GeoGAS

Moranbah North Coal Seam Gas Development – Technical and Statutory

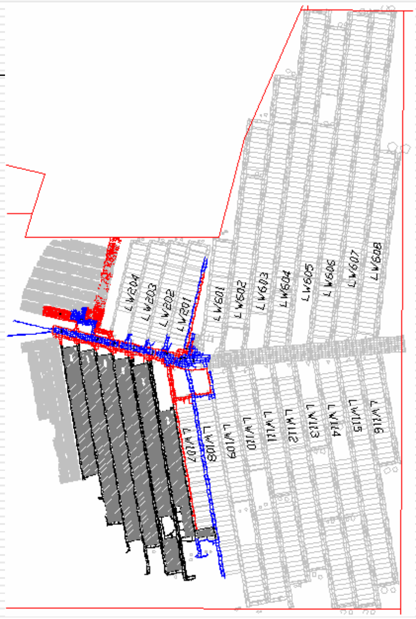
Anglo Coal Australia Pty. Ltd./GeoGAS Pty. Ltd.
ACARP Gas and Outburst Workshop
Mackay 29th June 2007

Hugh Luckhurst-Smith, Anglo Coal Australia Pty. Ltd.
Ray Williams, GeoGAS Pty. Ltd.

GeoGAS

To Cover

- Statutory and Legal (Hugh Luckhurst-Smith)
- Technical (Ray Williams)



GeoGAS

Regulations

- Queensland recent Statutory history.
- Coal Mine Health & Safety Act & Regulations 2000
- Petroleum & Gas Act & Regulations 2004
- “Surface activities related to [petroleum &] gas activities’

GeoGAS

ACA History

- Moura-> Dawson opencut mine: PL94/ATPs acquisition 2006
- Grasstree U/G mine: 32MW Power station 2006
- Moranbah North U/G mine:
- Gas sales 2006/Power station 2008
- U/G mines; gas drainage for ‘mineability & greenhouse

GeoGAS

Petroleum & Gas Act target compliance

- Moranbah North 1st quarter 2007
- Dawsonlate 2007
- Grasstree mid 2008

GeoGAS

Legal Aspects.

- Operational: Separate SSMs-Underground; Surface Coal; Surface Gas; Power Station
- Drilling: Each rig has own SSM.
- Clear signage & separation eg valve or flange.
- Where jurisdictions overlap
- CMHSA always takes precedence!

Compliance issues.

- AS4801: Corporate overview compliance
- ACA solution: Parallel HSEMSs

Recommendations

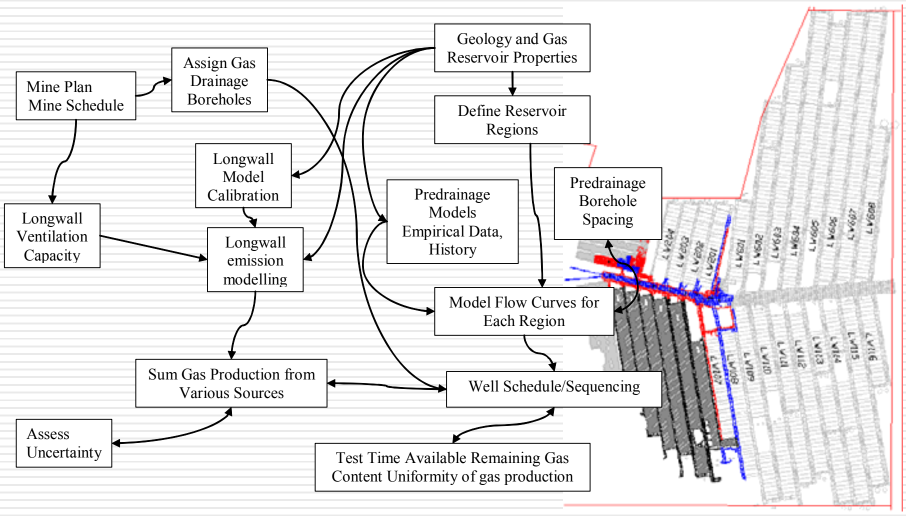
- 1.Adopt as many as possible of existing mine procedures
- 2. Conduct joint Risk Assessments
- 3. Audits, inspections to be based on SafeOP-a good tool!

