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Appendix B: Mine Closure Working Paper

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Contents

1 Introduction

Mining operations are finite economic activities, which are usually relatively short term. For a mining project to contribute positively to an area's development in any lasting way, closure objectives and impacts must be considered from project inception. Mine closure policy and planning defines a vision of the end result and sets out concrete objectives to implement that vision. To achieve this a mine closure plan should be an integral part of a project life cycle and be designed to ensure that (Sassoon, 2000):

- Future public health and safety are not compromised;
- Environmental resources are not subject to physical and chemical deterioration;
- The after-use of the site is beneficial and sustainable in the long term;
- Any adverse socio-economic impacts are minimised; and
- All socio-economic benefits are maximised.

These objectives can best be achieved by the preparation of a mine closure plan early in the process of mine development, in consultation with the regulating authority and local communities.

Closure planning includes a commitment to progressive rehabilitation and detailed plan development and implementation (ANZECC, 2000). The plan provides a framework against which short term actions can be measured during mine life and adjustments made to ensure a successful final closure. It also provides a view of the potential future for the community's economic and social life.

Operating mines that are close to the end of their economic life have limited options available for addressing sustainable development goals during closure. Mines that are in the middle of their operating life present more opportunities while those still in planning stage have maximum freedom to address sustainable development issues. Ideally, planning for closure should start during the pre-feasibility stage of a mining project.

The activities during the final closure stage include (1) the removal of infrastructure, (2) the implementation of public safety measures, (3) recontouring and revegetation (rehabilitation), (4) ongoing maintenance of site structures and monitoring of environmental issues, (5) the operation of site facilities required to mitigate or prevent long term environmental degradation and (6) the completion of company involvement in sustainable community economic and social programmes.

The full appreciation of mine closure and ways to manage the associated economic, environmental and social impacts is relatively new. The objective of this working paper is to evaluate how mine closure can be best designed in order for the mine to contribute to the long-term sustainable development of the area. Issues that need to be considered when planning for and implementing closure will be discussed.

2 Mine Closure Considerations

Planning for closure includes integrating the closure design for the entire mine area, identifying the timing of the planning process, considering issues which relate to specific disposal methods and economic and community objectives, as well as financial provisions. The process of establishing a closure plan should include:[1]

- A study of closure options – looking at the feasibility of all aspects of possible outcomes;
- A consultative process – involving all interested parties, to determine the preferred after use for the mine and associated facilities;
- A statement of closure objectives – the mining company's commitment to the outcome of the closure of its activities;
- An estimate of closure costs – the cost of achieving the stated objectives; and
- A programme of studies and test work – to confirm any assumptions inherent in the closure objectives.

Figure B1 below presents the closure planning process as outlined in the Mine Closure Guideline for Mineral Operations in Western Australia (Chamber of Minerals and Energy, 1999).

During the last ten years, a reasonable body of literature has been produced on the environmental aspects of mine closure planning and implementation. Waste disposal facility reclamation planning and implementation case studies are plentiful. These typically describe contouring, placement of topsoil or other suitable growth medium and the establishment of vegetation. Major advances have been made in this arena and regional experience is of importance. However, relatively few case studies are available on successful integrated mine closure, i.e. successfully closing all facilities at a mine site, while also considering the economic and social impacts in the area.

Integration of other aspects of sustainable development, i.e. economic and societal interests, has not taken place to the same extent as the considerations for environmental issues. It can be argued that the considerations related to environmental issues are still at a fairly rudimentary level and it is therefore clear that much is still to be learned about the successful closure of mines and integrating the economic and social aspects.

In discussing the approach to mine closure and rehabilitation four main stages can be identified. The length of time for each stage cannot be generally defined as it is a site-specific issue and the planning stage should be on-going, throughout the life of the project. These four stages are:

- **The Planning Stage** – a closure plan should be established and integrated into the mine plan and environmental (including socio-economic) management plan or system at the earliest possible opportunity and regularly updated during the operating life of the project.

[1] D. Richards, Rio Tinto, Pers. Comm.

