SR27/4/75[illegible]/0
75/13
R96/00604

Cost Code: 891/W133/810/XXX

Purpose of Programme: To perforate and test Wirrarie 2 prior to connection as a Patchawarra gas producer .

Primary Contact

Project Leader:	Liang Chen	Phone: (W) 7382 (H) 314889
Team Leader:	Mathew Barley	Phone: (W) 7913 (H) 2729904

Current Status of Well: Cased and completed as a monobore with 3-1/2 inch tubing.

Brief Well History: Wirrarie #2 was drilled in April 1995 as a Murta Block Appraisal well to evaluate reservoir quality and development on the southern culmination of the Wirrarie field. The well intersected 22 feet of net gas pay in the Patchawarra and 7 feet potential oil pay in the basal Patchawarra. No tests were conducted, and the well was cased and completed as a monobore with 3-1/2 inch tubing by the drilling rig.

Location:

Latitude:	28° 14' 43.70" S
Longitude:	139° 54' 11.94" E

Elevation:

Ground Level:	86' ASL
Kelly Bushing:	103' ASL

Casing Details:

Surface

7" 23# K55 LT&C casing run to 4629 ft KB. Cemented with 100sx Lead cement and topped up with 200sx Tail cement with returns to surface.

Production Liner

3-1/2" 9.3# J55 NK3SB liner to 7007 ft KB

PBTD: 7007 ft KB

Reservoir Pressure: Patchawarra: 3024 psi at 6715' KB - Wirrarie North #1 RFT

Reservoir Temperature: Patchawarra: 241°F - Wirrarie North #1 DST #1

Equipment Requirement

Flare pit
Flare line
Separator to measure gas and liquid rates, and tanks as required to enable oil / water measurements.

Procedure

1. Rig in Schlumberger. Run GR/CCL/CBL and correlate with DLL/MSFL/GR log dated 22 April 1995. Rig down Schlumberger.

2. Rig up Expertest to swab well to 4200 ft KB. Rig down Expertest.

3 Make up 2-1/2" HSD hollow carrier gun at 6 SPF, 60^0 phasing and 10.5 gm 31J charges and a MWPT(measurement while perforating) assembly. RIH and perforate the following intervals:

Sand	Depth	Interval
71-2	6860-6870 ft KB	10 ft
71-2	6874-6885 ft KB	11 ft

Correlate with DLL/MSFL/GR log of 22/4/95, using the GR/CCL to locate collars. Perforate the 71-2 sand and flow to clean up for 1/2 hour.

Note: Downhole sampling rate of 1 pressure and 1 temperature every minute.

4. Conduct a flow and build up test. The aim of this test is to obtain accurate data on the well productivity, reservoir pressure and skin. Continue to flow the well to a total of 3 hours (if possible), recording the following data:

Choke size
FTHP and temperature
Annulus pressure
All flow rates (gas, oil, water)

Pressurised samples of any condensate and gas produced should be taken shortly before the well is SI. Routine water samples should also be taken.

5. Before shutting in the well, change the sampling rate to one second increment. Shut the well in for a minimum build up time of 4 hours. Monitor the SRO for radial flow(indicated by flat log-log derivative plot).

If the well does not flow to surface it will be necessary to monitor the SRO and continue the build up for 6 hours or until the log-log derivative plot indicates radial flow.

Note : If the zone produces a significant volume of water, it may be necessary to set a **bridge plug** above this zone prior to perforating the upper gas sands. Depending on plug availability, the job may need to be suspended at this point until the plug can be mobilised.

6. Continue to perforate the Patchawarra gas sands with the same gun system as follows:

Sand	Depth	Interval
70-1	6734-6744 ft KB	10 ft
70-4	6770-6775 ft KB	5 ft
70-6/9	6806-6824 ft KB	18 ft
	6829-6836 ft KB	7 ft

Note: Correlate as in Step 3.

6 Rig down Schlumberger.

7. Flow well to clean up for 4 hours or until rate is stable. Measure and report rates of gas, water and condensate. Repeat compositional sampling as above.

8. Shut in well, pending static gradient survey.

Prepared by: _____ **Date:** 22/5/95
Petroleum Engineer

Approved by: _____ **Date:** 22-5-95
Team Leader - SWAT Petroleum Engineering

Distribution:

Well File	Original
PE Dept - Mba	(7)
PE Supt - Mba	(1)
Production Supt Mba	(1)
Mines & Energy SA	(1)
Contact Personnel	(2) MRB: KLC.

PRA:017/95

PERFORATION RECOMMENDATION APPROVAL

WELL: WIRRARIE 2 **DATE:** 26/04/95

FORMATION: PATCHAWARRA **AUTHOR:** G. MARCUS

DEPTH REFERENCE LOG: AS-MSFL-DLL-GR-AMS-SP TRANSMITTED LOG **LOG DATE:** 20/04/95

RECOMMENDED PERFORATIONS:

FORMATION	SAND	RECOMMENDED PERFORATION INTERVAL (ft.KB)	GROSS SAND INTVL (ft)	NET PAY (ft)	Ø Avg (%)	Sw Avg (%)	POTENTIAL FLOW (MMCFD)	POTENTIAL OGIP INCREASE (BCF)
Patchawarra	70-1	6734-6744	7	6	11.9	37.2	)	)
	70-4	6770-6775	3	3	12.0	47.0	) 4	) 6.3
	70-6/9	6806-6824	8	7	14.4	30.3	)	)
		6829-6836	6	6	13.9	44.2	)	)
	71-2	6860-6870	3*	-	-	-		-
		6874-6885	4*	-	-	-		-

* Potential oil zone - no resource mapped pending cased hole evaluation.

REASONS FOR PERFORATION:

Wirrarie 2 was drilled as a Patchawarra Formation gas appraisal well and reached TD on 20/04/95.

No DSTs were run, and the well was completed by the drilling department as a monobore completion with evaluation of all zones to be finalised through pipe.

It is recommended that the lower two zones (6860-6885) be perforated to test the potential of this interval to produce oil from what is interpreted to be fractured reservoir rock. Influx information from this zone is required.

The remaining zones should then be perforated and flow rates determined.

CURRENT WELL STATUS:

The well is currently cased with a monobore completion awaiting connection.

RECOMMENDATION:

It is recommended that Wirrarie 2 be perforated and tested at the earliest opportunity and then suspended as a future gas producer.

