NSW GOVERNMENT

NSW Resources Regulator

REPORT

TAILINGS MANAGEMENT TO SUPPORT POST-MINING FINAL LAND USE

Planned Inspection Program

November 2019 - May 2020

TAILINGS MANAGEMENT TO SUPPPORT POST-MINING FINAL LAND USE

Planned Inspection Program PP0001464

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Executive summary

The NSW Resources Regulator manages the risks to rehabilitation as part of a risk-based and outcomes-focused approach to compliance and enforcement. This includes targeted assessments and planned inspection programs across mines in NSW. This is a focus on assessing a mine's critical risks and the critical controls required to mitigate those risks.

To this end, we developed a bow tie risk management framework and standardised assessment checklists for a range of Targeted Assessment Programs (TAP). 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. Further details, including the bow tie risk assessment for tailings management, is available on our website.

The Tailings Management Targeted Assessment Program (TAP) was undertaken from November 2019 to March 2020. Nineteen mines were selected for the program.

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

- tailings characterisation (primarily geochemical properties)
- final landform design to take into account long-term settlement/ consolidation of tailings
- final landform design and surface water management requirements to ensure the long-term stability of the tailings storage facility post-closure
- capping design and performance requirements to support approved post-mining land use.

Of the 19 mines assessed under the inspection program, eleven mines were issued with assessment finding letters outlining various matters which needed to be addressed in the medium to longer term. These letters provided recommendations for improvement.

Seven mines received notices pursuant to section 240 of the *Mining Act 1992*. These notices directed the mines to take actions associated with tailings management, 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.

We will continue to maintain regulatory oversight on tailings management, with a particular focus on ensuring that effective environmental (rehabilitation) risk assessments and associated controls are in place to achieve sustainable rehabilitation outcomes.

Contents

Introduction

The Tailings Management TAP was undertaken from November 2019 until March 2020 to assess critical controls associated with tailings management (primarily tailings storage facility management), associated tailings facility rehabilitation and closure.

The TAP was run consecutively with Mining Safety's Tailings Dams TAP.

The program plan initially included 26 mines, which was reduced to 19 mines following restrictions implemented due to COVID 19 in March 2020.

Further information on the Tailings TAP Critical Control selection process and the TAP assessment setup is provided in Appendix A.

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
- 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

Critical Control: Dam Construction (Environmental)

What was assessed

Construction materials are characterised and managed appropriately, especially if an Acid Metalliferous Drainage (AMD) risk associated with sulphidic mineral processing is identified.

For sites that required specific subsurface drainage, the drainage system operation was understood, including subsurface drainage, collection system and monitoring program.

What we found

The assessment of this control was limited to those sites that were required to manage AMD materials. Where fair or poor control definition was identified, this was typically associated with deficient geochemical characterisation of construction material.

The risk

Limited characterisation of tailings storage construction materials presents a risk that unsuitable materials are incorporated into the tailings containment structure and contribute to leaching of contaminants including AMD, if left unmitigated.

Critical Control: Tailings Characterisation (Liner requirement)

What was assessed

Tailings geochemical properties are characterised, including regular ongoing testing or when potential changes in tailings deposition feed (i.e. different geology/seams processed).

What we found

The improvement in knowledge in relation to tailings characterisation will need to be a focus area for a number of mines. This will require ongoing or routine testing to verify geochemical characteristics to better understand tailings properties.

The risk

Tailings which have not been adequately characterised for geochemical properties present a risk that the tailings may contain contaminants or have properties that adversely impact the environment if left unmitigated or uncontained.

Critical Control: Liner

What was assessed

Liner requirements understood, including performance, QA/QC during installation and ongoing monitoring if compromised.

What we found

Given the relatively geochemically benign characteristics of the tailings materials that existed across the mines assessed, the installation of a liner was not relevant as a critical control in most instances. Where the need for a liner was identified as a critical control, groundwater monitoring processes to evaluate the effectiveness of the liner were observed to be effectively implemented. In these instances, opportunities for improvement related to the need to clarify trigger action response plans to address potential issues identified by monitoring data.

The risk

Inadequate or poorly performing liner presents a risk that leachate from tailings is released into the environment, adversely affecting the environment.

