THE DEVELOPMENT OF HAZARD PLANS AT KESTREL MINE

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ABSTRACT Kestrel Mine is currently longwalling in the 2.4-3.3 metre thick German Creek seam, at depths between 220 and 295 metres. Run of mine production for the year 2002 is budgeted at 5.3mt, ramping up to 6mt by 2004. Achieving these levels of production will require a thorough understanding of the geological and geotechnical environment. The identification of potential hazards prior to intersection, is vitally important to ensure a consistent coal flow, free of major disruptions and downtime. Hence the preparation of development and longwall panel hazard plans, is an integral part of the production process. Emphasis is on the compilation of detailed, but easy to read plans for the principal users, the workforce at the face.

INTRODUCTION

Kestrel Mine is located 48km northeast of Emerald and 354km by rail from the Port of Gladstone (Fig. 1). The mine is managed by Kestrel Coal Pty Ltd, a wholly owned subsidiary of Pacific Coal Pty Ltd, itself a subsidiary of Rio Tinto. Pacific Coal Pty Ltd gained control of the mine when it purchased ARCO's 80% interest in the project joint venture in late 1998. Mitsui Kestrel Coal Investment Pty Ltd holds a 20% interest.

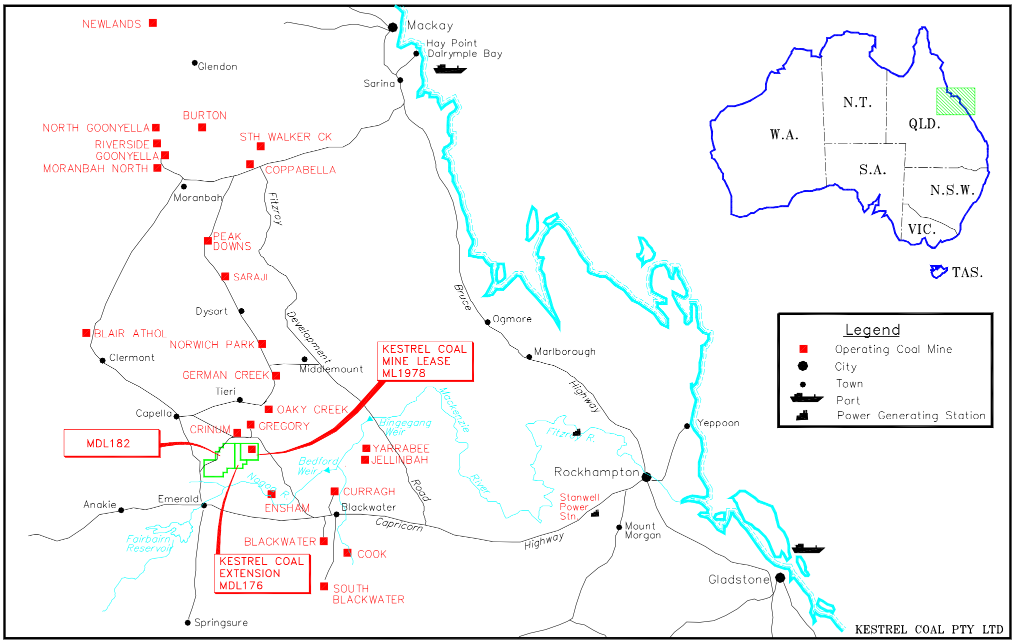

Fig. 1. Regional Location Plan

The Kestrel Coal mining lease (ML 1978) adjoins BHP Gregory and Crinum to the north and the Ensham deposit to the south (Fig. 1). Following the purchase of Kestrel (formerly Gordonstone) from ARCO, development by Kestrel Coal started on the 23rd February 1999. Extraction of Longwall 107 began on the 28th May 1999. By the end of 2001, more than 10 million tonnes ROM had been mined. Production is planned to ramp up to 6 million tonnes ROM by the year 2004.

Longwall extraction during 2002 will be in 205 (3.4km long) and 206 (2.9km long) Panels (Fig. 2). The majority of the development is scheduled in 207, 208, 301 and 312 Panels. By the end of 2003 longwalling will be

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complete on the 100 and 200 side of the mine, with production continuing in the 300 area, to the west of the Ti Tree Fault.