WELL: WIRRARIE 2

FORMATION: PATCHAWARRA

SANDS TO BE PERFORATED: 70-1, 70-4, 70-6/9, 71-2

SUBMITTED BY:

Geologist DATE: 26/4/95

Petroleum Engineer DATE: 27/4/95

RECOMMENDED BY:

Team Leader, Exploration/Development - SA DATE: 26/4/95

Team Leader, Petroleum Engineering - SA DATE: 27/4/95

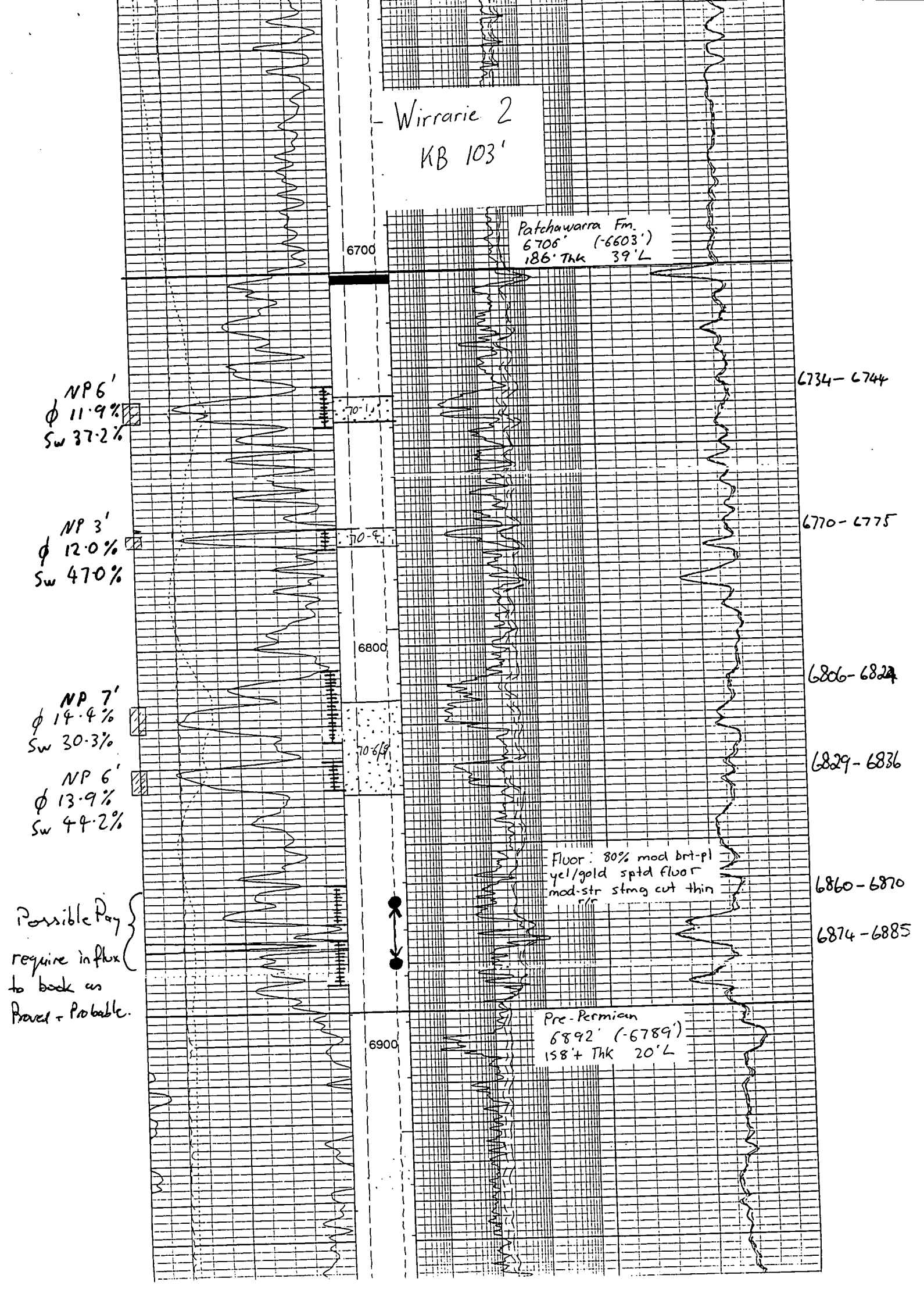
APPROVED BY:

Manager, Exploration/Development - SA DATE: 1/2/95

Manager, Petroleum Engineering - SA DATE: 2/5/95

WHEN SIGNED: ONE COPY TO PETROLEUM ENGINEERING DRILLING & COMPLETIONS GROUP AND THEN RETURN TO EXPLORATION/DEVELOPMENT.

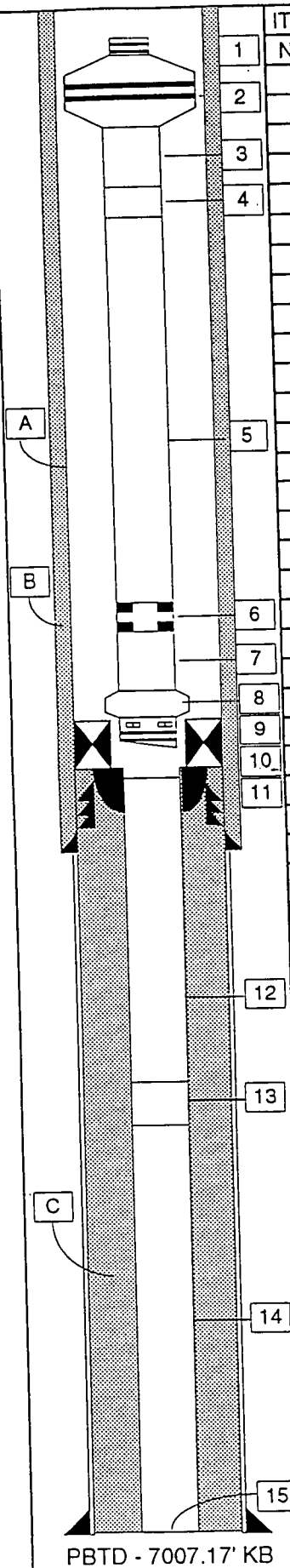
+ 1 copy to Lang Chen


Wirrarie 2
KB 103'
Patchawarra Fm.
6706' (-6603')
186' Thk 39'L
6700
NP 6'
ϕ 11.9%
Sw 37.2%
6734 - 6744
NP 3'
ϕ 12.0%
Sw 47.0%
6770 - 6775
6800
6806 - 6824
NP 7'
ϕ 14.4%
Sw 30.3%
NP 6'
ϕ 13.9%
Sw 44.2%
6829 - 6836
Fluor: 80% mod brt-pl yel/gold sptd fluor mod-str stmg cut thin r/r
6860 - 6870
6874 - 6885
Possible Pay
require influx to back as Proved + Probable.
Pre-Permian
6892' (-6789')
158'+ Thk 20'L
6900

