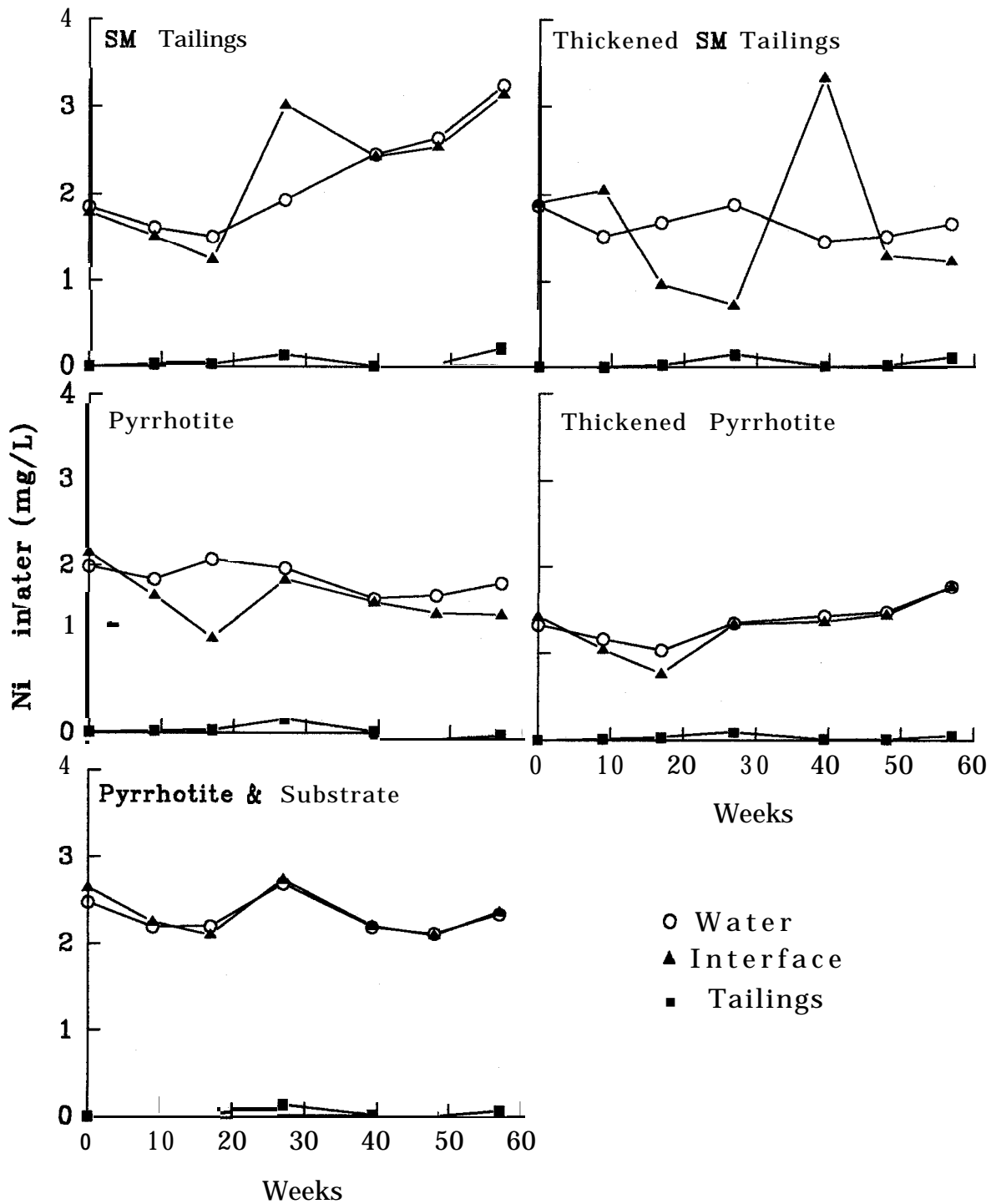
3.4.6 Changes in Nickel Concentrations

The changes in the Ni concentrations over time in the water samples collected are illustrated in Figure 11. The Ni concentrations in the waters collected from the tailings layers of all the columns were generally low (<0.20 mg/L).

The Ni concentrations of water samples collected from the water cover and the interface of the SM tailings column decreased, respectively, from 1.86 to 1.51 mg/L and from 1.79 to 1.26 mg/L during the first 4 months of the test, and then both increased with time to 3.2 mg/L at the 13 month sampling date (Figure 11). In the thickened SM tailings column, the Ni concentration of the water cover remained constant over time at 1.7 mg/L, while the Ni concentrations in the water sampled from the interface showed a general decreasing trend, although fluctuating between 0.73 and 3.33 mg/L (Figure 11).

Figure 11: Water Ni Concentrations vs. Time

EVALUATION OF SUBAQUEOUS TAILINGS DEPOSITION IN ACIDIC WATER



In the pyrrhotite tailings column, the Ni concentration of the water cover remained relatively constant at approximately 2.0 mg/L. The Ni concentrations at the interface decreased slightly from 2.15 to 1.44 mg/L during the program (Figure 11). In the thickened pyrrhotite tailings column, the Ni concentrations of water samples collected from the water cover and the interface decreased, respectively, from 1.32 to 1.03 mg/L and from 1.42 to 0.76 mg/L during the first 4 months of the testing, both then increased with time to 1.77 mg/L at the 13 month sampling date. The Ni concentrations in the water cover and at the interface of the column containing pyrrhotite and 100 mm sediment substrate fluctuated between 2.1 and 2.7 mg/L (Figure 11).

3.4.7 Changes in Thiosulphate in the Water Cover and Pore Water of Tailings

The initial thiosulphate concentration (expressed as SO_4^{2-}) in the Upper Strathcona tailings treatment system water was <10 mg/L (Table 1). The initial thiosulphate concentrations for the liquid portions of pyrrhotite tailings and SM tailings were 2761 and 1882 mg/L, respectively (Table 3). The thiosulphate concentrations in the pore water collected from the thickened SM tailings or thickened pyrrhotite tailings were two to four times the thiosulphate concentrations in the unthickened SM tailings or unthickened pyrrhotite tailings, respectively (Table 4). After 6 months of column testing, the thiosulphate concentrations in the water cover and the interface of all the columns were less than 100 mg/L, with the exception of the concentrations of thiosulphates in the water cover and at the interface of the thickened pyrrhotite tailings column, which were measured at 307 and 560 mg/L, respectively (Table 4).

Table 4. Thiosulphate Concentrations (mg/L SO₄²⁻) in the Pore Waters of the Water Cover, Interface and the Tailings Layer After 6 and 13 Months of Column Testing

Column	Water	Interface	Tailings
After 6 Months			
Strathcona Mill tailings	< 100	< 100	1075
Thickened Strathcona Mill tailings	< 100	< 100	4636
Pyrrhotite Tailings	< 100	< 100	2333
Thickened Pyrrhotite Tailings	307	560	5053
Pyrrhotite Tailings + Substrate	< 100	< 100	< 100
After 13 Months			
Strathcona Mill tailings	< 100	< 100	< 100
Thickened Strathcona Mill tailings	< 100	< 100	3492
Pyrrhotite Tailings	< 100	560	2432
Thickened Pyrrhotite Tailings	1034	632	2380
Pyrrhotite Tailings + Substrate	100	206	< 100

After 13 months of testing, thiosulphates were not detected in the water covers of the SM tailings column and SM thickened tailings column. However, thiosulphates were observed in the water covers in the other three columns (Table 4). The concentrations of thiosulphates in the tailings layers decreased over the latter half of the testing period. The presence of thiosulphates in the water covers and decrease in the tailings may indicate diffusion of thiosulphates from the underlying tailings.

3.4.8 Changes in Concentrations of Other Elements

A 24-element scan using ICP-ES was conducted on the acidic Upper Strathcona tailings treatment system water and pore waters collected from the sampling ports at the beginning of the test, after 6 months and after 13 months. The results, which are attached in Appendix B, are summarized below.

- In all the columns, the concentrations of Al, Ca, Cu, Mg, Mn and Si increased in the water cover and at the interface over time.
- There was a concentration gradient between the tailings layer and the water cover for Ca, Mg and Si. Osmotic reaction to this gradient may have caused the observed increase in concentrations of these elements in the water covers over time.
- The concentrations of Fe, P and Zn decreased in the water cover and at the interface. This decrease may have been caused by the hydrous ferric oxide solid formation and precipitation of iron and zinc phosphates.
- At the beginning of the testing, the concentrations of P and Zn were markedly higher in the water cover and at the interface of the SM tailings column (P, >6.9 mg/L and Zn, >2.8 mg/L), thickened SM tailings column (P, >7.2 mg/L and Zn, >3.0 mg/L) and pyrrhotite tailings column (P, >1.8 mg/L and Zn, >0.9 mg/L) than the acidic Upper Strathcona tailings treatment system water (P, 0.10 mg/L and Zn, 0.17 mg/L). Only the samples collected from the water cover and interface in the thickened pyrrhotite tailings column and pyrrhotite tailings with substrate column exhibited comparable P and Zn concentrations to the Upper Strathcona tailings treatment system water.
- In general, the total dissolved S concentrations in the water cover and at the interface for all columns were below the total dissolved S concentration of the Upper Strathcona tailings treatment system water (600 mg/L). The total dissolved S concentrations in the tailings pore waters were substantially higher than those in the water covers and decreased with time.

3.4.9 Visual Observations

After 6 months of testing, the water cover of the SM tailings column appeared clear. After 8 months of testing, Fe precipitation began to occur on the monitoring probes

and at the interface, resulting in the appearance of iron precipitates and formation of a rust colored band at the interface (Plate #5). The water cover of the thickened SM tailings column was clear initially and after about four months looked cloudy with a 60 mm yellow brown band visible 50 mm above the interface (Plate #6). The width of this band has expanded over time. Extensive Fe precipitation occurred on the column wall of the pyrrhotite tailings column, with a 110 mm wide dark brown band forming 20 mm above the interface over the first six months of testing (Plate #7). The water cover of the thickened pyrrhotite tailings column looked reddish gold in color and, at the interface there was extensive buildup of filamentous materials and Fe precipitation (Plate # 8) over the first five months. The water cover of the column containing pyrrhotite and 100 mm sediment substrate was light yellow, and filamentous materials were seen both at the interface and on the monitoring probes (Plate #9) over the first five months. The color in this column began to clear after 11 months of the program. Plate #10 also illustrates these visual changes occurring in the columns #1 to #5.

4.0 SUMMARY AND DISCUSSION

Upper Strathcona tailings treatment system water was very acidic (pH<3), very conductive (2270 $\mu\text{mhos/cm}$), and high in concentrations of SO_4^{2-} (941 mg/L), Fe (6.9 mg/L) and Ni (2.1 mg/L). The treated lower Strathcona tailings treatment system process water was slightly alkaline (pH 7.4), low in Fe (<0.02 mg/L) and Ni (0.17 mg/L) concentrations. Both waters were low in total cyanide (<0.01 mg/L) with low thiosulphate concentrations (<10 mg/L).

The pyrrhotite tailings contained 30.2% S and 56% Fe, and the SM tailings (50:30 pyrrhotite tailings:slimes) contained 19.0% S and 37% Fe. The liquid portions of the pyrrhotite and SM tailings were low in metal concentrations (except Ca and Na), high in conductivity (>5000 $\mu\text{mhos/cm}$), high in SO_4^{2-} concentrations (990-1230 mg/L) and

high in thiosulphate concentrations (1880-2760 mg/L). The pH of the liquid portions of the pyrrhotite tailings and the SM tailings were 7.9 and 6.8, respectively.

Five subaqueous testing columns were filled with different types of tailings (SM tailings, thickened SM tailings, pyrrhotite tailings, thickened pyrrhotite tailings, and pyrrhotite tailings with 100 mm sediment substrate) and submerged under 1000 mm of the Upper Strathcona tailings treatment system water. In-situ measurements were recorded for Eh, conductivity and temperature on a two-week interval. Pore waters were collected from the water cover, the interface and the tailings layer on a two-month interval, and analyzed for metal and SO_4^{2-} concentrations and pH.

Over the first six months, the conductivity of the water column and in the tailings pore water increased slightly for all of the sampling ports. This increase was caused by the diffusion of salts from the tailings layer to the water cover due to conductivity gradient between the tailings layer and the water cover. Over the remaining seven months monitored, the conductivity at all the sampling ports remained essentially constant, near their initial values, possibly due to the precipitation reactions occurring at the interface or consolidation of the tailings surface.

The in-situ Eh measurements indicated that the tailings layer of all the columns remained under anoxic conditions ($\text{Eh} < -100$ mV, standard hydrogen electrode), although the overlying waters were oxic ($> +200$ mV). Negative Eh values were also observed at the interfaces of the SM tailings column and thickened SM tailings column during the first six month period, but these Eh values turned positive during the remaining seven month period. Positive Eh measurements were always observed in the water column and at the interface of the pyrrhotite tailings column, the thickened pyrrhotite tailings column and the column containing the pyrrhotite tailings and 100 mm sediment substrate.

The pH of the pore waters sampled from the tailings layer of all the columns remained relatively constant over time (pH 6.6-7.7). There was a gradual increase in the pH, over time, of the water samples collected from the water cover and the interface in the thickened pyrrhotite tailings column and the column containing pyrrhotite tailings and 100 mm sediment substrate. The increase in water cover pH was likely due to the diffusion of alkalinity from the underlying tailings layer. No changes in pH were observed in the water samples collected from the water cover and interface in the SM tailings column, the thickened SM tailings column and the pyrrhotite tailings column. The extensive hydrolysis of Fe^{3+} and precipitation may be responsible for maintaining the pH of the water covers at 3.0 in these three columns, even though the alkalinity may have also diffused upwards from the underlying tailings.

The SO_4^{2-} concentrations in the water cover and at the interface of pore waters of all the columns remained relatively constant over the 13 months of testing. The lowest SO_4^{2-} concentration was observed in the pore waters collected from the water cover and the interface of the thickened pyrrhotite tailings column (slightly above 500 mg/L). The SO_4^{2-} concentrations of the water samples collected from the water cover and the interface in the remaining columns fluctuated around 1000 mg/L. The SO_4^{2-} concentrations in the pore waters collected from the tailings layer of all the columns were consistently higher than those in the water cover and at the interface, suggesting that there was a concentration gradient between the tailings layer and the water cover. This gradient may have caused the movement of SO_4^{2-} from the tailings layer into the water cover.

The SO_4^{2-} concentrations in the tailings pore waters of the SM tailings column increased steadily with time. It was suggested that the oxidation of thiosulphates present in the tailings layer between the time of sampling and analysis may have been

partly responsible for this observed increase. Analytical results from the tailings filtrate and from the tailings pore waters after 6 and 13 months of testing indicated that the thiosulphates gradually decreased or disappeared. To determine if the SO_4^{2-} was from the oxidation of thiosulphates, a pore water sample was extracted from the SM tailings layer and filtered through $0.45\ \mu\text{m}$. The pH was measured immediately after filtration and 10 days after sulphate analysis. If thiosulphate was present and then oxidized to form sulphate, the filtrate pH would be expected to be lower after sulphate analysis than after the filtration. On the contrary, the pH values were recorded at 7.5 after filtration and 8.2 after sulphate analysis. This showed that the increase in SO_4^{2-} concentrations in the SM tailings pore water was not due to the oxidation of thiosulphates. It would be possible that the increase in SO_4^{2-} concentrations in the tailings pore water may have caused by the dissolution of gypsum. In the column leach test conducted at NTC, it suggested that Ca and SO_4^{2-} may mobilize from gypsum dissolution.

The increase in the tailings pore water SO_4^{2-} concentrations of the SM tailings column appeared to follow an observed increase in the tailings pore water Fe^{3+} concentrations. The Fe^{3+} may have originated from the oxic acidic Upper Strathcona tailings treatment system water, which would have mixed with the tailings during the filling of the column. The Upper Strathcona tailings treatment system water contained 6.9 mg/L total dissolved Fe, possibly as Fe^{3+} . As Fe^{3+} is a strong oxidant, it may have oxidized sulphide minerals present in the tailings layer, releasing sulphate into the pore waters of tailings.

After six months of testing, the concentrations of thiosulphates were not detected in the water samples collected from the water cover and the interface in the SM tailings column, thickened SM tailings column, pyrrhotite tailings column or the pyrrhotite tailings with substrate column. However, in the thickened pyrrhotite column, the

concentration of thiosulphates in the water samples collected from the water cover and the interface increased from <10 to 300 mg/L and from <10 to 560 mg/L, respectively. After 13 months of testing, the concentrations of thiosulphates were detected in the water cover and at the interface in all the pyrrhotite tailings columns. The concentrations of thiosulphates in the tailings pore water were observed to decrease with time. Diffusion has been interpreted to be the main mechanism for the increase of thiosulphates in the water cover and the parallel decrease in the tailings pore water.

The lowest dissolved Fe concentrations were observed in the pore waters collected from the tailings layer of all the columns, with the exception of the SM tailings column, where the total dissolved Fe concentrations increased to 45.5 mg/L at the end of the 13 month sampling date. The Fe concentrations in the water cover and at the interface exhibited a general decreasing trend with time in all columns. An initial increase followed by a decrease in the Fe concentrations in the water cover and at the interface was interpreted to be due to extensive precipitation of iron oxyhydroxides.

The precipitation of iron oxyhydroxides and reddish brown discoloration of the acidic water cover were observed in all the columns. The precipitates were found both on the column walls and at the interface in the SM tailings column, thickened SM tailings column and the pyrrhotite tailings column, but only at the interface in the thickened pyrrhotite tailings column and the pyrrhotite tailings with substrate column. The general chemical reaction describing this precipitation process is:



This reaction naturally occurs in any water with at least 0.01 mg/L of iron at pH below 5. The Upper Strathcona tailings treatment system water was very acidic (pH 3.0) and contained 6.9 mg/L of dissolved iron. These conditions would be favorable for the above precipitation reaction. Goethite and sometimes lepidocrocite (both FeOOH)

can also be formed if the pH is greater than 3.5 or through the long-term aging of the amorphous material.

The above equation shows that Fe^{3+} hydrolysis and precipitation produce hydrogen ions, which may contribute to the acidification of the waters or maintenance of existing acid conditions. As the rate of formation of the hydrous ferric oxides is very sensitive to the acidity of the solution, variations in the precipitation rates of hydrous ferric oxides may exist between the columns. The pH values in the water cover and at the interface remained at pH 3.0 in the SM tailings column, thickened SM tailings column and pyrrhotite tailings column, while those in the thickened pyrrhotite tailings column and the pyrrhotite tailings with substrate column increased gradually with time, from 3.0 to close to 6.0.

The lowest Ni concentrations were observed in the pore waters collected from the tailings layer of all the columns (<0.20 mg/L). The Ni concentrations in the water cover and at the interface in the SM tailings column increased from 1.8 to 3.2 mg/L during the 13 months of testing. The reason for this increase has not yet been explained. The following two possibilities exist:

1) Ni is transferred from the tailings layer into the water cover. The SM tailings liquid filtrate contained 0.21 mg/L Ni, whereas the pyrrhotite tailings liquid filtrate contained 0.05 mg/L Ni.

2) Ni is released from the tailings at the interface due to the changes in redox potential from reducing to oxidizing.

The Ni concentrations in the water cover and at the interface in the remaining four columns either remained below the Ni concentration of the Upper Strathcona tailings treatment system water (2.08 mg/L) or exhibited a slight decrease with time. This may have been a result of coprecipitation of Ni with the iron oxyhydroxides.

The concentrations of other elements such as Al, Ca, Cu, Mg, Mn and Si increased and the concentrations of P and Zn decreased in the water cover and at the interface over time. Again, diffusion is believed to be the main mechanism for the observed increases. Precipitation of zinc phosphate or co-precipitation on the ferric oxyhydroxides may have caused the observed decrease in P and Zn concentrations.

The water chemistry in the pilot columns has generally confirmed the column leach test results. In the column leach test, Cu, Co, Zn, Ni, Pb and Al were removed from the influent (Upper Strathcona tailings treatment system water) and retained by the tailings, while the Fe, Ca, Mg, Mn, Si, K, Na, and SO₄ were released from the tailings. The effluent pH remained above 5.

5.0 CONCLUSIONS

This subaqueous testing program was designed to evaluate the effects of the subaqueous deposition of pyrrhotite and Strathcona Mill tailings from the Strathcona Mill on the water quality of Strathcona tailings treatment system water and to determine if subaqueous tailings deposition is a viable alternative to control acid generation. The following conclusions are based on the data collected from the five columns over a 13 month test period:

- A stagnant 1000 mm water cover was capable of maintaining the underlying tailings in a reducing condition.
- Deposition of thickened pyrrhotite tailings or the pyrrhotite tailings with a shallow cover of substrate increased the overlying water pH from 3.0 to close to 6.0.
- A conductivity gradient between the tailings and the water cover caused a diffusion of salts upwards into the overlying water column.
- The precipitation of ferric oxyhydroxides resulted in the decrease in Fe concentrations in the water cover.

- The Ni concentrations of the water cover did not increase by the deposition of tailings into the Strathcona tailings treatment system.
- A sulphate concentration gradient between the tailings and the water cover likely caused the diffusion of SO₄ from the tailings into the water cover.
- The formation of precipitates and a biological growth layer at the interface and the consolidation of the tailings may all contribute to the observed decrease in the diffusion of salts from the tailings into the water cover at the later stage of the testing program.

Based on the data collected to date, it is concluded that the deposition of pyrrhotite tailings under a shallow cover layer of sediment substrate would be the most effective for reducing acid generation than other deposition scenarios studied.

6.0 RECOMMENDATIONS

The results of the column tests provide a model of the worst case impacts expected on Upper Strathcona tailings treatment system, if the fresh tailings are deposited above the chemocline and thermocline in shallow, acidic waters.

The data presented in this report provide a summary and interpretation of the results after 13 months of testing and monitoring. As the main process being monitored in the columns is a slow process (molecular diffusion) under static conditions, it will take considerable time to reach equilibrium conditions in the columns. Changes are on-going and shifts in trends have been detected during the 13 month program, therefore, continued monitoring has been recommended to reach equilibrium and establish the worse case impact.

It is also recommended that computer modeling, such as MINTEQA2 using the available data, be conducted to determine the solubility and saturation of the ferric oxyhydroxide precipitates and the changes of metal concentrations with pH. This information would assist in the interpretation of the observed trend, and could be used with the existing water quality data to predict longer term geochemical changes as the system proceeds towards equilibrium.

Microbiological examinations are also recommended to identify the microorganisms and their roles in metal release and mobilization.

The issue of long term effects are still uncertain in the water column tests. In the short term the effects on the overlying water column are minor. The observed increase in sulphate concentrations in the subaqueous tailings is showing a constant trend and is both consistent and dramatic. This may result in increased sulphate loading to the water column.

It is possible that the continued oxidation of the tailings and production of sulphate is occurring at a substantial enough level in the subaqueous tailings to have a measurable effect on the lake water. This could result in unexpected long term costs for water treatment if the results from the one year program are considered conclusive. By replacing the water column with fresh rainwater the long term effects could be examined and the need for treatment addressed.