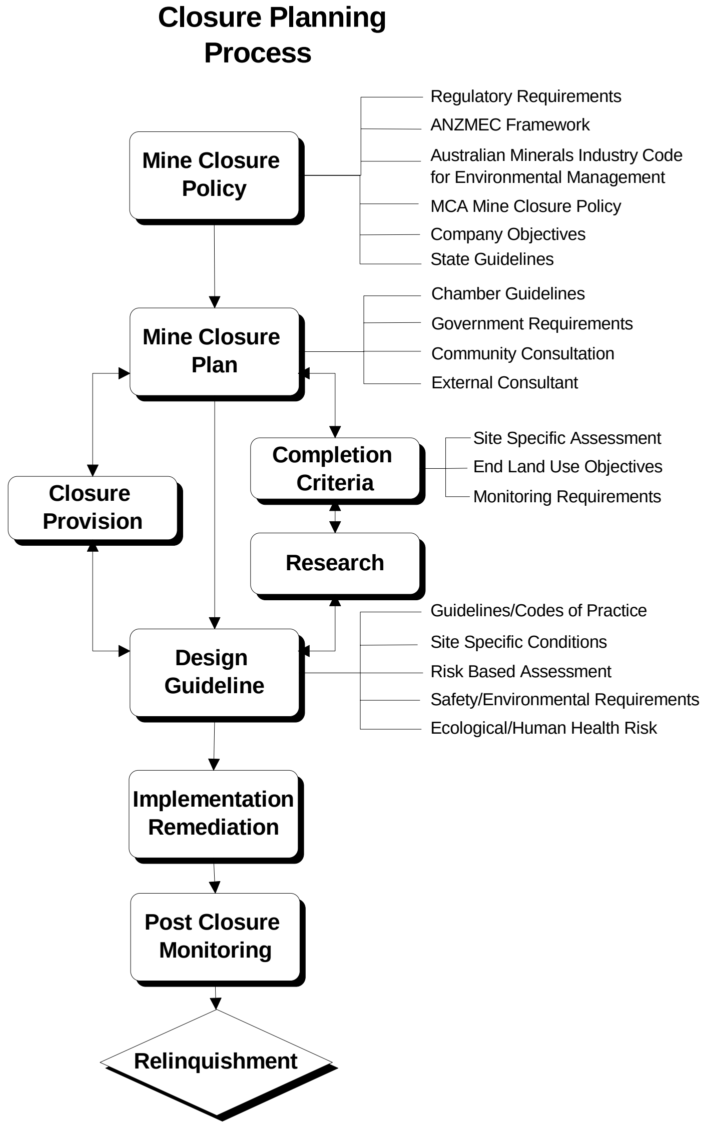

Figure B1. The closure planning process

- **The Operational Stage** – during production the management tests the closure objectives and takes the opportunity to review, improve and enhance the programme.
- **The Active Care Stage** – following decommissioning the physical rehabilitation of the site is carried out and the social mitigation programmes are completed.
- **The Passive Care Programme** – the passive care programme is a period of monitoring and management designed to demonstrate that the active care programme has been successful and the 'walk-away' state has been achieved.

It must be noted that moving from the active care stage to the passive care stage requires that there is not ongoing mechanical water treatment on the site, such as a lime treatment plant for acid drainage. Similarly, moving from the active care stage to walk-away may not be accomplished at all at mine sites where passive treatment, water monitoring, and ongoing maintenance are required.

2.1 Timing

The timing of planning for closure is determined by a number of different factors and can influence the closure process itself. Ideally, closure plans should be developed as early as possible during the feasibility and design stages of new mines. On-going reviews of the closure objectives and design are necessary to allow for changes in political, legislative, physical or socio-economic conditions. If planning is delayed, it may affect which mine closure objectives can be met.

Mine closure planning is an ongoing process that must start during the pre-feasibility stage of a project and be an integral part of the environmental and social impact assessment and mine planning phase. It is ideally a process where multidisciplinary teams will work together to optimise the design and operations of the mine such that the closure objectives can be established prior to the location of facilities. Fine-tuning of this plan will then be carried out throughout mine life and at the end of operations. The rehabilitation plans prepared as part of the environmental impact assessment will be of a preliminary nature as site trials can be carried out during mine life.

As is discussed in Section 2.5 (Unforeseen Circumstances), one purpose of developing a mine closure plan is to obtain a cost estimate of closure so that financial surety can be established. It is important to establish a fairly accurate plan for the potential closure of the mine during the first few years of operations as that is a particularly vulnerable time for smaller and more marginal projects. Unexpected early closure or bankruptcy may require that such a plan be implemented. It is also customary, at the early stage of project review and design, to develop an idea of progressive disturbance and therefore the closure liabilities at different stages of the mine life.

Uncertainties about specific closure technologies may be a concern at the environmental impact assessment stage. One example, the effectiveness of proposed measures in establishing vegetation may be difficult to predict. The methodologies can then be evaluated in field trials, etc. during the mine life and lead to updates of the closure plan.

Another possibility is that new technologies will be developed that will change the approach to mine closure. An example of this is gold heap leach facilities. In the 1980's, when many of these were developed in Nevada, the closure plans called for rinsing with fresh water to reduce pH and cyanide. Experience with closure of these facilities has shown that pH and weak acid dissociable cyanide are not of major concern, but those heavy metals and salts (such as selenium, sulphate and nitrate) are.[2] This is not necessarily true for all gold heap leach facilities, where cyanide related complexes may be present.

Since the 1980's, improved technology for evaporative covers has been developed and this is now becoming the approach for closing the spent gold heap leach sites.[3] A change in

[2] See information about the heap leach closure workshops on http://www.mackay.unr.edu/mlc
[3] See http://www.mackay.unr.edu/mlc

technology may result in a change in closure details and in the closure cost; all issues that must be addressed throughout the life of a project.

Improved technology may lead to re-treatment of tailings or other mined materials at a site, or alternatively the re-opening of the mine, may provide some revenue towards the cost of improved closure. At many mines, this should be taken into account so that closure does not destroy the potential for future mining.

