Underground CMM Capture and Emission Reduction - a case study

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Introduction

A major research project under the auspices of the Australian Government Coal Mining Abatement Technology Support Package (CMATSP)

Objective

To develop a holistic and optimal approach of planning, design and operational control of coal mine methane drainage and ventilation systems to maximise methane capture and minimise fugitive emissions in gassy and multiple seam conditions

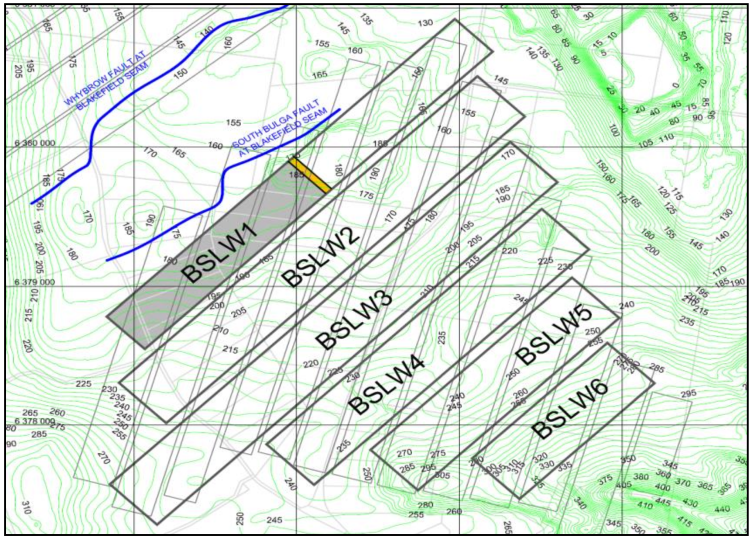
Collaborative parties

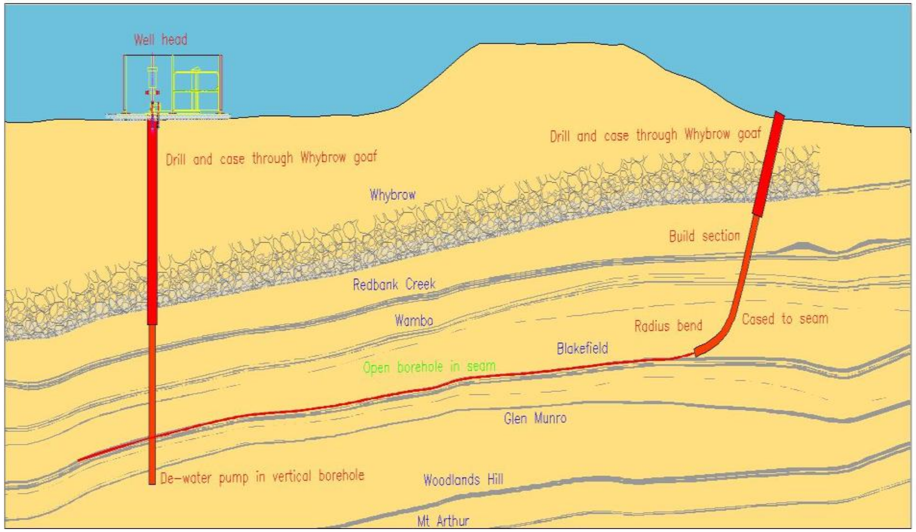
- Bulga Underground Coal Operations, Glencore (formally Xstrata)
- Coal Mining Research Program, CSIRO

Project Scope

- **Extensive site characterisation** of in-situ strata, hydrogeological and gas conditions
- **Systematic field measurements and monitoring** of mining induced strata, ground water and gas changes at and around longwall panels
- **Continuous monitoring** of goaf gas pressure and composition changes
- **Comprehensive 3D numerical modelling studies** to develop a fundamental understanding of mining induced strata, groundwater and gas behaviour
- **Assessment** of key parameters in gas drainage design and operation
- **Development** of design methodology for optimal and practical gas drainage systems
- **Implementation and demonstration** of new drainage systems

