NSW Trade & Investment Mine Safety

NSW CODE OF PRACTICE | WHS (MINES) LEGISLATION

Strata control in underground coal mines

This code of practice has been approved under section 274 of the *Work Health and Safety Act 2011*.

Notice of that approval was published in the NSW Government Gazette referring to this code of practice as *Strata control in underground coal mines* on 23 January 2015. This code of practice commenced on 1 February 2015.

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NSW code of practice: Strata control in underground coal mines

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www.resourcesandenergy.nsw.gov.au/safety

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Foreword

This *NSW code of practice: Strata control in underground coal mines* is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act, *the Work Health and Safety Regulations 2011* (WHS Regulations), *Work Health and Safety (Mines) Act 2013* (WHS (Mines) Act) *and Work Health and Safety (Mines) Regulations 2014* (WHS (Mines) Regulations[1]).

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS laws, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS laws. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the WHS laws may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

The development of this code of practice

This code of practice has been developed under the 'Inter-Governmental Agreement for Consistency or Uniformity of Mine Safety Legislation and Regulations in NSW, Queensland and Western Australia' and forms part of the mining safety legislative framework for these states. Under this agreement, tri-state model legislation was developed although designed to be structured and customised differently in each of these states.

This code was developed in consultation with the Non-Core (tri-state) Legislative Working Group representing the following stakeholders from the mining industry in the tri-states:

- NSW Minerals Council
- University of New South Wales (mining school)
- Construction, Forestry, Mining and Energy Union (CFMEU) – NSW and Queensland
- NSW Trade & Investment (Mine Safety)
- Queensland Resources Council
- Queensland Department of Natural Resources and Mines
- Western Australian Department of Mines and Petroleum
- Western Australia Chamber of Mines and Energy

Strata Engineering Pty Ltd made a significant contribution to writing the code through providing consultancy services to NSW Trade & Investment Mine Safety.

[1] It will sometimes be convenient to refer generally to 'WHS laws', which includes:

- WHS Act
- WHS (Mines) Act
- WHS Regulations
- WHS (Mines) Regulations

Accordingly, this code of practice is based on both:

- The Non-Core (tripartite) Legislative Working Group endorsed tri-state model code on 10 December 2013.
- National Mine Safety Framework model code original version, developed in conjunction with Safe Work Australia.

A draft of this code of practice was released for public consultation on 30 May 2014 and was approved by the Minister for Energy and Resources, the Hon Anthony Roberts MP on 19 January 2015. The code will be reviewed as required or when legislation is reviewed.

Contents

Scope and application

This code is a practical guide to assist the mine operator to identify and control strata failure hazards as part of developing and implementing a principal mining hazard management plan, as required under the WHS (Mines) Regulation. This code applies to the underground workings of a coal mine.

People should use this code if they have functions and responsibilities that are contained in the principal hazard management plan (PMHMP) for strata failure. This code may be used by workers and health and safety representatives who need to understand the hazards and risks associated with strata failure.

How to use this code of practice

This code includes references to both mandatory and non-mandatory actions. The references to legal requirements contained in the WHS Act and Regulation, and the WHS (Mines) Act and Regulation are not exhaustive and are included for context only.

This code has been prepared to be consistent with the WHS laws as at the date of publication and should be interpreted, to the extent that there is any ambiguity, in a manner that is consistent with the WHS laws. To ensure you comply with your legal obligations you must refer to the latest legislation, which is available on the NSW legislation website (www.legislation.nsw.gov.au).

This publication does not represent a comprehensive statement of the law as it applies to particular problems or to individuals or as a substitute for legal advice. Seek independent legal advice if you need assistance on the application of the law to your situation.

The words ‘must’, ‘requires’ or ‘mandatory’ indicate that legal requirements exist and must be complied with. The word ‘should’ indicates a recommended course of action, while ‘may’ indicates an optional course of action. Unless otherwise indicated in the text, lists of points in the code should not be read as exhaustive.

Examples and samples provided in Appendices B - G are based on specific mining environments. For example, the triggers in each of the Trigger Action Response Plans (TARPs) and Strata Control Action Response Plans (SCARPs) set out in Appendix G have been designed to monitor the critical factors that, in that environment, indicate a deterioration of the strata or ground controls. The action/responses are similarly specific to the environment. Appendices B - G are included as examples, some drawn from current practices, as to how a process may be undertaken (for example, task allocation) or how a document may be set out (for example, a support plan). Every process developed or document prepared for a mine should be developed to suit the nature, complexity and location of the particular mining operation and the risks associated with that mining operation.

Some samples or examples are drawn from practices that existed before the start of the WHS (Mines) Act and Regulation in NSW, and/or from other jurisdictions. Therefore, some of the content and terminology used in these appended examples/samples are referrable to statutory requirements under previous or interstate legislation and do not represent a current statement of the law as it currently applies in NSW.

1 Introduction

There were 67 fatalities due to falls of roof and sides at Australian underground coal mines from 1980 to 2008 (see References).

These strata-related incidents included:

- nine fatalities associated with rib falls
- 23 fatalities in 18 pillar extraction incidents
- 13 fatalities in 11 incidents that occurred while mining was taking place
- 13 fatalities while supporting the roof.

Several actions have followed these incidents, including the widespread introduction of breaker line supports for pillar extraction, the use of temporary roof supports during support activities and increased use of rib support.

In the same period, there has been a major change to longwall extraction and the use of full-face gate road development machines with multiple rib and roof bolters. After 2001 there was a resurgence in pillar extraction. These changes have led to differing hazards and controls for the strata management systems to cater for and control.

For further information regarding these incidents, see the Reference section at the end of the code.

1.1 What is strata control?

Strata control may be defined as the prediction and control of strata behaviour during development and extraction operations. It was a widely used term in the mining industry before the development of alternatives, such as geomechanics, rock mechanics and mining geomechanics (Galvin, 2008). It continues to be widely applied in the coal mining industries of Australia, Europe and South Africa. In the USA, the analogous term 'ground control' is more common.

Strata control is the practical application of the science of rock mechanics, which includes all studies relative to the physical and mechanical behaviour of rocks and rock masses and the application of this knowledge for the better understanding of geological processes in the fields of engineering. Rock mechanics is in turn a sub-set of geomechanics, which is concerned with the physical and mechanical properties and responses of soils and rocks, including their interactions with water. Geotechnical engineering is an associated term focused more on design and construction. Collectively, these disciplines aim to develop and implement a ground behaviour/geotechnical model, building on a geological model. Current practice is to title the person with the responsibilities for strata control as the Geotechnical Engineer.

Key aspects of strata control include:

- the practical application of the available knowledge
- predicting and effectively influencing rock behavior in the mining environment, with regard to the safety of the workforce and the required serviceability of openings
- understanding and identification of the potential failure mechanisms, including their relevance to a specific design issue or problem
- managing the related hazards throughout the life cycle of the excavations, from development through extraction and ultimately to mine closure.

In most engineering disciplines design aims to prevent structural failure. The designer selects construction materials to nominated specifications, with tight control of material quality from manufacture to construction. The loading conditions of the structure are often very accurately defined. The situation with respect to strata control is quite different.

Key issues for strata control design include:

- mining may involve deliberately failing the material and managing the hazards associated with working with a material in the process of failure
- the financial value of the activity is found in the excavated material and not in the formation of a long-term stable void. This often results in the formation of very large excavations of minimal life expectancy
- limited knowledge of the ground stress environment, as well as rock composition and engineering properties before mining
- the rock mass may be heterogeneous, anisotropic, discontinuous and porous/permeable (refer to Appendix A for *Geotechnical and mining terms*)
- the strength of the rock mass is size-dependent
- the stress environment commonly varies in terms of principal stress magnitude and direction. Also, mining itself changes the stress environment
- in situ and mining-induced stresses are often highly relative to the strength of the material, such that ground behaviour is non-linear
- changes in the stress environment alter the level of confinement and, therefore, the strength of the rock mass
- design loads may be uncertain and control of working loads may be limited.
- rock mass strength and failure may be time-dependent, particularly within a dynamic mining process (for example, gate road roof behaviour during longwall extraction).

Consequently, the application of rock mechanics principles to rock mass behaviour is not definitive. The complexity of geological environments and the simplifications and assumptions required in conceptualising and modelling these environments requires judgements to be made that are premised on knowledge, skill and experience (Galvin, 2008).

1.2 Who has duties for strata control in underground coal mines?

Who has duties for a principal mining hazard management plan?

The mine operator must prepare and implement a PMHMP for a mine if they identify a principal mining hazard is present, including strata failure:

WHS (Mines) Regulations

24 Preparation of principal mining hazard management plan (cl 628 model WHS Regs)

(1) The mine operator of a mine must prepare a principal mining hazard management plan for each principal mining hazard associated with mining operations at the mine in accordance with this clause and Schedule 1.

(details of penalty omitted)

...

In preparing the plan, the mine operator must specifically consult with workers when conducting the risk assessments:

WHS (Mines) Regulations

120 Safety role for workers in relation to principal mining hazards (cl 675Q model WHS Regs)

The mine operator of a mine must implement a safety role for the workers at the mine that enables them to contribute to:

(a) the identification under clause 23 of principal mining hazards that are relevant to the work that the workers are or will be carrying out, and

(b) the consideration of control measures for risks associated with principal mining hazards at the mine, and

(c) the consideration of control measures for risks to be managed under principal control plans, and

(d) the conduct of a review under clause 25.

(details of penalty omitted)

121 Mine operator must consult with workers (cl 675R model WHS Regs)

For the purposes of section 49 (f) of the WHS Act, the mine operator of a mine must consult with workers at the mine in relation to the following:

(a) the development, implementation and review of the safety management system for the mine,

(b) conducting risk assessments for principal mining hazard management plans,

…

Further guidance on consultation, cooperation and coordination can be found in the *NSW Code of Practice: Work health and safety consultation, cooperation and coordination.*

While the mine operator has the duty for the PMHMP for the mine, all persons conducting a business or undertaking (PCBU) have the duty to manage risks to health and safety associated with mining operations at the mine:

WHS (Mines) Regulations

9 Management of risks to health and safety (cl 617 model WHS Regs)

(1) A person conducting a business or undertaking at a mine must manage risks to health and safety associated with mining operations at the mine, in accordance with Part 3.1 of the WHS Regulation.

Note: See sections 19, 20 and 21 of the WHS Act as applicable (also see clause 4 of this Regulation and clause 9 of the WHS Regulations).

...

To meet these legislative requirements all PCBUs at the mine must consult, cooperate and coordinate with each other to carry out their duties in relation to risk-managing principal hazards:

WHS Act - Part 5 Consultation, representation and participation

Division 1 Consultation, co-operation and co-ordination between duty holders

46 Duty to consult with other duty holders

> If more than one person has a duty in relation to the same matter under this Act, each person with the duty must, so far as is reasonably practicable, consult, co-operate and co-ordinate activities with all other persons who have a duty in relation to the same matter.

General guidance on the risk management process is available in the *NSW Code of Practice: How to manage work health and safety risks.*

Finally, officers, workers and other people must satisfy their general duties under sections 27 to 29 of the WHS Act in relation to the principal mining hazard management plan and when consulted by the mine operator. Workers must comply with all reasonable instructions and cooperate with any reasonable health and safety policy or procedure (for example, procedures in relation to their safety role at the mine).

2 Overview of strata control risk management

Under clause 23 of the WHS (Mines) Regulation, the mine operator must carry out a comprehensive risk assessment for the PMHMP for strata failure and document it (refer to Chapter 6). It follows from the legislation requirements that strata control issues should be addressed on a risk management basis within an overall work health and safety legislative and management framework, incorporating a PMHMP for strata failure. The risk assessment is the basis for developing an effective PMHMP.

Strata control practice in underground coal mining has significant implications for safety and the mine operator. Risk management should be applied at a number of levels within an organisation, including strategic planning and operational roles.

Within this framework, the basic functions of mine management are to:

- plan
- do (implement)
- check (control and monitor)
- act (review and take effective corrective/remedial action where required).

For the purpose of strata control, these management functions should address and be consistent with the requirements of the PMHMP (as outlined in Chapter 6).

Clause 24 of the WHS (Mines) Regulation requires certain matters to be considered in the risk management process. It should be noted that the matters listed in Schedule 1 are generic and should be interpreted with respect to underground coal mining (for example, ‘stope’ can be regarded as a secondary extraction panel). Refer to Chapter 6.

At the mine design stage, hazards should be assessed on the basis of technical studies and experience from similar operations.

At the operating stage, there are a number of additional ways that should be used to identify hazards at the mine. These include:

- consulting with workers because they can provide valuable information about potential hazards
- conducting visual inspections of the mine, focusing on strata control
- reviewing available information, including incident and accident reports
- monitoring/instrumentation systems and analysis.

Trends or common problems may be identified from the information collected and may suggest locations or areas that are more hazardous. This could indicate a problem with the design and layout of the work area or the way work is carried out there. These trends may help to identify those areas where action is a priority.

The risk assessment does not constitute the strata failure PMHMP for the mine. However, it should be referenced throughout the strata failure PMHMP, and a copy of the most recent risk assessment must be included.

3 Identifying, assessing hazards through planning and design

There are a range of investigation and analysis methods that may be used in conducting risk assessments for the principal mining hazard required under clause 23 of the WHS (Mines) Regulations. This section outlines some planning and design methodologies commonly used individually or in combination to comprehensively risk manage strata failure hazards.

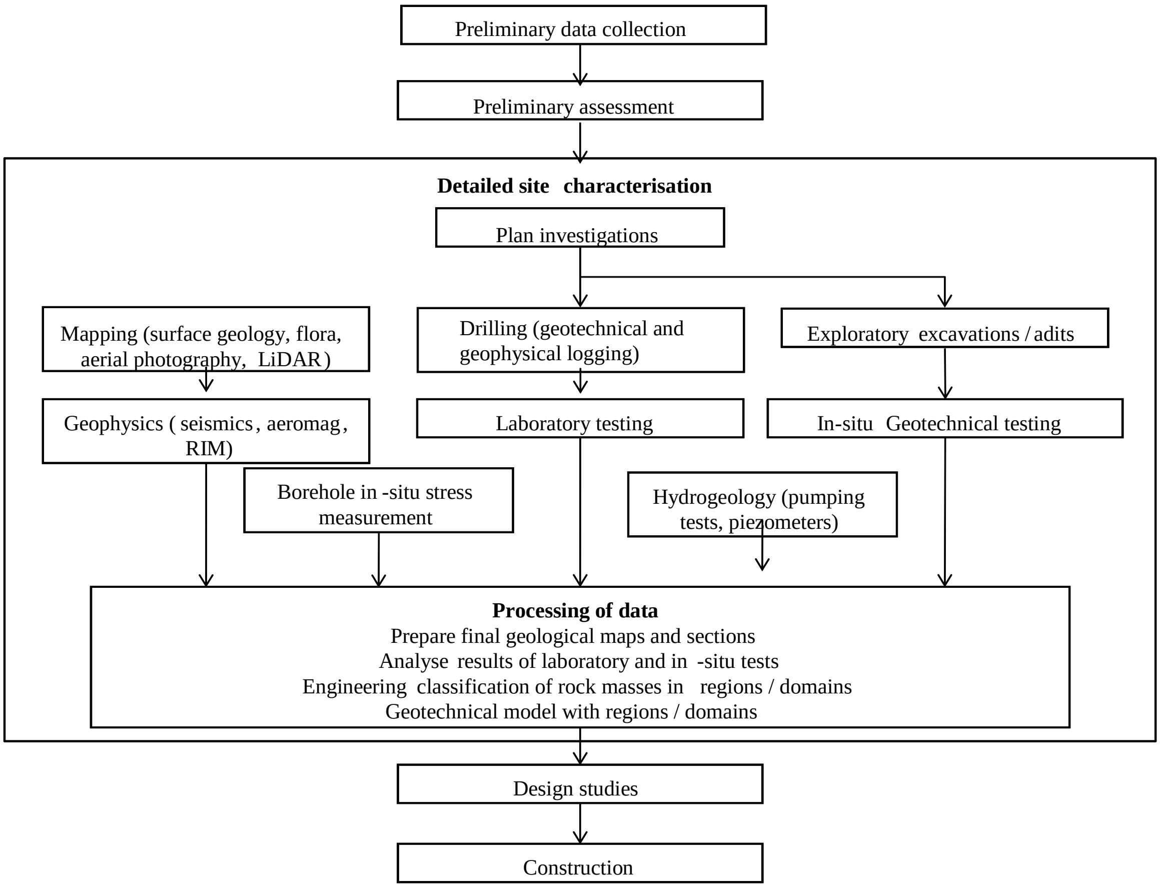
3.1 Site characterisation

From a strata-control perspective, planning may range from initial site characterisation and design as part of an assessment at the project stage, through to ongoing update and recalibration of the geological/geotechnical model (including progressive refinement of support designs) at the operating stage.

An example of the scope of a site characterisation exercise is in Figure 1. A key additional aspect of an initial characterisation and design exercise is usually a review of experiences from other local and/or equivalent mining operations. Therefore, from the outset there should be significant interaction between various technical disciplines (e.g. geologists, mining engineers, geotechnical engineers, geophysicists, surveyors and hydro-geologists).

Also, from the outset, there is a need to understand the association between the strata control design issues and other key aspects of design, including ventilation and subsidence management (noting that the latter may involve the same group of engineers).

Figure 1: Flowchart example of an initial site characterisation exercise.



Hazard identification and risk assessment are key issues from project inception, guiding the content and scope of preliminary data collection, subsequent ground characterisation exercises and the resulting design studies. As understanding of the relevant potential hazards and associated risks improves, it may guide further investigation.

Site characterisation culminates in the engineering classification of the rock mass and the development of a geotechnical model, often with identified regions or domains. The aim is to develop an adequate understanding of the physical characteristics of the rock mass (higher overburden, roof, seam(s) and floor) to undertake initial design. Characterisation requires a widely appreciable and appropriate estimate of rock mass strength that can be related to the *in situ* stress environment, such that the response of the rock mass can be predicted. For example, the coal mine roof rating, or CMRR system (Molinda and Mark, 1994), is used widely to characterise the immediate roof strata, focusing particularly on the bolted horizon. It also entails an understanding of the level of variability of the rock mass, including the impact of lithological changes and geological anomalies (for example, faults and dykes).

Rock mass classification schemes which endeavour to encapsulate the complexity and diversity of a natural rock mass in a single numerical index are attractive and offer advantages because:

- of their simplicity
- they cause rock mass properties to be evaluated in a systematic and continuous manner
- they can be calibrated to previous experience.

However, they have shortcomings and must be used with care (Galvin, 2014). In general:

- Most give little or no consideration to:
  - o the characteristics of the surrounding rock mass

  - impacts which might arise from deformation and mobilisation of the surrounding strata during mining
  - single geological features, such as an unfavourably orientated plane of weakness or a thin stratum with poor mechanical properties, the behaviour of which is the dominant factor causing structural failure.
  - stress anisotropy
  - the influence of mining direction.
- Not all of the critical factors which control ground response in a mining environment may be incorporated into the rating system. For example, the number of joint sets or the dip of joint sets.
- Adjustments which are made to account for the influence of mining are often of a subjective nature.
- The systems are suited primarily to situations where failure is controlled by sliding and rotation of intact pieces of rock at low to moderate stress levels. They do not cater for situations where failure is associated with squeezing, swelling, spalling or pressure bursts, or where failure develops progressively.
- The numerical value of the resulting rock mass index can be highly dependent on the local knowledge and experience of the person assessing the rock mass.

Hence, rock mass behaviour mechanisms and failure modes are largely ignored in rock mass classification systems and all important controlling aspects may not be fully evaluated. Two quite different rock mass structural settings or rock mass behaviour mechanisms, for example, can have the same rock mass classification index. Similarly, a change in a critical factor will not be reflected in a classification index unless this factor is explicitly included in the classification rating scheme. Caution is required, particularly with design procedures that rely on direct correlations to rock mass ratings.

Given the inherent variability of coal measures strata, the degree of confidence that can be placed in any prediction of rock mass behaviour and associated design is a function of the extent of calibration to local and industry experience, typically captured in quantified databases. As a mining project moves into the operating stage, the emphasis on site characterisation shifts to capturing practical experiences from initial development through to extraction so that design calibration may be improved. The PMHMP should provide the framework to maintain the currency of technical studies and capture the practical experiences, so that risks at the operational stage are effectively managed.

There are requirements for seismicity of the mine to be considered and any risks arising to be controlled.

WHS (Mines) Regulations

30 Mining induced seismic activity

(1) In complying with clause 9, the mine operator of a mine must manage risks to health and safety associated with mining induced seismic activity at the mine.

(2) In managing risks to health and safety associated with mining induced seismic activity at the mine, the mine operator must:

(a) ensure, so far as is reasonably practicable, that appropriate equipment and procedures are used to provide for the monitoring, recording, interpretation and analysis of data relating to seismic activity and the behaviour of the mine in respect of that activity, commensurate with the level of risk, and

(b) adopt, so far as is reasonably practicable, an effective seismic monitoring plan which contains trigger or action points to ensure that actions or procedures are undertaken on the occurrence of certain criteria specified in the plan, and

(c) ensure, so far as is reasonably practicable, that the design of the mine mitigates the damage arising from the sudden release of energy from the build-up of mining-induced stresses, and

(d) ensure, so far as is reasonably practicable, that geotechnical engineered ground support systems are installed and those systems take into account the following:

(i) the intended life of the excavation

(ii) the mining-induced stress changes and potential cycles of loading and unloading

(iii) blast vibrations during development mining and from surrounding stopes

(iv) the potential impact of voids and the management of voids

(v) the tolerance for stability problems and rehabilitation

(vi) the potential for rock burst, and

(e) ensure, so far as is reasonably practicable, that the ground support system is designed to contain events that have already been recorded or expected by appropriate modelling, allowing for an appropriate factor of safety, and

(f) ensure that, so far as is reasonably practicable, mining by remote methods is implemented when mining areas at risk of high or unpredictable seismic activity, and

(g) ensure that mine design, mining methods and sequences, ground support design and assumptions and modelling are documented and reviewed on an on-going basis and, where necessary, revised.

Most NSW coal mines do not have issues with mining-induced seismicity. There have been reports of seismic like events in areas of high vertical or horizontal stress as the energy is released at the face. The support regime at the mine should take into account this possibility and be designed to contain any such energy release.

3.2 Design

Moving from the site characterisation stage, geotechnical issues are not addressed in isolation but as part of an overall mine planning and design methodology. An appropriate sequence of activities for decision making in the geotechnical aspects of this planning process may be the following (adapted from Gale and Hebblewhite, 2005):

- layout selection with respect to total extraction, partial extraction or first workings only, including the key issue of whether the regional overburden is to be supported or allowed to collapse (goaf)
- selection of mining method
- identification of critical regional geotechnical factors (e.g. massive strata, soft strata, subsidence constraints, structural geology, stress regime and anomalies)
- collation and review of all data relevant to the geotechnical issues, including the identification of any old/other workings in the vicinity
- identification of the types of pillars required in relation to the overall mine plan
- pillar system design
- excavation and support design.

This process is often iterative as the overall mine design is optimised.

Effective risk-based design:

- is conducted by competent people
- is based on adequate input data
- uses relevant design methodologies, appropriate to the defined, specific strata control issue

- produces practical outcomes
- acknowledges the uncertainties that are intrinsic to a limited input data set and to the majority of design techniques and chooses appropriate factors of safety as well as a “monitor and react” strategy based on this uncertainty.

Effective design recognises that:

- different support functions may involve different geotechnical duties, mechanisms and associated hazards, each requiring individual assessment
- support functions and roadway serviceability requirements may change through the mining life cycle
- geotechnical design interacts with and has implications for operations and other technical disciplines (e.g. subsidence, ventilation and gas management)
- design methodologies should be readily understandable/transparent and auditable
- regardless of the methodology, there is a need for design calibration and ongoing audit/monitoring.

The designer should:

- choose a methodology appropriate to the issue
- work within the limitations of the methodology
- understand the significance of the applied parameters
- use appropriate data
- recognise the limitations and confidence levels associated with the methodology.

There are many available design methodologies and they generally fall into the following categories (Galvin, 2008):

- regulatory/legislative
- experiential/rule of thumb
- analytical
- empirical
- numerical
- hybrid.

These generic methodologies are outlined in the following sub-sections.

3.2.1 Regulatory/legislative

The WHS (Mines) Regulations require mine operators to determine if strata failure is a principal mining hazard at their mine and, if determined to be, carry out risk assessments and develop control measures with particular components and considerations (see Chapter 6).

Historically, legislative requirements commonly provide a rational basis for at least preliminary minimum design, based on long-standing experience.

However, the technical content of the legislative requirements may not be sufficient to manage all the risks of strata failure for every application and set of mining and ground conditions encountered. The designer may need to obtain additional information and carry out further risk assessments, in consultation with the mine operator. Nevertheless, the legislative requirements in NSW must be complied with.

3.2.2 Experiential/rule of thumb

The traditional application of experience and associated ‘rules of thumb’ is the oldest design methodology and the practical foundation of all later methodologies. Roof support rules have often had their origins in this methodology. Although this approach can be applied to all aspects of strata control, it should be used with caution when applied on its own. The method may be reliable if the designer can be sure that the environment and application representing the source of the experience is comparable to that of the current design issue.

