# DRAFT ARD GUIDELINES FOR MINE SITES IN BRITISH COLUMBIA

William A. Price, John C. Errington, and Victor M. Koyanagi

Ministry of Energy, Mines and Petroleum Resources
Mine Review and Permitting Branch
4th Floor, 1810 Blanshard Street
Victoria, BC V8V 1X4

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## BACKGROUND

### Mine Regulation and Policy

Mining is a very productive land use generating significant wealth, while occupying a very small proportion of the provincial land base. In addition to maximizing returns to the provincial economy, the provincial government's mining policies include protection of the environment and where possible to make mining a temporary land use. For the most part, minesites can be returned to their pre-mining capability. This latter objective is enforced by current provincial mining legislation which requires that disturbed land and water resources be reclaimed to a level of productivity not less than that which existed previously, and that water released from the minesite meet long-term water quality standards.

Although the overall objective is to make mining a temporary land use, there are situations where the reclamation potential of mine facilities is limited or where long-term maintenance will be necessary. Any long-term maintenance requirement or "permanent" reduction of productivity must be minimized to the extent technically and economically feasible with current technology. These environmental impacts are considered in land use and approval decisions relating to proposed mine developments, in conjunction with other environmental and socio-economic impacts and benefits.

As part of the regulation of the mining industry, all mine proposals and closure plans are reviewed by inter agency Regional Mine Development Review Committees (RMDRC). The Victoria-based Reclamation Advisory Committee (RAC) reviews the decisions of the RMDRC and issues the Reclamation Permits which are required before mining can proceed. A major factor in many mine reviews is the consideration of acid rock drainage (ARC) and associated metal release, an issue of particular concern to the Ministry of Energy, Mines and Petroleum Resources, Ministry of Environment, Lands and Parks, and Environment Canada.

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What is ARD?

Acid rock drainage (ARD) is a natural part of our global heritage. It occurs when sulphide minerals in rocks are exposed to the weathering effects of oxygen and water, and results in the chemical change of the sulphur within minerals to sulphuric acid. The acidity in ARD is first generated from the oxidation of sulphide minerals, a process often accelerated by microbiological activity. Acid drainage results when the acidity is entrained by water flowing through areas of sulphide oxidation.

Acid rock drainage results from complex chemical and physical processes, involving a great number of factors. The negative effects associated with acid rock drainage are primarily caused by the impact of dissolved metals released either directly from sulphide minerals or by weathering reactions occurring concurrently with sulphide oxidation. Within the normal pH range of soils and water, the rate of weathering is typically slow and any metals released are relatively immobile.

Under highly acidic conditions, the rate of weathering is much faster, most metals remain soluble and, entrained in runoff and seepage, can have an impact in the receiving environment. Because of the high release rates, even neutralized ARD can contain elevated levels of metals that will have an adverse impact on the receiving environment. These natural effects are enhanced by man-made activities such as highway and logging road construction which frequently expose sulphide-bearing rocks. Acid drainage is associated with mining because many precious and base mineral, and some B.C. coal deposits contain metal sulphide-minerals, and because the mining process breaks the sulphide-bearing rock apart, greatly increasing the surface exposure, and thus the potential for oxidation.

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The leaching of sulphide oxidation products is not however confined to lands disturbed by mining. Low pH values and the characteristic rust-coloured iron staining are often found in natural water courses in the vicinity of undisturbed outcrops of sulphide-bearing rock. The provincial geochemical survey, which has sampled and analyzed streams throughout British Columbia, has found over one hundred occurrences of natural acid generation. Sulphide oxidation and very acidic pH values are also common in marine soils drained for farming in the Fraser Valley and in many other parts of the world.

Nor do all mining operations that expose sulphide-bearing rock create acid rock drainage. For example, ARD will not occur if sulphide minerals are non-reactive. Even if significant sulphide oxidation does occur, ARD will not occur if there is insufficient water to transport the acid weathering products or if pH changes are buffered by a concurrent release of alkalinity from other minerals. Acid neutralization and the precipitation of acid weathering products may occur in the immediate area or as the drainage passes through other more alkaline portions of rock.