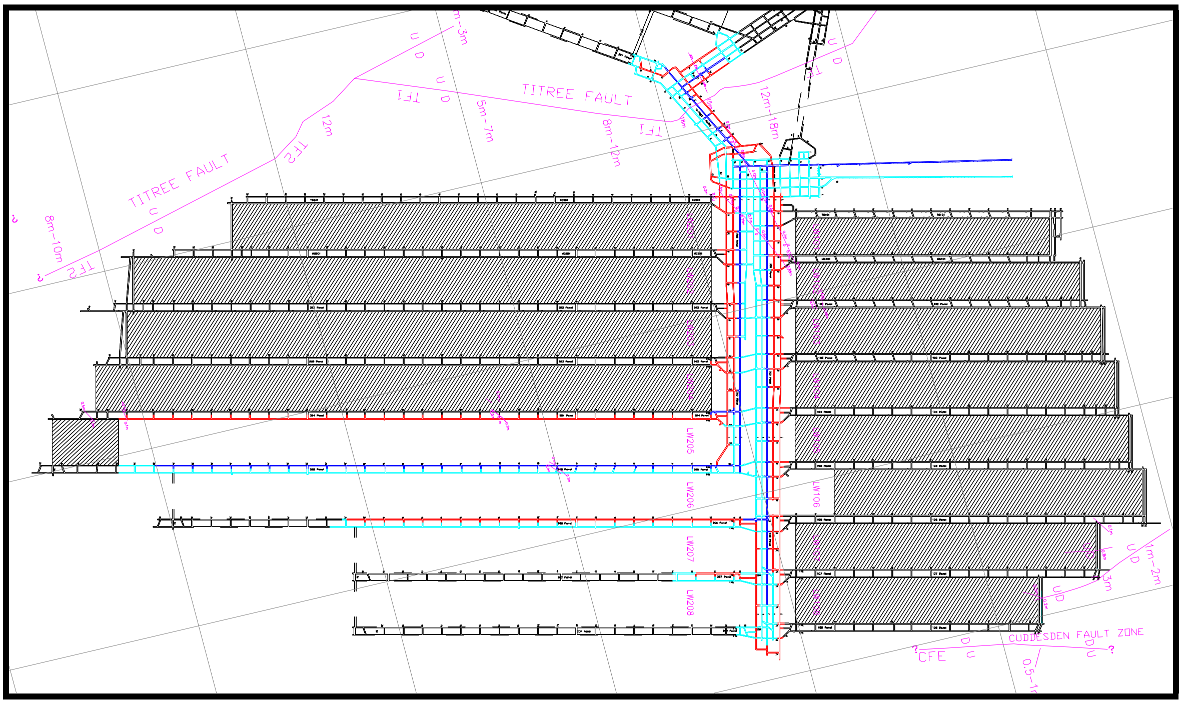


Fig. 2. Mine Plan (December 2001)

GEOLOGICAL AND GEOTECHNICAL ISSUES AFFECTING MINING

Kestrel Mine is located in a relatively undeformed and stable area of the Bowen Basin. However, as with all underground operations, there are a number of geological and geotechnical issues, which affect both development and longwall extraction:

- ***Variability in strata.*** This can occur within short distances laterally. This is the major issue at Kestrel and is well illustrated in Fig. 3 which shows two roof cores sampled only 200 metres apart in a gateroad development panel. Critical to the recognition of weak roof and floor zones has been the compilation of roof and floor strata condition maps, an example of which is shown in Fig. 4. The zones are based not only on strength, but also on the number of laminations and presence of weaker layers. It is these weaker layers and laminations that play an important role in roof behaviour at Kestrel. The strata condition maps form the basis for determining the primary and secondary support patterns. For example, in the current mining area, roof with a rating of two is bolted with 4x2.1m bolts/m with six bolts through intersections. Areas, at similar depths of cover, with rating five roof require a minimum of 6x2.1m bolts/m with eight bolts through intersections and a denser secondary support pattern.

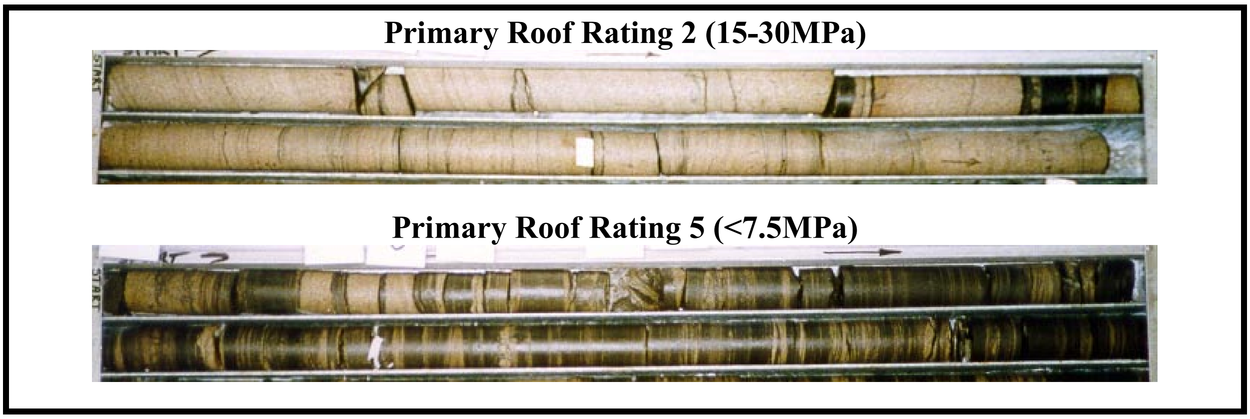


Fig. 3 Comparison of Primary Roof (0-2m above seam) Ratings

- ***Weak roof.*** Typically this occurs on the 100 side of the mine and shallower side of the 300 series panels. Roadways in an unfavourable orientation to the horizontal stress direction may be adversely affected, both on development and retreat.

- ***Weak floor.*** This affects the majority of the Kestrel mining area. The most significant operational issue is reduced clearance, due to floor heave, both along the longwall face and in the gates. In addition build up of floor material around the pontoons is exacerbated in soft floor conditions. Elsewhere around the mine, floor heave can damage drivehead installations. In development weak floor, especially when wet, causes difficult wheeling conditions.

- ***Faulting.*** Mining areas are bounded by major fault zones (>10m). Within these blocks minor faults (<3m) occur. The location of faulting in the current mining area is shown on Fig. 2.