It is also possible that changes in the regulations will change the closure requirements and planning process during operations. Changes in water use, water quality standards, expectations with respect to vegetation type and distribution, etc. may affect closure plans.

It is currently common practice to develop a final closure plan for a facility (such as a waste rock disposal facility or spent ore facility) or for a whole project closer to the time of closure implementation. These closure plans are then be submitted to the regulatory authority for approval prior to implementation. Depending on the project schedule, these plans should be prepared within the last two years of operation. Some jurisdictions also require an update of the environmental impact assessment (or preparation of a new one) for the closure process. This obviously adds time to the approval process for the final closure plan.

The timing for development of the closure plans, throughout the project life, must take into account the input from stakeholders. The objective of stakeholder involvement is 'to enable all stakeholders to have their interests considered during the mine closure process'.[4] The stakeholders must be identified and effective consultation must be implemented. While it is ideal to work with communities to develop mine closure plans, it rarely happens this way. It is more typical for the mining company to develop a closure plan, submit it to the regulatory agency and then allow stakeholder input as part of the official public comment period. It is recommended that this approach should change to one where the community has a much larger contribution to the development of closure plans, both from the physical and socio-economic perspectives.

The mine closure process also includes progressive or concurrent rehabilitation. By closing facilities as they are completed, the total area of disturbance remains smaller and the impacts are reduced. There may be specific benefits for the speedy rehabilitation of facilities containing acid generating materials. Such rehabilitation may be aimed at reducing or eliminating the infiltration of meteoric waters into some facilities or the complete flooding of others to eliminate acid generation.

Not all operating mines have closure plans in place. This creates a challenge to mine operators and regulators. Closure plans developed for operating mines must also undergo regular reviews. Once the operator is aware of the specific issues addressed in the mine closure plan, ongoing operations can start to address these. It is much better to make advances towards closure during the life of the mine than for companies to have to make large expenditures on rehabilitation when they are no longer receiving an income from the project. This was the approach taken by Peru in the 1990's, when the new mining environmental regulations were put in place.

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[4] ANZMEC (2000)

2.2 Integrated Mine Closure

Mine closure planning must integrate a number of concepts on a site wide basis, e.g. social aspects, physical and chemical stability including surface water management, the management of remaining process solutions, the selection and implementation of covers and the post-mine use of the infrastructure. Decisions on closure are based on the post mining land use and regulatory criteria.

Integrated closure planning includes a number of elements:

- A **statement of closure objectives**, which is the mining company's commitment to the outcomes of the closure and its activities. It may be drawn from the study of options but other factors such as regulatory requirements, community preferences, the precautionary principle and corporate culture may also influence the choice. It is the company's statement, after accommodating all inputs, of what it intends to do.
- A **study of closure options**, often a task commissioned to be carried out by consultants, covering the feasibility of all aspects of possible outcomes, not necessarily leading to the recommendations of a preferred option;
- A **consultative process** involving local communities, regulators and others to determine the preferred long-term use for the mine and all associated land;
- An estimate of closure costs, that is the cost of achieving the stated objectives produced by the other elements above.
- A **programme of studies and test work** to confirm any assumptions inherent in the statement of closure objectives, to reduce the uncertainties surrounding some of the options for closure, and to investigate new technologies or socio-economic models.

The first pass at this cycle takes place during the environmental impact assessment, but a regular review process for closure ideally leads to revisions or confirmation of closure objectives, costs and research needs.

Closure planning must integrate all aspects of sustainable development, i.e. environmental, economic and social issues must be addressed in integrated closure plans. Such integrated thinking must become standard operating procedures throughout the mine life. A comprehensive approach is at this time a theoretical ideal to strive towards and much work remains to implement it universally.

Clark *et al*. (2000) summarise the challenge of integrated mine closure as follows:

"*Comprehensive mine closure for abandoned mines, presently operating mines, and future mines remains a major challenge for virtually every mining nation in the world. To accommodate the need to close abandoned mines and to ensure that existing and future mines are appropriately closed will require the co-operation of a diverse stakeholder community, new and innovative methods of financing closure and major policy and legislative change in most nations to ensure post-mining sustainable development*".

Closure plans developed, as part of the environmental impact assessment and mine design, must be taken up in the environmental management plan or system implemented during mining operations. There must be continuity in the process all the way through to the development and implementation of the final closure plan. Mine closure should be integral to the whole of mine life plan (ANZMEC, 2000).

The long-term sustainability of the community associated with a mine must be considered as part of the total closure plan. For this to be successful it has to start during the planning of a project so that full advantage can be taken of the economic activities created by the project. If this integrated planning starts too late in a mine's life cycle, then it could be difficult to ensure long-term economic and social sustainability of a community. Although the closure may be successful from an environmental perspective, it may fail from a sustainable development perspective. At many mines, it is a challenge to develop an environmentally successful closure and the expectations will be much higher if an integrated approach is used. This should not deter the development of integrated planning.

