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IN-PIT DISPOSAL PROGRAM FOR ACID GENERATING WASTE ROCK

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ABSTRACT

For many years open pits have been used for the disposal of waste rock. Mine waste disposal has become an environmental issue that is watched closely by government agencies and the public due to the legacies of past mine waste disposal methods.

An in-pit disposal program for acid generating waste rock was: conducted by Lakefield Research Limited at an abandoned mine site which operated as an open pit and underground mine. *The* mine was closed in 1975 and the mine property was included in a provincial park.

Prior to commencing the in-pit disposal program, an Environmental Site Assessment (ESA) of the mine property was conducted. The data collected during the ESA was used to develop a reclamation program that would address the site specific conditions that would maximize the on site resources to minimize the costs of the reclamation program. A testing program was conducted as part of the ESA.

The data from the testing program was used to determine the acid generating potential of the waste rock and the surface water quality. Two locations containing waste rock were generating acid during the ESA which had not generated acid at the time of closure, in 1975. One location was an acid generating waste rock dump at a ramp location, hi addition, the access road to the ramp area was constructed of acid generating waste rock. The second location was along the shore of a river, where acid generating waste rock had been used for construction of an access road for a pump house. The water quality of the pit water was within the Class 1 and Class 2 Manitoba Surface Water Quality Objectives and there was no evidence of the pit wall rock degrading the water quality. The quality of the pit water determined that a volume of the pit water could be discharged to the environment prior to placement of the waste rock in the pit.

Prior to the field program, the effect of placing the waste rock into the flooded open pit was determined by completing a laboratory column test with the waste rock and the open pit water. The results of the program were used to help predict any changes in water quality that would occur during dewatering of the open pit and waste rock placement.

The acid generating waste rock was effectively disposed of in the flooded open pit using a simple underwater disposal method.

INTRODUCTION

There are four major concepts that have been used for the in-pit disposal of acid generating waste rock and these are: 1) underwater disposal, 2) elevated water tables, 3) dry disposal, and 4) perched water tables (Senes, 1995).

It should be noted that in-pit disposal is not suitable for all types of waste material or for all open pits. Many technical factors would determine the appropriate method of disposal. Some of the factors follow: (Senes 1995).

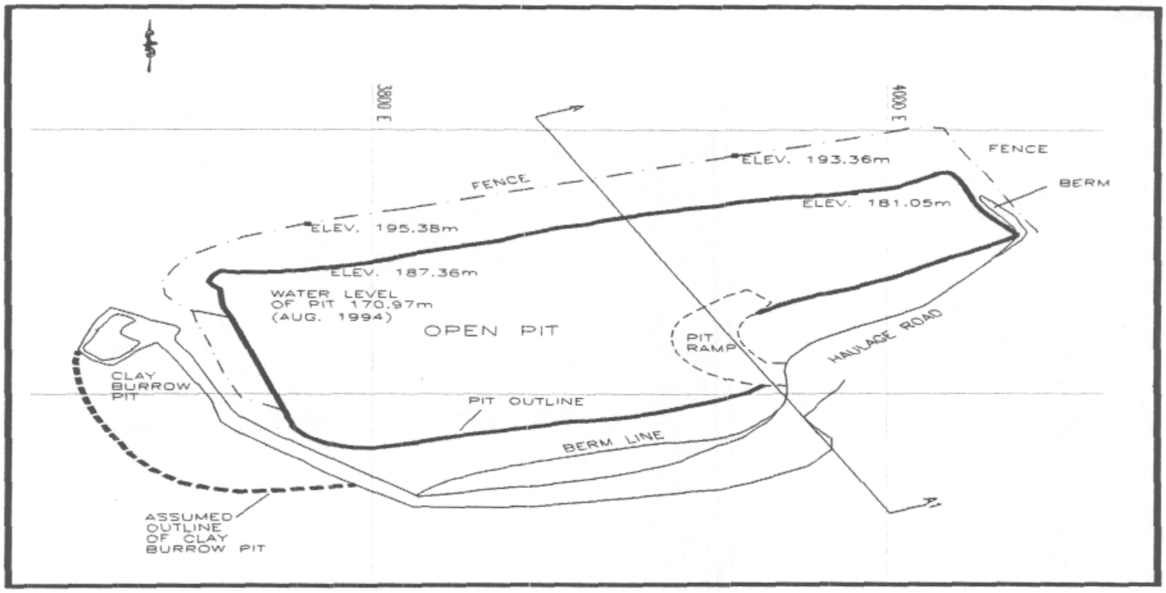
1. the acid generation potential of the pit walls and the waste rock;
2. the geotechnical characteristics of the pit walls;
3. the underground development at the open pit location;
4. the surface water, pit water and ground water quality; and,
5. the hydrology and hydrogeology of the open pit.

