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WORKERS EVACUATED AFTER GAS LEVELS RISE

Causal investigation

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Executive summary

Seventy workers were withdrawn from Metropolitan Colliery, an underground coal mine in Helensburgh, south of Sydney, on 21 March 2019 after carbon dioxide and methane levels increased unexpectedly to hazardous levels.

A supervisor on the longwall face initially detected increasing gas levels that appeared to be coming from floor cracks.

Supervisors continued to monitor gas levels, and when gas levels continued to increase, the decision was made to withdraw workers and remove power to the underground parts of the mine, in accordance with the mine's procedures.

Remote gas monitoring systems indicated levels in the longwall return airway and the main return airway continued to increase. Peak levels measured 16.1 per cent methane and 15.9 per cent carbon dioxide in the longwall return airway, and 4 per cent methane in parts of the main return airway.

Workers remained out of the mine for seven days until carbon dioxide and methane levels returned to non-hazardous levels.

Following the incident and preliminary investigation, the NSW Resources Regulator decided to undertake a causal investigation to better understand the causes of the incident and to publish the lessons learned.

A causal investigation team comprising representatives from the mine operator Peabody Energy - Metropolitan Colliery, worker representatives and the NSW Resources Regulator, was established on 2 April 2019.

The team was formed to investigate the circumstances that required the unplanned withdrawal of workers from the mine and the reasons for the prolonged period required to establish safe mine re-entry conditions.

The contributing causal factors had not been considered holistically. Had a systematic approach been taken, it may have resulted in the consideration and implementation of additional control measures. The contributing causal factors have been identified as:

- incomplete knowledge of the strata, gas contents and geology in the current mining area
- elevated stress loading on the longwall face supports, influenced by increasing depth of cover
- the fracture profile into the strata around the extraction area exacerbated by regional syncline
- Gas migration due to a reduction of confinement resulting from geological conditions.

Contents

Causal investigation

A preliminary investigation and assessment of the incident was carried out by the NSW Resources Regulator, which did not identify any material breaches of the work health and safety laws. Following this assessment, the Regulator determined that an investigation under the Regulator's causal investigation policy was the most appropriate way to enable the quick and full understanding of the causes of the incident and publication of the corresponding lessons to reduce the likelihood of recurrence.

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

A causal investigation team, comprising representatives from the mine operator Peabody Energy – Metropolitan Colliery, worker representatives and the Regulator, was established on 2 April 2019.

The team was formed to investigate the circumstances that required the unplanned withdrawal of workers from the mine and the reasons for the prolonged period required to establish safe mine re-entry conditions.

This included the identification of deficiencies in procedures, equipment and training that may have contributed to the exposure of workers or other people to hazards.

The scope of the causal investigation included, but was not limited to, the:

- identification of the source and magnitude of the gas release and the failed or absent controls that may have prevented or mitigated the incident
- effectiveness of the implementation of the mine's response plans
- effectiveness of gas monitoring systems from the time of the gas release to re-entry
- management of risks to critical surface infrastructure, both private and public, during the event – in consideration of elevated levels of carbon dioxide and methane gas being exhausted from the main ventilation fans, and
- management of risks during the re-entry to the mine.

The purpose of the causal investigation was to determine the cause and circumstances of an incident and provide timely dissemination of information about the cause and circumstances. The investigation was undertaken using the Incident Cause Analysis Method (ICAM) framework, with human factors analysis to be conducted where appropriate. The causal investigation team considered:

- the causal circumstances of the incident, including an incident timeline
- maintenance of critical controls
- human and organisational factors
- the regulatory environment in which the incident occurred
- recommendations for the mining industry to prevent a similar incident reoccurring
- recommendations for the NSW Resources Regulator to assist with better regulation.

1.1. Preliminary report

A preliminary report was issued within 14 days of the incident and made recommendations based on the information known at the time of publishing. The preliminary report stated that the circumstances of the incident should prompt mine operators to review their safety management systems, focusing on:

- managing the gas reservoirs around extraction panels
- withdrawal trigger action response plans (TARPs)
- post incident monitoring
- re-entry procedures
- workers' access to return airways during extraction activities
- the determination of acceptable methane levels passing through the ventilation fans
- management of ventilation fan exhaust gases around surface infrastructure.

1.2. The mine operator

Metropolitan Colliery is owned and operated by Peabody Energy and is a coking coal operation about 45 kilometres south of Sydney, with a workforce of about 410 people.

The mine works the Bulli seam and produces about 2 million tonnes ROM per annum. The bulk of this is high quality coking coal primarily used for steel making in blast furnaces, both in Australia and overseas.

The area of the Bulli seam that the mine operates has a high carbon dioxide gas content, and the mine has a history of areas above outburst threshold levels. The mine uses in-seam gas drainage to lower the gas levels to safe limits.

2. The incident

Production in longwall 303 panel was stopped at 6 pm on 21 March 2019 due to elevated levels of carbon dioxide at the tailgate monitoring point. The longwall deputy went to the tailgate and adjusted the brattice ventilation wing and returned to mid-face. He noted that the carbon dioxide level was above the measuring range of his hand-held gas detector. Moving to the maingate, the two workers heard ‘hissing’ sounds behind the shields, and all shields along the face were yielding. No methane was detected at this time.

The undermanager and the longwall deputy began to inspect the face about 6.50pm. At number 20 shield, the gas detector alarmed with 2.21 per cent carbon dioxide and detected 0.7 per cent methane. They also saw gas bubbling from the floor.

The undermanager and longwall deputy obtained updated information from the control room about the increasing methane and carbon dioxide levels in the return airways.

Methane levels at the tailgate methane monitor increased to greater than 1.25 per cent 10 minutes later, automatically tripping the electrical power to the longwall face. The undermanager checked the measurement from the tailgate methane monitor at the display in the maingate and noted the tailgate monitor had increased to 2.31 per cent methane. His hand-held gas detector was measuring 0.7 per cent methane in the maingate. The longwall crew and undermanager withdrew to the crib room and the undermanager contacted the mining engineering manager and ventilation officer.

The undermanager started the withdrawal of workers from the mine at 7.15pm.

The deputy isolated power to the longwall district at 7.33pm and at 8pm all underground conveyors were turned off.

After confirmation that all workers were withdrawn and accounted for, underground electrical power was isolated at 8.50pm.

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2.1. The incident response

Following the safe withdrawal of workers, the mine formed an incident management team and notified the incident to the NSW Resources Regulator, who deployed an inspector to site.

The inspector issued a section 195 prohibition notice preventing workers from returning underground until gas levels returned to safe levels. A further section 195 prohibition notice was issued, prohibiting the resumption of longwall mining activities until the source of the release was identified and control measures were established to manage the risks associated with any potential gas release.

The measured carbon dioxide concentration, detected by the tube bundle gas monitoring system in the longwall return, reached a peak of 15.9 per cent at 8.32pm. The measured methane concentration peaked at 16.1 per cent at 9.08pm.

Gas levels in the main return airways of the mine were continuously monitored and decreased over six days. Following a risk assessment, the mine undertook a limited re-entry on the afternoon of 27 March 2019 to increase ventilation to the longwall ventilation circuit.

As a result of the ventilation change, methane levels in the longwall return dropped below 2 per cent and stabilised around 1.7 per cent, indicating that gas was still being released.

The initial investigation suggested that a substantial floor break, originating in the goaf of longwall 303, allowed gas from underlying coal measures to migrate into the working seam. The quantity of gas was significant, and the rate of the release overcame the capacity of the mine's ventilation system.

Gas monitoring systems continued to monitor the mine atmosphere at points throughout the mine.

Table 1 Timeline and actions taken on 21 March 2019

APPROX. TIME	FACT	ACTIONS TAKEN
6pm	Longwall ceased cutting due to carbon dioxide > 3% at tailgate shields. Carbon dioxide fluctuated at this time. No methane present. The longwall deputy went to check the tailgate at #86 chock where 2.21% carbon dioxide was measured and started adjusting brattice wing. No methane detected. A longwall operator called the deputy on the intercom system. The longwall deputy and longwall operator met mid-face, noting carbon dioxide was off scale (>5%) on hand-held gas detectors. They moved towards the maingate.	

	Moving to the maingate, they note hissing sounds behind chocks and all shields along face were yielding. No methane noted at this point.	
6.30pm	Longwall deputy contacted control room to request undermanager to attend longwall due to increased carbon dioxide levels.	**Undermanager notified by control room to attend longwall.**
6.40pm	Outbye deputy and offsider enter north west mains return with man transport vehicle.	**Notified control room operator**
6.45pm	Undermanager arrives at longwall.	
6.50pm	Undermanager and longwall deputy inspect face, get to #20 chock and hand-held gas detectors alarm. 2.21% carbon dioxide and 0.7% methane. Observed visible bubbling of gas from floor. Control room updated undermanager and longwall deputy of methane and carbon dioxide levels and trends.	**First time methane noted.**
7pm	Face power trips to longwall on methane 1.25%. Undermanager checks the longwall face overview computer screen at the maingate and observes the tailgate chock monitor is showing 2.31% methane and at the maingate the hand-held gas monitors are showing 0.7% methane. Outbye deputy and offsider in north west mains proceed to waste area bleeder return. Gas levels 1.96% carbon dioxide, 0.14% methane and 20.4% oxygen, normal.	**Control room informed that gas levels in longwall return are increasing.**
7.05pm	Longwall crew and undermanager withdraw to crib room.	
7.10pm	Undermanager contacts mining engineering manager and ventilation officer.	
7.15pm	Undermanager begins withdrawal of mine. Undermanager requests control to assist with coordinated withdrawal of mine.	**All underground personnel contacted.**
7.20pm	Outbye deputy hand-held gas detector alarms at >3% carbon dioxide. At the same time, methane was 0.7% and oxygen was decreasing. They begin to retreat in the man transport vehicle while monitoring the gas levels on the hand-held gas detectors.	**Exit to fresh air leaving the man transport vehicle shut down in the return. Notify control room operator and withdraw**

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		to the surface with the undermanager.
7.29pm	Ventilation officer communicates with mining engineering manager and goes to site with production manager.	
7.33pm	Deputy isolates power to the longwall district.	
7.56pm	Industry safety health representative is notified by the mining engineering manager.	**Industry safety health representative advises he will contact site safety health representative.**
8.00pm	All underground belts turned off.	
8.45pm	All underground personnel withdrawn and accounted for.	**Undermanager confirms all underground personnel on surface.**

2.2. Source and magnitude of the gas release

2.2.1. Geotechnical assessment

Geological and geotechnical factors contributing or coinciding with floor gas emissions that occurred on 21 March 2019 in longwall 303 include the following items:

- Coinciding with the floor break, the longwall face was subjected to elevated loading conditions. Longwall visual analysis demonstrates this.
- Known geological structures (F-0008 and F-0027) strike slip faults were not mapped in longwall 303 extraction area. It is probable that both faults (F-0008 and F-0027) exist in adjacent longwall 304.
- F-0008 strike slip fault zone is predicted to extend within adjacent longwall 304 extraction block and has been mapped outbye between 1 and 5 cut through maingate 303.
- Longwall 303 is the third longwall extracted in the 300 series and the first longwall to develop and experience peak loading conditions as indicated by numerical modelling.
- The depth of cover is 500 metres at this location and marks a transition from deep cover (500-530 metres to shallow cover (440 metres).

2.2.2. Longwall visual analysis assessment

Loading of shields recorded by longwall visual analysis monitoring system demonstrates rapid leg pressure increase across the face (tailgate in foreground/maingate in background - Figure 1) at the time of the incident.

Figure 1- Longwall visual analysis shows the shearer position and chock pressures

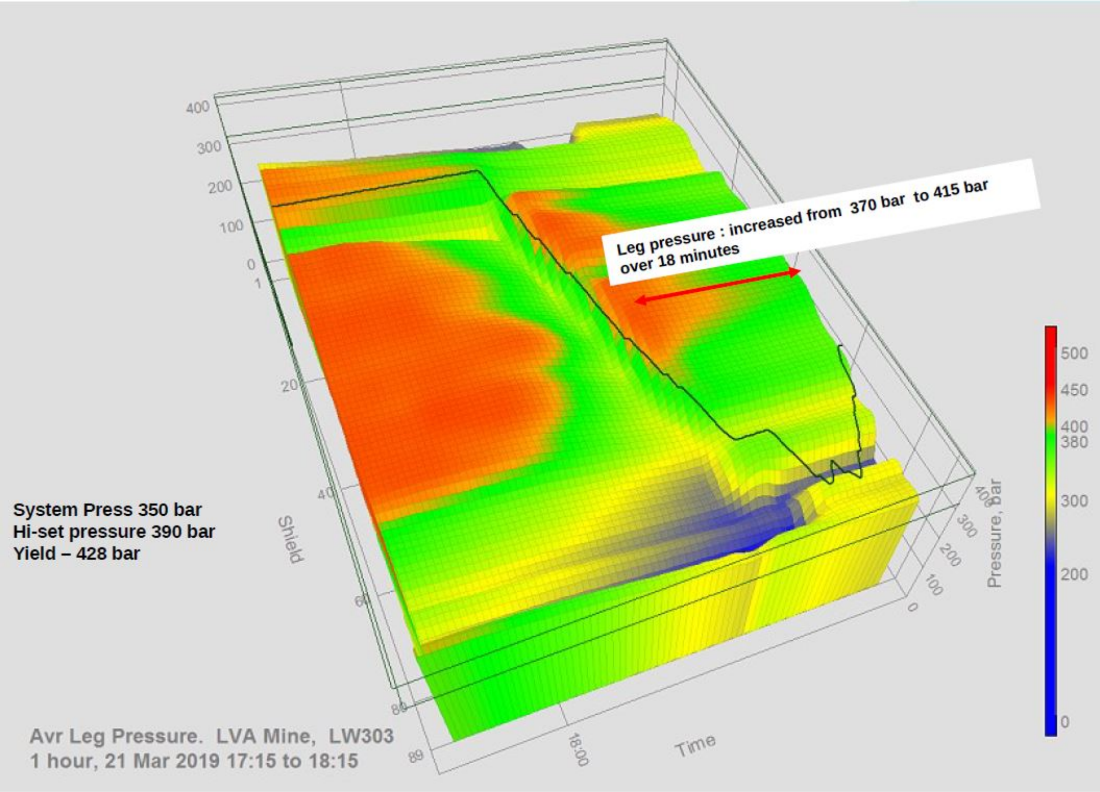

Figure 2 – Longwall visual analysis shows the shearer position and chock pressures at 5.10pm

Figure 3 – Longwall visual analysis shows the shearer position and chock pressure at 5.34pm

