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Causal investigation

Polyurethane foam fire at a metalliferous underground mine

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Resources Regulator, Central Assessment Unit - 1300 814 609 - cau@regional.nsw.gov.au

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Executive summary

A significant underground fire occurred during a polyurethane foam (PUR) void fill remediation project at Perilya's Southern Operations in Broken Hill on 12 January 2025. The incident, which originated at a previously mined section of the haulage shaft above level 23 (about 1,000 metres below surface), resulted in the emergency evacuation of 46 workers, temporary entrapment of 5 personnel in a fresh air base, and a complete halt to operations for an extended period. Although no injuries were reported, the event exposed critical failures in planning, contractor oversight, hazardous chemical identification, and risk management.

The remediation work aimed to stabilise a wedge failure intersecting the haulage shaft and an old platform area that had potential consequences to both infrastructure, production and personnel safety. However, due to geotechnical hazards within the historical mining void, the area was not physically inspected before the commencement of works. Planning instead relied on incorrect mine plans provided by Perilya at the request of the principal contractor MCA. MCA assumed the void was in another area and also used 3D photogrammetry. Planning failed to detect key fire risks including a timber-lined ventilation rise and the potential for residual ventilation materials such as hessian and paper-based sheeting, which could not be seen from the shaft access area.

Polymerics are a licenced product in NSW underground coal mines but not underground metal mines.

In January 2025, specialist contractors began applying a two-component PUR product (Frankengrout) to fill the void. The product had not been previously used on site and had not been confirmed as licensed for use in the NSW coal industry, contrary to the belief of Perilya and MCA staff that were under the impression that this product was used in the coal industry on a regular basis for this purpose.

No one was aware of a safety bulletin published by the Resources Regulator in 2021, which clearly stated that polyurethane foams should not be used to fill large voids due to their exothermic properties and flammability. Other NSW licencing documents and Queensland Recognised Standard 16 also stated that no more than 200 kg of PUR should be pumped into a single void due to its self-heating potential.

Although the total estimated void was 140 cubic metres, only 2 tonnes of chemical was ultimately pumped during day shift operations, which filled the void to about 80%. Critically, this volume represented more than 10 times the maximum allowable volume for PUR use under QLD and NSW coal industry guidelines. This was a direct contributing factor to the ignition and fire that followed, as the chemical's exothermic reaction generated critical heat in the confined space which either self-combusted or ignited flammable refuse, which in turn ignited the PUR.

Risk management is critical when introducing new chemicals and techniques to a mining environment.

Hazard identification during planning was narrow in scope and failed to address chemical and combustion risks. The risk assessment focused almost exclusively on ground stability, neglecting known hazards associated with PUR including flammability, toxic by-products, and heat generation.

No structured consultation occurred with operational teams, no procedures were developed for high-risk chemical application, and key controls such as fire watch protocols or surface temperature monitoring tools were not employed. Interestingly a risk assessment by the specialist contractor, BMS Strata Systems, dated September 2024, highlighted the hazard of fire when exceeding theoretical volumes, however, this was never provided to the shaft maintenance contractor, MCA, or the mine operator, Perilya.

Project oversight was insufficient. Perilya and MCA failed to verify the competence of BMS workers to carry out large-scale PUR application. Contractor engagement processes did not include independent validation of the product's suitability, nor did they confirm alignment with site risk management frameworks. Decisions were driven in part by production pressure and an urgent desire to stabilise the site, which overshadowed critical planning checks.

Emergency preparedness must be integral to any risk management process.

When nightshift crews arrived to install formwork, they saw several small chimneys (burn holes in the foam) possibly indicating localised overheating. Due to their concerns that fume or smoke had started emanating from these holes, they withdrew from the mine shaft where they raised their observations with the control room and senior management.

Evacuation was, in part, delayed due to perceived concerns relating to the ramifications of sounding an alarm when not required, which highlights a cultural issue that has manifested as minimal hazard reporting onsite.

Another reason the evacuation was delayed was due to the incomplete knowledge of the characteristics of the reacted, partially set product and the fact that the product emitted steam/fume/vapour immediately after the components were reacted. When the evacuation was called, most workers self-escaped, while 5 workers remained in a fresh air base until mine rescue deemed conditions safe.

Although smoke exposure was confirmed, no workers used their self-contained, self-rescuer escape units, raising questions about emergency preparedness, training confidence and cultural issues. Ventilation at a fresh air base also reversed due to the fire that led to workers being exposed to smoke and forced their evacuation from this location to another fresh air base.

Causal factors

This incident was not the result of a single failing, but the systemic breakdown of contractor management, hazard awareness, procedural compliance, and risk governance systems:

- Hazard identification was incomplete due to an inappropriate risk assessment and lack of subject matter experts; the fire and chemical hazards of PUR were not evaluated or addressed in controls.
- Critical risk information was ignored or misunderstood, including fire thresholds, material limitations, and regulatory guidance. It appears mine personnel asked the question of fire safety once and were left assured that the product was fireproof.

- The decision to use PUR at volume, 2 tonnes, violated established safe-use limits established for underground coal mines in NSW and QLD by a factor of 10, noting that there were **no formal regulated safe use limits** for metal mines in NSW at the time of the operation.
- Contractor competencies and product suitability were assumed, not verified, relying on undocumented knowledge and lacking specialist contractor advice.
- Time pressures and desensitisation to hazards drove premature execution without appropriate due diligence or structured planning.

This event underscores the importance of thorough contractor engagement, adherence to regulatory guidance, comprehensive hazard analysis, and informed decision-making when introducing unfamiliar chemical systems into complex underground environments. The following recommendations should be considered by industry and safety regulators when developing or regulating safety systems that control the introduction to site of novel hazardous chemicals:

Recommendation 1

Mine operators and principal contractors should review and revise their risk management and risk assessment frameworks in the context of this incident to ensure that:

- specific and appropriate risk assessment tools are selected for each task, and their use and requirements are fully understood by all personnel involved, including the need for formal facilitation and subject matter expertise when required.
- risk assessments comprehensively identify and evaluate all foreseeable hazards, including chemical, environmental, and operational risks, and clearly define corresponding control measures.
- all control decisions documented in risk assessments are demonstrably based on:
  - a structured review of relevant documented information, including industry safety alerts, past incidents, regulator guidance (across sectors and jurisdictions), Safety Data Sheets (SDS), licensing and compliance information, OEM documentation, and other authoritative publications.
  - Timely consultation with workforce representatives and qualified subject matter experts prior to finalising risk control decisions or commencing any high-risk task.
  - Cross-checks with supporting site processes (e.g., contractor capability validation, chemical approval and trial protocols, emergency preparedness including firefighting capacity) to verify their ability to meet the control requirements identified in the risk assessment.
  - Appropriate supervision arrangements are in place to ensure implementation of critical controls.

