Government of Western Australia
Department of Mines and Petroleum

GOVERNMENT OF WESTERN AUSTRALIA

Environmental Protection Authority


# Guidelines for Preparing Mine Closure Plans

June 2011

# Foreword

Planning for mine closure is a critical component of environmental management in the mining industry. Nationally and internationally, industry leading practice requires that planning for mine closure should start before mining commences and should continue throughout the life of the mine until final closure and relinquishment. This approach enables better environmental outcomes. It is also good business practice as it should avoid the need for costly remedial earthworks late in the project lifecycle.

Recognising the importance of this issue, the Department of Mines and Petroleum (DMP) and the Environmental Protection Authority (EPA) have jointly prepared these *Guidelines for Preparing Mine Closure Plans*. The joint guidelines will improve the efficiency of the assessment and approvals process by harmonising the requirements of DMP and the EPA.

The aim of the guidelines is to ensure that, for every mine in Western Australia, a planning process is in place so the mine can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State.

Mine closure planning should be an integral part of mine development and operations planning and as such the level of information required will correspond to the life span of the mine and reflect the various stages of the life cycle of the project.

There are a number of issues that continue to challenge effective mine closure and DMP and the EPA support a risk based approach to manage these issues. An overview of some specific mine closure issues is provided in Appendix H and should be referred to in the preparation of mine closure plans. These issues include acid and metalliferous drainage and closure considerations for mine pit lakes.

Although the guidelines focus on the ecological aspects of mine closure planning, DMP and the EPA encourage proponents to consider socio-economic aspects of closure planning, in particular, impacts of mine closure on local communities. This is in line with the sustainable development principles defined by the International Council on Mining and Metals and enshrined in the Minerals Council of Australia's *Enduring Value – the Australian Minerals Industry Framework for Sustainable Development*.

The guidelines have been approved by DMP and the EPA for publication. To ensure continuous improvement, the guidelines will be reviewed within two years after the publication date and thereafter as required.

Director General
Department of Mines and Petroleum

Chairman
Environmental Protection Authority

# Contents

## 1. PURPOSE OF THE GUIDELINES

The purpose of these guidelines is to provide guidance on the preparation of Mine Closure Plans (or referred to as "the Plans") to meet Western Australian regulatory requirements.

Consistent with industry leading practice, the guidelines are based on the principle that planning for mine closure should be an integral part of mine development and operations planning and should start "up front" as part of mine feasibility studies, before mining begins.

DMP and the EPA recognise that closure planning is a progressive process and that mine closure plans are living documents which should undergo on-going review, development and continuous improvement throughout the life of a mine. The level of information required needs to recognise the life span of a mine (e.g. a short term, medium term or long term project), and the detail should increase with time to closure. However, at all stages, DMP and the EPA expect mine closure plans to demonstrate, based on reliable science-based and appropriate site-specific information, that ecologically sustainable closure can be achieved.

The following references have been used extensively in preparing these guidelines:

- *Strategic Framework for Mine Closure*; Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia (ANZMEC/MCA 2000);
- *Mine Closure and Completion, Leading Practice Sustainable Development Program for the Mining Industry*; Department of Industry, Tourism and Resources (DITR 2006a);
- *Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry*; Department of Industry, Tourism and Resources (DITR 2006b); and
- *Planning for Integrated Mine Closure: Toolkit*; International Council on Mining and Metals (ICMM 2008).

A glossary of definitions and terms is provided in Appendix A.

## 2. REGULATORY AND ADMINISTRATIVE CONTEXT

This section provides an overview of the WA Government's regulation and administration concerning mine closure.

### 2.1 Key regulators and regulatory framework

DMP is the lead regulator and decision-making authority for mining projects in Western Australia (WA) under the *Mining Act 1978*. DMP has the role of regulating the industry to ensure the closure conditions applied and commitments made are implemented during the life of the mining project.

The 2010 amendments to the *Mining Act 1978* require a Mine Closure Plan to be submitted to DMP for approval as part of Mining Proposal applications received after 30 June 2011. The Plan must be prepared in accordance with these guidelines. The approved Plan must then be reviewed and submitted again for approval by DMP three years after its initial approval, or at such other time as required in writing by DMP.

DMP also has an advisory role in relation to the environmental management aspects of mines which are regulated under the *Environmental Protection Act 1986* and State Agreement Acts.

The EPA is a statutory authority established pursuant to the *Environmental Protection Act 1986* and one of its functions (section 16 of the Act) is to conduct environmental impact assessment (EIA) of significant proposals in WA in accordance with Part IV of this Act. Where the EPA assesses mine closure planning as part of the EIA process (provided under section 40 of the Act), the EPA's primary objective is to ensure that the mine is *capable* of being closed in an ecological sustainable manner. Proponents will need to provide, as part of their EIA documentation, a Mine Closure Plan with sufficient information to meet that objective.

The Department of State Development administers State Agreement Act projects. Although these projects are subject to the *Environmental Protection Act 1986*, some are not subject to the *Mining Act 1978.* For those where tenements were not granted pursuant to the *Mining Act 1978*, a Mine Closure Plan in accordance with the guidelines, if required, will be subject to the provisions of Part IV of the *Environmental Protection Act 1986* and/or State Agreement Acts.

The approval processes for Mine Closure Plans often require advice or endorsement from other environmental regulators including the Department of Environment and Conservation (administering Part V of the *Environmental Protection Act 1986*, the *Wildlife Conservation Act 1950*, the *Conservation and Land Management Act 1984*, and the *Contaminated Sites Act 2003*) and the Department of Water (administering the *Rights in Water and Irrigation Act 1914, Country Areas Water Supply Act 1947, Waterways Conservation Act 1976 and Water Agencies Powers Act 1984* ).

For uranium mines and other types of mines where radioactivity may be an issue (for example mineral sands mines), management of radioactivity will also be regulated by DMP under Part 16 of the *Mines Safety and Inspection Regulations 1995*, and by the Radiological Council under the provisions of the *Radiation Safety Act 1975.*

### 2.2 New Mining Operations/Projects

From 1 July 2011, DMP requires all new Mining Proposal applications to contain a Mine Closure Plan prepared in accordance with these guidelines. This requirement will be stipulated as tenement conditions under the relevant provisions of the *Mining Act 1978* (including section 84), as from 1 July 2011.

From the 1 July 2011, the EPA will generally not assess mine closure as part of its EIA of mining proposals under the *Environmental Protection Act 1986*, where they are subject to the *Mining Act 1978*. The EPA will only assess mine closure in these circumstances if it considers there are particular issues which pose a high environmental risk. The EPA would consult with DMP before making any such decision.

For mining projects not subject to the *Mining Act 1978* (such as Pre 1899 title or minerals-to-owner tenure, Hampton locations or State Agreement Act projects) the EPA will normally assess mine closure as part of its EIA process. As a matter of course the EPA will consult with DMP on these assessments.

Where the EPA assesses mine closure, an approval condition will normally be applied under the *Environmental Protection Act 1986*, requiring a Mine Closure Plan to be prepared in accordance with the guidelines. Where it is considered that regulatory efficiencies would be gained, compliance monitoring of these conditions may be delegated to DMP. This would assist in achieving consistency of application of the guidelines, and minimise the potential for any duplication.

Mine Closure Plans that fail to provide the necessary information or requirements specified in these guidelines, particularly if critical closure issues have not been adequately addressed, will not be accepted by DMP or the EPA, and this could result in a delay in the assessment of a Mining Proposal or EIA.

In general, a Mine Closure Plan prepared in accordance with these guidelines should meet both DMP and the EPA requirements, unless a period of twelve months or more has elapsed between approval of the EIA and submission of a Mining Proposal to the DMP. In this case, the Mine Closure Plan, as part of the Mining Proposal, may need to be updated to incorporate current closure information/data.

### 2.3 Existing Mining Operations/ Projects

For mining operations that have a Mining Proposal and/or a Notice of Intent (NOI) approved under the *Mining Act 1978* prior to 1 July 2011, DMP will require existing mine closure plans and rehabilitation plans to be reviewed in accordance with the guidelines and submitted to DMP by 30 June 2014. DMP will use a prioritisation system to specify in writing to tenement holders when the new Mine Closure Plans must be submitted. This requirement will be stipulated as tenement conditions after 1 July 2011, under the relevant provisions of the *Mining Act 1978* (including section 84).

Before preparing a Mine Closure Plan for existing sites or operations with approved commitments and/or conditions that contain specific closure outcomes, landform design parameters (e.g. waste dump heights, bench and berm distances) or rehabilitation criteria, proponents/operators are strongly encouraged to contact the relevant DMP environmental officers for advice on application of the guidelines to these sites /operations that will achieve the best practicable closure outcomes.

For existing operations that are not administered under the *Mining Act 1978* and mine closure is not regulated under the *Environmental Protection Act 1986*, operators are expected to liaise with the relevant regulators (see Section 2.1) about requirements for mine closure planning, and are encouraged to have in place mine closure planning and implementation consistent with these guidelines.

### 2.4 Small Mining Operations

For small-scale operations, the level of detail required to assess the environmental impacts and closure requirements is much less than that required for typically larger mining operations. To accommodate the reduced information requirements of small operations, a Mine Closure Plan pro forma has been developed for these operations and the forms are available from DMP. Small mining operations are defined in the pro forma.

It is essential for proponents to contact the relevant DMP environmental officer for the mineral field (Appendix B) in which the small scale mining operation is proposed for advice on whether the pro forma form can be used to submit the mining proposal and the associated closure plan.

### 2.5 Review of approved Mine Closure Plans

All Mine Closure Plans approved by DMP on or after 1 July 2011 must be regularly reviewed over the life of a mine. The *Mining Act 1978* requires these Plans to be reviewed and submitted for approval by DMP every three (3) years or such other time as specified in writing by DMP. This requirement will be stipulated in a tenement condition.

The review of Mine Closure Plans does not necessarily require a large rework of the original or previous Plans unless extensive changes have occurred, but it does need to provide a confirmation of the current status of closure planning (e.g. incorporating new data or closure related changes) and reflect the continual nature of the closure work planning and progress.

For projects that are not regulated under the *Mining Act 1978*, the Mine Closure Plan will be reviewed, as required, in accordance with conditions of approval under Part IV of the *Environmental Protection Act 1986* and/or the relevant State Agreements.

### 2.6 Changes to approved Mining Proposals and/or Mine Closure Plans

Before making a formal submission on a change to an approved mining proposal and/or a mine closure plan, proponents/operators are strongly encouraged to contact the relevant environmental officer at DMP or the Office of the EPA (OEPA) for advice on whether the intended change is substantial or non-substantial.

Substantial changes are major changes or addition to the approved mining operations and/or major changes to post-mining land use(s) and closure objective(s), which are determined by DMP to have a substantial increase in the overall environmental impacts. Any substantial change to a Mining Proposal and/or a Mine Closure Plan regulated under the *Mining Act 1978* will require a new Mining Proposal to be submitted to DMP for approval. The Mining Proposal will be subject to the same approval requirements as those for a new mining operation or project (as described in Section 2.2). If the new Mining Proposal constitutes changes to a proposal approved under Part IV of the *Environmental Protection Act 1986,* the changes must also be approved in accordance with processes and procedures under that Act.

Non-substantial changes are minor changes that do not result in any significant increase in the overall environmental impacts of the approved mining operation or significant changes to post-mining land use(s) and closure objective(s), as determined by DMP. All non-substantial changes must be submitted as an Addendum to Mining Proposal document and/or documented in the reviewed Mine Closure Plan (required in Section 2.3 or 2.5) for approval by DMP.

### 2.7 Unexpected Closure and Temporary Closure

Mining operations may be forced to close prematurely (referred to as *unexpected* closure) or on care and maintenance (referred to as *temporary* closure). In these circumstances, mine operators need to take into account the safety obligations required under sections 42 and 88 of the *Mines Safety and Inspection Act 1994* relating to mine suspension or abandonment. One of those obligations is to notify the relevant DMP District Inspector before a mining operation is suspended or abandoned.

In the event of *unexpected* closure, the closure process should be accelerated (ANZMEC/AMC 2000, page 13). Immediate review of the pre-existing Mine Closure Plan to include a detailed Decommissioning Plan will be required by DMP and/or the EPA, within three months of notification to DMP or at such other time as specified in writing by DMP.

If a *temporary* closure is imminent, a detailed Care and Maintenance Plan must be prepared, based on the pre-existing Mine Closure Plan, and submitted to DMP within three months of its notification to DMP or at such other time as specified in writing by DMP. The Care and Maintenance Plan (see Environmental Notes on Care and Maintenance available on DMP website, http://www.dmp.wa.gov.au/836.aspx) must demonstrate that on-going environmental obligations will be met during this period.

Operators are encouraged to contact the relevant environmental officers at DMP as early as possible for advice on site-specific requirements in the event of these closures.

### 2.8 Tenement Relinquishment

Relinquishment of a tenement requires formal acceptance from the relevant regulators to certify that all obligations under the Mine Closure Plan associated with the tenement, including achievement of closure criteria have been met, and that arrangements for future management and maintenance of the tenement have been agreed to by the subsequent owners or land managers (e.g. pastoralist, aboriginal community or land-management agency).

Where relinquishment requires the transfer of ownership of infrastructure and/or land to other parties, the tenement holder(s) will be required to demonstrate that these parties have been involved in the process and understand their responsibilities and liabilities associated with the transfer. Any transfer of residual liability to the subsequent owners or land managers including management of contaminates sites, must be clearly communicated, agreed to and documented, to the satisfaction of the relevant regulators. There must be an explicit, written legal agreement with the subsequent land managers to accept the mining legacy obligations and any outstanding costs of remediation, monitoring and reporting. For any transfer of responsibility for remediation to be recognised under the

*Contaminated Sites Act 2003*, the written approval of the Chief Executive Officer of DEC must be obtained in accordance with section 30 of that Act.

It is important to note that, under section114B of the *Mining Act 1978,* the tenement holder may retain liability for environmental impacts caused by the project after the tenement has been relinquished.

The *Contaminated Sites Act 2003* requires that appropriate investigations be carried out to identify, assess and manage any contamination issue. In accordance with regulation 31 (1) (c) of the *Contaminated Sites Regulations 2006*, a mandatory auditor's report is required to accompany every report submitted to DEC relevant to the investigation, assessment, monitoring or remediation of a site prepared for the purpose of complying with a condition or requirement imposed under another written law (such as conditions of Ministerial Statements). The Act also has enduring powers relating to the operator or tenement holder causing contamination.

Part V of the *Environmental Protection Act 1986* regulates pollution on mine sites. A "Closure Notice" may be issued to require monitoring, reporting and active management of a decommissioned facility after a licence has ceased to have effect. This would apply particularly to tailings storage facilities.

Mine operators also need to take into account the safety obligations required under sections 42 and 88 of the *Mines Safety and Inspection Act 1994*, relating to mine suspension or abandonment.

### 2.9 Submission of Mine Closure Plans

Directions on how to submit a Mine Closure Plan to DMP and/or the EPA are provided in Appendix C.

The Mine Closure Plan will not be accepted for assessment by DMP if the checklist provided in Appendix D is incomplete or is found to be incorrect.

### 2.10 Public Availability of Documents

Mine Closure Plans submitted as part of the Mining Proposal application, and the reviewed Plans will be made available to the public after they have been assessed and approved by DMP.

Proponents must identify information of a confidential nature, such as commercially sensitive information or intellectual property that should not be in a public document, and provide two separate electronic versions (one for assessment by DMP and one which will be published).

DMP will not make publicly available any confidential information provided it is clearly identified as such. Any request for such information must be subject to the Freedom of Information legislation.

Mine Closure Plans submitted to the EPA as part of the EIA document, or in accordance with the approval condition under Part IV of the *Environmental Protection Act 1986* will be publicly available.

## 3. PRINCIPLES AND APPROACHES FOR MINE CLOSURE

Proponents are expected to follow the principles and objectives identified in the *Strategic Framework for Mine Closure* (ANZMEC/MCA 2000), and to refer to the methodology and approaches described in relevant guidance including the national *Leading Practice Sustainable Development in Mining* handbooks and the *Planning for Integrated Mine Closure: Toolkit* (ICMM 2008).

Planning for mine closure should be treated as an integral component of operations planning (ANZMEC/MCA 2000), since decisions made during the operational planning process have the potential to significantly impact on rehabilitation and mine closure outcomes. As such, mine closure planning needs to be appropriately integrated into the different stages of the life of a mine (Figure 1), and flexible enough to allow for adaptive management. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of the operational program (DITR 2006a, ICMM 2006).

Consequently, closure planning should be also integrated into the environmental management system for the operation or site as much as possible. An integrated approach to mine closure planning is critical to achieve successful closure outcomes (Bentel 2009).

The planning process should include strategies and contingency plans to identify how unexpected or temporary closure of mining operations will be managed. This will provide the mine operators with the ability for timely evaluation of the knowledge gaps and risks associated with closure and to develop an appropriate plan, such as a Care and Maintenance Plan.