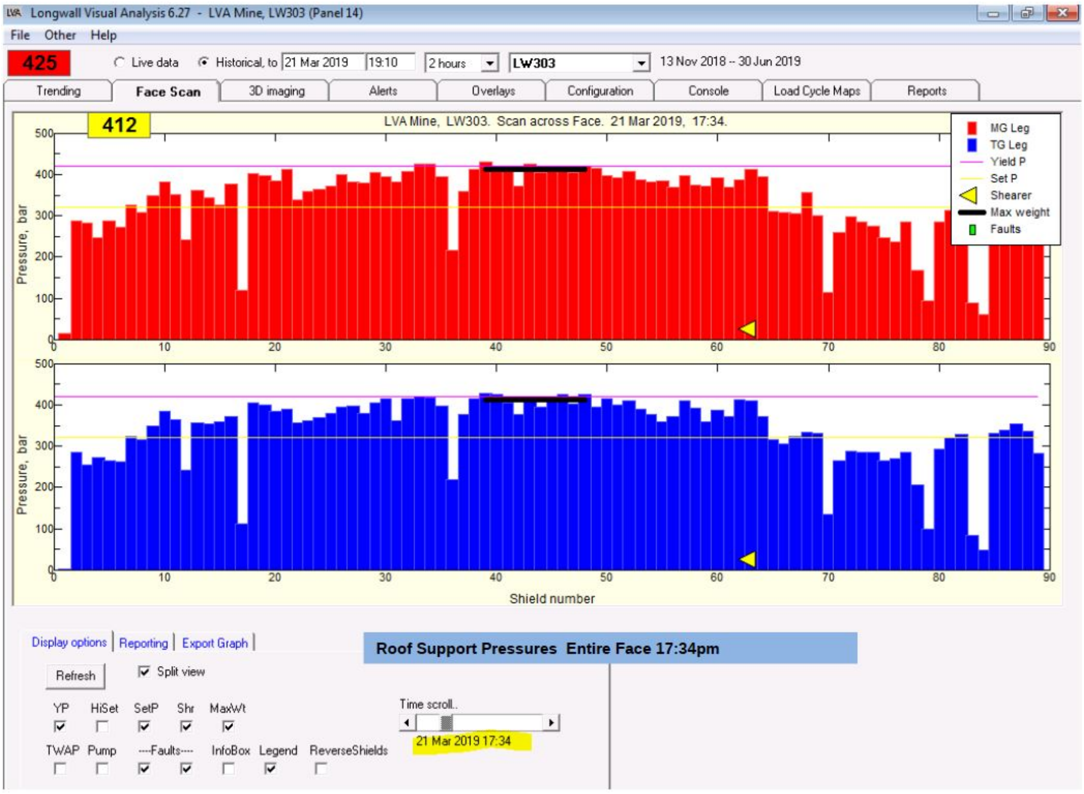

Figure 4 – Longwall visual analysis shows the shearer position and chock pressure at 5.42pm

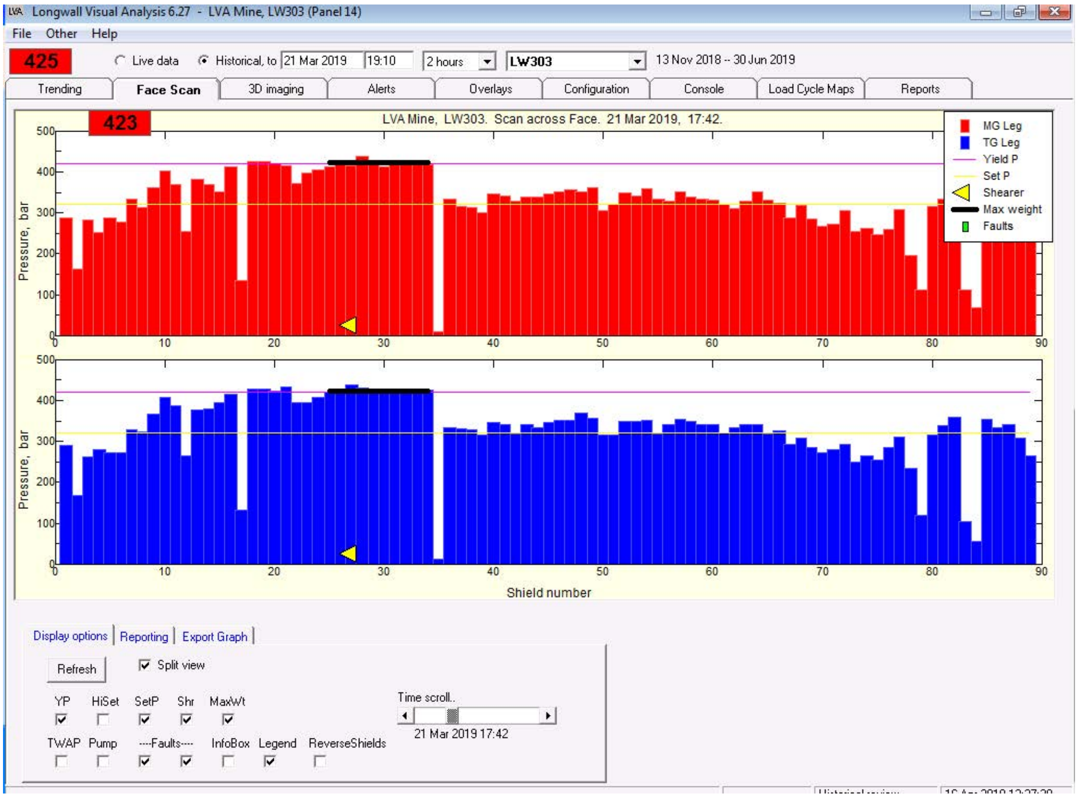

Figure 5 – Longwall visual analysis shows the shearer position and chock pressure at 5.54pm.

Note: yield areas.

Figure 6 - Metropolitan geological prediction plan of longwall 303 area

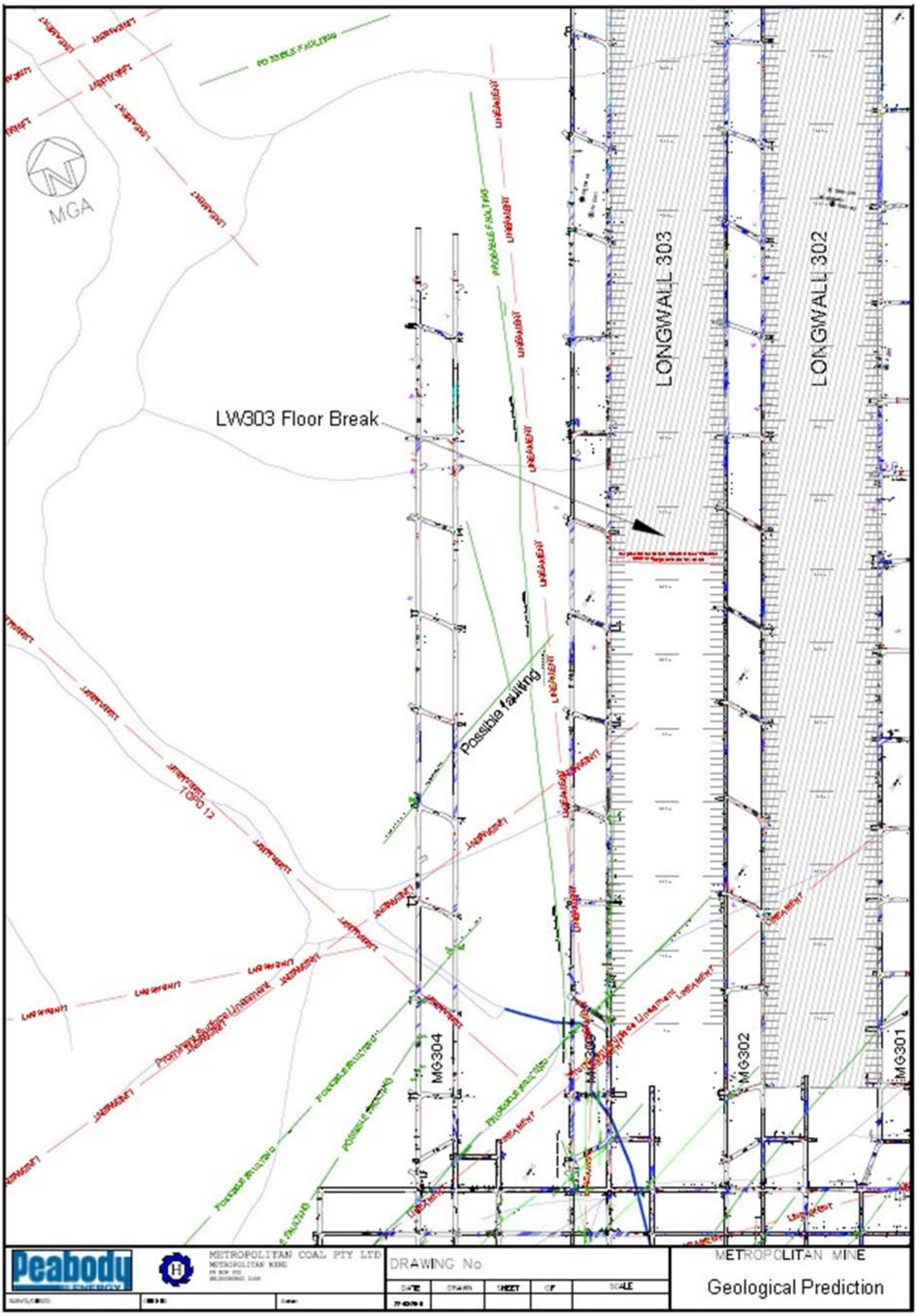

Figure 7 - Depth of cover plan

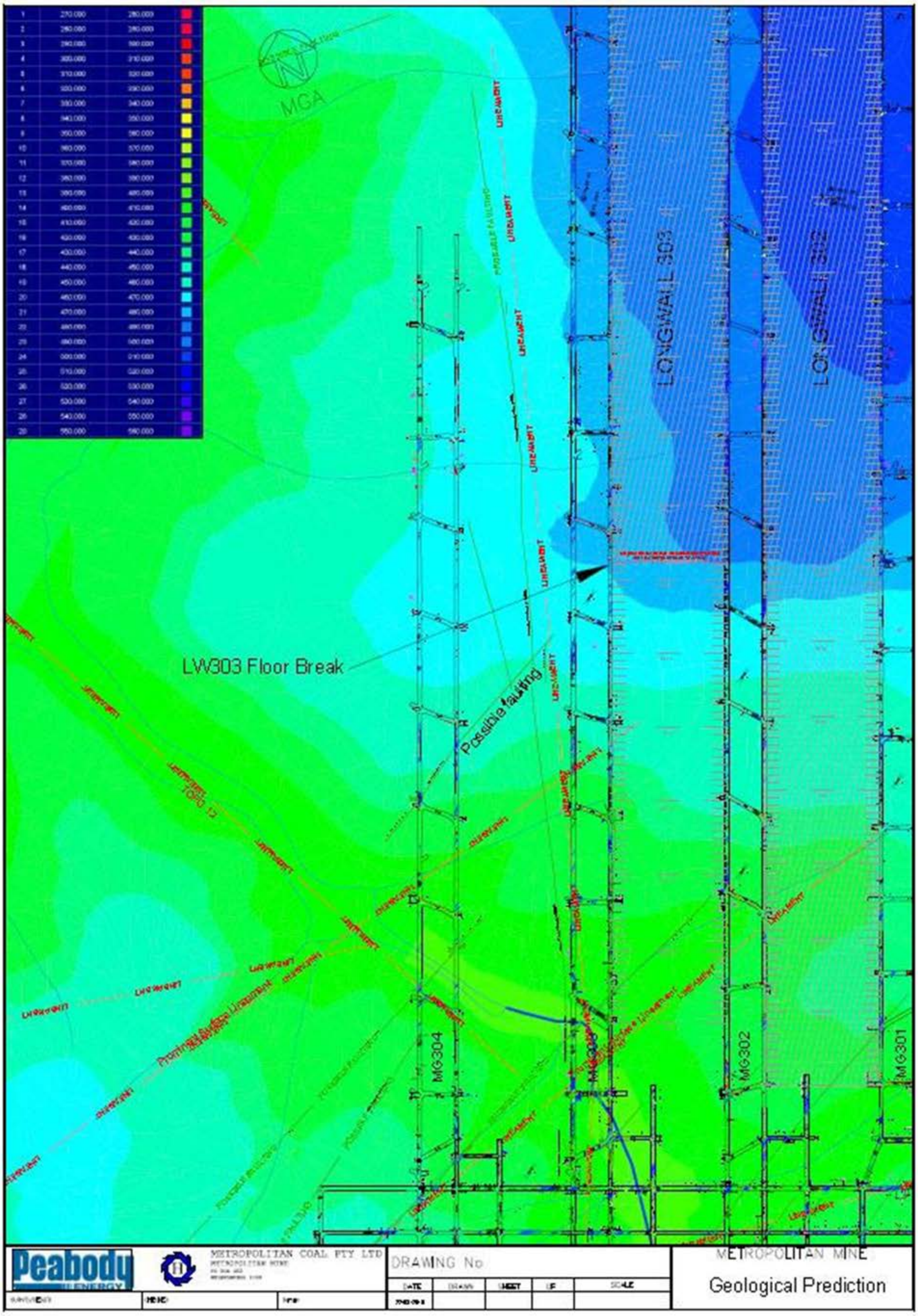

Figure 8 - Topographic view of longwall 303 area showing Woronora dam catchment and M1 Princes Motorway

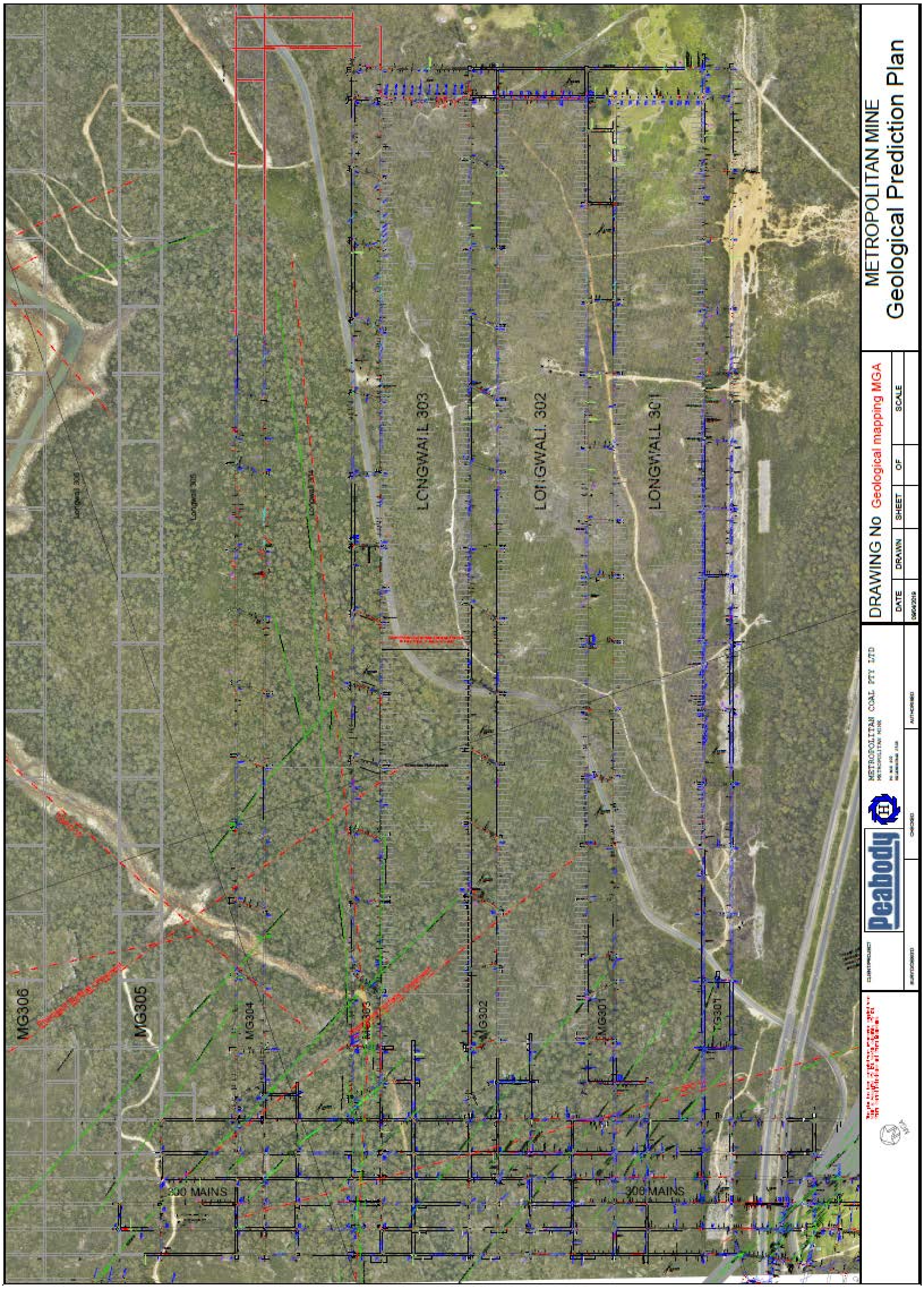

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Figure 9 - S872 borehole log from surface to Woronora seam at tailgate 301 about 800 metres south of the incident site