Recommendation 2

Mine operators should ensure that a comprehensive, risk-based review and revision of their contract management plan, policy, checklists, and associated processes is conducted to ensure robust contractor engagement and oversight. This revised framework should include, at a minimum, the following controls:

- Contractors are only engaged following formal verification of their competencies, specifically aligned with the technical and safety requirements of the task. Verification should include:
  - documented checks of licences, qualifications, and relevant task-specific experience
  - background reviews confirming industry capability and performance history
  - on-site validation of task knowledge and practical capability where formal industry qualifications are absent or insufficient.
- Site familiarisation and hazard context awareness are critical. Contractors should:
  - visit the site and, where practical, the specific job location prior to engagement
  - demonstrate understanding of site-specific risks, operational requirements, and environmental factors relevant to the work.
- All materials, hazardous tools, and chemicals proposed by contractors should undergo formal hazard evaluation prior to use. This includes:
  - a documented risk-based review incorporating available industry guidance, SDS, regulator alerts, previous incidents, and licensing information
  - verification of manufacturer or supplier safety claims through objective evidence or third-party validation.
- Contract scope of work must be risk-informed and developed collaboratively, incorporating:
  - a structured task risk assessment.
  - consultation with relevant stakeholders, including site representatives, technical SMEs, and HSE personnel.
- Contractual arrangements must incorporate clear hold-points and authorisation protocols to:
  - prevent unauthorised commencement or fast-tracking of work
  - ensure project or task-specific risk assessments are completed in advance with the contractor to enable mutual understanding of hazards, required controls, and task execution standards.
- Where contractor employees are supervising or leading tasks, they must:
  - be demonstrably competent and authorised by site management
  - have the appropriate level of technical and safety knowledge to lead the activity effectively and safely.
- Where tasks involve collaboration with site personnel or other contractors; roles, responsibilities, and required competencies must be clearly defined and risk assessed
- Implement a formal education package for all contractors to refresh the sites' contract management systems and requirements.
- Follow up periodic audits by the mine operator should be undertaken to ensure that the contractor management plan is implemented.

Recommendation 3

Mine operators should review and revise their site-wide chemical management system and associated protocols to ensure that the introduction, handling, and storage of chemicals are comprehensively risk-managed. The updated system must be implemented with clear ownership assigned and documented training delivered to all relevant personnel. The updated protocol must include, at a minimum:

- pre-approval evaluation of all chemicals prior to site introduction, including:
  - comprehensive assessment of hazardous properties as outlined in the SDS, regulatory guidance, and relevant technical documentation
  - verification that appropriate risk controls are identified and able to be implemented on site.
- products composed of multiple components (e.g. two-part systems) must be:
  - evaluated both individually and in combination for chemical interaction, hazardous characteristics, and control measure effectiveness.
- manufacturer or supplier safety claims should be substantiated by:
  - independent verification through recognised testing facilities, documented evidence, or up-to-date licensing/certification as applicable to Australian industry standards.
- chemical storage must comply with all relevant regulations and guidance, including:
  - SDS requirements, supplier documentation, and applicable legislative obligations
  - clear documentation that storage conditions have been implemented and verified onsite.
- chemical manifests must be actively maintained and readily accessible to all authorised personnel, with update cycles reviewed and enforced as part of the site's chemical inventory system.
- introduction of trial chemicals is to be subject to strict procedural controls, which should:
  - reflect the specific properties and hazards of the product
  - be supported by temporary but effective control measures as appropriate to the trial scope
  - require risk assessment and approval before use.
- all new or trial chemical introductions must follow a robust change management procedure, including:
  - risk assessment
  - stakeholder consultation
  - documentation of controls
  - review and authorisation at appropriate management levels.

Recommendation 4

Mine operators must have a process to complete a comprehensive review and revision of their emergency management plan (EMP) on a regular basis. Revisions to the EMP must be formally implemented and communicated across the site and include a verification process to ensure all workers (including contractors) are competent in the updated procedures. A sites EMP must specifically address, as a minimum:

- enhanced emergency notifications from the control room or emergency notification system:
  - Notifications must include relevant incident-specific information to support situational awareness and timely identification of specific hazards (e.g., fire, smoke, or chemical exposure).
- guidance for self-contained self-rescuer use (SCSR):
  - Clear procedural advice must be included for when smoke or chemical fumes are detected, reinforcing the use of SCSRs during fire-related incidents.
- debriefing protocols:
  - All workers exiting the mine during an emergency must receive structured debriefings to enhance real-time information flow to the incident management team (IMT) and emergency management team (EMT), and to support early identification of potential health impacts.
- medical clearance protocols:
  - All personnel exposed to smoke or chemical fumes must be assessed by a qualified medical practitioner immediately after evacuation, with records retained for future reference.
- chemical manifest access:
  - Up-to-date, accurate chemical manifests must be maintained and immediately accessible to the IMT, EMT, and emergency responders.
- mock emergency exercises:
  - Site-specific mock emergency scenarios must be conducted at minimum annually to validate the effectiveness of the emergency response systems, with findings formally reviewed and improvements tracked.
- consultation and communication:
  - All revisions to the EMP must undergo formal consultation with workforce representatives (including contractors) as well as local emergency services and be communicated clearly across the site.
- integration with the mine operators change management procedure:
  - Any updates or changes to the EMP must be documented, risk-assessed, and approved in line with the site's formal change management framework.
- training and competency verification:
  - All site personnel (including contractors) must be re-inducted into the revised emergency procedures, with competency assessments documented and retained.

Recommendation 5

The Regulator, in collaboration with relevant Australian mining regulators and industry representative bodies, will complete a coordinated review and reform package aimed at improving the safe use, regulation, and understanding of polymeric products in mining operations. This package should include the following specific, measurable actions:

- Training and competency framework review:
  - Investigate the applicability and adequacy of existing units of competency related to chemical handling and application in mining (with a focus on polymeric chemicals).
  - Identify any competency gaps and develop recommendations for the amendment or creation of industry-specific units of competency, supported by formal pathways for training and assessment to ensure consistent standards across jurisdictions.
- Industry-wide risk communication and engagement:
  - Issue an industry-wide technical reference guide, detailing known hazards, risks, and control measures associated with the use of polymerics in mining environments.
  - Develop a structured, cross-jurisdictional (coal, metalliferous, opencut, tunnelling, construction) inspection program targeting polymeric-related activities and introduction to site of hazardous chemicals at work sites.
- Guidance and education programs:
  - Deliver updated industry guidance materials on polymeric handling, selection, and emergency preparedness, to be released via regulator-hosted forums and technical workshops.
- Regulatory licensing review:
  - NSW and other Australian regulators should review licensing requirements for polymeric chemicals, including PUR, to determine consistency and sufficiency under all relevant legislation.
- Cross-jurisdictional communication:
  - The Regulator will formally share the findings of its investigation into the January 2025 PUR incident with SafeWork NSW and other Australian mining regulators to promote national consistency in polymeric chemical safety.

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Causal investigation

A preliminary inquiry and assessment of the incident was carried out by the Regulator that did not identify any material breaches of the work health and safety laws that would prevent a causal investigation from proceeding. Following this assessment, the Regulator determined that an investigation under its causal investigation policy was the most appropriate way forward to enable quick and full understanding of the causes of the incident and publication of the corresponding lessons to reduce the likelihood of a recurrence.