Site Characterisation

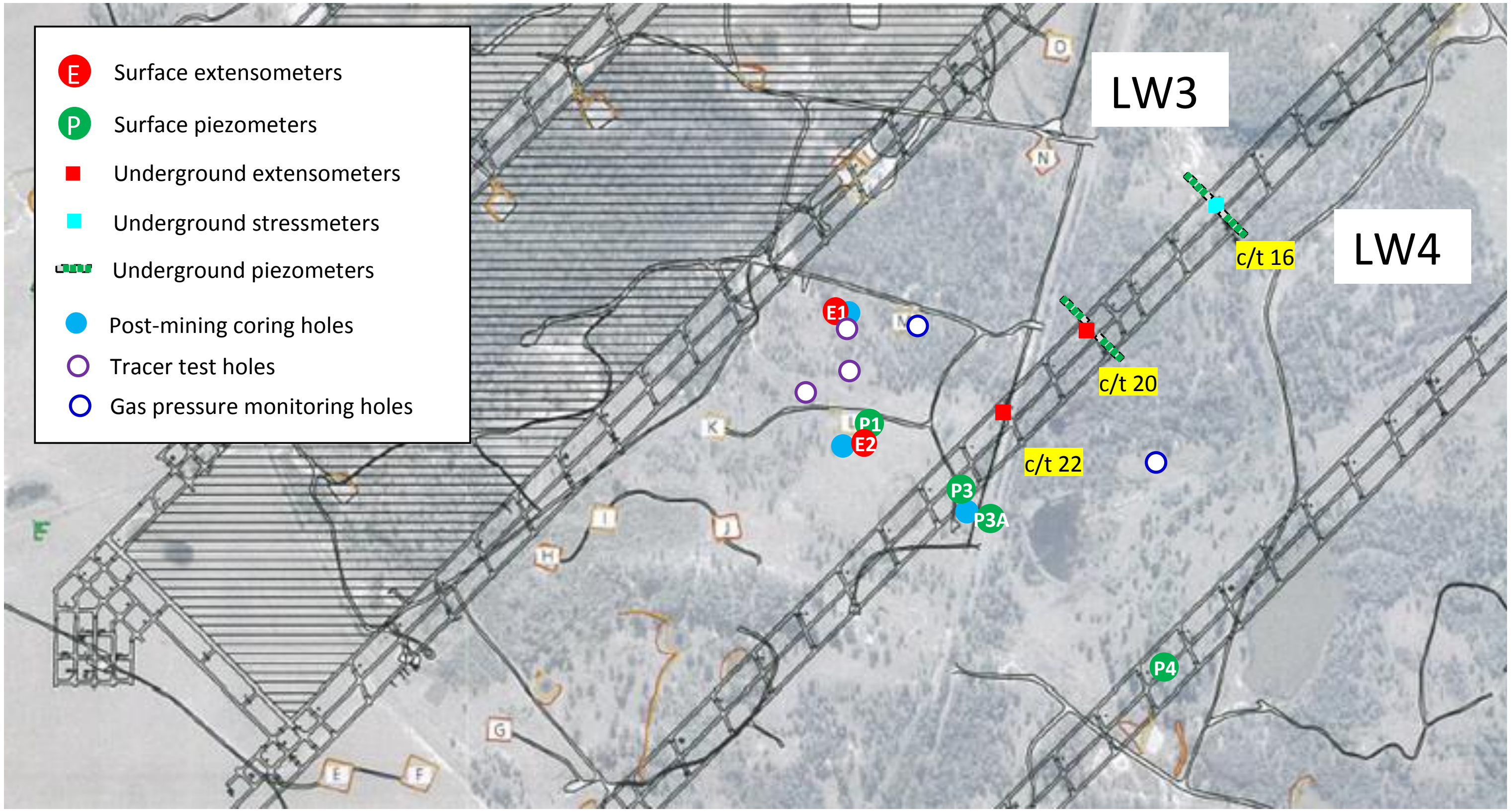




Site geological and mining conditions characterised

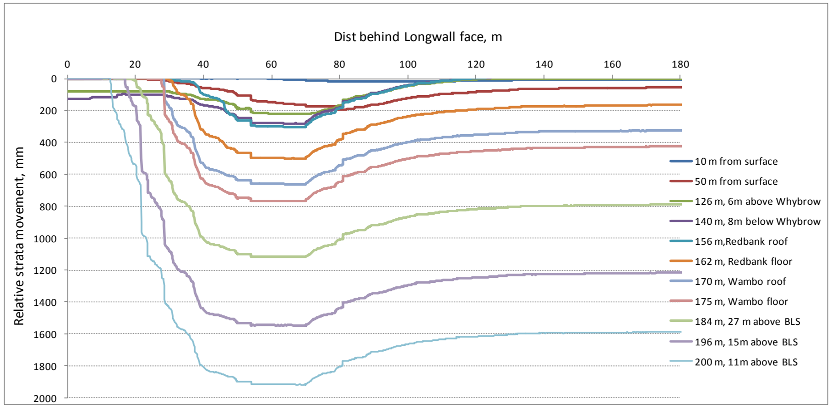
- Geology and hydrogeology
- Gas reservoirs and gas bearing parameters
- Mining and gas drainage technical data
- Gas drainage operational data
- Mine ventilation

Extensive Monitoring and Measurement

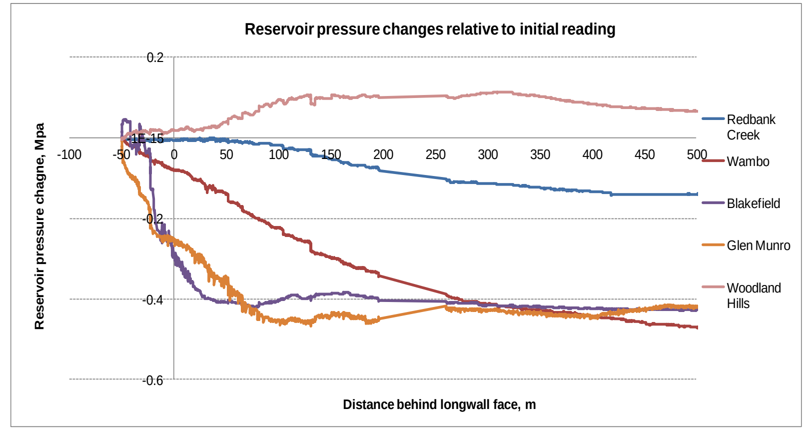


- Strata deformation and stress changes
- Gas reservoir pore pressure changes
- Goaf gas flow dynamics
- Goaf gas pressure and composition changes
- Longwall ventilation gas levels
- Gas drainage performance
- Pre and post mining gas content measurement
- Borehole stability and integrity inspections