PETROLEUM ENGINEERING MOOMBA
DOWNHOLE COMPLETION

Santos
Santos Ltd A.C.N 007 550 923

WELL: WIRRARIE 02 **DATE: 25/4/95**



ITEM No.	DESCRIPTION	LENGTH (ft)	DEPTH KB (ft)	MIN. ID (in)
1	K.B. - top of bradenhead (tbg hgr landed in bradenhead)	17.38		
2	COT FBB-EN tbg hgr 3-1/2" NK3SB B x 3-1/2" CS-Hydril	0.83	17.38	2.950
3	1 x 3-1/2" 9.3# J55 NK3SB Tubing HT 36429	31.49	18.21	2.901
4	1 x 2', 1 x 10' x 3-1/2" 9.3# J55 NK3SB Pup jts HT 93425	12.34	49.70	
5	13 x 3-1/2" 9.3# J55 NK3SB Tubing HT 36429	4239.51	62.04	
	40 x 3-1/2" 9.3# J55 NK3SB Tubing HT 93904		4301.55	
	20 x 3-1/2" 9.3# J55 NK3SB Tubing HT 36429		4301.55	
	62 x 3-1/2" 9.3# J55 NK3SB Tubing HT 38969		4301.55	
6	OTIS Landing Nipple 711X33, 3-1/2" NK3SB c/w Collar	1.25	4301.55	2.750
7	1 x 3-1/2" 9.3# J55 NK3SB Tubing HT 38969	30.74	4302.80	
8	Baker Tie Back Locator Seal Stem 3-1/2" NK3SB Box up	1.00	4333.54	4.275
	c/w 3 x Moly Glass seal units. (LOA = 6.83')		4334.54	
	Bottom of tubing string		4341.37	
	Locator seal OD 5.25" w/ 5.75" OD stop shoulder at top of seal section			
9	Baker Type CPH Liner packer 5" 18#	12.13	4334.75	
10	Baker Spacer nipple 5" x 18#	6.10	4346.88	
11	Baker Type HYFLO 2 Liner Hanger 5" 18# 3-1/2" NK3SB	6.80	4352.98	
12	73 x 3-1/2" 9.3# J55 NK3SB Tubing (HT not recorded)	2291.70	4359.78	2.901
13	1 x 3-1/2" 9.3# J55 NK3SB marker joint (HT not recorded)	9.31	6651.48	
14	11 x 3-1/2" 9.3# J55 NK3SB Tubing (HT not recorded)	346.48	6660.79	
15	Float Collar / dart catcher (Drilling PBTD: 7007.27)	2.75	7007.17	
A	Surface casing 118 jts 7" 23# K55 LTC R3 Sfc Csg float/guide shoe @		4633.82	
B	Surface Casing Cement			
C	Liner Cement			

PERFORATION INTERVALS:

FORMATION	INTERVAL (FT / KB)	GUN: SIZE	GUN: TYPE	GUN: PHASE	GUN: SPF	CHARGES: TYPE	CHARGES: WT(g)
Not Perforated as of 26/4/95.							

REMARKS:	Filtered 2% 8.43 ppg KCl Brine in tubing, same in main hole liner.
ANNULUS FLUID:	Filtered inhibited 2% KCl Brine in annulus.
INDICATED STRING WEIGHT:	53,000# (18,000# Blocks weight)
CALCULATED STRING WEIGHT:	52,000# (18,000# Blocks weight)
SLACK-OFF WEIGHT:	10,000#
TENSION:	Not Applicable

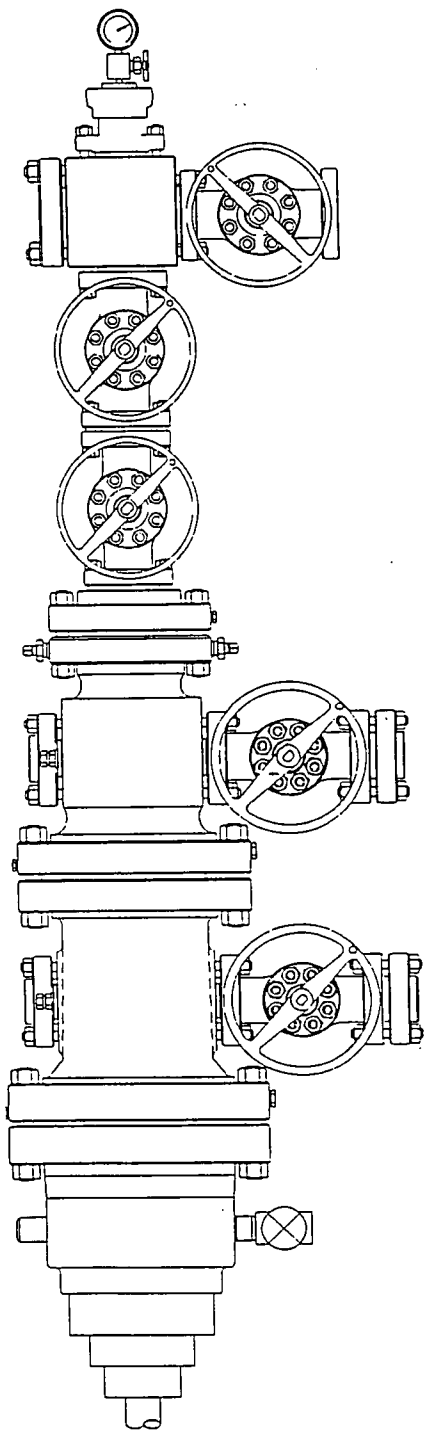
NOT TO SCALE	Wellsite Representative	B. Assels	
OTHER: Hanger Yield = 105M#	DATE OF INSTALLATION	27/4/95	
Proposed: G. Soulmatis	Drafted: B. Assels	Date:	26/4/95
Completion: B. Assels	27/4/95	Checked: M. Gillies	29/4/95

OTHER: 27/4/95; 2.625" Gauge ring found soft fill 6907' - 6940' KB. Could not pass 6940' KB.

PETROLEUM ENGINEERING MOOMBA
SINGLE WELLHEAD AS INSTALLED

Santos
Santos Ltd A.C.N 007 550 923

WELL: WIRRARIE 02 **DATE:** 26/4/95



DESCRIPTION			
TREE CAP	MAKE/TYPE		COT
	SIZE/RATING		3-1/8" / 3000
	LIFT THREAD		3-1/2" EUE
	FITTINGS		1/2" AG Valve
FLOW CROSS	MAKE		COT
	SIZE		3-1/8" x 3-1/8" x 3-1/8" x 2-1/16"
	RATING		3000
	OUTLET	FITTINGS	
	WING VALVE	MAKE	McEvoy Willis
		TYPE	
		SIZE	3-1/8"
		RATING	3000
		TRIM	CS / AS / AS
UPPER MASTER VALVE	MAKE		COT
	TYPE		FL
	SIZE		3-1/8"
	RATING		3000
	BODY / TRIM		Alloy /CR13-HF-CO
LOWER MASTER VALVE	MAKE		COT
	TYPE		FL
	SIZE		3-1/8"
	RATING		3000
	BODY / TRIM		Stainless /CR13-HF-CO
ADAPTOR FLANGE	MAKE/TYPE		COT / Seal Pocket
	SIZE/RATING		7-1/16" x 3-1/8" / 3000
TUBING SPOOL	MAKE/TYPE		
	SIZE/RATING		
	OUTLET 1	VALVE	Not Applicable - Monobore Completion
	OUTLET 2	FITTINGS	
*CASING SPOOL	MAKE/TYPE		
	SIZE/RATING		
	OUTLET 1	VALVE	Not Applicable - Monobore Completion
	OUTLET 2	FITTINGS	
CASING BOWL	MAKE/TYPE		COT- threaded & w/ FBB hanger profile
	SIZE/RATING		7" x 7-1/16" / 3000
	OUTLET 1	VALVE	2" NPT PxP nipple c/w 1-1/2" thread prep
			COT 2" NPT x 2-1/16" 3000 gate valve
	OUTLET 2	FITTINGS	2" NPT PxP nipple c/w 1-1/2" VR Plug
COND. PIPE	SIZE,WT./GR./THD./DEPTH		9-5/8" 36# K55 to approx 40 ft
SFC. CSG	SIZE,WT./GR./THD./DEPTH		7" 23# K55 LTC R3 / 4633.82'
LINER	SIZE,WT./GR./THD./DEPTH		3-1/2" 9.3# J55 NK-3SB / 7043.00'
TUBING	SIZE,WT./GR./THD./DEPTH		3-1/2" 9.3# J55 NK-3SB / 4341.37
TUBING HANGER	MAKE/TYPE		COT / FBB-EN
	LIFT THD./BPV PREP.		3-1/2" CS-Hydril / 3" H-1, H-2
REMARKS	STRING WT. INDICATED		53,000# (18,000# Blocks weight)
	CALCULATED		52,000# (18,000# Blocks weight)
	SLACKOFF WT.		10,000#
	OTHER		