An in-pit disposal program for acid generating waste; rock was conducted by Lakefield Research Limited at an abandoned mine site which had operated as an open pit and underground mine. The mine was operational from 1969 until its closure in 1975. The mine property was included in a provincial park subsequent to its closure.

Prior to commencing the in-pit disposal program, an Environmental Site Assessment (ESA) of the mine property was conducted. The data collected during the ESA was used to develop a reclamation program that would address the site specific conditions that would maximize the on site resources to minimize the costs of the reclamation program. The ESA included: 1) a site reconnaissance; 2) sampling and testing of the waste rock; 3) sampling and testing of the surface water on site; 4) sampling and testing of the open pit water; 5) the construction of test pits along the access roads to establish the depth of the waste rock and to collect samples; and, 6) a topographic survey of the mine site.

Once the ESA was completed the mine plans were reviewed. The primary focus of the review was to assess the layout of the open pit, determine the ideal location for end dumping the material and locating the deepest area of the open pit. The underground development was also reviewed to determine if the underground development had advanced under the open pit. The pit wall stability was evident. The general layout of the open pit is shown in Figure 1.

FIGURE 1: General Layout of the Open Pit



ENVIRONMENTAL SITE ASSESSMENT

There appeared to be no known stability problems as the pit was idle for the last 20 years without a known pit wall stability problem. In addition the water quality of the pit water was within the provincial water quality objectives and there was no evidence of degradation of the pit water quality from the pit wall rock. It appeared that the open pit was suitable for a Simple Underwater Disposal (SUD) method.

Two areas were discovered during the ESA that contained acid generating waste rock. One area was called the "F" zone which contained approximately 21,584 tonnes of potentially acid generating waste rock. The primary area of focus was the 'F' Zone ramp location and to the west of the existing swamp area including the access road. The second area, known as the Pumphouse Road, contained approximately 7,700 tonnes of acid generating waste rock.

ANALYTICAL TESTING & RESULTS

Waste rock and water samples were collected in 1994, by the property owners, in accordance with a protocol provided by Lakefield Research Limited. These samples were analyzed and the data was used in determining the chemical characteristics of the surface water and the waste rock. A bulk water sample from the open pit was retrieved for a laboratory column test to simulate the placement of the acid generating waste rock into a flooded open pit.

Surface Water Quality Testing

Twelve surface water samples were collected to chemically characterize the quality of the water at designated locations. The water samples were tested for pH, acidity, alkalinity, and conductivity. An Inductive Coupled Plasma Emission Spectroscopy (ICP-ES) total metal scan and sulphate analysis were also performed. The results of the tests were compared to the Manitoba Surface Water Quality Objectives (Class 1- Domestic Consumption and Class 2 - Aquatic Life and Wildlife). The Manitoba Surface Water Quality Objectives lists a Class 3 - Industrial Consumption category, but this class was not used as it is site specific and no guidelines were issued for surface water quality objectives at the site in question. Class 1, Domestic Consumption, defines objectives that ensure the protection of waters that are suitable for human consumption, culinary or food processing purposes aïs well as other household purposes. Guidelines for the Manitoba Class 1 Water Quality Objectives also state that changes in water quality due to human influence should not cause an unacceptable increased risk to public health or an unacceptable increased treatment cost to the water user or supplier. Class 2, Aquatic Life and Wildlife, objectives have been established to ensure the protection of streams, lakes, marshes, swamps, lowlands, and any other aquatic community or wildlife which may rely upon the surface water for habitat and or food supply. These objectives also ensure the passage, maintenance and propagation of fish species and additional flora and fauna which are indigenous to a cool water habitat.