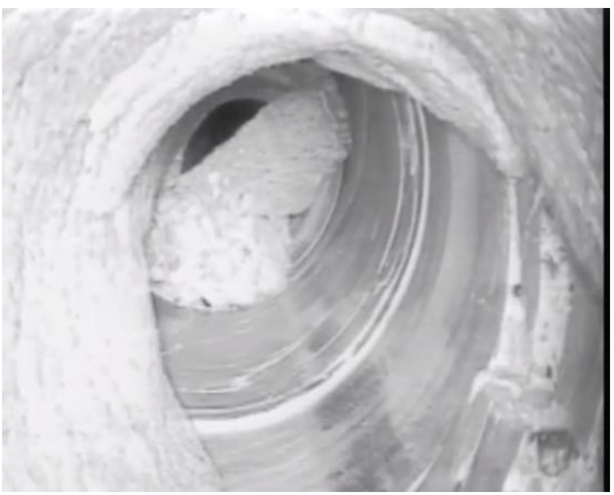
Monitoring Results



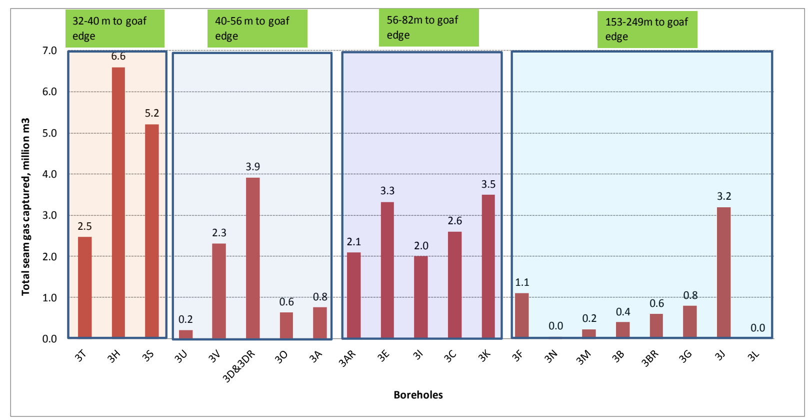
Overburden movement



Seam pore pressure changes



Vertical well stability

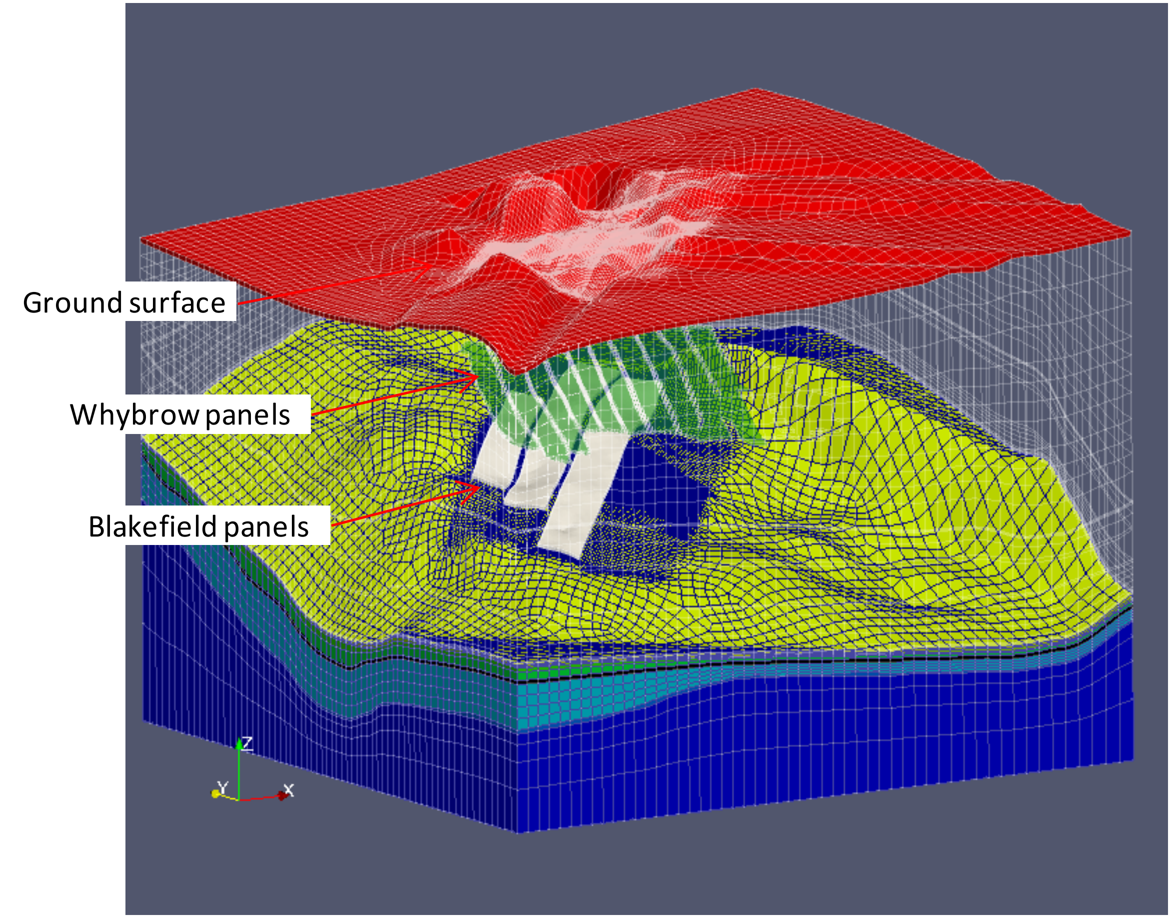


Effect of well location on drainage preformation

Key Observations

- Mining induced fractures and delamination extended up to all overlying coal seams in 36 m above the longwall
- Coal seam pore pressure decreased quickly between 50 m outbye and 100 m inbye of the longwall face
- Gas drainage boreholes were often blocked 30 m above the mining seam
- Sources of gas emissions are Redbank Creek and Wambo seams in the roof, and Glen Munro in the floor
- Gases stored in overlying Whyrow goaves did not flow down into the active goaf
- Vertical wells located in tailgate side of goaf within 30 – 80 m performed much better than those located in mid panel and main gate side

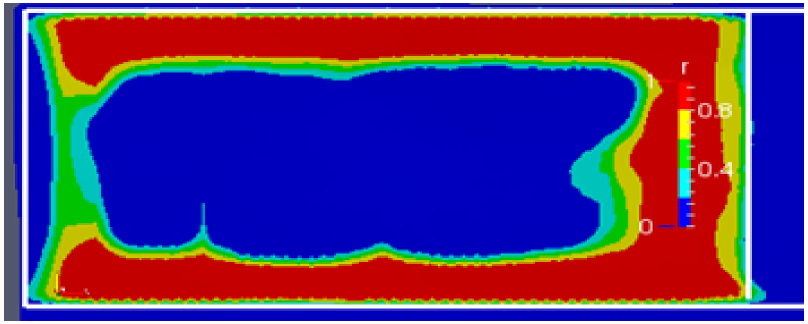
Coupled Numerical Modelling



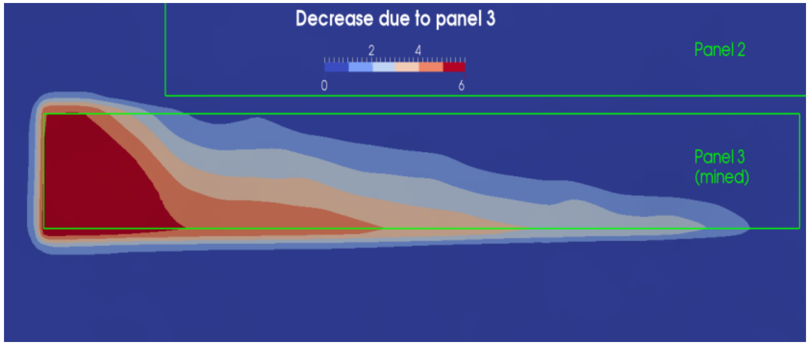
3D COSFLOW model of Blakefield South Mine

- Using CSIRO's COSFLOW code
- Calibrated by field studies
- Coupled modelling of strata, water and gas