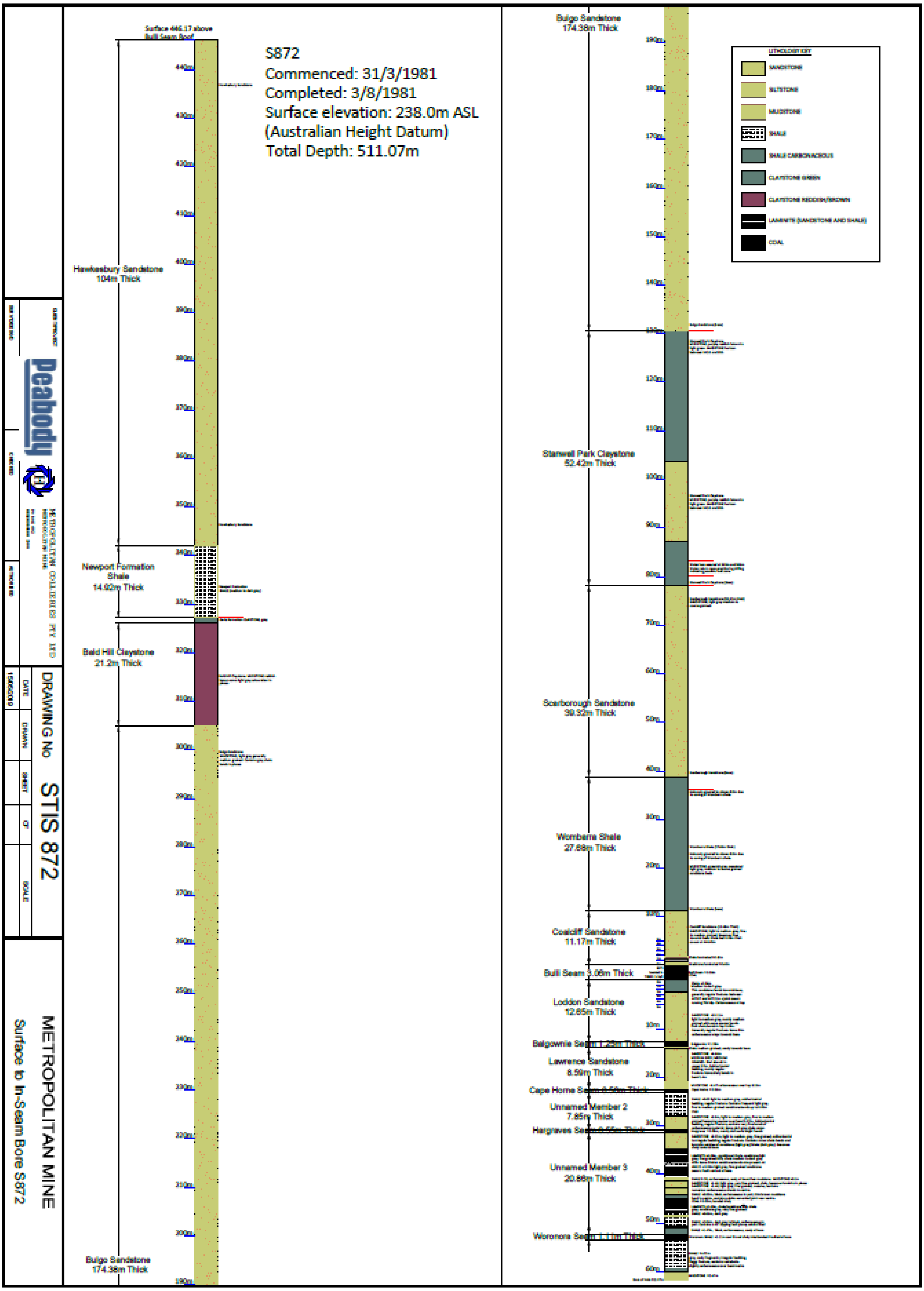


Figure 10 – Borehole log S872 showing lower section lithology

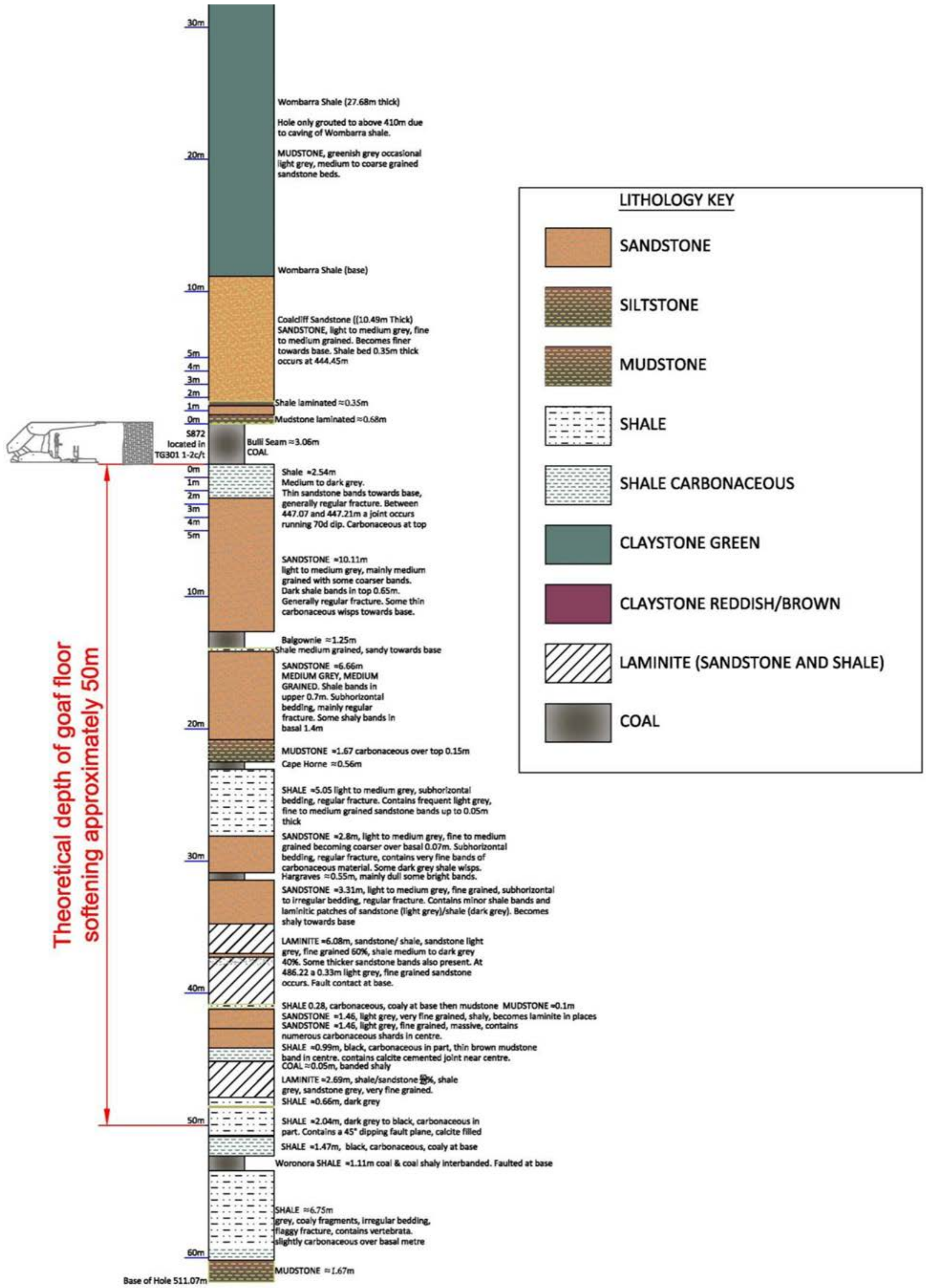
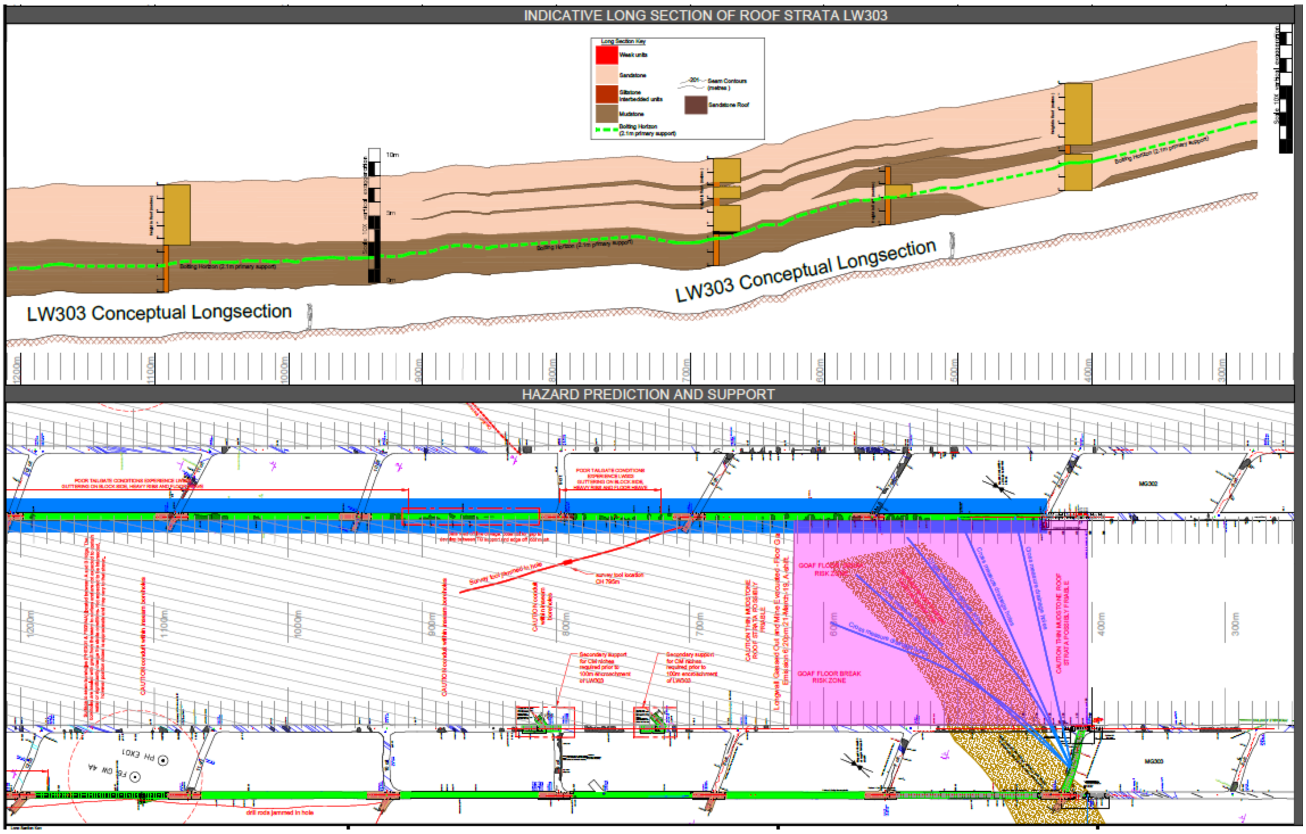


Figure 11 Longwall 303 hazard prediction plan and conceptual long section



2.2.3. Longwall face geotechnical inspection after re-entry

A geotechnical inspection was conducted at longwall 303 face on 27 March 2019 at 6.:30pm with the longwall superintendent and afternoon shift undermanager to record post event strata conditions and to identify any features that may provide an improved understanding for the longwall 303 goaf floor break mechanism.

At the time of the inspection, the longwall had been unpowered for six days following the incident. The longwall shearer was positioned between 10# and 19# (Note: # denotes a longwall face support or chock) and all supports from 19# to the maingate were positioned back one web or 0.8 metres to accommodate the shearer.

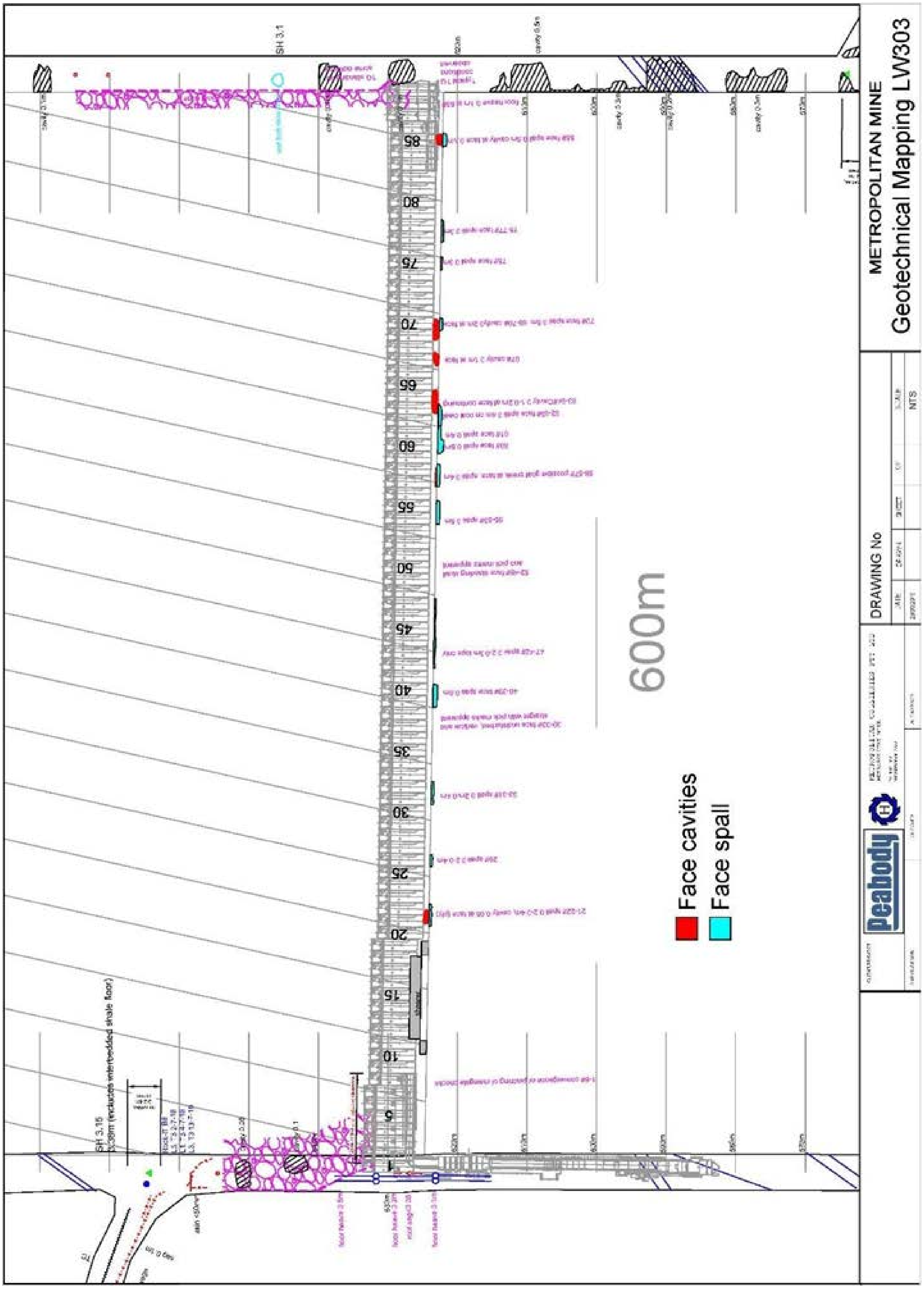
Figure 12 shows the mapping compiled during the inspection. The main observations included:

- There was no apparent faulting or fault-related characteristics (i.e. slickensides, mylonite, slickensides on bedding planes, intense jointing, changes in coal cleat direction/dip) that would raise suspicions that a fault may be present.
- There was no abnormal face spall or extended tip to face outside of normal operating conditions. Face spall ranged between 0.1 to 0.6 metres, most commonly observed between

0.2 and 0.4 metres. Sections of the face were noted as undisturbed since the last completed shear characterised by a vertical standing, straight face with visible pick marks. The locations were: 52-58# and 39-33#.

