ABSTRACT

A comprehensive Closure Plan was developed for the Bell Mine which ensured minimal post-closure environmental impacts and public safety. Since much of the information required to develop closure scenarios was not available, a major task in the development of the plan was collecting, collating and interpreting factual data from several studies including hydrology, hydrogeology and the aquatic environment. The key issues identified to be addressed in the closure design were:

- thorough assessment of mine rock and tailings geochemistry;
- prediction of long-term water chemistry;
- establishment of historical and existing environmental conditions in the vicinity of Bell Mine;
- and
- environmental assessment of the closure approach.

It is determined that the onset of net acidic conditions in mine rock, not presently generating acid, is estimated to be in the order of 20 to 30 years. The water management system is designed to discharge runoff with acceptable water quality either by surface or submerged outfall into Babine Lake. If metal concentrations in these flows increase subsequently to unacceptable levels for safe release into Babine Lake, these flows will be directed into the open pit. When the pit fills to capacity, in approximately 50 years, the pit water may require treatment prior to release into Babine Lake. A lime neutralization treatment plant will be constructed 3 years prior to attaining the maximum storage in the pit.

Reclamation and rehabilitation activities focus on integrating the landscape to wildlife habitat. Removal of equipment, infrastructure and development of revegetation programs using proven grass and legumes assist in achieving this objective.

INTRODUCTION

Bell Mine, a former open pit copper concentrate producer, is located on Newman Peninsula within Babine Lake, approximately 10 kilometers north of the Village of Granisle, B.C. Mine operation commenced in 1970 with prestripping of the orebody, construction of the plant and ancillary facilities, and development of a tailings impoundment. The plant and tailings facilities were completed in 1972 and milling operation commenced in the fall of 1972.
Initially, pit development rock (oxidized ore) produced during the prestripping phase was utilized in the construction of tailings pond starter dams, preparation of the plant site or was disposed in a rock dump. Subsequent pit development rock was utilized for raising tailings dams, construction of new dams and the remaining rock was placed in four rock dumps (figure 1).

In 1982, the operation closed due to the combination of rising operating costs and low copper prices. In 1983, a limited prestripping operation commenced in anticipation of re-opening. In 1985, the Bell Mine re-opened with a projected life of three years. Through perseverance and commitment to maintaining operations, the Bell Mine continued to survive with a series of minor pit expansions to the ultimate closure in 1992.

The presence of small and localized acid rock drainage raised concerns regarding the potential for acid drainage at other areas. Effluents containing elevated copper levels were being collected in areas where oxidized development rock was placed during the initial development stage. Predictions of nature, extent and future potential of acid rock drainage were required in order to develop a closure plan. In 1990, preliminary studies were focused on characterizing mine rock and tailings for acid generating potential. Concurrently, Bell Mine was investigating the potential to extend operations through the development of a massive mineralized zone below the open pit.

In 1991, Bell Mine formed a Closure Team to develop, plan, and execute the Closure Plan, known as the Bell 92 Project. The key issues in developing this closure plan were:

- An understanding of the rock and tailings mineralogy and geochemistry;
- Prediction of interim and long-term water chemistry;
- An assessment of historical and existing environmental conditions in the vicinity of Bell Mine;
- Public safety, long-term stability of earth structures, and land rehabilitation;
- Management after closure; and,
- Impact of post closure discharges on the local environment.

The obstacles for this project included the collection, collation and interpretation of massive amounts of information within a target date of one year. Unlike other minesites, Bell did not have many of the basic 'building blocks' needed for developing a Closure Plan. More detailed information on hydrology,
hydrogeology and geotechnical conditions was required for Bell Mine. Therefore, much of the basic information had to be assembled to satisfy the key issues of closure.

The evolution of this closure plan was complicated due to the inter-relationships with the information being compiled. For example, closure design, water management, and environmental assessment of closure discharges were dependent upon the mine rock and tailings geochemistry and prediction of water chemistry study. In contrast, the prediction of water chemistry study required the information from the water management study. A number of distinct studies were developed for the closure plan and compiled into the following support documents:

- Site Description
- Hydrology
- Geotechnical Assessment
- Hydrogeology
- Mine Rock and Tailings Geochemistry and Prediction of Water Chemistry
- Water Management
- Review of Historical Environmental Data of Babine Lake
- Existing Environmental Conditions in the Vicinity of Bell Mine
- Environmental Assessment of Bell Mine Discharge on Babine Lake
- Reclamation Plan

Each support document contains data, designs and interpretations. Development of closure designs is based on the information in these support documents. The highlights and conclusions of the key documents are included in the following sections.

