NSW GOVERNMENT

NSW Resources Regulator

REPORT

LANDFORM ESTABLISHMENT TO SUPPORT POST-MINING FINAL LAND USE

Planned Inspection Program

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Executive summary

This report summarises assessment findings from 40 mines in relation to landform establishment to support the post-mining final land use and achieve sustainable rehabilitation outcomes. Assessments were conducted during the period from February 2021 until July 2021. The threats, critical controls assessed are shown in Appendix B. Figures 1-3 present the compliance findings for each de-identified mine and critical control. Explanatory notes on the assessment system are also listed in Appendix C.

A key issue identified is that risk assessments were variable. Although we observed some that would be considered satisfactory, a significant portion were considered 'broad-brush' and lacked specificity regarding rehabilitation controls for landform establishment risks.

The TAP findings suggest that some mines need to place increased focus on implementing the following critical controls:

- Waste materials characterisation. Specifically, ongoing verification testing for geochemical problematic material.
- Emplacement strategy. Consideration of emplacement construction practices to limit gas transport (air ingress) for the management of geochemical problematic material (where it occurs).
- Design and installation of emplacement area capping. Including quarantining adequate quantities of suitable capping material throughout the mine life cycle.
- Design and implementation of final landform design. Including use of appropriate modelling to assess the stability of the landform design, with consideration of both long-term erosion of the landform and hydrological performance of surface water management features. Also, implementation of robust quality assurance practices for the constructed landform against the design.

Assessment finding letters were issued to each mine in the program, which included a summary of key observations made by the Regulator during the assessment as well as recommendations for improvement in the medium to longer term.

Statutory notices pursuant to section 240 of the *Mining Act 1992* were issued to seven mines, directing them to take actions associated with further assessment of the stability of their final landform design, in order to achieve sustainable rehabilitation outcomes that will support the final land use. In accordance with section 240(1)(c) of the *Mining Act 1992*, each direction issued included information on the specific risk identified during the TAP and the required actions to address the risk.

It is recommended that mine operators, upon reading this report, review and amend (where relevant), their site's relevant risk assessment, rehabilitation management plans and management practices to manage the risks associated with landform establishment that are unique to their site.

Introduction

The NSW Resources Regulator undertakes targeted assessments and planned inspection programs at mines in NSW assessing a mine's critical rehabilitation risks and the critical controls required to mitigate these risks.

To this end, we developed a bowtie risk management framework and standardised assessment checklists for a range of targeted assessment programs (TAP). Each TAP focuses on the implementation of identified critical controls (categorised in accordance with the ICMM handbook[1]) to determine whether measures have been identified and implemented to ensure sustainable rehabilitation outcomes. Further details, including the bowtie risk assessments, are available on our website.

An extract from the bowtie risk assessment is included in Appendix A.

A summary of the TAP assessment setup, including objectives and assessment criteria for each critical control is provided in Appendix B.

The TAP applies the following principles:

- Consideration of the mine's risks to achieve effective rehabilitation.
- A focus on the implementation of the identified critical controls.
- Evaluation of the effectiveness of the control measures implemented.

The Landform Establishment TAP was undertaken from February 2021 until July 2021 to assess critical controls associated with landform establishment. This includes how a mine is managing any problematic material that requires containment within the rehabilitated landform, such as waste rock emplacement for the management of Acid Metalliferous Drainage (AMD) and tailings.

The program plan initially included 45 mines, which was reduced to 40 mines following restrictions implemented due to COVID-19 in July 2021.

Scope

The TAP incorporates:

- a desktop assessment of documents and records to identify the control measures the mine utilises to prevent and mitigate the risks to achieving sustainable rehabilitation outcomes

[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

- a site inspection of the mine to assess the implementation of those controls.

The process

The process for undertaking a TAP generally involves the following stages:

- written notification to the mine providing details of the proposed TAP. This includes:
  - the focus areas of the assessment
  - assessment timing and assessment team composition
  - a list of the likely documents and records that should be made available for assessment
  - the resources that should be made available by the mine, including site personnel that may be required to participate.
- a site visit to the mine (normally one day) to undertake both the desktop assessment and site inspection
- verbal discussion and feedback to the mine management team on the findings and likely actions that need to be taken by the miner operators in response
- written feedback to the mine, which may include an assessment finding letter and/or a direction to address certain matters pursuant to section 240 of the *Mining Act 1992*.

Assessment findings

Controls assessed

MRP1.1- Rehabilitation Risk Assessment

The risk

Rehabilitation risk assessments are required for each mine to identify the risks that need to be addressed for landform establishment relevant to their site and circumstances. The rehabilitation risk assessment will then identify the appropriate risk control measures that must be implemented and identify how risk control effectiveness will be assessed.

A deficient rehabilitation risk assessment will result in appropriate control measures not being identified and implemented to manage landform establishment risks to ensure rehabilitation achieves the final (post-mining) landform and land use.

What was assessed

A rehabilitation risk assessment should identify, assess and evaluate the risks that need to be addressed when managing landform establishment to achieve sustainable rehabilitation outcomes.