Coupled Numerical Modelling continued…



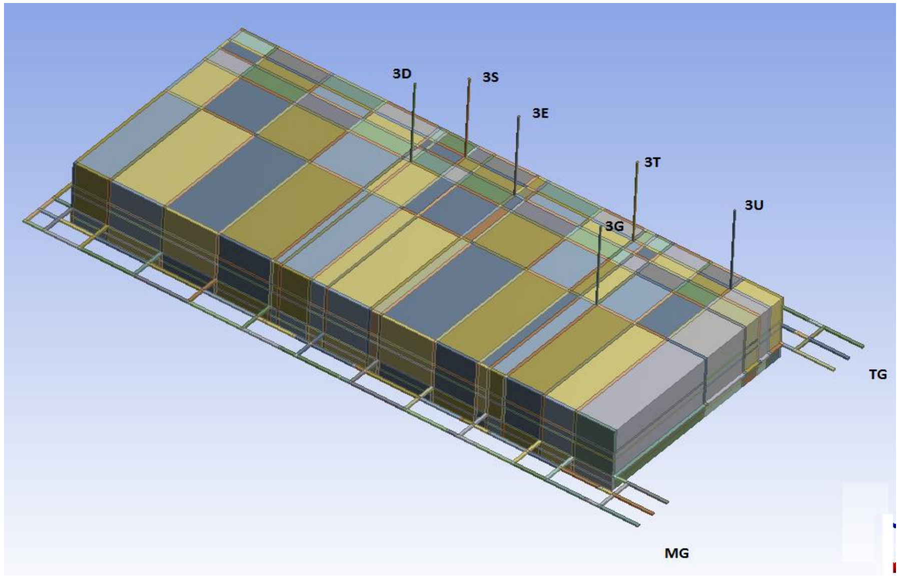
Vertical stress reduction



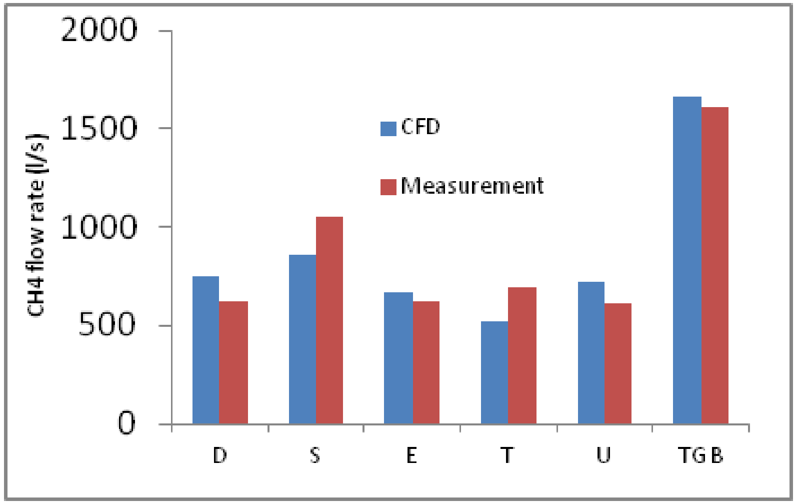
Gas release pattern from Wambo seam

- 3D distribution of strata stress, fractures and permeability
- Gas emission patterns
- Annular zone of relatively high de-stressing and high permeability observed
- Critical input for subsequent CFD simulations

CFD Simulations



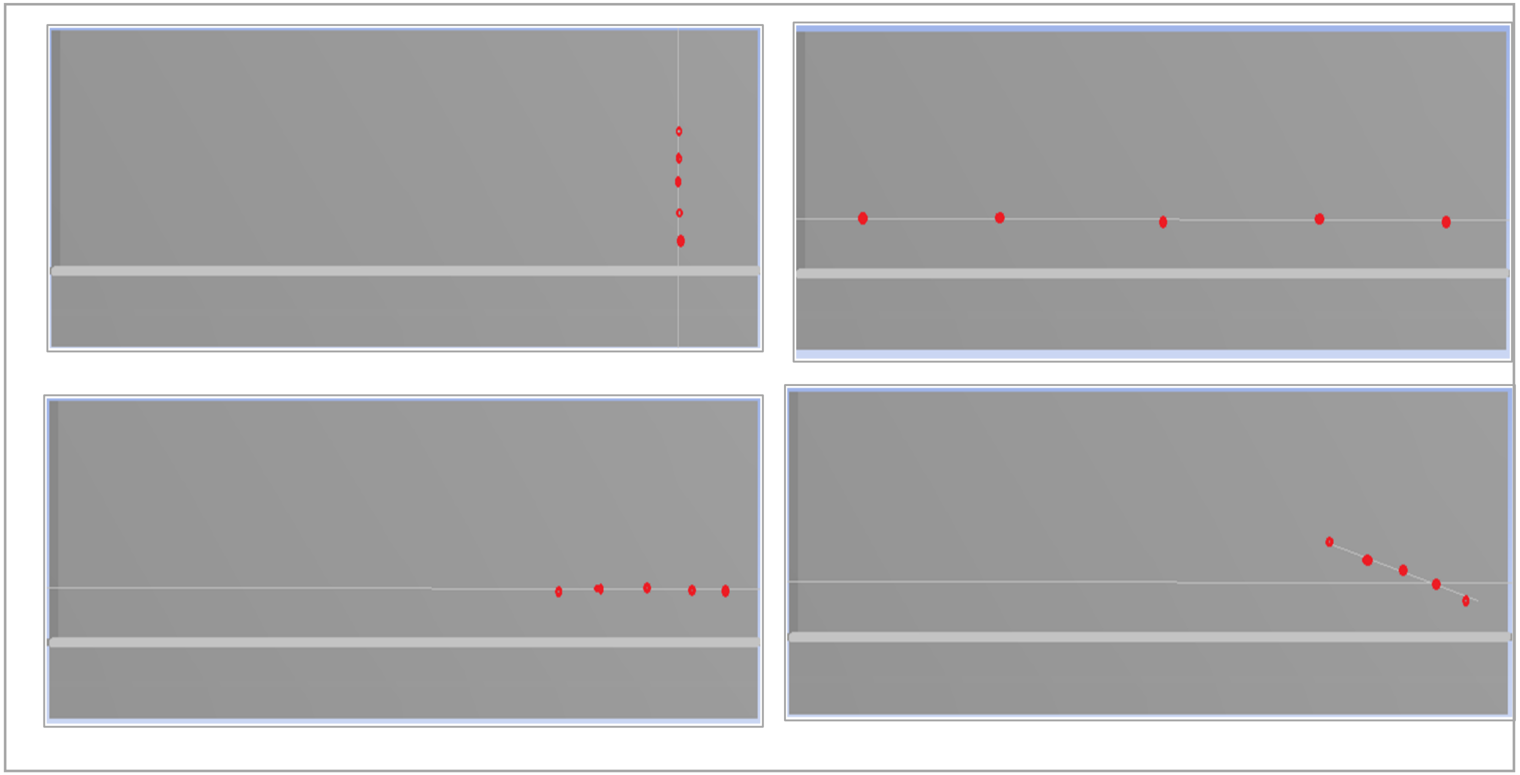
CFD model



Model calibration

- Study goaf gas flow patterns and dynamics
- Based on site characterisation and measurements
- Calibrated by site ventilation and drainage data

