Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

GUIDELINES

Mine Closure Plan Guidance -

How to prepare in accordance with Part 1 of the *Statutory Guidelines for Mine Closure Plans*

Version 4.0

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Document Hierarchy for mine closure plans under the *Mining Act 1978*

Legislation	*Mining Act 1978*
Statutory Documents	Statutory Guidelines for Mine Closure Plans
Policy	Environmental Regulatory Strategy Environmental Objectives Policy for Mining
Guidelines	**This Document** Technical Guidance - A framework for developing mine-site completion criteria in Western Australia (2019). The Western Australian Biodiversity Science Institute, Perth, Western Australia.
Procedures	Environmental Applications Administrative Procedures

Version History

Version	Date	Changes
1.0	2011	Initial publication
2.0	2015	Document reviewed
3.0	2020	Statutory requirements and guidance material published into separate documents
4.0	2023	Document reviewed and minor administrative amendments made

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PURPOSE

The purpose of this guidance document is to assist applicants in preparing mine closure plans to meet Western Australian regulatory requirements.

The Department of Mines, Industry Regulation and Safety's (DMIRS) objective for rehabilitation and closure is that mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geo-technically stable, geo-chemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use without unacceptable liability to the State.

Any residual liabilities relating to the agreed land use should be identified and agreed to by the key stakeholders.

Consistent with industry-leading practice, this guidance document is 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.

DMIRS recognises that closure planning is a progressive process and that mine closure plans are evolving documents which should undergo ongoing review, development and continuous improvement throughout the life of mine. The level of information required is reflective of the stage of mine development (i.e. planning and design/ approvals, construction, operations, decommissioning, post-closure maintenance and monitoring), with detail increasing as the mine moves towards closure. DMIRS recognises that not all technical information will be available at the early stages of development, however knowledge gaps relating to closure specific technical information are expected to be listed in the initial mine closure plan and then refined/developed in future iterations. At all stages, DMIRS expects 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 this document:

- *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, 2009b);
- *Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry; Department of Industry*, Tourism and Resources (DITR, 2006); 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 1.

SCOPE

The *Mining Act 1978* defines a mine closure plan as a document that:

(a) is in the form required by the guidelines

(b) contains information of the kind required by the guidelines about the decommissioning of each proposed mine, and the rehabilitation of the land, in respect of which a mining lease is sought or granted, as the case may be.

The *Statutory Guidelines for Mine Closure Plans* detail the mandatory form and content of information required in a mine closure plan.

The purpose of this document is to assist proponents in the preparation of mine closure plans under Part 1 of the Statutory Guidelines.

FORM AND CONTENT OF A MINE CLOSURE PLAN

A mine closure plan submitted for approval under the Mining Act must meet the form and content requirements of Part 1 of the *Statutory Guidelines for Mine Closure Plans*. This guidance document provides additional detail on how to prepare a mine closure plan that meets those statutory requirements.

Mine closure plans for Small Mining Operations as categorised in Part 2 of the *Statutory Guidelines for Mine Closure Plans* must be submitted on the pro forma provided in Appendix 1 of the *Statutory Guidelines for Mine Closure Plans*.

A mine closure plan is a dynamic document that needs to be regularly reviewed and refined over time to ensure that it reflects the current knowledge relevant to the development and rehabilitation status of the mine.

DMIRS accepts that not all the necessary details for final closure are available in the early stages of the project, particularly in the project assessment and approval stages. However, the mine closure plan addressing rehabilitation and closure submitted at these stages must enable DMIRS and other key stakeholders to understand the issues that require management at closure, and provide confidence that all relevant issues have been identified and will be appropriately managed. This is to enable an accurate assessment and informed decision by DMIRS.

The first mine closure plan submitted as part of a mining proposal must relate to that particular mining proposal or, where practicable, can be prepared for the whole site. DMIRS encourages reviewed mine closure plans to be prepared for the whole environmental group site.

A mine closure plan required under the Mining Act must meet the form and content requirements of Part 1 of the *Statutory Guidelines for Mine Closure Plans*.

1. Cover Page(s)

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan cover page(s) must include:

- title;
- site name and code (environmental group site name and code from EARS2 system or note if this is a greenfields or new site);
- revision and version numbers (revisions constitute each new registration; versions constitute amendments to revisions);
- date (day month year) (must be updated with each new version);
- tenement(s); and
- tenement holder or authorised company/person.

2. Project Summary

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include a description of the mining operation, and a map of the location of the mining operation showing all relevant mine activities, land disturbances, tenements and other land tenure. An estimated project completion date must be included.

This section provides background information on the history and status of the project, including proposed and existing mining operations.

3. Identification of Closure Obligations and Commitments

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must detail all legal obligations for rehabilitation and closure that will affect the post-mining land use and closure outcomes.

All statutory 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.

The register must include all legally binding conditions and commitments and/or legal obligations for rehabilitation and closure that are applicable under relevant State and Federal legislation. The register should also include references to individual tenement conditions, mining proposals, Notices of Intent, Letters of Intent, 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 completion criteria, as environmental commitments can be cross referenced. Compliance with closure conditions is an unconditional requirement for the Government's sign off prior to closure completion. At closure, this tool can be used as a checklist to demonstrate that all conditions, commitments and obligations have been met.

An example of a Legal Obligations Register is provided at Appendix 4.

4. Stakeholder Engagement

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include information on the engagement that has been undertaken with stakeholders relevant to rehabilitation and mine closure, a record of the engagement undertaken to date and include a strategy for ongoing engagement.

Stakeholder engagement is a key component of mine closure planning. Early and continuous engagement with stakeholders enables operators to better understand and manage stakeholder expectations and the potential risks associated with closure. Failure to undertake a stakeholder engagement program may compromise the approval process and mine closure outcomes. An example stakeholder engagement register is shown in Table 1.

Table 1 Stakeholder Engagement Register

Safe Hands Mining - Stakeholder Engagement Register 2020					
Date	Description of Engagement	Stakeholders	Stakeholder comments/issue	Proponent Response and/or resolution	Stakeholder Response
2018 - 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 keeping the traditional owners informed	Acceptable
27/06/19	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

The engagement process should follow the five principles from the *Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia, Strategic Framework for Mine Closure (ANZMEC/MCA, 2000)*. These include:

Principle 1: Identification of stakeholders and interested parties

For the purpose of this document, the term **"stakeholders"** includes both internal and external parties who are likely to affect, to be affected by or to have an interest in mine closure planning and outcomes.

The internal stakeholders should include:

- mine managers;
- mine planners;
- engineers;
- environmental advisor/specialist; and
- relevant staff involved in mine planning and technical/operational decision making.

The **external stakeholders** typically include:

- 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;
- interested Non- Government Organisations (NGOs);
- adjacent landholders; and
- downstream (or down-gradient) users of surface or groundwater resources.

The term **"key stakeholders"** refers to post-mining land owners/managers and relevant regulators.

Principle 2: Effective engagement is an inclusive process which encompasses all parties and should occur throughout the life of the mine.

Stakeholder engagement should continue throughout all stages of mine closure planning, including project approvals (Figure 1). A range of approaches to stakeholder engagement can be employed throughout the different mine phases or when certain issues need to be addressed. The International Association of Public Participation (IAP2) has developed a public participation spectrum that includes: informing, consulting, involving, collaborating, and empowering. For further guidance, the leading practice *Community Engagement and Development handbook (DITR 2009a)* may be referred to.

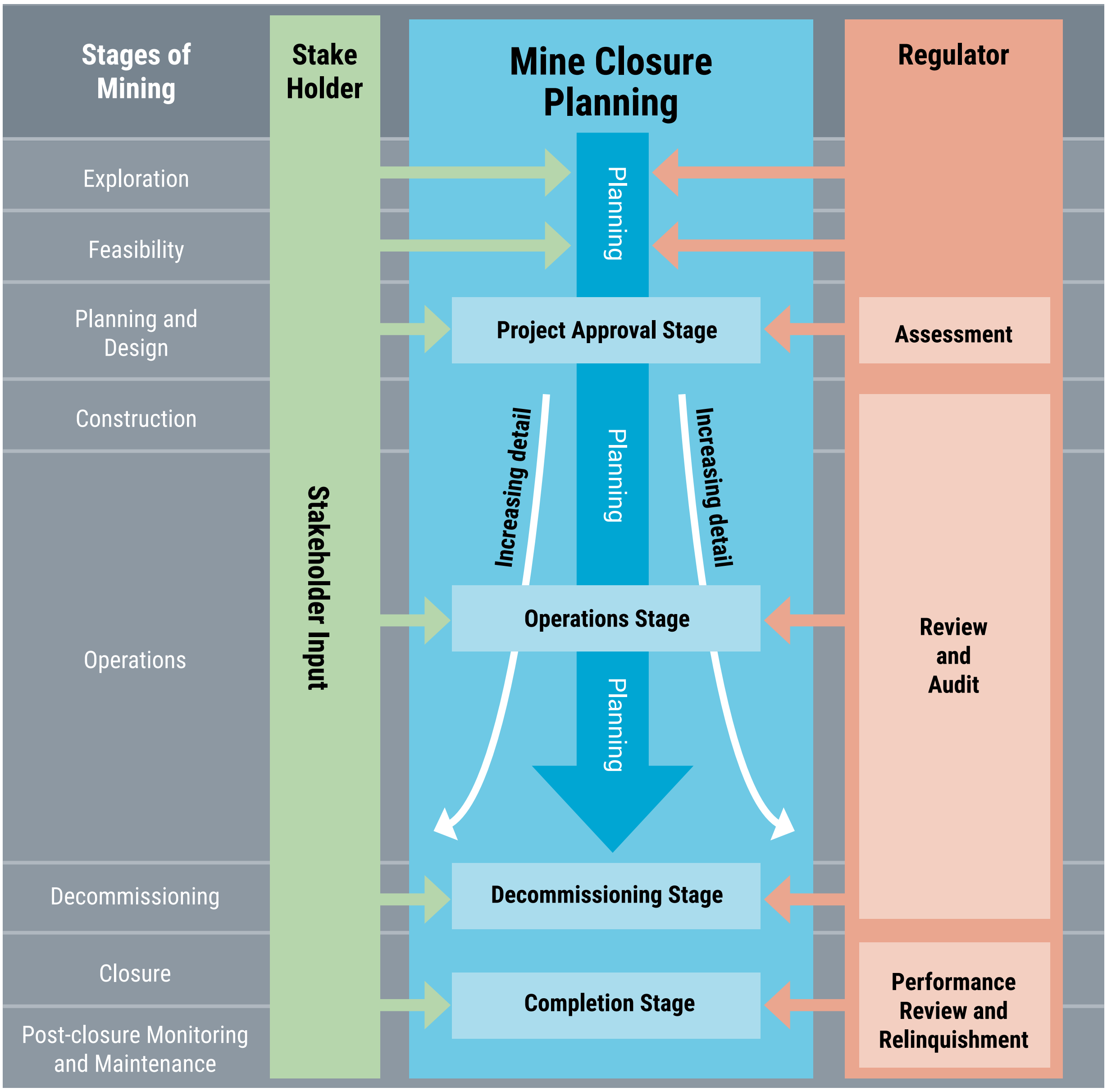

Figure 1 Integrating stages of mining and mine closure planning (adapted from DITR 2006, ICMM 2008)

Principle 3: A targeted communication strategy should reflect the needs of the stakeholder groups and interested parties.

The mine closure plan should demonstrate that an effective engagement strategy has been developed and implemented. It is important that all stakeholders have their interests and concerns considered and where appropriate, addressed, and that the key stakeholders have an opportunity to provide feedback on the response or proposed action to address their interests and concerns, particularly when determining post-mining land-use and closure outcomes.

The mine closure plan requires a tabulated summary of all engagement between the operator and the relevant parties. It should include:

- date of engagement;
- a description of the nature of the engagement;
- level of information provided to stakeholders;
- who the stakeholders were;
- the comments and issues raised by the stakeholders; and
- how the operator has responded to the concerns raised and report the stakeholder response to the proposed resolution (see example above for the format of a Stakeholder Engagement Register).

Principle 4: Adequate resources should be allocated to ensure the effectiveness of the engagement process.

Adequate and appropriate resourcing is critical to good quality and successful engagement. It is important that resourcing for engagement is understood and considered in the early planning process and detailed in the Stakeholder Engagement Strategy. Resources may include financial, human and technological support, and can also include stakeholder-related expenses.

Principle 5: Wherever practical, work with communities to manage the potential impacts of mine closure.

DMIRS encourages regular engagement between a mining company and the local community or communities throughout all stages of mine development in order to manage the potential socio-economic and environmental impacts of mine closure. While the operational phase brings many social and economic changes and opportunities to communities, mine closure will bring different challenges. Development of community programs should be aimed at strengthening a community over the long term. When managing potential environmental impacts from mine closure, an informed community (e.g. by establishing a consultative closure committee) can provide a useful forum for discussion and communication on closure issues (DITR, 2009 a & b).

For further guidance on stakeholder engagement, the international standards *AA1000 Stakeholder Engagement Standard 2011* and the International Association for Public Participation can be referred to as benchmark quality engagement.

5. Baseline and Closure Data and Analysis

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include baseline data that:

- informs successful rehabilitation and closure;
- identifies the issues to be managed through the mine closure process and the environmental closure risks;
- informs the development of criteria or indicators for closure monitoring and performance;
- informs the establishment of achievable closure outcomes and goals in a local and regional context; and
- establishes baseline conditions for closure monitoring programs.

The mine closure plan must include:

- an analysis of the baseline data that describes how the wider receiving environment, receptors and exposure pathways have been considered;
- an analysis of the baseline data that identifies the knowledge gaps and the risk of not having that information; and
- details of the methodology of analysing the baseline data.

All relevant technical reports must be attached as appendices.

Baseline studies should be undertaken prior to commencement of mining operations and continue through the life of the project. Before closure issues can be managed, they need to be identified through the collation of relevant 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; and
- consideration of the wider receiving environment, receptors and exposure pathways.

From a closure planning perspective, information from baseline studies undertaken prior to the commencement of mining operations, and from ongoing studies, is necessary.

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 outcomes and completion criteria, and the setting of indicators for management intervention.

The mine closure plan should provide a summary of the best available data on aspects of the physical and biological environments, as well as the social and economic aspects (where relevant) that are critical for successfully meeting mine closure outcomes. The following information should be included (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 resource details – type, location, extent, 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 materials, heavy metals and materials with potential to produce contaminated drainage).

Comprehensive characterisation of materials (including soils and mine waste) is critical to effective closure planning and successful progressive rehabilitation. This process should start during the exploration phase and continue throughout the life of the mine. Characterisation of materials allows for separation and selective placement of materials considered beneficial to rehabilitation and segregation of materials that may inhibit rehabilitation or cause detrimental effects.

5.1 Other Closure Related Data

Other available information should be collated and referred to throughout mine closure planning with the objective of building a "base" of information or knowledge important to the closure of a particular landform or infrastructure.

Information is to include, but should not be limited to:

- Learnings from closure experience generated from other mines.
- Spatial datasets and databases.
- Design and construction of landforms and voids, including 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; and
    - the long-term geotechnical stability of the final landforms post-mining.
- 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.
- 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.

5.2 Data Analysis and Implications for Mine Closure

Analysis of the collected data is a critical element in understanding the issues affecting mine closure and identifying knowledge gaps. Knowledge gaps should also be included in the summary tables and the risk of not having this information should be analysed. This will enable the information gaps to be prioritised and acted upon appropriately.

Where applicable, 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.

6. Post-Mining Land Use(s)

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include the post-mining land use(s) that has been proposed or agreed with key stakeholders, including regulators.

The mine closure plan must describe how the post-mining land use(s) is:

- 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; and
- ecologically sustainable in the context of the local and regional environment.

The post-mining land use(s) and closure outcomes are necessary to provide the basis for developing completion criteria.

The post-mining land use(s) should 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 2.4); 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. DMIRS acknowledges that end land uses may change over time and this can be reflected in mine closure plan revisions. Agreed end land use(s) may change in iterations of mine closure plans as more information is acquired through progressive rehabilitation and continued stakeholder engagement.

The mine closure plan should identify all potential (or pre-existing) environmental legacies (including contaminated sites) that may restrict the post-mining land use.

The following land use options provide a guide to identifying appropriate post-mining land use(s):

- Reinstate “natural” ecosystems to be as similar as possible to the original ecosystem.
- Develop an alternative land use with higher beneficial uses than the pre-mining land use.
- Reinstate the pre-mining land use.
- Develop an alternative land use with beneficial uses other 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 engagement 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 engagement process.

For further guidance refer to the Western Australian Biodiversity Science Institute, *A framework for developing mine-site completion criteria in Western Australia* (2019).

7. Closure Risk Assessment

As per the *Statutory Guidelines for Mine Closure Plans* a reviewed mine closure plan must include an environmental closure risk assessment that:

- identifies all the environmental closure risk pathways;
- evaluates these risks to derive an inherent risk rating, prior to the application of treatments;
- identifies appropriate risk treatments, using the hierarchy of control; and
- re-evaluates the risk pathways to derive a residual risk rating; and
- demonstrates that all residual risks are as low as reasonably practicable (ALARP).

The reviewed mine closure plan must provide information on the processes and methodologies undertaken to identify the closure risks and their potential environmental impacts post-mining, including a description of the risk assessment criteria and risk evaluation techniques.

DMIRS requires 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, regulatory risks and opportunities have been identified.

7.1 Identification of closure risks

Mine closure plans should provide adequate information on the methods used and processes undertaken to identify the closure risks and their potential environmental impacts post-mining, and must propose workable management mechanisms. This will allow strategies, mitigation measures and closure designs to be developed and refined, assessed and reviewed in the years leading up to closure and will address standard or site-specific management of inherent risks as well as identifying any continuous improvement actions.

This process should be integrated with stakeholder engagement (see Section 2.4) and take into account stakeholder concerns and learnings from previous experience. The information can be presented in a tabulated format and included as an appendix.

Depending on the size and complexity of the project, detailed information on the key closure risks and proposed management mechanisms may be presented for the project/site in its entirety or broken down into domains or features (Appendix 9).