GINPOLE INSTALLED: **YES**

* INTERMEDIATE CASING INSTALLED? **NO**

AUTHOR: B. Assels 26/4/95

CHECKED: M. Gillies 29/4/95 MG 2/4/95

E.753

Santos Limited	Report File:	S021205A.PAN

Wirrarie #2 BHP Survey May 1996

Well Test Analysis Report

Analyst name	Edmund Leung
Company	Santos Limited
Field	Wirrarie
Well	2
Date	14 / 05 / 96
Formation	Patchawarra
Test	BHP / SGS
Depth Reference	103 ft.ASL
Gauge Type	McAllister
Gauge Number	553
Gauge Depth - Measured	6810 ft.KB
Gauge Depth - Vertical	-6707 ft.SS
Perforated Interval Top	6770 ft.KB
Perforated Interval Bottom	6885 ft.KB

Remarks: This was an in-line test and therefore no flow rates were recorded prior to a 96 hour shut-in. A gas flow rate of 0.767 MMscf/d was used in this well test analysis.

Phase redistribution in the early-time data (ETR) and mechanical problems in the late-time region (LTR) have affected the quality of the pressure data and are clearly evident from the Log-Log plot. From the Test Overview, a pressure drop occurred 50 hours into the build-up. This pressure disturbance lasted about 20 hours. Therefore the quantitative results presented in this report has only considered reliable data to be 50 hours into the build-up. Hence, the results below should be used with caution.

A radial flow regime was identified in the middle-time region (MTR) from the Log-Log plot. Using the MTR on the Horner plot, a reservoir conductivity of 27.6 md.ft (1.3 md) was determined with negligible skin damage.

An extrapolation of the MTR of the Horner plot yielded a reservoir pressure of 2206 psia at a guage depth of 6810 ft.KB.

Santos Limited	Report File:	S021205A.PAN
Wirrarie #2 BHP Survey May 1996		
Well Test Analysis Report		

Reservoir Description
Fluid type : Gas
Well orientation : Vertical
Number of wells : 1
Number of layers : 1

Layer Parameters Data

	Layer 1
Formation thickness	22.00 ft
Average formation porosity	0.132
Water saturation	0.382
Gas saturation	0.00
Formation compressibility	4.3331e-6 psi-1
Total system compressibility	5.6614e-6 psi-1
Layer pressure	2206.1501 psia
Temperature	247.0000 deg F

Well Parameters Data

	Well 1
Well radius	0.25 ft
Distance from observation to active well	0.0000 ft
Wellbore storage coefficient	0.037 bbl/psi
Well offset - x direction	0.00 ft
Well offset - y direction	0.00 ft

Fluid Parameters Data

	Layer 1
Gas gravity	0.7306 sp grav
Water-Gas ratio	0.0000 STB/MMscf
Water salinity	0.0000 ppm
Check Pressure	2500.0000 psia
Check Temperature	247.0000 deg F
Gas density	7.58653 lb/ft3
Initial gas viscosity	0.0177017 cp
Gas formation volume factor	7.3535e-3 ft3/scf
Water density	59.1385 lb/ft3
Water viscosity	0.20457 cp
Water formation volume factor	1.05458 RB/STB
Initial Z-factor	0.92038
Initial Gas compressibility	3.9121e-4 psi-1
Water compressibility	3.4771e-6 psi-1

Layer 1 Correlations
Ug Correlation : Carr et al

Layer Boundaries Data
Layer 1 Boundary Type : Infinitely acting

	Layer 1
L1	0.0000 ft
L2	0.0000 ft
L3	0.0000 ft
L4	0.0000 ft
Drainage area	0.0000 acres
Dietz shape factor	0.0000

Layer 1 Model Data
Layer 1 Model Type : Radial homogeneous

Santos Limited	Report File:	S021205A.PAN
Wirrarie #2 BHP Survey May 1996		
Well Test Analysis Report		

	Layer 1
Permeability	1.2539 md
Skin factor (Well 1)	-0.5423
Rate dependent skin coefficient (D)	0.0000 1/(Mscf/day)

Layer 1 P/U/Z Table

Pi psia	Initial gas viscosity cp	Zi
0.0000	0.01372714	1.000
103.4483	0.01374948	0.99336
206.8965	0.013831	0.98693
310.3448	0.01393964	0.98071
413.7931	0.01407912	0.97471
517.2413	0.01418799	0.96896
620.6896	0.01438453	0.96347
724.1379	0.01457882	0.95824
827.5862	0.01471415	0.9533
931.0344	0.01485151	0.94866
1034.4827	0.01496861	0.94433
1137.9310	0.01508647	0.94031
1241.3793	0.01525004	0.93663
1344.8275	0.01540752	0.93328
1448.2759	0.01558841	0.93029
1551.7241	0.0157884	0.92765
1655.1724	0.01598839	0.92537
1758.6206	0.01618837	0.92346
1862.0688	0.01638836	0.92191
1965.5172	0.01658835	0.92073
2068.9653	0.01678833	0.91992
2172.4138	0.01700506	0.91947
2275.8621	0.01722506	0.91938
2379.3103	0.01744506	0.91964
2482.7585	0.01766506	0.92025
2586.2068	0.01788506	0.9212
2689.6550	0.01810506	0.92248
2793.1033	0.01832946	0.92408
2896.5518	0.01858759	0.92599
3000.0000	0.01884573	0.9282