Regulatory criteria such as 'restoring the area to pre-mining conditions' may be in conflict with sustainable development in an area. Mining can alter the landscape and changes in the long-term land use plans and regulations may be necessary to allow new uses for the land. For example, pre-mining conditions in an area may be ideally suited for grazing and wildlife. The infrastructure established as part of the mine includes electrical transmission lines. The large flat areas created by waste storage facilities may be ideally suited for wind farms and the transmission infrastructure exists to provide this long-term sustainable land use. While some parts of the mine site may be returned to the original use of grazing and wildlife, other parts can make use of the mining infrastructure to provide renewable energy generation.

There are certain activities that can be undertaken to reduce the hardship of mine closure on local communities. While these measures may help, they will not alleviate the concerns about long-term sustainability of a specific community. In developing countries, mines introduce a cash economy that may be difficult to sustain after the end of operations. Many of the workers may be trained only to perform mining related work and will have to move to other communities to maintain a cash economy. In some cases broader training and education may be more useful to the workers as that may provide them job opportunities in other sectors of the economy as well. The US Borax Sustainable Development programme considers transferable occupational skills as one of its important indicators.[5]

Another approach is to consider the potential self-sustainability of a community in the area of the mine following closure. This investigation should be carried out at the time of mine development. If it is found that the community will not be self-sustainable then alternatives such as fly-in fly-out employment policy may have to be considered to reduce impacts of mine closure to new communities formed in support of the mine.

Part of integrated closure planning must be transparency by the mining company about its plans for a mine. Sudden mine closures can be very disruptive to local communities. Advance notices about closure can help the government and local communities prepare better. While early announcements of planned closure provide useful input to planning by

[5] See http://www.borax.com/pioneer/riotinto.html#

local and regional governments and individuals, it does affect the mining company's abilities to maintain a productive workforce to the end of operations.

2.3 Specific Mine Closure Approaches

Application of specific mine closure measures depend on the location of the site and the type of mining and waste disposal method used. The experience base about environmental issues related to closure is better developed than that for socio-economics and that may be reflected in this section.

An important consideration for planning the environmental aspects of mine closure is the design criteria for various extreme conditions. For mines having a relatively short operating life, it is typical to use a 100-year return period for precipitation (ie: the 100 year storm). This implies a relatively low risk of exceedance during a short project life, which may not reflect true conditions or take into consideration climate change. Similarly, appropriate design criteria are selected with respect to seismic loading. Closure design requires that facilities be stable for a very long period and it is therefore necessary to review the design criteria, e.g. for the design of surface water diversion works it may be appropriate to use a 10,000 year (or longer) return period.

This section will provide information on technical aspects of mine closure. Some of these are related to issues that can be implemented at more than one facility at a mine while others are very focused on closure of specific facilities. Water management is one of the integrated issues to be considered for a mine site. Long-term water diversions and other structures may be necessary to manage surface water on the closed mine site. Leachate, acid generation and erosion must be controlled at each facility and the natural ground and surface water quality must be protected. It is crucial to consider overall water quality as part of an integrated water management plan for the site.

In a recent paper, Sassoon (2000) discusses the various environmental aspects of mine closure. Summary tables are presented for the issues, objectives and control of the various aspects as they relate to physical stability, chemical stability and land use. (Note that the October 1994 Ontario Guidelines for the Rehabilitation of Mines presented a similar set of tables, albeit in a different format). These tables are provided in this section as they relate to the various topics. Table B1 provides a summary for water management.

Infrastructure on a mine site, such as buildings, roads, electrical supply, etc. could be left in place if other uses could be found; otherwise these will be removed and the land reshaped and revegetated. There may be fuel or chemical spills on site that must be treated or removed during the mine closure. Table B2 provides a summary of the issues associated with infrastructure.

Table B1. Mine closure and water management

Issues	Objectives	Control
Physical Stability		
• dam walls • structures • pipelines • ditches • settling ponds • culverts • erosion	• long-term stability • safety of structures • flood capacity • prevent blockage • prevent erosion • free passage of water	• breach dam or provide other forms of water runoff control • remove structures • plug intakes and decants • upgrade flood design • remove pipes • fill in ditches • provide for long-term maintenance • monitor
Chemical Stability		
• contamination of surface water • contamination of groundwater	• clean water	• remove or prevent contamination • drain, treat and discharge • install barriers • establish vegetation • monitor
Land Use		
• interruption of water supply • productivity of land drainage	• restore drainage patterns or establish alternative • return to appropriate land use	• stabilise and maintain dam or breach and establish erosion resistant drainage • establish vegetation

An important issue at many mine sites is the management of remaining mine related fluids at the time of closure. These include fluids remaining on tailings impoundments or in heap leach ponds, which can be treated and discharged or evaporated. The latter depends on the climatic conditions of the site. It is advantageous to operate the mine so that there is very little process water left at the time of closure.

Much research has been done in recent years about covers for tailings and other waste disposal facilities. Advances have been made in the design of wet and dry covers, to reduce water infiltration and oxygen ingress, in a variety of climatic regions. Ongoing monitoring of covers is necessary to evaluate their performance.