- ***Rib instability due to the cleat direction.*** Ribs and CT corners oriented poorly with respect to the cleat direction are prone to rib spall.

- ***High gas rib emissions.*** This is caused by high coal seam permeability and necessitates gas capture drilling.

- ***Sedimentary dykes.*** These mostly consist of clayey sandstone (<1m wide). Occasionally associated with flanking faults (sedimentary not tectonic), which to date have not impacted significantly on the mining operation.

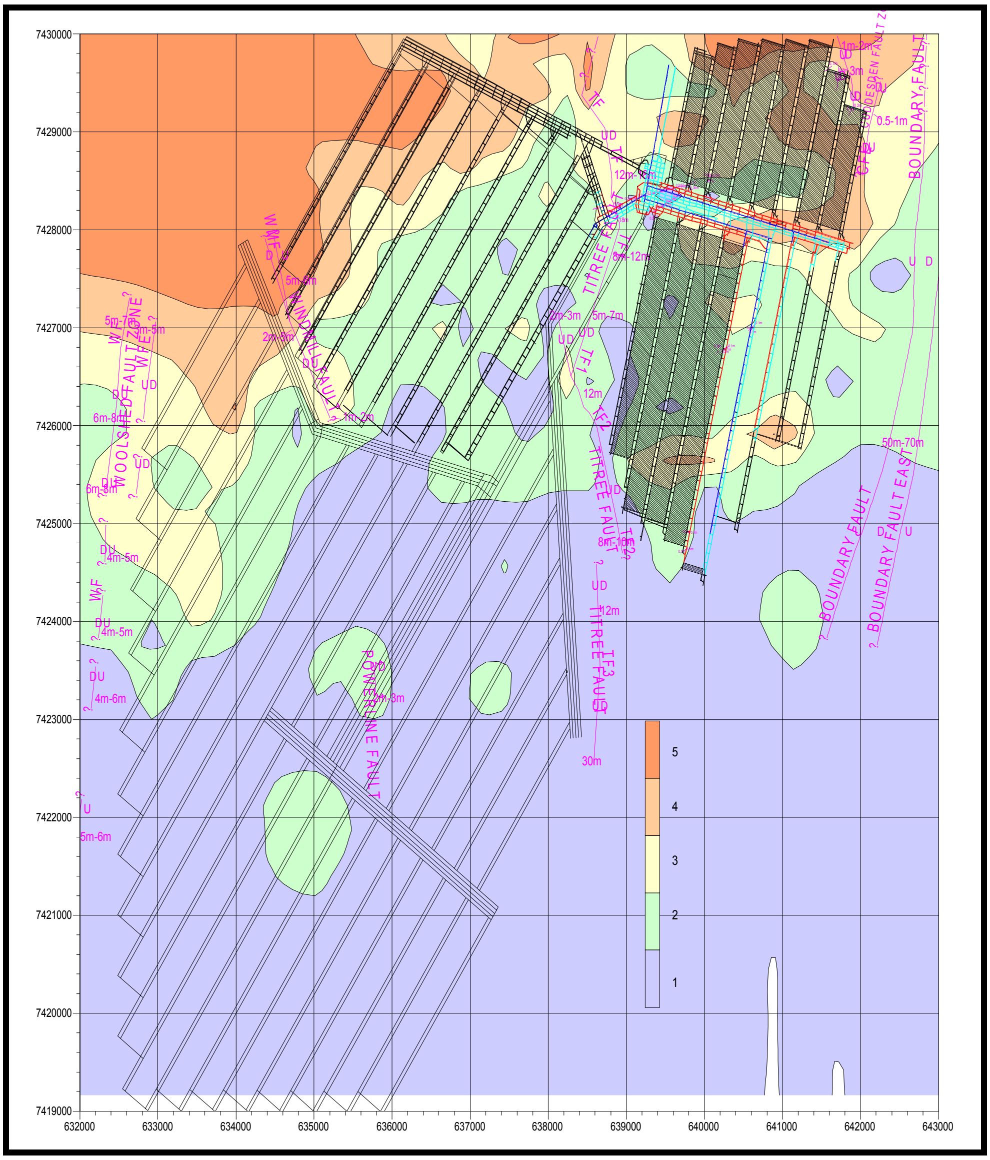


Fig. 4 Primary Roof (0-2 metres above the Seam) Condition Map.

HAZARD PLANS

The function of the hazard plans is to communicate to the workforce the main geological and geotechnical features, which will impact on production. As such there are two types of hazard plan compiled at Kestrel, namely:

- Development and
- Longwall

These hazard plans are therefore a key component of the strata management system. As defined by Macgregor (1998) this system also includes the Strata Control Hazard Management Plan (Kestrel, 2001a), Trigger Action Response Plans (TARPs), together with the relevant Standard Operating and Working Procedures and a training and a strata management team.

A schematic to illustrate the data sources used in the compilation of these hazard plans, is shown in Fig. 5. The main source is the geological and geotechnical database, which is discussed in more detail below. This is supplemented by the Hazard Management Plans, TARPs, Managers Support Rules, risk assessments and previous mining experience.

