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Benefits of Planned Versus Unplanned Mine Closure and Strategies for Both

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1 INTRODUCTION

The mining industry is an important contributor to local and national economies world wide and it will continue to underpin the economies of many countries in the future.

Australia is one of the world's leading exploration and mining nations. The resources sector makes a significant economic and social contribution to the Australian economy and is the nation's largest single exporter. Australia is the world's largest exporter of coal, iron ore, lead, diamonds and zinc, and the second largest exporter of gold and uranium (DITR, 2006).

A sustainable mining industry is vital for Australia's development. The future of the mining industry is likely to become more and more dependant on its reputation and its ability to maintain a social licence to operate. Unfortunately the reputation of the mining industry has been effected by poor examples of mine closure resulting in long-term environmental impacts and legacy sites.

Current standards for mine rehabilitation and closure are much more stringent than they were even a few years ago and this reflects changing public priorities and the concept of sustainable development. Increasing public expectations for environmental protection and the increasing value of the natural environment as recreational space will continue to drive regulatory requirements and mining practice in the future.

Mine closure planning has been and in many cases still is, left until near the end-of-mine life, often leaving little time, financial provision and/or resources for effective closure planning and decommissioning. This scenario is termed herewith as 'unplanned mine closure'. Current estimates in the Australian mining industry are that the cost of prevention, through careful planning, can be one-fifth the cost of remediation at closure (Dowd, 2005). Clearly, there are significant economic considerations at stake when planning for mine closure.

Developing a mine closure plan at or very near the end of mine life, can present a major hurdle to a mining company. Mine closure occurs at a time when the economic recovery of minerals has ceased, cash-flows are minimal or non-existent and material resources are often no longer accessible. This is obviously not the optimal stage to be planning and undertaking the bulk of rehabilitation and closure activities.

In comparison, the benefits of progressive rehabilitation and closure (planned mine closure) are well documented but seldom are the principles adopted as a life-of-mine process. Recently, increased regulatory requirements and public interest has encouraged mining companies to consider mine closure issues during the project feasibility stage and to make on-going commitments to progressive rehabilitation and closure as part of the approvals process (DoIR, 2006).

2 UNPLANNED MINE CLOSURE

Mine closure planning may be addressed in general terms during operation but too often mines fail to have undertaken adequate planning prior to site closure. In the event of 'unplanned mine closure' an accelerated closure planning process needs to be implemented. The authors have been involved in accelerated mine closure planning at a number of mine sites throughout Australia and have developed a staged approach to accelerated mine closure planning, based on the principals of the 'Strategic Framework for Mine Closure' (ANZMEC, 2000).

2.1 Why Mines Close

In some cases mines close at a planned point in time when the mineral reserves have been extracted. However, due to the variability in commodity price and a host of other factors, mines often close before the ore reserves have been extracted. Approximately 70 percent of the mine site closures in the past 25 years have been unexpected (Laurence, 2005), resulting from factors including:

- Low commodity prices.
- High operating costs.
- Reduced reserve estimates.
- Adverse geotechnical conditions.
- Equipment failure.
- Safety or environmental breaches.
- Government policy changes.
- Community pressure.
- Flooding.

2.2 Limitations of Unplanned Mine Closure

The limitations of not planning for mine closure, especially in the case of unexpected closure, are varied and in many cases can be severe. The financial burden of unplanned mine closure is well documented and current estimates in the Australian mining industry are that the cost of a planned closure can be one-fifth the cost of an unplanned closure (Dowd, 2005).

Newmont is the world's largest gold producer with annual production of around 7 million ounces. Newmont's current estimated global closure liability is in the order of several hundred million dollars. Just a 10 percent reduction in liability is worth tens of millions of dollars in direct benefit to Newmont's net asset value (Dowd, 2005). Failure to make cover materials available operation at Newmont's Woodcutters project, lead to closure costs of $40 million compared to an estimated $10 million if progressive reclamation had been integrated into mine planning.

