22 February 2011

Concept and Project Application for Gloucester Gas Project

1.0 INTRODUCTION

AGL Upstream Infrastructure Investments Pty Ltd ('AGL'), the proponent, proposes to construct and operate the Gloucester Gas Project which involves the extraction, processing, transport and delivery of coal seam gas to the existing gas supply network in the Hunter region of NSW.

1.1 The Proposal

Concept plan approval is sought for the Gloucester Gas Project comprising the following 5 elements and concurrent project approval for elements 2 to 5:

1. Staged development of gas extraction wells and associated infrastructure within an approximately 210 km^2 area of the Gloucester Basin in the Gloucester and Great Lakes Local Government Areas (LGA);
2. Construction and operation of up to 110 gas extraction wells and associated infrastructure as the first stage of the gas extraction area (approximately 50 km^2), in the Gloucester LGA ('Stage 1 Gas Field Development Area');
3. Construction and operation of a central processing facility to compress and process the extracted gas ready for transport, at one of two potential sites in the Gloucester LGA (Central Processing Facility Site 1 and Site 7);
4. Construction and operation of a gas transmission pipeline within an overall 100 m wide assessment corridor to transport gas from the central processing facility to the existing gas supply network at Hexham; and
5. Construction and operation of a gas delivery station at Hexham in the Newcastle LGA, to deliver gas to the existing Sydney-Newcastle gas pipeline.

2.0 DELEGATION TO THE COMMISSION

The application was submitted with a Political Donations Disclosure Statement disclosing a reportable political donation.

The project application fulfils the existing terms of delegation and the Planning Assessment Commission (the Commission) may determine the Project Application under delegated authority. However, the concept plan falls outside the general terms of delegation issued by the Minister on 18 November 2008 to the Commission.

On 28 September 2010, the Minister for Planning delegated his powers and function as an approval authority for the concept plan to the Commission for determination.

On 21 December 2010, the Deputy Director General of the Department of Planning referred the concept plan and project application (MP08_0154) to the Commission for determination under delegations issued by the Minister.

The Commission consisted of Mr Garry Payne, AM (chair) and Mr John Court (member of the PAC).

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3.0 INFORMATION PROVIDED TO THE COMMISSION

The Commission was provided with the Director General's (DG) Assessment Report, Environmental Assessment (EA), Response to Submissions (RTS) and draft conditions of approval. Submissions provided from the NSW Office of Water were also reviewed.

A total of 136 submissions from the public and 11 submissions from government agencies were received by the Department during the notification period. The range of issues raised in the submissions included:

- Surface and Groundwater;
- Flora and Fauna;
- Hazards and Health Risks;
- Land Use and Property;
- Consultation;
- Noise and Vibration;
- Air Quality;
- Visual and Landscape; and
- European Heritage.

Of the issues raised in submissions, over 20% of submissions raised concerns with surface and groundwater management. These included concerns with the risk to groundwater during gas extraction and the management of water extracted from wells.

The Department's assessment identified the following key issues:

- Surface and Groundwater;
- Air Quality;
- Flora and Fauna;
- Noise and Vibration;
- Heritage; and
- Visual Amenity.

The Department is satisfied that the impacts of the proposed development have been adequately addressed in the EA, RTS, the proponent's Statement of Commitments and the recommended conditions of approval.

4.0 MEETINGS WITH THE DEPARTMENT OF PLANNING

Following Commission members' examination of the DG's report and associated documents provided by the Department, the Commission met with Department staff, Mr Chris Wilson and Mr Neville Osborne, on 5 January 2011 for a briefing. The meeting focussed on the following key issues:

- Coal seam gas industry in NSW – the Coal Seam Gas industry in NSW is relatively new. As such, the Commission indicated that to assist with the determination, further understanding of the industry should be obtained by visiting existing AGL operations. The Department advised that two coal seam gas extraction and processing facilities are presently operating in NSW, the Camden Gas project and a small experimental facility at Wilga.
- Groundwater and hydrogeology – discussion on the potential interaction between groundwater aquifers, surface waters and the geology in the Gloucester area.
- Flora and fauna offsets based on surveys of areas impacted by the gas field and pipeline development.
- Commonwealth government involvement under the *Environment Protection and Biodiversity Conservation Act 1999*.
- Air quality impacts – discussion on possible odour impacts from the potential presence of contaminants in water discharged to evaporation ponds.