- There were no abnormal face cavities or areas adversely affected by goaf breaks advancing ahead of the rear of the shields. Cavities and a potential minor goaf break were noted at the following locations:
  - 21-22# 0.05 metres cavity at face (delamination on bedding)
  - 57-58# possible minor goaf break at support tips
  - 63-64# 0.1-0.2 metres cavity at face
  - 67# 0.1m cavity at face
  - 69-70# cavity 0.2 metres at face and
  - 84# cavity 0.1 metres at face.
- The goaf was observed to readily cave immediately at the rear of the canopies, with no abnormal hang ups or areas of concern outside of normal face conditions.
- Low clearance of the main gate chocks from about 1-8#. While some portion of the low clearance may be contributed to face convergence that occurred either at the time of the event or in the following six days of standing the longwall, the low clearance of the main gate was a pre-existing operational issue before the gas emission incident.
- Maingate floor heave and chain pillar rib side fracturing/softening. Floor heave was estimated to be less than 0.1 metre at chainage 623 metre increasing to approximately 0.2 metre at the maingate corner (approximate chainage 630 metre) and into the goaf besides number one face support where it is estimated to be 0.5 metre. The face is at chainage 624.7 metre.
- Maingate roof sag was less than 0.05 metre besides and above number one face support.

Figure 12 Geotechnical mapping of longwall 303 face after the incident



2.2.4. Geological summary

The occurrence of fracturing into the floor strata below longwall mining has been well established through studies using numerical modelling, micro seismic monitoring and observations of cross measure gas flows. Numerical modelling based on Metropolitan Colliery's conditions indicates under normal mining conditions. Floor fracturing is believed to occur to a depth of approximately 50 metres.

Numerical modelling has also demonstrated that strata softening and slip/dilation along bedding can extend significant (>100 metres) distances ahead of goaf development. The presence of an underlying geological structure would be expected to increase the depth of goaf floor softening, providing a mechanical weakness and triggering a zone of elevated stress.

The following are considered contributing factors in the mechanisms operating in the accumulation and potential release of gas from the floor strata:

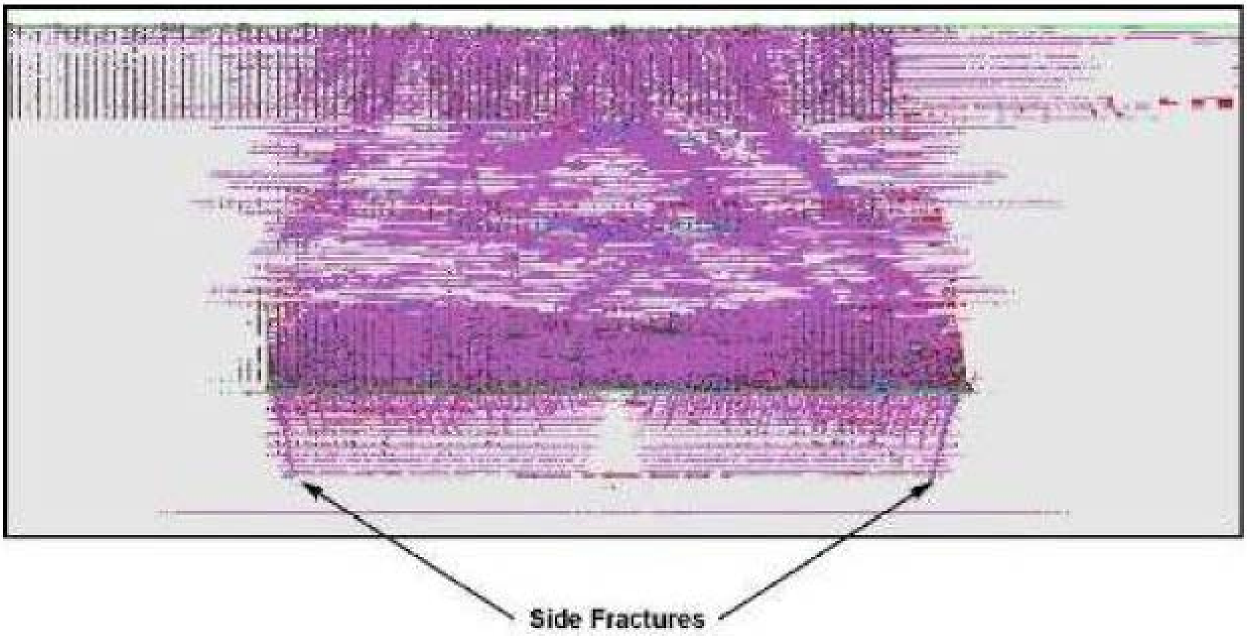
1. Fracture generation below Bulli seam and possibly intersection with lower coal measures.
2. Laterally propagating of shear fractures with slip dilation sufficiently ahead of the goaf, possibly interacting with approaching geological structures.
3. An expectation that the most extensive mining induced fracture networks would be biased to the tailgate side of the longwall.
4. Gas migration from lower seams that would be most significant when confinement to the floor is removed and gas pathways can open (i.e. after the longwall has passed and within the goaf).
5. The position of the longwall face relative to cut through may contribute to depth and position of fractures generation, that later act as gas migration pathways.

Despite the above comments, the frequency of the events is low, with the majority of longwall panels extracted not experiencing goaf floor breaks and related floor gas emissions.

A strike slip fault (F0008) exists to the north in the 304 longwall block and adjacent to the 303 longwall block, which has a near vertical hade. Previous gas outbursts have been associated with this structure.

Longwall 303 is the third longwall block to be extracted in the 300 series with 301 and 302 extracted.

Figure 13 Example of cross section of fractures from modelling



2.2.5. Gas drainage and gas content

The virgin Bulli seam gas content in this area averages about $13m^3/t$ varying in places between 6 and $16m^3/t$. The gas content is generally measured at 98% carbon dioxide. In-seam gas drainage proactively reduces the gas content to below outburst threshold levels before mining activities.

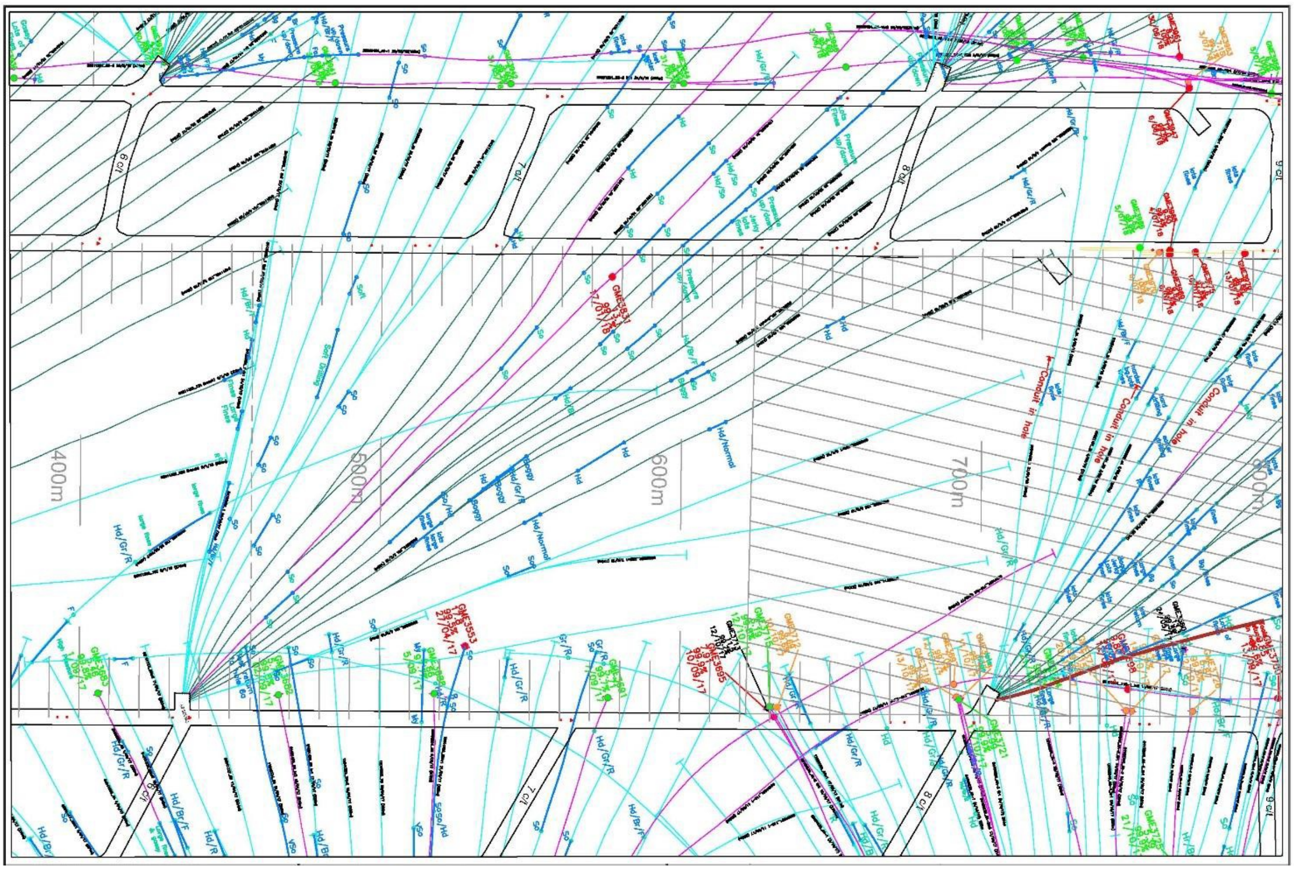
In-seam drainage was drilled from 6 cut through maingate 302 before maingate 304 development and subsequent longwall extraction. The drilling process did not identify any boggy zones or other geological features at the location of the floor emission.

Following pre-drainage, the Outburst Review Committee held a meeting before starting the extraction of the longwall block through the area. After reviewing the drilling and geological data, a permit to mine was developed and issued.

Cross measure drainage was not used for longwall 303 because there were no geological structures mapped in longwall 303 extraction area.

A surface vacuum plant was commissioned on 14 March 2019 and cross measure drilling was scheduled in the 2019 operational budget for longwall 304. This was because there were known geological structures associated with previous floor break events under longwall 304.

Figure 14 In-seam gas drainage holes drilled in the incident area of longwall 303 floor break



2.3. Identifying likely sources of gas

2.3.1. Interburden gas contents

The interburden units are assumed to contain gas at uniform 2.63m3/t with the composition split of the seam below. Woronora 1 (upper) contained no coal and sampled at 1.78m3/t. Woronora interburden sampled at 2.63 m3/t after the event.

Table 2 Inburden gas contents

Coal seam	Thickness (m)	Distance from Bulli seam floor (m)	Gas content m^3/t	Gas composition (CH_4/CH_4+CO_2)
Bulli	2.9m	0m	10.5	0.3
Balgownie	1.57 (net coal 1.48)	11.9	8.6	0.17
Cape Horne	0.8 (net coal 0.8)	22.9	10.3	0.25
Hargraves	0.445 (net coal 0.345)	29.1	10.0	0.25
Woronora Coal (upper split)	0.75 (net coal 0.0)	49.3	1.78	0.84
Woronora Coal (Lower split)	1.01 (net coal 0.71)	50.4	10.5	0.81
Wongawilli	3.24 (net coal 2.485)	74.8	7.3	0.9

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Figure 15 Modelled fracture zone profile for gas disturbance. Reproduced by the NSW Resources Regulator

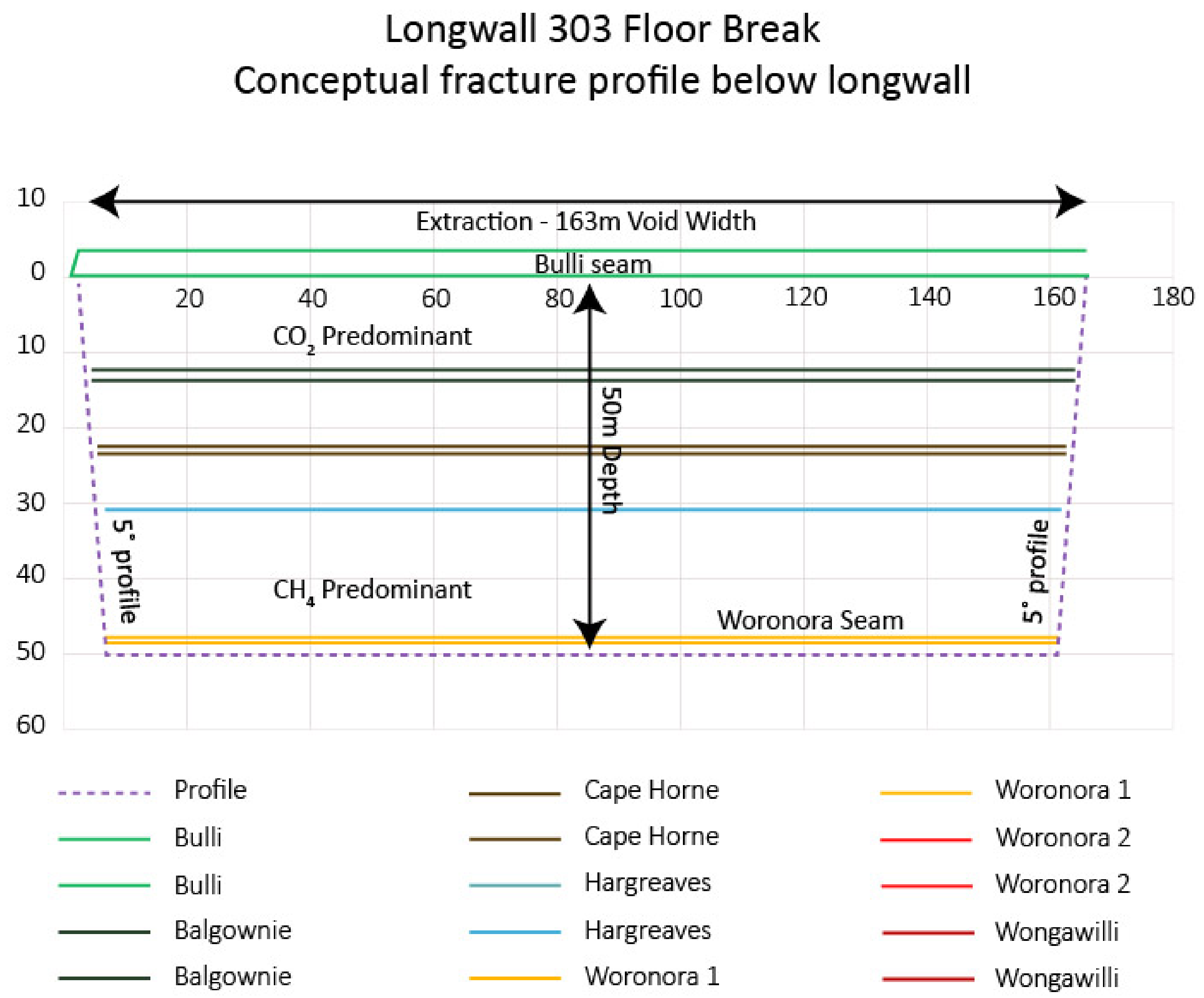


Figure 16 Measured gas composition between 21 and 27 March 2019. Reproduced by NSW Resources Regulator