7.2 Risk Management Process

Consistent with a risk-based approach, DMIRS requires a structured risk management process to be undertaken to identify, assess and manage the potential risks associated with closure, particularly those identified in Appendix 7. 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 10).

7.3 Risk assessments where mine closure plan is included in a mining proposal

All phases of mining, including closure, should be considered in the environmental risk assessment provided in the relevant mining proposal. While Part 1 of the DMIRS *Statutory Guidelines for Mining Proposals* in Western Australia and the *Statutory Guidelines for Mine Closure Plans* both require a risk assessment, the risk assessments do not need to be undertaken separately. Undertaking one holistic risk assessment that considers both operational and closure risks is recommended for the mining proposal. This can reduce the likelihood of inconsistencies between the mining proposal and mine closure plan and reduces duplication of effort. In these instances, the mine closure plan submitted as part a mining proposal can refer back to the risk assessment provided in the mining proposal. When a reviewed mine closure plan is re-submitted for approval every three years, or at a date otherwise advised by DMIRS, as required under the Mining Act, an updated closure risk assessment must be included.

7.4 Risk Assessment Information

It is important to fully describe each risk, pathway and potential impact as this demonstrates that the risks are understood and allows for the adequacy of the proposed treatments to be assessed; there should be a direct link between the cause/source of the risk and the proposed treatment measures. This also enables the identification of any potential gaps in risk identification. See example 2 in Appendix 6 for further explanation.

Generally, the most common scenario for lowering the environmental consequence is through the elimination or substitution of a risk pathway; this often occurs during the project planning phase. Examples include altering the planned location of infrastructure to avoid direct impacts to conservation significant flora or opting for smaller scale fuel storage rather than the storage of large volumes of hydrocarbons on site.

Decisions to eliminate or substitute risk pathways may have already been made when it comes time to draft the mining proposal or mine closure plan. Proponents are encouraged to include these treatments in the risk assessment to demonstrate the ways in which risk has been reduced during the planning phase. If the consequence rating within the risk assessment is reduced post-treatment by means other than elimination or substitution, adequate justification should be provided. Refer to the bottom table in example 3 of Appendix 6.

The level of information provided for the risk treatments, management strategies or risk mitigations, should be commensurate to the level of risk that is being treated. For raw (untreated) risks that are considered low, less detail is generally required for the risk treatments, especially if these treatments utilise existing industry standards or codes, however these standards should be outlined. For raw (untreated) risks that are considered high or greater and require specific and significant management measures, the mining proposal will need to contain a comprehensive description of the proposed treatments e.g. encapsulation plan for Potentially Acid Forming (PAF) materials and associated diagrams/drawings of the encapsulation cell. This information may not fit within the risk assessment table and may need to be supported by details provided in an Appendix; however the key management points should still be included in the risk assessment. See example 4 of Appendix 6.

7.5 Further guidance material

Detailed guidance on how to identify and manage these closure issues is widely available in references including the Leading Practice Sustainable Development in Mining handbooks. For example: Cyanide Management (DITR 2008); Mine Rehabilitation (DITR 2006), Hazardous Material Management (DITR 2009c) Mine Closure (DITR 2016); Preventing Acid and Metalliferous Drainage (DITR 2016).

7.6 Site specific assessment

Risk assessment and management should be site specific; a risk assessment that is suitable for one site will not necessarily be suitable for use at another. Mining proposals and mine closure plans require an environmental risk assessment. The risk assessment should consider risks to the environment from the operation; corporate risks – such as company reputation damage from an environmental incident – are not required.

Risk assessment and management needs to take into account site specifics such as location, baseline environment, proposed infrastructure and operations and specific practices and processes. The environmental risk assessment provided in the mining proposal and mine closure plan needs to demonstrate that site specifics have been considered and addressed. It can be problematic to try and use a risk assessment from another site as the starting point or template for an assessment of a new site as it is likely to cause the new risk assessment to be inherently biased by the issues that were present at the previous site.

It is essential for the risk assessment to be based on, and informed by, the baseline environmental data relating to the site. It should be easy to relate the risk assessment back to the issues that have been identified in the site activities, stakeholder engagement and baseline data sections of the mining proposal or mine closure plan. Whilst it is important for the risk assessment to include all the issues identified for the site, there is no requirement to include risks that are not relevant based on project site description, stakeholder engagement and environmental baseline data (see example 1 in Appendix 6). For example, if the project site has no conservation significant flora then risks to conservation significant flora are not relevant.

DMIRS expects the ALARP principle to be used when determining which risk treatments to apply. In some instances past practices and standard procedures may meet the ALARP principle; however in some cases it may be reasonable to apply more stringent treatments to the risk. It ultimately depends on each individual scenario. Example 3 in Appendix 6 illustrates how the ALARP principle can be applied.

7.7 Materials characterisation

Adequate characterisation of materials is critical to the identification and management of closure issues, and should include the delineation of potentially problematic materials (such as acid-generating or sulphidic mineral waste, sodic, radioactive and asbestiform materials). Proponents should estimate the location of problematic materials and the amount that may be disturbed during operations. Materials characterisation should also be carried out for the benign materials intended for use in mine rehabilitation activities so that the physical, chemical and nutrient characteristics of the material are understood and evaluated to ensure it will perform according to planning expectations. The volumes of rehabilitation materials required to fulfil closure plans should be reconciled against inventories of available material to ensure sufficient volumes are available for use in rehabilitation activities.

7.8 Contaminated sites

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.

8. Closure Outcomes and Completion Criteria

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include:

- Site-specific closure outcomes consistent with the post-mining land use(s) that are realistic and achievable based on the closure risk assessment.
- Completion criteria that are specific, measurable, achievable, relevant and time-bound, and will demonstrate the achievement of the closure outcomes and monitoring.

8.1 Closure Outcomes

Closure outcomes reflect the environmental outcomes for closure identified in the mining proposal. These outcomes must be consistent with the post-mining land use(s) and must be specific to provide a clear indication to Government and the community on what the proponent commits to achieve at closure. Closure outcomes are considered to be a sub-set of a project's environmental outcomes and rehabilitation and mine closure is an environmental factor under the DMIRS Environmental Objectives Policy for Mining. The ability to specify closure outcomes will depend on the amount and quality of the environmental data; it is essential that the best available data is used for this purpose.

At the project approval stage, closure outcomes may be broadly identified and further refined in the stakeholder engagement process. However, they must be based on the best available data and be specific enough to guide closure development and design. There is no need to duplicate closure outcomes and completion criteria across the Mining Proposal and the Mine Closure Plan. DMIRS suggests closure outcomes and criteria can be included in the mining proposal to holistically consider all project phases. However, reviewed mine closure plans (those submitted three years or alternative period of review after mining proposal approval) must include closure outcomes and their associated completion criteria as required by the *Statutory Guidelines for Mine Closure Plans*.

The use of environmental outcomes and performance criteria within mining proposals is designed to follow the same method as closure outcomes and completion criteria in mine closure plans. Appendix 5 provides some examples of closure outcomes.

Once agreed, the post-mining land use(s) and closure outcomes will form the basis on which DMIRS approves a mining proposal or a mine closure plan. Where variations to these outcomes are proposed subsequent to the environmental approvals of the project, a request must be submitted to DMIRS to vary the outcomes. This request must be supported by suitable evidence to justify the proposed changes. If these changes have the potential to significantly compromise the intent of the mine closure outcomes, they may be considered by DMIRS to be a substantial change to the approved mining proposal.

8.2 Completion Criteria

Completion criteria are necessary to demonstrate the success of rehabilitation and mine closure and the achievements of closure outcomes. They should be developed in consultation with key stakeholders including DMIRS and should be appropriate to the phase of the project. Completion criteria must follow the S.M.A.R.T principle (ANZMEC/MCA 2000) and be:

- Specific enough to reflect a unique set of environmental, social and economic circumstances.
- Measurable[1] to demonstrate that rehabilitation is trending towards analogue indices.
- Achievable or realistic so that the criteria being measured are attainable.
- Relevant to the outcomes that are being measured and the risks being managed and flexible enough to adapt to changing circumstances without compromising outcomes.
- Time-bound so that the criteria can be monitored over an appropriate time frame to ensure the results are robust for ultimate closure completion.

[1] *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.*

Development of completion criteria and associated performance indicators should commence upfront 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. The identified completion criteria and associated performance indicators must be able to demonstrate that rehabilitation is progressing as anticipated, particularly where mathematical modelling is utilised to predict long term (usually 300 years or longer) environmental performance (e.g. waste rock landforms). Where applicable, details on the mathematical modelling used, including assumptions and limitations, should be provided as an appendix to the mine closure plan.

Once established and agreed to by the relevant 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 and/or performance indicators must be documented, together with sufficient explanation, in the reviewed mine closure plan (section 13).

For further guidance refer to the Western Australian Biodiversity Science Institute, *A framework for developing mine-site completion criteria in Western Australia* (2019).

9. Closure Implementation

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include:

- a closure work program for achieving the closure outcomes, with implementation strategies and timeframes for each domain and/or feature of the mining operations;
- closure designs for landforms; and
- contingencies for premature or early closure or suspension of operations.

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, stage of rehabilitation and estimated closure date;
- applicable land use outcomes, 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 closure data;
- key tasks for premature 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 an indicative timeframe that 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 should demonstrate that closure requirements and potential knowledge gaps have been appropriately identified, with adequate lead time 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.

9.1 Research, investigation and trials

The information obtained from these activities can be used to help close information gaps and determine the most appropriate rehabilitation strategies to implement. Research tasks may be a one-off investigation such as undertaking a waste characterisation program for a landform or a series of tasks leading to trials that can take years to provide relevant data/information (for example a trial to ascertain the best cover material for a tailings storage facility).

9.2 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 completion of planned activities.

Progressive rehabilitation is a key component of mine closure implementation and has many benefits, including:

- reduced financial liability under the MRF as all required rehabilitation earthworks are completed in accordance with the closure obligations that apply;
- demonstrating responsible closure commitment to the community and regulators by reducing the un-rehabilitated "footprint" of the mine; and
- costs of rehabilitation are managed throughout the life of the mine.

Mine planning and engineering decision-making processes should optimise opportunities for progressive rehabilitation consistent with the post-mining land use(s) and closure outcomes.

Progressive rehabilitation activities need to 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;
- contamination management;
- 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
- ongoing improvement and refinement of rehabilitation techniques.

9.3 Early Closure - Permanent Closure or Suspended Operations under Care and Maintenance

Although practical planning for premature closure (permanent or suspended operations under care and maintenance) may not be very detailed in the early stages of the project, consideration should be given in the mine closure plans relating to how closure scenarios that may arise from economic, environmental, safety or other external pressures will be dealt with. In particular, this should include confirmation that appropriate materials are available on site and contingencies are provided to make landforms such as tailings storage facilities and waste dumps secure, stable and non-polluting/ non-contaminating.

In such an event, implementation of an accelerated closure process will need to occur. Operators should contact the relevant Environmental Officers at DMIRS as early as possible for advice on site-specific requirements. If an approved mine closure plan is in place, and a premature closure occurs, the operation will be well placed to respond.

Proponents need be aware that under the *Work Health and Safety Act 2020* they are required to notify the district inspector of mines of the suspension of a mining operation. There are template documents available on the DMIRS webpage for commencement, suspension, recommencement and abandonment.

9.4 Decommissioning

Since the decommissioning phase usually takes place at the end of mine life, limited detail on the strategy and activities required for decommissioning of plant and infrastructure may be acceptable in the early stages of the project. As the implementation of mine closure progresses, the level of detail should increase and include information on:

- the safe 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 stakeholder engagement;
- 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, DMIRS will require the mine closure plan to contain more specific detail on the planning and implementation of the decommissioning phase. This timing requirement may need to be reviewed on a case by case basis as circumstances change, due to factors such as economic or business conditions.

10. Closure Monitoring and Maintenance

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include:

- a monitoring framework to monitor the progress of the closure implementation strategies for achieving closure outcomes and completion criteria;
- description of proposed post-closure monitoring; and
- a description of the monitoring methodology.

The mine closure plan should include appropriate detail on closure performance monitoring and maintenance framework during progressive rehabilitation and post closure, including descriptions of the methods used, quality control system and remedial strategy.

The performance monitoring results will be reported to DMIRS in an Annual Environmental Report (AER). The report must document progress against the agreed completion criteria. Where applicable, the results of rehabilitation trials should be analysed and presented in the AER; remedial action undertaken in response to not meeting agreed targets should also be reported. The results should also be used to update the mine closure plan where appropriate. The guidelines for the preparation of an AER are available on the DMIRS website.

A preliminary plan for closure monitoring and maintenance may be acceptable in the early stages of the project. As the operations approach closure, DMIRS will require the mine closure plan to contain a detailed Post-Closure Monitoring and Maintenance Program. This should include the type and frequency of monitoring proposed to address/show achievement of the relevant completion criteria.

It is important that provision be made in closure planning for an adequate period of post-closure monitoring and maintenance, including provision for remedial work if monitoring shows completion 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 proposed monitoring techniques 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 post closure monitoring and maintenance is required. There must be a sufficient timeframe nominated to undertake monitoring and maintenance until it can be demonstrated that closure 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 post closure monitoring period should be provided for in the mine closure plan, usually in the order of 10 years.

For further guidance refer to the Western Australian Biodiversity Science Institute, *A framework for developing mine-site completion criteria in Western Australia* (2019).

11. Financial Provisioning for Closure

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include the details of closure costing methodology, including clearly documented assumptions and uncertainties.

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.

DMIRS recognises that providing verifiable closure cost estimates at the early stages of a mine's life is subject to many assumptions and unforeseen events. DMIRS expects assumptions to be summarised and ± cost variation to be provided. This per cent variation should then be refined during operations and decommissioning.

The financial provisioning process and method(s) has to be transparent and verifiable, assumptions and uncertainties have to be clearly documented, and they have to be based on reasonable, site-specific information and data throughout the life of the project.

The closure cost estimates need to be regularly reviewed to reflect changing circumstances and levels of risk. This will ensure that the accuracy of closure costs is refined and improved with time, and will assist with management and mitigation of high-risk issues.

It should be noted that levies paid into the MRF required under the *Mining Rehabilitation Fund Act 2012* and the Mining Rehabilitation Fund Regulations 2013 are non-refundable and separate from the internal accounting provisions for closure and rehabilitation and should not be used to offset the costs for rehabilitation. The mine closure plan must contain a summary of the mine closure costing methodology, assumptions and financial processes to demonstrate that the proponent has properly considered and fully understood the costs of meeting closure outcomes identified in the mine closure 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 methodology must be provided in the plan. Where necessary, DMIRS 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).

12. Management of Information and Data

As per the *Statutory Guidelines for Mine Closure Plans* the mine closure plan must include a description of data management strategies, including systems and processes for the retention of mine records and all information and data relevant to mine closure.

Adequate data management is an important step in quality control of data, with leading practice data management and reporting systems able to provide automated alerts for key parameters and facilitate timely production of reports (DITR 2009b).

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 and relevant 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 manuals 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.

The domain/feature database can then be utilised to efficiently obtain relevant closure information. For example, for an existing waste dump domain or feature, a search should be carried out on the information available on the waste dump(s), such as:

- the year of construction of a waste rock dump;
- angle of batter slope angles;
- waste rock mineralogy types;
- chemical and physical properties of the waste material;
- presence of encapsulation cells;
- status of rehabilitation;
- trials undertaken and 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 requiring regular review and updates, 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 environmental management system functionality can provide an effective tool for capturing current closure planning activities and, 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-specific data and information should not be underestimated; it is essential to have a system in place to capture all relevant closure knowledge in the event that key personnel leave the site. Electronic mine closure systems that can store large amounts of data are suitable for this purpose.

13. Reviewed Mine Closure Plans

As per the *Statutory Guidelines for Mine Closure Plans*, in addition to the above information, where a mine closure plan is reviewed under s84AA of the Mining Act or included in a revision to an approved mining proposal, the reviewed mine closure plan must also include:

- A revision summary table that clearly outlines all changes made in the reviewed mine closure plan.
- A summary table documenting how the aspects identified by the department for improvement in the prior revision of the mine closure plan have been addressed.
- A table documenting how the knowledge gaps identified in the prior revision of the mine closure plan have been addressed, as well as any new gaps identified.

All mine closure plans approved by DMIRS must be regularly reviewed over the life of a mine: the Mining Act requires these plans to be reviewed and submitted for approval by DMIRS every three (3) years or such other time as specified in writing by DMIRS. This requirement will be stipulated in a tenement condition.

DMIRS requires a complete reviewed version, as well as summary table indicating the sections where changes have been made and a summary of information pertaining to the changes. DMIRS may request the modifications in the revised and resubmitted document during assessment to be highlighted to assist in finalising the assessment process. Please see the mine closure plan checklist (Appendix 3) that can be a useful tool for reviewing mine closure plans.

In the circumstance where there has been no mining and/or rehabilitation activities undertaken during the review period, proponents will still be required to submit a reviewed mine closure plan. This reviewed mine closure plan should include other closure planning activities that will have taken place during this period (e.g. ongoing stakeholder consultation and rehabilitation monitoring); and these activities need to be reported in the context of mine closure planning.

REFERENCES

ANZMEC/MCA 2000, *Strategic Framework for Mine Closure*, Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, National Library of Australian Catalogue Data.

ARPANSA 2002, *Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (1995)*, Radiation Protection Series No. 1, a publication produced by the Australian Radiation Protection and Nuclear Safety Agency, republished March 2002

ARPANSA 2005, Code of Practice and Safety Guide for *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*, Radiation Protection Series No. 9, a publication produced by the Australian Radiation Protection and Nuclear Safety Agency, August 2005

ARPANSA 2010, *Environment Protection: Development of an Australian approach for assessing effects of ionising radiation on non-human species* Technical Report TR154, a publication produced by the Australian Radiation Protection and Nuclear Safety Agency, October 2010

AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*, and HB 203:2006: *Environmental Risk management – Principles and process, Australian* Standards and New Zealand Standards.

AusIMM 2013, *Abandoned Mines Policy Statement*, The Minerals Institute.

DEH 2002, *Mine Decommissioning*, Best Practice Environmental Management in Mining, Commonwealth Department of Environment and Heritage, July 2002, Canberra (available on

DITR 2006, *Mine Rehabilitation*, Leading Practice Sustainable Development Program for the Mining Industry Department of Industry Tourism and Resources, Canberra.