Notably, a causal investigation is an investigation into a safety incident notified to the regulator under the work health and safety laws, not to obtain evidence for a prosecution but rather to identify the causal factors of safety incidents, the effectiveness of the controls being used and what factors may have contributed to the failure of the controls. Timely communication helps ensure that duty holders under the work health and safety laws can better understand the risks they must manage, and the necessary controls to prevent reoccurrences of similar safety incidents.

The Regulator invited relevant stakeholders to participate in the causal investigation process. An investigation team comprising of representatives from Perilya Broken Hill Pty Ltd, MCA Australia, and the regulator was established. Dr Tillman Rache from SafetyWise Solutions provided expert facilitation of the ICAM investigation into the incident.

This report highlights the causal factors that were identified in the ICAM investigation.

Preliminary report

A preliminary incident report was issued within 14 days of the incident, consistent with the existing causal investigation policy. The report made the following recommendations based on the information known at the time of publishing.

- Metalliferous mine operators are expected to take a risk-managed approach to introducing and using chemicals on site and are encouraged to review their chemical manifests because of this incident. The risks associated with fire and exothermic reaction runaway in polymerics are well known and should be considered during any risk assessment or introduction-to-site process.
- Polymerics are licensed for use in the NSW underground coal industry. The Regulator has guidance available regarding testing requirements and licence conditions that may be relevant and should be considered as part of any risk managed process review. For further information, the Regulator has published a Guide – Licence testing requirements – materials to be polymerised underground.[1]

The mine

The Southern Operations Mine, on the south-western border of the city of Broken Hill, is owned and operated by Perilya Broken Hill Limited, a wholly owned subsidiary of Perilya Limited. The Company acquired the mine from Pasminco Limited in 2002. Mining in this orebody commenced in the late

[1] Investigation information release – causal investigation – polyurethane ground stabiliser fire exposes workers to health, safety risk IIR25-02, 31 January 2025, p2-3

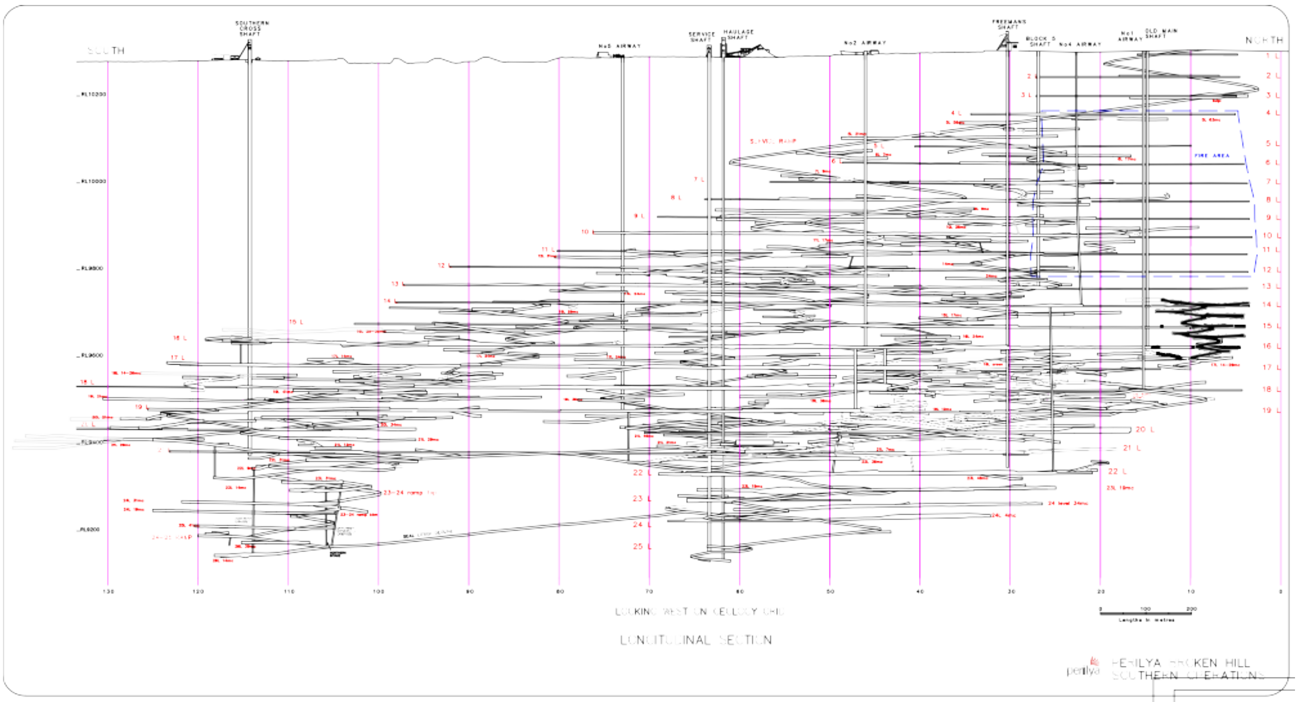
1800s and has resulted in a vast, complex underground network with many legacy geotechnical issues that require remediation.

The mine relies on a single haulage shaft to transfer the ore to the surface. The winder and shaft are aged and require ongoing remedial work to remain operational. The winding system runs at a duty of about 200 ore transfers per day (max capacity is about 210 skips per day). MCA Engineering Pty Ltd is contracted to undertake shaft maintenance work at the mining operation.

Based on extraction rates at the time of writing, and the extent of known mineralisation at the mine site, it is anticipated that mining operations will cease by 2030. However, it was noted that changes to anticipated extraction and production rates and/or the discovery of additional mineralisation could result in the actual completion date being extended.[2]

The Broken Hill operation produces 2 products, a zinc, silver concentrate and a lead concentrate. Concentrates from the mine are a premium, coarse-grained product, being of low complexity and containing a grade of about 50% zinc in the zinc concentrate and 70% lead in the lead concentrate. Mining is principally conducted using a long hole open stope method of mining. Long hole stoping accounts for 70% of underground production, with pillar extraction and development ore contributing approximately 30% of the total production.

