

# Santos Pty Ltd

## Dewhurst 8A

### Gas Desorption Analysis Report

---

7 JULY 2014

---

## Contents

Contents .....	1
Executive Summary .....	1
Gas Content .....	1
Gas Composition .....	1
1 Introduction .....	4
2 Procedures .....	5
2.1 Field .....	5
2.2 Laboratory .....	6
2.2.1 Gas Volume Measurement .....	6
2.2.2 Lost Gas (Q1) .....	6
2.2.3 Desorbable Gas (Q2) .....	6
2.2.4 Residual Gas (Q3) .....	7
2.2.5 Coal Analysis .....	7
2.2.6 Total Gas Content ( $Q_m$ ) .....	7
2.2.7 Gas Composition .....	7
3 Results .....	10
3.1 Sample Geology .....	10
3.2 Gas Content .....	10
3.2.1 Lost Gas (Q1) .....	10
3.2.2 Desorbable Gas (Q2) .....	10
3.2.3 Residual Gas (Q3) .....	10
3.2.4 Total Gas Content ( $Q_m$ ) .....	10
3.3 Gas Composition .....	14
4 QAQC .....	15
4.1 Initial Desorption rate (IDR30) .....	15
4.2 Lost Gas (DAF) vs Diffusivity .....	15
4.3 Ash and Moisture Content .....	16
5 ALS Earth Data Desorption Glossary .....	18
6 References .....	20

## List of Tables

<b>Table ES-1:</b> Desorption Sample Properties .....	2
<b>Table ES-2:</b> Gas Composition Results .....	2
<b>Table 1:</b> Well Information .....	4
<b>Table 2:</b> Standard Frequency of Field Desorption Measurements .....	5
<b>Table 3:</b> Analysis Performed on Desorption Samples .....	8
<b>Table 4:</b> Service Providers and Methodologies .....	9

**Table 5: Gas Desorption Summary (Raw and DAF) ..... 11**

## List of Figures

**Figure 1: Combined Lost Gas and Desorbed Gas (Q1+Q2) vs Elapsed Time (DAF) ..... 11**  
**Figure 2: Lost, Desorbed and Residual Gas Content Summary (DAF) ..... 13**  
**Figure 3: Lost, Desorbed and Residual Gas Content Summary as % of Total Gas (DAF) ... 13**  
**Figure 4: Gas Composition Methane Concentrations for Desorption ..... 14**  
**Figure 5: Gas Content (Raw) vs Initial Desorption Rate (IDR30) ..... 15**  
**Figure 6: Lost Gas (DAF) vs Diffusivity ..... 16**  
**Figure 7: Correlation of Ash and Moisture Content to Relative Density ..... 16**  
**Figure 8: Correlation of Q2 Ash Content to Q3 Ash Content ..... 17**

## List of Appendices

**Appendix I ..... Gas Desorption Measurement Report**  
**Appendix II ..... Gas Composition Analyses**  
**Appendix III ..... Geological Information**  
**Appendix IV ..... Coal Analyses**  
**Appendix V ..... Definition of Confidence Constraints**

## Executive Summary

In November 2013, ALS Earth Data Pty Ltd was engaged by Santos Pty Ltd to provide well site and gas desorption analysis services for the well Dewhurst 8A in New South Wales, Australia. Gas desorption properties were measured on twenty-seven (27) core samples, with a combined thickness totalling 20.270 m collected from the cored interval of Dewhurst 8A. Additional analyses were performed on the core samples once the desorption measurements were completed.

### *Gas Content*

Confidence in these results has been determined as high as defined in Table A in Appendix V. Total gas content, on a dry, ash-free (DAF) basis, varies between 6.51 m<sup>3</sup>/tonne and 15.18 m<sup>3</sup>/tonne. These results are presented in Table ES-1.

### *Gas Composition*

Three (3) gas composition samples were scheduled for collection from each desorption sample: the first at 2-6 hours after the first desorption measurement (A), the second at 12 hours after the first desorption measurement (B), and the third at time of the final desorption measurement (C). Not all desorption samples were sampled for gas composition as scheduled due to insufficient volumes of gas produced at the scheduled times.

The C gas composition samples were not analysed by ALS Earth Data as they were suspected to contain H<sub>2</sub>S due to foul odour. H<sub>2</sub>S combines with any moisture in the sample or moisture that is on the columns in the Gas Chromatograph (GC) to form sulphuric acid. The acid corrodes the columns in the GC and causes major damage to the instrument. These gas composition samples were instead sent to ALS Environmental for analysis, the results are presented in Appendix II.

Only the A and B gas composition results have been reported in Table ES-2 of this report.

One (1) gas isotope sample was scheduled for collection from each of the desorption samples DWH8A\_004, DWH8A\_010, DWH8A\_012, DWH8A\_014, DWH8A\_017, DWH8A\_020, DWH8A\_024, DWH8A\_025, and DWH8A\_027 for analysis; at the time of the final desorption measurement (IC). These desorption samples were not selected for gas composition analysis.

The confidence in the results for cases where the air contents exceed 40 mol% is considered low as defined in Table A in Appendix V.