DITR 2007, *Managing Acid and Metalliferous Drainage*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry, Tourism and Resources, Canberra.

DITR 2008, *Risk Assessment and Management*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry, Tourism and Resources, Canberra.

DITR 2009a, *Community Engagement and Development (currently being revised)*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry, Tourism and Resources, Canberra.

DITR 2009b, *Mine Closure and Completion (currently being revised)*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry Tourism and Resources, Canberra

DITR 2009c, *Hazardous Materials Management*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry Tourism and Resources, Canberra.

DMIRS 2014, *Mining Rehabilitation Fund – Guidance*, Department of Mines and Petroleum, Western Australia.

Dixon K W 2010, *Minesite Rehabilitation/Restoration Guidelines*, unpublished paper by Kings Park and Botanical Garden, Western Australia.

DRET/GS/DEWHA 2010, *Australia's In Situ Recovery Uranium Mining Best Practice Guide: Ground waters, Residues and Radiation Protection*, Department of Resources, Energy and Tourism, Geoscience Australia, Department of Environment, Water, Heritage and the Arts, Canberra.

ELAW 2010, *Guidebook for Evaluating Mining Project EIAs*, Environmental Law Alliance Worldwide, July 2010.

EPA 2006, *Guidance for the Assessment of Environmental Factors No. 6 – Rehabilitation of Terrestrial Ecosystems*, Environmental Protection Authority, Western Australia.

EPA 2018a, *Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual*, Environmental Protection Authority, Western Australia.

EPA 2018b, *Statement of Environmental Principles, Factors and Objectives,* Environmental Protection Authority, Western Australia.

EPA 2013, *Annual report 2012-13,* Environmental Protection Authority, Western Australia.

EPA 2014, *Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986*, Environmental Protection Authority, Western Australia.

Government of Western Australia 2014, *WA Environmental Offset Guidelines.*

IAEA 2002, *Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium*, IAEA Safety Reports Series No. 27, a publication produced by the International Atomic Energy Agency.

IAEA 2009, *Establishment of Uranium Mining and Processing Operations in the Context of Sustainable Development*, IAEA Nuclear Energy Series No.NF-T-1.1, a publication produced by the International Atomic Energy Agency.

IAEA 2010, *Best Practice in Environmental Management of Uranium Mining,* IAEA Nuclear Energy Series No.NF-T-1.2, a publication produced by the International Atomic Energy Agency.

ICMM 2008, *Planning for Integrated Mine Closure: Toolkit,* International Council on Mining & Metals, London, United Kingdom.

ICRP 2007, *The 2007 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 103, Ann. ICRP 37 (2-4), a publication produced by the International Commission on Radiological Protection.

ICRP 2008, *Environmental Protection* – the Concept and Use of Reference Animals and Plants, ICRP Publication 108, Ann. ICRP 38 (4-6), a publication produced by the International Commission on Radiological Protection.

INAP 2009, *Global Acid Rock Drainage Guide (GARD Guide)*, International Network for Acid Prevention.

Johnson S L and Wright A H 2003, *Mine Void Water Resources Issues in Western Australia*, Report Number HG9, Water and Rivers Commission, Perth.

Jones D R, Humphrey C, van Dam R Harford A, Tuner K and Bollhofer A 2009, *Integrated chemical, radiological and biological monitoring for an Australian uranium mine – a best practice case study*, International Mine Water Conference, Pretoria.

Lemley A D 2007, A *Procedure for NEPA Assessment of Selenium Hazards Associated with Mining*, Environmental Monitoring and Assessment 125:361-375.

MCA 2008, *Risk Communication in the Australian Minerals Industry – principles, tools and opportunities*, Minerals Council of Australia, March 2008.

MCMPR and MCA 2010, *Strategic Framework for Managing Abandoned Mines in the Minerals Industry*, produced by the Ministerial Council on Mineral and Petroleum Resources and the Minerals Council of Australia.

Ryser A l and Strawn D G 2005, *Micro-spectroscopic investigation of selenium-bearing minerals from the Western US Phosphate Resource Area*, Geochemical Transactions 6(1) 1-11.

US Geological Survey 2007, *Selenium Concentrations in Middle Pennsylvanian Coal-bearing Strata in the Central Appalachian Basin*. US geological Survey Open File Report 2007-1090.

van Dam RA, Hogan AC, McCullough CD, Houston MA, Humphrey CL and Harford AJ 2010 *Aquatic toxicity of magnesium sulfate, and the influence of calcium, in very low ionic concentration water*, Environmental Toxicology and Chemistry 29(2) 410-421.

WNA, World Nuclear Association Policy Document *Sustaining Global Best Practices in Uranium Mining and Processing – Principles for Managing Radiation, Health and Safety, Waster and the Environment.*

APPENDICES

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Appendix 3	Mine Closure Plan Checklist
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Appendix 5	Example of Closure Outcomes
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APPENDIX 1 - GLOSSARY

When preparing the mine closure plan, it is suggested that the following definitions are used.

Abandoned Mine Site	Non-operational mines where mining tenure no longer exists and the responsibility for rehabilitation cannot be allocated to any individual, company or organisation responsible for the mining activities. Such sites are also called "derelict", "orphan" or "former" mines.
Boundary of a landform	The edge of a landform is taken as being the base of the slope. This may be the battered footprint or the non-battered footprint. The footprint must not exceed the area specified in approval documentation.
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, that typically culminates in completion of all obligations under the *Mining Act 1978*, government "sign-off" and responsibility has been accepted by the next land user or manager. It includes decommissioning and rehabilitation.
Closure Outcomes	Required outcomes that will allow return of disturbed land to a safe, stable, non-polluting/ non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining and is consistent with the agreed post-mining land use. Closure outcomes should be i) realistic and achievable; ii) developed based on the proposed post-mining land use(s); and iii) as specific as possible to provide a clear indication on what the proponent commits to achieve at closure.
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.
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
Contaminated	Contaminated, in relation to land, water or a site, means having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value. This definition may apply to the artificial concentration (localised accumulation) of natural substances or minerals that have the potential to present a risk of harm to human health, the environment or any environmental value through this accumulation, such as mineral processing sites or tailings storage facilities.
Decommissioning	A process that begins near, or at, the cessation of mineral production and ends with removal of all unwanted infrastructure and services.
Disturbance Type	A feature created during mining or exploration activity as listed in Schedule 1 of the Mining Rehabilitation Fund Regulations 2013, e.g. waste dumps, transport or service infrastructure corridor (haul roads, access roads), ROM pad, plant site, tailings storage facility, borrow pits, land (other than land under rehabilitation or rehabilitated land) that has been disturbed by exploration operations (e.g. drill pads), waste dump or overburden stockpiles, building (other than workshop) or camp site, etc.
Disturbed	Area where vegetation has been cleared and/or topsoil (surface cover) removed.
DMIRS	Department of Mines, Industry Regulation and Safety Western Australia.
Domain	A group of landform(s) or infrastructure that has similar rehabilitation and closure requirements and objectives.

DBCA	Department of Biodiversity Conservation and Attractions.
DWER	Department of Water and Environmental Regulation.
Earthworks	Reshaping, capping, water/wind erosion control, rock armouring, ripping.
Ecologically Sustainable	Meeting the goal and principles of the National Strategy for Ecologically Sustainable Development, endorsed by all Australian 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.
Environmental Value	A beneficial use and/or an ecosystem health condition.
Key Stakeholders	The term "key stakeholders" refers to post-mining land owners/managers and relevant regulators.
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.
Performance Indicators	Also known as 'completion, closure, success or performance criteria', 'indicator', 'standard' or 'target'. Agreed standards or levels of performance that indicate the success of rehabilitation and enable an operator to determine when its liability for an area is able to cease. A criterion is a condition to be achieved for a particular attribute that is critical in achieving the objective. Where possible, criteria should be quantitative and/or capable of objective verification. Sometimes presented as separate indicator (what to measure) and standard (the level to be achieved).
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.
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.
Problematic materials	Materials that have the potential to detrimentally impact on humans and the environment and require careful and appropriate management (e.g. Potential Acid Forming (PAF) materials, radioactive materials, asbestiform materials, dispersive materials, arsenic etc.).
Risk pathway	The causal mechanism through which a hazard or risk would be realised or occur.
Rehabilitation	The return of disturbed land to a safe, stable, non-polluting/ non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining consistent with the agreed post-mining land use.

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 with an interest in a particular decision, either as individuals or representing 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.
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, the community, landowners or land managers having to take on responsibility for ongoing management, maintenance or monitoring above that which applied before mining, or that which applied to managing land uses comparable to the agreed land uses.
Waste Landforms (or Dumps)	Areas associated with the storage of unprocessed waste material resulting from a mining operation.

APPENDIX 2 - PLANNING FOR MINE CLOSURE

Principles of mine closure planning

DMIRS' objective for rehabilitation and mine closure is that mining activities are rehabilitated and closed in a manner to make them (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.

It is recommended that any residual liabilities relating to the agreed land use are identified and agreed to by the key stakeholders. Key stakeholders would not be accountable for any residual liabilities not identified by proponents that occur as a result of unexpected closure or failure to close a site properly.

The following key principles and approaches should be considered when preparing a mine closure plan (DITR 2006):

- From the project approval stage throughout mine life, 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 accepted.
- 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 (including but not limited to site activities or infrastructure) and environmental receptors.
- Consultation should take place between proponents and stakeholders which should include acknowledging and responding to stakeholders' 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 upon as soon as practicable.
- Materials characterisation 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. Materials characterisation should include the identification of materials with potential to produce acid, metalliferous or saline drainage, dispersive materials, erosive rock, fibrous and asbestiform materials, and radioactive materials, as well as benign materials intended for use in mine rehabilitation activities. The identification of good quality rehabilitation material (e.g. benign, fresh rock) should also be carried out.
- Closure planning should be based on adaptive management. Closure plans should identify relevant experience from other mine sites 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.

Risk Based Approach to mine closure planning

DMIRS endorses a risk-based approach to mine closure planning as it reduces cost and uncertainty in the closure process (ANZMEC/MCA 2000). The benefits of a risk-based mine closure process include:

- identifying a range of closure scenarios commensurate with risk;
- 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).

Further details on Risk Assessment and Management are provided in Appendix 6.

Staged Approach to mine closure planning

Progressive development of a mine closure plan throughout the mine lifecycle, as shown in Figure 1, and progressive rehabilitation, are critical to the successful implementation of mine closure planning (DITR 2006) and achieving DMIRS' rehabilitation and closure objective.

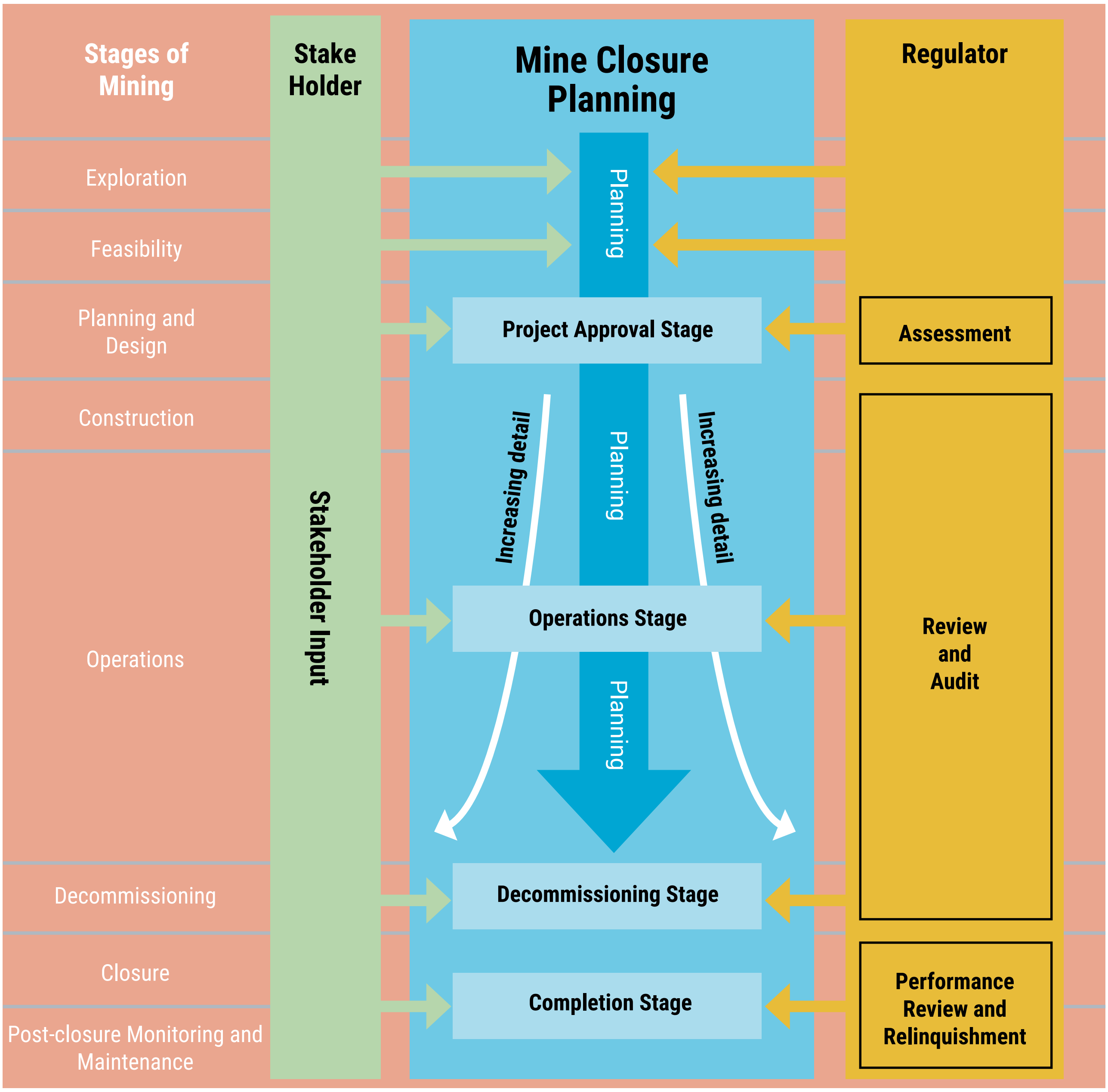

Figure 1 Integrating Stages of Mining and Mine Closure Planning (adopted from DITR 2006, ICMM 2008)

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

As outlined in Table 1, proponents must provide a sufficient level of detail on key closure components at each stage of mining. Key closure components include:

- post-mining land use;
- closure outcomes;
- completion criteria;
- collection and analysis of closure data; and
- materials characterisation, including mineral waste.

Figure 2 below summarises the planning stages that are incorporated into a mine closure planning framework, highlighting the timing of stages that ensures mine closure plans are developed with all the relevant information available from one stage to the next. The structure of a mine closure plan is designed to assist industry compile mine closure plan information in a sequential order that is easier to use and for DMIRS to assess.

Mine closure planning for Rehabilitation

Rehabilitation is a critical part of mine closure planning and is referred to throughout this document. Key sections relating to and providing information on rehabilitation are Post-mining Land Use(s) and Closure Outcomes, Completion Criteria, Collection and Analysis of Closure Data, Identification and Management of Closure Issues, Examples of Closure Outcomes, Overview of Specific Mine Closure Issues and Examples of Completion Criteria.

For mine closure planning, it is important to separate the different components of a mine site into those that can be restored, those that can be rehabilitated, those that can be revegetated, and those that will not return any environmental value in the foreseeable future (i.e. areas that will remain a significant residual impact). This allows different outcomes to be considered across a mine site.

Some disturbances may be able to be ecologically restored - to restore the landscape to conditions similar to the surrounding (non-mined) environment, including physical, biological and chemical processes. However, there can be significant challenges to achieving this level of mine closure in WA.

It is important to remember that continual improvement in rehabilitation techniques will occur over time and proponents should actively include this in their mine closure planning.

Effective, early planning will minimise rehabilitation costs. Taking a more integrated and progressive approach to mine rehabilitation can achieve effective mine rehabilitation and aid in meeting closure outcomes (DITR, 2006). DMIRS encourages proponents to progressively rehabilitate, where possible, recognising that some forms of mining, e.g. strip mining (minerals sands) may make progressive rehabilitation more feasible. For large scale hard rock mines, proponents should consider using pits for backfilling waste (particularly where there are multiple pits) and progressively rehabilitate areas where possible, e.g. linear and supporting infrastructure areas. DMIRS recognises that revegetation is likely to be more successful in temporarily disturbed areas.

Progressive rehabilitation can also provide an early indication as to whether the mine closure plan needs to change to meet closure outcomes proposed by the proponent and whether closure outcomes are realistic and achievable. Furthermore, progressive rehabilitation enables contamination issues to be adequately managed in an appropriate manner and within an appropriate timeframe based on the risk posed. Not managing contamination issues in a timely manner can result in an increase of the extent of that contamination, and represent an exponentially greater cost of remediation at mine closure. There is a large overall benefit, not only in cost, to dealing with contamination through a progressive process, rather than leaving such actions to the point of closure, which can be many years (or decades) in some cases.

For existing mine sites, attention needs to be given to the best pragmatic options for mine closure. DMIRS recognises the issues with older mine sites where no or little mine closure planning has occurred early enough in the process and the challenges this presents in returning environmental values. Proponents in this position are encouraged to commence discussions with DMIRS as early as possible to review what options are available. The options may include determining which areas of a mine site can realistically be rehabilitated to return environmental values and which cannot. These options are not about removing environmental responsibilities in preparing for mine closure, which should be ongoing throughout the life of a mine. There is an expectation that should alternative options be considered, it must still be demonstrated that there is an overall environmental net benefit. Where changes to conditions are proposed that cause additional environmental impacts to the original proposal, proponents will need to consider any significant residual impacts that may result from those changes.