Monitoring station 144-100, which is upstream of the mine site on an adjacent river was used as a background station. Comparison of sample data collected from the monitoring stations 144-111 (downstream of creek mix zone at the river), 144-103 (old pumphouse location at the river, upstream of the access road) and 144-106 (old pumphouse location at the river, downstream of the access road) with monitoring station 144-100, indicated that the mine site did not cause a major impact on the receiver (the river). However, the data also indicated that there were small localized impacts.

Data from a monitoring station located at the toe of the waste rock at the "F" Zone, suggested that there was an impact on the small pond at the toe of the waste rock. Higher concentrations of some metals were noted at this location than at other monitoring stations. The conductivity, sulphate, sulphur and iron were also higher at this location than at other monitoring stations. The pH (2.86) noted at this monitoring station was lower than the pH noted at the other stations. Field observations also note a visual difference at this location, as the water was a brown tea color and evidence of hydroxide precipitate was present. The data from the downstream monitoring stations showed & decline in heavy metal concentrations downstream of 144-104.

The water quality of the pit water was acceptable and there was no evidence of the pit wall rock degrading the water quality. From the pit water quality data, it was determined that a volume of the pit water could be discharged to the environment prior to placement of the waste rock.

Waste Rock Testing

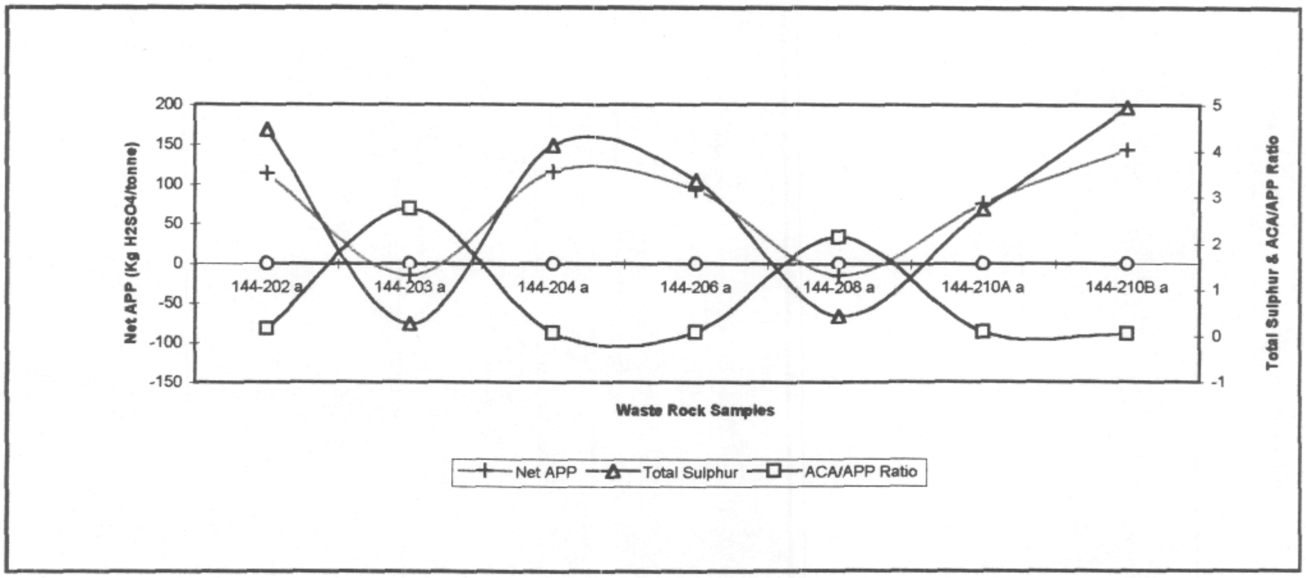
The data from the testing program was also used to determine the acid generating potential of the waste rock. Two locations containing waste rock had started generating acid, which had not generated acid at the time of closure, in 1975. One location was an acid generating waste rock dump at a ramp location ("F" Zone). In addition, the access road to the ramp area had been constructed of acid generating waste rock. The second location was along the shore of the adjacent river, where acid generating waste rock had been used for construction of an access road for a pump house.