Inadequate groundwater quality monitoring presents a risk that any impacts to groundwater systems, by the tailings storage facility, are not detected in a timely manner to allow mitigation to be put in place to remediate the impacts.

Critical Control: Consolidated Tailings

What was assessed

Tailings consolidation properties are understood (i.e. physical properties, such as particle size distribution) and optimum consolidation is modelled, including long-term settlement.

Implementation of strategies to maximise consolidation including treatment (i.e. flocculation) and tailings distribution, including the use of distribution system (i.e. multiple spigots), placement depth and time for settlement. The strategy takes into account surface drainage (or decant) to adequately remove water, unless required for dust suppression or potential acid forming (PAF) material treatment.

Monitoring of tailings levels to inform optimisation of tailings placement and settlement achieved. Where available, intrusive sampling of place tailings to determine strength profile and settlement at depth.

What we found

Tailings physical characteristics were generally well defined and regularly assessed. The majority of mines assessed have developed strategies to maximise consolidation. Of the few mines which had deficient consolidation strategies, plans were in place to implement improved strategies. A key opportunity for improvement that was identified across most sites related to the need to undertake modelling to assess the risk of long-term differential settlement.

The risk

Deficient deposition management strategies can result in poorly consolidated tailings, presenting a risk that the tailings facility cannot be accessed for decommissioning activities (placement of capping) for extended periods of time, resulting in unnecessary delays to rehabilitation of the tailings facility at closure. Long-term settlement presents a risk of deformation (including differential settlement) to final landform. If not accounted for in the design, this may lead to changed surface water flows, leading to erosion and/or landform depressions. The latter issue may lead to extended ponding and or seepage issues, which may limit the ability to achieve a stable landform.

Critical Control: Erosion Control

What was assessed

Final landform is designed for long-term stability post-closure, including erosion control/surface water management considerations. Consideration of relevant guidelines for engineering design requirements

for closure (i.e. ANCOLD Tailings Dam Guidelines). Where final landform establishment has commenced, this is conducted in accordance with design and construction quality assurance programs in place.

What we found

Some mines need to place increased focus on long-term stability in consideration of ANCOLD design life recommendation for closure. This should include designing surface water management structures to be implemented as part of the final landform to accommodate flows from significant weather events, such as spillways/drop structures over tailings storage embankments.

The risk

Uncertain landform design presents a risk that the final landform and surface water management structures are not designed to accommodate significant rainfall events, leading to erosion and depletion of capping or the storage embankments.

Critical Control: Capping

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 tailings) and permeability (control seepage into tailings). The capping material type, source and quantity is nominated and methods to quarantine the capping material in place.

What we found

Conceptual capping design was established at most mines, however, the following opportunities for improvement were identified:

- performance requirements of the cap to support the nominated post-mine land use need to be defined, particularly to ensure problematic tailings materials remain encapsulated (e.g. potential acid forming material; combustible material associated with coal tailings etc.);
- the performance of the cap in relation to groundwater seepage will need to be assessed across a number of mines, which may involve water balance modelling to confirm that the capping design will be effective in minimising the risk of long-term seepage;
- development of capping designs that will accommodate tree growth without compromising the integrity of the cap. Noting that the exclusion of trees as part of the nominated a final land use may require long-term land management practices to be implemented post-closure.

- the need to quarantine suitable quantities of suitable capping material to ensure availability at closure.

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.

Assessment findings by mine

Figures 1 and 2 show assessment criteria (control support) scoring and assessment finding result bands results applicable to each mine assessed. Note that specific mines are not identified in this report.

Information on critical control performance scoring is provided in Appendix B.

Figure 1: Assessment criteria (control support) scoring results by mine and critical control

