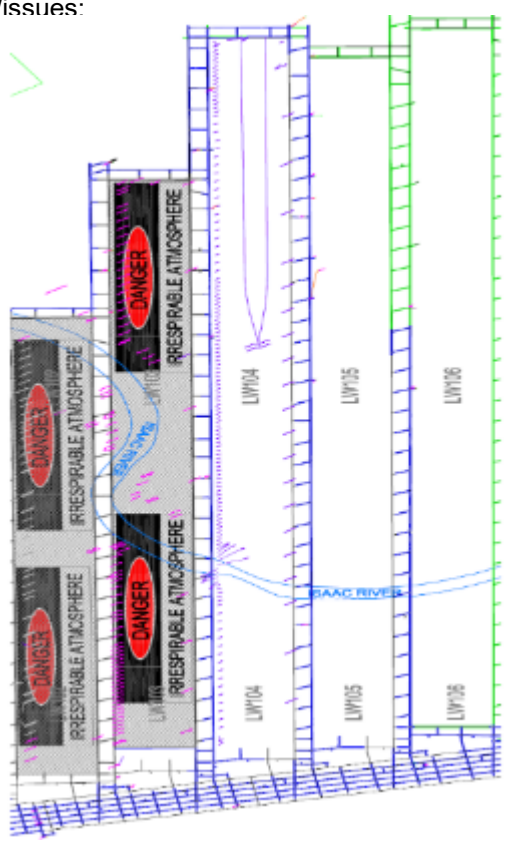
CONTEXT			
DATE WRAC WAS CONDUCTED:	15/01/2020	**WRAC FACILITATOR:**	Aaron Smith

1. SCOPE

The scope of the WRAC was to complete a broad brush risk assessment on the proposed Goaf Drainage for Grosvenor's LW104. The risk assessment provided an opportunity to identify any potential issues/risks that may result from the proposed design/strategy for LW104 goaf drainage system and to develop suitable controls to minimise the potential impacts. The scope included reviewing some of the following key financial and compliance risks/issues:

- Planning and design ***(refer to Annex Pages 1 & 2)***
- Construction & Installation of the Seamgas infrastructure
- Borehole location, design, spacing's
- Goaf Drainage capacity (considering pipe sizing, Gas Plant at Grosvenor and forecast gas make)
- Utilisation of other indirect drainage means (existing P/GM Seam drainage including SIS or UIS)
- Water management (from pipework)
- Equipment failures/management (boreholes and surface infrastructure)
- Ongoing monitoring and management of the LW103 goaf drainage system (communications, meetings)
- Surface threats and barriers (Heritage, Cultural and physical barriers e.g. river)
- Weather and access to the system for maintenance and management
- Commissioning & Decommissioning



The risk assessment was held at "the Hub" 2nd boardroom on the 15/1/20 in accordance with;

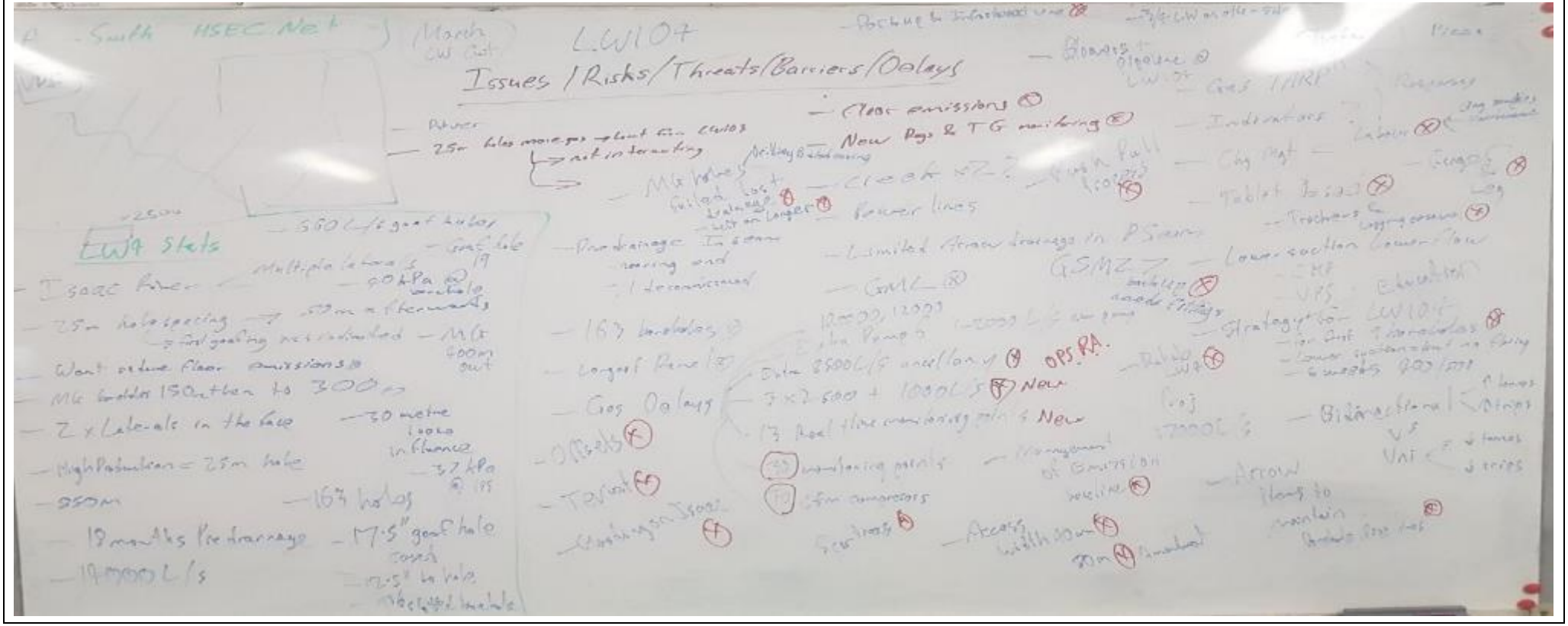
- GRO-201-PLAN-Risk Management Plan
- GRO-200-PRO-Change Management Procedure
- QDL Mine Dept: Recognised Standard 02 Control of risk management practices
- AS/NZS ISO 31000 – Risk Management

This scope was reviewed and approved by: Garry Needham

CONTEXT
The risk assessment did not include the drilling process, day to day operations/maintenance tasks on the goaf drainage system or direct operation of the Gas Vacuum Plant System (VPS) at Grosvenor Coal Mine (GCM).

2. BACKGROUND & DESCRIPTION OF ACTIVITY/EVENT/HAZARD/ISSUE BEING ASSESSED

Refer to Annex Pages 1 & 2 for more information on goaf drainage strategies and planning arrangements. This risk assessment should also be read in conjunction with LW4 Second Workings RA. Below is the teams brainstorm whiteboard.



CONTEXT

3. ASSUMPTIONS *In this section enter all the assumptions for example; introduction to site has been completed, designed to an Aust Std or MDG, all modifications signed off by OEM*

All major emergencies or "out of control" events (earthquakes, flood or similar) are not considered in the scope of this risk assessment.

4. WORK ENVIRONMENT *Provide a brief description of the mine and the physical environment in which the activity is to take place*

The Anglo American Metallurgical Coal Grosvenor Coal Mine involves the development of a stand-alone green field mining operation (construction of a underground longwall mine) and infrastructure at the Grosvenor tenements (Mining Lease Application 70378) located directly north of the township of Moranbah in Central Queensland, approximately 150 km south-west of Mackay. The activities will take place in the LW103 panel at Grosvenor mine.

5. COMPLIANCE CHECKLIST ☑ *all items to be checked for relevance & included as part of the RA process*

- ☑ DME Hazard Database https://www.business.qld.gov.au/industries/mining-energy-water/resources/safety-health/mining/hazards/hazards
- ☑ CMSHA Act 1999 https://www.legislation.qld.gov.au/view/pdf/2017-03-30/act-1999-039
- ☑ CMHRS Regulation 2017 https://www.legislation.qld.gov.au/view/pdf/asmade/sl-2017-0165
- ☑ WHS Regulation 2011 https://www.legislation.qld.gov.au/view/pdf/inforce/current/sl-2011-0240
- ☑ QLD Codes of Practice https://www.worksafe.qld.gov.au/laws-and-compliance/codes-of-practice
- ☑ Anglo Fatal Risk Standards https://www.angloamerican.com/~/media/Files/A/Anglo-American-PLC-V2/documents/supplier/fatal_risk_standards.pdf
- ☑ Anglo Safety Golden Rules https://www.angloamerican.com/~/media/Files/A/Anglo-American-PLC-V2/documents/approach-and-policies/safety-and-health/safety-golden-rules.pdf
- ☑ QLD Mines Recognised Standards https://www.business.qld.gov.au/industries/mining-energy-water/resources/safety-health/mining/legislation-standards/recognised-standards
- ☑ QLD Mines Guidelines https://www.business.qld.gov.au/industries/mining-energy-water/resources/safety-health/mining/legislation-standards/recognised-standards
- ☑ Relevant GCM PHMP, HMP, SOP or SWI's (search on Anglo Docs)

CONTEXT

6. REFERENCE MATERIALS *add any additional references as required to this generic list*

- Anglo Safety Golden Rules
- DME Hazard Database
- GRO-201-PRO-Risk Management
- QLD Coal Mining Safety & Health Act 1999
- QLD Coal Mining Safety & Health Regulation 2017
- QLD Mines Guidelines
- QLD Mines Recognised Standards
- Recognised Standard 02 Control of risk management practices

TEAM SHEET

In accordance with Section 10(1)(a) of the Coal Mining Safety and Health Regulation 2017 a list of all persons contributing to the risk assessment process together with their organisational roles, experience and qualifications is to be recorded below.

Name	Company	Role & Qualifications	Date	Industry Experience (yrs)	Consensus (Y/N)	Signature
Aaron Smith	HSEC Net	Facilitator – Ad Dip OHS – Lead Auditor – Director – B Sc (U)	15/1/20	20+	Y	Confidential
Joshua Lancaster	Anglo	ERP Controller LW Coordinator	15-1-20	19	Y	
CENGIEBRECHT	ANGLO	TRADE, ESTABLISH & IMPLEMENT OHS ENVIR SEAMGAS SUPER S1,2,3,G2	15-1-20	20+	Y	
DANNY MOORE	ANGLO	SEAMGAS COORDINATOR MECH TRADE S1,2,3 + G2	15/1/20	14	Y	
JASON Scott	Anglo	Seamgas Supervisor S1,2,3 Cert IV WHS	15/01/20	10	Y	
HAYDEN HEARNE	ANGLO	VENT / GAS SUPER / VO	15.1.20	14	Y	
Stephen Giese	Anglo	Geo + Geotech Supv S1,2,3 G2	15/1/20	6	Y	
Daniel Perrin	Anglo	Environmental Coordinator S1, S2, S3, G2	15/1/20	8	Y	
Alisha Penrose	Anglo	H+S Officer	15/1/20	9	Y	
Bevin Mulcahy	Anglo	Seamgas Supervisor	15/1/20	13	Y	
RUSSELL LACHMAN	AAMC	VO BSc Hons S1 S2 S3	15	20	Y	
Raymond Kostanski	Anglo	Gas Drainage Coordinator	15/01/20	10	Y	
GARY MORRISON	ANGLO	SEAMGAS MAINTAINER	15/1/2020	32	Y	

ADDITIONAL CONTROLS *All additional controls to be entered in Enablon*					
Line Ref No.	**Hazard/Issue**	**Additional Controls**	**Action by Whom**	**Target Date**	**Enablon No.**
Adam Heap					
38	Rehab plan not considering the increase of the land use, equipment used and overall repair	Need to review the plan in regard to rehab to check costs involved for LW4 due to the increased "volume" of equipment/items A Heap 18/9/20	Adam Heap	18/9/20	TS.01263631
Ben Bomford					
7	Gas concentrations prevent operation of face equipment	VPS upgrade including 6th vac pumps to be installed and commissioned	Ben Bomford	2/6/20	*(Already actioned – HAZOP completed Feb 2020)*
Bevin Mulcahy					
6	GSM27 not adequately setup leading to delays in gas drainage and/or increased gas levels in the underground *GSM27 – planned for disuse following advancement of the longwall. Noted that at Grasstree this was beneficial for gas drainage if not used for goaf drainage then could lead to less than adequate results*	Need to flush the GSM27 borehole (dip and flush) Need to investigate the status of the borehole (GSM27) before cleaning or using	Bevin Mulcahy	28/2/20	TS.01263642
38	Rehab plan not considering the increase of the land use, equipment used and overall repair	Cut n cap contractor to be sourced for LW4 BM 26/6/20	Bevin Mulcahy	26/6/20	TS.01263644
Chris Englebrecht					

ADDITIONAL CONTROLS *All additional controls to be entered in Enablon*					
Line Ref No.	**Hazard/Issue**	**Additional Controls**	**Action by Whom**	**Target Date**	**Enablon No.**
1	Labour and resources less than adequate leading to delays in operation (longwall and gas levels)	Additional labour to be sourced to assist with LW4 seamgas operations – to be assessed in terms of "numbers"	Chris Englebrecht	28/2/20	TS.01263645
7	Gas concentrations prevent operation of face equipment	Additional Gas Drainage skid Blower skids to 7500L/s capacity to be ordered, installed & commissioned	Chris Englebrecht	31/6/20	TS.01263646
17	Surface infrastructure impacted on by the goaf drainage installations and subsidence leading to business loss	Develop strategy and mitigation for the subsidence impacts on the spine	Chris Englebrecht	27/3/20	TS.01263648
21	Arrow infrastructure – subsidence and intersection of arrow infrastructure from longwall mining activities leading to reimbursements (absorbing additional items and equipment)	Arrow infrastructure to be maintained in line with operating standards (submit schedule for remediation for Dam 6 Node 2)	Chris Englebrecht	27/3/20	TS.01263638
Danny Moore					
1	Labour and resources less than adequate leading to delays in operation (longwall and gas levels)	Need to source a critical spares list for the new equipment and check what is required (for all of LW4)	Danny Moore	29/5/20	TS.01263649
2	Delays due to limited "loader" units on site leading to delays in mining/Seamgas operation	Require additional "loader" or similar to assist (only 1 unit on site for Seamgas)	Danny Moore	27/3/20	TS.01263653

ADDITIONAL CONTROLS *All additional controls to be entered in Enablon*					
Line Ref No.	**Hazard/Issue**	**Additional Controls**	**Action by Whom**	**Target Date**	**Enablon No.**
5	Operations requesting more suction leading to a less than adequate “draw” form the underground workings	Need to circulate a LW4 strategy for the first 100m (include the use of venturi skids and free vent if required)	Danny Moore	28/2/20	TS.01263654
6	GSM27 not adequately setup leading to delays in gas drainage and/or increased gas levels in the underground	Need to utilize this borehole for additional suction – requires “plumbing” to the Seamgas circuit Need to select the correct skid for GSM27 and install (Crowntech skid)	Danny Moore	29/5/20	TS.01263655
Garry Needham					
5	Operations requesting more suction leading to a less than adequate “draw” form the underground workings	The strategy for the first 100m of a panel needs to be included in every goaf drainage plan (include the use of venturi skids and free vent if required)	Gary Needham	28/2/20	TS.01263656
5	Operations requesting more suction leading to a less than adequate “draw” form the underground workings	Need to formalise the goaf/gas drainage strategy for LW104 to be formalized and signed off - include all the technical information and provide to SLT Need to commence development of the LW5 goaf drainage strategy (based off learning from LW1-2-3-4 and include all technical and baseline data)	Garry Needham	28/2/20 18/9/20	TS.01263657 TS.01263658
38	Rehab plan not considering the increase of the land use, equipment used and overall repair	Need to include into the 5 years mine plan the installation and recovery of pipeline network (NB: this drives the rehab process)	Garry Needham	27/3/20	TS.01263659
Jason Scott					

ADDITIONAL CONTROLS *All additional controls to be entered in Enablon*					
Line Ref No.	**Hazard/Issue**	**Additional Controls**	**Action by Whom**	**Target Date**	**Enablon No.**
1	Labour and resources less than adequate leading to delays in operation (longwall and gas levels)	Additional maintenance documents to be developed for new equipment/boreholes Need to arrange for risk management and introduction to site of the new skids for LW4	Jason Scott	27/3/20	TS.01263660
Russell Packham (Chris Williams)					
11	Peaks and lows goaf drainage not managed adequately leading to delays in mining (excessive gas make/trips)	Review the potential to remove the orifice plates from the Goaf Skids to reduce potential fluctuations/ restrictions Review the orifice readings versus ultrasonic readings on the goaf skids	Russell Packham (Chris Williams)	27/3/20	TS.01263661
16	Determination of the spacings after initial longwall advancement - not formalised leading to delays in mining due to poor goaf drainage performance	Review LW104 start up data versus the design success (for LW5 planning)	Russel Packham (Chris Williams)	27/3/20	TS.01263662

NON-CONSENSUS ITEMS *All Non-Consensus Items to be entered into Enablon for immediate follow up*				
Line Ref No.	**Item or Issue**	**Reason for Non-Consensus**	**Immediate Follow up by Whom**	**Date**

HAZARDS/ISSUES RANKED

Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR

Line Ref No.	List A - Hazard/Issue	IRR	Line Ref No.	List B - Hazard/Issue	Conseq
7	Gas concentrations prevent operation of face equipment	13 S	25	Connection with powerlines leading to electrical shock and/or damage to equipment during vegetation removal	S4
1	Labour and resources less than adequate leading to delays in operation (longwall and gas levels)	12M	26	Connection with powerlines leading to electrical shock and/or damage to equipment during equipment mobilisation (non-standard travelling routes for larger vehicles and equipment)	S4
26	Connection with powerlines leading to electrical shock and/or damage to equipment during equipment mobilisation (non-standard travelling routes for larger vehicles and equipment)	10M	28	Connection with electrical services (powerlines or buried) leading to potential for electrical shock and/or damage to equipment	S4
25	Connection with powerlines leading to electrical shock and/or damage to equipment during vegetation removal	10M	27	Personnel working or installing gas drainage infrastructure leading to potential for ignition of gas due to proximity of hazardous zones (and our live electrical energy); could result in injury to personnel given proximity of the work and hazardous zone	S3
28	Connection with electrical services (powerlines or buried) leading to potential for electrical shock and/or damage to equipment	10M	7	Gas concentrations prevent operation of face equipment	M3
8	Gas drainage capacity resulting in a potential for elevated gas make (above expected emissions) leading to delays in mining	9M	8	Gas drainage capacity resulting in a potential for elevated gas make (above expected emissions) leading to delays in mining	M3

HAZARDS/ISSUES RANKED *Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR*					
Line Ref No.	**List A - Hazard/Issue**	**IRR**	**Line Ref No.**	**List B - Hazard/Issue**	**Conseq**
9	Conductivity of the borehole into active underground workings/goaf leading to potential for ignition	9M	9	Conductivity of the borehole into active underground workings/goaf leading to potential for ignition	M3
27	Personnel working or installing gas drainage infrastructure leading to potential for ignition of gas due to proximity of hazardous zones (and our live electrical energy); could result in injury to personnel given proximity of the work and hazardous zone	9M	1	Labour and resources less than adequate leading to delays in operation (longwall and gas levels)	M2
10	Borehole locator not being input into borehole database leading to statutory compliance issue for the mine	5L	10	Borehole locator not being input into borehole database leading to statutory compliance issue for the mine	M2
11	Peaks and lows goaf drainage not managed adequately leading to delays in mining (excessive gas make/trips)	5L	11	Peaks and lows goaf drainage not managed adequately leading to delays in mining (excessive gas make/trips)	M2
12	Loss of gas drainage capability causing production loss	5L	12	Loss of gas drainage capability causing production loss	M2
13	Gas concentrations prevent operation of face equipment	5L	13	Gas concentrations prevent operation of face equipment	M2
14	Gas concentrations prevent operation of face equipment	5L	14	Gas concentrations prevent operation of face equipment	M2