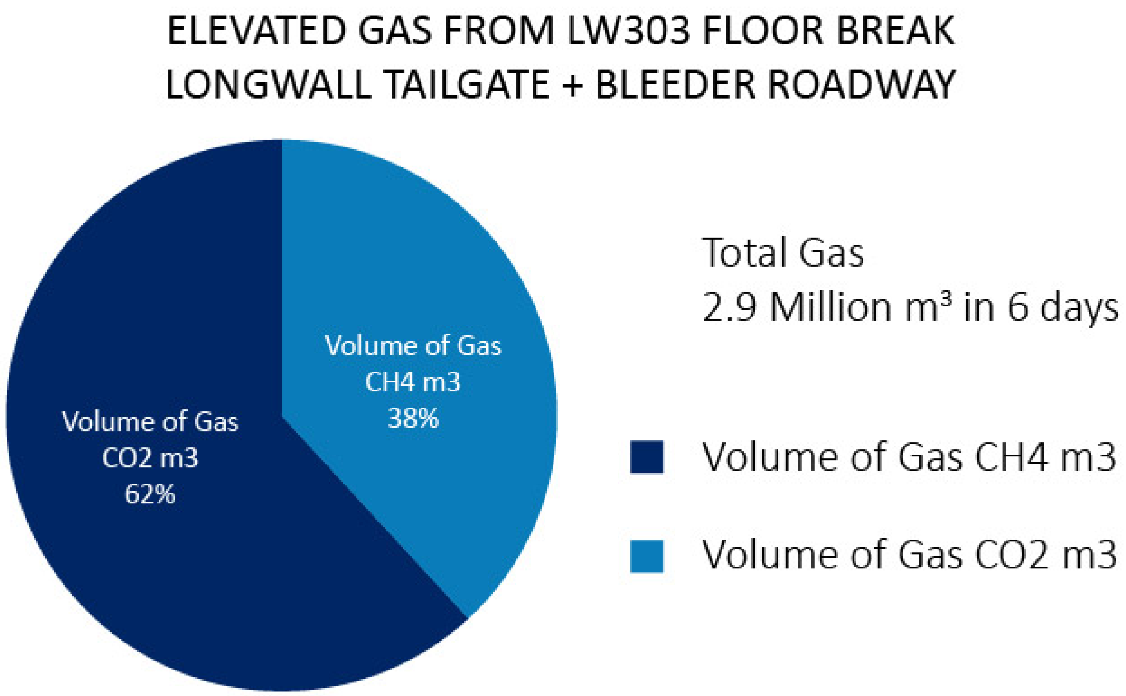


Figure 17 Gas distribution by formation. Reproduced by NSW Resources Regulator

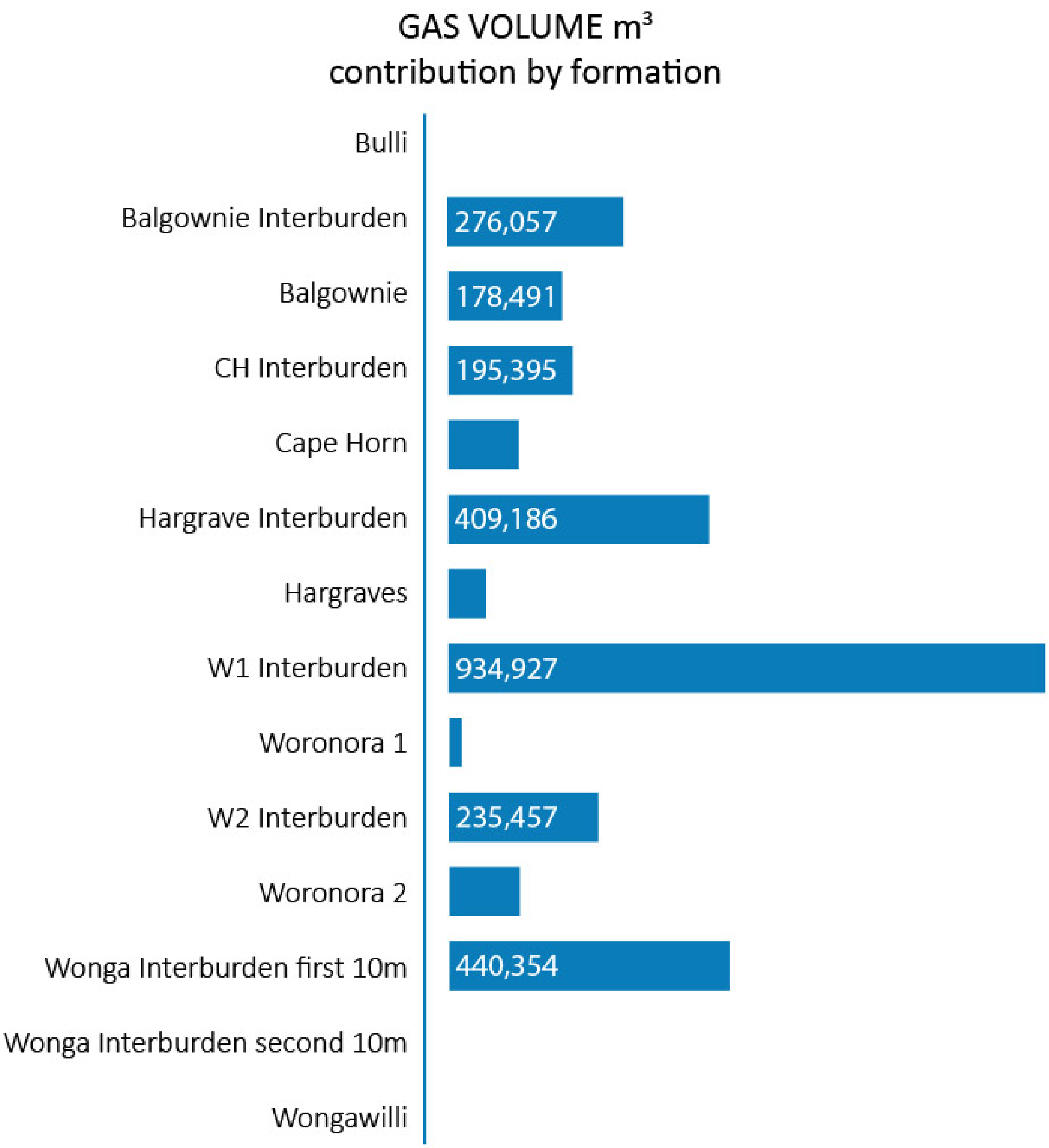
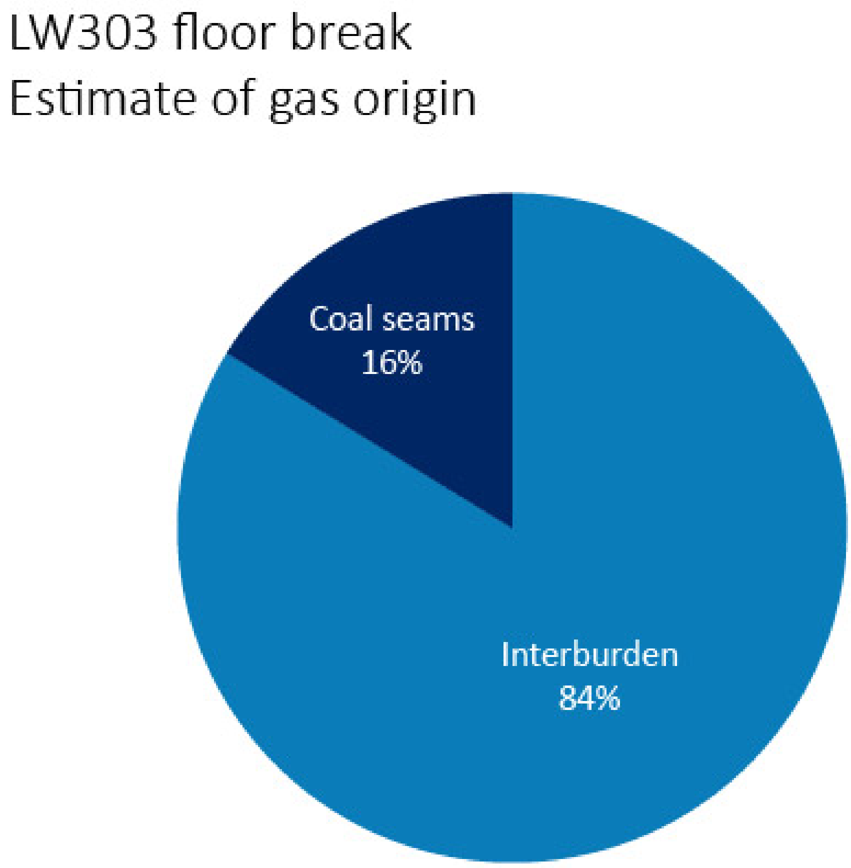


Figure 18 Estimate of gas origin. Reproduced by NSW Resources Regulator



In the week following the re-entry to the underground workings, five cross measure gas drainage holes were drilled into the interburden below the Bulli seam to the Woronora seam some 50 metres below.

One core indicated a gas content of $2.63m^3/t$ in the sandstone above the Woronora seam.

These holes did not have any gas flow when drilled.

Following further mining activities holes one and four started low flows on 1 May 2019 at 523 metres chainage. The gas content for these holes was tested on an air free basis resulting in 44.5% methane and 55.3% carbon dioxide for hole one and 48.4 % methane and 51.3% carbon dioxide for hole four.

At 490 metres chainage on 7 May 2019 with the hole flows increased and measured 18 and 38 litres/second respectively.

At 417 metres chainage on 14 May 2019 all five drainage holes became significantly more active.

Further measurements taken on 16 May 2019 indicated the flows generally decayed.

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Figure 19 Interburden gas drainage holes drilled after re-entry

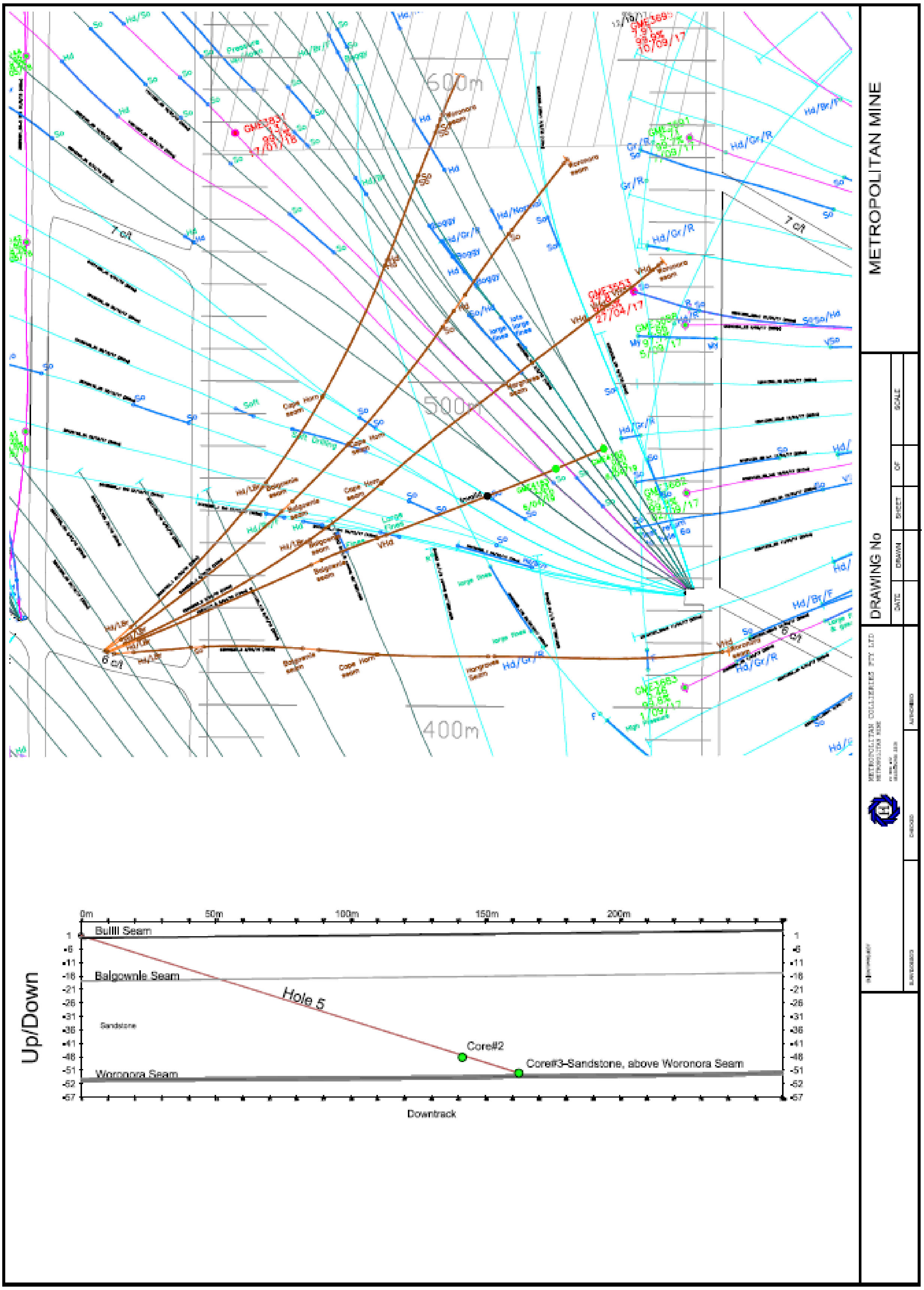


Table 3 Measured gas flows from interburden below longwall 303. Reproduced by NSW Resources Regulator

Date	Temp (deg C)	Orifice size (mm)	Upstream pressure (mmH20)	Orifice plate pressure drop (mmH20)	Gas flowrates (Vs)
Down hole 1	22	50	0		
7/05/2019	22	50	0	20	17.99
14/05/2019	22	75	0	250	167.59
16/05/2019	22	75	0	85	97.72
Down hole 2					
7/05/2019	22	50	0	Checked - No flow	0.00
14/05/2019	22	75	0	290	180.50
16/05/2019	22	75	0	38	65.34
Down hole 3					
7/05/2019	22	50	0	Checked - No flow	0.00
14/05/2019	22	75	0	70	88.68
16/05/2019	22	75	0	105	108.61
Down hole 4					
7/05/2019	22	50	0	90	38.16
14/05/2019	22	75	0	211	153.97
16/05/2019	22	75	0	94	102.77
Down hole 5					
7/05/2019	22	50	0	Checked - No flow	0.00
14/05/2019	22	75	0	90	100.56
16/05/2019	22	75	0	111	111.67

2.3.2. Ventilation and gas monitoring summary

At the time of the floor break, the longwall panel was ventilated with a total of 61m3/s. This was distributed as 18m^3/s in the longwall bleed system, and 43m^3/s in the longwall tailgate.