Progressive development of a Mine Closure Plan through the mine lifecycle, as shown in Figure 1, and progressive rehabilitation, are critical to the successful implementation of mine closure planning (DITR 2006a). Progressive rehabilitation has many benefits including:

- A reduction in project costs by maximising the use of on-site resources during mine life;
- Allowing rehabilitation costs to be spread over the life of the mine;
- The potential for better rehabilitation outcomes through the use of recently disturbed topsoil;
- Knowledge gained from past rehabilitation trials and efforts; and
- Minimising the amount of time required for monitoring and maintenance post mine life.

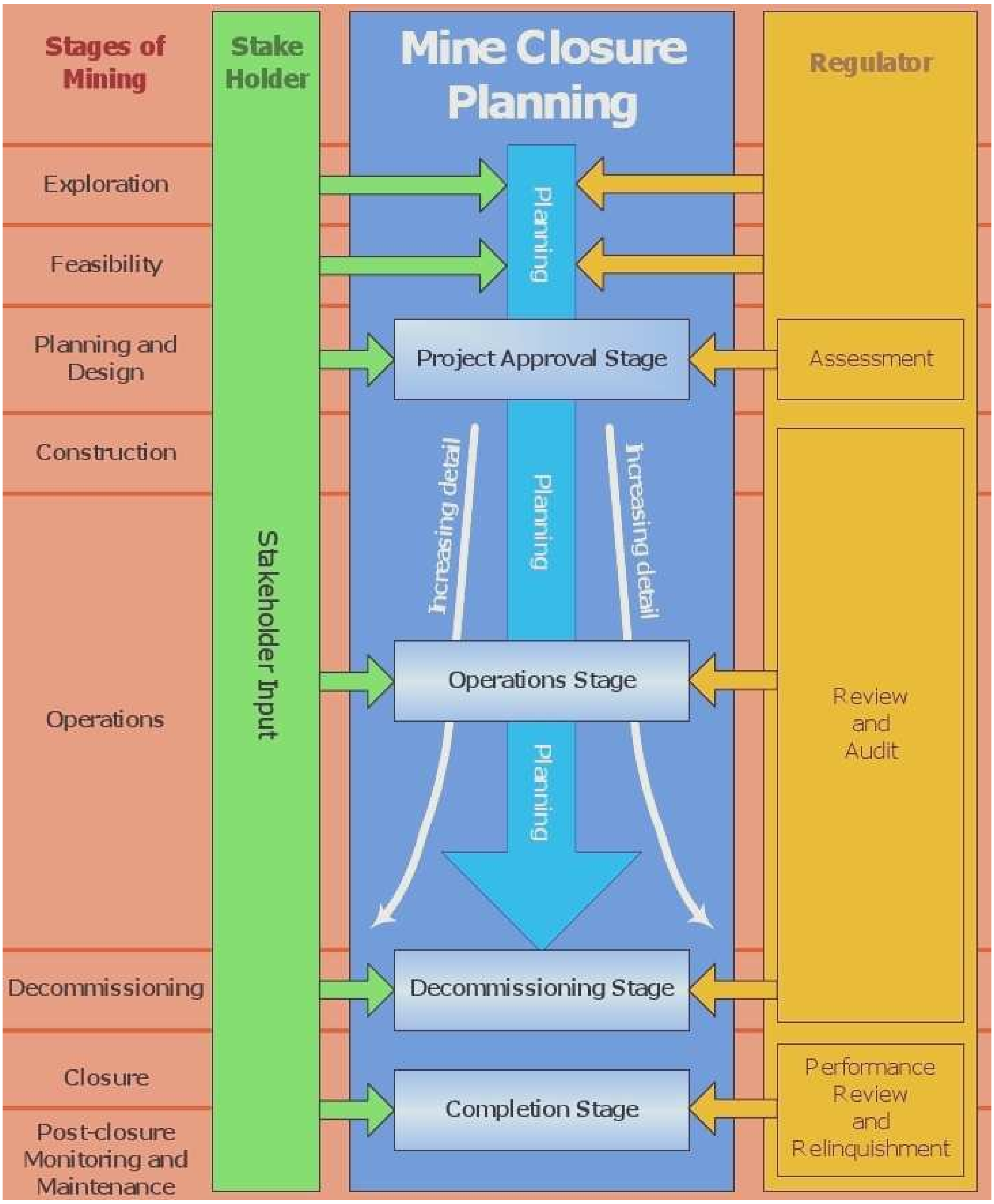


Figure 1: Integrating Stages of Mining and Mine Closure Planning (adopted from DITR 2006a, ICMM 2006)

DMP and the EPA endorse a risk-based approach to mine closure planning (EPA 2009a) since it reduces both cost and uncertainty in the closure process (ANZMEC/MCA 2000). The benefits of a risk based mine closure process include:

- Early identification of potential risks to successful closure;
- Development of acceptable and realistic criteria to measure

- performance;
- Orderly, timely and cost-effective closure outcomes;
- Reduced uncertainty in closure costs; and
- Continual improvement in industry rehabilitation standards (e.g. cover design, and management of contaminated drainage, erosion and seepage).

Consistent with the risk-based approach, the level of detail required by DMP and EPA increases with the level of risk associated with each key closure issue and time to closure, as generally indicated in Table 1 below:

Table1: Indication of required level of closure detail

| **Life of Mine** | **Post-mining Land use** | **Identification and Management of Key Environmental Issues** | **Closure Outcomes** | **Closure Costing (**not to be submitted unless requested by DMP**)** | **Closure Implementation and Monitoring Plans** |
|---|---|---|---|---|---|
| Long term (25+ years) | Provisional targets unless agreed to by all key stakeholders as being final | High risk components completed | Indicative except for high risk operations | Indicative | Preliminary except for high risk operations |
| Medium term (10 to 25 years) | Well advanced | Completed | Well advanced | Increased accuracy | Well advanced |
| Short term (Up to 10 years) | Well advanced to Completed | Completed | Well advanced to Completed | Accurate | Completed |
| Small Mining Operations | Completed | Completed | Completed | Accurate | Completed |
| Existing operations | Determined on a case by case basis depending on mine life and risk | Completed | Determined on a case by case basis depending on mine life and risk | Determined on a case by case basis depending on mine life and risk | Determined on a case by case basis depending on mine life and risk |

The preparation of Mine Closure Plans should give specific consideration to the following key principles and approaches (DITR 2006a):

- **At all stages, from the project approval stage onwards, the Mine Closure Plan should demonstrate that ecologically sustainable mine closure can be**

**achieved consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State.**

- **Planning for mine closure should be fully integrated in the life of mine planning, and should start as early as possible and continue through to final closure and relinquishment. For new projects, closure planning should start in the project feasibility stage (before project approvals).**
- **Mine closure plans must be site-specific. Generic "off-the-shelf" closure plans will not be acceptable.**
- **Closure planning should be risk-based taking into account results of materials characterisation, data on the local environmental and climatic conditions, and consideration of potential impacts through contaminant pathways and environmental receptors.**
- **Consultation should take place between proponents and stakeholders which should include acknowledging and responding to stakeholder's concerns. Information from consultation is central to closure planning and risk management.**
- **Post-mining land uses should be identified and agreed upon through consultation before approval of new projects. This should take into account the operational life span of the project, and should include consideration of opportunities to improve management outcomes of the wider environmental setting and landscape, and possibilities for multiple land uses. For existing mining projects, post-mining land uses should be agreed as soon as practicable.**
- **Characterisation of materials needs to be carried out prior to project approval to a sufficient level of detail to develop a workable closure plan. This is fundamental to effective closure planning. For existing operations, this work should start as soon as possible. Characterisation of materials should include the identification of materials with potential to produce acid, metalliferous or saline drainage, dispersive materials, fibrous and asbestiform materials, and radioactive materials, as well as benign materials intended for use in mine rehabilitation activities.**
- **Closure planning should be based on adaptive management. Closure plans should identify relevant experience and research, and how lessons learned from these are to be applied.**
- **Closure plans should demonstrate that appropriate systems for closure performance monitoring and maintenance, and for record keeping and management are in place.**

Figure 2 (adapted from ELAW 2010) provides a general guide to assist proponents, DMP and the EPA assessors in evaluating the adequacy of the Mine Closure Plan.

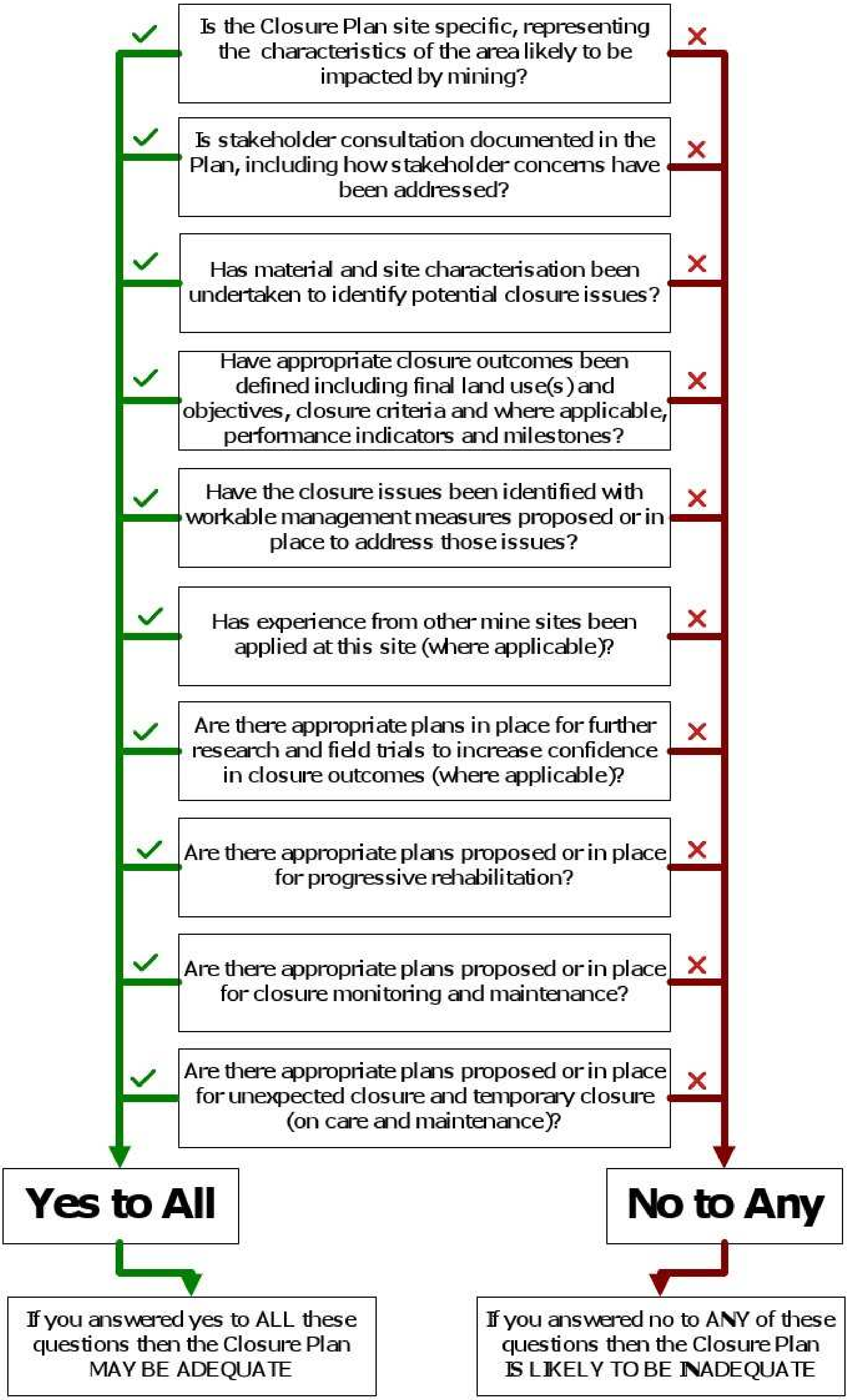


Figure 2: General Guide for evaluating a Mine Closure Plan (adapted from ELAW 2010).

## 4. STRUCTURE AND CONTENT OF A MINE CLOSURE PLAN

A Mine Closure Plan is a dynamic document and will be regularly reviewed and progressively developed and refined over time, to ensure that detail in the Plan reflects current knowledge and relevant to the development status of the mine (Figure 1 and DITR 2006a, Chapter 3).

DMP and the EPA accept that not all the necessary detail for final closure is available in the early stages of the project, particularly in the project approval stage. The Mine Closure Plan submitted at these stages must enable DMP and the EPA to understand the issues that require management at closure, and have confidence that all relevant issues have been identified and appropriately managed (Figure 2). This is to ensure an accurate assessment and informed decision by DMP and the EPA can be determined.

For short term projects (up to 10 years), due to the relatively short time before closure, DMP and the EPA expect the Mine Closure Plan submitted at the project approval stage provides more detailed level of information on final closure , including specific information on final landforms and rehabilitation, plant and infrastructure decommissioning, and closure monitoring and maintenance. For longer term projects (more than 10 years), due to the longer time before closure, less detailed information on the final closure may be required at the project approval stage (see Table 1, Section 3). However more detailed information may be required for longer-term projects where there is a high level of environmental risk.

A Mine Closure Plan submitted as part of a Mining Proposal document (Section 2.2), must relate to that particular mining proposal or, where practicable, can be prepared for the whole site. A reviewed Mine Closure Plan (as required in Section 2.5) must be prepared for the whole site.

Where a mining proposal is subject to assessment by the EPA, the mine closure plan should cover the whole site.

To reduce duplication when the Mine Closure Plan is submitted as part of a Mining Proposal or an EIA document, references should be made in the Mining Proposal or in the EIA document to the relevant closure information provided in the Mine Closure Plan. The Mining Proposal or the EIA document can describe the key components of mine closure and rehabilitation, with closure details provided in the Mine Closure Plan.

The Mine Closure Plan must be accompanied by site plans (surveyed), aerial photographs, and appendices with detailed information supporting the plan, where appropriate.

To ensure efficient assessment, DMP and the EPA require of the Mine Closure Plan to be structured in the following format:

1. Cover Page
2. Checklist with corporate endorsement
3. Table of Contents
4. Scope and Purpose

5. Project Overview
6. Identification of Closure Obligations and Commitments
7. Collection and Analysis of Closure Data
8. Stakeholder Consultation
9. Post-Mining Land Use and Closure Objectives
10. Identification and Management of Closure Issues
11. Development of Completion Criteria
12. Financial Provision for Closure
13. Closure Implementation
14. Closure Monitoring and Maintenance
15. Management of Information and Data

Written agreement must be obtained from the DMP and/or the OEPA for any variation to the above required structure for Mine Closure Plans.

## 4.1 Cover Page

The cover page must include:

- Title of project
- Document title
- Document ID number and version number
- Date of submission
- Mineral Field number(s)
- Company name
- Contact Details (including the name, address and contact of the proponents, tenement holder(s) and/or operator)

## 4.2 Checklist

DMP requires a checklist for a Mine Closure Plan, as provided in Appendix D, to be completed with corporate endorsement and placed after the title page of the Mine Closure Plan document.

The checklist is designed to assist the proponent to ensure that all required information has been included, prior to submitting the document. This will reduce or minimise the need for the DMP assessing officer to seek further information or clarification.

## 4.3 Table of Contents

The Table of Contents for a Mine Closure Plan must include a List of Figures, Tables and Maps as appropriate.

## 4.4 Scope and Purpose

This section outlines why the Mine Closure Plan is being submitted – is it part of approval documentation, ministerial condition requirement, tenement condition requirement, requirement under the Mining Act or a combination of above, or a reviewed Mine Closure Plan. This section should also provide the scope of the Plan and other relevant introductory information.

## 4.5 Project Summary

This section provides background information on the history and status of the project including proposed and existing mining operations. This information is necessary where the Mine Closure Plan is a not submitted with a Mining Proposal or an EIA document.

Required information includes:

- Land ownership including occupancy, mining tenure, postal and site address, and contact details.
- Location of the operation, including a list of all relevant tenements, the location of the mine in relation to the local and regional setting with maps and a list of tenements.
- An overview of the operations with a description of the major mine components.
- A comprehensive site plan for identification of all disturbed areas, tenement boundaries and proposed or existing disturbance types within each tenement (coloured aerial photos with an overlay of tenement boundaries and disturbance types are preferred).

## 4.6 Identification of Closure Obligations and Commitments

All legal obligations relevant to rehabilitation and closure at a given mine site must be identified and provided in a suitable format, usually referred to as a Legal Obligations Register. The Register should form part of the operator’s overarching legal register for all operations on the site. An example of a tabulated format for the Register is provided in Appendix E.

The Register must include all legally binding conditions and commitments and/or legal obligations applicable under relevant State and Federal legislation. The Register must also include references to individual tenement conditions, Mining Proposals, Notices of Intent, Letters of Intent, Programmes of Work, Ministerial Statements, Commitments, licence conditions and all other legally binding documents.

The Register may also include the safety obligations (and non-legally binding commitments) pertaining to closure.

The Register provides a valuable tool when setting closure criteria, as environmental commitments can be cross referenced. Compliance with closure conditions is an absolute requirement for the government’s sign off before relinquishment. At closure, this tool can be used as a checklist to demonstrate that all conditions, commitments and obligations have been met.