Figure 2: Assessment findings result band results by mine and critical control

Mine Location	1	2		3	4	5	Grand Total
	RELEASE TO ENVIRONMENT AND POST CLOSURE FAILURE	RELEASE TO ENVIRONMENT		POST CLOSURE FAILURE	RELEASE TO ENVIRONMENT AND POST CLOSURE FAILURE	POST CLOSURE FAILURE	
	2. Problematic tailings 3. Contaminants leaching from structure	2. Problematic tailings		5. Excessive tailings settlement	1. Extreme wet weather	1. Extreme wet weather 2. Problematic tailings 4. Tailings release though capping 5. Excessive tailings settlement	
	Dam Construction (Environmental)	Liner requirements - tailings characterisation	Liner	Consolidated tailings	Erosion control	Capping	
Mine A	83%	75%		75%	63%	65%	74%
Mine B	69%	50%		67%	67%	66%	66%
Mine C	50%	75%		75%	25%	63%	59%
Mine D	88%	75%	25%	63%	63%	85%	73%
Mine E	81%	25%	50%	81%	50%	44%	63%
Mine F	83%	75%	75%	83%	75%	50%	75%
Mine G	50%	50%		50%	42%	66%	56%
Mine H	75%	50%	56%	67%	25%	47%	51%
Mine I	75%	75%		69%	75%	56%	67%
Mine J	100%	100%	75%	83%	75%	92%	89%
Mine K	81%	50%	50%	67%	50%	67%	67%
Mine L	83%	50%	50%	83%	50%	50%	67%
Mine M	67%	25%		83%	50%	63%	65%
Mine N	58%	50%		69%	63%	72%	67%
Mine O	81%	75%		75%	50%	75%	75%
Mine P	50%	75%	56%	33%	58%	50%	51%
Mine Q	50%	25%		50%	42%	53%	48%
Mine R	85%	75%	75%	63%	75%	64%	71%
Mine S	83%	75%	79%	69%	50%	65%	73%

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

Response to mines and notices issued

Of the 19 mines assessed under the inspection program, eleven mines were issued with assessment finding letters outlining various matters which needed to be addressed in the medium to longer term. These letters provided recommendations for improvement.

Seven mines received notices pursuant to section 240 of the *Mining Act 1992*. These notices directed the mines to take actions associated with tailings management, 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 findings

One of the key findings of the program was that the physical characteristics of tailings were generally well defined and regularly assessed across the mines. Knowing these characteristics, the majority of these sites have developed strategies to maximise consolidation with the objective of achieving a stable final landform following rehabilitation.

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

- tailings characterisation (primarily geochemical properties)
- final landform design to take into account long-term settlement/ consolidation of tailings
- final landform design and surface water management requirements to ensure the long-term stability of the tailings storage facility post-closure
- capping design and performance requirement to support approved post-mining land use
- quarantining adequate quantity of suitable capping material.

Recommendations

Mine operators should:

- Conduct a comprehensive rehabilitation risk assessment that identifies, assesses and evaluates the risks that need to be addressed when managing tailings in order to achieve sustainable rehabilitation outcomes. The rehabilitation risk assessment should identify the appropriate risk control measures that must be implemented.

- Undertake a review of their tailings management processes to address the key findings as outlined in Section 4, where critical control supporting activities were found to be not adequately defined or implemented.
- As part of future mining proposals and/or modifications, consider alternatives to conventional slurry tailings to dewatered tailings technologies and other innovative tailings treatment methods, which do not necessarily rely upon the use of a tailings storage facility structure to contain the material.

To enable industry to understand and fulfil their obligations, detailed guidance and information has been added to our website with dedicated pages for tailings storage facility management. The webpage now includes information on consideration of risk for tailings management, as well as copies of the risk bow tie diagrams to determine critical controls.

Information on the range of issues that we assessed for tailings assessments for mine closure matters is now provided in a guidance note.

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

Critical Control Selection Process

We manage the risks to rehabilitation as part of a risk-based and outcomes-focused approach to compliance and enforcement. This includes targeted assessments and planned inspection programs across mines in NSW. This is a focus on assessing a mine's critical risks and the critical controls required to mitigate these risks.

To this end, we developed a bow tie risk management framework and standardised assessment checklists for a range of Targeted Assessment Programs (TAP). 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. Further details, including the bow tie risk assessment for tailings management is available on our website.

