

Santos

CSG Drilling & Completions

Technical Challenges for 2010 -12

December 2009

Santos

CSG D&C Overview

- Substantial activity increase since 2007
 - Increase from 2 to 12 rigs in 15 months
- Currently 10 rigs operating (7 for GLNG)
 - 4 “large” drilling rigs
 - 3 coring rigs (All in NSW)
 - 3 completions/workover rigs
 - Forecast ~170 wells for 2009
- Range of well designs & technology
- Innovative environment
- Activity level allows trialling of new technology



Current Operations Overview

■ Drilling

- 170 wells forecast for 2009
- Mix of exploration, appraisal & development wells across QLD and NSW
 - 3-7 day cycle time for vertical development wells
 - 14-21 day cycle time for exploration/appraisal
- 200 – 300 well capacity
 - Dependent on well type (e.g. vertical or deviated)

■ Completions

- Average 15 day cycle time for cavitated wells with PCP
- Both rigless and rig-assisted fracture stimulation
- 2 day cycle time for pump installation only



Rig fleet

- Rigs
 - Currently sourced from 2 rig contractors
 - Easternwell Group (3 drilling/3 workover)
 - Lucas Mitchell (4 drilling, including 3 HQ core rigs)
 - Rigs on long term contract (12 month – 5 year)
 - Day rate operations
- Santos have 50% ownership of one drilling contractor



Rigs – Exploration & Appraisal



- HQ coring rigs (continuous coring)
- Rigs have BOPs and are hazardous zone rated
- Wells P&A'ed or completed with piezo pressure gauges



Drilling Rigs - Development

- Drilling Rigs
 - Purpose built conventional rigs
 - Appraisal & Development drilling
 - Ability to continuous core
 - Ability to directionally drill
 - Highly automated
- Completions
 - Cavitation rigs
 - Small service rigs



Well Types

- Currently vertical wells are base case
- Currently carrying 7 well designs for Roma/Fairview/Arcadia
 - Well designs are “fit for purpose” in their application
- Currently carrying 3 well stimulation types
- Most wells currently require artificial lift (for water)

Drilling Technology & Challenges

Technology

- More than 20 ECP jobs
- Continuous coring - 27 km cut in 2008
- More than 100 DST's
- Underbalanced drilling on MDC-151
- Casing drilling – 6 well trial conducted
- Under-reaming while drilling now routine operation
- Piezometer installations in 13 wells



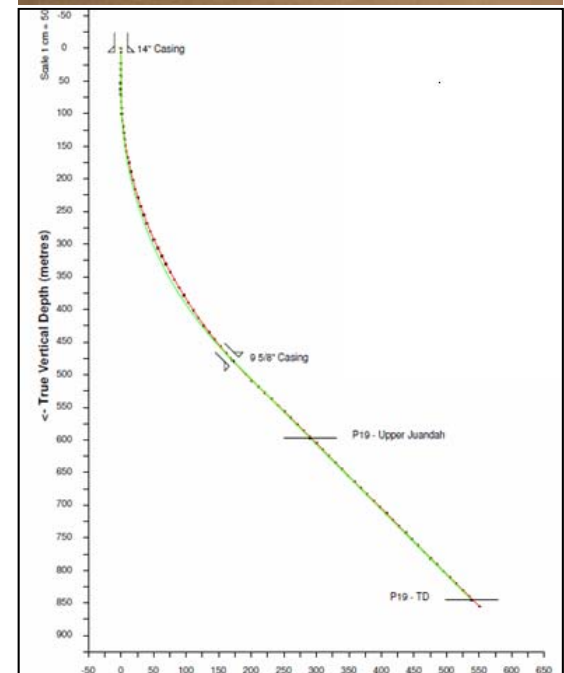
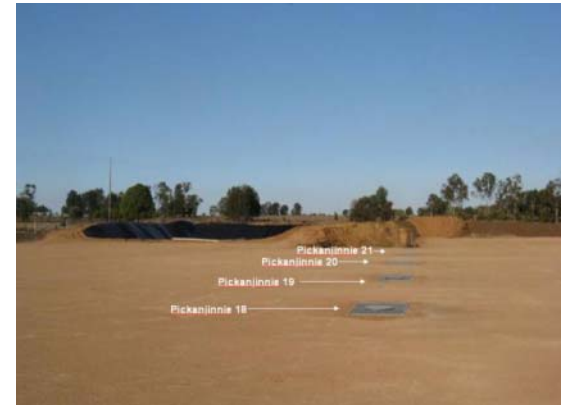
Challenges