### 4.7 Collection and Analysis of Closure Data

Where applicable, collection and analysis of closure data must be designed and implemented to meet the following minimum requirements:

- Use of recognised or acceptable methodologies and standards;
- Incorporating appropriate quality management systems and procedures (such as ISO 9000);
- Consideration of the wider receiving environment, receptors and exposure pathways; and
- Providing a basis to develop criteria or indicators for closure monitoring and performance (see Section 4.14).

<u>Environmental Data</u>

Information from baseline studies undertaken prior to the commencement of mining operations, and from on-going studies including studies of suitable reference sites is necessary to:

- Establish achievable closure outcomes and goals in a local and regional context.
- Establish baseline conditions for closure monitoring programs, including the identification of reference sites.
- Identify the issues to be managed through the mine closure process.

It is important that the collection of environmental data is continued and expanded throughout the project life to include data from research, field trials and investigations, and to identify the spatial and temporal variations in the surrounding environments. The data will assist in the refinement of closure objectives and completion criteria and the setting of indicators for management intervention (DITR 2006b).

The Mine Closure Plan must provide a summary of the best available data on aspects of the physical and biological environments that are critical for successfully meeting mine closure outcomes, including the following information (where relevant and as determined by the impact assessment):

- Local climatic conditions and projected future climate change for the area.
- Local physical conditions – topography, geology, hydrogeology, hydrology, seismicity and geotechnical data.
- Local and regional environmental information on flora, fauna, ecology, communities and habitats.
- Local water resources details – type, location, extent, hydrology, quality, quantity and environmental values (ecological and beneficial uses).
- Soil and waste materials characterisation – soil structure and stability (e.g. erodibility), growth medium type and block modelling of waste materials;

solubility, mobility and bioavailability of hazardous materials (e.g. radioactive substances, heavy metals and materials with potential to produce contaminated drainage).

Comprehensive characterisation of materials (including soils and wastes) is critical to successful progressive rehabilitation and should start during the exploration phase and continue throughout all stages of the mine. The information from materials characterisation allows rigorous separation and selective placement of materials to achieve a sustainable vegetative cover and a stable/effective barrier that prevents long-term pollution (DITR 2006a).

<u>Other Closure Related Data</u>

Other available information should be collated with the objective of building a 'base' of information or knowledge important to the closure of a particular landform or infrastructure. Information may include, but not be limited to:

- Spatial datasets and databases.
- Design and construction of landforms and voids.
- Availability and volumes of key materials required for rehabilitation such as competent waste rock, subsoil, topsoil and low permeability clays (i.e. encapsulation material).
- Relevant scheduling information with respect to material stockpiling and deployment to ensure that rehabilitation materials mined early in the process are appropriately segregated and preserved for later use.
- Mathematical models to predict long term performance or environmental impacts.
- Learnings from closure experience generated from other mines.
- Seed mixes used in rehabilitation and any information gathered from trials.

All technical reports must be referenced in the Mine Closure Plan, with relevant reports provided as appendices, as appropriate.

<u>Analysis of Data</u>

Analysis of the collected data is a critical element in understanding the issues impacting mine closure and identifying knowledge gaps (Mackenzie *et al.* 2006, ICMM 2008).

Once all the closure related information has been obtained, the next step is to analyse the information and identify any 'information gaps', which may potentially affect the rehabilitation and closure outcomes. The risk associated with not having this information should also be investigated and documented. This will enable the information gaps to be prioritised and acted upon appropriately.

Where appropriate, the data analysis should take into account the natural background levels of particular elements (such as naturally occurring radioactive materials or heavy metals) and possible environmental impacts from other sources including nearby mining operations and other land uses, which may affect the closure strategy or management of the site.

## 4.8 Stakeholder Consultation

For the purpose of the guidelines, the term “**stakeholders**” include both internal and external stakeholders who are likely to affect, to be affected or to have an interest in mine closure planning and outcomes. The internal stakeholders should include mine managers, mine planners, engineers and relevant staff involved in mine planning and technical/operational decision making. The external stakeholders typically include the government (such as regulatory agencies, local authorities), post-mining land owners/managers (such as private land holders, indigenous/traditional land owners, lease holders, Pastoral Lands Board, State land managers), local community members or groups and interested Non-Government Organisations (NGOs). The term “**key stakeholders”** refers to post-mining land owners/managers and relevant regulators.

Stakeholder consultation is a key component of the mine closure planning process. Early engagement with stakeholders enables operators to better understand and manage their expectations and the potential risks associated with closure. Where practicable, this process should be part of the consultation process for project approvals. The consultation process should continue throughout the different stages of mine closure planning (Figure 1). Failure to undertake a consultation program may compromise the approval process and mine closure outcomes.

The consultation process should follow the five principles (ANZMEC/MCA 2000):

- Identification of stakeholders and interested parties is an important part of the closure process.
- Effective consultation is an inclusive process which encompasses all parties and should occur throughout the life of the mine.
- A targeted communication strategy should reflect the needs of the stakeholder groups and interested parties.
- Adequate resources should be allocated to ensure the effectiveness of the consultation process.
- Wherever practical, work with communities to manage the potential impacts of mine closure.

It is important that all stakeholders have their interests and concerns considered and where appropriate, addressed, and the key stakeholders have an opportunity to provide feedback on the response or proposed action to address their interests and concerns, particularly in the process to determine post-mining land use, closure objectives and outcomes (Sections 4.9 and 4.11).

As an example, the establishment of a consultative closure committee, integrated into an overall stakeholder engagement strategy, can provide a useful forum for discussion and communication on closure issues (DITR 2006a).

The Mine Closure Plan must demonstrate that an effective communication strategy has been developed or put in place to engage with stakeholders, and that the interests and concerns of the key stakeholders (as defined above) have been considered and if appropriate, captured in the development of the plan.

A summary of the consultation process must be provided in a suitable format, such as a Stakeholder Consultation Register (Appendix F). Where necessary, DMP or the EPA may require written evidence, including acknowledgement by the key stakeholders that they have been consulted in the preparation of the Mine Closure Plan being submitted.

## 4.9 Post-mining Land Use(s) and Closure Objectives

The Mine Closure Plan must identify post-mining land use(s) and set out site-specific closure objectives consistent with those land use(s).

The post-mining land use(s) and closure objectives are necessary to provide the basis for developing completion criteria and performance indicators (Section 4. 11).

Post-mining land use(s)

The post-mining land use(s) must be:

- Relevant to the environment in which the mine will operate or is operating;
- Achievable in the context of post-mining land capability;
- Acceptable to the key stakeholders (as defined in Section 4.8); and
- Ecologically sustainable in the context of local and regional environment.

Where possible, proponents are encouraged to consider applying resources to achieve improved land management and ecological outcomes on a wider landscape scale, as well as the potential for multiple land uses.

The following land use hierarchy provides a guide to determine post-mining land use(s):

1. Reinstate “natural” ecosystems as similar as possible to the original ecosystem.
2. Develop an alternative land use with higher beneficial uses than the pre-mining land use.
3. Reinstate the pre-mining land use.
4. Develop an alternative land use with other beneficial uses than the pre-mining land use.

In the early stages of a mining project, it may be acceptable for provisional or proposed post-mining land use(s) to be identified, provided that there has been adequate consultation with the key stakeholders and that there is a clear process and timeline to further identify or refine the agreed post-mining land use(s), as part of the stakeholder consultation process.

Closure Objectives

Closure objectives must set out the long term goals for closure outcomes, and should be outcome based (EPA 2009b). These objectives must be developed based on the proposed post-mining land use(s) and, be as specific as possible to provide a clear indication to government and the community on what the proponent commits to achieve at closure. The ability to specify closure objectives will depend on the amount and quality of the environmental data collected at the time. Therefore it is essential that adequate baseline data, such as materials characterisation, and/or the best available data are used for this purpose.

As a general guide, the Government's broad closure objectives are (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting, and capable of sustaining an agreed post-mining land use. Any residual liabilities relating to the agreed land use must be identified and agreed to by the key stakeholders.

At the project approval stage, it may be acceptable for the closure objectives to be more broadly identified and further refined in the stakeholder consultation process, provided that they are based on the best available data at the time and specific enough to guide closure development and design (ANZMEC/ MCA 2000).

Appendix G provides some examples of closure objectives.

The Mine Closure Plan should include a diagram or map showing the final landform design concept based on the post-mining land use(s), to illustrate in visual form (e.g. a 3D diagram/map or a cross-sectional diagram/map) what the surrounding landscape and the final landforms will look like post-mining.

Once agreed to, the post-mining land use(s) and closure objectives will form the basis on which DMP and the EPA approve a mining proposal or a mine closure plan. Where variations to these objectives are proposed subsequent to the environmental approvals of the project, the proponent must submit a request to the EPA and/or DMP supported by suitable evidence to justify the proposed changes. If these changes have the potential to significantly compromise the intent and objectives of the mine closure outcomes, they may be considered by DMP and/or the EPA to be a substantial change to the originally approved project or mining proposal. Section 2.6 provides further information on the change process.

## 4.10 Identification and Management of Closure Issues

DMP and the EPA require that sufficient work is undertaken prior to the project approval stage (for new proposals) or as early as possible (for existing operations), to ensure that all key environmental issues and workable management mechanisms relevant to mine closure are identified. This will allow strategies, mitigation measures and closure designs to be developed, assessed and reviewed in the years leading up to closure.

Some closure issues currently facing mining projects include, but are not limited to:

- Hazardous materials;
- Hazardous and unsafe facilities;
- Contaminated sites;
- Acid and metalliferous drainage or AMD;
- Radioactivity;
- Fibrous ( including asbestiform) minerals ;
- Non-target metals and target metal residues in mine wastes;

- Management of mine pit lakes;
- Adverse impacts on surface and groundwater quality;
- Dispersive and sodic materials;
- Design and maintenance of surface water management structures;
- Dust emissions;
- Flora and fauna diversity/threatened species;
- Visual amenity;
- Heritage issues.

Detailed guidance on how to identify and manage these issues is widely available in references including the Leading Practice Sustainable Development in Mining handbooks on mine rehabilitation (DITR 2006b) and on mine closure and completion (DITR 2006a).

Appendix H provides information on some specific closure issues relating to AMD, mine pit lakes, radioactivity, dispersive materials and rehabilitation.

Adequate characterisation of materials is critical to the identification and management of closure issues, and should include potentially problematic materials (such as AMD, radioactive and asbestiform materials). Characterisation of materials should also be carried out for the benign materials intended for use in mine rehabilitation activities such that the physical, chemical and nutrient characteristics of the material is sufficiently well understood to ensure it will perform according to planning expectations. The volumes of rehabilitation materials required to fulfil closure plans should be reconciled against inventories.

When assessing closure issues, the potential for contamination over the life of a mine needs to be considered so that the contamination can be removed, treated, contained or managed to meet the purposes of the agreed post-mining land use(s) and where practicable, to maximise the beneficial use(s) of the land after mining. To ensure compliance with the *Contaminated Sites Act 2003* and *Contaminated Sites Regulations 2006*, closure strategies will need to be designed to incorporate investigation and remediation of contamination (refer to Section 2.8).

The Plan must demonstrate that all the key issues associated with closure are identified early in the initial mine feasibility and planning stages for new proposals or as early as possible for existing operations, and that these issues can be effectively managed, with the level of detail evolving during the life of the mine (Figure 1).

The Plan must provide adequate information on the processes and methodologies undertaken to identify the closure issues, their potential environmental impacts post-mining and workable mitigation/management measures. This process needs to be integrated with the stakeholder consultation process (see Section 4.8). Concerns from the key stakeholders and learnings from experience must be incorporated into this process. The information can be presented in a tabulated format and included as an appendix. Detailed information on the key issues and mitigation/management measures should be provided in the text, where applicable. Depending on the size and complexity of the project, this may be done across the whole project/site or broken down into domains (Appendix I).

Consistent with a risk-based approach (Section 3), DMP and the EPA encourage a structured risk management process to be undertaken to identify, assess and manage the potential risks associated with closure issues, particularly those identified in Appendix H. This approach allows a systematic review and analysis of risk and cost benefit in both engineering and environmental terms, as well as identification of opportunities associated with closure. The risk assessment can be qualitative, semi quantitative or quantitative, and the outcomes can be presented in the form of a risk register, which includes the likelihood and consequence, risk ranking, mitigation measures and management of residual risk.

A number of risk assessment and management frameworks already exist (Appendix J) and many of which are utilised by the mining industry in closure planning and implementation (G. Bentel *et al.* 2003, ICMM 2008).

## 4.11 Development of Completion Criteria

Completion criteria are necessary to provide the basis on which successful rehabilitation and mine closure, and achievements of closure objectives are determined. They must be developed in consultation with the key stakeholders (as defined in Section 4.8).

Completion criteria should be appropriate to the developmental status of the project and should be (ANZMEC/MCA 2000):

- Specific enough to reflect a unique set of environmental, social and economic circumstances;
- Flexible enough to adapt to changing circumstances without compromising objectives;
- Include environmental indicators suitable for demonstrating that rehabilitation trends are heading in the right direction;
- Undergo periodic review resulting in modification if required due to changed circumstances or improved knowledge; and
- Based on targeted research which results in more informed decisions (EPA, 2006).

Development of completion criteria and associated performance indicators must commence up-front in the project approval stage for new projects or as early as possible for existing operations, and be reviewed and refined throughout the development and operation of the project to respond to monitoring, research and trial information and any other information or change as appropriate.

Indicative completion criteria, based on a conservative estimate of closure performance, may be acceptable at the project approval stage, provided that they are capable of objective verification and based on the best available data at the time. As more information becomes available, more comprehensive and detailed completion criteria can be progressively determined.

In developing completion criteria the proponent/operator should identify criteria that lead to the design and construction of final landforms, voids and ecosystems, and upon being met, will demonstrate achievements of closure objectives of the mine being closed. The final landforms, voids, and ecosystems must be designed and constructed in the context of the agreed land use and closure objectives (Section 4.9). The completion criteria should include performance indicators to demonstrate that rehabilitation trends are following the predicted performance, particularly where mathematical modelling is utilised to predict any long term environmental impact (usually 300 years or longer). Where applicable, details on the mathematical modelling including assumptions and limitations should be provided as an appendix to the Mine Closure Plan.

The completion criteria and associated performance indicators must be site-specific, scientifically supported and capable of objective measurement or verification of closure performance or success (ANZMEC/MCA 2000), in order to provide certainty for reporting and auditing to define rehabilitation endpoints (EPA, 2006).

Appendix K illustrates the development of closure completion criteria.

Once established and agreed to by the regulators, the completion criteria (and associated performance indicators) will form the basis on which mine closure performance is measured and reported to government (and the community where applicable). Further refinement or minor variations to the agreed completion criteria/performance indicators must be documented, together with sufficient explanation, in the reviewed Mine Closure Plan to be submitted subsequently (Section 2.6).

## 4.12 Financial Provisioning for Closure

The objective of financial provisioning for closure is to ensure that adequate funds are available at the time of closure and that the community is not left with an unacceptable liability. To that end, it is essential that the cost of closure be estimated as early as possible.

The financial provisioning must be based on the life of mine closure costs, and the cost estimates must take into account all aspects of rehabilitation and closure activities including:

- Earthmoving and landscape forming;
- Management of problematic materials where relevant;
- Post Closure management of surface water drainage;
- Research and trials;
- Decommissioning and removal of infrastructure;
- Remediation of contamination:
    - Survey program
    - Remediation program
    - Maintenance and monitoring
- Progressive and final rehabilitation;
- Maintenance and monitoring programs including post closure phase (need to allow for earthmoving machinery to be available on site after closure for

remedial earthworks or else provide funding for remobilisation of equipment if required);

- Ongoing stakeholder consultation process;
- Closure project management costs:
    - Administration
    - Specialist and consultant fees
    - Legal requirements
- Provision for unexpected closure or temporary closure (on care and maintenance);
- Provision for installing additional infrastructure if required for the agreed land uses; and
- Provision for potential delays, extreme events or other external factors relevant to closure.

Indicative closure cost estimates may be acceptable in the project approval stage provided that the process and methodology are transparent and verifiable, assumptions and uncertainties are clearly documented, and they are based on reasonable site-specific information and data.

The closure cost estimates must be regularly reviewed to reflect changing circumstances and to ensure that the accuracy of closure costs will be refined and improved with time.

It should be noted that financial securities (or environmental bonds) required under the *Mining Act 1978*, the *Environmental Protection Act 1986* and/or State Agreement Acts are separate from the internal accounting provisions for closure and should not be offset against these provisions (ANZMEC/MCA 2000).

The Mine Closure Plan must contain a summary of the mine closure costing methodology, assumptions and financial processes to demonstrate to DMP and the EPA that the proponent has properly considered and fully understood the costs of meeting closure outcomes identified in the plan, and made adequate provisions in corporate accounts for these costs.

The process and methodology for calculating the cost estimates must be transparent and verifiable.

Reference to the detailed closure costing report must be provided in the Plan. Where necessary, DMP may require a fully detailed closure costing report to be submitted for review, and/or an independent audit to be conducted on the report to certify that the company has adequate provision to finance closure. Where appropriate, the costing report should include a schedule for financial provision for closure over the life of the operation (ANZMEC/MCA 2000).