This encompasses:

- mining method and layout detail (that is all geometrical aspects)
- mining equipment, rate and scale of mining (that is the time factor)
- seam geology and geotechnical properties
- roof and floor geology and geotechnical properties
- regional geological conditions
- stress environment
- groundwater environment.

It is rare for the designer to be able to state with confidence that all these conditions are comparable. Accordingly, the more appropriate applications of experiential methods are generally those involving a limited number of well-defined variables, with small increments of change involving one variable only, generally in a positive, more conservative context (e.g. the extension of a proven pillar layout into a shallower area is usually appropriate).

Not surprisingly, long-term application of experience as a sole design methodology tends to culminate in radical change subsequent to a significant unforeseen event. An example was a widespread shift from mining on 12.2 metres (40 foot) to 18.3 metres (60 foot) pillar centres at shallow South African bord and pillar mines, following the 1960 Coalbrook Colliery disaster (the first reaction of a significant proportion of the industry was to simply double the pillar width).

Significant relevant trends within the Australian coal mining industry include:

- wider longwall faces
- deeper workings
- workings in both thinner and thicker seams
- larger items of equipment requiring bigger excavations
- more multi-seam working
- more workings in weaker ground
- progressively increasing safety, environmental and production expectations
- changes in support hardware
- planning changes and constraints
- increased emphasis on training and procedures
- formalised strata management.

Some of these trends have both positive and negative connotations for strata control.

A specific aspect of experiential methods that warrants caution is the application of the results of ‘trials’, especially when such trials:

- are of limited geographical extent
- involve restricted timeframes
- involve more rigorous levels of control
- are assessed solely on the basis of simple observational methods.

Effectively, the small ‘sample’ constituted by the trial may not accurately represent the overall ‘population’ (which means the circumstances prevailing in practice across significant areas of the operating mine). However, well-designed trials, regardless of size, with correct oversight, can provide valuable information that may be useful in the design of strata control.

Against this background, experience is rarely appropriate as a sole design methodology, particularly given that better alternatives are commonly available. The most appropriate application of this methodology is usually only as a first pass estimate or 'sanity check' of other design outcomes.

3.2.3 Analytical methods

These methods apply equations developed from fundamental mechanistic or engineering principles to the analysis of rock behavior, so that when controls are applied, design outcomes can be expressed numerically (e.g. as a Factor of Safety). One of the earliest and simplest examples of analytical 'models' relates to the calculation of dead weight load and the associated design of standing support. Such methodologies tend to rely on input parameters measured in the laboratory and/or field. They can involve hand calculation, nomograms and/or spreadsheets so that the outcomes are reasonably transparent. An advantage of analytical methods is that the sensitivity of the outcome to a particular input parameter is usually easy to compute.

A disadvantage of analytical models is that it is rare for a design problem to involve one mode of behaviour or failure only. Deformation is generally more complex, with multiple potential failure modes. Also, most geotechnical design problems have input parameters that are not fully defined, either in terms of the expected value or the degree of variability. Engineering judgement is required, with some link to actual experience to provide design 'calibration'.

3.2.4 Empirical methods

These methods are design approaches and formulations developed from statistical analysis of controlled, quantified databases of experience. They are well defined and calibrated rules of thumb. The geographical extent of their validity/applicability can vary from an individual mine site to global. The use of empirical methods is common across a range of scientific disciplines and they have become the most widely applied and accepted methodologies in the field of strata control since the 1960 Coalbrook disaster led to the development of a South African coal pillar design formula (Salamon and Munro, 1967).

The advantage of empirical methods is that they use full-scale, four-dimensional models (i.e. strata behaviour in coal mines over time). As such, they draw inferences directly from reality, whereas alternative approaches draw inferences from simplified simulations of reality.

Most empirical methodologies do not rely on pure statistical correlations of conditions and associated support requirements.

Typically, there is some initial understanding of the underpinning fundamental mechanistic/engineering principles, with statistics then applied to derive critical design parameters, within such a mechanistic framework. The coal pillar strength formulae developed by Salamon and his co-workers in South Africa and later Australia (Salamon *et al*, 1996) provides an example. The methodology fixes one half of the system capacity to demand relationship (i.e. pillar strength versus pillar stress) in a deterministic fashion by assuming tributary area loading. This is a reasonable assumption given that the underpinning database is deliberately restricted to cases involving regular arrays of pillars in panels that are wide with respect to depth. Fixing pillar stress facilitates the statistical derivation of the key pillar strength parameters, with the process guided by a pre-existing understanding of the significance of geometrical relationships, such as pillar width to height ratio, as well as size (volume) dependency, founded on analytical results (i.e. laboratory and *in situ* testing of coal).

Empirical methods are reliant on credible databases, noting in particular that:

- The risk-based parameters quoted for a particular database and design system are unique to that system, and must not be applied to other applications or design equations (Gale and Hebblewhite, 2005*)*.

- An understanding of the origins, nature and limitations of the database is important. Confidence reduces towards the boundaries of the database and particular caution should be adopted in attempting to apply the results of an empirical study outside the range of the underpinning database.
- A common weakness of empirical methods is a limited database of relevant failed cases (that is unwanted outcomes), whereas successful cases are often plentiful. One issue is that the focus of design is usually the prevention, or at least minimisation, of such unwanted outcomes, with expectations from multiple stakeholders tending to mandate conservative designs. A second issue is that failures have historically often gone unreported and/or have been insufficiently documented to facilitate meaningful subsequent analysis. Relevant failed cases have a significant bearing on the ability of the designer to assess the impact of natural variability on both capacity and demand, which is the key to defining rational Factors of Safety linked to system reliability (i.e. the probability of success/failure).
- The definition of failure within the database and methodology is a paramount issue, dictating the design outcomes and associated hazards and risks.
- Should the mechanics of the problem not be fully / correctly understood when compiling the database, fundamental input parameters may be omitted, rendering extensive scatter in the output relationship.
- It follows that the compilation of extensive, reliable databases has become a major focus for strata control researchers over the past 20 years, with an increasing emphasis on industry-wide and also international experience databases. Often these provide considerable insight regarding the mechanics of a design issue, especially where the combined databases are complementary and cover gaps that might exist at a more regional level. An example is the improved understanding of coal pillar strength that developed from analyses of combined South African and Australian databases (Salamon *et al*, 1996).

3.2.5 Numerical methods

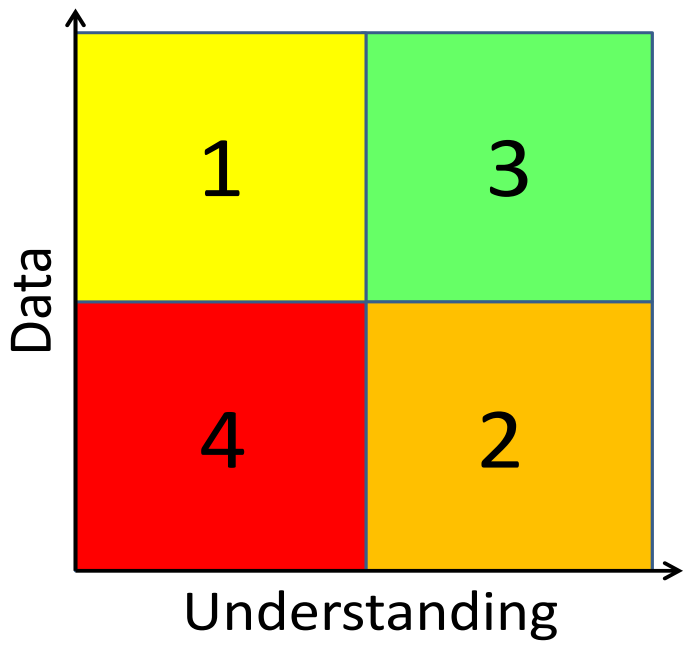
Numerical design methods involve the application of computer codes to the analysis of ground behaviour. These can range from relatively simple, two-dimensional (2D) computer codes incorporating elastic models of ground behaviour to very powerful, three-dimensional (3D) codes capable of modelling complex mining geometries, multiple failure modes, large strains and discrete block behaviour. Numerical modelling applications have grown rapidly since the 1970s as a result of enormous improvements in computer power and affordability, and significant funding in related ground control fields (i.e. military and nuclear waste engineering) resulting in the development of sophisticated codes.

The appropriateness of a numerical methodology depends on the approach adopted and the ability to estimate the relevant strength characteristics of the rock materials and mass. It is not possible to define all rock strength properties and any model is only an estimate based on available properties and experience (Gale and Hebblewhite, 2005). Numerical approaches may be hampered by the inability to accurately define rock mass properties and develop constitutive laws that fully define rock mass behaviour through to the post-failure mechanics.

The commonly recommended approach is parametric modelling, namely examining the sensitivity of ground deformation to changes in key parameters, such as rock mass strength or mining geometry. Modelling is, therefore, often comparative, aimed at assessing the role of critical parameters, rather than in a deterministic fashion focussed on deriving absolute ground behaviour. In this way, an improved understanding of the mechanics of the deformation process and the relative impact of various material properties and/or other environmental factors can be incorporated into a design.

Numerical modelling can, accordingly, be a very powerful tool for gaining information and building understanding on an issue, rather than for deriving quantified solutions. Given the sensitivity of all numerical models to the input parameters adopted, this is considered the most useful approach. Figure 2 below presents a useful classification of numerical modelling problems (Starfield and Cundall, 1988).

Figure 2: Classification of modelling problems.



The x-axis refers to the fundamental understanding of the problem, whereas the y-axis refers to the quality and / or quantity of the available data. In many other branches of mechanics, problems tend to fall into Quadrant 3, with good understanding and reliable data. In this region, numerical models can be built, validated and applied with conviction. It was argued by Starfield and Cundall that rock mechanics problems tend to fall into data-limited Quadrants 2 and 4, requiring the more experimental use of numerical models in the parametric fashion discussed earlier. Effective modelling improves the understanding of an issue, moving the problem from Quadrant 4 towards Quadrant 2. At the same time, modelling can highlight the key input parameters and ground deformation outcomes for which the data are inadequate, guiding subsequent programmes of data collection and field investigations. In this way, the problem moves more readily towards Quadrant 3.

However, in coal mine strata control, issues have often fallen into Quadrant 1, with limited understanding of the mechanics, but significant potential for data collection (Mark, 1999). A key aspect of this is that geotechnical investigations have historically tended to focus on relatively limited field measurement/monitoring exercises to achieve some form of model calibration, whereas the greatest potential source of data is experiential and/or empirical (i.e. the actual panels mined, each of which may be considered a full-scale test, with the potential for back-analysis).

The selection of a numerical code involves a high level of understanding of its capabilities and limitations, as well as the rock failure mechanics requiring simulation. Not all codes represent rock failure in the same manner or have the same capabilities with respect to multiple failure modes. Expanding computer power and more sophisticated numerical codes have helped to foster a trend towards increasingly detailed numerical models, with the aim of more accurately simulating the constitutive behaviour of the rock materials, as well as the failure mechanics of the ground.

A high level of detail may indeed be warranted for a particular issue. However, in general:

- In any major exercise, it is often preferable to develop some initial understanding of the problem on the basis of a two-dimensional simplification, as opposed to a more powerful three-dimensional approach. If the fundamental aspects of an issue cannot be understood in two-dimensions, there's usually little merit in proceeding to a three-dimensional approach.
- Relatively simple initial models often provide tests of the sensitivity of an outcome to a particular input parameter, guiding the scope and process of data collection at an early stage of the investigation.
- More detailed models require a greater understanding of the expected values and ranges of the input parameters, which may be simply unavailable.

Lack of transparency may be regarded as a drawback of numerical methods, particularly as the complexity of the model increases. This places an emphasis on:

- calibration to experience/empirical outcomes (the four-dimensional real world)
- sensitivity analysis to test the model rationale
- comparing the outcomes of alternative design methodologies.

An illustration of the application of numerical modelling to a parametric analysis of a geotechnical problem is provided by the work conducted by the University of NSW during the 1990s on soft strata environments and, in particular, claystone floor (Vasundhara, 1999). This work encompasses a program of complementary studies, including laboratory testing and fieldwork, aimed at arriving at engineered design solution.

3.2.6 Hybrid methodologies

Hybrid methods involve using elements or combinations of the approaches already described, especially for the solution of complex problems (e.g. assessing the stability of irregular pillar layouts using a combination of a numerical model for stress analysis and an empirical strength formula).

Individual methodologies tend to evolve with application and experience, incorporating outcomes or components of other relevant methodologies. Thus analytical and numerical methods are most effective when they are calibrated to actual experience and contain an empirical element. On the other hand, many empirical methods contain analytical and/or numerical elements that enhance the understanding of the physical mechanisms related to a problem.

Generally, there is more understanding and consensus regarding the relative merits of various approaches and more ‘synergy’ than in the past. Key issues often warrant the application of hybrid methodologies and/or multiple parallel approaches offering different insights, noting that some issues should not be over-simplified. The need to assess and understand the sensitivity of a key outcome to various inputs is a key aspect. Empirical, analytical and numerical methods all, in different ways, allow the sensitivity of an outcome to be tested.

3.2.7 Pillar design methodologies

A coal pillar system comprises the pillar itself, the roof and floor strata and the pillar roof and floor contacts. Pillar systems may collapse gradually and give ample warning, or suddenly to the point of being instantaneous. In general, pillar system failures initiated by roof or floor failure develop gradually. Sudden collapses are usually associated with pillar system failures involving competent roof and floor strata in which the coal pillar itself fails. Exceptions occur when low strength floor material is suddenly loaded through the pillars by massive roof failures. Sudden failures present a great hazard to workers.

The appropriateness of a design methodology depends on the functions of the pillars. In this regard, reference should be made to publications authored by Gale and Hebblewhite (2005) and Galvin (2008). Examples of pillar types and relevant methodologies are provided in Table 1 below, with an example pillar design methodology outlined in Appendix C.

Table 1: Pillar design methodologies (Gale and Hebblewhite, 2005)

Pillar type	Design Issue	Applicable Methodologies
Subsidence protection	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
Barrier pillars	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
	Abutment stress protection	Experiential
		Numerical
		Empirical – statistical
	Partition pillars	Experiential
		Numerical
Main development	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
Chain pillars	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
	Abutment stress protection	Experiential
		Numerical
		Empirical – statistical
Bord & pillar (production)	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
Fenders	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
	Abutment stress protection	Experiential
		Numerical
Yield pillars	Load bearing stability/yield	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid
Highwall web pillars	Load bearing stability	Experiential
		Numerical
		Empirical – mechanistic
		Hybrid

Note that in this table, Gale and Hebblewhite classify the empirical design methodologies according to whether or not the approach incorporated some understanding of the mechanisms associated with the design issue or was purely statistical (i.e. ‘empirical-mechanical’ versus ‘empirical-statistical’). Further development of empirical and hybrid methodologies in recent years makes such distinctions less valid, most empirical methodologies incorporate elements that involve an understanding of the mechanisms involved.

3.2.8 Roadway support design methodologies

The initial design of an effective strata (roof, ribs and occasionally floor) support system requires an understanding, from the preliminary geotechnical model, of the likely strata failure mechanisms and associated hazards. For example, failure may be limited to the immediate ‘skin’ of the roof, or may involve buckling to a significant height. Also, both the likelihood and nature of failure may change with variations in the stress environment, rock mass strength and/or in the presence of an anomaly, such as major geological structure or a seam split.

Once an understanding of the relevant failure mechanisms has been established, all of the previously outlined generic methodologies have at least some potential applicability to support design. The mine operator should determine and employ those techniques most appropriate to the mine. The initial design of roadways is of paramount importance and should be performed by a person or people with appropriate expertise and experience. The design methodologies employed should be detailed in a PMHMP, including the associated limitations, assumptions and preliminary monitoring controls.

When designing a mining layout, the purpose of the roadways should be considered along with the likely life of that roadway and the potential impact of multiple loading cycles. For example, the life of a longwall gate-road is likely to be considerably shorter than main heading roadways, but the gate-road experiences a more complex loading history. The design of a short life roadway for pillar splitting and extraction will be different to a longwall tailgate.

The effectiveness of strata control strategies should be verified. For example, a roadway may be driven on a primary support system only, with subsequent secondary or tertiary support at a later period (e.g. for longwall gate road support). The requirements and effectiveness of the support system at each stage in the process should be evaluated.

Practical experiences during and following roadway drivage will usually assist in the ‘fine-tuning’ or rationalisation of strata control measures to maintain safety. In particular, a key aspect of support design is the review or ‘back analysis’ of accident and incident data. In this way, the understanding of both the operational and technical aspects of strata control hazards improves. At the initial design stage, this may be limited to a quite general review of regional, industry and international experiences, but as local experience accumulates, this should be incorporated into the design process.

3.2.9 Secondary extraction design

Any form of secondary extraction involves a redistribution of stress and some reduction in stability, if not deliberate failure of the rock mass. In the case of longwall mining, extraction results in the formation of extensive goaf (caved) areas. In the case of pillar extraction, the designed outcomes can range from partial extraction with controlled pillar size reduction and associated increases in roof span, through to the formation of extensive goaf areas.

Key strata control issues to be considered for extraction are:

- overburden weighting windblasts, roof and floor competency, including:
    - changes in lithology
    - traversing of major structures, such as faults and dykes
    - roadway stability, including adverse horizontal stress conditions
    - interaction effects with existing workings.

The PMHMP should include provisions (especially in the design phase) for assessing the impact of stress re-distribution associated with extraction, including potential fluctuations in overburden weighting on the working area/face (cyclic or periodic weighting), abutment loading on adjacent solid/pillar areas and concentrations of horizontal stress in the roadways, along with potential failure and the strata control measures required to mitigate the threats.

At the design stage, a key task is an assessment of the caveability of the overburden, how readily both the immediate and upper roof will cave or "goaf". This should include an assessment of the potential for variability in caving behaviour and its impact.

A windblast is a sudden, mass movement of air caused by the collapse of strata that has the potential to injure people, damage equipment and/or seriously disrupt ventilation. An air velocity of 20 metres/second is considered a threshold value, above which a windblast event has occurred.

When the goaf collapse occurs, the air or gas occupying the void is displaced by rock, resulting in a pressure wave and windblast that moves along the roadways of the mine. This may be followed by an airflow reversal or 'suck back' as the air pressure is equalised with the low pressure created higher in the goaf.

When designing secondary extraction layouts, the mine operator should consider the possibility of windblast. Where windblast is a potential risk, the management of this risk should be included in the PMHMP for strata failure.

Two specific factors generally accompany their occurrence:

- The presence of a thick and massive strata unit(s) with the ability to bridge the panel and so generate the potential for large area, plate-like goaf falls.
- Inadequate 'caveable' material beneath the bridging massive unit(s), such that incomplete 'choking' of the gate ends occurs and a flow-path exists from the goaf beneath the bridging strata into the mine workings.

Other factors, such as geological anomalies (e.g. faults), may also be associated with such events.

Experiences have shown that both criteria (i.e. an extensive goaf fall and a flow-path into the workings) are required for a windblast to be a high likelihood event.

More common are significant air movements (not necessarily windblasts) in conjunction with an initial goaf fall. This is usually a single event that does not recur with further extraction. Such air movements can still be hazardous and require consideration.

3.3 Specific longwall extraction issues

In the case of longwall mining, extraction results in the formation of extensive goaf (caved) areas. For the safety of longwall workers, the control of the roof and face is of paramount importance. The strata control for longwall mining is primarily a set of hydraulic roof supports ('powered supports', 'chocks' or 'shields'). The mine operator should provide shields that are designed for the duty required. This requires consideration of the geotechnical environment, including an analysis of the significance of face width, height, web depth and tip-to-face distance, as well as operational aspects, including intended rate of retreat and operating systems. The shields should be kept in a fit for purpose state and the operators should be trained and competent for the task.

Periodic or cyclic weighting of the overburden is a potential risk to a longwall operation. Periodic weighting of longwall supports occurs during retreat of the face under certain geologic conditions. Strong, massive strata in the immediate and/or main roof tend to cantilever over the goaf, weighting the face and supports periodically.

The distance between weighting peaks, as well as the intensity of periodic weighting, is determined by the strength and thickness of roof members, their location relative to the seam, the frequency of jointing, and characteristics of the goaf. The outcomes can be roof and face deterioration with the associated potential for roof falls, as well as collapsed and pinned ('iron bound') longwall roof supports ('shields') and/or physical damage to the shields.

When designing longwall layouts, the mine operator should consider the possibility of periodic weighting. Where periodic weighting is a potential risk, the management of this risk should be included in the PMHMP for strata failure.

When recovering the longwall face there are potential hazards related to falling roof, face spall and, during shield removal, goaf flushing. Provisions should be incorporated into the PMHMP for strata failure for the measures required to mitigate the risk of these threats.

When designing roadways for the purpose of longwall recovery (‘take-off’), consideration should be given to the impact of the approaching abutment zone, which may substantially increase the loading on the roadway and associated pillar system.

3.4 Specific pillar extraction issues

Extraction causes pillar stress increases due to abutment loading. Associated hazards are increased rib spall and/or pillar collapse, windblasts, periodic weighting, premature unplanned roof failure and burials of continuous miners and other equipment due to roof falls. *MDG 1005, the NSW Trade & Investment’s Manual on Pillar Extraction in NSW Underground Coal Mines (Parts 1 and 2)* includes useful case histories of issues associated with pillar extraction.

When a panel of regularly sized standing pillars is totally extracted, the load acting on the pillars adjacent to the goaf is increased. The increase is influenced by the overall span of the goaf, the material properties of the overburden and the sequence and speed of extraction. An extreme situation can occur when the panel width is sub-critical and the super-incumbent strata span across the extracted area, resulting in minimal caving and load transfer to the goaf.

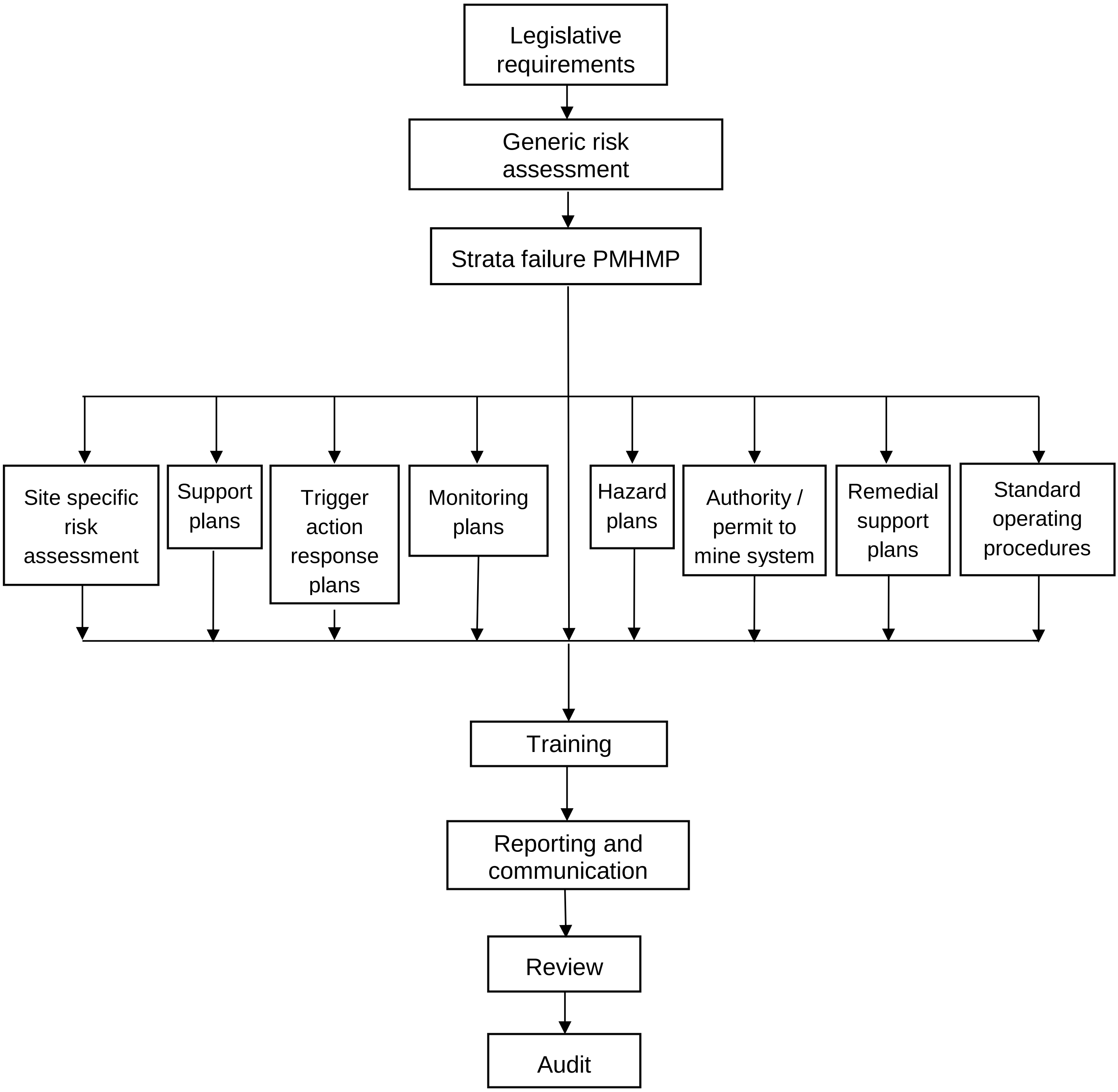
Close to the active face line, pillar load is constantly changing and is highly dependent on the rate of extraction. Periodic weighting of breaker line supports occurs under certain geologic conditions. Strong strata in the immediate and main roof tends to cantilever over the goaf, weighting the pillars and supports periodically. Again, the distance between weighting peaks, as well as the intensity of the weighting, is determined by the strength and thickness of roof members, their location relative to the seam, the frequency of jointing, the characteristics of the goaf and the panel geometry.The PMHMP should include provision for estimating the abutment loading on the pillars in the extraction area. This should particularly be so in the design phase. The potential failure and the strata control measures required to control the hazards should be included.