Introduction

- ✓ Statutory and Legal (Hugh Luckhurst-Smith)
- → Technical (Ray Williams)
  - Objectives to
    - Produce gas at the required rate
    - As uniformly and as long as possible
    - At minimum cost (maximum spacing/drainage times)
    - Meeting requirements for mine gas management as the priority
  - For this presentation:
    - To demonstrate the forecasting process
    - To highlight issues related to meeting the twin needs of mine gas emission control and gas utilisation.
    - To comment on risk and uncertainty

GeoGAS

Outline of Forecasting Process

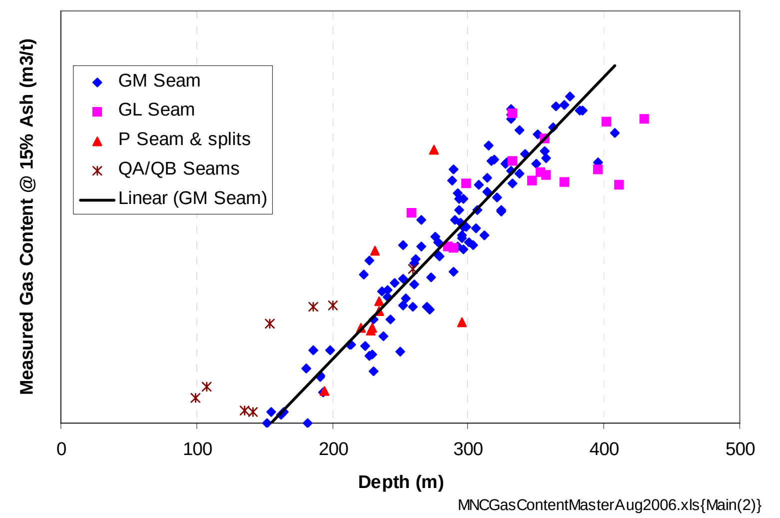


GeoGAS

Gas Reservoir

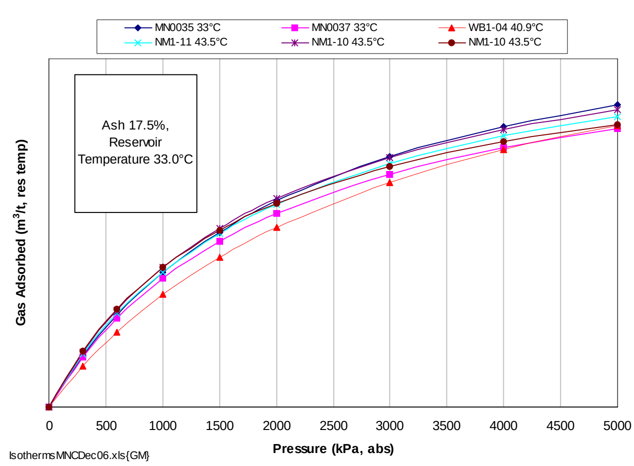
GeoGAS

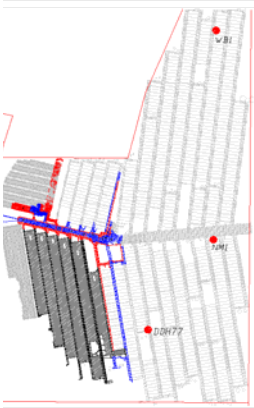
Gas Content



GeoGAS