Closure considerations for underground mine workings, open pit mines, waste rock and spent ore and tailings disposal facilities are presented in Tables B3–B6. Detailed discussions of these will not be presented here and the reader is referred to Sassoon (2000).

Table B2. Closure considerations relating to mine infrastructure

Issues	Objectives	Control
Physical Stability		
• buildings • equipment • roads • airstrips • services	• make area safe • control access	• disassemble and remove all buildings, equipment and other services • excavate buried tanks and backfill • restore drainage • revegetate
Chemical Stability		
• fuel and chemical storage areas • PCB's and insulation • explosives • fuel or oil spills	• make secure and safe • clean water	• remove all unwanted materials • treat contaminated soil or dispose of in an approved site • control and treat drainage
Land Use		
• alternative uses • productivity • visual impact	• return to appropriate land use	• remove foundations and re-contour • restore natural drainage • re-vegetate

Table B3. Closure considerations for underground mine working

Issues	Objectives	Control
Physical Stability	•	
• shafts • adits • declines • subsidence	• prevent access • seal • safety • stabilisation	• backfill • plug openings • vent water and gas • infill underground and surface spaces • re-contour surface
Chemical Stability		
• mineral leaching • acid drainage • contaminants • methane	• clean water • meet water • quality regulations • prevent release	• flood workings • plug openings • remove contaminants • treat water discharge • collect and use gas
Land Use		
• productivity • aesthetics • drainage	• restore to original or accepted alternative use • re-establish drainage patterns	• backfill disrupted areas • contour surfaces • flood workings

Table B4. Open pit mine workings

Issues	Objectives	Control
Physical stability	•	
• steep slopes • unstable faces • erosion • hydrology • safety	• stable surfaces • remove hazards • control erosion • clean water	• re-contour • establish vegetation • fence and erect signs • bunding • install drainage
Chemical stability		
• metal leaching • acid drainage	• clean water • meet water quality regulations	• seal surfaces • flood pit • control hydrology/ hydrogeology • treat discharge
Land use		
• productivity • visual impacts • drainage	• restore to original or accepted alternative use • re-establish drainage patterns	• backfill pit • re-contour slopes • establish vegetation • flood

Table B5. Waste rock and spent ore

Issues	Objectives	Control
Physical Stability		
• steep slopes • unstable faces • erosion • drainage • dust	• stable surfaces • avoid failures, slumps and sediment release	• site selection • internal drains • gentle slopes • contour surfaces • cap • water ditches • settling ponds • establish vegetation • monitor
Chemical Stability		
• metal leaching • acid drainage • mill reagents • contaminants	• clean water • prevent spontaneous combustion	• dump design • isolation of reactive material • cap and re-vegetate • control drainage • collect and treat effluent • prevent spontaneous combustion • monitor

Table B5 – contd.

Land Use • productivity • visual impacts • drainage	• restore to original or accepted alternative use • establish new drainage pattern	• re-contour • establish vegetation

Table B6. Closure considerations for tailings impoundments

Issues	Objectives	Control
Physical Stability • dust • erosion • dam wall • drainage	• stable surfaces • avoid failures and slumps • control sediment	• site selection • dam design • tailings disposal method • cap and re-vegetate • control drainage
Chemical Stability • metal leaching • acid drainage • mill reagents • dam structure	• clean water (surface and groundwater) by: - control reactions - control migration - collect and treat	• use chemically stable material in dam wall construction • pre-treatment of tailings • cover to control reactions • form wetland • divert run-off • collect and treat effluent • monitor
Land Use • productivity • visual impacts	• restore to appropriate land use	• re-contour, cap and establish vegetation • flood and form wetland

The closure of a mine that has used riverine disposal of waste will depend on the characteristics of the material as well as the site. The case histories of historic riverine disposal (see Appendices H, I andJ) indicate how complex these issues can be. Some of the issues include deposition of tailings along the length of the river that can be resuspended and deposited over time, as well as long-term chemical instability (such as acid drainage) that releases metals and salts into the river system.

Closure of marine disposal facilities requires ongoing monitoring for a period decided on a site-specific basis.

The impacts of mine closure on the socio-economic status of the surrounding communities must be considered. Mine closure may remove the major source of economic activity in an area. Table B7 identifies the important considerations for socio-economic mitigation for mine closure. These mitigation measures are stated in terms of the work force and local communities.

Table B7. Socio-economic mitigation

Issues	Objectives	Control
• work force	• re-employment • re-location	• assistance with looking for other work and moving • financial assistance • counselling • retraining
• local communities	• stable economy • good health • education facilities	• regional development plan • develop local self-sustainable enterprises • establish foundation or trust fund for essential services • re-locate in-migrants

2.4 Post Closure Activities

The closure of a mine invariably affects economic activity and community development in the mining area. Measures to deal with job losses and other impacts on economic activities exist and will be highlighted through examples. The sustainability of community activities that are directly or indirectly supported by the mine is also put at risk and measures to maintain them can be incorporated into a mine closure plan. Methods for maintaining post-mine economic activity and community development will be identified in this section.