The rehabilitation risk assessment must be relevant to the mine site's current operations and produced by a team of appropriately skilled people representing a cross-section of the workforce.

The rehabilitation risk assessment should identify the appropriate risk control measures that must be implemented to reduce the risks and the control measures that should be implemented.

What we found

We found that risk assessments were variable. Although we observed some mines had risk assessments that would be considered satisfactory, a significant portion were considered 'broad-brush'. For instance, we found that risk assessments tended to refer to the management plan as a control, rather than nominate the specific controls.

We noted a portion of these assessment were dated (in same cases several years) and not reflective of the current operations and risk controls utilised at the mine.

We also observed uncertainty to how risk control effectiveness was assessed. In instances where failed controls were observed during the TAP inspection (for example erosion was occurring and likely to result in an unstable landform), we found that reviews of the risk assessment and effectiveness of risk control was ad-hoc, with most mines not maintaining formal records that the review had taken place.

In the majority of cases, the risk assessment had been prepared by a range of suitably qualified people. We also noted some mines with large and complex landforms had utilised the services of landform stability experts as part of the risk assessment process i.e. attendance at the risk assessment workshop.

MP3.1 & MP4.1 Characterisation analysis (geochemical & geotechnical)

The risk

Waste materials which have not been adequately characterised for geochemical properties present a risk that the materials (e.g. tailings, rejects, overburden etc.) that form part of the final landform may contain contaminants or have properties that adversely impact the environment if left unmitigated or uncontained.

What was assessed

Waste material emplaced within the rehabilitation landform are characterised so that their geochemical and physical properties are understood. An ongoing sampling program is in place to identify potential changes in material properties.

Where relevant, an appropriate geological model (typically block model for metalliferous mines) has been adopted to determine the source of problematic material.

A strategy (including procedure and management plans) has been developed for selective handling and management of problematic materials.

What we found

Although mines have undertaken characterisation analysis as part of baseline analysis associated with their initial project application and development, a significant portion did not have in-place any verification testing as the mine progressed. This is was noted to be more associated with coal mines.

We noted that improvement in knowledge is required for how geochemical properties of emplaced waste material may affect final land use, such as potential for geochemical constraints to surface vegetation if tree roots penetrate into emplaced wastes. Also, the potential combustibility of coal reject material emplaced in the landform. This is in addition to testing for spontaneous combustion which is typically undertaken.

MP3.3 & MP4.2 Design & implement emplacement strategy

The risk

Inadequate consideration of the geotechnically problematic material in the emplacement strategy present the risk that the emplacement will be unstable and will impact the final landform stability and final land use.

Inadequate consideration of the geochemical problematic material in the emplacement strategy presents the risk that these materials will release contaminants that adversely impact the environment.

What was assessed

Where identified as a specific control, a drainage system to collect seepage from the emplacement as well as use of liners and the associated requirements are understood. This includes performance, QA/QC during installation and ongoing monitoring, if compromised.

Strategies to ensure the emplacement is stable during construction, including methods to promote compaction/consolidation during construction. Where relevant, the strategy takes into consideration of material selection and treatment – i.e. handling of low strength or dispersive/sodic soils.

The emplacement dimension (i.e. height) and location are consistent with those approved by the Mining Operations Plan and/or the development consent.

Where identified as a specific control, a strategy has been developed to manage geochemical problematic material, including consideration of emplacement construction design to limit gas transport (air ingress) and resulting acidity/salinity/spontaneous combustion production, if relevant.

Material handling field practices are in accordance with defined management practices (i.e. placement method, lift height, treatment).

What we found

For the majority of mines included in the TAP, the use of drainage systems and liner was not identified as a specific control. This was due to the relatively geochemically benign characteristics of the waste material emplaced at these facilities.

Most mines had implemented an effective surveying system to monitor emplacement location and dimensions.

Where geotechnical problematic material was identified, most mines had developed a strategy for this material to be appropriately managed as it was emplaced. However, poor consideration of low-strength material remaining in-situ within the mining pit walls/benches was identified at two separate mines.

We noted that improvements are required for management of geochemical problematic material within emplacements during construction. Consideration is required to limit gas transport (air ingress) as part of the emplacement strategy, rather than rely upon final capping/sealing to manage potential seepage during emplacement final rehabilitation as the only control.

MP4.3 Design & install a cap (waste/reject emplacement)

The risk

Uncertain capping design and performance presents a risk that the materials used for capping may not be a suitable growth medium or placed at a suitable thickness to support the final land use. Inadequate strategy to ensure sufficient quantity of suitable capping material presents a risk that the cap cannot be constructed in accordance with the design. In addition, the need to source material for capping may lead to significant delays in the rehabilitation process.

What was assessed

The performance requirements of capping and the design are aligned to support the final land use. Where relevant, performance requirements for capping considers building strength profile (low strength waste/reject) and permeability (control both air-ingress and seepage into emplaced waste). The capping material type, source and quantity is nominated and methods to quarantine the capping material in place.