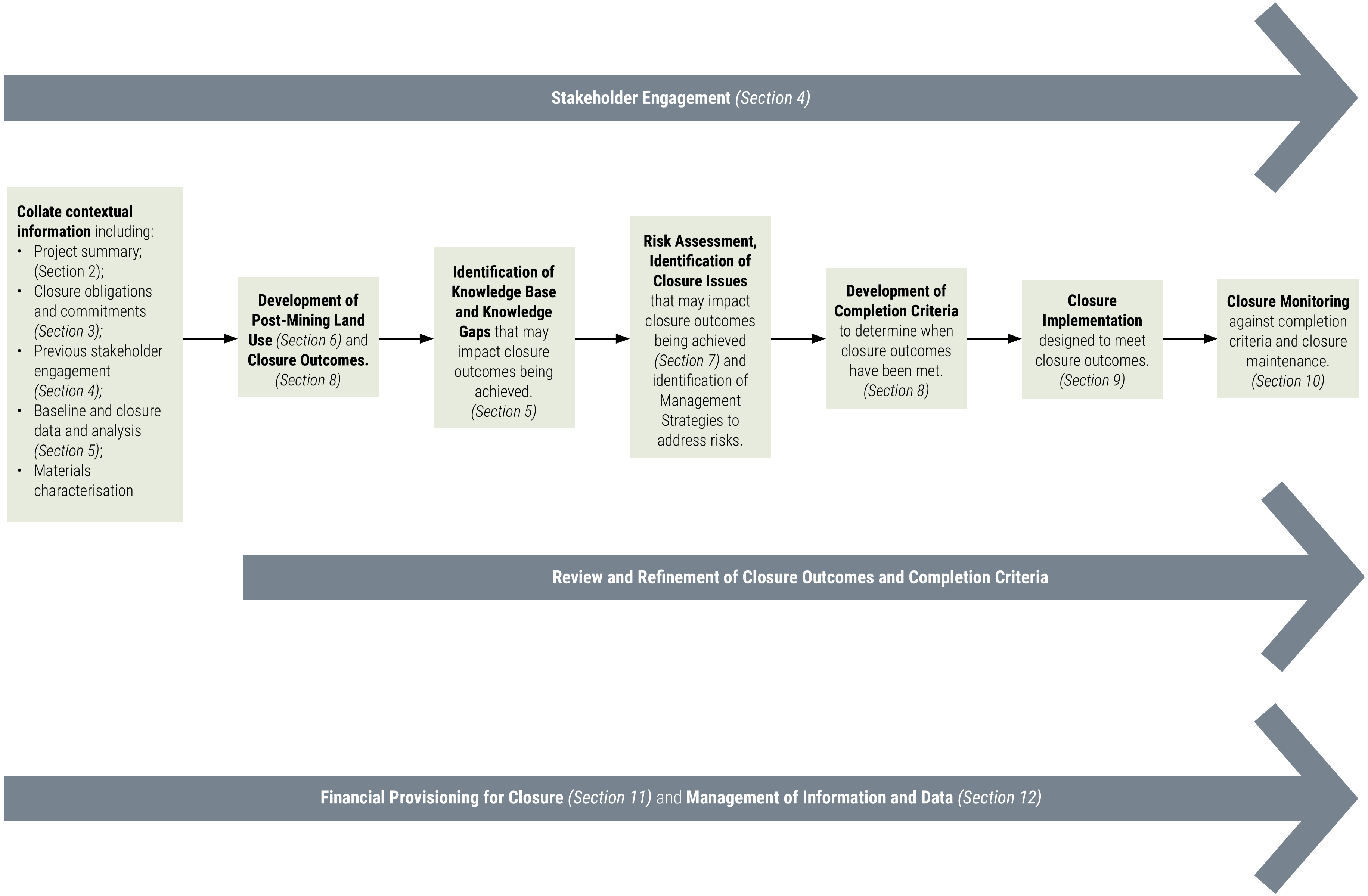

Figure 2 – Planning framework for mine closure

Table 1 Indication of required level of closure detail

Stages of Mining	Stakeholder Engagement	Post-mining Land Use	Closure Outcomes	Development of Completion Criteria	Collection and Analysis of Closure Data	Materials Characterisation	Identification and Management of Key Environmental Issues	Closure Implementation and Monitoring Plans	Financial Provisioning Assumptions
Exploration	Stakeholders identified. Stakeholder engagement instigated – proposed end land use options and plans for closure discussed	Provisional targets unless agreed to by all key stakeholders as being final	Indicative except for high risk	• Drill holes secured immediately after drilling (capped/plugged) • Drill holes securely plugged below ground at minimum depth of 400mm within 6 months of drilling • Scarifying/ripping of compacted areas on the contour • Blocking access to tracks • Drill sample piles rehabilitated or buried • Sample bags removed within 6 months of drilling • All rubbish removed from site (including any hydrocarbon spills) • Excavations (e.g. sumps, costeans etc.) backfilled and respread with topsoil and cleared vegetation	Exploration information to be used in rehabilitation and closure planning collated (e.g. waste characteristics and drill hole database)	Sampling of drilling program		Preliminary except for high risk operations	Process, methodology and assumptions transparent and verifiable and based on reasonable site-specific information
Planning and Design/ Environmental Assessment Stage	Consultation continues – proposed end land use options refined and plans for closure discussed. Ongoing consultation strategy defined	Well advanced	Well advanced	Qualitative	Development of the operation with rehabilitation and closure in mind (e.g. waste landform design and location)	Detailed material characterisation including geochemical and physical properties, volumes and proposed uses.	Closure-based risk assessment conducted and mitigation strategies incorporated into mine design.	Well advanced	Process, methodology and assumptions transparent and verifiable and updated to reflect increased knowledge of the operation.

Stages of Mining	Stakeholder Engagement	Post-mining Land Use	Closure Outcomes	Development of Completion Criteria	Collection and Analysis of Closure Data	Materials Characterisation	Identification and Management of Key Environmental Issues	Closure Implementation and Monitoring Plans	Financial Provisioning Assumptions
Construction	Consultation continues – proposed end land use options refined and plans for closure discussed	Well advanced to completed	Well advanced to completed	Qualitative, analogue establishment	Construction practices that make rehabilitation and closure easier (e.g. topsoil clearing management and appropriate surface water management)	Validation and verification sampling and analysis.	Initial risk assessment reviewed to ensure mitigation strategies have been implemented appropriately and are working,any new risks captured and mitigation strategies put in place	Completed	Process, methodology and assumptions transparent and verifiable and updated to reflect increased knowledge of the operation.
Operations	Review stakeholder engagement plan. Consultation continues	Completed	Completed	Criteria updated to quantifiable and reviewed against ongoing analogue monitoring and the commencement of rehabilitation monitoring Criteria can be reviewed and discussed with regulators as refinement progresses depending on outcomes of monitoring	Progressive rehabilitation undertaken during operations including research trials, and/or closure of satellite operations	Continued validation and verification sampling and analysis through operations	Risk assessment reviewed to ensure mitigation strategies have been implemented appropriately and are working, and any new risks captured and mitigation strategies put in place (a number of reviews may take place depending on mine life)	Completed	Process, methodology and assumptions transparent and verifiable and reviewed to reflect changing circumstances and to ensure that the accuracy of closure costs will be refined and improved with time

Stages of Mining	Stakeholder Engagement	Post-mining Land Use	Closure Outcomes	Development of Completion Criteria	Collection and Analysis of Closure Data	Materials Characterisation	Identification and Management of Key Environmental Issues	Closure Implementation and Monitoring Plans	Financial Provisioning Assumptions
Decommissioning	Consultation continues	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	Criteria quantifiable and reviewed against ongoing analogue and rehabilitation monitoring	Closure and decommissioning as per an approved decommissioning plan	If required from rehabilitation monitoring results	Risk assessment reviewed to ensure risks associated with decommissioning have been identified and mitigation strategies incorporated into the decommissioning plan	Determined on a case-by-case basis depending on mine life and risk	Process, methodology and assumptions transparent and verifiable and reviewed to reflect changing circumstances and to ensure that the accuracy of closure costs will be refined and improved with time
Post-closure monitoring and maintenance	Consultation continues through to closure completion			Monitoring of rehabilitation against approved closure criteria	Monitoring of rehabilitation against approved closure criteria	If required	Risk assessment reviewed to ensure risks associated with post-closure monitoring and maintenance activities have been identified and mitigation strategies incorporated into monitoring plan		

APPENDIX 3 - 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. For mine closure plan revisions please indicate where updates have been made to the previous revision and a brief summary of the change.

Q No	Mine Closure Plan (MCP) checklist	Y/N/NA	Page No.	Comments	Changes from previous version (Y/N)	Page No.	Summary
1	Has the Checklist been endorsed by a senior representative within the tenement holder/ operating company? (See bottom of checklist.)						
Public Availability							
2	Are you aware that all approved MCPs will be made publicly available?						
3	Is there any information in this MCP that should not be publicly available?						
4	If “Yes” to Q3, has confidential information been submitted in a separate document/section?						
Cover Page, Table of Contents							
5	Does the MCP cover page include: • Project title • Company name\ Contact details (including telephone numbers and email addresses) • Document ID and version number • Date of submission (needs to match the date of this checklist)						*E.g. company name change*
Scope and Purpose							
6	State why the MCP is submitted (e.g. as part of a mining proposal, a reviewed MCP or to fulfil other legal requirements)						*E.g. As part of mining proposal*
Project Overview							
7	Does the project summary include: • Land ownership details (include any land management agency responsible for the land / reserve and the purpose for which the land / reserve [including surrounding land] is being managed). • Location of the project. • Comprehensive site plan(s). • Background information on the history and status of the project.						
Legal Obligations and Commitments							
8	Does the MCP include a consolidated summary or register of closure obligations and commitments?						
Stakeholder Engagement							
9	Have all stakeholders involved in closure been identified?				N		

Q No	Mine Closure Plan (MCP) checklist	Y/N/NA	Page No.	Comments	Changes from previous version (Y/N)	Page No.	Summary
10	Does the MCP include a summary or register of historic stakeholder engagement with details on who has been consulted and the outcomes?				Y	60	*E.g. new stakeholders identified and stakeholder engagement register updated*
11	Does the MCP include a stakeholder consultation strategy to be implemented in the future?				Y	61	*E.g. stakeholder strategy included*
Post-mining land use(s) and Closure outcomes							
12	Does the MCP include agreed post-mining land use(s), closure outcomes and conceptual landform design diagram?				Y	62	*E.g. Updated closure outcomes*
13	Does the MCP identify all potential (or pre-existing) environmental legacies, which may restrict the post mining land use (including contaminated sites)?						
14	Has any soil or groundwater contamination that occurred, or is suspected to have occurred, during the operation of the mine, been reported to DWER as required under the *Contaminated Sites Act 2003*?						
Development of Completion Criteria							
15	Does the MCP include an appropriate set of specific completion criteria and closure performance indicators?				Y	62	*E.g. Updated closure outcomes*
16	Does the MCP include baseline data (including pre-mining studies and environmental data)?						
17	Has materials characterisation been carried out consistent with applicable standards and guidelines (e.g. GARD Guide)?						
18	Does the MCP identify applicable closure learnings from benchmarking against other comparable mine sites?						
19	Does the MCP identify all key issues impacting mine closure outcomes and outcomes (including potential contamination impacts)?						
20	Does the MCP include information relevant to mine closure for each domain or feature?				Y	64	*E.g. MCP updated as a new mining proposal was submitted*
Identification and Management of Closure Issues							
21	Does the MCP include a gap analysis/risk assessment to determine if further information is required in relation to closure of each domain or feature?						
22	Does the MCP include the process, methodology, and has the rationale been provided to justify identification and management of the issues?						

Q No	Mine Closure Plan (MCP) checklist	Y/N/NA	Page No.	Comments	Changes from previous version (Y/N)	Page No.	Summary
Closure Implementation							
23	Does the MCP include a summary of closure implementation strategies and activities for the proposed operations or for the whole site?				Y	66	*E.g. Updated as a new mining proposal for the operation was approved*
24	Does the MCP include a closure work program for each domain or feature?						
25	Does the MCP contain site layout plans to clearly show each type of disturbance as defined in Schedule 1 of the MRF Regulations?						
26	Does the MCP contain a schedule of research and trial activities?						
27	Does the MCP contain a schedule of progressive rehabilitation activities?						
28	Does the MCP include details of how unexpected closure and care and maintenance will be handled?						
29	Does the MCP contain a schedule of decommissioning activities?						
30	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?						
Closure Monitoring and Maintenance							
31	Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance?						
Financial Provisioning for Closure							
32	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?				Y	67	*E.g. Costings updated to reflect current market values*
33	Does the MCP include a process for regular review of the financial provision?						
Management of Information and Data							
34	Does the MCP contain a description of management strategies including systems and processes for the retention of mine records?						

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 Mine Closure Plans approved by the Director General of the Department of Mines, Industry Regulation and Safety.

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 4 - EXAMPLE OF A LEGAL OBLIGATIONS REGISTER

MINE NAME – Legal Compliance Register		
Relevant DMIRS 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

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 5 - EXAMPLES OF CLOSURE OUTCOMES

The following examples are provided to illustrate types of closure outcomes and should not be used as copy-and-paste templates. Each operation will need to develop its own site-specific set of outcomes that are realistic and achievable.

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 landforms will be stable and consistent with local topography.
- Constructed Tailings Storage Facilities will be non-polluting/ non-contaminating, 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 the 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 environmental values as surrounding natural ecosystems.
- The rehabilitated ecosystem has equivalent functions and resilience as the target ecosystem.
- Soil properties will be appropriate to support target ecosystem.

Fauna

- Rehabilitated areas provide appropriate habitat for fauna.
- Fauna utilisation, abundance and diversity are present in appropriate proportions given the 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 will be installed and maintained.

APPENDIX 6 - PRACTICAL EXAMPLES OF RISK ASSESSMENTS

Example 1: Link between baseline data and risk assessment; considering all mine phases.

Project Phase	Activity	Risk Pathway	Likelihood	Consequence	Raw Risk	Treatment	Likelihood	Consequence	Treated Risk
Construction/ Operation	Vegetation clearing or other ground disturbing activities.	Unauthorised clearing / ground disturbing activities resulting in impacts to conservation significant flora.	Possible	Major	High	**No known conservation significant flora located in the Project site area or broader vicinity.**	Rare	Major	Moderate

Project Phase: Adding a 'Project Phase' column to the risk assessment table is a useful way of ensuring all phases of mining are considered.

Treatment: The environmental baseline data does not appear to have adequately informed the identification of risks for this site. The baseline studies have indicated that there are no conservation significant flora located in the project site area or broader vicinity, however the risk assessment indicates the impact on conservation significant flora is possible. Although the risk is high, no treatment is offered for the risk, just a statement to explain that there is no reasonable risk present. Only risks that are actually relevant to the project site should be included in the risk assessment, and an appropriate level of treatment should be applied to each of these risks.

Example 2: Fully describing the risk

Project Phase	Activity	Risk Pathway and Impact	Likelihood	Consequence	Raw Risk	Treatment	Likelihood	Consequence	Treated Risk
Operation	Pit dewatering.	**Discharge of dewater into Blackadder Creek.** ------------------------ **Discharge of dewater into Blackadder Creek leading to increased salinity, turbidity and heavy metal levels within the creek and broader catchment, resulting in negative impacts to the ecological function of the creek.**	Likely	Moderate	High	Adherence to Department of Water and Environmental Regulation (DWER) licence conditions.	Unlikely	Moderate	Moderate

The description of the risk in the top (red) version is quite limited. The bottom version (green) describes in more detail the specific environmental elements of the risk. This makes it easier for a reviewer to determine whether all the environmental risks for the project have been identified in the risk assessment, and to ensure the treatments appear appropriate.

Adding a column for 'impact' can be used to clearly differentiate the impact from the risk pathway. For the above example, the risk pathway is 'discharge of dewater from Blackadder Creek' and the impact is 'increased salinity, turbidity and heavy metals within the creek and broader catchment'. The risk treatment should address the causes of the risk event. Refer to the below.

Project Phase	Activity	Risk Pathway	Impact	Likelihood	Consequence	Raw Risk	Treatment	Likelihood	Consequence	Treated Risk
Operation	Pit dewatering.	Discharge of dewater into Blackadder Creek.	**Increased salinity, turbidity and heavy metal levels within creek and broader catchment.**	Likely	Moderate	High	Adherence to Department of Water and Environmental Regulation (DWER) licence conditions.	Unlikely	Moderate	Moderate

Example 3: Using the ALARP principle

Project Phase	Activity	Risk Pathway	Likelihood	Consequence	Raw Risk	Treatment	Likelihood	Consequence	Treated Risk
Construction, Operation, Care and Maintenance, Closure	Incidental mining and exposure of PASS[2] material within the mine void.	Oxidation of PASS material causing lowering of pH and release of metals to the soil profile, groundwater, and surface water.	Possible	Major	High	Place any mined PASS material within a lined and bunded area prior to backfilling within the mine void. Groundwater quality monitoring to detect any reductions in pH or elevations in heavy metals.	Unlikely	Major	Moderate
Project Phase	**Activity**	**Risk Pathway**	**Likelihood**	**Consequence**	**Raw Risk**	**Treatment**	**Likelihood**	**Consequence**	**Treated Risk**
Construction, Operation, Care and Maintenance, Closure	Incidental mining and exposure of PASS material within the mine void.	Oxidation of PASS material causing lowering of pH and release of metals to the soil profile, groundwater, and surface water.	Possible	Major	High	**Mining levels set to avoid PASS; 5m buffer maintained above mapped PASS layer.** Groundwater quality monitoring to detect any reductions in pH or elevations in heavy metals.	Rare	Moderate	Low

The top table has not demonstrated that the risk has been treated to ALARP in comparison to the bottom table. The bottom table has applied an avoidance strategy to avoid the risk, as opposed to just control and mitigation strategies.

NB – DMIRS acknowledges that avoidance may not always be possible in every circumstance, however this scenario is provided as an example.