- Well control events – loss/kick situation
- Losses – drilling blind
- Regular fishing jobs
- Landowner issues

Pad drilling

Pad drilling pilots commenced

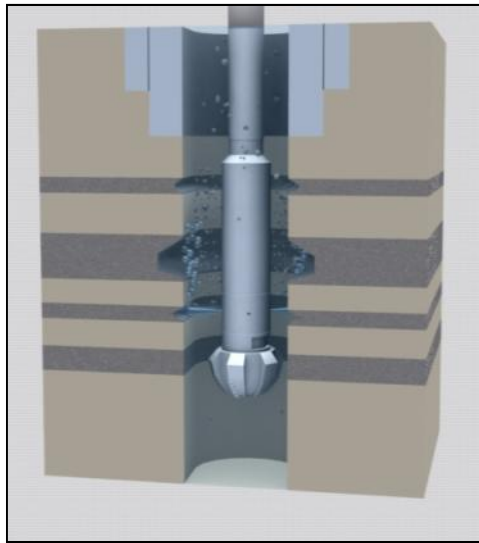
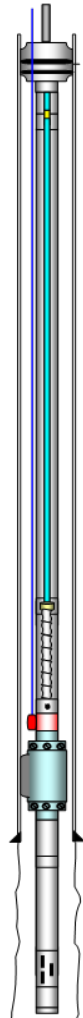
- Pickanjinnie 19 reached total depth 7 Oct 09 well within target tolerance
- Represents first directionally drilled well in Santos CSG.
- 2 further wells were drilled on the pad at 120° apart
- Directionally drill surface hole to 549 m MD (45° inclination)
- Drill tangent section (holding at 45°) to 1057 m MD



Current completion Activities

- Currently completing wells in Fairview, Arcadia, Roma and Gunnedah
- Predominantly CSG wells, some conventional well legacy assets
- Dedicated 2 cavitation rigs and 1 service rig
- Frac spreads mobilised when required
- Vertical wells are base case
- Currently 7 well designs for Roma/Fairview/Arcadia
 - Well designs are “fit for purpose” in their application
- Currently 3 well stimulation types – cavitation, fracing, under-reaming
- Most wells currently require artificial lift (for produced water)

Stimulation Techniques - Cavitation

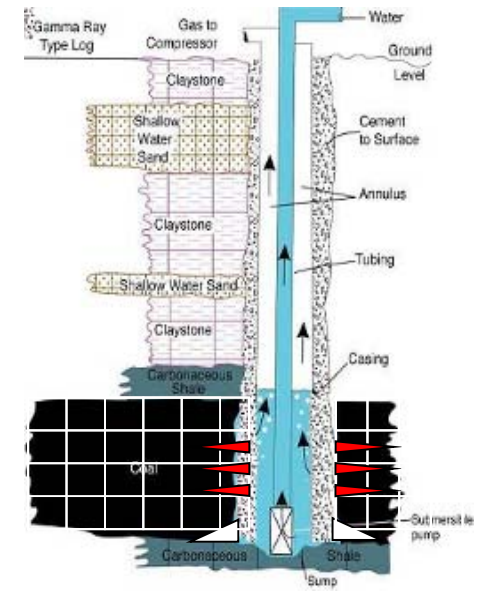


- Predominant stimulation technique in Fairview to date.
- Casing set above the coals leaving a open hole section
- Air pumped from surface jetted across coals through ported sub causing coal break up and hole enlargement
- The hole enlargement provides additional surface area for gas desorption and also increases the connectivity of the well to fracture and cleat networks.
- New fractures may also be created whilst surging.
- Cavitation typically lasts 14 days, can last up to 40 days, difficult to predict time.