4 Controlling the risks and implementation

The WHS (Mines) Regulations has certain requirements for the content of the PMHMP, as listed and explained in Chapter 6.

Implementation should take place within the framework provided by a PMHMP, which formalises and links the relevant systems, standards, methods and procedures used at the mine. The typical framework for a strata failure PMHMP is shown in Figure 3, noting that this flows directly on from the site characterisation and design phase depicted in Figure 1 in section 3.1 and can be regarded as the strata control activities associated with ‘construction’ in that earlier figure.

Figure 3: Typical strata failure hazard management plan framework.



4.1 Ongoing assessment

The overall aim of the PMHMP is a process of ongoing assessment to maintain the currency/relevancy of the geotechnical model, associated support designs and controls, with appropriate changes made as and when necessary. This incorporates the following elements.

4.1.1 Estimation of the geological conditions

The PMHMP for strata failure should make provision for the ongoing estimation of the geological environment likely to be encountered.

The collection, modelling and interpretation of data are the primary means of identifying strata related hazards.

Geological information

Geological information may be obtained from the following:

- exploration boreholes – the smaller the distance is between holes increases the confidence level of the information.
- inseam boreholes
- geophysical surveying
- projection of known structures and features to future workings
- mapping, monitoring and observations of excavations and installed support
- information from other mines.

Geological mapping

Geological mapping should clearly show areas where the risk of poor mining conditions is higher than normal. For example, zones of domain change, major regional faults or dykes, plugs, sills, seam grade changes and associated stress concentrations. Plans should show areas of “normal” conditions and areas of “elevated risk”.

Some strata control measures are more appropriate to specific conditions and should be implemented in a proactive way.

Underground geological mapping should be continued during the course of development and any extraction system to delineate and describe any visible hazards to mining.

Major features (e.g. faults, dykes and shear zones), should all be mapped and presented on a plan as soon as possible after exposure following mining. Significant features should be transferred to the geological database of the mine.

The following are considered particularly significant to roadway stability:

- reverse or thrust faults
- any mid-angled structures, any structures aligned at a shallow (i.e. $<30^{o}$) angle to the roadway and
- areas where two or more geological structures intersect
- normal faults with significant displacements / throw
- dykes that have significantly altered the surrounding coal seam

This function should be allocated in the PMHMP for strata failure (usually a geologist). It should also be the function and responsibility of the mining supervisors to record any significant geological features on their shift report.

4.1.2 Geological/geotechnical data collection

A range of information should be collected to assist in developing the most effective controls. The following would provide valuable details:

Regional assessment of roof and floor lithology

The following information should be sought for typically up to 5 metres into the floor and 10 metres into the roof (noting that some circumstances may require more):

- rock types
- bed thicknesses
- variability in thicknesses, especially in the immediate roof
- bedding angles
- strength data (selected quantitative data)
- regional qualitative integrity (logging data) and rock mass quality assessment.

Coal seam integrity

- assessment of strength/friability
- cleat intensity and direction
- existence of planes of weakness.

Local structural features

- joint sets
- slickensides or greasy backs
- low angle bedding planes or 'feather' edges intersecting roof horizon
- minor faulting
    - seam, roof or floor rolls.

Regional structural features

- major faulting, dykes, sills, shear zones
- extrapolation of structures from adjacent workings, surface lineaments or other exploration input.

Stress

- review any available quantitative stress measurement data taking caution regarding its reliability and applicability
- mapping of any evidence of stress-induced features to indicate direction of dominant horizontal stress (e.g. biased roof deformation evident from preferential guttering)
- Obtain depth of cover and surface topography contours to establish significant variations in vertical stress and concentrations due to cliff lines and valley effects.

4.1.3 Mining geometry

The effect of changes to mining geometry can have a major impact on the effectiveness of strata control measures.

Mining geometry should be regarded as a variable that requires management as part of the PMHMP for strata failure.

The management of mining geometry should be considered at each of the following stages:

- design
- implementation (a supervisory or control step)
- review (monitoring actual dimensions)
- feedback.

4.1.4 Calculations and modelling

Calculating the probability of failure may involve different approaches (refer to Chapter 3).

Insofar as these records form part of the risk assessment, the records must be retained in electronic and/or written form and kept in accordance with WHS laws (refer to WHS (Mines) Regulations clauses 24(3)(d) and 133). Additionally, these and other records of calculations and modelling should also be kept in a form and for an additional period determined by the mine operator so they can be referred to if necessary in future strata stability calculations.

4.1.5 Geological and geotechnical hazard (survey) plans

The relevant identified geological and geotechnical hazards and features should be mapped onto a surveyed plan of the mine (hazard plan) and can be used as a current picture of the strata hazards in the current mine working.

Before starting each mining phase in any section, a hazard plan should be prepared showing predicted seam, roof and floor conditions along with predicted faults, dykes, structural zones and any other known or potential hazards likely to have an impact on mining.

The hazard plans should include a plan of the proposed working section to be mined and the location of known and predicted geological hazards to mining and indicate their extrapolation across the section. The locations of all surface boreholes likely to be mined should be marked on the plan. The hazard plan should be available to workers and updated regularly.

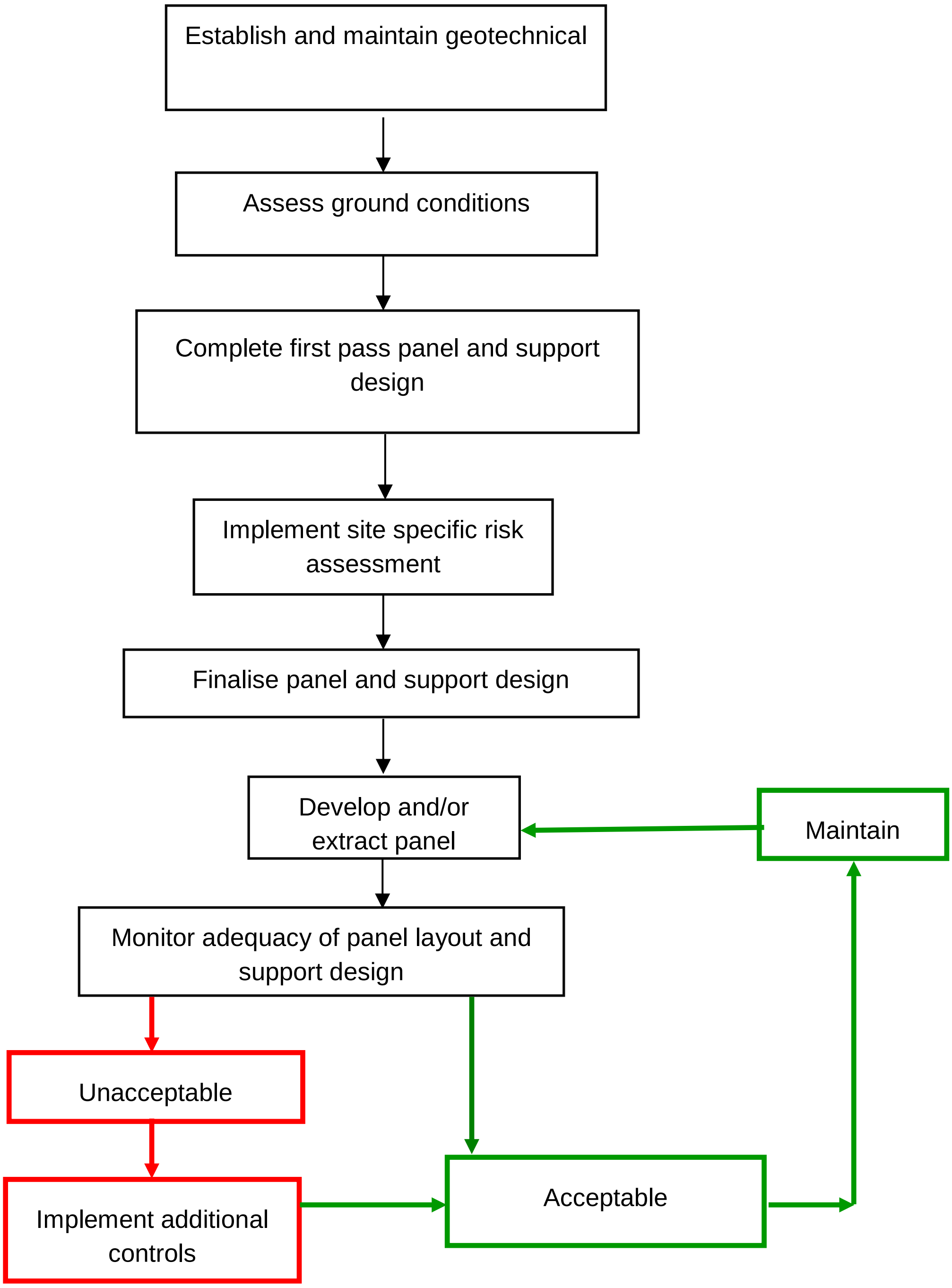
Measures/standards should be adopted in the preparation of such plans so that both the consistency of the output and a style of presentation that enables the geological and geotechnical data to be communicated effectively. An Authority/Permit to Mine System may be considered to check that the relevant information is available before mining takes place in any area. Examples of hazard (survey) plans are contained in Appendix E. An example of an Authority/Permit to Mine System is also included in Appendix F.

4.1.6 Strata control failure model and design of roadway support rules

The geotechnical model developed at the site characterisation/design stage should identify likely modes of strata deformation and failure, providing the technical foundation of the PMHMP for strata failure. This guides the development of roadway support plans and rules (see Figure 3).

The strata control process is one of panel by panel continuous improvement, incorporating investigation, design, implementation and ongoing review. The review process is illustrated by the flow chart in Figure 4 below, which operates within the overall PMHMP framework (see Figure 3) and should ultimately feed back into the geotechnical database and model.

Figure 4: Strata control model for panel design and review.



The following issues should be considered in the development of strata control support rules.

Strata control support rules

There are minimum requirements for support rules in clause 52:

WHS (Mines) Regulations

52 Ground and strata support

The mine operator of an underground mine, having an area of unsupported ground or strata that is required to be supported to ensure compliance with clause 9, must ensure that:

(a) no person enters the area at any time that there is no ground or strata support, and

(b) no person enters the area to install ground or strata support unless sufficient temporary ground or strata support is provided, and

(c) plans of the proposed support arrangements for the area are prepared and displayed in locations readily accessible to workers at the mine.

(details of penalty omitted)

…

The PMHMP for strata failure should include the preparation and distribution of support plans that clearly describe the "rules" that are to apply regarding strata. These rules, in addition to the requirements of clause 52, should cover:

- the type of support
- dimensions of the support
- locations of the varying types of supports in use
- distance between supports
- maximum distance roadways can be advanced before support is installed
- intersection support
- breakaway rules
- brushing rules
- removal of support rules
- periodic inspection and/or testing of installed support
- quality checks of support consumables
- common installation problems, indicators and fixes.

The rules should be readily understood by those installing the roadway support.

The PMHMP must clearly state that nothing shall prevent the installation of additional support, as required under schedule 1(1)(3) (see Chapter 6).

Installation of strata support

The PMHMP for strata failure should include provision for safe, effective and systematic work methods for the installation and removal of the roadway strata support (including strata support in connection with the carrying out of roof brushing operations or the recovery of plant).

The mine operator should provide adequate plant and resources to effectively install or remove the roadway support.

Any material used to install strata control support must be fit for purpose and available for workers before installation, as per clause 37 of the WHS Regulations. Important considerations are:

- ordering the correct material
- the product quality
- storage and handling that maintains the product quality (especially resins and chemical binders).

Installed strata control support must be inspected in accordance with the WHS (Mines) Regulations clauses 85(5)(g) and (h), and may be subject of additional inspections under the mine's inspection schedule. The support should also be monitored and audited regularly to ensure that it effectively controls the risks to health and safety.

The mine operator should develop procedures for installing strata support. The mine operator must consult with workers in relation to certain matters under clause 121 of the WHS (Mines) Regulations. Consultation on the procedure should include the workers whose safety may be affected by installing supports, including those workers directly carrying out the task.

Any person installing or removing strata control support should be trained and capable of performing the tasks competently to the appropriate standard identified by the mine operator, based on any legislative and mining operation requirements.

When resin anchored bolts are used, training should include:

- correct hole diameter, length and straightness (oversize hole diameter or excessive length can consume extra resin and reduce the anchorage strength)
- cleanliness of the hole (poorly flushed holes can leave a dust or slime residue on the rock surface dramatically reducing bond strength between resin and rock)
- resin mixing and nut tightening
- installing surface reinforcement tight against the rock surface (for example, plates, washers, straps, mesh)
- location of strata control support in accordance with the plan.

Oversize roadways

Introduction of bigger plant and machinery has meant that roadways are often required to be developed considerably higher and/or wider than normal main and gate roads.

Care should be exercised when designing support plans and rules for oversized roadways since small increments in width and/or height can substantially decrease the roadway's stability.

The PMHMP for strata failure should include provision for oversized roadways, including the monitoring of these roadways.

Pillar extraction production

Strata control plans and rules for pillar extraction primarily involve the installation of roof and rib support when developing the split or entry and the application of either a set of breaker line supports (BLSs) or passive supports, such as wooden props during lifting.

Mine operators should provide BLSs that are designed for the function required. The supports must be kept in a fit for purpose state, as per clause 37 of the WHS Regulation.

When using passive supports, such as wooden props, the procedure for installation and recovery, if conducted, should be included in the PMHMP for strata failure.

Where caving is planned to occur then consideration should be given to positive goaf edge control through the use of BLSs. The use of timber for goaf edge control should only be considered for partial extraction, non-caving systems.

Recovering after a fall

There should be procedures when workers are required to recover roadways or equipment. The procedures should include the strata control measures and plans/rules required to maintain control of the roof in the area where recovery work is conducted.

These general provisions should be incorporated into the PMHMP for strata failure and be supported by a specific analysis of the particular nature of the failure.

When any provision requires reinforcement support of the roof or work area, the people installing it should be supplied with support rules for the purpose. These people should be trained and competent to install such support.

4.1.7 Longwall support rules and procedures

Longwall support rules and plans should encompass:

- the configuration of the powered roof supports (commonly referred to as shields or chocks) and the face as a whole
- operating procedures and TARPs, including provisions for remedial and maintenance activities (that is activities requiring persons to work on the face side of the armoured face conveyor)
- where reinforcement/remedial support of the roof and/or face is required, specific support rules should be provided.

Some key principles for the control of cavities on the longwall face:

- keep the face straight
- keep canopies at the normal roof horizon
- maintain canopies in the correct attitude, with skin to skin contact to restrict the ingress of material from above and to prevent the canopies from ‘interlocking’
- double chock through cavities. This restricts material inflow and increases the support density when the roof is being caught, or where heavy face spall has occurred.
- turn off the automated setting system in cavities, to prevent jack-knifing and losing tip contact
- use base lift to overcome debris in front of the pontoons, which can build up and restrict shield advance, creating bends on the face
- keep cutting at the correct horizon to establish a lip. Use the ‘tip-up’ feature to get under the lip and provide maximum tip set load, even when the legs cannot be pressurised
- reactivate automated setting system as soon as possible, once the roof is caught
- as far as is practicable, keep the conveyor system running
- use TARPS with triggers for appropriate actions in cavity/poor roof situations, including criteria for stopping the face. Actions should include planned early application of remedial support, such as consolidation techniques (e.g. polyurethane ‘PUR’) and foam fill
- in known poor ground conditions, specialist remedial support/ground injection resources should be readily available
- in difficult conditions, establish a cyclic regime of (a) consolidation/remedial support and (b) cutting set distances, until the roof is re-established.

5 Monitoring, audit, review and notifications

5.1 Monitoring

Monitoring the response of the strata to mining excavation and subsequent installation of active or passive support is a key part of a PMHMP for strata failure. Monitoring is intended to avoid a ground or strata failure event by identifying any indication of potential problems, including changes to the hazard, hazard-related conditions or the effectiveness of controls. Monitoring should include areas that are not part of the day-to-day mining operations of the mine.

The mine operator should provide for:

- establishing the type, extent and frequency of monitoring of strata behaviour and installed support
- strata monitoring devices such as “tell tales”, so that roof behaviour trends can be readily defined. The installation and monitoring of devices requires training of the workforce
- requirements for ongoing monitoring should be formalised into a TARP (see section 5.2 below)
- investigation of any abnormalities in the monitoring results
- monitoring the quantity and quality of available support materials, with storage conditions to maintain material quality
- communicating any significant changes to plans to the workforce.

The mine’s inspection schedule should contribute significantly toward monitoring the effectiveness of strata control support.

The hazard management plan for strata failure should also include actions to be taken when established trigger points are reached. Trigger points may include:

- changes in the behaviour of the strata, for example, overbreaks/cavities, opening of joints, excavating outside of defined height and width limits
- changes in behaviour of established roadways, for example, roof buckling, damage to supported roof and ribs, spalling
- reaching a pre-determined threshold for the monitoring devices.

Indicators will be selected on the basis that they will give early warning of an increased risk from the hazard. They may be either monitoring of the hazard (for example, tell tales) or monitoring of the controls (for example, bolt pull test).

Each indicator should have individual triggers and specific response plans, which may mean that one or more TARP documents for a hazard may be developed (see below 5.2 Trigger action response plans (TARPs)).

5.2 TARPs

A TARP may be effective method to use for monitoring. It is widely used in the Australian mining industry. This management tool summarises the overall monitoring arrangements, but also adds actions to be taken when certain triggers are reached. If used, it should be developed after deciding on the control measures and monitoring requirements, including indicators relevant to the hazards.

The important factors to be considered in TARPs development include:

- simplicity – easily understood triggers designed for the workers who are expected to identify them
- clear linkage – the actions required to be taken are linked to, and appropriate to, the trigger that initiates the action

- clear accountability – the actions are assigned to a position that has the authority to take the appropriate actions and that is available in an appropriate timeframe to take that action
- communication – there is a clear line of communication between relevant mining workers (such as operators, engineers and so on) and also between shifts
- monitoring frequency – risks may change during the mining cycle and this should be reflected in monitoring frequencies and triggers for each phase of the cycle
- escalation – there are escalating actions linked to deteriorating conditions (generally including ceasing mining and evacuation at the higher trigger levels)
- focus on significant items – most hazards are influenced by a number of variables and TARPs may try to cover too many parameters, leading to confusion. The TARP should focus on the most significant items, rather than trying to cover all eventualities.

The overall advantage of developing a TARP is that it provides a summary of the considered and planned early responses if monitoring has indicated that a deteriorating trend exists and it has heightened the risk of strata failure occurring, or that planned controls are not in place or operable. As part of this, TARPs prevent ‘normalisation’, which is the effect of accepting a slow deterioration of any indicator as normal because it is not much different from day to day. This can delay the decision-making process until the hazard is out of control.

For TARPs to be effective all relevant people should be required to demonstrate they understand the triggers and actions in order for effective monitoring (and evacuation if required) to occur.

The following are regarded as particular issues for strata control TARPs.

Simplicity

The TARP should be based on simple visual triggers (e.g. height of guttering, roof sag, faults and joint swarms) with commonly understood language, employing brevity and colour coding.

Key geotechnical ‘drivers’

Strata behaviour is influenced by a number of variables and TARPs should focus on the significant ones.

Roadway stability at any given mine site is often primarily reflected by only one or two geotechnical variables. At depths of typically 400 to 500 metres, the main geotechnical driver is horizontal stress and the TARP process should focus on the height of guttering. Alternatively, where geological structure has a more destructive influence on conditions, TARPs should focus on guttering/cavity height and geological structure.

Empowerment

Depending on the ground conditions, the TARP should empower workers to:

- install more support
- install roof monitoring
- reassess conditions with a supervisor, and/or
- where necessary, stop mining.

The TARP should also stipulate authority levels for a reduction in the level of support.

Monitoring

Recent advances in monitoring equipment and data processing software help operators and engineers to assess and manage strata support. The monitoring scheme should reflect the level of hazard associated with specific excavations, according to the strata conditions. Widened roadways and other critical excavations (e.g. for longwall recovery) should be a particular focus of monitoring. Hazards will tend to change during the mining cycle and this should be reflected in monitoring frequencies and triggers (e.g. on drivage, due to widening and/or due to stress changes associated with extraction).

Monitoring triggers should involve both displacement magnitudes and displacement rates.

Example TARPs

Example TARPs are contained in Appendix G. See 'How to use this code of practice' in Scope and Application regarding the relevance of these examples. For the purpose of anonymity, some TARP identifying details have been omitted.

5.3 Audit

The mine operator must carry out audits of the strata failure hazard management plan, as part of the safety management system, under the WHS (Mines) Regulations:

WHS (Mines) Regulations

15 Performance standards and audit (cl 623 model WHS Regs)

The safety management system for a mine must include the following:

(a) performance standards for measuring the effectiveness of all aspects of the safety management system that:

(i) are sufficiently detailed to show how the mine operator will ensure the effectiveness of the safety management system, and

(ii) include steps to be taken to continually improve the safety management system,

(b) the way in which the performance standards are to be met,

(c) a system for auditing the effectiveness of the safety management system for the mine against the performance standards, including the methods, frequency and results of the audit process.

The primary purpose of the audit is to determine whether the controls for strata failure hazard management plan are in place and measure their effectiveness, as required in clause 15(c) above. Aspects of the PMHMP that may be audited include whether:

- mine workers understand their responsibilities and carry them out
- training and testing has been carried out, for example in accordance with the PMHMP
- plant required is fit for purpose, available and maintained, including any monitoring equipment
- inspections specified have been carried out
- corrective actions have been carried out, such as a predefined response to a trigger under a TARP
- corrective actions have been carried out
- any required reports have been completed.

The audit will provide information regarding how well the plan is being maintained.

The mine operator should develop an audit plan for inclusion in the safety management system, which requires the PMHMP to be audited. The audit plan should include, in addition to the matters that must be addressed in the SMS under clause 15(c) above, the following:

- scope of the audit
- competency of the auditor
- those responsible to ensure the audit is conducted
- reporting protocol for the audit
- those responsible for acting on audit reports.

One performance standard that should be included in the audit plan is for the audit to find 100% compliance with legislation.

5.4 Review

The mine operator must review the strata failure hazard management plan, in accordance with the WHS (Mines) Regulations:

> **WHS (Mines) Regulations**
>
> **25 Review** (cl 629 model WHS Regs)
>
> (1) The mine operator of a mine must ensure that a principal mining hazard management plan is reviewed and as necessary revised if a risk control measure specified in the plan is revised under clause 38 of the WHS Regulations or clause 10 of this Regulation.
>
> (details of penalty omitted)
>
> **Note:** A principal mining hazard management plan is part of the safety management system for a mine (see clause 14 (1) (c) (i)), which must be audited under clause 15, maintained under clause 16 and reviewed and as necessary revised under clause 17.
>
> (2) If a principal mining hazard management plan is revised, the mine operator must record the revisions, including any revision of a risk assessment, in writing in the plan.
>
> (details of penalty omitted)

The purpose of the review is to identify if the strata failure management plan is effective in managing the strata failure hazards and how it may be improved.

The PMHMP for ground or strata failure must also be reviewed as part of the safety management system for the mine:

> **NSW WHS (Mines) Regulations**
>
> **17 Review (cl 625 model WHS Regs)**
>
> (1) The mine operator of a mine must ensure that the safety management system for the mine is reviewed within 12 months of the commencement of mining operations at the mine and at least once every 3 years after that to ensure it remains effective.
>
> (details of penalty omitted)
>
> (2) In addition, if a control measure is revised under clause 38 of the WHS Regulations or clause 10 of this Regulation, the mine operator must ensure that the safety management system for the mine is reviewed and as necessary revised in relation to all aspects of risk control addressed by the revised control measure.
>
> (details of penalty omitted)

In the first part of the review, the process should examine the underpinning risk-assessment to see if it is still appropriate to the hazards at the mine.

In undertaking the review, workers and their health and safety representatives at the mine must be consulted and the following questions should be considered:

- Is the risk of strata failure adequately managed?
- Are the control measures working effectively in both their design and operation?
- Are the relevant workers aware of the control measures and do they understand them?
- How effective is the risk-assessment process? Are all hazards being identified?