What we found

Consistent with the previous Tailings Management TAP[2], most mines have developed conceptual capping design. The majority of the conceptual capping designs had no, or minimal assessment undertaken to demonstrate the capping will be appropriate for the site-specific geochemical and physical constraints in order to sustain final land use outcomes.

We found performance requirements were not well defined for how the cap will manage geochemical problematic waste (e.g. potential acid forming material; combustible material associated with coal tailings etc.).

We also noted a lack of consideration of how the capping design will accommodate tree growth without compromising the integrity of the cap. Noting that the exclusion of trees as part of the nominated final land use that require long-term land management practices to be implemented post-closure is not considered a sustainable risk control.

Implementation of management practices to quarantine suitable quantities of suitable capping will be available at closure was variable. We noted that deficiencies are more prevalent in metalliferous mines which manage AMD material, due to the nature of the waste rock and the use of limited benign material prioritised for construction of containment structures. The ability for some mines to estimate the

[2] Tailings Management to Support Post-mining Land Use, Planned Inspection Program, November 2019 - May 2020

quantity and type of capping material and implement strategies to quarantine was restricted by the lack a definitive capping design.

MP5.1 Design & implement landform based on hydrological and geomorphic assessment

The risk

Inadequate consideration of landform design presents a risk that long-term erosional stability of the final landform, which may lead to landform stability issues. This may subsequently lead to an unstable final landform not being able to support the nominated final land use and the release of sediments to the surrounding environment at levels significantly higher than natural landscapes post closure.

In circumstances where geochemically problematic materials are contained in emplacements (such as material subject to AMD or combustion/heating), erosion can deplete the cap over these emplacements, exposing this material and impacting the final land use.

What was assessed

Final landform is designed for long-term stability of rehabilitation land post-closure, including consideration that is commensurate with surrounding natural landform and, where appropriate, incorporates geomorphic design principles.

Appropriate use of erosion models to optimise the landform design and to show where high-risk erosion areas are likely to occur and nominate how risk controls will be incorporated into the final landform design to appropriately treat these risks.

Consideration of surface water management in the final landform design including appropriate use of hydrological projections to demonstrate the long-term competency of the capping of problematic material emplacement (i.e. AMD waste rock emplacements and tailings).

Where final landform establishment has commenced, this is conducted in accordance with design and construction quality assurance programs in place.

What we found

We found that the consideration of the assessment of erosion and stability of the landform design was variable. Some mines utilise appropriate erosion modelling including the use of leading practice assessment tools, such as Landform Evolution Models (LEMs).

We noted that mines that utilised LEMs were more likely to adopt geomorphic design principles with natural relief and landforms with smaller catchments, instead of traditionally engineered landforms with linear slopes that rely on contour drains to break up the slope length.

We noted that ongoing risks associated with linear landforms with contour banks were not well defined. It is likely that these types of landform will require maintenance to ensure contour drains continue to function via removal of sediment collected, especially before vegetation is established.

The use of erosion monitoring to assess site-specific erosion rates was not broadly implemented. A few mines have identified the need to collect erosion monitoring data to improve the quality of data into modelling, however, erosion monitoring data was not included in the development of rehabilitation completion criteria.

Assessment of surface water management in the final landform was variable. The use of hydrological projections when designing surface water management in the final landform was not adequately considered for a majority of the mines assessed. We noted this as being a key deficiency for emplacement structures, such as tailing storage facilities and waste rock emplacement storing AMD material, that due to the nature of the material being contained, require their long-term stability to be demonstrated. We also noted that a lack of specifications for surface water management drains/channels has resulted in structural failures of these features, mostly associated with inadequate sizing (too small) and competency of rock material used to armour the drains/channels.

Landform construction quality assurance was variable, with some mines implementing leading practice quality assurance practices with clear requirements for material placement within well-defined tolerances. A large portion of mines assessed had deficient quality assurance practices, mainly associated with poor record management.

Assessment findings by mine

The assessment findings by mine are summarised in the figures below. More details explaining the assessment system are found at Appendix C.

Figure 1 presents the overall assessment findings for each assessment category.

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Figure 1: Overall findings ratings by criteria group