[2] PASS – Potentially acid sulphate soils

Example 4: Providing adequate information on treatments for higher risk issues

Phase	Activity	Risk Pathway	Likelihood	Consequence	Raw Risk	Treatment	Likelihood	Consequence	Treated Risk
Operation, Care and Maintenance, Closure	Storage of potentially hostile materials in the waste landform.	Exposure of the highly reactive black shale causing acid and/ or metalliferous drainage, contaminating the soil and groundwater and preventing revegetation of the waste landform.	Likely	Major	Very High	**Implementation of the XY Project Black Shale Management Plan (Appendix X) to ensure:** • **All material capable of generating acid mine drainage is identified as it is mined.** • **All PAF material is temporarily stored on the PAF holding pad.** • **The material is dumped within the PAF cell.** **Encapsulation of all PAF material within an engineered containment in accordance with the design report (Appendix X).**	Unlikely	Major	Moderate

The raw (untreated) risk in this example is very high and requires specific and detailed treatments to lower the risk to moderate. Therefore additional details regarding these treatments will be supplied as technical appendices to the Mining Proposal and/or Mine Closure Plan.

APPENDIX 7 - OVERVIEW OF SPECIFIC MINE CLOSURE ISSUES

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 (AMD);
- Radioactive materials;
- Fibrous (including asbestiform) materials;
- 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;
- Erosive materials;
- Design and maintenance of surface water management structures;
- Dust emissions;
- Flora and fauna diversity/threatened species;
- Challenges associated with rehabilitation and revegetation (see section 4.16 Closure Implementation);
- Visual amenity;
- Heritage issues;
- Sensitive receptors;
- Regulatory requirements;
- Alteration of the direction of groundwater flow;
- Alteration of the depth to water table of the local aquifers; and
- Alteration of the hydrology and flow of surface waters.

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 identified above. Technical advice should be sought from appropriately qualified experts and/or regulators in relation to identification and management of issues at any particular site.

Key rehabilitation and closure issues identified by DMIRS are:

- acid and metalliferous drainage;
- dispersive materials;
- rehabilitation;
- radioactivity; and
- mine pit lakes.

This appendix provides a general overview of the following specific mine closure issues:

1. Acid and metalliferous drainage;
2. Dispersive materials;
3. Rehabilitation; and
4. Radiation management.

More detailed Pit Lake Assessment guidance is provided in Appendix 8.

1. Acid and Metalliferous Drainage

Acid and metalliferous drainage has the potential to impact on water quality during operations and post closure.

i. Definition

Mine drainage may consist of acid drainage and/or metalliferous drainage. Acid and metalliferous drainage (AMD) originates when sulphide material is exposed to air and water. Metalliferous drainage can occur when acid is neutralised but concentrations of some metals remain elevated at near neutral or alkaline conditions (DITR 2007). Potential sulphide-bearing material includes waste rock, pit wall rock and tailings.

ii. Potential impacts

AMD is recognised one of the most serious environmental issues associated with mining (http://www.inap.com.au). Over the past 30 to 40 years, as mining operations have evolved to large-tonnage open cut operations, the mass of sulfidic material with the potential to create AMD has increased dramatically (DITR 2007).

Acid and metalliferous drainage from old mine sites can cause ongoing pollution lasting for centuries or even millennia. As AMD (containing sulphuric acid, high concentrations of metals and low oxygen concentrations) enters groundwater and surface water systems, it can present a major risk to aquatic life, riparian vegetation and water resources (DITR 2007).

Where there are AMD issues at mine sites, remediation and treatment costs can be high and can prevent the closure completion of mining leases. There is also the potential for impacts from other contaminated mine drainage, particularly drainage which contains toxic metals and metalloids and saline drainage.

iii. Identification and characterisation

Proponents need to collect adequate information to be able to identify the potential for AMD and other contaminated mine drainage. Adequate geochemical characterisation is critical to be able to accurately predict water quality (Kuipers et al 2006). Sampling for geochemical testing must be representative of geological materials at the project site (including country and host rock). Sampling designs should consider existing data, mine plans and spatial variability of the geological materials. Geochemical characterisation of deposits and determination of potential environmental issues can be complex. DMIRS recommends suitably experienced geotechnical professionals undertake this work.

If testing shows there is a significant risk of acid, metalliferous, or other contaminated drainage, the proponent should demonstrate in the initial mine closure plan that the proposed management strategy will provide a sustainable closure solution. This includes sustainable closure of mine waste rock landforms, tailings facilities and mine pit lake(s).

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.

Progressive evaluation of AMD risk, commencing during the exploration phase and continuing throughout mine planning, provides the data necessary to quantify potential impacts and management costs prior to significant disturbance of sulfidic material (DITR 2007).

If the geology of the area is such that AMD 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.

Static tests take a "stocktake" of the minerals present and their potential to cause or alleviate AMD. Kinetic and other detailed tests can be used to assess how AMD may develop over time (DITR 2007). Proponents should estimate the location of sulphide-bearing rock and the amount that may be disturbed during operations. Proponents should also estimate the total sulphur content of waste rock and fines. While a total sulphur content of 0.3 per cent is used as a guide, below which the risk to water quality may be low, there may be risks to water quality at lower sulphur content values. Proponents must undertake a site-specific assessment, including identifying sensitive receiving environments, to determine the AMD risk.

DMIRS recognises that kinetic leach testing can take up to 24 months before sufficient data is available for effective interpretation of the AMD characteristics of a material, and this may affect assessment and approval timeframes. Where kinetic and other long duration testing is required due to potentially harmful materials being present, but has not been completed during the assessment/approval stages, it may be required as part of the mine closure plan.

In addition to characterising potential AMD sources, other chemical and physical processes that can affect water quality must be considered when assessing management options and the potential for AMD risk. For example, 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).

Current 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 Global Acid Rock Drainage Guide (GARD Guide) (INAP http://gardguide.com/).

iv. Management

If the potential for AMD and/or other contaminated mine drainage has been identified, proponents must demonstrate through the mining proposal or Environmental Impact Assessment process that there are measures capable of managing the issue. Efforts should focus on prevention or minimisation, rather than control or treatment.

It is strongly recommended that proponents refer to the GARD Guide (INAP http://gardguide.com/) for detailed guidance on characterisation, prediction, management and treatment for AMD.

2. Dispersive Materials

Dispersive materials are those materials that are structurally unstable and disperse in water into basic particles (such as sand, silt and clay). Dispersive materials tend to be highly erodible and present problems for rehabilitation and successfully managing earthworks (DITR, 2006). Dispersive materials affect stability of post-mining landforms and can also contribute to contaminated mine drainage.

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, contributing 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 as 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:

- electrical conductivity (EC) to assess potential salinity constraints on dispersion;
- exchangeable cations, with particular emphasis on exchangeable sodium percentage (ESP) to assess dispersion potential;
- potentials for slaking and dispersion (Emerson test);
- particle size distribution (to provide an indication of soil cohesion and liquefaction contributions to tunnel formation/failure); and
- 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 ensure that those materials are not exposed to ponded runoff or through drainage. Early diagnosis of potential tunnelling problems and adoption of strategies to prevent such long-term instability are essential for successful mine closure.

3. Rehabilitation

i. Definition

Rehabilitation is defined as the return of disturbed land to a safe, stable, non-polluting/non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining and consistent with the agreed post-mining land use. Rehabilitation outcomes may include revegetation, which is defined as the establishment of self-sustaining vegetation cover after earthworks have been completed.

Mine site rehabilitation should be designed to meet three key objectives:

1. The long-term stability and sustainability of the landforms, soils and hydrology of the site.
2. The partial or full repair of ecosystem capacity to provide habitats for biota and services for people (WA EPA 2006).
3. The prevention of pollution of the surrounding environment.

ii. Applying the mitigation hierarchy to minimise disturbed areas

DMIRS expects proponents to apply the mitigation hierarchy (avoid, minimise and rehabilitate) to minimise the area associated with the mining proposal that will be disturbed, and hence the area to be rehabilitated. DMIRS recognises that rehabilitation can be a considerable cost. Maximising planning reduces site disturbance and ensures that material such as waste rock is close to its final location which can reduce some of the costs associated with rehabilitation (DITR 2006).

iii. Rehabilitation objectives

Rehabilitation objectives are established through defining the post-mining land use(s) and site-specific closure outcomes consistent with those land use(s). Completion criteria are necessary to provide the basis on which successful rehabilitation and mine closure, and achievements of closure outcomes are determined. See Appendix 5 for examples of closure outcomes.

iv. Progressive Rehabilitation

DMIRS expects mine sites to be progressively rehabilitated where possible. Progressive rehabilitation is important as it provides opportunities for testing rehabilitation practices, and for the gradual development and improvement of rehabilitation methods (DITR 2006). Progressive rehabilitation can reduce costs over the long term by improving rehabilitation outcomes and minimising the requirement to rework poorly rehabilitated areas.

Mine planning and engineering decision-making processes should optimise opportunities for progressive rehabilitation consistent with the post-mining land use(s) and closure outcomes. 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.

v. Key elements of rehabilitation

For more general information on mine rehabilitation, including environmentally sustainable design of artificial landforms, proponents should refer to the Leading Practice Handbook on Mine Rehabilitation (DITR 2006).

vi. Landform design

It is critical to design landforms to minimise the costs of construction and long-term maintenance. Landform design should consider (DITR 2006):

- Placement of landforms - avoid surface water flow paths, proximity to project boundaries);
- Height/footprint – balance footprint to minimise disturbed area, with height to be able to construct and maintain a stable landform;
- Drainage – consider control of drainage, with engineered solutions, if appropriate;
- Mode of construction – to enable selective placement of problem materials; and
- Profiles – angle and shape of battered slopes, use of berms.

vii. Landform construction

The mine closure plan should demonstrate landforms, soil profiles and soil characteristics will be consistent with the proposed final land use.

viii. Materials Characterisation

Characterisation of topsoils and overburden should start as early as the exploration phase and continue throughout the pre-feasibility and feasibility phases as a basis for mine planning. The requirement for materials characterisation continues during the operation of the mine, particularly where the ore grade and mine plan change in response to altered market conditions (DITR 2006).

For stabilisation and rehabilitation of landforms, characterisation of materials present may enable selective placement during landform construction to minimise risks of erosion or revegetation failure. It may also enable remedial work, planning or investigations to be timelier and more cost-effective (DITR 2006).

ix. Materials Handling

Waste rock landforms should be constructed to avoid oxidation, which can occur when waste is end-dumped and oxygen enters the larger boulders at the toe of the dump and flows upwards to the finer material (DITR 2006). Sufficient benign material should be available to encapsulate problem material in waste rock landforms and tailings storage facilities.

x. Drainage

Landforms should be constructed to mimic natural drainage patterns as much as possible to avoid erosion. Where drainage, infiltration and seepage from landforms may impact the water quality of surface and groundwater systems, engineered solutions may be required, such as covers, liners, and drainage systems to collect and direct runoff and seepage.

xi. Revegetation

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

A key to the successful creation of compliant post-mining revegetation 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 revegetation 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).

xii. Species and community identification – vegetation surveys

Information necessary for benchmarking and establishing species/community revegetation targets includes:

- 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; and
- 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.

xiii. Topsoil

Soil seedbanks have many advantages as sources of material for rehabilitation including that 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 Western Australia.

Research has demonstrated that the following key standards are critical for effective use of topsoil to maximise soil seedbank retention, seedling germination and seedling establishment:

- Stripping: seeds of native species mostly reside in the top 10cm. Due to technical limitation, stripping should focus on retrieving this top layer to a maximum depth of 20cm.
- Timing of stripping: always strip dry soil and ensure soil remains dry at all times, including transfer, storage and replacement phases.
- Topsoil storage: Based on emerging research, dry topsoil piles can be maintained with effective biodiverse capability through use of windrows or bins, with a height likely to be substantially greater than 2m. Covering topsoil (e.g. through use of tarpaulins, erosion control matting or geotextiles) will retain topsoil in a dry state. This is critical, as wetting will trigger germination and subsequent anaerobic conditions, substantially decreasing the effectiveness of the topsoil. Where covering is not an option, soil slope gradients should optimise run-off with drainage constructed at the base of the pile to direct water away, and should be used as soon as possible.
- Topsoil spreading: replace topsoil at the depth appropriate to emergence capability of seeds – ideally, this is a depth no greater than 5cm as most native seeds cannot emerge from depths greater than 5cm (optimum is 1-2cm).

xiv. Growth Medium

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

xv. Standards for Seed Collection and Use

For areas where topsoil is not capable of returning the stipulated level of biodiversity, the reliance on seed to achieve targets is increased.The seed supply chain (Figure 1) provides the key steps that are critical for considering how wild seed is sourced and utilised correctly. For most regions, information on site and species-specific requirements is not available.

Procedures to optimise seed resources should focus on those below (summarised also in Figure 2):

xvi. 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 in which 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 per cent relative humidity stored for short to medium-term (1-5y) at 5°C; long-term (>5y) at -18°C.

xvii. 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 optimisation, and stress control.
- Understanding interactions of seed-use technologies with post-mined.
- Landscapes (biotic and abiotic) to optimise plant regenerative capacity.

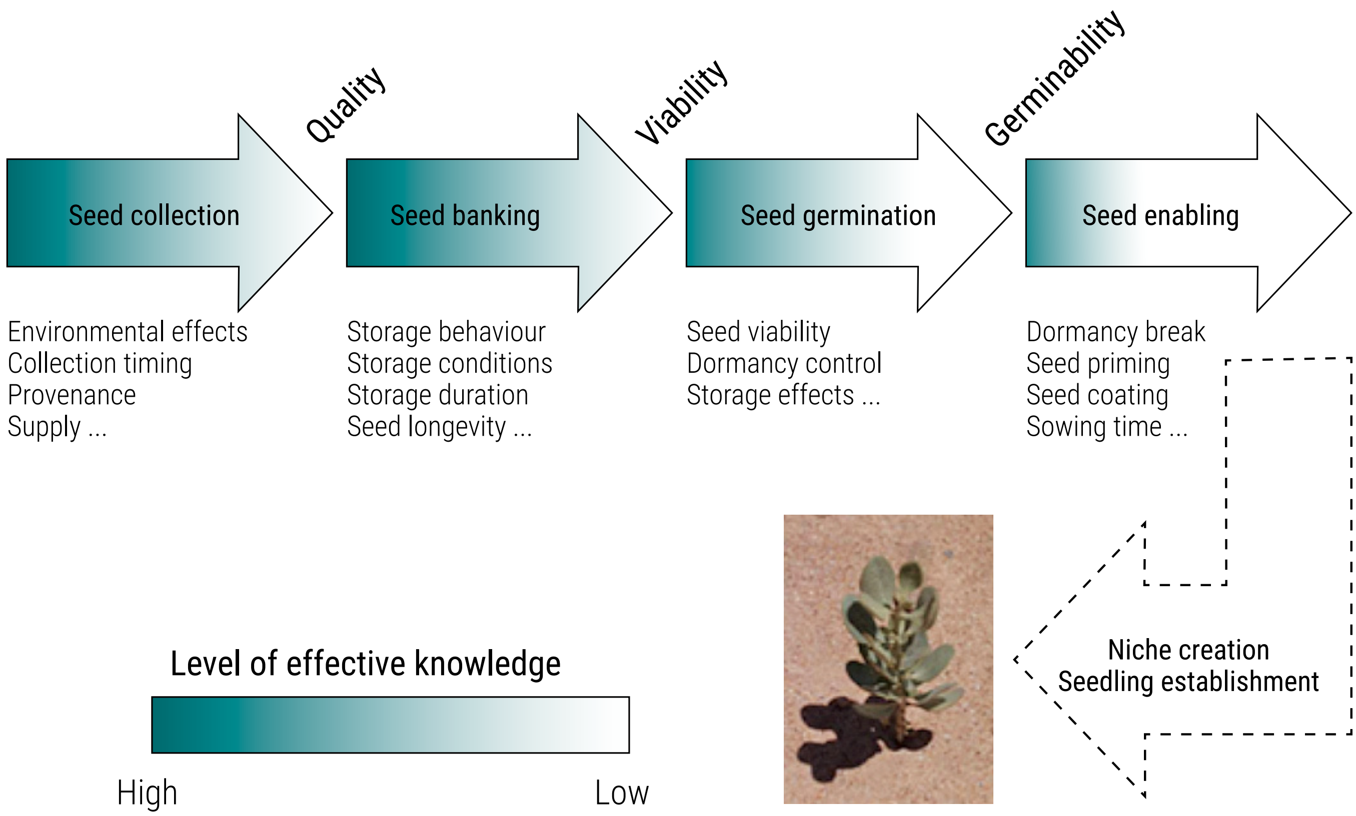

Figure 1: The seed supply chain

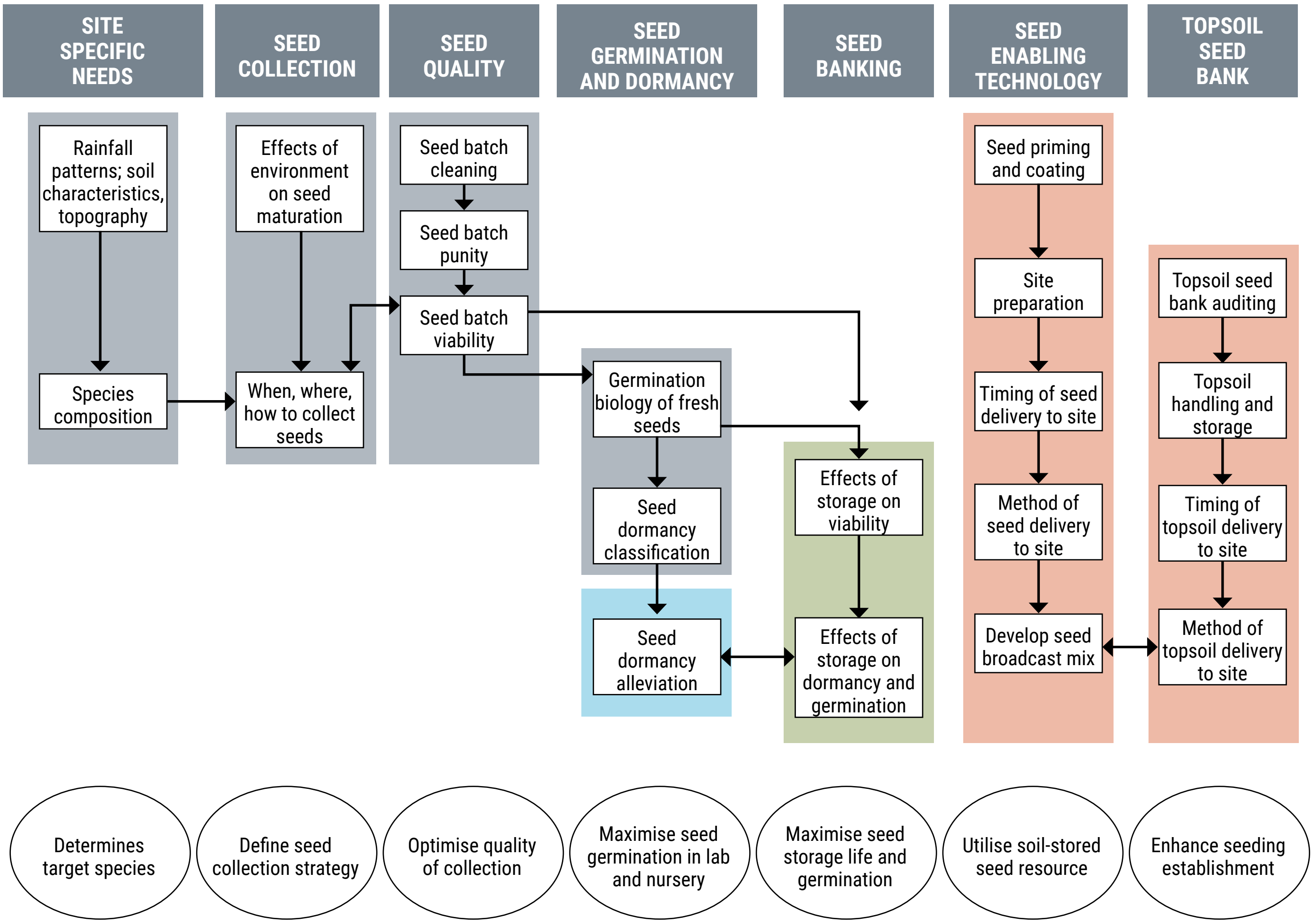

Figure 2: A systematic approach to developing whole-of-mine revegetation techniques

xviii. Research and trials

Research and on-site rehabilitation trials are important to collect data that will assist in the refinement of closure outcomes and completion criteria. This is particularly important for elements of the mine site where it is difficult for progressive rehabilitation to occur (e.g. large scale open pits and permanent waste rock landforms). For example, monitored trials are generally required to develop the most appropriate slope treatments for landforms at a particular mine site (DITR 2006). Research and field trials are also important to optimise the success of revegetation.

xix. Monitoring and maintenance

As progressive rehabilitation and trials occur, monitoring should begin to assess the success of rehabilitation, identify whether changes to the mine closure plan are required and whether any remedial action is necessary. This will provide an early indication of whether the plan needs to change to meet closure outcomes and whether closure outcomes are realistic and achievable.