Irreversible damage to a company's reputation can result from poor planning and environmental performance in the event of mine closure. Many such examples, well documented in the media, have resulted in damage to a company's relationship with the community and government. This can severely restrict a company in their commercial interests, mostly in terms of community and political resistance to:

- Land access.
- New development projects.
- Expansions of existing projects.
- Take-over bids for other companies.
- Purchases of existing projects.

The results of poor closure planning impact the mining industry as a whole and may include:

- On going damage to the reputation of the mining industry from substandard mine closure legacies.
- Increases in levels of environmental performance bonding on industry disturbance and over unsuccessfully rehabilitated mining areas.
- Reactive and unreasonable industry wide regulations.
- The application and use of more stringent legal instruments.
- Political reaction in response to community outrage, resulting in bad publicity.

By way of example, a recently applied regulation to a Western Australian mining operation reads:

> *"The lessee submitting to the Environmental Inspector a Mine Closure and Rehabilitation Plan of an acceptable standard detailing all aspects of closure and progressive rehabilitation with timeframes for his/her assessment and written approval. A progress report detailing area rehabilitated, changes to closure plan and research and development undertaken to reduce closure/rehabilitation issues to be included in the Annual Environmental Report. Any significant change in closure objective/criteria or rehabilitation strategies should be forward to the department for review and approval as an amendment to the site Mine Closure and Rehabilitation Plan prior to implementing the changes"* (DoIR, 2005).

More specifically, some of the limitations in trying to close a mine site in an unplanned manner may include:

- Substandard and expensive rehabilitation, as works are remedial rather than integrated with mine planning.
- Limited access to rehabilitation materials including, for example, topsoil, subsoil, armouring material, and appropriate types of waste rock. This material may not have been identified as a useful resource during mine planning and operation and therefore was not stockpiled for future access.
- Capital for closure planning and rehabilitation works is required when the mine is generating little or no cash-flow.
- The bulk or all of the mining fleet and/or earthmoving fleet has often left site and remobilisation is required to undertake or complete closure works.
- There is little or no opportunity to establish trials to test rehabilitation options and therefore demonstrate preferred rehabilitation designs to regulators and stakeholders.
- Much of the corporate memory that is essential to effective planning has often left site.
- Much of the documentation and records relevant to closure planning is difficult to access and can even be missing.
- Extended monitoring and maintenance period prior to relinquishment due to "late start" for areas that could have been rehabilitated earlier in the mine life.

2.3 Unplanned Closure Strategy

The Authors have developed a staged approach to accelerated mine closure planning in the event of unplanned mine closure. The staged approach is modelled on the principals of the 'Strategic Framework for Mine Closure' (ANZMEC, 2000) and has been refined over time with experience.

Our approach to unplanned mine closure consists of five stages (Figure 1):

Stage 1 - Initial review of current site status, gap analysis and planning.

Stage 2 - Investigations to address information gaps.

Stage 3 - Preparation and approval of a draft mine closure plan.

Stage 4 - Decommissioning and closure works.

Stage 5 - Post closure monitoring, reporting and bond review.

A summary of each stage is provided herewith.

2.3.1 Stage 1 - Initial planning and review

The initial stage of planning and review involves a site visit, extensive document research and analysis of information gaps, stakeholder engagement, a review of current site status, confirmation of appropriate post-mining land uses and the development of site specific closure objectives and standards.

A legal compliance register containing all legally binding conditions and commitments relating to rehabilitation and closure at the site is developed.

Identification of and consultation with stakeholders is undertaken. All stakeholders are identified and a review of all relevant stakeholder consultation to date is undertaken. Contact is made with stakeholders to canvass their interest and/or potential concerns relating to mine closure, with particular regard to post-mining land use options.

All documents and information relevant to rehabilitation and closure are identified and reviewed. The information gaps limiting the development of an acceptable closure plan are identified and documented. Information gaps are identified from an extensive review of all the relevant site information and documentation collected. Gaps are grouped into aspects to facilitate the closure planning process:

- Engineering, geotechnical and survey.
- Chemical, geochemical and physical characterisation.
- Soils and rehabilitation.
- Groundwater hydrology.
- Surface water hydrology.
- Contaminated sites.

