SECTION B.5

REGULATION AS A TOOL FOR REDUCING RISKS AND PREVENTING IMPACTS ASSOCIATED WITH METAL LEACHING AND ACID ROCK DRAINAGE

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INTRODUCTION

What is a Mine in British Columbia?

• jobs • resource production • taxes	during operation
• neighbour • **potential contamination of land & water**	during and **after** operation; mining is not a temporary land use at many minesites,

After mineral resource extraction, gravel pits and most British Columbia (BC) coal mines can be reclaimed to productive alternative land use. However at most metal and some coal mines reclamation is prevented in whole or in part by on-site contamination of land and water and/or the mitigation required to prevent contamination of off-site resources. An example of short term contamination is the presence of cyanide used in gold extraction. Cyanide can be cleaned-up (degraded). This is not the case with metal leaching (ML) and acid drainage (ARD), which can last virtually forever.

If not prevented, there is a potential for toxic metal release from at least some rock and waste types at most metal and some coal mines. ML/ARD is considered to have a **significant impact** if it precludes the attainment of reclamation objectives or causes an exceedance of receiving environment objectives.

Metal Leaching and Acid Rock Drainage

Metals and acidity in ML/ARD are direct or indirectly products of the oxidation of sulphide minerals, a process which occurs when sulphides are exposed to air and water. ML/ARD problems are common at mine sites because mined rock is typically rich in sulphide minerals and metals and because a mine excavates that rock, exposing it to oxidizing conditions.

In many cases the acidity created by sulphide oxidation is neutralized. Accelerated acid weathering conditions and acid drainage only result when sources of neutralization are too small, too slow or have been exhausted.

Due to limited leaching and low solubility, the products of sulphide oxidation are typically created at a much faster rate than they are removed. Consequently the resulting ML/ARD can continue long after the originating sulphide minerals have been oxidized.

Although ARD has received most of the attention, the primary source of toxicity are the metals (e.g., Cu, Mo and Zn) and metalloids (e.g., As and Sb). Elevated ML almost always occurs with acidic drainage due to the high solubility of most metals at low pH . While the concentrations of most metals is lower at neutral pH than acidic conditions, neutral pH ML may be significant for elements that remain relatively soluble (Zn, Mo, Cd, As, Sb) in neutral pH drainage. Neutral pH metal leaching is generally only a concern if:

- the material is enriched in the Zn, Mo, Cd, As, Sb,
- weathering is relatively rapid,
- the discharge is into a sensitive resource and/or
- there is relatively little dilution.

Often the initial cause of significant neutral pH metal leaching is localized acid weathering.

Regulation

The objective in regulation is to ensure mining is compatible with the provincial goals for environmental protection and reclamation:

- no off-site impacts (receiving environment objectives)
- minimize on-site impacts (reclamation and receiving environment objectives)
- little or no potential for future contaminant loss
  - ⇒ no outstanding liability (financial security)
  - ⇒ identify potential modes of failure or areas of uncertainty and minimize the associated risks

The primary tool in regulation is the permit which sets acceptable conditions for excavation, materials handling, mitigation, monitoring and the financial security, including material characterization, drainage monitoring and the maintenance of mitigation facilities. Acceptable conditions are based on an assessment of the risk to the environment (Risk = Probability and Consequences of Failure) and the measures required to make that risk negligible.

Failure can result from a wide range of causes:

- geological (e.g., unexpected materials or material composition),
- geochemical (e.g., unexpected metal leaching or weathering conditions),
- hydrological (e.g., unexpected drainage inputs or losses),
- geotechnical (e.g., ditch or dam failure) and
- a lack of power or money to run the treatment plant.

The objective of the ML/ARD program is to ensure the level of understanding, mitigation strategies and resources are sufficient to prevent events that may threaten the environment. An important part of this is a compatibility of the ML/ARD provisions with the site and mine plan.

Invariably the solution to one problem creates other risks. Practitioners must be aware of all the potential failure mechanisms. Significant risks must be addressed when evaluating different mitigation strategies. Under existing legislation and provincial policies, British Columbia mining companies must demonstrate the adequacy of their understanding and the effectiveness of their plans and the resulting work. Monitoring must be sufficient to allow timely detection of unforeseen events or conditions.

Historically

Historically the failure to recognize ML/ARD and the lack of containment of either waste or drainage has resulted in large environmental destruction and permanent devastation of large areas by abandoned mines in regions Eastern Canada, the US and many other parts of the world.

Most of the historic mines in BC were either very small, mining occurred in calcareous strata or wastes were disposed underwater. Thus British Columbia has fortuitously avoided the extensive problems other jurisdictions have with historic mines. Of the nine inactive, historic minesites with ARD, only three (Anyox, Britannia and Mt. Washington) have poisoned "major" watercourses.

At large historic mines, typically the only mitigation option is long term drainage collection and lime treatment with large lime, maintenance and sludge disposal costs. At smaller sites, where the amount of drainage and thus the required reduction in metal loading is smaller, limestone drains, covers and/or waste segregation may be adequate.

1970s to Recently

The recognition that ML/ARD was a potential concern resulted in the containment of mine wastes, drainage monitoring and identification of problems once they occurred, but there was very little prediction or prevention. These practices have resulted in similar long term drainage collection and lime treatment and large lime, maintenance and sludge disposal costs to historic mines. The only advantages compared to historic mines are the containment of wastes, better monitoring and in most cases mining companies still around to take care of problems.

This was era of very active mine development in BC. There are at least fifteen recently closed, or soon to close, BC mines where ARD is either occurring or is projected to occur. Many do not have an approved closure plan and there is significant ML/ARD uncertainty and inadequate securities. Fortunately most are owned by large, well financed mining companies.

The Present Situation

ML/ARD remains mining's number one reclamation and environmental protection issue:

- financially due to the great cost of remediation;
- technically due to the great deal of uncertainty; and
- public perception that mining is toxic to fish and wildlife, and therefore an unacceptable land use.

While there are significant concerns regarding other geochemical problems, such as high metal concentrations in the vegetation and water used by wildlife and humans (e.g., Mo), by far the greatest concern is the effect of accelerated metal release on fish.

In the United States, $1 billion is spent annually to collect and treat water at ARD minesites. Federal estimates of the projected costs for all forms of ARD cleanup in Canada are between $2 billion and $5 billion.

The historic record/legacy of ARD mismanagement haunts the North American mining industry, and its specter is raised whenever a new mine is opposed (e.g., for parks, land claims or other land use reasons). The other commonly voiced public concerns are the uncertainty in predicting when ARD will occur and the design and maintenance problems (risks) with remediation dams and collection systems that must last forever. In the best situations, conscientious companies collect and treat all the problem drainage, and are researching ways of reducing the liability (e.g. Brenda, Equity Silver, Myra Falls, Sullivan and Samatosum). In the worst cases, due to either isolation, a lack of surface flow or a lack of responsible parties, metal leaching occurs largely unchecked.

While BC remains one of the world leaders in many aspects of ML/ARD technology and regulation, this subject is receiving a lot of international attention. We can expect help in the future.

PREDICTION

The cornerstone of BC Ministry of Energy and Mines (MEM) strategy for risk reduction is the policy of 'Prevention through Prediction and Design'. The first step in this process is the prediction of future rock weathering and it's affect on the geochemical conditions, drainage chemistry and metal loadings. This information is required in order to identify potential impacts and determine mitigation requirements.

Effective ML/ARD prediction work, like any environmental inquiry, requires a good understanding of the materials, the contributing biological, chemical and physical factors and processes, the possible environmental impacts and the investigation methods. Sampling and analytical procedures must be carefully selected and practitioners must use accurate, clearly defined terminology to ensure results are not misused or misinterpreted. In most cases there are significant differences between test and field conditions, differences which must be considered in the interpretation of results. The use of consistent test procedures and terminology will allow comparisons to be made among sites or with previous conditions.

There are two forms of prediction failure. Type 1 is the failure to predict significant occurrences of ML/ARD. Type 2 is the prediction of significant ML/ARD when it will not in fact occur. A type 1 error can result environmental impacts, and the additional costs and technical problems when mitigation is planned after the fact and not in conjunction with the mine plan. The negative consequences of a type 2 error include the costs of wasting valuable resources on unnecessary mitigation, the associated hydrological and geotechnical risks and the constraints on mining.

Failures in prediction can be attributed to two sources:

- Limitations in the available prediction knowledge
- Errors and omissions in test work and analysis

One of the major causes of both of the above is the high cost of prediction, both in time and money. To ensure prediction test work is cost effective, a proponent should consider the purpose and likely impact of the results. In some cases, test work is required to reduce risk. In other cases, the provision of contingency mitigation measures coupled with operational testing during mining will be a more effective means of reducing risk than additional pre-mining prediction test work, which is likely to be inconclusive and unlikely to alter the mine plan.

Better Prediction Required at a Large Number of Mines

In part as a result of omissions in test work, there remains a great deal of uncertainty regarding the potential for ARD, and whether or not it will occur, at a large number of closed, operating and proposed mines. This uncertainty coupled with the large number of past errors results in:

- precautionary waste handling requirements and preventative measures that are very expensive and undoubtedly sterilize a significant proportion of the province's ore reserves,
- widely "ranging" estimates of potential reclamation costs and,
- significant exposure of the province to financial and environmental risk at sites where future ML/ARD is uncertain.

Present BC MEM Prediction Requirements

To ensure the necessary understanding and information is available to set acceptable conditions for excavation, materials handling and mitigation and determine the financial security, BC MEM requires:

- comprehensive site and material characterization prior to mining
- detailed inventory of materials excavated and/or exposed by operation
- comprehensive drainage monitoring
- ongoing testwork to verify pre-mining predictions
  - ◊ test assumptions regarding untested materials and
  - ◊ applicability of laboratory testing to actual conditions

Drainage monitoring is required both to verify pre-mining predictions and to inform present and future site management. Proponents are required to document trends in chemistry, flows and metal concentrations and predict metal loadings for the drainage chemistry conditions at the site.

Material Characterization

Material characterization, a requirement for all materials excavated and/or exposed by mining operations in British Columbia, is used to verify pre-mining prediction and guide future material management. Sampling and analysis requirements will depend on various factors including the previously collected information, geological variability, acceptable uncertainty and detection requirements.

One of tasks of pre-mining prediction is to determine which parameters should be measured. The answer will depend on the material and the material handling questions. For example, the primary goal in material characterization in the low sulphide Main Zone pit at the Huckleberry mine is to distinguish materials which can be used for downstream dam construction. The objective in the high sulphide East Zone is to predict the time to ARD onset. The quarterly ARD reports submitted by the Huckleberry mine are a good reference for those interested in the detailed material characterization required at BC mines with ML/ARD concerns (excerpts are attached in Appendix A).

It is important that characterization is done on the portion which will determine drainage chemistry. For waste rock, where a large proportion of the mass is physically occluded in coarse fragments, the important portion is the finer-sized particles (Price and Kwong, 1997). Operational waste rock monitoring is typically carried out on either blast hole cuttings and the post-blast fines. Companies often prefer blast hole sampling because of the ease of sample collection and compatibility with geological block models. However the analysis of blast hole cuttings may not provide an accurate picture of the eventual composition of the reactive finer particles in the waste rock.

While the compositional differences observed between different particle sizes in Table 1 are insignificant in terms of the overall potential for ARD, the acid potential (AP) and neutralization potential (NP) differences in the fine-sized fraction (< 2 mm) may have a significant impact on the time to onset of acid weathering conditions. Where blast hole sampling is proposed for waste rock characterization, initial and periodic post-blast fines monitoring is required to verify that the analysis of blast hole cuttings can accurately predict the reactive composition of waste rock.

	> 5 mm	< 2 mm	< 2 mm/> 5 mm
AP (kg/t)	86	257	3.0
NP (Sobek) (kg/t)	32	44	1.4
NP (TIC) (kg/t)	13	37	2.8

Table 1. An example where different ABA results are obtained for different particle sizes in waste rock

Errors in Test Work and Data Analysis

In the past many of the problems in prediction occurred from the errors in test work. These included the:

- use of inappropriate test procedures
- tests run incorrectly
- failure to recognize the test limitations and the misinterpretation of results
- test needs and results were ignored if incompatible with rapid project development

One of the important concerns that must be addressed in the interpretation of testwork results is the impact of **differences in scale** between testwork and the actual mine components. These differences can significantly affect geochemical, hydrological and physical conditions. A good example of this problem are the differences that occur between the operational composition of tailings and that predicted by metallurgical testwork. This has led to errors in the pre-mining prediction at two sites in north west British Columbia.