While ARD is a natural process, its potential magnitude can be greatly increased by mining. In most undisturbed areas sulphide oxidation is restricted to the thin unconsolidated surface layer and a few small outcrops. In mining, the extraction, cracking and crushing of the sulphide bearing bedrock in underground workings, pits, tailings and rock dumps greatly increases the exposure of rock to oxygen and drainage. The potential for environmental impact is further accentuated at some precious and base metal mines by the abnormally high concentrations of one or more trace elements.

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Acid Rock Drainage at Mine Sites in British Columbia

At mines in British Columbia, as well as in other parts of the world, acid drainage is a major impediment to providing long term environmental protection and returning the mined land to a productive sustainable state. Acid rock drainage is known to occur at seven operating mines and five recently closed mines in British Columbia. Three other operating mines are considered potentially acid generating, as are several proposed mines. Under the current reclamation legislation, all proposed and operating mines with a potential to generate acid rock drainage must develop acceptable plans to minimize ARD to a level that ensures long term environmental protection.

In addition to the presently operating and proposed mines, six mine sites abandoned prior to the enactment of reclamation legislation are known to be acid generating. The regulation of acid rock drainage from historic and operating mine sites is shared by two British Columbia ministries (Environment, Lands and Parks and Energy, Mines and Petroleum Resources) and Environment Canada.

ARD Research

To help the British Columbia mining industry comply with the present comprehensive reclamation requirements, the provincial government is participating in a program of research aimed at developing cost-effective solutions to major environmental problems. A major part of this program focuses on acid rock drainage. As part of this research, the provincial government coordinates and provides funding for the British Columbia Acid Mine Drainage Task Force, and is a vital participant in activities of the national acid drainage program (Mine Environmental Neutral

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Drainage Program - MEND). In 1992, research expenditures for the British Columbia Acid Mine Drainage Task Force amounted to $1.5 million, with funding shared by industry and the provincial and federal governments.

The problems of acid rock drainage will not be solved easily. However, work carried out during the last five years has done much to enhance our knowledge and ability to predict, prevent, control and monitor ARD. The cooperative efforts of the provincial government and the British Columbia mining industry are highly regarded by the rest of Canada, and British Columbia is a world leader in acid rock drainage technology.

## The MEMPR Acid Rock Drainage Policy

From previous project reviews and research, the RAC developed a set of working policies and technical initiatives to deal with acid rock drainage. These procedures, rules and guidelines were first complied as a working document (Errington, 1991). A revised working document was released by the RAC as a draft discussion document in July, 1993, both for public information, and industry discussion and comment. In attempting to cover the entire spectrum of ARD issues, the July 1993 Policy document contained sections dealing with exploration, proposed mine developments, prediction, prevention, collection and treatment, commercial leaching, permitting, bonding, monitoring, historic sites exploration, and existing mines. Presently, the RAC is compiling the comments received and forming an expert review group to consider the contentious issues.

In the meantime, a large number of projects are undergoing active development and review, including at least 9 proposed mines and 11 closure plans with ARD concerns. To guide our ongoing review and as a tool for advising proponents, MEMPR have produced this revised set of ARD guidelines, based in part on the July 1993 Policy, with revisions and additions derived from

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recent mine reviews and from comments received from the public and industry. The guidelines set forth in this paper govern the information required from a prediction program, the type of materials used for construction purposes, preventive techniques such as underwater disposal and blending, and inventory and monitoring requirements associated with waste handling. The ARD guidelines set forth herein reflects the RAC's current philosophy of **preventing** ARD generation through prediction and design, avoiding long-term treatment wherever possible.

## GENERAL PRINCIPLES

These guidelines are an attempt to provide formal-flexible guidance on ARD, while not limiting the options and approaches. Users are cautioned to consider the specific site and materials, when deciding which and how rules and procedures should apply. At some points, worst-case assumptions are used as the screening criteria for determining whether additional testwork is required. The final criteria used for waste handling and remediation decisions should be based on site-specific test results.

All mining and exploration activity will be regulated in a manner that protects the environment and minimizes the economic risks to the province. To the extent this is technically and economically feasible, ARD works should be compatible with the surrounding land use and should not preclude reclamation of the minesite to its pre-mining productivity.

All potential environmental and social impacts of acid drainage for a proposed mine will be assessed during the Mine Development Assessment Process or its successor, prior to issuance of a Mine Development Certificate.

