Strategic Framework for

Tailings Management

Ministerial Council on Mineral and Petroleum Resources
Minerals Council of Australia

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The **Ministerial Council on Mineral and Petroleum Resources** (MCMPR) consists of the Commonwealth Minister for Industry, Tourism and Resources, State and Territory Ministers with responsibility for minerals. The Papua New Guinea Ministers for Mining and Petroleum and Energy have observer status. MCMPR's mission is to promote the general welfare and progressive development of the Australian mining and petroleum industries.

The **Minerals Council of Australia** represents companies involved in mineral exploration, mining and processing of minerals. Its activities are funded entirely by its member companies which, between them, produce 90% of Australia's mineral output. The Mission of the Council is to promote the development of a framework that encourages safe, profitable and environmentally responsible minerals exploration, production, processing and marketing capable of sustaining an internationally competitive minerals industry attuned to community expectations.

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INTRODUCTION

Tailings is the fine grained waste material remaining after the economically recoverable metals and minerals have been extracted. The physical and chemical composition varies with the nature of the material being processed, and the process itself. These differences, along with the location of the operation, will dictate the level of management required for the tailings and for the tailings storage facility.

The ultimate purpose of a tailings impoundment is to contain fine grained tailings, often with a secondary purpose of conserving water for use in the mine or mill. This has to be accomplished in a cost-effective manner that provides for long-term stability of the embankment structure and the impounded tailings and the long-term protection of the environment (US EPA, 1994).

Nash (1998) makes the following observation.

> *"Tailings continue to concern the industry as well as regulators and the general public due to several highly newsworthy tailings dam failures. Several such failures have arisen from unexpected natural events, while others seem to be related to a deficiency in some aspects of the tailings life cycle. The mining industry strives to minimise human error in tailings disposal systems through improved technology and management practices."*

The mining industry has long sought to strike a balance between economic, social and environmental factors. In recent years the term "sustainability" has come to represent this approach. Sustainability is most commonly defined as a condition in which the needs of the present generation are met without compromising the ability of future generations to meet their needs. Applying this approach to tailings management requires consideration of many aspects of the activity.

Application of the principles of good environmental stewardship based on elements such as waste minimisation, continual improvement and innovation is essential to the development of a sustainable approach. Effective engagement with stakeholders is also required if businesses are to implement sustainable solutions to tailings management challenges. To continue to meet the expectations of communities with respect to sustainability, operators must strive for excellence in the management of risks and implementation of both the operational works and the closure plans for tailings facilities.

A key objective of this *Strategic Framework for Tailings Management* is to encourage the mining industry to take a longer-term approach to the planning of tailings storage facilities. One of the factors critical to the final rehabilitation of a tailings storage facility is the management of the tailings deposition during the mining operation. Without systematic tailings deposition and careful water management, the final rehabilitation could be very costly, at a time when cash flow is limited or non-existent. Much of this challenge can be overcome by adequate planning, associated with good tailings management and the use of a sound technical approach early in the life of the facility.

The Strategic Framework

This *Strategic Framework for Tailings Management* has evolved as a cooperative development between the Ministerial Council on Mineral and Petroleum Resources (MCMPR) and the Australian Minerals Industry (represented by the Minerals Council of Australia (MCA)). It is designed to provide a broadly consistent framework for tailings management across the various Australian jurisdictions.

The Strategic Framework is not a detailed set of guidelines for tailings management. There is already a comprehensive body of codes, guidelines and procedures relating to tailings management (see the end of this document for a list of some of the key documents). However, it is anticipated that, as both government and industry review and update these regulations, there will emerge a consistency of purpose reflecting the principles of this Framework and leading to an increase in the effectiveness of tailings management. It is hoped that these initiatives will reflect, and further develop, the principles outlined in this document.

The Strategic Framework is designed to cover a broad range of mining and mining related activities. In this context, mineral processing is considered part of the broader mining function. While it is acknowledged that the focus of the Strategic Framework is primarily on improving tailings related activities at operating mines, the principles are relevant to a broad range of activities.

Structure of the Report

The *Strategic Framework for Tailings Management* is structured around a set of objectives and principles grouped under five key areas (stewardship, stakeholder engagement, risk management, implementation and closure). The principles are summarised at the beginning of the report, and then expanded on in subsequent sections.

The Strategic Framework also contains a number of Boxes which are designed to amplify particular topics which, in the authors' opinion, required additional explanation. The treatment of these topics is not exhaustive, but is provided as additional guidance.

The Strategic Framework concludes with a listing of Supporting Documentation which includes Standards and Guidelines, References, Definitions and Acronyms. The inclusion of the list of definitions is an attempt to standardise the often confusing and ambiguous terminology surrounding the tailings debate (Box 1).

Box 1 Tailings Storage Facility or Tailings Dam

There is some confusion in the use of the terms Tailings Dam and Tailings Storage Facility. They are variously used to define the overall disposal facility and/or the physical dam wall.

The two terms have precise meanings as used in this document.

- Tailings Storage Facility is defined as an area used to confine tailings. It refers to the overall facility, and may include one or more tailings (or water) dams.
- Tailings Dam is defined as an artificial embankment used to retain tailings.