Eleven composite waste rock samples were collected to chemically characterize the quality of the waste rock at designated locations. The samples were tested for acid generating potential by using the B.C. Research Initial Static Test.

The following guidelines were used to evaluate the waste rock samples collected and to identify the materials which were potentially acid generating. Materials with an ACA/APP ratio greater than 4 were not considered to have acid generating potential. Materials with an ACA/APP ratio less than 1 were considered to have acid generating potential. The acid production potential of materials with an ACA/APP ratio between 4 and 1 was considered uncertain and confirmation testing may be conducted to determine the acid generating potential of the material.

The data presented in Figure 2 suggests that the majority of the waste rock sampled was potentially acid generating.

FIGURE 2: Summary of Net Acid Consuming Ability Using B.C. Research Acid Base Accounting Methods



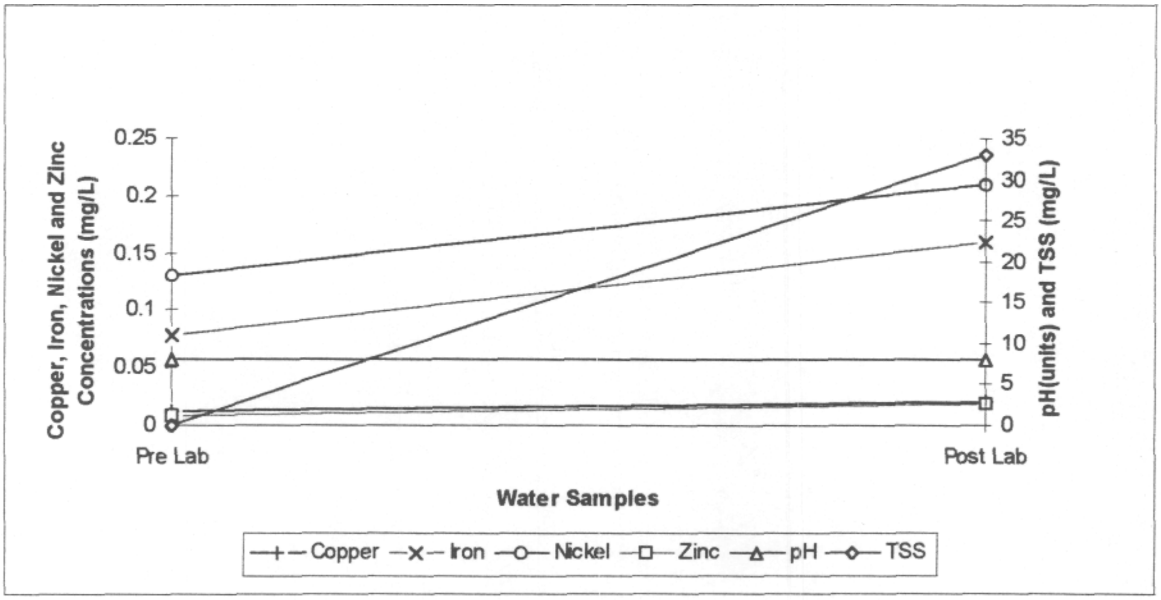
APP (Acid Producing Potential) = %S x 30.6
ACA (Acid Consuming Ability) = (Vol. consumed (ml) of 1.0 N H_2SO_4 x 49)
Net APP (Net Acid Producing Potential) = ACA - APP
APP and ACA are all Kg H_2SO_4 / tonne

Laboratory Column Testing

Prior to the field program, the effect of placing the waste rock into the flooded open pit was determined by completing a laboratory column test with the waste rock and the open pit water. The results of the program were used to help predict any changes in water quality that would occur during dewatering of the open pit and waste rock placement and to predict potential long term impacts.