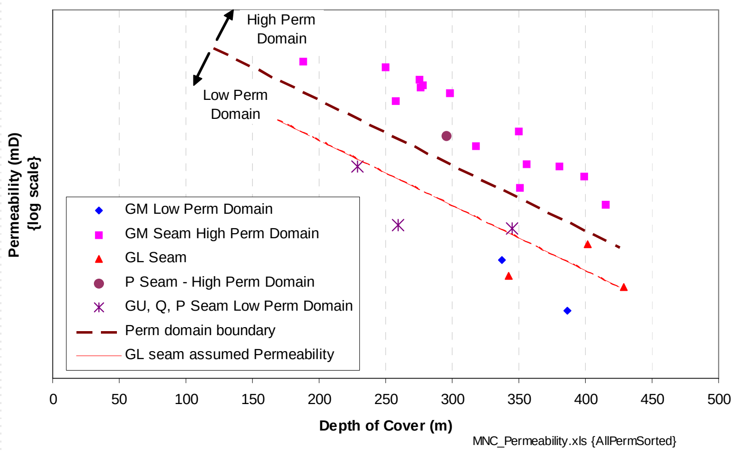
Gas Sorption Isotherms





GeoGAS

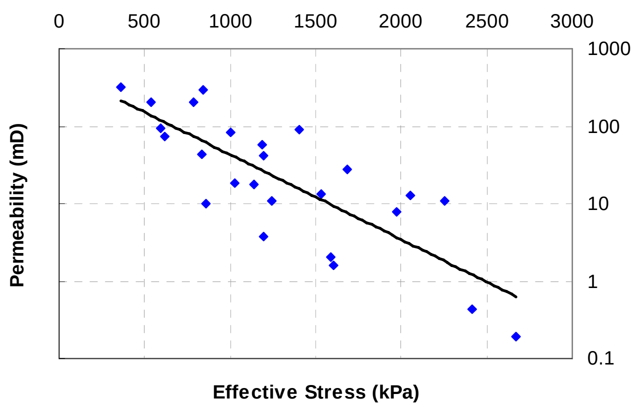
Permeability



GeoGAS

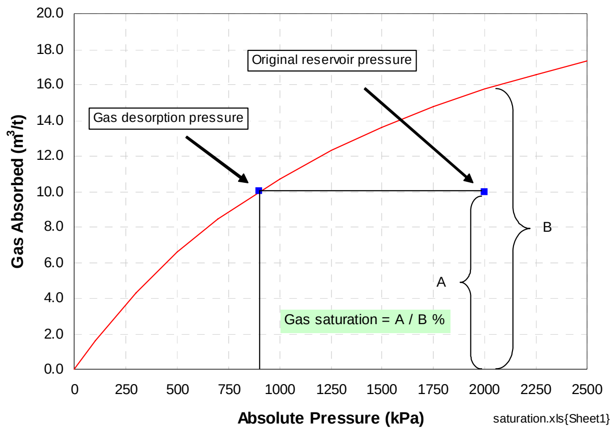
Effect of Stress

- 12 fold reduction in permeability for every Mpa increase in stress



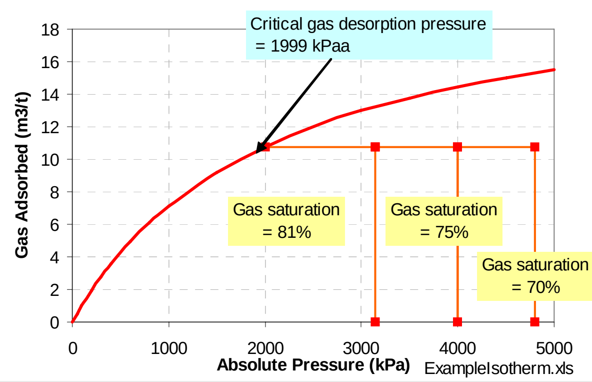
Gas Saturation

As important as permeability to gas deliverability



Comparing Different Gas Saturations

Even though gas content and permeability might be the same, changes in gas saturation have an enormous effect on gas production, gas content reduction and how the well will operate.



Getting gas out is all about reducing pressure throughout the reservoir. Gas sat of 70% may not seem too different from 80%, but the additional impost on pressure reduction is enormous.