REGULATORY SETTING

The regulation of tailings (and tailings storage facilities) in Australia is principally a State and Territory matter. The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* has established a new and nationally consistent framework for environmental assessment of new projects and variations to existing projects, based on consultative agreements between the Commonwealth and State and Territory Governments. Issues related to tailings management are an important consideration in the assessment process for mining proposals at both the State and Federal levels.

State and Territory

There are no uniform national requirements for tailings dams, their regulation being carried out by State Governments (Willgoose, 2000). The only national body, the Australian National Committee of Large Dams (ANCOLD), is a learned society providing expert advice on dam issues in the form of guidelines on recommended practice, but having no regulatory power. ANCOLD has developed a number of guidelines for dam construction and operation.

While the regulatory environment differs between States and Territories, there are some common themes. Generally, regulations make no distinction between:

- dams containing water and those containing tailings; nor
- an active tailings storage facility and an inactive one.

The regulation of tailings deposition and management (including rehabilitation and closure) is relatively straight forward. In all States and Territories this is the responsibility of the regulatory body charged with the oversight of the mining industry. In some areas, environmental regulation agencies may play a pollution control role, particularly if there is ongoing or intermittent discharge of water from the facility.

The regulation of tailings storage facility design, construction and ongoing integrity is more complex. In some jurisdictions, dam construction and operation is regulated by specific legislation[1], while in other States and Territories, tailings storage facilities are principally regulated by those agencies with responsibility for overall mining regulation. In some instances, regulation is based on the size of the dam, with large dams being formally regulated, and smaller facilities falling under general regulation.

1 *As an example, in New South Wales, the Dams Safety Committee oversees dam regulation under the Dams Safety Act (1978).*

International

At an international level, the International Commission on Large Dams (ICOLD) and the National Committees of its 81 member countries, provides a forum for technical interaction amongst dam designers and constructors. ICOLD has numerous technical committees that publish Bulletins giving guidance on various aspects of dam design, construction and monitoring.

Industry

For its part, the mining industry has responded directly to heightened community concerns regarding tailings management through the development of voluntary codes and guidelines. This is illustrated by the initiative of the Mining Association of Canada's (MAC) development of *A Guide to the Management of Tailings Facilities.* This guide was developed through a collaborative effort by representatives of the Canadian mining industry to provide guidance on good practices for the safe and environmentally responsible management of tailings facilities (MAC, 1998). Its purpose is threefold:

- to provide information on safe and environmentally responsible management of tailings facilities;
- to help companies develop tailings management systems that include environmental and safety criteria; and
- to improve the consistency of application of sound engineering and management principles to tailings facilities.

While there is no equivalent industry guideline for tailings management in Australia, the industry's commitment to improved tailings management is evident through the development of mechanisms such as the Australian Mining Industry (2000) *Code for Environmental Management* (the Code) and through the adoption of international environmental management system standards such as ISO 14001. The Code encourages self-regulation by the industry, with improved performance and enhanced community consultation as key components. Some key elements of the Code in relations to tailings management include:

- applying risk management techniques on a site-specific basis to achieve sound environmental outcomes over the life of the project;
- developing contingency plans to address residual risk;
- ensuring resources are adequate to implement the environmental plans during operations and closure;
- minimising wastes through recycling, and by re-using process residues; and
- encouraging external involvement in monitoring, reviewing and verifying our environmental performance.

The Minerals Council of Australia recognises nine key principles of effective tailings management in its Tailings Management Policy adopted in April 2000. The key principles are to:

- adopt a risk-based approach;
- minimise the production of tailings and maximise their safe re-use;
- ensure all tailings structures are operationally stable, able to be rehabilitated and retain their long-term integrity;
- consider economic, environmental and social aspects in all stages of tailings management to minimise short- and long-term impacts;
- contribute to focused and relevant research into strategic issues aimed at improved tailings management;
- share knowledge and expertise across industry on best practice approaches;
- recognise that effective stakeholder involvement is essential for successful planning, management and closure of tailings storage facilities;
- promote understanding of potential community health issues relating to tailings; and
- effectively monitor and report on tailings management practice.

OBJECTIVES AND PRINCIPLES

STEWARDSHIP

Objective

To adopt a stewardship approach to the safe management of tailings.

Principles

1. Commit to the implementation of **best practice** in tailings management.
2. Select mineral treatment and tailings management practices to **minimise potential impacts** on the environment.
3. Manage for **continual improvement**.
4. Promote and sponsor **innovation**.
5. **Benchmark** operations against industry standards and community expectations.

STAKEHOLDER ENGAGEMENT

Objective

To engage with the community and other stakeholders on issues of concern.

Principles

1. Identify key stakeholders and provide appropriate information for their needs.
2. Establish consultative processes to ensure ongoing engagement with the community.
3. Respond to community concerns in a transparent and effective manner.

RISK MANAGEMENT

Objective

To promote and facilitate a systematic and effective approach to minimising risks associated with the transportation and storage of tailings.

Principles

1. Ensure that risk assessment is an integral component of feasibility studies, facility design, and operations.
2. Adopt **risk management** principles in the design, construction, and operation of the tailings storage facility.
3. Develop and implement effective emergency response plans in consultation with regulators and the community.

IMPLEMENTATION

Objective

To develop and implement effective processes for tailings management.

