Updating the Leading Practice Sustainable Development (LPSD) Mine Closure Guide Australia 2015.

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Abstract

Throughout 2014/5 the authors have, with contributions from 13 other highly competent and expert sub authors, completed a major revision of the 2006 Mine Closure and Completion handbook for the Australian Government. The original document went through a thorough gap analysis, with the intention being to close these gaps and to bring advancing paradigms and ideas from a rapidly evolving industry into the guideline – so that the guide truly represents current leading practice.

This handbook has introduced and enhanced a number of aspects which are intrinsically linked to closure, including: legal and regulatory requirements, cumulative impacts, impacts on local and regional biodiversity, climate change, post-mine land use opportunities, physical, chemical and geochemical characterisation of soils and mine wastes and engineered landform design. Interaction and consultation with the community is considered integral throughout the guide reflecting for instance the requirements of the W. A. Guidelines. The handbook now includes 'Post-closure Management' a newly recognised phase, as a site moves toward post-mining land use and relinquishment.

In addition to these improvements this Handbook introduces the mineral "Resource Legacy" framework, for general discussion around the issue of legacy associated with the mineral industry, and the cyclical nature of mining and subsequent responsibilities in managing that legacy. The interrelationships in the discovery and utilisation of minerals, involves mining companies, communities and government and has global effects represented simply in the framework.

Planned mine closure and relinquishment is still at the early stage of implementation in Australia. There are limited examples of mine closure planning that have been applied from conception through to relinquishment in Australia's mining history. However, within the handbook the mining industry showcases some of the work undertaken by the mining industry and minerals sector in applying the principles of leading practice mine closure, and the authors will touch on those particularly relevant to legacy and community as case studies.

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Introduction

History of closure guidelines in Australia

With the guidance of a steering committee of mining professionals, Australia's federal government produced its first mine decommissioning guideline in 2002 (Lacy and Koontz, 2002) as part of the best practice environmental management in mining series. In preparing the original guideline, the authors were strongly influenced by the release of the Strategic Framework for Mine Closure (ANZMEC/MCA, 2000), a robust and simple framework established for the mining industry's consideration in the closure aspect of its business, and prepared by a working committee of the Australian and New Zealand Minerals and Energy Council and the Minerals Council.

During 2006, an updated version of the original 2002 decommissioning guideline, the Mine Closure and Completion Handbook, was written by a committee of 14, led by a chairperson, and prepared as part of the publication of 14 themes developed by working groups of government, industry, research, academic and the community. In the foreword, federal Minister Ian Macfarlane provided a foreword summarising the purpose of the guidelines: "To assist all sectors of the mining industry to reduce the negative impacts of minerals production on the community, and the environment, by following the principles of leading practice sustainable development" (Australian Government, 2006).

This current 2015 version, the Mine Closure Handbook (the handbook), is a general return to the original lead author model of 2002, but differs in that it involves 13 subject experts and guidance from a qualified steering committee. As the lead authors, we conducted a gap analysis, and were involved in coordination, completing sections and editing to advance a considerable expansion in the document. The handbook also needed to complement the other leading practice guides while retaining its quality as a standalone handbook. The document has been enhanced with an update and increase in the number of case studies from six to 10.

Gap analysis.

The first action to improve the handbook and ensure the updated book reflected the rapidly improving and advancing mine closure management process in Australia was to complete a gap analysis.
The key areas identified in the initial gap analysis as requiring enhancement included, but were not limited to:

- the information and flowcharts representing closure as being an integral part of the life of the mine;
- collection of environmental baseline data and material characterisation and incorporation of the material characterisation and environmental baseline data into the landform design;
- consideration of local and regional biodiversity;
- development of closure objectives and completion criteria;
- the community and mine closure;
- identification, mitigation and management of risks associated with closure;

- financial provision and aspects of closure and risk management;
- the stakeholder and legal components;
- mine completion and relinquishment;
- the conclusion;
- the case studies; and

the guidance on closure issues, closure options and techniques in Appendix B (which has been a feature since the original handbook), including a reference to closure within the enduring value framework (MCA, 2010).

Upgraded aspects — a discussion;

We concluded that to enhance the handbook, we needed to reinforce that a closure plan for an operation must consider up-to-date industry practice, opportunities for developing technologies and the best available and proven technologies on the market for sustainable and safe closure.

We wished to include more from the work of the International Council of Minerals and Metals, particularly the key principals and elements to expand the primary audience for the handbook (ICMM, 2011).