The mining company may directly sponsor many essential community services such as medical care, schools, etc. during operations. Consultation with the government and community leaders will be necessary to identify how these services can be continued after mine closure (Sassoon, 2000). A number of Foundations have been established in mining communities to provide long-term sustainability for some services, e.g. the Escondida Foundation in Antafogasta, Chile and the Rossing Foundation in Namibia (le Roux, 2000). A similar approach is to establish a community trust fund that is protected against inflation. The income from the fund could allow the communities to take a long-term view of sustainability. Such a fund also allows the communities to build their own capacity to manage the financial resources sustainably.

Through effective stakeholder engagement, it is possible to develop innovative approaches to long-term land use at mine sites. Salisbury (2000) describes the establishment of a regional training centre at the Ridgeway Mine in South Carolina, US.

Ongoing environmental monitoring during the post-closure period is a very important consideration at all mine sites. At some mine sites, there may also be ongoing water management and treatment activities for a number of years following closure. These activities must be maintained for a sufficiently long period of time to make sure that there will not be any further impacts from the mine and its facilities that must be monitored or controlled. It is impossible to estimate up front what the exact period may be. Furthermore, it is important that the mining company develops a plan for ongoing monitoring and reporting to regulatory agencies, as well as other stakeholders. Such a plan must be approved before its implementation and will typically call for ongoing reporting and meetings to review the results. Sufficient funds must be committed for this ongoing monitoring and other site activities. Long-term financial surety may have to remain in place for this activity.

2.5 Unforeseen Circumstances

Unanticipated closures can occur because of changes in economic conditions due to sharp falls in metal prices, poor economic health of the mining company leading to bankruptcy and other reasons. Even if closure plans are in place for the end of operations, most mines are poorly prepared for an orderly closure when operations suddenly cease. Large areas requiring rehabilitation, remaining process solutions and chemicals, the transfer of management of the site to the regulatory agency and sudden unemployment for the work force, with its associated socio-economic impacts, are all realities that must be dealt with.

Unforeseen circumstances can also result in the temporary closure, mothballing or placing a mine on stand-by. Temporary closure raises a number of considerations such as; how long can a mine be idle before it must implement full closure; how should employees and suppliers be treated (financially and otherwise) to ensure their services are available when the mine re-opens; and what level of environmental controls must be maintained to limit long-term impacts as well as short term costs.

Bankruptcies leading to the abandonment of mines by their operators can occur due to economic conditions such as sudden drop in metal prices, insurmountable mining/milling difficulties, and infrastructure problems. These, and other difficulties experienced by mining companies, can result in a lack of operating capital resulting in bankruptcy. The bankruptcy of a mine has many significant problems; from an environmental perspective ongoing water management may be required, especially if it is a heap leach project. From a socio-economic perspective, the bankruptcy affects many people's livelihoods and for them it can be disastrous.

The responsible regulatory agency must be prepared and have the capacity to immediately take over the operations of water management or other systems while they work towards implementing the closure plan. They must also be in a position to obtain the funds secured by the financial surety; this must happen quickly so that funds are available to perform the closure work. This is essential because, in the case of a collapse in price of one particular metal, a number of mines may cease operating at the same time, leaving governments short on income.

There have been a number of mining company bankruptcies in the US, in the States of Nevada, Montana, Idaho and South Dakota, during the last few years. Most of these have been gold heap leach projects that required ongoing water management activities. A number of lessons have been learned from these including;

- In many cases the surety was inadequate to cover the total closure cost;
- Funds were not easily available from the surety to proceed with water management, closure planning and implementation;
- Not all closure plans were up-to-date and it was necessary to develop new closure plans and environmental assessments;
- Regulatory personnel were not experienced and the management and legal systems were not suited for contracting consultants and contractors to design and implement plans;
- Site equipment was sold as part of the bankruptcy proceedings; this meant that new pieces of equipment, such as pumps had to be purchased; and
- In the case of one site in South Dakota, the State Regulatory Agency decided that, because of inadequate surety and capacity, to turn the site over to the USEPA under the Superfund programme.

Temporary closure, mothballing or placing a mine on stand-by is another concern. In this case, operations are suspended temporarily to allow the company to do more work to solve technical problems, wait for the commodity prices to improve or other more favourable conditions for operations (e.g. lower energy prices). At the time of temporary closure it is very difficult to estimate the length of time that it will remain in this state and it is therefore difficult to make contingency plans. The length of time will determine the level of effort in planning and the expenditure in the implementation of engineering measures. Some (or most) of the employees are terminated at the time and it is a difficult decision to identify the 'key employees' that will be required during temporary closure and potentially for future operations.

The regulations with respect to temporary closure should address the time frame that a mine can remain idle before going into full closure. This issue is usually addressed by allowing a series of extensions to the temporary closure. Annual reviews should be made of the mine to review the future plans.

3 Financial Considerations

Providing adequate funds for closure is a vital part of the planning process. Closure cost estimates are used by mining companies to provide funds for closure and by regulatory agencies to establish financial surety which may be in the form of trust funds, bonds, insurance etc. The method for calculating closure costs is an important consideration. Similarly, the way that these costs are used in project evaluations and the provisions that mining companies make for providing such funds at the time of closure need to be addressed. Financial surety can also be used to provide closure funds when the mining company cannot do so because of bankruptcy.