**GEOCHEMISTRY OF MINE ROCK AND TAILINGS**

A detailed study was initiated involving site investigations, laboratory test work, data interpretation and numerical modeling to:

- Determine which portions of the mine are currently generating net acidity and which portions may generate net acidity at some future time;
- Define the rates of acid generation, acid neutralization and metal leaching under all relevant site conditions;
- Predict water chemistry at locations around the mine site at various points in time.
The first step in this study was the mineralogical evaluation of the mine rock and tailings. Discussions with Bell Mine geologists provided detailed information on the mineralogy of rock types, physical geology of the Bell Mine area, estimated tonnages of rock types excavated from the pit and the distribution of the various rock types around the mine site.

Samples of significant rock types and tailings were obtained from the surface, trenches and drill hole cores. Analyses consisted of visual and x-ray mineralogical examinations as well as measurements of metal and non-metal concentrations. This information was combined to estimate the mineralogical composition of the major rock types and tailings and to assess the accuracy of geochemical data on the mine rock dumps.

**Acid Potential**

Acid-base accounting (ABA) is a mineralogical examination in which the balance of acid generating and acid neutralizing capacity of a sample is determined. In its basic form, ABA includes a measurement of total sulphur, which is mathematically converted to Acid Potential (AP), and a measurement of the amount of the neutralization over a 24 hour period under acidic conditions which is termed as Neutralization Potential (NP). Net Neutralization Potential (NNP) is calculated from the subtraction of AP from NP.

Whenever a negative NNP is obtained for a sample, the sample is declared "potentially acid generating". The word, *potentially*, is important because ABA cannot reveal whether a sample will indeed become acidic, but whether the sample might become acidic at some point in time. Kinetic tests are completed to determine if and when, and to what extent, the acidity may be generated.

There is a large ABA database of more than 200 ABA analyses for the Bell Mine which allows preliminary predictions on the acid generating potential of rock and tailings at the site.

ABA analyses of rock samples demonstrated that portions of most rock types are potentially capable of generating net acidity at some point in time. In fact, paste pH values indicated that some samples are already generating net acidity. Some of the rock types were also found to be capable of neutralizing a significant amount of acidity. Based on average NNP values, four rock types are declared to be potentially acid neutralizing; however, the relatively low average values and the NP/AP ratios do not support a firm conclusion on this acid generating potential.
### Table 1

GEOCHEMISTRY AND PREDICTION

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>VOLUME OF MATERIAL m$^3$ (millions)</th>
<th>GEOCHEMICAL PARAMETERS (mean)</th>
<th>PREDICTIONS FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PASTE pH</td>
<td>NNP</td>
</tr>
<tr>
<td>North Dump</td>
<td>6</td>
<td>7.7</td>
<td>-18</td>
</tr>
<tr>
<td>Dump 7</td>
<td>6</td>
<td>7.7</td>
<td>15.5</td>
</tr>
<tr>
<td>A-Frame</td>
<td>4.5</td>
<td>5.7</td>
<td>-34</td>
</tr>
<tr>
<td>Dam 1 and 2</td>
<td>16.8</td>
<td>7.6</td>
<td>-8</td>
</tr>
<tr>
<td>South Dump</td>
<td></td>
<td>8.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Plant Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dam 3 and 4</td>
<td>1.4</td>
<td>7.7</td>
<td>15</td>
</tr>
<tr>
<td>Tailings</td>
<td>49</td>
<td>6.5</td>
<td>-45</td>
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### Table 2