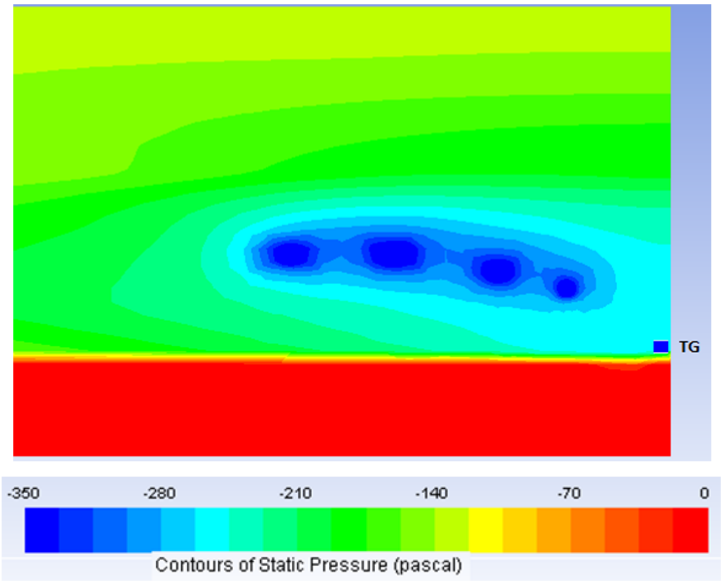
Optimisation of Drainage Design



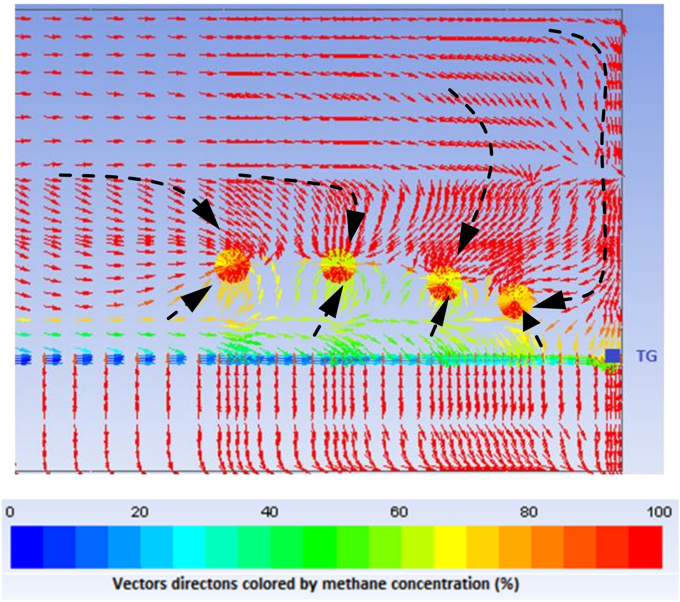
Examples of modelled lateral borehole arrangements

- Gas flow and capture dynamics
- Optimisation of borehole quantity, diameter, location, patterns
- Different combinations of 5 horizontal holes located within 30-110 m from tail gate with a diameter of 150 mm simulated

Horizontal Post Drainage Through Goaf Gas Pressure Control



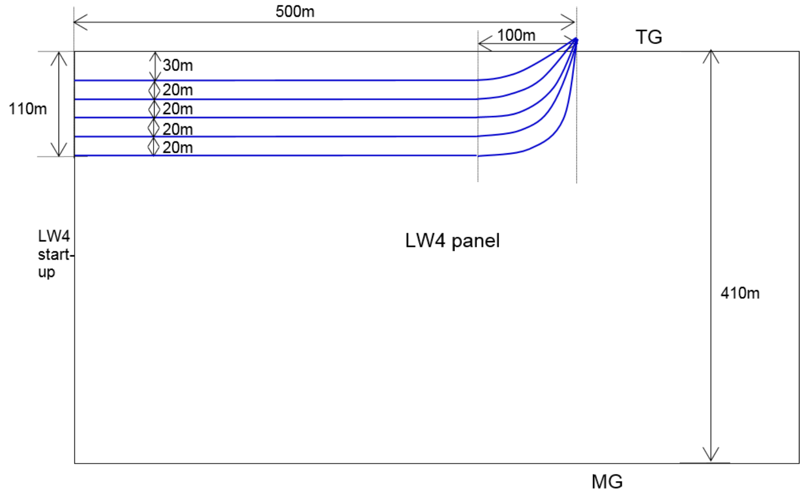
Goaf gas pressure distribution



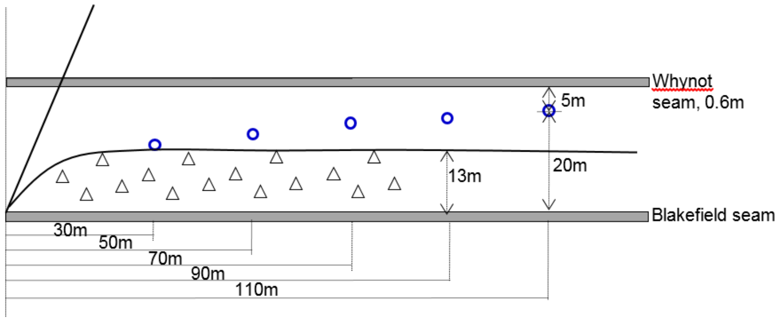
Goaf gas flow directions

- Create low pressure sinks that protect workings from gas flowing into ventilation by changing goaf gas flow directions
- Produce consistent gas flow rate and concentration
- Efficiently reduce methane levels in workings

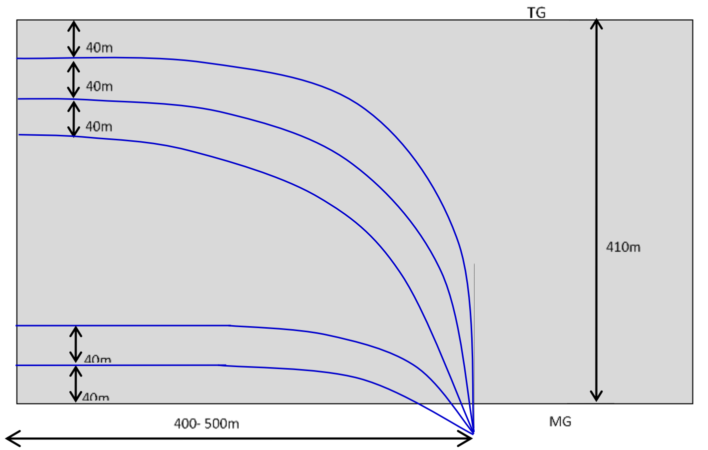
Optimal Goaf Gas Drainage Design



Plan view of roof lateral holes



Cross-section of roof lateral holes



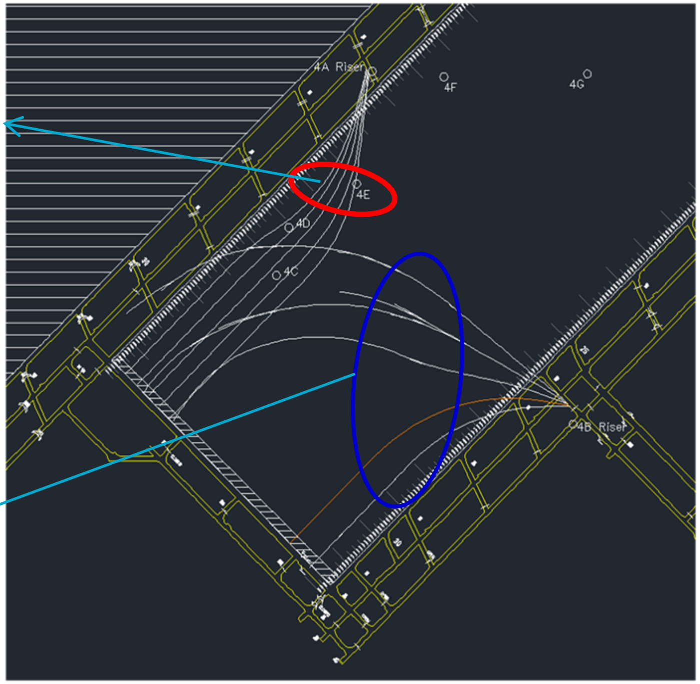
Plan view of Glen Munro seam lateral holes