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Research Scientist

Linda Elliott, M. Eng.
Project Manager

S. Wade Stogran
Manager

LIST OF PLATES

- Plate #1: Subaqueous Columns Prior to Filling
- Plate #2: Subaqueous Columns #1 (pyrrhotite) and #2 (thickened SM tailings), January 30, 1995
- Plate #3: Subaqueous Columns #3 (pyrrhotite and substrate) and #4 (thickened pyrrhotite), January 30, 1995
- Plate #4: Subaqueous Column #5 (SM tailings), January 30, 1995
- Plate #5: Subaqueous Column #5 (SM tailings), January 22, 1996
- Plate #6: Subaqueous Column #2 (thickened SM tailings), January 22, 1996
- Plate #7: Subaqueous Column #1 (pyrrhotite), January 22, 1996
- Plate #8: Subaqueous Column #4 (thickened pyrrhotite), January 22, 1996
- Plate #9: Subaqueous Column #3 (pyrrhotite and substrate), January 22, 1996
- Plate #10: Subaqueous Columns #1 to #5, January 22, 1996

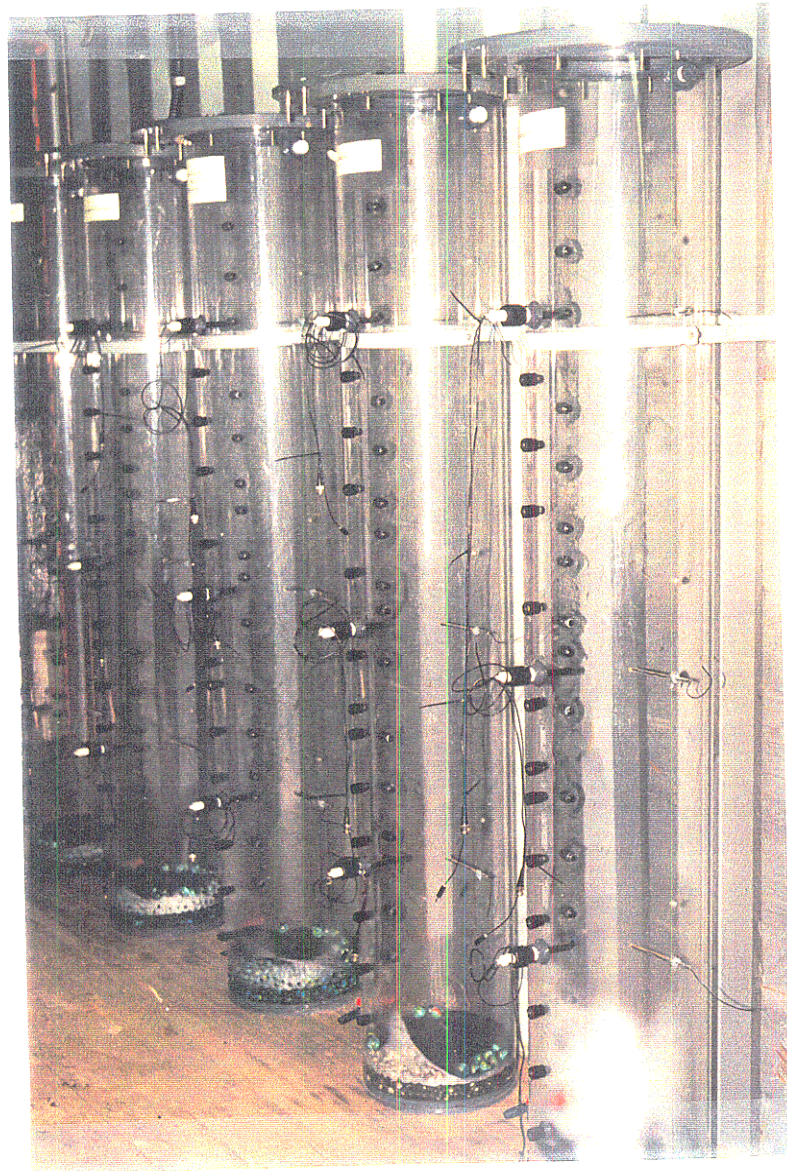


PLATE #1: Subaqueous columns prior to filling

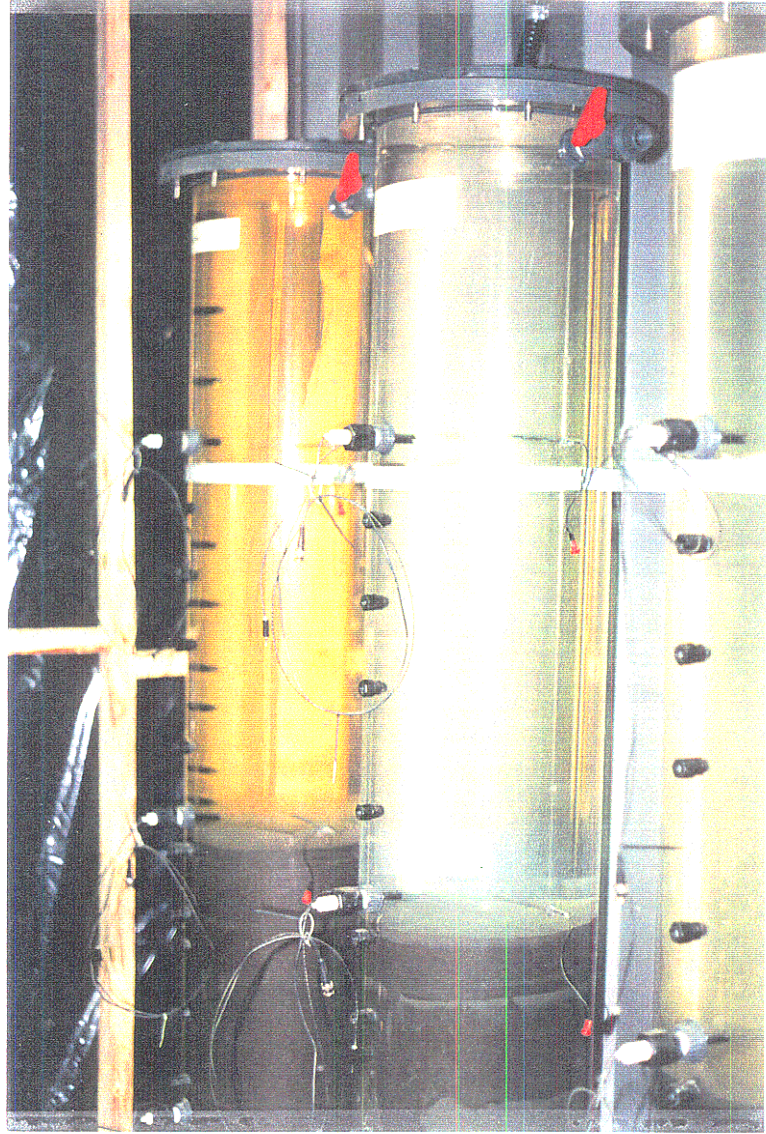
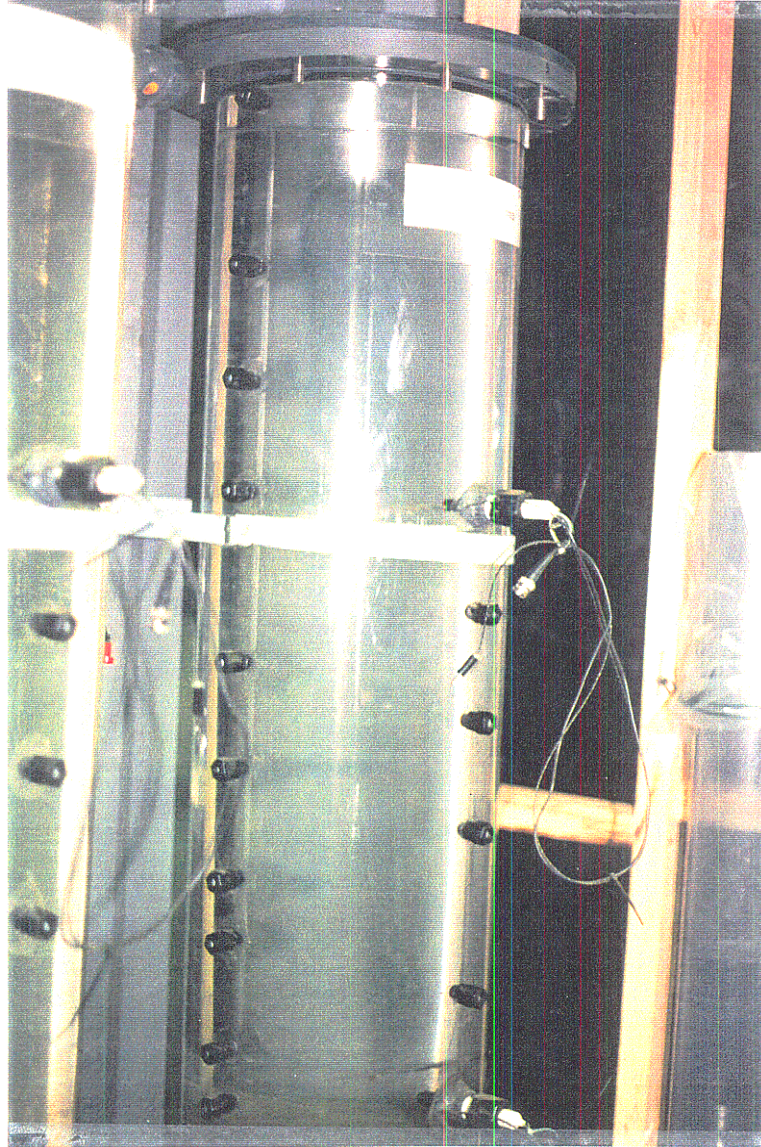




PLATE #3: Subaqueous columns #3 (pyrrhotite and substrate)
and #4 (thickened pyrrhotite)

January 30, 1995



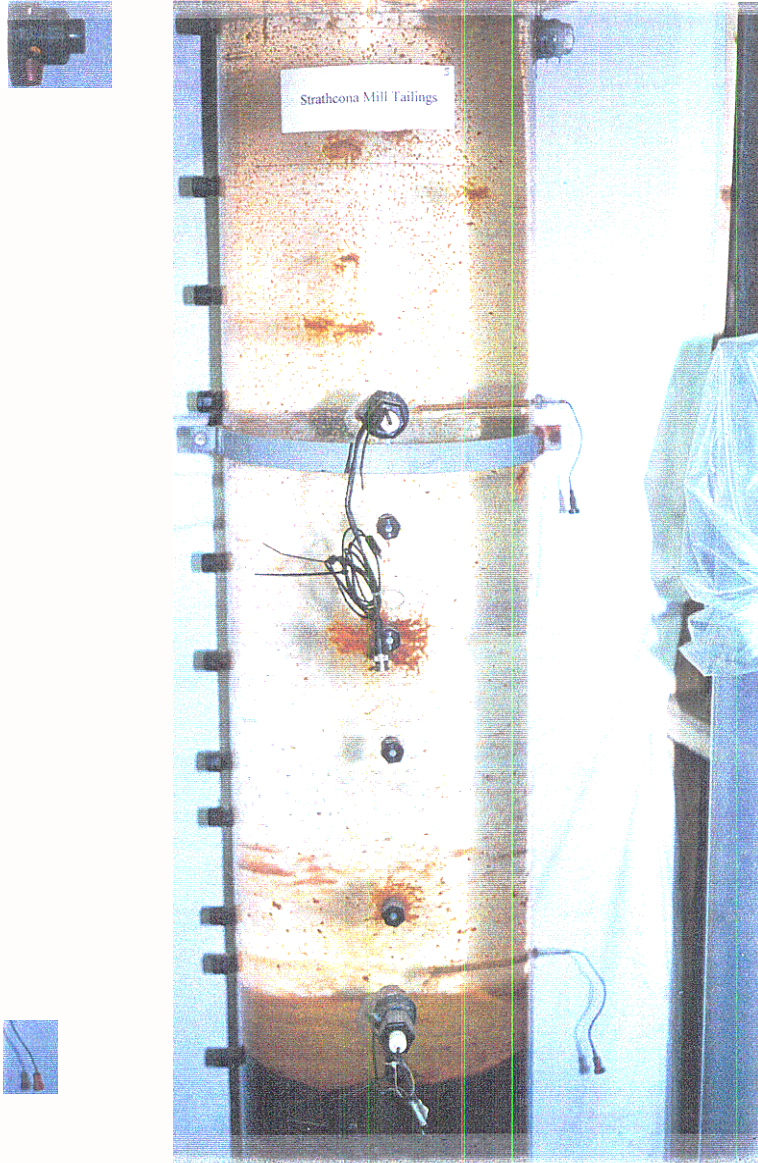


PLATE #5: Subaqueous columns #5 (SM tailings)

January 22, 1996

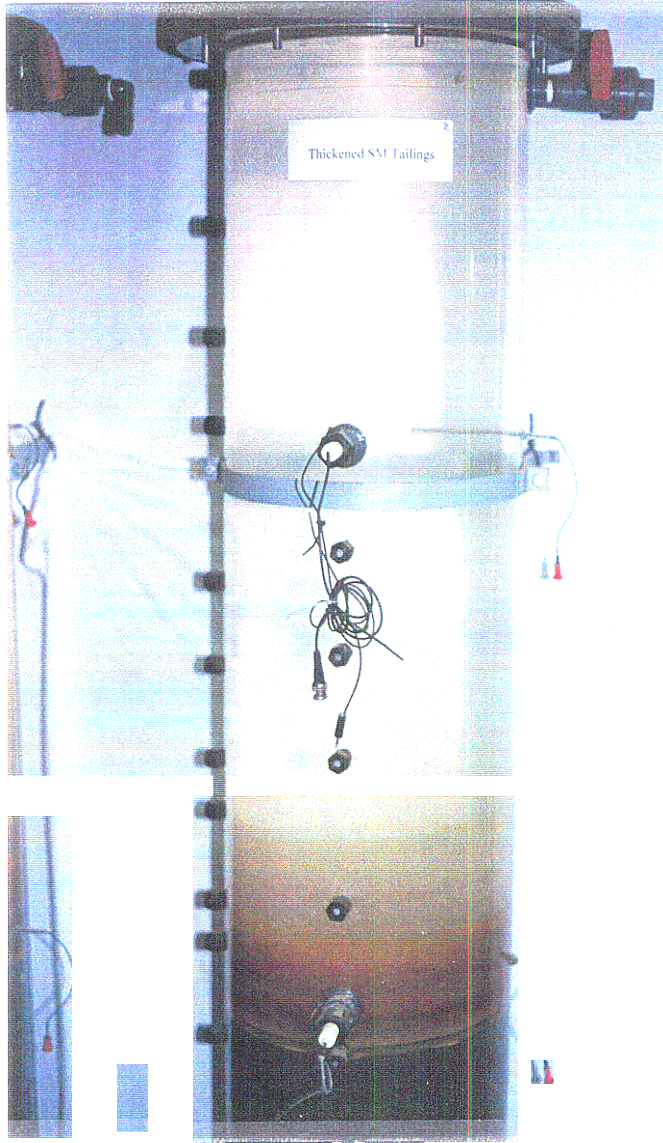
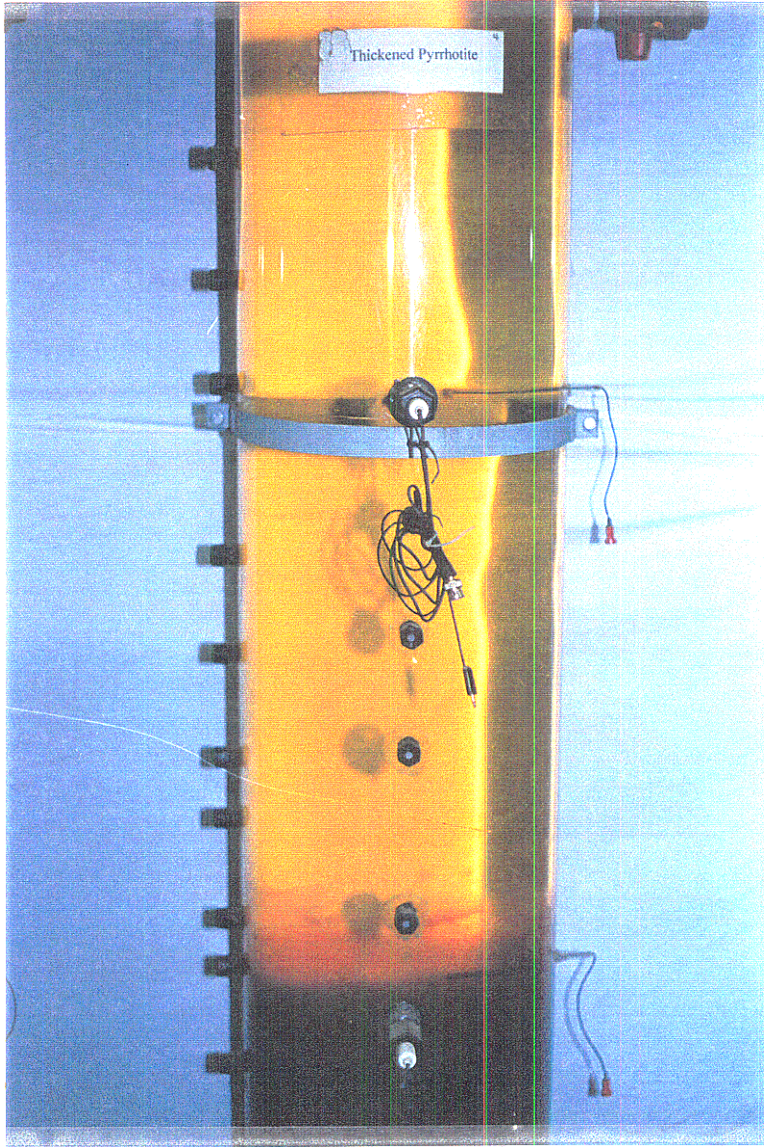


PLATE #6: Subaqueous columns #2 (thickened SM tailings)

January 22, 1996





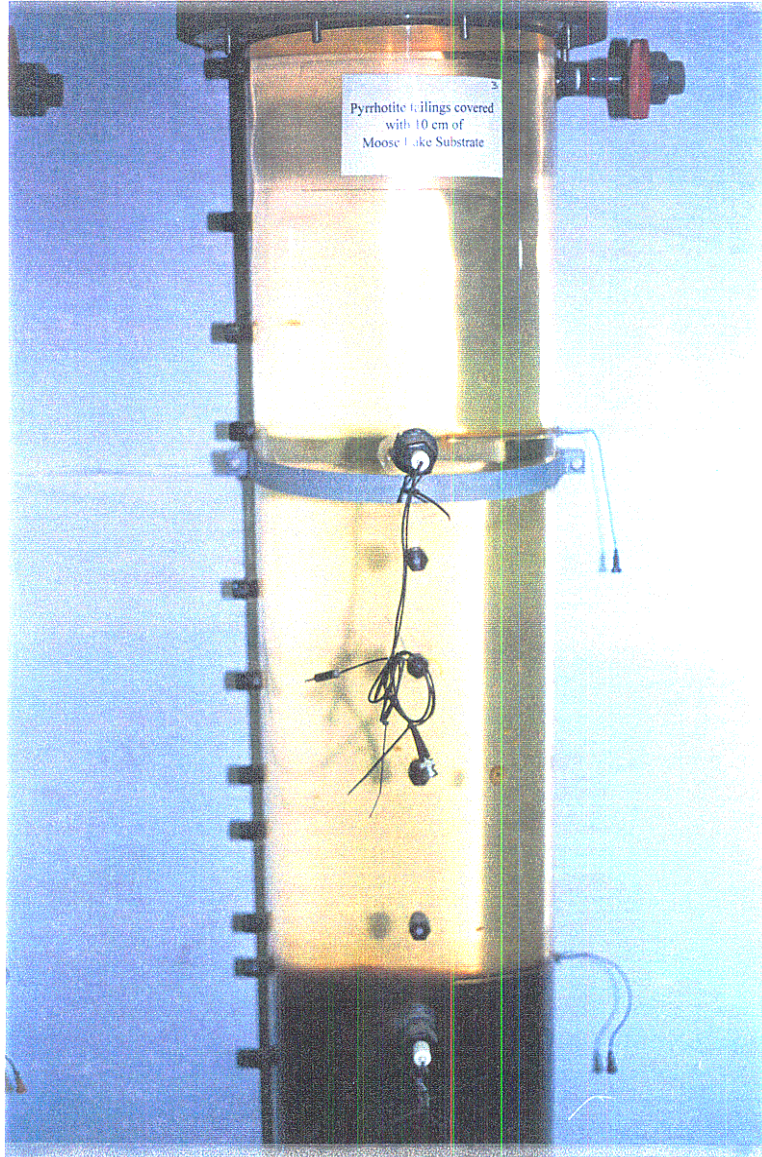


PLATE #9: Subaqueous columns #3 (pyrrhotite and substrate)

January 22, 1996



PLATE #10: Subaqueous columns #1 to #5, January 22, 1996

Column #1, pyrrhotite

Column #2, thickened SM tailings

Column #3, Pyrrhotite and substrate

Column #4, thickened pyrrhotite

Column #5, SM tailings

APPENDIX A

Analytical Procedure

QA/QC PROCEDURE FOR COLUMNS

CONDUCTIVITY (*2 weeks)

- (1) Calibrate 10,000 conductivity meter using external probe and standard solutions.
(10,000 **umohs** solution = 5,680 ppm)
 - (a) **Turn** meter on - hook up **external** probe.
 - (b) Put probe in standard solution; tum **standardize** dial and set reading to match standard solution conductivity (5.68).
 - (c) **Turn** dial to "CAL" and record the reading showing on meter. (A)
Note: Do not adjust knobs further.
- (2) Take **small** sample (by pipette) **from** top of each column near vicinity of top probe and measure conductivity with external probe. Record.
- (3) Turn control switch to "**TEMP**" position • **measure** the temperature of the sample and set temp control knob to this value • **return function** switch to "ON" position.
- (4) Measure conductivity using internal probes and record. Record temperature and conductivity.
- (5) **After** each set of three readings (i.e. for each column) switch meter back to "CAL" and check reading. **If different** from (A), use standardize knob to readjust back to (A).
- (6) Convert conductivity in ppm to conductivity in micro **mhos/cm**.

$$5,680 \text{ ppm} = 10,000 \text{ micro mhos/cm}$$

$$\frac{\text{Readine in ppm}}{0.568} = \text{Reading in micro mhos/cm}$$

PLUS EVERY 2 MONTHS

- (7) Take a pore water/water column sample and measure conductivity using external (calibrated) probe. Compare with internal probe readings.

QA/QC PROCEDURE FOR COLUMNS

Eh (*2 weeks)

- (1) Calibrate Eh meter using external Eh probe and standard solution. (475 **mV buffer**)
 - (a) hook up external Eh probe and the electrode with the meter.
 - (b) Press "**On/Off**" button to turn on the meter. Press "**mV**" key to place meter in **mV** mode.
 - (c) Rinse the Eh probe and the electrode with DI **water**; immerse the Eh probe and the electrode in the standard solution. While holding the electrode, rotate the hole in the cap ring **from** the closed to the open position.
Note: Be sure not to tilt the electrode **if the** hole in the cap ring is in open p o s i t i o n .
 - (d) Press "**mV**" key to measure the Eh. The stability bar continuously tracks absolute millivolts until it is steady (stop flashing). Record the reading (S).
- (2) Immerse the electrode into the sample solution and measure Eh using internal probes. Record the reading.
- (3) After the measurements are taken, rotate the hole in the electrode cap back to the closed position. Rinse the electrode and disconnect it from the meter.
- (4) Calculate the absolute Eh
 - (a) Compare (S) with 475 **mV**,
 $(S) - 475 = \text{Diff.}$
 - (b) Compare the **Diff.** to the readings of the sample,
Reading - Diff. = absolute Eh of the sample.

PLUS EVERY 2 MONTHS

- (5) Take a pore water/water column sample and measure Eh using external (calibrated) probe. Compare with internal probe readings.