HAZARDS/ISSUES RANKED *Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR*					
Line Ref No.	**List A - Hazard/Issue**	**IRR**	**Line Ref No.**	**List B - Hazard/Issue**	**Conseq**
21	Arrow infrastructure – subsidence and intersection of arrow infrastructure from longwall mining activities leading to reimbursements (absorbing additional items and equipment)	5L	19	Accuracy of the boreholes in terms of location and depth (borehole and casing) leading to potential for delays in longwall production due to exposing the borehole/casing to the longwall operations	M2
29	Borehole or drilling pads being developed near waterways – potential for environmental breach or damage with inadequate environmental controls	5L	21	Arrow infrastructure – subsidence and intersection of arrow infrastructure from longwall mining activities leading to reimbursements (absorbing additional items and equipment)	M2
30	Interruption of drainage systems or installation of inadequate drainage lines leading to environmental impacts/event	5L	29	Borehole or drilling pads being developed near waterways – potential for environmental breach or damage with inadequate environmental controls	Env 2
31	Connection with Water Sources or pipelines leading to environmental breach with uncontrolled “release”	5L	2	Delays due to limited “loader” units on site leading to delays in mining/Seamgas operation	M1
32	Damage to mining infrastructure when clearing vegetation leading to delays in operation	5L	3	Environmental offsets application, permits – delays due to increased “space” required for LW4	M1
2	Delays due to limited “loader” units on site leading to delays in mining/Seamgas operation	4L	4	MG Borehole – witnessed failures in LW102 for LW103 which caused drainage issues leading to potential for delays in longwall mining operations *NB: team discussed maybe caused by drilling technique*	M1

HAZARDS/ISSUES RANKED *Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR*					
Line Ref No.	**List A - Hazard/Issue**	**IRR**	**Line Ref No.**	**List B - Hazard/Issue**	**Conseq**
	NB: Changes to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network				
3	Environmental offsets application, permits – delays due to increased "space" required for LW4	4L	5	Operations requesting more suction leading to a less than adequate "draw" form the underground workings	M1
4	MG Borehole – witnessed failures in LW102 for LW103 which caused drainage issues leading to potential for delays in longwall mining operations	4L	6	GSM27 not adequately setup leading to delays in gas drainage and/or increased gas levels in the underground	M1
5	Operations requesting more suction leading to a less than adequate "draw" form the underground workings	4L	15	Capacity - restrictions in pipework (potentially) unknown leading to delays in goaf drainage process/mining delays	M1
6	GSM27 not adequately setup leading to delays in gas drainage and/or increased gas levels in the underground	4L	16	Determination of the spacings after initial longwall advancement - not formalised leading to delays in mining due to poor goaf drainage performance	M1
15	Capacity - restrictions in pipework (potentially) unknown leading to delays in goaf drainage process/mining delays	4L	17	Surface infrastructure impacted on by the goaf drainage installations and subsidence leading to business loss	M1
16	Determination of the spacings after initial longwall advancement - not formalised leading to delays in mining due to poor goaf drainage performance	4L	18	Power outage at the VPS leading to delays in goaf drainage	M1

HAZARDS/ISSUES RANKED *Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR*					
Line Ref No.	**List A - Hazard/Issue**	**IRR**	**Line Ref No.**	**List B - Hazard/Issue**	**Conseq**
17	Surface infrastructure impacted on by the goaf drainage installations and subsidence leading to business loss	4L	20	Skids not installed correctly leading to delays in goaf drainage/mining operations (utilising existing equipment and system documentation)	M1
18	Power outage at the VPS leading to delays in goaf drainage	4L	30	Interruption of drainage systems or installation of inadequate drainage lines leading to environmental impacts/event	M1
22	3rd Party interaction with Anglo (GCM) infrastructure leading to delays in mining operation (e.g. collision, theft, vandalism)	4L	31	Connection with Water Sources or pipelines leading to environmental breach with uncontrolled “release”	M1
23	Restricted gas flow via LW102 river crossing leading to delays in mining (due to current design limitations of the pipe) &/or breach of operating conditions	4L	32	Damage to mining infrastructure when clearing vegetation leading to delays in operation	M1
24	Restricted gas flow via LW102 river crossing leading to mine gas being free vented resulting in a cost (from NGERS)	4L	22	3rd Party interaction with Anglo (GCM) infrastructure leading to delays in mining operation (e.g. collision, theft, vandalism)	M1
33	Environmental impacts with stockpile eroded due to inclement weather	4L	23	Restricted gas flow via LW102 river crossing leading to delays in mining (due to current design limitations of the pipe) &/or breach of operating conditions	M1
34	Damage to mining infrastructure during stripping of topsoil	4L	24	Restricted gas flow via LW102 river crossing leading to mine gas being free vented resulting in a cost (from NGERS)	M1
35	Delays in operation due to personnel and equipment stranded with inclement weather	4L	34	Damage to mining infrastructure during stripping of topsoil	M1
36	Connection with pressurised gas leading to potential for ignition resulting in delays in operation	4L	35	Delays in operation due to personnel and equipment stranded with inclement weather	M1

HAZARDS/ISSUES RANKED *Taken From Initial Risk Rank IRR and Initial Consequence Rankings in IRR*					
Line Ref No.	**List A - Hazard/Issue**	**IRR**	**Line Ref No.**	**List B - Hazard/Issue**	**Conseq**
37	Environmental Permit not adhered to leading to environmental fines/breaches resulting in delays in Gas Drainage projects for LW102	4L	36	Connection with pressurised gas leading to potential for ignition resulting in delays in operation	M1
38	Rehab plan not considering the increase of the land use, equipment used and overall repair	4L	37	Environmental Permit not adhered to leading to environmental fines/breaches resulting in delays in Gas Drainage projects for LW102	M1
19	Accuracy of the boreholes in terms of location and depth (borehole and casing) leading to potential for delays in longwall production due to exposing the borehole/casing to the longwall operations	3L	38	Rehab plan not considering the increase of the land use, equipment used and overall repair	M1

AngloAmerican

GROSVENOR COAL MINE
RA-LW104 Goaf Drainage

MANAGEMENT APPROVAL

The Authorising Persons Shall Be either:

- The Process Manager for activities and the Statutory Manager; or
- The Site Senior Executive.

Signing below acknowledges that they have reviewed the risk assessment, authorise the additional controls and accept that the residual risk rank (RRR) is at an acceptable level

Name	Position	Signature	Date
GARY MEEHAN	Process Manager	Confidential [redacted]	27.2.2020
WALTER NIELAND	Statutory Manager		27.2.2020
TRUM GRIFFITHS	Site Senior Executive		27/2/2020

☐ INCREASED SPONTANEOUS COMBUSTION RISK DUE TO INCREASED GAS DRAINAGE HAS NOT BEEN ASSESSED IN THIS WRAC.

↳ ADDITIONAL WRAC REQUIRED TO ASSESS & CONTROL SPON COMB RISK.

W. NIELAND Confidential [redacted]

NOTE ACTION IN ELMSCON FOR GAS MONITOR TO COMPLETE BY 31/5/2020 (TASK # 01150023)

Confidential [redacted] 27/2/2020

Generic Energy Hazard	Definition
Biological	Potential for positive or negative impacts resulting from interaction of activities with biological agents. This could be harm by exposure to biological hazards, flora and fauna including insect stings, bites, bacteria and other disease agents, viruses and natural poisons or environmental harm to biodiversity.
Chemical	Potential for harm by chemicals, includes acids, alkalis, organic substance (e.g. gases, fuels, lubes, degreasers, solvents, paints) ozone depleting substances etc.
Climate / Natural Events	Potential for harm by exposure to extreme natural, environmental or climate sources and events (including lightning, high winds flooding).
Dust / Inhalable Particulates	Potential for harm by exposure to fine dry particles of matter in the air. Dusts, mists, vapours and aerosols (Coal dust, silica dust, environmental nuisance/community complaints).
Electrical	Potential for harm to people, equipment/assets or the environment by exposure to electrical sources.
Ergonomics	Potential for exposure to physical actions or forces, including poor design, thus presenting the potential for harm associated with exertion, excessive, unnatural or repetitive movement, poor posture or other undesired physical stress on the human body.
Explosives	Potential for harm by exposure to explosive material (e.g. unexploded detonators, tie down lines etc).
External Threats	Potential for harm resulting from an external event outside of the operations direct control (e.g. legislation., government actions, community lobby groups etc).
Fire	Potential for harm by exposure to a burning mass of material (e.g. building fires, spontaneous combustion).
Gravitational (Objects)	Potential for harm by exposure to falling objects, unexpected movement (ground, slope, structure) due to uncontrolled gravitational forces.
Gravitational (People)	Potential for harm to people caused by their being subject to falling, unexpected movement or in any other way resulting from their being exposed to uncontrolled gravitational forces (including slips, trips, falls).
Land	Potential harm on the naturally occurring environment due to the use or management of land resulting from pollution, clearance or any other degradation.
Lighting	Potential for harm resulting from excessive light or inadequate lighting in the workplace.
Mechanical (Fixed)	Potential for harm by exposure to interaction with sources of fixed mechanical energy (including those powered by electrical, hydraulic, pneumatic, combustion etc).
Mechanical (Mobile)	Potential for harm by exposure to interaction with sources of mobile (self-propelled) mechanical energy (including those powered by electrical, hydraulic, pneumatic, combustion etc).
Magnetic	Potential for harm to people, equipment/assets or the environment by exposure to magnetic sources (including handling metal objects in strong magnetic fields).
Noise	Potential for harm by exposure to sudden or prolonged exposure to excessive noise or community complaints.
Personal / Behaviour	Potential for harm associated with intentional undesired behavioural actions, stresses or stressors.
Pressure / Explosions	Potential for harm by exposure to sudden release of pressure from a specific source (including pressure waves from explosions, pressurised systems, cylinders, springs, chains, flying bits, or community complaints associated with air blast overpressure etc).
Psychological	Potential for harm associated with stressors from situations, conditions or events that could create negative emotional, cognitive or behavioural outcomes.
Radiation	Potential for harm by exposure to radiation waves whether natural or manufactured sources (characterised as either ionising or non-ionising sources).
Social / Cultural	Potential for positive or negative impacts resulting from interaction of business activities with social or cultural expectations (includes social licences to operate).
Thermal	Potential for harm by exposure to or variations in temperature (hot or cold) but excludes anything that is on fire which has a separate category.
Vibration	Potential for harm resulting from prolonged exposures to excessive vibration or blast vibration.
Waste	Potential for harm caused by the inappropriate use of resources, inadequate management or disposal of waste material (including pollution and green house gases).
Water	Potential for harm caused by the inappropriate use of water resources or inappropriate management or disposal of water.
Other	Potential for harm by exposure to other hazards/aspects e.g. friction, bio-chemical.

CONSEQUENCE LEVEL (Consider the maximum reasonable potential consequence of the event)						
Consequence Type (Additional "Impact Types" may exist for an event, identify & rate accordingly)		**1 - Insignificant**	**2 - Minor**	**3 - Moderate**	**4 - High**	**5 - Major**
(S) Harm to People - Safety		First aid case	Medical treatment case	Lost time injury	Permanent disability or single fatality	Numerous permanent disabilities or multiple fatalities
(H) Harm to People - Occupational Health		Exposure to health hazard resulting in temporary discomfort	Exposure to health hazard resulting in symptoms requiring medical intervention and full recovery (no lost time)	Exposure to health hazards/ agents (over the OEL) resulting in reversible impact on health (with lost time) or permanent change with no disability or loss of quality of life	Exposure to health hazards/ agents (significantly over the OEL) resulting in irreversible impact on health with loss of quality of life or single fatality	Exposure to health hazards/ agents (significantly over the OEL) resulting in irreversible impact on health with loss of quality of life of a numerous group/population or multiple fatalities
(E) Environmental Impact		Lasting days or less; limited to small area (metres); receptor of low significance/ sensitivity (industrial area)	Lasting weeks; reduced area (hundreds of metres); no environmentally sensitive species/ habitat)	Lasting months; impact on an extended area (kilometres); area with some environmental sensitivity (scarce/ valuable environment).	Lasting years; impact on sub-basin; environmentally sensitive environment/ receptor (endangered species/ habitats)	Permanent impact; affects a whole basin or region; highly sensitive environment (endangered species, wetlands, protected habitats)
(S) Social / Community Impact		Minor disturbance of culture/ social structures	Some impacts on local population, mostly repairable. Single stakeholder complaint in reporting period	On going social issues. Isolated complaints from community members/ stakeholders	Significant social impacts. Organized community protests threatening continuity of operations	Major widespread social impacts. Community reaction affecting business continuity. “License to operate” under jeopardy
(L&R) Legal & Regulatory		Technical non-compliance. No warning received; no regulatory reporting required	Breach of regulatory requirements; report/involvement of authority. Attracts administrative fine	Minor breach of law; report/investigation by authority. Attracts compensation/ penalties/ enforcement action	Breach of the law; may attract criminal prosecution, penalties/ enforcement action. Individual licence temporarily revoked	Significant breach of the law. Individual or company law suits; permit to operate substantially modified or withdrawn
(M) Material Losses / Damage / Business Interruption		< 0.01 % of Annual Revenue / Total Assets	0.01 - 0.1 % of Annual Revenue / Total Assets	0.1 - 1.0 % of Annual Revenue / Total Assets	1 - 5 % of Annual Revenue / Total Assets	> 5 % of Annual Revenue / Total Assets
(R) Reputation		Minor impact; awareness/ concern from specific individuals	Limited impact; concern/ complaints from certain groups/ organizations (e.g. NGOs) period	Local impact; public concern/ adverse publicity localised within neighbouring communities	Suspected reputational damage; local/ regional public concern and reactions	Noticeable reputational damage; national/ international public attention and repercussions
LIKELIHOOD Considering the presence and magnitude of the hazard and the exposure to that hazard (number of people and frequency of the tasks exposing those people), as also the status of existing controls						
5 - Almost Certain	The unwanted event is almost certain to happen within the LOM (Life of Mine). In the case of repetitive/frequent tasks the unwanted event has or will occur in order of one or more times per year. In terms of major events, as also in the case of long term health, environmental or social impacts, it may happen only once in the LOM.	**11 (Medium)**	**16 (Significant)**	**20 (Significant)**	**23 (High)**	**25 (High)**
4 - Likely	There is a high probability that the unwanted event will occur within the LOM. In the case of repetitive/frequent tasks the unwanted event has occurred or is likely to occur in order of less than once per year. In terms of major events, as also in the case of long term health, environmental or social impacts, it might happen once in the LOM.	**7 (Medium)**	**12 (Medium)**	**17 (Significant)**	**21 (High)**	**24 (High)**
3 - Possible	It is possible that the unwanted event can occur within the LOM. In the case of repetitive/frequent tasks, the unwanted event has occurred or is likely to occur in order of once every 5-10 years. In terms of major events, as also in the case of long term health, environmental or social impacts, there is a low probability for the event to happen in the LOM.	**4 (Low)**	**8 (Medium)**	**13 (Significant)**	**18 (Significant)**	**22 (High)**
2 - Unlikely	There is a low probability for the unwanted event to occur within the LOM. In the case of repetitive/frequent tasks, the unwanted event has occurred some time or is likely to occur not more than once every 10-20 years. In terms of major events, as also in the case of long term health, environmental or social impacts, there is a low probability for the event to happen in the LOM.	**2 (Low)**	**5 (Low)**	**9 (Medium)**	**14 (Significant)**	**19 (Significant)**
1 - Rare	There is a very low probability for the unwanted event to occur within the LOM. In the case of repetitive/frequent tasks there are no records of the event occurring or it is highly unlikely that it will occur within the next 20 years. In terms of major events, as also the case of long term health, environmental or social impacts, there is a very low probability for the event to ever happen.	**1 (Low)**	**3 (Low)**	**6 (Medium)**	**10 (Medium)**	**15 (Significant)**

Risk Rating	Risk Level	Guidelines for Risk Matrix
21 to 25	High	A high risk exists that management’s objectives may not be achieved. Appropriate mitigation strategy to be devised immediately
13 to 20	Significant	A significant risk exists that management’s objectives may not be achieved. Appropriate mitigation strategy to be devised as soon as possible
6 to 12	Medium	A moderate risk exists that management’s objectives may not be achieved. Appropriate mitigation strategy to be devised as part of the normal management process.
1 to5	Low	A low risk exists that management’s objectives may not be achieved. Monitor risk, no further mitigation required.

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
LW4 Specific Items												
1	LW4 Specific Items - Planning	Increased gas levels in the underground operations	Labour and resources less than adequate leading to delays in operation (longwall and gas levels) *NB: Changes to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network*	• Current workforce and resources in place covered LW1-2-3 with less infrastructure and boreholes • Known proposed Goaf drainage plan (still being revised) • Known costs and resources from LW1-2-3 • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • Tasks completed by Seamgas ○ GRO-5701-FRM-Seamgas Daily Reads ○ GRO-8529-FRM-Seamgas Goaf Daily Reads ○ GRO-7776-TARP-Seamgas Callout Alarms ○ GRO-7329-SWI-Seamgas Callouts ○ GRO-7436-SWI-Operation of Seamgas Blower Skid ○ GRO-8335-SWI-Gasco Goaf Skid Installation and Commissioning ○ GRO-8317-SWI-Goaf Skid Daily Inspections ○ GRO-7184-FRM - Venturi Intersection Skid Commissioning Background • New skids designed for quicker changeover being commissioned • New Draeger® systems being implemented to assist with changeout • Changes/upgrades to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network • A major absorption of Arrow infrastructure will occur for LW104 more than previous panels • Refer to Annex Pages 1 & 2 for more details on the strategy and equipment	M2	4	12M	Additional labour to be sourced to assist with LW4 seamgas operations – to be assessed in terms of “numbers” Additional maintenance documents to be developed for new equipment/boreholes Need to arrange for risk management and introduction to site of the new skids Need to source a critical spares list for the new equipment and check what is required	M2	2	5L	Yes

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					C	L	R		C	L	R	
2	LW4 Specific Items - Planning	Increased gas levels in the underground operations	Delays due to limited “loader” units on site leading to delays in mining/Seamgas operation *NB: Changes to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network*	• 1 loader currently on site for Seamgas use • Hire units are available • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • GRO-750-TARP-General Body Contaminant Background • Current GCM loader has had some reliability issues • Additional unit is on hire • New skids designed for quicker changeover being commissioned • New Draeger® systems being implemented to assist with changeout • Changes/upgrades to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network	M1	3	4L	Require additional “loader” or similar to assist (only 1 unit on site for Seamgas)	M1	2	2L	Yes
3	LW4 Specific Items - Planning	Delays to the Seamgas infrastructure installation	Environmental offsets application, permits – delays due to increased “space” required for LW4 *NB: if additional clearings are required then there is limited or no offsets available*	• GRO-8017-FRM-Biodiversity Offsets Stage Approval Form- Biodiversity Offset Application has been pursued • GRO-2561-PLAN-Soil and Vegetation Management Plan • Proposed Goaf Drainage plan (see Annex Pages 1 & 2) • GRO-300-HMP-Disturbance, Penetration, Excavation and Rehabilitation	M1	3	4L	No further actions	M1	3	4L	Yes
4	LW4 Specific Items - Boreholes	MG Borehole failures leading to reduced gas drainage	MG Borehole – witnessed failures in LW102 for LW103 which caused drainage issues leading to potential for delays in longwall mining operations *NB: team discussed maybe caused by drilling technique*	• 163 boreholes in total for the LW4 panel • 3 x 2500 skids & 1000l/s skid (existing) • VPS network • Underground gas monitoring • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • GRO-750-TARP-General Body Contaminant Background	M1	3	4L	No further actions	M1	3	4L	Yes