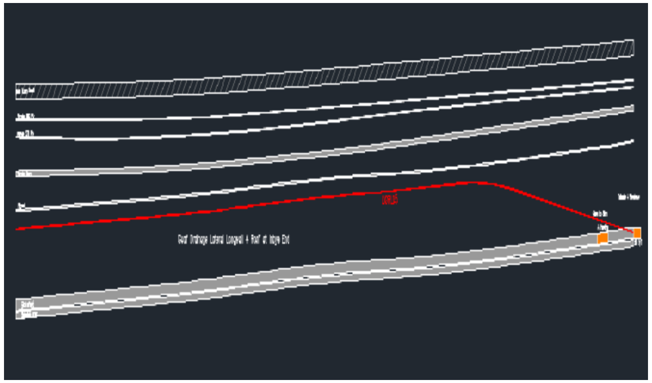
- Laterally located at tailgate side into annular high permeability and methane rich zone
- Vertically located in lower fractured zone above caved zone
- Floor lateral holes into Glen Munro to reduce gas from flowing up to goaf
- 150 mm holes to reduce friction loss and maintain flow rate

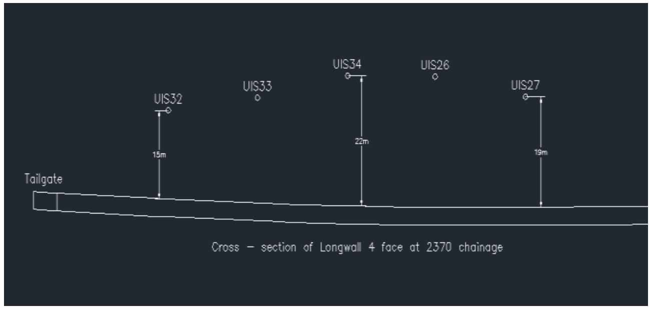
Trial at LW4 in 2014

5 roof lateral holes

5 floor lateral holes along Glen Munro seam



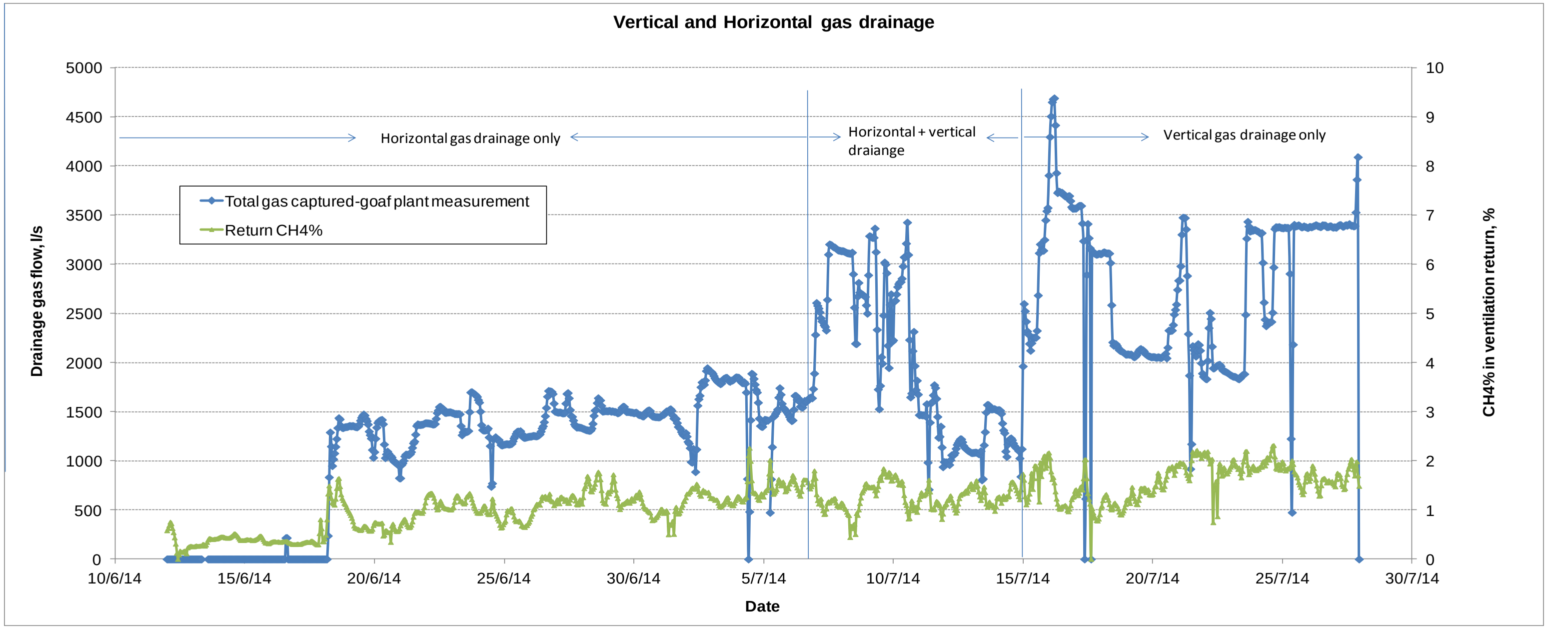




Roof lateral holes placed at 15-22m above mining seam

- Trialled at initial mining stage (400 m retreat) at LW4
- 5 roof lateral holes and 5 floor lateral holes, 400 m long lateral section
- 15-22 m above mining seam
- Roof lateral holes reamed to 145 mm in diameter

Trial Results - Improved Gas Capture Performance



- Drainage performed much better than conventional method
- Stable gas drainage flow rate
- Lower ventilation methane levels
- Reduced fugitive gas emissions

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Trial Results – Increased Drainage Efficiency