APPENDIX B

Analytical Results

9/26/96

Moose Lake Subaqueous Columns
Summary of Analytical Results

Project # 7777-1 11

	SO ₄ ²⁻ (mg/L)								S (mg/L)							
	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	11/20/95	1/22/96	6/6/96	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	11/20/95	1/22/96	6/6/96
Column 1, Pyrrhotite																
Water	958	1,041	946	1,032	1,100	1,116	1,054	1,130	358	275	314	344	377	372	386	400
Interface	1,146	1,137	1,297	1,017	1,098	1,194	1,158	1,187	368	322	388	339	379	398	409	407
Tailings	889	1,032	887	1,083	1,170	1,276	1,203	1,760	3,790	1,020	3,640	1,139	2,960	2,870	3,047	2,988
Column 2, Thickened Tailings																
Water	894	953	905	986	1,089	1,194	1,129	1,151	359	254	314	329	392	398	416	468
Interface	1,181	1,256	1,395	1,495	1,136	1,119	1,150	1,186	630	458	536	498	382	373	435	451
Tailings	1,359	1,456	1,202	1,528	1,542	1,722	1,653	2,127	8,556	1,860	5,680	2,054	8,390	1,450	6,151	1,100
Column 3, Pyrrhotite & Substrate																
Water	923	1,056	857	923	894	933	875	895	881	267	344	308	322	311	397	309
Interface	934	1,030	851	877	914	915	834	758	517	272	351	292	320	305	322	312
Tailings	939	1,254	1,686	1,928	1,801	1,860	1,652	1,779	3,289	1,030	1,080	643	713	620	633	609
Column 4, Thickened Pyrrhotite																
Water	567	570	461	611	585	618	565	606	401	219	260	306	335	342	375	383
Interface	503	697	593	669	571	653	618	601	320	443	528	410	343	337	411	455
Tailings	1,140	1,336	1,143	1,402	1,279	1,771	1,912	1,639	7,731	2,040	9,000	2,318	7,290	3,050	3,353	579
Column 5, Tailings																
Water	1,390	704	583	889	890	897	891	854	486	243	281	296	308	299	350	350
Interface	620	801	954	912	909	882	855	839	266	301	366	314	308	294	329	350
Tailings	934	1,232	931	1,613	2,250	2,363	2,197	2,019	2,932	936	3,970	896	919	805	785	705

Moose Lake Subaqueous Columns
Summary of Analytical Results

	Fe (mg/L)								Fe ²⁺	Fe ³⁺	Fe ²⁺	Fe ³⁺	Fe ²⁺	Fe ³⁺	Fe ²⁺	Fe ³⁺
	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	11/20/95	1/22/96	6/6/96	6/26/95	6/26/95	9/21/95	9/21/95	11/20/95	11/20/95	1/22/96	1/22/96
Column 1, Pyrrhotite																
Water	5.74	12.50	18.50	12.30	5.00	2.89	1.97	1.30	<5.0	12.30	<0.5	5.00	0.31	2.59	1.8	<0.5
Interface	9.36	40.00	52.60	13.60	7.65	23.90	19.90	1.83	<5.0	13.60	0.90	6.75	7.65	16.40	8.4	11.5
Tailings	<0.003	0.81	0.14	5.23	<0.05	0.06	0.21	0.08	<5.0	5.20	<0.5	<0.5	0.19	<0.05	<0.5	<0.5
Column 2, Thickened Tailings																
Water	4.60	3.90	4.53	10.00	3.04	1.88	2.58	1.76	<5.0	10.00	<0.5	3.04	0.28	1.62	2.6	<0.5
Interface	5.78	11.90	44.30	30.30	4.01	4.23	3.88	1.10	<5.0	30.30	<0.5	7.01	0.26	3.94	3.6	<0.5
Tailings	0.01	0.26	0.20	4.95	co.05	<0.05	0.19	co.02	<5.0	<5.0	<0.5	<0.5	0.10	co.05	<0.5	<0.5
Column 3, Pyrrhotite & Substrate																
Water	10.10	8.10	7.58	14.60	7.22	3.27	0.59	0.28	14.60	<5.0	2.54	4.68	0.27	3.03	0.6	<0.5
Interface	9.43	8.34	7.74	15.00	7.22	3.38	0.59	0.31	15.00	<5.0	2.32	4.90	0.25	3.15	0.6	<0.5
Tailings	0.02	0.30	0.16	5.35	1.45	2.57	1.37	1.70	<5.0	5.40	0.70	0.80	2.09	0.51	1.2	<0.5
Column 4, Thickened Pyrrhotite																
Water	5.05	4.76	3.81	9.55	3.11	3.00	3.39	2.88	6.10	<5.0	<0.5	3.11	0.26	2.74	3.1	<0.5
Interface	6.38	2.07	0.14	5.56	3.18	2.94	3.64	4.13	<5.0	5.60	<0.5	3.18	0.25	2.65	3.4	<0.5
Tailings	co.003	0.62	0.06	4.73	<0.05	<0.05	0.08	0.12	<5.0	<5.00	<0.5	<0.5	0.09	co.05	<0.5	<0.5
Column 5, Tailings																
Water	5.72	4.23	3.71	12.20	22.80	1.38	0.52	0.18	<5.0	12.20	18.80	4.00	0.84	0.56	0.5	<0.5
Interface	5.04	3.26	2.86	27.60	22.80	1.73	0.62	0.08	27.60	<5.0	19.00	3.80	1.06	0.64	0.4	<0.5
Tailings	0.03	1.95	0.44	5.30	2.09	20.30	45.50	42.10	5.30	<5.0	1.83	<0.5	9.38	10.60	9.2	36.3

Moose Lake Subaqueous Columns
Summary of Analytical Results

	Cond. (mmhos/cm)											Diss. O (mg/L)				
	12/21/94	2/7/95	2/21/95	4/17/95	6/26/95	9/21/95	10/23/95	11/20/95	12/20/95	1122196	6/6/96	12/21/94	1/12/95	2/21/95	4/17/95	6/26/95
Column 1, Pyrrhotite																
Water	2,580	2,526	2,563	2,475	2,835	2630	2470	2590	2480	2290	2330	9.0	10.4	7.0	9.6	8.6
Interface	2,490	2,509	2,668	2,576	2,923	2670	2610	2630	2530	2480	2340	7.2	9.4	4.0	6.3	8.5
Tailings	3,840	3,864	3,829	3,821	4,419	4270	4260	4200	3900	3860	3540	9.9	9.0	5.3	8.9	8.7
Column 2, Thickened Tailings																
Water	2,5501	2,6191	2,6521	2,6411	2,9401	2610	2560	2510	2380	2330	2250	9.01	9.21	7.01	9.91	9.21
Interface	2,480	2,906	2,960	3,087	3,204	2640	2600	2470	2420	2420	2340	9.5	8.2	4.3	8.9	8.9
Tailings	5,500	5,600	5,677	5,632	5,951	6120	6070	5820	5520	5130	3510	9.8	11.0	6.4	8.7	8.2
Column 3, Pyrrhotite & Substrate																
Water	2,660	2,454	2,487	2,496	2,852	2530	2550	2450	2370	2370	2340	9.6	10.9	7.5	9.5	9.0
Interface	2,620	2,460	2,487	2,480	2,905	2510	2570	2510	2390	2310	2380	9.5	10.3	7.4	9.9	9.1
Tailings	3,5501	3,830	3,774	3,592	3,996	3440	3510	3480	3190	3220	3200	9.1	9.4	5.3	8.3	8.6
Column 4, Thickened Pyrrhotite																
Water	1,610	1,587	1,596	1,604	2,060	1893	1934	1892	1899	1817	1847	9.5	11.3	8.3	10.1	8.8
Interface	1,620	2,080	2,126	2,257	2,518	1906	1936	1864	1903	1913	1990	9.6	9.8	4.9	8.6	9.2
Tailings	5,670	5,741	5,129	5,938	6,479	6,490	6,450	5,850	5,280	4,280	2,820	8.4	9.4	5.4	8.4	8.2
Column 5, Tailings																
Water	2,050	1,907	1,907	1,889	2,570	2100	2130	2120	2020	1969	1947	10.0	11.7	7.6	9.4	8.8
Interface	2,020	2,004	2,016	2,066	2,412	2100	2140	2030	2010	1954	1980	9.7	10.1	3.5	7.7	8.6
Tailings	3,430	3,733	3,726	3,742	4,225	4260	4450	4090	4020	3720	3490	8.0	7.7	5.2	8.8	8.2

Moose Lake Subaqueous Columns
Summary of Analytical Results

	pH (units)										CO ₂ (mg/L)			
	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	10/23/95	11/20/95	12/20/95	1/22/96	6/6/96	12/21/94	1/12/95	2/21/95	4/17/95
Column 1, Pyrrhotite														
Water	3.13	3.32	3.14	3.19	3.05	3.03	3.07	3.10	3.17	3.30	<10	<10	<10	<10
Interface	3.63	3.25	3.55	3.17	3.06	3.11	3.15	3.18	3.22	3.32	12	10	<10	<10
Tailings	7.58	7.17	7.31	7.40	7.62	7.20	7.13	6.69	7.04	7.02	690	20	<10	303
Column 2, Thickened Tailings														
Water	2.96	3.06	2.90	3.08	3.19	3.27	3.29	3.35	3.42	3.61	<10	<10	<10	68
Interface	3.38	3.48	3.45	3.61	3.21	3.35	3.34	3.42	3.49	3.73	<10	20	<10	<10
Tailings	7.70	7.13	7.18	7.38	7.64	7.35	7.18	6.64	7.06	7.03	620	710	<10	409
Column 3, Pyrrhotite & Substrate														
Water	3.03	3.701	4.021	4.24	4.81	5.10	5.19	5.50	5.70	6.06	140	160	<10	34
Interface	3.12	3.73	4.021	4.20	4.80	5.11	5.11	5.44	5.65	6.02	<10	40	<10	<10
Tailings	7.56	7.161	7.56	7.66	7.23	7.25	7.10	7.11	7.30	7.35	180	340	<10	51
Column 4, Thickened Pyrrhotite														
Water	3.32	3.71	3.92	4.87	5.49	5.49	5.46	6.07	5.67	6.20	<10	<10	<10	29
Interface	3.40	6.80	7.32	7.06	5.49	5.52	5.62	6.22	6.83	6.60	<10	<10	<10	22
Tailings	7.21	7.00	7.32	7.36	7.75	7.30	7.42	6.78	7.05	7.03	410	630	<10	748
Column 5, Thickened Pyrrhotite														
Water	3.12	3.88	3.73	3.21	3.67	3.59	3.53	3.77	3.79	4.26	280	140	<10	177
Interface	3.20	4.28	4.56	3.62	3.66	3.58	3.53	3.72	3.78	4.27	130	100	<10	45
Tailings	: 7.40	7.33	7.45	7.47	7.21	7.36	6.86	6.82	6.96	7.06	230	110	<10	211

	NI (mg/L)								TIC (mg/L)							
	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	11/20/95	1/22/96	6/6/96	12/21/94	2/21/95	4/17/95	6/26/95	9/21/95	11/20/95	1/22/96	
Column 1, Pyrrhotite																
Water	1.99	1.84	2.07	1.97	1.62	1.66	1.80	1.24	<1	<1	<1	<1	<1	<1	<1	
Interface	2.15	1.66	1.17	1.84	1.58	1.45	1.44	1.39	<1	<1	<1	<1	<1	<1	<1	
Tailings	0.01	0.02	0.03	0.15	<0.01	<0.01	<0.05	<0.05	3	4	3.8	4	4.4	3.9	3.4	
Column 2, Thickened Tailings																
Water	1.87	1.52	1.68	1.88	1.46	1.52	1.67	1.29	<1	<1	<1	<1	<1	<1	<1	
Interface	1.90	2.05	0.97	0.73	3.33	1.30	1.24	1.03	<1	<1	<1	6.7	6.4	<1	<1	
Tailings	<0.01	<0.02	0.02	0.13	<0.01	0.02	0.10	<0.05	5	3	3.2	6.4	2.9	2.9	2.4	
Column 3, Pyrrhotite & Substrate																
Water	2.48	2.19	2.20	2.69	2.19	2.12	2.34	1.39	<1	<1	<1	<1	<1	<1	<1	
Interface	2.65	2.25	2.10	2.74	2.21	2.10	2.37	1.52	<1	<1	<1	<1	<1	<1	<1	
Tailings	<0.01	<0.02	0.03	0.12	<0.01	0.01	0.07	<0.05	5	6	6.1	13.9	25	25.3	27.8	
Column 4, Thickened Pyrrhotite																
Water	1.32	1.16	1.03	1.34	1.42	1.47	1.77	1.34	<1	<1	<1	<1	<1	<1	<1	
Interface	1.42	1.04	0.76	1.33	1.36	1.44	1.77	1.96	<1	<1	5.4	<1	<1	<1	<1	
Tailings	<0.01	0.01	0.03	0.09	0.01	<0.01	<0.05	<0.05	<1	<1	<1	<1	<1	<1	<1	
Column 5, Tailings																
Water	1.86	1.62	1.51	1.94	2.45	2.64	3.24	2.85	<1	<1	<1	<1	<1	<1	<1	
Interface	1.79	1.52	1.26	3.02	2.43	2.54	3.14	2.78	<1	<1	<1	<1	<1	<1	<1	
Tailings	0.01	0.02	0.03	0.13	0.01	0.02	0.20	0.14	10	5	10.8	16.4	20.7	20.3	20.5	

ICP-ES Scan on Pore Water in Column 1 (Pyrrhotite)

Element	Unit	pH 3.0 Water	Water			Interface			Tailings		
			Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96
Al	mg/L	1.70	1.93	2.13	3.58	1.53	2.05	3.14	0.57	0.97	2.36
As	mg/L	< 0.01	< 0.01	< 0.10	0.28	< 0.01	< 0.10	0.24	< 0.01	< 0.10	0.17
Ba	mg/L	0.042	0.040	0.14	0.07	0.041	0.13	0.07	0.012	0.11	0.04
Be	mg/L	< 0.001	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005
Ca	mg/L	297	288	344	395	323	337	417	893	845	937
Cd	mg/L	< 0.002	< 0.002	< 0.005	< 0.01	< 0.002	< 0.005	< 0.01	< 0.002	< 0.005	< 0.01
Co	mg/L	0.057	0.040	0.050	< 0.02	0.045	0.046	< 0.02	< 0.004	< 0.010	< 0.02
Cr	mg/L	< 0.004	< 0.004	0.17	0.03	< 0.004	0.17	< 0.02	< 0.004	0.16	0.03
Cu	mg/L	0.21	0.20	0.040	0.96	0.13	0.038	0.81	< 0.003	< 0.010	0.50
Fe	mg/L	6.90	5.74	12.3	1.97	9.36	13.6	19.9	< 0.003	5.23	0.21
Mg	mg/L	14.4	13.7	14.8	20.0	15.1	14.7	23.4	22.2	31.3	43.7
Mn	mg/L	0.58	0.56	0.89	1.17	0.62	0.94	1.43	0.042	0.17	0.096
Mo	mg/L	0.013	< 0.007	< 0.020	0.09	< 0.007	< 0.020	0.14	< 0.007	< 0.020	0.15
Na	mg/L	127	135	131	147	131	124	141	89.2	125	153
Ni	mg/L	2.08	1.99	1.97	1.80	2.15	1.84	1.44	0.01	0.15	< 0.05
P	mg/L	0.10	2.25	0.41	0.30	1.78	0.22	< 0.10	0.16	0.25	0.18
Pb	mg/L	0.07	< 0.02	< 0.005	< 0.10	< 0.02	< 0.005	< 0.10	< 0.02	< 0.005	< 0.10
S	mg/L	597	358	344	386	368	339	409	3790	1139	3047
Sb	mg/L	< 0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Se	mg/L	< 0.02	< 0.02	< 0.01	co.10	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10
Si	mg/L	4.17	4.15	6.42	7.62	3.97	5.96	9.07	0.42	1.90	0.94
Sn	mg/L	0.02	< 0.02	< 0.05	co.10	< 0.02	< 0.05	< 0.10	0.02	< 0.05	< 0.10
Te	mg/L	< 0.04	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20
Zn	mg/L	0.17	0.98	1.60	1.04	0.89	1.40	0.83	< 0.004	0.88	0.07

ICP-ES Scan on Pore Waters in Column 2 (Thickened SM Tailings)

Element	Unit	pH 3.0 Water	Water				Interface				Tailings			
			Dec-21-94	Jun-26-95	Jan-22-96	Jun-6-96	Dec-21-94	Jun-26-95	Jan-22-96	Jun-6-96	Dec-21-94	Jun-26-95	Jan-22-96	Jun-6-96
Al	mg/L	1.70	1.83	2.12	3.14	1.43	1.70	1.46	3.20	1.53	0.77	1.06	2.04	0.5?
As	mg/L	<0.01	<0.01	<0.10	0.35	<0.05	<0.01	<0.10	0.31	<0.05	<0.01	<0.10	0.24	<0.05
Ba	mg/L	0.042	0.042	0.13	0.06	0.06	0.042	0.11	0.10	0.07	0.037	0.14	0.08	-0.05
Be	mg/L	<0.001	<0.001	<0.002	<0.005	<0.005	<0.001	<0.002	<0.005	<0.005	<0.001	<0.002	<0.005	<0.005
Ca	mg/L	297	307	335	408	222	370	446	444	225	1266	1260	1242	244
Cd	mg/L	<0.002	<0.002	<0.005	<0.01	<0.01	0.005	<0.05	<0.01	<0.01	<0.002	<0.005	<0.01	0.02
Co	mg/L	0.057	0.039	0.05	<0.02	<0.02	0.051	0.02	<0.02	<0.02	<0.004	0.014	<0.02	<0.02
Cr	mg/L	<0.004	<0.004	0.17	<0.02	<0.02	<0.004	0.16	0.05	<0.02	<0.004	0.16	0.09	<0.02
Cu	mg/L	0.21	0.16	0.018	0.76	0.2	0.12	<0.01	0.92	0.13	<0.003	<0.01	0.66	<0.02
Fe	mg/L	6.90	4.60	10	2.58	1.76	5.78	30.3	3.88	11	0.013	4.95	0.19	<0.02
Mg	mg/L	14.4	13.2	14.4	22.7	28.4	16.1	32.8	28.4	32.3	49.1	56.8	70.4	62.3
Mn	mg/L	0.58	0.57	0.87	1.06	1.05	0.62	1.63	1.39	1.28	0.065	0.18	0.15	0.073
Mo	mg/L	0.013	0.025	<0.020	0.09	<0.04	0.032	<0.02	0.17	<0.04	0.008	<0.020	0.24	<0.04
Na	mg/L	127	120	107	126	128	117	112	164	130	136	213	276	212
Ni	mg/L	2.08	1.87	1.88	1.67	1.29	1.90	0.73	1.24	1.03	<0.01	0.13	0.10	<0.05
P	mg/L	0.10	8.7	4.26	0.36	<0.20	7.18	0.27	0.14	<0.20	0.35	0.30	0.44	<0.20
Pb	mg/L	0.07	<0.02	<0.005	<0.10	<0.10	0.05	<0.00	<0.10	<0.10	<0.02	<0.005	<0.10	<0.10
S	mg/L	597	359	329	416	468	630	498	435	451	8556	2054	6151	1100
Sb	mg/L	<0.02	<0.02	<0.05	<0.10	<0.10	<0.02	<0.05	co.10	<0.10	<0.02	<0.05	<0.10	<0.10
Se	mg/L	<0.02	<0.02	<0.01	<0.10	<0.10	<0.02	<0.01	co.10	<0.10	<0.02	<0.01	<0.10	<0.10
Si	mg/L	4.17	4.41	5.75	8.98	8.61	4.88	12.2	10.9	10.1	1.12	2.61	1.74	1.03
Sn	mg/L	0.02	<0.02	<0.05	<0.10	<0.10	<0.02	<0.05	<0.10	<0.10	co.02	<0.05	co.10	<0.10
Te	mg/L	<0.04	<0.04	<0.05	<0.20	<0.20	<0.04	<0.05	<0.20	<0.20	co.04	co.05	<0.20	<0.20
Zn	mg/L	0.17	3.23	2.95	2.43	2.19	3.01	1.19	1.98	1.91	0.039	0.83	0.07	<0.02

ICP-ES Scan on Pore Waters in Column 3 (Substrate plus Pyrrhotite)

Element	Unit	pH 3.0 Water	Water			Interface			Tailings		
			Dec-2 1-94	Jun-26-95	Jan-22-96	Dec-2 1-94	Jun-26-95	Jan-22-96	Dec-2 1-94	Jun-26-95	Jan-22-96
Al	mg/L	1.70	2.66	3.80	1.97	2.54	3.94	1.79	0.29	1.04	1.69
As	mg/L	< 0.01	co.01	co.10	0.17	< 0.01	< 0.10	0.24	< 0.01	< 0.10	< 0.05
Ba	mg/L	0.042	0.059	0.13	0.07	0.057	0.14	0.06	0.014	0.13	0.04
Be	mg/L	< 0.001	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005
Ca	mg/L	297	352	350	401	364	350	386	759	693	638
Cd	mg/L	co. 002	co. 002	co. 005	< 0.01	0.004	< 0.005	< 0.01	< 0.002	< 0.005	< 0.01
Co	mg/L	0.057	0.056	0.071	co. 02	0.079	0.083	< 0.02	< 0.004	< 0.01	< 0.02
Cr	mg/L	co. 004	< 0.004	0.17	0.03	0.006	0.17	< 0.02	< 0.004	0.17	0.03
Cu	mg/L	0.21	0.25	0.022	0.69	0.23	0.023	0.67	< 0.003	< 0.010	0.78
Fe	mg/L	6.90	10.1	14.6	0.59	9.43	15	0.59	0.015	5.35	1.37
Mg	mg/L	14.4	15.6	14.7	18.7	15.8	14.8	18.3	27.6	67.7	101
Mn	mg/L	0.58	0.82	2.16	2.36	1.05	2.21	2.30	0.063	0.42	1.16
Mo	mg/L	0.013	0.0187	< 0.020	0.12	0.024	< 0.020	0.16	< 0.007	< 0.020	0.12
Na	mg/L	127	146	117	135	147	117	133	110	120	141
Ni	mg/L	2.08	2.48	2.69	2.34	2.65	2.74	2.37	< 0.01	0.12	0.07
P	mg/L	0.10	0.06	0.31	co.10	0.04	0.27	0.12	0.14	0.19	< 0.10
Pb	mg/L	0.07	< 0.02	0.006	< 0.10	0.06	0.005	< 0.10	< 0.02	< 0.005	< 0.10
S	mg/L	597	881	308	397	517	292	322	3289	643	633
Sb	mg/L	< 0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Se	mg/L	< 0.02	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10
Si	mg/L	4.17	5.84	9.93	10.7	6.15	9.75	10.5	0.44	3.07	2.35
Sn	mg/L	0.02	< 0.02	< 0.05	CO.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Te	mg/L	co. 04	< 0.04	< 0.05	co. 20	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20
Zn	mg/L	0.17	0.21	0.81	0.32	0.24	0.92	0.25	< 0.004	0.26	0.07

ICP-ES Scan on Pore Waters in Column 4 (Thickened Pyrrhotite)

Element	Unit	pH 3.0 Water	Water			Interface			Tailings		
			Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96
Al	mg/L	1.70	1.41	1.39	1.70	1.28	0.88	1.81	0.76	1.16	1.72
As	mg/L	< 0.01	< 0.01	< 0.10	< 0.05	< 0.01	< 0.10	0.07	< 0.01	< 0.10	0.21
Ba	mg/L	0.042	0.032	0.12	0.05	0.033	0.12	0.04	0.012	0.12	0.03
Be	mg/L	< 0.001	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005
Ca	mg/L	297	212	251	337	231	345	366	1353	1530	1190
Cd	mg/L	< 0.002	< 0.002	< 0.005	< 0.01	0.003	0.007	< 0.01	< 0.002	< 0.005	< 0.01
Co	mg/L	0.057	0.028	0.040	< 0.02	0.028	0.032	< 0.02	0.014	0.011	< 0.02
Cr	mg/L	< 0.004	< 0.004	0.18	0.02	< 0.004	0.18	< 0.02	0.006	0.12	0.04
Cu	mg/L	0.21	0.14	0.014	0.77	0.15	< 0.010	0.86	< 0.003	< 0.010	0.75
Fe	mg/L	6.90	5.05	9.55	3.39	6.38	5.56	3.64	< 0.003	4.73	0.08
Mg	mg/L	14.4	9.08	9.95	14.3	9.60	14.4	15.8	22.3	27.3	32.4
Mn	mg/L	0.58	0.38	0.49	0.54	0.40	0.64	0.61	0.015	0.14	0.033
Mo	mg/L	0.013	0.011	< 0.020	0.17	< 0.007	< 0.020	0.10	< 0.007	< 0.020	0.10
Na	mg/L	127	80.3	71.7	83.1	85.0	74.1	84.8	110	157	181
Ni	mg/L	2.08	1.32	1.34	1.77	1.42	1.33	1.77	< 0.01	0.089	< 0.05
P	mg/L	0.10	< 0.03	0.24	0.29	< 0.03	0.19	0.13	0.33	0.28	0.30
Pb	mg/L	0.07	< 0.02	< 0.005	< 0.10	< 0.02	< 0.005	< 0.10	0.10	< 0.005	< 0.10
S	mg/L	597	401	306	375	320	410	411	7731	2318	3353
Sb	mg/L	< 0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Se	mg/L	< 0.02	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10
Si	mg/L	4.17	2.98	3.19	3.37	3.00	3.56	3.49	0.44	1.50	0.73
Sn	mg/L	0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Te	mg/L	< 0.04	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20
Zn	mg/L	0.17	0.12	0.63	0.20	0.13	0.39	0.16	< 0.004	1.22	0.09

ICP-ES Scan on Pore Waters in Column 5 (SM Tailings)

Element	Unit	pH 3.0 Water	Water			Interface			Tailings		
			Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96	Dec-21-94	Jun-26-95	Jan-22-96
Al	mg/L	1.70	1.76	1.82	3.72	1.66	2.13	3.74	0.75	0.95	1.43
As	mg/L	< 0.01	< 0.01	< 0.10	0.17	< 0.01	< 0.10	0.24	< 0.01	< 0.10	0.31
Ba	mg/L	0.042	0.034	0.13	0.06	0.033	0.14	0.11	0.028	0.12	0.09
Be	mg/L	< 0.001	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005	< 0.001	< 0.002	< 0.005
Ca	mg/L	297	217	262	348	209	270.	349	692	642	690
Cd	mg/L	< 0.002	0.004	< 0.005	< 0.01	0.003	0.005	< 0.01	< 0.002	< 0.005	< 0.01
Co	mg/L	0.057	0.013	0.054	< 0.02	0.036	0.068	< 0.02	0.005	0.018	< 0.02
Cr	mg/L	< 0.004	0.004	0.18	0.03	< 0.004	0.18	0.09	0.006	0.17	0.05
Cu	mg/L	0.21	0.14	< 0.010	0.75	0.15	< 0.010	0.83	< 0.003	< 0.010	0.83
Fe	mg/L	6.90	5.72	12.2	0.52	5.04	27.6	0.62	0.029	5.3	45.5
Mg	mg/L	14.4	12.0	13.9	22.8	11.7	16.6	22.7	54.3	76.0	143
Mn	mg/L	0.58	0.51	0.69	1.01	0.49	0.90	1.07	0.30	0.37	4.15
Mo	mg/L	0.013	0.018	< 0.020	0.13	< 0.007	< 0.020	0.19	0.021	< 0.020	0.12
Na	mg/L	127	96.2	94.3	112	94.7	92.7	123	105	154	204
Ni	mg/L	2.08	1.86	1.94	3.24	1.79	3.02	3.14	< 0.01	0.13	0.20
P	mg/L	0.10	6.92	5.11	< 0.10	6.91	3.59	< 0.10	0.10	0.24	0.10
Pb	mg/L	0.07	0.05	< 0.005	< 0.10	< 0.02	< 0.005	< 0.10	0.06	< 0.005	< 0.10
S	mg/L	597	486	296	350	266	314	329	2932	896	785
Sb	mg/L	< 0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Se	mg/L	< 0.02	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10	< 0.02	< 0.01	< 0.10
Si	mg/L	4.17	3.86	4.65	10.5	3.67	6.85	10.4	1.70	3.19	7.25
Sn	mg/L	0.02	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10	< 0.02	< 0.05	< 0.10
Te	mg/L	< 0.04	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20	< 0.04	< 0.05	< 0.20
Zn	mg/L	0.17	2.85	2.87	2.25	2.81	2.70	2.34	< 0.004	0.63	0.07