The longwall face quantity is 48m^3/s, with 5m^3/s bleeding through the goaf from the longwall face, and the remaining 43m^3/s reporting to the longwall tailgate monitoring point.

Metropolitan Colliery's main ventilation system uses two surface centrifugal fans in parallel, producing a total quantity of 280 m^3/s at a collar pressure of 3.4 kPa. The background levels of carbon dioxide and methane running in the longwall tailgate were 2.0% and 0.1% respectively.

Real time monitoring used at Metropolitan Colliery is limited to 0-5% for methane and carbon dioxide, 0-50ppm for carbon monoxide, and the uninterrupted power supply uptime ranging from three minutes to 70 minutes.

A tube bundle system for gas monitoring is also used at Metropolitan Colliery.

The tube bundle gas monitoring shed is on the surface adjacent to the main surface exhaust fans infrastructure and houses the pumps and analysers.

Tubes are used to monitor the following locations:

- every working panel return
- the mine's bleeder system
- each of the two major outbye return splits
- the bottom of the up-cast shaft
- the mine's bleeder return airway after passing legacy areas
- the mine's intake air at mains west
- the surface inside and outside of the gas monitoring shed.

Figure 20 Longwall 300's ventilation circuit diagram

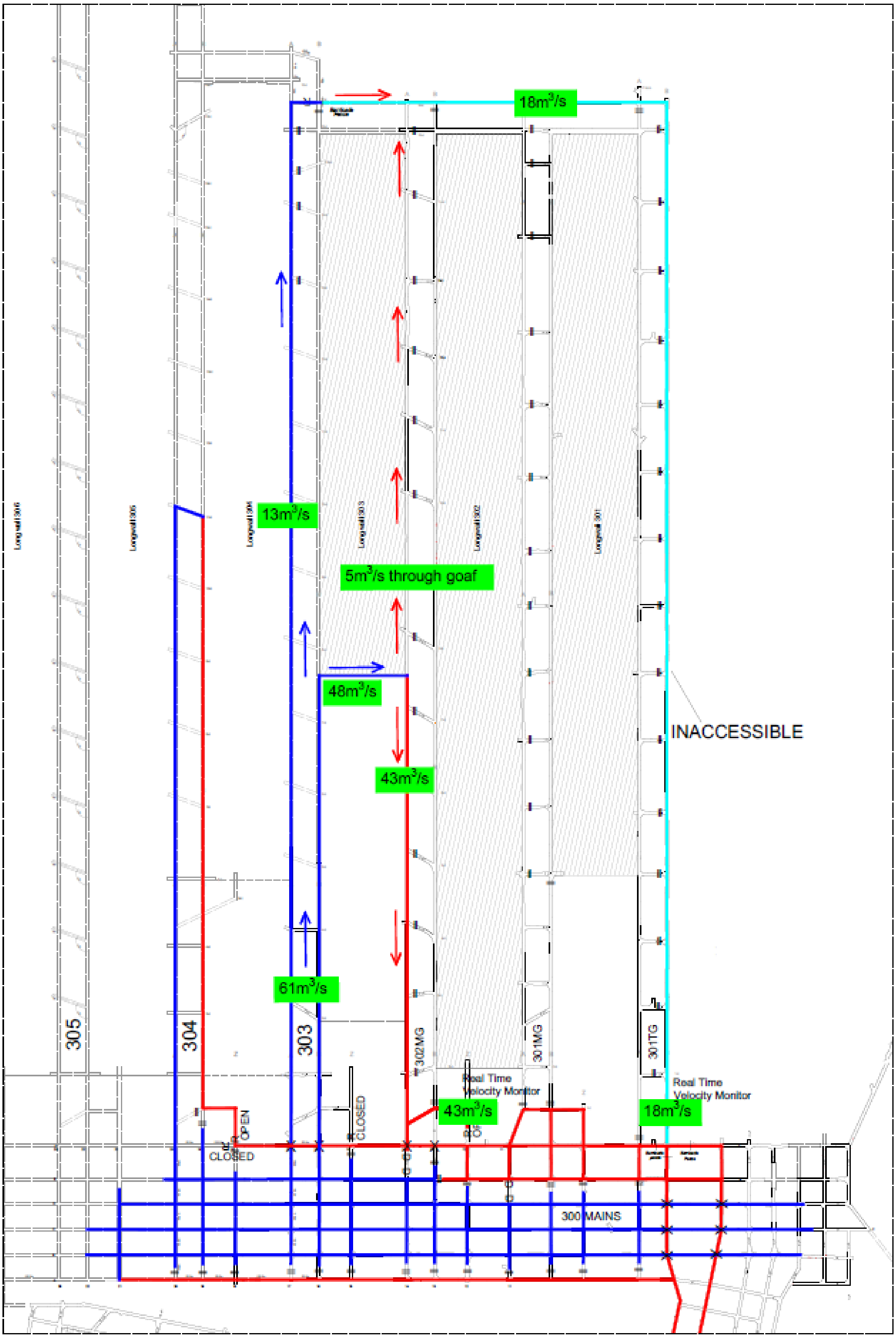
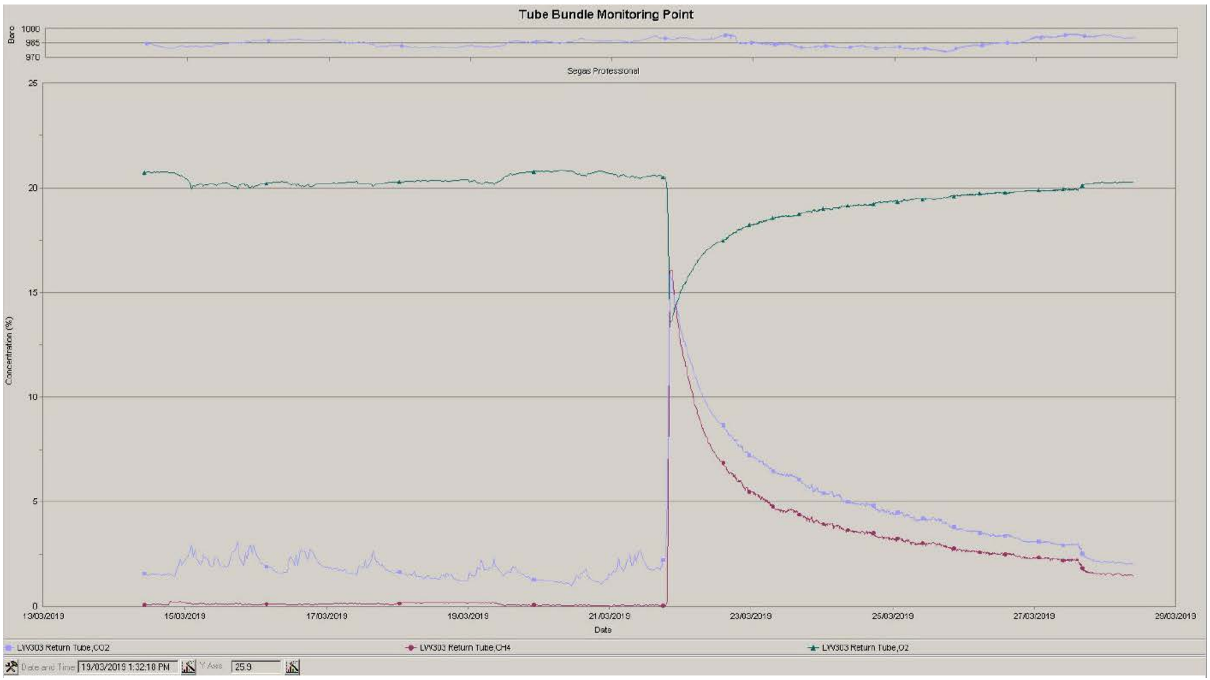


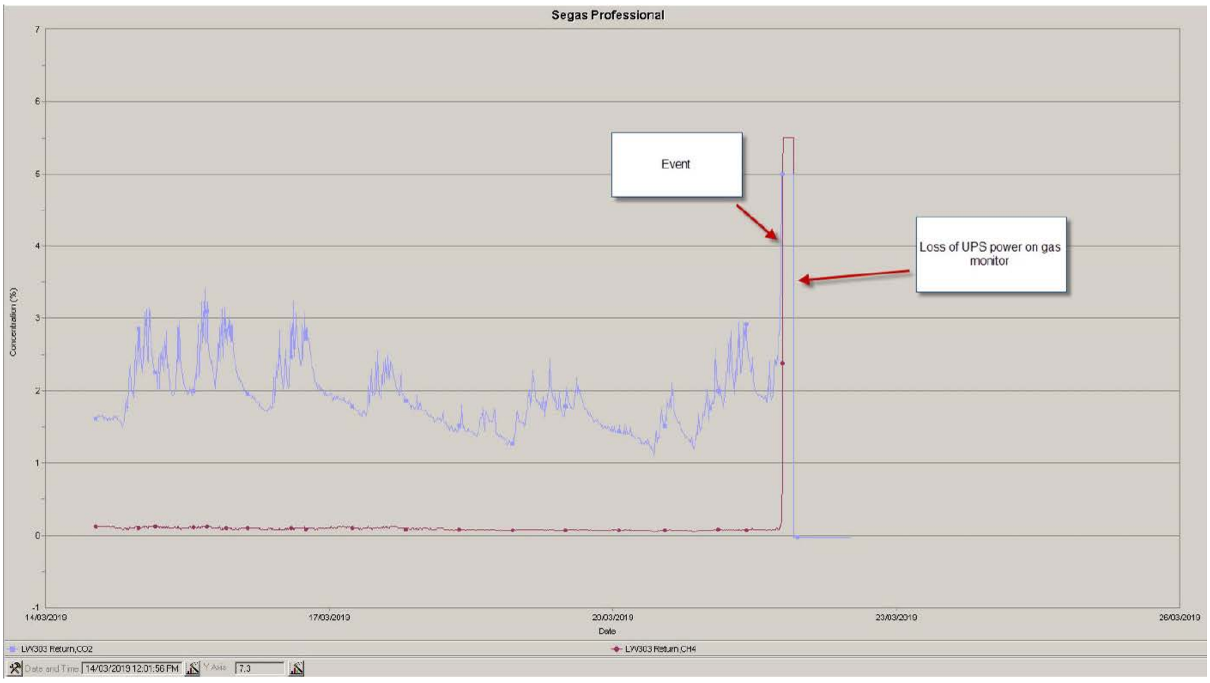
Figure 21 Longwall 303 tube bundle gas trends



As can be seen in the longwall 303 return airway tube bundle gas trends, methane reached 16.1%, carbon dioxide 15.9% and the oxygen decreased to 13.5% before slowly trending towards normal background levels. Longwall 303 return ventilation quantity at the time of the event was 43m^3/s.

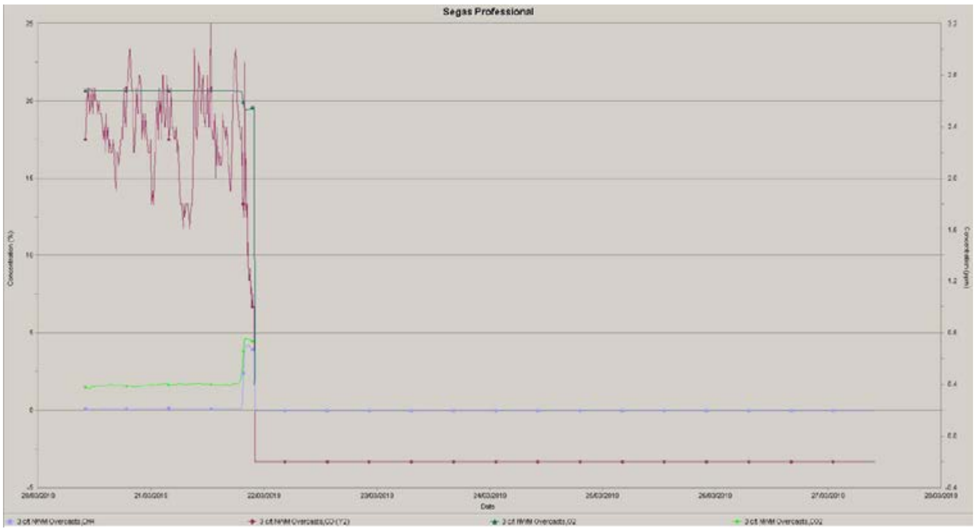
Note the increased longwall 303 ventilation adjustment effects on the trends at the lower right-hand side of the graph.

Figure 22 Longwall 303 real time gas trends



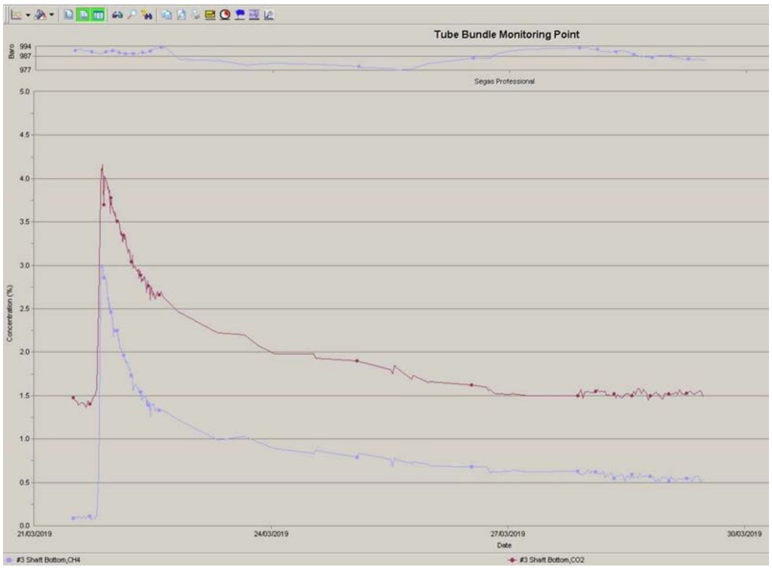
As can be seen in the real time gas trending, the monitors detection capacity was limited to the vicinity of 5% and the uninterrupted power supply loses functionality after one hour and 10 minutes.

Figure 23 North west mains three cut through real time gas trends



This real time gas trend for the north west mains return airway shows the carbon dioxide in green increased from 1.7% to 4.7% and the methane from almost zero to 4.2%. The uninterrupted power supply here again ceased functioning after one hour and 10 minutes.

Figure 24 Upcast #3 shaft bottom tube bundle gas trends for carbon dioxide and methane



The gas content exhausted through the main fans reached 4.16% carbon dioxide and 3.01% methane with 285m^3/s of ventilation.