### 4.13 Closure Implementation

DMP requires the Mine Closure Plan submitted as part of a Mining Proposal to contain a summary of closure implementation strategies and key activities for the proposed mining operation(s), and a description of the closure work programs for each domain (Appendix I) and/or feature related to the proposed operations.

The reviewed Mine Closure Plans (as required in Sections 2.3 and 2.5) submitted subsequently should contain a summary of consolidated closure implementation strategies and key activities for the whole site, and a description of the closure work programs for each closure domain or feature related to the site.

The description of the closure work programs, usually referred to as "closure task register", should include but not be limited to the following information:

- Description of domain or feature - including area of disturbance, status, estimated closure date;
- Applicable land use objectives, landform designs, closure completion criteria, and/or performance indicators for each domain or feature;
- A schedule of work for research, investigation and trials tasks - showing key tasks and key milestones and approximate timing required for each task;
- A schedule of work for progressive rehabilitation tasks - showing key tasks and key milestones and approximate timing required for each task;
- Availability and management of closure material sources - including topsoil, competent waste rock and subsoil;
- Identification and management of information gaps, including review of monitoring data and other data;
- Key tasks for unexpected closure and temporary closure;
- Decommissioning tasks - including management of contaminated sites; and
- A schedule of work for performance monitoring and maintenance tasks.

The closure work programs developed at the project approval stage may contain broadly identified tasks and indicative timeframe, which will be refined or expanded in the subsequent reviews of the Mine Closure Plan. However, the level of information provided at any stage of the project must demonstrate that for each feature, closure requirements and potential knowledge gaps have been appropriately identified, with adequate lead time being allowed to investigate these gaps and meet those requirements.

The closure work programs need to be reviewed and updated regularly to reflect operational changes and/or new information.

Further explanation on some of the above requirements is provided below:

<u>Research, investigation and trials:</u>
The information obtained from these activities can be used to help close information gaps and determine the most appropriate rehabilitation strategies to proceed with. Research tasks may be a one off task such as undertaking a waste characterisation program of a landform or they may be a series of tasks leading to trials that take years before relevant information is known (for example a trial to ascertain the best cover material for a tailings storage facility).

Progressive rehabilitation:
Progressive rehabilitation involves the staged treatment of disturbed areas during exploration, construction, development and mining operations, as soon as these areas become available, rather than undertaking large scale rehabilitation works at the end of planned exploration and/or mining activities (DERM 1995). This is a key component of mine closure implementation and has many benefits (see Section 3). Mine planning and engineering decision making processes should optimise opportunities for progressive rehabilitation consistent with the post-mining land use(s) and closure objectives.

Progressive rehabilitation activities should be fully integrated into the day to day mining operations to ensure materials and resources are available to undertake the work required, and should include:

- Design of final landforms and drainage structures;
- Estimating, reconciling and scheduling rehabilitation material inventories;
- Staged construction and earthworks;
- Landform surface treatments (ripping, selective application of topsoil, placement of materials);
- Revegetation research and trials;
- Rehabilitation performance monitoring; and
- On-going improvement and refinement of rehabilitation techniques.

Unexpected closure or temporary closure:
Although practical planning for unexpected closure or temporary closure (on care and maintenance) may not be done in detail in the early stages of the project, consideration must be given in the Mine Closure Plans for how a company plans to deal with these closure scenarios which may arise from economic, environmental, safety or other external pressures. In particular, this should include confirmation that appropriate materials are available on site and contingencies provided to make landforms such as tailings storage facilities and waste dumps secure and non-polluting in the event of unexpected or temporary closure.

In such an event, an accelerated closure process will need to be implemented (Section 2.6). If a systematic closure plan is in place, and an unexpected or temporary closure occurs, the operation will be well placed to respond (DEH, 2002).

Decommissioning:
Since the decommissioning phase usually takes place at the end of mine life (Section 2.7), less detail on the strategy and activities on decommissioning of plants and infrastructure may be acceptable in the early stages of the project. As the implementation of mine closure progresses, the detail should be further refined to include information on:

- The demolition and decommissioning of plant and infrastructure;

- Construction of final landforms and drainage structures;
- Completion of rehabilitation;
- Compliance with the requirements of the Contaminated Sites Act 2003 including remediation of contaminated areas;
- Commence monitoring and measurement against completion criteria;
- Ongoing consultation with stakeholders;
- Handover of infrastructure requested by other parties; and
- Finalise the post closure monitoring and maintenance program.

At least two years prior to the planned end of a mine site, project and/ or an operation, DMP or the EPA will require the Mine Closure Plan to contain more specific detail on the planning and implementation of the decommissioning phase.

### 4.14 Closure Monitoring and Maintenance

The Mine Closure Plan must include appropriate detail on closure performance monitoring and maintenance framework during progressive rehabilitation and post-closure, including the methodology, quality control system and remedial strategy.

The performance monitoring results will be reported to DMP or the EPA in an Annual Environmental Report (AER) and/or a Triennial Environmental Report. The report must document progress against the agreed completion criteria and rehabilitation targets. Any remedial action taken where the results are outside the agreed targets must also be reported. Where applicable, the results of rehabilitation trials should also be reported in the AER, and the results should be used to update the Mine Closure Plan. The Guidelines for preparation of an AER are available on the DMP website www.dmp.wa.gov.au.

A preliminary plan for closure monitoring and maintenance may be acceptable in the early stages of the project. As the operations approach closure, DMP will require the Mine Closure Plan to contain a detailed Post-Closure Monitoring and Maintenance Program.

It is important that provision should be made in closure planning for an adequate period of post-closure monitoring and maintenance, including provision for remedial work if monitoring shows closure criteria are not being met. Of particular importance is the development of support mechanisms for the monitoring and maintenance phase, when operational support (accounting, maintenance, earthmoving equipment, personnel, etc) are no longer available from the company (ANZMEC/MCA 2000).

The measurement techniques considered in the program must be able to demonstrate that the site specific completion criteria and environmental indicators have been met (ANZMEC/MCA 2000). Evidence that adequate resources have been set aside to implement the program is required. This will account for the expectation that the monitoring and maintenance period will extend for many years after closure, until it can be demonstrated that closures outcomes and completion criteria have been met. In the early stages of the project or where detailed information on closure performance is not available, a minimum monitoring period after closure should be provided for in the Mine Closure Plans, usually in the order of 10 years.

The closure monitoring and maintenance programs must be designed and implemented to meet the following minimum requirements:

- Use of recognised or acceptable methodologies and standards;
- Recognising the wider receiving environments, receptors and exposure pathways;
- Incorporating appropriate quality control systems and procedures in the sampling, analysis and reporting of results, such as the ISO 9000 quality management system;
- Showing trends against expected or predicted performance based on statistically robust data; and
- Providing intervention and contingency strategies if key environmental indicators move outside agreed parameters.

### 4.15 Management of Information and Data

The Mine Closure Plan must include a description of management strategies, including systems and processes for the retention of mine records and all information and data relevant to mine closure. These records are valuable during the operational phase as well as post-mining to provide:

- A history of closure implementation at the site;
- A history of past developments;
- Information for incorporation into state and national natural resource data bases; and
- The potential for improved future land use planning and /or site development.

Where practicable, the closure information system should contain an information database for each domain or feature, where all available information is collated and reviewed with the objective of building a ‘base’ of information for that particular domain or feature.  Information may include, but not be limited to, the current status of the domain or feature, information from spatial datasets and databases, design and construction information, operation and monitoring information or other information that meets a specific purpose (e.g. maps, area statistics, species lists or modelled environmental impacts).  All technical reports should be referenced and included in the database.

For example, for an existing waste dump domain or feature, an information search should be carried out on all the information available on the waste dump(s), such as the year of construction, angle of batter slopes, waste rock mineralogy types, chemical and physical properties of the waste material, status of rehabilitation, seed mixes used in rehabilitation and any information on trials that have been carried out on the waste dump(s).

Since mine closure planning is a dynamic process which includes regular review and updating, a system-based approach can facilitate management of information, and provide the ability to update documentation, in addition to integrating closure planning with day to day management activities (DEH, 2002).

Electronic systems which incorporate both mine closure planning and an environmental management system functionality can provide an effective tool for managing current closure planning activities, maintaining up to date closure information and data. These systems can hold data in perpetuity, and provide online or static output (information and data) as required.

The value of site knowledge should not be underestimated. It is essential to have a system in place to capture all relevant closure knowledge in the event of key personnel leaving the site. Electronic mine closure systems that can store large amounts of data are suitable for this purpose.

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# List of Appendices

## APPENDIX A: Definitions

When preparing the Mine Closure Plan, it is suggested that the following definitions are used. If you require further clarification please contact your Regional Environmental Officer (see Appendix B).

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| Care and Maintenance | Phase following temporary cessation of mining operations where infrastructure remains intact and the site continues to be managed. All mining operations suspended, site being maintained and monitored. |
| Closure | A whole-of-mine-life process, which typically culminates in tenement relinquishment. It includes decommissioning and rehabilitation. |
| Completion | The goal of mine closure. A completed mine has reached a state where mining lease ownership can be relinquished and responsibility accepted by the next land user (DITR 2006a) |
| Consultation | A process that permits and promotes the two-way flow of ideas and information. Effective consultation is based on principles of openness, transparency, integrity and mutual respect. Implicit in the concept is a requirement that the party consulted will be (or will be made) adequately informed so as to be able to make intelligent and useful responses (http://www.goodpracticeparticipate.govt.nz/levels-of-participation/one-off-consultation/index.html). . |
| DEC | Department of Environment and Conservation. |
| Decommissioning | A process that begins near, or at, the cessation of mineral production and ends with removal of all unwanted infrastructure and services. |
| DoW | Department of Water. |
| Disturbed | Area where vegetation has been cleared and/or topsoil (surface cover) removed. |
| Disturbance Type | A feature created during mining or exploration activity, e.g. waste dumps, haul roads, access roads, ROM, plant site, tailings storage facility, borrow pits, drill pads, stockpiles, office blocks, accommodation village, etc. |
| DMP | Department of Mines and Petroleum Western Australia. |
| Domain | A group of landform(s) or infrastructure that has similar rehabilitation and closure requirements and objectives. |
| Earthworks | Reshaping, capping, water/wind erosion control, rock armouring. |
| Ecologically Sustainable | Meeting the goal and principles of the National Strategy for Ecologically Sustainable Development, endorsed by all Australian |

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|---|---|
| | jurisdictions in 1992, to ensure that development improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. |
| Environment | Living things, their physical, biological and social surroundings and interactions between all of these. |
| EPA | Environmental Protection Authority Western Australia. |
| Environmental Value | A beneficial use and/or an ecosystem health condition. |
| Kinetic testing | Procedure used to measure the magnitude and/or effects of dynamic processes, including reaction rates (such as sulphide oxidation and acid generation), material alteration and drainage chemistry and loadings that result from weathering. Unlike static tests, kinetic tests measure the behaviour of a sample over time. |
| Legal Obligations Register | A register of legally binding conditions and commitments relevant to rehabilitation and closure at a given mine site. |
| Life Of Mine | Expected duration of mining and processing operations. |
| Mineral Processing Facilities | Includes all processing facilities for ore treatment including crushing plants, grinding, vat leach, heap leach, dump leach and tailings disposal facilities. |
| Pits | All open excavations including active mineral rock, gravel, sand, clay, bauxite and salt-pan extraction areas. |
| Post-mining land use | Term used to describe a land use that occurs after the cessation of mining operations. |
| Preliminary Earthworks | Reshaping, capping, water/wind erosion control, rock armouring |
| Project | The total integrated mining operations in which a number of sites contribute to the overall operation to supply ore, processing facilities and disposal of waste products. |
| Rehabilitation | The return of disturbed land to a stable, productive and/or self-sustaining condition, consistent with the post-mining land use. |
| Relinquishment | A state when agreed closure criteria have been met, government “sign-off” achieved, all obligations under the Mining Act removed and bonds retired, and responsibility accepted by the next land user or manager (DITR 2006a). |
| Revegetation | Establishment of self sustaining vegetation cover after earthworks have been completed, consistent with the post-mining land use. |
| Safe | A condition where the risk of adverse effects to people, livestock, other fauna and the environment in general has been reduced to a |

| | |
|---|---|
| | level acceptable to all stakeholders. |
| Stable | A condition where the rates of change of specified parameters meet agreed criteria. |
| Stakeholder | A person, group or organisation who have an interest in a particular decision, either as individuals or representative of a group, with the potential to influence or be affected by the process of, or outcome of, mine closure. |
| Static testing | Procedure for characterising the physical or chemical status of a geological sample at one point in time. Static tests include measurements of chemical and mineral composition and the analyses required for Acid Base Accounts. |
| Tailings Storage Facility | An area used to store and consolidate tailings, and may include one or more tailings storage features. |
| Tenement | Land tenure granted under the *Mining Act 1978* e.g. Mining Lease, Exploration Licence, Prospecting Licence, Miscellaneous Licence and General Purpose Lease. |
| Unacceptable Liability | Closure should not lead to regulators or the community having to take on responsibility for ongoing management, maintenance or monitoring over and above that which applied before mining or that which applied to managing land uses comparable to the agreed land uses. |
| Waste Landforms (or Dumps) | Includes all mullock and waste rock disposal areas (also called Overburden Storage Area, Waste Rock Landform, or Waste Rock Storage/or Area), low grade stockpiles and mineralised waste stockpiles.. |

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## APPENDIX B: Contact Details

Contact details for the Department of Mines and Petroleum Minerals Branch Regions

**South West Team**
*Minerals Manager*
Phone: +61 8 9222 3097
Mineral House
100 Plain Street
EAST PERTH WA 6004

**North West Team**
*Minerals Manager*
Phone: +61 8 9222 3593
Mineral House
100 Plain Street
EAST PERTH WA 6004

**Kalgoorlie Team**
*Environmental Co-ordinator*
Phone: +61 8 9021 9429
Corner of Hunter Street & Broadwood Street
WEST KALGOORLIE WA 6433
Or Locked Bag 405 KALGOORLIE WA 6430

The contacts for environmental officers for particular mineral fields can be found on the Environmental Regional Inspectorate Map at:
http://www.dmp.wa.gov.au/documents/ED_InspectorateMapSeptember2010.pdf

Contact details for other relevant regulatory agencies include:

**Department of Environment and Conservation** Online information provided at www.dec.wa.gov.au select *Contact us*

**Office of the Environmental Protection Authority**
Online information provided at www.epa.wa.gov.au select *Contacts*

**Department of Water**
Online information provided at www.water.wa.gov.au select *Contact us*

## APPENDIX C: Mine Closure Plan Submission

Mine Closure Plans required under the *Environmental Protection Act 1986* must be submitted to the EPA for assessment and approved by the Minister for Environment.

Mine Closure Plans required under the *Mining Act 1978* must be lodged and approved by DMP. Those submitted with a Mining Proposal can be submitted on-line as an attachment to the Mining Proposal application lodgement. For existing operations, Mine Closure Plans can only be submitted in hard copy, with a copy on a CD contained within. This is an interim arrangement until an on-line lodgement system for submission of these plans has been developed (expected to be available in early 2012).

For submission of Mine Closure Plans in hard copy to DMP:

**Two (2) copies to**:
Minerals Branch, Environment Division
Department of Mines & Petroleum
100 Plain Street
EAST PERTH WA 6004

**Or if your project is based in the Goldfields (see inspectorate map):**

**Three (3) copies to:**
Minerals Branch, Environment Division
Department of Mines & Petroleum
Locked Bag 405
KALGOORLIE WA 6433

For further assistance, DMP contact details for each region in Western Australia are given in Appendix B.