- Have new work methods or equipment been introduced to make the job safer? What is their impact on existing hazards, risks and control measures? Are safety procedures being followed?
- Has instruction and training provided to workers been successful?
- If new legislation or new information becomes available, does it warrant a review of current controls?
- What has been industry experience with strata failure since the last review?
- have any incidents occurred in relation to strata failure at the mine or other mines and what are the outcomes/trends identified from them?
- What is the current industry best practice for compliance and whether any activities have been benchmarked against them?
- Have there been technological advances made that may be of assistance in managing the risks of strata failure?
- Have there been any industry publications or technical reports published that may assist in the management of the hazards of strata failure?

If problems are found, the mine operator should revisit relevant points in the risk management process, review the information and make further decisions about risk control.

In compliance with the above clause 25 of the WHS (Mines) Regulations, reviews of the PMHMP for strata failure must be made during the course of mining if a risk control measure is reviewed under clause 38 of the WHS Regulations or clause 10 of the WHS (Mines) Regulation. For example, when any new relevant hazards or risks are identified, or before a change to the workplace itself or a system or work that is likely to give rise to a different risk that the measure may not effectively control, or where the control measure does not control the risk so far as is reasonably practicable. In relation to strata in particular, such relevant circumstances may include:

- a significant deviation from the assumptions or expected conditions
- major changes to roadway dimensions or mine layout are to occur
- new options for support or mining methods being implemented
- a major roof, rib, floor or pillar failure incident occurs (Note: any high potential or notifiable incident must result in a review of the relevant controls and as necessary revise, including any PMHMP, such as for a matter like this).

Following the completion of mining in a section of the mine, a review should be undertaken. A review can determine if actual hazards aligned with prediction models.

5.5 Record and report strata failures

The WHS (Mines) Act and WHS (Mines) Regulations makes provision for PCBUs at a mine to notify the regulator of certain events and activities.

Under WHS (Mines) Act section 15 there is a requirement to notify of a dangerous incident as listed in WHS (Mines) Regulations clause 179. These notifications are to be by the fastest possible means. The person giving the notice and each person with management and control of the workplace (or relevant part thereof) is under a duty to preserve the incident site until released by an inspector.

WHS (Mines) Regulations

179 Dangerous incidents

For the purposes of section 14 (c) of the WHS (Mines) Act, each of the following is prescribed as a dangerous incident:

(a) an incident in relation to a workplace that exposes a worker or any other person to a serious risk to a person's health or safety emanating from an immediate or imminent exposure to:

…

(v) the fall or release from a height of any plant, substance or thing, or

…

(viii) the collapse or failure of an excavation or of any shoring supporting an excavation, or

…

(xvi) a failure of ground, or of slope stability control measures, or

(xvii) rock falls, instability of cliffs, steep slopes or natural dams, occurrence of sinkholes, development of surface cracking or deformations or release of gas at surface, due to subsidence,

…

(d) any initial indication that any underground part of a coal mine is subject to windblast, outbursts or spontaneous combustion,

...

Under clause 128 of the WHS (Mines) Regulations there is a requirement to notify of a high potential incident as detailed in part below. These notifications are to be in writing and made as soon as reasonably practicable after becoming aware of the incident (but not more than 7 days, or 48 hours if it resulted in injury or illness). There is no requirement for site preservation.

WHS (Mines) Regulations

128 Duty to notify regulator of certain incidents (cl 675V model WHS Regs)

(5) In this clause:

high potential incident means any of the following:

(a) an event referred to in clause 179 (a) (i)–(xviii) that would have been a dangerous incident if a person were reasonably in the vicinity at the time when the incident or event occurred and in usual circumstances a person could have been in that vicinity at that time,

…

(c) an unplanned fall of ground, roof or sides that impedes passage, extends beyond the bolted zone or disrupts production or ventilation,

(d) a failure of ground support where persons could potentially have been present,

(e) the burial of machinery such that it cannot be recovered under its own tractive effort,

(f) progressive pillar failure or creep,

(g) a sudden pillar collapse,

…

(m) any indication from monitoring data of the development of subsidence which may result in any incident referred to in clause 179(a)(xvi) or (xvii),

…

There are several high risk activities that are required to be notified to the regulator before the activity commences. Clause 33 of the WHS (Mines) Regulations specifies the basic information to be provided for every activity and Schedule 3 specifies the additional details to be provided and the waiting periods for each individual activity. The activities that are particularly relevant to strata management from Schedule 3 Part 3 Underground coal mines (high risk activities) are:

- Driving underground roadway that is wider than 5.5 metres
- Widening underground roadway to more than 5.5 metres
- Formation of non-conforming pillars
- Secondary extraction or pillar extraction, splitting or reduction
- Shallow depth of cover mining

See Schedule 3 for full details.

6 Strata failure hazard management plan contents

6.1 Legislated content

The WHS Regulations require the mine operator to prepare a principal mining hazard management plan, as set out below in the greyed part of the table below. In the table's unshaded column is guidance on what details may be written in order to fulfil the legislated requirements:

24 Preparation of principal mining hazard management plan (cl 628 model WHS Regs)	**Guidance on what may be included in the plan details to satisfy the legislation**
(1) The mine operator of a mine must prepare a principal mining hazard management plan for each principal mining hazard associated with mining operations at the mine in accordance with this clause and Schedule 1.	A mine operator must prepare a plan for each principal mining hazard. The level of detail in the plan will depend on the nature, complexity, location and risks of the mining operations (refer clause 14(2) for the mine safety management system, of which PMHMP is an element). Ground or strata failure is a principal mining hazard at all underground coal mines (refer to meaning of principal mining hazard in clause 5). The contents of Schedule 1 for Ground or strata failure are set out in section 6.2 below for statutory requirements to be considered in developing controls for the PMHMP. The terms used apply to coal and non-coal mines, surface and underground, but in context of the scope of this code, should be read in a general sense as applying to coal mines.
(2) A principal mining hazard management plan must:	
(a) provide for the management of all aspects of risk control in relation to the principal mining hazard, and	A summary of how the controls identified in the risk-assessment will be managed to control the principal mining hazard. This may include the management functions of planning, doing, acting and checking. The activities involved may include at least consulting with workers, organising resources, training, audits and reviews.

24 Preparation of principal mining hazard management plan (cl 628 model WHS Regs)	**Guidance on what may be included in the plan details to satisfy the legislation**
(b) so far as is reasonably practicable, be set out and expressed in a way that is readily understandable by persons who use it.	The plan may be read and used in part or in full by people, so each part of it should be complete and appropriate for the potential needs. The use of headings, diagrams and common words may help understanding.
(3) A principal mining hazard management plan must: (a) describe the nature of the principal mining hazard to which the plan relates, and	This is a description of the principal hazard and how it may occur at the mine. For example, a potential hazard may be periodic weighting, pillar failure or rib failure.
(b) describe how the principal mining hazard relates to other hazards associated with mining operations at the mine, and	How the principal mining hazard affects other hazards and the nature of their relationship should be described so that this understanding is used as an ongoing consideration in managing their interactions, for example, the design of barriers for inrush control.
(c) describe the analysis methods used in identifying the principal mining hazard to which the plan relates, and	State the hazard identification technique(s) that will be used (if it is a general one, nominate this and/or its source), who will be involved (for example workers) and resources to be used (for example codes, technical publications), and the specific mine data used to identify the potential hazards from strata failure.
(d) include a record of the most recent risk assessment conducted in relation to the principal mining hazard, and	Records of the risk assessment must be included in the PMHMP. The record may be placed in one or more documents that make up the PMHMP, which may cross reference documents within the plan.
(e) describe the investigation and analysis methods used in determining the control measures to be implemented, and	State the risk management technique(s) that will be used (if it is a general one, nominate this and/or its source) to develop the control measures
(f) describe all control measures to be implemented to manage risks to health and safety associated with the principal mining hazard, and	List the control measures so the reader gains an overall understanding of what is to be implemented, but specific details and implementation may be referenced to separate documents, such as procedures. The mine operator may consider providing summary details for risk assessment of the individual and cumulative effects of strata failure hazards. The details should also include assessment of the interaction with other related hazards at the mine under

24 Preparation of principal mining hazard management plan (cl 628 model WHS Regs)	**Guidance on what may be included in the plan details to satisfy the legislation**
	clause 23(3)(b).
(g) describe the arrangements in place for providing the information, training and instruction required by clause 39 of the WHS Regulations in relation to the principal mining hazard, and	Clause 39 of the WHS Regulations is titled *Provision of information, training and instruction* and requires a PCBU to ensure it is suitable and adequate, depending on the nature and risks of the work, and control measures to be implemented. The plan should address how the mine operator will communicate and deliver the arrangements to the workers exposed to the principal mining hazard. For example, maintaining a training register.
(h) refer to any design principles, engineering standards and technical standards relied on for control measures for the principal mining hazard, and	These may be identified in the risk-assessment. They should be listed and how/where they can be accessed.
(i) set out the reasons for adopting or rejecting each control measure considered.	These may be stated in a summary in the plan and risk-assessment records referenced.

6.2 Considerations

Clause 24(1) requires the matters in Schedule 1 to be considered in the preparation of the PMHMP:

WHS (Mines) Regulations Schedule 1 Principal mining hazard management plans — additional matters to be considered

(Clause 24) (Sch 19 model WHS Regs)

1 Ground or strata instability

(1) The following matters must be considered in developing the control measures to manage the risks of ground or strata failure:

(a) the local geological structure,

(b) the local hydrogeological environment, including surface and ground water,

(c) the means by which water may enter the mine, and the procedures for removing water from the mine and the effect that those procedures have on rock stability over time,

(d) the geotechnical characteristics of the rocks and soil, including the effects of time, oxidation and water on rock support and stability,

(e) the timing of installation of ground and strata support for the mine, taking into account the geotechnical conditions and behaviour of the rocks and soil,

(f) the collection, analysis and interpretation of relevant geotechnical data, including the monitoring of openings and excavations,

(g) any natural or induced seismic activity,

(h) the equipment and procedures used to record, interpret and analyse data from the monitoring of seismic activity,

(i) the location and loadings from existing or proposed mine infrastructure such as waste dumps, tailings storage, haul roads and mine facilities,

(j) any previously excavated or abandoned workings,

(k) the proposed and existing mining operations, including the nature and number of excavations, the number and size of permanent or temporary voids or openings, backfilling of mined areas and stopes, abutments, periodic weighting and windblast or airblast,

(l) the proposed blasting activities (including the design, control and monitoring of each blast),

(m) the design, layout, operation, construction and maintenance of any dump, stockpile or emplacement area at the mine, including any open cut dumps or stockpiles,

(n) the filling requirements for mined areas and the material to be used as fill,

(o) the stability of any slopes,

(p) the size and geometry of the mine’s openings,

(q) the use of appropriate equipment and procedures for scaling,

(r) the design, installation and quality of rock support and reinforcement,

(s) the need to monitor areas at or around the mine where control measures are in place for the principal mining hazard of ground or strata failure,

(t) in the case of an underground mine, the stope and pillar dimensions,

(u) in the case of an underground coal mine, the strata support requirements for the mine and the pillar strength and stability required to provide that support and the probability of instability of any pillar taking into account the pillar's role,

(v) in the case of highwall mining, pillar and highwall support, the interaction of persons and plant.

(2) In determining the strata support requirements under subclause (1) (u), the maximum width between pillars and the minimum possible dimension of any such pillar for each part of the mine are to be included in the principal mining hazard management plan along with the calculations used to determine those matters.

(3) A principal mining hazard management plan that addresses ground and strata support is to include a statement that makes clear that any requirements in the plan for ground and strata support are a minimum requirement only and additional strata support such as more frequent rock bolt installations is always permitted.

When developing the PMHMP the mine operator should also cover in the plan the related following matters:

1. determine and define the functions and responsibility of person(s) at the mine who will develop and implement the hazard management plan for strata failure
2. estimation of the geological conditions likely to be encountered
3. assessment of the stability of roadways to be developed in those geological conditions
4. recording of geological conditions that may affect roadway stability
5. development of support measures that will provide roadway stability in those geological conditions
6. calculations (including maximum roadway width and height)
7. other information necessary to enable an employee to install support according to the requirements of the PMHMP
8. safe, effective and systematic work methods for the installation and subsequent removal (when required) of the roadway support (including support in connection with the carrying out of roof brushing operations or the recovery of plant)
9. availability of adequate plant and resources to effectively install or remove the roadway support
10. provision for monitoring, including referencing documentation such as TARPs
11. audit, review and change management of the PMHMP for strata failure including the performance of the design and support to verify its continuing adequacy,
12. recording of strata failures that have the potential to cause serious injury to people (whether as part of, or separate to, any procedure for recording notifiable incidents or as part of a review of control measures), including the mining activity and proximity at time of failure and any other conditions considered of relevance to the failure
13. a description of the following features and any special provision made for them:

- any multi-seam workings
- any mining that has the potential to cause windblast or rapid stress change
- any mining at shallow depths
- any slender coal pillars

14. training of workers in strata behaviour and control, including but not limited to failure mechanisms, basic geology, support design principles, support plan interpretation, placement and removal of support, understanding the need for and the importance of the various support systems and recognition of indicators of change that may affect roadway

stability, such as TARPs (refer to clause 104 'Duty to provide information, training and instruction' of WHS (Mines) Regulations)

15. a prohibition on mining in any place at the coal operation unless there is sufficient support for the place in accordance with the requirements of the PMHMP,
16. reference to work method statements and TARPs.

Clause 52 of the WHS (Mines) Regulations requires the minor operator to prepare plans of the proposed support arrangements and display such support plans in locations readily accessible to workers. Support plans should include the following:

- type of support
- dimensions of the support
- locations where there are varying types of supports in use
- distance between supports
- the maximum distance roadways can be advanced before support is installed
- the means of roadway support required to be installed in a manner such that they may be readily understood by those required to install the roadway support.

Appendix D contains samples of support plans. Please see 'How to use this code of practice' in Scope and Application regarding the relevance of these samples.

The mine operator must ensure that no person enters an area with unsupported ground or strata (where there is a risk to health and safety) unless the person does so for the purpose of erecting support, in which case sufficient temporary support should be provided.

References

Codes of practice

- *NSW code of practice: Safety management systems in mining*, NSW Trade & Investment

  www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/legislation/whs-mines/consultation

- *NSW code of practice: How to manage work health and safety risks*, NSW WorkCover

  www.workcover.nsw.gov.au/formspublications/publications/Documents/how-manage-work-health-safety-risks-code-of-practice-3565.pdf

- *NSW code of practice: Work health and safety consultation, co-operation and co-ordination*, NSW WorkCover

  www.workcover.nsw.gov.au/formspublications/publications/Documents/whs-consultation-cooperation-coordination-code-of-practice-3568.pdf

Documents that do not form part of the code

Below is a list of some published documents that may be useful to refer to in the management of ground and strata failure hazards in mines. These documents, whether or not referred to in the text of this Code, do **not** form part of this Code.

Please note the list below is not an exhaustive list of references that may be relevant to ground and strata failure management, and compliance with any one or more of the following documents does not guarantee compliance with WHS laws.

These documents provide useful information that persons may refer to so as to possibly support their compliance for Work Health and Safety legislation involving ground and strata management in mines.

Brady, B. H. G., & Brown, E. T. (2006). *Rock Mechanics for Underground Mining* (Third edition). Cordrecht: Springer.

Gale, W. and Hebblewhite, B. (2005*). Systems Approach to Pillar Design. Module 1: Pillar Design Procedures*. Final Report on ACARP Project No. C9018 (Volume 1 of 3).

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NSW Mining Design Guideline, MDG 1003 – *Windblast Guideline*, NSW Trade & Investment (2007).

www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/publications/mdg

NSW Mining Design Guideline, MDG 1005 *Manual on pillar extraction in NSW underground coal mines part 1 of 2,* NSW Trade & Investment www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/publications/mdg

NSW Mining Design Guideline, MDG 1005 *Manual on pillar extraction in NSW underground coal mines part 2 of 2*, NSW Trade & Investment www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/publications/mdg

NSW Trade & Investment International Mining Fatality Review-Database www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/publications/statistical-publications/international-mining-fatality-review].

Pells, P. J. N. (2008, April). What Happened to the Mechanics in Rock Mechanics and the Geology in Engineering Geology? Paper presented at the 6th Int. Sym Ground Control in Mining and Civil Engineering Construction, Capetown.

Salamon, M.D.G. and Munro, A.H. (1967). A Method of Designing Bord and Pillar Workings. Journal of the South African Institute of Mining and Metallurgy, V68.

Salamon, M.D.G., Galvin, J.M., Hocking, G. and Anderson, I. (1996). Coal Pillar Strength from Back Calculation. Research Report RP 1/96, Joint Coal Board Strata Control for Mine Design Project.

Starfield, A.M. and Cundall, P.A. (1988). Towards a Methodology for Rock Mechanics Modelling. International Journal of Rock Mechanics, Mining Science and Geomechanics, Vol. 25, No.3, pp. 99 - 106.

Vasundhara (1999). Engineered Mine Design in Soft Strata Environments – Geomechanical Behaviour of Soft Floor Strata in Underground Coal Mines. Final Report on ACARP Project No. C4026.

Appendix A - Geotechnical and mining terms

Abutment stress – mining-induced concentration of sub-vertical stress on the pillars or solid coal adjacent to an excavation.

Arching – historical term for the transfer of rock stress or load from an active mining area to adjacent pillars / solid areas, commonly associated with excavation dimensions that are small relative to depth.

Bedding planes – typically sub-horizontal planes of weakness in the rock formed by a change in the deposition of minerals under water.

Buckling – deformation of a beam or column due to axial loading.

Bump – dynamic, uncontrolled release of stored energy (associated with pillar/strata loading), which can cause fragmentation of coal and violent expulsion of failed material.

Cable bolt – generic term for a flexible multi-strand tendon longer than conventional roof bolts.

Cavity – unplanned increase in the height of an excavation due to failure of the immediate roof material.

Cleat – natural sub-vertical fractures in coal. There is generally a primary and secondary cleat direction.

Competent Person – a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task (for full definition see clause 5 of the WHS Regulations).

Compressive stress – ~~a~~ stress causing shortening / clamping, which tends to hold the rock mass together. The state of stress commonly found in the rock mass before mining.

Consolidation – injection of the strata with a cementitious or resin product (for example polyurethane ‘PUR’), generally to improve the strength of a highly fractured rock mass.

Creep – time-dependent deformation.

Dip – angle between a plane and the horizontal.

Discontinuity – generic term for natural or mining-induced planes of weakness in the rock mass (for example joints, slips, cutters, bedding planes, etc.)

Dowel – an un-tensioned rock bolt.

Dyke – an igneous sub-vertical intrusion into the rock mass

Elastic – capable of sustaining stress without permanent deformation, tending to return to its original shape or state when the applied stress is removed.

Empirical – relying on or gained from experiment or observation. Empirical methods are design approaches and formulations developed from statistical analysis of controlled, quantified databases of experience.

Fault – a naturally occurring plane or zone of weakness in the rock along which there has been movement. Faults are characterised by the direction and magnitude of relative movement between their surfaces, with terms such as normal, thrust and strike-slip being applied. The magnitude of displacement may not be indicative of the degree of instability; a small thrust fault can be more of a hazard than a large displacement normal fault.

Fill – a material used either for support or to fill voids.

Friable – easily broken up or crumbled.

Geological structure – general term that describes the arrangement of rock formations including folds, joints, faults, bedding planes and other natural planes of weakness in rock.

Geology – the scientific study of the Earth, the rock of which it is composed and the changes which it has undergone or is undergoing.

Goaf – the extracted area associated with a longwall or pillar extraction system.

Heterogeneous – a variable material.

Homogenous – a consistent material.

Induced stress – the change in stress due to mining. The induced stress depends on the level of the in-situ stress and the shape, size and orientation of the excavation.

In-situ (or ‘virgin’) stress – the stress within the rock mass before mining has altered the stress field.

Instability – a condition resulting from failure of the intact rock material or geological structure in the rock mass.

Isotropic – having the same physical properties in all directions.

Joint – a naturally occurring, non-bedding, discontinuity or break in the rock. Joints may show limited evidence of movement due to stress change.

Panel review – a review of strata control performance of a panel against the expected outcomes.

Passive support – support elements offering negligible active reinforcement to the rock mass, but rather relying on strata movement to generate support load and therefore a resistance. Support elements may be internal (that is non-tensioned dowels), but are largely external and applied to the excavation surface to limit movement (for example timber props, cribs and ‘Cans’).

Pillar – an area of coal left to support the overlying rock.

Pillar (barrier) – solid pillar, or region of large pillars, providing regional load-bearing support and/or a separation to protect roadways from the effects of stress concentrations due to adjacent extraction. Other functions may include water and spontaneous combustion control.

Pillar (chain) – pillar formed during gate road drivage. Their primary function is usually maintaining gate road serviceability under the influence of stress concentrations due to longwall extraction. Other functions may include subsidence, water and spontaneous combustion control.

Pillar (mains) – pillars formed by roadways providing long-term access to mining areas.

Pillar (yield) – a pillar deliberately designed to a relatively low width to height ratio to encourage controlled stress transfer to adjacent stiffer pillar elements. As an example, such relatively narrow pillars can be used for horizontal stress control (for example to assist with longwall installation road roof stability in deeper mines). When/whether or not the pillar actually yields (that is reaches a post-peak strength state of deformation) is a complex function of the stiffness of the pillar and surrounding strata.

Plane of weakness – a crack or break in the rock mass along which movement can preferentially occur.

Plastic – capable of deformation at constant stress once the yield point is exceeded. The ability of a material to undergo permanent deformation without returning to its original shape or failing.

Reinforcement – the use of rock bolts and cable bolts to actively support and maintain/enhance rock mass strength by applying forces to resist deformation. Reinforcement is primarily applied internally to the rock mass.

Rock bolt – a tensioned bar or hollow cylinder, usually steel, inserted into a drill hole in the rock. The rock bolt is usually anchored by means of grout (commonly polyester resin) or less commonly an expansion shell anchor. It is normally set with a face plate in contact with the rock surface and has a nut to facilitate tensioning.

Rock mass – the total in-situ medium, taking into account the intact rock material and the geological structure (joints, faults and other natural planes of weakness that divide the rock into interlocking blocks of varying sizes and shapes).

Rock mass strength – the overall physical and mechanical properties of a large volume of rock, which is controlled by the intact rock material properties, geological structure and groundwater.

Scaling – an activity aimed at making strata safe by removing loose rock and coal from the ribs, and/or roof of the workplace. Also referred to as 'barring down'.

SCARP – Strata Control Action Response Plan is a TARP specific to strata control. See TARP meaning below.

Serviceability – a measure of the ability of an excavation to perform its required functions, usually over a defined lifecycle.

Shear – a mode of deformation involving two objects (for example. pieces of rock) sliding past each other.

Shear stress – stress parallel to a plane, tending to cause sliding.

Slickenside or greasy back - joint surface that is polished and/or smoothly striated.

Spalling – failure resulting in pieces of rock falling or being ejected from the surface of an excavation. This term is most commonly used in connection with rib deterioration. The alternative term 'slabbing' is more common for failure of immediate roof beds prior to bolting.

Strain – the change in length per unit length of a body resulting from an applied force. Below the elastic limit, strain is proportional to stress.

Strata control – the prediction and control of strata behaviour during development and extraction operations, having due regard for the safety of the workforce and the required serviceability and design life of the openings. It is the practical application in underground coal mines of the science of rock mechanics, the latter being all studies relative to the physical and mechanical behaviour of rocks and rock masses and the application of this knowledge for the better understanding of geological processes in the fields of engineering. Rock mechanics is in turn a sub-set of geomechanics, which is concerned with the physical and mechanical properties and responses of soils and rocks, including their interactions with water.

Stress – the internal resistance of an object to an applied load. Stress is calculated by dividing the force acting by the original area over which it acts. Stress has both magnitude and orientation.

Stress field – the overall pattern of the rock stress (magnitude and orientation) in a particular area, considering both the original in-situ stresses and the influence of previous mining.

Stress shadow – an area of reduced horizontal stress level due to the re-distribution of stress around a nearby excavation (for example a longwall goaf).

TARP (Trigger Action Response Plan) – a plan designed to prevent a risk from escalating by identifying potential indicators to the hazard, assigning a hierarchy of alarms or trigger levels to each potential indicator, and specifying responses for each trigger level (adapted from Galvin (2012)).

Tectonic forces – forces in the Earth's crust due to plate movements. These influence the direction and magnitude of horizontal stresses.

Tensile stress – stress that tends to cause a material to stretch, whichcan cause joints to open and may release blocks causing rock falls.

Ultimate strength – the stress at failure.

Yield point - the maximum stress that a material can sustain without permanent deformation. The limit of proportionality between stress and strain is also known as the elastic limit.

Yield zone – rock around the perimeter of an excavation, where the stress has exceeded the strength of the rock mass at some phase of mining. The rock mass is in a post-peak loading condition, but may still be capable of carrying significant load, particularly if low levels of lateral confinement are provided by support.

Appendix B – Examples of task allocations

The following are examples of the allocation of tasks to people for the strata failure PMHMP. It may be used as a guide for this process. Please see 'How to use this code of practice' in the Scope and Application regarding the relevance of these examples.