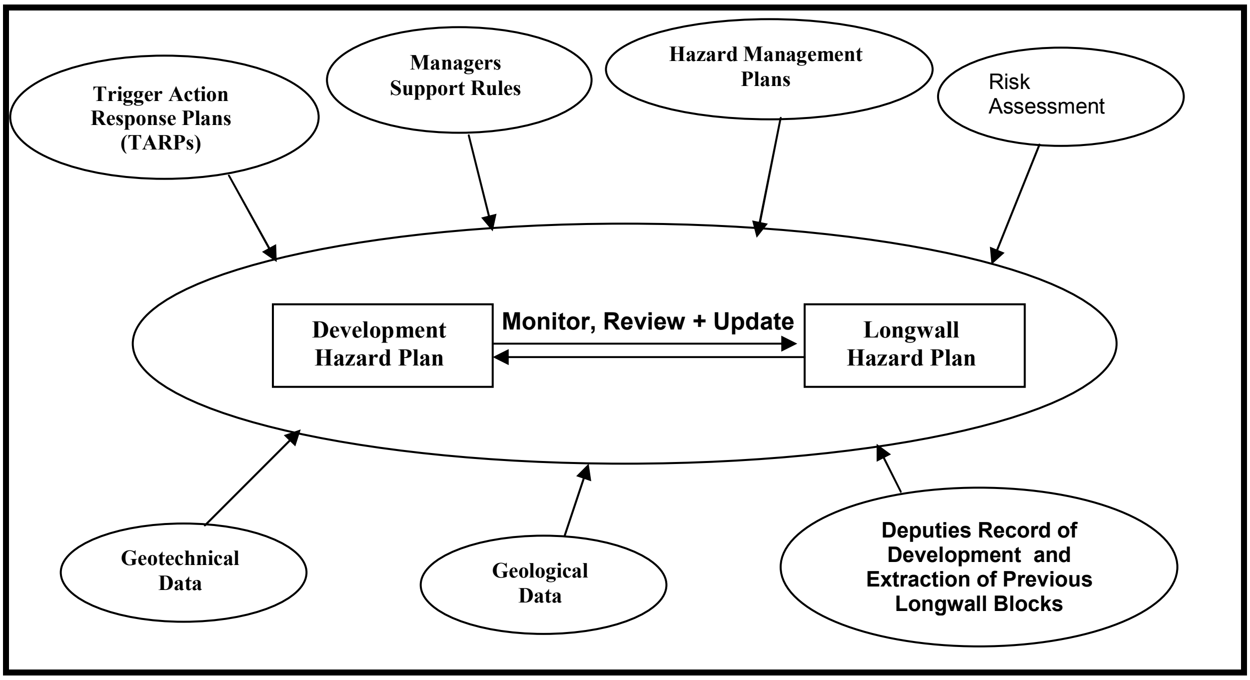


Figure 5. Schematic to Illustrate the Information used in the Compilation of Hazard Plans

GEOLOGICAL AND GEOTECHNICAL DATA

An extensive geological and geotechnical database has been collected at Kestrel and is constantly being updated as mining proceeds, both through exploration and in seam development. This includes:

- Compilation of roof and floor zone maps.
- Underground roof and floor coring along the gateroads.
- In-situ stress measurements - both from surface boreholes and in seam measurements
- Geological and geotechnical mapping of all development panels and longwall faces.
- Sedimentological model for the lease.
- Roof and rib monitoring using telltales and extensometers.
- Monitoring of instrumented roof bolts to provide data on bolt performance.
- Roof bolt pull out tests.
- Rock property testing, including determination of bedding plane and discontinuity properties.
- Gas quantity and content testing
- Longwall face monitoring.
- Thin section petrography and X-ray diffraction (XRD) analysis to better understand the rock composition, particularly for frictional ignition potential.
- Numerical modelling of pillar and roadway behaviour.
- Numerical modelling of longwall caving and support loading characteristics.

As evidenced by the amount of data required, the plans are only as accurate as the information available, prior to mining. The individual hazard plans are discussed below in the order of extraction i.e. development followed by longwall retreat.

DEVELOPMENT PANEL HAZARD PLAN

It is important that prior to the start of development in a new panel at Kestrel, an assessment of the strata conditions is made to enable design of the support patterns. This is based on both the geological and geotechnical data, primarily the roof condition maps, and experience from adjacent previously mined panels. The different strata zones are colour coded on the development plan for easy reference. Along side each zone is the relevant support rule number, both primary and secondary and the Level 1 Trigger, for both roadways and intersections.

The trigger levels are based on previous monitoring at Kestrel in different roof conditions and are defined in the Development Roadway TARP of the Strata Control Hazard Management Plan.