Closure cost estimates must be based on an actual closure design using site-specific requirements; not on per area or mining rate basis. In some jurisdictions, it was common in the past to base the 'reclamation' cost on a unit of disturbed area because rehabilitation or reclamation of this area was considered the main issue. Recent experience clearly indicates that it is the 'closure' cost that is required for financial surety and not the 'reclamation' cost.

The mine closure design must include all elements of the site and not only the reclamation or rehabilitation. In the case of bankruptcy the regulatory agency will be required to close the whole site, including demolition of structures, water management, soil contamination remediation, etc. Acid drainage concerns at a site may require special considerations such as active and or passive treatment.

A complete closure design must be prepared to estimate the closure cost and it must be based on realistic assumptions about closure technologies and implementation, including the time it would take to complete at the mine site. These costs should also be based on the work being carried out by a third party. Mine closure cost estimates are refined during the mine life as the final decisions about closure implementation, detailed land use issues, etc. become clear.

Miller (1998) presents a comprehensive review of financial assurance in various regulatory regimes and the common instruments in use. He defines financial surety instruments as "*guarantees issued by a bonding company, an insurance company, a bank, or another financial institution (the issuer is called the 'surety') which agrees to hold itself liable for the acts or failures of a third party*". It is indicated that: "today, the most common use of environmental surety instruments is to guarantee environmental performance after closure (through the funding of mine site reclamation or rehabilitation)".[6] It is recommended that the reader unfamiliar with financial surety issues and instruments carefully review this document.

Financial assurance or surety is therefore the amount of money available to a government entity for closure of the mine in the case when the mine owner is not available to perform the work, (such as bankruptcy) during operations or any time thereafter. The financial surety can be provided by a variety of financial instruments or cash deposited in a bank. Miller (1998) presents a very thorough review of the different types of financial surety instrument. However, it is important to realise that the governmental policy and local financial markets may determine the type of instrument available for a specific location.

Another important concept is that of financial accruals by mining companies for closure. It is common to base this accrual on a unit production basis (such as $ per ounce of gold produced). The total amount of the accrual is estimated from the environmental closure cost plus other liabilities at a specific mine, e.g. land holdings, personnel cost associated with the end of operations, etc. Financial auditors perform annual reviews to determine the adequacy of these closure funds (van Zyl, 2000).

The following should be noted regarding financial surety and closure cost accruals:

- Conceptually financial surety is in place during the total life of the mine and will only be released (in part or in total) after the regulatory agencies have established that rehabilitation has been completed to their satisfaction. It must be noted that the financial surety may not be a fixed amount throughout the life of the mine, but may vary as environmental issues develop at a mine, as regulatory changes occur and community expectations change. For example, acid drainage may not be considered an issue at the

[6] Note that Miller (1998) defines 'closure' as the end of mining operations and not as broad as it has been defined above for this paper.

time that the mine design is developed and may become a major issue during operations. Obviously the amount of financial surety will increase considerably after evidence of acid generation is found at a site;

- Closure cost accrual takes place over the life of the mine based on a planned mine life, it is not necessarily a linear function as it may vary also over the mine life; and,
- In the US and some other countries, the financial surety is not available to a mining operation for closure work at the end of the mine life. It may be released shortly after the work has been done, but the mining company must be a going concern in order to perform, or contract some entity to perform, the required activities.

A few mining companies have established sinking funds to pay for the closure of a mine. Money from a sinking fund will be available in cash to pay for closure while an accrual is an accounting allowance that is not liquid. It must be noted that such sinking funds may be attractive because they are liquid, however in the case of a bankruptcy it becomes part of the assets of the company and will not be available to pay for closure.

In recent surveys of financial reporting in the mining industry two international accounting firms report on the practices and trends for closure accounting (PricewaterhouseCoopers, 1999; KPMG, 2000). The following summarises the findings:

- Closure costs are divided in two parts: employee costs such as special retrenchment pay and additional costs such as retirement funds or pensions, and environmental costs including rehabilitation and environmental liabilities.
- KPMG found that of 40 companies surveyed, 6 provide for full closure liability while 33 accrues for closure liability over the life of the mine. These provisions are provided on the balance sheet or the notes to the financial statements, or both.
- There are three methods commonly used to account for rehabilitation costs, these are: expense as incurred, incremental method and full liability method. PricewaterhouseCoopers does not recommend the first. The incremental method is used to accrue for the present value of the closure cost using a 'units of production' accounting method. It is mentioned that the full liability method, where total present value of future costs are available when the commitment is incurred, is not in common use.
- There are considerable variations between countries of how the closure liabilities are treated in financial accounting practice. It ranges from not permitting the accrual of closure costs during the working life of a mine (Russia) to a standard that exists and where most mining companies adopt the incremental approach (Canada).