Present BC MEM practices aimed at reducing the risks associated with tailings prediction include:

- compiling data from similar ores and milling processes and
- use of safety factors and conservative interpretations, at least in the early phases of the project.

Neutralization Potential

The risk of impacts from metal leaching are often greatly reduced if there is sufficient neutralization to prevent acid weathering conditions. Where ARD is uncertain, one of the most important prediction questions is whether potentially neutralizing minerals are sufficiently reactive to maintain neutral pH conditions. This information is used to predict the effective neutralization potential (NP)[1].

[1] Effective NP is defined as the capacity of the materials under specified weathering conditions to neutralize acidity maintaining a pH 6.0 or above.

One of the most important tools in a determination of effective NP is static-test NP. Unlike practitioners who rely solely of static-test results, BC MEM also requires a knowledge of:

- type, location (exposure), concentration and reactivity of minerals with NP,
- future physical and hydrological conditions,
- the rate of acid generation and
- limitations of the test procedures.

To ensure the information requirements are met BC MEM usually requires the following minimum procedural requirements:

- a good mineralogical characterization
- two static laboratory NP measures,
  - ⇒ an acid-titratable and
  - ⇒ a carbonate measure, and
- humidity cell testing.

This information will allow proponents to:

- identify important carbonate and aluminosilicate minerals,
- estimate the magnitude and effectiveness of minerals as NP sources,
- correct static-test measures of NP for contributions from Fe and Mn carbonates or insufficiently reactive aluminosilicate NP and
- pick the procedure(s) required for operational material characterization.

The procedure used for operational material characterization will depend on the prediction questions and the neutralizing minerals. Due to speed and ease of measurement usually some form of static-test NP measurement is used. One of the objectives of pre-mining prediction test work should be to identify if a correction factor is required.

<u>Predicting Far into the Future</u>

Typically prediction becomes more difficult when the critical processes or events determining drainage chemistry, like onset of ARD or exhaustion of acid-neutralizing minerals will occur far in the future. One of the goals of BC MEM is improve the knowledge regarding the long term performance of the materials created by mining. A part of this is the requirement for mines to create field test pads for each different waste/rock type combination at each site.

<u>Mineralogy</u>

Mineralogy or rather the absence of reliable mineralogical information often creates significant uncertainty in ML/ARD prediction. Important questions include the contribution of siderite to carbonate measurements and the identity and rates of neutralization for different aluminosilicate minerals. Mineralogy is also important in the determination of acid potential (AP). In ABA, it is assumed that all the sulphide occurs as pyrite. Obviously this is not always the case. Significant quantities of non-pyritic sulphides may alter the relationship between sulphide-S and AP, especially if some are non-acid generating, and corrections will be required to the standard procedure for calculating AP.

While everyone seems to recognize the importance of mineralogy, far less is said about how hard it is to measure. The difficulty in providing comprehensive quantitative mineralogical information has been a major impediment in ARD prediction. The problem has been particularly evident in Canadian NP research, where the failure to consider (Lawrence, Marchant and Poling, 1989) and/or properly measure (Lawrence and Wang, 1996) mineralogy has greatly handicapped our progress in developing useful tools for NP prediction.

An example of some of the misleading conclusions that can be reached in the absence of reliable mineralogical and field data is shown in Figure 1. According to the figure and the accompanying text:

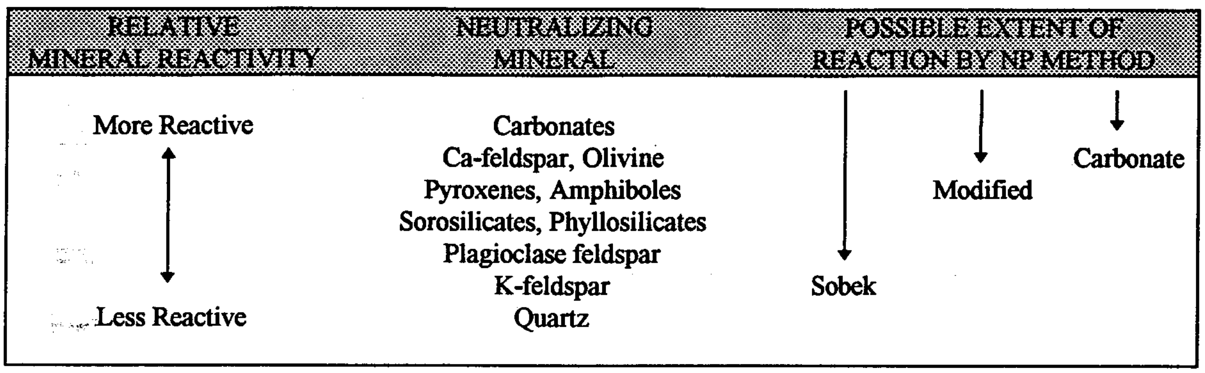

Figure 1: Relationship between mineral reactivity and method of NP determination (from Lawrence and Wang, 1996)

- if a rock contains no carbonate, Ca-feldspar or olivine, the Modified NP would be zero, and
- the Sobek NP test uniquely attacks a wide range of aluminosilicates minerals and greatly overestimates NP.

These conclusions are not supported by studies that included mineralogical and/or field evidence where it was found that:

- Results for the Modified and Sobek NP are usually similar; Sobek values are usually slightly higher, although sometimes the reverse is true (Lapakko, 1993).
- The Modified NP procedure dissolves a wide range of aluminosilicate minerals (Lapakko, 1993).

- Both the Sobek and Modified procedures rarely dissolve large amounts of aluminosilicate NP (more than 30 kg/t) even if the rock is rich in Ca-feldspar, olivine and pyroxene (Lapakko, 1993).
- In studies carried out on rocks containing negligible carbonate but a large proportion of plagioclase and phyllosilicate minerals, Sobek NP values were all less than 20 kg/t (Price and Kwong, 1998).
- A concern Sobek procedure is that non-neutralizing iron carbonates may contribute to the measured NP (Skousen et al., 1997). This is thought to be a function of the time of exposure to neutral pH and the pH of the titration end point (Lapakko pers. comm.). The higher pH value of the titration end point in the Modified procedure (pH 8.3) makes it more likely that the ferrous iron released in iron carbonate dissolution will be oxidized and not reported as NP. Notably the static-NP procedure most likely to erroneously include non-neutralizing carbonates in its NP measurement is the BC Research procedure. Usually considered a moderate NP measure, where significant non-neutralizing carbonates are present, the BC Research method can produce the highest NP results (Lapakko, 1993).

The aforementioned table illustrates three generic points with regards to risk. The first one is that good mineralogical data greatly reduces the risk of errors in NP assessment. The second point is the danger posed where conjecture is not properly identified. The third point is the danger of judging the accuracy of laboratory tests in the absence of information showing how the data will be used or the field phenomena the test is intended to predict.

Another good example of a recently promoted laboratory procedure that has some obvious utility in ARD assessment but presently lacks the mineralogical and field data required to determine its limitations and guide its use is the NAG test (Miller et al., 1997).

Receiving Environment Objectives (ML/ARD Goal Posts)

Presently most mines in British Columbia lack site-specific receiving environment objectives and rely on 'worst-case' provincial objectives. Where the present objectives appear to unnecessarily restrict the use of lower risk mitigation strategies, mines are encouraged to develop site-specific receiving environment objectives.

MITIGATION: PREVENTION OF POTENTIAL IMPACTS

The policies BC MEM's uses to reduce the risks associated with mitigation include:

- prevention through prediction and **design,**
- provision of financial security commensurate with the outstanding liability and
- comprehensive evaluation of expected performance and,
- detailed monitoring and maintenance requirements.

Achieving the required level of understanding is an important part of risk reduction and a crucial task in mitigative planning and plan implementation. Plans must identify all the possible mitigation outcomes, associated risks, mechanisms and likelihood of failure and the measures required to prevented their occurrence. This information can be used to determine the best mitigative approach, to refine the original strategy and to determine monitoring and maintenance requirements. Whenever there is significant uncertainty, contingencies should be available, with monitoring to inform their implementation.

Long Term Performance

Where ARD is predicted or has occurred, mitigation measures often must be maintained for ever. The requirement for constructed structures to function for hundreds of years creates onerous requirements for design, monitoring, maintenance and repair. Even in the best managed situations, the long term exposure to the extremes of natural phenomena and human error create a risk of failure that requires continued, strongly motivated monitoring and maintenance to prevent. Maintenance is required for the effective long term performance of mitigation measures and is consequently a critical part of the risk reduction strategy and a major regulatory requirement. Other requirements include strong evidence that the plan is adequate and compatible with the site, the mine plan and the biogeclimatic conditions,

Another critical part of any long-term mitigation strategy is the ability to operate or withstand extreme climate events. A major source of risk is if the design criteria are based on inappropriate climate events, for example rainfall when the maximum flood occurs as a result of ice jams, snow melt or rain on snow events.

One of the strongest tools used by BC MEM to reduce the long-term risk to the environment is the requirement for a financial security commensurate with the outstanding liability. The liability is reviewed with changes to the mine plan and at regular intervals during the life of a mine and after it closes. For consistency companies are requested to use BC MEM software (BC MEM, 1996). An example of some of the costing done for Snip mine is provided in Appedix B.

Consideration of Minesite as a Whole

Potential mitigation strategies for individual mine components should be evaluated in terms of their contribution to the cumulative risk, liability and land use impact of the entire mine. A good example of the considerable benefits that may result from using existing facilities on a minesite is provided by QR Gold, a small mine originally proposed in 1989. The ARD testwork provided in the mine proposal was limited to:

- Simple ABA with only one NP measure
- 20 wk humidity cell testing with no major cation or trace metal analysis

The main regulatory concern was with propylitic waste rock with an NP(Sobek) of 92-150 kg/t, an AP(Sulphide) of 61-224 and NPR values ranging from 0.5-2.0. The company and other regulators reviewing the project concluded that there was no ARD potential. BC MEM concluded that the available evidence was insufficient to reach this conclusion, that ARD status remained uncertain and a cautious materials handling was required. The initial mitigation plan was to prevent ARD using micro-scale blending with the calcareous basalt. This plan was scrapped due to the rehandling and micro-management costs. The eventual disposal strategy proposed for most of the propylitic waste rock was underwater storage in flooded impoundment already constructed for tailings. The propylitic waste rock stockpiled as low grade ore was backfilled into the open pit which flooded whenthe mine closed this year.

In both cases existing facilities were used for ARD prevention with little or no additional liability, risk and land use impacts.

Backfill

A good example of the use of existing facilities is the use of backfill. If properly managed, backfilling of mine wastes into exhausted mine workings can be a very effective disposal strategy. Backfilling in flooded pits and declined underground workings provides a means of avoiding the permanent maintenance requirements of constructed facilities. However, backfilling should not occur until material characteristics, disposal site hydrology and future waste drainage are well understood and there can be assurances that potentially problematic wastes will be hydrologically isolated or flooded within the required period of time. Particular caution is required in areas with fluctuating water tables or high rates of flow. Due to their subterranean location and high conductivity, mine workings often act as conduits for groundwater and have high flow rates.

Prior to mine development, the hydrology of mine workings must be predicted through limited site and groundwater monitoring and hydrologic modeling. Detailed operational and post-mining monitoring is required to verify pre-mining predictions. Important considerations include the effects of mine excavation on regional flow patterns and the possible interception of new water sources. Mining practices may change critical hydrological parameters by connecting or exposing isolated fractures, with possible impacts on the height of the water table, the rate of flooding and the rate of flow through potential sources of ML/ARD. Facets of mine design that may have a major impact on drainage rates and the ability to flood include whether adits decline or incline, the proximity of underground workings to the surface and the removal of crown pillars. At the Britannia Mine, infiltration through collapsed glory holes at the top of the mountain contributes much of ARD that is eventually discharged through lower elevation portals (Price et al., 1995).

Monitoring

In the past monitoring was primarily used to detect environmental impacts and determine permit compliance. This form of monitoring only detects impacts after the damage is done. In effective risk management, monitoring is used to:

- detect significant geochemical, material and hydrological changes,
- provide early warning of potential problems (e.g., detect a reduction in design capacity),
- inform corrective measures (e.g., direct maintenance) and
- allow timely implementation of contingency plans.