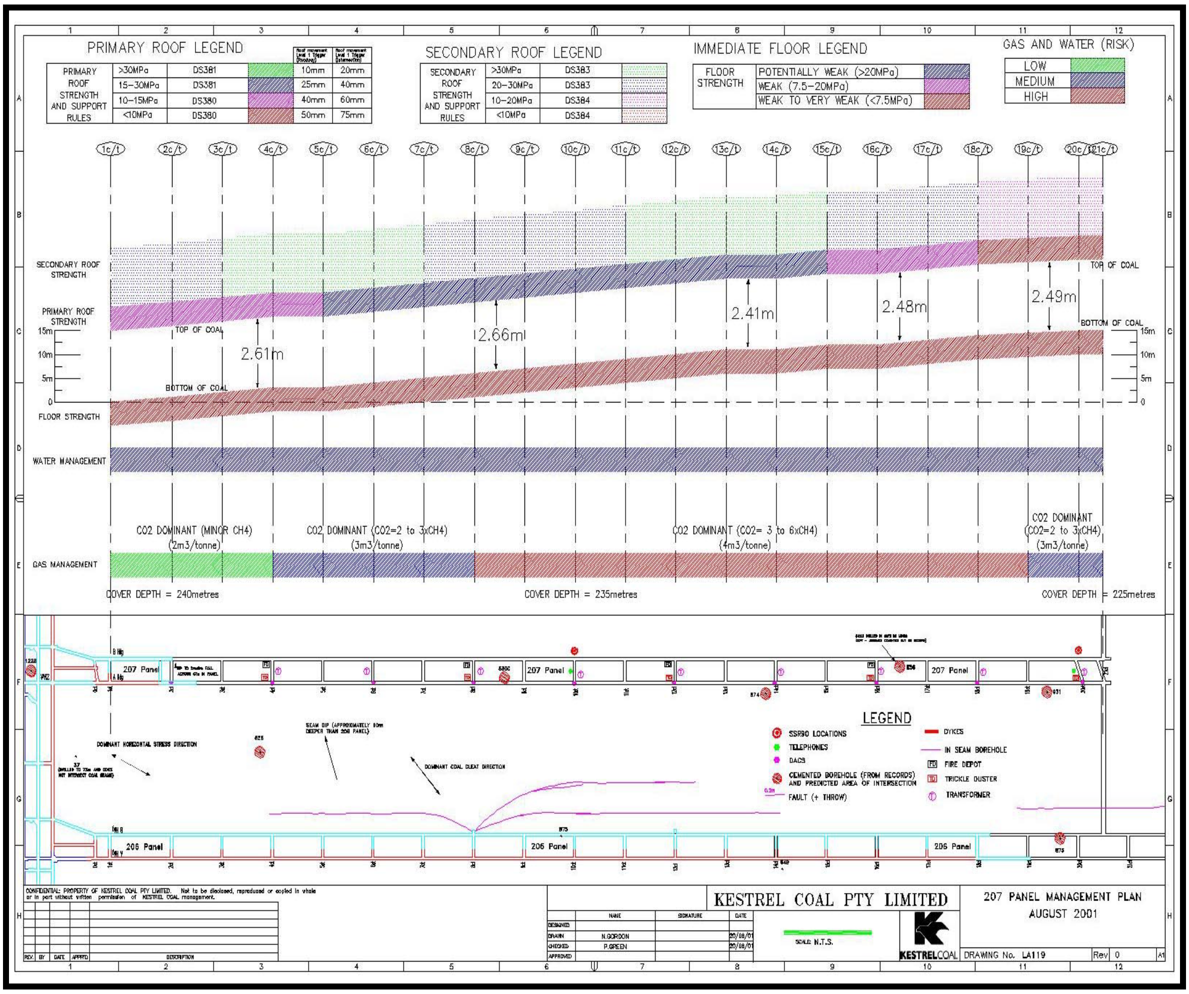


Fig. 6 Development Panel Hazard Plan

To supplement this information, other relevant geological and operational data is recorded as follows:

- Floor strength.
- Seam thickness and grade
- Depth of cover.
- Gas makes and content.
- Water makes.
- Stress direction.
- Location of geological features e.g. split lines, faults, dykes, and cleat direction.
- Location of boreholes both in seam and surface and cementing status.
- Location of phones, DACs, fire depots, trickle dusters, transformers and SSR90 (self contained rescurers) caches.

These plans are intended to provide a summary of the geological/geotechnical information, that is most relevant to the mining crews for each development plans. Laminated A0 colour copies are posted in the underground crib rooms. (Fig. 6). Additional copies are kept at various locations on the surface, but realistically it is the face area where this information, on predicted mining conditions, is required. The support rules referred to on the development panel plan are also displayed in the crib room. A standard used at Kestrel is the production of A4 laminated copies of the support rules with the roadway development TARP on the reverse side, for reference, attached to both sides of the continuous miner. This is where the information is most required, not back in the crib room some 200 metres away.

MONITORING AND UPDATING DURING DEVELOPMENT

During development, localised lithological changes may be encountered and these should be recorded to update the roof and floor strata condition maps. Although these maps form the basis for designing support rules, the importance of underground monitoring, to verify and continually fine tune the support design in future areas of the mine, should not be underestimated. This monitoring includes:

- Geological/geotechnical mapping by the geotechnical engineer.
- Observations by deputies and crews.
- Geotechnical monitoring (e.g. CLOCKITs) and
- Trials of new or alternative roof and rib support systems (Ward, 2000).