Proponents should develop a rehabilitation monitoring program for operations and post-closure that is specific for the mine site so that performance can be measured against completion criteria.

4. Radiation management

For sites where radioactive materials may be an issue (for example uranium or mineral sands mines), radiation management will be one of the key considerations for closure planning.

During all stages 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 Regulation 641 of the Work Health and Safety (Mines) Regulations 2022. A Radiation Management Plan must be prepared and submitted to the regulator (unless a written exemption is obtained). A Radioactive Waste Management Plan must also be submitted to the regulator prior to the commencement of operations.

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 should be applied 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. Radionuclide transport in groundwater should be modelled over the very long term (until it can be shown that concentrations have reached a state of equilibrium). 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 intervals 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 discernible 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 DMIRS website (http://www.dmp.wa.gov.au/Documents/Safety/MSH_GL_ManagNORM.pdf). 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.

i. 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 maximise 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.

APPENDIX 8 - GUIDANCE ON PIT LAKE ASSESSMENT THROUGH A RISK-BASED APPROACH

1. Introduction

The assessment of pit lakes is a key area of focus for a number of regulatory agencies. Pit lakes form once mining below the water table ceases and the mine pit is no longer dewatered, allowing the mine voids to fill with groundwater. DMIRS recognises that not all mine sites will have permanent pit lakes and the environmental risk will vary for sites where pit lakes will develop.

While many pit lakes may not present a critical risk (see Table 2), the long term nature of their presence represents a potentially significant public liability, health and ecological risk. WA has approximately 2000 mine voids of which more than half have the potential to become pit lakes (EPA, 2013). This Appendix has been developed to provide an overview of the appropriate approach to assessing the risk of pit lakes. A number of resources are referenced in this overview, however, due to the site-specific nature of pit lake assessments, proponents and consultants are encouraged to discuss proposed approaches with DMIRS.

DMIRS understands that aspirational end uses (such as a regional lake with recreational or agricultural values) are not always possible, especially in the many arid environments of WA. Any final management strategy for a pit lake that requires active remediation (ongoing water treatment or active pumping of fluids) is discouraged due to the ongoing financial liability. DMIRS will also give due consideration to the impact of the proposal upon future access to known or undiscovered resources.[3]

A sterilisation report should be submitted to DMIRS in cases where any resources are likely to be sterilised by infilling of a pit. A copy of the "Sterilisation report submission form for in-pit waste/tailings disposal proposals" is included as Appendix 11. The form is not required for shallow deposits such as mineral sands, bauxite or nickel laterite where resources are not likely to be sterilised.

i. Types of pit lakes

Pit lakes are characterised through a number of approaches, the most common of which is the hydrological system the lake develops. As shown in Figure 1, the hydrological systems a pit lake may develop are (1) sink, (2) throughflow and (3) recharge (Johnson and Wright, 2003). Pit lake systems also have the propensity to develop a number of geochemical and biological systems that need to be considered in their classification (Kumar et al., 2012). The examples below show what could occur with different types of pit lakes and different salinity regimes. Note that this may not apply to all pit lakes and a site specific assessment is required.

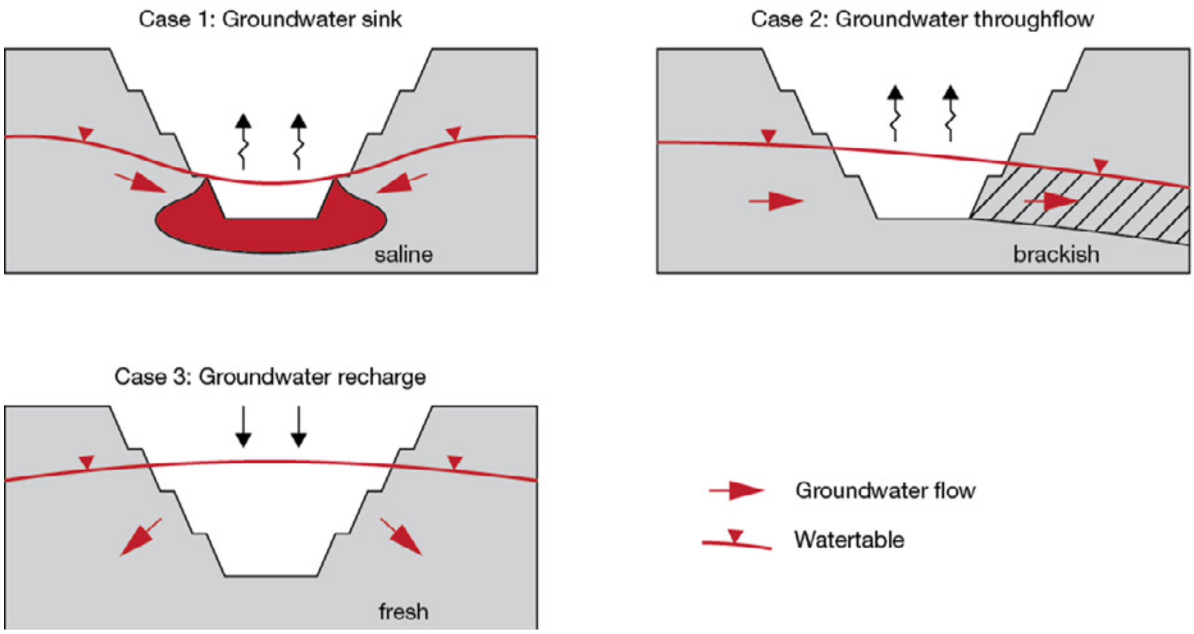

Figure 1. The three most common types of classification for pit lakes (from Johnson and Wright, 2003).

[3]*This is in the form of a sterilisation report to the Executive Director of the Geological Survey of Western Australia.*

2. Assessment of pit lakes

The difficulty with assessing the potential environmental impacts associated with pit lakes is that the impacts will occur after the mine closes. Water levels in the pit may take hundreds of years to recover to a stable water level. Changes in water quality and water chemistry may occur over thousands of years (EPA, 2013).

The assessment of pit lakes is a multidisciplinary science and requires a considerable understanding of the site characteristics, including aspects such as climate, hydrogeology, hydrology, geochemistry, geology and proximity to sensitive receptors. An understanding of the likely shape of the pit lake, it's potential to become colonised and develop into an ecosystem and likely visitation habits of humans and fauna are also critical (Schafer and Eary, 2009).

A site conceptual model, as shown in Figure 2 is critical to understanding how each aspect of a pit lake may interact (McCullough and Lund, 2010). The site conceptual model will identify potential sources, pathways and receptors which can be assessed further when data gathering has been completed and a risk assessment can be undertaken in more detail. It is also very common and often critical to develop conceptual models for each aspect of the pit lake assessment such as geochemistry, hydrogeology and hydrology, ecology and limnology (see Castendyk, 2009 for a review). An understanding of the aspects of a pit lake that might lead to a higher risk (see risk matrix, Table 2) will allow for more focus on these aspects during data gathering and monitoring programs, so that the level of work undertaken, avoidance measures and mitigation actions are commensurate with the risk that the pit lake represents.

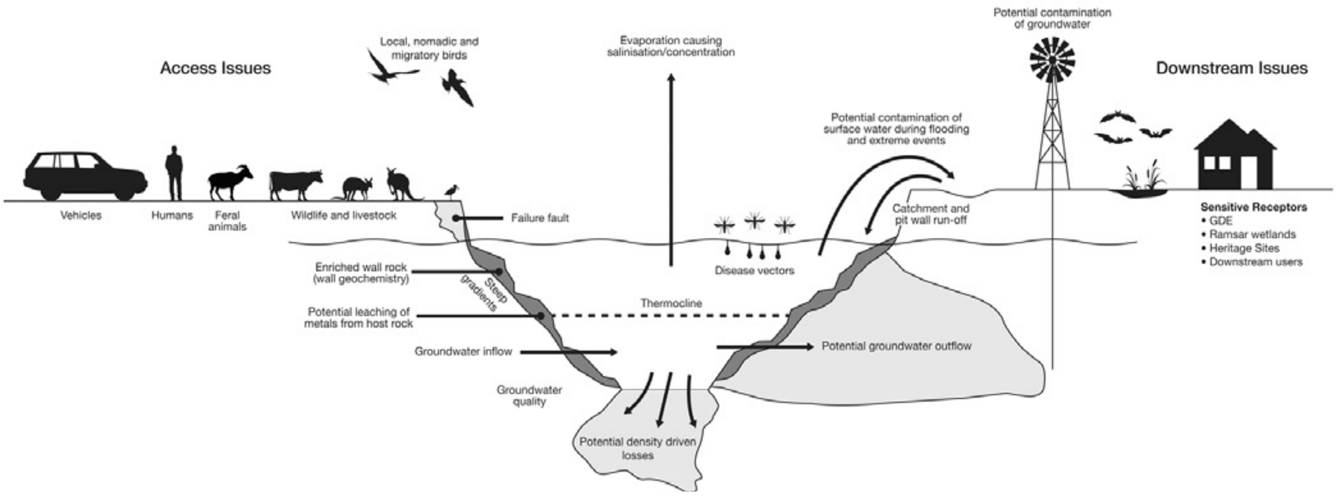

Figure 2. An example of a site pit lake conceptual model including examples of sources, pathways and receptors (adapted from McCullough and Lund 2006).

ii. Geochemistry and sources of metals or other contaminants

All pathways for contaminant transfer to a pit lake through appropriate testing methods should be understood when determining the final pit lake water quality. Source documents such as the GARD Guide (www.gardguide.com) and the national metalliferous and acid mine drainage guidelines (DTIR, 2007) are a good starting point for determining likely contaminant pathways. However there are other potential contaminant sources for pit lakes and standardised testing used for acid rock drainage may not always be appropriate. Proponents should use a fit-for-purpose approach when assessing a pit lake.

Pit lakes may receive inflows of water from a number of potential sources of contaminants such as tailing storage facilities, waste rock dumps, integrated and co-mingled waste landforms, mine site landfills and sewage treatment plants, the host rock and geology surrounding the pit, other mines in the nearby area and groundwater enriched with certain metals.

Typically, the most important source of pit lake contaminants will be groundwater and the geology surrounding the area of the pit void. The geology may contain sulphidic minerals or minerals that will leach metals/metalloids (metals herein) under neutral and alkaline conditions after exposure to oxidising conditions (MEND, 2004). If leaching does occur, metals may enter the pit lake from seepage through the pit walls and basement, groundwater inflows and potentially from surface runoff (Schafer and Eary, 2009).

In the early stages of understanding pit lake formation, it is critical to undertake appropriate geochemical testing such as kinetic humidifier tests or other appropriate leach tests (e.g. using sequential leaching methods) on the geological units that will leach metals (not necessarily just those high in sulphur) into a pit lake. The more information that is gathered on the geochemistry of an area, the greater the confidence will be with the pit lake model and the greater the ability to interpret and explain the likely source of metals entering a pit lake.

The large degree of upscaling for initial geochemical testing, the long term nature of pit lake development and the potential for changes to mine scheduling necessitate continued geochemical testing and monitoring for metal leaching during the operational phases of projects (Schafer and Eary, 2009). Post-closure monitoring for sites may also be required due to the potential for rebounding water to interact with oxidised layers of geology and also for the pit lake water to interact with the pit wall geology during lake formation (Oldham, 2014).

iii. Controls of geochemistry and analogues

The use of analogue sites or regionally known geological information to determine likely leaching of metals and dominate ions can be important for verifying and determining likely final metal concentrations in pit lakes. In regions such as Nevada in the United States, it is known that certain kinds of geologies will result in pit lakes with certain types of metals (Shevenell et al., 1999). Such an understanding becomes critical for modelling of pit lakes where there is not yet appropriate validation or optimisation because it can be used to verify modelling scenarios and likely dominating metal species.

iv. Hydrology and water chemistry

A good understanding of the hydrogeology (groundwater) and hydrology (surface water) is essential to be able to model and determine the nature of pit lake that will form after closure. For greenfield mine sites it is not possible to validate a pit lake hydrological model at the early stages of assessment, particularly aspects such as groundwater drawdown, rebound and water level stabilisation (see Modelling section below). However, it is possible to gather enough hydrogeological information to have a good understanding of the predicted groundwater drawdown and determine a number of potential rebound scenarios (Niccoli 2009).

Where surface water flows into a pit lake (e.g. creek diversion), it is critical that the seasonal flow rates are determined, as flow rates will vary throughout the year and can result in changes to the lake water quality and the type of lake (sink or through-flow) which forms during different times of the year and with different rainfall events e.g. 1 in 10 year, 1 in 100 year, 1 in 1000 year, Probable Maximum Precipitation event (PMP).

In arid zones, climate and water flowing into the pit lake will often be two key variables for determining pit lake water quality (Johnson and Wright, 2003). For this reason it is important that along with determining accurate water flows into a pit lake, the baseline quality of that water is determined over a suitable period of time (and appropriate flow events) e.g. two years. Due to phenomena such as evapo-concentration, it may also be useful to measure some groundwater contaminants to trace levels, as metals even at low concentrations can concentrate several orders of magnitude greater than their baseline value over the modelled period for the pit lake, e.g. 500-1000 years.

v. Climate

Climate has a major influence on pit lake formation and dynamics. The evaporative flux and the precipitation rate on a pit lake along with groundwater inflow are key variables for determining if a pit lake will become a throughflow or sink (Kumar et al., 2009). Evaporation (especially in many arid to semi-arid regions) will determine the rate at which evapo-concentration causes salinity and metal concentrations to increase (Shevenell, 2000). For this reason the evaporative flux is particularly important for modelling pit lakes but it is also very difficult to determine using pan evaporation data and coefficients for natural lakes. Shevenell also noted in a study on two pit lakes that were sinks, that the evaporative flux was significantly less than predicted and less than natural lakes.

Temperature and other climate variables such as storm frequency and wind will be key variables for determining the type of limnology a lake develops, including the likelihood of stratification, either permanently or semi-permanently (Jewell, 2009). For example, in WA many pit lakes greater than 10-20m deep stratify during the summer period where a thermocline develops between the upper warmer water and cooler lower water. During winter these two upper layers mix as the upper layer cools (e.g. Sivapalan, 2005). Mixing of the upper two layers can be hastened by the presence of storms and high wind events.

vi. Limnology and Water Quality

The dynamics of a pit lake, such as stratification and cycling of different layers within the lake during the year, will impact on water quality, in particular the redox state of the water and the solubility of metals. Mixing of water will also influence the salinity and concentration of metals in different layers of the lake. While stratification and pit lake dynamics can be difficult to accurately model in the early stage of an assessment, the initial assessment of a pit lake should consider how stratification may impact on water quality and provide suitable justification for the approach taken (see Figure 3). Later stages of pit lake assessment (as the mine moves towards closure), should include modelling of stratification, because at this stage pit lake models will need to be calibrated with field data to accurately predict the likely future lake water quality post-mining. The future shape of the pit lake may also need to be considered when mining in unconsolidated sediments or calcretes, which can collapse and result in shallower water bodies than those originally assessed.

vii. Modelling

Modelling of a pit lake is very difficult and should not be solely relied upon to assess the final pit lake characteristics. As with other types of environmental modelling, no model of a pit lake will be completely accurate, especially in the early stages of the assessment of a mining proposal. It should be noted that more detailed modelling at this early stage (coupling of models) may not be more accurate than simpler models. As with other types of modelling, a poor understanding of the system being modelled, and poor data quality or availability may produce a model with meaningless results.

Oldham (2014) notes that anyone modelling should:

- have appropriate field-based geochemical and hydrological data;
- model a number of potential scenarios including sensitivity analyses; and
- have continued updating of models during operations and closure.