Principles

1. Provide the necessary information, training and resources to **effectively manage** tailings.
2. Implement **appropriate operational controls** including procedures, monitoring and audit programmes.
3. **Comply** with all applicable laws and regulations.
4. **Report** tailings volume, composition and containment performance information on a regular basis to management, appropriate authorities and stakeholders.

CLOSURE

Objective

To ensure the effective long-term stability of tailings storage facilities.

Principles

1. Ensure tailings closure planning is an integral component of project development, design and operations.
2. Minimise the potential environmental impacts of decommissioned tailings facilities by designing for **long-term stability**.
3. Ensure that an effective **monitoring** programme is in place to demonstrate that the agreed completion criteria have been achieved.

TAILINGS MANAGEMENT

1 STEWARDSHIP

Stewardship is an approach to natural resource management that is based on the idea of the developer being a temporary custodian of community assets. In the development of mineral resources this approach is particularly appropriate since most ore bodies are eventually depleted and mines, along with their associated infrastructure, are then decommissioned. Stewardship implies that the proponent will take account of the foreseeable effects and consequences of the development and will seek to minimise the cost of the current development to future generations. Thus acceptance of stewardship principles includes efforts to achieve high standards in the reduction of wastes and their management, and a commitment to continual improvement. This imperative, to look beyond the narrow confines of production, will bring a new approach to the management of mine tailings.

As one of the biggest issues facing the minerals industry, tailings management will benefit from adopting a more holistic view. Managers need to understand the potential impacts that begins with reagent input and ends with the establishment of viable alternative land uses on decommissioned tailings storage facilities.

Objective: to adopt a stewardship approach to the safe management of tailings.

1.1 Best practice

Commit to the implementation of best practice in tailings management.

The term "best practice" describes a management approach involving a commitment to achieve outcomes beyond those expected for regulatory compliance. To achieve best practice, an operator would be expected to have developed management systems that ensure the identification of opportunities for improvement and to see that change is implemented, monitored and evaluated.

In achieving best practice it is expected that operators would have a commitment to minimising wastes and a well developed strategy to ensure continual improvement. Best practice should also incorporate the systematic evaluation of new technologies and opportunities for change. Finally, it is inherent in the notion of best practice that community expectations will be met so the strategy should also involve communication with key stakeholders (***see*** Section 2.).

1.2 Waste minimisation

Select mineral treatment and tailings management practices to minimise potential impacts on the environment.

The principles of waste minimisation include the reduction of waste stream volumes and/or toxicity. Beneficial outcomes can be achieved by process changes that reduce the generation of wastes, re-direct wastes to useful purposes or modify wastes so they are more benign to the environment. For example, process improvements that reduce the use of toxic reagents can result in a less toxic waste stream and cost savings to the operator.

It is now widely accepted that industry should implement the principles of waste minimisation in the management of production activities. This means that managers use the waste management hierarchy (Box 2) as a guide to assist them in making decisions. Waste characterisation is a key prerequisite to adopting one or more of these strategies.

Avoidance or elimination of wastes is not practical in most cases for mine tailings, although it may be possible to reduce the volume of tailings at some mines. In addition, some technologies which offer promise for elimination of tailings wastes, such as in-situ solution mining, introduce other environmental risks. In general, however, operators should demonstrate commitment to the improvement of tailings management practice and the better use of tailings wherever feasible. This approach should commence at the project design stage with a rigorous examination of available technologies. Regular re-evaluation of tailings disposal strategies should then be a part of the ongoing management system for the operation.

Box 2 Waste Management Hierarchy

In general, managers should use the following hierarchy to guide decisions about appropriate processes, technology and management of wastes.

In order of preference:

1. *Avoidance* – where possible, processes or materials should be changed to eliminate the generation of the waste.
2. *Reuse* – some wastes may be useful as feedstock for other processes.
3. *Recycling* – the raw materials contained in the waste may be reusable for further production.
4. *Recovery of energy* – wastes may be useful as fuel for energy production or substitution.
5. *Treatment* – it may be possible to make wastes innocuous by further treatment or processing.
6. *Containment* – secure storage of wastes in facilities that are isolated from the environment is often preferable to discharge.
7. *Disposal* – discharge of waste to the environment under controlled conditions and in a manner which does not harm the beneficial uses is the final alternative.

1.3 Continual improvement

Manage for continual improvement.

Tailings are the largest process waste stream resulting from mineral processing. To minimise the environmental risks associated with the management and storage of tailings it is important that operators are committed to continual improvement of their practices and processes. This implies a commitment to the identification, development and implementation of new and innovative technologies.

Effective management for continual improvement has a number of key elements including:

- setting appropriate objectives and goals;
- monitoring operational outcomes;
- evaluating the results;
- identifying changes in technology or widely accepted standards;

- implementing appropriate changes to practices or equipment; and
- setting new objectives and goals.

This is an iterative process and requires a long-term commitment to improvement by all levels of management.

The implementation of significant improvement to an existing operation requires careful planning, and will often involve incremental change over a long period. In addition to good operational management systems, these constraints underscore the need for careful planning prior to development of a facility.

1.4 Innovation

Promote and sponsor innovation.