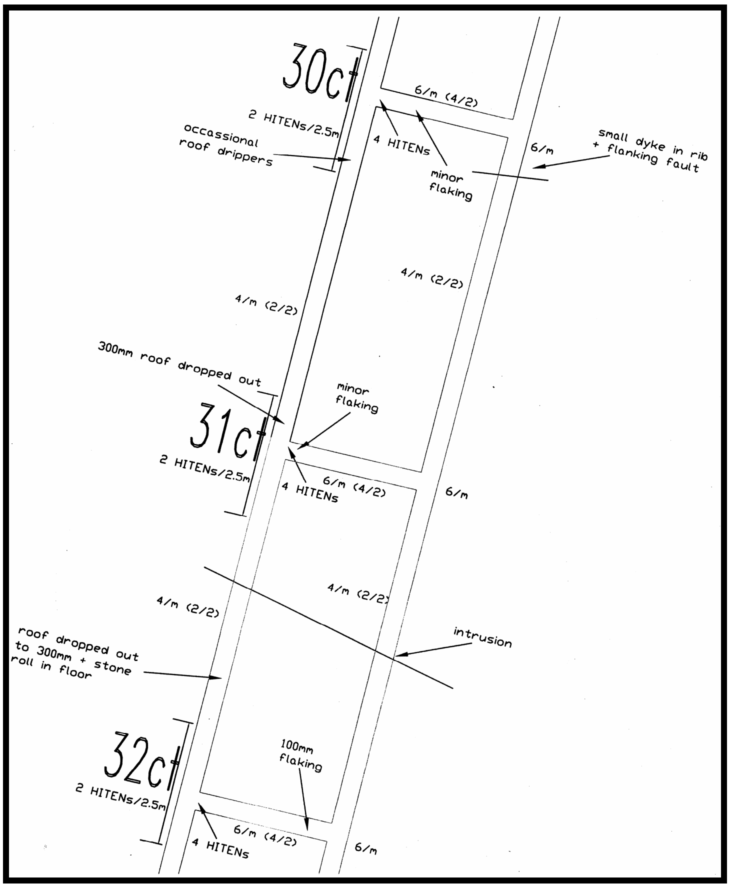
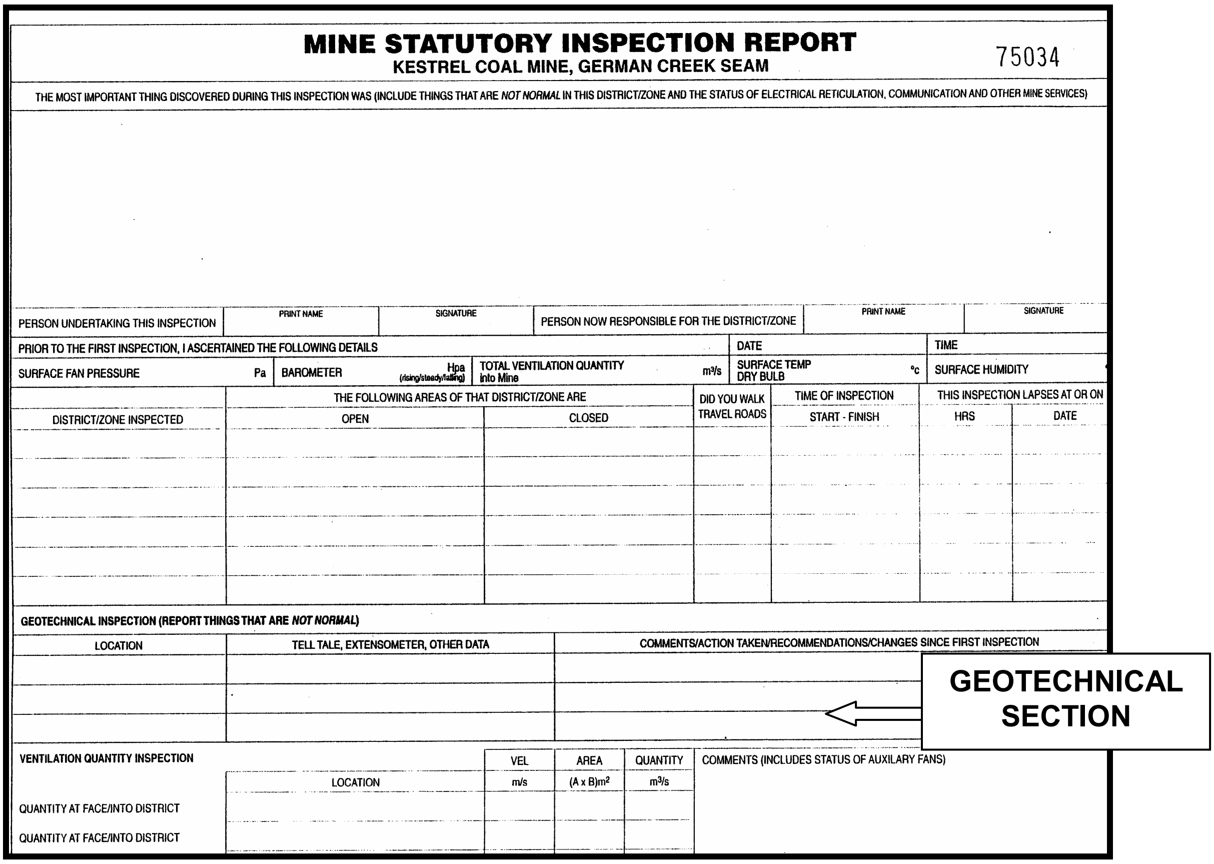


Fig. 7. Geological and Geotechnical Mapping Recorded during Development

Mapping in a development panel includes recording all geological features and conditions. In addition, the primary and secondary support density is also recorded, as shown in the example in Fig. 7. This mapping is supplemented by geotechnical data collection such as roof bolt pull out tests and roof coring.