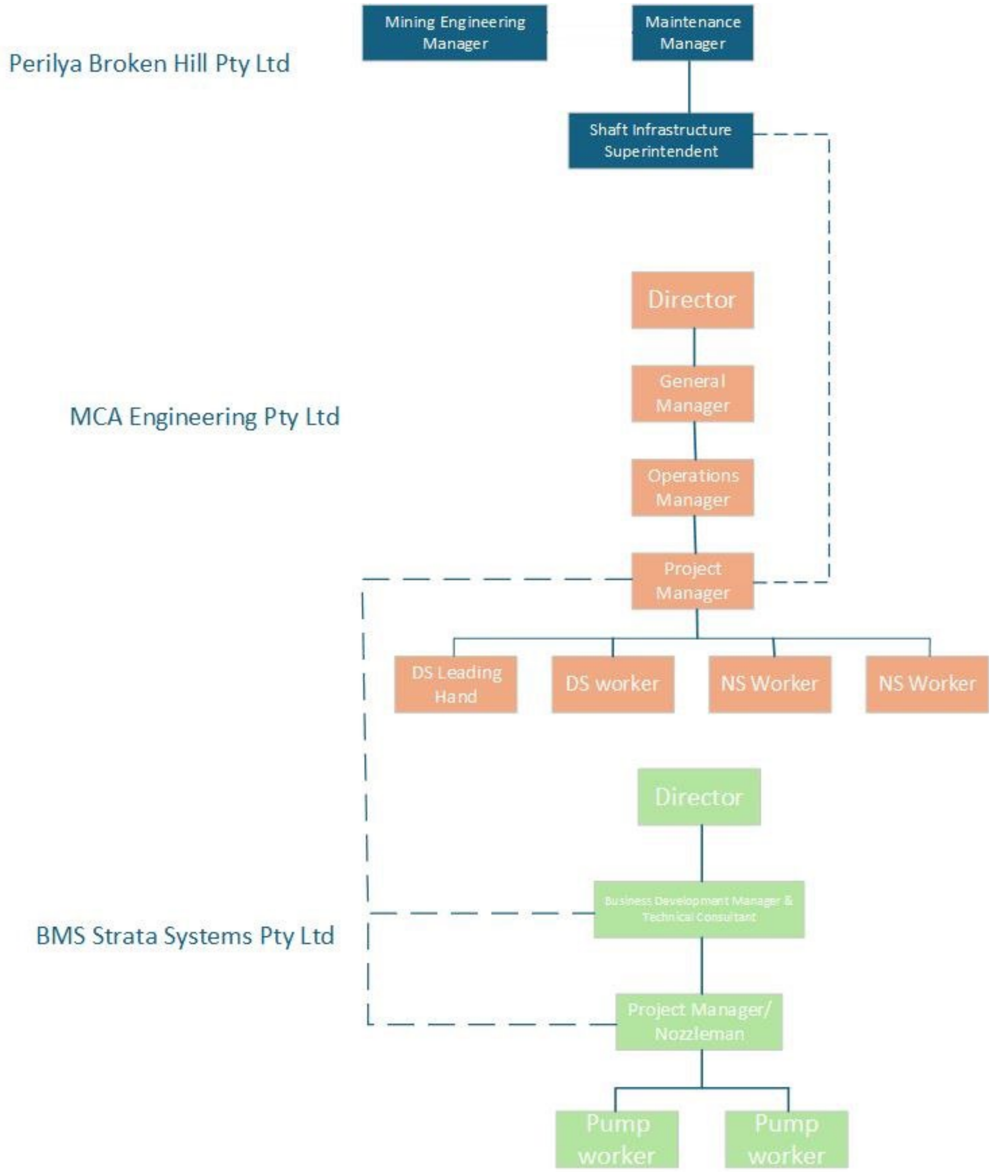
Figure 1: Longitudinal section view of Perilya Southern Operations demonstrating the vast network of mining areas



[2] Southern Operations – Annual Rehabilitation Report and Forward Program, Perilya Broken Hill Pty Ltd August 2022 p4

Organisational hierarchy

Figure 2: Incident organisational chart depicting reporting lines



The mine operator

Perilya Broken Hill Pty Ltd is the nominated operator of the mine. Perilya Limited is the ultimate holding company of Perilya Broken Hill Pty Limited.

The principal contractor

MCA Engineering Pty Ltd was contracted to provide shaft maintenance activities for the haulage shaft at Southern Operations. MCA Engineering is a provider of total engineering solutions for the mining, industrial and construction sectors. MCA has an established team of about 180 workers, which includes engineers and project managers. MCA has experience in underground work and conduct work relating to mine shaft engineering and maintenance.[3]

[3] https://www.mcaengineering.com.au/about/ accessed 22 April 2025

The specialist contractor

The principal contractor identified early that they lacked the specialised knowledge and skills to undertake remediation works using a polymeric chemical. It engaged BMS Strata Systems Pty Ltd to undertake the geotechnical remediation via the application of a polymeric chemical.

BMS Strata Systems claims to offer proven and innovative solutions that are formulated to be injected into soil and rock to deliver superior ground stabilisation. Customised to suit the application, BMS uses a range of products that react quickly to create tough, highly flexible and watertight barriers, helping to maintain the integrity of the structure.[4]

The product manufacturer and importer

BMS identified, purchased and renamed a polymeric chemical product from Era Polymers. Era Polymers is an Australian-owned and operated company specialising in the field of polyurethane chemistry. For over 37 years, Era has been developing and manufacturing polyurethane systems to meet the application needs of a global customer network.[5]

The chemical product

Polymerics

For the purpose of this investigation and report, a polymeric product is any material that is polymerised underground, including its constituent components but excluding polyester resin capsules inserted with primary and secondary strata support. In NSW coal mines, polymeric materials must be applied by a licenced person and the product itself must also be licenced. This is because of the significant risks associated with using these materials in the presence of combustible materials such as coal and gases such as methane. There are no licencing requirements for the use of these chemicals in underground metalliferous mines in NSW.

Polymeric processes, when undertaken in an underground metalliferous mine, can pose significant risks to workers if they are undertaken without proper and due regard to the risks involved.

Polyurethanes are a form of polymeric chemical and exhibit the following health and safety risk:

- They are exothermic – which means when the two-component chemical is mixed heat is released. Reaction temperatures can get hot enough to self-ignite or ignite surrounding combustibles. This is evidenced by multiple historical examples of polyurethanes self-combusting following large-scale application.
- They are extremely toxic when combusted – products of combustion include, hydrogen cyanide, hydrogen chloride, phosgene, carbon monoxide, nitrogen oxides, phosphorus oxides, carbon dioxide, other pyrolysis products typical of burning organic material including acrylonitrile and polyaromatic hydrocarbons.[6]

[4] https://bmsstrata.com/ accessed 22 April 2025

[5] https://erapol.com.au/ accessed 24 April 2025

[6] Makenna S and Hull T 2016 *The fire toxicity of polyurethane foams.* Fire Science Reviews

- They are an extremely effective insulator, which means that they can trap heat very well. Recent testing of polyurethanes at a Queensland research facility demonstrated that residual heat remained trapped in the foam for as long as a week.
- When layering polyurethanes the curing temperature can generate enough heat to boil the isocyanate liquid (prior to foaming), which can release isocyanate gas, which is a respiratory sensitiser.[7]
- They can be very flammable if a fire retardant is not added to the chemical. Sparks from grinding or welding can easily ignite the foam when fire retardants are not added. There are multiple examples of fatal fires occurring in underground mines where polyurethanes have been ignited by welding or grinding.

Despite these acute risks, polyurethanes have some appealing qualities for use in underground mining including:

- strata binding where unconsolidated material is effectively glued back together to prevent geotechnical degradation
- water proofing – can be used to seal small cavities where there is water ingress
- slab lifting and levelling.

Polyurethanes are not suitable for any application where a significant amount of product is required to fill a cavity or void. Recognised Standard 16 (Queensland jurisdiction) and the NSW coal licencing regime explicitly state that polyurethanes must not be used where there is a single void or cavity that requires more than 200 kg of product to be used.[8][9]

These limits were developed following international research into polyurethane fires that demonstrated a significant risk of self-combustion where more than 1 tonne of product was used in a single application. In instances where large voids are to be filled, there are other polymeric chemicals, such as phenolic based resins or urea silicates that may be more appropriate.