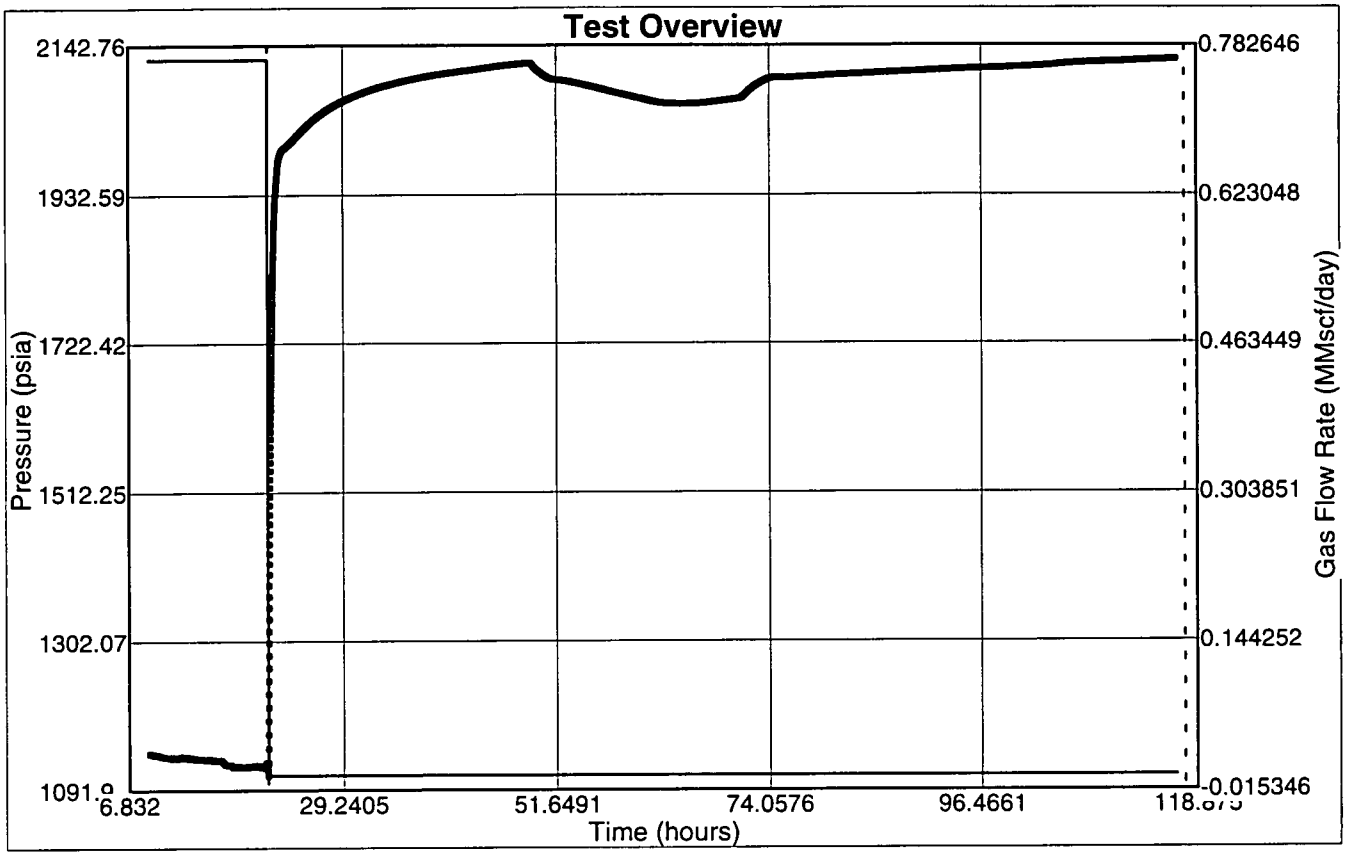
Rate Change Data

Time Hours	Pressure psia	Rate MMscf/day
-100.00000	2115.2351	0.0000
21.38761	1112.1920	0.7673
117.60840	2122.8469	0.0000

Santos Limited | Report File: S021205A.PAN

Wirrarie #2 BHP Survey May 1996

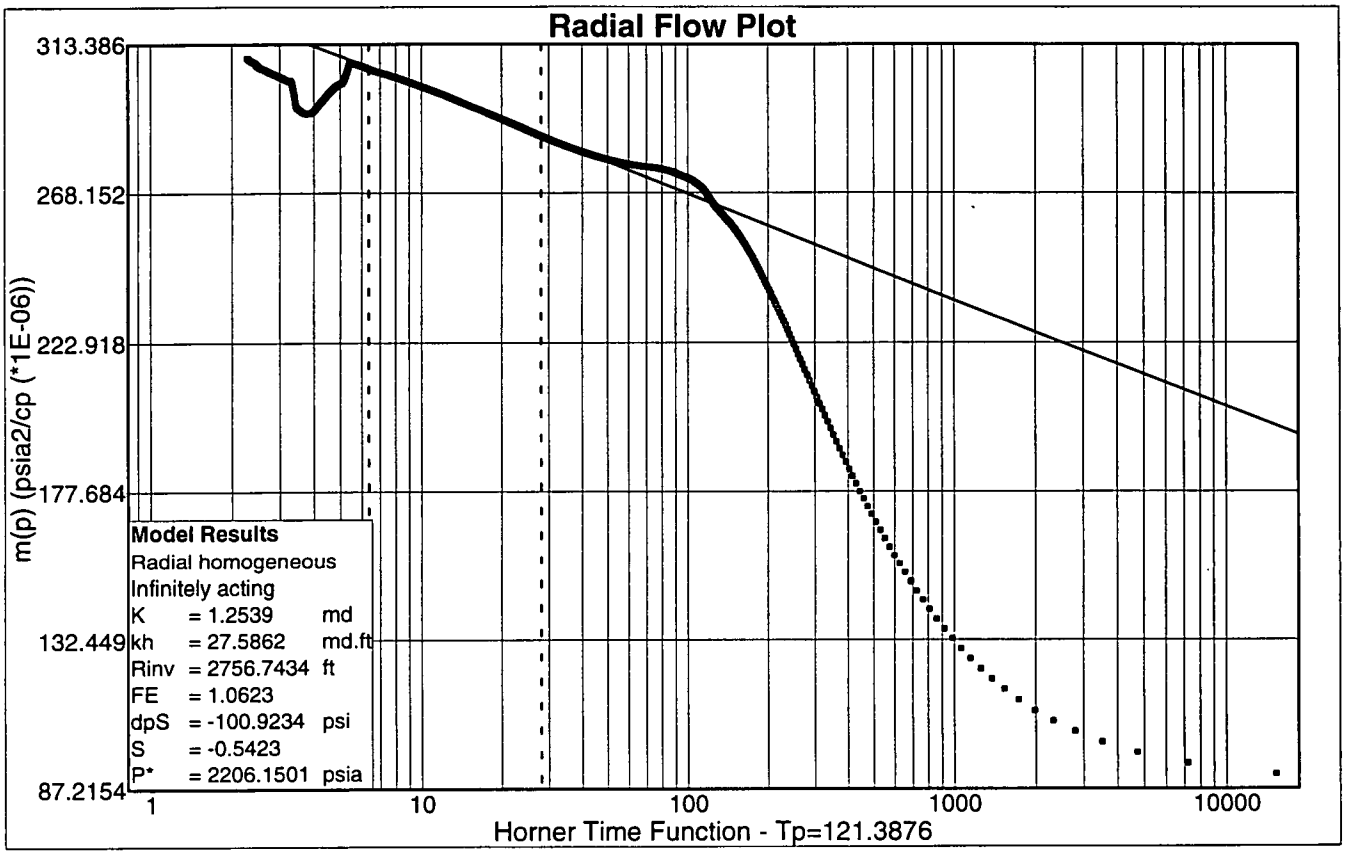
Well Test Analysis Report



Santos Limited | Report File: S021205A.PAN

Wirrarie #2 BHP Survey May 1996

Well Test Analysis Report



Radial Flow Plot Model Results

Radial homogeneous

Infinitely acting

	Value
Permeability	1.2539 md
Permeability-thickness	27.5862 md.ft
Radius of investigation	2756.7434 ft
Flow efficiency	1.0623
dP skin (constant rate)	-100.9234 psi
Skin factor	-0.5423
Extrapolated pressure	2206.1501 psia