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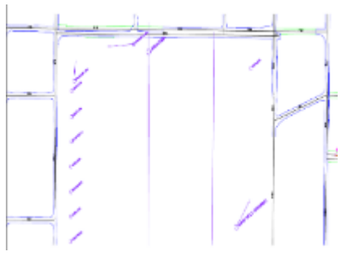
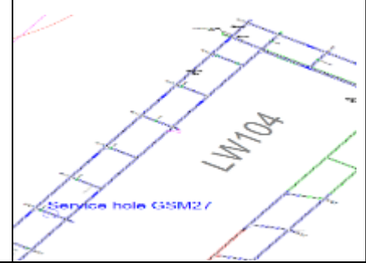
					C	L	R		C	L	R	
				• More MG boreholes have been planned and this could help alleviate the problem								
5	LW4 Specific Items - Planning	Increased gas levels in the underground operations	Operations requesting more suction leading to a less than adequate "draw" form the underground workings *Strategy for LW4 based on learnings from LW3 whereby venturi suction was more successful for the first start-up of the longwall.* 	• Venturi Method available • Underground gas monitoring • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • GRO-750-TARP-General Body Contaminant • Proposed Goaf Drainage plan (see Annex Pages 1 & 2) • Tasks completed by Seamgas ○ GRO-5701-FRM-Seamgas Daily Reads ○ GRO-8529-FRM-Seamgas Goaf Daily Reads ○ GRO-7776-TARP-Seamgas Callout Alarms ○ GRO-7436-SWI-Operation of Seamgas Blower Skid ○ GRO-8335-SWI-Gasco Goaf Skid Installation and Commissioning ○ GRO-8317-SWI-Goaf Skid Daily Inspections ○ GRO-7184-FRM - Venturi Intersection Skid Commissioning	M1	3	4L	Need to circulate a LW4 strategy for the first 100m (include the use of venturi skids and free vent if required) The strategy for the first 100m of a panel needs to be included in every goaf drainage plan (include the use of venturi skids and free vent if required) Need to formalise the goaf/gas drainage strategy for LW104 to be formalized and signed off - include all the technical information and provide to SLT Need to commence development of the LW5 goaf drainage strategy (based off learning from LW1-2-3-4 and include all technical and baseline data)	M1	3	4L	Yes
6	Planning	Increased gas levels in the underground operations	GSM27 not adequately setup leading to delays in gas drainage and/or increased gas levels in the underground *GSM27 – planned for disuse following advancement of the longwall. Noted that at Grasstree this was beneficial for gas drainage if not used for goaf drainage then could lead to less than adequate results* 	• 163 boreholes in total for the LW4 panel • 3 x 2500 skids & 1000l/s skid (existing) • VPS network • Underground gas monitoring • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • GRO-750-TARP-General Body Contaminant Background • More MG boreholes have been planned and this could help alleviate the problem	M1	3	4L	Need to utilize this borehole for additional suction – requires "plumbing" to the Seamgas circuit Need to flush the GSM27 borehole (dip and flush) Need to select the correct skid for GSM27 and install (Crowntech skid) Need to investigate the status of the borehole before cleaning or using Need to formalise the goaf/gas drainage strategy for LW104 to be formalized and signed off - include all the technical information	M1	3	4L	Yes

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								Need to commence development of the LW5 goaf drainage strategy (based off learning from LW1-2-3-4 and include all technical and baseline data)				
Seamgas Design Items												
7	Seamgas Design Items-Gas/Goaf Drainage	Gas liberation into face/tailgate area exceeding operational and legal requirements (CH4% >2.0%)	Gas concentrations prevent operation of face equipment *NB: legislation changes on the 6th Jan 2020 regarding monitoring in the TG*	• Sufficient vent quantity across face • Goaf Management Procedure – MG Goaf Drainage • Tube bundle monitoring/ sensors • Face monitoring - Gate end, Shearer monitors, NERZ/ERZ boundaries • Maingate Wing • Gas guard sensors installed on face to trip power at 2% • Gas content and specific emissions modelled • ERZ Controllers inspections • Gas sampling cores (known gas contents) • Permit to Mine • Longwall Standards (TG roadway and alignment) • GRO-750-TARP – General Body Contaminants Perimeter road sensor • TG Shearer speed sensor in place (section GRO-10221-SOP-Second Workings Second LW103) • Control of adjacent goaf emission via Adjacent Goaf drainage • Mine Production schedule and Plan • Ventilation standards • Tasks completed by Seamgas ○ Gas pre-drainage & Goaf drainage ○ GRO-1430-TARP-Goaf and UIS Gas Drainage Management ○ GRO-5701-FRM-Seamgas Daily Reads ○ GRO-8529-FRM-Seamgas Goaf Daily Reads ○ GRO-7776-TARP-Seamgas Callout Alarms ○ GRO-7329-SWI-Seamgas Callouts ○ GRO-7436-SWI-Operation of Seamgas Blower Skid ○ GRO-8335-SWI-Gasco Goaf Skid Installation and Commissioning ○ GRO-8317-SWI-Goaf Skid Daily Inspections	M3	3	13 S	VPS upgrade including 6th vac pumps to be installed and commissioned Additional Gas Drainage skid Blower skids to 7500L/s capacity to be ordered, installed & commissioned	M3	2	9M	Yes

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					C	L	R		C	L	R	
				○ GRO-7184-FRM - Venturi Intersection Skid Commissioning								
8	Seamgas Design Items-Gas/Goaf Drainage	Mine Gas	Gas drainage capacity resulting in a potential for elevated gas make (above expected emissions) leading to delays in mining	• Sufficient vent quantity across face • Goaf Management Procedure – MG Goaf Drainage • Tube bundle monitoring/ sensors • Face monitoring - Gate end, Shearer monitors, NERZ/ERZ boundaries • Maingate Wing • Gas guard sensors installed on face to trip power at 2% • Gas content and specific emissions modelled • ERZ Controllers inspections • Gas sampling cores (known gas contents) • Longwall Standards (TG roadway and alignment) • GRO-750-TARP – General Body Contaminants Perimeter road sensor • TG Shearer speed sensor in place (section GRO-10221-SOP-Second Workings Second LW103) • Control of adjacent goaf emission via Adjacent Goaf drainage • Mine Production schedule and Plan • Ventilation standards • MG Verticals from 150m to 300m depending on the requirements/location • laterals in place to capturing P seam gas prior to release into Underground workings • Additional drilling rigs to drill infill holes – already actioned • Changes/upgrades to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network • Refer to Annex Page 1 & 2 for the LW4 • Tasks completed by Seamgas ○ Gas pre-drainage & Goaf drainage ○ GRO-1430-TARP-Goaf and UIS Gas Drainage Management ○ GRO-5701-FRM-Seamgas Daily Reads ○ GRO-8529-FRM-Seamgas Goaf Daily Reads ○ GRO-7776-TARP-Seamgas Callout Alarms ○ GRO-7329-SWI-Seamgas Callouts ○ GRO-7436-SWI-Operation of Seamgas Blower Skid ○ GRO-8335-SWI-Gasco Goaf Skid Installation and Commissioning ○ GRO-8317-SWI-Goaf Skid Daily Inspections	M3	2	9M	No further actions	M3	2	9M	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
				○ GRO-7184-FRM - Venturi Intersection Skid Commissioning								
9	Seamgas Design Items-Gas/Goaf Drainage	Electrical	Conductivity of the borehole into active underground workings/goaf leading to potential for ignition	• GRO-1432-TARP-Lightning • Site Lightning Risk Assessment has been completed 6/11/2014 • Site Lightning Study • Boreholes to be maintained for our seal up management plan and for adjacent goaf drainage • Goaf borehole installation standard (includes earthing arrangement) • Commissioning sheet for the Goaf borehole installation • Maintenance and inspections for the borehole	M3	2	9M	No further actions	M3	2	9M	Yes
10	Seamgas Design Items-Gas/Goaf Drainage	Compliance	Borehole locator not being input into borehole database leading to statutory compliance issue for the mine	• Permit to Drill in place and actively used • GRO-7332-SWI-Drilling of Goaf Drainage Boreholes • Mine Survey plan with signoff on permit • Mine planning with signoff on permit • Acquire used to map all bore holes drilled • Complete update to the longwall goaf borehole plan for Grosvenor (indicates the borehole locations, longwall position and other relevant data)	M2	2	5L	No further actions	M2	2	5L	Yes
11	Seamgas Design Items-Gas/Goaf Drainage (VPS)	Mine Gas	Peaks and lows goaf drainage not managed adequately leading to delays in mining (excessive gas make/trips)	• SGE analysis has been completed • Mine Ventilation Monitoring • Mine Planning • Mine Ventilation Plans • Experience with gas/goaf operators from previous panels • Goaf Monitoring (at borehole and Gas plant) • Mine ventilation • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • GRO-5701-FRM-Seamgas Daily Reads • GRO-8529-FRM-Seamgas Goaf Daily Reads • Manual monitoring of the flow/pressure	M2	2	5L	Review the potential to remove the orifice plates from the Goaf Skids to reduce potential fluctuations/ restrictions Review the orifice readings versus ultrasonic readings on the goaf skids	M2	2	5L	Yes

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					C	L	R		C	L	R	
12	Seamgas Design Items-Gas/Goaf Drainage	Caving / subsidence closing off gas drainage boreholes	Loss of gas drainage capability causing production loss	• Borehole flow monitoring • MG Boreholes - more boreholes & decrease in spacing • Standard of fitting the perforated casing to goaf hole above working section • GRO-7481-PLAN-Subsidence Management Plan includes known boreholes • GRO-3602-CHK – Borehole Intersection Notice • Changes/upgrades to LW4 include 163 boreholes, 30 monitoring points, compressors, 3 x 2500 skids, 1000l/s skid (existing), tablets based system/network Background; The LW 3 action to develop Horizontal Goaf Hole contingency plan was not required and will not be completed for LW4	M2	2	5L	No further actions	M2	2	5L	Yes
13	Seamgas Design Items-Gas/Goaf Drainage	Gas liberation from floor "blowers"	Gas concentrations prevent operation of face equipment	• Goaf drainage plan • Tube bundle monitoring/ sensors • Sensors on shearer stops cutters at 1.25% • Sensors installed on face (except cutters) trip power at 2.0% • ERZ Controllers inspections • Longwall Operational Standards • Pre-drainage of panel inc. Arrow drainage • GRO-750-TARP-General Body Contaminant • Ventilation standards • Operational controls to be implemented Background • Investigation of under cross block drilling to relief zones of floor blowers (being completed for LW5 and was completed with LW4)	M2	2	5L	No further actions	M2	2	5L	Yes

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					C	L	R		C	L	R	
14	Seamgas Design Items-Gas/Goaf Drainage	Loss of vacuum to goaf plant (VPS)	Gas concentrations prevent operation of face equipment	• Refer to Annex Pages 1 & 2 for more details on the strategy and equipment • Venturi ejector operation capabilities at bore holes using mobile compressors • GRO-1430-TARP-Goaf and UIS Gas Drainage Management • 24/7 Seam Gas Coverage (Phone linked to citect alarms) • CRO monitoring gas plant Background; • Power outage occurs then the 7500L system will continue to operate • 10000L tanks for each unit of fuel if full	M2	2	5L	No further actions	M2	2	5L	Yes
15	Seamgas Design Items-Gas/Goaf Drainage	Mine Gas	Capacity - restrictions in pipework (potentially) unknown leading to delays in goaf drainage process/mining delays	• Refer to Annex Pages 1 & 2 for more details on the strategy and equipment • Gas plant designed to At -37kPa 9,000L/s is the plant design, with 5 pumps operating (6th has been planned for 2020) ○ Functional specification has been developed and lists operational maxs/mins ○ Gas Plant operational with all Vac pumps operating at 100% (93% speed) • CITECT monitoring at the Gas VPS (pressure, composition and flow) • Gas Plant has been fully tested at full capacity and has a known 9,000l/s capability. • GRO-1430-TARP-Goaf and UIS Gas Drainage Management	M1	3	4L	No further actions	M1	3	4L	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
16	Seamgas Design Items-Gas/Goaf Drainage	Mine Gas	Determination of the spacings after initial longwall advancement - not formalised leading to delays in mining due to poor goaf drainage performance	• 50m hole spacings on the TG. • P Seam Lateral well on the MG to cover 1600m of chainage placed along the MG side • MG vertical drilled for infill around lateral • In fill wells used in high gas areas • Goaf Lateral drainage to provide an increased area to drain from • Gas plant designed to At -37kPa 9,000L/s is the plant design, with 5 pumps operating (6th has been planned for 2020) ○ Functional specification has been developed and lists operational maxs/mins ○ Gas Plant operational with all Vac pumps operating at 100% (93% speed) • CITECT monitoring at the Gas VPS (pressure, composition and flow) • Gas Plant has been fully tested at full capacity and has a known 9,000l/s capability. • GRO-1430-TARP-Goaf and UIS Gas Drainage Management	M1	3	4L	Review LW104 start up data versus the design success (for LW5 planning)	M1	3	4L	Yes
17	Seamgas Design Items-Gas/Goaf Drainage	Boreholes, fencing, pipelines	Surface infrastructure impacted on by the goaf drainage installations and subsidence leading to business loss *Ranked on damage to the spine*	• Subsidence Management Plan • GRO-7731-EVP-Subsidence Rehabilitation Procedure • Mine Survey Plan • Site Surface Audit (Powerlines) • JIMP with Arrow • Workorder in place each month to check upcoming 500m of retreat to ensure all subsidence management is completed Background • Up to 3m subsidence witnessed on site • Venturi system can be used as redundancy	M1	3	4L	Develop strategy and mitigation for the subsidence impacts on the spine 	M1	3	4L	Yes

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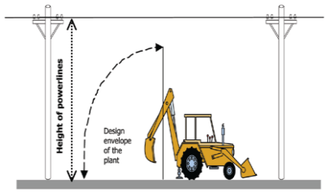
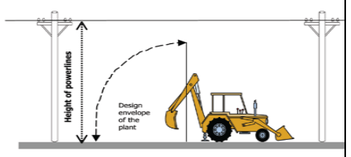
					C	L	R		C	L	R	
18	Seamgas Design Items-Gas/Goaf Drainage (VPS)	Electrical	Power outage at the VPS leading to delays in goaf drainage	• GRO-7710-SWI-Surface Power Restoration • GRO-9962-SWI-Gas Plant VPS Restart Procedure • Power line inspection workorder • Venturis on all goaf skids • GRO-1430-TARP-Goaf and UIS Gas Drainage Management	M1	3	4L	No further actions	M1	3	4L	Yes
19	Seamgas Design Items-Gas/Goaf Drainage	Borehole casing & longwall shearer	Accuracy of the boreholes in terms of location and depth (borehole and casing) leading to potential for delays in longwall production due to exposing the borehole/casing to the longwall operations	• Permit to mine • Mine Planning signed off on permit • Mine Survey signed off on permit • All boreholes are logged for depth • Drill Plans • Permit to drill • Hole completion report provided by Drilling Contractor for steered holes	M2	1	3L	No further actions	M2	1	3L	Yes
20	Seamgas Design Items-Gas/Goaf Drainage (borehole/skids)	Mine Gas Oxygen Ingress	Skids not installed correctly leading to delays in goaf drainage/mining operations (utilising existing equipment and system documentation)	• Existing SWI's for borehole installations and Goaf Skid commissioning • Experienced gas drainage personnel working on drainage skids at Grosvenor • Experienced operators with gas/goaf management • Goaf Monitoring (at borehole and Gas plant) • Purchase additional Goaf Monitoring Skids	M1	2	2L	No further actions	M1	2	2L	
Seamgas Core Items												

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR) C	L	R	ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR) C	L	R	Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
25	Seamgas Core Items - Clearing Vegetation	Electrical Energy	Connection with powerlines leading to electrical shock and/or damage to equipment during vegetation removal *An operator's competency, and the level of information, instruction, training and/or supervision they require, should be reviewed regularly to ensure the safety of workers and others in the workplace*. *NB: Personnel to check lift/swing radius before commencing vegetation operation (loaders, cranes, trucks or any other equipment in the area) – this has been included in PTW*  	• Inducted Personnel • Trained and Competent Personnel*** • GRO-244-SOP-Using Plant Near Electricity • GRO-518-FRM-High Voltage Access Permit • Mine Survey • HMP 300 Disturbance, Excavation, Penetration & Trenching • Mine Plans • Mine Planning • Contractor PTW • GCM Risk Management (SLAM, JSEA) • ACA Control of Energy • Audit of the site in relation to powerlines has been completed • Future action – boom gates will be installed at the front main road entrance • Designated roads developed • HMP working next to Electrical Installations • Surface transport rules - escorting of vehicles • Site vehicle standards • New PTW permit includes access and egress considerations for vehicles and personnel Background documentation; • Ergon Energy: Standard STNW0602 Ver 4 Standard for Vegetation Clearing Profile (annex Page 2)	S4	1	10M	No further actions	S4	1	10M	Yes
26	Seamgas Core Items - Trench and Install gas drainage infrastructure (gas	Electrical Energy	Connection with powerlines leading to electrical shock and/or damage to equipment during equipment mobilisation (non-standard travelling	• Inducted Personnel • GRO-244-SOP-Using Plant Near Electricity • GRO-518-FRM-High Voltage Access Permit • Mine Survey & Plans	S4	1	10M	No further actions	S4	1	10M	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
	pipes, water pipes, drains, fencing, earthing other)		routes for larger vehicles and equipment)	• HMP 300 Disturbance, Excavation, Penetration & Trenching • Mine Planning (travel routes) • GCM Risk Management (SLAM, JSEA) • Contractor PTW • Height indictors (balls and signage) • Aust Std for Powerline Design AS7000:2010 Background: GRO-244-SOP-Using Plant Near Electricity states for Non-standard travelling routes; • This section applies to all vehicles and plant other than a light vehicle. • Wherever possible, crossing below an overhead power line shall be at a designated road crossing. • Where circumstances dictate crossing by a vehicle or plant at a point below an overhead power line other than at a designated crossing point, then the supervisor shall contact a surveyor to determine – from records or measurement - the height of the overhead power line at the crossing point and the travel height of the vehicle or plant to determine what further action (if any) is required. • If the extent of the vehicle or plant in the travelling position are determined to encroach within the 3 metre exclusion zone of the overhead power line, the supervisor shall approach the EEM or delegate to consider reduction of the exclusion zone (refer section 4.4.4) or to raise a High Voltage Access Permit for the crossing activity. • If the extents of the vehicle or plant in the travelling position are determined not to encroach within the 3 metre exclusion zone of the overhead power line, then the supervisor is responsible for determining a safe method of crossing. • A JSEA reflecting the outcome of the determinations above shall be completed prior to the crossing and signed by the EEM or delegate. Use of a Safety Observer (Electrical) may be included as a control measure in the JSEA.							
28	Seamgas Core Items - Trench and Install gas drainage infrastructure (gas	Electrical	Connection with electrical services (powerlines or buried) leading to	• AS2885 requirements • Mine Planning • Mine Survey	S4	1	10M	No further actions	S4	1	10M	