In addition, we wished to reinforce that it is important for closure plans to be regularly reviewed and updated, that is, that closure plans developed during the definition phase of a project must be updated after construction to reflect the as-built status and changes. We also identified that a number of the items are important enough to be framed within independent sections under broader subject sections; these included:

- Baseline data and biodiversity: More information on the type of baseline data that can be collected and how these can be incorporated into the landform design at an earlier stage, an aspect related to local and regional biodiversity.
- Characterisation and selective placement of materials, and mine waste management: Place greater value on the importance of the characterisation and placement of waste materials and discuss best practice, that is, incorporation of waste units in block models, scheduling and specific handling when problematic waste will be mined. We wished to convey the importance of designing a landform based on the parameters of the material, and constructing it in accordance with the design from the onset of mining.
- Financial assurance and provisioning: The requirement to accurately identify the scope of current liabilities and the cost of engineered solutions to close the operation to standards agreed upon with stakeholders, and within all applicable regulations, was broadly discussed in the past but could do with improvement and expansion.
- Mature operations stage: The information incorporated under the mature operations stage in the 2006 handbook was to be considered at a much earlier stage of planning in the revised handbook, as this was leaving a critical planning component too late in the mine cycle.

Other gaps identified brought a greater focus to ongoing stakeholder consultation, agreement on closure objectives, completion criteria, improving monitoring standards and performance by revising with up-to-date methodologies.

Risk management is a key process today and was considered a gap in the 2006 handbook. In today's mining business, we believe it is essential to identify, mitigate and manage both current and future risks associated with closure.

The lack of a legal section was a gap that had to be addressed along with a review and update of the mine completion and relinquishment section within the 2006 handbook to capture additional information on monitoring, maintenance and relinquishment.

Systems thinking and the phased life of mine cycle

The first mine decommissioning manual stated that "mining operations needed to approach mine decommissioning and closure on a *systematic basis* from the very beginning of the operation" and added that "mine closure planning must be a dynamic process including regular review and updating" (Lacy and Koontz, 2002). We believe nothing has changed; this concept is as relevant as it was 15 years ago, and effective implementation of a mine closure system requires:

- support from the company board or mine owners;
- commitment from the operation management, particularly the senior manager;
- an accepted closure systems framework;
- involvement of stakeholders;
- adequate resources (financial and human) to implement;
- managers and champions in charge of the system at the site level;
- regular system audit and actioning of outstanding items;
- regular reporting to the board from mine managers;
- ongoing commitment to funding for closure options research;
- acceptance by the regulators;
- monitoring to ensure long term viability (Lacy and Koontz, 2002).

These concepts have been reinforced in the 2015 handbook, and, rather than just discuss the creation through many staged closure plans, we believe the handbook encourages companies and mine operators to make closure a life of mine (LoM) process through the seven cycles contained within an integrated business planning framework, as illustrated in Figure 1.

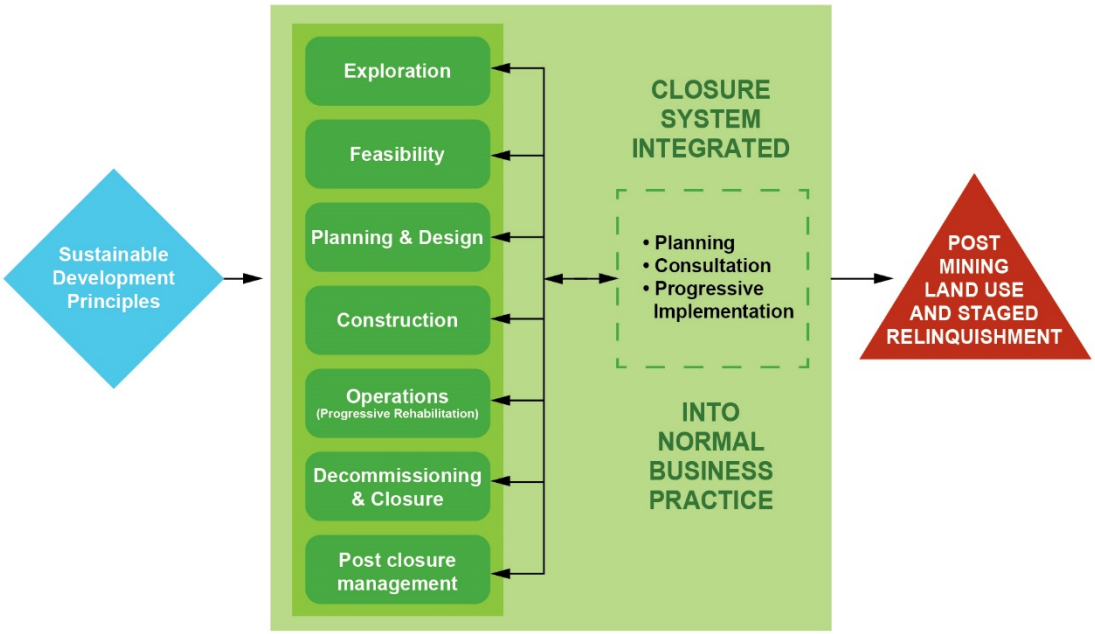

Figure 1. Phases of a Mining Project Integrated into a Closure System (Aust. Government, 2015)