Strategic research can be a powerful tool for identification and development of new technologies for the management of tailings. Research projects can be conducted at a small scale appropriate for individual operations, or may be much larger and only practical as collaborative projects sponsored by many stakeholders. Operators should evaluate their needs and decide on an appropriate research strategy for their circumstances. Where mine geology or local conditions create unique challenges, it is appropriate that the operator develop site specific research projects to address those issues. It may also be desirable for individual companies to fund research directed to improvements in technologies or processes specific to their operations. However, all operators should also consider participation in broader research programmes aimed at more general improvement in the management of tailings. Operators should consider forming strategic alliances to identify and promote useful research.

Operators should also maintain processes for regular review of relevant technical literature to ensure that they are aware of emerging technologies and can direct their own research or development resources to the best effect. There is a need to encourage and improve information exchanges on a variety of tailings related policy and technical issues. This will improve the ability of both industry and the regulator to locate the practical guidance they need to make effective day-to-day decisions.

The outcomes from sponsored research and work by others should be evaluated regularly. Current management and operational practices should be reviewed in light of any new technologies becoming available and strategies for change developed when appropriate.

1.5 Benchmarking

Benchmark operations against industry standards and community expectations.

To ensure best practice is achieved it is essential that effective communication is maintained with both the wider industry and the community.

Operators should maintain close contact with other companies and industry organisations.

Current tailings management systems should be regularly benchmarked against those in operation at other sites and those regarded in the wider industry as “state of the art” in technology and operation. Knowledge and expertise relating to tailings management should be shared and other operators should be encouraged to also implement best practice technologies and systems.

While technically sound operational systems may provide good protection for the environment, they may not be fully adequate if key concerns held in the local community are not also addressed. Mechanisms for community consultation should be used to ensure management has a good understanding of community expectations and concerns in relation to tailings management. Those concerns should also be considered in any programme for continual improvement.

2 STAKEHOLDER ENGAGEMENT

The challenge for the mining industry is to assure itself, regulators, local communities and other stakeholders that it is capable of meeting its responsibilities to manage tailings in a manner which achieves the highest standards (Brehaut, 1998).

Continual and constructive engagement between the community and the company is essential if confidence and trust are to be created. Successful consultation may lead to improved mutual understanding, a decrease in public criticism and adverse publicity, less contention during planning and environmental permitting, less prescriptive regulatory controls, and greater confidence in a company's environmental programme.

Objective:	to engage with the community and other stakeholders on issues of concern.

2.1 Information strategy

Identify key stakeholders and provide appropriate information for their needs.

Identifying key stakeholders and interested parties, and developing good communication with them, is fundamental for understanding and acceptance of tailings management strategies. Consultation should not be on a selective basis, but should involve all parties with a stake in the process. To be effective, communication must involve listening and feedback, as well as informing. Consultation is about both perception and reality (EPA,1995a), and perceptions can only be gauged by listening to key stakeholders.

Information distributed to stakeholders should be provided in a timely manner and in a form that is meaningful to the respective stakeholders. Adequate time should be provided for a response. The objective should be to ensure that all stakeholders have the necessary information and resources to participate meaningfully in the tailings management process.

2.2 Community consultation

Establish consultative processes to ensure ongoing engagement with the community.

Effective community relations demands that the company, its personnel and sub-contractors, have the capacity and desire to bridge the cultural and capacity gaps that often separate them from local communities (Dunn, 2000). To be effective, consultation requires corporate commitment and should be taken seriously by all company representatives involved.

Humphreys (1996) argues that the biggest challenge now is not a technical one. Rather it lies in the development of interactive and lasting relationships with the communities in which the industry operates. Ensuring that these relationships mature into robust structures in the long-term is the essence of effective consultation through operations and closure.

2.3 Responsiveness

Respond to community concerns in a transparent and effective manner.

Establishing effective consultation structures and procedures during the development phase of a project is essential to ensuring that all opinions are considered in the design of the tailings storage facility. Community concerns must continue to be identified and considered during operations, and system performance must be verified in a transparent manner (Brehaut, 1998). By demonstrating a commitment to high standards, and responding to community issues in an effective manner, industry can satisfy most of the concerns of key stakeholders.

3 RISK MANAGEMENT

Being amongst the largest man-made structures, tailings storage facilities present significant safety, health, environmental and financial hazards that must be managed to ensure risk levels are minimised. Although there are many possible mechanisms of failure, it can be argued that the majority of tailings related incidents can be avoided through effective management. In particular, all tailings design and management guidelines advocate a risk-based approach to tailings management.

Risk management encompasses the regular assessment of facility performance against its design, during which process the likelihood and consequence of identified hazards are rigorously assessed *(Box 3)*. The result allows clear definition and prioritisation of the actions required to minimise the occurrence or impact of the risks. .

Risk management principles can also be applied to hazards incidental to the operation of tailings facilities such as impacts on fauna, generation of dust, odour or other environmental effects. Appropriate cost-effective modifications and response strategies should be implemented to reduce the risks to a level acceptable to all stakeholders. An appropriate risk management programme can ensure that:

- incidents associated with tailings transportation and storage can be minimised;
- organisations have a risk-based tailings management strategy to minimise environmental, health, safety and business risks;
- monitoring of key performance indicators against design parameters is used to identify hazards, assess risks and prioritise action plans;
- all risks and scheduled actions are reviewed regularly and subject to periodic audits;
- tailings risk management performance is reported to the highest management level to promote transparency and to maintain risk awareness and to focus management attention; and
- tangible financial and social benefits accrue through implementation of a responsible risk-based tailings management process.