The site is divided into manageable 'project areas' to facilitate closure planning. All available information relating to current status, pre-mining land use and construction, operation and rehabilitation history, is collated and documented individually for each project area. Furthermore all relevant information and information gaps are considered and managed individually for each project area.

Closure standards and objectives are developed from the legal compliance register, company policies, industry standards, post-mining land use options and stakeholder expectations. Closure standards and objectives provide a framework in which to undertake closure planning and to develop more specific completion criteria.

A risk assessment of the site is undertaken to define priorities for closure planning. The risk assessment provides a basis for which to calculate residual risk when closure options are being defined and preferred options are being selected.

The initial planning and review stage sets the basis for additional research and investigations, where required, to address gaps and ultimately facilitate the development of an acceptable closure plan.

2.3.2 Stage 2 - Addressing information gaps

A number of information gaps may have been identified during the planning and review stage. Depending on the consequence of the information gaps, additional research, investigations and/or trials may be required to develop an acceptable closure plan. Specialist consultants may be required to help address information gaps under a number of aspects.

Engineering, geotechnical and survey information may be lacking. Predictive modelling of the long-term stability of a landform may be required to define design options based on the properties of available rehabilitation materials. Limited or unsuitable survey data, including material volumes, areas and slope angles, may be available and additional airborne or ground surveys may be required.

It may be necessary to undertake chemical, geochemical and physical characterisation of tailings, waste rock and/or available rehabilitation material if this information is required for rehabilitation planning.

Limited information may exist regarding the viability of existing topsoil stockpiles. The effectiveness of rehabilitation options, including cover profile design, ripping techniques and seed mixes, may need to be assessed.

Groundwater hydrology may be little understood and may require further investigation. The relationship between the groundwater aquifer(s) and each project area needs to be considered.

Surface water hydrology may need further investigation. The long-term interactions between surface water and each project area should be addressed.