Then there is also the effect on permeability of increasing effective stress

GeoGAS

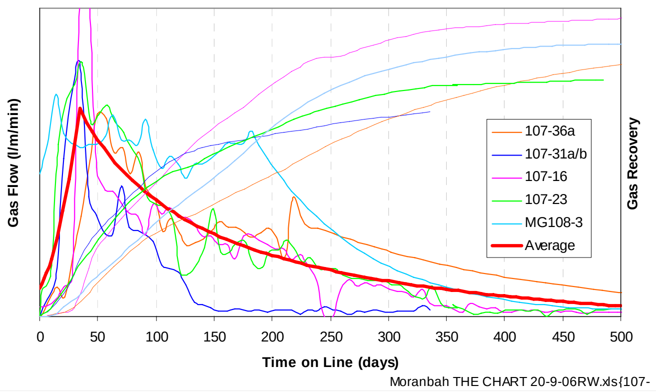
Predrainage Gas

GeoGAS

Underground In-Seam (UIS) Flow Curves

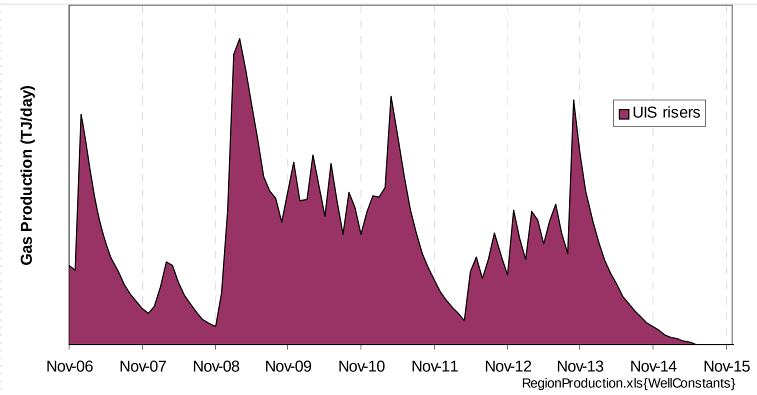
Basic curve defined empirically.

Application to each riser is based:
• Material balance
• Adjustment flow to account for actual metres drilled
• A flow factor producing 70~80% recovery with 1~2 m3/t remaining gas content.



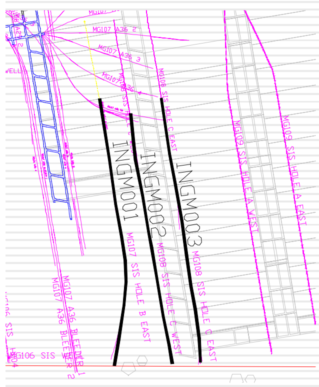
UIS Gas Total

Gas flows summed according to drilling schedule



Surface to In-Seam (SIS) Drilling

- Modelling uses SIMED II
- Models calibrated on SIS wells INGM001~3 to fix the not so easily measured parameters (compressibility, porosity, rel perm, n factor, skin).
- Model includes reduction in perm with increasing effective stress (n factor) and matrix shrinkage. Utilises experience from MGP.

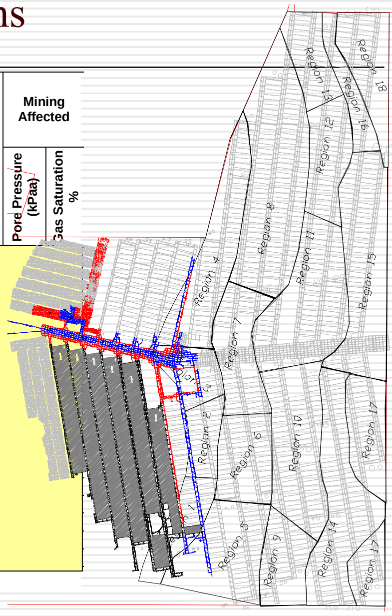


Reservoir Regions

- Concept of “reservoir regions” is applied to model the continuum of changing reservoir parameters with depth of cover.
- Parameters within each region are assumed constant – only for the purpose of managing the modelling.
- Applied to GM and P seams

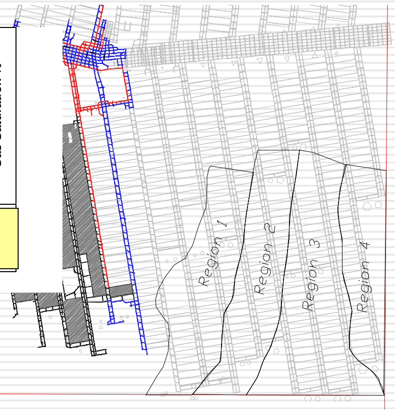
GM Seam Reservoir Regions

Region	Area (km2)	Depth (m)	Measured Gas Content at Seam Ash, 20°C Qm (m3/t)	Permeability (mD)	Seam Ash%	Seam RD g/cc	Thickness (m)	Before Mining: Pore Pressure (kPaa)	Before Mining: Gas Saturation %	LV @ Seam Ash calc 20°C & Res Temp (m3/t)	Reservoir Temperature °C	Mining Affected: Pore Pressure (kPaa)	Mining Affected: Gas Saturation %
1	1.17	260	Classified				5.5						
2	0.79	250					5.6						
3	0.98	230					5.9						
4	2.64	245					6.1						
5	2.41	300					5.5						
6	1.56	290					5.6						
7	1.78	290					6.1						
8	4.47	305					5.9						
9	1.32	345					5.7						
10	2.76	340					5.8						
11	3.19	335					6						
12	1.47	335					5.9						
13	1.16	320					5.9						
14	2.96	375					5.75						
15	3.25	360					6						
16	0.80	350					6.2						
17	2.14	395					5.55						
18	1.52	350					6.35						