## APPENDIX D: DMP Mine Closure Plan Checklist

Please cross reference page numbers from the Mine Closure Plan where appropriate, and provide comments or reasons for No (N) or Not Applicable (NA) answers.

| Q No | Mine Closure Plan (MCP) checklist | Y/N NA | Page No. | Comments |
|---|---|---|---|---|
| 1 | Has the Checklist been endorsed by a senior representative within the tenement holder/operating company? (See bottom of Checklist.) | | | |
| 2 | How many copies were submitted to DMP? (See Appendix C for requirements) | Hard copies =<br>Electronic = | | |
| | **Cover Page, Table of Contents** | | | |
| 3 | Does the cover page include;<br>• Project Title<br>• Company Name<br>• Contact Details (including telephone numbers and email addresses)<br>• Document ID and version number<br>• Date of submission (needs to match the date of this checklist) | | | |
| 4 | Has a Table of Contents been provided? | | | |
| | **Scope and Project Summary** | | | |
| 5 | State why is the MCP is submitted (as part of a Mining Proposal or a reviewed MCP or to fulfil other legal requirements) | | | |
| 6 | Does the project summary include;<br>• Land ownership details;<br>• Location of the project;<br>• Comprehensive site plan(s);<br>• Background information on the history and status of the project. | | | |
| | **Legal Obligations and Commitments** | | | |
| 7 | Has a consolidated summary or register of closure obligations and commitments been included? | | | |
| | **Data Collection and Analysis** | | | |
| 8 | Has information relevant to mine closure been collected for each domain or feature (including pre-mining baseline studies, environmental and other data)? | | | |
| 9 | Has a gap analysis been conducted to determine if further information is required in relation to closure of each domain or feature? | | | |
| | **Stakeholder Consultation** | | | |
| 10 | Have all stakeholders involved in closure been identified? | | | |
| 11 | Has a summary or register of stakeholder | | | |

| Q No | Mine Closure Plan (MCP) checklist | Y/N NA | Page No. | Comments |
|---|---|---|---|---|
| | consultation been provided, with details as to who has been consulted and the outcomes? | | | |
| | **Final land use(s) and Closure Objectives** | | | |
| 12 | Does the MCP include agreed post-mining land use(s), closure objectives and conceptual landform design diagram? | | | |
| 13 | Does the MCP identify all potential (or pre-existing) environmental legacies, which may restrict the post mining land use (including contaminated sites)? | | | |
| | **Identification and Management of Closure Issues** | | | |
| 14 | Does the MCP identify all key issues impacting mine closure objectives and outcomes? | | | |
| 15 | Does the MCP include proposed management or mitigation options to deal with these issues? | | | |
| 16 | Have the process, methodology, and rationale been provided to justify identification and management of the issues? | | | |
| | **Closure Criteria** | | | |
| 17 | Does the MCP include an appropriate set of specific closure criteria and/ closure performance indicators? | | | |
| | **Closure Financial Provisioning** | | | |
| 18 | Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring? | | | |
| 19 | Does the MCP include a process for regular review of the financial provision? | | | |
| | **Closure Implementation** | | | |
| 20 | Does the reviewed MCP include a summary of closure implementation strategies and activities for the proposed operations or for the whole site? | | | |
| 21 | Does the MCP include a closure work program for each domain or feature? | | | |
| 22 | Have site layout plans been provided to clearly show each type of disturbance? | | | |
| 23 | Does the MCP contain a schedule of research and trial activities? | | | |
| 24 | Does the MCP contain a schedule of progressive rehabilitation activities? | | | |
| 25 | Does the MCP include details of how unexpected closure and care and maintenance) will be handled? | | | |
| 26 | Does the MCP contain a schedule of decommissioning activities? | | | |
| 27 | Does the MCP contain a schedule of closure performance monitoring and maintenance activities? | | | |
| | **Closure Monitoring and Maintenance** | | | |

| Q No | Mine Closure Plan (MCP) checklist | Y/N NA | Page No. | Comments |
|---|---|---|---|---|
| 28 | Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance? | | | |
| | **Closure Information and Data Management** | | | |
| 29 | Does the mine closure plan contain a description of management strategies including systems, and processes for the retention of mine records? | | | |
| 30 | Confidentiality | | | |

**Corporate Endorsement:**
"I hereby certify that to the best of my knowledge, the information within this Mine Closure Plan and checklist is true and correct and addresses all the requirements of the Guidelines for the Preparation of a Mine Closure Plan approved by the Director General of Mines.

**Name**: ________________________ **Signed**: ________________________

**Position**: ______________________ **Date**: ________________________

(NB: The corporate endorsement must be given by tenement holder(s) or a senior representative authorised by the tenement holder(s), such as a Registered Manager or Company Director)

# APPENDIX E: Example of a Legal Obligations Register

**MINE NAME – Legal Compliance Register**

**Relevant DMP Tenement Conditions**

| Tenement No. | Condition No. | Closure Conditions |
|---|---|---|
| | | |
| | | |
| | | |

**Ministerial Statement (No and Date)**

| Condition No. | Date | Closure Condition |
|---|---|---|
| | | |
| | | |
| | | |

**Ministerial Statement (No and Date)**

| Commitment | Closure Condition |
|---|---|
| | |
| | |
| | |

**Works Approval (No and Date)**

**Relates to Tenement No**

| Condition | Aspect related to Closure |
|---|---|
| | |
| | |
| | |

***Environmental Protection Act 1986*** **Licence No: Category:**

| Condition No. | Date | Aspect related to Closure |
|---|---|---|
| | | |
| | | |
| | | |

## APPENDIX E: Example of a Legal Obligations Register (cont'd)

| **Licence to Take Water - GWL No** | | |
|---|---|---|
| **Tenement** | **No.** | **Condition** |
| | | |
| | | |
| | | |

| **NOI /Mine Proposal** | |
|---|---|
| **Document Name and Relevant Tenements** | |
| **Page No.** | **Closure Commitment** |
| | |
| | |
| | |

(may be numerous sections – related to each approval document)

| | **Non Legally Binding Commitments and Promises (letters, references, records and documents)** |
|---|---|
| **Document Name- No.** | |
| | **Closure Commitment** |
| | |
| | |
| | |

# APPENDIX F: Example of Stakeholder Consultation Table

| XYZ Mining - Stakeholder Consultation Register 2010 | | | | | |
|---|---|---|---|---|---|
| Date | Description of Consultation | Stakeholders | Stakeholder comments/issue | Proponent Response and/or resolution | Stakeholder Response |
| | | | | | |
| 2010 - ongoing | Quarterly meetings | Traditional owners | Concern that water in a nearby spring may be being contaminated with lead | Identifying and securing lead contaminated materials. Monitoring quality and quantity of the spring water. Remedial action as required. Health testing and keep the traditional owners informed | Acceptable |
| | | | | | |
| date | Meeting to discuss potential post-mining land uses | Pastoralist neighbour | Concerns about any hole or pit to be left behind after mining | Will include in closure design and provision practical measures to make safe (to human and animal) any hole or pit left after mining | Acceptable |
| | | | | | |
| 2010 - ongoing | Periodic meetings to discuss post-mining opportunities | Local Shire | Ongoing relationship with regular communication to explore potential uses of rehabilitated mine feature or infrastructure to be left after mining that would be of benefit to community | Continued open dialogue | N/A |
| | | | | | |

## APPENDIX G: Examples of Closure Objectives

The following examples are provided to illustrate the types of closure objectives and should not be used as acceptable standard, or used as ”cut-and-paste” templates. Each operation will need to develop its own site-specific set of objectives.

**Compliance**

- The disturbed mining environment shall be made safe; and closure requirements of the regulatory authorities are to be met.
- All legally binding conditions and commitments relevant to rehabilitation and closure will be met.

**Landforms**

- Constructed waste dumps will be stable and consistent with local topography.
- Constructed Tailings Storage Facilities will be non-polluting and toxic or other deleterious materials will be permanently encapsulated to prevent environmental impacts.
- Surface water bodies shall not be left in mining voids unless operator demonstrates there will be no significant environmental impact (such as salinisation, reduction in water availability, toxicity, algal problems, attraction to pest species or a local safety hazard).
- Any boreholes, mine shafts, costeans, ventilation shafts or similar below ground excavations filled in or sealed unless demonstrated as necessary to support an end land use.

**Revegetation**

- Vegetation in rehabilitated areas will have equivalent values as surrounding natural ecosystems.
- The rehabilitated ecosystem has equivalent functions and resilience as the target ecosystem.
- Soil properties will be appropriate to support the target ecosystem.

**Fauna**

- Rehabilitated areas provide appropriate habitat for fauna
- Fauna utilisation, abundance and diversity appropriate to specified post-mining land use.

**Water**

- Surface and groundwater hydrological patterns/flows not adversely affected.

- Surface and groundwater levels and quality reflect original levels and water chemistry.
- Any water runoff or leaching from tailings dams, overburden dumps and residual infrastructure shall have quality compatible with maintenance of local land and water values.
- There shall be no long term reduction in the availability of water to meet local environmental values.

**Infrastructure and Waste**

- During decommissioning and through closure, wastes will be managed consistent with the waste minimisation principles;
- No infrastructure left on site unless agreed to by regulators and post mining land managers/owners;
- Disturbed surfaces rehabilitated to facilitate future specified land use.
- The location and details of any buried hazards will be clearly defined and. robust markers be installed and maintained.

## APPENDIX H: Specific mine closure issues

This appendix provides a general overview of some specific mine closure issues. The information provided here is by no means exhaustive. Further, not all issues will be relevant for all mine sites and, at a particular mine site, there may be additional challenges to mine closure not considered here. Technical advice should be sought from appropriately qualified experts and/or regulators in relation to identification and management of issues at any particular site.

As a guide, a generic decision framework for some of the specific closure issues is provided in Figure H.1 below (adapted from ELAW 2010).

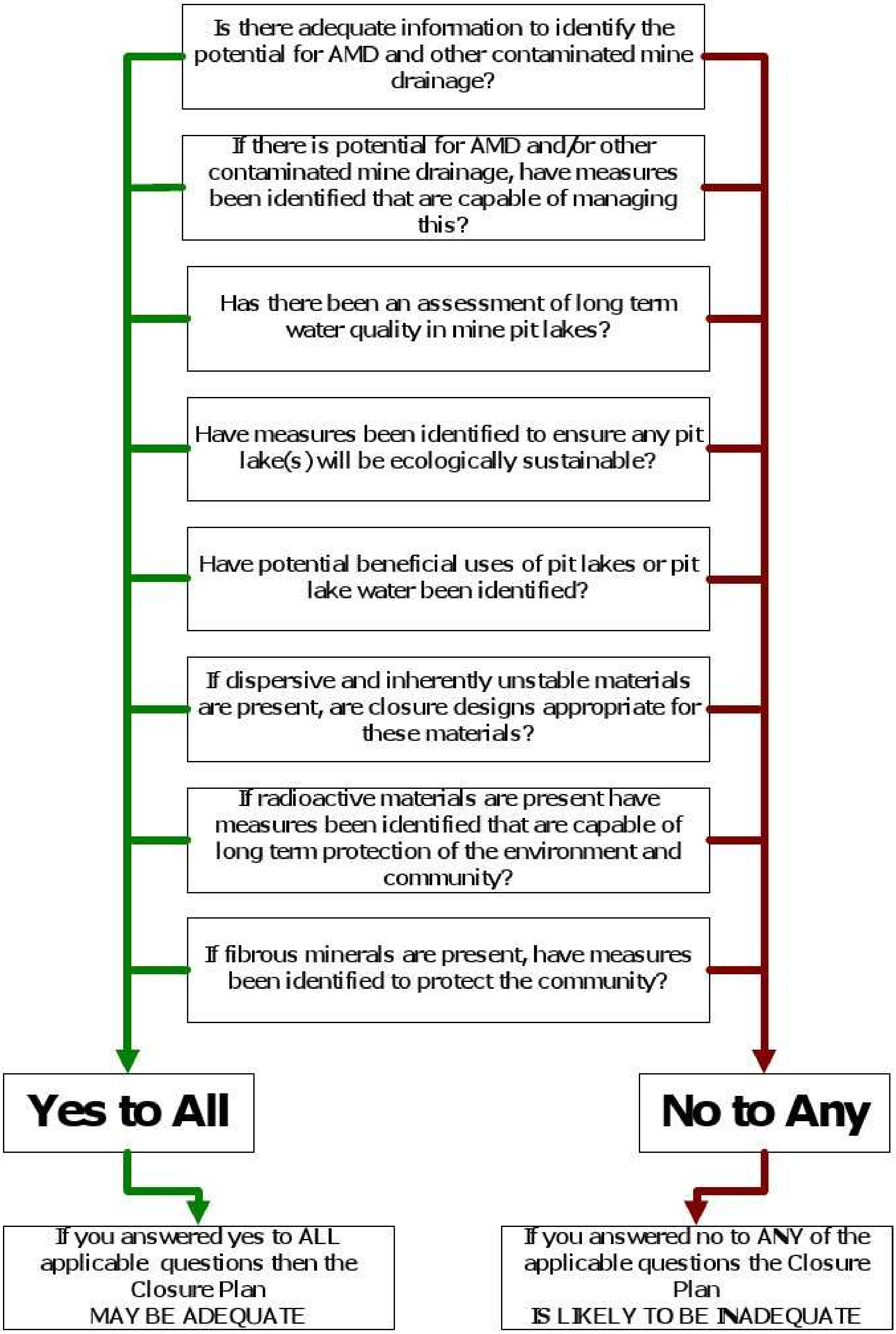


Figure H.1: Decision path for some specific closure issues(adapted from ELAW 2010).

## **Acid and metalliferous drainage[1]**

Internationally and in Australia, acid and metalliferous drainage (AMD) is recognised as one of the most serious environmental issues associated with mining. The website of the International Network for Acid Prevention (an international research initiative funded by the mining industry) notes that:

> *"Acid drainage is one of the most serious and potentially enduring environmental problems for the mining industry. Left unchecked, it can result in such long-term water quality impacts that it could well be this industry's most harmful legacy. Effectively dealing with acid drainage is a formidable challenge for which no global solutions currently exist."* (http://www.inap.com.au accessed 2 March 2008).

The Australian national leading practice handbook on AMD (DITR 2007) states that:

> *"At decommissioned and older operating mines sites where acid and metalliferous drainage characterisation and management has been poor, high remediation and treatment costs continue to impact on the profitability of mining companies. The term "treatment in perpetuity" has entered the mining vernacular as a result of intractable Acid and Metalliferous Drainage issues that prevent the relinquishment of mining leases, despite the closure of mining operations. Such situations are inconsistent with sustainable mining and must be avoided."*

Acid and metalliferous drainage from old mine sites can cause ongoing pollution lasting for centuries or even millennia. For example Bronze Age mining of sulphide deposits 5000 years ago is still causing pollution of the Rio Tinto River in Spain (Davis *et. al.* 2000).

A recent detailed review of the reliability of water quality predictions in environmental impact assessments for hard rock mine proposals in North America (Kuipers *et al* 2006) concluded that **the actual impacts of mining on water quality are nearly always significantly underestimated in the environmental assessment process**. The review concluded that:

> *"Lack of adequate geochemical characterisation is the single most identifiable root cause of water quality prediction failures. Improvements in geochemical characterisation can provide the greatest contribution to ensuring accurate water quality predictions at hardrock mine sites…"*

and that:

> *"... more extensive information on mineralogy and mineralisation should be included in EISs, and more attention should be paid to uncertainties in geochemical and hydrologic characterisation."*

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[1] The term acid and metalliferous drainage or AMD is preferred instead of the older term acid mine drainage in order to emphasise that contaminated mine drainage may consist of acid drainage and/or metalliferous drainage.

It is also important to stress that, in assessing the potential for acid generation, caution needs to be exercised in relying on limestone to neutralise acid drainage because of the phenomenon of armouring (i.e. the limestone becoming coated with non-reactive material) which results in rapid loss of neutralising capacity (Hammarstrom *et al* 2003).

Metalliferous drainage

In addition to acid drainage, it is important to note that metalliferous drainage from mine sites can have serious environmental impacts. Metalliferous drainage can occur under circum-neutral or basic conditions. Trace metals such as zinc, cadmium and copper which may occur in mine drainage are toxic at extremely low concentrations and may act synergistically to suppress algal growth and affect fish and other aquatic life (DITR 2009).

Cadmium is a substance of particular concern. Research in North America has shown that cadmium can cause serious effects on wildlife populations by causing bone necrosis, kidney disease and death (Larison *et. al.* 2000). Overseas, particularly in Japan, there are well documented historical cases of cadmium pollution from mine sites causing severe human health impacts (Jarup L 1998).

Other contaminated mine drainage

Selenium is another substance of particular concern which may occur in contaminated mine drainage. Selenium rapidly bio-accumulates and causes reproductive failure in fish (Lemley A D 1996 and 2004) and teratogenic effects (birth deformities) in water birds (Lemley A D 1996 and 2004). The North American guidelines for assessment of selenium risks associated with mining (Lemley A D 2007) describe the ecological effects of selenium as follows:

> *"Once in the aquatic environment, it [selenium] can accumulate and reach levels that are toxic to fish and wildlife…Impacts may be rapid and severe, with teratogenic deformities and reproductive failure eliminating entire communities of fish and causing total reproductive failure in local populations of aquatic birds…Few environmental contaminants have the potential to affect aquatic resources on such a broad scale, and even fewer exhibit the complex aquatic cycling pathways and range of toxic effects that are characteristic of selenium…"*

Common misconceptions about AMD

A common misconception is that rock with total sulphur values less than 0.3 percent does not pose a water quality risk. However a recent review by Rio Tinto (Richards *et al* 2006) of AMD risk at its mines noted that:

> *"…at several Rio Tinto mines, acidification risks have been noted, and special handling has been implemented, for materials at sulphur values as low as 0.05 percent, especially where there are special conditions in receiving environments."*

Another common misconception is that metalliferous drainage and acid mine drainage are one and the same thing and that, if there is no potential for acid drainage, there will be no metalliferous drainage. However it is important to note that metalliferous drainage, which may include elevated levels of substances such as cadmium or selenium, may occur under alkaline or near-neutral conditions, that is, in the absence of acid drainage (INAP 2009). For example a study by the US Geological Survey (US Geological Survey 2007) documented near-neutral drainage of selenium from coal mines in the Appalachian region. The study noted that inorganic sulphur or pyrite levels were not an indicator of selenium leaching hazard – that is, standard acid-base accounting static tests would not provide an adequate assessment of the selenium problem. Another study by the US EPA and the University of Idaho (Ryser and Strawn 2005) looked at leaching of selenium from shale and other rock types associated with phosphate deposits. This work showed that selenium was associated with pyrite, organic matter and silicate materials in the shale. The authors noted that selenium would leach most rapidly when pyrite was present, but selenium leaching in the absence of pyrite could not be excluded. Further, depending on the characteristics of the receiving environment, other forms of “non-acid” drainage may cause harm to the environment. For example, research by the Australian Commonwealth agency the Office of the Supervising Scientist (Jones et. al. 2009, van Dam et al 2009) found that the leaching of magnesium from waste rock could cause environmental harm to “soft” water wetlands which are naturally low in calcium and magnesium. This issue was unexpected and would not be detected by standard static testing and risk assessment.