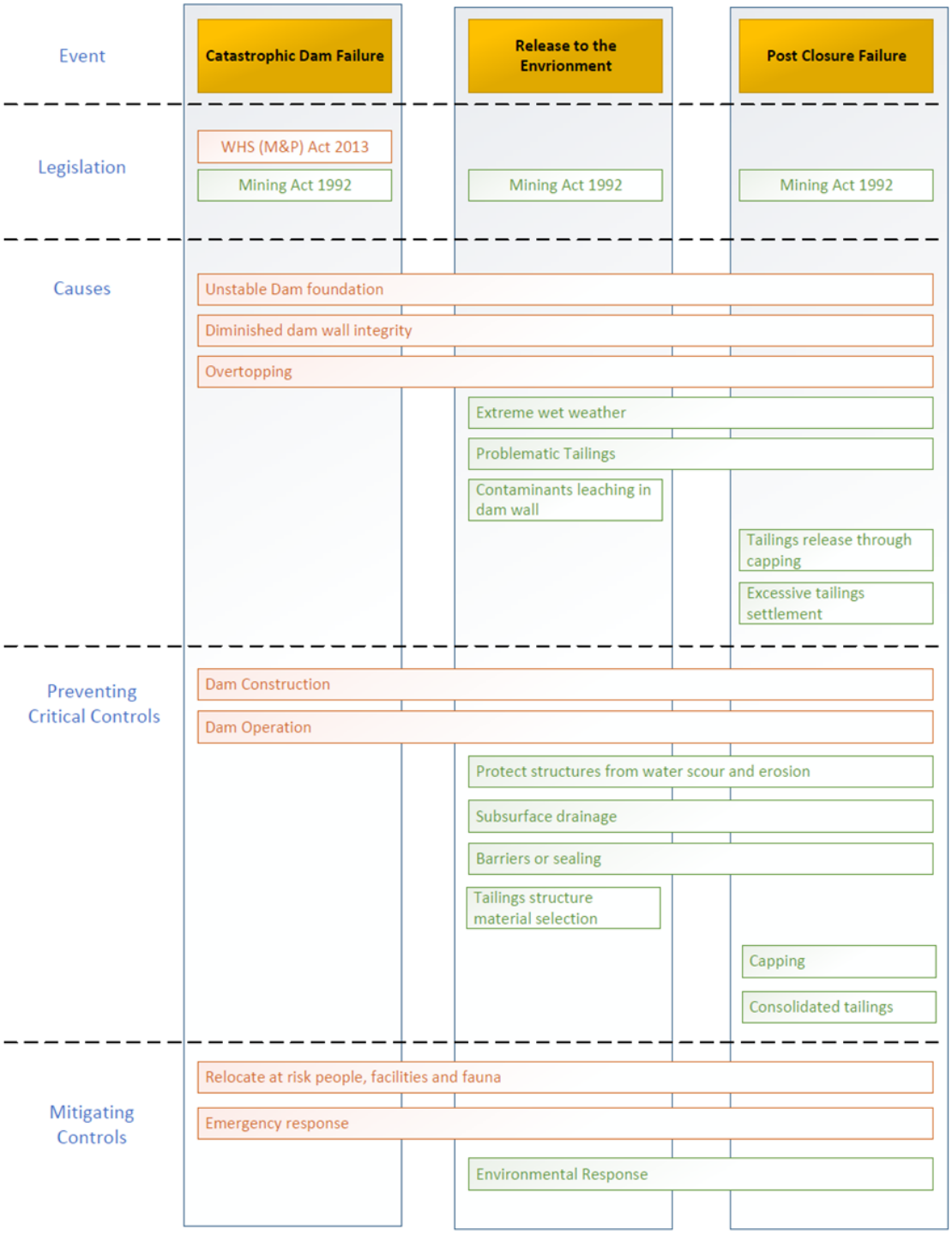
Critical controls are determined by using 'bow tie' risk assessment internal workshops within the Regulator. For tailings management, risks associated with events that affect both workers safety (WHS Act considerations) as well as environmental and mine closure matters (Mining Act considerations) were considered. This resulted in risk assessments that considered the following three events:

- catastrophic dam failure
- release to the environment
- post-closure failure.

It was determined that the 'catastrophic dam failure' event has implication for both workers' safety (*WHS (M&P) Act 2013*) as well as the environment (sustainable rehabilitation) under the *Mining Act 1992*). The remaining events being 'release to the environment' and 'post-closure failure' are primarily relevant to environmental considerations (facility closure and rehabilitation) under the *Mining Act 1992*.

Eight consolidated causes were identified, some of which were considered in multiple events. Following this, eight critical preventing controls and three mitigating controls were identified. A schematic showing the critical controls that relate to each event, and how some of these overlap events, is shown in the schematic presented in Figure 1 below.