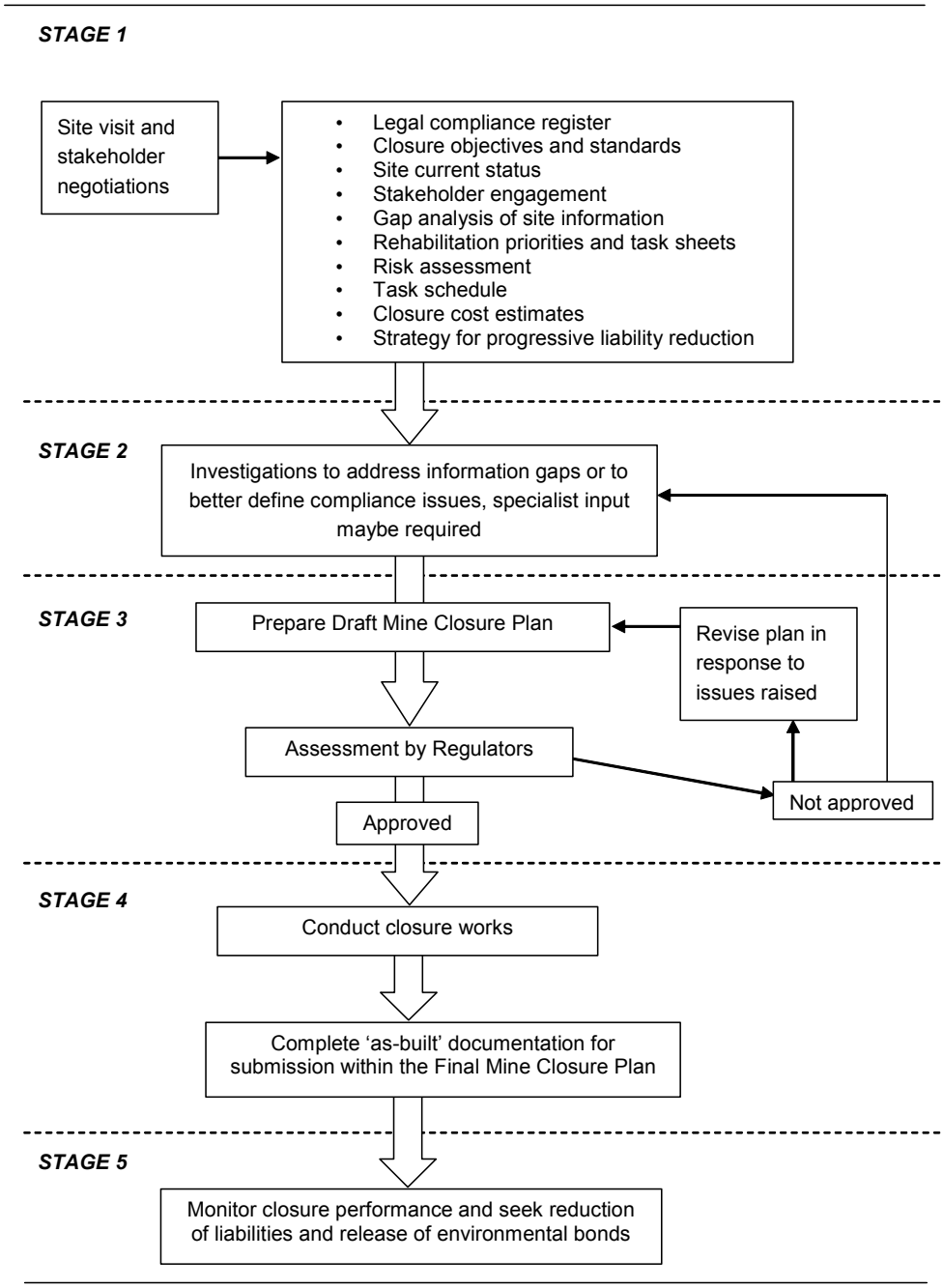

Figure 1 Staged approach to managing unplanned mine closure (adapted from Lacy and Campbell, 2000)

Potentially contaminated sites should be investigated and documented.

Consultants will be required to work closely together to transfer information from one investigation into another where necessary.

2.3.3 Stage 3 - Closure plan preparation and approval

The mine closure plan will likely consist of a number of volumes that document all relevant information and data collected in the previous stages. The closure plan should distil and integrate the technical information across each of the information aspects, and should establish realistic closure options for each project area.

Each closure option should be supported by all available and relevant technical information, using the findings of rehabilitation trials and investigations where possible. A risk assessment of each closure option should be undertaken and residual risks should be calculated.

The preferred closure option for each project area should be selected on the basis of risk. Ultimately the preferred option will help best achieve the closure objectives and standards, will be accepted by stakeholders, will result in environmentally acceptable outcomes and will be realistic in terms of costs. Site-specific and practicable completion criteria will also need to be developed, to be used as a measure of closure success.

The closure plan should be presented to the regulators and stakeholders for negotiation and ultimate endorsement.

2.3.4 Stage 4 - Closure and decommissioning works

Once approved, the preferred closure options can be designed and costed. This will be straight forward for less complex project areas including access roads, hardstand areas and offices, but will be more involved for complex areas such as the plant and tailings storage facilities. Closure works will proceed and the closure plan is updated as designs become 'as built' plans that will be submitted to the regulators within the final closure plan.

2.3.5 Stage 5 - Post closure monitoring

Post closure monitoring is undertaken to measure the performance of closure rehabilitation against established closure standards and objectives. The performance of closure rehabilitation is measured against a number of environmental indicators. Rehabilitation is generally considered successful when the environmental indicators consistently return values analogous to the surrounding natural landscape, or otherwise to an agreed set of criteria determined and developed through stakeholder consultation.

Post closure monitoring should be linked intimately with a strategy for progressive liability reduction and review of environmental performance bonds.