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Environmental Services

Lakefield, January 16, 1995

Date Rec. : December 21, 1994

LR. Ref. : DEC7679.C94

Reference : 7777-111

Project : 9448364

Attn : L. Elliott

CERTIFICATE OF ANALYSIS

Element	pH 4 Feed H2O	Column 1 W	Column 1 W/T	Column 1 T	Column 2 W
pH [mg/L]	2.91	3.13	3.63	7.58	2.96
cond. [µmhos/cm]	2770	2580	2490	3840	2550
Diss. O [mg/L]	10.4	9.0	7.2	9.9	9.0
co2 [%]	< 10	< 10	12	690	< 10
TIC [mg/L]	< 1	< 1	< 1	3	< 1
NO3 as N [mg/L]	0.95	0.85	0.57	< 0.005	0.90
NO2 as N [mg/L]	0.078	< 0.006	< 0.006	< 0.006	1.09
F [mg/L]	0.35	0.34	0.34	0.25	0.29
SOL [mg/L]	941	958	1146	889	894
PO4 [mg/L]	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Cl [mg/L]	230	196	193	146	170
Br [mg/L]	5.29	0.58	0.56	< 0.3	1.22
Al [mg/L]	1.70	1.93	1.53	0.57	1.83
As [mg/L]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ba [mg/L]	0.042	0.040	0.041	0.012	0.042
Be [mg/L]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ca [mg/L]	297	288	323	893	307
Cd [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Co [mg/L]	0.057	0.040	0.045	< 0.004	0.039
Cr [mg/L]	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Cu [mg/L]	0.21	0.20	0.13	< 0.003	0.16
Fe [mg/L]	6.90	5.74	9.36	< 0.003	4.60
Mg [mg/L]	14.4	13.7	15.1	22.2	13.2
Mn [mg/L]	0.58	0.56	0.62	0.042	0.57
Mo [mg/L]	0.013	< 0.007	< 0.007	< 0.007	0.025
Na [mg/L]	127	135	131	89.2	720
Ni [mg/L]	2.08	1.99	2.15	0.01	1.87
P [mg/L]	0.10	2.25	1.78	0.16	8.70
Pb [mg/L]	0.07	< 0.02	< 0.02	< 0.02	< 0.02
S [mg/L]	597	358	368	3790	359
Sb [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Se [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Si [mg/L]	4.17	4.15	3.97	0.42	4.41
Sn [mg/L]	0.02	< 0.02	< 0.02	0.02	< 0.02
Te [mg/L]	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Zn [mg/L]	0.17	0.98	0.89	< 0.004	3.23

NOTE: Some detection limits may be elevated due to sample matrix



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Environmental Services

Lakefield, January 16, 1995

Date Rec. : December 21, 1994

LR. Ref. : **DEC7679.C94**

Reference : 7777-111

Project : 9448364

Attn : L. Elliott

CERTIFICATE OF ANALYSIS

E Lement	Column 2 W/T	Column 2 T	Column 3 W	Column 3 U/T	Column 3 T
pH [mg/L]	3.38	7.70	3.03	3.12	7.56
Cond. [μ mhos/cm]	2480	5500	2660	2620	3550
Diss. O [mg/L]	9.5	9.8	9.6	9.5	9.1
co2 [%]	< 10	620	140	< 10	180
TIC [mg/L]	< 1	4.7	< 1	< 1	4.7
NO3 as N [mg/L]	0.43	< 0.005	0.95	0.81	< 0.005
NO2 as N [mg/L]	< 0.006	< 0.006	0.86	0.14	< 0.006
F [mg/L]	0.31	0.29	13.35	0.35	0.28
So4 [mg/L]	1181	1359	923	934	939
PO4 [mg/L]	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Cl [mg/L]	185	187	227	239	139
Br [mg/L]	0.55	< 0.3	10.8	17.2	< 0.3
Al [mg/L]	1.70	0.77	2.66	2.54	0.29
As [mg/L]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ba [mg/L]	0.042	0.037	0.059	0.057	0.014
Be [mg/L]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ca [mg/L]	370	1266	352	364	759
Cd [mg/L]	0.005	< 0.002	< 0.002	0.004	< 0.002
Co [mg/L]	0.051	< 0.004	0.056	0.079	< 0.004
Cr [mg/L]	< 0.004	< 0.004	< 0.004	0.006	< 0.004
Cu [mg/L]	0.12	< 0.003	0.25	0.23	< 0.003
Fe [mg/L]	5.78	0.013	10.1	9.43	0.015
Mg [mg/L]	16.1	49.1	15.6	15.8	27.6
Mn [mg/L]	0.62	0.065	0.82	1.05	0.063
Mo [mg/L]	0.032	0.008	0.018	0.024	< 0.007
Na [mg/L]	117	136	146	147	110
Ni [mg/L]	1.90	< 0.01	2.48	2.65	< 0.01
P [mg/L]	7.18	0.35	0.06	0.04	0.14
Pb [mg/L]	0.05	< 0.02	< 0.02	0.06	< 0.02
S [mg/L]	630	8556	881	517	3289
Sb [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Se [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Si [mg/L]	4.88	1.12	5.84	6.15	0.44
Sn [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Te [mg/L]	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Zn [mg/L]	3.01	0.039	0.21	0.24	< 0.004

NOTE: Some detection limits may be elevated due to sample matrix



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Environmental Services

Lakefield, January 16, 1995

Attn : L. Elliott

Date Rec. : December 21, 1994

LR. Ref. : **DEC7679.C94**

Reference : 7777-111

Project : 9448364

CERTIFICATE OF ANALYSIS

Element	Column 4 W	Column 4 U/T	Column 4 T	Column 5 u	Column 5 W/T	Column 5 T
pH [mg/L]	3.32	3.40	7.21	3.12	3.20	7.40
Cond. [µmhos/cm]	1610	1620	5670	2050	2020	3430
Diss. O [mg/L]	9.5	9.6	8.4	10.0	9.7	8.0
co2 [%]	< 1.0	< 10	410	280	130	230
TIC [mg/L]	< 1	< 1	< 1	< 1	< 1	9.6
NO3 as N [mg/L]	0.52	0.54	< 0.005	0.61	0.75	< 0.005
NO2 as N [mg/L]	0.078	0.15	< 0.006	0.54	< 0.006	< 0.006
F [mg/L]	0.18	0.20	0.31	0.28	0.29	0.22
SO4 [mg/L]	567	503	1140	1390	620	934
PO4 [mg/L]	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Cl [mg/L]	123	124	157	165	166	143
Br [mg/L]	10.2	13.9	< 0.3	2.20	1.77	< 0.3
Al [mg/L]	1.41	1.28	0.76	1.76	1.66	0.75
As [mg/L]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ba [mg/L]	0.032	0.033	0.012	0.034	0.033	0.028
Be [mg/L]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ca [mg/L]	212	231	1353	217	209	692
Cd [mg/L]	< 0.002	0.003	< 0.002	0.004	0.003	< 0.002
Co [mg/L]	0.028	0.028	0.014	0.043	0.036	0.005
Cr [mg/L]	< 0.004	< 0.004	0.006	0.004	< 0.004	0.006
Cu [mg/L]	0.14	0.15	< 0.003	0.14	0.15	< 0.003
Fe [mg/L]	5.05	6.38	< 0.003	5.72	5.04	0.029
Mg [mg/L]	9.08	9.60	22.3	12.0	11.7	54.3
Mn [mg/L]	0.38	0.40	0.015	0.51	0.49	0.30
Mo [mg/L]	0.011	< 0.007	< 0.007	0.018	< 0.007	0.021
Na [mg/L]	80.3	85.0	110	96.2	94.7	105
Ni [mg/L]	1.32	1.42	< 0.01	1.86	1.79	< 0.01
P [mg/L]	< 0.03	< 0.03	0.33	6.92	6.91	0.10
Pb [mg/L]	< 0.02	< 0.02	0.10	0.05	< 0.02	0.06
S [mg/L]	401	320	7731	486	266	2932
Sb [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Se [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Si [mg/L]	2.98	3.00	0.44	3.86	3.67	1.70
Sn [mg/L]	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Te [mg/L]	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Zn [mg/L]	0.12	0.13	< 0.004	2.85	2.81	< 0.004

NOTE: Some detection limits may be elevated due to sample matrix



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Environmental Services

Lakefield, January 16, 1995

Attn : L. Elliott

Date Rec. : December 21, 1994

LR. Ref. : **DEC7687.C94**

Reference : 7777-111

Project : 9448364

CERTIFICATE OF ANALYSIS

No.	Sample ID	EMF mV
5	pH 4 Feed H2O	417
6	Column 1 W	315"
7	Column 1 W/T	230 [~]
8	Column 1 T	137 [~]
9	Column 2 W	378
10	Column 2 W/T	233 [~]
11	Column 2 T	139 [~]
12	Column 3 W	364 [~]
13	Column 3 W/T	377 [~]
14	Column 3 T	140 [~]
15	Column 4 W	357 [~]
16	Column 4 W/T	339 [~]
17	Column 4 T	143 [~]
18	Column 5 W	311 [~]
19	Column 5 W/T	294
20	Column 5 T	141 [~]

NOTE: Some detection limits may be elevated due to sample matrix

d: 
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Environmental Project Analyses

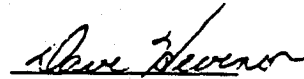
Lakefield, May 25, 1995

Attn : L. Liu

Date Rec. : May 9, 1995
LR. Ref. : **MAY6545.C95**
Reference : 9448364
Project : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	CNT mg/L	sulphide mg/L	SO4- mg/L	ThioSalto asSO4mg/l
4	Moose pH 7	c 0.01	< 0.5	812	< 10
5	Moose pH 4	< 0.01	< 0.5	627	< 10



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Environmental Services

Attn : Richard Wagner

Lakefield, January 16, 1995

Date Rec. : December 23, 1994

LR. Ref. : **DEC7696.C94**

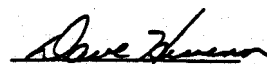
Reference : 7777-1 11

Project : 9448364

CERTIFICATE OF ANALYSIS

Element	Pyrrhotite	Tails	Slime	Mix	Head
Al [g/t]		7100			31000
As [g/t]		< 30			< 30
Ba [g/t]		49			250
Be [g/t]		< 1.0			< 1.0
Ca [g/t]		5900			20000
Cd [g/t]		27			21
Co [g/t]		170			140
Cr [g/t]		75			72
Cu [g/t]		720			1600
Fe [g/t]		560000			370000
La [g/t]		< 50			< 50
Mg [g/t]		3000			10000
Mn [g/t]		380			650
MO [g/t]		< 10			< 50
Na [g/t]		3000			12000
Ni [g/t]		7620			5600
P [g/t]		62			170
Pb [g/t]		76			140
Sb [g/t]		< 20			< 20
Se [g/t]		< 50			< 50
Sn [g/t]		< 20			< 20
Te [g/t]		< 20			< 20
Y [g/t]		< 5.0			< 5.0
Zn [g/t]		190			160

NOTE: Some detection limits may be elevated due to sample matrix



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Attn : Richard Wagner

Lakefield, January 16, 1995

Date Rec. : December 23, 1994

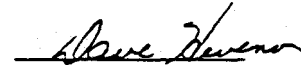
LR. Ref. : **DEC7695.C94**

Reference : 7777-111

Project : 9448364

CERTIFICATE OF ANALYSIS

No.	Sample ID	S
1	Pyrrhotite Tails	30.2
2	Slime Mix Head	19.0



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Environmental Services

Attn : Richard Wagner

Lakefield, January 16, 1995

Date Rec. : December 23, 1994

LR. Ref. : **DEC7694.C94**

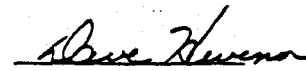
Reference : 7777-111

Project : 9448364

CERTIFICATE OF ANALYSIS

Element	Pyrrhotite Tails	Slime Mix Head
pH units	7.88	6.83
Cond. [μ mhos/cm]	5550	5354
TDS [mg/L]	5410	5180
Turbidity [NTU]	1.1	4.0
Alk. mg/L [as CaCO ₃]	7	11
Acidity [mg/L CaCO ₃]	< 1	< 1
F [mg/L]	0.27	0.37
Cl ⁻ [mg/L]	156	203
SO ₄ ⁻ [mg/L]	991	1129
*Sulphide [mg/L]	**	--
NH ₃ +NH ₄ [(N) mg/L]	3.87	4.37
NO ₃ (N) [mg/L]	< 0.005	< 0.005
NO ₂ (N) [mg/L]	< 0.006	< 0.006
TKN [mg/L]	4.92	5.37
CNT [mg/L]	< 0.01	< 0.01
S203 [mg/L]	2761	1882

* Can not run Sulphide due to S203 interference.



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Division of Falconbridge Limited

P.O. Box 4300, 185 Concession St., Lakefield, Ontario, K0L 2H0

Phone : 705-652-2000 • FAX : 705-652-6365

Environmental Services

Attn : L. Elliott

Lakefield, January 16, 1995

Date Rec. : December 23, 1994

LR. Ref. : **DEC7693.C94**

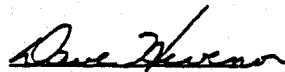
Reference : 7777-111

Project : 9448364

CERTIFICATE OF ANALYSIS

Element	Pyrrhotite Tails	Slime Mix Head
Hardness [mg/L]	3790	3430
Al [mg/L]	< 0.10	< 0.10
Ba [mg/L]	< 0.02	0.04
Be [mg/L]	< 0.005	< 0.005
Ca [mg/L]	1480	1290
Cd [mg/L]	< 0.01	< 0.01
Co [mg/L]	< 0.01	0.02
Cr [mg/L]	< 0.02	< 0.02
Cu [mg/L]	< 0.02	< 0.02
Fe [mg/L]	< 0.02	0.02
Mg [mg/L]	22.9	50.7
Mn [mg/L]	0.02	0.05
Mo [mg/L]	< 0.05	< 0.05
Na [mg/L]	162	163
Ni [mg/L]	0.05	0.21
P [mg/L]	0.20	0.14
Pb [mg/L]	< 0.05	< 0.05
Sb [mg/L]	< 0.05	< 0.05
Sn [mg/L]	< 0.10	< 0.10
Te [mg/L]	< 0.05	< 0.05
Ag [mg/L]	< 0.03	< 0.03
S [mg/L]	3180	2810
Zn [mg/L]	< 0.01	< 0.01

NOTE: Some detection limits may be elevated due to sample matrix


Dave Hevenor

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P.O. Box 4300, 165 Concession St., **Lakefield**, Ontario, K0L 2H0

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Environmental Services
--

Attn : Richard Wagner

Lakefield, January 6, 1995

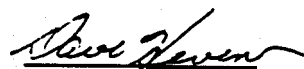
Date Rec. : January 4, 1995

LR. Ref. : **JAN7012.C95**

Reference : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	Diss. 0 mg/L	Cond. @ O S / -
3	Column#1 H2O prt	6.0	2630



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P.O. Box 4300, 185 Concession St., Lakefield, Ontario, K0L 2H0

Phone : 705-652-2000 FAX : 705-652-6365

Environmental Services

Lakefield, February 9, 1995

Attn : L. Elliott c.c. Richard Wagner

Date Rec. : January 12, 1995

LR. Ref. : **JAN7039.C95**

Reference : 7777-1 11

CERTIFICATE OF ANALYSIS

HO.	Sample ID	Diss. O mg/L	co2 mg/L
1	Col#1 H2O	10.4	< 10
2	Col#1 Interface	9.44	10
3	Col#1 Tailings	9.0	20
4	Col#2 H2O	9.2	< 10
5	Col#2 Interface	8.2	20
6	Col#2 Tailings	11.0	710
7	Col#3 H2O	10.9	160
8	Col#3 Interface	10.3	40
9	Col#3 Tailings	9.4	340
10	Col#4 H2O	11.3	< 10
11	Col#4 Interface	9.8	< 10
12	Col#4 Tailing8	9.4	630
13	Col#5 H2O	11.7	140
14	Col#5 Interface	10.1	100
15	Col#5 Tailing6	7.7	110



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Environmental Services

Attn : L. Elliott

Lakefield, February 9, 1995

Date Rec. : February 7, 1995

LR. Ref. : FEB7082. C95

Reference : 7777-1 11

CERTIFICATE OF ANALYSIS

No.	Sample ID	Cond. µmhos/cm
5	Col#1 Water	2526
6	Col#1 Interface	2509
7	Col#1 Tails H2O	3864
8	Col#2 Water	2619
9	Col#2 Interface	2906
10	Col#2 Tails H2O	5600
11	Col#3 Water	2454
12	Col#3 Interface	2460
1 3	Col#3 Tails H2O	3830
14	Col#4 Water	1587
15	Col#4 Interface	2080
16	Col#4 Tails H2O	5741
17	Col#5 Water	1907
18	Col#5 Interface	2004
19	Col#5 Tails H2O	3733



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copy : Linda Elliot

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Environmental Services

Lakefield, March 10, 1995

Attn : R. Wagner

Date Rec. : February 21, 1995

LR. Ref. .. FEB7117. C95

Reference : 9444836

Project : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	Br mg/L	CL- mg/L	F mg/L	NO3 mg/L	NO2- mg/L	PO4 mg/L	SO4- mg/L
6	Column #1 W	1.66	215	..	0.50	0.52	< 0.3	1041
7	Column #1 U/f	1.49	196	..	0.01	0.20	< 0.3	1137
8	Column #1 T	< 0.3	166	..	< 0.005	< 0.006	< 0.3	1032
9	Column #2 W	1.04	185	..	0.68	< 0.006	6.42	953
10	Column #2 W/T	2.28	188	..	0.27	< 0.006	2.07	1256
11	Column #2 T	< 0.3	209	..	< 0.005	< 0.006	< 0.3	1456
12	Column #3 W	13.2	212	..	1.13	< 0.006	< 0.3	1056
13	Column a W/T	82.6	228	..	0.34	< 0.006	< 0.3	1030
14	Column #3 T	0.94	167	..	< 0.005	< 0.006	< 0.3	1254
15	Column #4 W	39.8	119	..	1.08	0.06	< 0.3	570
16	Column #4 W/T	150.0	145	..	0.55	1.19	< 0.3	697
17	Column #4 T	1.67	176	..	< 0.005	< 0.006	< 0.3	1336
18	Column #5 W	3.89	166	..	0.61	< 0.006	13.4	704
19	Column #5 W/T	5.23	186	..	0.29	< 0.006	7.76	801
20	Column #5 T	< 0.3	172	..	< 0.005	< 0.006	< 0.3	1232

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Will only be issued for 304

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Environmental Services

Lakefield, March 10, 1995

Attn : R. Wagner

Date Rec. : February 22, 1995

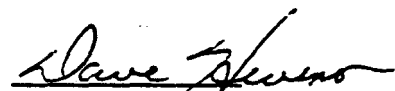
LR. Ref. : FEB7113.C95

Reference : 9444836

Project : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	S mg/L	Fe mg/L	Ni mg/L
6	Column #1 w	275	12.5	1.84
7	Column #1 W/T	322	40.0	1.66
8	Column #1 T	1020	0.81	0.02
9	Column #2 w	254	3.90	1.52
10	Column #2 W/T	458	11.9	2.05
11	Column #2 T	1860	0.26	< 0.02
12	Column #3 w	267	8.10	2.19
13	Column #3 W/T	272	8.34	2.25
14	Column #3 T	1030	0.30	< 0.02
15	Column #4 w	219	4.76	1.16
16	Column #4 W/T	443	2.07	1.04
17	Column #4 T	2040	0.62	0.01
18	Column #5 w	243	4.23	1.62
19	Column #5 W/T	301	3.26	1.52
20	Column #5 T	936	1.95	0.02



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Environmental Services

Lakefield, March 10, 1995

Date Rec. : **February 21, 1995**

LR. Ref. : **FEB7112.C95**

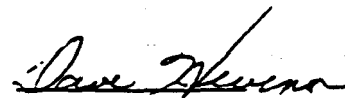
Reference : 9444836

Project : 7777-111

Attn : R. Wagner

CERTIFICATE OF ANALYSIS

No.	Sample ID	pH units	EMF mV	Cond. μ hos/cm	Diss. O mg/L	co2 mg/L	TIC mg/L
6	Column #1 w	3.32	483	2563	7.0	< 10	< 1
7	Column #1 W/T	3.25	327	2668	4.0	< 10	< 1
8	Column #1 T	7.17	38	3829	5.3	< 10	3.8
9	Column #2 w	3.06	461	2652	7.0	< 10	< 1
10	Column #2 W/T	3.48	187	2960	4.3	< 10	< 1
11	Column #2 T	7.13	83	5677	6.4	< 10	3.2
12	Column #3 w	3.70	303	2487	7.5	< 10	< 1
13	Column #3 W/T	3.73	289	2487	7.4	< 10	< 1
14	Column #3 T	7.16	54	3774	5.3	< 10	5.9
15	Column #4 w	3.71	381	1596	8.3	< 10	< 1
16	Column #4 W/T	6.80	298	2 1 2 6	4.9	< 10	< 1
17	Column #4 T	7.00	89	5829	5.4	< 10	< 1
18	Column #5 w	3.88	238	1907	7.6	< 10	< 1
19	Column #5 W/T	4.20	200	2016	3.5	< 10	< 1
20	Column #5 T	7.33	63	3726	5.2	< 10	5.4



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Phone : 705-652-2038 FAX : 705-652-6441

Environmental Services

Lakefield, May 4, 1995

Attn : Richard Wagner

Date Rec. : April 18, 1995

LR. Ref. : **APR6529.C95**

Reference : Moose Lake Sub-aqua

Project : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	Diss. O mg/L	pH	EHF mV	Cond. μ mhos/cm	SO ₄ - mg/L	TIC mg/L	Fe mg/L	Ni mg/L	S mg/L	co2 mg/L
5	Column #1 W	9.6	3.14	522	2475	942	< 1	18.5	2.07	314	< 10
6	Column #1 W/T	6.3	3.55	287	2576	1164	< 1	52.6	1.17	388	< 10
7	Column #1 T	8.9	7.31	90	3821	887	3.2	0.14	0.03	3640	303
8	Column #2 W	9.9	2.90	488	2641	905	< 1	4.53	1.68	314	68
9	Column #2 U/T	8.9	3.45	189	3087	1395	< 1	44.3	0.97	536	< 10
10	Column #2 T	8.7	7.18	93	5632	1202	< 1	0.20	0.02	5680	409
11	Column #3 W	9.5	4.02	277	2496	857	< 1	7.58	2.20	344	34
12	Column #3 W/T	9.9	4.02	279	2480	851	< 1	7.74	2.10	351	< 10
13	Column #3 T	8.3	7.56	107	3592	1686	6.1	0.16	0.03	1080	51
14	Column #4 W	10.1	3.92	391	1604	461	< 1	3.81	1.03	260	29
15	Column #4 U/T	8.6	7.32	163	2257	593	5.4	0.14	0.76	528	22
16	Column #4 T	8.4	7.32	30	5938	1143	< 1	0.06	0.03	9000	748
17	Column #5 W	9.4	3.73	217	1889	583	< 1	3.71	1.51	281	177
18	Column #5 W/T	7.7	4.56	174	2066	954	< 1	2.86	1.26	366	4s
19	Column #5 T	8.8	7.45	84	3742	931	10.8	0.44	0.03	3970	211



Dave Hevenor

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Environmental Services

Lakefield, June 24, 1996

Attn : Liang

Date Rec. : June 27, 1995
LR. Ref. : JUN6586 .R95
Reference : 9448364
Project : 7777-111

CERTIFICATE OF ANALYSIS

Element	1W	11	1T	2w	21	2T	3w
Hardness [mg/L]	920	902	2240	896	1250	3380	934
F [mg/l]	< 11	< 11	< 11	< 11	< 11	< 11	< 11
Cl- [mg/l]	180	168	77.7	175	182	170	199
NO2 as N [mg/l]	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66
NO3 as N [mg/l]	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55
Br [mg/l]	< 33	< 33	< 33	< 33	< 33	< 33	130
PO4 [mg/l]	< 33	< 33	< 33	< 33	< 33	< 33	< 33
SO4- [mg/l]	1032	1017	1083	986	1495	1528	923
Al [mg/L]	2.13	2.05	0.97	2.12	1.46	1.06	3.80
As [mg/L]	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Ba [mg/L]	0.14	0.13	0.11	0.13	0.11	0.14	0.13
Be [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ca [mg/L]	344	337	845	335	446	1260	350
Cd [mg/L]	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Co [mg/L]	0.050	0.046	< 0.010	0.050	0.021	0.014	0.071
Cr [mg/L]	0.17	0.17	0.16	0.17	0.16	0.16	0.17
Cu [mg/L]	0.040	0.038	< 0.010	0.018	< 0.010	< 0.010	0.022
Fe [mg/L]	12.3	13.6	5.23	10.0	30.3	4.95	14.6
Mg [mg/L]	14.8	14.7	31.3	14.4	32.8	56.8	14.7
Mn [mg/L]	0.89	0.94	0.17	0.87	1.63	0.18	2.16
Mo [mg/L]	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Na [mg/L]	131	124	125	107	112	213	117
Ni [mg/L]	1.97	1.84	0.15	1.88	0.73	0.13	2.69
P [mg/L]	0.41	0.22	0.25	4.26	0.27	0.30	0.31
Pb [mg/L]	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006
S [mg/L]	344	339	1139	329	498	2054	308
Sb [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Se [mg/L]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
si [mg/L]	6.42	5.96	1.90	5.75	12.2	2.61	9.93
Sn [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Te [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zn [mg/L]	1.60	1.40	0.88	2.95	1.19	0.83	0.81
K [mg/L]	38.9	37.2	39.7	38.9	47.7	93.0	40.4
Diss. O [mg/L]	8.6	8.5	8.7	9.2	8.9	8.2	9.0
TIC [mg/L]	< 1	< 1	4.0	< 1	6.7	6.4	< 1
TKN (N) [mg/L]	2.0	7.0	3.3	3.0	0.6	7.5	17.7
Alk. mg/L [as cacO3]	< 1	< 1	21	< 1	< 1	36	
Acidity [mg/lcacO3]	86	101	1040	117	142	586	390