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The proponent is responsible for development and implementation of an effective ARD program; including all necessary prediction, prevention, and monitoring. Owing to the significant cost and site-specific needs of each mining project, a proponent is advised to discuss the ARD prediction or remediation work with regulatory agencies prior to its implementation.

Because some uncertainty is associated with predicting the occurrence and extent of acid rock drainage, monitoring, treatment and control contingencies may be part of some mine approvals. Prediction is generally more difficult for waste rock dumps, open pits, and underground workings than for tailings impoundments. While the technology is available to prevent the release of acid rock drainage from operating mine sites, it is not yet possible to completely abandon acid-generating mines without requiring long-term programs to collect and treat acid rock drainage or to maintain prevention and control measures.

As a condition of a reclamation permit security bonds will be required to ensure that sufficient funds are available to cover all outstanding reclamation obligations, including long-term costs associated with monitoring, maintenance of preventive structures, and/or treatment of acid rock drainage following mine closure.

ARD and its associated metal leaching is highly site specific. Consequently, the policy and procedures outlined in this document must be tailored to fit the specific mining, geological and environmental conditions of each site.

Acid drainage and metal leaching are ongoing, dynamic processes whose rates and significance are controlled by biological, physical, and chemical thresholds. As a result, ARD studies and remediation programs must consider both the surrounding environment and long term changes in inputs and mitigating processes.

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Through research, B.C. MEMPR will continue to assist the development of improved acid rock drainage technology.

The Province will revise the ARD Policy and regulatory framework to reflect changes in acid rock drainage technology. Modifications and additional requirements for individual mines will be based upon site specific conditions.

## PREDICTION OF ACID ROCK DRAINAGE

In order to design a mine which will not result in a major financial liability, a proponent must have a thorough understanding of the nature of all materials exposed during the mining cycle. This information will be required in the development of the extraction, waste handling, and remediation plans.

The proponent is required to predict the acid rock drainage potential (variability and central tendency) for each overburden and rock unit* mined or exposed, and for any waste material, such as waste rock or tailings, created by the operation. The prediction process will consist of the following two phases:

1. Identify and characterize all the rock units, and determine their size, shape, and location.

2. Based on the mining and ARD requirements, create management units from waste type/exposure type/rock units that will be treated alike.

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*Overburden or rock unit: an operational term used to describe one or more types of rock, overburden or waste material that can be handled separately and that have unique properties of significance to ARD.

The choice of prediction methods will depend on the environment, status of the operation, types of exposed rock and the availability of materials such as drill core. A proponent should focus on the questions critical to their particular waste handling and remediation options. For example, the critical design feature for flooded tailings will be the effectiveness of the water barrier rather than the composition of the ore.

Typical questions asked in ARD prediction include:

- What is the potential for significant trace element release under the different possible geochemical conditions?
- What criteria should be used to distinguish acid drainage generating and non-acid drainage generating material?
- What disposal and remediation methods are needed, and what are the quantity or area requirements?
- What monitoring is required to inform the waste handling operation?
- How long will it take for acid drainage to develop in materials for which there is a delay prior to the application of remedial measures?

The identification of rock units and the creation of management units will typically require an iterative process of sampling, analysis, and classification, similar to that used to determine other geological characteristics such as ore reserves. Based on the results of the first round of sampling and analysis, it may be necessary to further subdivide some of the original rock or management units, or to do additional analysis. Conversely, it may be possible to reduce the number of management units by compiling materials whose difference are not significant with regards to ARD prevention and waste handling.

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Proponents are warned that prediction errors can result from the blind use of technology, incomplete analysis of the test materials, and the erroneous assumptions made in the interpretation of ARD test work. All test assumptions and analyses should be verified for their applicability to the specific site conditions and their usefulness in answering the specific analysis questions.

Sampling and Statistical Requirements

Perhaps the most important phase of the prediction program is sampling. The objective in sampling should be to collect representative samples of all the types of materials that will be exposed. Every sampling program is faced with questions regarding the number of samples, the size of the sample, and the method of sample collection. The answer to each of these questions will of course depend in part on the particular site and materials.