3 PLANNED MINE CLOSURE - PROGRESSIVE REHABILITATION AND CLOSURE SYSTEMS

Planning for rehabilitation and closure early in the mine life, ideally from feasibility, through development and operation, has a number of benefits to a mining company. Planned closure is a life-of-mine process rather than a 'static' process. Planned closure takes commitment, resources and some time to establish, however gives increased financial return through mechanisms of effective planning and enhanced efficiency.

The Strategic Framework for Mine Closure (ANZMEC, 2000) suggests that closure planning should include a commitment to progressive rehabilitation, the development of a more detailed closure plan and implementation of the plan over the life of the mine. It goes on to outline progressive rehabilitation as a "key component of the closure plan" in conjunction with active trials and research programs.

This process was advanced to a strategic level in Section 6.1 of the Best Practice Manual for Mine Decommissioning where it was proposed that mining operations could consider approaches to "mine decommissioning and closure on a systematic basis from the very beginning of the operation" (EIA, 2002).

3.1 The Benefits of Planned Mine Closure

In brief, the benefits of planned mine closure include:

- Identification of high risk priorities for research or rehabilitation.
- Reduction of ongoing environmental liabilities by progressive rehabilitation.
- Distribution of rehabilitation and closure costs during the productive phase of mining rather than deferral to the end of the project.
- Increased efficiency through reduction of double handling of waste rock and rehabilitation materials.

- Ongoing feedback, through monitoring, of the effectiveness of rehabilitation designs.
- Anticipated closure outcomes are more reliable as they are the product of considered decisions, scientific trials and investigation.
- Facilitation of timely bond recovery and tenement relinquishment.
- Early estimation of rehabilitation and closure costs so that sufficient financial and material resources can be set-aside.
- Improved access to capital from lending institutions.
- Lower risk of regulatory non-compliances and less regulatory interest.
- Improved access to land resources from governments.
- Greater acceptance by key stakeholders.
- Reduced, post-closure monitoring and maintenance period for areas rehabilitated earlier during the life of mine.

3.2 Regulatory Framework

Although the industry benefits of planned closure are well documented most closure planning remains regulator driven. The recent 'Guidelines for Mining Proposals in Western Australia' (DoIR, 2006), encourage companies to consider closure issues and develop a conceptual closure plan as part of the approvals process. Companies are also being encouraged to make commitments to progressive rehabilitation and closure in their approvals documents, especially in the case of Part IV approvals and formal EPA assessment.

The Western Australian Department of Industry and Resources (DoIR) has recognised the importance of environmental performance bonds in encouraging companies to progressively rehabilitate and close their mine sites. Bond reductions have been successfully negotiated in cases where DoIR agree that the risks associated with a landform for example, have been reduced significantly and that the State Government is covered, more than adequately, with the current bonds.

Conversely, environmental performance bonds have been increased in cases where the State Government is exposed to unacceptable risks, where the current bonds do not adequately cover the risk to the State. In most cases the company has been given the opportunity to develop an adequate plan for and a commitment to rehabilitating the area, to avoid the proposed bond increase.

3.3 Planned Closure Strategy

The Authors have developed site specific strategies for progressive rehabilitation and closure, and have been involved in progressive rehabilitation and closure at a number of mining projects at various stages of development. This approach is modelled on the principals of the 'Strategic Framework for Mine Closure' (ANZMEC, 2000) and has been developed over time with experience.

Progressive rehabilitation and closure shifts away from the conventional 'static' closure plan mentality, towards a systems approach that makes provision for rehabilitation and closure as a life-of-mine process. The 'progressive rehabilitation and closure system' (PRCS) essentially 'brings to life' the conventional static closure plan.

There are two stages to establishing a PRCS: 1) development and 2) implementation.

3.3.1 Development

The first step when establishing a PRCS on an already operating site, is to undertake the 'Initial Planning and Review' (Stage 1) as described for unplanned mine closure (see Section 2.3.1). The initial stage of planning and review involves a site visit, extensive document research and analysis of information gaps, some stakeholder engagement, a review of current site status, confirmation of post-mining land use options and the development of site specific closure objectives and standards.