Objective: to promote and facilitate a systematic and effective approach to minimising risks associated with the transportation and storage of tailings.

3.1 Risk assessment

Ensure that risk assessment is an integral component of feasibility studies, facility design and operations.

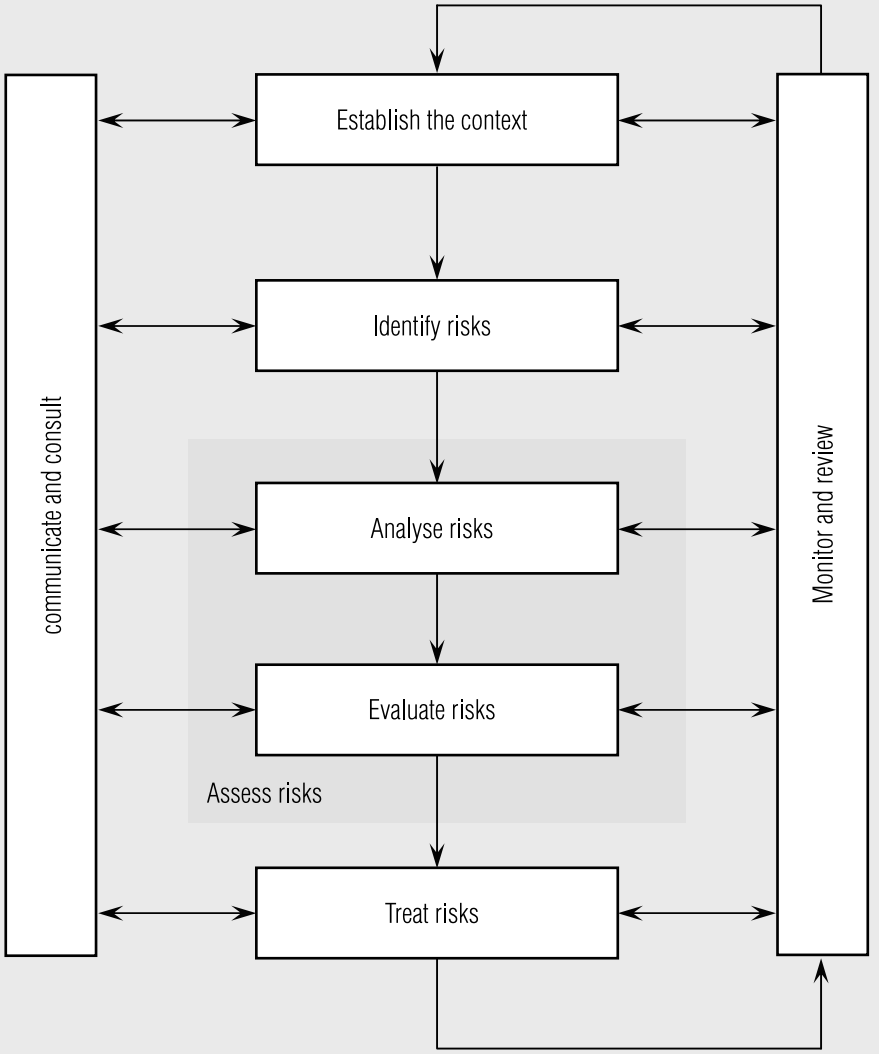
Risk assessment can be quantitative, qualitative or a combination of both, tailored to suit the complexity of the facility, the type of risk and the participants' skills level. Generally, the steps are:

1. identify the possible hazards or types of incidents;
2. assess the likelihood or probability that an incident may occur;
3. assess the potential consequences of an incident; and
4. implement risk mitigation actions according to priority ranking.

Where the emphasis is on pro-active incident avoidance, a qualitative approach is recommended. The risk assessment team, comprising a variety of operational roles, agree a qualitative assessment of risk, and schedule actions in order of agreed priority ranking. Quantitative risk assessment may be applicable to specific hazards relating to technical or design issues requiring closer definition for more accurate assessment and comparison.

Risk assessments should be updated on a regular basis to ensure currency, and to take account of altered processes or changing circumstances.

Box 3 Risk Management Overview (AS/NZS 4360:1999)



3.2 Risk mitigation

Adopt risk management principles in the design, construction and operation of the tailings storage facility.

The design of all components of tailings storage facilities should be carried out by competent practitioners. Appropriate investigations must be carried out to provide comprehensive design data and a robust design. Mitigation of risks should be undertaken in the following order of preference:

- elimination or substitution which is a permanent solution that eliminates the hazard altogether or substitutes one that presents a lower risk; then
- engineering controls or safety measures to reduce risk; then
- administrative controls which reduce or eliminate exposure to a hazard by adherence to procedures or instructions.

This risk-based design approach should clearly identify the lead indicators which need to be monitored during operation to minimise the risk of a failure or incident. The design of tailings storage and transportation facilities should attempt to minimise potential impacts by including automated monitoring systems and contingency elements such as flow diversion barriers.