Figure 15 Longwall 303 return tube bundle Ellicotts trend 13 to 29 March 2019

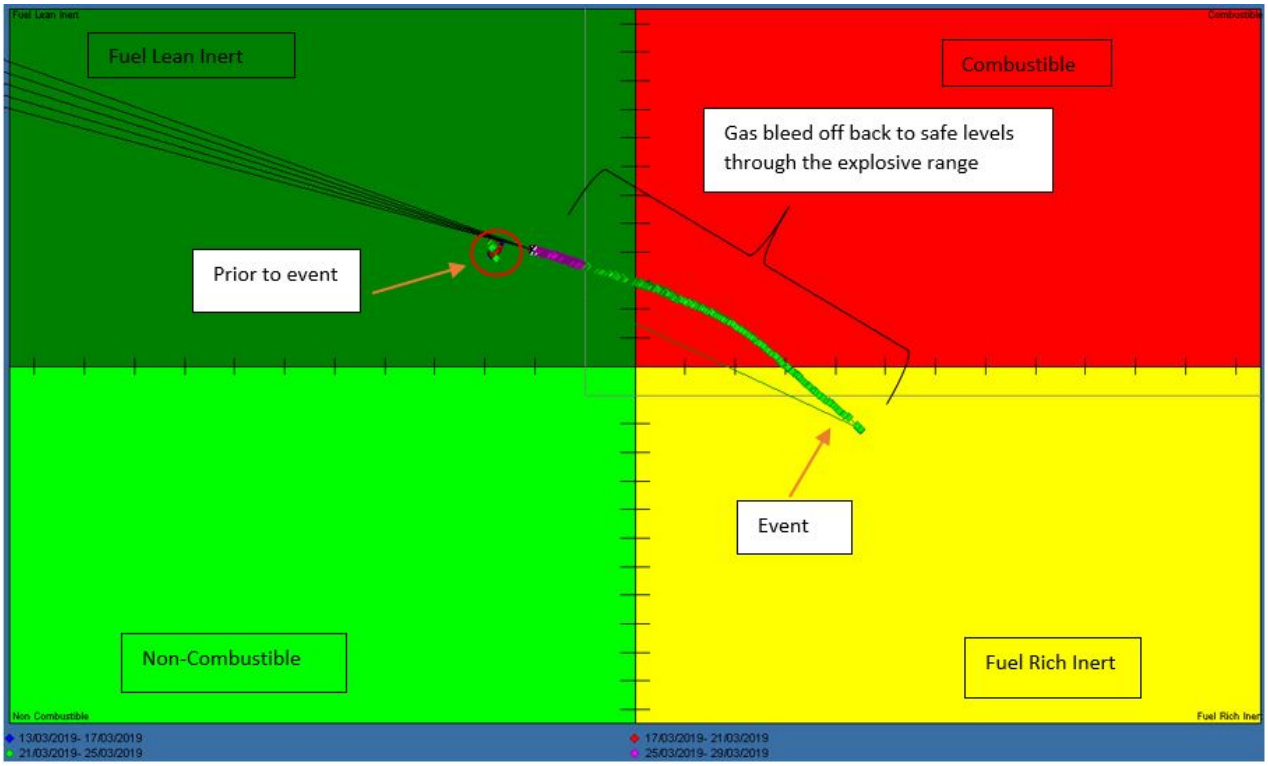


Figure 26 North west mains three cut through return tube bundle Ellicotts trend 13 to 29 March 2019

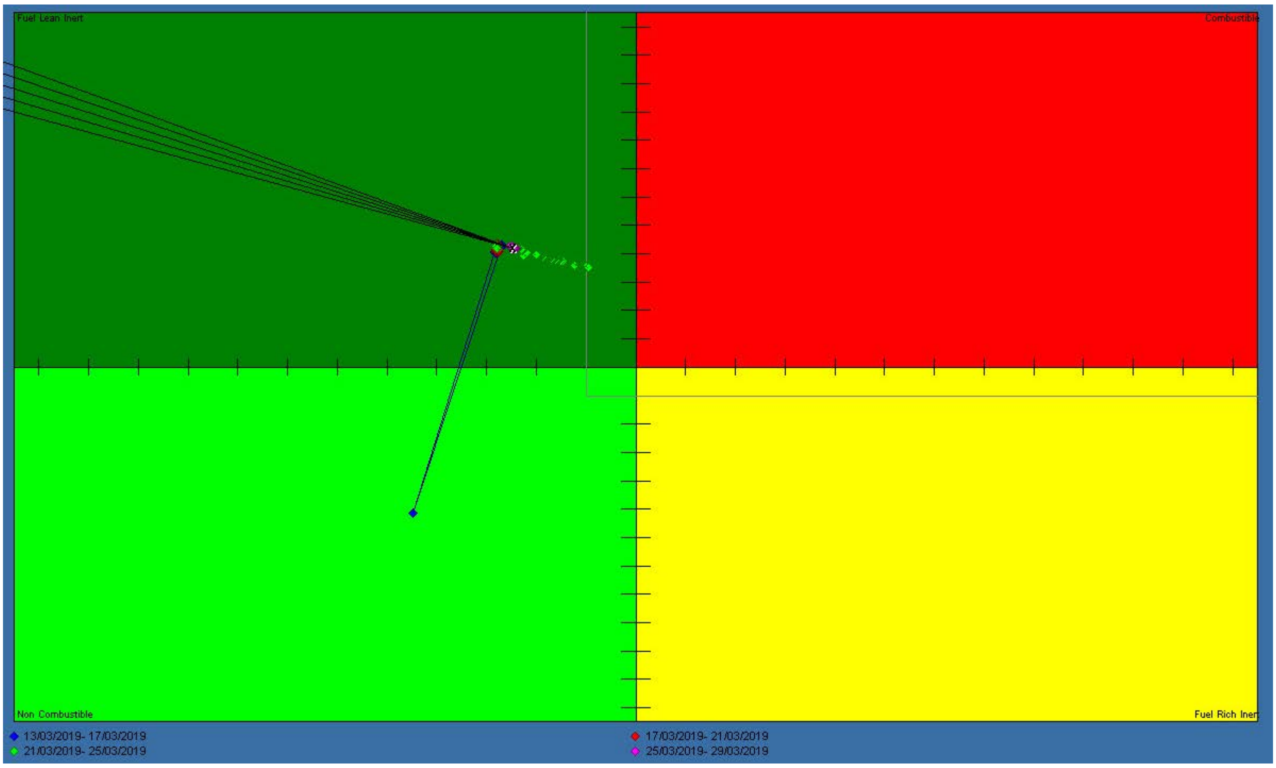
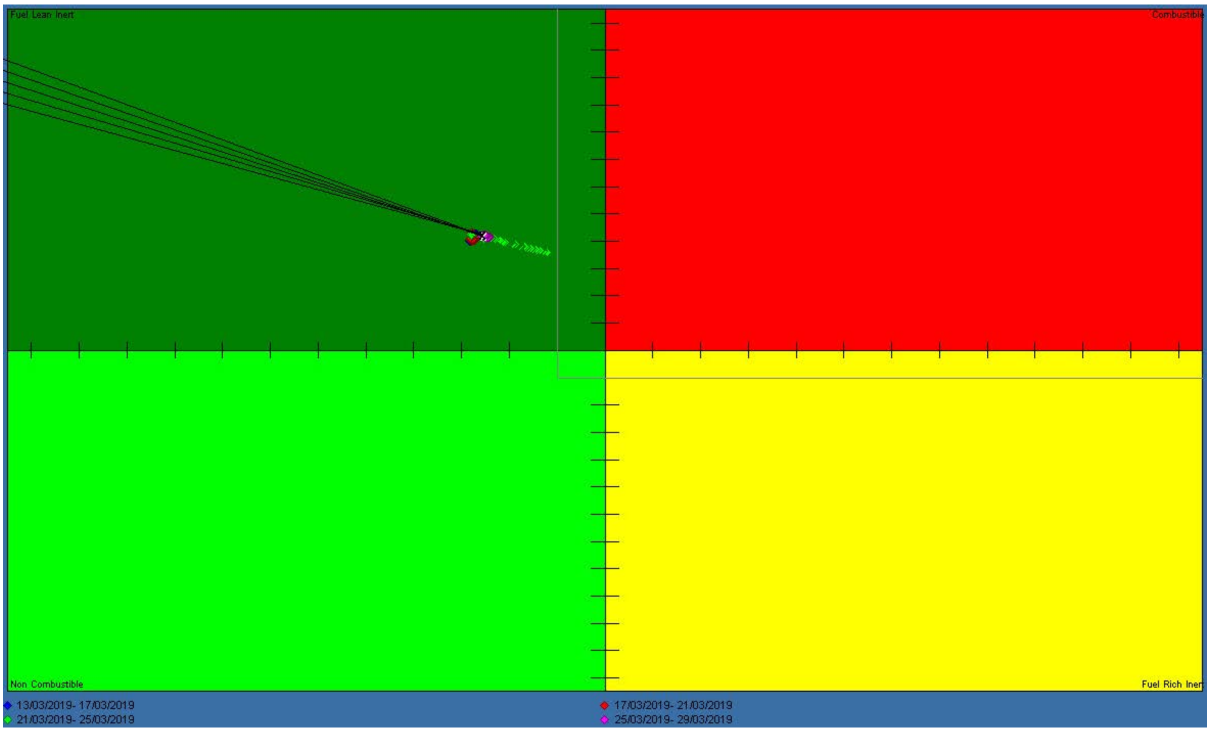


Figure 27 #3 shaft return tube bundle Ellicotts trend 13 to 29 March 2019



The methane levels in north west mains and the #3 return shaft did not reach an explosive atmosphere on the above two Ellicott trend diagrams.

2.3.3. Previous longwall gas emission events

Table 4 Metropolitan recorded longwall gas emission events

Date	Time	Longwall	CH_4 %	CO_2 %	Peak Flow L/s	Geological Comment	Mine Comment
12 Feb 2003	8am	LW9	Unknown	Unknown	Unknown	58m from Dyke	Withdrawal of personnel from mine
12 Mar 2014	8am	LW22B	2.8%	1.0%	1,700	50m from strike/slip structure	Withdrawal of personnel from mine
12 Feb 2015	6pm	LW23B	0.5%	1.4%	855	30m from strike slip structure	Withdrawal of personnel from mine
3 Feb 2016	11am	LW25	2.3%	1.5%	1,750	140m & 100m from strike slip structures	Withdrawal of personnel from LW
21 Mar 2019	6pm	LW303	16.0%	15.5%	13,803	No noted structure	Withdrawal of personnel from mine

The incident on 21 March 2019 had a peak gas flow almost eight times greater than any previous event recorded at Metropolitan Colliery. It is concerning the event occurred unexpectedly and with no recognised associated geological structure.

2.3.4. Effectiveness of the implementation of the mine's response plans

Table 5 Metropolitan withdrawal TARP for elevated gas levels

TARP – Withdrawal Conditions PRESENCE OF ELEVATED GAS LEVELS
Doc No.ME-MIN-TRP- 0028

	YELLOW – LEVEL 2	ORANGE - LEVEL 3	RED - LEVEL 4
Triggers	**General body gas levels > 30mins**: • CH4 > 0.25% at Start of Hazardous Zone • CH4 > 1% around diesel machinery • CO > 20ppm without TWA provisions • CO2 > 1.25% General body in an accessible roadway ventilated by the main mine fans - without TWA provisions • O2 < 20% General body in an accessible roadway ventilated by the main mine fans	**General body gas levels > 30mins:** • CH4 > 1.25% in general body in an accessible roadway ventilated by the main mine fans. • CO > 30ppm without TWA provisions • CO2 > 3% General body in an accessible roadway ventilated by the main mine fans • O2 < 19.5% General body in an accessible roadway ventilated by the main mine fans	**General body gas levels:** • CH4 > 2% General body in a roadway ventilated by the main mine fans. • CH4 > 2.5% General body in a roadway ventilated by the main mine fans.
Possible Causes	• Auxiliary fan stoppage (panel) • Incorrect ventilation setup • Geological structure intersection Development / LW • Inseam borehole intersection • "Gas out" (LW floor break) • Excessive number of poorly tuned diesels – CO • Conveyor heating or fire • Inadequate ventilation quantity • Damaged gas pipe range • Gas plant stoppage	• Auxiliary fan stoppage (dev. panel) • Incorrect ventilation setup • Geological structure intersection Development / LW • "Gas out" (LW floor break) • Borehole intersection • Damaged gas pipe range • Gas plant stoppage • Failure of main fans • Surface fire • Early stages of fire underground • Conveyor heating or fire	• Incorrect ventilation setup • Geological structure intersected Development / LW • "Gas out" (LW floor break) • Borehole intersection • Damaged gas pipe range • Gas plant stoppage • Failure of main fans • Surface fire • Fire underground
RESPONSIBILITIES	**ACTIONS**		
All employees	• Follow mining supervisors' instructions • CH4 >1% - Retreat machine from area • If CH4 > 0.25% at start of Hazardous Zone – cease production • If CO, report any unusual conditions (smoke, smell, sweating, heat or haze) to mining supervisor • If CO detected along conveyor system investigate source using gas detectors • If CO2, refer to TWA procedure	As per level 2 and; • CH4 >1% - Shutdown diesel vehicle and report to control • Turn off power - if not already tripped • If CO, check for potential fire locations, withdraw from the affected area and report to mining supervisor • If CO2, persons to withdraw from the affected area and report to mining supervisor • Cease production. • Follow instruction from mining supervisor / statutory official	**CH4 > 2.0% but < 2.5%** • Withdraw personnel from affected area and barricade • Contact mining supervisor / allocated statutory official and follow instruction **CH4 > 2.5%** • All UG personnel to withdraw to surface • No persons to leave the mine site without the UM permission • Follow instructions from Deputy or Shift Undermanager regarding controlled withdrawal from underground workings

Deputy	• Verify alarm validity using hand held detector (or fixed sensor if close proximity)
	• Investigate and check for potential sources of contamination. Notify UM and CRO with results
	• Determine if ventilation is adequate at location
	• Take remedial action as follows:
	  • CH4 > 0.25% (O/B hazardous zone intake) - take measures to dilute to normal levels
	  • CH4 > 1% - shutdown diesel vehicle, report to control, take measures to dilute to normal levels
	  • CO > 20ppm - monitor diesel activity and restrict as required. Investigate potential of fire and take appropriate response as required.
	  • CO2 > 1.25% - take measures to dilute to normal levels
	  • O2 < 20% - take measures to restore to normal levels
	• Record results in statutory report
		As per LEVEL 2 and;
		• CH4 > 1.25% isolate electrical power to location (if automatic trip has not already occurred)
		• CO – withdraw personnel from affected area and barricade, investigate cause
		• O2 < 19.5% withdraw personnel from affected area and barricade
		• CO2 > 3% withdraw personnel from affected area and barricade
		• Inform Shift Undermanager and or CRO
		• Ensure all crew except those being supervised to rectify ventilation have retreated to place with safe gas levels
		• Monitor atmosphere if safe to do so
		• For CO search for location of possible fire using gas detectors
			CH4 > 2% but <2.5%
			As Per LEVEL 3 and;
			• Contact control to discuss and confirm situation
			• Notify undermanager
			• Account for all personnel within district and withdraw from affected area
			• Make area safe if possible
			• Remove power from equipment and isolate compressed air / water hoses
			• No road entry to affected area with information tag explaining situation
			CH4 > 2.5%
			As Per LEVEL 3 and;
			• Commence withdrawal of all personnel to surface