Clark *et al*. (2000) reported that there are a number of countries that require cash deposits instead financial surety for closure. This cash deposit can be paid on a per tonne (or other production unit) basis and could be available for closure. While this may be a useful transition from zero to complete financial surety on projects, such a scheme may not allow sufficient accumulation of funds to pay for a closure in the case of early bankruptcy.

A lesson often learned in mine closure is that it is more cost effective in the long run to implement the 'appropriate' closure plan from the beginning of the planning process.

Closure cost estimates must be accurate to establish adequate financial surety:

- Costs must be estimated to close a mine not only for reclamation and rehabilitation but should be for complete closure;
- Closure cost estimates must be based on a realistic closure plan taking into account the best information about the site and socio-economic climate. For example, if it is expected that there will be acid generation then appropriate closure measures must be designed (such as covers).
- Closure cost estimates may be part of financial reporting requirements of public companies; there may be a tendency to underestimate closure costs.
- Regular updates of the closure plans and cost estimates are required.

Closure plans must be based on appropriate closure technology:

- 'You get what you pay for'. It is very rare that 'cheap' closure plans will result in successful long-term closure. Example: waste rock dump not completely covered by topsoil because not enough was available, now generating acid and new cover must be placed at high cost.
- Closures of bankrupt mines must use good technology instead of fitting the closure plan into the amount of money available. If not done properly then it may be necessary to redo it later using a more expensive approach and thereby costing taxpayers more money.

The financial model used for project evaluation does not allow for full accounting of the cash needs for closure in the future:

- Project evaluations are based on the Net Present Value. Any costs late in the life of a project (typically after 20 years) will not impact the present value and therefore the investment decision. The mining company could therefore commit to very high closure costs without it impacting the investment decision. However, the cash flow required to implement the closure plan may be so high that it could impact the viability of the company at that time.

4 Corporate Policy

Corporate policy will dictate the details and timing of closure planning, including the planning for post-mine activity in the mine community and the ongoing review of these plans. Mine closure guidelines issued by organisations, such as those by ANZMEC (Australia and New Zealand Minerals and Energy Council), are also changing mine closure practices.

- Most international mining companies have closure plans in place for their facilities. As a matter of corporate policy all these plans may conform to a uniform standard, regardless of where the mine is located. This may contribute to higher standards of closure in countries that do not have detailed closure regulations.
- Mining companies will endeavour to reduce their long-term liabilities and close their mines so that there is bond release and no further care and maintenance, this may result in higher capital cost for closure.

- Many mining companies see the benefits of concurrent reclamation; this usually reduces the overall closure liability at any time.
- Many mining companies accrue funds for mine closure that is based on a production rate (such as $ per ounce of gold). These accruals are not liquid and may mean nothing if the company experienced financial difficulties.
- Some companies also establish cash funds for mine closure, however this is rare.
- The cash flow for closing a mine is paid by the company from earnings at other mines because the mine being closed typically does not generate any income. It is therefore very important that a mining company has ongoing projects to fund the costs at closed mines.
- Potential close out costs may cause a buyer to value a take-over target in a different way than shown on the balance sheet.

5 Legislation and Regulatory Authority

The process of closure, the release of company responsibility of a site and the rights of landowners and communities around the mine are all driven by legislative requirements. These issues are addressed differently in various countries.

The temporary closure of mines presents a special issue for regulatory agencies. The length of time before full closure should be implemented, the amount of pressure that can or should be exerted on mine owners to declare bankruptcy and the ability of the authority to deal with abandoned mines need to be addressed. The following points from Clark *et al.* (2000) are particularly relevant:

- Most countries do not have comprehensive legislation for mine closure, this includes surety regulations
- Mine closure legislation and regulations are based on environmental aspects of a site, they rarely include socio-economic aspects. Temporary closure issues are not well addressed.
- Regulatory capacity specifically with respect to closure is not well developed in most agencies.

6 Public Opinion and Expectations

Public opinion can influence the closure objectives for specific mine sites. For example, total restoration may be perceived as an appropriate objective without taking into account the feasibility of such a goal or other potentially beneficial end uses. The role of public opinion should be paramount in the design of mine closure plans. In mine dependent communities mine closure planning should be everyone's business.

The typical boom-bust cycle of mining has influenced public opinion and perceptions about mining. The environmental record of companies, their openness during communications and how they treat their employees when it gets near closure can further influence public perceptions and opinions. A more comprehensive approach to developing a closure plan for a mine that includes extensive stakeholder involvement will result in closure plans with broader acceptance. Public perceptions with respect to the closure of a specific mine will be influenced by the openness of the company in making early announcements about the upcoming closure and how the company proposes to proceed with the closure, especially its policy towards impacts to the local communities.

Very few local communities are closely involved with the closure planning for a specific site and will therefore be influenced easily by incorrect information, which could become a real issue for accepting the implementation of the closure plan. During the last 5 years or so this trend is being reversed in some parts of the world and experiences gained from such efforts must be widely disseminated.

7 Conclusions and Recommendations

See the Main Report of *Mining for the Future* for general discussion and recommendations.

References

See separate References for the Main Report and Appendices.