Identification of AMD

The Australian national leading practice handbook on AMD (DITR 2007) states that, for the purpose of approvals:

> *“A mine closure plan must be developed and seen to be workable and convincing.”* (DTIR 2007 page 18).

The leading practice handbook also stresses that it is critical that sampling for geochemical testing be representative of geological materials at the project site (including country and host rock) and provides further specific information on sampling procedures (including sample sizes and maximum intervals between drill holes).

Consistent with that approach, if the geology of the area is such that acid and/or metalliferous drainage may be an issue, the results of appropriate geochemical testing and risk assessment for *both* acid drainage *and* metalliferous drainage (noting that metalliferous drainage can occur in the absence of acid drainage) must be presented upfront at the approval stage. Current state-of-the-art methods of geochemical testing and risk assessment are set out in the US AMD handbook (Maest *et al* 2005), and the international AMD handbook known as the “GARD Guide” (INAP 2009). State-of-the-art methods for assessing selenium risks associated with mining proposals are set out in the US selenium hazard assessment guidelines (Lemley A D 2007). **It is essential to note that AMD risk cannot be assessed based purely on potential to produce acid. As noted**

**above, metalliferous drainage can occur under near neutral or alkaline conditions.**

Geochemical testing is time consuming, as noted in the Australian national leading practice handbook:

> *"Kinetic leach tests need to operate for at least 6 months and typically 12 to 24 months before sufficient data are available for effective interpretation of the AMD characteristics of a material. Longer time frames may be involved for evaluating the performance of specific treatments or soil/rock blends."* (DITR 2007 page 36).

AMD characterisation work should begin to be carried out during the exploration stage, and that a risk based approach is taken in the identification and detailed assessment of AMD issues. To avoid the need to carry out extensive additional drilling for AMD risk assessment and possible delay in environmental approval processes, representative geochemical test work (geochemical characterisation, static testing and, where warranted, kinetic testing) should be completed for all materials to be mined *prior* to submitting the project for environmental approvals. **.**

If testing shows there is a significant risk of acid, metalliferous, seleniferous or saline drainage, the proponent should demonstrate in the Closure Plan at the approval stage that the proposed management strategy will provide a sustainable closure solution. This includes sustainable closure of mine rock waste dumps, tailings facilities and mine pit lake(s).

<u>Mine dewatering</u>

The risk of generating AMD through the mine dewatering process also needs to be assessed and managed appropriately. AMD can be generated through dewatering because, as the water table is lowered, chemical changes can occur as rock strata dry out, resulting in acid and/or metalliferous drainage being generated.

<u>Management of AMD</u>

It is strongly recommended that proponents refer to the Global Rock Drainage Acid Guide (INAP 2009) for detailed guidance on characterisation, prediction, management and treatment for AMD.

Figure H.2 (adapted from ELAW 2010) provides a generic framework for managing AMD, which also applies to other contaminated mine drainage including seleniferous drainage.

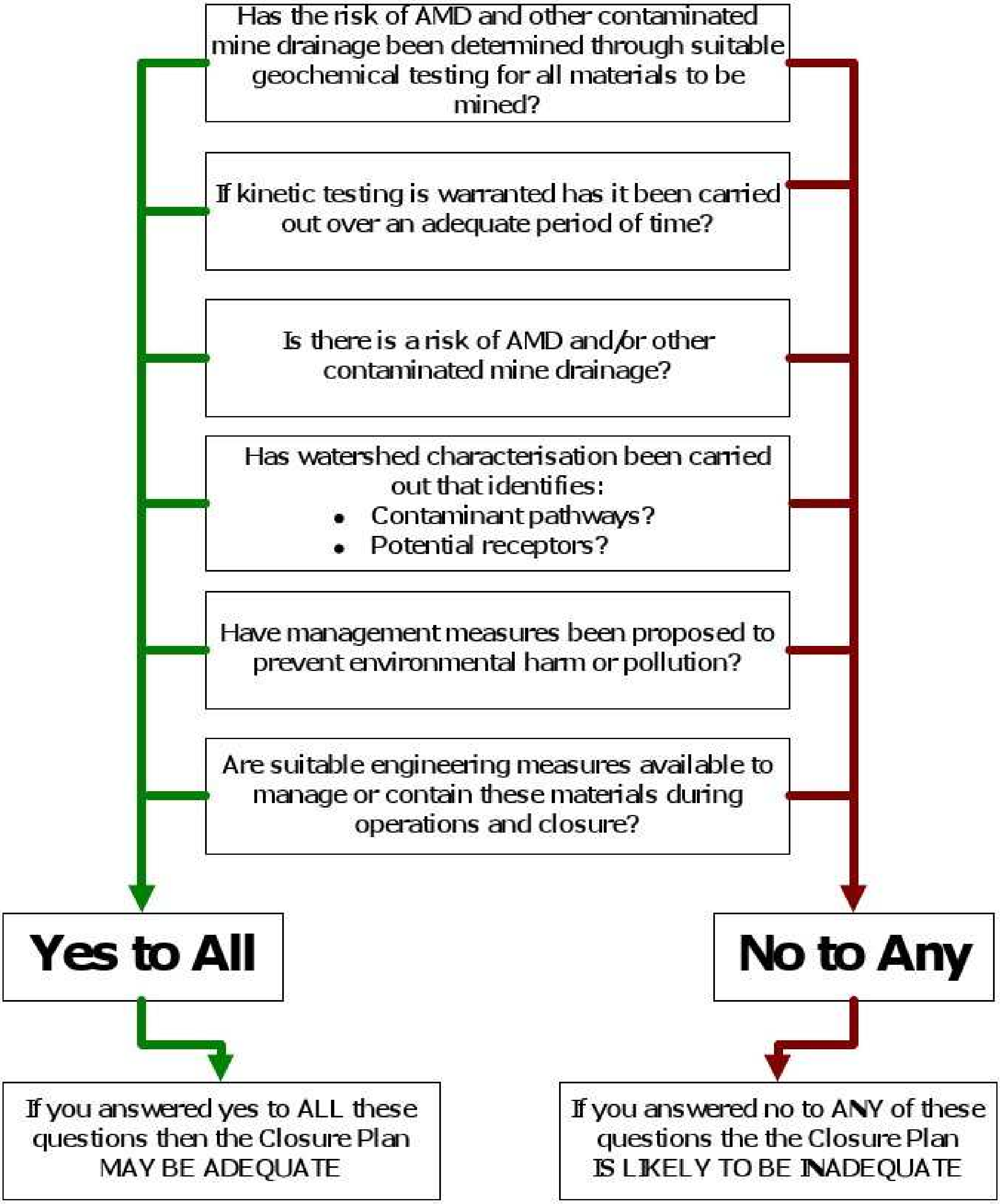


Figure H.2: Decision path for managing AMD and other contaminated mine drainage including seleniferous drainage (adapted from ELAW 2010).

**Mine pit lakes**

Table H.1 (page 58) summarises some closure considerations for mine pit lakes.

Assessments of pit lake closure options should be risk-based, taking into account the specific characteristics of the site (including hydrogeological and environmental conditions) and potential for both negative impacts and beneficial uses. It is expected that proponents will provide information necessary to allow an objective assessment of the future chemistry of pit lakes.

In addition to the issues to be considered in Table H.1, human safety (public risk) will be a key issue for consideration where a pit lake is to be retained.

The potential economic value of any remaining mineralisation should also be considered before a decision is made to backfill open mine pits. A sterilisation report should be submitted to DMP where any resources are likely to be sterilised by infilling of a pit. A copy of the "Sterilization report submission form for In-pit waste/tailings disposal proposals" is available on the DMP website (http://www.dmp.wa.gov.au/documents/SterilizationReport.doc). The form is not required for shallow deposits such as mineral sands, bauxite or nickel laterite where resources are not likely to be sterilised.

More detailed information on mine pit management is provided in a document titled *Mine Void Water Resource Issues in Western Australia* (Johnson & Wright 2003), and a copy is available on the DoW website (http://www.water.wa.gov.au/PublicationStore/first/42100.pdf).

Further information on ecological risk assessment for mine pit lakes can be found in the document *Ecological Risk Assessment Procedures for Open Pit Mine Lakes in Nevada* (available at www.blm.gov/nv/st/en/prog/minerals/mining.print.html).

Table H.1: Some closure considerations for mine pit lakes

| Pit lake scenario | Potential groundwater impacts | Potential biological impacts[1] | Closure options |
|---|---|---|---|
| **Saline pit lake surrounded by saline groundwater.** | Significant groundwater impacts unlikely. | In northern areas subject to monsoon rains, a layer of fresh water may form seasonally on the lake surface. Depending on the nature of the surrounding environment, this may attract grazing animals (stock, kangaroos), which may lead to overgrazing of vegetation, erosion and/or loss of native fauna habitat.<br><br>In addition, goats may be attracted even to saline water[2], also leading to overgrazing / erosion/habitat degradation. | Assess on case-by-case basis (Include consideration of any potential beneficial uses). |
| **Pit lake will progressively become saline through evaporation.** | Case 1: Groundwater sink<br><br>Rate of evaporation exceeds groundwater inflow (pit lake will be a groundwater sink).<br><br>Significant groundwater impacts unlikely. | Grazing animals (stock, kangaroos) may be attracted to the pit lake in the years before it becomes saline. Depending on the nature of the surrounding environment, this may cause overgrazing of vegetation, erosion, and/or loss of native fauna habitat.<br><br>In addition, goats may be attracted even to saline water[2], also leading to overgrazing / erosion / habitat degradation. | Assess on case-by-case basis (Include consideration of any potential beneficial uses). |
| | Case 2: Flow-through cell<br><br>Ground water inflow-exceeds evaporation. Pit lake will act as a “flow-through cell” forming potential environmental hazards with saline plumes moving out of the void and affecting other groundwater resources. | Grazing animals (stock, kangaroos) may be attracted to the pit lake in the years before it becomes saline. Depending on the nature of the surrounding environment, this may cause overgrazing of vegetation, erosion, and/or loss of native fauna habitat.<br><br>In addition, goats may be attracted even to saline water[2], also leading to overgrazing / erosion / habitat degradation. | Assess on case-by-case basis (Include consideration of any potential beneficial uses).<br><br>If impacts on surrounding groundwater resources assessed to be significant and cannot be otherwise mitigated effectively, possible closure options are:<br><br>• Backfill pit to above final water table; and/or<br>• Collapse pit walls to cover bottom of pit to above final water table. |

| Pit lake scenario | Potential groundwater impacts | Potential biological impacts | Closure options |
|---|---|---|---|
| **Contaminated pit lake** (Acid, alkaline, elevated metals or metalloids) | Possible contamination of surrounding groundwater. | Sickness or death of stock, native animals or birds which come in contact with the pit water.<br><br>Possible danger to humans who come in contact with lake water. | Leaving a contaminated pit lake after closure is not a sustainable practice.<br><br>Closure and remediation options will need to be assessed on a case-by-case basis. |
| **Pit lake with good quality uncontaminated water** (evaporation rate not sufficient to cause lake to become saline) | No impacts on groundwater quality. | Potential for attracting grazing animals (stock, kangaroos) leading to overgrazing of surrounding vegetation / fauna habitat needs to be assessed. | Retain for beneficial uses (water supply, recreation, aquaculture) provided that negative impacts from attraction of grazing animals (if this is a significant issue) can be managed effectively on an ongoing basis |

**Notes:**

[1] Consideration also needs to be given to the potential for pit lakes to act as breeding areas for mosquitoes, including risk of spread of mosquito-borne diseases. If mosquitoes are likely to be a significant issue, proponents will need to make arrangements for ongoing management.

[2] Goats prefer saline water with up to 12,500 mg/l total dissolved solids compared with freshwater. Goats adapted to saline water appear to be able to tolerate higher levels of salt than sheep and can live on seawater (McGregor, BA 2004, *Water quality and provision for goats*, Rural Industries Research and Development Corporation, Australian Government, Canberra.)

## Radioactivity

For uranium mines, as well as other types of mines where radioactivity may be an issue (for example mineral sands mines), management of radioactivity will be one of the key considerations for closure planning.

### Radiation Management

During any stage of closure planning, radiation management should demonstrate compliance with the two important guiding principles in radiation protection, the “as low as reasonably achievable” or ALARA principle and the “best practicable technology” principle. These principles have been defined by the International Commission on Radiological Protection (ICRP), endorsed by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and adopted in WA radiation protection legislation:

- *"The ALARA principle has the meaning stated in Clause 117 of ICRP Publication 60 (ICRP 1991, p.29, Item 4.3.2). The broad aim is to ensure that the magnitude of the individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received, are all kept as low as reasonably achievable, economic and social factors being taken into account".*
- *"'best practicable technology' is that technology available from time to time, and relevant to the project in question, which produces the minimum occupational doses, member-of-public doses both now and in the future, and environmental detriment that can be reasonably achieved, economic and social factors taken into account"*.

It should be noted that the current system of radiation protection has been based on human health considerations because it is generally believed that the standard of environmental control required for protection of people will ensure that other species are not put at risk (ARPANSA 2002 & 2005). Notwithstanding this, the ICRP (ICRP 2007) recommended that "*it is necessary to consider a wider range of environmental situations, irrespective of any human connection with them"*. ARPANSA is currently examining the recommendations of ICRP on radiological protection of non-human species (ICRP 2008) and applicability to the Australian uranium mining context (ARPANSA 2010).

In WA, the *Radiation Safety Act 1975*, administered by the Radiological Council, regulates all aspects of radiation protection including the transport of radioactive materials. In addition, there are radiation protection controls placed on the mining industry, through Part 16 of the *Mines Safety and Inspection Regulations 1995*. A Radiation Management Plan must be prepared and submitted for approval by the State mining engineer (unless a written exemption is obtained). The Radiation Management Plan must include a Radioactive Waste Management Plan (RWMP) and "*an outline of the proposal for the eventual decommissioning and rehabilitation of the mine*" (regulation 16.7).

The objective of a RWMP is "*to ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations*" (ARPANSA 2005). In designing and planning for mine closure, the RWMP should be developed in conjunction with the overall project environmental management plan and use a risk based approach (DRET/GS/DEWHA 2010). The RWMP should also demonstrate the application of the "ALARA" and "best practicable technology" principles (ARPANSA 2005).

Before mining operations commence, the results of an approved baseline environmental radiation monitoring program must be submitted to the relevant regulators. The establishment of the 'baseline' conditions is an important part of the development of a RWMP:

"*A monitoring program designed to evaluate baseline conditions should be developed in conjunction with the relevant regulatory authority. It is important that it be commenced early enough to allow seasonal variations in pre-existing conditions to be evaluated prior to commencement of the project. These 'baseline' conditions should be established prior to any collection of significant amounts of radioactive material through ground disturbance exercises"* (ARPANSA 2005).

The development of an environmental radiation monitoring program, including the "baseline" monitoring program, is essential to identify potential and critical radionuclide (and chemical) pathways by which the environment and humans may be affected during mining and post-mining (IAEA 2002). Such monitoring as is needed to verify the effectiveness of engineering design, to validate models and predictions, and to demonstrate compliance with discharge limits and operational discharge procedures (ARPANSA 2005). The RWMP, which includes appropriate radiation monitoring programs, must be referenced in the Mine Closure Plan.

Before abandoning a mining operation, a plan for the final management of radiation at the mine, including details of decommissioning and final rehabilitation must be submitted to the relevant regulators. This plan must be referenced in the Mine Closure Plan submitted prior to decommissioning.

It should be noted that after the mine is abandoned, rehabilitation sites are inspected and monitored at such intervals and in such a way as is approved by the relevant regulators. This requirement must be incorporated in the development of the post- closure monitoring program and referenced in the Mine Closure Plan as appropriate.

The post-mining environmental radiation level should not result in discernable changes to the baseline conditions and should preserve any environmental value or beneficial use that supports the agreed post-mining land use(s).

Detailed information on radiation management in mining is provided in the WA *Guidelines on Naturally Occurring Radioactive Material (NORM) in Mining and Mineral Processing* (or WA NORM Guidelines), available on DMP website (http://www.dmp.wa.gov.au/836.aspx). The WA NORM Guidelines provide a comprehensive set of guidelines for the management of NORM radiation, including guidelines for preparation of a radiation management plan, guidelines on radiation monitoring, radiation dose assessment and reporting, and guidelines on management strategies for radioactive dust and waste.