To seek further clarification on a number of detailed technical issues raised in the project, a further briefing was held on 21 January 2011 with Mr Neville Osborne and Ms Dinuka McKenzie. A summary of key discussion points are provided below:

- Groundwater and hydrogeology – discussion on the level of groundwater and hydrogeological assessment undertaken by the proponent and the proposed numerical modelling of the groundwater and hydrogeological system.
- Potential impacts from the fracture stimulation ('fraccing') process in the coal seam – discussion on the types of chemicals proposed in the fraccing process, as well as potential noise impacts.
- Potential odour impacts – discussion on the gas composition of the coal seam gas and potential for odour impacts from surface treatment of fraccing fluid.
- Flora and fauna – discussion on the biodiversity offsets required by the project and involvement from Department of Environment, Climate Change and Water (DECCW).

On 7 February 2011 the Commission met with Mr Neville Osborne and Ms Dinuka McKenzie to discuss amended conditions of approval prepared by the Department. The Commission was satisfied that their concerns have been addressed through the amendments to the conditions of approval. Further discussion is provided in Sections 8.0 and 9.0 of this report.

5.0 SITE INSPECTIONS

5.1 Gloucester Gas Project

A site visit of the Gloucester Gas project and a meeting with representatives from AGL was conducted on 28 January 2011.
Those in attendance were:

- Garry Payne PAC
- John Court PAC
- Paulina Hon PAC
- David Kelly AGL, Head of Land and Approvals
- Toni Laurie AGL, Land and Approvals Manager
- Mark Bonisch AGL, Operations Manager
- Andrew Parker AGL, Principal Geologist
- John Ross AGL, Manager, Hydrogeology

A broad range of matters relating to the Gloucester Gas Project were discussed at the meeting, including clarification on a number of technical aspects in the extraction and processing of coal seam gas. These included:

- Composition of coal seam gas;
- Geology and groundwater within the Gloucester area, including proposed monitoring
- Process of flaring gas from gas wells (including visual impacts);
- Outline of the fraccing process used by AGL, including fraccing chemicals and noise impacts; and
- Subsidence following gas extraction.

Following the meeting, a site visit to a number of key locations in the project was undertaken including:

- Site 1 – Viewed existing groundwater monitoring bores along Jacks Road which have been recently established by AGL.
- Site 2 – Viewed an existing flared gas well (one of six gas test wells), groundwater monitoring bores and storage ponds established on the 'Tiedman' property as part of the Stratford Pilot Project.
- Site 3 – Viewed the 'Atkins' property, where access for the Central Processing Facility (CPF) Site 1 would need to traverse.

- Site 4 – Viewed the operational Stratford no. 6 gas well, one of six gas test wells within the Stratford Pilot project.
- Site 5 – Viewed location of the proposed CPF Site 7.
- Site 6 – Viewed site of proposed biodiversity offset site at Seaham.
- Site 7 – Viewed a wetland section of the pipeline corridor proposed for 'underboring'.
- Site 7 – Viewed site of the proposed Hexham delivery station.

5.2 Camden Gas Project

As the coal seam gas industry is relatively new to New South Wales, the Commission considered it prudent to view existing AGL operations to gain further understanding of the extraction and processing facilities anticipated for the Gloucester Gas Project. As such, on 2 February 2011, the Commission undertook a site visit to AGL's Camden Gas Project and met with representatives from AGL. The Camden Gas Project currently consists of 130 gas wells, low pressure gas gathering lines and the central processing facility located at the Rosalind Gas Plant (in Gilead).