Forty-five liters of pit water and a 2 kilogram sample of the "F" zone waste rock were collected and transported to the Lakefield Research Limited environmental facilities for testing. The simulation was performed using a plastic column, 10 centimeters in diameter and 1.5 meters in height. A volume of water, 8,260 mls, was placed in the column. This water was sampled and analyzed before the placement of rock into the column. The water samples were analyzed for ICP metal scan (total and dissolved), pH, acidity, alkalinity, conductivity, total suspended solids and sulphate. The waste rock from the "F" zone, was crushed to minus 6 mesh (Tyler) and placed in the column at 2% of the volume of water, which was similar to the ratio of rock to water that would occur in the field. The total volume of rock placed into the column was 165.22 cubic centimeters. The water in the column was sampled and tested 24 hours after the placement of the rock in the column for the aforementioned parameters. These results were used to help predict any changes in water quality that would occur during dewatering of the pit and waste rock placement. These results are presented in Figure 3

FIGURE 3: Laboratory Results of Pit Water



FIELD PROGRAM

An in-pit disposal program was developed for the waste rock using the results of the laboratory test program. The following were considered during the design of the Simple Underwater Disposal (SUD) program.

- the flooded open pit contained no known surface discharge areas;
- the pit water quality was acceptable for discharging to the environment because there was no degradation of the pit water from the pit wall rock and ground water;
- the waste rock volume to be placed in the open pit was 2% of the open pit capacity;
- the acid generating waste rock would be placed at the deepest and central location of the open pit which would reduce the oxidation potential of the sulfides;
- elimination of long term liability of acid generating waste rock was required, and;
- the disposal method used must be cost effective.

The data from the waste rock sampling program and the topographic surveying that was completed in August of 1994 was used to determine the approximate quantities of waste rock that could be extracted and placed in the open pit.

The in-pit disposal program was discussed with the Manitoba Ministry of Environment prior to the start of the program. The Ministry of Environment verbally approved the concept of dewatering a percentage of the open pit after reviewing the water quality data. A work permit from the Manitoba Ministry of Natural Resources was obtained for mine reclamation.

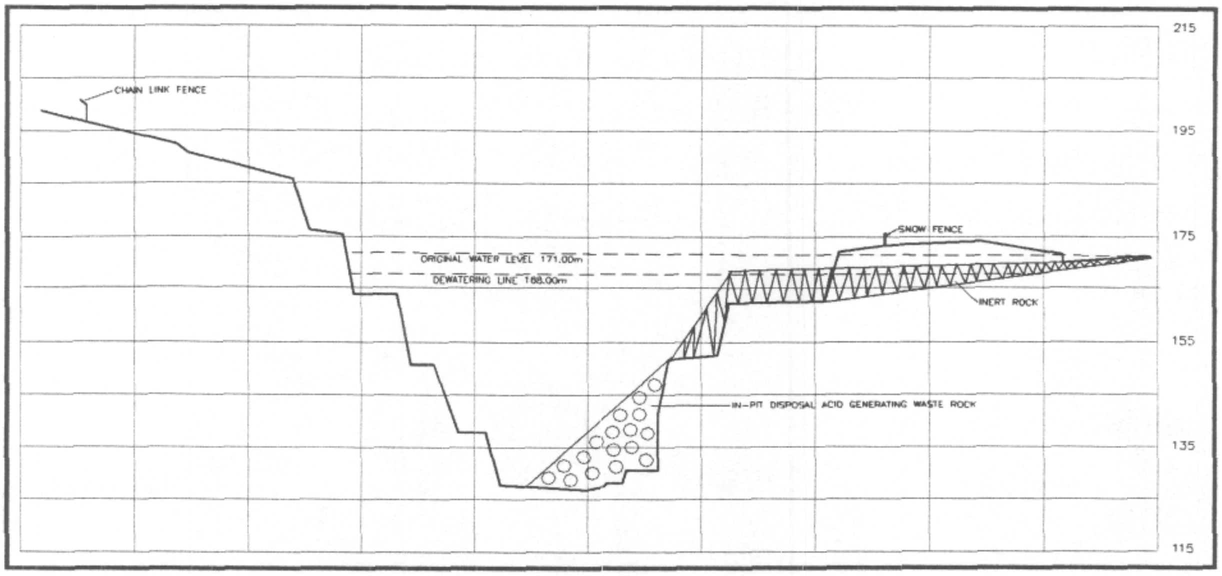
The in-pit disposal program commenced on May 7, 1995 and was finished on May 20, 1995, for a duration of 14 days. During the in-pit disposal program, it was necessary to dewater the open pit to 1.5 meters below the existing pit water elevation. Approximately 30,000 m^3 (7.9 million U.S. gallons) of pit water was discharged. The pit water was discharged to the creek adjacent to the open pit. This exposed the existing pit ramp which was used for the placement of the waste rock into the bottom of the flooded open pit.