The 2015 handbook encourages planning for mine closure to be undertaken progressively throughout the LoM. In order for mine closure planning to be successful, the management team needs to ensure closure planning is systemised early in the mine life and integrated deeply into the normal mine business planning and practice of the company, adopting an ethos of closure planning as part of normal business.

This approach ensures the practice flows into planning, consultation and implementation rather than being attended to at the exhaustion of known ore resources. The initial groundwork, even at the exploration phase, can impact the effectiveness and success of closure planning. The company can ensure optimal results if staff actively engage in all the steps of closure implementation, and should ensure that stakeholder engagement occurs strategically throughout the process of planning for mine closure and into the post-mining land use relinquishment phase (Australian Government, 2015).

In conducting the upgrade and review of the important LoM cycle section, we specifically worked to improve planning and design, which has doubled in content, followed by operations, which is slightly expanded, and decommissioning and closure, which has also doubled. This is followed by a new section on post-closure management and a section on closure planning that reflects a major change in addressing this gap. This was such an extensive rewrite of the guideline that it is impossible to fully represent in this paper, and so we only touch upon key aspects that we believe will be of most interest to the reader.

Improvements to aspects of the mine life cycle, post-closure management and closure planning sections.

Plan and design

In many Australian states or territories, the regulatory authorities require a closure plan as part of the approval process. This plan is used to assess the project, the environmental controls required and the long-term potential liability posed by development of the mine. The revised 2015 handbook extended this section markedly to stress that during planning, particularly for effective landform construction, some critical information is required in relation to mined waste:

- the estimated volumes of waste material to form the landforms;
- the physical, chemical and geochemical characteristics of the soil and waste materials;
- preferred material positioning in the landforms to accommodate material characteristics and volumes available of, for example, those materials that may be suited to placement near the surface, and those that may be best contained deep within the body of the landform;
- the sequence and timing of different materials being made available via the mining schedule.

The nature of the site and the degree to which there is choice for the location of the waste landforms makes every landform unique. If possible, it is important to consider the footprint location ahead of infrastructure placement, as the location of the landform can have multi-million dollar closure implications. Critical factors in location include:

- proximity to the open pit exit or exits;
- gradient of the footprint area, for both direction of drainage from the landform and the implications for dumping costs;
- placement in relation to natural drainage, where possible avoiding blocking natural surface flow or accommodating drainage beneath the landform;
- footprint constraints (tenement leases; future ore bodies; priority flora, fauna and ecological communities; cultural heritage sites and infrastructure [current and future]);
- topography, consideration of visual impact and opportunity to complement the local landscape; and stability of underlying material.

Construction

Mine and infrastructure construction has a major impact on a local region, and consultation has to be stepped up so that local landowners and the local community are not unnecessarily inconvenienced, as this is often when the foundations for long-term relationships are built. Sustainability requires that the complex relationships between various risks be well understood, especially the potential for links between environmental, social, political, economic and reputation risks, which can be seriously tested during mine and infrastructure construction.

Operations

There are some critical phases in a mine life during which systemised closure activities may be overlooked, particularly the mature operations stage and pre-closure stage. The 2015 handbook stresses that it is important during the mature stage for experienced personnel to be involved in overseeing the construction and placement of deleterious material in landforms. Failure to maintain quality control in this phase of the mine operation can jeopardise environmental protection during operations with considerable consequence post-closure. Consistency of workflow process, audit and well-resourced control are vital.

A mine's pre-closure stage — when known ore resources are exhausted — is often an unpredictable period, dependent on final ore reserves, discovery and unforseen events that can drive closure. It is often far too late to develop a detailed decommissioning and closure plan at this stage, yet in many Australian jurisdictions, it is only a requirement to take this step two years out from pre-closure. Research has shown that, historically, 70% of mine closures in Australia are unforseen, (Laurence, 2005) and so this is perhaps a risky position for regulators to maintain.