As much of the variability will result from differences in geology, sufficient samples should be taken to accurately characterize the variability and central tendency for critical parameters in each significant rock unit, based on accepted statistical procedures. The number of samples taken from a particular material will depend on its variability and the questions being asked. Where no additional guidance is available, the suggested *minimum* number of samples collected from *each* rock and/or overburden type during *initial* sampling is as follows:

| **Mass of Each Separate Rock Unit (tonnes)** | **Minimum Number of Samples** |
|---|---|
| <10,000 | 3 |
| <100,000 | 8 |
| <1,000,000 | 26 |
| 10,000,000 | 80 |

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The sample size should also be based on the prediction question, the variability of the materials, in addition to the proposed modes of extraction, exposure and deposition. Compositing of samples should be avoided unless the geological information indicates it is advisable (e.g., homogeneously disseminated sulphides and carbonate). One exception to this rule is where compositing is done to create more representative test materials. For example, subsamples may be combined to create a sample which matches:

- the minimum possible size for separate extraction (e.g., compositing over a bench or adit height).
- the geochemically functional area or mass that occurs from the mixing that occurs in waste handling (e.g., one lift of a dump).

Once mining is underway, samples can be taken from the actual waste or rock face. Prior to mining, the choice of test materials for predictive work is often restricted to drill core. One advantage in using drill core is that it is available for the entire deposit. Another advantage is that the location and visually detectable geological conditions will have already been recorded, allowing a preliminary separation into "operational" rock types and management units.

It is very important that the geological composition be provided for each sample, to show where the sample fits within the group it is purported to represent. Geological information, which can usually be derived from the drill log, will also be used to reassign samples if the rock units are reclassified, and can be used to explain anomalous ARD test results.

Owing to the significant cost and specific requirements of each mining project, a proponent is advised to discuss the sampling program with regulatory agencies prior to its implementation.

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Requirements of the Prediction Program

The prediction program should incorporate the following procedure:

Step 1. Identify and Characterize Different Materials

Step 1 should consist of three phases. Phase 1 is the initial identification, description and mapping of different rock and overburden types that will (for new mine proposals) or have (for existing or historical mines) been affected by mining. Phase 2 is the separation of geological and geomorphological strata into functionally significant units, and should include determination of their size, shape, and location. Phase 3 is to determine the eventual form of exposure (e.g., pit wall, tailings, or waste rock) for each unit.

The Phase 1 initial description and mapping of different rock and overburden types should be based on general physical and geological properties significant for ARD prediction. The geological description should include consideration of petrology, mineralogy, grain size, texture, structure, fracturing, competency, spatial distribution of the above, as well as any properties such as colour that could be used for identification. Physical properties that should be described include particle size and mode of deposition for unconsolidated materials, and competency or strength for all materials.

The Phase 2 separation of "geologically" different functional units should be based on size and distribution, in addition to differences in geological and physical properties. It is recognized that bedrock and overburden are often both very variable, with two or more types occurring over small distances. Where changes occur irregularly, along continums, or so often that it is impossible to separate the rock mass into discrete homogeneous units, the proponent should

separate the rock mass into "manageable" units. For example, bench or adit heights may be used to separate separately manageable units of waste rock.

Where new mining projects will affect or be affected by historical mining, or for prediction done on existing operation, Phase 1 should include the characterization of existing mine wastes, underground working, open pits and other mining-related disturbance. The characterization of existing mine workings should include the particle size distribution, mode of deposition and/or exposure, and the quantity (weight, volume, and aerial extent). Existing mining-related disturbance should be included on the overburden map produced in Phase 2. The map created should be of sufficient detail and quality to clearly show the topography of both the mined areas and the surrounding terrain, and the location of any permanent or intermittent water courses. Historical mining occurring in the same watershed should also be included.

While often overlooked in the rush to do less complicated ARD-specific testing, step 1 is necessary to ensure that the entire range of geological variability is addressed and that the ARD test work is comprehensive. The geological and physical properties used to separate different rock and management units will often strongly effect site specific ARD criteria.

Step 2. Initial Screening

Conduct initial screening of materials based on the sulphide content, available metal content, and pH value. Materials with a paste pH less than 3.5 will be considered a potential source of acid drainage. All materials with either more than 0.3% sulphide-S or a pH less than 5.0 should be tested further.

The form and amount of readily soluble constituents should be measured in materials that are already oxidized to identify situations where there is a potential for the dissolution of residual weathering products. The method for determining availability should be selected according to site-specific criteria.

For projects where the geology indicates there will be sulphides present, a proponent is advised to combine steps 2 and 3.