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
	pipes, water pipes, drains, fencing, earthing other)		potential for electrical shock and/or damage to equipment *NB: Personnel to check lift/swing radius before commencing vegetation operation (loaders, cranes, trucks or any other equipment in the area) – this has been included in PTW*  	• Known services and mining infrastructure • PTW Process • Inducted personnel • GRO-244-SOP-Using Plant Near Electricity • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) (2019 version) • GCM Risk Management (SLAM, JSEA) • ACA Isolation of Energy • GRO-9506-PLAN-Joint Interaction Management Plan								
27	Seamgas Core Items - Trench and Install gas drainage infrastructure (gas pipes, water pipes, drains, fencing, earthing other)	Pressurised Gas / Hazardous Zones	Personnel working or installing gas drainage infrastructure leading to potential for ignition of gas due to proximity of hazardous zones (and our live electrical energy); could result in injury to personnel given proximity of the work and hazardous zone *NB: the gas is not explosive on ignition it is flammable* *NB: ranked on safety; team considered legal and compliance risk* *NB: ranked on safety; team considered environmental fire risk*	• GRO-300-HMP-Cutting, Drilling or Excavating Near a Concealed Service • AS2885 requirements • Mine Planning & Survey • Known services and mining infrastructure • 80017630 GRVAuth Seam Gas Operator Level 1 • PTW Process • Personnel gas monitor training (hazardous zones) • Signage in place around Seamgas infrastructure • Gas Monitoring Devices (all personnel) • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA) • ACA Isolation of Energy	S3	2	9M	No further actions	S3	2	9M	Yes
21	Seamgas Core Items - Core Items - Gas/Goaf Drainage	Coal Seam Gas	Arrow infrastructure – subsidence and intersection of arrow infrastructure from longwall mining activities leading to reimbursements (absorbing additional items and equipment)	• JIMP with Arrow with subsidence mapping and data to assist in managing the impacts on pipework is in place • Mine Planning • Goaf System Design	M2	2	5L	Arrow infrastructure to be maintained in line with operating standards (submit schedule for remediation for Dam 6 Node 2)	M2	2	5L	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
				• Monthly safety/technical committee/interaction meeting • Quarterly Arrow/BCO meeting • Joint Interaction Management Plan (JIMP) • Intersection Schedule • Monthly technical meeting between Arrow and Anglo • Monthly liaison meeting in BCO with Arrow • Anglo reimburse Arrow for any damages or intersections of their infrastructure								
29	Seamgas Core Items - Stockpile	Mechanical	Borehole or drilling pads being developed near waterways – potential for environmental breach or damage with inadequate environmental controls	• Inducted personnel • Site Emergency Response (three C's) • Mine Survey • PTW System • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA) Background; • Risk Assessment is completed for any drilling activities within subsided areas and waterways	Env 2	2	5L	No further actions	Env 2	2	5L	
30	Seamgas Core Items - Implement Drainage	Hydro	Interruption of drainage systems or installation of inadequate drainage lines leading to environmental impacts/event	• Mine Planning • Mine Survey • Known services and mining infrastructure • PTW Process • Inducted personnel • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA) • ACA Isolation of Energy (only if required • GCM Environmental Management Plan	M1	3	5L	No further actions	M1	3	5L	Yes
31	Seamgas Core Items - Trench and Install gas drainage infrastructure (gas pipes, water pipes, drains, fencing, earthing other)	Hydro	Connection with Water Sources or pipelines leading to environmental breach with uncontrolled "release"	• GRO-300-HMP-Cutting, Drilling or Excavating Near a Concealed Service • AS2885 requirements • Mine Planning • Mine Survey	M1	3	5L	No further actions	M1	3	5L	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
				• Known services and mining infrastructure • PTW Process • Inducted personnel • GRO – 300 HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA) • ACA Isolation of Energy								
32	Seamgas Core Items - Clearing Vegetation	Mechanical	Damage to mining infrastructure when clearing vegetation leading to delays in operation	• Inducted Personnel • Mine Survey • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation • GRO-5697-FRM-Disturbance, Penetration, Excavation and Rehabilitation Permit • Mine Plans • Mine Planning • Contractor PTW • GCM Risk Management (SLAM, JSEA)	M1	3	5L	No further actions	M1	3	5L	Yes
22	Seamgas Core Items - Core Items - Gas Drainage/Mining	Gas/Mining Delays	3rd Party interaction with Anglo (GCM) infrastructure leading to delays in mining operation (e.g. collision, theft, vandalism)	• Purchase Agreement (pastoral/grazing activities) • Joint Interaction Management Plan (JIMP) • Monthly technical meeting between Arrow and Anglo • Monthly liaison meeting in BCO with Arrow • Boom gates (adjacent to BCO offices) Background; • Site security is being reviewed – entire site process	M1	3	4L	No further actions	M1	3	4L	Yes
23	Seamgas Core Items - Core Items - Gas Drainage/Mining	Gas/Mining Delays	Restricted gas flow via LW102 river crossing leading to delays in mining (due to current design limitations of the pipe) &/or breach of operating conditions	• Experience from LW101/2/3 of inefficient gas flow • Excess gas to be free vented • Projected gas make/volumes known for LW104 • Second river crossing has been installed (for access and maintenance) • Ringmained and installed blowers on the circuit	M1	2	4L	No further actions	M1	2	4L	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
			Background: with reduced gas flow the mine gas will be free vented resulting in a cost (from NGERS). This is the ranking basis									
24	Seamgas Core Items - Core Items - Gas Drainage/Mining	Gas/Mining Delays	Restricted gas flow via LW102 river crossing leading to mine gas being free vented resulting in a cost (from NGERS)	• Experience from LW101/2/3 of inefficient gas flow • Excess gas to be free vented • Projected gas make/volumes • Second river crossing has been installed • Ringmained and installed blowers on the circuit	M1	3	4L	No further actions	M1	3	4L	Yes
33	Seamgas Core Items - Stockpile	Mechanical	Environmental impacts with stockpile eroded due to inclement weather	• Inducted personnel • Site Emergency Response (three C's) • Mine Survey • PTW System • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA)	Env 2	2	4L	No Further Action	Env 2	2	4L	Yes
34	Seamgas Core Items - Stripping Topsoils	Mechanical	Damage to mining infrastructure during stripping of topsoil	• Inducted personnel • Mine Survey • PTW System • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA)	M1	3	4L	No Further Action	M1	3	4L	Yes
35	Seamgas Core Items - Access (inclement weather)	Mechanical	Delays in operation due to personnel and equipment stranded with inclement weather	• Inducted Personnel • Surface Tag Board (muster area) • GRO-1432-TARP-Lightning • GRO-1434-TARP-Flooding • CRO 24/7	M1	3	4L	No Further Action	M1	3	4L	Yes

No.	ISSUE OR STEP IN OPERATION	ENERGY/HAZARD/ISSUE THAT MAY BE PRESENT	DESCRIBE THE RISK	EXISTING CONTROLS	INITIAL RISK RATING (IRR)			ADDITIONAL CONTROLS	RESIDUAL RISK RATING (RRR)			Acceptable *YES = RRR below 13 NO = RRR above 13 and enter into High Risk (>13s) & Non-Consensus Items Table*
					C	L	R		C	L	R	
36	Seamgas Core Items - Trench and Install gas drainage infrastructure (gas pipes, water pipes, drains, fencing, earthing other)	Pressurised Gas	Connection with pressurised gas leading to potential for ignition resulting in delays in operation *NB: the gas is not explosive on ignition it is flammable* *NB: ranked on delays; team considered legal and compliance risk*	• GRO-300-HMP-Cutting, Drilling or Excavating Near a Concealed Service • AS2885 requirements • Mine Planning • Mine Survey • Known services and mining infrastructure • ATW & PTW Process • Inducted personnel • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit) • GCM Risk Management (SLAM, JSEA) • ACA Isolation of Energy Background; • *Action completed from 2016 LW101 - TBT personnel: If gas pipework "struck" then if the personnel are authorised (i.e. Gas Drainage Technicians) they can isolate the upstream gas supply. If not then contact Gas Drainage Immediately and organise for the gas source to be isolated. Maintain a 10 metre no go zone around the area and stand upwind while waiting for assistance*	M1	3	4L	No Further Action	M1	3	4L	Yes
37	Seamgas Core Items – Env Permits	Legal and Compliance	Environmental Permit not adhered to leading to environmental fines/breaches resulting in delays in Gas Drainage projects for LW102	• Inducted Personnel • GCM Environmental Management Plan • GRO – 300- HMP – Disturbance, Penetration, Excavation and Rehabilitation (includes permit)	M1	3	4L	No Further Action	M1	3	4L	Yes
38	Seamgas Core Items - Rehabilitation	Funding and resources for rehab	Rehab plan not considering the increase of the land use, equipment used and overall repair	• 5 year rehab plan in place • Experience from LW1,2,3 • GRO-7731-EVP-Subsidence Rehabilitation Procedure • GRO-7362-FRM-BioCondition and Rehabilitation Monitoring Form	M1	3	4L	Need to review the plan in regard to rehab to check costs involved for LW4 due to the increased "volume" of equipment/items Need to include into the 5 years mine plan the installation and recovery of pipeline network (NB: this drives the rehab process) Cut n cap contractor to be sourced for LW4	M1	1	1L	Yes

Annex Page 1 Seamgas LW4 Strategy and Design Background

Recommendations for the LW104 goaf gas management are based on observations from LW101, LW102 and LW103. A specific objective is to mitigate events of greater than 2.5% CH_4 in the longwall tailgate, further, that the normal operating conditions in the LW return should be less than 2.0% CH_4.

The longwall face goes beneath the Isaac River which prevents drilling of vertical goaf drainage. Additionally, during the initial goaf formation of LW103 tailgate CH_4 levels were higher than planned until the goaf holes came online. Measures proposed for LW104 are intended to address these issues specifically in the first 500m of retreat.

1.1 Isaac River

The Isaac River traverses the longwall from the 11ct in MG104 to 14ct in TG104. This requires additional slant holes to be drilled from areas on surface not effected by the Isaac River. There are 4 slant/ directional wells to be drilled in this section of LW104. With limited space surface room available there will be slant wells drilled from mid panel of LW 104 and goaf effected areas of LW103. All slant wells will be drilled as 17 $^{1/2}$" to production 13 $^{3/8}$" casing depth and completed 12 ^{¼}" drilled hole and cased with 9 $^{5/8}$" perforated casing.

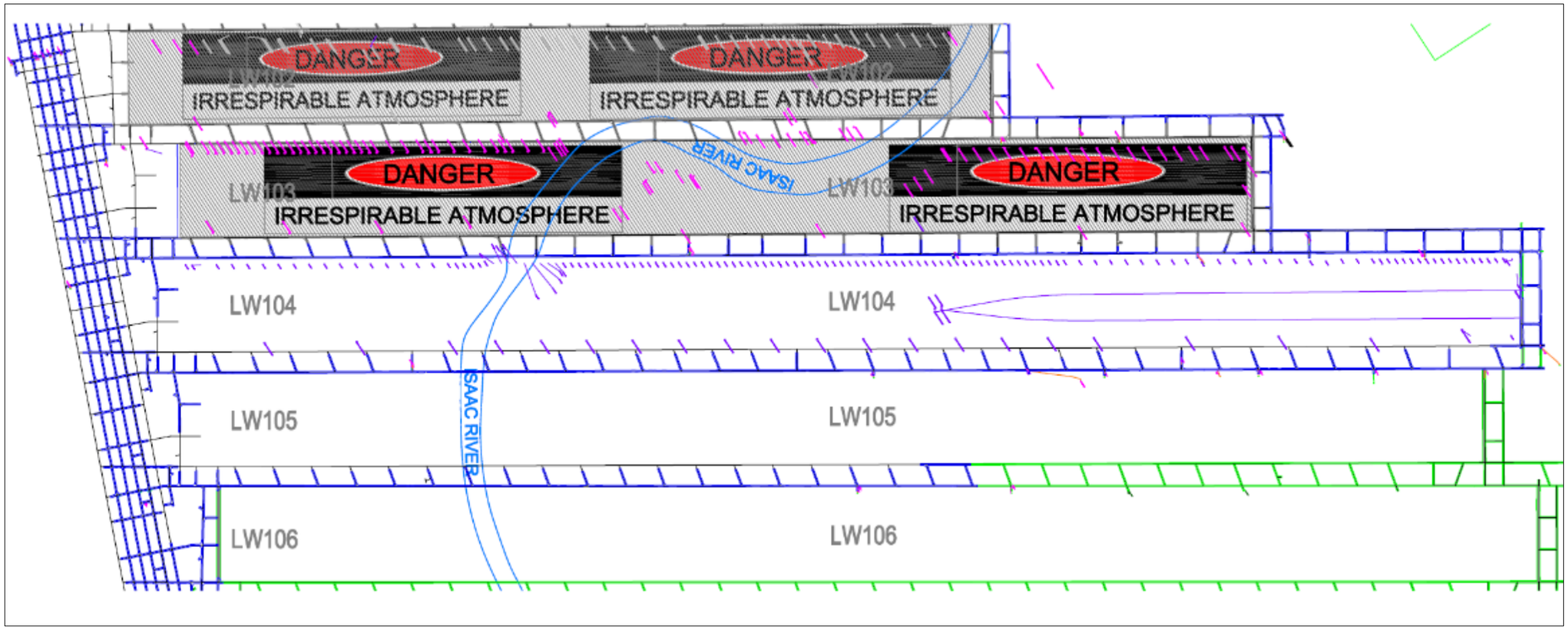


Figure 1 - Proposed goaf hole locations LW104

1.2 Longwall 104 surface features

The long wall face will start in an area without significant surface features, which will not prevent drilling of vertical goaf drainage. Additionally, during the initial goaf formation of LW103 tailgate CH_4 levels were higher than planned until the goaf holes came online.
Measures proposed for LW104 that intended to address these issues specifically in the first 500m of retreat. For the Start-up of LW104 the goaf drainage strategy will consist of 4 x 17.5” vertical goaf holes at 5 to 30m above the GM seam to aid in the early goaf drainage with minimal caving profile and 25m hole spacing for the first 500m retreat.
Initial Caving Conditions
TG gas levels during initial LW103 goaf formation exceeded 2% before the first two goaf wells came on stream. The origin of the early gas was considered from the floor and from localised roof fall/bed separation along the face which did not connect with the vertical goaf holes.

GRO4V001 - 5m below P Seam
GRO4V002A - 10m above GM Seam (connect to P seam lateral)
GRO4L001 - 10m Above GM seam
GRO4L002 - 15m Above GM seam
GRO4V003 - 15m Above GM seam
GRO4V004.5 - 20m Above GM seam

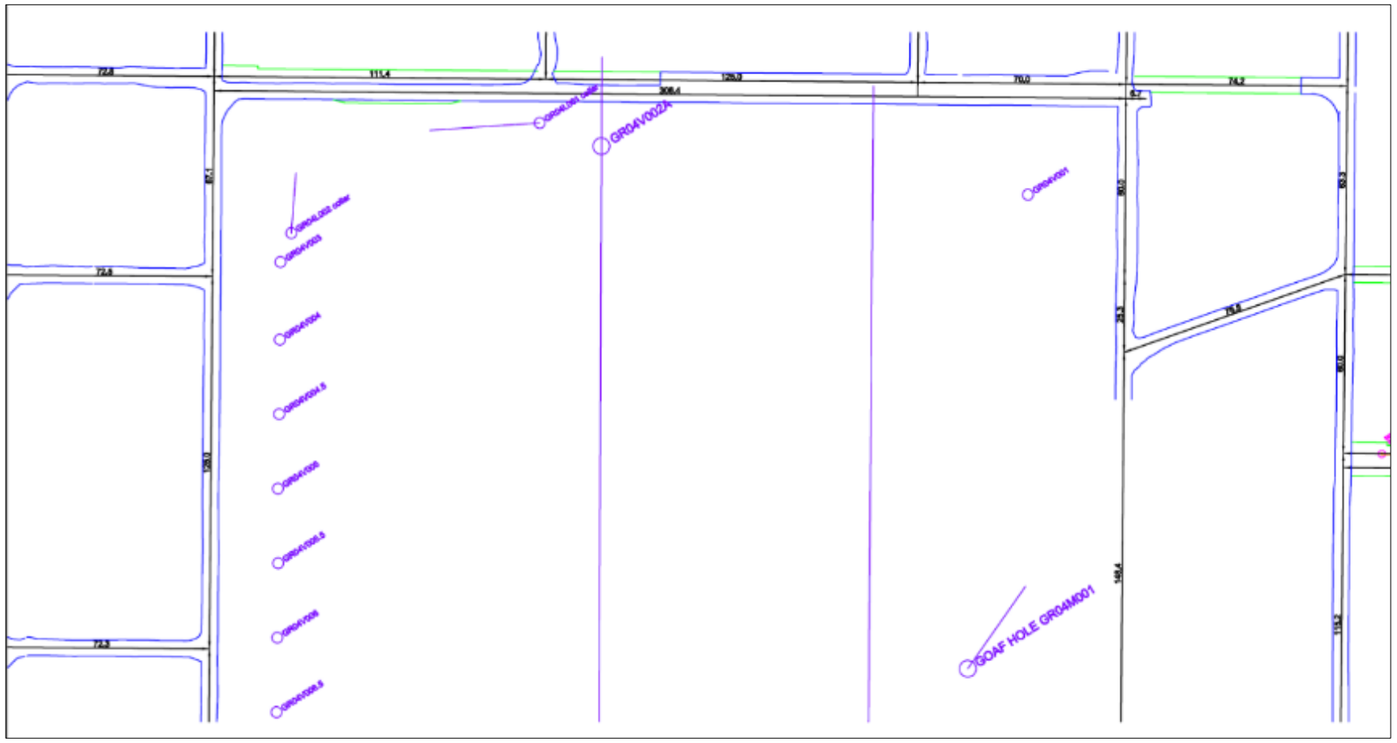


Figure 2 - Proposed surface horizontal goaf holes, TG LW104, central LW104 and MG LW104

1.3 Lateral Wells

The goaf holes were drilled at 8 ½” diameter, reamed to 17 ½” diameter then fitted with slotted 9 5/8” casing to the end of hole. Gas production from the three wells was poor –The 1 holes were drilled at varying elevations above the Goonyella Middle seam with good performance when in active goaf of the LW103.The four LW104 Lateral wells have been designed, to be drilled in the P seam to capture the gas released with the yielding/unloading of the strata below the P seam. This will allow the Post mining gas to be captured prior to the release to the long wall mining area.

Lateral goaf holes are to be attempted for the main gate to contend with the high production of the long wall. These holes will be drilled in the P seam at a nominal length of 1.6km and 12 ¼" drilled. 1 tailgate lateral at 165m off rib line and 1 Maingate lateral at 135m off rib line are attempted to be drilled to mitigate for the increase gas production of the LW104 block.