Radial Flow Plot Line Details

Line type : Radial flow

Slope : -32.1679

Intercept : 332.179

Coefficient of Determination : 0.99859

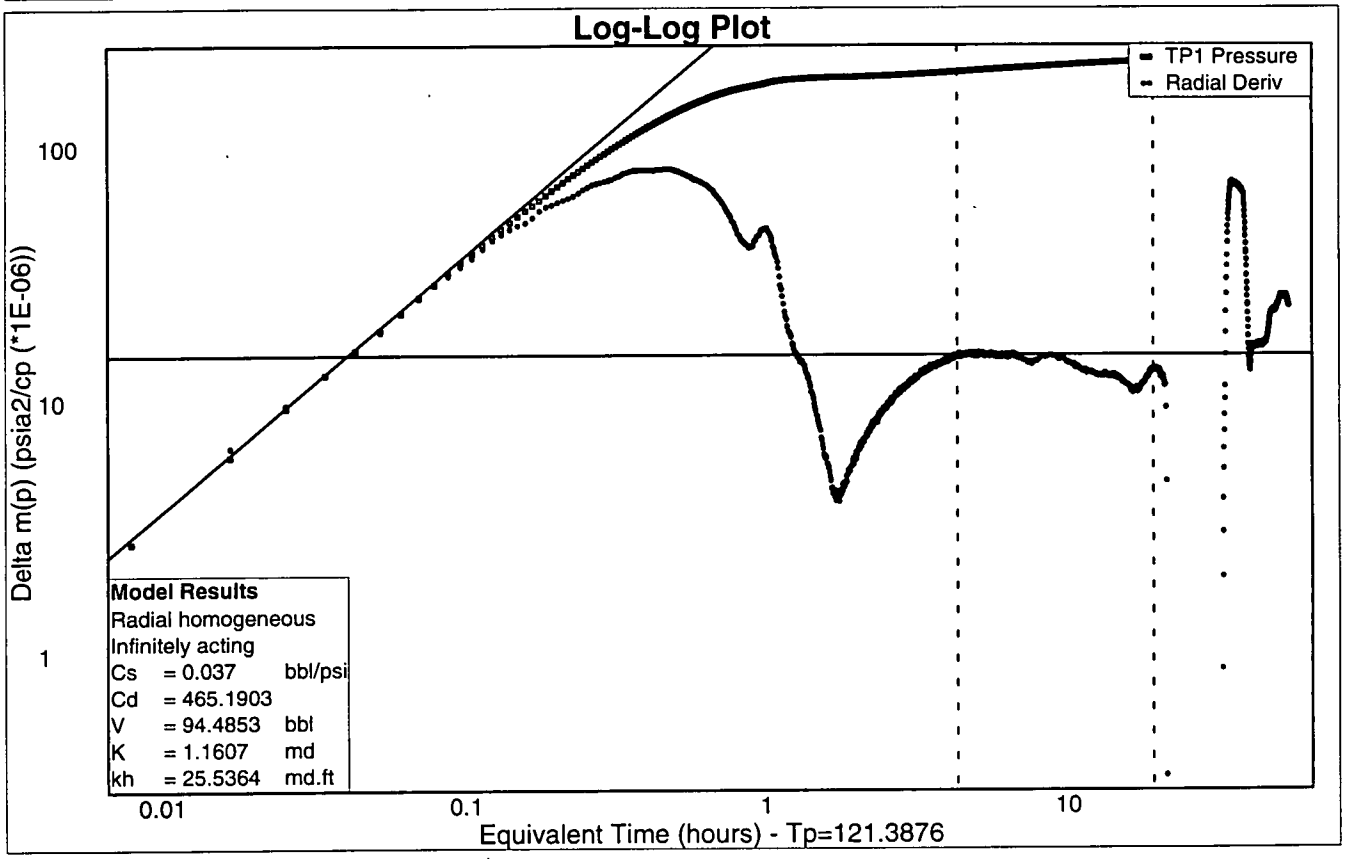
	Radial flow
Extrapolated m(p)	332.1792 psia2/cp (*1E-06)
Extrapolated pressure	2206.1501 psia
m(p) at dt = 1 hr	265.0211 psia2/cp (*1E-06)
Pressure at dt = 1 hour	1956.7075 psia

Number of Intersections = 0

Santos Limited | Report File: S021205A.PAN

Wirrarie #2 BHP Survey May 1996

Well Test Analysis Report



Log-Log Plot Model Results

Radial homogeneous

Infinitely acting

	Value
Wellbore storage coefficient	0.037 bbl/psi
Dimensionless wellbore storage	465.1903
Apparent wellbore volume	94.4853 bbl
Permeability	1.1607 md
Permeability-thickness	25.5364 md.ft

Log-Log Plot Line Details

Line type : Radial flow

Slope : 0

Intercept : 15.0918

Coefficient of Determination : Not Used

Line type : Wellbore storage

Slope : 1

Intercept : 370.216

Coefficient of Determination : Not Used

Number of Intersections = 0

→ to Wirrarie #2 SR

PETRA GROUP PTY. LTD.

Incorporated in South Australia
A.C.N. 008 164 690

PETROLEUM CONSULTANTS

7513/2

31 March, 1995

Mines and Energy South Australia
Petroleum Division
191 Greenhill Road
Parkside S.A. 5063

Attn: T. Aust - Chief Petroleum Engineer.

SANTOS WIRRARIE #2 DRILLING PROGRAMME

INTRODUCTION

PETRA Group Pty Ltd were commissioned by the Petroleum Division of Mines and Energy South Australia (MESA), 23 March 1995, to review the Santos Ltd. Wirrarie #2 'slimhole' drilling programme and well design with respect to good industry practice and adequacy of casing design to prevent and control blowouts; and in particular whether any criteria should be set for mud pit volumes and avoidance of swabbing. The commission was accepted by PETRA in line with their letter of proposal of 22 March 1995.

SUMMARY

General

The general geology and pressure regimes within the areas of the Cooper Basin are now reasonably well known. Data from offset wells, particularly Wirrarie #1 and Wirrarie North #1, means that the prognosed formation depths and pressures for Wirrarie #2, can be regarded with confidence. Thus the planning and drilling of the well would be considered routine, with likelihood of a kick generally limited to loss of overbalance due to swabbing action on pulling out of the hole on round trips or with test tools. Santos have developed standard operational procedures, for conventional holes, to reduce this risk.

The Wirrarie #2 'slimhole' section is unconventional for the Cooper Basin and the well kick risk referred to is greater because of the reduced annulus clearance, particularly around the drill collars.

The Santos Wirrarie #2 Drilling Programme, preliminary copy of which was submitted to MESA on 20/03/1995 Attachment 1), reflects the routine nature of this appraisal/development well, but does not cover in detail either the increased potential for a kick, nor the additional measures to be applied, or necessary, to ameliorate that risk.