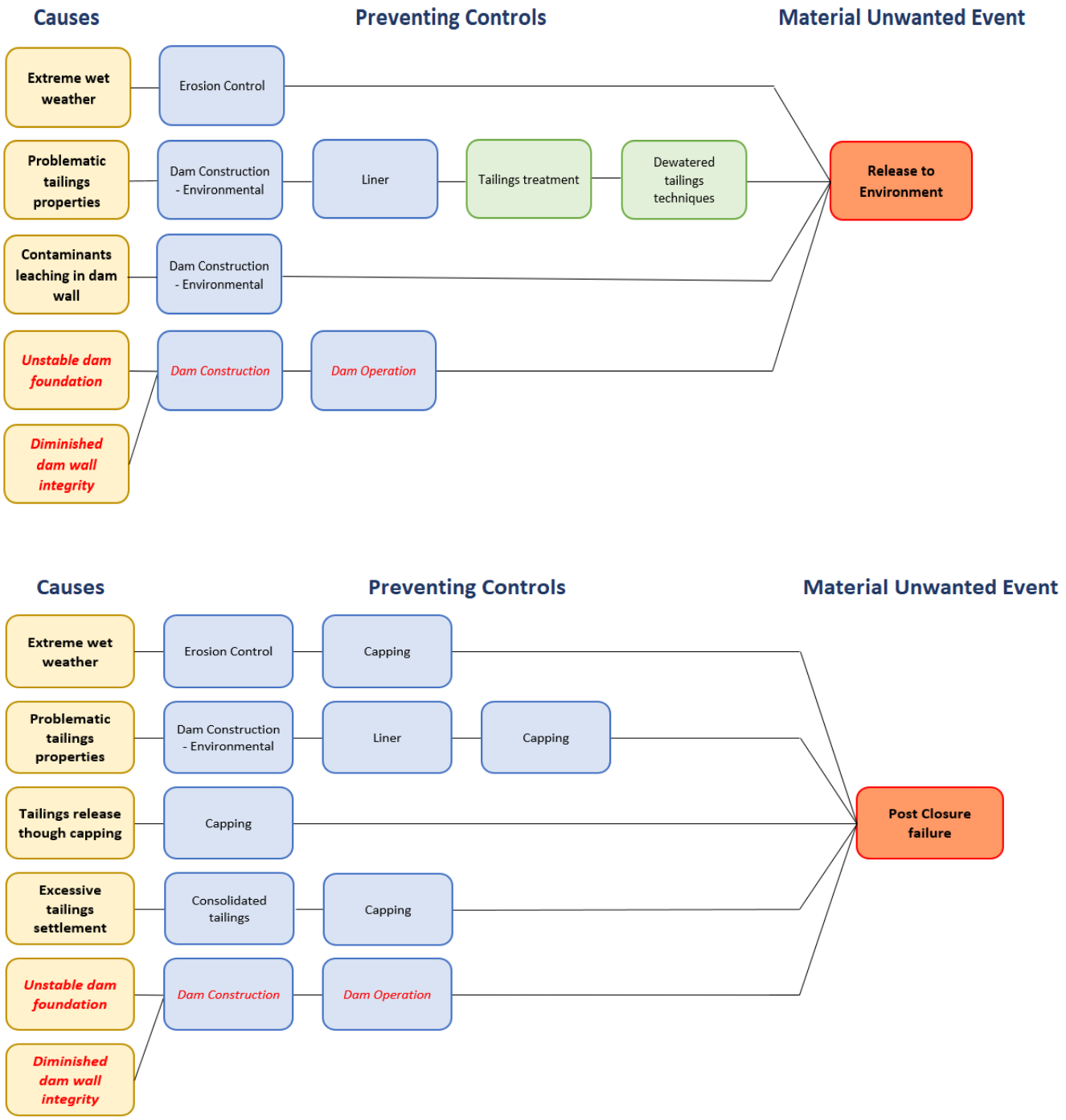
Figure 1: Schematic showing relationships of events, legislation, causes, preventing and mitigating controls for risk assessments conducted.



Further consolidation of critical controls associated with preventing “release to the environment” and “post-closure failure” are provided in the abridged risk bow tie diagrams in Figure 2 below. The

identification and grouping of the critical controls in these risk bow tie assessments were used for the TAP assessment template setup.