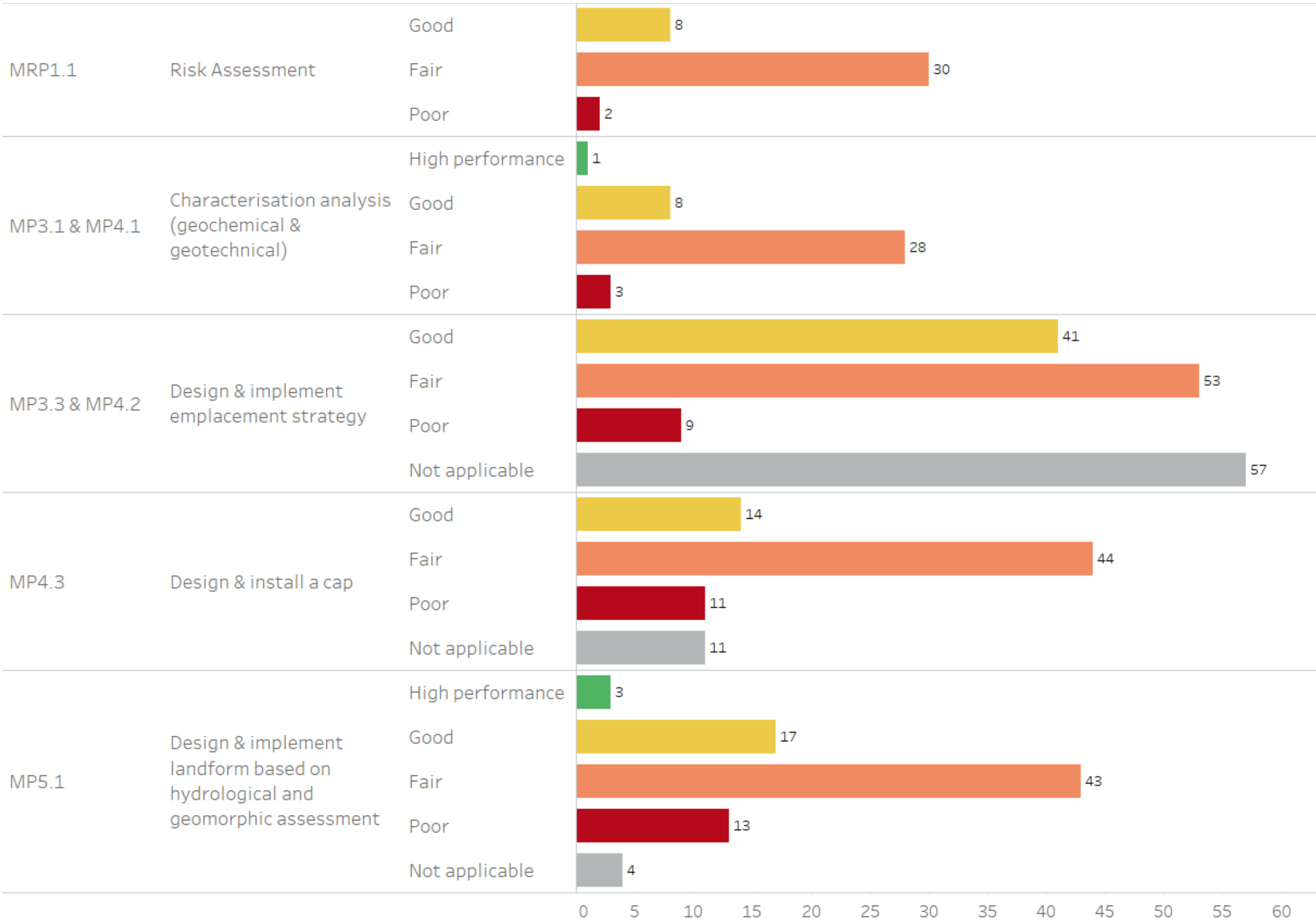

Figure 2 and 3 present the overall assessment findings for each of the assessment categories. Figure 2 shows mines that scored ≤55% of possible points. Figure 3 shows mines that scored >55%.

Figure 2: Overall assessment findings for each of the assessment categories – overall grand total result ≤55%

Location	MRP1.1 Risk Assessment	MP3.1 & MP4.1 Characterisation analysis (geochemical & geotechnical)	MP3.3 & MP4.2 Design & implement emplacement strategy	MP4.3 Design & install a cap	MP5.1 Design & implement landform based on hydrological and geomorphic assessment	Grand Total
Mine A	25%	50%	38%	25%	38%	34%
Mine B	25%	50%	38%	38%	25%	35%
Mine C	50%	25%	38%	38%	25%	36%
Mine D	50%	50%	25%	38%	38%	38%
Mine E	50%	50%	50%	38%	25%	43%
Mine F	50%	25%	50%	38%	50%	44%
Mine G	50%	25%	67%	38%	25%	47%
Mine H	50%	50%	50%	38%	50%	48%
Mine I	50%	50%	44%	50%	50%	48%
Mine J	50%	50%	50%	50%	50%	50%
Mine K	50%	50%	50%	50%	50%	50%
Mine L	50%	50%	50%		50%	50%
Mine M	50%	75%	50%	38%	50%	50%
Mine O	50%	50%	50%	50%	50%	50%
Mine P	50%	50%	50%	75%	38%	50%
Mine Q	50%	50%	50%	50%	50%	50%
Mine R	75%	50%	56%	50%	38%	53%
Mine S	50%	50%	56%	63%	25%	53%
Mine T	50%	50%	50%	50%	63%	53%
Mine U	50%	50%	58%		50%	54%
Mine V	50%	50%	75%		38%	54%

- Yellow (>50% and <=75%)
- Orange (>25% and <=50%)
- Red (<=25%)
- Not applicable

Figure 3: Overall assessment findings for each of the assessment categories – overall grand total result >55%