Narrative

A meeting was held, on the morning of 26 March 1995, with the Santos staff responsible for preparation of the drilling programme and well design. The design philosophy and check calculations were presented, various aspects of the programme examined and their implications discussed.

The intent to drill the slimhole as 6 1/4 inches, in place of 6 inch as in the issued drilling programme, was advised. This change would have increased annular clearance by 1/8 of an inch, a 20% increase at the drill collars.

Santos proposed the issue of an 'Alert Memo' to address matters of concern, with respect to well control in the slimhole section, not explicitly detailed in the programme document; these were

- Maintaining extra alertness for any indications of a kick.
- Avoiding uneven circulating mud weight (light spots).
- Reduction of mud yield point to reduce swabbing on pipe connections and tripping.
- Limiting pipe pulling and running speeds on trips to reduce chances of swabbing and surging.
- Maintain and update wellkick work sheet

The 'Alert Memo' was to have, as an attachment, a bit and hydraulics programme (annular velocities, pressure drops and dynamic overbalances etc), for revised mud properties.

The calculations for selected mud weight, kick and casing design were to be typed up as a formal record of the design support work.

Santos were giving consideration to the fitting of a paddle type flow sensor, to give qualitative indication of the rate of return mud flow and complement the pit volume totaliser system, for kick detection. (Refer Attachment 5).

Installation of a more sensitive return mud flow sensor and integrated pit volume monitoring system was not considered time achievable, or cost justifiable for this well.

Phone discussions/enquiries were made, resulted in agreed additions to the 'Alert Memo', as given below and a second meeting, at Santos' request, to clarify a method for validating the required mud weight (calculated as 9.3 ppg to provide 200 psi static overbalance).

- On tripping out; either circulating continuously, from the trip tank, across the top of the hole, or topping up the hole every prescribed (calculated minimum) number of stands, while monitoring the trip tank to ensure correct volume is taken.
- Frequency of updating of the slow pump rate pressure data and well kick pre recorded information sheets (N.B. suggest at each tour change or trip and for entering the Patchawarra gas sands).

At this second meeting, it was learnt that the programmed 'slimhole' size had reverted to 6 inch.

Subsequently, the advisability and practicality, of providing the field supervisors with the equations and plot of pre calculated maximum allowable casing pressures, at the slow kill pump rates, for incremental kick volumes (from the Patchawarra), was raised.

need explain

As the calculations would be theoretical, the plotted pressures would have to be field corrected for actual circulation pressure losses and measured casing shoe fracture gradient from leak off test.
Any such 'pre engineering' which could help reduce the time to determine the correct field response to a kick would be beneficial.

CONCLUSION

Issue of an 'Alert Memo', to accompany the drilling programme, adequately covering the points of concern, will provide additional guidelines, adherence to which should allow successful achievement of the programmed drilling, drill stem testing and casing of the well for completion.

A more detailed discussion of some of the points considered follows.

DISCUSSION

Well Design/Drilling Programme

The well design proposed in the Wirrarie #2 drilling programme may be summarised as follows:

- Drill 8 1/2 inch surface hole out of 9 5/8 inch conductor to circa 4630 ft KB, utilising 6 1/4 inch drill collars and 4 1/2 inch drill pipe.
- Run a 7 inch, 23 lb/ft, K-55 surface casing string, set in the Cadna-Owie formation at circa 4630 ft KB and cement to surface.
- Drill out and drill 6 inch hole to TD of circa 7025 ft KB, utilising 4 3/4 inch drill collars and 3 1/2 inch drill pipe.
- A Drill Stem Test (post logging) on the Patchawarra gas sands
- Run a 3 1/2 inch 9.3 lb/ft J-55 NK3SB tubing liner, hung on a liner hanger packer set in the 7 inch surface casing at circ 4400 ft KB and cement back to 200 ft within the liner lap.
- Complete with a 3 1/2 inch, 9.3 lb/ft, J-55 NK3SB tieback tubing string, stung into the liner hanger packer to provide a monobore production string.

Drilling of the surface hole is conventional, whereas the drilling of the reduced diameter production hole is unconventional for the Cooper Basin and poses additional risks to well control, primarily on tripping out of the hole, due to restricted annulus clearence.

Refer to Appendix 1 for comparison of 'Slimhole' and conventional drilling; hole and drillstring dimensions/volumes for this well

Programme Variations

Subsequent to issue of the programme, perceived practical problems in fishing for 4 3/4 inch drill collars with an overshot in 6 inch hole led Santos to plan increasing production hole size to 6 1/4 or alternatively 6 1/2 inches, dependent on bit availability.

Bit supply became problematic and on reviewing clearances required for overshot fishing of collars, it was decided to revert to a 6 inch hole.

Anticipated Reservoir Pressures

Formation/Reservoir Sand	Hutton	Epsilon	Patchawarra 70-1	Patchawarra 70-6	Merrimelia/ Dullingari
Formation Top, ft SS	5596	6382	6564	6564	6769
Maximum calculated Pressure @ top, psig	2590	2948	3021	3031	3051

Refer to Appendices 2a & b for derivation.

Mud Weight

The drilling programme gives mud weights of 9.2-9.4 ppg for the production hole section.
To provide a static drill pipe overbalance of circa 200 psi, as commonly used for the Cooper Basin Permian section, over anticipated maximum top Patchawarra pressure, a mud weight of 9.3 ppg (gradient of 0.4844 psi/ft) is required. This mud weight would adequately overbalance maximum expected Hutton, Epsilon and Merrimelia pressures (Refer to Appendix 2a).

It should be noted that the dynamic overbalance will be greater than in a conventional well due to increased annular friction and possibly (dependent on penetration and mud circulation rates), increased cuttings loading.

Casing Design

7 inch Surface Casing is to be set in the Cadna-Owie, providing a competent casing seat. The leak off test gradient in the closest well with surface casing set in the Cadna-Owie, Arrakis #1, was circa 0.84 psi/ft

Santos, applying a fracture gradient of 0.6 psi/ft to the surface casing shoe depth of 4630 ft KB to get a casing seat strength of circa 3775 psi, have calculated this as adequate to take the kick pressure caused by a 10 barrel gas influx from a 3000 psi reservoir at TD, with 900 ft of 4¾ inch drill collars in 6 inch hole, and 9.4 ppg mud (Refer Attachment 2).

The collapse rating of the casing exceeds the collapse pressure at the casing shoe of a 9.4 ppg mud column using a design safety factor of 1.
The tensile yield rating of the casing exceeds the combined weight in air of casing and suspended liner using a design safety factor of 1.6 (Refer Attachment 3).

3½ inch Production Liner collapse rating exceeds, by a factor of two, the collapse pressure at the shoe of a 9.4 ppg mud column using a design safety factor of 1.
The tensile yield rating of the liner exceeds the liner weight in air using a design safety factor of 1.6 (Refer Attachment 3).

The Rig

The rig scheduled to drill the well is Century Drilling Rig 3. Coincidentally, it is the smallest capacity rig under contract to Santos.
Details of the Rig, standard equipment and mud system are contained in Attacment 4.