Figure 2: Abridged risk bow tie showing relationship between critical controls (blue text boxes) assessed in TAP. Note: red text are critical controls assessed by Mine Safety Inspectorate.



TAP Assessment Setup

The critical control consolidation process resulted in five critical control groups for assessment in the TAP. Each of these critical controls and associated objective are listed in Table 1 below.

Table 1: Critical controls and associated objectives assessed in TAP

CRITICAL CONTROL	OBJECTIVE
1. Dam Construction (Environmental)	To control or limit the release of contaminants from tailings containment
2. Liner	Tailings leachate is contained and release to the environment is minimised
3. Consolidated Tailings	Tailings consolidation/settlement is maximised during placement to reduce impacts from settlement post-closure
4. Erosion Control	Ensure tailings containment structure and capping is protected from scour/erosion from water movement resulting from rainfall/wind
5. Capping	Provide a final barrier to contain tailings and prevent release to the environment and support the final land use

The assessment criteria (or control supports) were selected for each of the critical controls using information collected during the risk assessment process. Control assessment criteria were separated into two categories: control definition or control implementation. The controls, assessment criteria and application to control definition or control implementation is provided in Table 2.

Table 2: Critical controls assessment criteria (or control supports)

CRITICAL CONTROL	ASSESSMENT CRITERIA (CONTROL SUPPORT)
Dam Construction (Environmental)	Control definition: ■ construction materials are characterised and managed appropriately ■ drainage system operation understood. Control Implementation: ■ construction material tested and separated from unsuitable material (such as PAF) ■ drainage system consistent with design ■ monitoring system in place and consistent with plan (i.e. groundwater testing, piezometric surface).
Liner	Control definition: ■ tailings geochemical properties are understood* ■ liner requirements are understood ■ liner performance and installation is understood ■ monitor liner performance following installation. Control implementation ■ liner installed/constructed consistent with design (i.e. material type, thickness, other specific engineering controls) ■ monitoring program for liner performance in place and consistent with plan.
Consolidated Tailings	Control definition ■ tailings consolidation properties are understood ■ tailings deposition strategy to maximise consolidation understood.

	Control implementation ■ tailings distribution system consistent with design ■ tailings deposition and monitoring consistent with plan; decant water runoff from tailings not impeded unnecessarily.
Erosion Control	Control definition ■ landform is designed with performance requirements understood ■ final landform is constructed in accordance with design specification. Control implementation ■ final landform, (including water structures) implemented in accordance with design.
Capping	Control definition ■ final land use is known ■ tailings strength properties are understood ■ performance requirements of capping understood ■ capping material type, source and quantity is known. Control implementation ■ capping is constructed in accordance with design specification ■ capping material identified and quarantined in accordance with plan ■ capping material sourced from designated material ■ capping construction consistent with design (i.e. material type, thickness, other specific controls).

** Note: Further consideration of tailings characterisation assessment criteria has resulted in this being scored* separately *to the Critical Control: Liner, as tailings characterisation support a number of the critical controls.*

Appendix B

Critical Control Performance Scoring

Scoring of critical controls assessed

Assessment criteria nominated for each critical control required scoring to be assigned by officers undertaking the TAP. The scoring adopted a consistent description of the standard required for each score and allocated points as follows:

Table 3: Critical control performance scoring

SCORING	SCORING DESCRIPTION	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
Satisfactory	Methodology is described in MOP/RMP (or other relevant tailings management plan) and is reflective of constraints/opportunities that have been identified.	3
Fair	Methodology is described in the MOP/RMP (or other relevant tailings management plan) but is limited.	2
Poor	No documentation of methodology/process exists.	1
NA	Circumstances where the critical control/control support does not apply.	NA

The assessment findings scoring for mines and critical controls assessed is shown in Figure 1 in Section 2.2 Assessment Findings by Mine.

Calculation of results for critical controls assessed

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 comprises 10 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.

Results have been assigned a colour based on the assessment finding result bands presented in Table 4. The colour band results are used to identify industry focus areas requiring improvement.

Table 4: Assessment findings results colour bands

ASSESSMENT FINDINGS RESULT BANDS	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

The assessment finding results for mines and critical controls are shown in Figure 2 in Section 2.2 Assessment Findings by Mine.