Methane concentrations are between 36.90 mol% and 94.50 mol% on an air-free basis.

Concentrations of methane, higher order hydrocarbons, carbon dioxide and nitrogen for all samples are presented in Table ES-2.

**Table ES-1: Desorption Sample Properties**

Sample ID	Depth From (mMD)	Depth To (mMD)	Seam/Formation	Time on Test (Days)	Reservoir Temperature (°C)*	Total Raw Gas Content (m <sup>3</sup> /tonne)#	Total DAF Gas Content (m <sup>3</sup> /tonne)	Sorption Time (Days)^\wedge	Diffusivity (sec <sup>-1</sup> )	Relative Density	Ash (% ad)
DWH8A_001D	512.020	512.810	Black Jack Group	116	35.0	2.61	6.51	3.84	1.92E-05	1.91	55.4
DWH8A_002D	540.220	541.020	Black Jack Group	116	35.0	4.87	8.80	4.45	1.44E-05	1.72	40.2
DWH8A_003D	541.020	541.820	Black Jack Group	116	35.0	5.84	9.13	4.45	1.57E-05	1.62	31.6
DWH8A_004D	541.820	542.590	Black Jack Group	116	35.0	5.34	8.31	5.45	1.19E-05	1.62	31.4
DWH8A_005D	545.890	546.690	Black Jack Group	116	35.0	5.26	8.81	5.38	1.20E-05	1.68	35.8
DWH8A_006D	548.700	549.320	Black Jack Group	116	35.0	3.18	8.01	6.42	7.58E-06	1.91	56.6
DWH8A_007D	550.790	551.580	Black Jack Group	116	35.0	6.94	10.32	5.31	1.31E-05	1.59	28.4
DWH8A_008D	553.850	554.560	Black Jack Group	116	35.0	7.85	10.66	3.33	2.41E-05	1.53	21.5
DWH8A_009D	590.680	591.480	Hoskissons Coal	116	35.0	7.24	9.45	5.99	1.53E-05	1.50	19.0
DWH8A_010D	594.260	595.060	Hoskissons Coal	116	35.0	6.95	8.76	12.96	7.84E-06	1.46	16.0
DWH8A_011D	597.800	598.610	Hoskissons Coal	116	35.0	6.76	8.61	5.94	1.06E-05	1.51	16.6
DWH8A_012D	599.260	600.050	Hoskissons Coal	116	35.0	7.44	9.52	4.42	1.69E-05	1.49	16.8
DWH8A_013D	649.220	650.010	Arkarula	115	49.0	7.12	9.53	3.65	1.44E-05	1.53	22.0
DWH8A_014D	651.980	652.780	Arkarula	115	49.0	7.95	10.06	2.65	2.12E-05	1.47	17.8
DWH8A_015D	896.900	897.700	Rutley Seam	113	49.0	7.60	11.09	1.76	2.48E-05	1.67	29.6
DWH8A_016D	897.940	898.740	Rutley Seam	113	49.0	11.42	13.20	0.73	5.51E-05	1.42	10.8
DWH8A_017D	898.740	899.460	Rutley Seam	113	49.0	12.05	13.81	0.43	7.30E-05	1.43	9.7
DWH8A_018D	900.590	901.370	Rutley Seam	113	49.0	13.43	14.71	0.52	7.02E-05	1.38	5.0
DWH8A_019D	908.480	909.280	Namoi Coal	113	49.0	12.66	13.90	0.39	8.15E-05	1.38	5.5
DWH8A_020D	909.280	910.040	Namoi Coal	113	49.0	14.10	15.18	0.23	1.05E-04	1.37	3.5
DWH8A_021D	910.040	910.830	Namoi Coal	113	49.0	13.76	15.02	0.28	9.48E-05	1.38	5.1
DWH8A_022D	961.890	962.360	Bohena Upper Coal	112	49.0	11.11	12.27	0.70	5.78E-05	1.37	5.7
DWH8A_023D	964.370	965.170	Bohena Main Coal	112	49.0	10.18	11.16	0.45	7.92E-05	1.40	5.3
DWH8A_024D	965.660	966.470	Bohena Main Coal	112	49.0	10.77	12.60	0.42	8.00E-05	1.46	12.0
DWH8A_025D	968.130	968.930	Bohena Main Coal	113	49.0	11.46	13.56	0.44	7.83E-05	1.45	12.4
DWH8A_026D	974.730	975.030	Bohena Main Coal	113	49.0	7.82	11.60	4.90	2.09E-05	1.58	29.5
DWH8A_027D	977.600	978.370	Bohena Lower Seam	113	49.0	11.34	13.57	0.36	9.40E-05	1.45	14.0

\*As prescribed by Santos Pty Ltd

#Raw Gas Content is back-calculated from the Total DAF Gas Content using moisture and ash values from both the desorption sample and the sub sample used to measure residual gas. This is not equal to the sum of Q1 (Raw), Q2 (Raw) and Q3 (Raw).