Note: These chemicals come with their own specific hazards and use cases. Mine operators should complete a thorough risk assessment for the use of polymeric chemicals, facilitated by an appropriate expert and include a subject matter expert.

Frankengrout

Frankengrout is a polyurethane resin product made from equal parts of FRANKENGROUT CC ISOCYANATE, a polyurethane isocyanate, and FRANKENGROUT CC POLYOL, a polyurethane resin polyol.

Both ingredients are supplied by ERA Polymers Pty Ltd and are marketed under the Era Polymers tradenames Greenlink XPF24-2863 Isocyanate and Polyol. BMS originally purchased the product as Greenlink XPF24-2863 and renamed it Frankengrout through a commercial arrangement.

[7] ACIRL report, Investigation into the potential for development of spontaneous combustion initiated by the use of polyurethane resin or cementitious grout during strata stabilisation at Nth Goonyella Mine, Dec 1999 P5

[8] Recognised standard 16 The use and control of polymeric chemicals at underground coal mines 2 June 2020 p5

[9] NSW licence testing requirements www.resources.nsw.gov.au/resources-regulator/safety/licences-and-registrations/licensed-activities accessed

An independent NATA accredited laboratory undertook a series of tests following the incident and determined the following characteristics of the chemical:

- Maximum exothermic reaction temperature in small scale testing = 133 degrees Celsius.
- Not fire resistant. Product would not self-extinguish until all product was consumed.
- Oxygen Index – combustion could be sustained below ambient oxygen concentrations (20.9%) to as low as 19% oxygen.
- Autoignition temperature 530 degrees Celsius.

Based on the test results above, Frankengrout does not comply with licencing requirements for underground coal in NSW noting that at the time of use it was not required to comply for metalliferous mines.

Further testing is being undertaken to understand the toxicity index of the fire effluent. At the time of writing, this information was not available but will form part of a review of the regulatory regime of polymerics in the NSW mining industry.

Events leading to the incident

In late August 2024, a routine geotechnical and shaft infrastructure survey identified a significant geotechnical failure in an underground void within Perilya's Southern Operations haulage shaft. The void was about 1000 metres below the surface. The void contained a wedge failure in the strata that posed a clear stability risk within the haulage shaft. This threatened shaft infrastructure and the safety of workers below the 23-level loading platform if the rock wedge was to fall, prompting MCA and Perilya to develop an engineered solution. The void would be filled with a polymeric foam to secure surrounding rock and mitigate future hazards.

Due to hazardous conditions and restricted access, the team could not physically inspect the void. Instead, they relied on outdated mine plans – believed at the time to be accurate – and a 3D photogrammetric model to estimate the void's shape and size.

The plans misrepresented the vertical position of the platform relative to the reference level and failed to identify the configuration of the ventilation rise, including the potential presence of paper-lined hessian ventilation cloth or supporting timber structures.

These oversights would prove pivotal, and it was not until during the investigation that it was identified that it was not actually the level 23 area that was originally on fire. This lack of situational awareness could have proven fatal had the decision been made to send mines rescue personnel into the area to fight the fire.

By early September, MCA had engaged with a local phenolic resin supplier to assess product suitability.[10] However, the supplier was unable to meet the delivery requirements, and neither MCA nor Perilya possessed in-house expertise in polymeric void fill applications. As a result, a decision was made to subcontract the work to BMS Strata Pty Ltd, an external specialist company.

BMS was selected based on a combination of favourable product delivery timelines, perceived technical capability, and a recommendation to use a specific PUR known as Frankengrout. It was

[10] Phenolic resins, unlike PURs are specifically designed for large void fill applications. PURs are not to be used in void fill applications where more than 200 kg of product is required.

understood, albeit without documented validation, that Frankengrout was enhanced with fire-retardant properties, making it more suitable for underground application.

BMS was provided with MCA's '23 level wedge – presentation of options', and both Perilya and MCA management gave approval to proceed. A six-week lead time was estimated for the delivery of materials. However, critical aspects of the planning process were not executed. There is no evidence that BMS conducted a site inspection before mobilisation, nor that any comprehensive risk assessment was performed considering the known hazards of PUR resins, including their potential for exothermic reaction and fire.

On 20 September, 2024, BMS produced a safe work method statement (SWMS) titled Chemical grout injection works. Within this document, a single reference was made to the risk of thermal combustion if excessive foam material were injected. The SWMS advised halting work once the daily theoretical volume was reached, pending consultation with the site engineer. However, this guidance was vague and unsupported by specific control measures or clear definitions, and it did not appear to be integrated into subsequent risk assessments. It is also worth noting that the SWMS was not provided to the MCA project manager or Perilya until after the incident had occurred.

By late September, 20 intermediate bulk containers (IBCs) containing Frankengrout compounds and related chemicals, including Gunwash (a Class 3 flammable liquid), were delivered to site. Although standard hazardous substance approval processes were followed, there is no indication that a formal hazard identification or risk evaluation was conducted specific to the flammable nature of the substances or their underground use.

Originally, Gunwash was explicitly prohibited from being taken underground. However, records indicate that this directive was later amended to allow Gunwash use as part of a trial. Despite this reversal, there was no evidence of a documented risk assessment, trial plan, or justification for the volume used – 650 litres were taken underground. Further communications between MCA and Perilya indicated that no additional PPE requirements were established, despite Gunwash's SDS stating otherwise.

In the weeks leading up to the planned works, a power outage across Broken Hill delayed the project into January 2025. This presented an opportunity to revisit the risk assessment process, but no revisions or reassessments were made during this period.

On 8 January, 2025, a new risk assessment was drafted using a previous shotcreting template. It was not facilitated by a safety specialist but, instead, was developed by non-specialist project staff. This document did not reference the hazards associated with PUR, such as heating or combustion, nor did it reflect lessons learned or published industry guidance on polymeric resin injection. It was apparent that there was little due diligence / research undertaken by Perilya or MCA to determine the hazard burden that had been introduced to the site. Perilya and MCA were working under the incorrect assumption that the product was benign and fireproof.

Training and verification of BMS personnel competency was similarly limited. Due to tight scheduling, site induction, including self-rescuer training, was condensed into a two-hour session conducted by MCA's Group Project Manager. The assumption was made that BMS, as a specialist contractor, had the necessary competency to manage the risks and tasks independently.

On 10 January, the BMS team arrived at site. Changes in staffing meant that a resin applicator/nozzleman stepped into a supervisory role, and a compressed 16-hour shift roster was approved to align with the three-day operational window. Equipment and chemicals, including the full quantity of Gunwash, were moved to level 21.

The incident

On Sunday, 12 January, BMS and MCA personnel began foam application activities. Two BMS workers remained at level 21 to operate pumps, while the nozzleman was lowered to the void level on top of the ore flask in the shaft to conduct the spray operation – this was the first time any BMS personnel had seen the actual void.

