



**NSW
Resources
Regulator**

PLANNED INSPECTION PROGRAM

CONSOLIDATED REPORT: INUNDATION OR INRUSH OF ANY SUBSTANCE – UNDERGROUND COAL MINES

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Executive summary

A crucial part of the NSW Resources Regulator’s Incident Prevention Strategy involves targeted assessment and planned inspection programs for mines and petroleum sites. This is a focus on assessing an operation’s control of critical risks through evaluating the effectiveness of control measures in the mine’s safety management system.

To this end we developed a bowtie hazard management framework and standardised assessment checklist for each program plan. Under each program plan, the effectiveness of the safety management system at each mine site is assessed against a standard set of control supports and critical controls.

This final report summarises assessment findings from 17 mines in relation to assessments for the principal hazard of inundation or inrush of any substance, conducted during the period from October 2019 to May 2021.

The threats and critical controls assessed for the material unwanted event of inundation or inrush of any substance, are shown in Table 1.

Note that not all critical controls were applicable at all mines.

Table 1: Threats, consequence and critical controls for the material unwanted event –inundation or inrush of any substance – underground coal mines

THREAT OR CONSEQUENCE		CRITICAL CONTROL
Threat	Accumulation of fluid	PC1.1 – Minimise magnitude of fluid source PC1.2 – Design fluid pathways
Threat	Containment failure	PC2.1 – Containment design and construction
Consequence	One or more fatalities	MC1.1 – Restrict access to inundation or inrush zones

Legislative requirements and published guidance relating to the principal hazard of inundation or inrush of any substance is listed in Appendix A. Figure 1 presents safety compliance findings for each de-identified mine and critical control assessed for the material unwanted event of inundation or inrush of any substance. Explanatory notes on the assessment system are also listed in Appendix B.

Key Findings

Of the 17 mines assessed each mine had varying degrees of good practices and issues. These issues were in relation to the following items:

- The risk assessment and the principal hazard management plan (PHMP) were not aligned with each other.
- The risk assessment and the PHMP were not aligned with the current mining activities.
- Hazards or sources and magnitudes of inrush or inundation were not documented.
- Specific controls for the hazards or sources and magnitudes of inrush or inundation were not documented.
- Exploration works required to confirm and identify hazards or sources and magnitudes of inrush or inundation were lacking or incomplete.
- Exploration works required to confirm and identify barrier thickness to inrush or inundation were lacking or incomplete.
- Roles and responsibilities in the PHMP were of a generic nature and not specific to the subject risk management.
- Demarcation of the inrush control zone (ICZ) was not identified as a control or documented.
- Training of personnel accessing the ICZ including identification of the risks, controls and operating procedures was not identified or documented.
- Trigger action response plans (TARPs) did not have a trigger for a stop function if the ICZ barrier thickness reduction to an unsafe level.
- Some historical barrier and control infrastructure did not have any retained design documentation.
- Some barrier and control infrastructure were identified as deteriorating, with no strategy to maintain the infrastructure integrity.

Recommendations

Recommendations resulting from the inspections conducted include:

- Ensure appropriate exploration and investigation required to confirm hazards or sources and magnitudes of inrush or inundation are conducted to enable the risks to be managed to as low as reasonably practicable.
- Conduct an appropriate risk assessment with suitably qualified team members to assess the risks for each hazard and source of inrush and inundation identified.
- Identify the appropriate controls required to manage each of the risks identified within the associated risk assessment.
- Ensure that the hazards and controls identified are documented to adhere to legislative requirements.
- Conduct suitable training for persons who routinely manage and operate around inrush and inundation areas and ensure that it addresses the risks and controls for these areas.
- Review the risks and controls for inrush and inundation areas at appropriate intervals to maintain effectiveness.
- Consult with other mines to ensure a well-rounded knowledge of industry practices and identify industry leading controls, which may be able to be implemented where appropriate.