Longwall 3 Specific Gas Emissions from real time monitoring						
Week Ending	Longwall Retreat	Longwall Tonnes	Total seam gas m3	SGE	l/s aver.	Capture Efficiency
23/06/2013	6	11,140	226,785.1	20.4	375.0	0.0%
30/06/2013	30	60,388	723,379.8	12.0	1196.1	13.9%
7/07/2013	48	93,603	2,111,893.1	22.6	3491.9	17.0%
14/07/2013	66	130,715	2,600,429.6	19.9	4299.7	39.5%
21/07/2013	40	93,642	2,968,358.3	31.7	4908.0	36.9%
28/07/2013	35	70,126	2,005,781.9	28.6	3316.4	7.2%
4/08/2013	71	143,010	2,723,121.4	19.0	4502.5	37.0%
11/08/2013	50	107,718	3,343,867.9	31.0	5528.9	47.7%
18/08/2013	68	139,851	3,547,650.6	25.4	5865.8	50.0%
25/08/2013	105	217,981	3,966,521.7	18.2	6558.4	57.4%
1/09/2013	90	199,170	4,229,919.6	21.2	6993.9	59.4%
8/09/2013	93	185,241	4,068,782.5	22.0	6727.5	62.5%
15/09/2013	95	184,833	3,905,168.2	21.1	6457.0	61.6%
22/09/2013	99	224,859	3,902,172.7	17.4	6452.0	67.6%
29/09/2013	81	151,041	3,436,049.7	22.7	5681.3	71.8%
6/10/2013	80	184,193	3,231,376.1	17.5	5342.9	64.5%
13/10/2013	97	214,695	3,645,109.0	17.0	6027.0	62.2%
20/10/2013	99	211,289	3,384,164.7	16.0	5595.5	68.8%
27/10/2013	99	201,731	3,854,714.9	19.1	6373.5	68.0%
3/11/2013	96	203,860	3,816,564.4	18.7	6310.5	64.8%
10/11/2013	93	190,647	3,799,572.7	19.9	6282.4	64.0%
17/11/2013	77	171,318	3,802,011.7	22.2	6286.4	62.9%
24/11/2013	90	204,253	3,450,259.0	16.9	5704.8	68.1%

Longwall 4 Specific Gas Emissions from real time monitoring						
Week Ending	Longwall Retreat	Longwall Tonnes	Total seam gas m3	SGE	l/s aver.	Av. Capture Efficiency
22/06/2014	72	121,555	982,559	8.1	1625	51.4%
29/06/2014	92	166,440	1,531,120.7	9.2	2531.6	80.0%
6/07/2014	87	180,437	1,618,237.6	9.0	2675.7	79.0%
13/07/2014	106	209,436	1,800,573.2	8.6	2977.1	70.0%
20/07/2014	95	193,000	2,051,527.4	10.6	3392.1	70.2%
27/07/2014	96	201,000	2,328,688.9	10.6	3850.3	61.8%
3/08/2014	118	224,522	2,356,483.8	10.5	3896.3	68.6%
10/08/2014	101	214,586	2,240,978.7	10.4	3705.3	62.0%
17/08/2014	103	206,782	2,315,413.6	10.4	3828.4	62.1%
24/08/2014	88	187,272	1,803,763.8	11.2	2982.4	59.6%
31/08/2014	140	283,156	2,278,634.7	8.0	3767.6	65.4%
7/09/2014	138	282,806	2,179,147.7	7.7	3603.1	64.9%

Trial period

- Gas capture efficiency was increased to 80%
- Annual fugitive emission reduction estimated at 0.42 Mt CO_2-e (compared to LW3)

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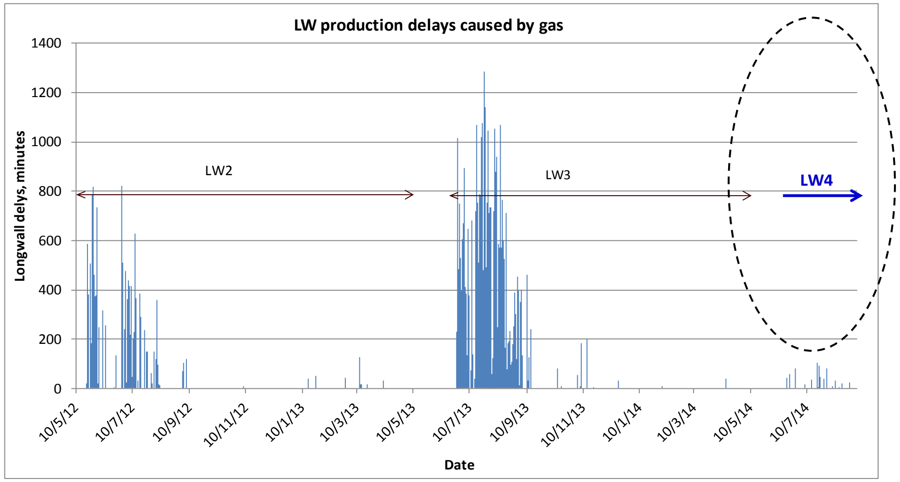
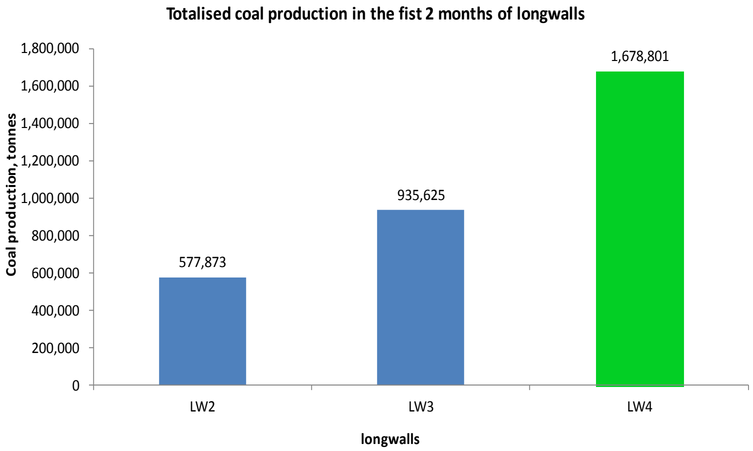
Trial Results – Improved Mining Safety and Coal Productivity





- Significant reduction of gas related coal production delays
- Significant increase of coal production in initial mining stage (an increase of 79% from LW3)