Those in attendance at the site meeting were:

- Garry Payne — PAC
- John Court — PAC
- Paulina Hon — PAC
- Mike Roy — AGL, Head of Gas Operations
- David Kelly — AGL, Head of Land and Approvals
- Janet Michalopoulos — AGL, Drilling and Completions Manager
- Adam Lollback — AGL, Manager Land and Approvals
- Peter Keep — AGL, Gas Plant Operations Manager
- John Ross — AGL, Manager Hydrogeology
- Andrew Fairley — AGL, Geologist

AGL briefed the Commission on the existing operations at the Camden Gas Project with the following key points being discussed:

- Gas processing operations
- Gas flaring undertaken in the Camden Gas Project
- Use of horizontal drilling to construct gas wells
- Fraccing process including: recovery of fraccing fluids and chemicals used in the process
- Outline of the methodology used in drilling a gas well
- Noise mitigation measures
- Management of gas field operations including use of contractors

Following the project briefing, a site visit was undertaken to the following locations within the Camden Gas project:

- Site 1 – Viewed the central processing facility at the Rosalind Park Gas Plant
- Site 2 – Viewed an operational enclosed well site (Sugarloaf no.2)
- Site 3 – Viewed an existing drill rig site located in the Macarthur area

6.0 ADDITIONAL INFORMATION MADE AVAILABLE TO THE PAC

The Commission sought clarification from the proponent, AGL, on the gas composition of the coal seam gas during a site meeting held on 28 January 2011. Following this meeting, AGL provided the Commission with a copy of the results from analysis of the gas composition from the six gas test wells in the Stratford Pilot project (dated September to November 2008). Refer to documentation provided at **Annexure A**.

The Commission forwarded the gas composition data to the Department on 17 February 2011 for information and comment. The Department, in letter dated 17 February 2011, advised the Commission that they reviewed the documentation and had no comment on the information provided. This documentation is considered to be supplementary information and has been reviewed by the Commission in considering the issue of air quality and potential odour impacts as part of the determination. Refer to discussions in Section 7.3.

7.0 KEY ISSUES

The Commission has considered the issues raised in the DG report and is satisfied that the Department has carried out an adequate assessment of the proposal, both as a Concept Plan and for the determination of the project application for the first stage of gas extraction.

As well as consulting the project documentation and related submissions, the Commission took steps, as outlined above, to inform itself more fully about the project by visiting the Gloucester site, sections of the connecting pipeline corridor, the proposed biodiversity offset site, the gas delivery site at Hexham and the proponent's coal seam gas extraction operation at Camden.

In considering the assessment before it the Commission was conscious of both the limited extent of experience with commercial coal seam gas extraction in New South Wales to date and the likely significant future expansion of this type of extraction in the State. The Commission also apprised itself of some of the extensive documented experience of coal-seam gas extraction in the USA and related environmental issues (USEPA 2004, *Evaluation of impacts to underground sources of drinking water by hydraulic fracturing of coalbed methane reservoirs*, EPA 816-R-04-003).

The Commission's consideration relied primarily on the DG's Report and the Department's assessment of impacts therein. However, aspects the Commission considered closely in coming to a decision included impacts on groundwater, noise impact and air quality as detailed below.

7.1 Groundwater and Surface Waters

A key concern in the assessment is the risk of the extraction process impacting adversely on surface and ground waters. There are several risk possibilities associated with geological fault zones in the gas field: possible release of coal seam waters to surface waters or shallow aquifers; possible loss of waters from existing surface streams and shallow aquifers; possible contamination of surface waters and shallow aquifers by substances in coal seam waters and fraccing fluids; and escape of gas to the surface and shallow aquifers.

Aspects of the geology are described as follows in the project documentation (SRK Consulting 2010, *Gloucester Basin Stage 1 Gas Field Development Project: Preliminary Groundwater Assessment and Initial Conceptual Hydrogeological Model)*:

> "The Gloucester Geological Basin stratigraphy indicates that the Permian Basin contains around 13 coal seams thicker that 2.5 m, with an average total coal seam thickness of around 30 m at depths of 200 m to 700 m. The coal seams are discontinuous across the basin and at depth." (section 3.3.2, page 8)
>
> "A number of faults have been reported in the area. Some have been geologically mapped on the surface and intersected by drilling whilst others have been identified as lineaments on aerial photos. Nevertheless, the exact location, dip and strike of these faults are not yet known but 3D seismic surveys acquired

by AGL in 2010 will assist in a better understanding of the structural complexity."...