The spray gun was modified using a metal bar to increase reach. Foam placement relied on visual observation alone, no thermal monitoring tools (e.g. infrared thermometers) were provided. Due to geometric constraints, foam accumulated near the front of the void, forming a dense plug.

By 4.15 pm, about 34 cubic metres of chemical (2 tonne) had been applied.

That volume represented a fraction of the estimated need, but was still 10 times more than what was typically permitted in operations across the QLD and NSW coal industries.

Spraying ceased for the day, and equipment was cleaned with Gunwash. It was estimated that 80% of the void had been filled and the wedge failure was completely supported. No fire watch or monitoring was established post-application, as the fire risk had not been meaningfully acknowledged or assessed.

The PUR foam used in the operation combined 2 reactive chemicals, an isocyanate and a polyol. When mixed, these components undergo an exothermic reaction, generating considerable heat during expansion. Safe handling requires precise control over the mixing ratio and application rate to manage thermal output. Although the product included tris (1-chloro-2-propyl) phosphate (TCPP) as a fire retardant, it offered limited flame-suppressing properties (as witnessed in the incident and independent laboratory testing), yet many workers incorrectly believed the chemical compound to be fireproof.

At 9 pm, MCA nightshift workers returned to install a mesh curtain. The intent of this was to create loose formwork so that the last 20% of the void could be filled creating a smooth, lined shaft wall. During their work, they observed smoke and localised charring on the foam surface.

There was no hot work that was undertaken by the workers. Despite an understanding that the product was fireproof, evidence suggested that something was not right, and the product was self-heating, they left the void to report their observations. The workers reported the presence of smoke to the control room operator who was reluctant to call an emergency. The belief that Frankengrout was fireproof likely contributed to the delay in action. By then, the situation had escalated. The foam had ignited within the void, initiating a fire that began to release smoke and combustion gases into adjacent mine workings.

At 11:34 pm, CCTV footage from multiple shaft levels recorded visible smoke. Four minutes later, an emergency was declared, and all underground personnel were ordered to evacuate or move to fresh air bases.

Most workers evacuated safely and unaided. However, 5 remained underground for several hours in a fresh air base. Workers who retreated to the level 18 fresh air base were forced to relocate after reversing ventilation flow exposed them to smoke. No physical injuries were reported.

Critically, no-one deployed a chemical oxygen self-contained self-rescuer (SCSR) during the event, despite widespread smoke and fume exposure. These belt-worn emergency devices are specifically designed for such scenarios yet were neither used nor referenced throughout the evacuation.

The incident ultimately exposed a series of critical failures, some of which contributed to the incident, but all of which had the capacity to expose workers to serious risk:

- Lack of proper hazard identification and risk control measures.
- Inadequate consultation with technical experts.
- Use of a polyurethane foam product for large-scale void filling.
- Failure to heed and act upon the only documented warning of thermal combustion risk.
- Uncontrolled introduction of a class 3 flammable liquid into the underground environment.

The combination of these factors culminated in a fire event that placed personnel at serious risk and highlighted systemic shortcomings in project planning, contractor management, and hazard control.

Incident response and activation of the mine emergency sub plan under the SERM Act

The General Manager of Southern Operations contacted the Regulator's incident reporting hotline on 13 January at 12:40 am, to notify that the mine site had sent their workers to fresh air bases due to fumes coming off a "grouting chemical", but that this was "unconfirmed". Due to the relative benign description of the incident, the on-call inspector did not form an appreciation of the severity of the incident that was forming at the mine. At 3:30 am, the General Manager informed the on-call inspector that a fire had developed and was unsure how long it would burn. At 6 am, the General Manager advised that the last 5 workers who were temporarily trapped in a fresh air base were able to safety return to the surface.

Around 6 am, the Regulator deployed 2 inspectors to the mine site to gain greater visibility of the escalating incident and to monitor for risks to health and safety. The inspectors obtained information and reviewed risk assessments created by the mine emergency response team.

About 4 pm on 13 January 2025, various matters were discussed with the Regulator's leadership team and the field inspectors, including the lack of information about the fire situation in the mine and the unacceptable risk to personnel being sent to fight the fire.

Further, given the incident extended beyond the capability of the mine, control should be assumed by the local emergency operations controller (LEOCON), as per the mine sub-plan. The Regulator raised these concerns with the LEOCON and at 5 pm, the mine sub plan was activated, and emergency services took control of the incident. The Regulator also stood up its Mine Safety Operations Centre (MSOC) where it coordinated inspector activities on the ground and provided information and advice to the LEOCON.

Re-entry was made by mine personnel under a Regulator-endorsed risk assessment and procedure, where attempts were progressively made to successfully extinguish the fire.

On 15 January 2025 at 11 am, the emergency operations centre was stood down by the LEOCON with carriage of the matter being handed back to the Regulator and the mine operator.

Investigation methodology and key lines of enquiry

The incident cause and analysis method (ICAM) was applied during the investigation and included:

a) data collection and data organisation to determine contributing factors.

b) data analysis of the contributing factors.

c) corrective actions to address the contributing factors.

d) key learnings for Perilya Southern Operations and its associated contractor groups.

In conducting this investigation, the following processes and techniques were applied.

- Provision of an independent incident investigation technical expert (lead facilitator – Safetywise) providing advice to the investigation team leader, a representative of the Regulator.
- ICAM team consisted of a suitable cross section of the workforce including health and safety representatives, superintendents, supervisor/leading hands, safety managers, regulatory inspectors.
- Site visit and joint ICAM workshop on March 25 and 26, 2025.
- Communication of the scope and intent of the investigation to key stakeholders to gain support via a pre-investigation meeting and post-site visit meeting with Perilya Southern Operations management.
- Obtain complete access to people for either interviews and/or discussions.
- Obtain complete access to documentation, equipment, computer process data, CCTV footage, and voice recordings relevant to the incident that will assist in the investigation.
- Allow access for taking photographs relevant to the incident.
- About 20 hours of interviews were conducted with witnesses and management.
- Analysis of about 300 documents including the mine operator’s safety management system.

Significant contributing factors

Basic cause

The basic cause of the incident was application of about 34 cubic metres (2 tonne) of a PUR self-expanding foam into an underground void that either self-heated and auto ignited or self-heated to a temperature sufficient to ignite mine refuse (paper-backed hessian or timber supports) which ignited the PUR.[11]

The incident marked an escalation of a project that contained multiple preventable failures. Reliance on flawed data, misjudged risk assessments, incorrect assumptions about chemical properties and inadequate hazard recognition. Injecting an expanding, heat-generating chemical

[11] The use of a PUR product to fill a large void is not recommended. Other chemical systems offer less risk of fire due to their lower exothermic reaction temperatures. Phenolic or urea silicate systems have been used successfully to fill large voids and are specifically designed for this application. Note: as with any chemical system, there are unique hazards associated with the type of chemical used. These other systems still contain risk to health and safety. An appropriate risk based system (including thorough risk assessment) must be developed and implemented by the duty holder prior to use of any hazardous chemical onsite.

into a confined, inaccessible, and timber-lined void – without proper inspection, thermal monitoring, or fire watch – led directly to a fire underground and a high-risk evacuation scenario.