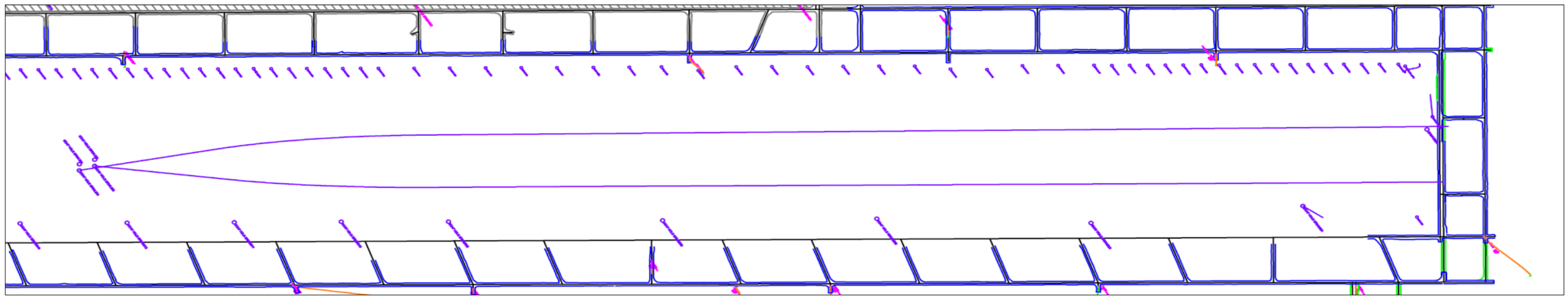


Figure 3 - LW104 goaf holes

1.4 Pre drainage

- Pre-drainage of the GM-Seam has been conducted from a combination of both SIS (owned by Arrow) and infilling of UIS drilling where required to achieve gas content of <4m^3/t for development production and <2m^3/t for Longwall production. Gas content of the GM seam is proven to be below 2m3/t outbye of CH1600 (MG104 17c/t) an no additional gas drainage has been implemented for this region.
- Pre-drainage of the P-Seam over LW104 has been conducted from SIS Boreholes drilled from Arrow. UIS drilling of the P-Seam was attempted from MG104 22c/t that resulting in 837m of drill string being stuck in the P-Seam inbye of MG104 22c/t.
- No pre drainage of the GML seam has been conducted for LW104 and is expected to release gas readily due to the GML reservoir size combined with proximity to the working seam up to approximately CH4000-2000 (MG104 20-36c/t)

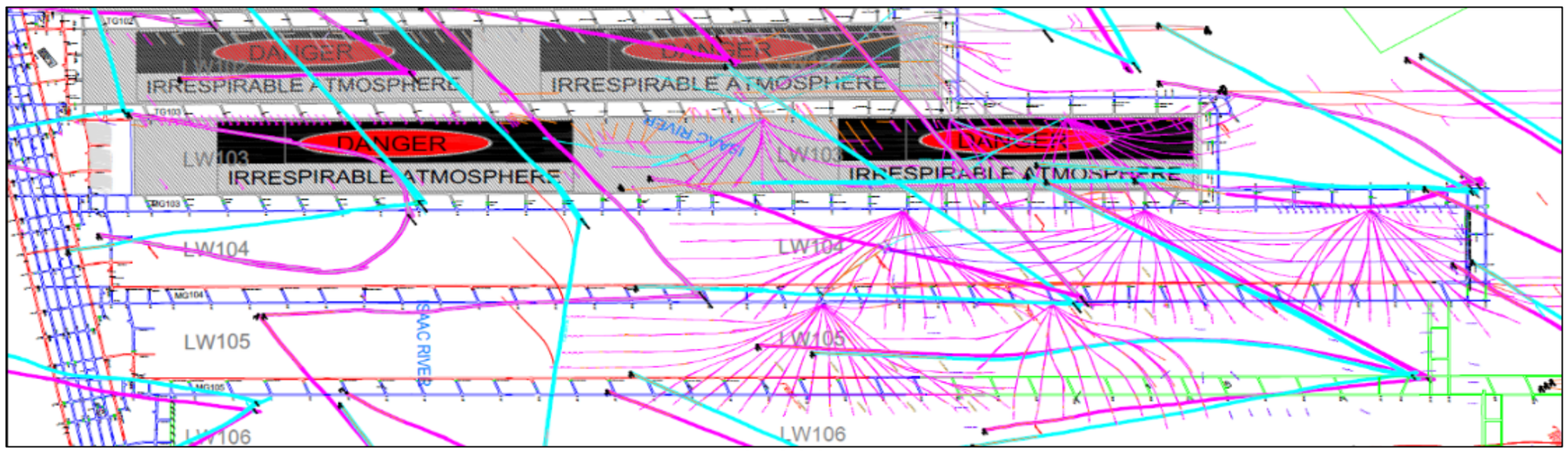


Figure 48 – Existing UIS & SIS Gas Drainage Boreholes

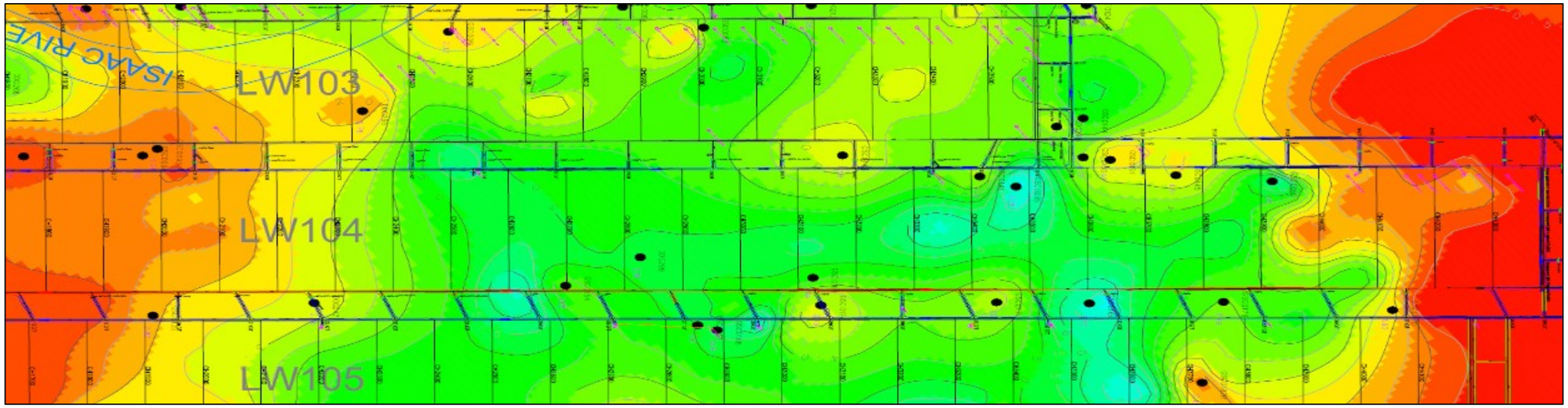


Figure 59 – Estimated GML gas reservoir size (m3 of gas per m2 of area)

Gas content from previous cores taken from 2017 onwards indicates that the P-Seam gas content varies from 4-6m^3/t at the commencement of the longwall block. There will be increased goaf emissions until LW104 meets the install roadway of LW103 as there will be gas desorbing from 3 sides, instead of 2. Diagram below for description:

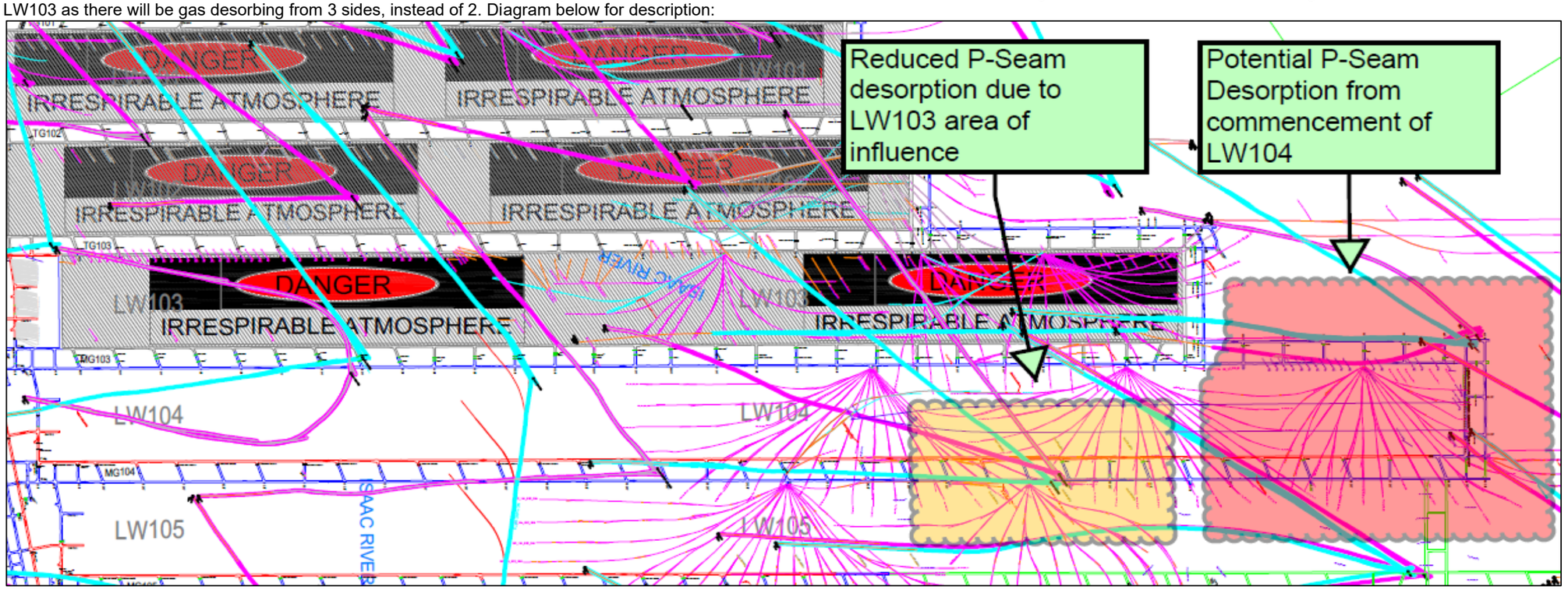
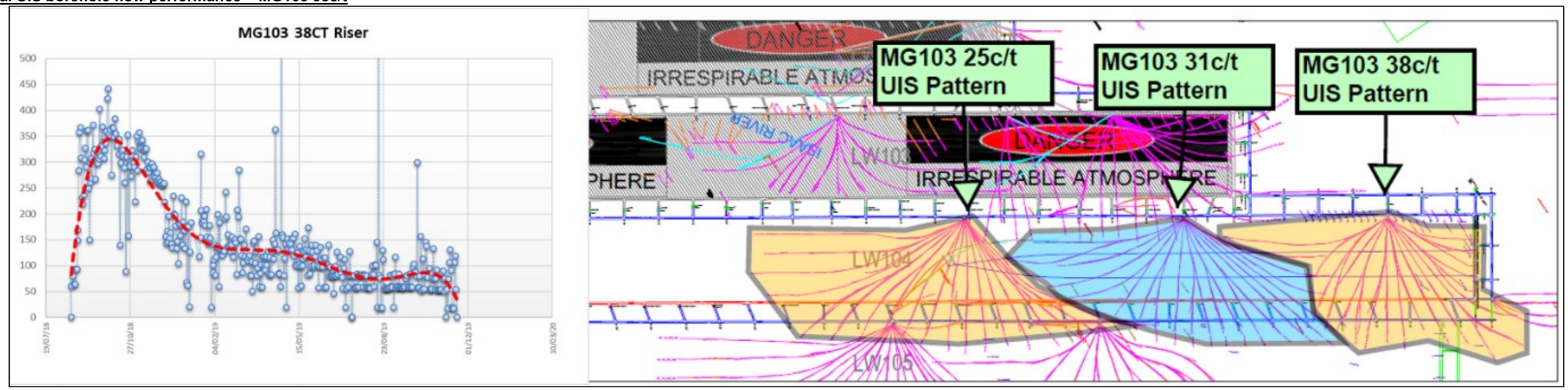
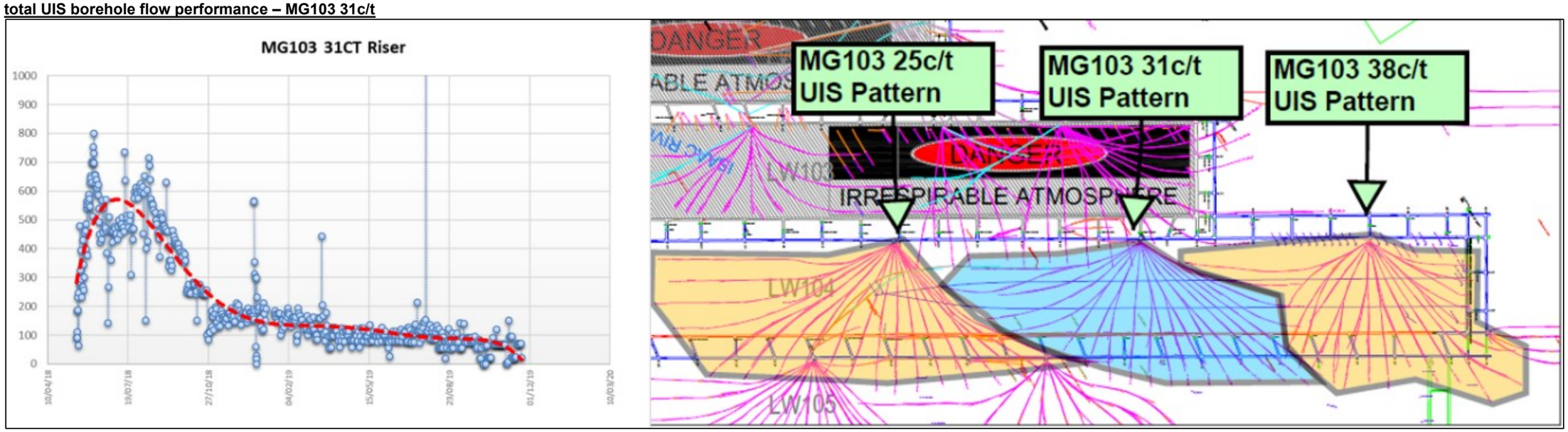


Figure 67 – P-Seam Area of Influence

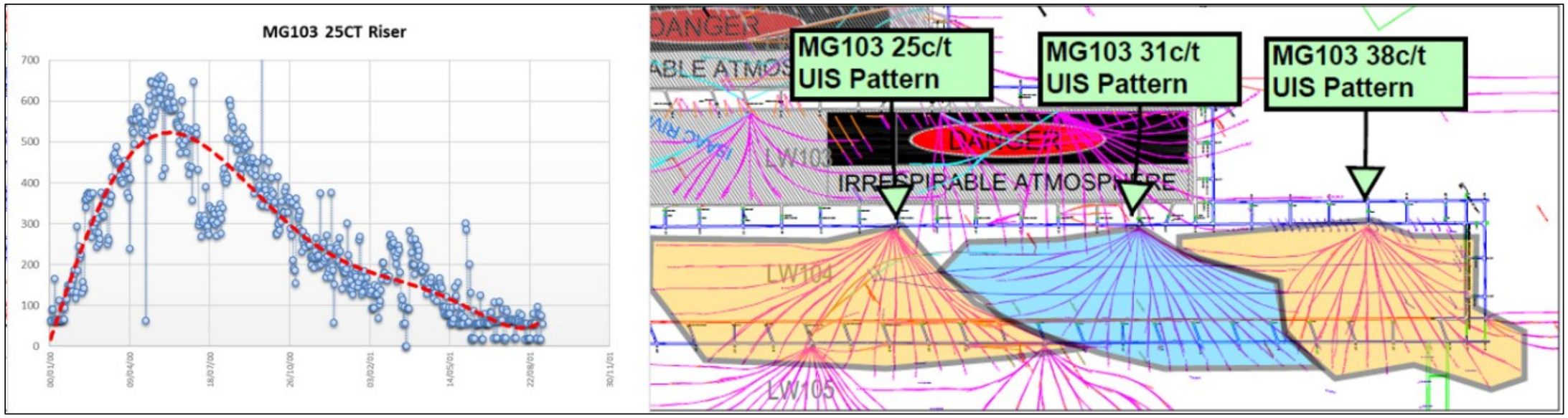
Total UIS borehole flow performance – MG103 38c/t



total UIS borehole flow performance – MG103 31c/t



Total UIS borehole flow performance – MG103 25c/t



1.5 Vertical Goaf Holes

Vertical goaf holes will be drilled on the north and south side of the river on the tailgate side of the longwall where surface conditions allow. Goaf hole spacing of 25-50m should be maintained unless otherwise indicated by flow monitoring results (potential vertical goaf hole interaction with directional goaf hole). Except for the face start line (FSL) hole spacing would be no less than 20- 30 apart, nominally 15-40m from the tailgate rib.
Main gate Verticals are planned at 140m to 350m hole spacing, to mitigate for high gas emission's during high production of the long wall.

The first two vertical holes may be offset from the rib by 25-30m to accommodate reduced bed separation due to cantilever support of the solid. Vertical goaf holes adjacent to LW103 goaf may be reasonably offset 15-35m from the tailgate rib. A main gate goaf hole is possible within 20m of the face start line. This location has worked well in the past for high gas level in the LW mining horizon.

Chainage	TG104 Spacing	TG104 Holes	MG104 Spacing	MG104 Holes	∑ Holes
4500m-3900m	25m	24	300m	2	26
3900m-2900m	50m	20	300m	3	23
2900m-900m	25m	80	150m	13	93
900m-0m	50m	18	300m	3	21
					163

1.6 Surface Infrastructure

The goaf holes will be fitted with real time flow and composition monitoring to manage tailgate gas levels and purity level being removed from Goaf.
A second connection to the goaf drainage plant by an alternative river crossing for LW102 via TG104 goaf pipeline. This will reduce capacity restrictions due to water make at the existing river low point.
At planned production rates where daily tonnage is consistently greater than 30,000 tonnes then increased goaf capture is sought to improve capture efficiency. This may be achieved by systematic maingate goaf drainage holes (trialling directional lateral holes). These holes would cover the longwall reserves >250m cover, nominally 2000m of retreat.

1.7 Gas Capture Reticulation System

Gas reticulation will use the existing 630mm buried HDPE pipeline, modelling indicates a peak capacity of 14000 L/s with the vacuum plant operating at 58 kPa and 3 blower units on the south side of the river. This flow rate is excess of the anticipated peak gas emission from the longwall. If higher gas flows arise due to poor gas composition wellhead venturi ejectors will be used.

1.8 Gas Monitoring

Gas monitoring sensors in the 104 panel include the following:

- Real-time NERZ/ERZ1
- Real-time Atmosphere (oxygen, methane, carbon monoxide, carbon dioxide)
- Real-time Pressure Differential
- Real-time Velocity
- Tube bundle
- Gas Chromatograph analysis of bag samples
- ERZ controller inspections with hand held units

Figure 7 presents typical longwall gas monitoring locations and type.

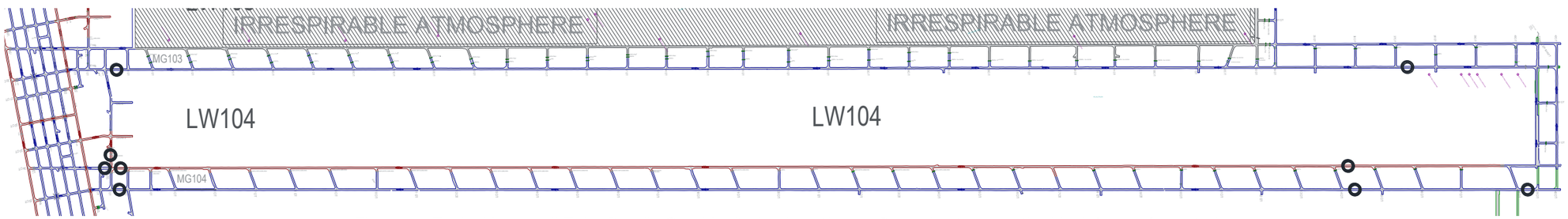


Figure 7 - Typical Longwall Tube Bundle Gas Monitoring Locations – Spread out across the block for goaf monitoring

Annex Page 2 Seamgas LW4 Strategy and Design Background

1.9 Summary

Goaf drainage strategy on LW104 is to maximize drainage volume through use of close spaced (25m) tailgate vertical goaf holes and mid-panel lateral goaf holes. Additionally, maingate goaf holes will be established at 150m centers.

Trialing of tailgate roadway horizon goaf drainage is warranted based on Grasstree experience. It is recommended that the concrete drop hole at MG103 35ct is used for this purpose.

Floor emissions from the GML appear to be caused either by mining induced shearing, bed separation and high-pressure desorption followed by sudden release into the longwall or longwall goaf. Alternatively caused by long term pre-drainage of the GM seam resulting in stress relief and desorption in the GML. Mitigation in both scenarios involves relieving the pressure of the free gas before it can cause a sudden emission. This may be conducted by close spaced UIS drilling in the floor. Optimal orientation (along the panel or across the panel) requires a trial to demonstrate effectiveness.

Increased surface drainage and flaring capacity of ~8500 sL/s will be established to minimize potential emissions costs.

Managing perimeter road pressure remains an option to mitigate gas spikes caused by dynamic events (shearer goaf flushing, roof falls).

1.10 Introduction

The design of LW104 goaf gas management is based on a review of LW103 gas experience, anticipated changes in the LW104 gas reservoir and aspirational peak longwall tonnage. The proposed design is modified from LW103 in three areas:

1. Significantly increased surface capacity to drain and flare goaf gas
2. Increased density of goaf drainage points (holes) along and across the longwall
3. Floor holes to prevent shearer trips associated with the Goonyella Middle Lower seam and floor holes to address potential emissions from deeper floor reservoirs around known structures.

1.11 LW103 specific gas emission

The specific gas emission model (m^3 of CH_4 per tonne of coal produced) for LW103 is derived from daily average goaf hole flow and composition against rolling 7 days tonnes. The model also includes gas measured in the tailgate.

Adjacent goaf drainage along with nitrogen injection, is conducted to reduce the methane composition of the gas in the adjacent goaf behind the seals. This is intended to reduce the impact of barometric fluctuations associated with the adjacent goaf (not the active goaf).