"Fractures present in coal seams or Permian formations can enhance the hydraulic conductivity of the formations by orders of magnitude. If open, and existing for long distances, fractures are also potential pathways for water to migrate to deep coal measures. If closed, fractures may in fact impede groundwater flow." (section 6.3.1, page 44)

While these extracts need to be read in the broader context of the above report, they indicate a level of uncertainty at various points in the predictions. Some geological uncertainty is, of course, inevitable in underground gas extraction and mining operations. But, a greater degree of definition of the geology and groundwater modelling in the Environmental Assessment and supporting documents would have given a greater degree of assurance that risks such as those outlined above were negligible. This is especially the case in moving from the Project Approval for Stage 1 to the Concept Plan approval for the whole gas field development area.

The Commission nevertheless accepts the position, implicit in the Department's recommendation for approval, that it is possible to develop the gas field by adaptive management, using modern geological, hydrogeological and drilling techniques, with acceptable minimisation of risks. The proponent has proposed, and the Department's conditions of approval require, the progressive development of the preliminary conceptual hydrogeological model supporting the application into a fully operational numerical model. This model will be based on the results of the more extensive drilling and geological testing which will accompany the gas field development. It will be an important tool in adaptive management. Since this development will be a complex task requiring the DG's approval, the Commission has included a requirement in the conditions of approval that the model be peer reviewed to assist the Department and relevant agencies in their assessment of the model, its outputs and its application in adaptive management.

The conditions of approval also require extensive monitoring of groundwaters and surface waters for quantity and quality through the life of the project in order to continually assess any adverse or non-planned environmental impacts. 'Hold Point' conditions are specified in the approval conditions, should any such impacts become apparent, with the 'Hold Points being established using risk analysis. These are important measures to ensure adaptive management action is initiated early enough to avoid any adverse impacts arising from unanticipated geological faults encountered during development of the gas field.

The Commission also noted conditions requiring water quality criteria to be met in relation to possible surface water discharges. It is not uncommon for existing water quality in rural areas to exceed the nominal relevant water quality criteria specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (ANZECC 2000 Guidelines). In such a situation site-specific water quality criteria need to be developed in accordance with the ANZECC 2000 Guidelines and this has been incorporated into the final condition of approval.

7.2 Impacts from the Fraccing Process

The hydraulic fracturing ('fraccing') process opens the coal seam to allow depressurisation, desorption and flow of the coal seam gas to the collection wells. A wide variety of materials has been employed to achieve the desired gas production outcomes. The fraccing fluids are designed to meet several engineering criteria. There has been an evolution in the development of this specialised technology, which can be expected to continue into the future. Future tailoring of fraccing fluids to optimise the development of this field can be

anticipated. The Commission has added a condition which requires detailed specification of the fraccing fluids to be used, with relevant toxicity and carcinogenicity information, and for the information to be updated annually.

Concern has arisen in other places related to the risk of some chemicals used in fraccing entering groundwaters. Specifically benzene, toluene, ethylbenzene and xylene (BTEX), a component in the diesel fuel sometimes added to fraccing fluids, has drawn attention in this industry. The proponent has not proposed to use BTEX in its fraccing operations. The Commission has added a condition specifically banning the use of fraccing fluids containing BTEX.

7.3 Air Quality including Odour

The Commission is satisfied that the air quality impacts from gas extraction and processing have been adequately considered in the Environmental Assessment and the Department's DG report. The gas field and processing will be licensed under the *Protection of the Environment Operations Act 1997* (*POEO Act*) and will be under close regulatory oversight from DECCW.

The process plant has not been closely specified in the EA, but is relatively standard for this industry involving compression of gas with air coolers and a triethylene glycol (TEG) process for removal of water vapour from the gas before distribution. Air quality problems are not anticipated from this source.