In the early stages of pit lake assessment it may be pertinent to produce simpler models and mass balances of major solutes (e.g. acidity, carbonates, sulfates) relative to the data availability. In the later stages of a mine life, it is important that these models are improved so that future water quality predictions with a certain degree of accuracy can be validated with post closure water quality data.

In all cases of pit lake modelling, it is critical for all pit lake assessments to consider and explicitly state:

- the assumptions used to model the pit lake;
- the limitations of data being used to model the pit lake, e.g. lack of appropriate evaporative flux data;
- the major sources of solutes into the system, e.g. groundwater vs geology of the pit walls;
- the limitations of the software, errors induced from coupling models, source code and geochemical databases used for the modelling, e.g. hydrological boundary condition cannot determine outflow;
- how the modelled lake may differ from the actual pit lake dynamics and how this may impact on water quality predictions, e.g. stratified lake likely to occur but model assumes a completely mixed lake;
- how the geometry of the lake and depth relative to the ground surface may impact on limnology and water quality (particularly important as mine scheduling and pit geometry typically change during operations); and
- which modelled scenarios are more realistic than others and which key variables (e.g. dominant ions in solution) are most sensitive to changes.

While pit lake modelling cannot be solely relied upon in a pit lake assessment, the research into this area is improving. Recently a number of valuable resources have been developed to guide modelling of pit lakes (e.g. Vandenberg et al. 2011, Oldham 2014). These provide an overview of the general models used for pit lakes and the assumptions for different models. The flow chart from Oldham, (2014) in Figure 3 below outlines the decision process to undertake when modelling pit lakes at the more advanced stages of mine life prior to closure. It should provide anyone attempting to model a pit lake with an understanding of what data may be missing when undertaking a modelling exercise or what aspects of a simpler model may not match the real life situation.

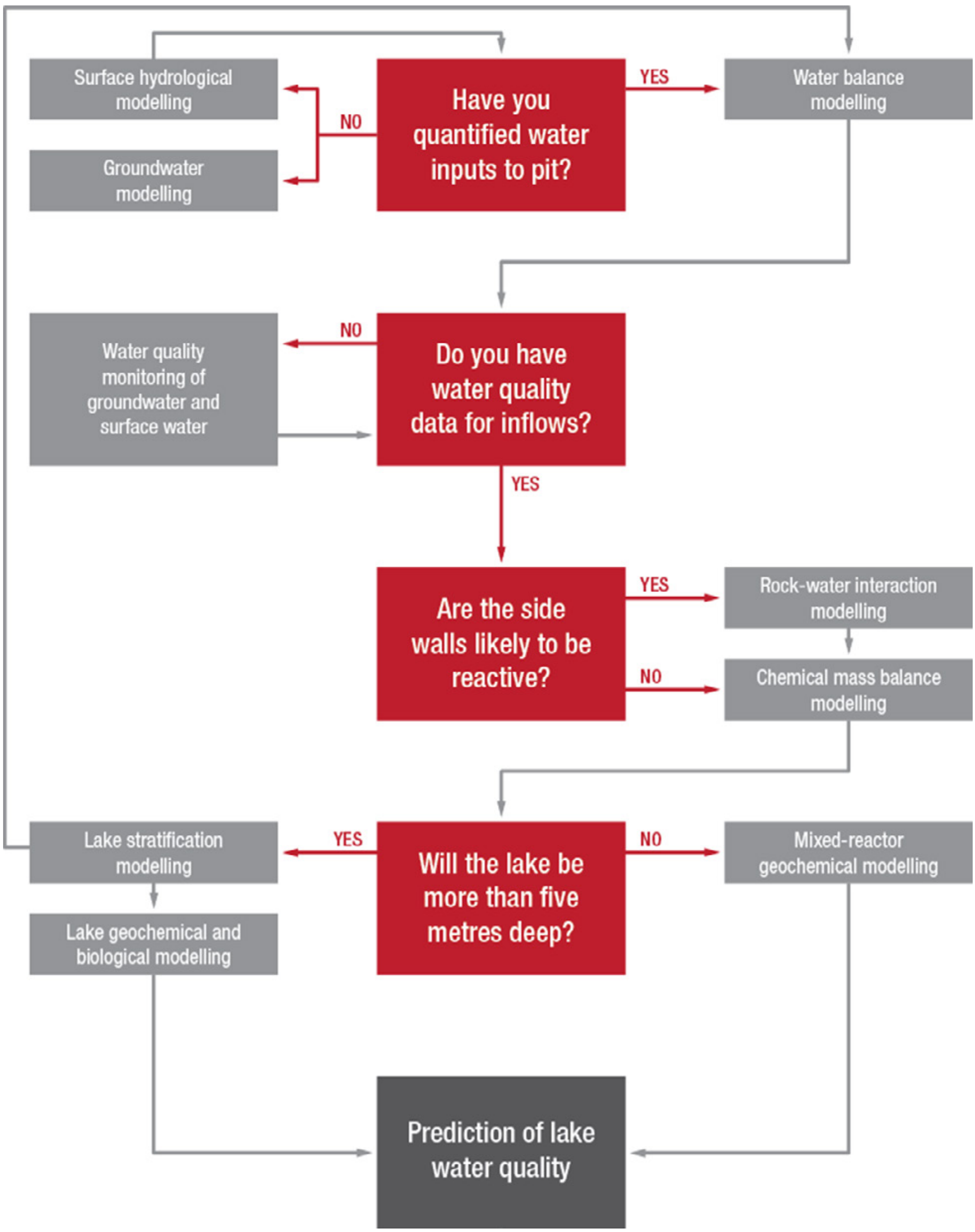

Figure 3. Decision process for modelling a pit lake (adapted from Oldham, 2014)

Scenario testing and sensitivity analysis

Scenario testing and sensitivity analyses should be used during modelling because it is difficult to predict water quality, in particular trace metal concentrations, with a high degree of accuracy during the initial assessment of water quality for mining proposals (Maest et al. 2005; Schafer and Eary 2009). Scenario testing should consider a range of likely (including worst case) scenarios for the different aspects of a pit lake, including geochemical and hydrological aspects (e.g. Muller et al. 2010 and 2011).

Examples of scenario testing for the hydrological components of a pit lake might include the potential for outflow from the lake during floods, unexpected increases in hydraulic conductivity (e.g. preferential pathways or large fractures not identified during initial assessment) or density-driven flow. Density-driven flow has been identified as a potential concern in many arid regions where terminal sinks have the propensity to leak into surrounding aquifers and offer a potential pathway for contaminants to be transported to sensitive receptors. Model scenarios should be run for an appropriate time period, commensurate with the risk of the pit lake, which could be until a geochemical equilibrium is reached or for a particular time period (e.g. 1,000 or 10,000 years).

Sensitivity analyses should be performed on both geochemical and hydrological components of a pit lake model to determine which parameters within the system are the most sensitive to change (Oldham 2014). Scenario testing and sensitivity analyses will provide information on the aspects of a mine, which if changed during operations, may lead to a pit lake representing a higher risk than anticipated during the initial assessment stage of the mining proposal and therefore requires appropriate contingency steps to be undertaken (e.g. avoidance or mitigation) to reduce the risk of the pit lake during operations.

Model validation

Pit lake models should continue to be refined through each stage of mining. The pit lake model will not be able to be validated during the initial assessment of the mining proposal or during operations. For many pit lakes hydrological rebound of the water level to a steady state or geochemical equilibrium will not be reached for many years after closure, e.g. a few to hundreds of years (Schafer and Eary 2009). For this reason it is imperative that pit lake assessments use the best available data during assessment and operations. Operation of a mine will offer insights into the character of a site that cannot be understood during the initial assessment and approval stages of a mine, such as potential leaching of metals from a particular geological unit or higher than anticipated flow rates during dewatering. Therefore, it is imperative that where a component of a pit lake model can be validated (e.g. groundwater model during assessment or drawdown model during operations), that this occurs, so that the pit lake model and the risk assessment of the pit lake can be updated.

While validation of a pit lake model cannot be completed until post closure, more data on pit lakes is becoming available (e.g. http://pitlakesdatabase.org/database/home.asp). DMIRS encourages proponents to verify (where they cannot validate) the pit lake models with information from other pit lakes with similar geology, climate and hydrology. Proponents can also use analogues of geology as noted above and can also undertake some laboratory studies to verify some results, e.g. batch tests (see Schafer and Eary, 2009). The verification process is focused primarily on reducing the uncertainty within the pit lake model and putting in place appropriate avoidance, mitigation and management actions so that any potential risks are reduced prior to becoming substantial liabilities. Where pit lakes represent a significant to critical risk or there is a substantial uncertainty with the understanding of the pit lake, post-closure monitoring of the pit lake over a long period of time (for example, decades) should occur until pit lake models can be optimised and validated, to accurately predict future water quality.

3. Risk Assessment

The risk assessment of pit lake water quality involves determining the possible linkages between water quality and sensitive receptors. The scenario of source –> pathways > receptor is commonly used to determine if any contaminants in the water are likely to interact with a sensitive receptor (see McCullough and Lund 2010 or the Contaminated Sites Series of Guidelines for more detailed information). Where pit lakes are highly polluted and/or represent a critical to high risk they may be subject to the *Contaminated Sites Act 2003*.

There are a number of scenarios for pit lakes where a receptor may interact with water quality (see Figure 3). For example, direct interaction may occur where birds fly onto the pit lake and drink the water, or indirect interaction may occur where an ecosystem develops and emergent insects which contain contaminants are consumed by birds. Table 1 below outlines potential sources, pathways and receptors. Note that it does not provide an exhaustive list and it has not identified primary sources of metals e.g. pit walls, groundwater or other sources as noted above.

Table 1. Common sources, pathways and receptors for pit lakes

Source	Pathways	Receptors
Mine pit lake water: • Source of salinity/acidity • Source of heavy metals and metalloids • Source of nutrients	Water: • Mine pit lake water • Groundwater outflow • Density-driven outflow Biota: • Biomagnification and/or bioaccumulation of heavy metals	Humans: • Workers • Public Biota: • Birds • Mammals (e.g. native, feral or agricultural) • Reptiles • Aquatic organisms • Groundwater Dependent Ecosystems Groundwater values • Public drinking water sources • High value wetlands and creeks

viii. Risk assessment and water quality criteria

The application of appropriate water quality criteria (such as ANZECC 2000) can be confusing when undertaking an assessment of a pit lake. The application of appropriate criteria will often be determined by the risk assessment undertaken and which pathways are likely to result in a receptor being exposed (Hakonson et al. 2009). For example, if it is likely that water from a pit lake will flow to a water abstraction bore used for potable water and there are no other exposed receptors, then the use of drinking water standards would be appropriate. Likewise, if it is likely that water from a pit lake will flow to a water abstraction bore for livestock watering and there are no other exposed receptors, then the use of the livestock drinking standards would be appropriate.

In many arid regions, where mammals and humans are excluded through good pit closure design and the lake is a terminal sink in which density-driven plumes are unlikely to occur, the main receptor that will interact with the pit lake water is likely to be birds and there may not be a specific water quality guideline available. In these cases, appropriate site specific assessment of impacts is warranted taking into consideration the types of pathways that avian or other flying vertebrates are likely to uptake contaminants e.g. food, water, dermal contact or secondary pathways for higher predatory birds. In these cases, it's also important to consider the potential for a pit lake to develop into some form of ecological system, either with limited (e.g. one or two trophic levels) or significant biological levels of organisation (e.g. several trophic levels including predatory vertebrates such as fish) (Hakonson et al., 2009). The key drivers for an ecosystem developing in a lake will include the nutrient levels, potential for seeding of the lake with organisms (e.g. diversion of a river into the lake) and future water quality.

Other types of risks

There are a few other types of risks that need to be taken into consideration when assessing a pit lake. These include:

- vectors (mosquitoes, birds etc.) and disease transfer;
- drowning of humans, wildlife and stock;
- increased abundance of feral animals (e.g. goats are highly tolerant of saline water) and the impacts of this on revegetation and regional conservation activities;
- changes to the pit lake from seismic and extreme events;
- discharge to waterways or groundwater receptors via connections with underground workings; and
- pit wall collapse and the impacts on humans, or by humans, in the nearby vicinity.

When assessing these types of risks, it is important to identify ways to avoid, mitigate or manage the risk through limiting access to the site or providing suitable egress points for anything to leave the pit lake. As for the risk assessment of impacts from water quality in a pit lake, the strategy chosen for other types of risks should consider the likelihood and consequence of the risks as identified through a risk assessment (see below for further details).

ix. Risk Matrix

The risk matrix below (Table 2) and examples that follow (Table 3) have focused on some common risks that a pit lake may represent. It has been developed as a guide and it is expected that other scenarios to those mentioned below will occur. The purpose of the matrix is to allow operators to assess their site and identify the risk from a future pit lake, so that the key aspects contributing to the risk can be avoided, mitigated and managed as much as possible during the operational phases of a project. For example, appropriate handling of potential acid-forming materials will reduce the potential for water quality problems when the pit lake develops. Likewise, understanding how pit geometry may impact on final water quality will allow operators to understand how partial backfilling may improve future water quality.

Table 2. An example of a risk matrix for assessing pit lakes

Likelihood Rating						
Consequence Rating		Almost certain	Likely	Possible	Unlikely	Rare
	Catastrophic	Critical#	Critical#	Critical	High	High
	Major	Critical	High	High	Medium	Medium
	Moderate	High	High	Medium	Medium	Medium
	Minor	Medium*	Medium	Medium	Low	Low
	Insignificant	Low	Low	Low	Low	Low

#Risk may result in the project becoming unacceptable.

**For some situations the risk could be high.*

Table 3. Examples of different risk ratings

Likelihood Rating	Consequence Rating	Risk Rating	Example	Comments and Corrective Actions
Almost Certain	Catastrophic	Critical	• Loss of life or serious injury to humans. • Regional scale impacts to groundwater will occur and groundwater has a high value e.g. priority drinking water source (i.e. if pit lake will become through flow system and pit lake quality is very poor). • Site contains significant quantities of acid forming materials and will represent a significant ongoing liability to the state. • Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site will be adversely impacted at a regional scale.	Risks need to be reduced to an acceptable level through avoidance and mitigation. This may be achieved through reducing the risk of a particular aspect of the pit lake, e.g. avoiding rocks high in acid-forming materials, identifying measures to stop water outflow. Risk can also be reduced by analysing possible future scenarios (e.g. backfill vs open lake). If the risks cannot be reduced, then the mine may not be considered to be acceptable. Monitoring and management will be required to prove that risks are reducing through good management actions on site. Post-closure monitoring for a significant period of time is likely to be required.
Likely	Major	High	• Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site likely to be adversely impacted at a local scale. • Acidification of water and major impacts to humans likely to occur from recreational use of water. • Assessment or modelling of long term pit water quality indicates likely prolonged degradation of local groundwater quality. • Stock watering bores within proximity of site likely to be impacted.	Risks are likely to need to be reduced through appropriate avoidance, mitigation and management measures. Monitoring would be required to show that risks are not increasing and any proposed measures are reducing the risk.
Almost certain	Moderate	High	• Water quality neutral and contains some contaminants well above recreational guidelines. Pit lake is accessible to humans for recreation and moderate impacts to humans will occur.	Site-specific risks need to be assessed through appropriate methodologies. Appropriate avoidance or mitigation methods need to be put in place to manage the risk. Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk

Likelihood Rating	Consequence Rating	Risk Rating	Example	Comments and Corrective Actions
Possible	Moderate	Medium	• Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site could potentially be impacted at a local scale. • Some acidification of pit water likely and some access to water available to humans, birds and mammals. • Possible localised groundwater impacts from pit lake water and potential groundwater use.	Risks may need to be reduced through appropriate mitigation or management measures. Monitoring would be required to show that risks are not increasing and any proposed measures are managing or reducing the risk.
Unlikely	Moderate	Low	Pit lake water found to be unlikely to impact any receptors through appropriate studies but will have a low salinity that would be palatable for birds.	Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk, e.g. potential acid-forming materials identified during mining.
Likely	Minor	Low	Pit lake will contain water with the same chemistry as groundwater and water will flow out of the lake to groundwater.	Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk, e.g. potential acid-forming materials identified during mining.

x. Stages of assessment towards closure

The assessment of pit lakes requires a staged approach with data gathering, monitoring and analysis requirements based on the risk that the aspect of the pit lake represents. For higher risk sites, due to the high level of liability involved, significant work and commitments are likely to be required during the environmental impact assessment of the project and will need to be continued through to operations and closure. It is anticipated that for higher risk sites, the risk may be reduced through avoidance, mitigation and management measures, which would need to be verified through monitoring during the operational and closure stages of a mine site.

4. Evolution of Pit Lake Science

Pit lakes represent some of the more complex systems to assess from an environmental viewpoint. The long term nature of the pit lake presence in the landscape coupled with the anthropogenic nature of their occurrence means that it is not possible to rely on all data from natural lake systems and the evolving science in this area can change relatively quickly. For this reason it is critical that proponents speak with DWER and DMIRS if they are likely to have a moderate to critical risk pit lake. DWER and DMIRS will be providing more detailed guidance on pit lakes in the future and are committed to working with proponents to ensure they are aware of the requirements when undertaking pit lake assessments.

5. Definitions (as they relate to a pit lake)

Avian	Flying vertebrates (birds) within the taxonomic class Aves.
Biota	Plants, animals and other living organisms that inhabit the lake.
Redox	Shortened form for reduction and oxidation reactions which include all chemical reactions within the lake in which atoms have their oxidation state changed.
Stratification	When two or more layers of water with different temperature or chemical properties form within a pit lake.
Thermocline	The area of a lake that shows a significant change in temperature. It typically occurs between the surface layer of the lake (epilimnion) and next layer down (hypolimnion).
Trophic Level	The trophic level of an organism is the position it occupies within a food chain. Algae, zooplankton, fish and predatory birds all represent different trophic levels.
Evaporative flux	The rate at which water is evaporated from the pit lake.
Metalliferous drainage	A form of acid and metalliferous drainage from a site characterised by near-neutral pH and elevated metal concentrations, and often with high sulphate and salinity concentrations.