P Seam Reservoir Regions

Region	Area (km2)	Depth (m)	Measured Gas Content at Seam Ash, 20°C Qm (m3/t)	Permeability (mD)	Seam Ash%	Seam RD g/cc	Thickness (m)	Pore Pressure (kPaa)	LV @ Seam Ash calc 20°C & Res Temp (m3/t)	Reservoir Temperature °C	Gas Saturation %
1	2.15	263	Classified				4.5				
2	2.03	288					4.5				
3	2.84	313					4.5				
4	1.41	332					4.5				

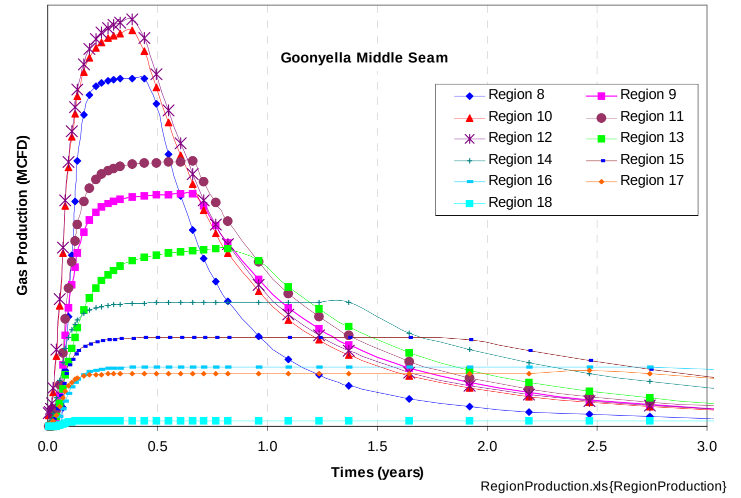


GM & P Seam Production Profiles

- Based on well spacing 390 m
- Lateral length in coal 900 m
- Laterals run down dip to vertical well
- Where structure permits, dual laterals are used
- Wells are oriented to avoid intersection by gateroads

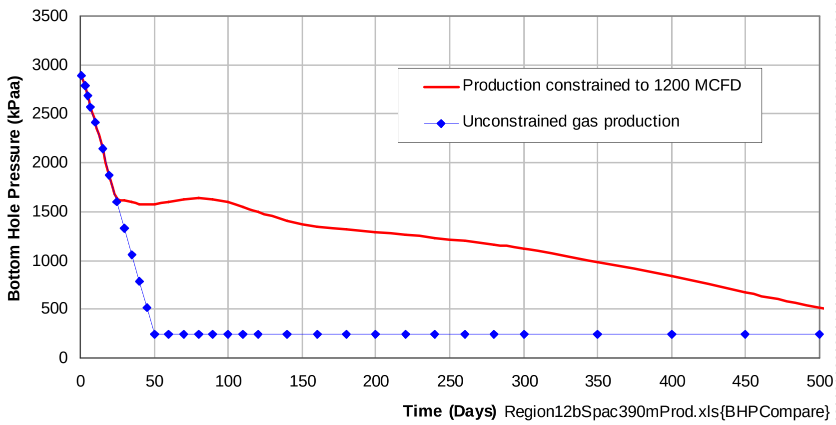
GeoGAS

GM Production Profiles



GeoGAS

Example of Bottom Hole Pressures Applied



GeoGAS

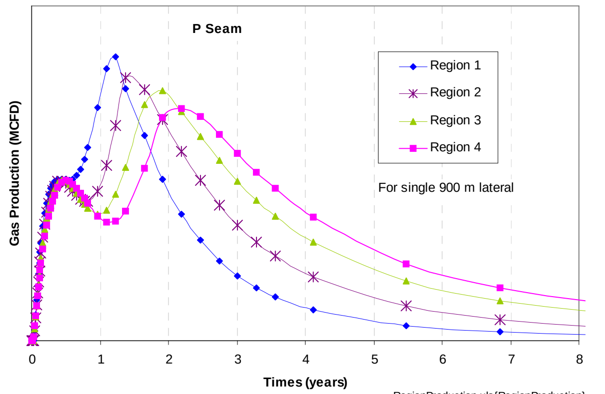
Gas Recovered Per Well and Remaining Gas Content