Stimulation Techniques - Fracing



- Initial trial fracs conducted in 2008
- Both rigless and rig-assisted fracture stimulation
- Casing set across coals and perforated, open hole fracs also possible
- Induced fracture increases the connectivity of the well to fracture and cleat networks.
- Far easier to predict length of job as typically only several days
- Preferred stimulation for deviated / horizontal wells
- Numerous technical options available

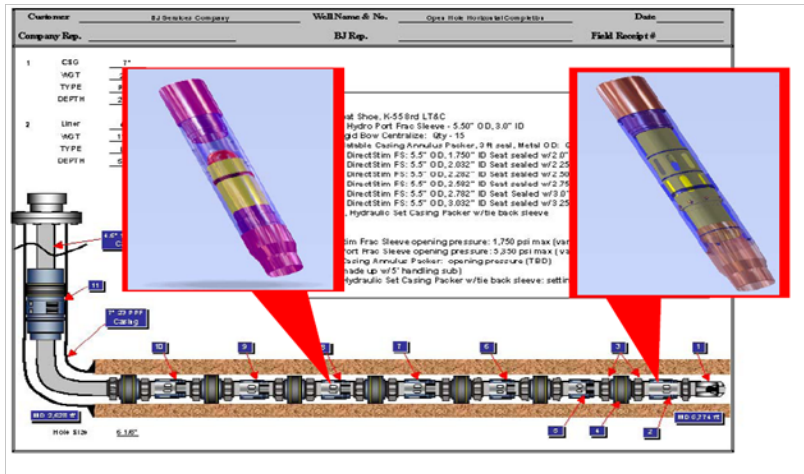


2010 Frac Campaign Technical Goals



Trialling Technologies and Techniques

- Proppantless Stimulation
- Open Hole Frac Tool
- Light Proppant
- Frac Stimulation in Deviated CSG Wells
- N₂ Foam Fracs
- Visco-elastic Frac Fluids
- Vapour Frac



Unknowns

- Technological success rates
- Well bore Stability
- Tortuosity Pressure Response on Deviated Wells

Z Packer

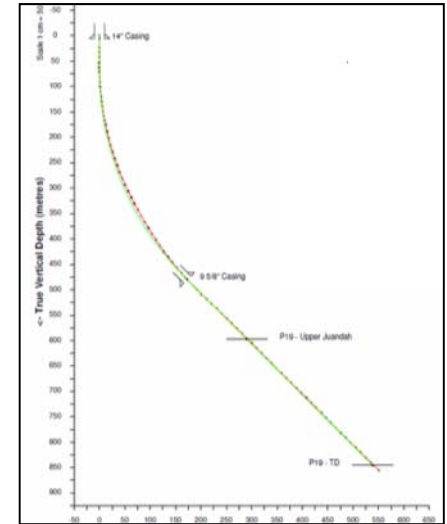
Z-Frac Straddle Packer

- Single trip, selective fracture stimulation of multiple zones
- For use in 7" casing,
- Achieved 3 pump jobs in one day,
- Allows a full multi-zone frac and cleanout in 2 days, vs. 5 days for a bridge plug system.
- Potential saving of \$ 40k per well
- Better isolation than sand plugs or 'ball & baffle' systems



Stimulation Techniques Summary

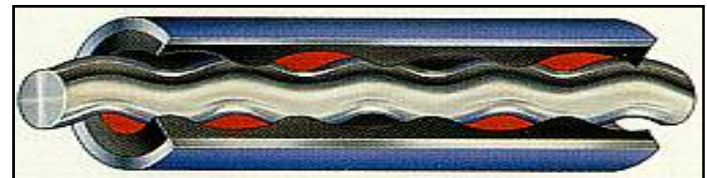
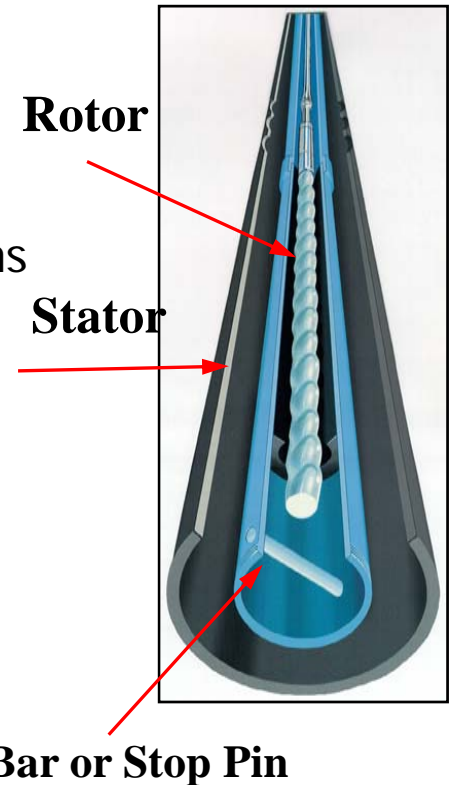
	Number Wells Completed	Vertical Wells	Stimulation Method	
			Cavitated Wells	Fracture Stimulated Wells
2008	38	100%	93%	7%
2009	45	95%	67%	33%
2010	101	30%	22%	78%