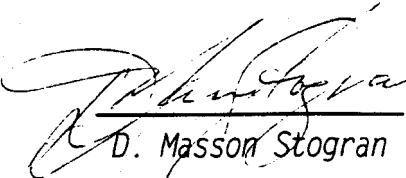
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Phone : 705-652-2038 • FAX : 705-652-6441

JUN6586.R95

Element	1W	11	1T	2W	21	2T	3w
Turbidity [NTU]	41	90	5.0	1.7	150	1.5	2.3
TDS [mg/l]	1410	1960	4120	2010	2540	6170	2380
CNT [mg/l]	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.12
Fe2+ [mg/L]	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5	14.6
Fe3+ [mg/L]	12.3	13.6	5.2	10.0	30.3	< 5.0	< 5.0
Thiosalts [as SO4]	< 100	< 100	2333	< 100	< 100	4636	< 100



D. Masson Stogran

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LAKEFIELD RESEARCH LIMITED

P.O. Box 4300, 185 Concession St., Lakefield, Ontario, KOL 2H0

Phone : 705-652-2038 - FAX : 705-652-6441

Environmental Services

Attn : Liang

Lakefield, June 24, 1996

Date Rec. : June 27, 1995
 LR. Ref. : JUN6586 .R95
 Reference : 9448364
 Project : 7777-111

CERTIFICATE OF ANALYSIS

Element	31	' 3T	4w	41	4T	5W	51	5T
Hardness [mg/L]	935	2010	668	921	3930	711	743	1920
F [mg/l]	< 11	< 11	< 11	< 11	< 11	< 11	< 11	< 11
Cl- [mg/l]	191	114	107	105	148	140	154	147
NO2 as N [mg/l]	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66	< 0.66
NO3 as N [mg/l]	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55	< 0.55
Br [mg/l]	131	< 33	72.6	139	< 33	< 33	< 33	< 33
PO4 [mg/l]	< 33	< 33	< 33	< 33	< 33	< 33	< 33	< 33
SO4- [mg/l]	a77	1928	611	669	1402	889	942	1612
Al [mg/L]	3.94	1.04	1.39	0.88	1.16	1.82	2.13	0.95
As [mg/L]	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Ba [mg/L]	0.14	0.13	0.12	0.12	0.12	0.13	0.14	0.12
Be [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ca [mg/L]	350	693	251	345	1530	262	270	642
Cd [mg/L]	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	0.005	< 0.005
Co [mg/L]	0.083	< 0.010	0.040	0.032	0.011	0.054	0.068	0.018
Cr [mg/L]	0.17	0.17	0.18	0.18	0.12	0.18	0.18	0.17
Cu [mg/L]	0.023	< 0.010	0.014	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fe [mg/L]	15.0	5.35	9.55	5.56	4.73	12.2	27.6	5.30
Mg [mg/L]	14.8	67.7	9.95	14.4	27.3	13.9	16.6	76.0
Mn [mg/L]	2.21	0.42	0.49	0.64	0.14	0.69	0.90	0.37
Mo [mg/L]	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Na [mg/L]	117	120	71.7	74.1	157	94.3	92.7	154
Ni [mg/L]	2.74	0.12	1.34	1.33	0.089	1.94	3.02	0.13
P [mg/L]	0.27	0.19	0.24	0.19	0.28	5.11	3.59	0.24
Pb [mg/L]	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
S [mg/L]	292	643	306	410	2318	296	314	896
Sb [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Se [mg/L]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Si [mg/L]	9.75	3.07	3.19	3.56	1.50	4.65	6.85	3.19
Sn [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Te [mg/L]	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zn [mg/L]	92	0.26	0.63	0.39	1.22	2.87	2.70	0.63
K [mg/L]	40.0	74.0	25.9	27.5	59.3	34.4	34.5	79.4
Diss. O [mg/L]	9.1	8.6	8.8	9.2	a.3	8.8	8.6	a.2
TIC [mg/L]	< 1	13.9	< 1	< 1	< 1	< 1	< 1	16.4
TKN (N) [mg/L]	nss	1.5	a.5	a.0	0.5	< 0.5	3.7	5.0
Alk.mg/L [as caco3]	< 1	a3	< 1	17	7	< 1	< 1	72
Acidity [mg/lcaco3]	402	< 1	469	406	315	116	134	566

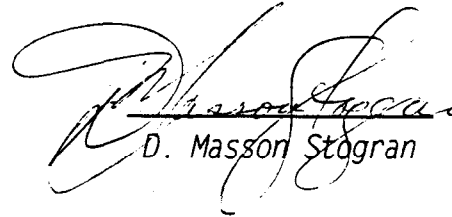
LAKEFIELD RESEARCH LIMITED

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Phone : 705-652-2038 - FAX : 705-652-6441

JUN6586.R95

Element	31	3T	4W	41	4T	5w	51	5T
Turbidity [NTU]	2.3	5.6	3.0	1.8	2.3	3.3	2.3	4.3
TDS [mg/l]	2450	3320	1520	2310	6220	1610	1630	3310
CNT [mg/l]	0.06	< 0.01	0.09	0.05	< 0.01	0.01	< 0.01	< 0.01
Fe2+ [mg/L]	15.0	< 5.0	6.1	< 5.0	< 5.0	< 5.0	27.6	5.30
Fe3+ [mg/L]	< 5.0	5.4	< 5.0	5.6	< 5.0	12.2	< 5.0	< 5.0
Thiosalts Cas S041	< 100	< 100	307	560	5553	< 100	< 100	1075



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Environmental Services

Lakefield, December 1, 1995

Attn : Liang Liu

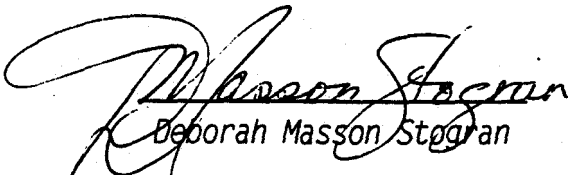
Date Rec. : November 20, 1995

LR. Ref. : NOV6722 .R95

Reference : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	S mg/L	SO4- mg/l	Ni mg/L	Fe mg/L	Fe3+ mg/L	Fe2+ mg/L	TIC mg/L
6	Analysis Date	24.11.95	24.11.95	24.11.95	21.11.95	22.11.95	22.11.95	23.11.95
7	Analysis Time	10:54	15:19	10:54	11:26	09:40	09:40	09:54
8	1W	372	1116	1.66	2.89	2.59	0.31	< 1
9	1I	398	1194	1.45	23.9	16.4	7.65	< 1
10	1T	2870	1276	< 0.01	0.06	< 0.05	0.19	3.9
11	2W	398		1.52	1.88	1.62	0.28	< 1
12	2I	373	1194 1119	1.30	4.23	3.94	0.26	< 1
13	2T	4450	1722	0.02	< 0.05	< 0.05	0.10	2.9
14	3W	311	933	2.12	3.27	3.03	0.27	< 1
15	3I	305	915	2.10	3.38	3.15	0.25	< 1
16	3T	620	1860	0.01	2.57	0.51	2.09	25.3
17	4W	342	618	1.47	3.00	2.74	0.26	< 1
18	4I	337	653	1.44	2.94	2.65	0.25	< 1
19	4T	3050	1771	< 0.01	< 0.05	< 0.05	0.09	< 1
20	5W	299	897	2.64	1.38	0.56	0.84	< 1
21	5I	294	882	2.54	1.73	0.64	1.06	28< 1
22	5T	805	2363	0.02	20.3	10.6		


Deborah Masson Stogran

LAKEFIELD RESEARCH LIMITED

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Environmental Services

Attn : Liang Liu

Lakefield, February 12, 1996

Date Rec. : January 23, 1996

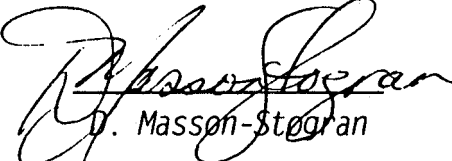
LR. Ref. : JAN7052 .R96

Reference : LR 9600262

Project : 7777-111

CERTIFICATE OF ANALYSIS

No.	Sample ID	TIC mg/L	S04- mg/L	Fe3+ mg/L	Fe2+ mg/L	Thi osal t s asS04mg/L	Al mg/L	AS mg/L	Ba mg/L	Be mg/L	Ca mg/L
9	1W	< 1	1054	< 0.5	1.8	< 100	3.58	0.28	0.07	< 0.005	395
10	1I	< 1	1158	11.5	8.4	560	3.14	0.24	0.07	< 0.005	417
11	1T	3.4	1203	< 0.5	< 0.5	2432	2.36	0.17	0.04	< 0.005	937
12	2w	< 1	1129	< 0.5	2.6	< 100	3.14	0.35	0.06	< 0.005	408
13	2I	< 1	1150	< 0.5	3.6	< 100	3.20	0.31	0.10	< 0.005	444
14	2T	2.4	1653	< 0.5	< 0.5	3492	2.04	0.24	0.08	< 0.005	1242
15	3W	< 1	875	< 0.5	0.6	100	1.97	0.17	0.07	< 0.005	401
16	3I	< 1	834	< 0.5	0.6	206	1.79	0.24	0.06	< 0.005	386
17	3T	27.8	1652	< 0.5	1.2	< 100	1.69	< 0.05	0.04	< 0.005	638
18	4W	< 1	565	< 0.5	3.1	1034	1.70	< 0.05	0.05	< 0.005	337
19	4I	< 1	618	< 0.5	3.4	632	1.81	0.07	0.04	< 0.005	366
20	4T	< 1	1912	< 0.5	< 0.5	2380	1.72	0.21	0.03	< 0.005	1190
21	5w	< 1	891	< 0.5	0.5	< 100	3.72	0.17	0.06	< 0.005	348
22	5I	< 1	855	< 0.5	0.4	< 100	3.74	0.24	0.11	< 0.005	349
23	5T	20.5	2197	36.3	9.2	< 100	1.43	0.31	0.09	< 0.005	690



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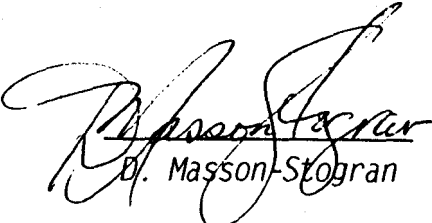
Attn : Liang Liu

Lakefield, February 12, 1996

Date Rec. : January 23, 1996
LR. Ref. : JAN7052 .R96
Reference : LR 9600262
Project : 7777-111

CERTIFICATE OF ANALYSIS

No. Sample ID	Cd mg/L	Co mg/L	Cr mg/L	CU mg/L	Fe mg/L	Mg mg/L	Mn mg/L	Mo mg/L	Na mg/L	Ni mg/L	P mg/L
9 1W	< 0.01	< 0.02	0.03	0.96	1.97	20.0	1.17	0.09	147	1.80	0.30
10 1I	< 0.01	< 0.02	< 0.02	0.81	19.9	23.4	1.43	0.14	141	1.44	< 0.10
11 1T	< 0.01	< 0.02	0.03	0.50	0.21	43.7	0.096	0.15	153	< 0.05	0.18
12 2w	< 0.01	< 0.02	< 0.02	0.76	2.58	22.7	1.06	0.09	126	1.67	0.36
13 2I	< 0.01	< 0.02	0.05	0.92	3.88	28.4	1.39	0.17	164	1.24	0.14
14 2T	< 0.01	< 0.02	0.09	0.66	0.19	70.4	0.15	0.24	276	0.10	0.44
15 3w	< 0.01	< 0.02	0.03	0.69	0.59	18.7	2.36	0.12	135	2.34	< 0.10
16 3I	< 0.01	< 0.02	< 0.02	0.67	0.59	18.3	2.30	0.16	133	2.37	0.12
17 3T	< 0.01	< 0.02	0.03	0.78	1.37	101	1.16	0.12	141	0.07	< 0.10
18 4w	< 0.01	< 0.02	0.02	0.17	3.39	14.3	0.54	0.17	83.1	1.71	0.29
19 4I	< 0.01	< 0.02	< 0.02	0.86	3.64	15. P	0.61	0.10	84.8	1.77	0.13
20 4T	< 0.01	< 0.02	0.04	0.75	0.08	32.4	0.033	0.10	181	< 0.05	0.30
21 5W	< 0.01	< 0.02	0.03	0.75	0.52	22.8	1.01	0.13	112	3.24	< 0.10
22 5I	< 0.01	< 0.02	0.09	0.83	0.62	22.7	1.07	0.19	123	3.14	< 0.10
23 5T	< 0.01	< 0.02	0.05	0.83	45.5	143	4.15	0.12	204	0.20	0.10



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Environmental Services

Attn : Liang Liu

Lakefield, February 12, 1996

Date Rec. : January 23, 1996

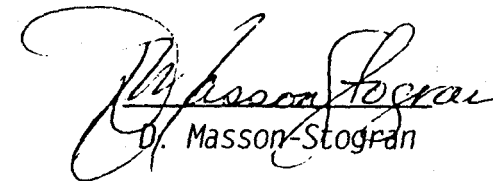
LR. Ref. : **JAN7052.R96**

Reference : LR 9600262

Project : 7777-111

CERTIFICATE OF ANALYSIS

No. Sample ID	Pb mg/L	S mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L	Te mg/L	Zn Hard mg/L as	CaCO3
9 1W	< 0.10	386	< 0.10	< 0.10	7.62	< 0.10	< 0.20	1.04	213
10 1I	< 0.10	409	< 0.10	< 0.10	9.07	< 0.10	< 0.20	0.83	227
11 1T	< 0.10	3047	< 0.10	< 0.10	0.94	< 0.10	< 0.20	0.07	504
12 2w	< 0.10	416	< 0.10	< 0.10	8.98	< 0.10	< 0.20	2.43	222
13 21	< 0.10	435	< 0.10	< 0.10	10.9	< 0.10	< 0.20	1.98	245
14 2T	< 0.10	6151	< 0.10	< 0.10	1.74	< 0.10	< 0.20	0.07	678
15 3w	< 0.10	397	< 0.10	< 0.10	10.7	< 0.10	< 0.20	0.32	216
16 31	< 0.10	322	< 0.10	< 0.10	10.5	< 0.10	< 0.20	0.25	208
17 3T	< 0.10	633	< 0.10	< 0.10	2.35	< 0.10	< 0.20	0.07	402
18 4w	< 0.10	375	< 0.10	< 0.10	3.37	< 0.10	< 0.20	0.20	180
19 41	< 0.10	411	< 0.10	< 0.10	3.49	< 0.10	< 0.20	0.16	196
20 4T	< 0.10	3353	< 0.10	< 0.10	0.73	< 0.10	< 0.20	0.09	621
21 5w	< 0.10	350	< 0.10	< 0.10	10.5	< 0.10	< 0.20	2.25	192
22 51	< 0.10	329	< 0.10	< 0.10	10.4	< 0.10	< 0.20	2.34	193
23 5T	< 0.10	785	< 0.10	< 0.10	7.25	< 0.10	< 0.20	0.07	462



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Environmental Services

Att n : Liang Liu

Lakefield, February 22, 1996

Date Rec. : February 9, 1996

LR. Ref. : PEB7101 .R96

Reference : LR 9600487

Project : 7777-1 11

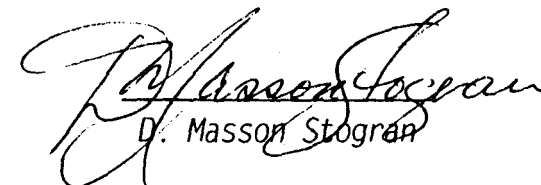
CERTIFICATE OF ANALYSIS

No.	Sample ID	S04- Thiosalts mg/L. asS04	mg/L	pH filter units	pH (S04) units	S mg/L
6	Analysis Date	20.02.96	20.02.96	12.02.96	21.02.96	14.02.96
7	Analysis Time	22:27	22:28	11:15	07:35	18:29
9	SM Tailings	2170	143	7.53	8.23	793

Sample Date: Feb 9 96

Sample Received: Feb 9 9.6

Instructions: write down time when sample is filtered
write down time when analyze S04
pH right after filtration
pH (2nd) right after analyze S04



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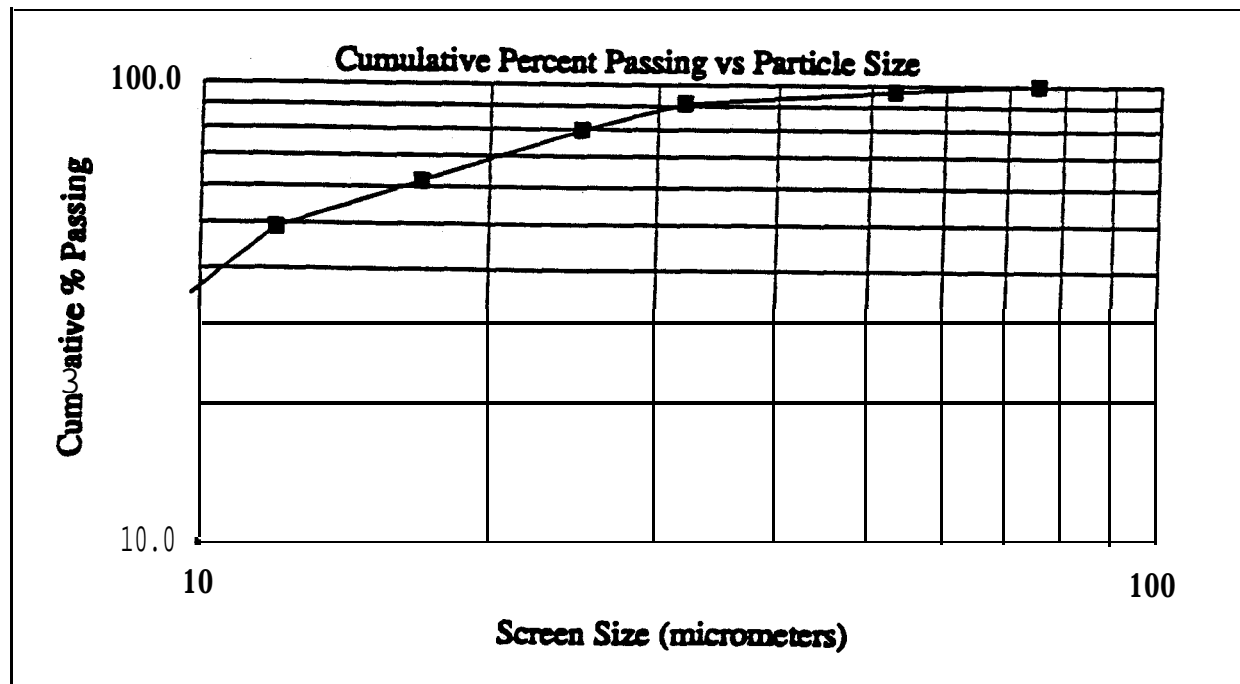
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Sample: Pyrrhotite Tail

Test No.:

Mesh (Tyler)	Size	Weight grams	% Retained		% Passing Cumulative
	µm		Individual	Cumulative	
200	75	0.00	0.0	0.0	100.0
270	53	1.70	3.4	3.4	96.6
	32	2.84	5.7	9.1	90.9
	25	5.74	11.5	20.6	79.4
	17	8.94	17.9	38.4	61.6
	12	6.31	12.6	51.1	48.9
	9	9.04	18.1	69.1	30.9
	-9	15.43	30.9	100.0	0.0
Total	.	50.00	100.0	.	.
K80	26			S.G.=	4.32

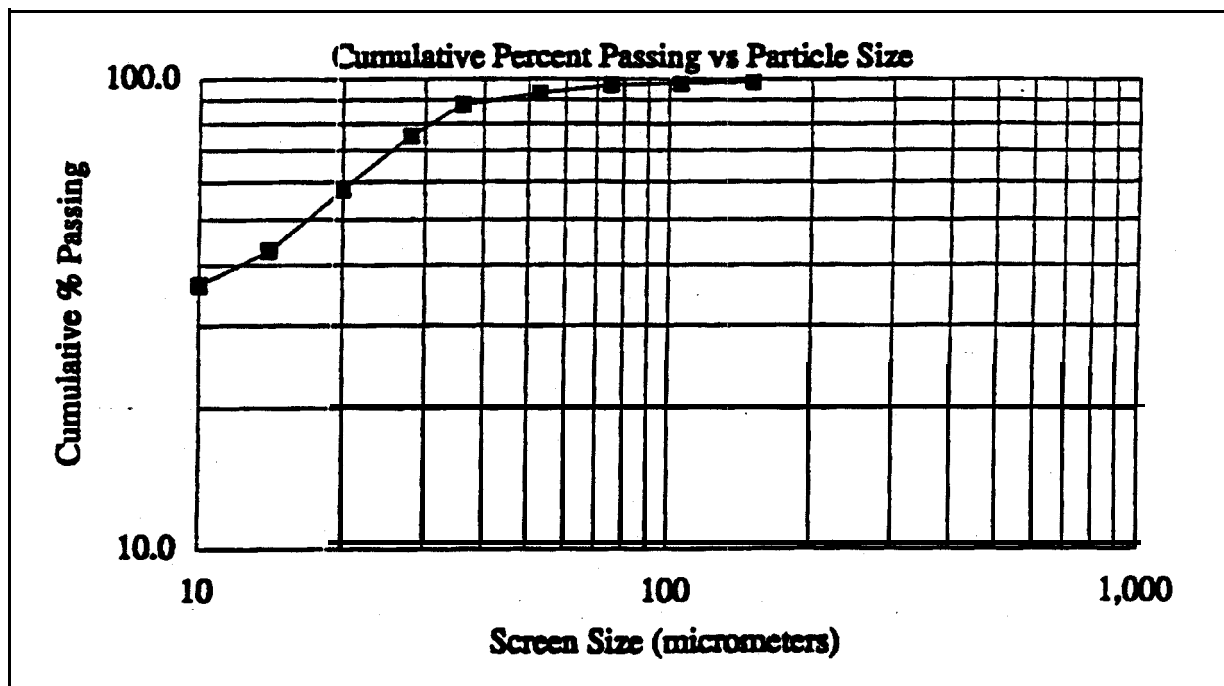


Size Distribution Analysis

Sample: **Slime Mix Head**

Tea No.:

Size		Weight grams	% Retained		% Passing Cumulative
Mesh (Tyler)	µm		Individual	Cumulative	
100	150	0.90	1.8	1.8	98.2
150	106	0.20	0.4	2.2	97.8
200	75	0.60	1.2	3.4	96.6
270	53	1.82	3.6	7.0	93.0
	36	2.59	5.2	12.2	87.8
	28	6.29	12.6	24.8	75.2
	20	8.80	17.6	42.4	57.6
	14	7.40	14.8	57.2	42.8
	10	3.24	6.5	63.7	36.3
	-10	18.16	36.3	100.0	0.0
Total	.	50.00	100.0	-	-
K80	31			S.G. =	3.66



LAKEFIELD RESEARCH

Project No. 7777- 111

Sample: Slime Mix

j-Jan-95

Viscosities:

Purpose: To measure and calculate the viscosities of the Slime Mix at **62%,solids**

Procedure: The Brookfield Viscometer: Model **RVT,Spindel LV1** with guard leg was used to measure the viscosity.

RPM	Dial Reading (Average of 2)	Instrument Factor	Viscosities cps
100	16.5	6.4	106
50	13.5	12.8	173
20	11	32	352
10	9.5	64	608
5	8	128	1024
2.5	5.8	256	1485
1	3.5	640	2240
0.5	3	1280	3840

Settling Density:

Purpose: To measure how much the sample settles in a 24 hour period

Procedure: The sample was pulped in a one liter graduated cylinder and settled for 24 hours

Initial Pulp Weight	1113 g
Initial Pulp Volume	690 ml
Initial % Solids	52.3 %
Weight of Dry Solids	589.5 g
Dry Solids S.G.	3.66 (pycnometer method)
Final settled Volume	375 ml
Final % Solids	73.4 %
Final Settled Density	2142.5 g/l

Porosity:

$$\text{porosity} = \frac{\text{Final settled Volume} - (\text{grams of solids/S.G.})}{\text{Final settled Volume}}$$

$$\text{porosity} = 0.57$$

LAKEFIELD RESEARCH

Project No. 7777-I 11

Sample: Pyrrhotite Tailing

5-Jan-95

Viscosities:

Purpose: To measure and calculate the viscosities of the Pyrrhotite Tailing at **62%,solids**

Procedure: The Brookfield Viscometer: Model **RVT,Spindel LV1** with guard leg was used to measure the viscosity.