Location	MRP1.1 Risk Assessment	MP3.1 & MP4.1 Characterisation analysis (geochemical & geotechnical)	MP3.3 & MP4.2 Design & implement emplacement strategy	MP4.3 Design & install a cap	MP5.1 Design & implement landform based on hydrological and geomorphic assessment	Grand Total
Mine W	50%	50%	63%	50%	63%	56%
Mine X	50%	50%	75%	50%	50%	56%
Mine Y	50%	50%	75%	50%	50%	56%
Mine Z	50%	50%	75%	63%	50%	57%
Mine AA	50%	50%	63%	63%	63%	59%
Mine AB	50%	50%	63%	63%	63%	59%
Mine AC	50%	50%	63%	75%	50%	60%
Mine AD	75%	50%	63%	50%	75%	61%
Mine AE	50%	75%	67%	63%	50%	61%
Mine AF	50%	75%	63%	63%	63%	63%
Mine AG	50%	100%	63%		50%	63%
Mine AH	75%	50%	75%	50%	63%	64%
Mine AI	50%	75%	67%	63%	63%	64%
Mine AJ	50%	50%	50%	75%	75%	64%
Mine AK	75%	50%	63%	50%	88%	66%
Mine AL	75%	75%	75%	50%	75%	70%
Mine AM	75%	75%	75%		63%	71%
Mine AN	75%	75%	75%	38%	100%	72%
Mine AO	75%	75%	75%	75%	75%	75%

- Green (>75%)
- Yellow (>50% and <=75%)
- Orange (>25% and <=50%)
- Not applicable

Response to mines and notices issued

Assessment finding letters were issued to each mine in the program, which included a summary of key observations made by the Regulator during the assessment as well as recommendations for improvement in the medium to longer term. In acknowledgement of the transition into the Operational Rehabilitation Reforms[3] and as part of preparing associated documentation required by the regulation[4], the key recommendations included:

- Improvements to rehabilitation risk assessment to address landform establishment risks.
- Undertaking material characterisation to identify geochemical properties of waste material so that specialist handling and management is implemented at extraction and/or processing.
- Development of tailings capping strategy to identify all capping performance requirements for the final land use, including the nomination of capping trials and research programs.
- Capping material inventories are to be developed for all emplacement area and the identification of risk controls to address the shortage of material for capping.
- Assessment of the final landform hydrological performance and surface water management requirements for emplacement area. Noting specific requirements in ANCOLD and recently the ICMM Global Tailings Standard Review that stipulates design life requirements for tailings facilities at closure.
- Implement of landform construction quality assurance processes to ensure a comprehensive validation that the landform has been constructed in accordance with the design as well as provide evidence to support the final landform sign-off.
- To assess the long-term stability of final landforms constructed across the site (both currently constructed and proposed), consider using a Landform Evolution Model (LEM) to determine the scope (if any) of management/maintenance requirements that may be needed to address potential erosion issues.
- The collection of actual erosion field parameters (e.g. soil loss and movement) to facilitate erosion model development and to validate the landform design performance over an

[3] Further information on the Operational Rehabilitation Reforms can be found at https://www.resourcesregulator.nsw.gov.au/environment/rehabilitation/rehabilitation-and-compliance-reforms

[4] Mining Amendment (Standard Conditions of Mining Leases—Rehabilitation) Regulation 2021

extended period of time. This will also facilitate in providing evidence to support the eventual closure and relinquishment sign-off process to demonstrate that the risk of unacceptable long-term erosion from the rehabilitated landform is low.

Of the 40 mines assessed under the inspection program, seven mines received notices pursuant to section 240 of the *Mining Act 1992*. These notices directed the mines to take actions associated with further assessment of the stability of final landform design, in order to achieve sustainable rehabilitation outcomes that will support the final land use. In accordance with section 240(1)(c) of the *Mining Act 1992*, each direction issued included information on the specific risk identified during the TAP and the required actions to address the risk.

Key measures included in these directions involved requests for mines to engage suitably qualified expert to undertake further assessments as follows:

- Assessment of the long-term erosional stability of the final landforms using an industry accepted Landform Evolution Model (for example CAESAR-Lisflood or SIBERIA) appropriate to the risk and scale of the landform of the site to determine the long-term landscape erosion behaviour.
- Assessment of the surface water management structures located in the rehabilitated landform using appropriate projections to model behaviour for significant rainfall events in accordance with standard industry practice.
- Review of the adequacy of the current surface water management structure design and construction, including an assessment of long-term competency of rock utilised.
- Assessment of the long-term geotechnical stability of constructed landforms, including pit walls that will remain as part of the current approved final rehabilitated landform.
- Assessment of all rehabilitation material inventories that will be required to achieve sustainable rehabilitation outcomes within the Authorisations at the mine.
- Assessment of the conceptual final landform design for tailings storage facility that validate the final landform to address long-term stability, surface water erosion and potential settlement of tailings. Design of surface water management structure requirements including the final landform spillway (where relevant) meeting appropriate hydrological projections.