This event underscores the critical importance of verifying assumptions, applying robust risk controls, and maintaining rigorous due diligence, especially in complex underground operations involving chemical products.

Contributing factors identified though the ICAM investigation are summarised below.

Absent or failed defences

Awareness hazard identification: Project management and oversight by both Perilya, MCA and BMS of the PUR project was done without sufficient due diligence and adherence to the site's contractor management processes.

Awareness hazard identification: The risk assessment team did not comprehensively research and incorporate information around PUR hazards and precautions. For instance, the system could have verified that the product used was licensed for use in the NSW coal industry. This would have increased awareness regarding specific hazards and whether the product was fit for use. There was a specific Regulator safety bulletin SB21-07 Polyurethane resin selection that provides that licence conditions stipulate that polyurethane resins should not be used to fill large voids.

Awareness hazard identification: Controls put forward in the risk assessment largely dealt with failing of ground hazards, and did not address any hazards with regard to application of the PUR product.

Awareness competence/knowledge: The risk assessment lacked quality and credibility as the right information, expertise and experience was not considered.

Awareness competence/knowledge: Perilya and MCA allowed the job to be supervised by BMS workers without confirming appropriate competencies, or experience to fill such a large void, including correct product knowledge.

Awareness work instruction/procedures: The risk assessment did not involve the sites risk assessment facilitator, nor did it involve any structured consultation and communication with any of the MCA and BMS workers (stakeholders) later involved in the task.

Awareness work instruction/procedures: No formal risk-based procedures including any relevant precautions were given to the applicator and spray crew about filling the void with PUR. This is particularly concerning as the void had not been inspected prior, the void was considered as large, and this particular mix of Frankengrout had never been used prior at a mining operation.

Detection visual warning systems: Tools to help measure (surface) curing temperature, such as an infrared thermal gun, was not provided to the BMS PUR applicator. Although this is not a legal requirement in the NSW metalliferous mining industry, the coal industry apply this control measure, and it should have been considered.

Protection and containment firefighting: Fit for purpose firefighting equipment was limited and likely to be inadequate to deal with a PUR fire, or an issue with the other chemicals (gun wash) that had been taken underground.

Individual or team actions

Supervisory: Perilya and MCA staff failed to verify that BMS workers had relevant competencies to carry out the PUR application task.

Procedural compliance: Perilya and MCA staff did not adhere to the sites risk and contract management framework or basic quality requirements to identify key hazards in order to create effective risk control actions and hold points before the contractor and product was selected.

Task or environmental condition

Complacency/motivation/desensitisation to hazard: The decision to engage BMS and use large amounts of Frankengrout was based on advice that the product was a fit-for-purpose, large cavity filler, and that it contained fire retardant.

Time productivity pressures: Discussions with staff provided evidence of a perception that the mine was under severe pressure to have the boulder stabilised. Despite the urgency, and several potential planning windows, Perilya and MCA missed several opportunities to plan the task fully and effectively, including the verification of BMS to provide a safe product, and to do the task competently.

Reliance on undocumented knowledge: Perilya, MCA and BMS workers were under the false belief that Frankengrout was safe due to the addition of a fire retardant, and that the application did not require special precautions, such as a fire watch, after placement of the foam.

Organisational factors

CM contractor management, MS management systems: Perilya and MCA failed to verify that BMS workers were competent to carry out the PUR application task.

CM contractor management: Engagement of the BMS contractor did not ensure that the risks pertaining to the PUR placement contract were adequately risk assessed or managed including confirmation of competency of workers

CM contractor management: There were considerable oversights and delays to commencing a risk assessment to determine critical controls, and to verify contractor capabilities and suitability of proposed PUR chemicals. Key decisions were taken early in the complete absence of verifiable information and not challenged subsequently.

CM contractor management: Perilya and MCA allowed the job to be supervised by BMS workers without adequate competencies, experience to fill such a large void, and correct product knowledge.

CM contractor management: Project management and oversight by both Perilya, MCA and BMS of the PUR project was done without due diligence and adherence to the site's contractor management processes.

RM risk management: Perilya and MCA staff did not follow the sites risk management framework and basic quality requirements to identify key hazards and create effective risk control actions.

- The assessment did not involve the sites facilitator, nor did it involve any structured consultation and communication with any of the MCA and BMS workers (stakeholders) later involved in the task.

- The assessment team did not research and incorporate information around PUR hazards and precautions, and did not include a team brainstorm activity to identify issues that relate to the subject area of review, considering the assets, activities, products and services'
- The risk assessment hence lacked quality and credibility as the right information, expertise and experience was not considered.
- Controls put forward in the risk assessment largely dealt with falling of ground hazards, and did not address any hazards regarding grout application of the PUR product.

RM risk management: Neither Perilya nor MCA carried out any due diligence in the selection of the contactor. There were considerable oversights and delays to commencing a risk assessment to determine critical controls, and to verify contractor capabilities and suitability of proposed PUR chemicals. Key decisions were taken early in the complete absence of verifiable information and not challenged subsequently.

MS management systems: Perilya and MCA accepted BMS' internal competency verifications processes unchallenged.

MS management systems: There was no evidence to suggest that the sites approach to chemicals and hazardous materials was utilised.

HW hardware: While the components of the PUR were readily available, the Frankengrout as used at the Perilya mine was a bespoke product through the addition of a fire retardant. There was no evidence that this fire retardant Frankengrout was tested and verified to be fireproof.

HW hardware: There was no evidence to support that the 'new plant access approval' including necessary checks under MDG15 was followed to ensure any equipment brought on site was safe for use and authorised before being taken underground.

PR procedures: No formal procedure including any relevant precautions was given to the applicator and spray crew in regard to filling the void with PUR. This is particularly concerning as the void had not been inspected, the void was considered as large, and this particular mix of Frankengrout had never been used at a mining operation.

There was no evidence to suggest the 'critical hazard protocol' process was followed. For instance, no formal risk assessment was generated to identify the risks associated with hazardous substances (such as Frankengrout or Gunwash), appropriate personal protection equipment was made available to all workers at levels 21 and 23, and storage requirements were met.

Also it was not clear how the Gunwash trial was meant to be carried out.

Recommendations

Recommendation 1

Mine operators and principal contractors should review and revise their risk management and risk assessment frameworks in the context of this incident to ensure that:

- specific and appropriate risk assessment tools are selected for each task, and their use and requirements are fully understood by all personnel involved, including the need for formal facilitation and subject matter expertise when required.

- risk assessments comprehensively identify and evaluate all foreseeable hazards, including chemical, environmental, and operational risks, and clearly define corresponding control measures.
- all control decisions documented in risk assessments are demonstrably based on:
  - a structured review of relevant documented information, including industry safety alerts, past incidents, regulator guidance (across sectors and jurisdictions), Safety Data Sheets (SDS), licensing and compliance information, OEM documentation, and other authoritative publications.
  - Timely consultation with workforce representatives and qualified subject matter experts prior to finalising risk control decisions or commencing any high-risk task.
  - Cross-checks with supporting site processes (e.g., contractor capability validation, chemical approval and trial protocols, emergency preparedness including firefighting capacity) to verify their ability to meet the control requirements identified in the risk assessment.
  - Appropriate supervision arrangements are in place to ensure implementation of critical controls.