MINE STATUTORY INSPECTION REPORT
KESTREL COAL MINE, GERMAN CREEK SEAM
75034

THE MOST IMPORTANT THING DISCOVERED DURING THIS INSPECTION WAS (INCLUDE THINGS THAT ARE *NOT NORMAL* IN THIS DISTRICT/ZONE AND THE STATUS OF ELECTRICAL RETICULATION, COMMUNICATION AND OTHER MINE SERVICES)

PERSON UNDERTAKING THIS INSPECTION | PRINT NAME | SIGNATURE | PERSON NOW RESPONSIBLE FOR THE DISTRICT/ZONE | PRINT NAME | SIGNATURE

PRIOR TO THE FIRST INSPECTION, I ASCERTAINED THE FOLLOWING DETAILS | DATE | TIME

SURFACE FAN PRESSURE Pa | BAROMETER Hpa (rising/steady/falling) | TOTAL VENTILATION QUANTITY into Mine m³/s | SURFACE TEMP DRY BULB °c | SURFACE HUMIDITY

DISTRICT/ZONE INSPECTED	THE FOLLOWING AREAS OF THAT DISTRICT/ZONE ARE: OPEN	CLOSED	DID YOU WALK TRAVEL ROADS	TIME OF INSPECTION START - FINISH	THIS INSPECTION LAPSES AT OR ON: HRS	DATE

GEOTECHNICAL INSPECTION (REPORT THINGS THAT ARE *NOT NORMAL*)

LOCATION	TELL TALE, EXTENSOMETER, OTHER DATA	COMMENTS/ACTION TAKEN/RECOMMENDATIONS/CHANGES SINCE FIRST INSPECTION

VENTILATION QUANTITY INSPECTION

	LOCATION	VEL m/s	AREA (A x B)m²	QUANTITY m³/s	COMMENTS (INCLUDES STATUS OF AUXILARY FANS)
QUANTITY AT FACE/INTO DISTRICT					
QUANTITY AT FACE/INTO DISTRICT					

Fig. 8 Kestrel Mine Statutory Report

One of the most useful sources of information is that recorded by the deputies on their statutory report. The information recorded in the geotechnical inspection section (Fig. 8) which was obviously significant during the shift needs to be followed up. It has been found at Kestrel that by letting the deputies know that their statutory reports are being read and used in the compilation of hazard plans, improves the quality of information recorded (Table 1). Anyone who is recording information without any follow up and feedback will gradually lose interest and eventually stop. This information is invaluable and when talking about a strata management team the best resource is at the face.

Table 1. Deputies Record Of 205 Development

LOCATION	DATE	DESCRIPTION
A19 niche	17/1/01	Supported niche with mesh as the roof is very flaky.
20CT	23/1/01	Roof slabbing a bit in CT, more on the LHS.
20CT	24/1/01	Ribs poor on intersection breakoff.
B20	8/2/01	2 large cracks in B20 intersection. No signs of weight on bolts. Some rib fretting above phone.
A20-21	8/2/01	ODS rib flaky, 200mm rock D/S cut because roll in the seam, 28m mark inbye.
B21-22, 88m	16/2/01	Slabs out of floor.

LONGWALL PANEL HAZARD PLAN

With the completion of development, new data is reviewed and updated, to assist in the compilation of the longwall panel hazard plan as referred to in Fig. 5. A final inspection around the block is considered an essential part of this compilation process. This is carried out by the geotechnical engineer and a longwall operations person, usually the coordinator. Hazards identified during development from:

- geological and geotechnical mapping and
- deputies statutory reports.

are used as a checklist to ensure that none have been overlooked. Operational hazards such as offline belt road drivage, ballast, concrete, soft floor due to water, gas drainage discharge points, low clearance are documented during this inspection, for inclusion on the hazard plan.

In addition to hazards identified during development, deputies records of previous longwall extraction are very useful in predicting future extraction conditions, when used in conjunction with the geological and geotechnical database. A typical deputies record of extraction is shown below in Table 2. These reports are invaluable and also used for input into the hazard plans.

Table 2. Deputies Record Of 204 Extraction

Date	Chainage	Description
23/5/01 D/S	2081 22CT	B22 heavy left hand side, cogs needed next 2 CTs
23/5/01 N/S	2067 21-22CT	Some floor heave after being down at SOS
24/5/01 D/S	2059 21-22CT	Seam split. Not causing any problems floor a bit soft. 90-140 stone band 1m above floor at 90 but disappears at 110 (100mm thick).
24/5/01 N/S	2059 21-22CT	Shovelling soft floor Maingate.
27/5/01 N/S	2030 21-22CT	SOS floor heave 30-45.
28/5/01 N/S	2023 21-22CT	55-70 regular slabbing to 200mm.

At this stage a draft plan is prepared with the available data. Prior to finalising, a risk assessment process is carried out, as detailed in the Kestrel Coal SOP – Developing and Carrying out Second Workings (Kestrel 2001b). This assessment must cover the matters mentioned in the Queensland Coal Mining Safety and Health Regulation 2001, Section 317, namely:

1. Any surface features, artificial structures and water reserves that may create a hazard if disturbed by the workings.
2. Any other workings located in close proximity above, below or adjacent to the proposed second workings, whether in the same or an adjacent mine.
3. The known geology affecting the intended workings.
4. The anticipated gas make.
5. The pillar stability.
6. The proposed method and sequence of coal extraction.
7. Support methods necessary to control the edges of the each goaf area in active workings.
8. The suitability of the plant, and its controls, used for the workings.
9. The proposed methods for the following:
    a. Strata control and support
    b. Ventilation
    c. Controlling spontaneous combustion

During the risk assessment the draft plan is presented and discussed, to identify any changes or additions. Following the risk assessment, the hazard plan can be finalised and then presented to the crews, prior to mining (Fig. 9).