6. References

Castendyk (2009) Chapter 6: Conceptual models of pit lakes. In Castendyk D.N., Eary L.E. (Eds.) *Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability,* Published by the Society for Mining, Metallurgy and Exploration, Adam Aircraft Circle, Englewood, CO 80112.

DITR (2007) Managing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Industry, Tourism and Resources, Canberra.

Eary L E and Schafer W M (2009) Chapter 15: Approaches for evaluating the predictive reliability of pit lake numerical models. In Castendyk D.N., Eary L.E. (Eds) *Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability*, Published by the Society for Mining, Metallurgy and Exploration, Adam Aircraft Circle, Englewood, CO 80112.

EPA (2013) *Annual report 2012-13*, Environmental Protection Authority, Western Australia.

Hakonson T E, Meyer V F, and Dean A (2009) Significance of biological productivity of pit lakes for interpreting ecological risks. In Castendyk D.N., Eary L.E. (Eds) *Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability*, Published by the Society for Mining, Metallurgy and Exploration, Adam Aircraft Circle, Englewood, CO 80112.

Jewell P W (2009) Stratification controls of pit mine lakes. Mining Engineering February 2009. Pgs. 41-45.

Johnson S.L., Wright A.H. (2003) *Mine Void Water Resource Issues in Western Australia*, Water and Rivers Commission, Resource Science Division, Perth, Western Australia.

Kumar, R. N.; McCullough, C. D. & Lund, M. A. (2012) Pit lakes in Australia. In, *Acidic Pit Lakes - Legacies of surface mining on coal and metal ores*, Geller, W. & Schultze, M. (eds.) Springer, Berlin, Germany.

Kumar R.N., McCullough C.D., Lund M.A. (2009) *Water Resources in Australian Mine Pit Lakes*, Presented at the Water in Mining Conference, Perth, Western Australia, 15-17 September 2009.

Maest A S, Kuipers J R, Travers C L and Atkins D A (2005) *Predicting water quality at hard rock mines methods and models, uncertainties and State of the Art*. Published by Earthworks.

MEND (2004) *Review of Water Quality Issues in Neutral pH Drainage: Examples and Emerging Priorities for the Mining Industry in Canada.* MEND Report 10.1

McCullough, C. D. & Lund, M. A. (2006) *Opportunities for sustainable mining pit lakes in Australia*. Mine Water and the Environment 25: 220-226.

McCullough, C. D. & Lund, M. A. (2010) *Mine Voids Management Strategy (IV): Conceptual Models of Collie Basin Pit Lakes*. Department of Water Project Report MiWER/Centre for Ecosystem Management Report 2010-12, Edith Cowan University, Perth, Australia. 95pp. Unpublished report to Department of Water.

Muller, M., Katja E., McCullough C D and Lund M (2011) *A Model-based investigations of acidity sources and sinks of a pit lake in Western Australia*. In: proceedings of the International Mine Water Association Congress. Arachen, Germany.

Müller, M, Eulitz, K., McCullough, C. D., Lund, M. A. (2010) *Mine Voids Management Strategy (III): Water Quality Modelling of Collie Basin Pit Lakes.* Department of Water Project Report MiWER/Centre for Ecosystem Management Report 2010-10, Edith Cowan University, Perth, Australia. 105pp. Unpublished report to Department of Water.

Niccoli W L (2009) *Predicting groundwater inputs into pit lakes*. In Castendyk D.N., Eary L.E. (Eds) Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability, Published by the Society for Mining, Metallurgy and Exploration, Adam Aircraft Circle, Englewood, CO 80112.

Oldham, CE. (2014) *Environmental sampling and modelling for the prediction of long-term water quality of mine pit lakes*. UWA Publishing, Perth, Western Australia.

Schafer W M and Eary L E (2009) Chapter 10: Approaches for developing predictive models of pit lake geochemistry and water quality. In Castendyk D.N., Eary L.E. (Eds) *Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability*, Published by the Society for Mining, Metallurgy and Exploration, Adam Aircraft Circle, Englewood, CO 80112.

Shevenell L (2000) *Water quality on pit lakes in disseminated gold deposits compared to two natural, terminal lakes in Nevada*. Environmental Geology 39(7): 807-815.

Shevenell L, Connors K A, and Henry D (1999) *Controls on pit lake water quality at sixteen open-pit mines in Nevada.* Applied Geochemistry. 14(5): 669-687.

Sivapalan M (2005) *Modelling the evolution of Mount Goldsworthy Pit Lake*. Student Thesis. UWA. Perth. Western Australia.

Vandenberg J A, Lauzon N, Prakash S, Salzsauler K (2011) *Use of water quality models for design and evaluation of pit lakes*. In McCullough (ed) Mine pit lakes: closure and management. Australian Centre for Geomechanics. University of Western Australia, Perth, Australia.

APPENDIX 9 - DOMAIN MODEL

A useful approach to mine closure planning and implementation is to divide up the closure work and segregate the facility into specific areas or domains. Each domain is treated as a separate entity within an overall plan and includes landforms or infrastructure with similar rehabilitation, decommissioning and closure requirements/outcomes.

Examples of domains at a mine are:

- ore processing area;
- infrastructure;
- tailings storage facilities;
- waste dumps;
- process and raw water facilities; and
- open voids and declines/shafts.

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

Figure 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.

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 10 - 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 203:2012) provide key processes and principles to identify, assess, manage and review closure risks. These standards require appropriate communication and engagement with internal and external stakeholders all the way through the risk assessment and management process.

There are a variety of possible risks that require assessment prior to mine closure including risks associated with the long-term stability of mine infrastructure and landforms, risks to public safety, and environmental risks to terrestrial and aquatic ecosystems in the vicinity of the mine site. Proponents will generally be required to undertake detailed environmental risk assessments of closed mine sites to fulfil their obligations under the *Contaminated Sites Act 2003*.

A structured risk assessment framework and a meaningful stakeholder engagement process enable identification early in the planning process of mine closure risks and opportunities associated with closure, using a range of management and remediation strategies to preserve, maintain or enhance environmental values or beneficial uses after closure (DITR 2007 section 6.2, IAEA 2010 section 3.4).

Environmental risks at a mine site are determined by identifying specific chemical and physical hazards associated with mine wastes at the site, identifying specific fauna and flora ("ecological receptors") that have the potential to be affected by those hazards, and identifying the physical pathways (such as ingesting contaminated soil or water) that will lead to those receptors being exposed to the hazard. Guidelines prepared by the Department of Water and Environmental Regulation provide specific guidance on undertaking ecological risk assessments (DER, 2006) (Located at: http://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/risk_framework.pdf). The National Environment Protection (assessment of site contamination) Measure 1999, as adopted by the Department Water and Environment Regulation (Located at: http://www.der.wa.gov.au/your-environment/contaminated-sites), is the appropriate guidance for the assessment of ecological risk in WA.

Further detail on the 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 outcomes.

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 summarises the risk management process:

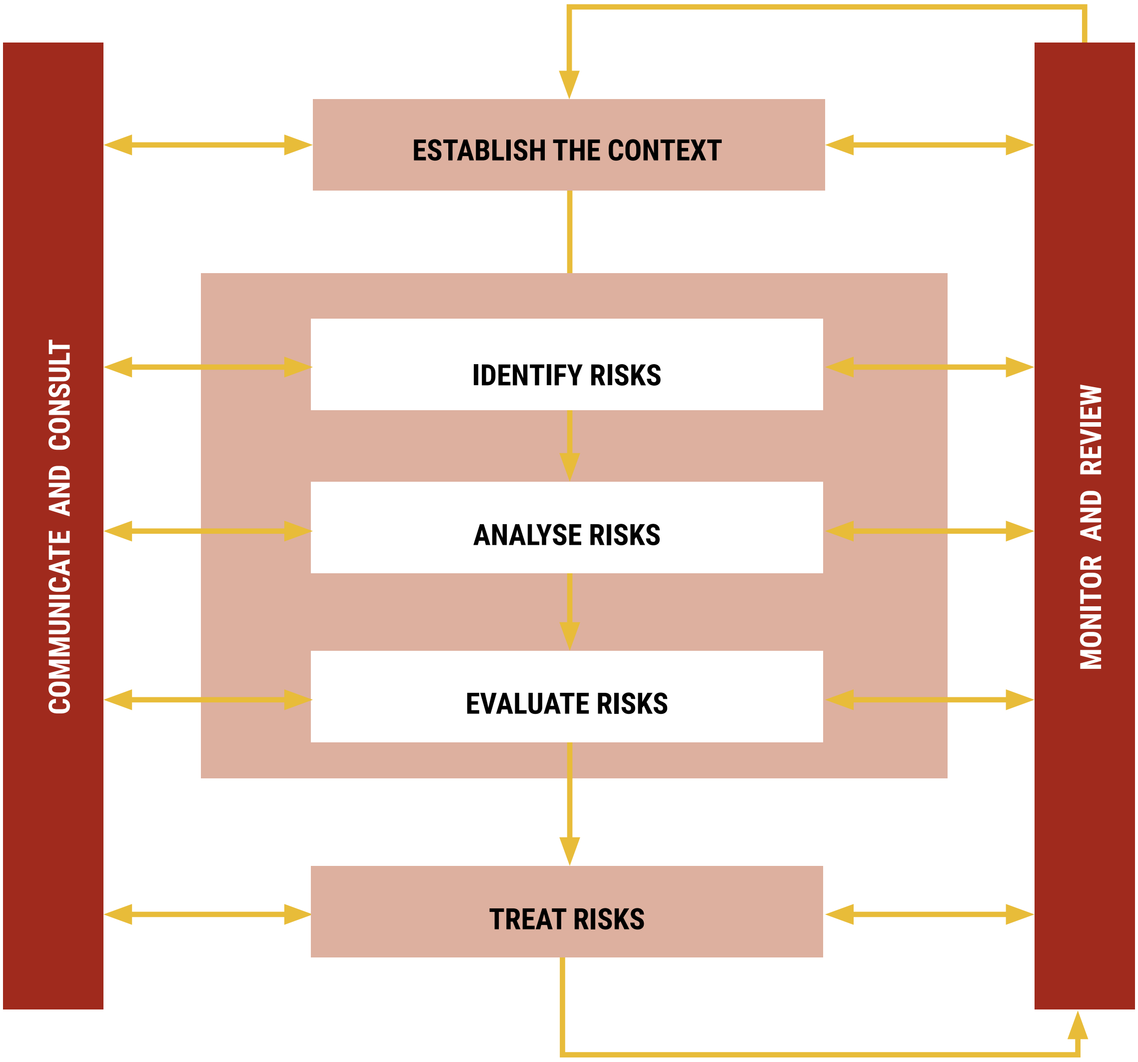

Figure 1 – Risk Management Process (DITR 2008)

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).

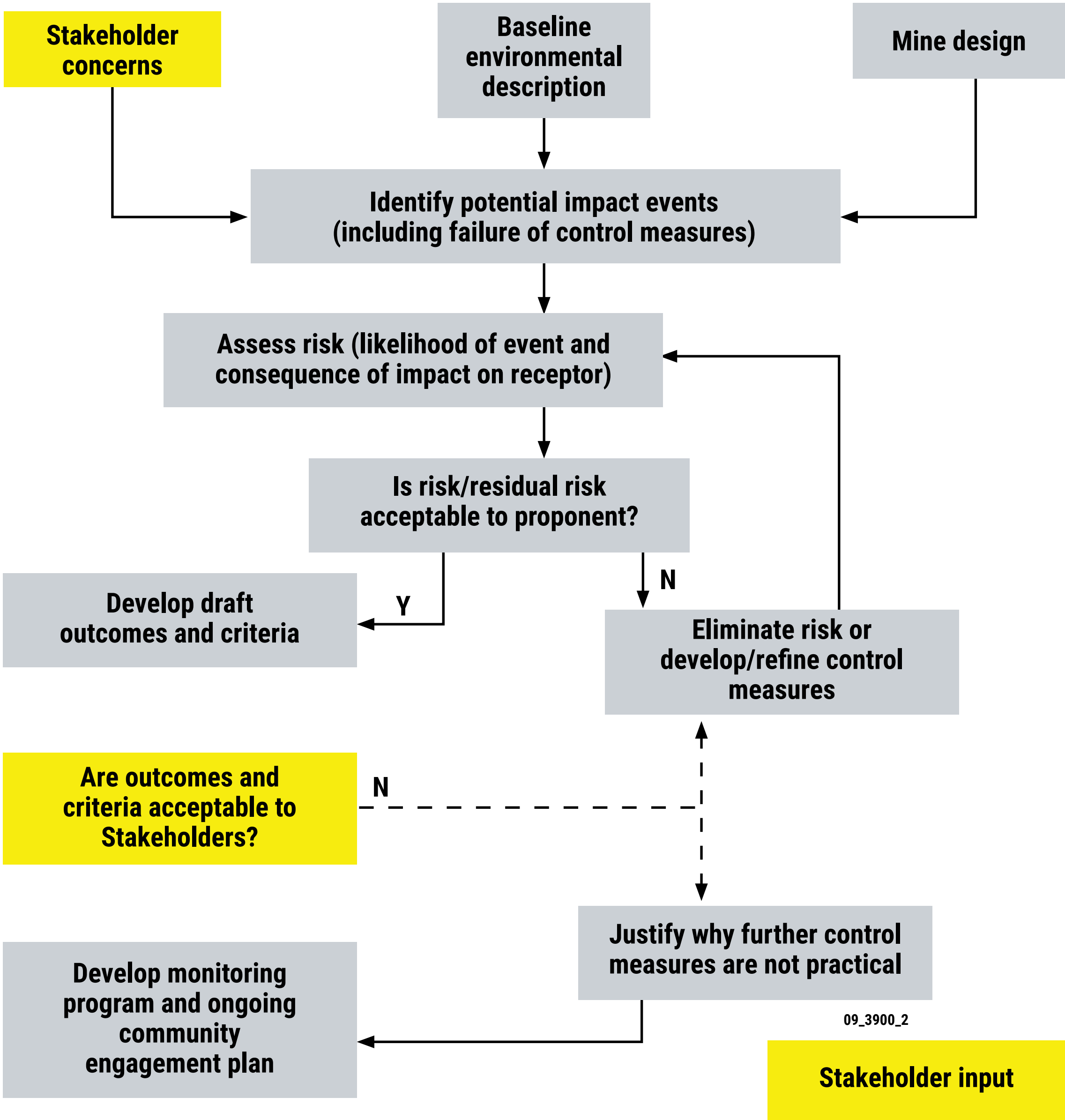

Figure 2 – An iterative risk-based impact assessment process (DRET/GS/DEHWA 2010, Attachment 1)

The International Council on Mining and 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.

Where risk assessment identifies potential impacts to groundwater, specific risk assessment framework provided in Schedule B6 of the National Environment Protection (Assessment of Site Contamination) Measure 1999, should be applied. Similarly, for surface and subsurface contamination impacts, assessment of risk should draw on appropriate guidance published or endorsed by the Department of Water and Environmental Regulation.

The Appendix 5A of 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 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; and
- 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.

Sterilisation report submission form for In-pit waste/tailings disposal proposals

(Note this form must be completed where any resources are likely to be sterilised by infilling of pit. This form is not required for shallow deposits such as mineral sands, bauxite or nickel laterite where resources are not likely to be sterilised.)

Mining company: ______________________________

Contact person: ______________________________

Position: ______________________________
(also name consulting company/affiliation if different to above)

Telephone number: ______________________________

Email address: ______________________________

Postal address: ______________________________

Title of current mining proposal: ______________________________

Department of Mines and Petroleum mining proposal registration number: *(if known)* ______________________________

Project name: ______________________________

Affected mining tenements: ______________________________

____

Project overview

Location: ______________________________
(location plan with GDA lat/long or MGA grid coordinates preferred)

Mineral commodity (-ies): ______________________________
(e.g. iron ore, gold)

Planned annual ore production or current annual mine production: ______________________________
(if part of an existing mining project): (metric tonnes, and grade)

Planned annual waste/tailings production: *(cubic metres or tonnes)* ______________________________

Current waste/tailings disposal practice *(if applicable):* ______________________________

Sterilisation proposals *(NB. complete separate details for each pit)*

- Name of pit proposed for infilling: ____
- Dimensions: ____
  (include grid referenced orthophoto and/or cadastral plan(s) showing pit outlines with long section and cross section lines as referred to below)
- Maximum depth: *(metres)* ____
- Quantity of waste/tailings for infill: ____
  (cubic metres or tonnes)
- Statement indicating reason(s) for not using alternative storage/disposal options: ____________________
  (*e.g. environmental and economic considerations)*
- Sterilised reserves: *(metric tonnes and grade)* ____
- Mineral commodity (-ies): ____
  (with reference to the above mentioned reserves)
- Sterilised resources: *(metric tonnes and grade)* ____
- Mineral commodity (-ies): ____
  (with reference to the above mentioned resources)
- A long section and/or 3D model of deposit showing pit outline, drilling and extent of known mineralisation: *(At A4 or A3 size all text must be readable, vertical scale and units identifiable, legend colours and text to grade e.g. <2 g/t clear, and the section line shown on the pit outline plan).*

  ____
- A typical cross-section showing pit outline, geology, drilling and extent of known mineralisation: *(At A4 or A3 size all text must be readable, vertical scale and units identifiable, legend colours and text to grade e.g. <2 g/t clear, and the section line shown on the pit outline plan).*

  ____
- Will a portal to underground workings be decommissioned due to infilling? If so, what reserves will be sterilised?

  ____
- Statement concerning the potential for untested depth extensions including small high grade shoots:

  ____
- Statement giving reasons why the above reserves/resources are not considered economic to mine:

  ____

SIGNATURE: ____

NAME AND POSITION OF THE PERSON RESPONSIBLE FOR THE INFORMATION PROVIDED IN THIS REPORT:

____

(NB. include details of qualifications and professional affiliations)

DMIRS OFFICE USE ONLY

Internal file number: ____

DMIRS project officer: ____________________________________

Geological Survey of Western Australia (GSWA) geologist: ____________________________

Date of submission of the sterilisation report: ________________________________

GSWA assessment: ____

Recommendation by the Executive Director, GSWA: ____________________________

Date of recommendation: ____

Government of Western Australia

Department of Mines, Industry Regulation and Safety

8.30am – 4.30pm

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