RPM	Dial Reading (Average of 2)	Instrument Factor	Viscosities cps
100	46	6.4	294
50	37.8	12.8	484
20	26.8	32	858
10	17.5	64	1120
5	12	128	1536
2.5	8	256	2048
1	6.3	640	4032
0.5	3.7	1280	4736

Settling Density:

Purpose: To measure how much the sample settles in a 24 hour period

Procedure: The sample was pulped in a one liter graduated cylinder and settled for 24 hours

Initial Pulp Weight	1402 g
Initial Pulp Volume	930 ml
Initial % Solids	43.8 %
Weight of Dry Solids	628.2 g
Dry Solids S.G.	4.32 (pycnometer method)
Final settled Volume	360 ml
Final % Solids	74.5 %
Final Settled Density	2341.1 g/l

Porosity:

$$\text{porosity} = \frac{\text{Final settled Volume} - (\text{grams of solids/S.G.})}{\text{Final settled Volume}}$$

$$\text{porosity} = 0.60$$

VISCOSITY TEST REPORT

DATE: _____ FOR: _____
B: _____

EST INFORMATION: 7777-111 SLIME MIX

AVG OF 2

SAMPLE	MODEL	SPINDLE	R.P.M.	DIAL READING	FACTOR	VISCOSITY CPS.	TEMP. °C	TIME	NOTES
55%	LVTOW	LV1	60			—	20°		
			30			194			
			12			375			
			6			659			
			3			1135			
			1.5			1650			
			.6			2580			
			.3			5290			

CONCLUSIONS:

VISCOSITY TEST REPORT

DATE: _____

FOR: _____

BY: AKR

TEST INFORMATION:

SLIME MIX

7777-111

SAMPLE	MODEL	SPINDLE	R.P.M.	① DIAL	② READING	R.V.F.	FACTOR	VISCOSITY CPS.	TEMP °C	TIME	NOTES
62%	LVT	LVI	100	16	17	16.5	8.24	105.6	20°		
			50	14	13	13.5	12.8	172.8			
			20	11	11	11	32	352.0			
			10	9.5	9.5	9.5	64	609.0			
			5	8	8	8	128	1024.0			
			2.5	5.5	6	5.8	256	1485			
			1	3	3	3	640	1920			
			.5	3	3	3	1280	3840			
62%	LVTOV	LVI	60					—			
			30					—			
			12					—			
			6					424			
			3					975			
			1.5					1780			
			.6					2800			
.3					3821						

CONCLUSIONS:

VISCOSITY TEST REPORT

DATE: _____

FOR: _____

BY: _____

TEST INFORMATION:

7777-111 PYRRHOTITE TAILS

SAMPLE	MODEL	SPINDLE	R.P.M.	DIAL READING			FACTOR	VISCOSITY CPS	TEMP. °C	TIME	NOTES	
				①	②	③						
62%	RVT	LV1	100	46.5	45.5	46	6.4	294.4	20°			
			50	38.5	37.0	37.9	12.9	493.8				
			20	26.5	27.0	26.9	32	857.6				
			10	18.0	17.0	17.5	64	1120				
			5	8	9	8.5	128	1088				
			2.5	9	8.5	8.8	256	2253				
			1	55	7.0	6.3	640	4032				
			.5	35	4.0	3.7	1280	4736				
62%	LVTDV	LV1	60					—				
			30					—				
			12						422			
			6						820			
			3						1030			
			1.5						2150			
			.6						5950			
			.3						13700			

CONCLUSIONS:

Mineralogical Examination
of the Moose Lake Sulphide Tail

E. C. Walker, Ph.D.
Mineralogist

Summary

The polished sections consisted predominantly of liberated, irregularly shaped, angular pyrrhotite (92 to 95%) with lesser amounts of magnetite and nonopaques. Trace amounts of chalcopyrite, goethite, ilmenite and pentlandite also were identified. Composite grains consisting of varying proportions of pyrrhotite, chalcopyrite, magnetite and nonopaques were observed as minor components (< 5%) of the sample.

Goethite (< 0.5%) occurred in three forms, including discrete round to irregular grains, porous mineral aggregates and as thin laminations around nonopaque minerals.

Introduction

One sample, identified as Moose Lake sulphide tailings, was submitted to Lakefield Research mineralogy laboratory for opaque mineral identification.

Procedures

Samples for opaque mineral identification were prepared as polished gram mounts (**PS** 4933 and 4934).

The polished sections were examined under incident and transmitted light using the ore microscope at 56x to **500x** magnifications.

Mineralogical Results

The relative proportion and size of the minerals identified are summarized in the accompanying table and the textures, forms and associations of the major minerals are **discussed** below.

Pyrrhotite, magnetite, and chalcopyrite occurred predominantly as liberated irregular shaped angular grains. Composite grains with variable proportions of pyrrhotite, magnetite, chalcopyrite and nonopaques were a minor component of the sample (< 5%). Ilnenite and pentlandite were present as exsolution lamellae within magnetite and pyrrhotite, respectively.

Goethite occurred in three forms, including discrete round to irregular grains, porous mineral aggregates and as thin laminations around nonopaque minerals. Although most of the minute inclusions in the porous goethite were unidentifiable, pyrrhotite and nonopaques **were** identified. The laminations around the nonopaques were 5 μm thick and encompassed over 70% of the grain.

Nonopaque minerals occurred as discrete irregular shaped angular grains. Up to 15% of the nonopaques occurred as composites with chalcopyrite, pyrrhotite and magnetite.

Mineralogy of Moose Lake Sulphide Tailings

Sample PS 4933 and 4934

<u>Mineral</u>	<u>Relative Proportion</u>	<u>Size Range</u>	<u>Comments</u>
Pyrrhotite Fe_{1-x}S	92 to 95	< 1 to 200 μm	> 95% liberated typical size: 50 to 100 μm
Magnetite Fe_3O_4	3 to 5	10 to 70 μm	> 95% liberated
Chalcopyrite CuFeS_2	< 0.5	10 to 120 μm	> 95% liberated
Goethite $\text{FeO}(\text{OH})$	< 0.5	< 5 to 70 μm	
Ilnenite FeTiO_3	< 0.5	< 10 μm	exsolution lamellae in magnetite
Pentlandite $(\text{Fe},\text{Ni})_9\text{S}_8$	< 0.5	< 5 to 25 μm	exsolution lamellae in pyrrhotite
Nonopaques	3	<10 to 250 μm	typical size: 30 to 80 μm

**Mineralogical Examination
of the Strathcona Slimes 55% Head**

E. C. Walker, Ph.D.
Mineralogist

Summary

The polished sections consisted predominantly of liberated, irregularly shaped, angular non-opaque minerals (85 to 90%). The opaque minerals were comprised of liberated, irregularly shaped, angular pyrrhotite, chalcopyrite and magnetite with lesser amounts of ilmenite and pentlandite. Composite grains consisting of varying proportions of opaque and non-opaque minerals were observed as minor components (< 15%) of the sample.

Goethite (< 0.5%) occurred as rare grains that formed a matrix for composite grains of non-opaques.

Introduction

One sample, identified as Strathcona Slimes 55% Head, was submitted to Lakefield Research mineralogy laboratory for opaque mineral identification.

Procedures

Samples for opaque mineral identification were prepared as polished gram mounts (PS 5256 and 5257).

The polished sections were examined under incident and transmitted light using the ore microscope at 56x to 450x magnifications.

Mineralogical Results

The relative proportion and size of the minerals are summarized in the accompanying table and the textures, forms and associations of the major minerals are discussed below.

The majority of opaque minerals in the sample consisted of liberated irregular shaped angular **grains** of pyrrhotite, chalcopyrite, and magnetite. The opaques also occurred as composites grains with one another and in varying proportions with non-opaques. Composites with non-opaques typically did not exceed 100 pm.

Lesser amounts of ilmenite and pentlandite were observed. Ilmenite typically occurred **as** liberated grains or as composites with magnetite. Pentlandite primarily occurred as composites with pyrrhotite and, to a lesser degree, as exsolution lamellae within pyrrhotite:.

Goethite (< 0.5%) occurred as rare grains that formed a matrix for composite grains of non-opaques.

Non-opaque minerals occurred as discrete, irregular shaped angular grains. Up to 15% of the non-opaques occurred as composites with chalcopyrite, magnetite and pyrrhotite.

Mineralogy of Strathcona Slimes 55% Head

PS 4933 and 4934

Mineral --	Relative Proportion	Typical Size	Comments
Pyrrhotite Fe_{1-x}S	5 to 8%	80 to 700 pm	typically liberated
Chalcopyrite CuFeS₂	3 to 5%	50 to 500 pm	typically liberated
Magnetite Fe₃O₄	2 to 3%	50 to 350 pm	typically liberated
Ilmenite FeTiO₃	< 1%	50 to 300 µm	typically liberated
Pentlandite (Fe,Ni)₉S₈	< 1%	10 to 80 µm	composites grains and lamellae in pyrrhotite
Goethite FeO (OH)	< 0.5%	< 10 µm	matrix for composites of non-opaque
Non-opaque	85 to 90%		Quartz, Albite, Actinolite, White Mica

APPENDIX C

In-situ Redox (Eh) and Conductivity Results

Moose Lake Sub-Aqueous Deposition Monitoring Sheet
7777 - 111
In-Situ Conductivity Results

	* 12/19/1994		* 12/23/1994				* 1/2/1995			* 1/9/1995			* 1/16/1995		
Column # 1 Pyrrhotite															
	T (C)	Cond (ppm)	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	19.6	1660	21.6	1720	2580	0.67	18.7	1770	2655	18.6	1730	2595	15.7	1720	2580
Interface	17.8	1580	19.0	1650	2490	0.66	17.5	1600	2415	16.9	1490	2249	14.9	1650	2490
Tailings	14.9	1050	14.6	1050	3840	0.27	14.8	1040	3803	13.3	1090	3986	13.2	1070	3913
Column #2 Thickened Tailings															
	T (C)	Cond (ppm)	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	19.6	1580	21.8	1670	2550	0.65	18.9	1680	2565	18.9	1720	2626	15.7	1690	2581
Interface	17.3	1530	18.3	1700	2480	0.69	16.8	1730	2524	16.2	1820	2655	14.3	1770	2582
Tailings	15.0	1550	14.7	1560	5500	0.28	14.8	1540	5429	13.5	1590	5606	12.8	1600	5641
Column #3 Pyrrhotite & Substrate															
	T (C)	Cond (ppm)	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	18.7	1190	20.9	1200	2660	0.45	18.0	1160	2571	18.1	1170	2594	14.9	1160	2571
Interface	17.7	1530	18.0	1570	2620	0.60	16.3	1500	2503	16.0	1500	2503	13.8	1500	2503
Tailings	14.3	837	13.8	940	3550	0.26	13.8	940	3550	12.7	980	3701	11.8	960	3626
Column #4 Thickened Pyrrhotite															
	T (C)	Cond (ppm)	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	14.5	776	21.7	940	1610	0.58	18.7	950	1627	18.9	970	1661	15.5	950	1627
Interface	12.4	897	18.6	1030	1620	0.64	17.4	1210	1903	17.0	1310	2060	15.0	1290	2029
Tailings	15.0	2040	14.8	2010	5670	0.35	14.6	1990	5614	13.7	2050	5783	12.7	2060	5811
Column #5 Tailings															
	T (C)	Cond (ppm)	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	17.5	1500	22.3	1400	2050	0.68	19.0	1400	2050	19.3	1420	2079	15.7	1400	2050
Interface	16.7	1500	18.2	1390	2020	0.69	17.1	1340	1947	16.5	1380	2005	14.5	1370	1991
Tailings	15.3	868	15.4	980	3430	0.29	14.7	940	3290	13.8	940	3290	12.7	930	3255

Lab Cond - Laboratory conductivity results, measured in micro mhos/cm.

Ratio - Ratio of measured conductivity vs laboratory conductivity.

Corrected Cond - Calculated conductivity in micro mhos/cm - referred to Corrected Conductivity Procedure

* - As per initial method followed - no calibration with standard solution

• - As per method given by ESD and plasticated procedure

	* 1/23/1995			* 1/30/1995			* 2/21/1995				** 3/6/1995			** 3/20/1995		
Column # 1 Pyrrhotite																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.6	1770	2655	18.3	1640	2460	18.9	1650	2563	0.64	25.2	1810	2812	13.0	1980	3076
Interface	9.8	1710	2581	16.5	1640	2475	16.7	1650	2668	0.62	22.7	2010	3250	13.0	2110	3412
Tailings	8.2	1100	4023	12.8	1080	3950	13.7	1080	3829	0.28	19.1	1270	4503	12.0	1330	4715
Column #2 Thickened Tailings																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.7	1760	2687	18.2	1670	2550	18.7	1650	2652	0.62	25.0	1830	2941	13.0	1920	3086
Interface	9.8	1860	2713	15.7	1840	2684	15.9	1850	2960	0.63	21.4	2170	3472	12.6	2330	3728
Tailings	7.9	1690	5958	12.7	1630	5747	13.6	1610	5677	0.28	18.5	1890	6664	12.0	1990	7017
Column #3 Pyrrhotite & Substrate)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.0	1120	2483	17.4	1130	2505	18.1	1110	2487	0.45	23.7	1300	2913	12.2	1410	3159
Interface	8.5	1560	2603	15.3	1420	2370	16.1	1460	2487	0.59	21.6	1780	3032	11.6	1940	3305
Tailings	7.1	1000	3777	11.7	970	3663	12.5	950	3774	0.25	17.1	1120	4449	11.0	1170	4648
Column #4 Thickened Pyrrhotite																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.5	970	1661	18.0	920	1576	18.5	930	1596	0.58	24.2	1120	1922	12.8	1190	2042
Interface	10.4	1280	2013	16.5	1320	2076	16.7	1250	2126	0.59	21.8	1540	2619	13.2	1620	2755
Tailings	8.4	2000	5642	12.5	1850	5219	13.4	1950	5829	0.33	17.9	2280	6815	11.7	2460	7354
Column #5 Tailings																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.6	1430	2094	18.5	1360	1991	18.7	1320	1907	0.69	24.6	1580	2283	12.9	1680	2427
Interface	9.4	1370	1991	16.0	1340	1947	16.3	1300	2016	0.64	21.9	1620	2512	12.2	1730	2683
Tailings	8.1	950	3325	12.5	920	3220	13.3	850	3726	0.23	17.9	990	4340	12.0	970	4252

	** 4/3/1995			** 4/17/1995				** 5/1/1995			** 5/29/1995			** 5/31/1995		
Column # 1 (Strathcona Pyrrhotite)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.3	2140	3324	14.0	1940	2475	0.78	15.9	1860	2883	17.1	1930	3236	20.5	1660	2782
Interface	9.1	2360	3816	12.7	2120	2576	0.82	15.1	2110	3169	17.5	2410	3922	20.9	2080	3292
Tailings	8.1	1470	5212	11.3	1260	3821	0.33	14.1	1250	4777	17.0	1390	5098	20.6	1220	4507
Column #2 (Thickened SM Tailings)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.1	2230	3584	13.9	2050	2641	0.78	15.9	2050	3178	17.0	2070	3374	20.4	1830	2993
Interface	8.8	2710	4336	12.5	2370	3087	0.77	14.8	1690	2772	16.7	2290	3803	20.0	2040	3380
Tailings	8.0	2210	7793	11.5	1880	5632	0.33	14.3	1920	7303	17.0	2040	7042	20.7	1840	6303
Column #3 (Pyrrhotite Tls & Substrate)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	8.4	1530	3428	16.4	1270	2496	0.51	15.2	1330	3204	17.0	1370	3216	19.6	1270	2975
Interface	7.5	2120	3611	12.0	1840	2480	0.74	14.1	1890	3221	16.3	1680	2689	20.0	1830	2923
Tailings	6.9	1260	5006	10.7	1070	3592	0.30	13.4	1090	4660	16.0	1160	4749	19.8	1060	4384
Column #4 (Thickened Pyrrhotite)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.1	1290	2214	13.8	1050	1604	0.65	15.9	1240	2306	17.0	1270	2192	20.3	1140	1972
Interface	9.7	1750	2976	13.3	1450	2257	0.64	15.6	1650	3139	17.7	1630	2958	20.8	1460	2641
Tailings	7.7	2690	8041	11.5	2410	5938	0.41	14.3	2310	7072	16.8	2630	7591	20.4	2350	6831
Column #5 (Strathcona Mill Tailings)																
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Lab Cond	Ratio	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond
Water	9.4	1780	2572	13.9	1690	1889	0.89	15.9	1720	2337	16.9	1640	2367	20.4	1590	2289
Interface	8.3	1840	2853	12.4	1740	2066	0.84	14.6	1680	2493	16.7	1660	2586	19.8	1560	2430
Tailings	7.9	980	4296	11.7	980	3742	0.26	14.3	930	4490	16.8	940	4597	20.2	920	4454

	** 6/12/1995			**6/26/1995			***9/21/1995			***10/23/1995			***11/20/1995			***12/20/1995			***1/22/1996		
Column # 1 (Stnthconr Pyrrbotite)																					
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)			
Water	19.0	1560	2182	23.5	1710	2835	17.9	2630	16.1	2410	18.5	2590	14.0	2480	17.8	2290					
Interface	19.7	1990	3099	23.9	1190	2923	17.4	2670	15.9	2610	17.8	2630	11.8	2530	16.5	2480					
Tailings	19.3	1190	4366	23.4	1300	4419	16.3	4270	14.6	4260	16.8	4200	7.8	3900	13.9	3860					
Column #2 (Thickened SM Tailings)																					
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)			
Water	18.9	1830	2923	23.5	1810	2940	17.8	2610	16.2	2560	18.1	2510	15.2	2380	17.6	2330					
Interface	18.7	2070	3327	23.0	2080	3204	16.7	2640	15.2	2600	17.2	2470	11.1	2420	15.7	2420					
Tailings	19.3	1810	6144	23.2	1900	5951	16.3	6120	14.7	6070	16.4	5820	7.3	5520	14.1	5130					
Column #3 (Pyrrhotite Tls & Substrate)																					
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)			
Water	18.1	1280	2835	22.4	1310	2852	16.9	2530	15.3	2550	17.2	2450	13.7	2370	16.9	2310					
Interface	19.3	1870	2887	22.7	1920	2905	16.3	2510	14.9	2510	17.5	2510	11.1	2390	15.8	2310					
Tailings	18.5	1050	4014	22.2	1060	39%	15.3	3440	13.9	3510	15.91	3480	6.5	3190	12.9	3220					
Column #4 (Thickened Pyrrhotite)																					
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)			
Water	19.1	1070	1831	23.4	1200	2060	17.6	1893	15.8	1934	17.7	1892	14.3	1899	17.5	1817					
Interface	19.4	1290	2165	23.6	1430	2518	17.4	1906	16.2	1936	18.4	1864	11.9	1903	16.5	1913					
Tailings	19.4	2200	6180	23.1	2360	6479	16.2	6490	15.1	6450	16.5	5850	7.9	5280	14.6	4280					
Column #5 (Strathcona Mill Tailings)																					
	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (ppm)	Corrected Cond	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)	T (C)	Cond (µS/cm)			
Water	21.9	1560	2447	23.3	1740	2570	17.8	2100	16.0	2130	18.5	2120	14.9	2020	17.1	1969					
Interface	22.6	1430	2394	23.2	1610	2412	16.9	2100	16.7	2140	17.5	2030	11.6	2010	16.3	1954					
Tailings	19.3	910	4366	23.1	960	4275	16.7	4260	15.4	4450	16.8	4090	8.2	4020	14.2	3720					

1/23/96

Moose Lake Subaqueous Columns
In-Situ Eh Results

Project # 7777-I 11

	12/19/94		1/2/95		1/9/95		1/16/95		1/23/95		1/30/95		2/6/95		2/13/95	
	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)
Column # 1 (Strathcona Pyrrhotite)																
Water	19.6	30	18.7	-61	18.6	-67	15.7	26	9.6	278	18.3	205	-	210	20.4	252
Interface	17.8	23	17.5	-187	16.9	-30	14.9	-72	9.8	-49	16.5	-117	-	-93	16.8	-88
Tailings	14.9	305	14.8	-290	13.3	-287	13.2	-296	8.2	-314	12.8	-322	-	-338	10.9	-319
Column #2 (Thickened SM Tailings)																
Water	19.6	-7	18.9	-176	18.9	-84	15.7	83	9.7	293	18.2	232	-	9	20.4	27
Interface	17.3	-66	16.8	-363	16.2	-400	14.3	-404	9.8	-361	15.7	-383	-	-381	16.2	-360
Tailings	15.0	-223	14.8	-261	13.5	-255	12.8	-251	7.9	-213	12.7	-249	-	-304	11.0	-260
Column #3 (Pyrrhotite Tls & Substrate)																
Water	18.7	-58	18.0	13	18.1	71	14.9	27	9.0	43	17.4	81	-	103	19.6	132
Interface	17.7	-33	16.3	-74	16.0	-26	13.8	-1	8.5	80	15.3	29	-	44	16.4	73
Tailings	14.3	-298	13.8	-331	12.7	-334	11.8	-341	7.1	-338	11.7	-354	-	-367	10.0	-341
Column #4 (Thickened Pyrrhotite)																
Water	14.5	248	18.7	7	18.9	9	15.5	28	9.5	31	18.0	4	-	-22	20.1	28
Interface	12.4	-24	17.4	-134	17.0	-119	15.0	-128	10.4	-70	16.5	-134	-	-151	16.7	-138
Tailings	15.0	-274	14.6	-298	13.7	-305	12.7	-306	8.4	-300	12.5	-327	-	-348	11.1	-225
Column #5 (Strathcona Mill Tailings)																
Water	7.5	-7	19.0	6	19.3	42	15.7	67	9.6	81	18.5	84	-	67	20.4	93
Interface	6.7	0	17.1	-104	16.5	-123	14.5	-156	9.4	-234	16.0	-305	-	-322	16.4	-304
Tailings	15.3	-339	14.7	-447	13.8	-446	12.7	-403	8.1	-395	12.5	-396	-	-385	11.1	-369

1/23/96

Moose Lake Subaqueous Columns
In-Situ Eh Results

Project # 7777-1 11

	2/20/95		3/6/95		3/20/95		4/3/95		4/17/95		5/1/95		5/15/95		5/29/95	
	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)	T(C)	Eh (mV)
Column #1 (Strathcona Pyrrhotite)																
Water	19.2	218	25.4	218	12.51	259	8.4	222	13.91	192	15.9	196	.	230	17.1	241
Interface	16.7	-124	23.0	-76	12.6	-54	8.3	-32	12.7	-17	15.1	-7	.	71	17.5	200
Tailings	13.1	-312	19.2	-321	11.5	-309	7.2	-303	12.3	-315	14.1	-339	.	-3251	17.0	-316
Column #2 (Thick)																
Water	19.0	54	25.4	-81	12.7	-32	8.3	7	13.8	47	15.9	102	.	122	17.0	135
Interface	15.5	-359	22.11	-371	11.91	-355	8.01	-344	12.4	-346	14.8	-341	.	-3491	16.7	-342
Tailings	12.6	-254	18.91	-3181	11.3	-291	7.11	-265	11.51	-2731	14.31	-334	.	-346	17.0	-360
Column #3 (Pyrrhote Tls & Substrate)																
Water	18.4	143	24.4		11.6		7.7		13.2				.			
Interface	15.6	60	14.3	21.8	-166	11.0	-192	7.2	11.1	11.6	11.0	178	.	148	16.3	158.03
Tailings	11.5	-339	17.61	-383	10.21	-375	6.1	-3651	10.51	-379	13.41	-3921	.	-391	16.0	-368
Column #4 (Thinned Pyrrhotite)																
Water	18.3	33	24.8	31	12.61	58	8.2	96	13.6	811	15.91	66	.	87	17.0	90
Interface	16.2	-147	22.5	-158	12.51	-130	8.71	-119	13.2	-103	15.6	-110	.	-127	17.7	-73
Tailings	12.4	-225	18.51	-354	11.0	-337	6.91	-3421	11.31	-364	14.31	-365	.	-3691	16.8	-376
Column #5 (Strathcona Mill Tailings)																
Water	19.0	103	25.2	100	12.3	100	8.4	107	13.7	109	15.9	103	.	119	16.9	138
Interface	16.1	-294	22.4	-303	11.01	-221	7.51	-211	12.0	-238	14.6	-108	.	-216	16.7	-218
Tailings	12.3	-366	18.5	-384	10.91	-386	7.01	-375	11.5	-390	14.3	-396	.	-393	16.8	-390