GM Seam Region	SIMED Data File	Remaining Gas Content Qm		PJ/Well to 50 MCFD
		Days to Target Qm	Years to < 3 m3/t	
8	Reg8a			Classified
9	Reg9a			
10	Reg10a			
11	Reg11a			
12	Reg12a			
13	Reg13a			
14	Reg14a			
15	Reg15a			
16	Reg16a			
17	Reg17a			
18	Reg18a			
8	Reg8b			
12	Reg12b			
9	Reg9_192			
9	Reg9_268			

(1) Target is < 4 m3/t these wells

GeoGAS

P Seam Production Profiles



Wells peak lower and later than GM

RegionProduction.xls{RegionProduction}

P Seam Region	Data File *.dat	Remaining Gas Content		PJ/Well to 50 MCFD	
		Days to Target Qm	Years to < 3 m3/t	Single Lateral	Dual Lateral
1	RegP1a			Classified	
2	RegP2a				
3	RegP3a				
4	RegP4a				

GeoGAS

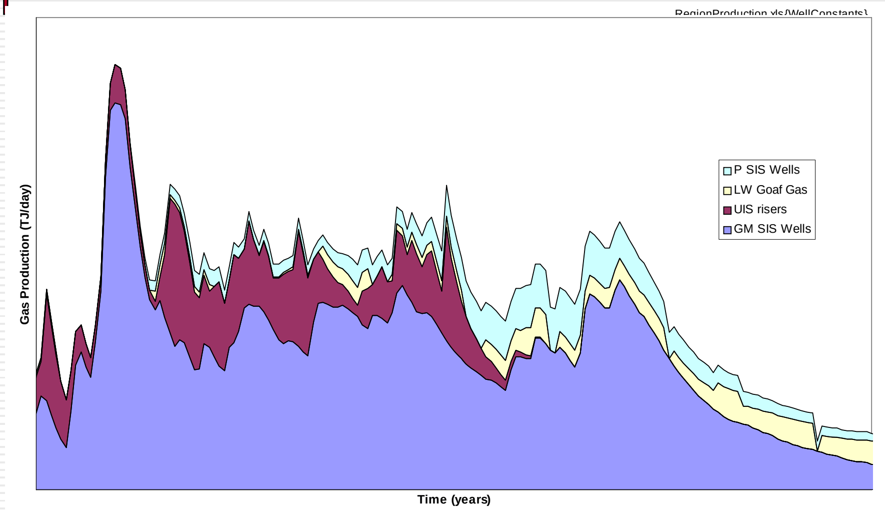
Well Sequencing

Seam	Data File *.dat	Well No	Well Sequence	Single or Dual Lateral	Date on Gas	Mined Through	Days on Line	Days Needed	Gas Drained < Target
GM	Reg9_192	INGM006							OK
GM	Reg9_192	INGM007							OK
GM	Reg9_268	INGM008							OK
GM	Reg8a	R8-01							OK
GM	Reg8b	R8-02							OK
GM	Reg8a	R8-03							OK
GM	Reg8a	R8-04							OK
GM	Reg8a	R8-06							OK
GM	Reg10a	R10-01							OK
GM	Reg10a	R10-02							OK
GM	Reg10a	R10-03							OK
GM	Reg9a	R9-01							OK
P	RegP1a	R1-01(P)							OK
P	RegP1a	R1-02(P)							OK
GM	Reg8a	R8-07							OK
GM	Reg8a	R8-08							OK
GM	Reg8b	R8-05							OK
GM	Reg14a	R14-01							OK
GM	Reg14a	R14-02							OK
GM	Reg10a	R10-06							OK
GM	Reg11a	R11-01							OK
GM	Reg15a	R15-02							OK
GM	Reg15a	R15-01							OK
GM	Reg14a	R14-04							OK
P	RegP2a	R2-01(P)							OK
GM	Reg14a	R14-03							OK
GM	Reg17a	R17-03							OK
GM	Reg13a	R13-01							OK

58 wells in all
First 28 shown here

GeoGAS

GM & P Seam Pre Drainage Gas Production



GeoGAS

Uncertainty

GeoGAS

Predrainage Gas Production

- UIS
  - Delays in mining will impact on gas production ✗
  - Air dilution under negative pressure □
- SIS
  - Not tied to mining ✓
  - Pipeline quality gas ✓
  - Design and operational risks ✗
  - Changes to mine plan and schedule ✗