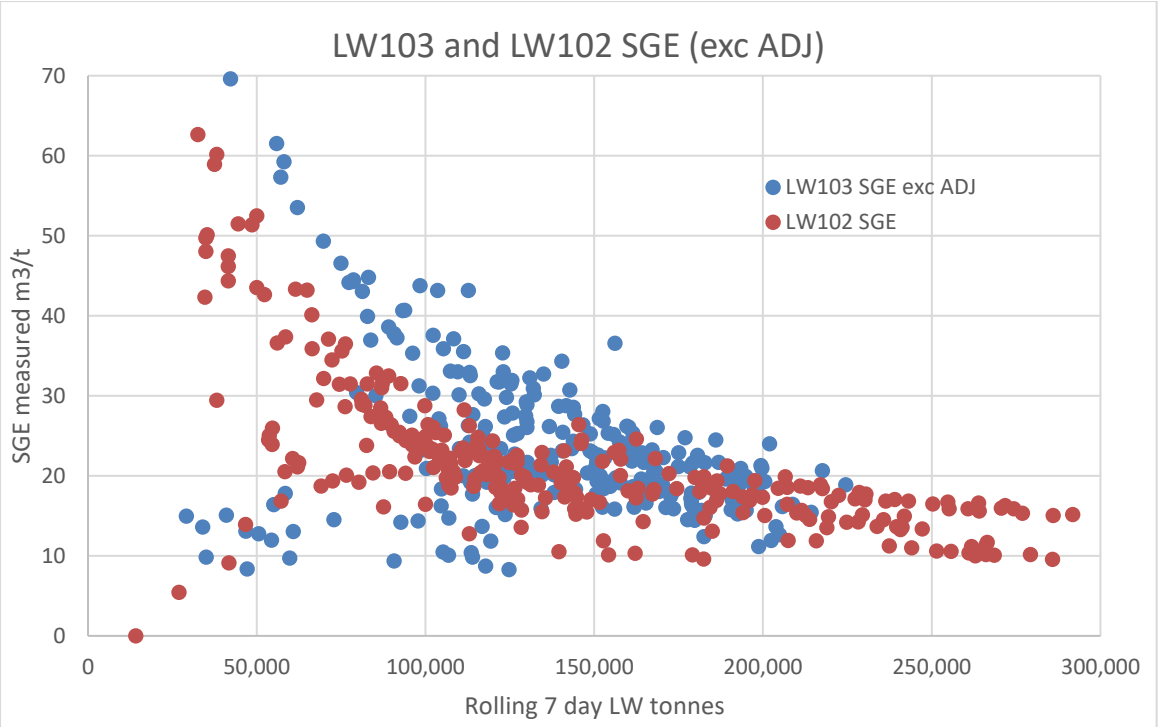


Figure 8. LW102 and LW103 SGE 7 day rolling tonnes as at 31st August 2019[1]

Actual SGE levels for LW103 where typically over 20 m^3/t (as at 31st August). The emissions can also be seen (Figure 1) to be higher than those of LW102 in the production range 100,000 to 150,000 tpw. In LW103 average goaf hole flow is 660 sL/s whereas average MG goaf hole flow is 826 sL/s.

[1] LW103 SGE V2.xlsx

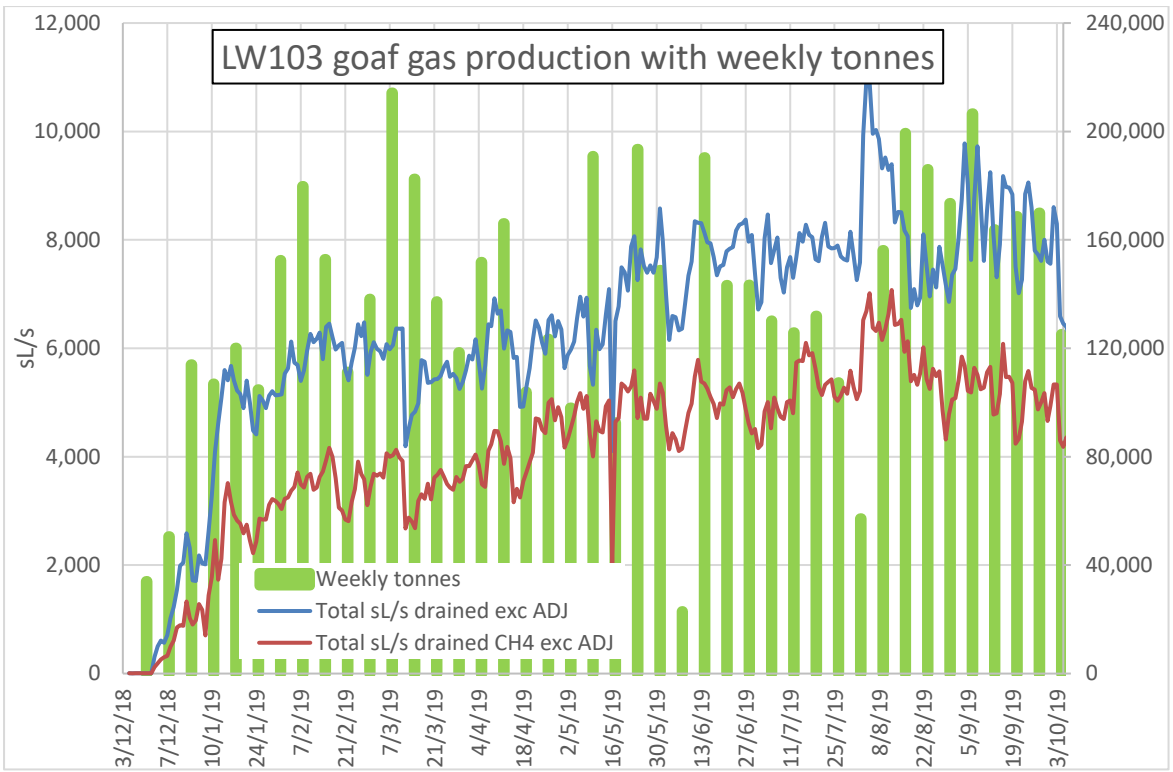


Figure 9. LW103 Goaf gas drained and longwall tonnes.

Figure 9 shows that the total gas drained from the longwall has progressively increased throughout the panel although SGE predictions indicate the panel becomes less gassy as it retreats (reference Figure 10 borehole DDG261).

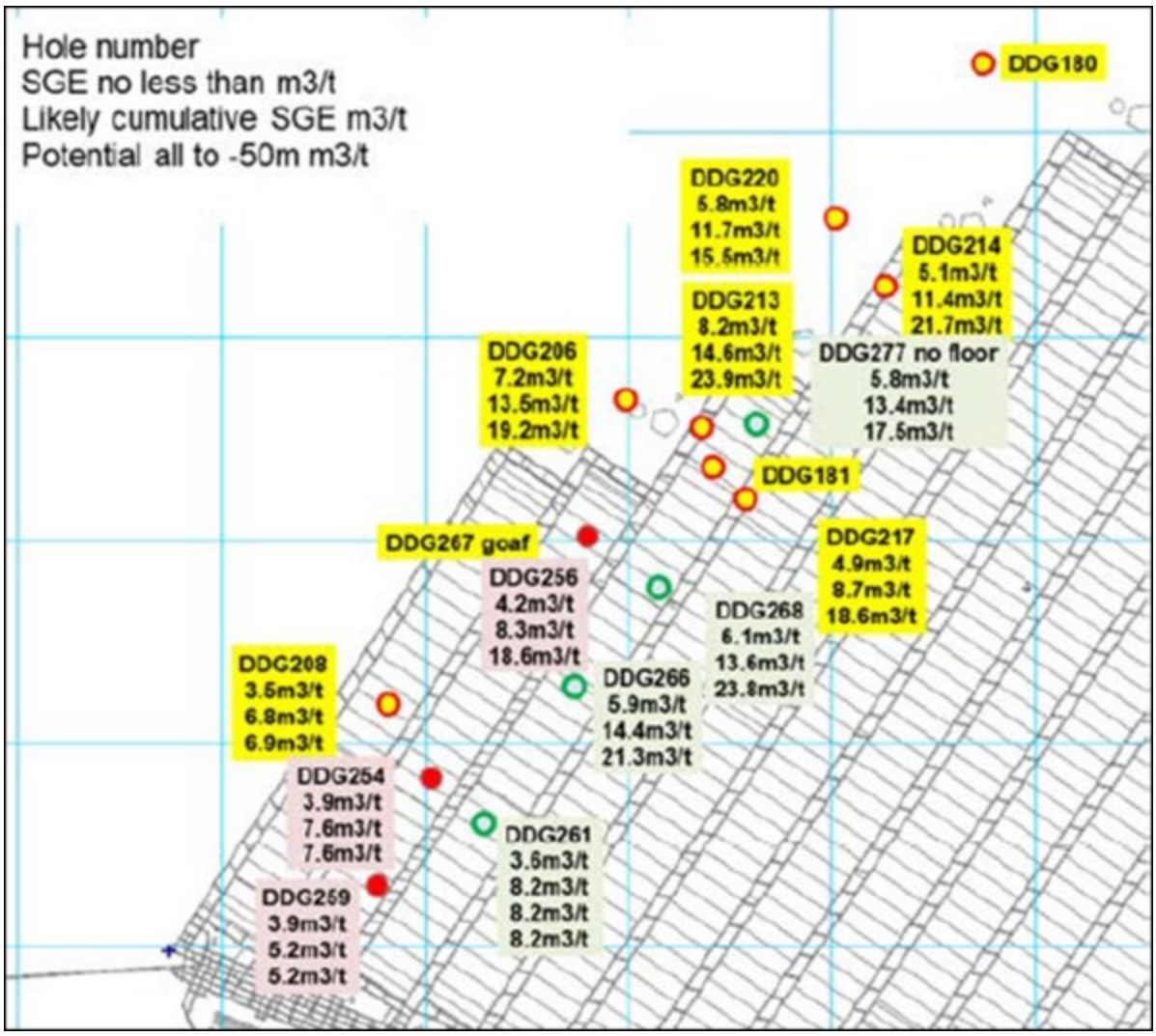


Figure 10. SGE boreholes showing reduced emission rates in the outbye section of the longwall.

1.12 Production constraints

Constraints for drainage volume include:

1. Goaf hole purity requiring well to be shutin
2. Availability of wellhead infrastructure
3. Surface plant capacity and flaring capacity.

Longwall production is constrained where tailgate CH_4 level approaches that which could exceed 2.5% if a typical flushing spike occurred. Several causes of spikes have been observed:

1. Sudden floor emissions on the faceline
2. Sudden floor emissions in the goaf
3. Goaf flushing due to falls, typically at the tailgate end of the longwall.
4. Tailgate flushing caused by the shearer, compounded by barometric pressure changes.

1.13 Sudden floor emissions on the LW103 faceline

Where the GML seam is ~1m from the GM floor sudden emissions have occurred causing both shearer trips at 1.25% CH_4 and shearer stoppages due to an increase in the TG CH_4 to >2%.

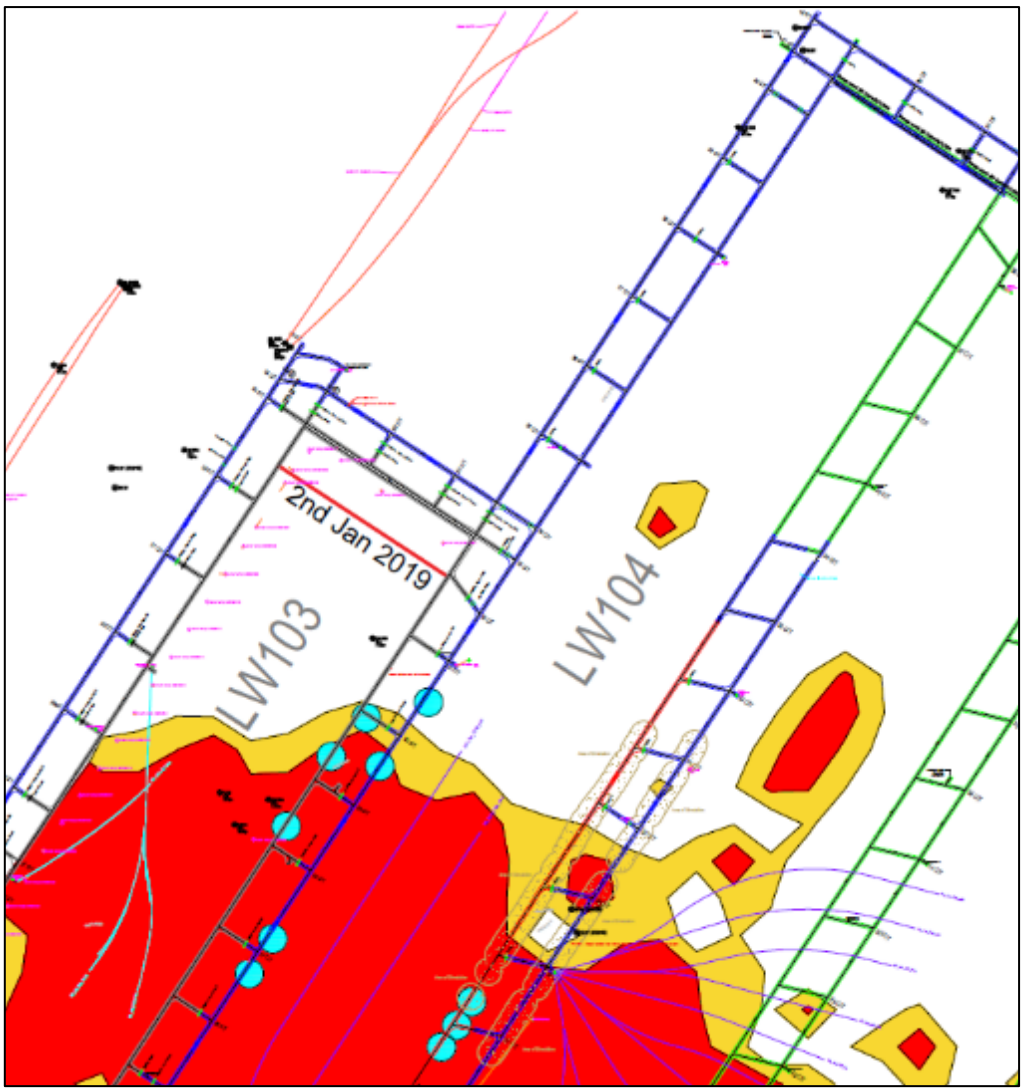


Figure 11. Location of LW103 on 2nd January 2019, also showing anticipated region of development floor emissions.

Figure 11 shows the location of the longwall at the 2nd January when floor emissions were contributing to the LW stoppages. It can be seen the LW emissions occurred north of the region associated with development floor emissions. Prior to LW103, registering of gas spikes at the shearer was not common. The gas originates from the GML seam, which when it is close to the floor of the GM seam, causes sudden emissions of gas into the longwall faceline.

In relation to shearer delays, Figure 12, note the 2% delays in the TG correlate to spikes measured at the shearer (white line) whilst the shearer is cutting to the TG. This must either be floor gas or gas from the cut. The shearer spikes were not enough to trip the shearer (1.25%) however contributed to 2% in the return causing shearer stoppages. It is notable that the shearer spikes occur predominantly whilst the shearer is cutting from MG to TG, although the TG drive CH_4 increases from TG to MG . On the 2nd of January the LW was at 3509mm, active goaf drainage was 2100 sL/s at 35% CH_4.

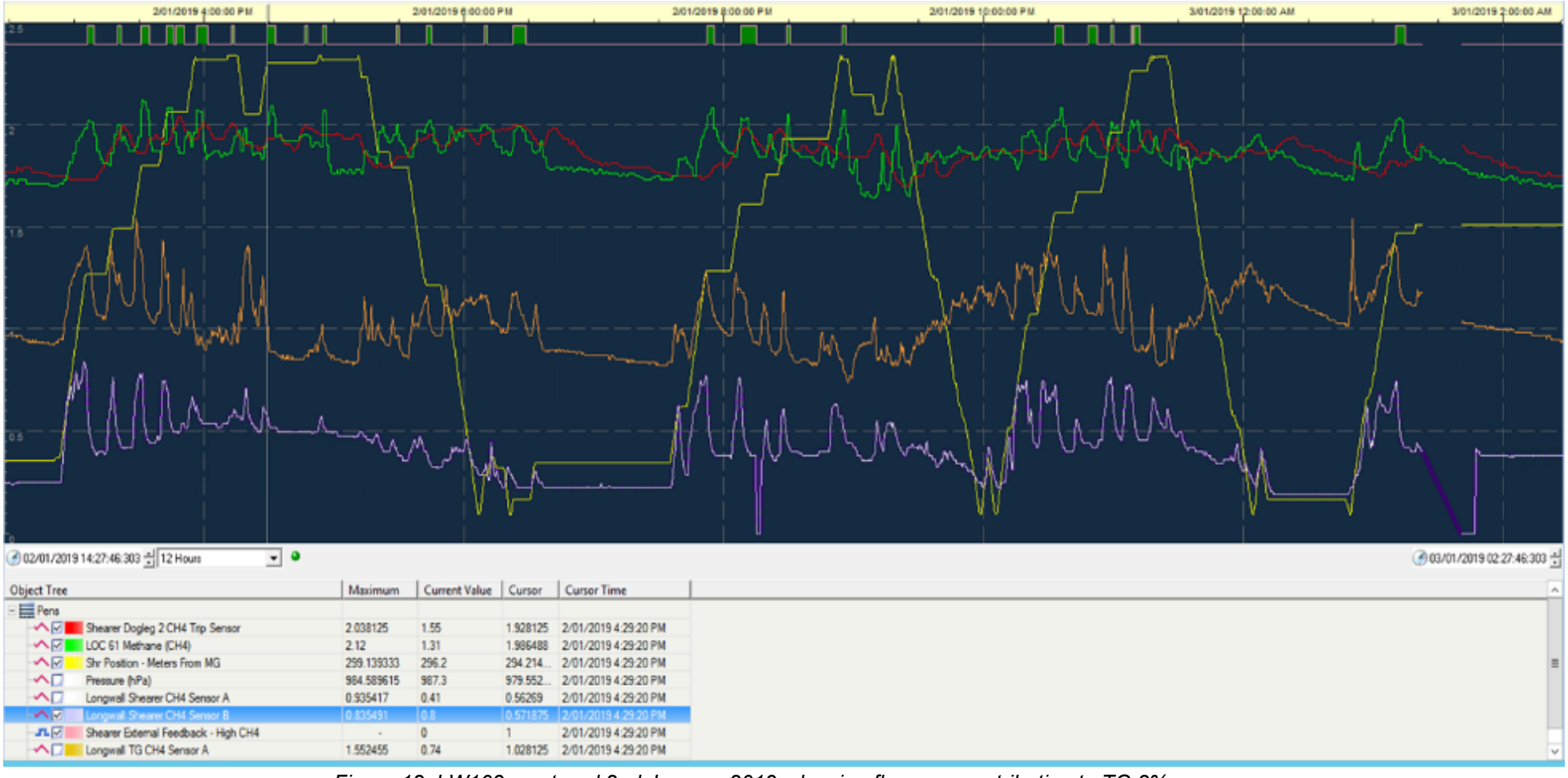


Figure 12. LW103 gas trend 2nd January 2019, showing floor gas contribution to TG 2%

1.14 Sudden floor emission in the goaf, LW103.

On the 11th of July a sudden floor emission occurred on LW103, the event occurred south of the interburden split that defines the emission events encountered in the development headings (Figure 13) and is consistent with gas coming from the floor in the goaf. The longwall was at ~1700m chainage, the gas was reported as coming from behind 55 chock.

In general, the height of the peak relates to the gas content (and thus gas pressure) of the source reservoir, the volume of gas released relates to the size of the source reservoir. The comparatively small amount of gas released suggests the source is the GML rather than the Harrow Creek or Dysart upper seam (Figure 14).

Similar events have occurred in LW102 and LW101.