Step 3. Acid Base Accounting

The next phase of the ARD test work is to measure the maximum acid generation potential (AP) and maximum neutralizing potential (NP) of each rock and overburden type, and to use traditional acid base accounting procedures to calculate the net neutralization potential (NNP) and neutralization potential ratio (NPR).

Acid base accounting is the primary screening tool used to determine whether further site specific ARD testwork is required. The screening criteria used to evaluate a need for further testwork based on acid base accounting tests are:

- Materials with sulphide minerals whose net neutralizing potential (NNP=NP-AP) is negative are likely to be a acid drainage source. Exceptions are possible if the sulphide content is very low and/or there are significant slow release, non-carbonate sources of alkalinity.
- The acid drainage potential will be considered uncertain if materials have a ratio of neutralization potential to potential acidity (NP:AP) of less than 4:1.

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The ratio of 4:1 represents the worst case to date and was selected to ensure the detection of sites where there is an unfavorable balance between long-term acid generation and neutralization reactions or where the composition of a waste rock's fine-sized fraction varies significantly from that of the whole rock. It is recognized that a 4:1 ratio is conservative and will be higher than the actual composition of acid drainage generating materials at most sites.

Where the acid rock drainage potential of a waste material or geological unit is uncertain, it will be considered acid drainage generating until the proponent can show through further testing (step 4) that the acid and neutralization reaction rates are favorably balanced.

It is cautioned that acid base accounting provides only a rough assessment of the potential for acid drainage. More refined site and material-specific interpretation or testing should be used if less conservative, more accurate information is required.

Step 4. Determine Site and Material Specific Prediction Criteria

To predict the ARD potential and to address the prediction questions listed previously, the proponent is required to develop site and material-specific criteria based on the relative rates of acid generation and neutralization reactions, and the size of the reactive fraction. The data used may be obtained from a variety of sources, including a more detailed characterization of the material, comparisons with similar materials at other sites, weathering and leachate quality observed in soils and outcrops, the quality of seepage from existing waste materials, kinetic laboratory tests, and field trials.

Often there is no one piece of evidence or conclusive test, and the proponent must combine information from a variety of sources. For example, experience at other sites might be presented

in combination with detailed geological data showing that the rock or waste types are very similar.

Kinetic tests are often used to estimate relative acidity-neutralization reaction rates and to predict metal release and loading. The value of kinetic tests as a predictive tool will be greatly enhanced where it is shown that these tests simulate either the real field release rates or the actual balance of important processes, such as oxidation, dissolution, and entrainment. A geological description should be provided for the kinetic test material to show how each sample fits within the rock or management unit it is supposed to represent.

Valuable field evidence may be obtained from trends in the relative elemental ratios of seepage water, and from the relative weathering rates and fine particle replenishment observed in old wastes or similar natural soils. If the materials can be matched to the new mine wastes, field evidence is a very good prognostic tool.

Depending on the materials and site, it may be necessary to determine the neutralizing potential of non-titratable, slow release minerals, or the size and rate of additions from biotic and climatic sources.

Although universal ABA rules may not apply, ABA characteristics can often be the best criteria to use for distinguishing materials.

Often overlooked in the desire to do simpler ARD-specific tests, detailed geological characterization is usually necessary if one is to predict how materials will perform. Where there is a potential for the generation of acid drainage or metal release through weathering or dissolution, the proponent should determine the range, variability, and central tendencies for the following properties:

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- Mineralogy and associated elemental composition
- Readily soluble constituents
- Sulphide types (amount, reactivity, and spatial distribution)
- Carbonate types (amount, reactivity, and spatial distribution)
- Mineralogical and rock fabric characteristics that will influence weathering.

The properties listed above may be modified to match the specific conditions of each site, material and disposal option.

In addition, and in many cases in preference, to doing whole rock analysis, the proponent should estimate the composition of the fine-sized fraction and the surfaces of coarse particles. For proposed operations which do not yet have wastes to analyze, comminution effects may be predicted from the geological characteristics of the rock and weathering simulation methods, such as grinding and slaking.

**PREVENTION OF ACID ROCK DRAINAGE**

All mines with a potential for acid drainage must provide operational reclamation and abandonment plans showing how they will reduce the generation of acid drainage to levels not exceeding receiving water quality objectives, both in the short and long term. In cases where the

success of prevention measures cannot be assured, an assessment of the potential for failure and of the possible impacts will be required. Detailed contingency plans to reduce the risk to the environment will also be needed. This will usually consist of plans for a collection and treatment system.