Inert waste rock was placed over the existing pit ramp to ensure the safety of the trucks when transporting waste rock to the open pit. A berm was constructed at the water edge of the ramp to ensure the safety of the trucks while on the ramp.

The acid generating waste rock from the "F" zone was extracted, transported and place into the flooded open pit. The waste rock was excavated to the clay horizon. The clay was recontoured at the areas of extraction. The potentially acid generating waste rock along the road was extracted to a depth between 0.5 meters and 1.0 meters, depending on the quality of the waste rock.

Approximately 7,700 tonnes of waste rock material from the Pumphouse Road area was extracted to the clay horizon, transported and placed into the flooded open pit (see figure 4). The primary area of focus was the previous pumphouse location along the shore of the river and the access road which was constructed of acid generating waste rock.

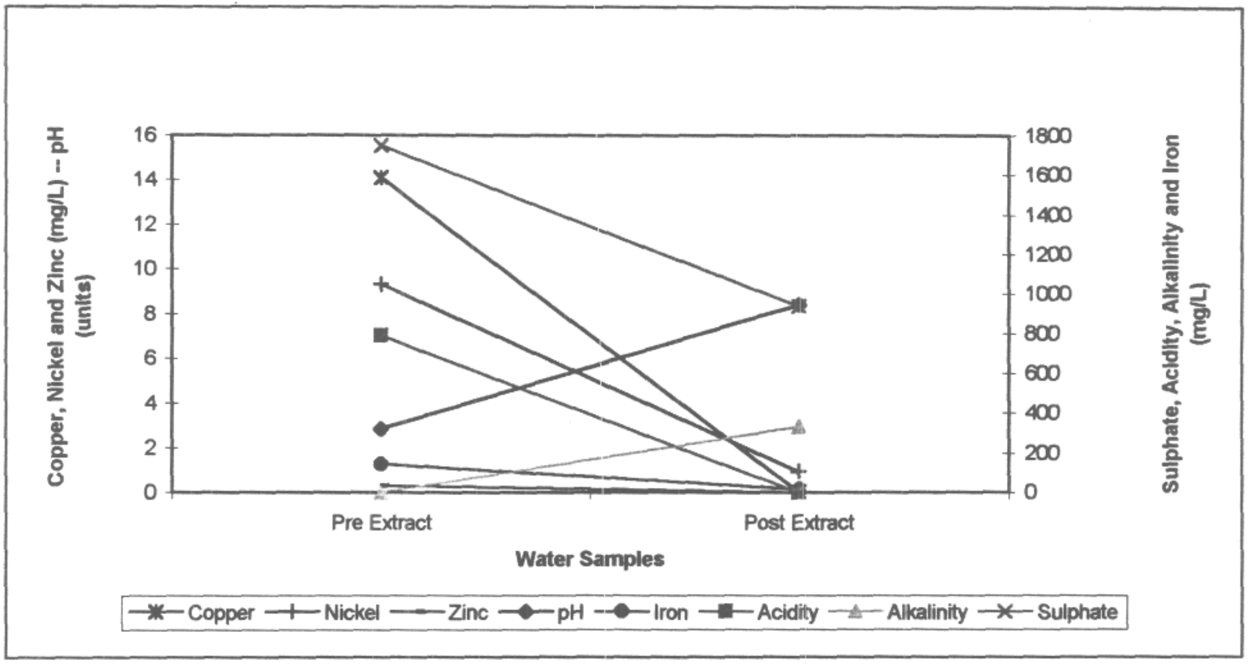
FIGURE 4: Cross- Section (A-A,) of the Open Pit Showing the Conceptual Disposal Area of the Acid Generating Waste Rock



After all of the waste rock had been placed into the open pit, the upper 0.5 metres of the ramp was excavated and placed into the open pit. This was done to ensure that all the waste rock that spilled onto the ramp was placed in the open pit. It appeared that the majority of the waste rock had been successfully placed into the deepest cut of the open pit. This was determined by measuring the depth of the disposal area at the open pit with a depth indicator.