A good example of the role of monitoring as a risk assessment and management tool is provided by innovative system for passive treatment of ARD at Island Copper on the west coast of Vancouver Island. At closure the pit, which is below sea level, was flooded with salt water. ARD is discharged into the pit and confined beneath a fresh water cap which has developed from surrounding runoff and incident precipitation. Acidity in the ARD is neutralized by the alkalinity in the salt water. Some metal precipitation results from the neutral pH and adsorption. Further decreases are projected from anoxic conditions developing in the sea water as a result of organic matter additions and a lack of contact with the surface.

BC MEM accepted this innovative passive treatment strategy because there are a large number of safety factors and therefore little or no risk while the system is being tested. The main risk is the uncertainty about long term performance, much of which results from the lack of previous experience in operating such a system. To reduce this risk the company is required to carry out detailed monitoring physical, chemical and biological monitoring of the water column. The information serves both to provide an early warning of potential problems and to inform the corrective measures and preventative maintenance which should insure near surface drainage migrating into the ocean is of acceptable quality.

Benefits to the company are that the mine avoids the large operating and security costs associated with active chemical treatment. Benefits to the province include avoiding the risks associated with sludge disposal and environmentally safe, cost effective technology development.

Disposal in Natural Water Bodies

Underwater disposal in natural water bodies has a number of potentially negative impacts including the smothering, in-filling and other depositional effects on aquatic ecosystems and effects on biological cycling. Containment is a potential problem in large water bodies or sites with moving water. However from a number of perspectives, including potentially huge reduction in the geotechnical and geochemical risks, underwater disposal in natural water bodies is the best, long-term, least risk waste disposal option.

Approval for underwater disposal in natural aquatic systems is presently only given for deposition in non-fish-bearing headwater lakes. This is due in part to the outstanding uncertainty regarding potential disposal and biological impacts. Due to the potential benefits if it were a environmentally safe disposal option, research should be carried out to assess the validity of the potential concerns and determine whether there are significant impact on the environment or downstream water uses, both during and following disposal.

Notably, there is no equivalent legislation which similarly limit the use of terrestrial ecosystems for waste disposal.

Mine Plans Change

Mine plans are dynamic entities continually being modified to adapt to changing economic conditions, unexpected site conditions, better operating information and new technological developments. Often changes are dictated by ML/ARD requirements. A comprehensive prediction program, including detailed material characterization and an understanding of site hydrology, provides a company with the necessary information to determine the impact of modifications on the ML/ARD mitigation plan. A recent example occurred at the proposed Tulsequah Chief mine, which made some significant changes to its materials handling and drainage plans during the mine review.

Limited Number of Strategies

A major limitation faced by the mining industry with regards to ML/ARD is a lack of cost effective, proven mitigation techniques, supported by well documented case studies at other sites.

Presently, the tool box of proven stand-alone ARD mitigation procedures is limited to underwater disposal for prevention and lime treatment for water quality improvement. The use of other prevention strategies, such as blending to create a non-ARD generating composite and covers to reduce drainage, is constrained by uncertainty regarding the method of application and their long term performance. Even the final requirements for underwater disposal (water depth, surface conditions etc.) are still under discussion because of a lack of information on biological cycling.

While the requirement to demonstrate effectiveness is an important component of risk reduction, it is recognized that may have some adverse effects on the long term goal of reducing risk through new technology development. The concern is it that this might restrict innovative mitigation strategies which significantly reduce risk but cannot provide complete assurance of their performance. In situations where mitigation performance is uncertain and additional contingency measures are required, the total mitigation costs may become prohibitive, and only the more conservative contingency measure, typically collect and treat, will be adopted. This is an important concern for technologies such as blending and covers.

The ideal situation is that there will be safety factors, like those at Island Copper, and therefore little or no risk while the new system is being tested. This will not always be the case and further consideration of this topic is required by all stakeholders.

CHALLENGES IN ML/ARD REGULATION

ML/ARD puts high demands on mines, regulators and the public with regards to:

Skills: technically very demanding and many new technical developments
Effort: plans and reviews must be comprehensive and detailed
Political Implications of Results: review results influence land use conflicts, decisions may affect viability of the mine and others uses of the land
Conservative, Precautionary Design: due to prediction uncertainty and requirement for mitigation to last for ever
Costs: very expensive in time and money, impacts may continue after mining

Present British Columbia Regulation

Three agencies consider themselves responsible for ML/ARD regulation: BC MEM, BC MELP and Environment Canada. BC MEM is responsible for enforcing the Mines Act. BC MELP is responsible for enforcing the Waste Management and Water Acts. Environment Canada is responsible for enforcing the Metal Mining Liquid Effluent Regulations (Annex to Fisheries Act) and Section 36 (3) of the Fisheries Act. Health Canada and Natural Resources Canada have also started to become involved in certain projects.

The large number of regulators creates a number of problems including a lack of accountability, confusion regarding whose advice to follow, long meetings and a tendency to aim for consensus rather than the best decision.

Cumulative Regulatory Load / Risk

Type of Mines	Number	Cumulative Total
Historic	12	12
Closed in Last 10 Years	16	28
Operating	15	43
Proposed	14	57

Table 2. 1996 Estimate of Mine Sites with an ARD / Metal Leaching Potential

Lack of resources and lack of training of existing personnel create concerns that initial review and/or subsequent inspections will not be done properly and regulations will not be enforced. There is a growing back-log of operating or recently closed projects without acceptable closure plans. Resources must keep step with increased technical demands and ever increasing number of minesites (operating plus closed). Some of the back-log is due to errors and omissions rather than lack of resources.

Notably there is no money and little time to fix historic problems.

Creation of the Environmental Assessment Act

The new provincial **Environmental Assessment Act** (EAA) is a good example of the present emphasis in environmental management on stakeholder participation and reviews, and the lack of importance placed on technical review and its role in informing the eventual decision makers. In the EAA process, making the right decisions, developing the best possible project and being technically efficient all take a back seat to process needs. The scheduled events and documentation requirements of the EAA process are primarily driven by the needs of the project committee, requirements which are often not conducive to the iterative process required in the development and review of a ML/ARD prediction/prevention plan. Another aspect of an EAA review which hampers the ML/ARD assessment is the lack of technical responsibility or accountability. There is no effort to evaluate the validity of comments or participants expertise or track record in the review of previous projects.

Most new mine developments - QR Gold, Kemess, Huckleberry and Tulsequah - and future projects - Telkwa, Prosperity, Silvertip and Red Chris - have major ML/ARD costs and concerns. The EAA has greatly increased the number of meetings, the need to review minutes and update non-technical participants. Increased resources were provided to organize the process. No additional help was provided for the technical work.

Notably public participation in the EAA and on the technical subcommittees is limited to the representatives of First Nations and local government.

Skills

ML/ARD is very demanding, due to the large number of factors involved, the large number of unknowns, the technical nature of the work and the many new technical developments. Industry, government and public participant groups continually need to upgrade the technical skills of its practitioners. Mine plans developed for ML/ARD prediction and prevention are commonly rejected. The most frequent technical reasons for rejecting ML/ARD plans are:

- the mine values non-mining resources differently or has a different view of the consequences of failure than government and as a result has a much greater tolerance of risk and of the risks to those resources,
- there are a great number of factors / interactions to consider: something is missed
- poor standard of technical work

Specific factors which make the assessment and development of plans for ML/ARD prediction and impact prevention difficult include:

- ARD onset is typically delayed hampering the prediction of ARD potential and future drainage chemistry.
- Mitigation must last for ever and function over widely ranging climatic conditions;, creating onerous requirements for design, monitoring, maintenance and repair.
- Large differences in scale exist between testwork and the actual operations.
- Many critical parameters are difficult to measure.
- Testwork is expensive, time consuming and often conflicts with development timelines and mining objectives.
- ML/ARD is a relatively new field. Much of the information is not readily accessible.
- ML/ARD is very site specific. There are no off-the-shelf solutions.

Wide Area of Knowledge Required

Major challenges are created by the breadth and depth of the information required in ML/ARD plans which requires an understanding of aspects of:

- geology
- hydrology
- environmental geochemistry
- mining
- geotechnical engineering
- rock weathering
- metallurgy
- ML/ARD specific terminology

While the review of ML/ARD and the assessment of risks often occurs separately for geochemical, hydrological and geotechnical factors, it is often the combined effect which is important. For example, geotechnical and hydrological factors will affect the stability and effectiveness of dams and bulkheads, while geochemistry and hydrology are primary determinants of the consequences of failure. ML/ARD reviewers must be capable of identifying where important issues have not been adequately addressed. This requires a broad understanding of the accepted methods and critical information requirements.

Providing Scientific Evidence

Many past failures in ARD mitigation can be attributed to an operating and regulatory philosophy that substituted "professional judgment" for scientific evidence. Professional judgment has a number of advantages. It avoids time consuming data collection and analysis, and limits the technical demands on the proponent and the reviewers. While a reliance on professional judgment might have some short-term process advantages, the long-term results include huge costs for unplanned remediation and a lack of public support for subsequent mining projects. A recent example was the Summitville Project where a recent review concluded that "All doubtful decisions erred on the side of keeping the mine operating on schedule.6

There are a number of situations where the need for scientific evidence tends to be ignored. One is with complex computer models, which can be a very useful tools but need verification. Another example is in the adoption of remediation strategies from other distant jurisdictions. The best example of this in BC is the use of blending. Significant unplanned ARD has resulted where blending criteria were adopted from other jurisdictions based on expert advice, with an inadequate site-specific testwork and without proper consideration of the supporting data and limiting factors.

In risk assessment, regulators rely heavily on previous experience. Procedures like underwater storage and lime treatment have an extensive track record that can be consulted to determine how materials or a minesite compare with others which are similar and whose performance is known. However, all materials are somewhat unique and proponents will be expected to consider how differences in important parameters will affect the planned mitigation.

For the most part, past errors in ML/ARD were not caused by gaps in basic knowledge, but resulted from a failure to consider (or perhaps understand) the science of the day. The sentiment that 'ARD assessment is an Art' is somewhat understandable given the breadth and depth of the information involved. However it is not the approach taken by BC MEM. Our policy is to require a scientific approach to assessment, requiring comprehensive data analysis, documentation of rationale and testing of hypotheses. While the requirement for 'Great Information rather than Great Experts' is technically demanding and initially time consuming, the reduced uncertainty, the development of a clear understanding of what is and is not known and a proper documentation of risks saves time in the long-term, cuts company costs and results in greater public confidence.

An example of the type of problems that could have been avoided by if there had been a comprehensive review of all the mine components is as follows:

- The original ML/ARD plan did not address the waste rock and as a result its ARD potential was overlooked.
- Subsequently the waste rock became a source of ARD contaminating the adjacent creek and a downstream lake.
- The lake, which feeds a towns drinking water supply and a famous salmon river, was at that time used to store the mine tailings. In the lake the sub-aqueously deposited tailings were in a geotechnically stable and geochemically relatively inert location.
- Water quality monitoring identified rising metal concentrations in the creek and the lake.
- The sub-aqueously deposited tailings in the lake were wrongly blamed for elevated lake metal concentrations and as a result tailings deposition in the lake was prohibited.
- Subsequently the tailings have been deposited on-land in a constructed subaerial environment in which they will produce ARD, creating additional treatment costs, contamination risks, geotechnical concerns and the problem of treatment sludge disposal. This is a relatively active seismic zone.

- The mine operates a complex drainage management system and costly drainage treatment for the waste rock.
- The overall result of the failure of the original plan to address waste rock has been an unnecessary in significant increase in the risk of contamination, costs and the problem of treatment sludge disposal.

Accountability: Regulatory Requirements

Common complaints regarding regulators are that information demands are too vague and fail to say how the results will be used or what constitutes adequate technical evidence or provide documented examples of review process. Having made the mines responsible for demonstrating the effectiveness of their plans, it is incumbent on the regulators to indicate what it considers to be acceptable mine designs and adequate technical evidence.