Best Practice Uranium Mining:

The World Nuclear Association (WNA) provides the following principle for decommissioning and site closure (principle 11):

*"In designing any installation, plan for future site decommissioning, remediation, closure and land re-use as an integral and necessary part of original project development. In such design and in facility operations, seek to maximize the use*

*of remedial actions concurrent with production. Ensure that the long-term plan includes socio-economic considerations, including the welfare of workers and host communities, and clear provisions for the accumulation of resources adequate to implement the plan. Periodically review and update the plan in light of new circumstances and in consultation with affected stakeholders. In connection with the cessation of operations, establish a decommissioning organisation to implement the plan and safely restore the site for re-use to the fullest extent practicable. Engage in no activities – or acts of omission – that could result in the abandonment of a site without plans and resources for full and effective decommissioning or that would pose a burden or threat to future generations".*

The International Atomic Energy Agency (IAEA) has also published guidelines on sustainable development principles (IAEA 2009) and best practice principles (IAEA 2010) specific to uranium mining, based on global experience. Designing and planning for closure through an integrated and iterative process is a key to sustainable development (IAEA 2009, Section 2). Guidance on best practice application in environmental management and mine closure planning includes baseline data collection, stakeholder involvement, impact assessment, risk assessment, designing for closure and waste management (IAEA 2010, Section 3).

The Commonwealth guide "Australia's In Situ Recovery Uranium Mining Best Practice Guide: Ground waters, Residues and Radiation Protection" (DRET/GS/DEWHA 2010) outlines best practice principles and approaches to in situ recovery (ISR) or in situ leach (ISL) uranium mining, including guidance on best practice mine closure and site rehabilitation (Attachment 1, page 18-21). The majority of these principles would be applicable to uranium mining by traditional mining techniques (underground and open cut).

The best practice principles and approaches outlined in the above references are consistent with the principles of the *Strategic Framework for Mine Closure* (ANZMEC/MCA 2000), and should be incorporated in mine closure planning and the preparation of Mine Closure Plans for uranium mining and processing operations.

## **Dispersive Materials**

The information in this section is based on a study report coordinated by the then Australian Centre for Mining Environment Research (C.A Vacher et al, 2004).

Note that the information provided here focuses on soil properties and may not be applicable to crushed rock materials. Specific advice should be sought from a suitably qualified expert in relation to identification and management of dispersive materials at any particular mine site.

Ensuring that constructed landforms have adequate resistance to erosion is a major component of mine site rehabilitation works. The presence of soil materials susceptible to tunnelling or piping has large impacts on landform stability and rehabilitation. In general, the development of tunnel erosion has been attributed to the presence of dispersive soils or mine wastes. Tunnel erosion can lead to gully erosion being the dominant erosion mechanism, leading to the failure of engineered structures aimed at controlling erosion. The presence of tunnel erosion also typically means that site remediation and stabilisation are extremely difficult, and that erosion problems are likely to be particularly persistent.

Dispersion occurs when the individual particles in a soil are separated from each other when excess water is supplied. Soils containing high levels of exchangeable sodium ($Na^+$), known as 'sodic' soils, are widely recognised to be particularly susceptible to dispersion. Saline soils may initially be non-dispersive, but continued leaching of the contained salts can result in the material becoming dispersive over time. Application of saline water (e.g. for dust suppression) on non-dispersive soils can also result in the material becoming dispersive over time.

Materials susceptible to tunnelling fall into three groups:

- saline sodic;
- non-saline sodic; and
- fine, non-sodic materials of low cohesive strength.

Dispersion tests are the most useful laboratory tests for identifying the susceptibility of a soil to tunnelling, though it should be noted that tunnel formation is not entirely confined to dispersive materials.

There are strong interactions between the design of constructed landforms and the development of tunnel erosion. Water ponded on saline sodic materials can result in: the leaching of salt by the ponded water; reduced soluble salt; increased dispersion, followed by development of tunnel erosion. For non-cohesive materials, long durations of ponding are also a major factor in developing tunnel erosion.

In order to predict the mid to longer term performance of landforms ('as mined' materials can have properties that change after placement in landforms), it is essential that the inevitable micro-structural, chemical and mineralogical evolution of wastes can be predicted and the impact of these changes on erosion hazard determined. Initial soil parameters that provide information on tunnel erosion potential are:

i) Electrical Conductivity (EC) to assess potential salinity constraints on dispersion;

ii) Exchangeable cations, with particular emphasis on exchangeable sodium percentage (ESP) to assess dispersion potential;

iii) Potentials for slaking and dispersion (Emerson test);

iii) Particle size distribution (to provide an indication of soil cohesion and liquefaction contributions to tunnel formation/failure); and

iv) Clay mineralogy (for swelling influence).

Based on the data obtained, a judgment can be made on which subsequent tests are most appropriate. Leaching column tests provide a good indication of the hydraulic conductivity of a material and of its potential for sealing or blockage of soil pores to occur. Erodibility measurements provide an indication of the potential for continued development of tunnels (and tunnel gullies). Characteristics contributing to high erodibility are also factors in the initiation (dispersive and poor structural strength nature) and potential progression and severity of tunnelling when it has occurred.

The best management option available to mine sites that excavate materials susceptible to tunnelling is to avoid the problem, by ensuring that those materials are not exposed to ponded runoff or through drainage. Therefore, the importance of early diagnosis of potential tunnelling problems and adoption of strategies to prevent such long-term instability is essential for successful mine closure.

## Rehabilitation

The Closure Plan should demonstrate that closure planning is being carried out to optimise rehabilitation outcomes, consistent with the proposed post-mining land use. This will include:

- Demonstrating that suitable land forms, soil profiles and soil characteristics will be reinstated consistent with the proposed final land use; and
- Demonstrating that any risk of uptake of toxic materials by vegetation or pasture will be managed to avoid harm to native animals or stock which may feed on the vegetation or pasture.

EPA guidance note No. 6 *Rehabilitation of Terrestrial Ecosystems* (EPA 2006) sets out the EPA's general expectations about re-establishing biodiversity values where a site is to be rehabilitated back to native vegetation. Guidance note No. 6 is particularly relevant to rehabilitation of mine sites in cases where the requirement is to reinstate high quality native vegetation as close as possible to that which existed prior to mining.

For more general information on mine rehabilitation, including environmentally sustainable design of artificial landforms, proponents should refer to the leading practice handbook (DITR 2006b).

The following information has been provided by Professor K W Dixon (Kings Park and Botanic Garden in WA), as a guide towards leading practice in mine site rehabilitation where the objective is to return land to native vegetation. Approaches to successful rehabilitation are rapidly evolving in WA, and companies are encouraged to keep abreast of current research and development advances in this field.

A key to the successful creation of compliant post-mining rehabilitation is the incorporation of rehabilitation considerations from the commencement of exploration through to mine closure - the “whole of mine life” approach, and maximising available resources particularly topsoil, seed and soil substrate (growing medium).

The rehabilitation of sustainable native vegetation communities using local species requires consideration of a number of key components including identifying the community’s constituents and their attributes, and identifying abiotic (soil, geology, hydrology, aspect, topography, micro-niche) conditions necessary for the establishment and persistence of the community.

Biotic components in rehabilitation after mining include optimising use of available plant (topsoil, seed and plants) and soil substrate (plant growth medium and parent material).

*Species and community identification – vegetation surveys*

Information that is necessary for benchmarking and establishing species/community rehabilitation targets should include:

- A full list of species for the impacted area and associated communities.
- Clear delineation of communities, including species whose presence / absence or variation in abundance defines each community.
- The appropriate spatial scale at which to assess communities.
- The range of variation for species richness and cover that can be expected.
- The relative abundance of the most important species in each community.
- Post-rehabilitation monitoring to inform operators of the level of success in re-establishing appropriate plant communities and to assist in the refinement of rehabilitation procedures.

*Topsoil*

Soil seedbanks have many advantages as sources of material for rehabilitation, they are species rich, genetically representative of original populations, and may be relatively easy to manage if standards (see below) are adhered to. Topsoil is therefore a vital and highly effective medium for restoring terrestrial ecosystems in WA. Research has demonstrated that the following key standards are critical for effective use of topsoil to <u>maximise</u> soil seedbank retention, seedling germination and seedling establishment:

- Stripping: seeds of native species mostly reside in the top 10cm. Thus stripping should focus on retrieving this layer to a maximum depth of 20cm (due to technical limitations).
- Timing of stripping: always strip dry soil and ensure soil remains dry at all times including transfer, storage and replacement phases.
- Topsoil storage: dry topsoil piles can be maintained with effective biodiverse capability in windrows or bins with height likely to be substantially higher than 2m based based on emerging research. Covering (tarping) topsoil to retain it in a dry state is critical otherwise wetting will

tripper germination and subsequent anaerobic conditions will substantially decrease the effectiveness of the topsoil.

- Topsoil spreading: replace topsoil at the depth appropriate to emergence capability of seeds – and no greater than 5cm as most native seeds cannot emerge from depths greater than 5cm (optimum is 1-2cm).

*Growth Medium*

For most mine sites there will be a deficit in growing medium that will need to be met by investigating the use of waste mine materials to support plant establishment. Plant growth and function is therefore an appropriate indicator of potential long-term sustainability of rehabilitation sites. The growing medium for rehabilitated sites should reflect the functional nature of the pre-mined landscape and provide:

- Seasonal groundwater dynamics allowing for comparable plant water use and acquisition strategies with pre-mined systems.
- Comparable plant nutrition potential with pre-mined systems and include chemical attributes that are: non-toxic; non-acid producing; non-saline; non-sodic; and of suitable pH.
- Comparable structural attributes with pre-mined systems ensuring environmental stability and non-hostility for plant growth characterised by: low erosion potential; suitable air filled porosity; suitable bulk density and being non-dispersive.

*Seed Collection and use standards*

For areas where topsoil does not or is not capable of returning the stipulated level of biodiversity, the reliance on seed to achieve targets is increased. The seed supply chain (Figure H.3) provides the key steps that are critical for considering how wild seed is sourced and utilized correctly. However, for most regions, information on site and species-specific requirements is not available.

Procedures to optimize seed resources should focus on those below (summarised also in Figures H.4):

*Collection and Storage*

- Correct species identification (all seed must be represented by a herbarium-quality voucher specimen).
- Adequate genetic provenance is delineated (consult relevant provenance specialists for advice).
- Timing of seed harvest to maximise seed quality, viability, and storability.
- Correct seed handling to ensure seed is not damaged during the collection and cleaning phases.
- Processing approaches that optimise seed quality and purity.
- Developing seed production systems where seed supply or collection capability does not or cannot meet seed demand.
- Ensuring adequate and appropriate storage of seed in a purpose-designed and managed seedbank facility preferably with seed equilibrated to 15%

relative humidity stored for short to medium-term (1-5y) at 5ºC; long-term (>5y) at -18ºC.

*Seed use*

- Understanding seed dormancy and germination limitations of target species.
- Utilising seed-germination enhancement technologies including seed priming, seed cueing, seed dormancy release and seed dormancy control, seed coatings, delivery-to-site techniques, germination and establishment optimization, stress control.
- Understanding interactions of seed use technologies with post mined landscapes (biotic and abiotic) to optimise plant regenerative capacity.

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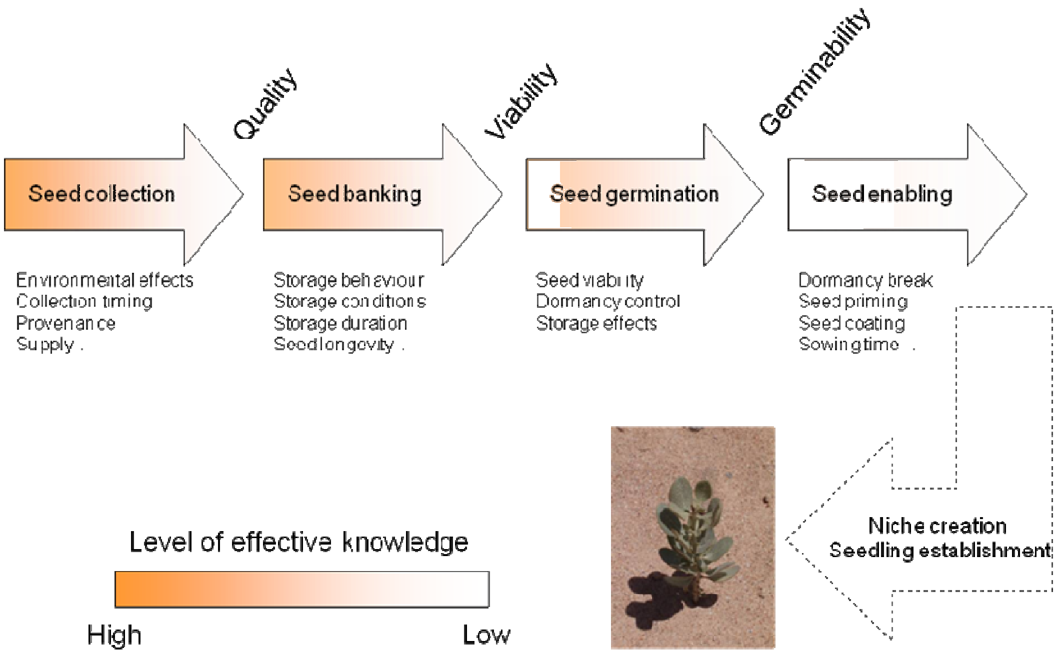


Figure H.3: The seed supply chain outlining the key steps that are critical for considering how wild seed is sourced correctly, quality assured, cleaned and stored in a suitable seedbank environment and exits the seedbank in a state suitable for germination

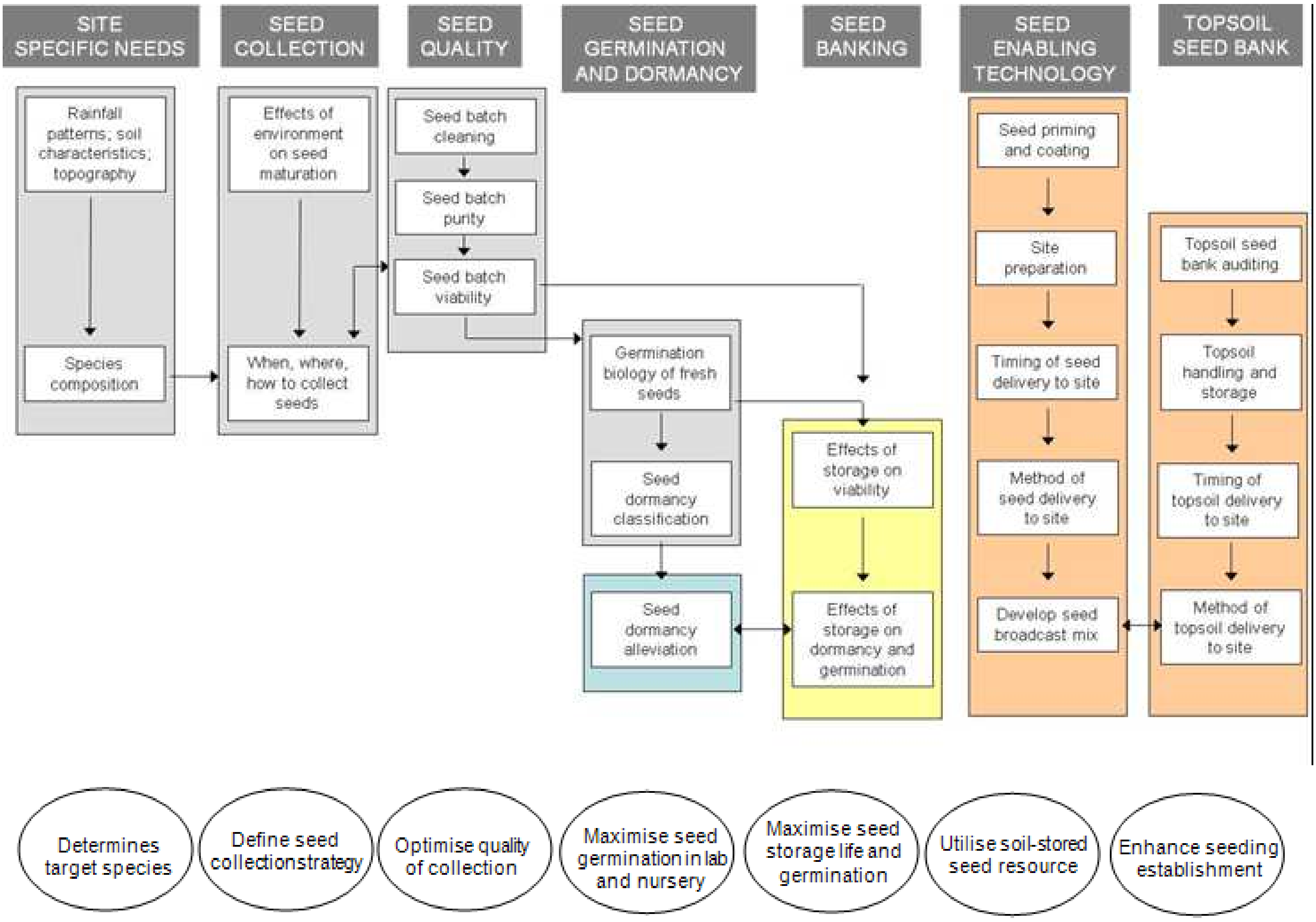


Figure H.4: A systematic approach to developing whole-of-mine rehabilitation techniques. Integration of each research and development theme is necessary to achieve efficient and effective use of biological resources.