Construction quality control by competent practitioners is important in ensuring that all elements of the facility are constructed in accordance with the design specifications.

Daily inspections by operations' personnel and regular performance and risk audits by competent geotechnical engineers should monitor key performance indicators against the design. The frequency of the audits should ensure that there is sufficient time to implement remedial actions where necessary.

Operational monitoring should be used to validate the assumptions of the risk management plan and to indicate aspects of the operation where further risk assessment is warranted. Where monitoring or audit indicates deficiencies in previous risk assessment or reduction activities, there should be a clearly defined process for review of those measures.

The results of risk audits and risk assessments should be reported to the highest levels of management within the organisation to deter complacency in actioning risk avoidance measures. Management should ensure responsibility is clearly assigned for actions critical to the management of risks and that outcomes are reviewed on a regular basis.

3.3 Emergency response

Develop and implement effective emergency response plans in consultation with regulators and the community.

Carrington (2001) suggests that *"as an industry, our responsibility for emergency preparedness and response capability does not stop at the mine gate. It is a truism of modern mining that we don't*

operate in isolation, especially when it comes to the safety and well-being of our surrounding communities".

Each facility should have an emergency response plan to ensure that:

- all potentially affected parties understand the possible causes and consequences of tailings failures or incidents; and
- a warning system is in place to ensure that all potentially affected persons are isolated from the impacts of a tailings failure.

Emergency response should also include strategies to minimise the impact of a failure, but such actions should only be implemented if there is no danger to personal safety.

Emergency response procedures should include provision for de-briefing and analysis of incidents and to ensure appropriate changes are made to risk management measures.

4 IMPLEMENTATION

Much is said about the need to ensure that all tailings storage facilities are operationally stable, able to be rehabilitated and retain their long-term integrity (MAC, 1998). There is clearly an imperative to avoid environmental, health and safety impacts.

The process for tailings management must commence at the very inception of mine development. It should be factored into every aspect of the mine's planning processes. The handling and storage of tailings should be considered at every design and decision making stage and should account for the specific requirements of the process under consideration, siting of operation, consideration of alternatives and ultimately the cost of closure[2].

An effective management system involves:

- top management commitment and the setting of challenging but achievable objectives;
- plans, procedures, and resources to attain the objectives;
- communicating the company's objectives and expectations to employees;
- providing employees with the necessary resources, training and incentives;
- monitoring progress and adjusting objectives and methods accordingly; and
- transparent performance reporting.

Objective: to develop and implement effective processes for tailings management.

4.1 Effective management

Provide the necessary information, training and resources to effectively manage tailings.

Many tailings storage facility failures can be traced back to poor or ineffective management decisions, whether this relates to decisions made with inadequate information, or that no formal decision making or risk management process was in place to facilitate these decisions. Accountabilities need to be defined for a wide range of individuals representing operating, maintenance, environmental and other disciplines. A tailings management plan is a prerequisite for establishing individual duties. Such a plan cuts across the site management structure, and necessitates a senior manager to assume overall accountability for tailings.

Effective management has to be driven from the corporate level and will be demonstrated by clear policies, and a commitment to implement the policy and principles. The commitment starts with the

2 *Issues to do with risk assessment and management and closure are dealt with elsewhere in this document and also in ANZMEC/MCA (2000) Strategic Framework for Mine Closure.*

establishment of a tailings management team, selected for their knowledge, skills and competency in planning, designing and managing all aspects of tailings operations. The membership of the team may vary from time to time depending on the demands at different stages of development however their roles, responsibilities and authority should be clearly defined and understood (MAC, 1998).

The tailings management team will be held responsible for all aspects of tailings management. It will establish and set the objectives from conceptual planning through to final closure within the following broad objectives:

- identifying and managing risk, including the identification and evaluation of possible failure modes, performance monitoring, and developing contingency and emergency response plans;
- managing the changes that are often required during the implementation of plans; and
- providing the resources and scheduling to effectively implement the plans. This will include, staffing, specialised skills development, technology and financial resources.

Managers are accountable to ensure that competent and suitably qualified people are involved in all stages of the process. Where these are not available then training should be undertaken to enable the development of existing personnel. This is applicable to staff, contractors and consultants, and for all levels of relevant personnel in the management structure.

Management should ensure all relevant staff are aware of their roles and responsibilities in the process and that they understand the potential risks and impacts of their actions. Ongoing monitoring and assessment of staff performance should ensure they are cognisant of these responsibilities and that they are aware of any changes that may have taken place.

4.2 Appropriate operational controls

Implement appropriate operational controls including procedures, monitoring and audit programmes.

The key to successful operations is the development and implementation of appropriate procedures for all aspects of the operation. Coupled with this is the identification of the roles, responsibilities and authorities of those carrying out the various activities. The assigned activities need to cover all aspects of the tailings management process, including:

- the initial site selection, design, construction, operation, decommissioning and closure of the facility;
- financial control and provisions to ensure that capital, operational and closure costs are understood and meet the objectives of the plan;
- maintaining an accurate set of documents that record the objectives, changes to design or operating requirements and the status of the structure over time;
- the selection and employment of suitably qualified staff who are competent to meet the responsibilities and technical requirements of their roles;

- providing for routine and regular inspection, monitoring and reporting on the performance of the tailings facility; and
- senior management due diligence review of the whole process including policy, objectives and performance of the designs and management processes.