Introduction

The NSW Resources Regulator's planned assessment programs provide a planned, risk-based and proactive approach to assessing how effective an operation is when it comes to controlling critical risk. These programs apply the following principles:

- a focus on managing prescribed 'principal hazards' from the Work Health and Safety (Mines & Petroleum Sites) Regulation 2014
- evaluation of the effectiveness of control measures implemented through an organisation's safety management system
- consideration of the operation's risk profile.

The objective of risk profiling is to identify the inherent hazards and the hazard burden that exist at individual operations in each mining sector in NSW. The information is then used to develop the operational assessment and inspection plans that inform the program.

Scope

Planned inspection programs include two assessment types:

- targeted assessments, incorporating:
 - desktop assessment of:
 - compliance against legislation with respect to the management of health and safety risks associated with inundation or inrush of any substance – see Appendix A for details
 - the definition of the controls the mine utilises to prevent and mitigate the risks to health and safety associated with inundation or inrush of any substance.
 - a workplace assessment of the implementation of those controls through the inspection of plant and worker interviews.
- planned assessments, which involve a workplace assessment of the implementation of controls through the inspection of plant and worker interviews only.

The process

The process for undertaking an assessment under a planned inspection program generally involves the following stages:

- preliminary team meetings, preparation and review of documents
- execution of an on-site assessment involving:
 - an on-site desktop assessment of relevant plans and processes measuring legislative compliance of the relevant plans (targeted assessments only)
 - the inspection of relevant site operations (both targeted assessments and planned inspections).
- discussion and feedback to the mine management team on the findings and actions that need to be taken by the mine operators in response.

Assessment findings

Threats/Consequences and Controls assessed

Threats:

- Accumulation of fluid.

Critical control: PC 1.1 – Minimise magnitude of fluid source.

Control objective: Eliminate or reduce the stored energy available to an inundation or inrush event.

Performance requirement:

- Risks associated with inundation and inrush are identified.
- Procedures describe how potential inundation and inrush hazards are identified.
- Procedures describe how the risk posed by identified inundation or inrush hazards is assessed.
- Procedures direct a hierarchy of controls approach to the inundation or inrush risk.
- Inundation and inrush sources are identified.
- Inundation or inrush risk treatment options are evaluated, selected and implemented.
- Inundation and inrush information, training and instruction are provided.

Specific findings for this critical control included:

- Adequate personnel were not always included within risk assessment teams.
- On occasions, risk assessments did not align with current workings.
- PHMPs did not always align with the associated risk assessment.
- Thickness of barriers to inrush hazards were not sufficiently detailed within the PHMP.
- Roles and responsibilities listed within PHMPs were generally generic and not hazard specific.
- Training requirements for an ICZ were not adequately detailed, or sometimes not available.

- Magnitudes of inrush hazards were unknown and/or monitored irregularly.
- Document owners were not specifically identified (rather this was identified as a qualification).
- Hazards associated with adjacent historical mine workings were not regularly included in risk assessments, nor the PHMP.
- Controls for managing the hazards associated with adjacent historical mine workings were not regularly included in the risk assessment or the PHMP.

Critical control: PC 1.2 – Design fluid pathways.

Control objective: Prevent the accumulation of fluid that could become an inundation or inrush hazard.

Performance requirement:

- Procedures describe how inundation or inrush hazards arising from compromised fluid pathways are identified and assessed.
- Potential fluid pathways are identified.
- Fluid pathway inundation or inrush potential is identified.
- Fluid pathways are designed.
- Fluid pathways are installed or constructed to the design criteria.
- The condition and performance of fluid pathways are monitored.

Specific findings for this critical control included:

- Adequate personnel were not always included within risk assessment teams.
- On occasions, risk assessments did not align with current workings.
- PHMPs did not always align with the associated risk assessment.
- Maximum flow rates were not always adequately detailed.
- TARP documents often had no stop reference with regards to barrier thickness.

- Some historical, yet still active, bulkheads had no specific design documentation or confirmation of integrity testing.
- There was generally a lack of maintenance on old water dams.
- Hazards associated with adjacent historical mine workings were not regularly included in risk assessments, nor the PHMP.
- Controls for managing the hazards associated with adjacent historical mine workings were not regularly included in the risk assessment, nor the PHMP.
- Some sites did not have an existing TARP process for this critical control.