PREDICTION OF WATER CHEMISTRY

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>*</th>
<th>pH</th>
<th>Acidity (mg/L)</th>
<th>Cu(d)</th>
<th>Fe(d)</th>
<th>Zn(d)</th>
<th>SO$_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Dump</td>
<td>a</td>
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<td></td>
<td>&lt;0.01</td>
<td>&lt;0.03</td>
<td>&lt;0.01</td>
<td>2000</td>
</tr>
<tr>
<td>(CP 8)</td>
<td>b</td>
<td>7.0</td>
<td>20</td>
<td>0.20</td>
<td>0.08</td>
<td>0.06</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>2.5</td>
<td>3400</td>
<td>800</td>
<td>500</td>
<td>5.0</td>
<td>10,000</td>
</tr>
<tr>
<td>Dump 7</td>
<td>a</td>
<td>7.0</td>
<td></td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.01</td>
<td>2000</td>
</tr>
<tr>
<td>(CP D7)</td>
<td>b</td>
<td>7.0</td>
<td>20</td>
<td>0.20</td>
<td>0.8</td>
<td>0.06</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>2.5</td>
<td>3400</td>
<td>800</td>
<td>500</td>
<td>5.0</td>
<td>10,000</td>
</tr>
<tr>
<td>A-Frame</td>
<td>b</td>
<td>6.3</td>
<td></td>
<td></td>
<td>&lt;0.03</td>
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<td>1600</td>
</tr>
<tr>
<td>(CP 4, CP 5)</td>
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<td>3400</td>
<td>800</td>
<td>500</td>
<td>5.0</td>
<td>10,000</td>
</tr>
<tr>
<td>Dam 1 &amp; 2</td>
<td>a</td>
<td>7.6</td>
<td></td>
<td></td>
<td>&lt;0.03</td>
<td>0.07</td>
<td>1800</td>
</tr>
<tr>
<td>(1-3, 1-5)</td>
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<td>7.0</td>
<td>20</td>
<td>0.20</td>
<td>0.08</td>
<td>0.06</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>2.5</td>
<td>3400</td>
<td>800</td>
<td>500</td>
<td>5.0</td>
<td>10,000</td>
</tr>
<tr>
<td>South Dump</td>
<td>a</td>
<td>7.0</td>
<td></td>
<td>&lt;0.01</td>
<td>&lt;0.03</td>
<td>&lt;0.01</td>
<td>&lt;2000</td>
</tr>
<tr>
<td>Plant Site</td>
<td>b</td>
<td>7.0</td>
<td>7.0</td>
<td>0.20</td>
<td>0.08</td>
<td>0.06</td>
<td>2000</td>
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<tr>
<td>(CP 2)</td>
<td>c</td>
<td>2.5</td>
<td>3400</td>
<td>800</td>
<td>500</td>
<td>5.0</td>
<td>10,000</td>
</tr>
<tr>
<td>Dam 3 &amp; 4</td>
<td>a</td>
<td>7.8</td>
<td></td>
<td>&lt;0.02</td>
<td>&lt;0.03</td>
<td>&lt;0.01</td>
<td>&lt;2000</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>7.0</td>
<td>20</td>
<td>0.20</td>
<td>0.08</td>
<td>0.06</td>
<td>2000</td>
</tr>
<tr>
<td>Tailings</td>
<td>a</td>
<td>7.0</td>
<td></td>
<td>&lt;0.01</td>
<td>&lt;0.03</td>
<td>&lt;0.01</td>
<td>&lt;2000</td>
</tr>
</tbody>
</table>

* a = Measured in 1992
  b = Predicted at pH = 7.0
  c = At full NP Depletion
ABA analyses show that portions of the older and fresh tailings are potentially capable of net acid
generation. Evidence of pyrite oxidation is limited to ferric-iron staining to a depth of approximately 1
meter and the observed tarnished appearance of concentrated pyrite bands in a few test pits. However, no
acidic water has ever been reported within the impoundment indicating NP remains available and reactive
within the tailings area.

Modified "flow-through" humidity cells were used for kinetic testing of rock and tailings samples.
Interpretation of humidity cell data reflected the recent understanding of the less-than-ideal neutralization
reactions causing neutralizing minerals to be consumed at a faster rate than acid generating minerals.

Additional information was obtained from heap leaching column tests conducted by Bell Mine to evaluate
heap leach technology for the recovery of copper. The data from these tests were used to estimate: the
availability of neutralization potential; general rates of metal leaching; effect of scale on rates of acid
generation, acid neutralization, and metal leaching; and maximum worst-case water chemistry.

Prediction of Water Chemistry
In order to predict the onset and severity of acid drainage in Bell Mine dumps and dams, the following
simplifications were made:

- onset of acidic conditions was assumed to occur when the average value of available NP is
  consumed;
- onset of acidic conditions is instantaneous throughout the entire rock dump and the accelerated
  acidic rate of oxidation then becomes applicable; and,
- range of NP within a dump or dam is taken as indicative of the uncertainty in the predicted time
to net acidity.