Recommendations

Mine operators should:

- Conduct a comprehensive rehabilitation risk assessment that identifies, assesses and evaluates the risks that need to be addressed for landform establishment in order to achieve sustainable rehabilitation outcomes. The rehabilitation risk assessment should identify the appropriate risk control measures that must be implemented and identify how risk control effectiveness will be assessed. The risk assessment must be reviewed and updated on a regular basis and when a risk control is determined to not be effective.
- Review waste characterisation practices so that the geochemical and geotechnical properties are understood and geological models are developed to determine the source of problematic material. This should include ongoing verification testing based upon geological risk factors i.e. increased testing frequency where geology is more uncertain or heterogeneous.
- Where geochemical problematic material is a risk, consideration of risk controls that are implemented during the emplacement construction to limit gas transport into the waste (air ingress) rather than relying upon final capping/sealing to manage potential seepage during emplacement final rehabilitation as the only control.
- Review capping design over emplacement to ensure the performance requirement to support approved post-mining land use is taken into account. As part of the risk assessment process, review risk controls for inevitable tree growth within the capping over the emplacement.
- Quarantine adequate quantity of suitable capping material throughout the mine life cycle.
- Assess long-term erosional stability of landforms using erosion modelling appropriate to the risk of the landform i.e. mine sites with large and complex landforms should consider the use of Landform Evolution Models. Ensure that input data is appropriate and 'fit for purpose'.
- Use erosion modelling for existing landforms to identify high-risk erosion areas that require intervention before areas of instability or high erosion occur.
- Consider geomorphic design principles for landform design rather than traditionally engineered landforms with linear slopes and reliance on contour drains to break up the slope length.
- Use erosion monitoring to assess site-specific erosion rates that could be used to improve input data into modelling and to assist in the development of rehabilitation completion

criteria. Erosion monitoring data is also used to verify models and to support successful rehabilitation and relinquishment.

- Assess the surface water management requirements to ensure the long-term stability of the rehabilitated landform, including utilisation of hydrological projections when designing water management features i.e. appropriate sizing and armouring of drainage channels.
- Use closure design specifications provided in an industry accepted guideline (ANCOLD, ICMM Global Tailings Review) for surface water management for the final landform over tailings facilities
- Implement robust quality assurance practices and record keeping, including well defined tolerances for the constructed landform against the design

It is recommended that mine operators, upon reading this report, review and amend (where relevant), their site's relevant risk assessment, rehabilitation management plans and management practices to manage the risks associated with landform establishment that are unique to their site. During the review process, mine operators are also encouraged to consider and implement the above recommendations as a minimum.

Further information

For more information on targeted assessment programs, the findings outlined in this report, or other mine rehabilitation information, please contact the Regulator:

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Appendix A. Bowtie risk assessment framework

A risk assessment focusing on rehabilitation and mine closure has been conducted by the Regulator in consultation with industry stakeholders and other government agencies. The bowtie risk assessment method was used to clearly display the links between the potential causes, the preventative and mitigative controls and the consequences of the material unwanted event - being where the post-mining conditions and environment are unsuitable to support the final land use(s).

The bowtie assessment addressed the rehabilitation risks during the operational mining phase and the rehabilitation phase.

The mining phase included:

- land clearing
- active mining operations
- decommissioning following completion of mining
- construction of the final landform.

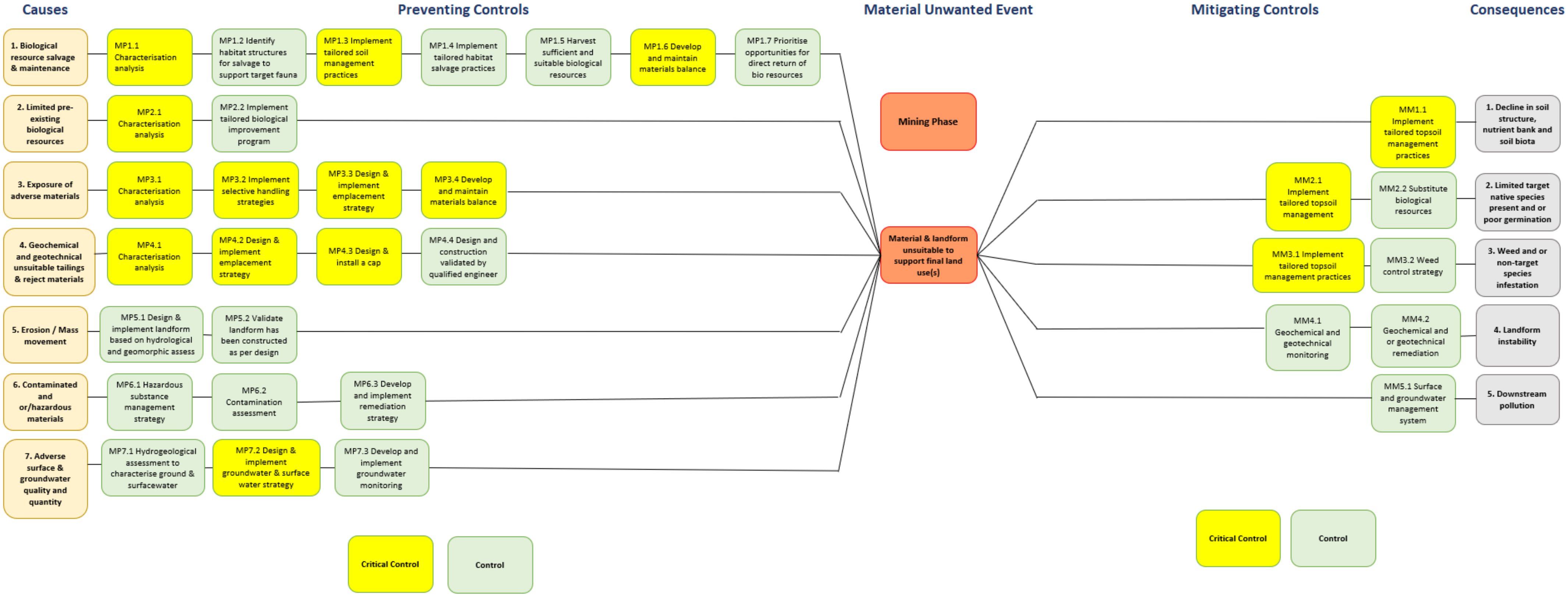
The key unwanted event during the mining phase is that the material and landform is unsuitable to support the final land use(s).