Threats:

- Containment failure.

Critical control: PC 2.1 – Containment design and construction.

Control objective: Isolate the stored energy of the inundation or inrush hazard from people.

Performance requirement:

- Procedures describe the inundation or inrush containment design considerations.
- Containment structure locations are selected considering potential downstream impacts. Downstream impacts of a containment structure failure are understood and mitigated.
- Inundation or inrush containment structures are designed for long-term stability under worst case conditions.
- Inundation or inrush containment structures are constructed to the required design.
- Changes in the magnitude of the inundation or inrush hazard are detected. Deterioration of containment structure integrity is detected.
- Inundation or inrush containment structures are maintained in a fit-for-purpose condition.
- Inundation and inrush information, training and instruction is provided.

Specific findings for this critical control included:

- PHMPs did not always align with the associated risk assessment.
- On occasions, risk assessments and PHMPs did not align with current workings.

- There was often insufficient geophysical exploration to define barrier thicknesses.
- Some sites failed to detail within their PHMP how barrier thicknesses were determined.
- Hazards and controls in relation to gases and windblast from adjacent goaf were not always considered within the risk assessment or PHMP.
- Magnitude of inrush or inundation was not sufficiently calculated or estimated.

Consequence:

- One or more fatalities.

Critical control: MC1.1 – Restrict access to inundation or inrush zones

Control objective: Eliminate the exposure of people to an inundation or inrush event.

Performance requirement:

- Risks associated with inundation and inrush are identified.
- Procedures describe how potential inundation and inrush hazards are identified.
- Remote systems of work eliminate people being exposed to inundation risks.
- People are prevented from entering areas where an inundation risk is present.
- Access to established inrush control zones is restricted.
- People who work on processes or in areas where an inundation or inrush hazard exists understand the access restriction requirements.

Specific findings for this critical control included:

- Adequate personnel were not always included within risk assessment teams.
- On occasions, risk assessments did not align with current workings.
- Signage requirements when identifying an ICZ were not regularly documented.
- Controls for restricting access to an ICZ were often not documented or effective.
- In some instances, people were found to be working in an ICZ who had not undertaken appropriate training in ICZ processes.

Findings by mine

The figure below presents aggregate assessment findings by critical control, providing a summary view of the status of each mine’s hazard management processes. Importantly, the system recognises the value of fully implemented and documented controls by awarding an additional point if both elements were assessed as present. More details explaining the assessment system are found at Appendix B.

Figure 1: Assessment findings for the planned inspection program – inundation or inrush of any substance – underground coal mines – overall results

	Threat			Consequence
	Accumulation of fluid		Containment failure	One or more fatalities
	PC1.1	PC1.2	PC2.1	MC1.1
	Minimise magnitude of fluid source	Design fluid pathways	Containment design and construction	Restrict access to inundation or inrush risk zones
Mine A	Yellow	Green	Orange	Red
Mine B	Yellow	Green	Yellow	Orange
Mine C	Yellow	Green	Green	Red
Mine D	Yellow	Orange	Yellow	Green
Mine E	Green	Green	Green	Yellow
Mine F	Green	Green	Green	Green
Mine G	Green	Grey	Green	Green
Mine H	Green	Green	Green	Grey
Mine I	Green	Green	Green	Grey
Mine J	Grey	Green	Green	Green
Mine K	Green	Green	Green	Green
Mine L	Green	Green	Green	Green
Mine M	Green	Green	Green	Grey
Mine N	Green	Green	Green	Green
Mine O	Green	Green	Green	Green
Mine P	Green	Green	Green	Green
Mine Q	Green	Green	Green	Green

- Green (=100%)
- Yellow (>= 80% and <100%)
- Orange (>= 65% and <80%)
- Red (<65%)
- Grey Not applicable

Notices issued

Of the 17 mines assessed under the inspection program, eight mines received notices relating to the principal hazard of inundation or inrush of any substance, while some mines received notices in relation to other matters. For the purposes of this report, contraventions related to other matters have been removed from the analysis. The notices issued for inundation or inrush of any substance were examined in detail and Table 2 below lists the notices issued by type and details.