BC MEM uses three documents to advise mining companies of their requirements for ML/ARD:

- **Provincial Policy** (BC MEM and BC MELP, 1998): outlines general policy, practices and information requirements
- **BC MEM Guidelines** (Price and Errington, 1998 and Price, 1997): describes policy, practices and information requirements in greater detail and outline common problems and constraints
- **Mine Reviews**: provide detailed, comprehensive site- and project-specific assessment, including outstanding information requirements and proposed regulatory conditions

These documents are critical to BC MEM's goals of having clear regulatory goal posts, improving industry and regulatory practices and being technically accountable.

A primary concern of industry with the guidelines is that they would be misinterpreted by other agencies or by regulators in other jurisdictions without the expertise of BC MEM. An example of the erroneous reporting of BC regulatory conditions are provided in the Tables 3 and 4. Table 3 is clearly wrong. NNP is not used in British Columbia to separate acid (ARD) and non-acid (ARD) generating material. Table 4 is misleading in that it compares the BC NPR criteria, which is used to determine where further testing is required, with criteria used in other jurisdictions to identify ARD generating materials. Mines in British Columbia are required to develop site/material specific criteria for distinguishing ARD generating materials to avoid overly conservative criteria and detect anomalous conditions. The eventual NPR values used to identify ARD generating materials vary not just with the site conditions and geochemical characteristics, but also depending on the type of samples analyzed and the analyses.

Jurisdiction	Interpretation of NNP
British Columbia	> +20. non acid generating < 0 acid generating
Montana	> 20 low risk of acid generation <-20 acid generation likely

Jurisdiction	NP:AP Ratio Criterion
British Columbia	4
California	3
Idaho	2
Montana	3
Nevada	1.2

Tables 3 and 4: Examples of the misrepresentation regarding how ABA criteria are used in the characterization of wastes in British Columbia

Much of the misinformation regarding BC ARD prediction has come from university publications, raising a concern regarding how BC MEM Guidelines are being presented to students.

Mine Reviews

The table of content from the 'Review of Metal leaching and ARD Aspects of the Project Report for the Tulsequah Chief Mine' in Appendix C provides an outline of the manner in which BC MEM reviews ML/ARD. Goals of a BC MEM ML/ARD review document are to:

- summarize BC MEM's assessment of the prediction data and the mine's ML/ARD prediction and mitigation plans,
- show how submitted information and plans are used in the evaluation of the project and will be used to set regulatory conditions,
- identify the critical questions and tasks, identify potential errors and omissions, including areas of critical uncertainty, and provide guidance regarding possible procedures for resolution, and
- communicate the ML/ARD requirements, the progress of ML/ARD test work and the development of mine plans to other stakeholders and reviewers of other aspects of the closure plan.

By showing the link between the mine's proposals and future regulatory criteria BC MEM provides guidance regarding the purposes for required information, the consequences of different results, the final goals and the manner in which regulatory conditions are set, information which can be used to identify information gaps and problems and make improvements.

BC MEM's comprehensive ML/ARD reviews have proven to be very successful in identifying outstanding problems, providing companies with sufficient direction to allow them to resolve problems and generating public confidence. On recent reviews of QR Gold, Kemess, Huckleberry and Tulsequah, the BC MEM mine review, as the only comprehensive documentation of concerns and the submitted information, served as the template for discussion and issue resolution with the company, public review group's and regulators in other jurisdictions. In addition to ensuring comprehensive coverage of the complex multidisciplinary aspects of ML/ARD, BC MEM mine reviews speed up issue resolution, reduce meeting time and provide an effective means of communicating the current status of review to the project committee.

Reduce Risk of Errors in BC MEM's Own Practices

Measures taken by BC MEM to ensure their are no major errors and omissions in its own practices include:

- inform company, other regulatory agencies and public of proposed regulatory conditions and the supporting rationale and permit them to participate in the review and suggest alternative solutions,
- detailed consultation with mining company and stakeholders to ensure regulatory conditions are effective and compatible with the site and the operation, and
- external review of BC MEM ML/ARD practices by expert advisory committee.

Expert Advisory Committee

The expert advisory committee includes representatives of mining companies, consultants, environmental review groups, major professions doing ML/ARD work, the engineers and geologists, and researchers whose work is used in mine proposals and closure plans. All have practical experience in mine review or in developing company ML/ARD programs. One of the major objectives of MEM is to improve existing practices. It was therefore very important that review panel consist of those who shared BC MEM's general vision of the need for comprehensive, scientifically defensible, well informed ML/ARD work. Notably, all the invitees were members of small group of concerned practitioners who submitted written comments to BC MEM in earlier unsolicited requests for advice.

Lack of Standard Terminology (Tower of Babel)

Clearly understood definitions and accepted meanings are critical to the development of any field of scientific inquiry. Clear definitions allow unambiguous testing of the existing concepts and theories, and provide the foundation for future development. Entities and processes may be defined according to their composition, form of action, or contextually according to their relative properties or performance.

Clear definitions are especially critical in ML/ARD work due to the public and international nature of the work. ML/ARD work is now being carried out by mines throughout the world and many jurisdictions and organizations are sponsoring research programs. Effective communication will help avoid unnecessary duplication of effort and repetition of errors and aid in the constructive review of methods, theories, data and methods of data interpretation. Presently there is little consistency in terminology even between practitioners on the same project or between different projects within the same jurisdiction. Even larger differences exist between different geographical areas.

To address the problems listed above and as an aid to those using the BC MEM ML/ARD Guidelines, the ministry is producing a glossary. The glossary borrows heavily from and/or adapts terms from various fields of study, a reflection of the multidisciplinary nature of ML/ARD. Like the guidelines, the glossary is being produced to assist companies, regulators and members of the public who are interested in carrying out or reviewing ML/ARD work.

A number of problems must be overcome in order to develop consistent, well-defined ML/ARD terminology. These include the large amount of detail and the technical nature of ML/ARD and the lack of standard definitions for many of the terms. Other obstacles to effective communication include the multidisciplinary nature of the subject, the complexity of key concepts (e.g., neutralization potential), the large amount of jargon and acronyms, the difficulty in measuring key parameters (e.g., mineralogy) and the presence of vague or somewhat misleading terms (e.g., paste pH).

Clear consistent terminology requires an increase in the precision of ML/ARD terminology. Part of the reason for the large number of definitions ascribed to ML/ARD terms has been the lack of clarity regarding many of the key concepts. More accurate and precise terminology requires the provision of different terms:

- for different phenomena (for example, the distinction between acid generation and acid rock drainage generation),
- for measurements determined on radically different sample types (for example, paste pH versus rinse pH) or with different laboratory procedures (for example, the various forms of acid potential), and
- to distinguish laboratory measurements from the phenomena in the field they may or may not be used to predict.

An obvious disadvantage of the increased precision in ML/ARD terminology is the proliferation of cumbersome prefixes. To some degree this is an unavoidable consequence of increased understanding and a recognition of the large number of complicating factors. Possible measures to reduce the size of terms include the use of acronyms like NP and ARD or the creation of new terms.

Research and Technology Transfer

Presently the primary focus of BC MEM with regards to ML/ARD education is on its guideline documents, including the nearly completed Glossary of Terms and Manual of Recommended Prediction Methods, documents produced with assistance from practitioners in industry, consultant and environmental advocacy groups .

Other initiatives include:

- the annual BC ML/ARD workshop held in November or December, usually in cooperation with MEND (MEND, 1996)
- ministry/industry/university research, such as Molybdenum research consortium
- our own limited research program
- work with MEND and others, (e.g., Mehling, 1998).

Unfortunately much of the best information about ML/ARD is buried in mine proposals and monitoring reports which are often not widely available. Some information is available in the BC ARD Task Force and MEND Reports and BC MEM has provided some case studies in its various publications. It was hoped that the BC ARD Database would be useful in this regard. The collapse of this data compilation project after its move to the University of British Columbia (UBC) has been a disappointment and progress on this issue is considered a major priority.

The research capacity of BC MEM is limited and so most of our effort is as a part of research cooperatives. In this BC MEM has, with mixed success, tried to ensure that provincial and nationally funded research address addresses practical concerns, has realistic goals and results in progressive, incremental improvements in our understanding and tools. The problems encountered in research, a lack of comprehensive monitoring and materials characterization and a clear definition of the problem, were similar to those in operational ML/ARD work. Progress to date has been limited by poorly selected or insufficiently monitored case studies, the erroneous conclusion that there would be a simple engineered solution, promotional speculation by researchers feeding the unachievable expectations of industry and the public and a failure to consider the constraints in environmental management, the large number of uncontrollable or poorly understood factors, and the long term temporal aspects of many critical processes. It is hoped that future work will focus on well monitored long term case studies and carefully controlled experiments, aimed at increasing our understanding of specific mechanisms or conditions.

CONCLUSIONS

The challenge faced by the B.C government in regulating metal leaching and acid rock drainage (ML/ARD) is to ensure that there are no off-site impacts (receiving environment objectives), to minimize on-site impacts (reclamation objectives) and avoid unacceptable future liability and risk. Problems result from limitations in tools and knowledge, a substitution of judgment for scientific evidence and a lack of time and resources, in part due inefficiencies. To make the best use of available resources BC MEM attempts to prevent problems through prediction and design. Effective problem prevention requires problem recognition at the outset.

Many past errors were not caused by gaps in basic knowledge, but resulted from the failure of practitioners to test all mine components and consider the unique challenges faced in ML/ARD test work. A major part of the province's risk reduction strategy is to ensure that projects have the necessary understanding of their site-specific conditions, requirements and constraints and recognize the limitations of the available tools. Important factors to consider include the potential for significant delays in ML/ARD onset, the large differences in scale between test work and actual operations, the difficulty in measuring many important parameters and the fact that mitigation facilities may have to function almost forever.

Although our understanding of ML/ARD is far from complete, the presently available prediction and mitigation tools should allow safe management of ML/ARD producing wastes. When BC MEM approves a mine plan, whether for start-up or for closure, it must be assured that the site and materials are accurately characterized and the necessary mitigation measures and resources are in place to protect the off-site environment and minimize on-site land alienation. Regulation based on a thorough investigation, good science and a recognition of past mistakes is a important part of this, ensuring all risks are identified and significant adverse impacts are prevented.

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Appendix A: Excerpts from the Quarterly ML/ARD Reports of the Huckleberry Mine

Bill Price, MEM

Huckleberry
MINES LTD.

January 7, 1999.

Wally Bergen
Regional Manager
Ministry of Energy and Mines
3793 Alfred Avenue, Bag 5000
Smithers, B.C. V0J 2N0

Dear Mr. Bergen:

Re: December 1998 ARD Report

Please find enclosed the following information:

- Mined PAG Materials Handling Report for 1998
- Summary of PAG Disposition to the end of December, 1998
- Monthly Production spreadsheet with detailed PAG rock disposition
- Detailed ABA spreadsheets, including fines monitoring data, quality control checks and duplicates
- Weather data for December, 1998
- Colour site plan showing PAG disposition areas
- Water quality data
- Schedule of Disposed PAG Material Flooding
- TMF-2 Water Level plot

Fines monitoring was carried out in December in the East Zone Pit, Main Zone Pit and at the same sites around the property where the exposed waste rock monitoring was conducted. The East Zone fines data have been added to the spreadsheets with the bench composites, and the Main Zone fines data has been inserted into the Main Zone spreadsheet adjacent to the respective blast that the samples represent. Analyses on the other samples taken from around the site have not yet been completed, but will be included in the next ARD report.

P.O. Box 3000 • Houston, BC • V0J 1Z0
Phone (604) 517-4700 • Facsimile (604) 517-4701

Huckleberry Mines Ltd.