The rehabilitation phase included:

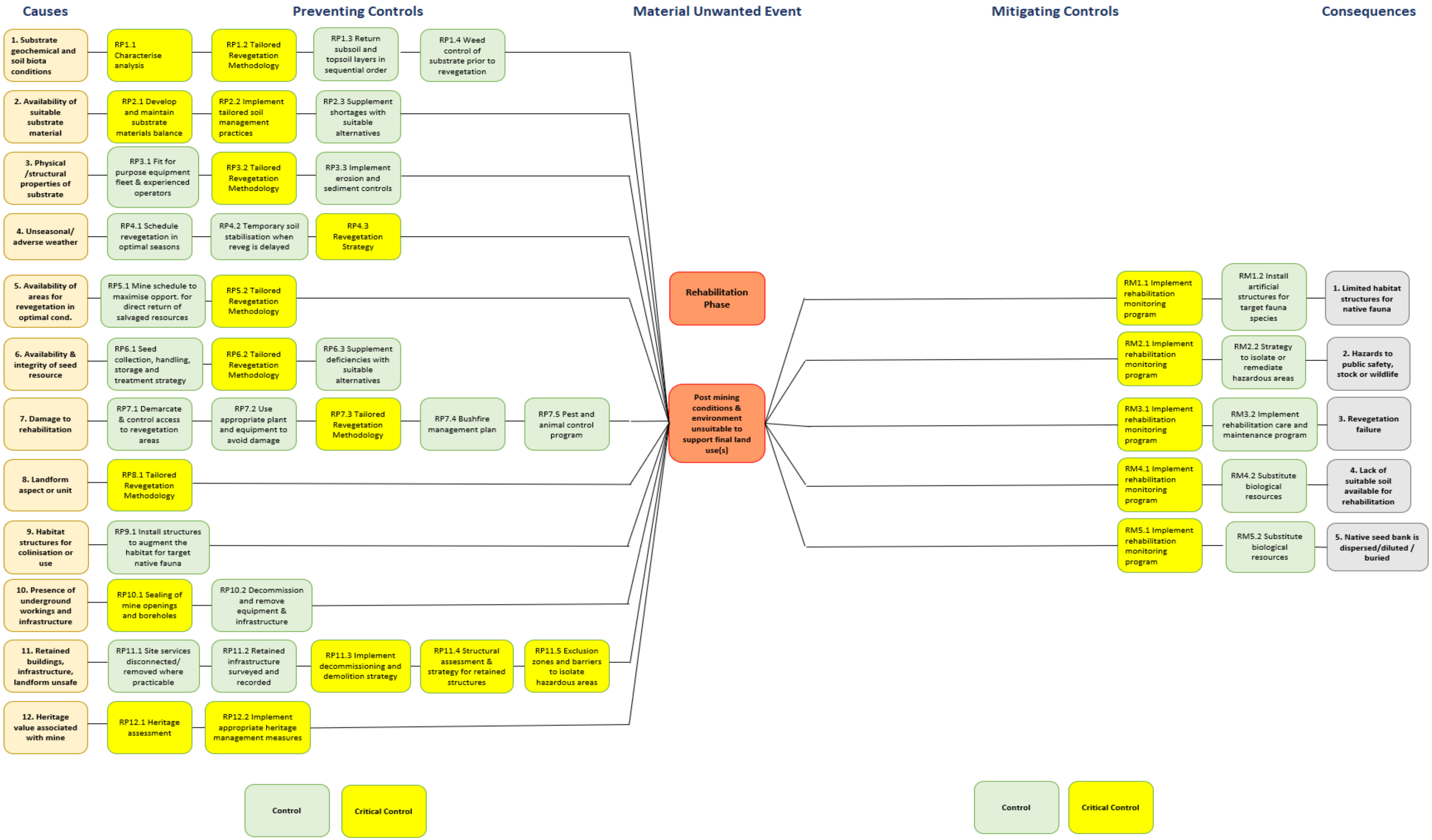
- growth medium development
- ecosystem and land use establishment
- ecosystem and land use development to achieve a sustainable, post-mining land use.