GENERAL TITLE	TASK
Site senior executive	• Establish the development and implementation of the principal mining hazard management plan for strata failure • Specify functions and responsibility and provide training
Nominated person on behalf of the mine operator (for example the underground mine manager)	• Approve the PMHMP for strata failure, its updates and associated standards and procedures • Establish that all individuals with functions and responsibilities under this plan are trained and competent to carry out those responsibilities • Establish that all workers are aware of, and understand their responsibilities as stated in the plan, and that these responsibilities are included in their position descriptions • Establish that training material is developed and provided for all functions of the plan • Establish that any systems and procedures are developed and implemented in accordance with the requirements of the plan • Establish that the plan is monitored, audited, reviewed at intervals not exceeding 12 months, or if a specific event occurs as defined in the plan. Any changes should be conveyed to the workforce • Establish that all risk-assessment processes are formally documented • Verify that any corrective action undertaken has been conducted • Compile and maintain reports of any roof failure with the potential to injure persons • Co-ordinate remedial action necessary in the event of any emergency occurring underground • Sign off on the panel reviews as soon as practicable. • Authorise changes to this plan • Cause copies of the mine support plans are posted on the surface notice board and underground panel notice boards • Establish that sufficient resources are allocated. • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function.
Technical services manager	• Facilitate the implementation of the principal mining hazard management plan for strata failure, and

GENERAL TITLE	TASK
	ensure it is updated and modified as necessary • Assist the underground mine manager in identifying the resources required to meet the requirements of this plan • Ensure that other hazard plans are prepared prior to the commencement of mining in the relevant sections of the mine • Liaise with the technical experts such as geologists and geotechnical workers regarding any additional information or investigation that may be warranted for the compilation of the hazard plans • Review the system before the mining of any new section of the mine along with a review at the completion of the section • Oversee intermediate reviews as required • Oversee compilation of the support plans as detailed in the principal mining hazard management plan for strata failure • Determine the nature, location and frequency of monitoring. • Organise internal/external reviews • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Geotechnical engineer	• Ensure a geotechnical model is maintained • Develop and maintain geotechnical database that is relevant to strata control • Maintain a program of data collection to enable an assessment of strata control requirements • Provide support designs based on an appropriate geotechnical hazard assessment. This includes remedial support work • Provide geotechnical analysis of changes to the mine plan or operation, ground support equipment, materials and systems • Prepare TARPs, monitoring plans and hazard plans • Confirm quality control (regular testing of support elements) and monitoring schedule is maintained • Ensure the reported defects are effectively managed

GENERAL TITLE	TASK
Geologist	• Ensure exploration data is obtained and interpreted to provide an assessment of the geological conditions and threats to mining • Review and issue a statement confirming the sealing status of all surface boreholes in the hazard plan area • Maintain the geological database • Assist management in the preparation of section hazard plans • Ensure underground geological mapping is conducted and potential structures defined and recorded on the hazard plan • Ensure exploration boreholes (as necessary) are grouted to a specification upon completion • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Mine surveyor	• Ensure surveying of underground roadways is undertaken • Check that the roadways are driven to design and in relation to orientation and dimensions • Ensure surveys are carried out and transferred onto suitable plans for filing and reference purposes and roadways are plotted as constructed • Ensure all boreholes are shown on section hazard plans • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Production manager (or equivalent, such as the underground mine manager)	• Ensure the installation of monitoring stations is in accordance with the principal mining hazard management plan for strata failure • Ensure the strata support is installed in accordance with the mine support plans • Promote the use of trigger action response plans • Establish strata control material stock levels and monitor and rectify if required • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function

GENERAL TITLE	TASK
Senior shift mining supervisors (for example, undermanagers)	• Check the installation of monitoring stations is in accordance with the principal mining hazard management plan for strata failure • Check the strata support is installed in accordance with the mine support plans • Ensure corrective action for the above if required • Respond to alerts from section mining supervisors • Record details and notify appropriate supervisors of any strata failure with the potential to injure people or cause significant downtime • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Mining supervisors (for example deputies)	• Inspect any areas where new strata is exposed or existing strata is being interfered with. This should be conducted in accordance with the inspection requirements of the mine (as a minimum) • Check the installation of monitoring stations is in accordance with the principal mining hazard management plan for strata failure • Check the strata support is installed in accordance with the mine support plans • Facilitate corrective action for the above if required • Respond to alerts from section workers • Record details and notify shift supervisor of any strata failure with the potential to injure people or cause significant downtime • Record significant geological features on the shift report • Check sufficient materials are available and expedite if necessary • Check that equipment used for strata control is in operating condition • Direct installation of extra strata control support if necessary • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Workers involved with strata control	• Work in accordance the requirements of the principal mining hazard management plan for strata failure, which includes the installation or removal of strata control support or the installation of monitoring devices • Be aware of and fully understand any TARP that applies to the work

GENERAL TITLE	TASK
	• Check the condition of strata before removing it or supporting it and periodically check during your work • Install additional strata control support if deemed necessary • Advise supervisors when abnormal conditions are encountered • Cease production and withdraw to a safe location in the event of a major fall of strata or imminent risk of and immediately notify the supervisor • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function
Training manager	• Ensure training in accordance with the requirement of the PMHMP for strata failure. • Maintain records of training. • Comply with any other requirement of the principal mining hazard management plan for strata failure for this function

Appendix C – Example of a pillar design methodology

Please see 'How to use this code of practice' in Scope and Application regarding the relevance of this example.

Pillar design should adopt a risk based functional approach, whereby the functions of the pillar are identified at the outset and the pillars are then designed on an engineering basis, according to those functions, using risk-based engineering methodologies.

This approach can be considered to have at least five essential elements (adapted from Gale and Hebblewhite, 2005).

1. Identify the type of pillar and the purpose(s) for which the pillar is to be used.
2. For the type and purpose identified, specify the associated geotechnical duty or function that the pillar must perform (for example local or regional load bearing, abutment stress protection, subsidence angle of draw limits, etc.).
3. Determine the pillar life expectancy (that is the time for which it is required to perform its duties).
4. On the basis of purpose, duty and life expectancy, an engineering determination / judgement should be made of the acceptable level of risk associated with the pillar not performing each duty. Pillars may be required to perform different duties over their lifetime, either in series (i.e. sequentially), or in parallel (simultaneously). Different duties may require different levels of risk management.
5. The design procedure should then incorporate an appropriate Factor of Safety (FoS) or other appropriate risk management index or margin.

Pillar design impacts on adjacent roadway conditions and support requirements. These issues are all inter-related, so an iterative process should be followed through the overall mine design methodology to ensure that critical geotechnical risk factors have been recognised and adequately controlled, with the design optimised from all perspectives.

Once the pillar satisfies geotechnical criteria, it should also be checked for compliance with respect to other operational issues (for example, wheeling / flitting distances, ventilation, spontaneous combustion and so on). These are again linked to the overall, iterative mine planning and design process.

The process illustrated by the following flowcharts (Figures A and B) is typically applied to main headings design in Australia using pillar strength formulae such as those developed by Salamon *et al* (1996). It is not absolute; alternative models are available.

Figure A: Example pillar design process

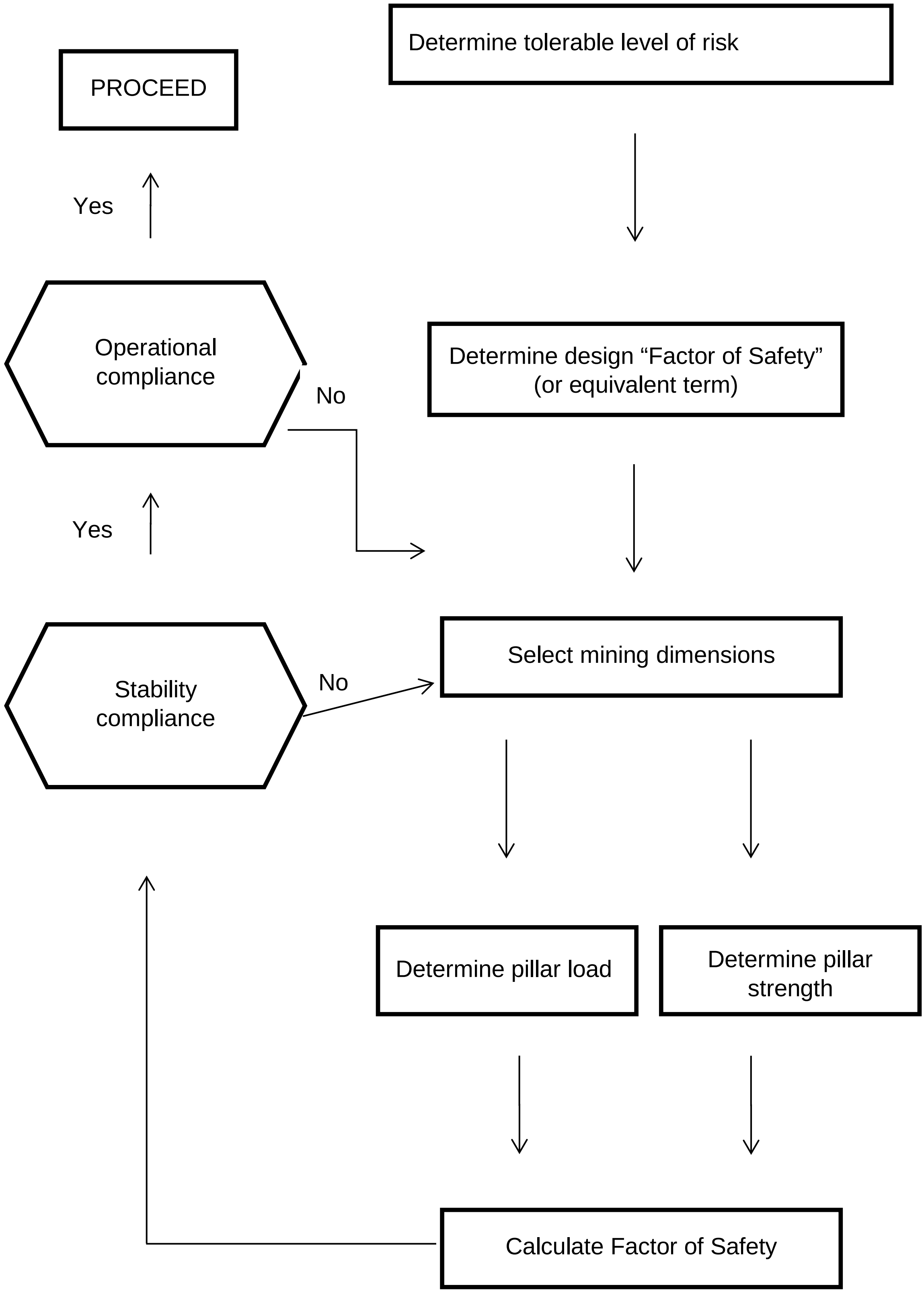
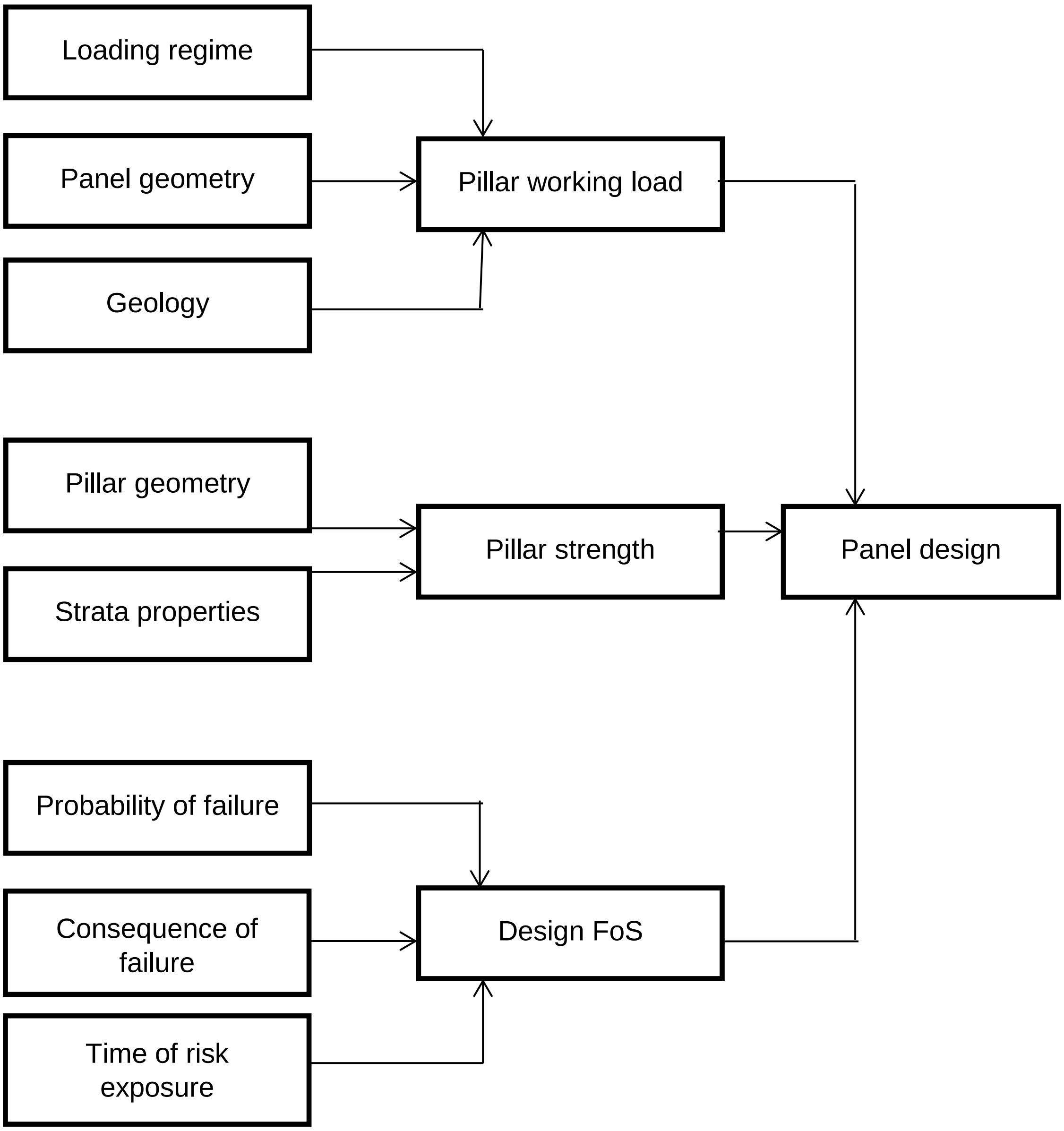
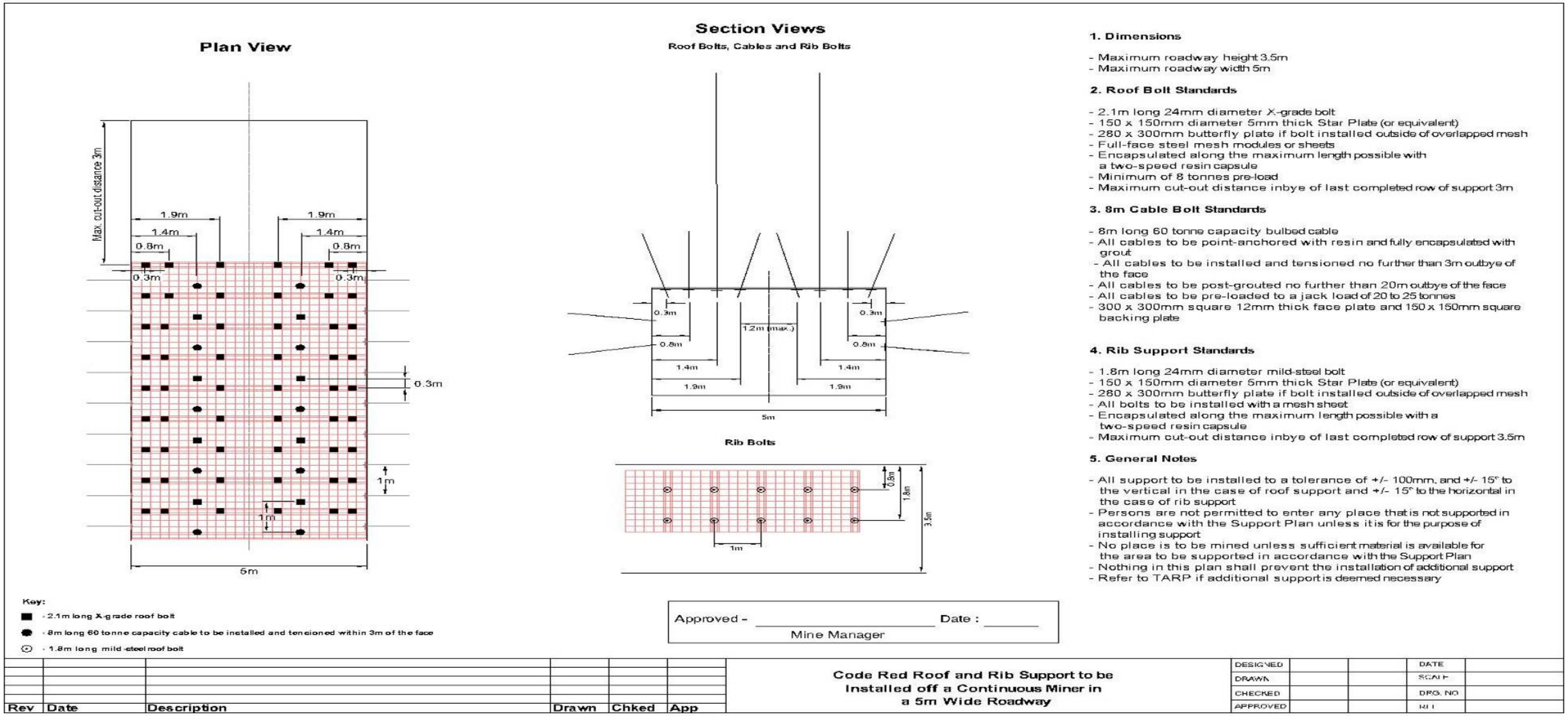


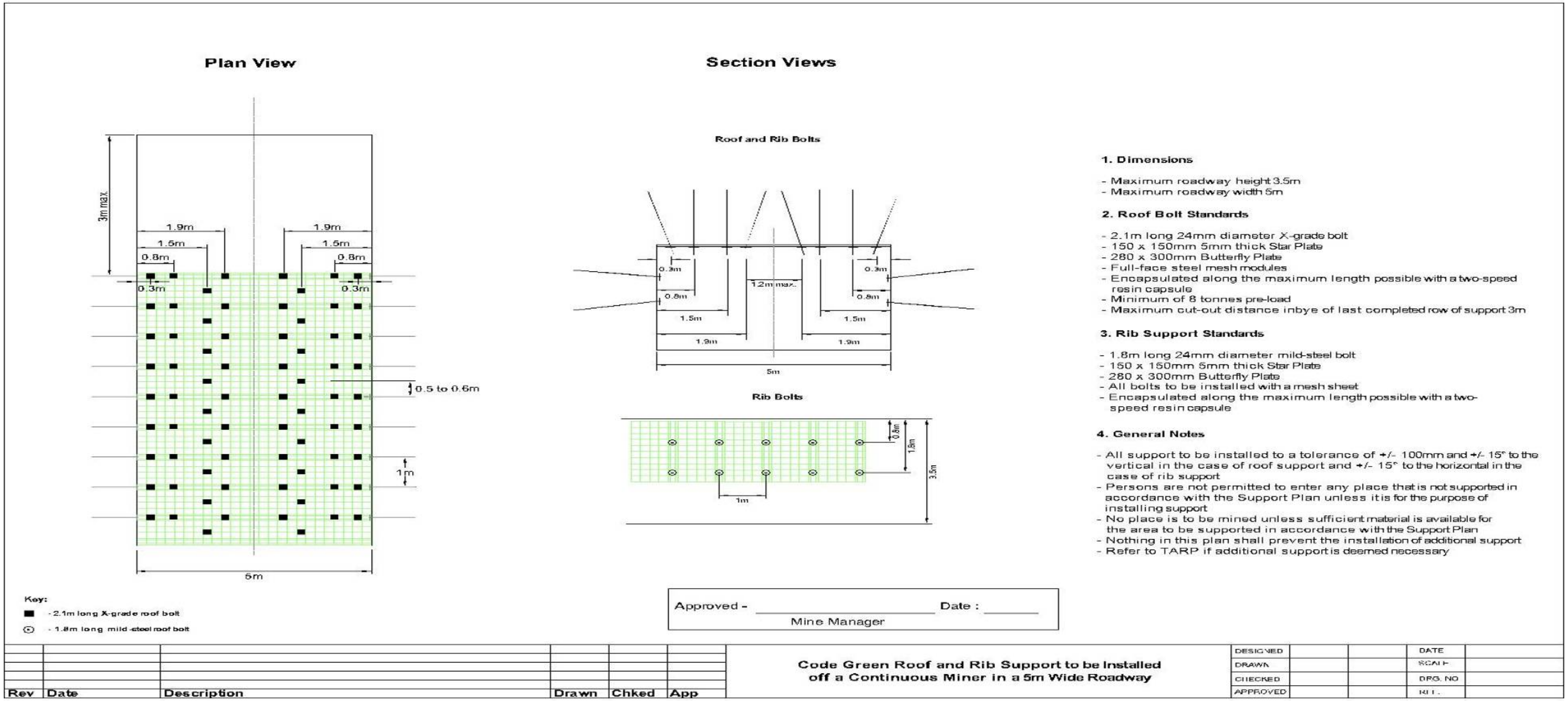
Figure B: Principal Influences on pillar load, strength and FoS



Appendix D – Support plans

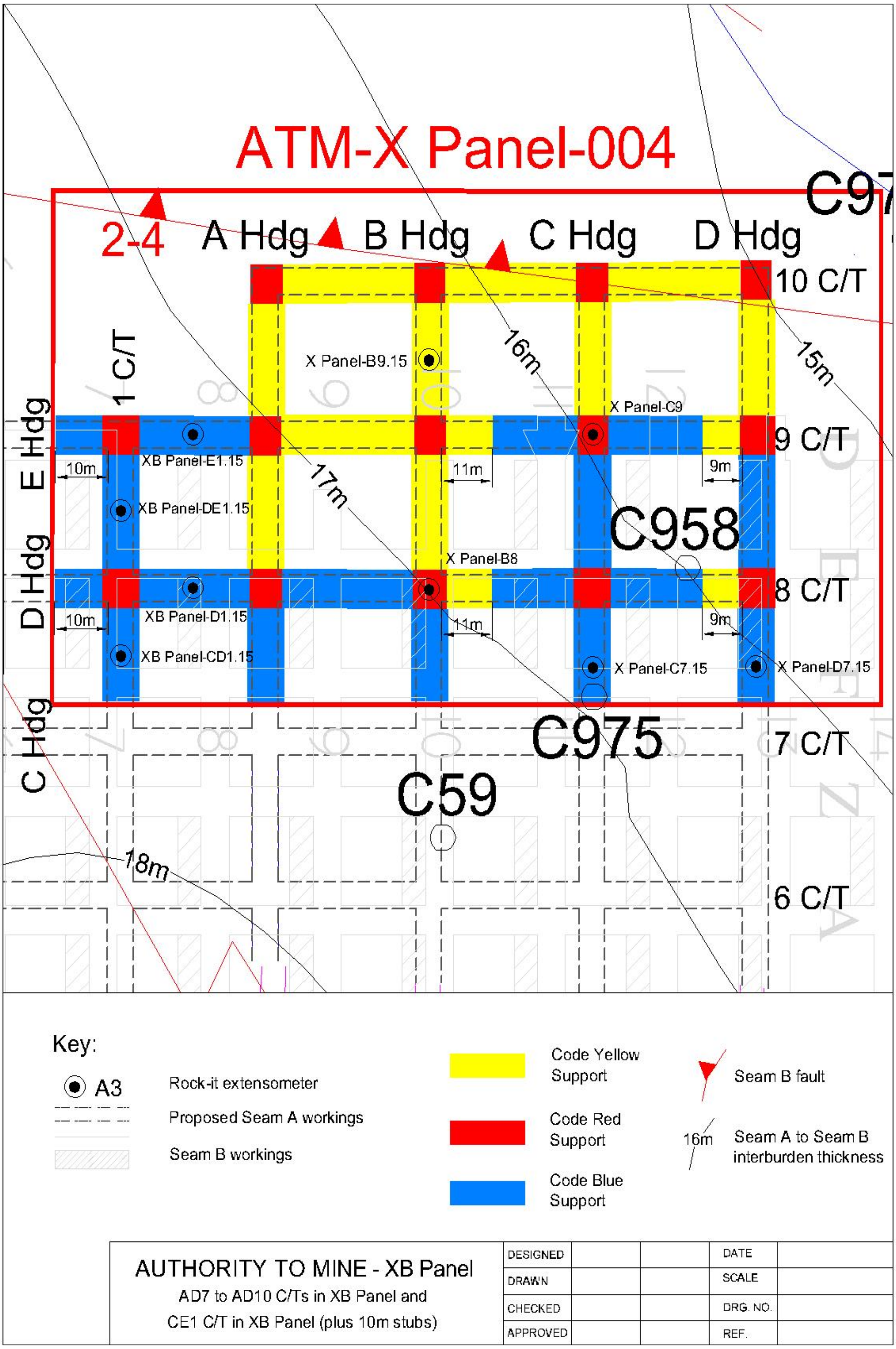
Please see 'How to use this code of practice' in Scope and Application regarding the relevance of these examples.