Mined PAG Materials Handling Report

Summary of PAG Disposition to End of Dec 1998

Revised to Reflect Corrected Truck Count Tonnages

Dumping Location	December 98	1997	1998	Project to Date
	Tonnes	Tonnes	Tonnes	Tonnes
In front of Crusher (North)		38,420		38,420
Truck Shop Backfill		684		684
1045 Waste Dump	118,928	699,890	433,917	1,133,807
1027 Waste Dump	61,706	76,753	943,903	1,020,656
Haul Roads	28,269	821,348	261,347	1,082,695
MZ Truck Shop		683		683
Crusher Pad		177,564	4,560	182,124
Reclaim Barge Pad		27,052	10,867	37,919
Ore Stockpile Pad		37,617		37,617
Temporary Explosive sites		6,003		6,003
Winter PAG Gravel - Stockpiled	4,104	60,261	76,304	136,565
Winter PAG Gravel - Used	(4,788)	(683)	(27,588)	(28,271)
Live Ore Stockpile		27,274		27,274
Powerpoles		836		836
Tailings Line		3,420		3,420
Emulsion Access		1,367		1,367
TMF-2 Diversion Access		6,307		6,307
TMF-2 Running Surface		3,443		3,443
North Saddle Dam		45,671		45,671
TMF-2 Abutment, upstream	25,154		918,555	918,555
Main Zone Access			2,736	2,736
Berms and Laydown Areas	760		15,200	15,200
Total PAG disposition by Truck Count	**234,133**	**1,988,239**	**2,639,801**	**4,673,711**

Schedule of Disposed PAG Material Flooding

to Dec 31, 1998

Location of PAG Materials	Quantity of PAG Material Disposed (tonnes)	Elevation of Location (metres)	Date of Placement (month/year)	Date of Flooding (year)	Duration of Exposure (mos/yrs)	PAG exposed @ 24 months (tonnes)	PAG exposed @ 5yrs (tonnes)	PAG Exposed @ 10 yrs (tonnes)	Comments
Fill Area North of Crusher Base	38,420	1045	Sep-Oct-96	n/a	life of mine	38,420	38,420	38,420	Outside TMF2 flood area; crusher excavation cut & filled to North
Under Truck Shop Foundation	684	1039	Apr-97	n/a	permanent	684*	684*	684*	Outside TMF2;under foundation slab; leave in place at closure
1045 Waste Dump	1,133,807	1045	97-98	2002	5 yrs	793,665	226,761	0	Inside TMF2 initial flood zone
1027 Waste Dump	1,020,656	1027	97-98	99-2000	1-3 yrs	127,584	0	0	Inside TMF2 initial flood zone
Haul Roads	1,082,695	980-1060	97-98	1998-13	<1-16 yrs	920,291	541,348	433,078	Est. 5 km total; 3.5km inside TMF2/MZ; 1.5km outside TMF2 flood area
MZ Truck Maintenace Yard	683	1045	Jul-Sep-97	1998	<24 mos	0	0	0	Inside MZ pit area; to be removed in Yr 2 with MZ development
Crusher Access & Pad (Cut & Fill)	108,945	1050-1060	Apr-97	n/a	permanent	108,945**	108,945**	108,945**	Outside TMF2 flood area;cut & fill material buried in place under till fill
Crusher Access & Pad (Capping)	73,179	1045-1065	97-98	n/a	life of mine	73,179	73,179	73,179	Outside TMF2 flood area; capping for access, safety berms & ore storage
Reclaim Barge Pad	37,919	1000	97-98	1998	<24 mos	0	0	0	Inside TMF2 initial flood zone
MZ Ore Stockpile Pad	37,617	1040	Jun-Jul-97	1998	<24 mos	0	0	0	Inside MZ pit area; to be removed in Yr 2 with MZ development
Temporary Explosives Site	6,003	1040	Jun-Jul-97	2001	4 yrs	6,003	0	0	Inside TMF2 initial flood zone
Winter PAG Gravel	108,294	1060	97-98	2004	1yr	0	0	0	Inside TMF2 initial flood zone; gravel for use on haul roads over winter
Mill Crushed Ore Stockpile Pad	27,274	1050	Jul-Aug-97	n/a	life of mine	27,274***	27,274***	27,274***	Outside TMF2 flood area; to be run through mill at closure
Powerpole Footings	836	1040	Jul-97	n/a	n/a	836	836	0	Outside TMF2 flood area;to be removed with EZ pit & East Dam
Tailings Line	3,420	1065	Jul-97	2005	8 yrs	3,420	3,420	0	In TMF2 initial flood zone
Emulsion Site Access	1,367	1050-1065	Aug-97	2003-4	6-7yrs	1,367	1,367	0	In TMF2 initial flood zone
TMF2 Diversion Ditch Access	6,307	1020-1050	Aug-Nov-97	1999-02	2-5 yrs	3,154	0	0	In TMF2 initial flood zone
TMF2 Running Surface	3,443	1016	Aug-97	1998	<24 mos	0	0	0	Outside TMF2 flood area;to be removed to TMF2 in spring of 1998
TMF2 Upstream Abutment	918,555	1016	1998	2000	<24 mos	0	0	0	In TMF2 initial flood zone
North Saddle Dam	45,671	1070	Nov-97	2006	9 yrs	45,670	45,670	0	inside TMF2 final flood zone
Main Zone Access	2,736	1040	Jun-Dec 97	2003	5yrs	152	0	0	In TMF2 initial flood zone
Laydown Area	15,200	1040	Jun-Dec 98	2008	10yrs	3,040	3,040	0	Originally the North American Construction Laydown
Totals	4,673,711					2,016,781	934,041	544,677	

Notes:

* 684 tonnes of PAG material under truck shop foundation proposed to be left in place at closure

**108, 945 tonnes of PAG material excavated as cut & fill; subsequently covered with substantial quantities of till fill; proposed to be left in place at closure

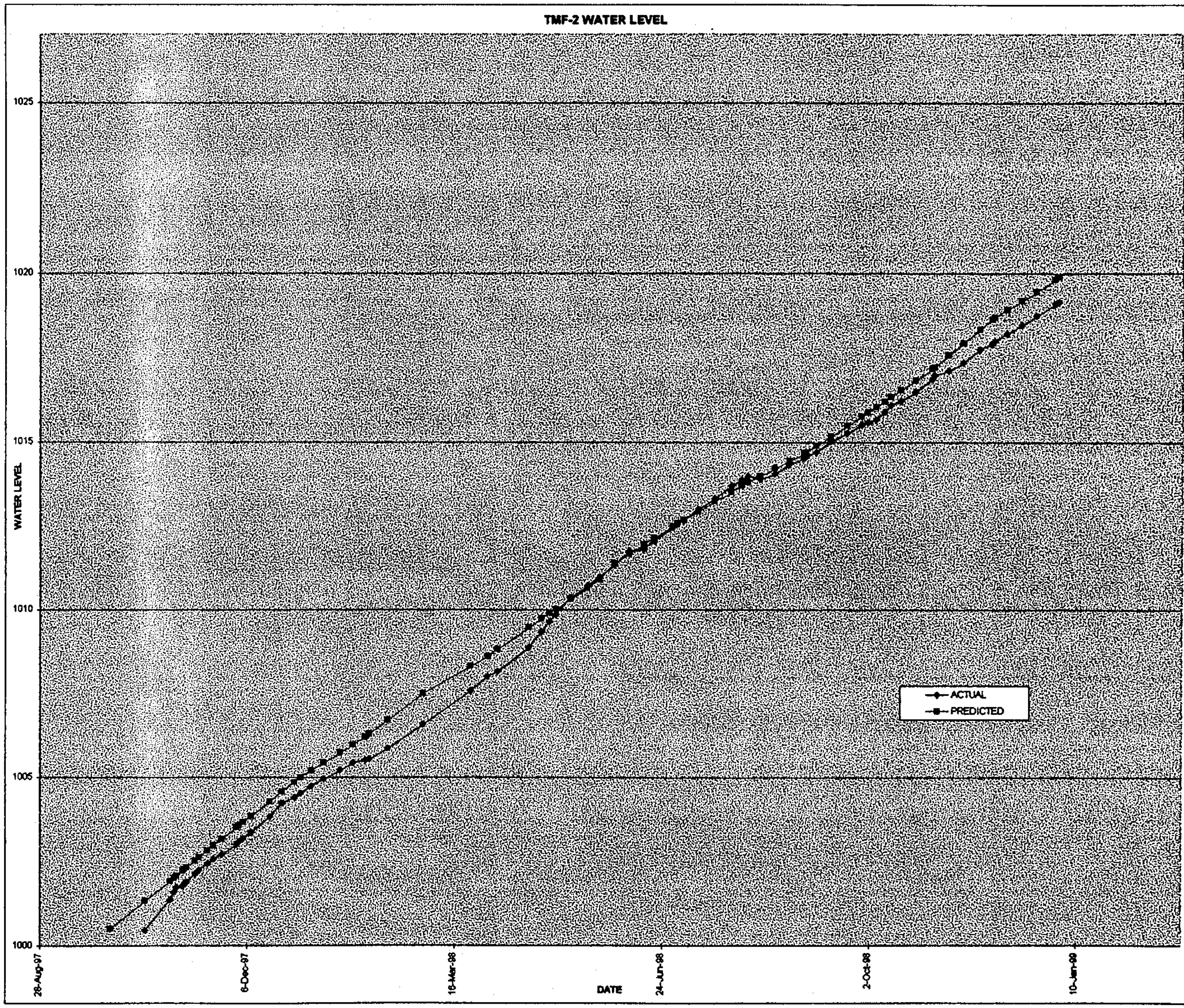
*** 27,274 tonnes of PAG material used as capping of pad for 175,000 tonne crushed ore stockpile; proposed to be run through mill at closure

TMF-2 Dam Construction Schedule

	Year-1	Year 1	Year 2	Year3	Year 4	Year 5	Year 6	Year 7	Year 8
	1997	1998	1999	2000	2001	2002	2003	2004	2005
Dam Crest Elevation (m)	1016	1029	1039	1046	1052	1059	1065	1069	1072
Average Pond Elevation (m)	997.7	1014.9	1025.2	1034.3	1042.3	1050	1057	1063.6	1067.2

	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
	2006	2007	2008	2009	2010	2011	2012	2013
Dam Crest Elevation (m)	1075	1079	1079	1079	1082	1086	1086	1086
Average Pond Elevation (m)	1070.8	1074	1077.2	1067.5	1078	1081.2	1084.1	1084.3

DATE	ACTUAL	PREDICTED	
1-Oct-97		1000.5	
18-Oct-97	1000.456	1001.323	WATER SHOT
30-Oct-97	1001.35	1001.903	WATER SHOT
1-Nov-97	1001.59	1002.0	INTERPOLATED
2-Nov-97	1001.71	1002.05	ROD
5-Nov-97	1001.76	1002.20	ROD
6-Nov-97	1001.83	1002.25	ROD
7-Nov-97	1001.875	1002.30	WATER SHOT
11-Nov-97	1002.12	1002.50	WATER SHOT
13-Nov-97	1002.21	1002.60	WATER SHOT
17-Nov-97	1002.425	1002.80	WATER SHOT
20-Nov-97	1002.544	1002.95	WATER SHOT
24-Nov-97	1002.676	1003.15	WATER SHOT
1-Dec-97	1002.98	1003.50	WATER SHOT
1-Dec-97	1002.98	1003.50	INTERPOLATED
2-Dec-97	1003.05	1003.548	WATER SHOT
4-Dec-97	1003.15	1003.645	WATER SHOT
8-Dec-97	1003.352	1003.839	WATER SHOT
17-Dec-97	1003.81	1004.274	WATER SHOT
23-Dec-97	1004.21	1004.565	WATER SHOT
29-Dec-97	1004.382	1004.855	WATER SHOT
1-Jan-98	1004.516	1005.00	INTERPOLATED
6-Jan-98	1004.74	1005.194	WATER SHOT
12-Jan-98	1004.95	1005.428	WATER SHOT
20-Jan-98	1005.22	1005.735	WATER SHOT
26-Jan-98	1005.433	1005.968	WATER SHOT
1-Feb-98	1005.521	1006.20	INTERPOLATED
3-Feb-98	1005.55	1006.293	WATER SHOT
12-Feb-98	1005.86	1006.711	WATER SHOT
1-Mar-98	1006.59	1007.50	WATER SHOT
24-Mar-98	1007.59	1008.32	WATER SHOT
1-Apr-98	1008.00	1008.60	WATER SHOT
6-Apr-98	1008.156	1008.817	WATER SHOT
21-Apr-98	1008.86	1009.467	WATER SHOT
27-Apr-98	1009.33	1009.73	WATER SHOT
1-May-98	1009.627	1009.90	INTERPOLATED
4-May-98	1009.85	1010.025	WATER SHOT
11-May-98	1010.36	1010.316	WATER SHOT
19-May-98	1010.71	1010.648	WATER SHOT
25-May-98	1010.99	1010.898	WATER SHOT
* 1-Jun-98	1011.35	1011.4	WATER SHOT
8-Jun-98	1011.76	1011.68	WATER SHOT
15-Jun-98	1011.84	1011.96	WATER SHOT
20-Jun-98	1012.074	1012.16	WATER SHOT
29-Jun-98	1012.49	1012.52	WATER SHOT
1-Jul-98	1012.57	1012.6	INTERPOLATED
4-Jul-98	1012.68	1012.706	WATER SHOT
11-Jul-98	1013.02	1012.95	WATER SHOT
19-Jul-98	1013.34	1013.242	WATER SHOT
27-Jul-98	1013.7	1013.52	WATER SHOT
1-Aug-98	1013.88	1013.7	WATER SHOT
4-Aug-98	1013.98	1013.80	WATER SHOT
** 10-Aug-98	1013.90	1013.99	WATER SHOT
17-Aug-98	1014.05	1014.22	WATER SHOT
24-Aug-98	1014.33	1014.44	WATER SHOT
31-Aug-98	1014.54	1014.67	WATER SHOT
1-Sep-98	1014.57	1014.7	INTERPOLATED
6-Sep-98	1014.7	1014.90	WATER SHOT
13-Sep-98	1015.03	1015.18	WATER SHOT
21-Sep-98	1015.29	1015.50	WATER SHOT
28-Sep-98	1015.53	1015.78	WATER SHOT
1-Oct-98	1015.59	1015.9	INTERPOLATED
5-Oct-98	1015.68	1016.07	WATER SHOT
9-Oct-98	1015.92	1016.24	WATER SHOT
12-Oct-98	1016.12	1016.36	WATER SHOT
17-Oct-98	1016.256	1016.57	WATER SHOT
24-Oct-98	1016.52	1016.86	WATER SHOT
1-Nov-98	1016.9	1017.2	INTERPOLATED
2-Nov-98	1017.02	1017.25	WATER SHOT
9-Nov-98	1017.15	1017.60	WATER SHOT
16-Nov-98	1017.38	1017.95	WATER SHOT
24-Nov-98	1017.77	1018.35	WATER SHOT
30-Nov-98	1017.94	1018.65	WATER SHOT
1-Dec-98	1018.00	1018.7	INTERPOLATED
7-Dec-98	1018.24	1018.93	WATER SHOT
14-Dec-98	1018.48	1019.20	WATER SHOT
21-Dec-98	1018.75	1019.47	WATER SHOT
30-Dec-98	1019.10	1019.82	WATER SHOT
1-Jan-99	1019.17	1019.9	INTERPOLATED