Until it is determined that there is no potential for acid drainage or other water quality problems, material with one or more of the following properties shall not be used for roads, dams or other construction purposes:

- A total sulphide-S level greater than 0.3%
- A paste pH less than 5
- A potential for significant metal loss from residual weathering products.

Underwater Disposal

Underwater disposal of tailings or waste rock in secure manmade structures is currently an acceptable form of acid rock drainage prevention. Underwater disposal in natural water bodies will only be considered where there is shown to be no significant impact on water quality, fisheries*, recreation, or downstream flow, and where the water bodies are shown to be the most environmentally suitable disposal site.

Further research is required to assess the impact of the underwater disposal of tailings or waste rock in biologically or water-quality-sensitive lakes before this disposal alternative will be considered.

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*In the case of disposal into natural water bodies, appropriate approval would have to be obtained from federal authorities under the Fisheries Act.

In cases where underwater disposal of tailings or waste rock is proposed, the proponent must show that:

- The mine wastes do not contain significant readily soluble deleterious substances.
- The water balance ensures that all potentially acid-generating wastes will be continuously covered by water.
- There will be no significant impact as a result of wave action, ice, drought, flooding, avalanches, earthquakes, thermal overturn, surface and groundwater movement, and other relevant natural factors.
- The mode of deposition, the water depth and other design features satisfy the requirement for long-term prevention of acid drainage.

Manmade impoundments shall be designed and maintained for long-term geotechnical stability, taking into account the possible effects of biological activity, seismic and extreme meteorological conditions.

A water cover is currently an acceptable form of acid rock drainage prevention for underground workings or open pits. Where only partial flooding can be achieved, the proponent must predict both the extent of flooding and water quality impacts from unflooded mine walls.

The timing and inflow rate requirements in flooding open pits and underground workings will be based on the hydrologic conditions, the relative reaction rates of acid generation versus neutralization, and the potential release of acid products. Proponents must demonstrate that any water released to the environment will be of acceptable quality. Hydraulic bulkheads or material barriers in underground workings shall be designed to allow ongoing verification of the water level and of geotechnical stability.

Blending

Blending of acid generating and acid consuming materials to create an overall acid consuming material is an acceptable acid rock drainage prevention strategy. The proponent will be required to show that there is sufficient information about the materials and sufficient neutralizing capability to ensure that blending can be carried out successfully. Given the potential for incomplete mixing, more conservative NNP and NPR criteria will likely be required than those set for single homogeneous materials (see earlier discussion of acid rock drainage prediction).

The proponent will also be required to demonstrate that the blending plan is compatible with the mine plan, that it is possible to achieve the required control in materials handling and that there is sufficient disposal capacity. This should include any interim prevention measures required for the protection of exposed material stockpiled prior to final disposal.

At permitting, the proponent will be required to itemize the sample type and size, sampling frequency, the list of analyses, proposed QA/QC and processes for communicating monitoring results to the blending operation. In addition to the analysis of source materials, monitoring will also be required to verify the composition of the resulting blend.

## COLLECTION AND TREATMENT OF ACID ROCK DRAINAGE

Although prevention will be the primary method of acid rock drainage control for new mines, collection and treatment may be accepted as a mitigation method if the proponent can demonstrate that -

- All preventative methods have been examined and are determined to be technically and economically unfeasible with current technology

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- The risk (likelihood of occurrence and consequences) to the environment caused by a failure to the system is acceptable
- The quantity of acid rock drainage is readily manageable
- Treatment sludge can be disposed of safely.

In addition, the proponent must provide adequate security to finance long-term collection and treatment.

Where collection and treatment is proposed as the principal means of protection, the proponent must show that the system can be maintained in perpetuity. The supportive evidence should include detailed engineering and economic analysis, including consideration of relevant biological factors, and a comprehensive risk analysis to show that environmental values will not be jeopardized. Any proposed collection and treatment system should include adequate resources to support its operation.

While treatment technology is generally effective, long-term collection and treatment is among the most expensive remediation options. Because of the long time frame and uncertainties about future costs, government's bonding requirements are likely to make collection and treatment an unattractive option for new mines. Since final site reclamation is not possible and there are ongoing sludge disposal problems, proponents must recognize that the use of collection and treatment as a primary means of control will only be approved after consideration of the land use, environmental and socio-economic impacts and benefits. Approval of such programs will be at the discretion of review agencies.