Recommendation 2

Mine operators should ensure that a comprehensive, risk-based review and revision of their contract management plan, policy, checklists, and associated processes is conducted to ensure robust contractor engagement and oversight. This revised framework should include, at a minimum, the following controls:

- Contractors are only engaged following formal verification of their competencies, specifically aligned with the technical and safety requirements of the task. Verification should include:
  - documented checks of licences, qualifications, and relevant task-specific experience
  - background reviews confirming industry capability and performance history
  - on-site validation of task knowledge and practical capability where formal industry qualifications are absent or insufficient.
- Site familiarisation and hazard context awareness are critical. Contractors should:
  - visit the site and, where practical, the specific job location prior to engagement
  - demonstrate understanding of site-specific risks, operational requirements, and environmental factors relevant to the work.
- All materials, hazardous tools, and chemicals proposed by contractors should undergo formal hazard evaluation prior to use. This includes:
  - a documented risk-based review incorporating available industry guidance, SDS, regulator alerts, previous incidents, and licensing information
  - verification of manufacturer or supplier safety claims through objective evidence or third-party validation.
- Contract scope of work must be risk-informed and developed collaboratively, incorporating:
  - a structured task risk assessment.

- consultation with relevant stakeholders, including site representatives, technical SMEs, and HSE personnel.

- Contractual arrangements must incorporate clear hold-points and authorisation protocols to:
  - prevent unauthorised commencement or fast-tracking of work
  - ensure project or task-specific risk assessments are completed in advance with the contractor to enable mutual understanding of hazards, required controls, and task execution standards.
- Where contractor employees are supervising or leading tasks, they must:
  - be demonstrably competent and authorised by site management
  - have the appropriate level of technical and safety knowledge to lead the activity effectively and safely.
- Where tasks involve collaboration with site personnel or other contractors; roles, responsibilities, and required competencies must be clearly defined and risk assessed
- Implement a formal education package for all contractors to refresh the sites' contract management systems and requirements.
- Follow up periodic audits by the mine operator should be undertaken to ensure that the contractor management plan is implemented.

Recommendation 3

Mine operators should review and revise their site-wide chemical management system and associated protocols to ensure that the introduction, handling, and storage of chemicals are comprehensively risk-managed. The updated system must be implemented with clear ownership assigned and documented training delivered to all relevant personnel. The updated protocol must include, at a minimum:

- pre-approval evaluation of all chemicals prior to site introduction, including:
  - comprehensive assessment of hazardous properties as outlined in the SDS, regulatory guidance, and relevant technical documentation
  - verification that appropriate risk controls are identified and able to be implemented on site.
- products composed of multiple components (e.g. two-part systems) must be:
  - evaluated both individually and in combination for chemical interaction, hazardous characteristics, and control measure effectiveness.
- manufacturer or supplier safety claims should be substantiated by:
  - independent verification through recognised testing facilities, documented evidence, or up-to-date licensing/certification as applicable to Australian industry standards.
- chemical storage must comply with all relevant regulations and guidance, including:
  - SDS requirements, supplier documentation, and applicable legislative obligations
  - clear documentation that storage conditions have been implemented and verified onsite.

- chemical manifests must be actively maintained and readily accessible to all authorised personnel, with update cycles reviewed and enforced as part of the site's chemical inventory system.
- introduction of trial chemicals is to be subject to strict procedural controls, which should:
  - reflect the specific properties and hazards of the product
  - be supported by temporary but effective control measures as appropriate to the trial scope
  - require risk assessment and approval before use.
- all new or trial chemical introductions must follow a robust change management procedure, including:
  - risk assessment
  - stakeholder consultation
  - documentation of controls
  - review and authorisation at appropriate management levels.

Recommendation 4

Mine operators must have a process to complete a comprehensive review and revision of their emergency management plan (EMP) on a regular basis. Revisions to the EMP must be formally implemented and communicated across the site and include a verification process to ensure all workers (including contractors) are competent in the updated procedures. A sites EMP must specifically address, as a minimum:

- enhanced emergency notifications from the control room or emergency notification system:
  - Notifications must include relevant incident-specific information to support situational awareness and timely identification of specific hazards (e.g., fire, smoke, or chemical exposure).
- guidance for self-contained self-rescuer use (SCSR):
  - Clear procedural advice must be included for when smoke or chemical fumes are detected, reinforcing the use of SCSRs during fire-related incidents.
- debriefing protocols:
  - All workers exiting the mine during an emergency must receive structured debriefings to enhance real-time information flow to the incident management team (IMT) and emergency management team (EMT), and to support early identification of potential health impacts.
- medical clearance protocols:
  - All personnel exposed to smoke or chemical fumes must be assessed by a qualified medical practitioner immediately after evacuation, with records retained for future reference.
- chemical manifest access:
  - Up-to-date, accurate chemical manifests must be maintained and immediately accessible to the IMT, EMT, and emergency responders.
- mock emergency exercises:

  - Site-specific mock emergency scenarios must be conducted at minimum annually to validate the effectiveness of the emergency response systems, with findings formally reviewed and improvements tracked.
- consultation and communication:
  - All revisions to the EMP must undergo formal consultation with workforce representatives (including contractors) as well as local emergency services and be communicated clearly across the site.
- integration with the mine operators change management procedure:
  - Any updates or changes to the EMP must be documented, risk-assessed, and approved in line with the site's formal change management framework.
- training and competency verification:
  - All site personnel (including contractors) must be re-inducted into the revised emergency procedures, with competency assessments documented and retained.

Recommendation 5

The Regulator, in collaboration with relevant Australian mining regulators and industry representative bodies, will complete a coordinated review and reform package aimed at improving the safe use, regulation, and understanding of polymeric products in mining operations. This package should include the following specific, measurable actions:

- Training and competency framework review:
  - Investigate the applicability and adequacy of existing units of competency related to chemical handling and application in mining (with a focus on polymeric chemicals).
  - Identify any competency gaps and develop recommendations for the amendment or creation of industry-specific units of competency, supported by formal pathways for training and assessment to ensure consistent standards across jurisdictions.
- Industry-wide risk communication and engagement:
  - Issue an industry-wide technical reference guide, detailing known hazards, risks, and control measures associated with the use of polymerics in mining environments.
  - Develop a structured, cross-jurisdictional (coal, metalliferous, opencut, tunnelling, construction) inspection program targeting polymeric-related activities and introduction to site of hazardous chemicals at work sites.
- Guidance and education programs:
  - Deliver updated industry guidance materials on polymeric handling, selection, and emergency preparedness, to be released via regulator-hosted forums and technical workshops.
- Regulatory licensing review:
  - NSW and other Australian regulators should review licensing requirements for polymeric chemicals, including PUR, to determine consistency and sufficiency under all relevant legislation.

- Cross-jurisdictional communication:
  - The Regulator will formally share the findings of its investigation into the January 2025 PUR incident with SafeWork NSW and other Australian mining regulators to promote national consistency in polymeric chemical safety.