Surface Competent Person (CRO)	• Accept alarm and check recent trend • Record the event in the Alarm Log • Check surface fan operation and fan collar pressure • Check UG Velocity monitors for steady trend • Check adjacent / related monitoring points • Notify mining supervisor and Undermanager of (with the exception of CO2 <3%); • Trend of all relevant monitoring points • Barometric trend • Status of main fans	As per LEVEL 2 and; • Inform undermanager and affected mining supervisors if situation not controlled or being rectified by deputy • Inform Ventilation Officer and Mining Engineering Manager • Record actions and timing in report alarm Log • If fire is detected, initiate emergency response • Isolate affected conveyors	**CH4 > 2% but <2.5%** As Per LEVEL 3 **CH4 > 2.5%** As per LEVEL 3 and; • Confirm and monitor > 2.5% by trending and monitoring nearby monitors / tube bundle points • Contact underground personnel to commence withdrawal to surface in conjunction with shift UM • Notify and liaise with Shift UM, VO and MEM • Prevent any additional persons entering the mine
Shift Undermanager	• Communicate with mining supervisor to rectify problem • Investigate cause and review corrective actions to rectify problem • Record event in statutory report • Communicate with oncoming shift • No action needed if deputy has identified and is rectifying problem • Review and sign event form	As per LEVEL 2 and; • Investigate cause of alarm • No action needed if deputy has identified and is rectifying problem • Review and organise transport for controlled withdrawal if problem trending >60min • Complete incident investigation form	**CH4 > 2.0% but < 2.5%** As per Level 3 and; • Confirm CH4 concentrations • Investigate cause and advise MEM and VO • Rectify problem and provide resources following instruction from Ventilation Officer and mining Engineering Manager. **CH4 > 2.5%** • Coordinate withdrawal of all personnel to surface • Liaise with CRO and assign person at each portal entry to record names of people exiting • Notify MEM on status of withdrawal
Ventilation Officer (VO)	• Review the cause of the incident • Analyse mine ventilation system as required	As per Level 2 and; • Formulate plan to reduce gas levels	**CH4 > 2.5%** Assess concentration of CH4 through main fans: • Enact on fresh air dilution through fans if CH4 > 3% and rising • Assess monitoring trend, and turn main fans off if CH4 > 3.5% and rising
Mining Engineering Manager (MEM)	• Review incident and ensure corrective actions are implemented	• Review incident and ensure corrective actions are implemented • Initiate Incident Management Team if required • Record event and steps taken to rectify	As per level 3 and; • Review compliance with withdrawal situation and re-entry process required • Notify regulator under clause 128 (5b) and Clause 128 (5k) – consider Clause 10 • Implement IMT and consider EMP if escalating event or issue • Undertake investigation and complete PSI communication

TARP – Withdrawal Conditions PRESENCE OF ELEVATED GAS LEVELS
Document Number: ME-MIN-TRP-0028 Version: 7 — Uncontrolled when printed — 1 of 2

The decision to withdraw workers from the longwall 303 face area back to the crib room was made at 7.05pm by the undermanager because gas levels were increasing on the longwall face and the power was automatically tripped. After further consideration of the increasing gas levels in the longwall 303 return, and in accordance with the site TARP for elevated gas levels, the decision to withdraw all workers from the underground workings was made at 7.15pm.

The mine's withdrawal TARPs describe withdrawal from the affected area if methane is greater than 2% and withdrawal to the surface if greater than 2.5%.

With the assistance of the control room operator communicating with various work groups, all workers were withdrawn to the surface and accounted for by 8.45pm. The withdrawal process lasted about 90 minutes.

The normal travel time to exit the mine is about 60 minutes. Generally, all work groups have access to a man transport vehicle, assisting with a timely, controlled withdrawal. There are rubber-tyred vehicle roads from panels to the end of the Centenary area, where diesel man rail transports travel through the older workings to a downcast shaft, transporting workers to the surface, where two cages alternately traverse the shaft. Each cage generally allows for six to nine workers at a time. There is another drift entrance to the underground workings with a drift winder arrangement, however this was not used during the withdrawal process.

During the withdrawal, power was isolated to the longwall 303 district and conveyors. Following confirmation that all workers were withdrawn from underground, power was isolated at the surface. Barricades were installed to prevent access to any mine openings.

All key workers were notified and mobilised to the mine site to assist with the process, monitor the environment and assess associated risks.

The following issues were identified:

1. The deputy and offsider conducting inspections in the longwall 20s returns and bleeder circuit had no communications while in the returns. They had communicated with the control room operator when entering and exiting. The reason they were alerted to the event was due to the gas levels increase detected on the hand-held gas detector the deputy was carrying. Due to this increase, the deputy decided to make his way to the nearest fresh air and contact the control room operator. A more positive means of communication when accessing the remote areas would be beneficial.
2. While the deputy and offsider were evacuating from the return airway, they were travelling in a diesel man transport. Records downloaded from the hand-held gas detector indicated the environment at the time contained up to 4.89% carbon dioxide, 3.92% methane and oxygen reduced to 19.0%. Exposure levels greater than 3.3% carbon dioxide and 1.43% methane are recorded over a three-minute period. The oxygen levels at less than 19.5% were recorded for about two and a half minutes. The man transport was shut down before exiting the return to

intake air via access doors. At no time was a self-contained self-rescuer activated by either of the workers.

3. When the site Incident Management Team formed and proceeded to the incident room, it was found the facilities for communications and access to gas monitoring data were lacking. Alternative arrangements were made to manage these issues at the time and more permanent arrangements were in place at the time of writing.

2.3.5. Effectiveness of gas monitoring systems from the time of the gas release to re-entry

Metropolitan Colliery has a gas monitoring system that includes both real time and tube bundle sampling arrangements with supporting software and hardware. The siting of the monitoring points were determined by the ventilation officer and mining engineering manager.

The extent of the gas event is shown by the tube bundle monitoring information, as this remained active throughout the event.

The real time gas monitoring shows some limitations in relation to the range of the specific gas detected and the amount of time the supporting uninterrupted power supply powered the monitor after the general power was removed.

The current gas monitor ranges are 0 to 50ppm for carbon monoxide, and 0 to 5% for carbon dioxide and methane.

The uninterrupted power supply up-time had been tested and ranged from three minutes to 72 minutes.

The entire event was well monitored and showed the extent of the gas liberated. The tube bundle system allowed for accurate (with a 52-minute sample delay time) analysis of the underground environment. This allowed risks to be assessed using accurate data and decisions made after interpretation of this data.

As no-one was at risk after the withdrawal process, there was sufficient time available to gather and interpret the tube bundle monitoring results.

However, if the situation was different, and workers were still underground and real time monitoring data was required to inform decisions for rescue or other incident management, then this would have been unavailable due to the poor, uninterrupted power supply up-time.

Mines that have identified significant gas risks should be encouraged to enable real time monitoring of higher ranges of gases to be monitored and have a greater up-time for the associated uninterrupted power supply arrangement.

For example, a proactive approach would be to add additional real time gas monitors with an extended detection range to detect larger levels of gas contamination. Methane and carbon dioxide 0 to 5% gas monitors could be complimented with a 0 to 100%. Similarly, carbon monoxide 0 to 50ppm could be complimented with a 0 to 1% detector, which would be useful in the event of a fire underground.

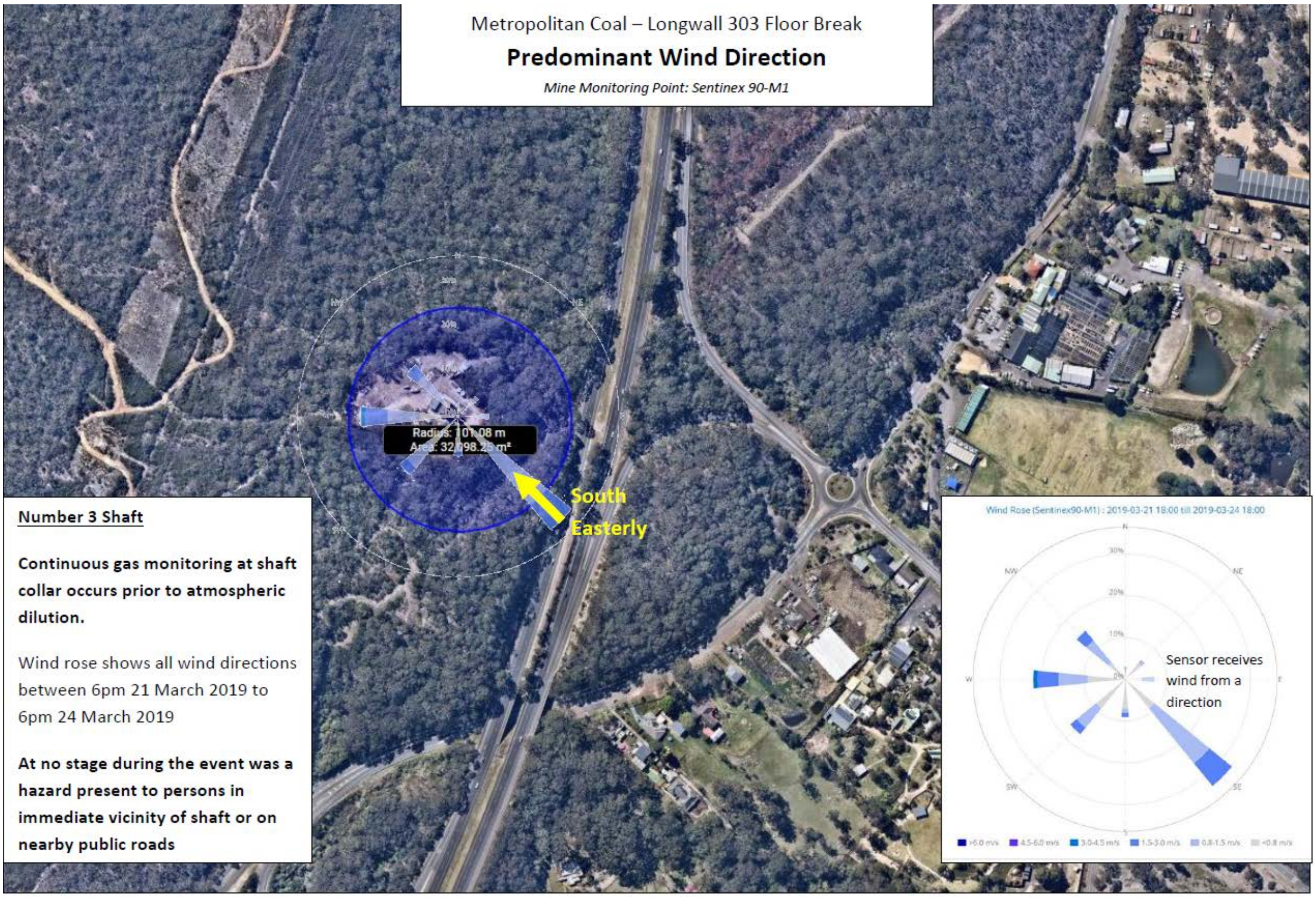
Calibration of instrumentation was in order, with the appropriate certificates observed during the investigation process.

2.3.6. Management of risks to critical surface infrastructure, both private and public, during the event

The gas plume that exhausted from the surface ventilation fans into the air was diluted and dispersed with the general wind in a south easterly direction away from surrounding public surface infrastructure. This data was measured by the on-site weather monitoring station.

Surface gas monitoring did not measure any gas levels that may be harmful to the public.

Figure 28 Surface fans and gas drainage plant infrastructure



2.3.7. Management of risks during the re-entry to the mine

The methane level in the longwall 303 return had reduced to 2.17% and was stable around this amount by 27 March 2019. A risk assessment was conducted at the mine site, a procedure developed, and approval given for a controlled re-entry by four workers to conduct a modelled ventilation change underground to increase the ventilation to the longwall ventilation circuit. Their object was to dilute the methane gas level in the longwall return airway to below 2% methane.

The ventilation change was conducted without incident on the afternoon of 27 March 2019 and showed immediate results with the methane level reduced to 1.74%. The methane level had reduced to 1.47% by 28 March 2019.

Additional risk assessments were conducted, and procedures developed for general re-entry underground as well as repowering the mine and longwall 303.

Following a site ICAM investigation, risk assessment, modification of TARPs and procedures, the mine restarted extraction at longwall 303 on 5 April 2019.

The investigation process had independent contributions, local workforce consultation and used acknowledged risk management processes.

A cautious approach was taken to ensure the quality of the process and desired outcomes were attained.

3. Recommendations

Further analysis of the causal factors involved in this incident are continuing at Metropolitan Colliery. The mine operator is continuing to gather data confirming the assumptions made during this investigation, as well as increase the integrity for future decision making in the 300s area.

Mine and petroleum site operators are reminded of their duty to identify hazards and manage risks to health and safety in accordance with the provisions of the *Work Health and Safety Act 2011* and *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and Regulations.

3.1. Recommendations for the mining industry

The circumstances of this incident should prompt mine operators to review their safety management systems, focusing on:

1. Managing the gas reservoirs around extraction panels:
    a. Ensure there is enough reliable exploration data available to determine the geotechnical risks and gas reservoir affected by the proposed mining method.
    b. Include a means to determine which reservoir the gas is released from to confirm design and modelling assumptions.
    c. Include lithology above as well as below the intended working seam.
    d. Consider significant gas capture with the gas drainage process and have minimal contamination of accessible mine airways.
2. Withdrawal trigger action response plans (TARPs):
    a. Design TARPs to reflect realistic triggers and actions that are simple to follow.
    b. Develop a process to ensure the workforce are aware and understand the TARPs in use at the mine.
3. Use of self-contained self-rescuers:
    a. Consider expanding the training on self-rescuers to include use during times where low oxygen environments are encountered and excessive levels of carbon-dioxide gas.
    b. Develop TARPs in relation to the circumstances when self-rescuers are expected to be used.
4. Post incident monitoring:
    a. Mines should conduct a risk assessment to determine atmospheric monitoring requirements post incident (explosion, fire, gas event, etc.). This should include both real time and tube bundle.

   b. The selection of post incident monitoring arrangements should consider the post incident survivability of the system and system elements.
   c. Post incident monitoring arrangements should operate effectively when power is removed from all or parts of the mine.
   d. Post incident monitoring points should be installed in optimal locations such as intake airways, return airways and escape routes.
   e. Monitoring for gases relevant to the incident should form part of the post incident monitoring arrangements. This should ensure the concentration range of the gases being monitored are appropriate.
   f. Implement a program of testing the effectiveness of the post incident monitoring arrangements.
5. Re-entry procedures:
   a. Mines should conduct a risk assessment to determine re-entry conditions appropriate for the various risks identified.
   b. Develop TARPs to reflect acceptable and unacceptable conditions.
6. Workers' access to return airways during extraction activities:
   a. Mines should conduct a risk assessment to determine the controls necessary for workers to safely access return airways.
   b. Develop a procedure to reflect those controls identified.
   c. Consider the timing of access, barometric change effects, production activities, whether working alone is appropriate, remote workings, communications and gas detection.
   d. Review requirements for appropriate gas monitoring, communications and emergency escape for those workers accessing return airways in the event a withdrawal is required.
7. The determination of acceptable methane levels passing through the ventilation fans:
   a. Mines should conduct a risk assessment to determine the maximum levels of methane that will be allowed to pass through the main ventilation fans.
   b. Develop TARPs to guide workers at the mine in the decision-making process when excessive quantities of various gases are being exhausted from the mine.
   c. Explore options to be able to conduct simple ventilation changes remotely from the surface to manage unexpected gas issues underground.
   d. Explore options to be able to remotely limit the volumes of methane gas levels that pass through the fan infrastructure.
8. Management of ventilation fan exhaust gases around surface infrastructure:
   a. Mines should conduct plume modelling in relation to the main surface ventilation fans.
   b. Conduct hazardous area assessments to include relevant infrastructure that may be affected by these exhaust gases.

9. Review site emergency management and withdrawal procedures:
    a. Include accurate monitoring of the locations of workers and man transport vehicles to facilitate timely and efficient withdrawal.
    b. Include the availability of man transports in work areas.