**Table ES-2: Gas Composition Results**

Desorption Sample ID	Composition Sample ID	Sample Timing (Days from Time Zero)	Air Content (mol%)	Methane (mol% Air Free)	C <sub>+</sub> (mol% Air Free)	CO <sub>2</sub> (mol% Air Free)	N <sub>2</sub> (mol% Air Free)
DWH8A_001D	A	0.3	4.57	92.00	0.07	5.64	2.29
	B	0.5	9.84	94.50	0.02	5.48	0.00
DWH8A_002D	A	0.3	4.57	78.90	0.03	20.00	1.07
	B	0.6	4.34	77.40	0.01	21.40	1.19
DWH8A_003D	A	0.4	2.88	78.60	0.00	19.70	1.76
	B	0.6	3.64	77.10	0.00	21.50	1.40
DWH8A_004D	A	0.4	7.01	79.70	0.00	20.10	0.21
	B	0.7	4.80	77.40	0.06	21.30	1.24
DWH8A_005D	A	0.4	2.61	72.20	0.02	26.20	1.58

Desorption Sample ID	Composition Sample ID	Sample Timing (Days from Time Zero)	Air Content (mol%)	Methane (mol% Air Free)	C <sub>+</sub> (mol% Air Free)	CO <sub>2</sub> (mol% Air Free)	N <sub>2</sub> (mol% Air Free)
	B	0.6	2.66	71.00	0.05	27.30	1.65
DWH8A_006D	A*	0.4	84.88	-	-	-	-
	B	0.6	15.93	71.80	0.10	28.10	0.00
DWH8A_007D	A	0.3	3.07	70.70	0.10	27.40	1.80
	B	0.6	1.96	70.00	0.06	28.30	1.64
DWH8A_008D	A	0.4	2.09	68.60	0.25	29.70	1.45
	B	0.6	1.67	68.60	0.17	29.90	1.33
DWH8A_009D	A	0.3	2.27	56.80	0.06	41.90	1.24
	B	0.5	2.78	55.90	0.00	43.20	0.91
DWH8A_010D	A	0.4	7.46	54.30	0.00	45.70	0.00
	B	0.9	3.84	54.00	0.00	44.90	1.14
DWH8A_011D	A	0.4	3.38	56.80	0.05	41.80	1.35
	B	0.9	2.86	56.10	0.03	42.60	1.27
DWH8A_012D	A	0.3	2.78	55.90	0.05	43.10	0.95
	B	0.7	5.81	55.00	0.00	45.00	0.00
DWH8A_013D	A	0.3	6.21	73.80	0.10	25.90	0.20
	B	0.6	2.32	72.40	0.01	26.30	1.29
DWH8A_014D	A	0.3	6.31	75.70	0.00	24.00	0.34
	B	0.6	1.62	75.00	0.01	23.60	1.39
DWH8A_015D	A	0.3	3.17	56.40	0.30	43.30	0.00
	B	0.6	10.05	53.50	0.30	44.40	1.80
DWH8A_016D	A	0.3	1.67	57.50	0.28	42.20	0.02
	B	0.6	3.51	56.40	0.20	43.40	0.00
DWH8A_017D	A	0.3	1.33	57.90	0.23	41.80	0.07
	B	0.6	3.73	56.70	0.30	43.00	0.00
DWH8A_018D	A	0.3	1.22	55.70	0.24	44.00	0.06
	B	0.5	2.98	55.40	0.30	44.30	0.00
DWH8A_019D	A	0.3	1.80	53.10	0.40	46.50	0.00
	B	0.5	3.29	52.50	0.40	47.10	0.00
DWH8A_020D	A	0.3	2.01	52.60	0.50	46.90	0.00
	B	0.5	5.09	51.60	0.50	47.90	0.00
DWH8A_021D	A	0.3	62.47	44.30	0.50	55.20	0.00
	B	0.5	1.84	53.70	0.40	45.90	0.00
DWH8A_022D	A	0.3	1.83	43.10	1.00	55.90	0.00
	B	0.5	2.23	42.30	1.10	56.60	0.00
DWH8A_023D	A	0.3	1.18	44.80	1.30	53.90	0.00
	B	0.5	1.58	43.30	1.40	55.30	0.00
DWH8A_024D	A	0.3	0.83	46.20	1.38	52.30	0.12
	B	0.6	1.14	42.60	1.60	55.80	0.00
DWH8A_025D	A	0.3	0.66	45.50	1.20	53.10	0.20
	B	0.6	1.23	42.20	1.50	56.30	0.00
DWH8A_026D	A	0.3	55.03	36.90	0.70	62.40	0.00
	B	0.6	5.42	40.20	0.90	58.90	0.00
DWH8A_027D	A	0.3	40.19	40.00	1.10	58.90	0.00
	B	0.5	3.57	42.10	1.20	56.70	0.00

\*Gas Composition results unable to be reported as sample contains <5% of measured components after air and purge gas corrections. This could be due to the following issues; (i) failure of a vessel or a leak, or (ii) low gas content of a desorption sample.

Note: Air content calculated using N<sub>2</sub>:O<sub>2</sub>+Ar ratio of 3.57 based on results obtained using He carrier gas.