Decommissioning

This section was expanded considerably as we identified many aspects requiring attention for decommissioning prior to the post-closure phase that have to be addressed in order for a company to relinquish a mine site with all obligations for future maintenance and funding discharged. Particular attention has to be paid to the early establishment of verifiable completion criteria. Acceptance and approval by the regulator with an agreed-upon verifiable process to monitor and demonstrate completion criteria and gain relinquishment are very important. It can take considerable persistence by a company to achieve relinquishment, particularly if early rehabilitation is inadequate for the task. Activities that can run for some years at the decommissioning phase are numerous and are expanded in the text (Australian Government, 2015).

A new section: Post-closure management

The 2006 handbook only briefly discussed completion, relinquishment and post-closure monitoring. We believe that since that time, a maturing management cohort in industry, government and within the wider stakeholder community has led to greater awareness of the need for post-closure management. The 2015 handbook includes a sustained and detailed process that addresses this matter.

The mining industry is embracing the concept that completion and relinquishment incorporate delivery of a defined post-mining land use rather than just closure when the operational stage of a mine ceases and decommissioning is complete. Thus, post-closure management (Chapters 3.7 and 8) (Australian Government, 2015) was added to the handbook to accommodate guidance for companies to manage post-decommissioning conditions en-route to and at relinquishment.

Even after the bulk of the mine infrastructure has been demolished and removed and the site has been fully rehabilitated, there is a requirement for ongoing management and monitoring of the site. This phase continues until final sign-off and relinquishment are achieved and the new land users take ownership and responsibility. Common closure issues, like acid mineral drainage (AMD), for instance, can have a long lag time before they become evident. It is often necessary to monitor the success of revegetation, the effectiveness of cover systems and any impacts on water resources, for many years until evidence of stability is on hand and relinquishment can be obtained from the regulator. While leading practice involves early definition of, and agreement on, completion criteria and progressive sign-off, some criteria may need to be monitored for an extended period (possibly 10 to 20 years).

This phase of the closure process can require considerable resourcing, as there are many tasks, logistics, personnel, safety issues and responses to change to consider. Retaining company staff or caretakers to attend to post-closure management may require the retention of offices, amenities and equipment, but can be more cost effective than looking to others external to the site, who may lack site knowledge and have large mobilisation costs. There is more awareness in the Australian industry that some closed sites may have to retain a medium- to long-term presence on site to meet the requirements, particularly those related to long-term water treatment.

Closure planning and financial assurance

While the 2006 handbook briefly discussed some of the complexities in closure planning and the financial aspects of mine closure, merit was seen in expanding these elements within the handbook (Australian Government, 2015). Having the right information to make the best technical and social decisions in closure planning requires the collection, assessment and management of environmental, social and economic data, which have to be adequately managed to be easily retrievable and accessible.

Mining engineers, geologists, planners and, in some instances, consultants generally have the most influence in mine planning and design. They need to take into account the mine closure issues and integrate economic, environmental and social elements into the decision-making process. In order for mine closure planning to be successful, the management team needs to ensure it is integrated into planning early rather than being attended to at the end of the mine life, particularly in the construction and closure of mine waste landforms.

The handbook also makes the point that the management of water through all phases of the mining cycle is as critical to closure as is the management of mine waste. The handbook (Australian Government, 2015) links the characterisation of prospective waste materials and process residues (tailings), and the potential risk of future contamination to the environment via waterborne pollutants with appropriate design of waste landforms. Experience has shown that appropriate landform design needs to incorporate the management of surface water and have the capacity to achieve target completion criteria.

Early recognition of financial aspects and overall closure costs promotes improved strategies for operations to plan mitigation strategies and anticipate progressive closure and rehabilitation activities. Closure planning and consideration of closure costs throughout the LoM can create shareholder value if this long-term closure liability can be reduced or eliminated during operations. Chapter 6 of the handbook presents three processes that can be utilised for closure cost estimation. These processes reduce the potential environmental liability, as they ensure investment, development and operating decisions made today are made in full recognition of the potential financial impacts for closure in the future.

Minerals resource legacy — a paradigm for communication

The future of the mining industry is dependent on the legacy it leaves. Industry reputation is affected when mines are abandoned or long-term detrimental environmental impacts emerge because closure was not appropriately addressed during the LoM (Australian Government, 2006). The industry today recognises that to gain access to future resources, it needs to demonstrate that it can effectively manage and close mines with the support of the communities in which it operates (Australian Government, 2006). Ongoing engagement with the community throughout the LoM makes good business sense for companies as they seek to contribute to the building of sustainable regional communities through long-term partnerships.