1/24/91

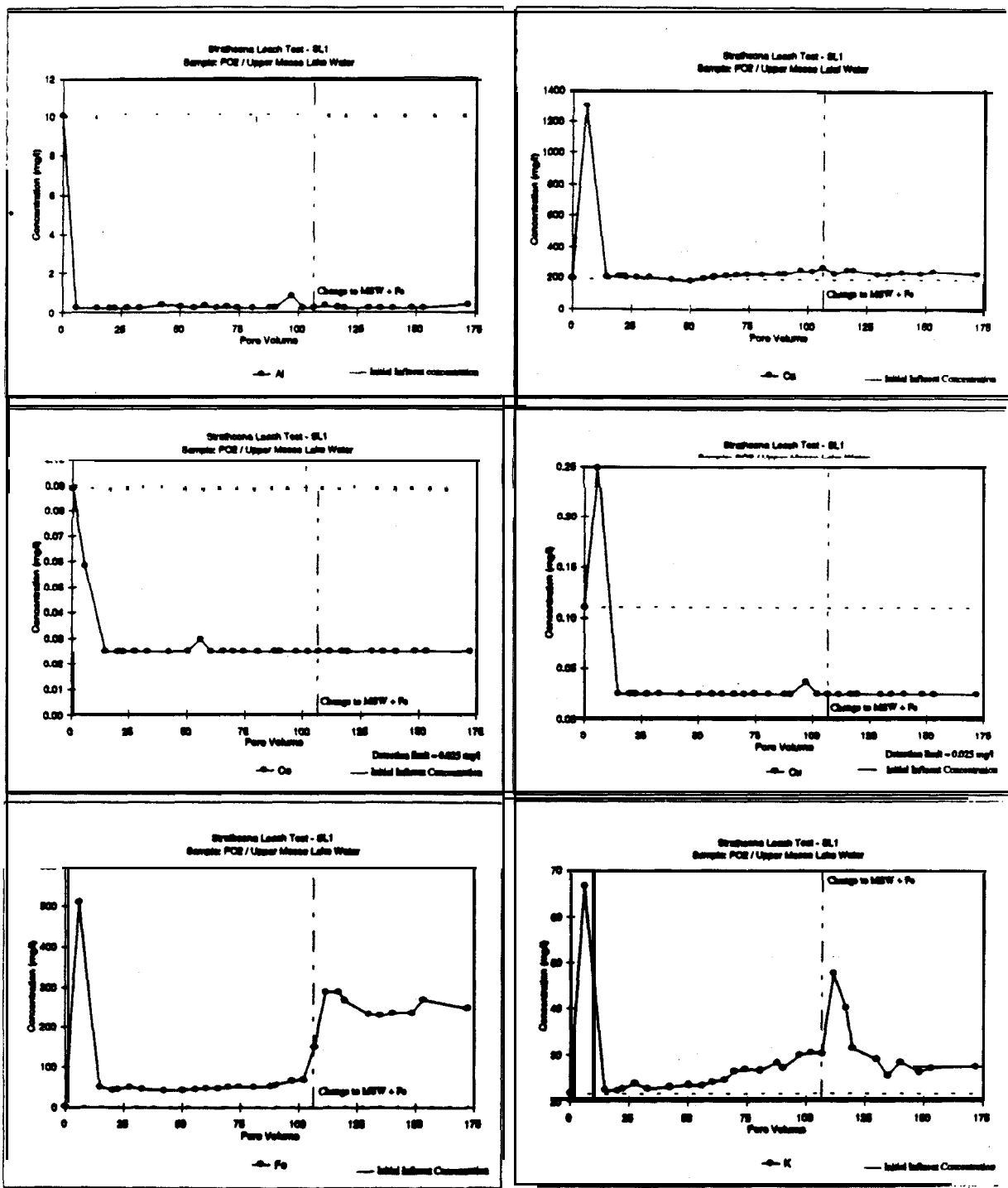
Moose Lake **Subaqueous** Columns
In-Situ Eh Results

Project # 7777-111

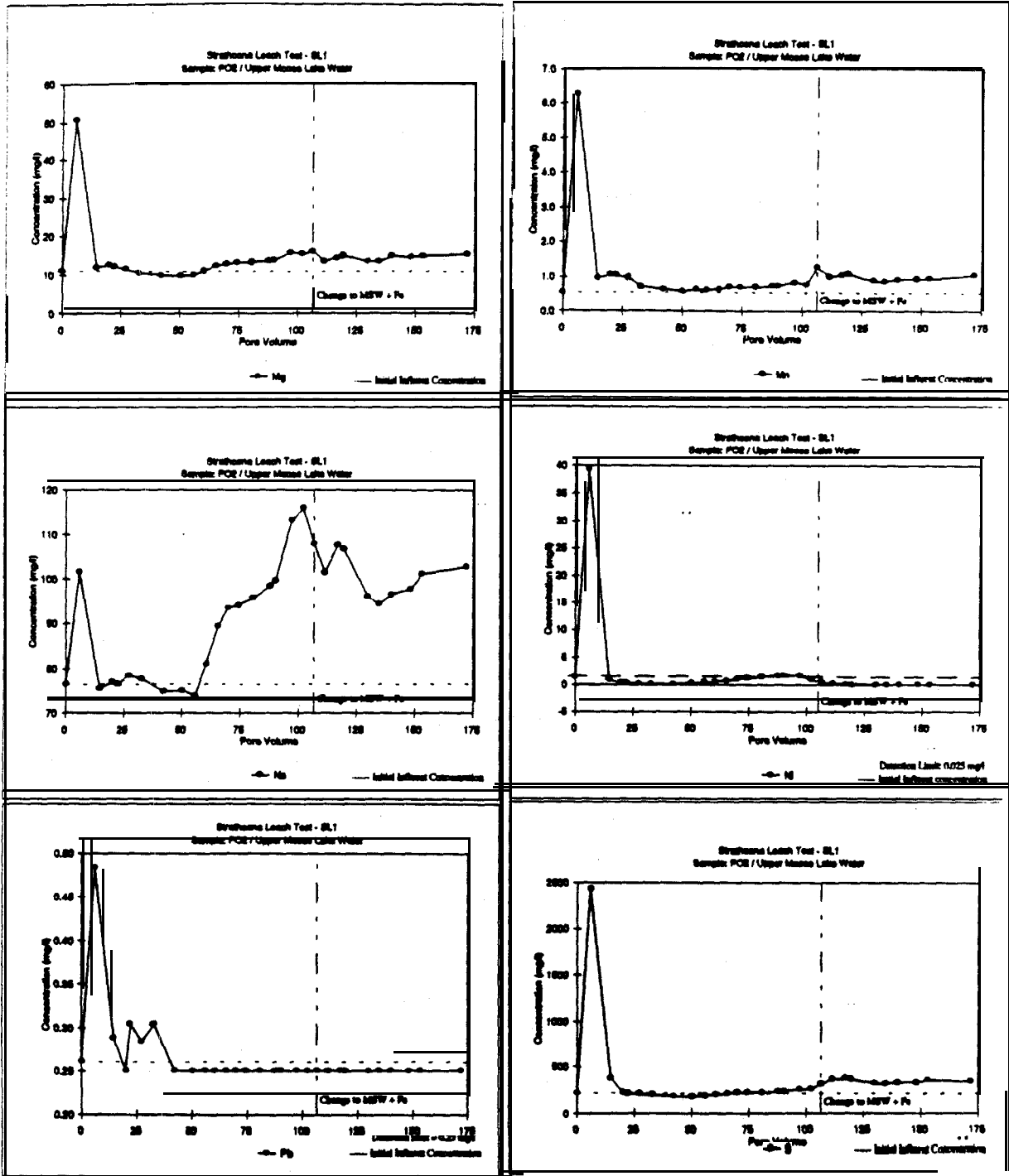
T (C)	5/31/95		6/12/95		6/26/95		9/21/95		10/23/95		11/20/95		12/20/95		1/22/96	
	ET (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	T (C)	Eh (mV)	(mV) T			
Column 1 (Strathcona Pyrrhotite)																
Water	20.5	224	19.0	228	23.5	196	17.9	174	16.1	171	18.5	169	14.0	189	17.8	168
Interface	20.9	337	19.7	240	23.9	207	17.4	290	15.9	330	17.8	289	11.8	241	16.5	162
Tailings	20.6	334	19.3	-315	23.4	-310	16.3	-309	14.6	-312	16.8	-305	7.8	-288	13.9	-311
Column 2 (Thickened SM Tailings)																
Water	20.4	159	18.9	93	23.5	191	17.8	243	16.2	191	18.1	246	15.2	291	17.6	276
Interface	20.0	-341	18.7	-352	23	364	16.7	205	15.2	222	17.2	267	11.1	325	15.7	260
Tailings	20.7	-374	19.3	-373	23.2	-385	16.3	-420	14.7	-409	16.4	-388	7.3	-365	14.1	-378
Column 3 (Pyrrhotite Tls & Substrate)																
Water	19.6	155	18.1	137	22.4	122	16.9	129	15.3	119	17.2	136	13.7	158	16.9	140
Interface	20.0	122	19.3	102	22.7	103	16.3	109	14.9	105	17.5	120	11.1	124	15.8	117
Tailings	19.8	-391	18.5	-368	22.2	-350	15.3	-334	13.9	-333	15.9	-317	6.5	-301	12.9	-319
Column 4 (Thickened Pyrrhotite)																
Water	20.3	84	19.1	80	23.4	66	17.6	44	15.8	48	17.7	57	14.3	-136	17.5	-232
Interface	20.8	-74	19.4	-44	23.6	-88	17.4	78	16.2	67	18.4	80	11.9	59	16.5	30
Tailings	20.4	-383	19.4	-370	23.1	-370	16.2	-335	15.1	-355	16.5	-375	7.9	-359	14.6	-371
Column 5 (Strathcona Mill Tailings)																
Water	20.4	133	21.9	-38	23.3	-27	17.8	155	16.0	192	18.5	154	14.9	177	17.7	159
Interface	19.8	-227	22.6	-198	23.2	-218	16.9	66	16.7	114	17.5	143	11.6	147	16.3	142
Tailings	20.2	-397	19.3	-390	23.1	-391	16.7	-365	15.4	-360	16.8	-349	8.2	-328	14.2	-340

APPENDIX D

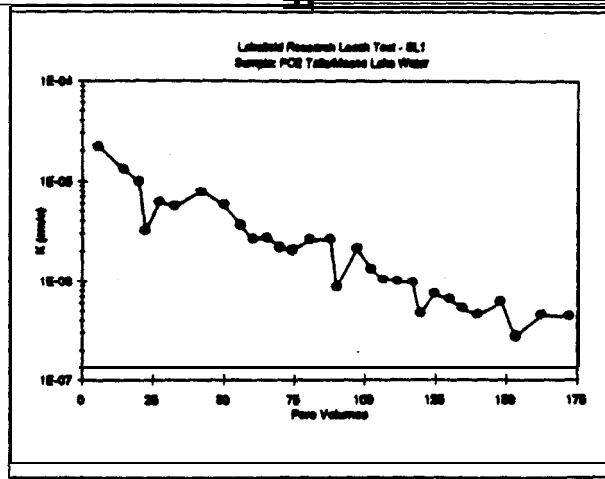
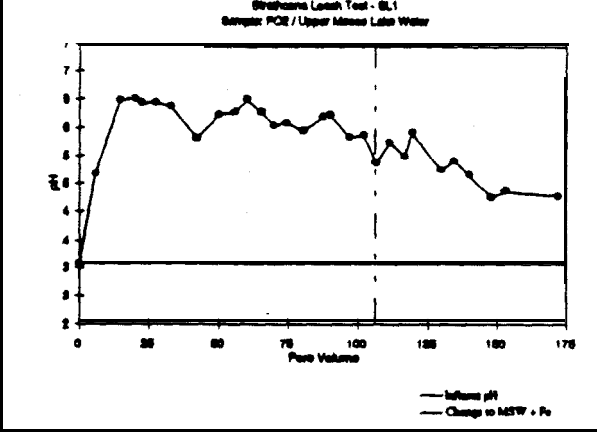
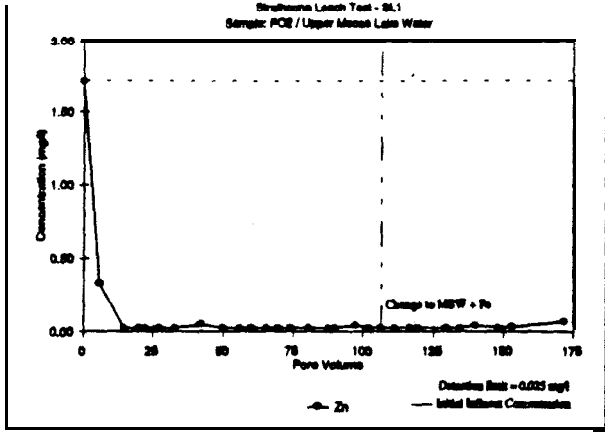
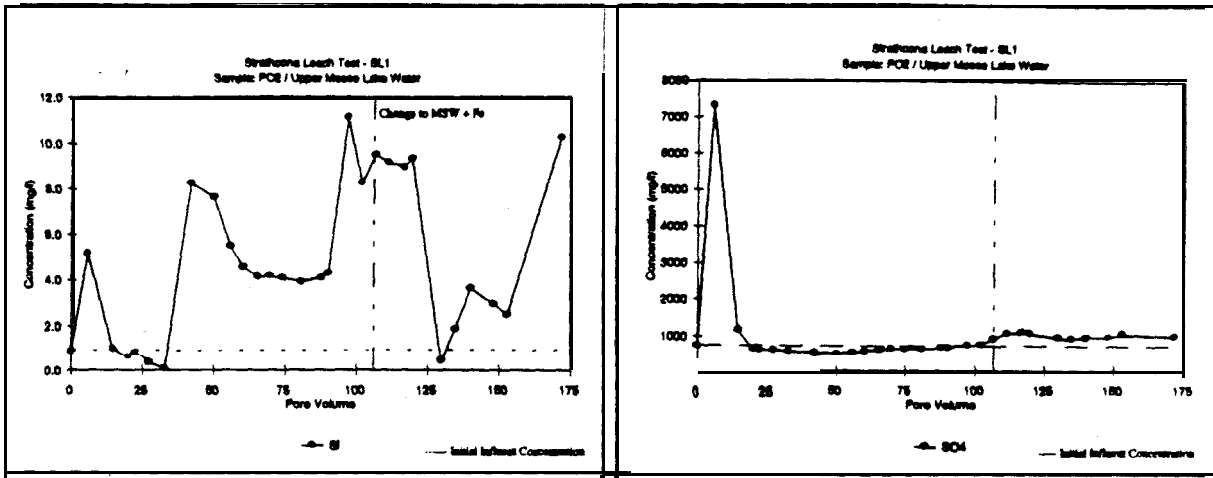
Column Leach Test Results from Noranda Technology Centre



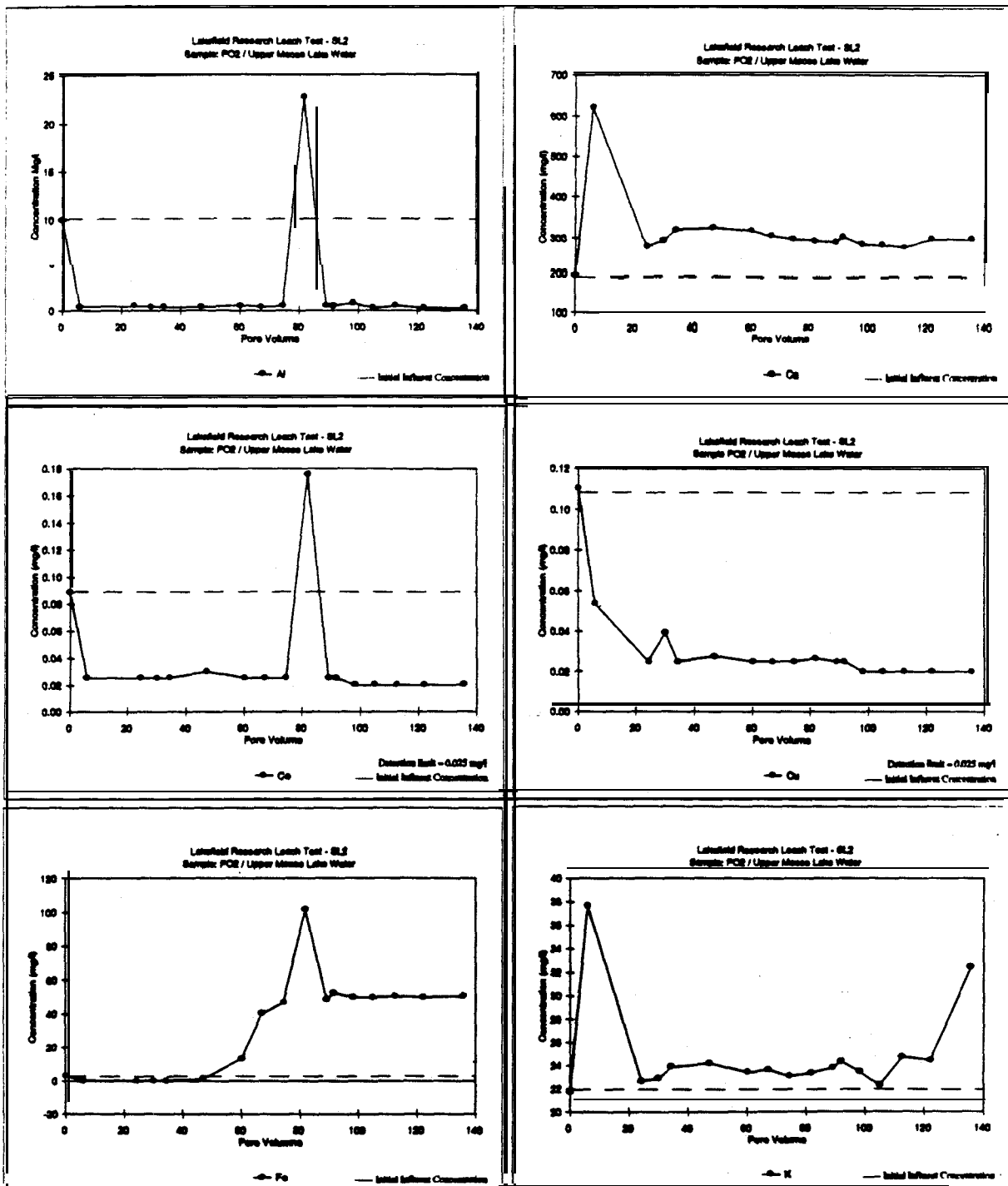
SL1 Concentrations for A & Ca, Co, Cu, Fe & K



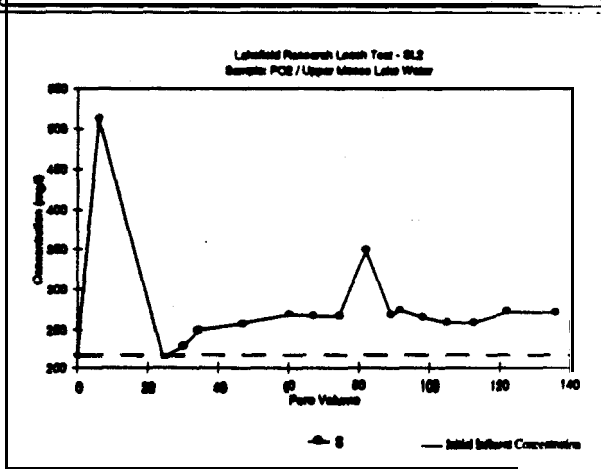
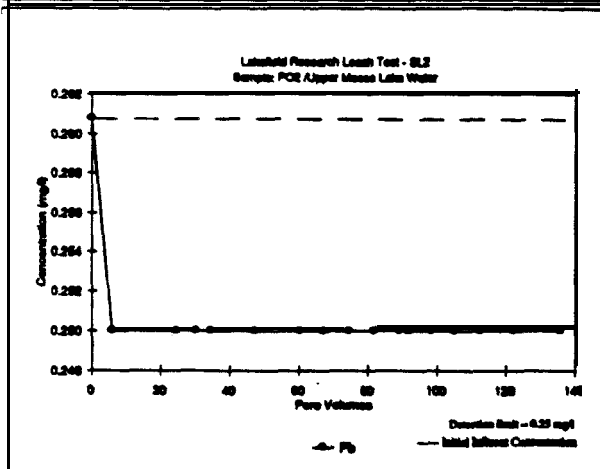
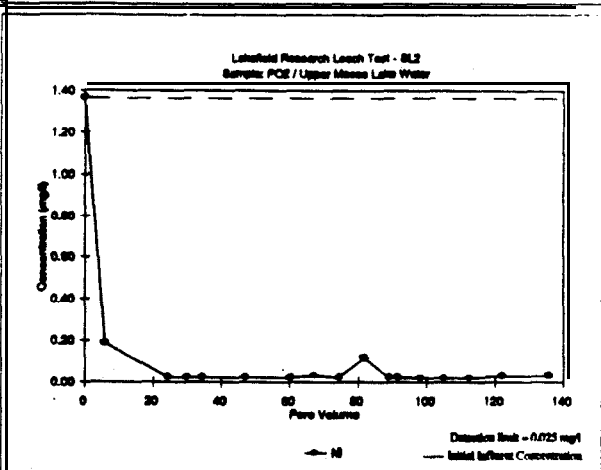
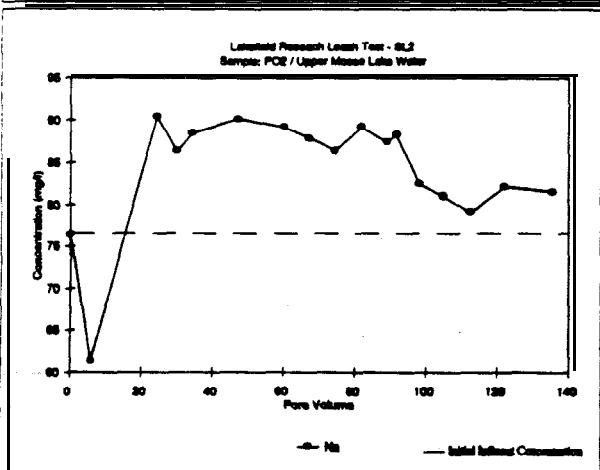
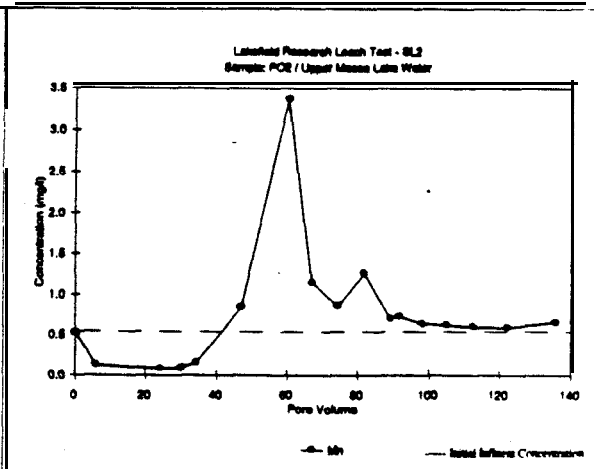
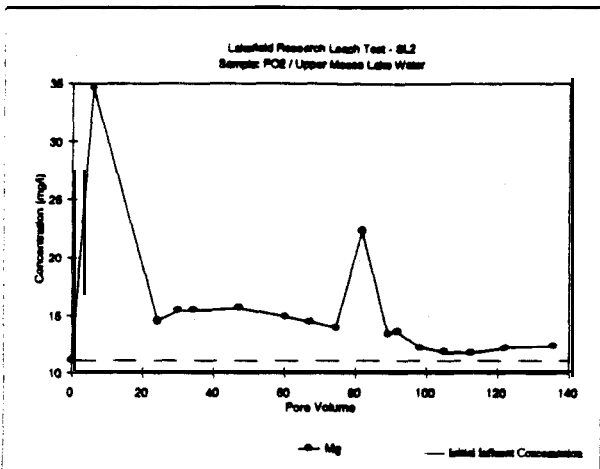
SL1 Concentrations for Mg, Mn, Na, Ni, Pb & S



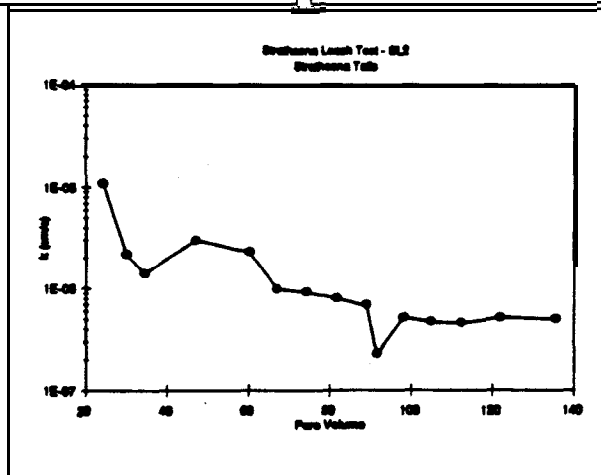
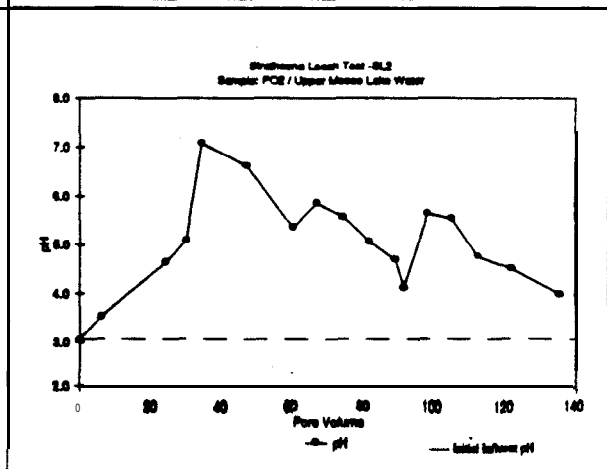
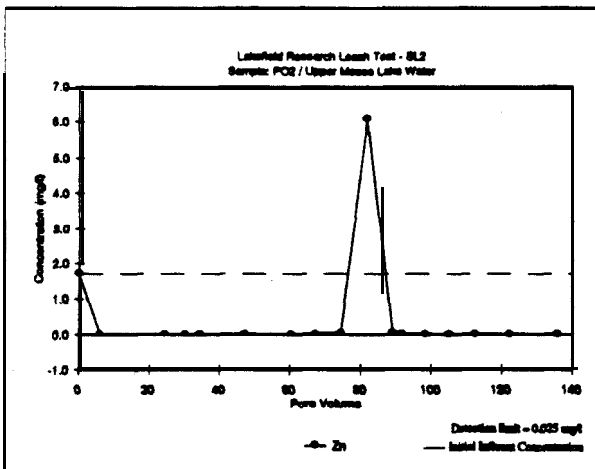
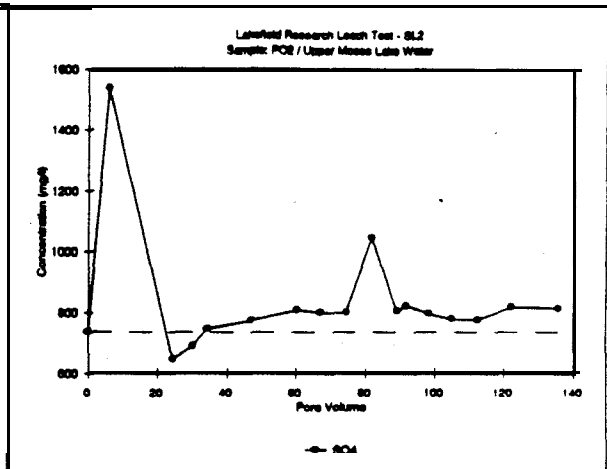
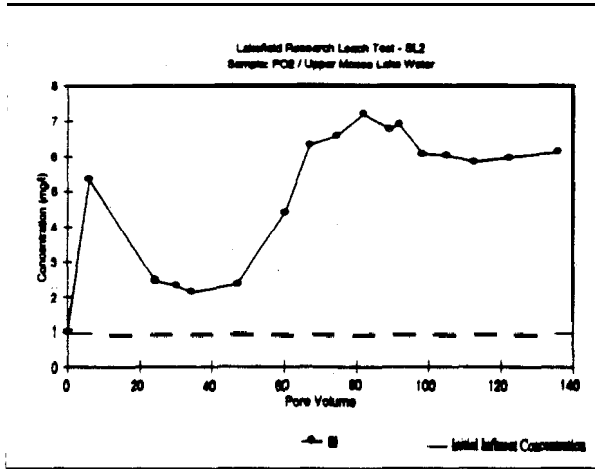
SL1 Concentrations for Si, S04, Zn, pH vs PV & K vs PV