Of particular relevance is the trip tank capacity of 25 barrels, which should facilitate detection of a kick while tripping.

Kick Detection

The mud logging contractor, Geoservices Overseas S.A., have a mudpit volume monitoring system installed on the rig mud system which, they advise Santos, can easily detect a mud pit gain of 10 barrels and the potential of detecting a 5 barrel gain with closer monitoring (Refer Attachment 5).

Geoservices would be the supplier of the paddle type mud flow sensor referred to in page 2 of this report (Refer Attachment 5).

PROGRAMME REVIEW BASIS

The above review has been prepared on the basis of the data supplied by MESA and Santos Ltd., applying general relevant industry experience and standards, and without purporting to specialist knowledge of Slimhole Drilling.

The review has been prepared for the Petroleum Division of MESA and is not intended for reproduction or dissemination to third parties without the express consent of PETRA Group Pty. Ltd.

Yours faithfully,

W.J. Waterhouse
for
PETRA Group Pty. Ltd.

APPENDIX 1

WIRRARIE #2

'Slimhole' Drilling, Hole and Drillstring Dimensions/Volumes
and comparison with conventional hole

	SLIMHOLE				CONVENTIONAL			
Dimensions/Capacity								
	Weight lb/ft	O.D. ins	I.D ins	Capacity Bbls/ft	Weight lb/ft	O.D. ins	I.D. ins	Capacity Bbls/ft
Casing	23.0	7 Nom.	6.366'	0.039366	40.0	9⅝ Nom	8.835	0.075824
Open Hole	-	-	6 Nom	0.034970	-	-	8½ Nom	0.076018
Drill Collars	47.0	4.75	2.250	0.004918	n/a	6.25	n/a	
Drill pipe	13.3	3.50	2.764	0.007421	16.6	4.50	3.826	0.014219
Annular Dimensions and Volumes								
Between	Clearance ins	Flow Area ins^2		Capacity Bbls/ft	Clearance ins	Flow Area ins^2		Capacity Bbls/ft
Open Hole and Drill Collars	⅝ Nom	10.554		0.013053	1½ Nom	26.065		0.032238
Drill Pipe	1¼ Nom	18.653		0.023070	1⅞ Nom	40.841		0.050512
Casing and Drill Collars	0.808	14.108		0.017449	1.292	30.626		0.037879
Drill Pipe	1.433	22.208		0.027467	2.167	45.402		0.056153

DIMDATW2
W.J. Waterhouse
PETRA GROUP PTY LTD
30 March, 1995.

APPENDIX 2a.

WIRRARIE #2
Expected maximum formation pressures and calculated mud weights

	A	B	C	D	E	F	G	H	I		
FORMATION/	RES PRESS	FORMATION		EXPECTED	RESERVOIR	FLUID	TOP RESERVOIR		O'BALANCED	STATIC MUD COLUMN	
RESERVOIR/	GRADIENT	BASE	TOP	PRESSURE	ALLOWED	GRADIENT	DEPTH	PRESSURE	MUD WEIGHT	PRESSURE	O'BALANCE
SAND	psi/ft SS	ft SS		MAX psig	COLUMN ft	psi/ft	ft KB	psig	ppg	psig	psi
Hutton	0.45403	6119	5596	2778	523	0.346	5702	2597	9.43	2757	160
Epsilon	0.45399	6471	6382	2938	89	0.060	6488	2932	9.28	3138	205
Patchawarra 70-1	0.45728	6615	6564	3025	51	0.080	6670	3021	9.29	3226	205
Patchawarra 70-6	0.45523	6681	6564	3041	117	0.080	6670	3032	9.32	3226	194
Merrimelia/ Dullingari	0.44112	6919	6769	3052	150	0.080	6875	3040	9.06	3325	285

NOTES:
A Formation Pressure Gradients calculated, wrt SS depth, from nearby wells.
Refer to FMPGRADS V2 of 30 March 1995
Merrimelia/Dullingari pressure gradient considered low and unreliable
D C*B, Maximum formation pressure
E Maximum hydrocarbon column anticipated
F Assumed likely hydrocarbon column gradient
G Top of formation depth (KB), C+KB of 106 ft
H D-(F*G), Highest pressure anticipated at top of formation
I (200+H)/G, Equivalent mud gradient to overbalance formation by 200 psi
J Static mud column pressure provided by 9.3 ppg mud (Gradient 0.48360 psi/ft)
K Static mud column overbalance on H, provided by 9.3 ppg mud

FMPRESW2 Version 2.
W.J. Waterhouse
PETRA GROUP PTY LTD
30 March, 1995.

APPENDIX 2b.

WIRRARIE AREA FORMATION PRESSURES

FORMATION/ RESERVOIR/ SAND	A RESERVOIR PRESSURE psig	B MEASURED AT DEPTH ft SS	C ft KB	D RES PRESS GRADIENT psi/ft SS	E EQUIVALENT MUD GRAD psi/ft KB	F EQUIVALENT MUD WEIGHT ppg	G OVERBALANCED MUD GRAD psi/ft	H EQUIVAL MUD WEIGHT ppg	SOURCE WELL/DST/RFT
Hutton	2627	5786	5904	0.45403	0.44495	8.56	0.47883	9.21	Caladan #1, RFT
Epsilon	3271	7205	7328	0.45399	0.44637	8.58	0.47366	9.11	Arrakis #1, DST 2
Patchawarra 70-1	3024	6613	6715	0.45726	0.45034	8.66	0.48012	9.23	Wirrarie North #1, RFT
Patchawarra 70-6	3040	6678	6780	0.45523	0.44838	8.62	0.47788	9.19	Wirrarie North #1, RFT
Merrimelia/ Dullingari	3225	7311	7446	0.44112	0.43312	8.33	0.45998	8.85	Farina #1, DST 3
			Average	0.45233					

NOTES:

A Referenced measured formation pressures
Merrimelia/Dullingari pressure considered low and unreliable

D A/B, Formation Pressure Gradient calculated wrt SS depth

E A/C, Equivalent mud gradient to balance formation pressure, calculated wrt KB depth

F E/0.052, Equivalent mud weight to E

G (200+A)/C, Equivalent mud gradient to overbalance formation by 200 psi

H (200+A)/(C80.052), Equivalent Mud weight to G

FMPGRADS Version 2.
W.J. Waterhouse
PETRA GROUP PTY LTD
30 March, 1995.

Santos Meet 3/4/95 Wirrania 2° Sidetrack

Tom Johnstone, Peter Archer, George Koulmatis, Chris Abbot.

Q 1. Does the well comply with API standards

Q 2. Is it safe?

MESA → want ensure that Santos processes can handle unusual / new well

What's unusual, how has Santos handled it?

- 10 bbl kick can be detected. ⇒ normally expl^n wells = 30 bbl kick detect?

→ most tripping will cause problems

→ surge & swab pressure

Peter ⇒ well easier to kill?

Kick will move twice as fast, because volumes are less.

→ crews need to be schooled up on this.

⇒ Santos have generate ALERT MEMO.

Bit trips to be done in daylight.

Santos will review.

Kim Knuckey ⇒ digitized flow lines —

⇒ what do they have digitized