The Commission nevertheless considered the possibility of odours being generated from trace impurities in the gas stream finding their way into the proposed water treatment and evaporation facilities at the surface. In the Gloucester Valley odours from exposed water surfaces could travel considerable distances under 'still', winter-night meteorological conditions. Upon review of the gas composition information provided from the test wells in the Stratford Pilot Project, it does not appear likely that any odorous hydrocarbon materials will be encountered in the gas extraction and processing activities (see attached tables in **Annexure A**).

The Commission is not aware of any history of such problems from this industry. It is understood that foul smells can develop if some of the organic gums used in fraccing fluids are allowed to degrade anaerobically, but biocides are applied to prevent this. Nevertheless a condition of approval has been recommended by the Department which reinforces section 129 of the *POEO Act* prohibiting the emission of offensive odours from the site.

The air quality assessment for dispersion of pollutants has been carried out using meteorological data synthesised for the Gloucester Valley by the CSIRO TAPM model. While the Commission considers this adequate for initial assessment purposes, it has added a condition of approval requiring the establishment of an appropriate meteorological station near the project site and the collection of a year's data before the required performance verification is undertaken.

7.4 Noise and Visibility

Noise from the use of heavy rotating machinery such as pumps and compressors, flaring at well heads during start up and at the process plant and from construction activities can constitute a significant impact in the relatively 'quiet', rural environment in the Gloucester Valley and along the pipeline corridor. The Commission is confident that noise mitigation measures can be applied to control noise to acceptable levels. Noise monitoring is relatively straightforward and engineering techniques are available for stationary plant likely to be

encountered in gas extraction and processing. The proponent demonstrated various successful measures at its Camden operation, both at the well head and the process plant.

Both well-head and process-plant flares should be shielded as ground level noise sources. Since the flames from these flares can be luminous due to traces of salt in the unrefined gas, shielding provides a double benefit in reducing visibility of the operations, especially at night. The proponent demonstrated shielding provisions both at Gloucester (the well head) and Camden (the process plant).

The Commission has added a condition of approval specifying that receptor acoustic screening is only to be considered where engineering treatment at source is not reasonable or feasible.

7.5 Ecology

The Commission has reviewed the ecological assessment and is satisfied that adequate mitigation measures and biodiversity offsets for threatened and endangered species likely to be impacted by the project will be provided. Much of the land traversed by the pipeline has been subject to agricultural activity over a long period and is therefore not likely to be especially ecologically sensitive. However, it will be important for the targeted ecological survey work specified to be undertaken to confirm the project's impacts and to ensure that a suitable biodiversity offset site is secured in perpetuity prior to the commencement of construction of the project for Stage 1. The Department has recommended a condition of approval to this effect.

7.6 Section 94 Developer Contributions

The Commission notes that concern was raised in submissions from a number of Councils on the need for additional Section 94 developer contributions. The Commission acknowledges and supports the conclusion of the Department that developer contributions would not be warranted for the project. The project would only pose a temporary increase in traffic as a result of construction traffic and the increase in population during the construction phase is also considered temporary and will not warrant ongoing developer contributions.

7.7 Consideration of the Concept Plan

In considering the Concept Plan approval, the Commission was conscious of the implicit assumption in granting such an approval that the environmental outcomes anticipated for the Stage 1 development, based on some experimental drilling, could be expected for the whole gas field, where geological and hydrogeological information is less defined.

The Commission is aware of the high costs involved in acquiring the information needed for a comprehensive understanding of the geology and hydrogeology of a gas field. Drilling, geological testing and modelling are costly activities. The cost for a more thorough definition of these aspects at this stage needs to be weighed against the commitment to install a long pipeline for the development not only of Stage 1 but of the whole gas field. Approval of the Concept Plan gives a measure of assurance to the proponent that the return on investment to cover this commitment by the development of the whole field can be realised.

Nevertheless, in the circumstance of limited information being available for the whole field, the Commission considered it prudent to incorporate an additional environmental assessment requirement on future Project Applications which requires a demonstration that the nature of environmental impacts associated with the development of the whole gas field would be generally consistent with the nature of environmental impacts identified for the Stage 1 Project.