The key unwanted event during the rehabilitation phase is that the post-mining conditions and environment are unsuitable to support the final land use(s).The bowtie risk assessments addressing the mining and rehabilitation phases are depicted overleaf and are also available on our website.

MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control



MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control



MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control

Appendix B. TAP Assessment Setup

The critical control consolidation process resulted in five critical control groups for assessment in the TAP. For each of these critical controls, the threats that they address, the objective and the assessment criteria used in the TAP are listed in Table 1 below.

Table 1: Critical controls and associated objectives assessed in TAP

CRITICAL CONTROL	TREAT	OBJECTIVE	ASSESSMENT CRITERIA (CONTROL SUPPORT)
MRP1.1 - Rehabilitation Risk Assessment	NA	To ensure that the range of risks associated with landform establishment are identified and appropriate controls are in place to facilitate sustainable rehabilitation outcomes.	• Risk Assessment
MP3.1 & MP4.1 Characterisation analysis	Exposure of adverse materials Geochemical and geotechnical unsuitable tailings and rejects	To enable the selective handling and management of mine materials (e.g. overburden, tailings, reject materials etc.) to address potential geochemical and geotechnical constraints for rehabilitation	• Waste materials are characterised (geochemical & geotechnical)
MP3.3 & MP4.2 Design & implement emplacement strategy	Exposure of adverse materials Geochemical and geotechnical unsuitable tailings and rejects	Ensure emplacement construction is stable. Limit the generation of contaminants from emplaced waste/reject material.	• Emplacement area design: Drainage system operation understood (seepage control) • Emplacement area design: Liner performance and monitoring are understood • Emplacement strategy: Geotechnical stability is understood and a strategy is implemented • Emplacement strategy: Management of geochemical unstable material is understood and a strategy is implemented

MP4.3 Design & install a cap (waste/reject emplacement)	Geochemical and geotechnical unsuitable tailings and rejects	Sufficient suitable material is available to provide a final barrier to contain waste/reject emplacement, control gas and seepage transport (where applicable) and to support final land use.	• Capping Strategy: Performance requirements of cap understood • Capping Strategy: Capping material type, source and quantity is known and readily available
MP5.1 Design & implement landform based on hydrological and geomorphic assessment	Erosion / Mass movement	Ensure rehabilitated landform is protected from scour/erosion from water movement resulting from rainfall. Adopt geomorphic design principles to achieve a long-term stable landform	• Final Landform: Landform is designed with performance requirements understood • Final Landform: Constructed in accordance with design specification (including capping)

Appendix C. Assessment system explained

We use a bowtie framework to proactively assess how mine sites manage the risks to rehabilitation. Bowties are a widely used risk management tool that integrate preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised in accordance with the ICMM handbook[5] to identify the 'critical controls'.

Standardised assessment checklists for a range of TAPs have been developed. Each TAP focuses on the implementation of an identified critical control(s) to determine whether measures have been identified and implemented to ensure sustainable rehabilitation outcomes.

Assessment findings

During each mine's site assessment, inspectors rate each control support and record the findings. Points are awarded depending on whether there was evidence that the control support had been documented and/or implemented, as summarised in the table below.

SCORING	FINDING OUTCOME	POINTS
High Performance	As per satisfactory criteria, however, continued improvement can be demonstrated. For example, the scope of control support methodology has been updated to reflect feedback from research and monitoring.	4
Good	Methodology is described/documented in the Mining Operations Plan/Rehabilitation Management Plan (or other relevant document) and is reflective of constraints and opportunities that have been identified. Methodology has been implemented.	3
Fair	Methodology is described/documented in the Mining Operations Plan/Rehabilitation Management Plan (or other relevant document) but is limited (in terms of scope and implementation).	2
Poor	Not documented and not implemented	1
NA	Circumstances where the critical control/control support does not apply.	NA

For each critical control, an overall result was calculated based on the total points scored as a proportion of the maximum possible points for that critical control. For example, if a critical control

[5] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

comprises ten control supports and five were assessed as ‘high performance’ and five were found to be ‘poor’ then the overall assessment result for that critical control would be 62.5%.

Critical control calculations have taken into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

CRITERIA	COLOUR
An assessment result of >75% of possible points	Green
An assessment result of >50% but ≤75% of possible points	Yellow
An assessment result of >25% but ≤50% of possible points	Orange
An assessment result of ≤25% of possible points	Red
Not Applicable	