The focus of the development stage is to divide the site into 'project areas' and establish rehabilitation priorities, from basic tasks to complex research, for each area. Rehabilitation priorities are established from a detailed review of all relevant site information and subsequent risk assessment, just as 'stage 2' investigations were defined as part of the staged approach to unplanned mine closure (Section 2.3.1).

The main advantage of planned closure is that the rehabilitation priorities for each project area can be planned and scheduled over the life of the project, rather than as a rapid assessment in a short time frame. Rehabilitation priorities and estimated closure costs will change over time to reflect the ever changing mine plan and the current economy.

3.3.2 Implementation

Once developed, the PRCS can be implemented. The environmental department should be responsible for administering the PRCS, in close consultation with the management team and all other service and planning departments.

Many of the rehabilitation priorities for each project area can be managed by the environmental department. Priorities such as establishing rehabilitation trials or undertaking physical characterisation of available rehabilitation material, should be managed by the environmental department, with assistance from specialist consultants or internal departments where required. When necessary, rehabilitation priorities will have to be outsourced to other departments and the environmental team may play a supervisory role (provided they have adequate experience). Priorities such as earthworks, relocating rehabilitation material or reshaping existing landforms will be delegated to mining, mine planning and survey for example.

The ultimate aim of the rehabilitation priorities for each project area is closure and decommissioning of that area. Rehabilitation designs for less complex project areas, including ripping and seeding hardstand areas for example, should be documented in task sheets. Final rehabilitation designs for more complex areas, such as the plant or tailings storage facility, should be documented within a decommissioning plan.

Environmental monitoring of progressively rehabilitated areas should be undertaken to measure their performance against closure standards and objectives. Remedial works on less successful rehabilitation should be rescheduled back into the rehabilitation priorities for the relevant project area.

The primary driver for the PRCS is the regular process of review. The review process should involve a review and update of the following elements:

- Rehabilitation priorities should be updated to reflect changes in current site status, to reflect the investigations and/or progressive rehabilitation undertaken, and the monitoring data obtained from trials and/or rehabilitated areas.
- Review completion criteria to ensure that these are practical and consistent with the overall closure objectives and standards.
- Closure costs should be updated to reflect changes in the mining plan and economic changes.

Periodical reviews can be undertaken at less frequent intervals early in the operation's history (biennially) and more frequently closer to the end of mine life (annually or more often if required).

An important tool in the PRCS is the site Annual Environmental Report (AER). The AER should be used as a transparent reporting document to maintain an open relationship with regulators. The AER should be used to:

- Report on progressive rehabilitation achievements.
- Establish rehabilitation objectives for the coming reporting period.

3.4 Limitations of Planned Mine Closure

With transient staff in an ever changing mining industry and the day-to-day pressures of an operating mine, there is often frequent loss of corporate memory relating to approvals commitments and also limited time

and resources to track closure commitments and drive progressive rehabilitation and closure planning. With increasing pressure on regulators in a highly active mining industry, there is often limited opportunity for the regulators to track a company's progress against approvals commitments that are often buried in archived documents.

A common problem of the progressive closure and rehabilitation concept is that it can suffer from a lack of support on site and is seldom integrated into the day-to-day business of a mine. However, if such a system is to succeed a conscious decision by upper management has to be made to integrate and resource the process into all aspects of the mining plan.

The company's environmental department should ultimately be responsible for administering the PRCS, reporting on an annual basis to mine management and on to the executive committee. The rehabilitation priorities established for each project area should be built into the business plan of the environmental department. Ultimately many of the tasks to be managed by the environmental department will be outsourced to the technical service and planning departments on site, such as survey, mining, geology, maintenance and metallurgy. These tasks should be written into the key performance indicators (KPI's) for each of these departments, to ensure that the work is completed and that rehabilitation and closure is integrated into every day business activities.

Systemised and planned progressive rehabilitation and closure, throughout the life of a project, is insurance against the many consequences of unplanned closure. Companies who embrace and implement this concept will deliver considerable yields not only to their shareholders, but to the mining industry and to society as a whole.

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