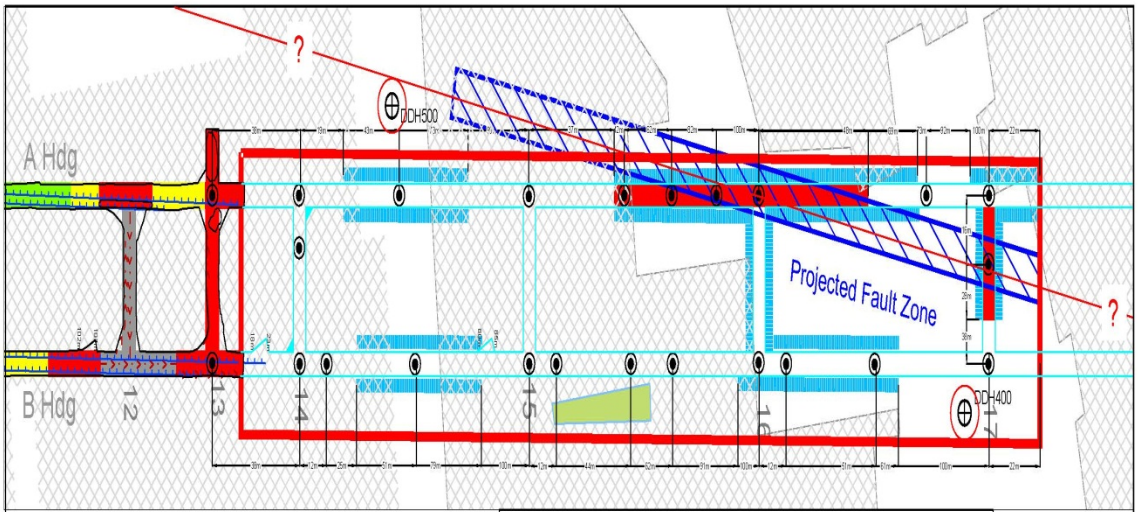



Plan View
Section Views
Roof and Rib Bolts
Rib Bolts
3m max.
1.9m
1.5m
0.8m
0.3m
0.5 to 0.6m
1m
5m
1.2m max.
3.5m
1.8m
Key:
- 2.1m long X-grade roof bolt
- 1.8m long mild-steel roof bolt
1. Dimensions
- Maximum roadway height 3.5m
- Maximum roadway width 5m
2. Roof Bolt Standards
- 2.1m long 24mm diameter X-grade bolt
- 150 x 150mm 5mm thick Star Plate
- 280 x 300mm Butterfly Plate
- Full-face steel mesh modules
- Encapsulated along the maximum length possible with a two-speed resin capsule
- Minimum of 8 tonnes pre-load
- Maximum cut-out distance inbye of last completed row of support 3m
3. Rib Support Standards
- 1.8m long 24mm diameter mild-steel bolt
- 150 x 150mm 5mm thick Star Plate
- 280 x 300mm Butterfly Plate
- All bolts to be installed with a mesh sheet
- Encapsulated along the maximum length possible with a two-speed resin capsule
4. General Notes
- All support to be installed to a tolerance of +/- 100mm and +/- 15° to the vertical in the case of roof support and +/- 15° to the horizontal in the case of rib support
- Persons are not permitted to enter any place that is not supported in accordance with the Support Plan unless it is for the purpose of installing support
- No place is to be mined unless sufficient material is available for the area to be supported in accordance with the Support Plan
- Nothing in this plan shall prevent the installation of additional support
- Refer to TARP if additional support is deemed necessary
Approved - Date :
Mine Manager
Rev
Date
Description
Drawn
Chked
App
Code Green Roof and Rib Support to be Installed off a Continuous Miner in a 5m Wide Roadway
DESIGNED
DRAWN
CHECKED
APPROVED
DATE
SCALE
DRG. NO

Appendix E – Samples of hazard (survey) plans

Please see 'How to use this code of practice' in Scope and Application regarding the relevance of these examples.





Operational Notes

- Mining is First Workings Development with a Joy 12CM30 or Caterpillar 30MB3.
- For Roof Support Rules refer to PLANX & For Rib Support Rules refer to PLANY
- For Bolt Specs refer to DRAWINGX
- For TARP Details Refer to TARPX
- Refer to PLANSA-D for Safe Standing Zones during mining
- The laser line is generally aligned with the RHS TRS for both CMs, which is 1.45m from right hand rib on the Joys and 1.25m from the right hand rib on the Cat - See Plan PLANZ
- For detailed pillar dimensions and surveyed measurements refer to the relevant panel plan
- Toto dollies are repairable and should be returned to surface if damaged
- "Spin to stall" roof bolts and 25mm diameter rib dowels and accompanying resins now in regular use
- All dimensions shown from CT or heading centrelines
- This ATM replaces all other previous ATMs for the panel

Geology and Hazards

- Colliery records indicate the following surface to seam boreholes in the defined ATM area

Borehole No.	Location	Status	Intercept Workings
DDH400	B Hdg-90m	Grouted	No
DDH500	A Hdg-70m	Grouted	No

*See ATM plan for borehole locations

- Joint sets are aligned at a low and therefore unfavourable angle to the headings and conversely a high and therefore reasonably favourable angle to the cut-throughs
- Roof lithology above the coal seam workings has been determined by borescoping as ~1.5m of coal roof and thin to medium siltstone & sandstone units above this
- Mid-angled structures in heading ribs have the potential to slide and/or topple
- Potential for structures to be present in A Heading 14-15 CT blockside rib forming unstable wedges **Crews to remain aware for indicators of unstable blocks in this rib and follow TARP**

Inrush

- There are existing workings in the Overlying Seam
- Water level plans of the Overlying Seam indicate that there is no stored water directly above the area covered by this ATM
- External advice about the interburden assess it as being adequate for the prevention of inrush
- All boreholes have been grouted

Geotech

- Minimum roadway roof and rib support is "CODE GREEN" as per Roadway Development TARPS except for where shown otherwise on this ATM

Code Blue Rib Support | Code Yellow Roof Support
Code Purple Rib Support | Code Red Roof Support
Code Black Roof Support

- High vigilance is required when mining under overlying seam goaf edges and pillars
- High vigilance is required when mining through structured zones
- Encapsulation measurements to be recorded once per production shift for roof bolts and cables
- All Toto cables to be tensioned with tensioning dolly immediately after installation
- All Clockits are to be installed on development from the Miner and as close to centreline of intersections/roadways as possible in locations shown on this plan, Deputy's Permit and as per TARPS
- An 8m long borescope hole is to be drilled adjacent to each clock-it and well flushed with water
- Installed Clockits should be read according to the Strata Monitoring Results Report. Any displacement shall be actioned as per Strata Failure TARP
- Deputy to ensure Clock-its installed correctly and functional

Ventilation

- The production face is ventilated by an auxiliary fan
- Slider ventilation ducting is to be used when the CM is cutting
- Standing dead end places are to be ventilated as per PROCEDURE X in Ventilation Arrangements Management Plan DOC#123
- Variations to VCD installations are to be authorised by the Senior Mining Supervisor on shift or the Ventilation Officer

Spontaneous Combustion

- Coal Seam property testing indicates low to medium propensity for spontaneous combustion
- Gas Monitoring is installed for panel return

Limit of current ATM - mining is not to continue outside this area or within 5m vertically of the coal seam

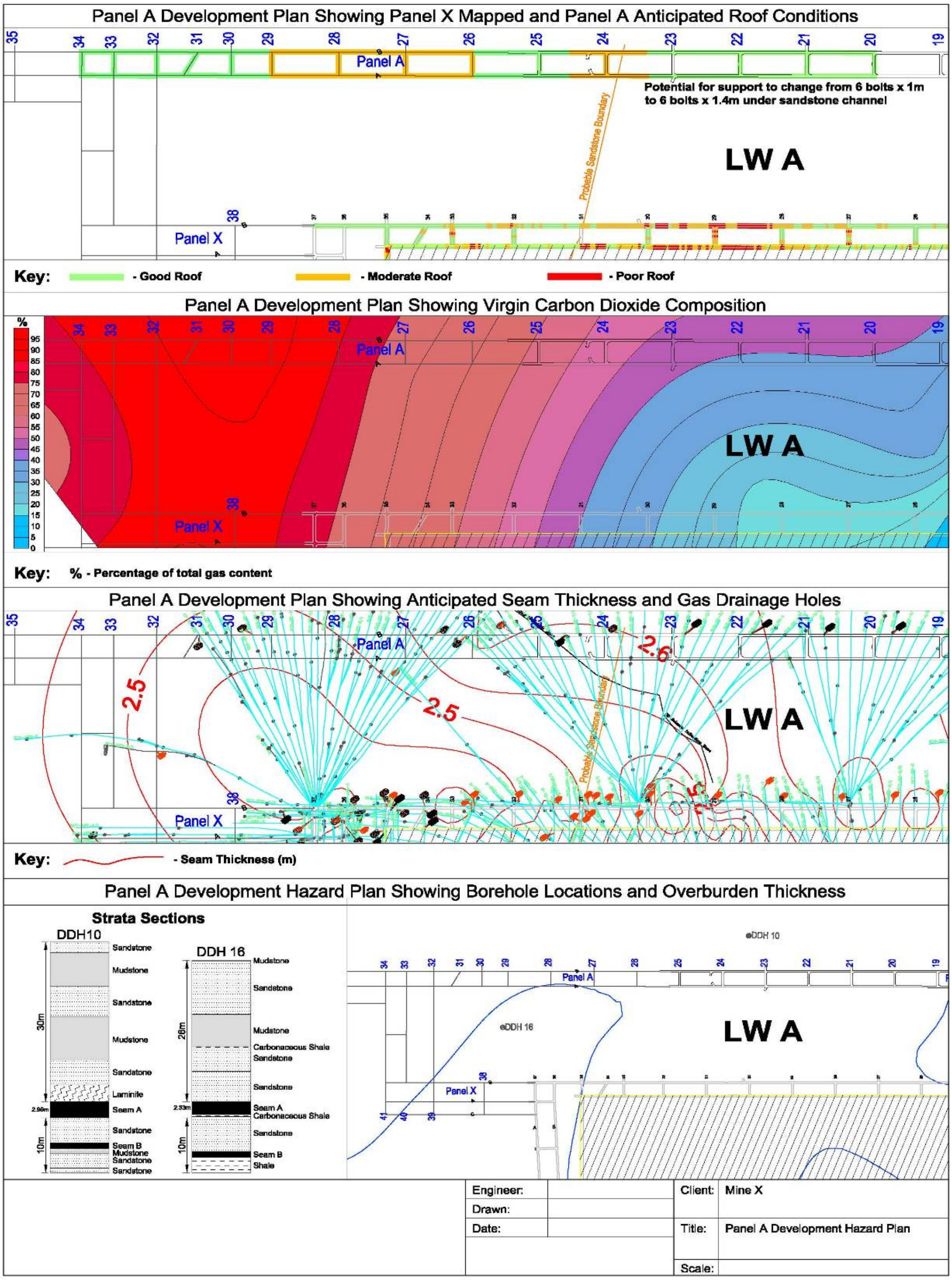
LEGEND

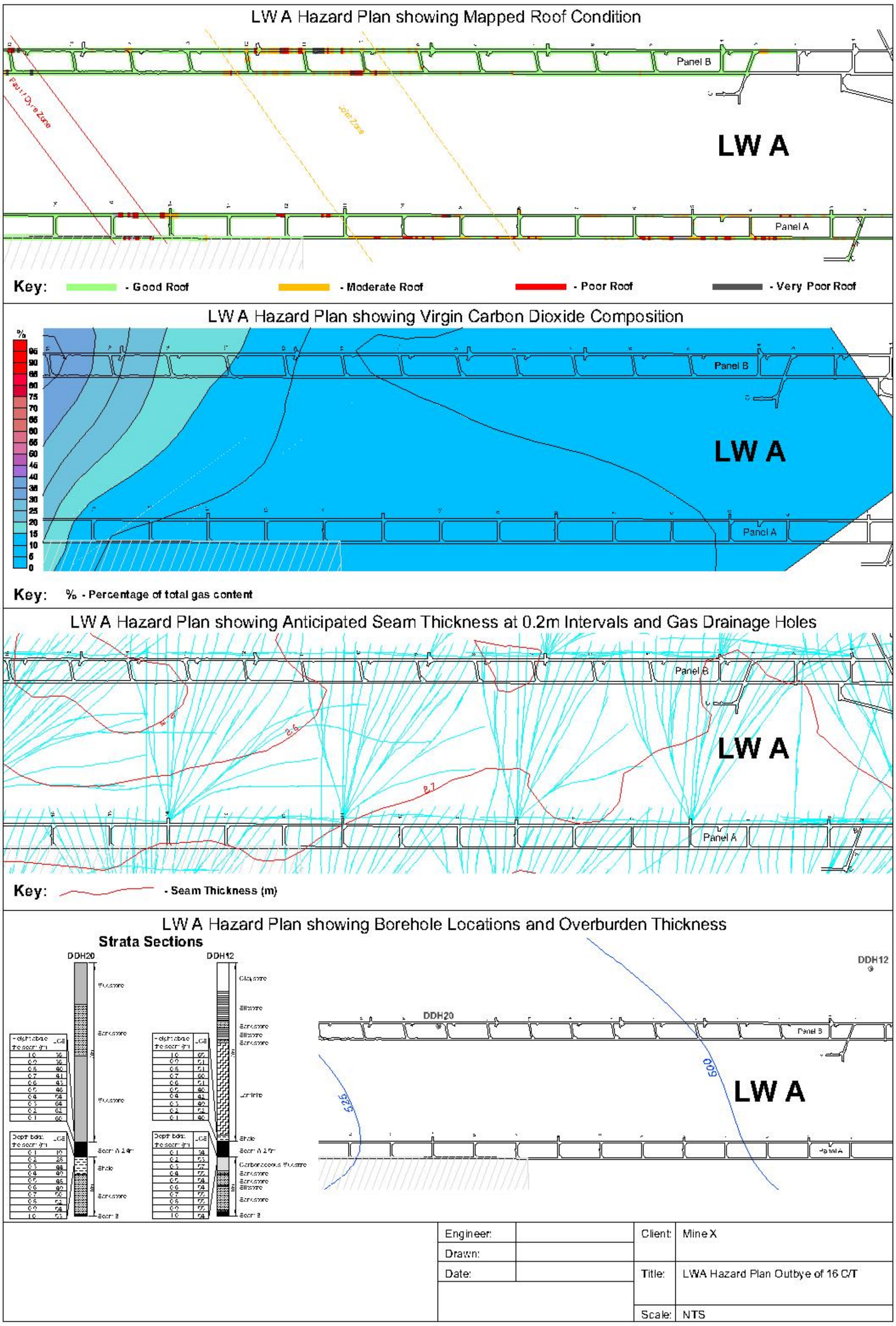
- Potential Hazard
- Overlying seam goaf
- Overlying seam remnant pillar
- Clock-it & Borescope
- Surface to Seam Borehole
- Precautionary zone around borehole

OUTBYE ROOF CONDITION

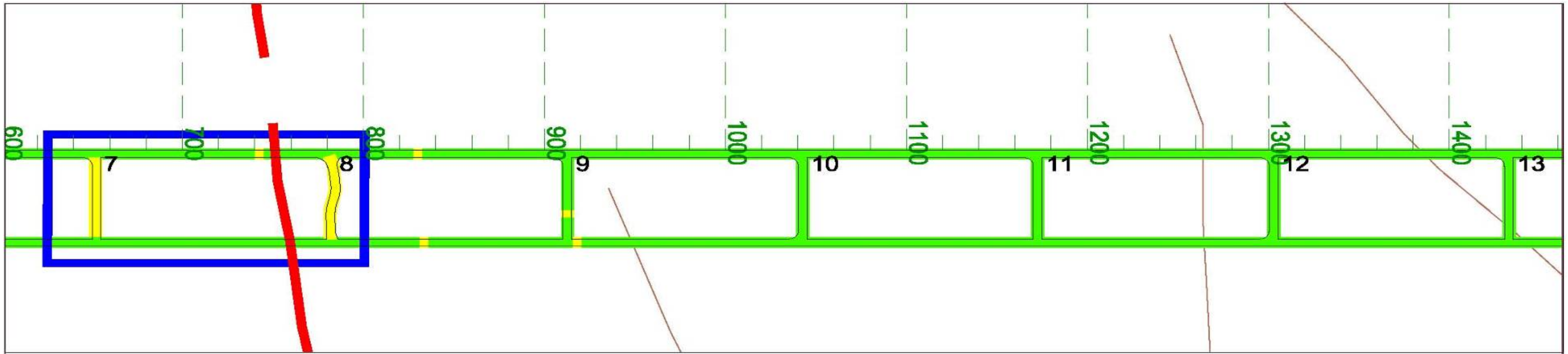
- Very poor roof condition
- Poor roof condition
- Moderate roof condition
- Good roof condition
- Mapped fault location
- Projected fault location
- Mapped mid-angled structure
- Mapped sag / gutter

Manager of Mining Engineering .... Date	MINING COMPANY AA COLLIERY	SCALE : 1:2500	DATE :	
Production Manager .... Date		DRAWN :	DRG NO : 123456	
Ventilation Officer .... Date	MAINGATE 57 DEVELOPMENT ROADWAYS AUTHORITY TO MINE	CHECKED:		
Technical Services Manager .... Date		REVISION : 7	SIZE : A3	


Panel A Development Plan Showing Panel X Mapped and Panel A Anticipated Roof Conditions
Panel A
Panel X
Probable Sandstone Boundary
Potential for support to change from 6 bolts x 1m to 6 bolts x 1.4m under sandstone channel
LW A
Key:
- Good Roof
- Moderate Roof
- Poor Roof
Panel A Development Plan Showing Virgin Carbon Dioxide Composition
%
Key:
% - Percentage of total gas content
Panel A Development Plan Showing Anticipated Seam Thickness and Gas Drainage Holes
2.5
2.6
Key:
- Seam Thickness (m)
Panel A Development Hazard Plan Showing Borehole Locations and Overburden Thickness
Strata Sections
DDH10
DDH 16
Sandstone
Mudstone
Laminite
Seam A
Seam B
Carbonaceous Shale
Shale
30m
26m
10m
2.90m
2.33m
DDH 10
DDH 16
Engineer:
Drawn:
Date:
Client:
Mine X
Title:
Panel A Development Hazard Plan
Scale:



LW A Hazard Plan showing Mapped Roof Condition
Panel B
LW A
Panel A
Fault/Dyke Zone
Key:
- Good Roof
- Moderate Roof
- Poor Roof
- Very Poor Roof
LW A Hazard Plan showing Virgin Carbon Dioxide Composition
%
Panel B
LW A
Panel A
Key:
% - Percentage of total gas content
LW A Hazard Plan showing Anticipated Seam Thickness at 0.2m Intervals and Gas Drainage Holes
Panel B
LW A
Panel A
2.6
2.7
Key:
- Seam Thickness (m)
LW A Hazard Plan showing Borehole Locations and Overburden Thickness
Strata Sections
DDH20
DDH12
600
525
LW A
Panel B
Panel A
Engineer:
Drawn:
Date:
Client: Mine X
Title: LWA Hazard Plan Outbye of 16 C/T
Scale: NTS



LEGEND:

- Good Roof / Code Green Primary Roof Support (ie, standard primary roof bolts plus 2 x 8m Megabolts x 1m in intersections)
- Moderate Roof / Code Orange Primary Roof Support (ie, standard primary roof bolts plus 2 x 8m Megabolts x 2m in roadways and an additional 2 x 8m Megabolt x 1m in intersections)
- Poor Roof / Code Red Primary Roof Support (ie, standard primary roof bolts and 2 x 8m Megabolts x 1m)
- predicted basement faults
- anticipated structures (seam level)
- Poor C/T or roadway conditions anticipated on development
- Mapped in-seam faults
- confirmed structures (seam level)

NOTE:

- The proposed primary support designs are based on conditions experienced in previous panels (see Mine A Roadway Development Geotechnical Hazard Plan).
- The location of all predicted structures is a best estimate only and as such, caution is warranted leading up to these features.
- Where structures are encountered the TARP overrides the Roadway Development Geotechnical Hazard and Support Plan

DATE		ROADWAY DEVELOPMENT GEOTECHNICAL HAZARD AND PROPOSED PRIMARY SUPPORT PLAN 7 TO 13 C/TS A PANEL		PLOTFILE No.
SEAM				
DRAWN				
REFERENCE				DRG. No.
SCALE				

Appendix F – Sample of authority/permit to mine system

Please see 'How to use this code of practice' in Scope and Application regarding the relevance of this example.

ABC COLLIERY

AUTHORITY TO MINE

Date of Authority: 1st January 2012
Limit of Authority: AD7 to AD10 C/T's X Panel and CE1 C/T XB Panel (plus 10m stubs)

1. **Survey:**
   - The proposed workings are below previous Seam B workings. It is expected that these workings are not a potential inrush source due to previous drilling.
   - The following boreholes fall within 15m of the proposed workings and may be intersected –

     C 958 (8 C/T C-D +20m)
   - These holes are reported to be cemented. No open holes are anticipated.
   - Survey control is considered sufficient to mine the proposed area

   …………………………..

   Mine Surveyor

2. **Geotechnical Issues:**
   - Flat roof and ribs are anticipated in all areas.
   - The only exceptions to the above include (i) areas affected by faulting where roof cavities at the face, roof buckling and/or rib spall are anticipated and (ii) in and around overlying goaf edges where a minor increase in roof and rib buckling is considered possible – *note: mapping in Seam B suggests that a fault will probably be intersected between B10 and D10 intersections and between D9 and D10 intersections.*
   - All roadways and intersections are to be driven and supported as per the attached ATM Plan and the associated Support Plans.
   - Tell-tales are to be installed <u>within 3m of the face</u> at the locations shown on the ATM Plan – note: a) all tell-tales are to be read at least once a shift and the data recorded by the ERZ Controller on the report sheet provided and b) all tell-tales recommended in breakaway intersections are to be installed in the first driven roadway and not in the breakaway.

   ………………………..

   Geotechnical Engineer

3. Mining & Ventilation Issues:

- Panels to be ventilated in accordance with approved Manager's Ventilation Plan.
- Outburst risk considered low. Normal mining permitted with Manager's Approval.
- Gas make in this area is expected to be low with the main gas predicted Methane
- Persons are to be aware of the sealed areas in Y Panel and Z Panel in Seam A.

4. Statutory:

- There are no exemptions in place for this area

…………………………..