Analytical testing conducted before and after the field program showed the water quality at the "F" Zone dramatically improved after the extraction of the acid generating waste rock. The water was sampled at the toe of the waste rock pile prior to the extraction process (Pre Extract) and 14 days after the extraction process of the waste rock (Post Extract) (see Figure 5).

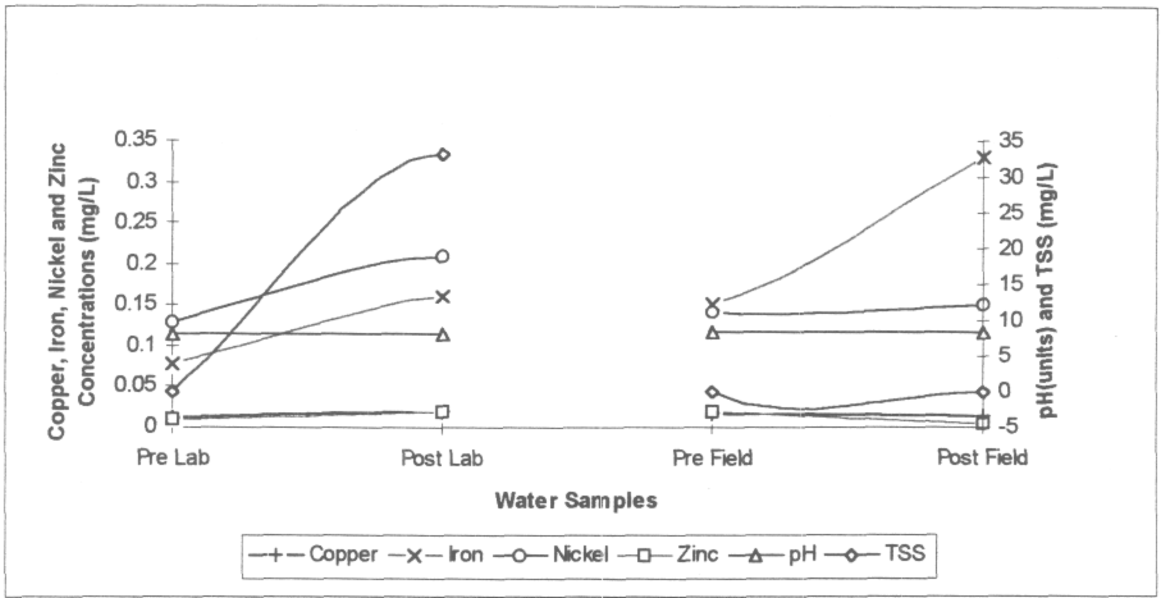
FIGURE 5: Water Quality at "F" Zone Before and After Extraction



COMPARISON OF BENCH AND FIELD RESULTS

The results of the laboratory column test and the analytical results conducted on samples collected during the field program showed that the column test was a good indicator of what occurred in the field. The column test and field results showed an iron concentration increase of 2 fold. The pH of the water in the column test remained constant and this was also observed in the field (see Figure 6). The conductivity of the column test water decreased. This decrease was also reflected in the field results.

FIGURE 6: Laboratory and Field Results of Pit Water



Some discrepancies were also noted between the field and laboratory results. The column test showed that the nickel concentrations would increase, however the field results showed that the nickel concentration remained stable. The analytical results of the column test results also showed that the Total Suspended Solids (TSS) concentration levels would increase, but the field results showed that the TSS were not detectable both before and after placement of the acid generating waste rock into the open pit. This may have been due to the increased settling time available in the field. It was anticipated at the beginning of the program that the increased dilution and settling time in the field would result in better water quality than in the laboratory. Therefore the laboratory was used to determine the worst case scenario which was not observed during the field program.

REFERENCES

Senes Consultants Ltd. 1995. Review of in-pit disposal practices for the prevention of acid drainage, case studies. MEND Report 2.36.1. Canadian Centre for Mineral and Energy Technology (CANMET), Ottawa. Ontario 89 p. + appendices