Table 2: Notices issued for the planned inspection program – inundation or inrush of any substance – underground coal mines

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	-	-
s.191 improvement notice	7	5
s.23 notice of concerns	6	6
Total	13	8

Of the combined 13 notices issued, there were some common themes which were apparent throughout the program plan. Table 3 summarises the type of contraventions and also outlines the total occurrences encountered. These themes can be related back to the critical controls outlined earlier and identify some trends which are of concern.

Table 3: Notices issued - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
Documentation relating to controls for inundation or inrush of any substance (i.e. risk assessment, PHMP, TARPs) not relevant, current, or readily available	7
Lack of controls to restrict unnecessary personnel from entering an inrush control zone	4
Workers not familiar with sources of hazard or what controls to use	4
Inundation or inrush types and sources (i.e. extreme weather, overflow of dams, gas drainage) not identified or assessed	3
The size, nature, energy content or potential flow rate confidence level is undetermined	2
Workers not trained adequately on inrush control zones	2
Bulkhead installation monitoring poor, inadequate, not understood	2
Entry points (i.e. adits, drill holes, boreholes, shafts, disused or abandoned workings, geological structures, aquifers) into the mine that could allow for a potential inrush event have not been identified or assessed	2
The presence and location of an inrush hazard has not been physically determined by exploratory bore holes or other exploratory methods	1
Bulkhead installations need remedial action to cease deterioration and scaling	1

Further information

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

CONTACT TYPE	CONTACT DETAILS
Email	cau@planning.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	https://www.resourcesregulator.nsw.gov.au/
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Legislative requirements and published guidance relating to the principal hazard inundation or inrush of any substance

The following is a list of certain legislative requirements for the management of inundation or inrush of any substance risks referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 and Work Health and Safety Regulation 2017.

Work Health and Safety (Mines and Petroleum Sites) Regulation 2014:

- Clause 14, Content of safety management system
- Clause 23, Identification of principal hazards and conduct of risk assessments
- Clause 24, Preparation of principal hazard management plan
- Clause 45, Inrush hazards.

Work Health and Safety Regulation 2017:

- Clause 36, Hierarchy of control measures.

Other published guidance:

- MDG 1024 - Guideline for inrush hazard management
- MDG 3008 - Guideline for managing the risk of inrush with hydraulic fill systems
- Learning from disasters - 1996 Gretley Colliery Inrush.

Appendix B. Assessment system explained

We use a bowtie framework to proactively assess how mine sites manage their principal hazards. 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. Only controls deemed critical¹ are assessed under a planned inspection program. For a control to be assessed as effective, each of its control supports must be in place and operational.

Assessment findings results calculation

During the program, each control support assessed at each mine was rated and the findings recorded. Points were awarded depending on whether there was evidence that the control support had been documented and/or implemented. Importantly, the system recognises the value of fully implemented and documented controls by allocating four points if both these elements were present.

For finding outcomes, points were awarded for each control support identified within a critical control. An overall assessment result for the critical control was then calculated as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises ten control supports and five were assessed as fully implemented ('documented and implemented') and five were found to be 'not documented and not implemented' then the overall assessment result for that critical control would be 50%.

Table 3: Finding outcome and points

FINDING OUTCOME	POINTS
Documented and implemented	4
Implemented but not documented	2
Documented but not implemented	1
Not documented and not implemented	0

Critical control calculations also took 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.

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

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.

Table 4: Assessment results and colour code

CRITERIA	COLOUR
An assessment result of 100% of possible points	Green
An assessment result of $\geq 80\%$ but $< 100\%$ of possible points	Yellow
An assessment result of $\geq 65\%$ but $< 80\%$ of possible points	Orange
An assessment result of $< 65\%$ of possible points	Red