4.3 Compliance

Comply with all applicable laws and regulations.

It is essential that the statutory requirements for the design, construction, operation and closure of the tailings storage facility are identified and understood. These may vary between different jurisdictions, so it will be essential to verify particular requirements with local authorities.

There is a move towards less prescriptive and more enabling legislation that places the onus of responsibility on the developer. This "duty of care" approach firmly places the responsibility and accountability on the operator and emphasises the need for effective risk assessment and management in the design, construction, operation and closure of the tailings storage facility.

4.4 Reporting

Report tailings volume, composition and containment information on a regular basis to management, appropriate authorities, and key stakeholders.

The most important aspect of reporting is to ensure that the results of monitoring are routinely fed back to management in a manner which enhances their understanding of the operation of the tailings transport and storage facility. This will improve management efficiency, and encourage preventative maintenance and timely changes to management procedures.

Relevant information in regard to the design and construction of the facility should be reported. Typically designers need to clearly define the parameters and assumptions that are made in the design process and develop an appropriate design response. Reports should document parameters important to the design and verify their application in construction. The retention of construction records is essential for the effective monitoring of long-term performance.

A key component in any management process is feedback on how the process is working. Due diligence review of tailings management is no exception. Reporting should be on a regular basis and should reflect the true status and performance of the tailings storage facility. It should record key performance aspects of the facility and should summarise and provide comment on the implications of monitoring results with recommendations for changes where necessary.

Statutory agencies require regular reporting to demonstrate compliance with the conditions of approvals and licences, as well as the overall performance of the tailings storage facility. This information should be complementary to data the tailings management team use in their own internal monitoring and assessment of the facility for ongoing management decisions.

5 CLOSURE

All man-made structures remaining after mine closure should be physically and chemically stable (Ricks, 1997). The closed tailings storage facility should present no hazard to public health and safety, or the environment, as a result of failure or physical deterioration. At any time, it should be capable of performing the functions for which it was designed.

There are a number of objectives that need to be considered when planning the final land form of a tailings storage facility (EPA, 1995b). They include:

- containing/encapsulating tailings to prevent leaching into ground and surface waters;
- providing surface drainage and erosion protection to prevent surface water transporting tailings from the storage area;
- providing a stabilised surface cover to prevent wind erosion; and
- designing the closure to minimise post-closure maintenance.

The sections below deal specifically with the closure of tailings storage facilities. The broader principles of mine closure can be found in ANZMEC/MCA (2000) *Strategic Framework for Mine Closure*.

Objective: to ensure the effective long-term stability of tailings storage facilities.

5.1 Integrated closure planning

Ensure tailings closure planning is an integral component of project development, design and operations.

The closure plan examines the best means of planning and subsequently managing the environmental changes and socio-economic effects that occur when mining ceases. Closure planning is dynamic and evolves with the mine (Ricks, 1997).

Tailings closure planning should not be an "end of mine life process" but must be integral to "whole of mine life" if it is to be successful. Planning for tailings closure should commence at the feasibility phase of an operation. In this way, future constraints on, and costs of, closure can be minimised, post-mining land use options can be maximised and innovative strategies have the greatest chance of being realised.

The plan for tailings closure should evolve throughout the operational life of the facility, being subject to periodic review to ensure operational changes and evolving closure objectives are integrated into long-term planning. The progressive closure and rehabilitation of individual dams, or cells of dams, is encouraged, provided this is integrated into the overall closure strategy. Progressive closure provides the opportunity to monitor the success of reclamation strategies, and to refine future programmes in the light of operational experience.

5.2 Long-term stability

Minimise the potential environmental impacts of decommissioned tailings facilities by designing for long-term stability.

The potential environmental impacts of decommissioned tailings facilities include water and windblown particulate dispersal, groundwater contamination and acid drainage. While the threat of catastrophic failure is usually reduced due to the dewatered nature of the deposit, under certain circumstances it remains an important consideration. The final landform design must be compatible with community needs, any legal requirements, climate, topography and the level of management available after reclamation.

A risk-based approach to closure design is recommended. Taking a risk management approach recognises the underlying uncertainty in engineering structures for long-term stability. Comprehensive risk analysis should provide sufficient understanding to either eliminate hazards, or to minimise their likelihood and/or minimise possible consequences (Box 3).

There is a wide range of options for the closure design of a tailings storage facility, from stable cappings or wet closure systems to restrict oxygen ingress, to closure systems which actively or passively manage emissions. Environment Australia (1998) Landform Design for Rehabilitation and the Minerals Council of Australia (1998) Mine Rehabilitation Handbook provide useful basic introductions to some of the options. Ultimately, designing for long-term stability is highly site-specific, and depends on the individual characteristics of the tailings, as well as the climatic, topographic, hydrogeologic and geotechnical characteristics of the disposal site.

All closure situations are unique, and although past experience and good planning can minimise the risks of failure, some remedial activity may be necessary.

5.3 Performance Monitoring

Ensure that an effective monitoring programme is in place to demonstrate that the agreed completion criteria have been achieved.