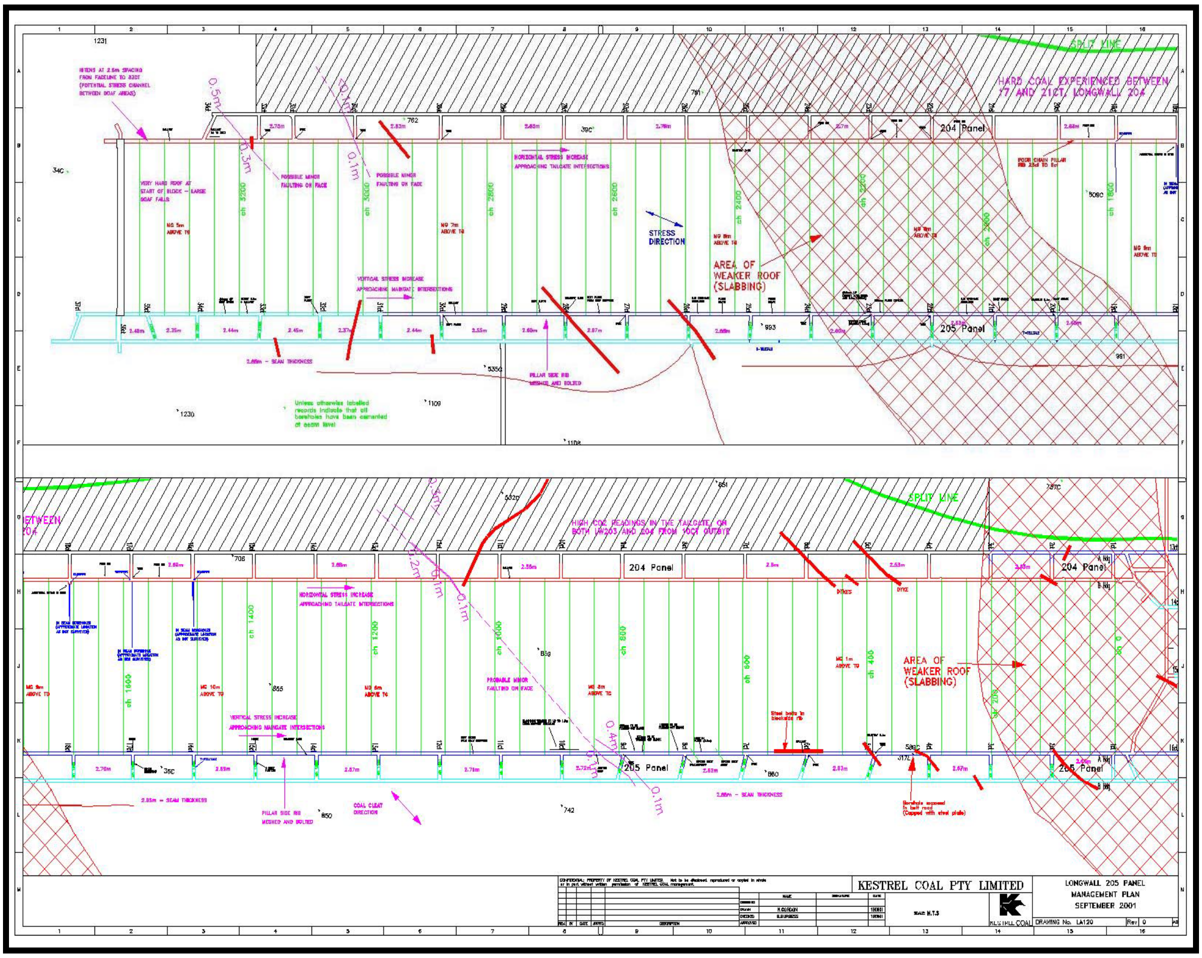


Fig. 9 Longwall Extraction Hazard Plan.

As with the development plans, the longwall plans are intended to highlight the main hazards in an easy to read format (Fig. 9). It is important that any variations from those shown on the development and longwall hazard plans are recorded to allow the continual improvement in the accuracy of future hazard plans.

ACKNOWLEDGEMENTS

The author would like to thank Kestrel Coal for permission to publish and present this paper. The views expressed are those of the author, and not necessarily Kestrel Coal.

REFERENCES

Kestrel Coal Pty Ltd (2001a). Kestrel Mine Strata Control Hazard Management Plan (Version 5). Unpublished.

Kestrel Coal Pty Ltd (2001b). Kestrel Coal SOP – Developing and Carrying out Second Workings. Unpublished.

Macgregor, S (1998) Development and Application of Strata Management Systems in Coal Mines. International Conference on Geomechanics/Ground Control in Mining and Underground Construction. p667-677.

Ward, B (2000) Process Control for Geotechnical Hazards in Longwall Mining. AJM Longwall Mining Summit, Yeppoon.