During the mine operation all collection ditches, dikes, impoundments, and pumping systems must be designed to handle a one-in-200-year flood during the mine operation. For

abandonment, the minimum design criteria for structures whose failure would jeopardize the effectiveness of the acid rock drainage prevention plan should be based on the consequence of failure. Where the consequences of failure are high, the minimum design criteria should be the probable maximum flood (PMF) and the maximum credible earthquake (MCE).

**RECLAMATION PERMITTING**

Following a detailed review under the Mine Development Assessment Process, mines are regulated under mine plan approvals, reclamation permits, and waste and water management approvals, permits, and licenses. All of these approvals, permits, and licenses are issued subject to
monitoring and confirmation of predictions, and with conditions to prevent the generation and dispersal of acid rock drainage.

**BONDING**

As a condition of a reclamation permit, a security will be required to ensure that sufficient funding is available to cover all outstanding reclamation obligations, including long-term costs associated with the necessary monitoring, maintenance, collection, and treatment of acid rock drainage following mine closure.

Bonding requirements will be addressed at each stage of the Mine Development Assessment Process. The Regional Mine Development Review Committee, following a detailed technical review, will recommend an appropriate level of security to be required as a condition of the reclamation permit. The level of security will increase as reclamation obligations increase during mine operation. The security will be set at a level that will, in a self-perpetuating manner, pay for:

- the long-term inspection, monitoring, and maintenance, and if necessary the operation of collection, containment, and treatment plant facilities
- the long-term inspection, monitoring, and maintenance of preventive and control structures.

The security will take into account the high degree of uncertainty in predicting these costs. Securities attached to existing mines will be increased should acid rock drainage be discovered. Should remediation or prediction work reduce the extent of acid generation or the risk of future acid generation, security levels will be reduced.

**MONITORING**

Monitoring programs designed for environmental protection and for the early detection of acid rock drainage will be required as a condition of permits issued by the Ministries of Energy, Mines and Petroleum Resources and Environment, Lands and Parks. Intermittently, QA/QC programs should be carried out to verify the accuracy and precision of the data.

During mine operation, companies will be required to maintain a detailed inventory for all waste or exposed materials. This information should be continually updated and readily accessible in a complete package, including analysis results for drill core, waste materials, exposed surfaces, and water draining from various wastes and off site. The ARD information should include the rock or overburden type, acid/base accounting data, mineralogical and elemental composition, storage location, and date of emplacement. pH and readily soluble constituents should be measured where some weathering has already occurred.

Following mine closure, the permittee will be required to undertake all long-term requirements including monitoring, inspecting, reporting on, and maintaining the mine site and ancillary ARD

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facilities. Monitoring programs will be designed to ensure that operational procedures are being carried out and to determine if prevention techniques have been successful.

## ANNUAL REPORTS

Annual reports summarizing the materials, methods, and results of the acid rock drainage monitoring program will be required as a condition of all reclamation permits. The annual reports should also summarize the previous year's mining and waste disposal, the materials mined and any anticipated changes to the mine plan. Cumulative detailed ARD monitoring records should be appended.

## HISTORIC SITES WITH ACID ROCK DRAINAGE

Under the **Mines Act**, the responsibility for containing acid rock drainage from historic mining operations currently rests with the "owner" of the mineral rights, whether or not this owner caused the problem. The Ministry of Environment, Lands and Parks, under the **Waste Management Act,** may assign responsibility to past and current owners.

The Ministry of Energy, Mines and Petroleum Resources recognizes that, in many cases, the most efficient and effective method of eliminating acid rock drainage from historic mine properties is to recommence mining using modern mining and environmental control practices. Consequently, the Ministry believes the regulatory policy should encourage active exploration and development when considering the liability of the present or prospective owner.

**The Ministry of Energy, Mines and Petroleum Resources, in cooperation with the Ministry of Environment, Lands and Parks, is committed to establishing a registry of mines and**

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**exploration properties with an existing acid rock drainage problem, as well as sites where a potential for acid rock drainage exists. To date, nine historic minesites have ARD concerns.**

## EXISTING MINES WITH ACID ROCK DRAINAGE

There are five recently closed and seven operating mines that currently are known to be producing acid rock drainage. Four recently closed and three operating mines have an uncertain ARD status.