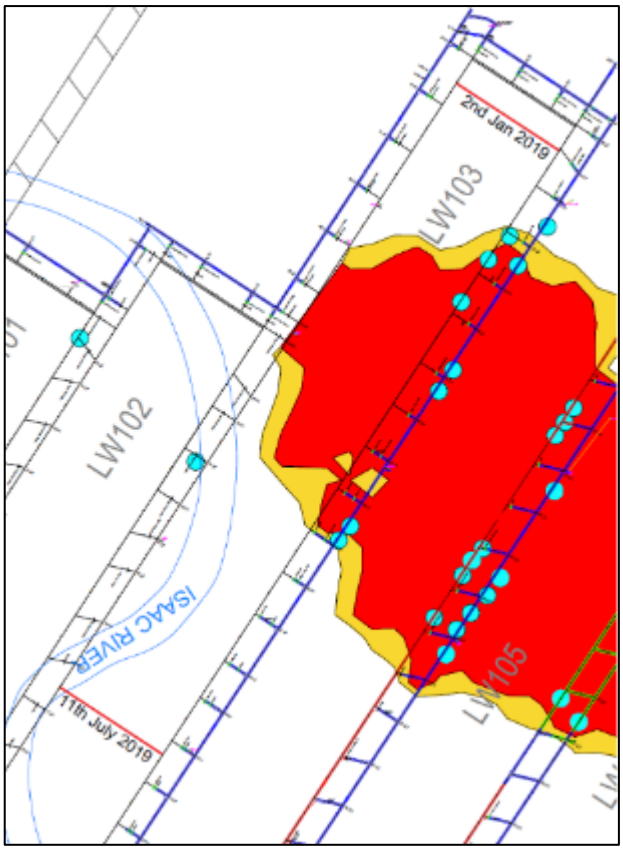


Figure 13 Location of the sudden floor emission on 11th July 2019

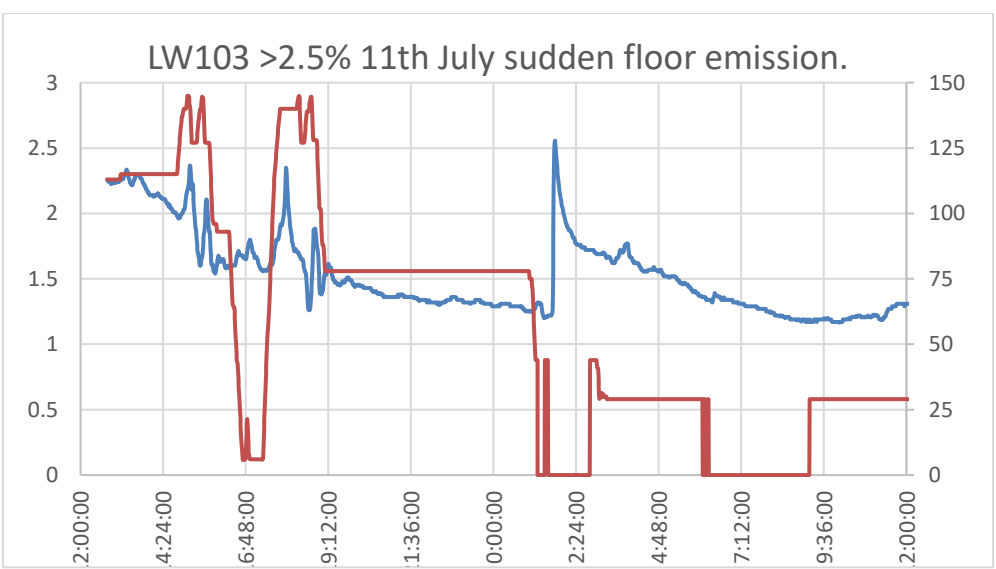


Figure 14. Sudden floor emission whilst the shearer was standing.

In relation to the longwall emissions, the mechanism resulting in the floor emissions is related to:

1. The longwall front abutement causing shearing in the floor seams followed by bed separation and change in pore space. This allowing desorption to occur which, where the interburden is brittle and fractures underneath the longwall face or goaf, subsequently results in sudden emission.

2. Long term pre drainage of the GM seam (by Arrow) resulting in de-stressing of the GML seam and desorption of free gas. The gas however is trapped in the GML due to the very low permeability of the interburden. This hypothesis has been proposed by G and R Williams (Wilbur Systems)[2].

The latter is supported by anecdotal reports from Radco drillers that surges of gas occur whilst drilling in and through the GML seam. Additionally, reports of floor blowers at the MG of LW103 at 637m chainage suggest floor emissions are not limited to regions of thin GM-GML interburden.

1.15 Mitigation of floor emissions arising from the GML seam

UIS drilling in developments in the GML floor seam indicates that it is not readily pre-drainable, however, whilst being drilled holes do release free gas from time to time. It is also clear that floor gas can be generated from mining induced stress. This implies a pressure relief system may be appropriate i.e. drilling UIS holes in the GML or interburden along the face to relieve free gas rather than pre-drain

The relief hole spacing is not known although it is likely to be ~10m. Floor holes for gas relief could be drilled from three directions

1. Across the panel from MG104 (red holes in Figure 15)
2. From face start line outbye (black holes in Figure 15)
3. From an outbye UIS stub inbye (yellow holes in Figure 15)

Options 1 and 3 allow gas captured from mining induced stress to be drained away from the longwall face. Option 2 will relieve free gas encountered while drilling however may allow gas generated by mining induced stress to relieve into the goaf.

Each option requires standpipes to extend underneath the face start line or the maingate conveyor road.

Each option could also be considered with a fracturing program to allow gas to relieve onto the faceline. This

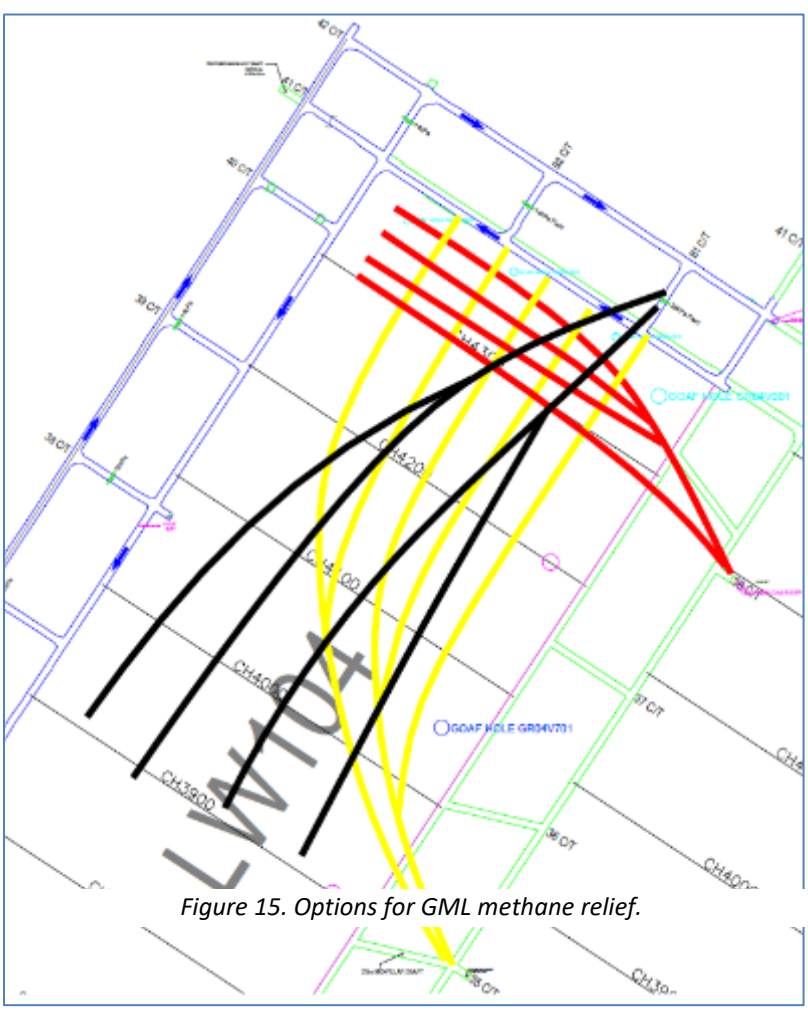


Figure 15. Options for GML methane relief.

[2] G and R Williams, 24th June 2019, "Draft Report Grosvenor Gas Desorption Study_June2019.pdf"

would require an extensive interburden fracturing program, the benefit of which is not yet known in a longwall environment.

1.16 Mitigation of floor emissions arising from the HCL and DY seams

In addition to potential emissions from the GML seam, the lower seams may be the source of longwall gas and sudden emissions. These seams comprise the Harrow Creek (HL) and Dysart Upper (DYU). Gas emissions from these horizons is considered more likely where faulting exists which can become a conduit in the goaf.

In LW104 two fault sets have been mapped through the LW104 panel, these faults may provide conduits for lower seam gas emission into the workings in LW104. A possible cross measure UIS arrangement is shown below (Figure 16). Alternatively access from MG103 38ct stub might be possible.

A section of the floor seams under the GM seam in the inbye portion of LW104 are shown below. The thickness of the seams is typically <0.5m making them dubious UIS drainage targets (Figure 17).

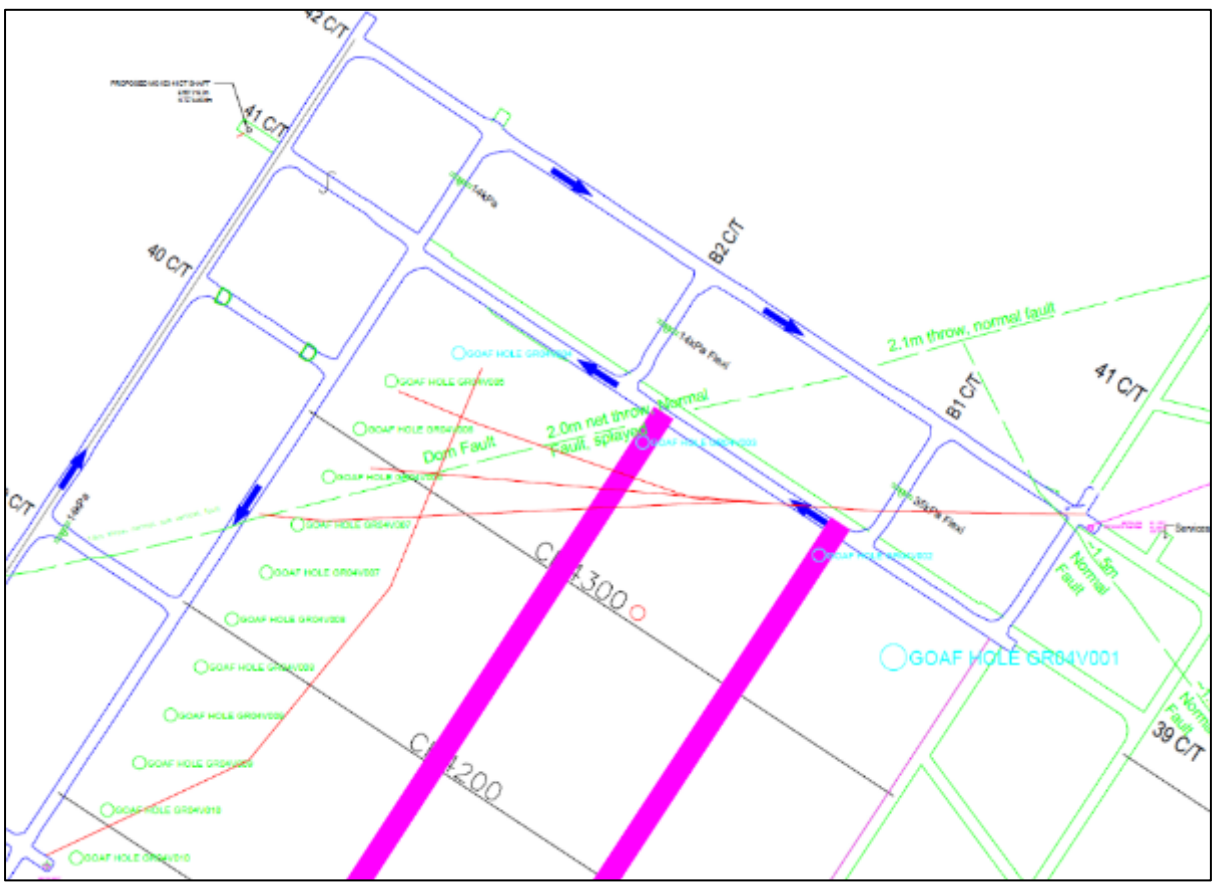


Figure 16. Dom fault as a potential conduit from the CL and DYU seams, showing possible cross measure UIS from 40ct riser.

It is recommended that cross measure UIS holes are established through the fault plane into the HCL and DYU. One branch should be close to the face start line.

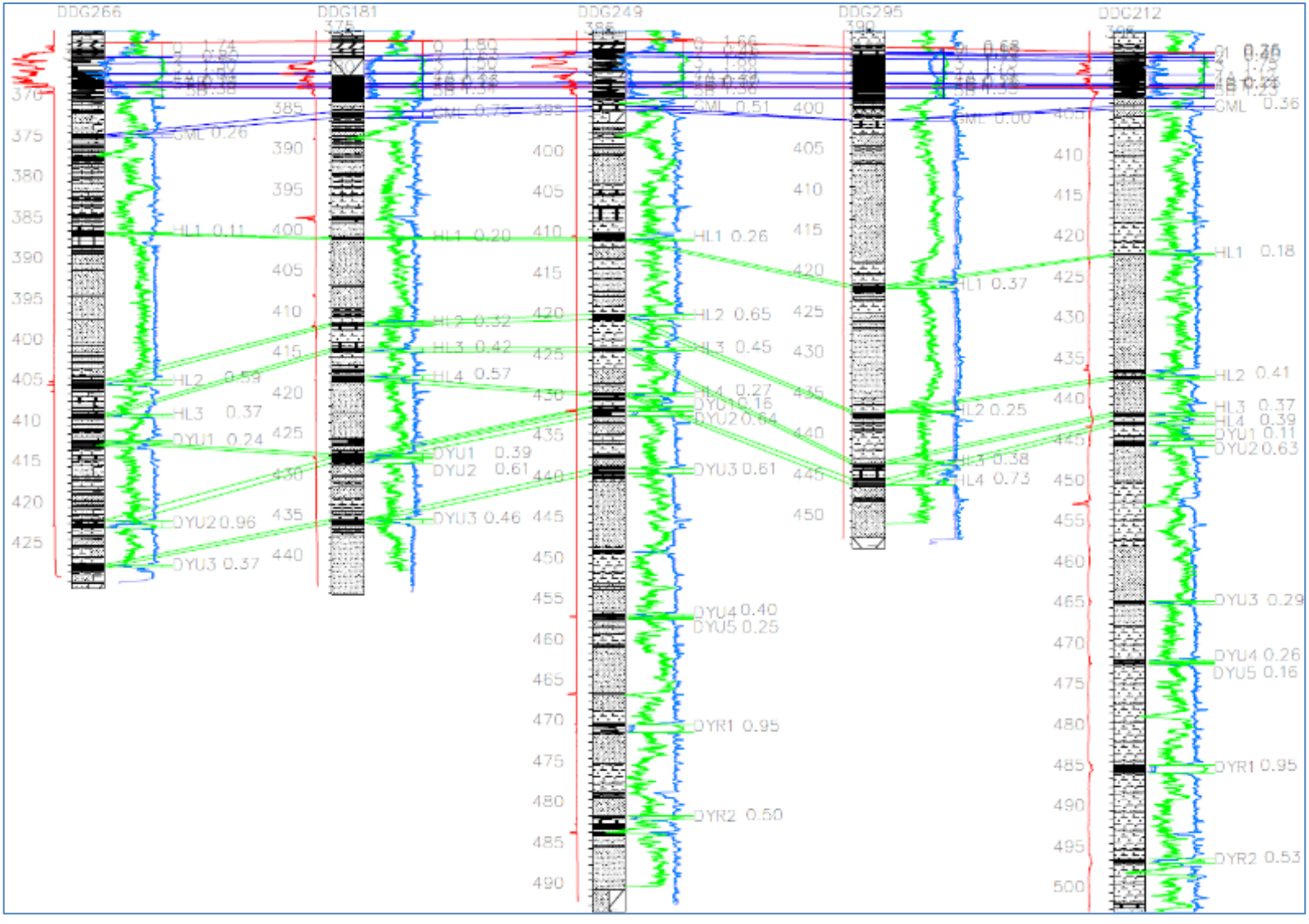


Figure 17. Floor seam relative depth and thickness, (refer Figure 3 for location).

1.17 Gas spikes arising from goaf flushing

Goaf flushing spikes can occur due to roof falls at the tailgate end of the face. As goaf gas migrates to the tailgate corner, any gas displaced can cause a temporary spike in the return airway. An example on the 22nd of July is shown below (Figure 18).

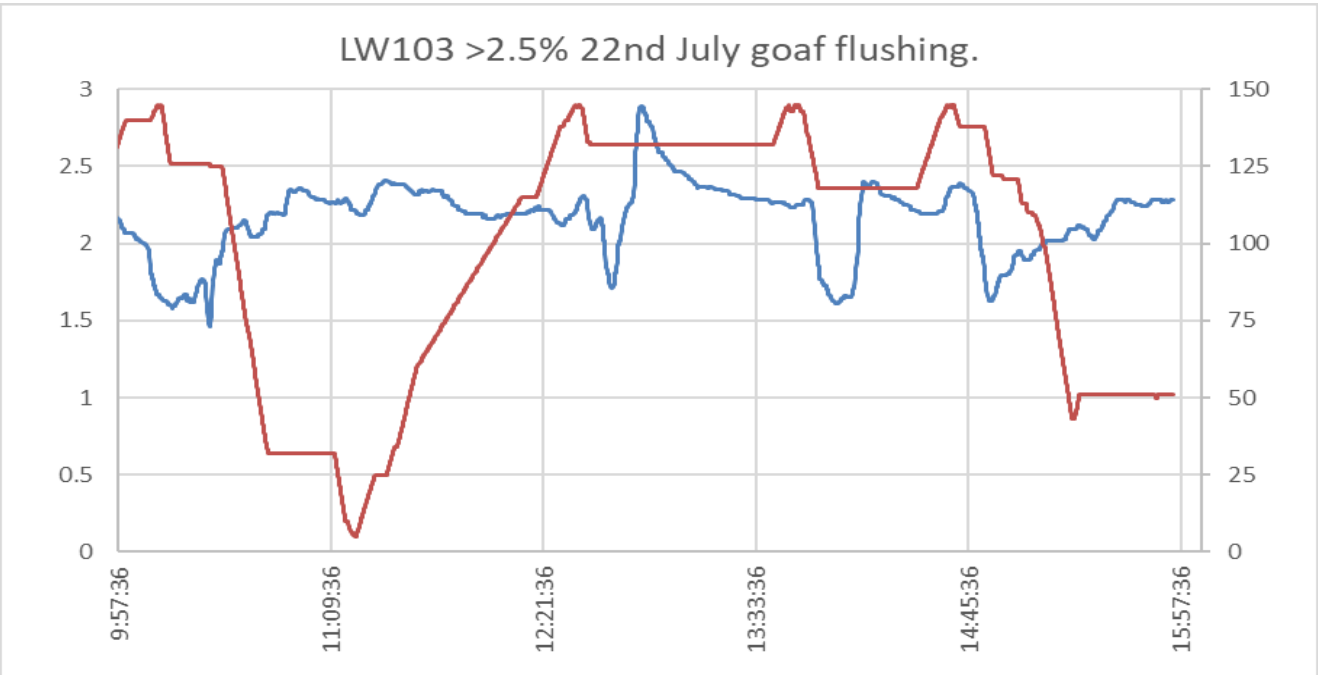


Figure 18. Goaf flushing with LW at 1585mm

Management of spikes arising from tailgate flushing involves reducing the methane composition of the gas immediately behind the longwall. This logic also extends to managing emissions arising from barometric changes. This can be improved by perimeter road pressure management.

It should be noted that operating deep goaf goaf drainage (to mitigate emissions caused by barometric changes) will not prevent the goaf gas from expanding.

1.18 Goaf gas management

1.18.1 Increased drainage volume

Between the 2nd and 16th of August a trial was conducted to maximise goaf drainage by venting gas[3]. During the trial period longwall production was not interrupted by precautionary gas trips. An increase in goaf gas flow from 7800 sL/s to 10,500 sL/s was achieved with the use of 8 extra goaf wells.