Underground Mine Manager

Appendix G – Samples of TARPs

Please see ‘How to use this code of practice’ in Scope and Application regarding the relevance of these examples:

G1 Longwall Maingate TARP

G2 Development Roadways - SCARP

G3 Maingate 10 Rib Support - TARP

G4 Roadway Development TARP

G5 LW8 Tailgate TARP

G6 LW5 Tailgate TARP

G7 LW5 Take Off TARP

G8 Installation Road – Roadway Widening TARP

G9 Longwall Retreat Strata Action Plan (Longwall Production District)

G10 Longwall Face TARP

G11 SCARP Outbye Roadway

G1 LONGWALL MAINGATE TARP

	Normal	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger
Strata conditions	• Goaf break line at rear of canopy • Minimal maingate corner face spall • No visible roof deformation, with minor flaking and no guttering • No abnormal rib spall/slump	• Goaf break line over canopies • Maingate corner face spall • Increasing rib spall/slump on block side, which influences roof stability, ie increase span • Visible roof deformation and fracturing and/or guttering close to ribs, extending less than 5m outbye canopy tip	• Goaf break line over canopies • Visible weight on majority of roof bolts and long tendons • Gate-end shields having reduced clearance to top of MG drive • Goaf advancing alongside shields • Increasing rib spall/slump on pillar side, in either road • Visible roof deformation and fracturing and/or guttering close to ribs, extending more than 5m outbye canopy tip	• Cannot cut due to lost clearance and inability to push MG drive • Maingate roof fall
Measured displacement (telltale/exto)	<50mm total deformation due to longwall abutment or >50mm total deformation but <5m outbye face,	>50mm total deformation due to longwall abutment and 5 to 20m outbye face	>50mm total deformation due to longwall abutment and >20m outbye face	
Support advance	Auto support advance behind leading drum on tailgate to maingate run	• Ensure canopy tips are kept hard to roof • Continually clean debris from top of canopy (allows solid contact with roof, particularly for tip contact) • Maintain creep towards maingate	• Ensure canopy tips are kept hard to roof • Continually clean debris from top of canopy (allows solid contact with roof, particularly for tip contact) • Maintain creep towards maingate	Stop production and formulate recovery plan

	Normal	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger
Special actions	• Follow fault cutting plan if fault present • Place travel road cogs against pillar as per plan • Monitor hydraulic supply • Check support leg pressures • Cut to correct roadway profiles • Ensure good canopy tip contact • Keep canopies clean • Keep the face moving • Keep floor in front of main gate shields clean • Set Heintzmann props where possible under steel girders	• Follow fault cutting plan if fault present • Double push at maingate to support roof • Slower shear speed if shield advance is lagging • Monitor hydraulic supply • Check support leg pressures • Cut to correct roadway profiles • To arrest block side roof deformation moving further outbye use minimum 125mm (5”) props • Set Heintzmann props under steel girders nearest face, wood props under other girders • Set Rocprops on walking side where guttering is present • Keep floor in front of main gate shields clean	• Follow fault cutting plan if fault present • Double push at maingate to support roof • Slower shear speed if shield advance is lagging • Monitor hydraulic supply • Check support leg pressures • Cut to correct roadway profiles • To control block side guttering stand props/propsetters if safe to do so • For pillar side roof deformation stand propsetters/Rocprops to control guttering • Build wood cogs where feasible from face going outbye • For pillar side rib spall/slump, place propsetters/props against rib and sprag as required • Set steel props under steel girders nearest face, wood props under other girders • Keep floor in front of main gate shields clean	• No road entries to fall • Set up new 2nd Egress as required (eg belt road if face is blocked) • Only authorised visitors
Notification		Record Trigger on Statutory Report and report to Comms	Longwall and Technical Services Superintendents.	Longwall and Technical Services

	Normal	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger
				Superintendents. Registered Mine Manager
Operator	Continue production	• Inform ERZ controller • Maintain canopy tip contact	As per Level 1 response	Withdraw equipment to place of safety
ERZ controller	• Produce to daily production plan • Ensure operators are aware of current operating procedures • Continue statutory and other inspections • Monitor tell-tales within 100m of face and record in tell-tale monitoring book	• Continue production • Record current trigger level on shift report. • Ensure operators are aware of current operating procedures • Describe maingate geotechnical conditions, including rib and floor observations, on shift report • Confirm canopy tip contact and creep to maingate • Ensure materials available to stand propsetters/props	• As per Level 1 response • Stand propsetters/props as required to control guttering	• As per Level 2 response • Stand propsetters/props as required to control guttering and propagation of fall • No road entries to fall area • Arrange for initial support materials and equipment • Supervise fall recovery
Longwall superintendent	Produce to daily production plan	• Inspect face daily • Review situation daily with Technical Services Superintendent or Geotechnical Engineer • Adjust TARP as required • Inform Registered Mine Manager	• Review situation daily with technical services super, geotechnical engineer and face supervisor • Adjust TARP as required • Plan and manage appropriate operating procedures and installation of supplementary support • Registered Mine Manager to be kept informed	• Develop and implement fall recovery plan • Monitor and adjust fall recovery plan in cooperation with Registered Mine Manager and Technical Services Superintendent
Technical services	Weekly inspection	• Daily inspection (may be completed by geotechnical	• Prompt inspection (may be completed by geotechnical engineer)	Assist Longwall Superintendent in

	Normal	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger
Superintendent		Engineer) • Review situation daily with longwall superintendent	• Review situation daily with longwall superintendent	developing, implementing, monitoring and adjusting fall recovery plan
Geologist	Weekly inspection and report, including expected conditions for next week	• Inspection and report frequency as directed by technical services superintendent, e.g daily • Map and record changing strata conditions	• Inspection and report frequency as directed by technical services superintendent, eg daily • Map and record changing strata conditions	As directed by technical services superintendent
Geotechnical engineer	Weekly inspection	• Inspection and assessment as directed by technical services superintendent • Advise on required supplementary support and changes to operating procedures • Monitor for step change in roof movement due to longwall loading	• Inspection and assessment as directed by technical services superintendent • Advise on required supplementary support and changes to operating procedures • Monitor for step change in roof movement due to longwall loading	As directed by technical services superintendent
Registered Mine manager		Review situation as required with longwall and technical services superintendents	• Review situation with longwall and technical services superintendents • Approve and supplementary support installation	• Develop and approve fall recovery plan • Monitor and adjust fall recovery plan in cooperation with longwall and technical services superintendents • Inform Inspector of Mines

Mine manager Technical services superintendent

Date: Date:

G2 Development Roadways - SCARP

CONDITION		GREEN	ORANGE	RED
STRATA CONDITIONS		▪ NIL structure ▪ Closed vertical (greater than 70° to the horizontal) joints. Note: joint likely to be either vertical or not evident in the cut rib or face. ▪ *Roof guttering* less than 50mm over 3m of roadway advance	▪ Mid angled structure (45 – 70° to the horizontal) evident in roof, rib or face ▪ A single shear, open and/or in-filled vertical joint ▪ *Roof guttering* 50mm to less than 300mm over 3m of roadway advance	▪ Multiple shears, open and/or in-filled vertical joints across a single support row (i.e. mesh module) ▪ Fault(s) ▪ *Roof guttering* 300m or more over 3m of roadway advance
ROOF MONITORING minimum standard		▪ Tell-tail at all conveyor roadway intersections or ▪ As per Sequence Plan or Planning Notes	▪ Tell-tail at every intersection plus ▪ At mid pillar (heading only) where the pillar length exceeds 60m	▪ Tell-tail at every intersection plus ▪ Every 20m of roadway advance
ROOF & RIB SUPPORT refer to Support Plan	**Roadway (roof)**	▪ 6 x 1.8m long roof bolts x 1.0m	▪ 6 x 1.8m long roof bolts x 1.0m plus ▪ 2 x 4.3m long GXT cables x 3m	▪ 6 x 1.8m long roof bolts x 1.0m plus ▪ 2 x 6.3m long GXT cables x 3m
	Intersection (roof ±4m of centre)	▪ 6 x 1.8m long roof bolts x 1.0m	▪ 6 x 1.8m long roof bolts x 1.0m plus ▪ 2 x 4.3m long GXT cables x 2m	▪ 6 x 1.8m long roof bolts x 1.0m plus ▪ 2 x 6.3m long GXT cables x 2m
	Ribs (per side)	▪ 1 x 1.8m long bolt x 1.0m	▪ 1 x 1.8m long bolt x nominal 1.0m or ▪ As per Condition RED rib support where a mid angled structure is identified	▪ 2 x 1.8m long bolt x 1.0m and ▪ Assess for installation of rib mesh
CONDITION RESPONSE				
Roof Monitoring		▪ Normal: less than 10mm ▪ Trigger 1: more than 10mm then *Notify* ▪ Trigger 2: more than 20mm then *Action (refer to Notes #1)*	▪ As per GREEN	▪ As per GREEN

Minimum Level Authority to Change Up	▪ Miner Driver or ▪ Supervisor	▪ As per GREEN	▪ As per GREEN
Minimum Level Authority to Change Down	▪ N/A	▪ Miner Driver and ▪ Supervisor. Check list to be completed.	▪ As per ORANGE and ▪ Shift Mining Supervisor
Notification of Condition Change	▪ Noted in Statutory and Production Report ▪ Tell-tail reports to be completed in tell-tail log book or on shift statutory report.	▪ As per GREEN ▪ Shift Mining Supervisor to inspect within 24 hours to confirm SCARP condition	▪ As per ORANGE ▪ Shift Mining Supervisor to inspect within 6 hours to confirm SCARP condition and notify Geotechnical Engineer ▪ Area to be hazard mapped within 24 hours
Hazard Mapping by Geologist, Geotechnical Engineer or UMM	▪ Weekly	▪ Every 100m of development or ▪ As per Action Response Note	▪ Every 50m of development & prior to forming a breakaway or ▪ As per Action Response Note

NOTES

1. Tell-tails to have anchors set at 0.5m (Lower) and 8.0m (Upper). Displacement measured excludes immediate skin failure (i.e. roof to 0.5m horizon).
    - Trigger Level 1: Notify Geotechnical Engineer at end of Shift.
    - Trigger Level 2: As per site specific *Action Response Note* as generated from Trigger Level 1 notification *OR* if no *Action Response Note* issued then STOP Mining and notify Geotechnical Engineer or Production Manager.
2. Where full encapsulation of roof bolts is not evident on more than 1 bolt per row when using 1000mm dual speed resin, the encapsulation length shall be tested and if greater than 300mm of free length is measured 1200mm resins are to be used. If greater than 300mm of free length is again identified on more than 1 bolt per row then code ORANGE (minimum) shall apply.
3. GXT cable bolts are to be point anchored with 1200mm resin anchors and tensioned to 15 tonnes prior to the working face advancing. If the desired tension cannot be achieved after 2 attempts, longer cables should be installed and the Geotechnical Engineer notified prior to the end of shift.
4. Where a feature causes the change in SCARP code then the corresponding support must be installed no less than 1m either side of the mapped feature.
5. In absence of the Shift Mining Supervisor, an Outbye Mining Supervisor shall action as per SCARP response.

Checked by: ------------------------------------- ---------- Date

Technical Support Superintendent

Authorised by ---------------------------------- ---------------------------- Date

Underground Mine Manager

G3 Maingate 10 Rib Support – TARP

	Condition Green	Condition Yellow	Condition Red
TRIGGERS			
Visible deterioration (detected during ongoing work area inspections or periodic geological mapping)	Geological structure • Normal coal cleating. • No geological structures. Visual condition • Competent ribs with spall less than 300mm. • No weight on rib bolt plates. • Roadway height is < 3.0m.	Geological structure • Cleat more open, friable or closely spaced. • Faulting < 300mm in throw. • Visible jointing in the ribs. Visual • Uneven ribs with minor deterioration/ spall between 300mm-500mm. • Rib bolt plates taking minor weight. • Roadway height >3.0m but <3.3m.	Geological structure • Open cleat, friable and brittle coal. • Cleating prominent in two directions. • Faulting >300mm in throw or any fault running sub-parallel to rib line. • Dyke and/or sill present with cindered coal. • Prominent jointing in the ribs. Visual • Uneven ribs with frequent spall greater than 500mm. • Ribs bulging and/or toppling. • Rib bolt plates taking moderate weight. • Roadway height >3.3m.
SUPPORT			
Minimum Support (as per Plan GLB1055)	• Roadway height < 3.2m: 2 x 1.2m rib bolts per 1.1m with mesh underpinned by the outside roof bolt or secured to the roof mesh. Install Rib Bolts as per support plan (00_1)	• As per condition GREEN. • Roadway height > 3.2m • Install Rib Bolts as per support plan (00_2).	• As per condition YELLOW. • Extra spot bolts are to be installed as deemed necessary to secure the rib. • Install Rib Bolts as per support

			plan (00_3).

- The Deputy has the authority to determine and select the appropriate support for Conditions Green to Red (from mode of failure and recommended support list), with the exception that the Undermanager with a written explanation or a member of the Strata Management Team must authorise any reduction in support from Condition Red.

Rib Bolt Notes:

- All rib bolts are to be installed as per SWP_02 Primary Rib Bolt Installation.

	Condition Green	Condition Yellow	Condition Red
Action/Response			
Operator	• Normal mining cycle tasks. • Support plan and TARP's.	• Install rib support as identified by deputy. • Support plan and TARP's.	• Install rib support as identified by deputy. • Support plan and TARP's.
Deputy	• Record mining conditions (including rib behaviour and any bolting issues) and any actions taken on Deputies' report. • Ensure that the support is installed as per support plans.	• Record mining conditions (including rib behaviour and any bolting issues) and any actions taken on deputies' report. • Notify Shift Undermanager when ground first deteriorates from Condition Green to Condition Yellow. • Ensure that the support is installed as per support plans.	• Record mining conditions (including rib behaviour and any bolting issues) and any actions taken on deputies' report. • Notify Shift Undermanager when ground first deteriorates from Condition Green or Yellow to Condition Red. • Ensure that the support is installed as per support plans.
Undermanager	• Ensure compliance with this TARP and investigate any non-compliance. •	• Inspect area when first notified by the Deputy of Condition Yellow and pass on condition to current shift and next shift. •	• Inspect area when first notified by the Deputy of Condition Red and note condition on shift report and any action taken. • Notify Development Superintendent of change to

			Condition Red.
Development Superintendent	• Ensure compliance with this TARP and investigate any non-compliance	• Notify the geologist of change to Condition Yellow on next available shift.	• Notify the geologist of change to Condition Red on next available shift.
Geologist	• Geological mapping, noting rib conditions. • Assess statutory reports and report to Mine Management as required.	• Assess statutory reports and report to Mine Management as required. • Inspect and map as required and confirm rib condition classification. • Assess mode of rib failure and recommend remedial support as required.	• Assess statutory reports and report to Mine Management fortnightly. • Inspect and map as required and confirm rib condition classification. • Assess mode of rib failure and recommend remedial support as required.

G4 Roadway Development TARP

WITHIN MINER LENGTH OF FACE	TRIGGER	ACTION IF TRIGGER ACTIVATED
Guttering or sag	• Less than 100mm	• Install Code Green support
	• 100 to 300mm	• Install Code Yellow support
	• Greater than 300mm	• Install Code Red support • Install a Rock-it every 30m in affected ground • Assess whether additional support is required
Cavities	• Less than 300mm	• Install Code Green support
	• 300 to 600mm	• Install Code Yellow support
	• Greater than 600mm	• Install Code Red support • Install a Rock-it every 30m in affected ground • Assess whether additional support is required
Geological Structure	• None present	• Install Code Green support
	• Cutters present	• Install Code Yellow support
	• Fault or dyke	• Install Code Red support • Install a Rock-it every 30m in affected ground • Assess whether additional support is required

OUTBYE OF MINER	TRIGGER	ACTION IF TRIGGER ACTIVATED
Fresh roof guttering or sag	• No signs of fresh guttering or sag	• Continue to mine as planned
	• Fresh guttering or sag	• Assess whether additional support is required
Displacement on Rock-it	• Less than 30mm	• Continue to mine as planned
	• Greater than 30mm	• Assess whether additional support is required

TARP Approved:	Date:	Manager of Mining Engineering:		Geotechnical Engineer:		Revision No.	1

1. If Yellow or Red triggers are activated, Deputy is to specify TARP level and location on shift report sheet.

2. If Yellow or Red triggers are activated, the area is to be mapped and the need for additional support / monitoring is to be assessed by a Geotech. Engineer.

G5 LW8 TAILGATE TARP

	Condition Green - Mine as Normal	Condition Yellow - Install Additional Roof Support and Mine with Caution	Condition Red - Install Additional Roof Support and Review Support Design
Conditions During LW Extraction	• Goaf edge located at or inbye of rear of canopy on TG powered support • Negligible fresh roof or rib deterioration outbye of the LW face	Any of the following: • Fresh roof sag or guttering <10m outbye of face • Goaf edge between legs and rear of canopy on TG powered support	Any of the following: • Fresh roof sag or guttering >10m outbye of face • Goaf edge located outbye of legs on TG powered support
Minimum Support Action	• No additional support required	Install either: • One 800mm Link-n-Lock crib every 6m (centres), a minimum of 1m from the pillar rib, to a distance of at least 18m outbye of the face (ie at least 4 cribs) or: • One Propsetter every 4m along the roadway centre line, to a distance of at least 20m outbye of the face (ie at least 6 props) or: • One Propsetter every 2m along the pillar side, 1m from the rib, to a distance of at least 20m outbye of the face (ie at least 11 props)	Install either: • One 800mm Link-n-Lock crib every 4m (centres), a minimum of 1m from the pillar rib, to a distance of at least 28m outbye of the face or to the outbye edge of the deterioration (ie at least 7 cribs) or: • One Propsetter every 2m along the roadway centre line, to a distance of at least 30m outbye of the face or to the outbye edge of the deterioration (ie at least 16 props)
Inspection Action	• Normal statutory / shiftly inspections.	• Deputy to inform Shift Undermanager when ground (first) deteriorates from Condition Green to Condition Yellow • Deputy to inform Shift Undermanager of any face stoppage of >4 hours with an intersection ≤20m outbye • Deputy to inform Shift Undermanager of any stoppage of >24 hours	• Deputy to inform Shift Undermanager when ground (first) deteriorates from Condition Green or Yellow to Condition Red. • Deputy to inform Shift Undermanager of any face stoppage of >24 hours with an intersection ≤20m outbye • Shift Undermanager and Deputy then to

	Condition Green - Mine as Normal	Condition Yellow - Install Additional Roof Support and Mine with Caution	Condition Red - Install Additional Roof Support and Review Support Design
		• Shift Undermanager and Deputy then to inspect TG ASAP to determine if any additional support is required. • Shift Undermanager to report Condition Yellow trigger in writing to: **A)** Oncoming Deputy **B)** Oncoming Undermanager **C)** LW Coordinator • Shift Undermanager to continue with daily inspections of the area affected until Condition Green is attained.	inspect TG ASAP to determine if any additional support is required. • Shift Undermanager to contact LW Coordinator immediately and report Condition Red trigger in writing to: **A)** Oncoming Deputy **B)** Oncoming Undermanager • LW Coordinator and Second Member of Strata Team to inspect within 24 hours to determine adequacy of support. • LW Coordinator to: a) Ensure that the area is inspected by the Geologist and / or Geotechnical Engineer within 48 hours b) Report on the actions taken within 24 hours to the Operations Manager.

G6 LW5 TAILGATE – TARP

	Condition Green - Mine as Normal	Condition Yellow - Install Additional Roof Support and Mine with Caution	Condition Red - Install Additional Roof Support and Formally Review Support Design
Pre-LW Extraction Ground Condition	• Typical sandstone / siltstone roof • No major geological structure • Width ≤5.5m; height ≤3m • Minimal signs of roof buckling (ie no visible sag, <50mm guttering, dry, pick marks visible or <200mm skin loss, bolt plate loading as driven)	Any of the following: • Coal and/or shale roof • Major geological structure (ie faults, dykes or joint swarms) • Roadway width >5.5m, but ≤6m; height >3m, but ≤3.5m • Roof buckling (ie ≥50mm, but <100mm sag, ≥50mm, but <300mm guttering, occasional drippers, ≥200mm, but <500mm skin loss, tensile cracking, increased load on bolt plates)	Any of the following: • Within 50m either side of LW Square Position. • Water has contacted roof. • Four-way (stub) intersections and roadways • Width >6m, but <7m; height >4m, but <4.5m • Roof buckling (ie ≥100mm sag, ≥300mm guttering, multiple drippers, ≥500mm skin loss, bolt and/or cable plates flattening or inverting)
Minimum Pre-LW Extraction Level of Secondary Support	• One Link-n-Lock / 5m (skin to skin) OR one Propsetter / 3m OR one 4m JSS cable / 3m (all on C/L) • Two Link-n-Locks per intersection (C/T side) • One Link-n-Lock at every GEB niche	• One 4m JSS cable / 2m OR one Propsetter / 2m (all on C/L) • One additional 4m JSS cable / 2m OR one Propsetter / 2m OR one Link-n-Lock / 3m (skin to skin) (all 1.5m from block) • Two Link-n-Locks per intersection (C/T side) • One Link-n-Lock at every GEB niche	Site specific design may be required; the following is a guide: • One 4m JSS cable/ 2m OR one Propsetter / 2m (all on C/L) • One additional 4m JSS cable / 2m OR one Propsetter / 2m OR one Link-n-Lock / 3m (skin to skin) (all 1.5m from block) • One additional 4m JSS cable / 2m OR one Propsetter / 2m OR one Link-n-Lock / 3m (skin to skin) (all 1.5m from pillar) • Two Link-n-Locks per intersection (C/T side) • One Link-n-Lock at every GEB niche

	Condition Green - Mine as Normal	Condition Yellow - Install Additional Roof Support and Mine with Caution	Condition Red - Install Additional Roof Support and Formally Review Support Design
Instrumentation	• Tell-Tales to be installed at 100m intervals (ie every intersection)	• Tell-Tales to be installed at 50m intervals and at all major geological structures	• Tell-Tales at 50m intervals and at all major geological structures • Additional instruments specified by Strata Management Team
Conditions During LW Extraction	• Fresh guttering or roof sag ≤10m outbye of face • Fresh continuous rib spall to a depth of ≤0.3m and ≤5m outbye of the face • Goaf edge located at or inbye of rear of canopy on TG powered support • Cables or timber loading up ≤5m outbye of face • Tell-Tale Movement (T-L) ≤3mm as face passes	Any of the following: • Fresh guttering or roof sag >10m, but ≤20m outbye of face • Fresh continuous rib spall to a depth of >0.3m, but ≤1m for a distance of >5m outbye of face • Goaf edge between legs and rear of canopy on TG support • Cables or timber loading up >5m, but ≤20m outbye of face • Tell-Tale Movement (T-L) >3mm, but ≤10mm as face passes • ≤10m of LW retreat in any continuous 72 hour period	Any of the following: • Fresh guttering or roof sag >20m outbye of face • Fresh continuous rib spall to a depth of >1m for a distance of >5m outbye of face) • Goaf edge located outbye of legs on TG support • Cables or timber loading up >20m outbye of face • Tell-Tale Movement (T-L) >10mm as face passes • ≤10m of LW retreat in any continuous 7 day period
Minimum Support Action	• Nil	• Replace any failed Propsetters with support of equivalent capacity. • If Pre-LW Extraction Support is as per Condition Green, install two extra Propsetters per 3m (one on C/L and one 1.5m from block) OR support of equivalent capacity.	• Replace any failed Propsetters or cables with support of equivalent capacity. • If distance between block-side roof bolt and spalled rib is >1.5m assess the need for additional roof bolts and mesh. • If Pre-LW Extraction Support is as per Condition Yellow, install one Link-n-Lock / 3m OR one Propsetter / 2m (all 1.5m from pillar) OR support of equivalent capacity.

	Condition Green - Mine as Normal	**Condition Yellow - Install Additional Roof Support and Mine with Caution**	**Condition Red - Install Additional Roof Support and Formally Review Support Design**
Inspection Action	• Normal statutory / shift inspections. • Cables only to be used if roof composition is satisfactorily confirmed as sandstone/siltstone.	• Deputy to inform Shift Undermanager when ground (first) deteriorates from Condition Green to Condition Yellow • Shift Undermanager and Deputy to inspect TG before end of shift to determine whether additional support is required. • Shift Undermanager to report Condition Yellow trigger in writing to (a) Oncoming Deputy, (b) Oncoming Undermanager, (c) LW Co-ordinator and (d) Senior Mining Engineer. • LW Co-ordinator and Senior Mining Engineer / Geologist / Geotechnical Practitioner to inspect TG within 24 hours to check whether additional support is required. • Shift Undermanager to continue with daily inspections of the area affected until Condition Green is attained.	• Deputy to inform Shift Undermanager when ground (first) deteriorates from Condition Green or Yellow to Condition Red • Shift Undermanager and Deputy then to inspect TG before end of shift to determine whether additional support is required • Shift Undermanager to contact LW Co-ordinator immediately and report Condition Red trigger in writing to (a) Oncoming Deputy, (b) Oncoming Undermanager and (c) Senior Mining Engineer • LW Co-ordinator and Senior Mining Engineer / Geologist / Geotechnical Practitioner to inspect TG within 24 hours to check whether additional support is required • Senior Mining Engineer to ensure that the area is (or has been) inspected by the Geologist and a Geotechnical Engineer, such that site specific roof support advice is obtained and report actions taken within 24 hours to the Mine Manager.

G7 LW5 Take-Off TARP

Date: _________ Shift: _________ Deputy: ______________ Undermanager: _______________ Longwall Coordinator: _________________

During Bolt-Up	Trigger	Shield No.	Action if Trigger Activated
Roof guttering / cavity	≥ 0.5m.		• Level 2 Roof support – one 4m cable per shield (vertical, 1.4m from final rib line (as per LW5 Take-off support plans).
Geological Structures	Fault, dyke or joint swarm.		• Level 3 Roof support – one 6m cable per shield (at 70°, 1.4m from final rib line (as per LW5 Take-off support plans).
Face spall	>0.2m to ≤ 0.4m.		• Increase bolt density to two rib bolts per powered support.
	>0.4m, over more than 5 shields.		• LW Coordinator and Technical Services Manager to review rib support requirements.
Face breaks / open joints sub-parallel to face	In front of shield canopies.		• LW Coordinator and Technical Services Manager to review roof support requirements.
Initial borescope results	>10mm to ≤ 30mm of separation.		• Level 3 Roof support – one 6m cable per shield (at 70°, 1.4m from final rib line (as per LW5 Take-off support plans).
	>30mm of separation.		• LW Coordinator and Technical Services Manager to review roof support requirements.
Roof monitoring	Ongoing creep >2mm / week.		• LW Coordinator and Technical Services Manager to review roof support requirements.
Roof bolt quality	Bolts / cables not tensioning and / or not adequately encapsulated.		• LW Coordinator and Technical Services Manager to review roof support requirements, including the potential need to increase the cable length

During shield removal	Trigger	Shield No.	Action if Trigger Activated
Caving behind walkers	Caving irregular.		• LW Coordinator to review standing support density.
Sag ahead of walkers	Sag impeding chock removal.		• Undermanager to assess the need to (i) stop shield recovery and (ii) install additional support.
Guttering or face breaks along rib corner	Fresh deterioration migrating outbye of walker shields.		• Stop shield recovery and review support requirements.
Monitoring (displacement on total [8m] anchor)	>20mm to ≤ 30mm.		• LW Coordinator and Technical Services Manager to review roof support requirements.
	>30mm, with the tell-tale still more than 10 line shields from the walker shields.		• Stop shield recovery and review support requirements.