All operating and recently closed mines are required to submit, or have already submitted, detailed closure plans.

**Reclamation bonds are being reviewed to ensure that sufficient funding is available to pay for the abatement of acid rock drainage, including, where necessary, the costs of long term collection, treatment and monitoring.**

## COMMERCIAL LEACHING

Commercial leaching with acidic solutions can provide a cost effective means of recovering copper, which maximizes the utilization of the provinces mineral reserves.

**Commercial leaching operations may only be approved where they are designed and constructed to ensure adequate environment safeguards and where sufficient bonding is in place to adequately secure the necessary long term prevention, control, collection and treatment of acid rock drainage. Assuming it is required, all the guidelines for collection and treatment should also apply to commercial leaching.**

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Similar to the case for the collection and treatment of incidental acid rock drainage, the proponent of a commercial leaching operation must provide detailed engineering and economic analysis to demonstrate that acid drainage collection, containment and treatment can be maintained in perpetuity. Commercial leaching operations by their nature result in the production and processing of high strength acid rock drainage. As such, the level of detail for environmental and engineering analysis will be higher than that required for most mine operations. Small scale field pilot studies may be required to demonstrate that these facilities can be operated safely. The proponent must also provide a comprehensive risk analysis that considers adjacent land use and shows that environmental values will not be jeopardized. Because the risk is strongly affected by the proximity of environmental resources, siting of such facilities is critical.

## EXPLORATION

**The Ministry of Energy, Mines and Petroleum Resources will ensure that all exploration activity is regulated in a manner which limits the risk of acid rock drainage.**

Companies engaged in exploration activities for coal and mineral resources are required to submit their proposed programs to the Ministry of Energy, Mines and Petroleum Resources for approval. These proposals are referred to all pertinent government agencies for review. A reclamation permit is required for all mechanical exploration, and a reclamation security or bond is required prior to issuance of this permit.

**Previous guidelines for prediction (page 9) apply to exploration activities resulting in sufficient rock disturbance to create a potential for ARD. A general rule of thumb is that exposure of a hundred tonnes of rock constitutes significant disturbance. The exact**

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**amount will depend on both the environment and the type of rock. Examples of these types of activities included the construction of an exploration adit or the removal of a bulk sample.**

Significant rock disturbance does not generally occur and thus ARD work will not be required in exploration activities such as drilling, surface trenching and soil sampling. The necessity for having proponents consider ARD during exploration and development is supported by the strong ARD generation and metal release observed for waste rock extracted from exploration adits at a number of pre-mining developments. For exploration to be an accepted, temporary land use, compatible with surrounding land uses, prospectors must take the necessary provision to ensure that ARD and consequent metal release does not compromise productivity and water quality standards.

**Where exploration includes underground activities or significant surface rock disturbance, applicants are required to determine the theoretical acid generating potential for all rock units encountered.**

The reclamation permit conditions for any exploration activity with a potential for creating acid rock drainage are set by the Regional Mine Development Review Committee. Where a theoretical potential for acid generation is indicated, the proponent must present plans to prevent the release of acid rock drainage. In cases where the success of prevention measures cannot be assured, the security required will reflect the cost of long term acid rock drainage control, and will take into account the risk to the environment. Where a potential for acid rock drainage is identified, more detailed site and receiving water monitoring may be required to determine what, if any, environmental impacts may occur. If the environmental risk and consequences are too great, the Committee may recommend that the permit application be rejected.

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## COMMITMENT TO TECHNICAL SOLUTIONS

**The RAC is committed to incorporating new technology into mine design and closure plans, and updating this ARD policy as this technology becomes available.**

The provincial and federal governments have demonstrated their commitment to technical solutions through support of the British Columbia Acid Mine Drainage Task Force and the Mine Environment Neutral Drainage (MEND) programs, updates of the Acid Rock Drainage Technical Guide and the creation of the U.B.C. Chair on Mining and the Environment.

REFERENCES:

Errington, J.C. 1991. The Regulation of Acid Mine Drainage. Second International Conference of the Abatement of Acidic Drainage. Tome 2. pp. 89-99.

# ENVIRONMENTAL MANAGEMENT FOR MINING

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