GeoGAS

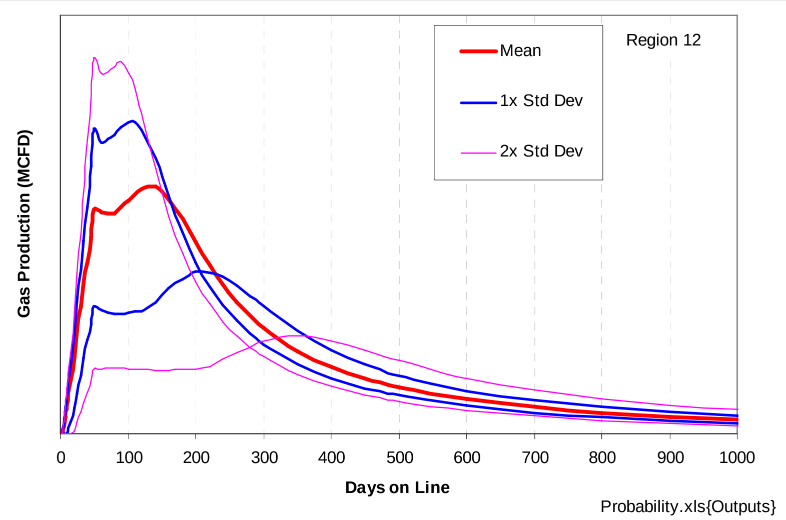
Modelling Uncertainty

- Uses the three main variable parameters
  - Gas content
  - Sorption capacity
  - Permeability
- Aiming for combined output of 1 standard deviation for these parameters

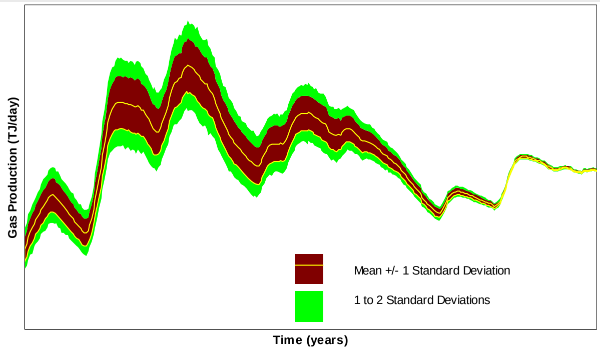
P Case	# of Standard Deviations		
	1 param	2 params	3 params
P90	0.1257	0.01253	0.001253
P68.3	0.4088	0.1265	0.04005
P50	0.6745	0.3186	0.1573
P31.7	**1**	**0.6221**	**0.41**
P10	1.645	1.311	1.101

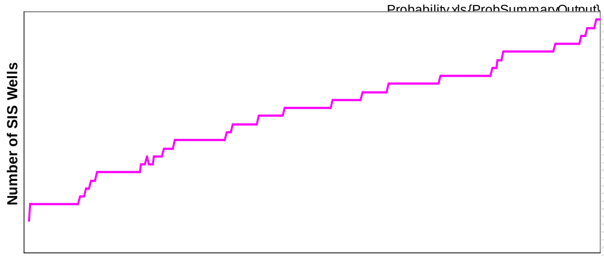
GeoGAS

Gas Production Distribution



Probability Distribution SIS Well Production





Days Required to Reach Target Gas Content

	Region X	Region Y
+2*1 Std Dev	650	2000
+1 Std Dev	750	2250
Mean	900	2750
-1 Std Dev	1200	4000
-2 Std Dev	1750	5500

GeoGAS

Conclusions

- A drilling and drainage schedule was defined that utilised the available drainage time at the widest spacing to produce the required level of gas but with priority on satisfying mine gas management requirements.
- The power station off-take is a managed, but independent and subsidiary outcome to mine gas management.
- Gas production begins to tail down with the completion of SIS well drilling from 2016~2020. Maintenance of gas production beyond this time is expected with higher rates of gas capture of longwall gas and with capture of gas from the destressed reservoir above the GM seam.
- The SIS methodology has been deliberately "simple" and timely.

GeoGAS

Conclusions (cont)

- An assessment of SIS well modelling output has shown a wide range of production variability on a well-by-well basis. This uncertainty can be managed by bringing forward production wells and operating at higher well head pressures if production exceeds demand and is consistent with mining requirements.
- As indicated in probability modelling, variations in remaining gas content from SIS drilling can be high.
- Realisation of the project gas production rates will require operating the field at as low a well head pressure as possible. Modelling assumed a wellhead pressure of 150 kPag. Intended field pressure beyond 2010 is 100 kPag.