* Revised water balance used from this point onwards.

** Flooding of TMF-2 Borrow Pit

HUCKLEBERRY MINES LTD.
Acid - Base Accounting Sampling Program
East Zone Pit Waste Materials

Location	Sample Date	Sample No.	Paste pH	Total-S (%)	SO_4-S (%)	SO_4-S/T-S	Sulphide-S (%)	NP titr (t/1000t)	TIC (%)	NP calc TIC x 83.3	AP (t/1000t)	NNP (t/1000t)	NPR	Represents # Tonnes	Deposition Site	Geological Desription
Average for 1030 Bench			**7.86**	3.18	**0.12**	**0.04**	**3.07**	**34.62**	**0.18**	**15.10**	**95.78**	**-61.16**	**0.36**			
East Zone 1018 Bench																
E1018c01			7.89	3.44	0.03	0.01	3.41	38.46	0.08	6.66	106.56	-68.10	0.36			
E1018c02			8.00	3.88	0.03	0.01	3.85	36.66	0.15	12.49	120.31	-83.65	0.30			
E1018c03			7.90	3.90	0.05	0.01	3.85	32.75	0.06	5.00	120.31	-87.56	0.27			
E1018c04			7.70	4.74	0.61	0.13	4.13	34.25	0.17	14.16	129.06	-94.81	0.27			
E1018c07		44797	8.20	[illegible]	0.50	0.13	3.81	40.78	0.27	22.49	107.50	-66.72	0.38			
E1018c08		44798	8.09	4.82	0.65	0.13	4.69	35.72	0.23	19.16	130.31	-94.59	0.27			
E1018c09		44799	7.88	2.47	0.38	0.15	2.32	41.97	0.28	23.32	65.31	-23.34	0.64			
Average for 1018 Bench			**7.95**	3.88	**0.32**	**0.08**	**3.72**	**37.23**	**0.18**	**14.75**	**111.34**	**-74.11**	**0.33**			
Main Zone 1042 Bench																
M1042-01			7.68	0.20	0.01	0.05	0.19	50.78	0.43	35.82	24.06	26.72	2.11			
East Zone 1006 Bench																
E1006c01		44794	7.92	2.56	0.03	0.01	2.53	38.70	0.25	20.83	79.06	-40.36	0.49			
E1006c02		44795	8.32	2.89	0.03	0.01	2.86	46.14	0.29	24.16	89.38	-43.24	0.52			
E1006c03		44796	8.10	3.60	0.71	0.20	2.89	56.85	0.38	31.60	90.31	-33.46	0.63			
E1006c04		44793	8.00	5.52	1.04	0.19	4.48	28.88	0.15	12.50	140.00	-111.12	0.21			
E1006c05			8.22	3.38	0.19	0.06	3.19	40.11	0.16	13.33	99.69	-59.58	0.40			
E1006c06			8.12	5.11	1.19	0.23	3.92	37.84	0.13	10.83	122.50	-84.66	0.31			
E1006c07			8.10	3.97	0.92	0.23	3.05	33.22	0.19	15.83	95.31	-62.09	0.35			
E1006c08			8.15	3.33	0.46	0.14	2.87	36.98	0.24	19.99	89.69	-52.71	0.41			
E1006c09	Jul-98		7.60	4.28	0.46	0.11	3.82	24.30	0.30	24.99	119.38	-95.08	0.20	55000	TMF-2 upstream	
E1006c10	Jul-98		7.80	2.47	0.41	0.17	2.06	42.85	0.24	20.00	64.38	-21.53	0.67	54000		
Average for 1006 Bench			**8.03**	3.71	**0.54**	**0.13**	**3.17**	**38.59**	**0.23**	**19.41**	**98.97**	**-60.38**	**0.39**			
East Zone 994 Bench																
E994c01		44790	8.10	3.41	0.05	0.01	3.36	37.81	0.04	3.33	105.00	-67.19	0.36			Biotite/magnetitehornsfeld andesite with
E994c02		44791	8.22	3.22	0.03	0.01	3.19	34.53	0.04	3.33	99.69	-65.16	0.35			0.3% cpy, 3-5% py and trace Mo.
E994c03		44792	8.00	3.30	0.03	0.01	3.27	44.35	0.28	23.32	102.19	-57.83	0.43			
E994c04			7.98	2.32	0.03	0.01	2.29	13.45	0.04	3.33	71.56	-58.11	0.19			
E994c05			8.31	0.98	0.09	0.09	0.89	56.32	0.33	27.50	27.81	28.51	2.03			
E994c06			8.25	3.76	0.87	0.23	2.89	45.35	0.34	28.32	90.31	-44.96	0.50			
E994c07			7.88	5.21	0.98	0.19	4.22	46.75	0.21	17.50	131.88	-85.13	0.35	60000	TMF-2 upstream	
E994c08	Jul-98		8.10	4.71	0.71	0.15	3.99	48.00	0.19	15.83	124.69	-76.69	0.38	50000	TMF-2 upstream	
E994c09	Jul-98		8.10	3.72	0.03	0.01	3.69	40.60	0.30	25.00	115.31	-74.71	0.35	36000	1045 waste dump	
E994c10	Sep-98		8.10	3.09	0.55	0.18	2.54	67.00	0.28	23.33	79.38	-12.38	0.84	80000	1027/1045 dump	
E994c11	Oct-98		8.10	[illegible]	0.27	0.32	0.57	79.55	0.52	43.33	17.81	61.74	4.47	45000	1027/1045 dump	
Average for 994 Bench			**8.10**	3.14	**0.33**	**0.11**	**2.81**	**46.70**	**0.23**	**19.47**	**87.78**	**-41.08**	**0.53**			
Fines Monitoring on 994																
From area of E994c10 +2mm	Dec-98	45010A	8.00	2.25	0.44	0.20	1.81	43.44	0.47	39.17	56.56	-13.12	0.77		1027/1045 dump	Hornfelsed andesite with 4% py, 5% gypsum
-2mm	Dec-98	45010B	7.70	3.73	0.94	0.25	2.79	45.63	0.51	42.50	87.19	-41.56	0.52		1027/1045 dump	and 0.3% cpy.
Dyke material on 994 +2mm	Dec-98	45009A	8.20	0.05	0.01	0.20	0.04	86.52	0.36	30.00	1.25	85.27	69.22		1027/1045 dump	Post mineral basalt dyke, no visible sulfides.
-2mm	Dec-98	45009B	8.10	0.06	0.01	0.17	0.05	79.72	0.36	30.00	1.56	78.16	51.02		1027/1045 dump	
East Zone 982 Bench																
E982c01	Sep-98		7.90	5.87	1.47	0.25	4.40	40.70	0.21	17.50	137.50	-96.80	0.30	36000		Biotite/magnetitehornsfeld andesite with
E982c02	Sep-98		8.20	4.44	1.18	0.27	3.26	49.50	0.30	25.00	101.88	-52.38	0.49	75000	1027/1045 dump	0.3% cpy, 3-5% py and trace Mo.