8.0 COMMISSION'S COMMENT

The Commission is generally satisfied that the conditions specified by the Department adequately address all aspects of environmental impact for the Stage 1 Project. The conditions have been supplemented or strengthened at several points by the Commission.

The proponent, AGL, presented in its contact with the Commission as a competent and responsible commercial operator in this field. However, the Commission is satisfied that the conditions are adequate in an administrative and legal sense to regulate the development in the hands of any commercial operator.

The Commission raised with the proponent the possibility of land subsidence due to gas field development. On the basis of the proponent's response in the meeting (dated 28 January 2011), the Commission is satisfied that subsidence is not a significant impact for this development, in contrast to the phenomenon in underground coal mining. At several locations along the pipeline path compliance with conditions of the local Mine Subsidence Board will be relevant.

The Commission is satisfied that the conditions attached to the Concept Plan approval are adequate, on the clear understanding that the environmental outcomes anticipated can be demonstrated to be consistent with those for the Stage 1 Project.

9.0 COMMISSION'S DETERMINATION

The Commission has considered the application and associated documents provided by the Department

The Commission has noted the Department's assessment of key issues raised in the submissions. On the basis of that assessment and its own review, the Commission recommend the application should be approved subject to the Department's recommended conditions of approval, except as amended by the Commission as summarised in Table 1:

Table 1 Summary of amendments to conditions of approval
Note: Amendments to conditions are highlighted in italics

Condition #	Amendments to Condition	Reason
Concept Approval Conditions		
2.1 Project Applications and Specific Requirements	Amend item (c) to include: "*In addition demonstration that the nature of environmental impacts associated with the project are generally consistent with the nature of environmental impacts identified for the Stage 1 project*;"	To ensure future Project Applications with the Concept Plan achieve the same environmental benchmarks set for the Stage 1 project application.
Project Approval Conditions		
2.1 Project Design Requirements	Amend first sentence of condition to: "The Proponent shall *in consultation with DII and NOW* ensure that gas wells within the Stage 1 Gas Field Development Area are located consistent with the locational principles identified in Statement of Commitment 3 (concept area) of the Environmental Assessment, with	To ensure the AGL consults with Department of Industry and Investment (DII) and NSW Office of Water (NOW) in the final location of gas wells.

	consideration to flood prone land and with consideration to minimising the risk of groundwater impacts consistent with the requirements of condition 3.9. “	
2.3 Project Design Requirements	Amend condition to: “The Proponent shall ensure that the final design of the gas transmission pipeline makes provisions for all reasonable requirements of the Mine Subsidence Board, *where the gas pipeline route traverses a Mine Subsidence District*.”	To ensure the requirements of the Mine Subsidence Board are addressed where the proposed pipeline traverses a Mine Subsidence District.
2.4 Project Design Requirements	Add new condition: “*The Proponent shall ensure that engineering measures are incorporated into the design of the central processing facility so that the associated flare plant is shielded (visually and in relation to noise emissions) from nearest sensitive receptors, as far as reasonable and feasible. The Proponent shall also ensure that gas wells are designed so as to ensure that associated flaring is visually shielded from nearest sensitive receptors as far as reasonable and feasible. The Proponent shall submit details of engineering measures incorporated into the design of the flare plant and gas wells for the approval of the Director-General, prior to the commencement of construction*.”	To ensure the flares at the Central Processing Plant are adequately shielded to ameliorate visibility and noise impacts.
3.7 Groundwater Management	Add new condition: *“The Proponent shall ensure that no fraccing fluids containing Benzene, Toluene, Ethylbenzene and Xylene (BTEX) chemicals are used in gas field development*”	Although AGL have indicated the use of BTEX is not anticipated, it is considered this commitment needs to be explicitly stated as a condition.
3.9 Groundwater Management	Add new item (d): *“d) include an independent peer review by an appropriately experienced and qualified hydrogeologist (who is approved by the Director-General for the purposes of this condition) on the robustness and technical veracity of the model.”*	To assist the Department and agencies in their decision on the veracity and robustness of the hydrogeological modelling required for the Stage 1 Project.