Using data from kinetic tests, heap leach tests and historical water quality analyses, the time to acidification
was calculated. Table 1 displays the predictions for acid generation and sulphide depletion (i.e. when acid
generation ceases). Two water quality predictions were also generated: 1) water quality during pH neutral
periods when NP is being consumed; 2) water quality during full NP depletion. Table 2 contains the
prediction of water chemistry of the various structures. In general, the onset of net acidic conditions in
rock dumps and dams, not presently generating acid, is estimated to be in the order of 20 to 30 years.
**Tailings**

There is net deficiency of available neutralization potential in the tailings mass, and net acid generation can be expected from the near surface tailings. This results in the creation of a geochemical 'acid front' which migrates downward, consuming NP, followed by a sulphide depletion front above where there are no active acid generating minerals remaining. However, acidic water moving downward into the deeper tailings will be neutralized by the available deeper NP. Due to factors such as oxygen diffusion, the downward migration rates of these fronts will slow with time. In fact, the migration of the acid front is predicated to essentially cease decades in the future. Modeling indicates that acidic water is not expected to seep from the tailings mass. However, because the rock within the tailings dams are predicted to generate net acidity in time, the pH neutral seepage from the tailings through the rock dams is expected to become acidic.

**Open Pit**

Pit water chemistry was determined by assessing input flows and loadings. These inputs include: alkaline groundwater, acidic runoff from the pit perimeter and water pumped from the collection ponds. The compilation of the flows and loadings indicates the pit will fill to maximum design capacity by about year 2050. The pH and net acidity of the pit water are predicted to reach steady values of pH 2.7 and acidity of 2,200 mg CaCO₃/l, by the year 2060. Through the centuries after the pit is full, pit water quality is predicted to recover slowly.

**WATER MANAGEMENT**

During the initial development of the closure plan, Bell Mine pursued a comprehensive water management system to handle both interim and long-term requirements. During operations, the water management system was developed as a response to developing needs, without the use of engineered design or construction. Consequently, the system required frequent monitoring and maintenance. In 1991, construction of engineered collection facilities commenced.

Each collection pond is constructed to store a one-in-200 year flood event and allow the overflow of a PMF through an emergency spillway. Each collection site has a concrete block constructed pumphouse containing two stainless steel vertical turbine pumps with a combined capacity of 2700 or 5400 m³/day. Identical pump station design has been utilized to minimize and simplify future maintenance and repairs. Two pumps and pipelines work alternately during normal flows and together during flood conditions. The
pipelines are installed to be self draining in two directions and will include air valves at high points. The pipelines are buried 2 meters below the ground for frost and wildlife protection.

The goal of water management is divert as much water as possible into Babine Lake without causing an environmental effect, while utilizing the open pit for storage of flows containing elevated metal levels. Since the evaluation of rock and tailings geochemistry concluded that the rock and tailings are potentially acid generating, but the onset of acidic conditions may not occur for up to 30 years, there was an opportunity to maximize open pit water storage through on-going discharges. The discharges proposed included shedding surface water from tailings and rock dumps as well as seepage from various structures. The discharge designs evaluated were either surface discharges or submerged pipeline outfalls. The water quality criteria for the various discharge options were developed through an iterative process addressing acceptable impacts to the lake. The water quality criteria for lake and underwater discharges and locations are given in Table 3 and Figure 2. The water management system is designed to divert these discharges into the open pit once discharge criteria shown in Table 3 is exceeded.

Water Treatment

The maximum water storage capacity of the open pit is estimated to be $48 \times 10^6$ m$^3$. The open pit will be able to store collected water for approximately 50 years before discharge is required.

Open pit water will be treated and discharged annually prior to the water reaching the maximum water level. The treatment method will be a function of the final water quality in the pit and the best practical and economic effluent process technology. It is anticipated that new methods will be developed which will reduce sludge volume and improve the efficiency and economics of water treatment. The final process could involve insitu passive treatment, like wetlands application or an improved lime neutralization technology. For the purposes of this closure plan, it is assumed that a lime neutralization treatment plant will be constructed 3 years prior to the water reaching the maximum storage level. The submerged outfall into Babine Lake will be utilized for discharge.

AQUATIC ENVIRONMENT OF BABINE LAKE

A major goal in the development of the Bell 92 Project was protection of the Aquatic Environment. Babine Lake accounts for 90% of the Sockeye salmon production in the Skeena River system which supports a
SCHEMATIC OF COMPLETED CLOSURE PLAN
COLLECTION AREAS AND WATER DIVERSION

Noranda Minerals Inc.