Huckleberry Mines Ltd
ABA Sampling Program
Main Zone Pit

Location	Date	Sample No. (Hole no.)	Paste pH	Total-S (%)	SO_4-S (%)	SO_4-S/T-S	Sulphide-S (%)	NP (t/1000t)	TIC %	NP Calc. (t/1000t)	AP (t/1000t)	NNP (t/1000t)	NPR	Represents # Tonnes	Deposition Site	Geolgical Description
Min-En check	Oct, 98	mz1042-06-1081	8.09	0.39	0.06	0.15	0.33	37.65	0.38	31.67	10.31	27.34	3.65	6500	TMF-2 d/s	
	Sept, 98	mz1042-06-1084	8.10	0.33	0.01	0.03	0.32	51.60	0.49	40.83	10.00	41.60	5.16	7500	TMF-2 d/s	
	Oct, 98	mz1042-06-1085	8.00	0.34	0.01	0.03	0.33	37.39	0.36	30.00	10.31	27.08	3.63	6500	TMF-2 d/s	
	Oct, 98	mz1042-06-1086	8.00	0.74	0.02	0.03	0.72	90.29	1.07	89.16	22.50	67.79	4.01	6500	TMF-2 d/s	
	Oct, 98	mz1042-06-1096	8.10	0.27	0.02	0.07	0.25	41.13	0.48	40.00	7.81	33.32	5.26	6500	TMF-2 d/s	
	Oct, 98	mz1042-06-1102	8.00	0.25	0.02	0.08	0.23	42.73	0.36	30.00	7.19	35.54	5.95	6500	TMF-2 d/s	
Fines monitoring,1042 blast 5&6																
- MZ #3 +2mm	Oct, 98		7.90	0.13	0.01	0.08	0.12	41.66	0.39	32.50	3.75	37.91	11.11			These samples were from the 5th and 6th blast,
- MZ #3 -2mm	Oct, 98		7.90	0.18	0.01	0.06	0.17	54.21	0.51	42.50	5.31	48.90	10.20			screened through a 2mm sieve, and the fine and
- MZ #4 +2mm	Oct, 98		7.80	0.24	0.01	0.04	0.23	37.34	0.34	28.33	7.19	30.15	5.20			coarse portions were then analyzed.
- MZ #4 -2mm	Oct, 98		7.80	0.47	0.01	0.02	0.46	50.74	0.58	48.33	14.38	36.37	3.53			
Main Zone Pit - seventh blast	Oct, 98	mz1042-07-1121	8.00	0.35	0.01	0.03	0.34	40.91	0.38	31.67	10.63	30.29	3.85	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1125	8.00	0.18	0.02	0.11	0.16	35.36	0.34	28.33	5.00	30.36	7.07	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1131	8.00	0.22	0.01	0.05	0.21	43.85	0.41	34.17	6.56	37.29	6.68	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1135	8.00	0.17	0.01	0.06	0.16	40.91	0.41	34.17	5.00	35.91	8.18	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1138	8.10	0.31	0.01	0.03	0.30	43.80	0.36	30.00	9.38	34.43	4.67	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1148	8.10	0.38	0.01	0.03	0.37	46.57	0.41	34.17	11.56	35.01	4.03	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1150	8.00	0.35	0.01	0.03	0.34	50.26	0.41	34.17	10.63	39.64	4.73	6400	TMF-2 d/s	
Min-En check	Oct, 98	mz1042-07-1150	8.33	0.37	0.03	0.08	0.34	39.77	0.41	34.17	10.63	29.15	3.74	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1159	8.10	0.20	0.01	0.05	0.19	44.65	0.43	35.83	5.94	38.71	7.52	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1161	7.80	0.13	0.02	0.15	0.11	104.55	1.16	96.66	3.44	101.11	30.41	6400	TMF-2 d/s	
	Oct, 98	mz1042-07-1163	7.80	0.16	0.01	0.06	0.15	80.47	0.84	70.00	4.69	75.78	17.17	6400	TMF-2 d/s	
1038 Bench - first blast	Nov, 98	mz1038-01-1172		0.25	0.01	0.04	0.24	28.20	0.26	21.67	7.50	20.70	3.76	6300	TMF-2 d/s	Granodiorite, 1% quartz veins, unweathered,
	Nov, 98	mz1038-01-1179		0.36	0.02	0.06	0.34	31.70	0.34	28.33	10.63	21.08	2.98	6300	TMF-2 d/s	0.3% cpy, 0.1% MoS_2, 0.1% py.
	Nov, 98	mz1038-01-1180		0.22	0.01	0.05	0.21	77.95	0.87	72.50	6.56	71.39	11.88	6300	TMF-2 d/s	
1038 Bench - second blast	Nov, 98	mz1038-02-1188	8.10	0.14	0.02	0.14	0.12	31.35	0.24	20.00	3.75	27.60	8.36	6200	TMF-2 d/s	Granodiorite, 1% quartz veins, unweathered,
	Nov, 98	mz1038-02-1191	8.10	0.21	0.01	0.05	0.20	41.98	0.36	30.00	6.25	35.73	6.72	6200	TMF-2 d/s	0.3% cpy, 0.1% MoS_2, 0.1% py.
	Nov, 98	mz1038-02-1194	8.20	0.18	0.01	0.06	0.17	71.43	0.83	69.16	5.31	66.12	13.45	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1196	8.10	0.19	0.01	0.05	0.18	32.73	0.34	28.33	5.63	27.11	5.82	6200	TMF-2 d/s	
Min-En Check	Nov, 98	mz1038-02-1196	8.45	0.26	0.01	0.04	0.25	26.12	0.22	18.33	7.81	18.31	3.34	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1200	8.10	0.20	0.03	0.15	0.17	50.30	0.54	45.00	5.31	44.99	9.47	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1203	8.00	0.24	0.01	0.04	0.23	41.50	0.47	39.17	7.19	34.31	5.77	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1209	8.00	0.23	0.01	0.04	0.22	44.05	0.52	43.33	6.88	37.18	6.41	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1212	8.00	0.32	0.01	0.03	0.31	41.95	0.45	37.50	9.69	32.26	4.33	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1214	8.00	0.24	0.02	0.08	0.22	43.75	0.47	39.17	6.88	36.88	6.36	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1218	8.10	0.30	0.02	0.07	0.28	70.90	0.79	65.83	8.75	62.15	8.10	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1219	8.00	0.20	0.01	0.05	0.19	41.45	0.38	31.67	5.94	35.51	6.98	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1220	8.10	0.20	0.01	0.05	0.19	41.25	0.32	26.67	5.94	35.31	6.95	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1222	8.10	0.24	0.02	0.08	0.22	51.05	0.51	42.50	6.88	44.18	7.43	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1225	8.00	0.30	0.02	0.07	0.28	36.80	0.43	35.83	8.75	28.05	4.21	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1228	8.00	0.31	0.03	0.10	0.28	43.40	0.41	34.17	8.75	34.65	4.96	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1233	8.10	0.21	0.01	0.05	0.20	32.60	0.24	20.00	6.25	26.35	5.22	6200	TMF-2 d/s	
Min-En Check	Nov, 98	mz1038-02-1233	.60	0.16	0.02	0.13	0.14	36.43	0.36	30.00	4.38	32.06	8.33	6200	TMF-2 d/s	
	Nov, 98	mz1038-02-1245	8.10	0.09	0.02	0.22	0.07	42.30	0.77	64.16	2.19	40.11	19.34	6200	TMF-2 d/s	
Fines monitoring, 1038 2nd blast																
+2mm	Dec, 98	45007A	8.40	0.14	0.01	0.07	0.13	35.43	0.28	23.33	4.06	31.37	8.72		TMF-2 d/s	Unoxidized porphyritic granodiorite with 0.3% cpy,
-2mm	Dec, 98	45007B	8.30	0.21	0.01	0.05	0.20	35.56	0.28	23.33	6.25	29.31	5.69		TMF-2 d/s	0.1% MoS2 and trace py.

Huckleberry Mines Ltd.
ABA Sampling Program
Quality Control Samples

Sample No.	Date		Total-S	SO_4-S	Sulphide-S	NP - titr	TIC	NP - calc	AP	NNP	NPR
			(%)	(%)	(%)	(t/1000t)	%		(t/1000t)	(t/1000t)	
WCM 105	Certified Values		0.52	0.15	0.35	28			10.9	17.1	2.56
WCM 106	From		1.26	0.39	0.82	47			25.6	21.4	1.83
WCM 107	West Coast Minerals		2.25	0.36	1.85	49			57.8	-8.8	0.85
WCM 105	10-Aug-98		0.52	0.16	0.36	27.85			11.25	16.60	2.48
WCM 106	12-Aug-98		1.27	0.39	0.88	46.60			27.50	19.10	1.69
WCM 106	16-Aug-98		1.23	0.41	0.82	44.15			25.63	18.53	1.72
WCM 106	20-Aug-98		1.24	0.38	0.86	45.70			26.88	18.83	1.70
WCM 105	25-Aug-98		0.53	0.15	0.38	27.25			11.88	15.38	2.29
WCM 106	29-Aug-98		1.26	0.41	0.85	46.70			26.56	20.14	1.76
WCM 106	5-Sep-98		1.26	0.39	0.87	47.00			27.19	19.81	1.73
WCM 105	13-Sep-98		0.54	0.16	0.38	29.00			11.88	17.13	2.44
WCM 105	18-Sep-98		0.52	0.12	0.40	27.45			12.50	14.95	2.20
WCM 106	19-Sep-98		1.24	0.39	0.85	48.00			26.56	21.44	1.81
WCM 105	25-Sep-98		0.51	0.15	0.36	28.25			11.25	17.00	2.51
WCM 107	3-Oct-98		2.26	0.37	1.89	50.27			59.06	-8.79	0.85
WCM 105	15-Oct-98		0.50	0.15	0.35	28.10			10.94	17.16	2.57
WCM 106	18-Oct-98		1.25	0.39	0.86	47.00			26.88	20.13	1.75
WCM 107	20-Oct-98		2.26	0.37	1.89	48.92			59.06	-10.14	0.83
WCM 105	25-Oct-98		0.51	0.15	0.36	27.50			11.25	16.25	2.44
WCM 106	1-Nov-98		1.27	0.42	0.85	48.00			26.56	21.44	1.81
WCM 107	3-Nov-98		2.24	0.37	1.87	49.00			58.44	-9.44	0.84
WCM 106	9-Nov-98		1.25	0.42	0.83	49.75			25.94	23.81	1.92
WCM 107	14-Nov-98		2.24	0.37	1.87	49.00			58.44	-9.44	0.84
WCM 107	23-Nov-98		2.24	0.34	1.91	49.00			59.69	-10.69	0.82
WCM 105	27-Nov-98		0.50	0.15	0.35	29.50			10.94	18.56	2.70
WCM 106	3-Dec-98		1.25	0.39	0.86	47.27			26.88	20.40	1.76
WCM 107	8-Dec-98		2.27	0.37	1.90	47.85			59.38	-11.53	0.81
WCM 105	17-Dec-98		0.52	0.16	0.36	27.60			11.25	16.35	2.45
WCM 106	19-Dec-98		1.24	0.39	0.85	46.90			26.56	20.34	1.77
WCM 107	20-Dec-98		2.28	0.37	1.90	47.85			59.38	-11.53	0.81

Huckleberry Mines Ltd.
ABA Sampling Program
Tailings Samples

see discussion

Sample Description	Date	Paste pH	Total-S (%)	SO_4-S (%)	Sulphide-S (%)	NP - titr (t/1000t)	TIC %	NP - calc	AP (t/1000t)	NNP (t/1000t)	NPR	Comments
Bulk Rougher Tails	Jul-98	8.01	1.18	0.09	1.09	62.20	0.48	40.00	34.06	28.14	1.83	July monthly composite from Mill
Final Tails	Jul-98	7.91	1.36	0.06	1.3	63.85	0.57	47.50	40.63	23.23	1.57	July monthly composite from Mill
Cleaner Scav Tails	Jul-98	6.86	11.24	0.42	10.82	38.95	0.21	17.50	338.13	-299.18	0.12	July monthly composite from Mill
Bulk Rougher Tails	13-Aug-98	7.80	1.12	0.33	0.79	45.05	0.24	20.00	24.69	20.36	1.82	Grab sample from Mill
Bulk Rougher Tails	17-Aug-98	8.00	1.36	0.09	1.27	36.05	0.13	10.83	39.69	-3.64	0.91	Grab sample from Mill
Bulk Rougher Tails	25-Aug-98	8.06	0.95	0.04	0.91	42.10	0.17	14.17	28.44	13.66	1.48	Grab sample from Mill
Final Tails	30-Aug-98	8.13	0.68	0.10	0.58	42.40	0.23	19.17	18.13	24.28	2.34	Grab sample from Mill
Bulk Rougher Tails-Day	31-Aug-98	8.04	1.23	0.35	0.88	47.10	0.23	19.17	27.50	19.60	1.71	Bulk flotation test in Mill
Bulk Rougher Tails-Night	31-Aug-98	8.03	0.51	0.26	0.25	43.50	0.11	9.17	7.81	35.69	5.57	Bulk flotation test in Mill
Bulk Rougher Tails	31-Aug-98	8.20	0.66	0.27	0.39	48.35	0.26	21.67	12.19	36.16	3.97	Bulk flotation test in Mill
Bulk Rougher Tails	31-Aug-98	8.15	0.89	0.37	0.52	46.65	0.34	28.33	16.25	30.40	2.87	Bulk flotation test in Mill
Bulk Rougher Tails	31-Aug-98	8.28	0.37	0.05	0.32	38.75	0.13	10.83	10.00	28.75	3.88	Bulk flotation test in Mill
Bulk Rougher Tails	1-Sep-98	8.40	0.3	0.05	0.25	34.75	0.15	12.50	7.81	26.94	4.45	Bulk flotation test in Mill
Bulk Rougher Tails	Aug-98	8.04	1.2	0.32	0.88	45.80	0.13	10.83	27.50	18.30	1.67	August monthly composite from Mill
Final Tails	Aug-98	8.00	1.65	0.26	1.39	50.50	0.34	28.33	43.44	7.06	1.16	August monthly composite from Mill
Cleaner Scav Tails	Aug-98	6.82	13.05	0.39	12.66	41.20	0.17	14.17	395.63	-354.43	0.10	August monthly composite from Mill
Bulk Rougher Tails	10-Sep-98	7.80	1.26	0.84	0.42	65.7	0.43	35.83	13.13	52.58	5.01	Grab sample from Mill
Final Tails	10-Sep-98	7.60	2.24	1.00	1.24	63.6	0.47	39.17	38.75	24.85	1.64	Grab sample from Mill
Bulk Rougher Tails	15-Sep-98	7.88	0.83	0.68	0.15	62.13	0.66	55.00	4.69	57.44	13.25	Grab sample from Mill
Final Tails	15-Sep-98	7.64	1.69	0.59	1.10	62.96	0.54	45.00	34.38	28.59	1.83	Grab sample from Mill
Bulk Rougher Tails	21-Sep-98	8.13	2.28	0.47	1.81	50.60	0.37	30.83	56.56	-5.96	0.89	Grab sample from Mill
Final Tails	21-Sep-98	7.89	2.69	1.8	0.89	56.70	0.28	23.33	27.81	28.89	2.04	Grab sample from Mill
Bulk Rougher Tails	Sep-98	8.20	0.98	0.21	0.77	47.28	0.13	10.83	24.06	23.22	1.96	September monthly composite from Mill
Final Tails	Sep-98	8.00	2.78	0.61	2.17	57.78	0.45	37.50	67.81	-10.03	0.85	September monthly composite from Mill
Bulk Rougher Tails	Oct-98	8.10	1.14	0.77	0.37	53.84	0.26	21.67	11.56	42.28	4.66	October monthly composite from Mill
Final Tails	Oct-98	8.10	1.89	0.96	0.93	61.14	0.38	31.67	29.06	32.08	2.10	October monthly composite from Mill
Cleaner Scav Tails	Sep-98	7.60	19.96	0.76	19.2	45.00	0.26	21.67	600.00	-555.00	0.08	September monthly composite from Mill
Cleaner Scav Tails	Oct-98	7.60	14.03	0.97	13.06	49.90	0.23	19.17	408.13	-358.23	0.12	October monthly composite from Mill
Bulk Rougher Tails-Day	11-Nov-98	7.70	2.12	1.25	0.87	62.35	0.43	35.83	27.19	35.16	2.29	Shift composite from Mill
Bulk Rougher Tails-Night	11-Nov-98	7.70	1.84	1.17	0.67	59.25	0.43	35.83	20.94	38.31	2.83	Shift composite from Mill
BRT - Day	12-Nov-98	7.70	1.48	1.24	0.24	57.60	0.40	33.33	7.50	50.10	7.68	Shift composite from Mill
BRT - Night	12-Nov-98	7.70	2.38	1.31	1.07	66.00	0.45	37.50	33.44	32.56	1.97	Shift composite from Mill
BRT - Day	13-Nov-98	7.80	1.52	0.76	0.76	73.47	0.60	50.00	23.75	49.72	3.09	Shift composite from Mill
BRT - Night	13-Nov-98	7.80	1.64	0.85	0.79	69.80	0.50	41.67	24.69	45.11	2.83	Shift composite from Mill
BRT - Day	14-Nov-98	7.80	0.93	0.41	0.52	81.10	0.68	56.66	16.25	64.85	4.99	Shift composite from Mill
BRT - Night	14-Nov-98	7.90	0.51	0.32	0.19	70.67	0.68	56.66	5.94	64.73	11.90	Shift composite from Mill
BRT - Day	15-Nov-98	7.90	0.62	0.26	0.36	76.25	0.63	52.50	11.25	65.00	6.78	Shift composite from Mill