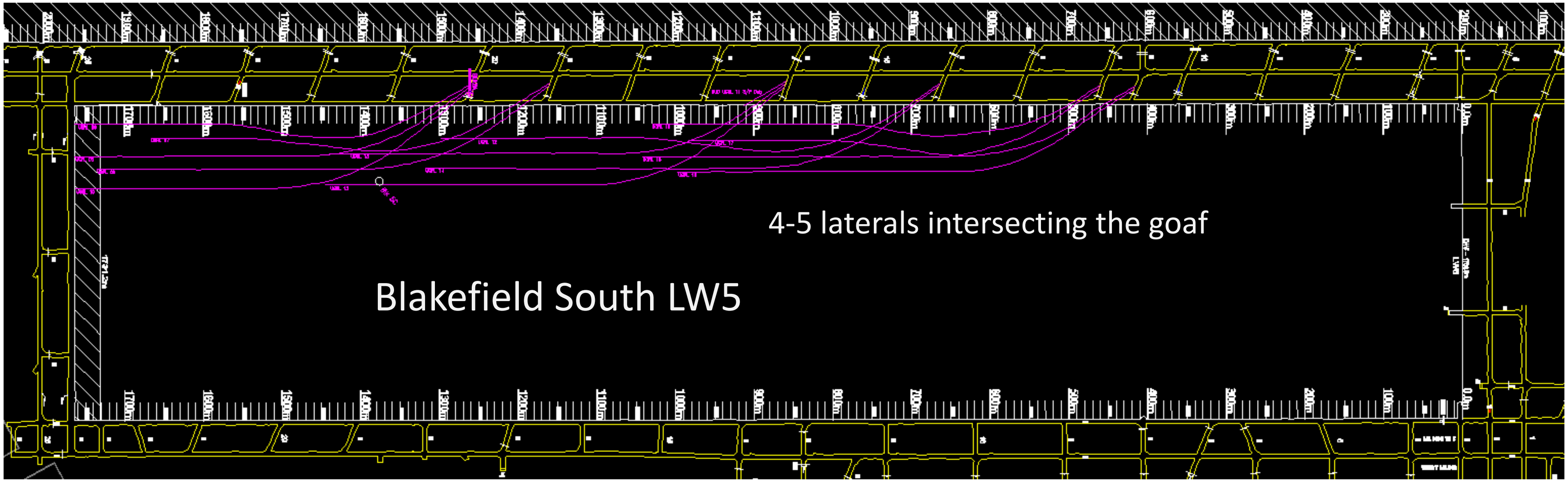
Trial Results – Methane Utilisation and Emission Reduction

- Methane captured by the floor lateral holes was utilised by a 9MW power generation unit (capacity: 850 l/s)
- Methane captured by the roof lateral holes from goaf was incinerated by three (3) goaf flares (total capacity: 4,500 l/s)

9 MW power generation unit

Goaf gas flaring facility

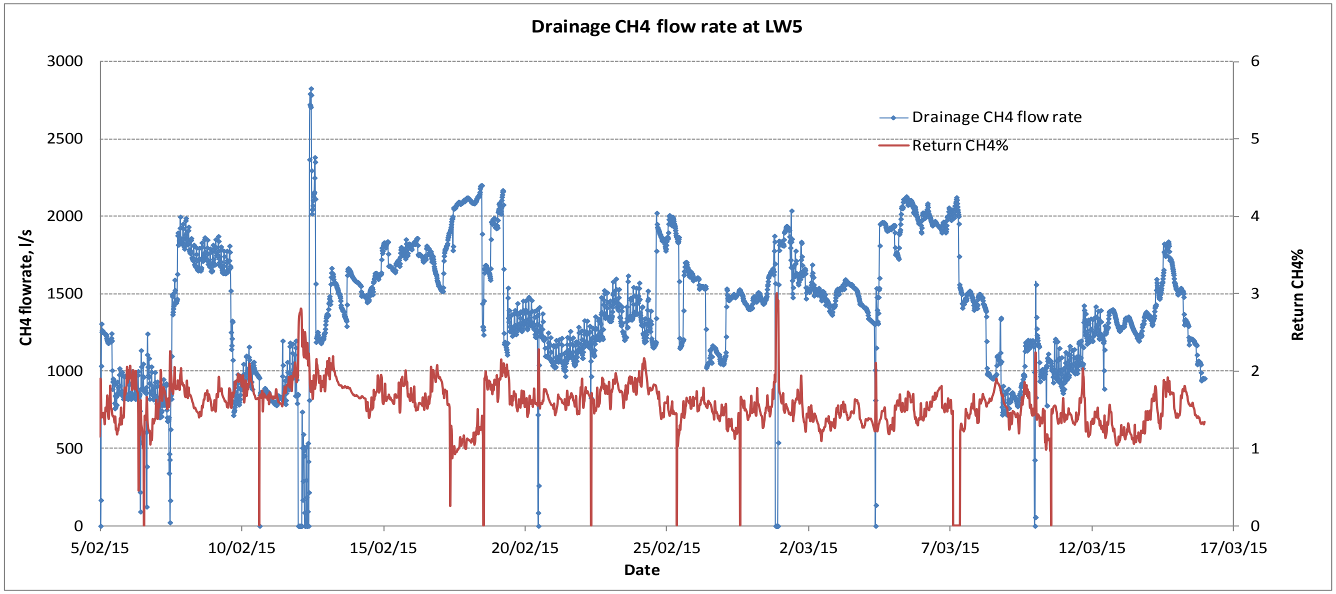
Application at LW5



LW5 goaf gas drainage roof lateral holes

- Following the successful trial at LW4, the mine has replaced the surface vertical goaf drainage system with underground lateral holes at the entire panel of LW5
- The floor lateral holes were not implemented due to site constraints

Result of LW5 Gas Drainage in 2015



LW5 drainage CH4 flow rate to 15/03/2015 (retreat of 398 m)

- Roof lateral holes performed well at LW5
- Roof lateral hole gas flow rate and daily coal production were 1252 l/s and 22,411 t on average, close to that in the trial at LW4 (1279 l/s and 23,121t)

Conclusions

- The largest integrated study of field investigation, numerical modelling, and CFD simulation
- Important insights into the coupled strata, gas and groundwater behaviour in complex multi-seam longwall mining that are critical to optimal goaf gas drainage design and emission reduction
- The new gas drainage system, consisting of underground horizontal holes into roof and floor seams, was designed, trialled and applied successfully at the mine in 2014 and 2015:
  - Gas drainage efficiency improved
  - Gas related down time reduced substantially (by 2 months each year)
  - Annual net fugitive emissions reduction estimated by up to 0.42 Mt CO_2-e

Conclusions continued...

The success of the optimal gas drainage system demonstrated that the scientific gas drainage design methodology used in this study is reliable and effective:

- Comprehensive site characterisation including geology, hydrogeology, strata and gas reservoir conditions
- Field studies to determine key information such as gas emission sources and drainage targets
- Coupled numerical modelling to determine 3D gas flow environment
  - Goaf and surrounding strata conditions of destressing and fracturing
  - Annular zone of high permeability and rich methane
  - Gas emission patterns
- CFD simulation to test and optimise gas drainage design

Acknowledgements

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Thank you

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