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Table 3

DISCHARGE CRITERIA FDR HAGAN ARM
AND MAIN BODY OF BABINE LAKE

<table>
<thead>
<tr>
<th>Discharge</th>
<th>Initial Mixing Area (10^3 m^3)</th>
<th>Discharge Criteria Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cu</td>
</tr>
<tr>
<td>SURFACE DISCHARGE TO HAGAN ARM</td>
<td></td>
<td>Cu</td>
</tr>
<tr>
<td>CP 3-1</td>
<td>8</td>
<td>0.3</td>
</tr>
<tr>
<td>CP 4-1</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>CP D7</td>
<td>5</td>
<td>0.1</td>
</tr>
<tr>
<td>CP 8</td>
<td>6</td>
<td>0.1</td>
</tr>
<tr>
<td>SUBMERGED DISCHARGE INTO HAGAN ARM AND MAIN BODY</td>
<td></td>
<td>Cu</td>
</tr>
<tr>
<td>TPW</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>CP 2, 1-3, 1-5</td>
<td>18</td>
<td>1.0</td>
</tr>
<tr>
<td>CP D7</td>
<td>N/A</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Noranda Minerals Inc.
major commercial fishery. Salmon enhancement facilities are operated on Fulton River and Pinkut Creek. While the perceived sensitivity is evident, little to no data was available examining the effects of Bell Mine operations on the Aquatic Environment. A significant effort was devoted to reviewing the historical information of Babine Lake, as well as examining the aquatic environment in the vicinity of Bell Mine through a detailed monitoring program. All the information was utilized to evaluate the potential effects of discharges resulting from the closure design.

**Water Quality**

The water quality data gathered for Babine Lake over the last two decades shows that in general, the water quality of the main body of Babine Lake has not changed significantly over the last 16 years. Periodic increases in conductivity, total residues, sulphates, calcium, total and dissolved copper, and total and dissolved zinc were noted at sample locations located on the west side of Newman Peninsula in close proximity to the mine. These increases do not appear to have had any significant long-term impact on the overall quality of water in Babine Lake and the source of these increases is not known.

Water quality for Hagan Arm, where Bell Mine discharged effluent, suggests that the general physical and chemical characteristics of the water in this arm are comparable to those in the main arm of Babine Lake. Total and dissolved copper levels were slightly higher in Hagan Arm than in the main part of the lake, but remain largely unchanged relative to conditions reported in 1974 and 1984. Mining activities have had a minor to immeasurable effect on the copper content of Hagan Arm.

During operations, tailings water was discharged into Rum Bay of Hagan Arm. Rum Bay water quality, measured in the vicinity of the tailings water discharge, exhibited elevated levels of conductivity, chloride, and sulphate relative to water taken from other parts of Hagan Arm. However, trace metal concentrations indicate minimal spatial variability.

The copper complexing capacity of Babine Lake was determined to be 0.06 mg/l in 1992 with a historical high reported of 0.01 mg/l. The complexing capacity is well in excess of background copper concentrations, therefore there is a large reservoir of dissolved organic constituents capable of complexing significant levels of copper.
**Sediment Geochemistry**

Lake sediments from sites affected by mine related incidents, such as tailings and seepage spills, were examined. High copper content observed at localized areas in Woolverton Bay sediments are a result of seepage inputs from a rock dump (A-Frame) prior to the installation of seepage collection. The relative abundance of biogenic sulphide (indicative of a highly reducing condition) was present combined with elevated levels of copper. Given the strong reducing conditions in Woolverton Bay sediments, there is a high potential for the accumulation of copper sulphide (rendering copper insoluble).

Sediment cores were obtained from Woolverton Bay to determine the effect of elevated copper in sediments on the overlying water. The interpretation of the data indicated that a steady-state benthic efflux of copper from the sediments could add about 0.00003 mg/l of dissolved to the Woolverton Bay waters. This is a small, nondetectable fraction of the copper concentration commonly measured in Hagan Arm.

Sediments containing high levels of copper were also found at a site which was not affected by mining activity. The talus-like distribution of these sediments and their proximity to undisturbed steep, shoreline cliffs suggest that natural sloughing and erosion in this area is responsible for the elevated copper content.

**Lake Biology**

Phytoplankton, zooplankton and benthic invertebrates were examined. The benthic invertebrate communities in Main Arm were dominated by facultative organisms (those benthic organisms that may persist in relatively poor as well as good water quality conditions). Less abundant groups included tolerant (those organisms which tend to dominate communities which are affected by severe habitat degradation) and sensitive taxa (those organisms which are found primarily in clean water quality or little organic matter). Based on comparisons with historical baseline data (DFO, Bell), the 1992 data indicated increases in the composition of facultative and sensitive taxa, in addition to observed declines in maximum densities for all three tolerance groups.