Huckleberry Mines Ltd

East Zone Pit E228086

ate	Cond.	TDS	pH	Hardness	Total Alkalinity	SO_4	NO_2	TSS int	TSS ext	Al-D	Sb-D	As-D	Cd-D	Ca-D	Cr-D	Cu-D	Fe-D	Pb-D	Mg-D	Mo-D	Zn-D
nit	uS/cm	mg/L		$CaCO_{3(mg/L)}$	$CaCO_{3(mg/L)}$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
mit			6 to 10					50	50		0.1		0.01		0.05	0.05	1			5	0.2
Oct-97	1100		7.42	569	67.8	642	0.017		5	< 0.20	< 0.20	0.0013	< 0.0002	201	< 0.001	0.006	< 0.030	< 0.001	16.3	0.08	< 0.005
Oct-97				622						< 0.20	< 0.20	0.0012	< 0.0002	218	< 0.001	0.009	< 0.030	< 0.001	18.8	0.09	< 0.005
Oct-97				549						< 0.20	< 0.20	0.0009	< 0.0002	192	< 0.001	0.014	< 0.030	< 0.001	17.2	0.09	< 0.005
lov-97				935						< 0.20	< 0.20	0.0161	< 0.0002	351	< 0.001	0.015	< 0.030	< 0.010	14.1	0.07	0.012
lov-97				735						< 0.20	< 0.20	0.0115	< 0.0002	273	< 0.001	0.014	< 0.030	< 0.010	13.0	0.05	0.007
lov-97	1360	1120	7.61	763	99.0	669	0.376		16	< 0.20	< 0.20	0.0055	< 0.0002	282	< 0.001	0.003	< 0.030	< 0.010	14.3	0.06	0.005
lov-97	1430		7.46	861	91.0	889	0.053		3	< 0.20	< 0.20	0.0026	< 0.0002	310	< 0.001	0.009	< 0.030	< 0.010	21.2	0.10	< 0.005
lov-97	1460		7.59	889	88.0	901	0.064		6	< 0.20	< 0.20	0.0033	< 0.0002	321	< 0.001	0.005	< 0.030	< 0.010	21.2	0.09	< 0.005
)ec-97	1610	1670	7.42	1050	79.0	1130	0.419		43	< 0.20	< 0.20	0.0052	< 0.0002	403	< 0.001	0.003	< 0.030	< 0.010	11.6	0.04	< 0.005
)ec-97	1600	1600	7.55	1070	81.0	1100	0.172		11	< 0.20	< 0.20	0.0071	< 0.0002	412	< 0.001	0.002	< 0.030	< 0.010	10.6	0.04	< 0.005
)ec-97	1870	155	7.64	1110	82.0	1190	0.174		546	< 0.20	< 0.20	0.0049	< 0.0002	431	< 0.001	0.006	< 0.03	< 0.010	9.39	0.04	< 0.005
)ec-97	1890	1940	7.38	1300	79.0	1370	0.223		5660	< 0.20	< 0.20	0.0040	< 0.0002	501	< 0.001	0.021	0.03	< 0.010	11.1	0.05	0.011
)ec-97	1690		7.57		91.6	1210	0.230		61	< 0.20	< 0.20	0.0053	< 0.0002	472	< 0.001	0.008	< 0.03	< 0.010	9.21	0.05	< 0.005
lan-98	1810	1960	7.52	1300	93.9	1320	0.249		38	< 0.20	< 0.20	0.0062	< 0.0002	504	< 0.001	0.008	< 0.03	< 0.010	9.07	0.04	< 0.005
eb-98	2040	1990	7.57	1270	82.3	1290			15	< 0.20	< 0.20	0.0062	< 0.0002	496	< 0.001	0.011	< 0.03	< 0.010	6.68	< 0.03	< 0.005
lar-98	2090	1950	7.52	1170	81.2	1120			979	< 0.20	< 0.20	0.0086	< 0.0002	453	< 0.001	0.004	< 0.03	< 0.001	9.1	0.06	0.005
pr-98	1870	1770	7.73	1060	90.7	1120			17	< 0.20	< 0.20	0.0042	< 0.0002	415	< 0.001	0.016	< 0.03	< 0.001	5.9	0.05	< 0.005
lay-98	2090	1920	7.77	1140	79.0	1250			23	< 0.20	< 0.20	0.0101	< 0.0002	447	< 0.001	0.016	< 0.03	< 0.001	4.9	0.06	0.015
lun-98	2090	2040	7.73	1210	85.0	1290			12	< 0.20	< 0.20	0.0100	< 0.0002	476	< 0.001	0.020	< 0.03	< 0.010	5.0	0.06	0.009
Jul-98	2270	2140	7.82	1370	142.0	1140			1170	< 0.20	< 0.20	0.0140	< 0.0002	540	< 0.001	0.060	0.04	0.002	5.6	0.05	< 0.005
ug-98	1900	n/a	7.68	1290	85.0	1480	0.120		538	< 0.2	< 0.2	0.0100	< 0.0002	508	< 0.001	0.012	< 0.03	< 0.001	5.40	0.06	0.008
ep-98	2140	2110	7.88	1290	102.0	1250	0.471		136	< 0.2	< 0.2	0.0110	< 0.0002	510	< 0.001	0.040	< 0.03	< 0.010	4.30	0.09	0.009
)ct-98	2230		7.86	1280		1530	0.184		839	< 0.2	< 0.2	0.0081	< 0.0002	500	< 0.001	0.009	< 0.30	< 0.010	7.20	0.12	< 0.005
lov-98	1960	1990	7.86	1190	78.0	1280	0.057		34	< 0.2	< 0.2	0.0061	< 0.0002	465	< 0.001	0.030	< 0.03	< 0.001	6.20	0.10	0.012

IUM	2270	2140	7.88	1370	142	1530	0.471		5660	0.2	0.20	0.0161	0.0002	540	0.001	0.060	0.30	0.010	21.2	0.12	0.015
UM	1100	155	7.38	549	68	642	0.017		3	0.2	0.20	0.0009	0.0002	192	0.001	0.002	0.03	0.001	4.3	0.03	0.005
AGE	1825	1740	7.63	1044	88	1159	0.201		508	0.2	0.20	0.0068	0.0002	403	0.001	0.014	0.04	0.007	10.7	0.07	0.007
EV.	316	526	0.16	256	15	233	0.141		1268	0.0	0.00	0.0040	0.0000	108	0.000	0.013	0.06	0.004	5.2	0.02	0.003
NCE	99826	276833	0.02	65318	235	54462	0.020		1606819	0.0	0.00	0.0000	0.0000	11637	0.000	0.000	0.00	0.000	27.5	0.00	0.000

Appendix B: An Example of Mine Reclamation Costing at the Snip Mine

Summary Report

Version 3.5

19-Aug-98
12:53 PM

Project Name:	SNIP MINE CLOSURE
Permit #:	
Costing Year:	1997

Mine Activity Category	AREA (ha)				RECLAMATION PRESCRIPTION			Total Cost
	Total Disturbed	Perm. Disturb.	Current Reclaimed	To be Reclaimed	Site Preparation	Revegetation	Maintenance	
AREA DISTURBANCE								
Dump Face Resloping								
Resloped	7.7	0	0	7.7	$36,340	$5,617	$0	$41,957
MINE ACCESS ROADS	9.4	0	0	9.4	$4,790	$6,784	$0	$11,574
BORROW AREA "D"	6	0	0	6	$1,600	$4,377	$0	$5,977
AIRSTRIP AREA, MAGS	27.3	0	14.2	13.1	$4,730	$9,556	$0	$14,286
EXPLORATION ROADS	10			10	$3,200	$2,395	$0	$5,595
MILL/PLANT/CAMP AREA	16.8	0	0	16.8	$5,440	$12,256	$0	$17,696
SKY BORROW PIT	5	0	5	0	$0	$0	$0	$0
TAILINGS IMPOUNDMENT	24	14	8.5	1.5	$9,600	$3,130	$0	$12,730
BRONSON CK. BORROW	1	0	0	1	$400	$730	$0	$1,130
DYKE 1	1	0	0	1	$0	$240	$0	$240
DYKE 3	1	0	0	1	$0	$240	$0	$240
BRONSON CK. DIVERSION	1.2	1.2	0	0	$0	$0	$0	$0
SKY CK. DIVERSION	0.3	0.3	0	0	$0	$0	$0	$0
Master 13				0	$0	$0	$0	$0
Master 14				0	$0	$0	$0	$0
LUMP SUM ITEMS								
ARD Capital Costs to Closure (ARD operating costs are included in Post Closure Worksheet)								$0
Miscellanous items as per Addendum 1								$1,454,850
Kitchen, Fire pumps, Office equipment, Shop equipment								-$86,800
Mill Equipment								-$161,500
Mine Equipment								-$885,150
Mechanical Shop Equipment								-$22,750
Surface Equipment								-$301,000
Warehouse Inventory and Equipment								-$214,000
Powerhouse								-$161,600
Sealing of Openings-Mine Portals								$120,000
Hauling -- surfacing material & 130 & 440 waste removal								$90,000
Air Freight Cost for 4,000,000 lb								$836,000
Ocean Freight Cost for 4,000,000 lb								$155,892
Landfill & Removal of Reagents, Waste Oil								$200,000
Bronson Ck. Additional Rip-Rap								$12,000
Dyke 1 Construction-Closure Configuration,inc. spillway								$400,000
Dyke 3 Construction-Closure Configuration								$851,805
0								$0
POST CLOSURE COSTS								
Present Value								$666,667
TOTAL	110.70	15.50	27.70	67.50	$66,100	$45,324	$0	$3,065,838

Appendix C: The Table of Contents for the BC MEM Review of ML/ARD Aspects in the Project Report for the Tulsequah Chief Project

BRITISH COLUMBIA

TULSEQUAH CHIEF PROJECT

Review of Metal Leaching and ARD Aspects of the Project Report Submitted in Support of Application for Project Approval Certificate

- Working Document -

January 12, 1998

by:

William A. Price

Reclamation Section of Mines Branch
B.C. Ministry of Energy and Mines

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