- Significant increase in deviated / horizontal wells
- Significant swing towards fracking as the preferred stimulation technique for well conditions encountered
- Numbers do not include Roma wells which to date have not been stimulated

Artificial Lift – Post Stimulation

- Predominantly PCP completion \ Free flow (wells range from 100% water production to 12mmscf/day dry gas)
- Live or dead wells (incl live PCP completions)
- Pump run inside casing, set above any open hole sections
- Most common pump sizes used produce between 100 to 3000 bpd
- Down hole monitoring and pump control via down hole gauge or SAM unit increasingly used
- VSD & Surface skids installed by connections



Completion Challenges

- Directional wells – Difficult to stimulate at angle. Increased angle = increased risk for downhole equipment.
- Cavitation in directional wells – difficulty stimulating deep low permeability coals
- Managing tie in and production lag:
 - Many wells completed but not operational - Increased risk of infant mortality of pumps.
 - Many wells stimulated but not completed (to avoid infant mortality) - Second rig visit require to install the pump.
- Water handling / disposal of water from wells (during cavitation or post frac). Wells can produce water >1000bbl/day and salinity >5000 μ S
- Difficulty in removing PCP's from live wells.
- Roma gas storage – number of conventional wells need to be remediated so gas injection can occur. Often complex and time consuming due to the age (most 40+ years) and construction of the wells.
- Rig fleet requirement – less cavitation rigs required if work switched to predominantly fracs.

Summary of changing requirements of D&C

Significant changes to base business

2009

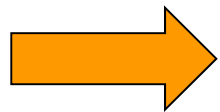
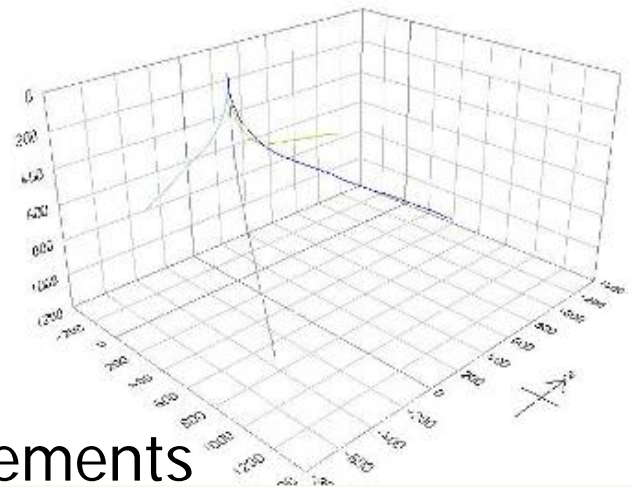
- Forecasting 170 drilled wells by end 2009 (95% vertical)
- 45 completions (67% cavitation/33% fracture stimulated)

2010

- 100 drills planned (70% directional)
- Consideration given to use of slant rigs in 2010 and beyond
- 101 completions (78% fracture stimulation/22% cavitation)

Well Designs for Field Development

- Pad Drilling
- Slant drilling
- Horizontal wells in well developed coal seams
- Fracture stimulation in deviated wellbores



Changing rig fleet requirements

Technologies Under Review

- Surface to in-seam drilling
- Application of Slant Rigs
- Open hole hydraulic fracturing
- Extreme under-reaming
- Fracture stimulation in deviated wellbores