## APPENDIX I: Domain Model

A useful approach to mine closure planning and implementation is to divide up the closure work to be carried out and segregate the facility into specific areas or domains (ICMM 2008). Each domain is treated as a separate entity within an overall plan and includes landforms or infrastructure that has similar rehabilitation, decommissioning and closure requirements/objectives.

Examples of domains at a mine are:

- Ore processing area
- Infrastructure
- Tailings storage facilities
- Waste dumps
- Process and raw water facilities
- Open voids and declines/shafts

Figure I.1 below shows the allocation of domains for a typical mine layout:


Figure I.1: An example of the allocation of domains

For accuracy, it is recommended that the operation should use Geographical Information System (GIS) digital terrain models and aerial photos to illustrate the domain features and boundaries; 3D models of waste dumps, voids, tailings dams and other structures (ICMM 2008).

Each domain should have its own closure plan and the same factors outlined in Section 4 of the Guidelines should be taken into account when developing a plan for each domain (ICMM 2008).

The domain model provides a good focal point for developing strategy for closure implementation, and helps to facilitate structured risk assessment and management. However, closure planning and implementation should also consider the whole of landscape scale to ensure effective integration of final land uses.

## APPENDIX J: Risk Assessment and Management

The *Risk Management Standard – Principles and guidelines* developed by the joint Australian and New Zealand standard (AS/NZS ISO 31000:2009) and the *Environmental risk management – Principles and process* (HB 203:2006) provide key processes and principles to identify, assess, manage and review closure risks. These standards require communication and consultation with internal and external stakeholders as appropriate all the way through the risk assessment and management process.

A structured risk assessment framework and a meaningful stakeholder consultation process enable identification early in the planning process of mine closure risks and opportunities associated with closure, and management strategies to preserve, maintain or enhance environmental values or beneficial uses (DITR 2007 Section 6.2, IAEA 2010 Section 3.4) after closure. On a case by case basis, it may be necessary to assess the risk to a particular ecosystem. Although methodology for ecological risk assessment has not been fully developed, probabilistic ecological risk assessment (ERA) can provide a means to evaluate the risk posed by an environmental hazard to the organisms living within the receiving environment (DITR 2007 Section 6.3).

More detail on application of the risk standards to mining and mineral processing operations is provided in the Leading Practice Sustainable Development in Mining handbook on *Risk Assessment and Management* (DITR 2008).

The main elements of risk management are described below (DITR 2008):

(1) Communicate and consult

Communicate and consult with internal and external stakeholders as appropriate at each stage of the risk management process and concerning the process as a whole. AS4360 requires this all the way through the risk process.

(2) Establish the context

Establish the external, internal and risk management context in which the rest of the process will take place. Criteria against which risk will be evaluated should be established and the structure of the analysis defined.

(3) Identify risks

Identify where, when, why and how events could prevent, degrade, delay or enhance the achievement of the objectives.

(4) Analyse risks

Identify and evaluate existing controls. Determine consequences and likelihood and, therefore, the level of risk. This analysis should consider the range of potential consequences and how these could occur.

(5) Evaluate risks

Compare estimated levels of risk against the pre-established criteria and consider the balance between potential benefits and adverse outcomes. This enables decisions to be made about the extent and nature of treatments required, and about priorities.

(6) Treat risks

Develop and implement specific cost-effective strategies and action plans for increasing potential benefits.

(7) Monitor and review

It is necessary to monitor the effectiveness of all steps of the risk management process. This is important for continuous improvement. Risks and the effectiveness of treatment measures need to be monitored to ensure changing circumstances do not alter priorities.

The following diagram summarised the risk management process:

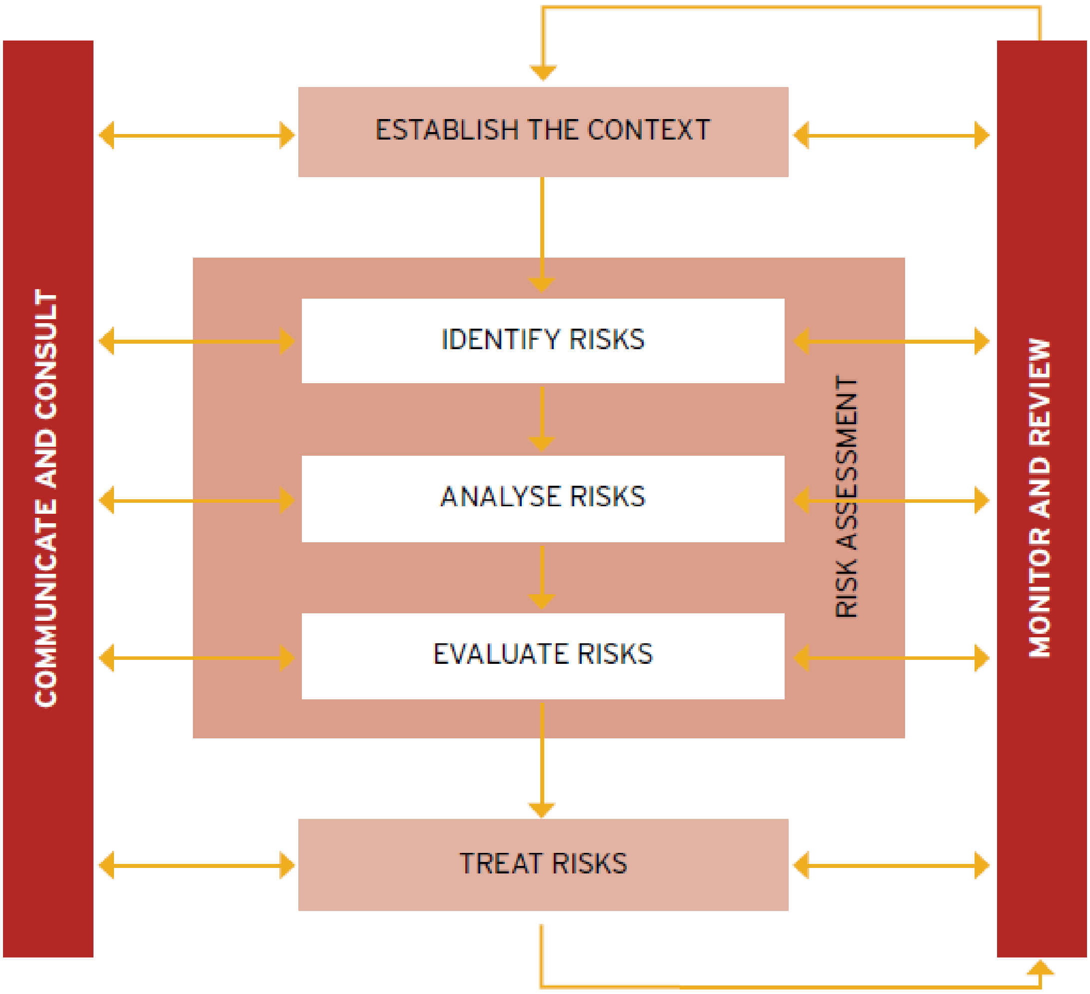


Figure G.1: Risk management process (DITR 2008)

The following flowchart provides a summary of an iterative risk based impact assessment process that can be applied to management of potential impacts associated with mine closure (DRET/GS/DEWHA 2010).

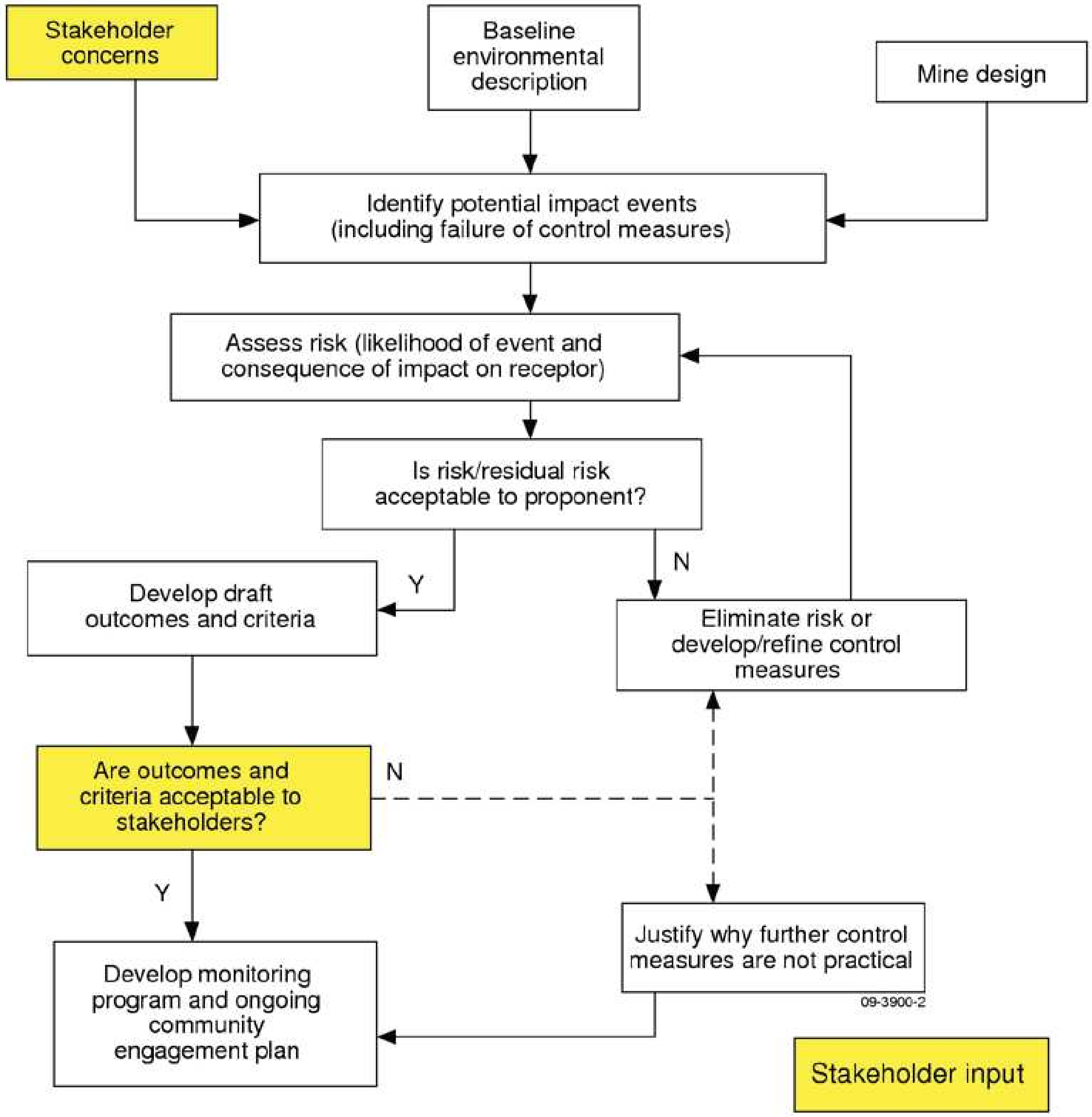


Figure G.2: An iterative risk based impact assessment process (DRET/GS/DEWHA 2010, Attachment 1)

The International Council on Mining & Metals guideline on *Planning for Integrated Mine Closure: Toolkit* (ICMM 2008) identifies a number of useful techniques for undertaking a risk (and opportunity) assessment. The outcomes of the risk/opportunity assessment conducted during the project approval stage can be used to identify potential issues that could elevate closure risks, so strategies and mitigation measures can be developed to control such risks.

The *Guidelines for miners: preparation of a mining lease proposal or mining and rehabilitation program (MARP) in South Australia* (January 2011) produced by the Primary Industries and Resources South Australia (PIRSA), provides one methodology for qualitative risk assessment (Appendix 5A) and some closure risks that should be considered, including:

- financial
- sudden closure due to market changes
- poor management of rehabilitation activities
- experimental or novel rehabilitation techniques
- ongoing maintenance requirements for protective structures
- unexpected or unusual climatic conditions
- changes in legislative requirements or community expectations (if the mine has a long life)
- changes to surrounding land use
- inadequate understanding of the existing environment and the impacts of the operations

Recognising that effective communication is a necessary ingredient for effective risk management, the Minerals Council of Australia developed a set of recommended principles and approaches to risk communication specifically for the mining industry (MCA, 2008). Such a risk communication framework and principles can be applied to the management of risks associated with mine closure.

## APPENDIX K: Examples of Completion Criteria

The following examples are provided to illustrate the development of completion criteria and should not be used as acceptable standard, or used as ”cut-and-paste” templates. Each operation will need to have its own site-specific set of completion criteria and performance indicators. (See Appendix G for examples of closure objectives).

For each closure objective, a set of completion criteria should be developed to demonstrate the attainment of that objective. Closure criteria usually include post-closure environmental outcomes together with measurement tools, and where applicable, final landform designs and construction specifications. Although completion criteria should be quantitative, indicative completion criteria (used in the early stages of closure planning) may be qualitative or semi-quantitative, provided that they can be objectively verified

| Closure Objectives | Indicative Completion Criteria | Completion Criteria | Measurement Tools |
|---|---|---|---|
| All waste dumps and Tailings Storage Facilities (TSF) are stable and complimentary to surrounding land use | Concept level engineering designs and specifications for final landforms that will not be prone to slumping, mass movement or significant erosion | Detailed final landform design specifications including slopes, surface water and drainage design parameters and erosion rates | Audit of constructed landforms for compliance with design specifications/required standards |
| Topography and surface drainage are consistent with, and complimentary to the overall landscape. | Concept level engineering designs and specifications for surface water and drainage which are compatible with the surrounding landscape and proposed land use.<br><br>Meeting relevant Australian Standards | Detailed engineering designs and specifications / required Australian standards | Audit of construction for compliance with design specifications/required standards.<br><br>Monitoring of surface drainage. |

| Closure Objectives | Indicative Completion Criteria | Completion Criteria | Measurement Tools |
|---|---|---|---|
| Vegetation in rehabilitated areas will have equivalent values as surrounding natural ecosystems. | Vegetation composition on the rehabilitated site is representative of the target ecosystem in species diversity/diversity and vegetation structure.<br><br>All plants used in rehabilitation to be of local provenance.<br><br>No weeds to be introduced into the area. | Reaching agreed species or ecosystem diversity targets, such as areas to have at least X of particular species per m2.<br><br>Species richness is greater than Y% of the mean value recorded in all 20m x 20m reference plots in analogue sites in the target ecosystem.<br><br>Foliar cover is within the range of values from analogue sites in the target ecosystem.<br><br>All plant material used in rehabilitation sourced from within 10km of the project site.<br><br>No evidence of weed species, including both declared agricultural weeds and environmental weeds. | Quantitative vegetation monitoring using recognised standard techniques acceptable to regulators. .<br><br>Audit of rehabilitation records for sources of plant materials used in rehabilitation. |
| The rehabilitated ecosystem has equivalent functions and resilience as the target ecosystem. | The capacity to retain water and nutrient resources is equivalent to target ecosystems. | Infiltration Index is within the range of values from analogue sites in the target ecosystem.<br><br>Nutrient Cycling Index is within the range of values from analogue sites in the target ecosystem. | EFA Infiltration Index.<br><br>EFA Nutrient Cycling Index. |
| Soil properties are appropriate to support the target ecosystem | Soil physical, chemical and biological characteristics will be consistent with those of the target landscape.<br><br>Soils to the depth of reconstruction have similar pH and salinity as soils from the target ecosystem. | Soil physical, chemical and biological specifications.<br><br>Soils to the depth of reconstruction have: pH ($H_2O$) >X; and<br>EC (1:5 $H_2O$) <Y dS/m | Soil analysis using accredited laboratory, plus field measures |

| **Closure Objectives** | **Indicative Completion Criteria** | **Completion Criteria** | **Measurement Tools** |
|---|---|---|---|
| All identified AMD materials are adequately contained or covered to prevent contamination of surface and ground water. | Concept level engineering designs and specifications for waste rock dumps (and/or TSFs) to ensure suitable placement and encapsulation of AMD materials.<br><br>Concept level engineering designs and specifications for landforms containing AMD materials to limit rainfall and, oxygen ingress.<br><br>Surface water and groundwater quality down-hydraulic gradient of the contained AMD materials will not exceed baseline water quality conditions, or acceptable water quality guidelines | Detailed landform designs and specifications<br><br>Detailed surface water drainage specifications<br><br>Seepage and water quality meeting specific criteria levels for pH, salinity, $SO_4$, heavy metals and other substances of concern (such as selenium);<br>Or<br><br>Seepage from all TSFs will meet the National Water Quality Management Strategy guidelines (available online at www.environment.gov.au/**water**/policy-programs/nwqms/, papers 4, 6, 7 & 8). | Audit of constructed landform showing compliance with design specifications/required standards, and as-constructed report showing where AMD materials are located, the amount of lime added to base and/or sides, depth of non-acid or metalliferous forming waste rock on top of and surrounding cells)<br><br>Water and oxygen infiltration rates, and temperature profile of encapsulated cells<br><br>Surface water and groundwater analysis using accredited laboratory analysis and field measurements<br><br>Visual assessment and surveying (stained seepage, iron precipitates, vegetation die-off) |