The word *legacy* is mentioned many times in the three closure handbooks and is a critical term. The word is generally used with a negative connotation by the industry and its detractors; however, in reality, legacy is defined as, and implies “a gift handed down” (OED Online, 2014). We acknowledge that, depending on your particular point of view, legacy can be either positive or negative.

Figure 2 The Mineral Resource Legacy; a framework (Lacy and Bennett 2015)

Figure 2 illustrates the prime relationships in the discovery and utilisation of minerals: between mining companies, local communities and government, and lists and describes some of the broad effects as verbs. The common interface of these three primary stakeholders is the resource legacy itself.

By providing the legacy framework (Figure 2) within the handbook, we provide a visual context for approaching the broader discussion of the nature of the mineral resource legacy in the interest of fostering understanding in the continuing LoM cycles between company employees, local communities, regional stakeholders, shareholders, company managers, non-government organisations and society as a whole.

Social equity and a new way of looking at the resource legacy are needed more than ever as conflict over humankind's search for and use of minerals, and the resource input necessary to extract and process resources, have massive global effects. However, mining is a vital primary industry concerned with obtaining or providing natural raw materials for conversion into commodities and products for the consumer. In economic terms, it is these primary industries that determine our economic success.

Case studies

Within the handbook, we were able to draw upon examples from a number of the earlier handbooks that are still considered viable and valuable for this subject, including leading examples of leading practice. In addition, we added such recent examples as replacement of streamlines (Yogunup — Iluka, Maryland Creek — Glencore), power generation and multiple land use (Woodlawn — Veolia), progressive relinquishment of underground coal operations (Kestrel — Rio Tinto) and many others.

Final reflections and concluding statements from the handbook

The handbook we prepared with our joint contributors outlines that the following essential elements are required to achieve mine closure and relinquishment:

- recognising and addressing the closure issues a mining operation needs to consider in its planning for closure through to relinquishment;
- development of a risk management approach to mine closure planning that applies from mine concept to post-closure and is integrated with whole LoM planning;
- closure activities associated with each step in the LoM cycle, and the need to integrate these into the business practice via progressive implementation of a closure system;
- processes and tools that can assist a mining operation in achieving good practices in mine closure and relinquishment;
- the need for engagement with communities and regulators in establishing and implementing leading practice closure outcomes, as the community inherits the resource legacy;
- the requirement to collect quality baseline data, and development of a high-quality knowledge base that is easily accessible;
- the requirement to develop closure objectives and completion criteria in the planning phase of a mine in consultation with key stakeholders, and then regularly review them as research, monitoring and progressive rehabilitation are undertaken;
- recognition that the physical, chemical and geochemical characterisation of soils and mine waste are important components of engineered landform design and construction;
- recognition that mine tailings rehabilitation and closure require a unique focus;
- recognition that water management and its interaction with the mine landforms is a critical closure element;
- the requirement to consider mine closure planning and associated financial provisioning across all LoM phases, with estimates generally developed for provisioning purposes, regulator reporting for environmental bonding and long-term LoM planning and budgeting;
- awareness that the pre-decommissioning and closure planning stage is critical and requires a focus on aspects of liability, final decommissioning planning, assets and divestment, remediation, legacy infrastructure, and post-closure monitoring and management; and
- advanced and careful planning to ensure the transition to the post-mining land use and relinquishment is as smooth as possible (DIS, 2015).

Mine closure and rehabilitation ultimately determine the nature of the legacy left behind as a post-closure land use for future generations. If mine closure and rehabilitation are not undertaken in a planned and effective manner throughout the LoM, a site may continue to be hazardous and a source of pollution for many years to come. The overall objective of mine closure and relinquishment is to prevent or minimise adverse long-term environmental, physical, social and economic impacts, and to create a stable landform suitable for some agreed-upon subsequent land use.

The 2015 handbook emphasises the need for mining to focus on developing closure objectives and completion criteria based on the post-mining land use as the goal of mine closure. The handbook encourages systemised closure planning, as unplanned closures are not cost effective and often result in sub-standard rehabilitation outcomes. Early recognition of rehabilitation and closure costs promotes improved strategies for operations to plan additional mitigation strategies and anticipate progressive closure and reclamation activities.

Mine closure is a process; to be successful, it should commence with early planning, involve progressive rehabilitation during operations and culminate with final decommissioning, rehabilitation and relinquishment. Closure may be only temporary in some cases, or may lead into a program of care and maintenance. In this sense, the term *mine closure* encompasses a wide range of drivers, processes and outcomes.

The global minerals industry is and will continue to be a cornerstone of human civilisation and development. The Australian leading practice series supports the Australian industry and we hope the handbook will assist in and complement the progressive mine closure process in any country that seeks assistance and guidance.

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