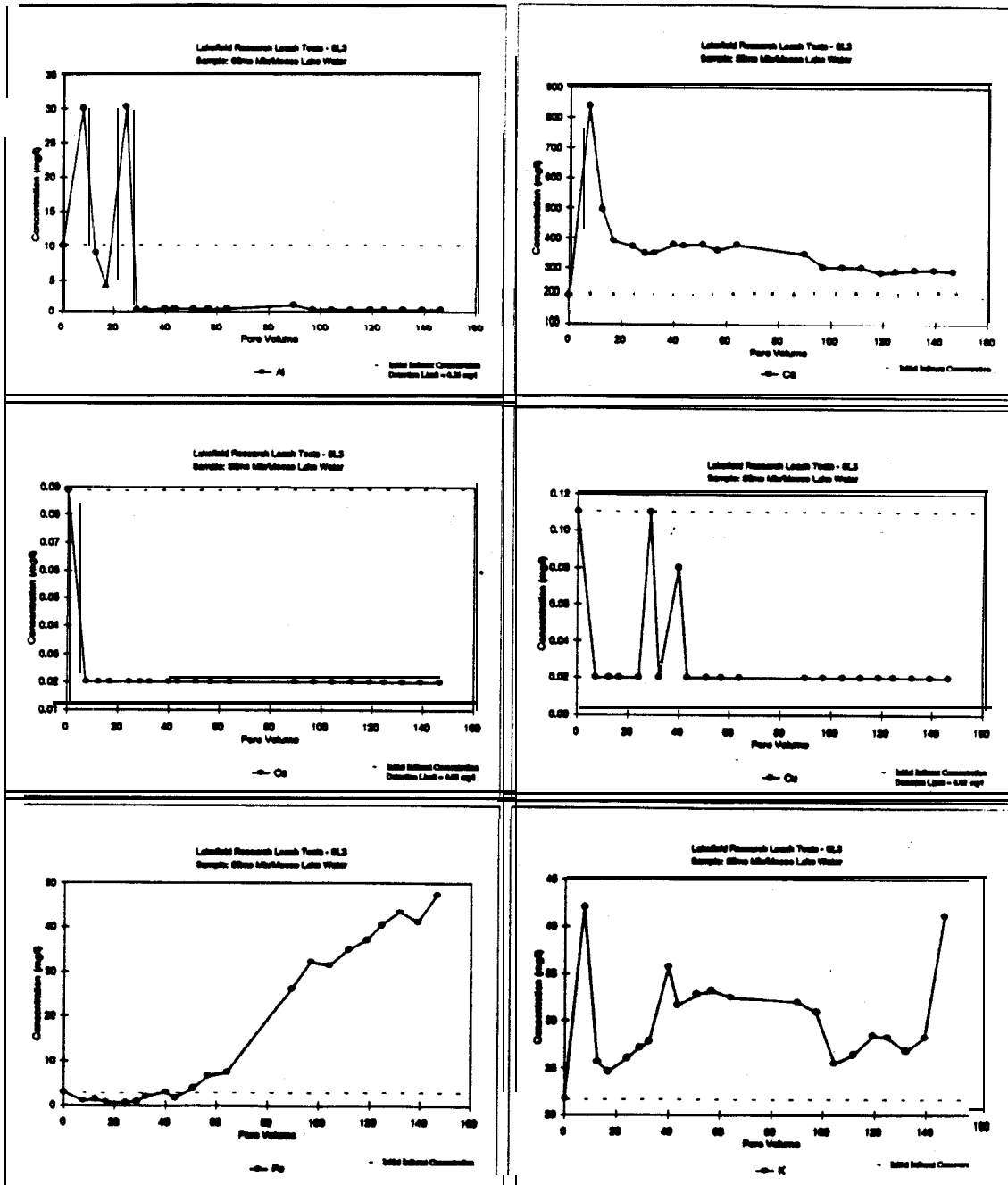
SL2 Concentrations Al, Ca, Co, Cu, Fe & K



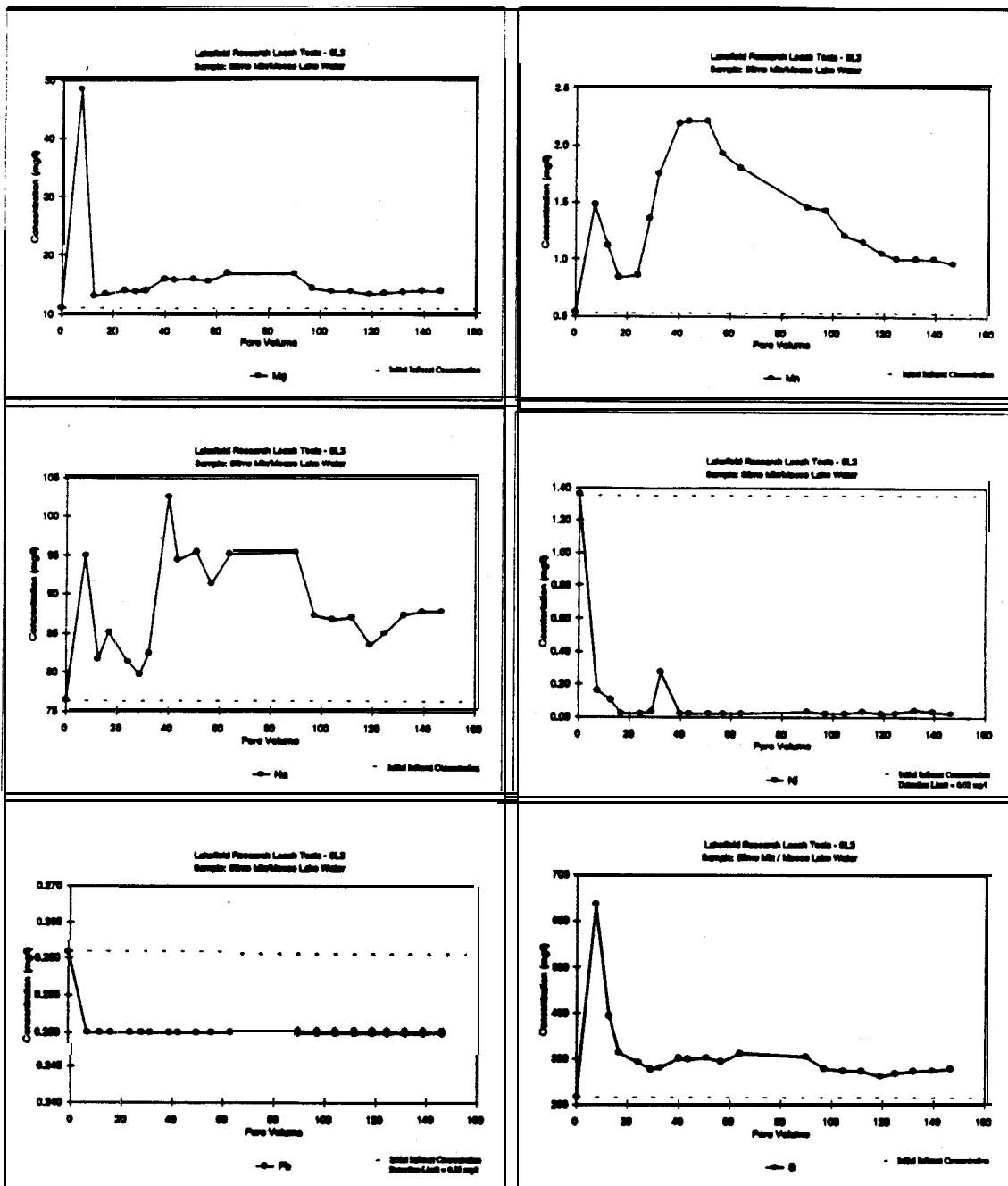
. SL2 Concentrations Mg, Mn, Na, Ni, Pb & S



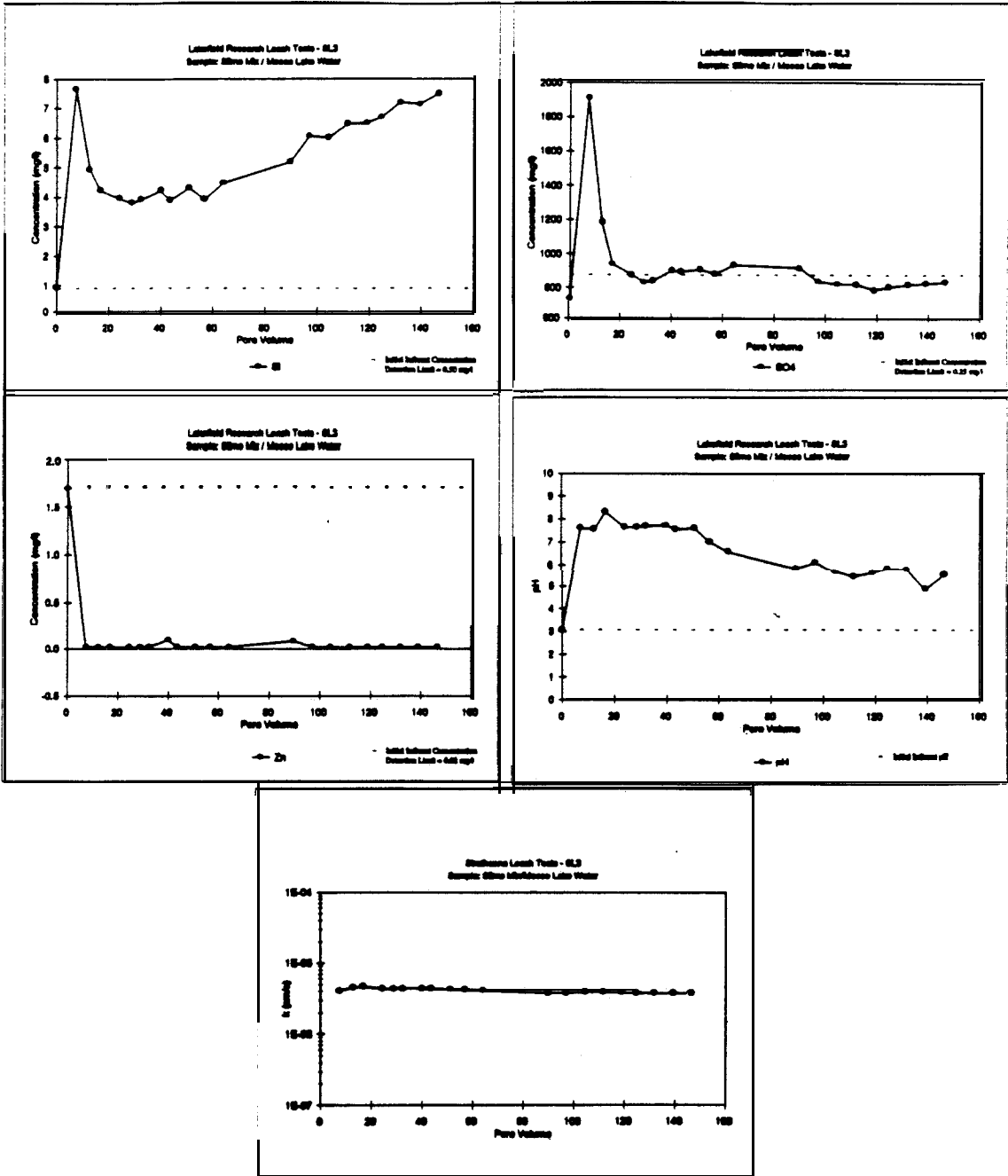
SL2 Concentrations Si, S04, **Zn, pH vs PV** & **K vs PV**



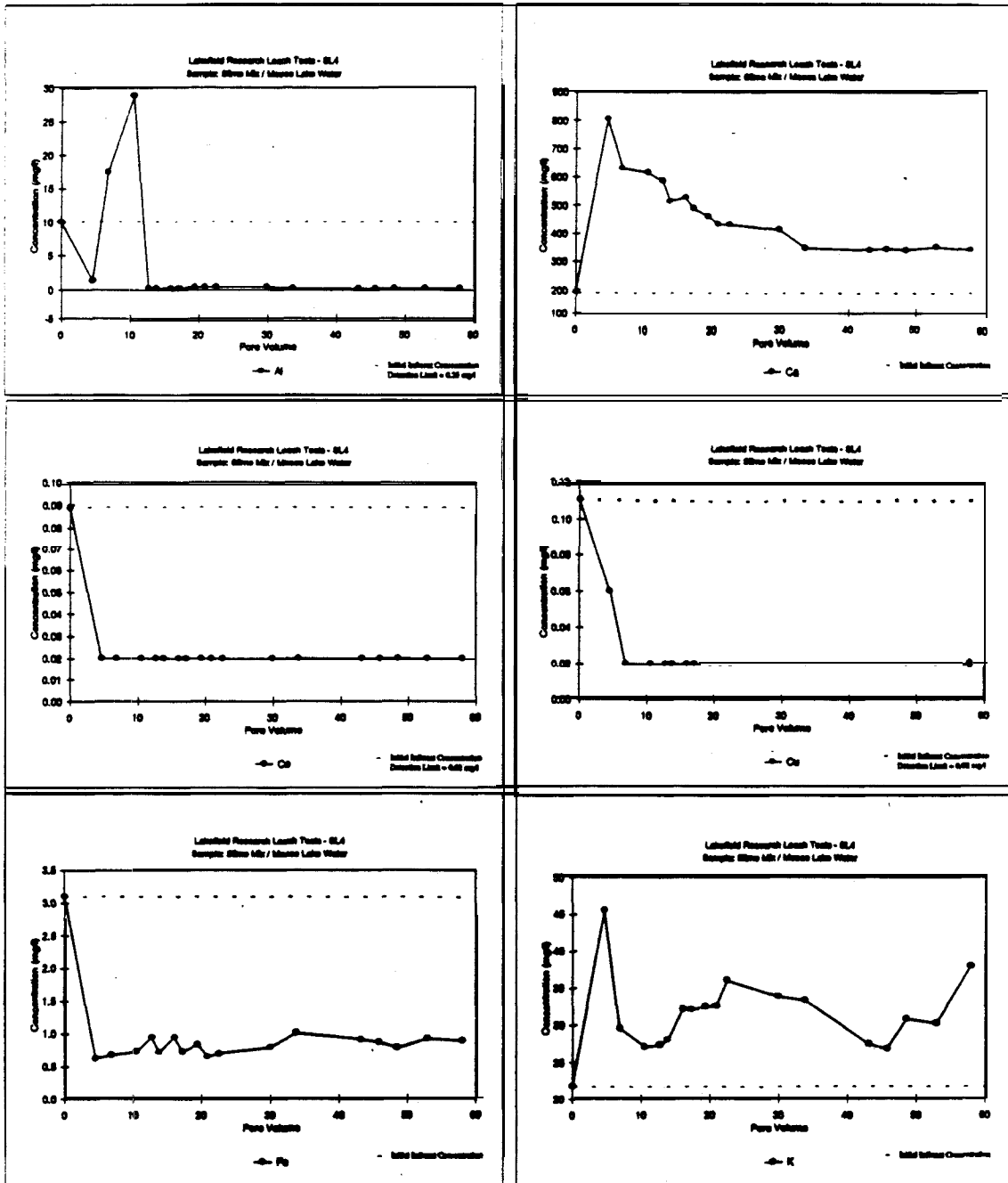
SL3 Concentrations Al, Ca, Co, Cu, Fe & **K**



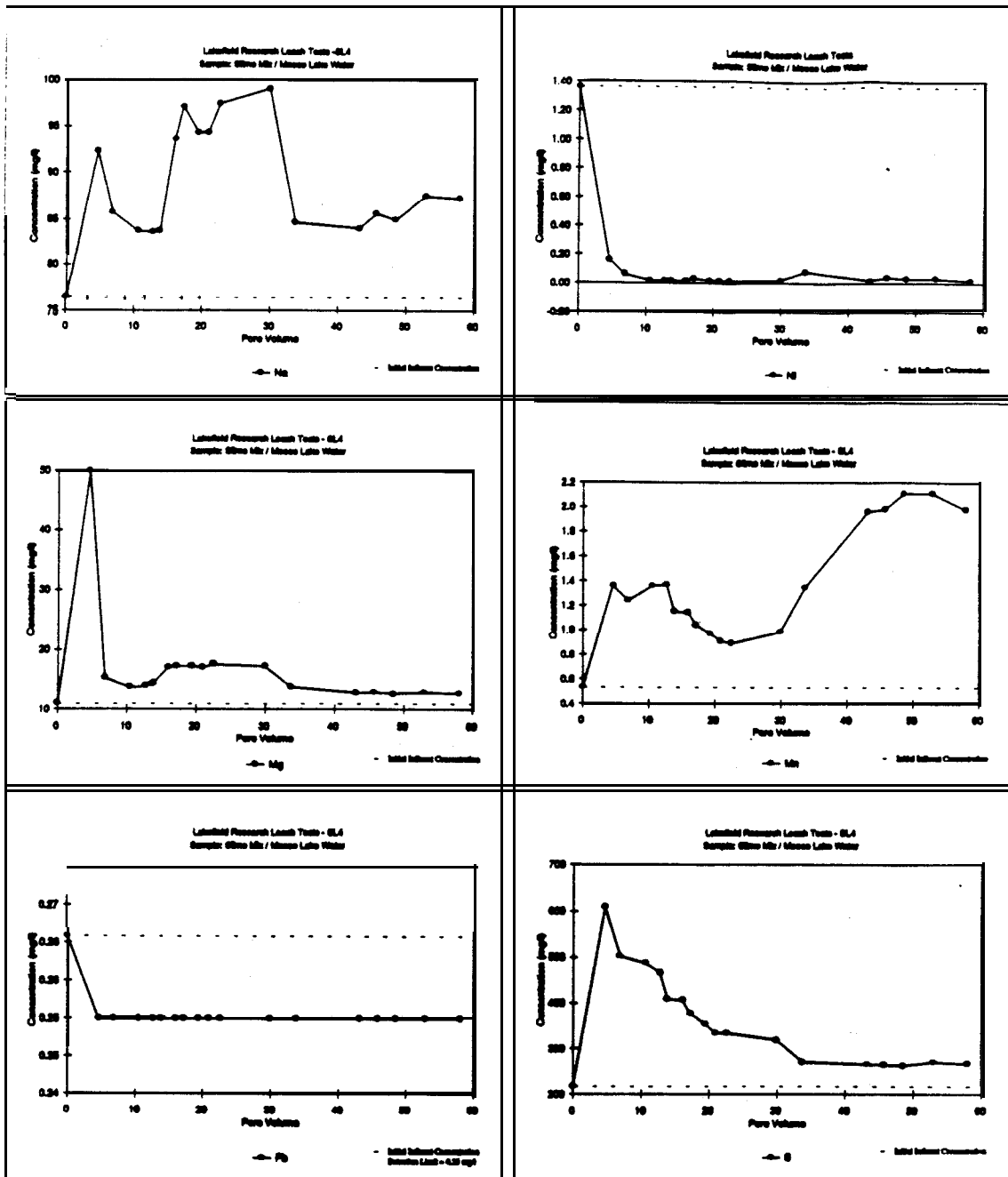
SL3 Concentrations **Mg, Mn, Na, Ni, Pb & S**



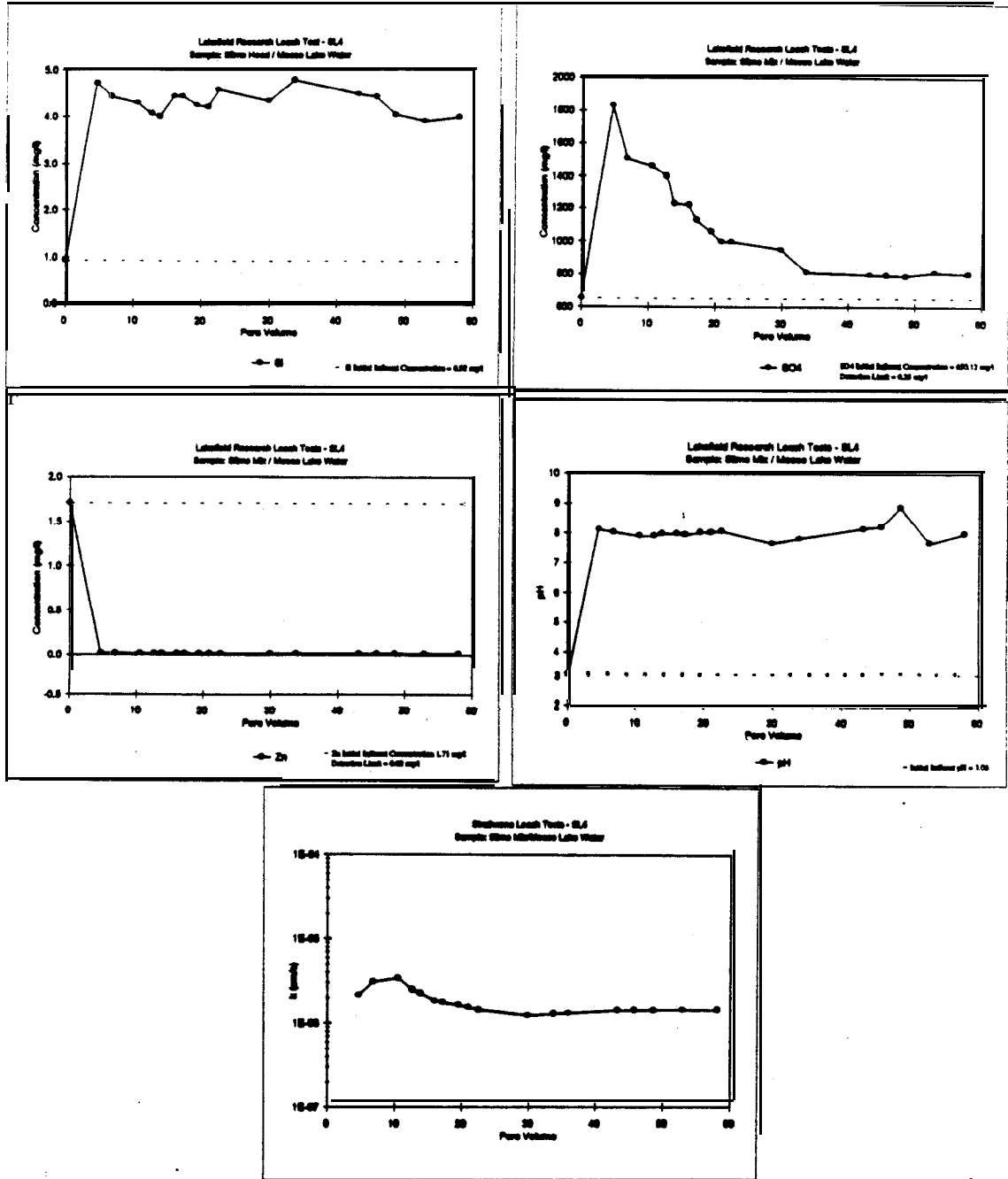
SL3 Concentrations Si, S04, Zn, pH vs PV & K vs PV



SL4 Concentrations Al, Ca, Co, Cu, Fe & K



∴ SL4 Concentrations Mg, **Mn**, **Na**, Ni, Pb & S



. **SL4** Concentrations Si, **SO4**, **Zn**, **pH** vs PV & K vs PV