Completion criteria are the basis on which successful rehabilitation is determined, and should be developed in consultation with stakeholders. This ensures that there is broad agreement on both the end land use objectives and the basis for measuring the achievement of that objective. Ideally, completion criteria should reflect the specific environmental and socio-economic circumstances of the site.

Monitoring should be designed to demonstrate that completion criteria have been met and that the site is safe and stable. Broadly, and within the land use objectives set for closure, monitoring should demonstrate that:

- structures are geotechnically stable, and covers are not eroding at unacceptable rates;
- there is a low risk of an uncontrolled release of tailings or contaminants;
- should this occur, the release of contaminants or tailings will not result in recognisable detrimental effects on the water, soil and air surrounding the closed facility; and
- plant growth has been successful and that, over a period of several growing seasons, a self-sustaining community has developed.

When the Responsible Authority has agreed to relinquishment of a tailings storage facility, the management and maintenance of the facility would rest with subsequent owners or the State.

SUPPORTING DOCUMENTATION

Standards and Guidelines

- ANCOLD (1994) *Guidelines on Dam Safety Management.*
- ANCOLD (1998) *Guidelines on Tailings Dam Design, Construction and Operation.*
- ANZMEC/MCA (2000) *Strategic Framework for Mine Closure.*
- Australian Minerals Industry (2000) *Code for Environmental Management.*
- Department of Natural Resources and Environment (2002) *Discussion Paper on Tailings Storage Guidelines for Victoria.*
- Environment Australia (1998) *Landform Design for Rehabilitation.* Best Practice Environmental Management in Mining, Commonwealth of Australia.
- Environment Australia (1999) *Environmental Risk Management.* Best Practice Environmental Management in Mining, Commonwealth of Australia.
- Environment Protection Agency (1995) *Community Consultation and Involvement.* Best Practice Environmental Management in Mining, Commonwealth of Australia.
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- ICME/SIDA/UNEP (1997) *Proceedings of the International Workshop on Managing the Risks of Tailings Disposal.* Stockholm, Sweden, May 1997.
- ICME/UNEP (1998) *Case Studies on Tailings Management*
- ICME/UNEP (1998) *Proceedings of the Workshop on Risk Management and Contingency Planning in the Management of Mine Tailings.* Buenos Aires, Argentina, November 1998.
- ISO (International Standards Organisation) (1996) *Environmental management systems - Specification with guidance for use.* ISO 14001.
- Minerals Council of Australia (1998) *Mine Rehabilitation Handbook.*
- Minerals Council of Australia (1999) *Tailings Management Policy.*
- Mining Association of Canada (1998) *A Guide to the Management of Tailings Facilities.*
- NSW Dam Safety Committee (1995) *Operation, Maintenance and Emergency Management Requirements for Dams.*
- Queensland Department of Minerals & Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland - Part D - Rehabilitation Guidelines.*
- Standards Australia (1999) *Risk management.* AS/NZS 4360:1999.

- US Environmental Protection Agency (1994) *Design and Evaluation of Tailings Dams.* Technical Report 530-R-94-038.
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Mining Association of Canada (1998) *A Guide to the Management of Tailings Facilities.*

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Definitions

Acceptable risk: that level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable.

Acid rock drainage (ARD): the seepage of sulphuric acid solutions (pH 2.0-4.5) from mines and tailings; these solutions are produced by the interaction of oxygen in ground and surface water with sulphide minerals exposed by mining.

Comparative risk assessment: process that generally uses the judgement of experts to predict effects and set priorities among a wide range of environmental problems.

Contingency plan: a programme intended to address malfunctions, accidents or unplanned events that may occur in connection with the undertaking.

Dam: an artificial barrier, together with appurtenant works, constructed for storage, control or diversion of water, other liquids, silt, debris or other liquid-borne material.

Dam failure: the uncontrolled release of the contents of a dam through collapse of the dam or some part of it, or the inability of a dam to perform functions such as water supply, prevention of excessive seepage or containment of hazardous substances.

Hazard analysis: that part of the overall planning process which identifies and describes hazards and their effects upon the community.

Risk assessment: the process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria.

Risk management: the process of evaluating and selecting alternative regulatory and non-regulatory responses to risk. The selection process necessarily requires the consideration of legal, economic, and behavioural factors.

Stable: a condition where the rates of change of specified parameters meet agreed criteria.

Stakeholder: a person, group or organisation with the potential to be affected by the process of, or outcome of, an activity or process.

Tailings: the fine grained waste material remaining after the economically recoverable metals and minerals have been extracted.

Tailings dam: an artificial embankment used to retain tailings.

Tailings storage facility: an area used to confine tailings; its prime function is to achieve solids settling and improve water quality. It refers to the overall facility, and may include one or more tailings (or water) dams.

Waste minimisation: measures or techniques that reduce the amount of wastes generated during industrial production processes; term is also applied to recycling and other efforts to reduce the amount of waste going into the waste stream.

Acronyms

ANCOLD	Australian National Committee on Large Dams
ICME	The International Council on Metals and the Environment
ICOLD	International Commission on Large Dams
SIDA	Swedish International Development Cooperation Agency
UNEP	United Nations Environment Programme