Based on the observations from the trial period, the strategy of increasing total volume drained by operating more goaf holes is valid and will be implemented in LW104. Acknowledging however, that during initial longwall goaf development limited goaf holes are available. To increase the volume that can be drained goaf holes will be:

1. TG drilled at close spacing (25m)
2. MG drilled at 150m spacing
3. Twin lateral goaf holes drilled into the P seam

[3] C Badenhorst. 26th August 2019. Venting Trial Report, internal report.

It is recommended that the 25m spacing is drilled for the first 1000m to allow a review of effectiveness in LW104. Outbye of 1000m TG holes to be drilled at 50m with the facility to infill to 25m if required.

A concern with close spaced goaf holes is that the gas purity may fall to levels that require borehole to be shutin (TARP level 2, 11% oxygen and 30% CH_4).

1.18.2 Surface capacity

Increased surface capacity is to be installed by March 2020 to enable an additional 7500 sL/s of drainage and flaring. This is in addition to existing vacuum plant capacity of 9000 sL/s and an additional 1000 sL/s blower.

Reticulation of gas to the plant/blower arrangements will be by MG and TG 630mm goaf drainage pipes. Goaf well wellhead system are to be increased from 17 to 30 units. Assuming 30 goaf holes are available, at a typical goaf hole flow of 660 sL/s, total wellhead flow of 19,800 sL/s would accommodate the plant capacity.

1.18.3 Additional drainage sources

Whereas high volume goaf drainage utilising progressively deeper goaf holes may provide some benefit to tailgate gas levels, two additional drainage modes are recommended:

1. Lateral goaf holes in the mid panel region
2. Gas drainage from the TG roadway horizon.

1.18.4 Gas drainage from the TG roadway horizon

In relation to the latter, experience from Moranbah has been variable however recent experience at Grasstree mine has demonstrated a direct benefit from TG roadway goaf drainage. Gas at the roadway horizon tends to be low purity and is known to fluctuate rapidly with diurnal barometric changes.

At Grasstree 16” diameter ventilation holes are drilled into the TG to supplement the airflow in the TG. When these holes are goafed they are used for venting goaf gas directly from the TG behind the face.

One such vent hole, “909_vent 11” was in operation on the 28th of July when the compressor supplying the surface venturi was stopped for servicing. The tailgate gas response was immediate (Figure 19) and very similar in scale to the volume of gas being vented (Table 1.)

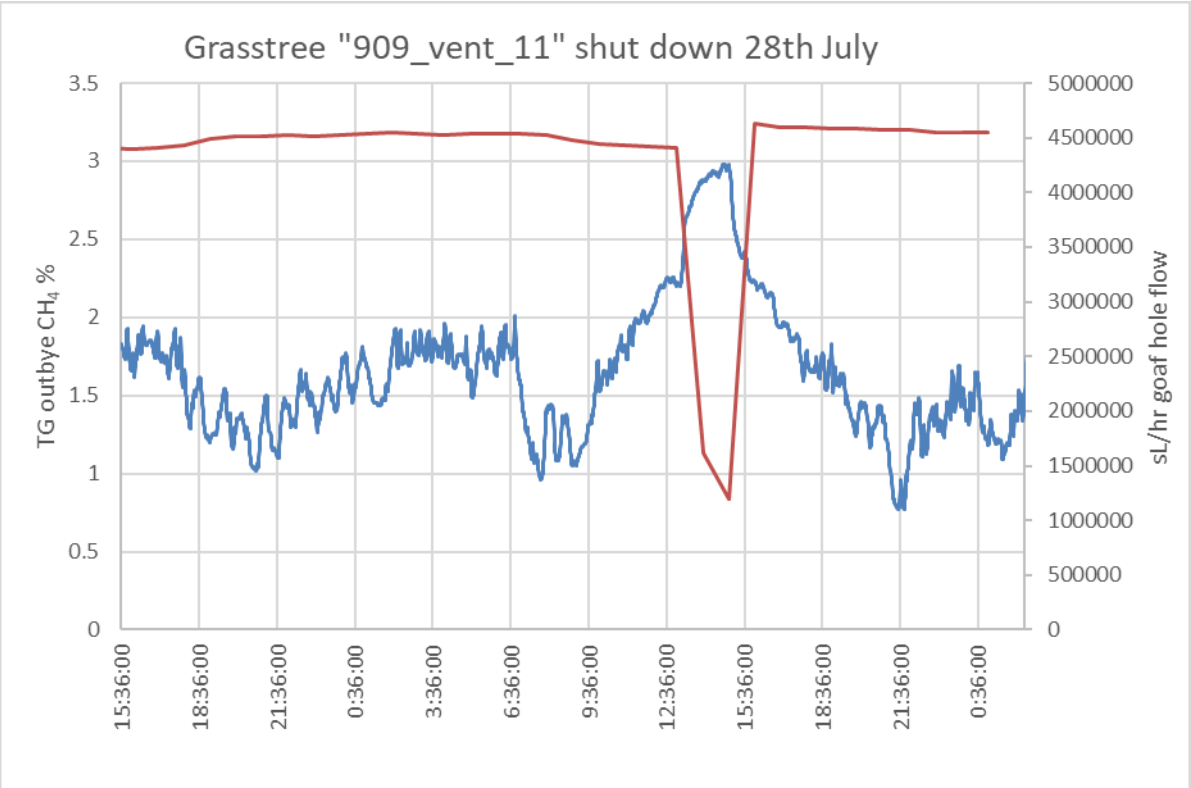


Figure 19. Grasstree 909_vent_11 stoppage - effect on tailgate gas level

Table 1. Summary of gas flow changes during "909_vent_11" shutdown.

Grasstree "909_vent 11" hole flow interruption 28th July				
	m^3/s	sL/s	%	L/s CH_4
Vent hole was flowing at		1225	37	453
dropped to		448	37	166
change		777	37	287
TG airflow at 12:28	68.55		2.23	
TG airflow at 15:02	68.55		2.93	
change	68.55		0.70	479

At the time of the incident the longwall was at 583m chainage approximately 462m outbye of the 909_vent_11 hole (Figure 20). The longwall goaf drainage was operating at approximately 17,489 sL/s.

It can be seen that the vent hole was draining ~7% of the total goaf gas but having a direct effect on the tailgate.

There is opportunity to attempt similar drainage at Grosvenor LW104 using Service hole GSM27 in MG103 35ct, (Figure 21).

Due to the susceptibility of holes in the gateroad horizon to produce low purity gas it is recommended that the wellhead arrangement utilise a Crowne goaf skid with a Rotork actuated inlet valve. This arrangement should be automatically modulated based on oxygen content.

Future gas riser locations may be more suitable for goaf drainage if they are drilled into the cut throughs rather than into the drainage stubs.

Locating UIS risers in cut throughs will still facilitate back filling of gas drainage stubs using the riser.

Experience using stone dust drop holes for goaf drainage shows that surface flame arrestors quickly become blocked with stonedust hence the riser must be flushed after use.

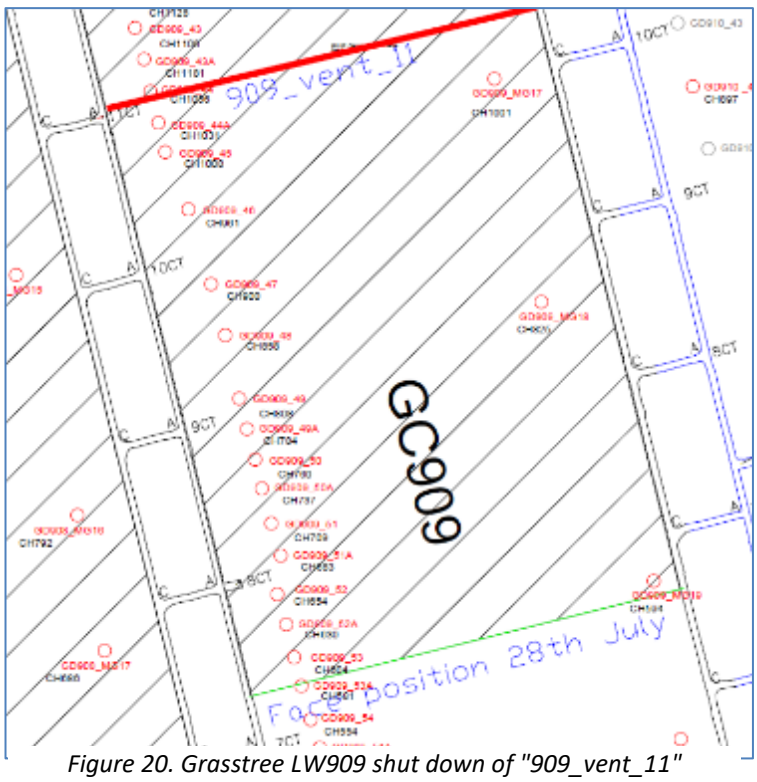


Figure 20. Grasstree LW909 shut down of "909_vent_11"

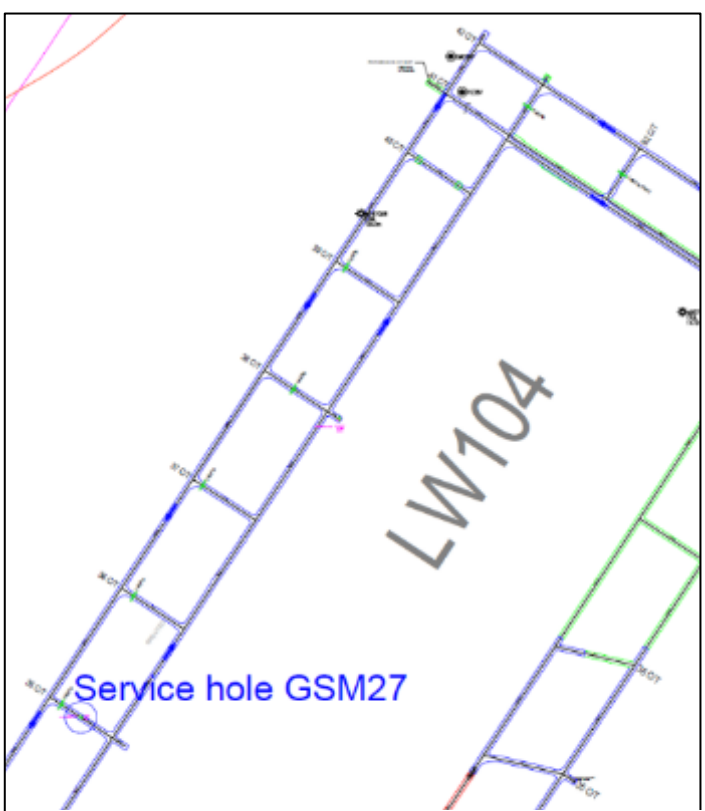


Figure 21. Location of GSM27 in MG103. Potential for TG 104 goaf drainage.

1.19 Lateral Goaf holes in the mid panel

A wide range of residual gas contents in the P seam have been measured around the face start line of LW104 (Figure 22). The results show that pre-drainage by Arrow has not been uniform.

The lateral goaf hole GRL026L was drilled at 12 ¼" diameter inseam in LW103. The hole was initially found to be blocked however came on stream with a peak flow of 1200 sL/s of 85% CH4 (Figure 23).

The use of lateral goaf holes to reduce the gas pressure in the freshly caved P seam at the leading edge of the goaf helps reduce gas that would otherwise migrate onto the longwall.

This method of drainage will assist in achieving the high-volume strategy adopted in response to the high SGE values. The laterals will be drilled to intersect face start line vertical goaf holes. The intent is to provide mitigation for well blockage and to allow dewatering before the longwall starts.

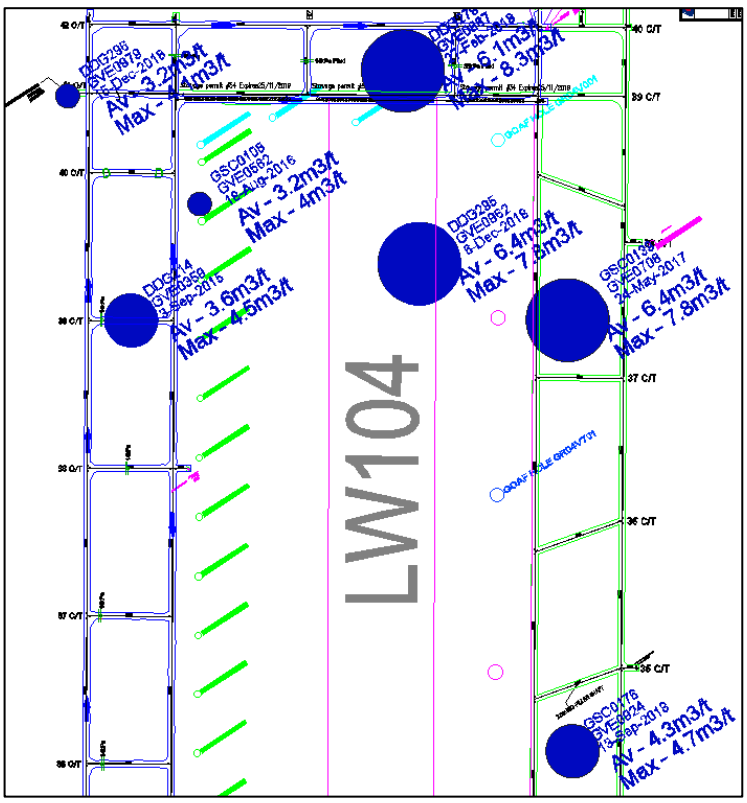


Figure 22. LW104 inbye showing "P" seam gas content by date. Note older results show lower gas content

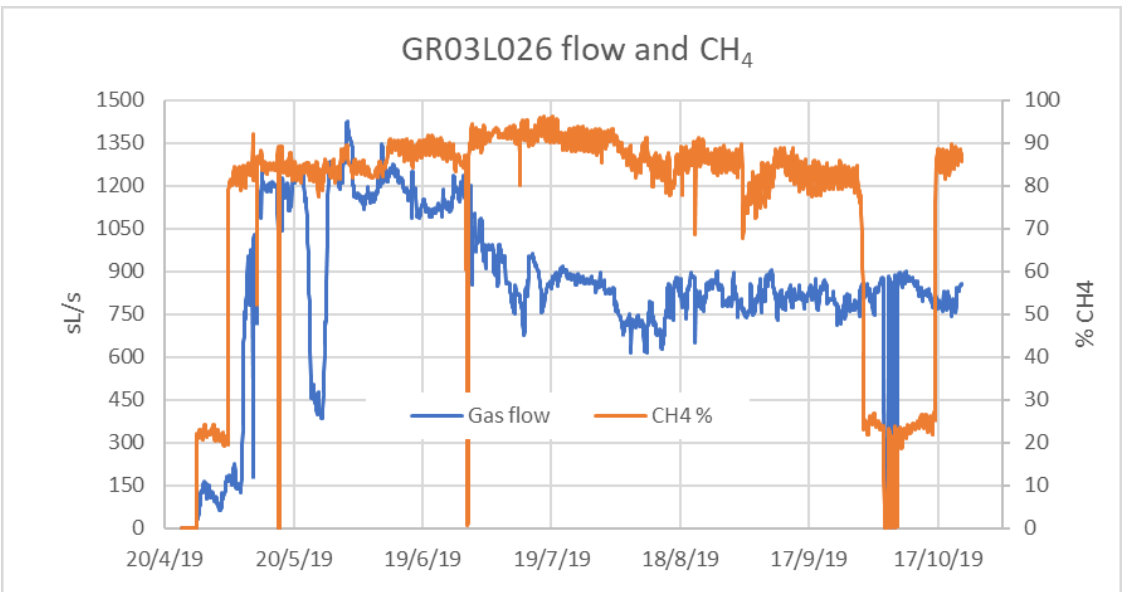


Figure 23. GRO3L026 lateral goaf hole performance

Dewatering will enable the laterals to perform as pre-drainage holes. If this is shown to be effective the strategy (pre-drainage of goaf laterals by use of end of hole vertical goaf holes should be implanted on LW105 to provide more extended pre-drainage.

The proposed P seam laterals (Figure 24) are 1400m in seam. The laterals are to be offset from the tailgate vertical goaf hole and maingate vertical goaf holes to provide maximum tributary coverage.

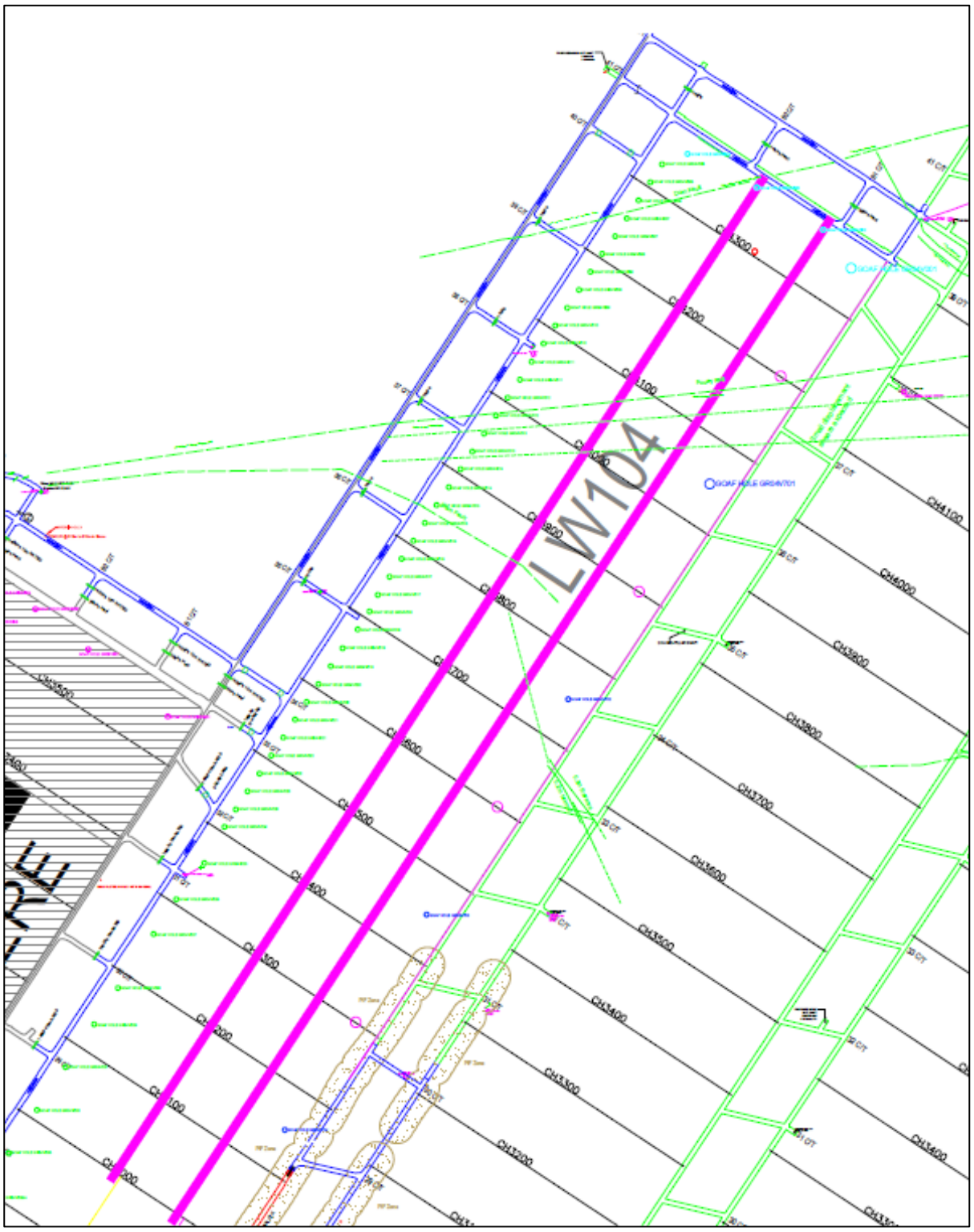


Figure 24. Location of LW104 inbye laterals showing TG vertical goaf holes at 25m centres and MG vertical holes at 150m centres.