Bolt-up Position S.O.S: ____________ E.O.S: ______________ Last Line Shield in Place S.O.S __________ E.O.S___________

G8 Installation Road – Roadway Widening TARP

Date: ________ Shift: _______ Deputy: ___________ Undermanager: ______________Face position at S.O.S: ______ Face position at E.O.S: _______

	TRIGGER	LOCATION (m from MG)	ACTION IF TRIGGER ACTIVATED
Deformation in 1st Pass Roof	No signs of fresh guttering or sag		• Mine as normal
	Up to 100mm of fresh guttering or sag		• Deputy to assess whether additional support is required
	Greater than 100mm of fresh guttering or sag		• Deputy to ensure tell-tale is installed in affected area • Deputy to ensure additional support is installed as directed by a member of the Strata Management Team
Deformation in 2nd Pass Roof	Any sign of guttering or sag		• Deputy to ensure tell-tale is installed in affected area of widened roof • Deputy to ensure additional support is installed as directed by a member of the Strata Management Team
Audible Roof Deformation	Nothing to report		• Mine as normal
	Consistent loud bangs		• Deputy to assess whether additional support and monitoring is required
Roadway Width	Up to 0.2m over-wide		• Mine as normal
	0.2 to 0.5m over-wide		• Miner driver to correct roadway width immediately • Deputy to assess whether additional support and monitoring are required

	TRIGGER	LOCATION (m from MG)	ACTION IF TRIGGER ACTIVATED
	Greater than 0.5m over-wide		• Miner driver to correct roadway width immediately • Deputy to ensure tell-tale is installed in affected area • Deputy to ensure additional support is installed as directed by a member of the Strata Management Team
Measured Surge in Roof	Up to 25mm		• Mine as normal
Displacement following Widening	Greater than 25mm		• Deputy to assess whether additional support is required • Deputy to read tell-tale at least twice per shift until further notice
	Greater than 20mm in one shift		• Deputy to stop stripping and assess condition of roadway with Undermanager to determine (i) whether or not the miner should be pulled back and (ii) additional support should be installed • Deputy to read tell-tale at least 4 times a shift until further notice

1. Deputy to report all Red triggers to Undermanager and Development Coordinator immediately
2. If Yellow or Red triggers are activated, the area is to be assessed by a Geotech. Engineer and the Development Coordinator

G9 Longwall Retreat Strata Action Plan (Longwall Production District)

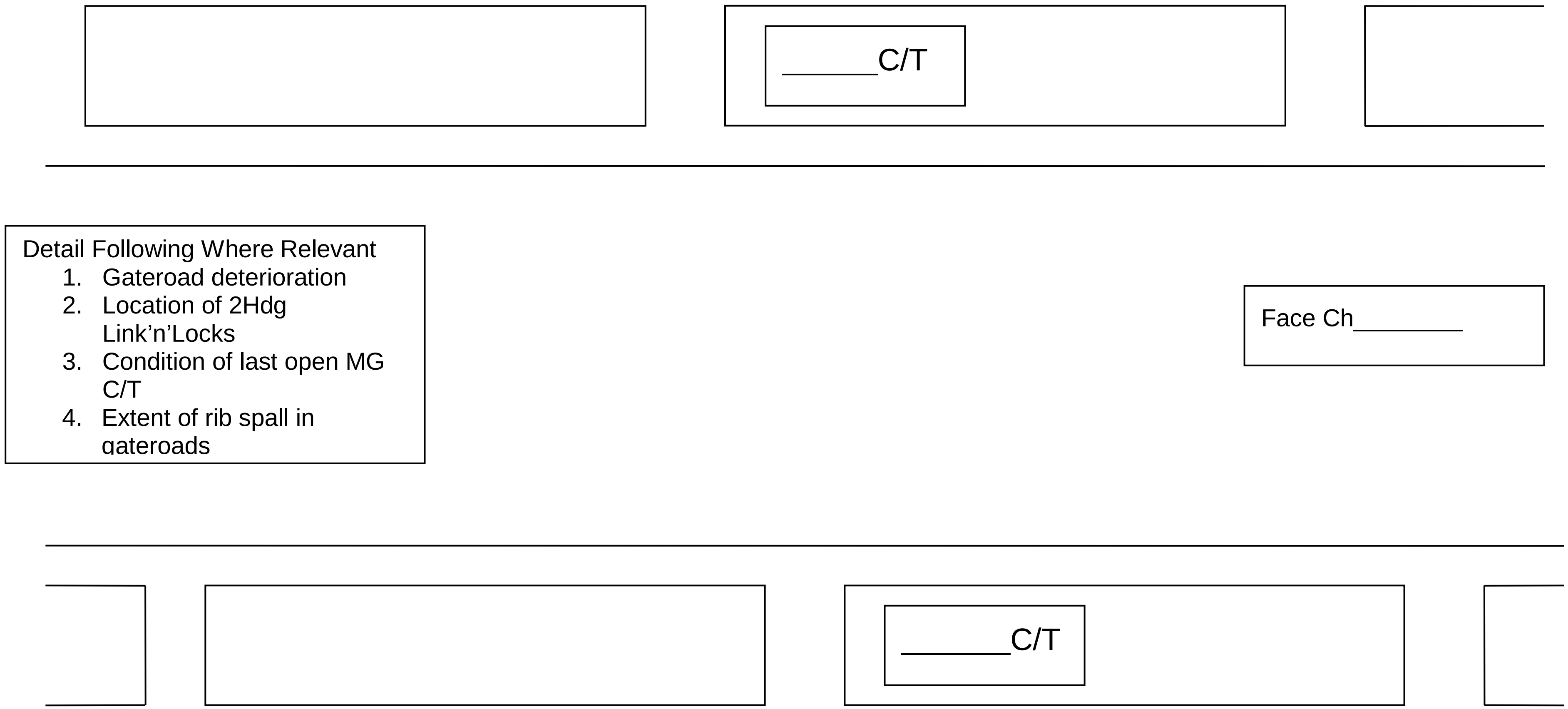
Date: __________ Shift: _____ Deputy: _______________ Face at S.O.S:____________ Face at E.O.S:______________U/M_________________

	TRIGGER	TICK BOX	CHAINAGE	ACTION IF TRIGGER ACTIVATED
MAINGATE				
Roof Conditions	Normal			• Mine as normal
	Gutter or sag 10 to 30m outbye of face			• Assess whether additional support is required
	Deterioration of C/T or 2 Hdg O/B of face			
	Guttering or sag >30m outbye of face			• Install support in affected area
Clearance above BSL	200 to 500mm			• Assess for additional support / floor brushing
	<200mm			• Install support in affected area and/or brush floor
Goaf Edge	Goaf holding up inbye of MG support			• Record Distance in Chainage Box
TAILGATE				
Roof Conditions	Normal			• Mine as normal
	Blockside roof or rib failing			• Assess whether additional support is required
	>250mm of roof sag 10 to 30m O/B of face			
	Blockside roof guttering >5m O/B of face			• Deputy and U/M to assess whether LW should be stopped and additional support installed
	>250mm of roof sag >30m O/B of face			

Standing Supports	Timber splitting 10 to 30m O/B of face			• Assess whether additional support is required
	Timber splitting >30m outbye of face			• Deputy and U/M to assess whether LW should be stopped and additional support installed
Goaf Edge	Up to or past legs on TG support			• Deputy and U/M to assess whether LW should be stopped and additional support installed
LONGWALL			CHOCKS	
Roof Conditions	Normal			• Mine as normal
	Gutter above clay band over >2 but <10 chocks			• Close up face and assess for re-support
	Gutter above clay band >10 chocks			• Close up face, stop production, resupport and/or PUR
Chock Convergence	>300mm over >2 but <10 adjacent chocks			• Close up face and assess for re-support
	>300mm over >10 adjacent chocks			• Close up face, stop production, resupport and/or PUR
Face Spall	Spall >1m beyond reach of cantilever			• Close up face and assess for re-support
Anomalous Geology	Fault, white staining on joints, soft coal			• Close up face and assess for re-support

Note: report YELLOW and RED triggers to U/M and RED triggers to LW Superintendent and Technical Services Manager before end of shift.

Use Diagram Below To Sketch Detail of Gateroad / Face Issues (If Required)



TELLTALES

LOCATION	LOWER	TOTAL	LOCATION	LOWER	TOTAL

FACE CUTTING HEIGHTS

CHOCK No.	CUT HEIGHT	CHOCK No.	CUT HEIGHT

G10 Longwall Face TARP

CONDITION	GREEN – NORMAL OPERATIONS
FACE STATUS NORMAL ROOF	• This condition includes the falling out of the stone that occurs from time to time without consequence or imminent danger of a serious roof fall • No faulting present

Face and gradient Conditions	• Extraction height as per block management Plan
	• Pans following seam grade in retreat direction as apparent by eye.
	• Support canopies and base level and parallel.
	  - No excessive rolls on face
	  - Shields set correctly throughout the face

Breakline/Goaf	• Supports generally below yield • Breakline on rear edge of canopy
Creep and Alignment.	• Creep <300mm of centre • Face visually straight. • Landmark Operating, if Landmark does not operate, a string line MUST be used
Face Spall	• Canopy to face distance of 900mm • Face spall to less than 500mm depth. • Maximum of approximately 200mm of coal/tuff falling between canopy tips and face.
Hydraulic Pumps	• Pumps cycling as normal operation • All pumps available • Pump pressure maintained at 330 bar
G Set	• G set turned on across face and operational
ACTIONS	
Mode of Operation	• Bi-Di primers switched on
Support Advance	• Automation RS20, shearer initiation
Face Alignment	• Check alignment • Use Landmark, if landmark does not operate on the requested shear -string line to be used.
Horizon Control	• Check Horizon Continuously

Creep Control	• Check rate of creep; fly (wedge) cut if:
	  - Creep is over 300mm AND
	  - Creep is getting worse.
	• Don't do more than 1 wedge cut in 4 shears

CONDITION	GREEN – NORMAL OPERATIONS
Maingate Roadway – clearance over the MG drive	• Maintain 250mm clearance – Remedial floor actions implemented if excessive convergence.
Gate Roads	• Monitor Maingate and Tailgate Horizons
Maintenance	• As Scheduled
Inspections	• As per Standards.
Supervision	• Crew Supervisor
Decision to change status to YELLOW	• Crew Supervisor

CONDITION	Yellow
FACE STATUS BAD ROOF/FAULTING	• Cavities up to 500mm high over 5 supports. • Not including those small cavities that occur from time to time. • Faulting with vertical displacement >1.0m. • Soft coal from 1-3m width & increased jointing.
Face and gradient Conditions	• Extraction height >3.1m or < 2.8m • Tops falling out. • Pans noticeably dipping into floor or rising into seam in retreat direction. • Noticeable difference in the grade of the support tips and bases. • Notable rolls on face.
Breakline / Goaf	• Some supports reaching yield • Breakline advancing forward from rear edge of canopy. • Goaf coming forward in either TG or MG end around the side of 1 or 153 support.
Creep and Alignment.	• Creep 300mm - 500mm of datum. • Visual face misalignment greater than one web.
Face Spall	• Face spall to 0.5m to 1.5m in depth.
Hydraulic Pumps	• Pumps not cycling in normal operation • Not all hydraulic pumps available • Pump pressure not able to be maintained at 330 bar
G Set	• G set is not turned on across face or operational • When the goaf break point moves to the front of the support the G set will force the rear of the canopy up into the broken roof, this will break the comp ram in the rear of the support. In this case the G set is to be turned off to prevent this happening
Creep and Alignment.	
Mode of Operation	• Bi-Di Conventional mode.
Support Advance	• Immediately behind lead drum. • Re-advance supports locally if tip to face is excessive, double chock. • Check that the pan push has been achieved.
Face Alignment/Creep control	• Do not fly or wedge cut with in 15m either side of a cut through. • Keep pans flat, face straight and canopy supports level

CONDITION	Yellow
Horizon Control	• Adjust the height of the trailing drum and/or leading drum by <100mm increments per shear to alter the extraction height as required. • Pull back pans and recut floor if pans rising (<100mm undercut) • Lower tip of support to remove build-up of material so that tip may be raised. Manually set support maintaining tip pressure. • Continually review grade of pans on every pass.
Maingate Roadway – clearance over the MG drive	• Maintain 250mm clearance – Remedial floor actions implemented if excessive convergence.
Hydraulic Pumps	• Stop the face until face pressure can be maintained
G Set	• G set is not turned on across face or operational – Turn off G set, level supports to be able to move under the lip – When the support have regained full canopy contact turn G set back on
Special Actions	• Check that the explosive magazine has stock of plugs and dots • Check that the borer and drills are on the maingate drive.
Maintenance	• No maintenance stoppages 15m either side of a cut through.
Inspections	• As per Standards.
Supervision	• Crew Supervisor
Decision to change status to RED	• L/W Coordinator and Crew Supervisor
Decision to change status to GREEN	• L/W Coordinator and Crew Supervisor

CONDITION	RED
FACE STATUS VERY BAD ROOF Notify Manager	• Cavities over 1m high and/or extending for more than 5 supports. • Faulting with vertical displacement >1.5m. • Soft coal over 3m width
Face and gradient Conditions	• Extraction height > 4.0m and <2.8m • Pans excessively dipping. • Excessive rolls on face. • Supports on constant Yield. • Stone falling • Stone falling and burying shearer • Stone blocking AFC and crusher • Stone free falling onto the AFC
Breakline / Goaf	• Breakline flushing forward over chocks.
Creep and Alignment.	• Creep >500mm off datum. • Visual face misalignment greater than 1 web.
Hydraulic Pumps	• Pumps not cycling in normal operation • Not all hydraulic pumps available • Pump pressure not able to be maintained at 330 bar
G Set	• G set is not turned on across face or operational • When the goaf break point moves to the front of the support the G set will force the rear of the canopy up into the broken roof, this will break the comp ram in the rear of the support. In this case the G set is to be turned off to prevent this happening
Face Spall	• Spall to 2.0m or greater.
ACTIONS	
Mode of Operation	• Bi-Di Conventional. • Chock in behind lead drum. • Primes turned off and keep canopies level • G set turned off in fall zone only
Roof and Face Control	• Stop Production and secure face by advancing supports and conveyor.
Creep and Alignment Control	• Implement conditions as for code Yellow.
Face Horizon and gradient Control	• Pull back pans and recut floor if pans rising (<75mm undercut) • Lower tip of support to remove build up so that tip may be raised.

CONDITION	RED
Maingate Roadway – clearance over the MG drive	• Maintain 250mm clearance – Remedial floor actions implemented if excessive convergence.
Hydraulic Pumps	• Stop the face until face pressure can be maintained
G Set	• G set is not turned on across face or operational • Turn off G set, level supports to be able to move under the lip • When the support have regained full canopy contact turn G set back on
Special Actions	• Inspection by L/W Coordinator • Formulate Recovery Plan and Action Recovery Plan
Maintenance	• During stoppages when equipment is not required
Inspections	• Undermanager to inspect each shift. • L/W Coordinator to inspect daily.
Supervision	• Crew Supervisor
Decision to change status to YELLOW or GREEN	• L/W Coordinator and Crew Supervisor

STRATA CONTROL ACTION RESPONSE PLAN
OUTBYE ROADWAYS

G11

SCARP CODE		Condition Green	Condition Yellow	Condition Orange	Condition Red
Triggers	Roof Conditions	<u>Visual</u> **1.** No visible deformation or slabbing <u>Noise</u> **1.** Roof quiet <u>Supports</u> **1.** No sign of additional support loading 2. Placed support intact <u>Water</u> **1.** None	<u>Visual</u> **1.** Some fresh coal (fretting) along roof edge or across roof <u>Noise</u> **1.** Roof quiet <u>Supports</u> **1.** Some minor sign of additional support loading **2.** Support rusted but largely intact <u>Water</u> **1.** Roof damp, minor drippers	<u>Visual</u> **1.** Guttering developing <u>Noise</u> **1.** Occasional cracking sounds <u>Support</u> **1.** Roofbolt/ long tendons plates flattening **2.** Support heavily rusted and broken <u>Water</u> **1.** Water dripping continuously across roof	<u>Visual</u> **1.** FALL OF SUPPORTED GROUND **2.** Active guttering progressing into roof <u>Noise</u> **1.** Roof noisy, frequent cracking sounds <u>Support</u> **1.** Heavy support loading. Bolts/tendons pulling into roof <u>Water</u> **1.** Heavy water make
	Rib Conditions	<u>Visual</u> **1.** Ribs good. Minimal post development spall (less than 0.3m) <u>Supports</u> **1.** Placed support intact	<u>Visual</u> **1.** Increased rib spall (0.3m to 0.5m), ribs deteriorating <u>Supports</u> **1.** Some rib bolts broken or exposed and hanging out	<u>Visual</u> **1.** Soft ribs or large blocky spall between (0.5m to 1.0m additional) <u>Supports</u> **1.** Large number of rib bolts broken off or exposed and hanging out	<u>Visual</u> **1.** FALL OF SUPPORTED RIB **2.** Heavy spall greater than 1m **3.** Bolts pulling into rib and not effective
		IN THE ASSESSMENT OF ROOF AND RIB CONDITIONS ABOVE, IT IS ASSUMED THAT ADVERSE GEOLOGICAL STRUCTURE AND/OR ROADWAY GEOMETERY WAS ADDRESSED ON ROADWAY DEVELOPMENT USING THE APPROPIATE SCARP			

	Monitoring trigger	Response	Monitoring trigger	Response
Monitoring	<u>PRIMARY SUPPORT TRIGGERS AND RESPONSES (4 OR 6 BOLT PATTERN AREAS)</u>		<u>SECONDARY SUPPORT TRIGGERS AND RESPONSES (LONG TENDONS 2/2M INPLACE)</u>	
	Total Roof Movement T<10mm Upper Roof Movement T-L <5mm	→ Continue routine monitoring to SCARP	Less than 30mm additional movement since tendons placed or Less than 50mm Total Movement	→ Monitor for other signs of instability as per SCARP
	Total Roof Movement T=10mm to T=20mm Upper Roof Movement T-L=5mm to T-L=10mm	→ Inform ERZ Controller, Development Coordinator and Geotech Engineer	30mm to 50mm additional movement since tendons placed or 50mm to 70mm Total Movement	→ Install additional tendons infilling to 2/1m. Inform Undermanager
	Total Roof Movement T>20mm and rate of movement increasing Upper Roof Movement T-L>10mm and rate increasing	→ Install 8m Tendons 2/2m minimum 5m either side of Tell Tale in absense of other visual indications	Greater than 50mm additional movement since tendons placed or greater than 70mm Total Movement	→ Formulate Remedial Response Plan

Response	Roof Support	**1.** No additional support required **2.** Monitor conditions during routine inspections	**1.** No additional support required **2.** Increase frequency of inspection and tell tale monitoring in the area	**1.** Where tell tales are not installed and no secondary support exists, install fully encapsulated 8m tendons 2/2m. Install a tell tale in area **2.** Where tell tales exist install support as per monitoring responses **3.** Increase frequency of inspection to shiftly in area affected **4.**Broken roof support/mesh scheduled to be replaced	**1.** Set temporary support to secure fall brow **2.** Support plan to be formulated by Geotech Engineer in consulation with Area Superintendant and Mine Manager. In most cases minimal additional support to include 8m tendons fully encapsulated 2/2m. **3.** Tell tale to be installed in affected area
	Rib Support	**1.**Monitor rib condition during routine inspections	**1.** Schedule for the installation of additional rib bolts as reqd **2.** Review conditions of pillar corners	**1.** Ribs to be mesh and additonal bolts installed as required	**1.** Ribs to be fully meshed with use of longer bolts as reqd
	Monitoring	**1.** Monitor tell tales on a monthly basis	**1.** Monitor tell tales daily until stable.	**1.** Monitor tell tales in affected area shiftly until stable	**1.** Monitoring plan to be developed and installed as required
	Change Condition Up	**1.** The ERZ Controller has the authority to change condition up	**1.** The ERZ Controller has the authority to change condition up	**1.** The ERZ Controller has the authority to change condition up	
	Change Condition Down		**1.** The ERZ Controller has the authority to change to Condition Green	**1.** The ERZ Controller after consultation with the Geotech engineer	**1.** The Mine Manager has the authority to change condition down in consultation with the Outbye Superintendent and Geotech Engineer
	Accountability	The immediate Supervisor is to fulfil the role when a person under the SCARP is unavailable			
Responsibilities	All	**1.** Observe for deteriorating or unusual conditions	**1.** Inform the ERZ Controller of any signs of instability that they become aware of	**1.** Inform the ERZ Controller of any signs of instability that they become aware of	**1.** Notify the ERZ Controller of any signs of instability **2.** If conditions are particularly poor, restrict acces to the area **3.** Operate to the remedial support plan
	ERZ Controller	**1.** Has the authority to change condition up **2.** Complete monitoring as per above requirements **3.** Note current Outbye SCARP condition in the Statutory Book **4.** Ensure that there is a copy of the SCARPs, Managers Support Rules and hazard plans in the cribroom	**1.** Has the authority to change condition up or down **2.** Complete monitoring as per above requirements **3.** Inform the Outbye Coord/Undermanger of condition Yellow **4.** Note current Outbye SCARP condition in the Statutory Book	**1.** Has the authority to change condition up **2.** Complete monitoring as per above requirements **3.** Inform the Outybe Coord/Undermanger of condition Orange as soon as possible **4.** Note current Outbye SCARP condition in the Statutory Book **5.** Ensure that appropriate remedial responses as outlined are being employed safely	**1.** Ensure access is restricted and area is secured. **2.** Restrict access to fall area except for those securing the fall. Ensure safe measures are being taken. **3.** Inform the Outbye Coord/Undermanger of condition Red as soon as possible **4.** Note current Outbye SCARP condition in the Statutory Book **5.** Participate in formulating a remedial response plan **6.** Ensure that appropriate remedial responses as outlined are being employed safely
	Control Room Operator	**1.** Continue routine monitoring	**1.** Note changed condition in Shift Log Book **2.** Inform Undermanager of condition yellow within that shift	**1.** Note changed condition in Shift Log Book **2.** Inform Undermanager of condition orange as soon as possible **3.** Inform the Outybe Superintendent and Geotech Engineer of condition orange within 24 hours	**1.** Note changed condition in Shift Log Book **2.** Inform Undermanager of condition red as soon as possible **3.** Inform the Mine Manager, Outbye Superintendent and Geotech Engineer of condition red as soon as possible
	Shift Supervisor/ Undermanager	**1.** Has the authority to change condition up **2.** Ensure support and monitoring requirements are met	**1.** Has the authority to change condition up or down **2.** Visit the affected area in the shift it was reported **3.** Ensure the support consumables for condition orange are available in the panel	**1.** Has the authority to change the condition up or down **2.** Visit the affected area as soon as possible **3.** Ensure appropriate responses are being implemented (tendons, tell tales etc)	**1.** Visit the affected area as soon as possible **2.** Participate in formulating a remedial response plan **3.** Ensure that appropriate remedial responses as outlined are being employed safely
	Geologist	**1.** Mapping of outbye areas up to date			
	Geotech Engineer/ Tech. Manager	**1.** Has the authority to change condition up **2.** Design and provide Managers Support Rules **3.** Ensure monitoring is updated monthly	**1.** Has the authority to change condition up or down	**1.** Has the authority to change condition up **2.** Visit the affected site within 48hours of being informed **3.** Provide guidance on appropriate support to be installed **4.** Update the monitoring for the area and interpret trends	**1.** Visit the site as soon as possible **2.** Participate in formulating a remedial response plan
	Outbye Superintendent	**1.** Has the authority to change condition up **2.** Ensure support and monitoring requirements are met	**1.** Has the authority to change condition up or down	**1.** Has the authority to change condition up or down in consultation with Geotech Engineer **2.** Visit the affected site within 48hours of being informed **3.** Ensure appropriate responses are being implemented (tell tales, tendons etc)	**1.** Visit the site as soon as possible **2.** Lead the remedial response team in formulating a plan **3.** Ensure that appropriate remedial responses as outlined are being employed safely
	Mine Manager	**1.** Has the authority to change condition up **2.** Sign off on Managers Support Rules	**1.** Has the authority to change condition up or down	**1.** Has the authority to change condition up or down	**1.** Has the authority to change condition down **2.** Participate in formulating a remedial response plan

THIS DOCUMENT DEFINES CHANGES IN SUPPORT CODES BASED ON OBSERVATIONS IN THE ROADWAY. ANY ONE TRIGGER WILL BE SUFFICIENT. ALL REQUIREMENTS OF LOWER SCARP LEVELS MUST ALSO BE MET WHEN COMPLETING ACTIONS
When a roof response is triggered, rib responses are not necessarily triggered unless ribs conditions have also deteriorated as indicated by the TARP codes (vice versa).

Approved: Mine Manager

Approved: Geotech Engineer