Consistent with the results in the Main Arm, the benthic invertebrate communities in Hagan Arm and Woolverton Bay were predominantly comprised of facultative fauna, with the balance of the communities biased in favour of tolerant taxa. Sensitive taxa were observed in bethos samples from only a few sample sites.
A comparison of 1992 data with historical data indicated marginal shifts from tolerant to facultative fauna for benthic invertebrate composition and a general increase of approximately three-fold at Hagan Arm sites. The 1992 mean density of benthic invertebrates in Woolverton Bay was greater than historical values.

Fish sampling in the Main Body and Hagan Arm of Babine Lake obtained Kokanee, Rainbow trout, Lake trout, Lake whitefish and Burbot species. Their food preferences and positions in the water column clearly showed that all aspects of the available fish habitat are being utilized, from the plankton in the water column to the substrate at the bottom of the lake. Finally, it appears that overall numbers of important fish species in the lake such as Rainbow trout, Lake trout, and Kokanee have been on the decline for some time. There is no clear understanding of the cause of this decline.

The results of muscle tissue metal analyses indicated that the mean concentrations of trace metals are within the ranges of values observed for fish from unpolluted sources in areas of B.C. and Canada. Differences in metal levels in fish from Hagan Arm relative to those observed in fish from Main Body are marginal. In conclusion, analysis and review of the data did not reveal any increase of metal concentrations in fish tissues nor any correlation between water quality and fishery resources which would indicate an impact from mining on the surrounding aquatic environment.

**Aquatic Effects of Closure Plan Discharges**

No long term impacts on the aquatic biota of Main Body and Hagan Arm are forecast due to increased concentrations of copper, zinc, and aluminum beyond the discharge dilution zones as concentrations of these metals are projected to be within the present background levels.

Direct copper or aluminum toxicity to the aquatic biota is not forecast from any of the discharge options proposed for the Main Body or Hagan Arm. Copper complexing data indicates Babine Lake water is capable of organically complexing significantly more copper than will be available in any of the proposed discharges. Ameliorating effects of organic complexation on aluminum toxicity suggest the aquatic biota in the lake will not be impacted by dissolved concentrations of aluminum.
In summary, the Bell Mine has had a minimal impact on the Babine Lake aquatic environment. The closure technology selected will have a negligible effect on the long term aquatic environment of Babine Lake.

**RECLAMATION PLAN**

Mine site reclamation includes the removal of all equipment and infrastructure not required for the long term operations and maintenance of the property. Where feasible, concrete foundations will be covered and revegetated. Refuse and scrap metal will be recycled, if economically feasible, or disposed of in a manner appropriate with existing regulations. All fuels, chemicals and related reagents will be disposed of in an acceptable manner. All geotechnical earth and rock structures will stand in a safe and stable condition.

Rock fill and tailings surfaces will be reclaimed to a wildlife habitat land use. Reducing visual impacts and restoring the aesthetic value of the site will be considered and implemented where feasible. Where practical, rock slopes will be regraded to improve equipment access and optimize vegetation growth results. At sites and structures where regrading or resloping would encroach upon water management facilities, other techniques will be used to establish vegetation. A mixture of grasses and legumes will be used to promote the invasion of adjacent native vegetative species. Landform modifications will be incorporated, such as the establishment of clay till islands planted with tree seedlings, to aid in developing suitable moose and deer habitat and enhance visual aesthetics.

**LONG TERM MANAGEMENT**

Pumping systems will be monitored and controlled by a computerized data acquisition and control system. Routine monitoring, maintenance, and operation of the site will be conducted by a caretaker living in the vicinity. Primary access to the site will be via the Northwood Barge across Babine Lake and a logging road to the north end of Newman Peninsula.

**CONCLUSIONS**

The selection of the closure technology described was based on minimizing post-closure environment impacts and ensuring public safety. Due to the volume of information being collated, it was important to make presentations on the progress of the plan. The terms of reference for the various studies and progress
results were presented to, and discussed with, the appropriate government agencies and the public. Presentations were made on September 1991, April 1992, and final presentation of the plan in May 1993. The intent of presentations was to guide participants through the information, allowing a thorough understanding of issues and the technical justifications for conclusions. Participants were provided the ten support documents which detailed the technical information, as well as a Summary document which summarized the details of the Closure Plan for Bell Mine. The plan was completed in 1.5 years versus the planned 1 year time frame. The extra time was required to gather additional information and conducted technical reviews of all the information. The result is a Closure Plan which provides a complete compendium of past, present and future information on Bell Mine.