3.12 Extracted Water Management	Add new item (i), *"i) provide for the development of site specific water quality criteria in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC 2000 Guidelines), as necessary, in consultation with DECCW, for the purposes of conditions b),c), d) and e) above."*	The water quality criteria established for the site are likely to involve the development of site-specific criteria in the Gloucester region according to the ANZECC 2000 Guidelines. The Proponent should be responsible for this development in consultation with DECCW.
3.33 Gas Flare Management	Add new condition: *"The Proponent shall ensure that records of gas venting from the central processing facility, either through flare or directly to the atmosphere shall be recorded and reported to the Director-General and DECCW on an annual basis".*	To confirm that venting of the gas flare in the central processing facility is in fact minimal.
4.1 Ground Water Monitoring	Amend item (c) as follows: **"**identify performance criteria for gas well development, including monitoring criteria to detect early indicators of drawdown impacts to beneficial aquifers or of cumulative drawdown effects and hold points *(based on risk assessment)* for further development where adverse impacts are identified*;* Amend item (e) as follows: "include provisions for the monitoring of coal seam dewatering rates and hold points *(based on risk assessment)* in the case that water volumes are greater than the predicted two mega litres per day (unless managed in accordance with condition 3.12g);"	The "hold points" are critical parts of the adaptive management proposed. They need to be adequately defined based on environmental risk management criteria.
4.1 Ground Water Monitoring	Amend item (g): *"g) provide detailed specifications (including information on toxicity and/ or carcinogenicity) of fraccing fluids to be used in gas well development, with annual updates;"*	Technological changes are anticipated with likely changes in fraccing fluids. The condition will allow for such development while keeping close track of any potential environmental risks.
4.4 Noise Monitoring	Amend condition as follows: "In the event that the program undertaken to satisfy condition 4.3 of the approval indicates that the operation of the project, under normal operating conditions, will	To ensure appropriate at source acoustic amelioration are considered in the first instance.

	lead to greater noise impacts than permitted under condition 3.22 of this approval, then the Proponent shall provide details of remedial measures to be implemented to reduce noise impacts to levels required by that condition, including (but not necessarily limited to) at-receptor acoustic screening as required under condition 3.27. *At-receptor acoustic screening shall only be considered where other at-source methods of acoustic amelioration are found to not be reasonable or feasible*. A report providing details of the remedial measures and a timetable for implementation shall be submitted to the Director-General for approval within such period as the Director-General may require, and be accompanied by evidence that the DECCW is satisfied that the remedial measures are acceptable.	
4.7 Air Quality Performance Verification	Add new condition: *"Unless otherwise agreed to by DECCW, the Proponent shall in consultation with DECCW, prior to the commencement of construction, establish a meteorological station(s) at a representative location(s) to collect meteorological information representative of the Gloucester Valley, to enable air quality performance verification for the central processing facility in accordance with condition 4.8. At least one year's data must be collected for the purpose of undertaking the air quality performance verification required under condition 4.8 for the central processing facility."*	At present meteorological data is only synthesized (by TAPM) for the Gloucester valley. It is understood AGL intends to establish a new meteorological station, but this requirement should be specified in the conditions of approval.
7.4 Operation Environmental Management Plan	Amend item (c) as follows: "c) a description of the roles and responsibilities for all relevant employees *and contractors* involved in the operation of the project including relevant training and induction provisions for ensuring that all employees, contractors and sub-contractors are aware of their environmental and compliance obligations under these conditions of approval"	To ensure both AGL employees as well as contractors engaged by AGL to undertake management of parts of the development are informed of all relevant environmental and compliance obligations.

The Commission is satisfied that the issues raised in submissions have been fully considered by the Department in their assessment and support their recommended conditions of approval, except as amended by the Commission. The Commission considers adequate measures have been included in the conditions of approval to ensure the project achieves acceptable environmental standards in relation to impacts on surface and groundwater, noise and vibration, flora and fauna, air quality and visual amenity. The application should be approved subject to conditions.

Garry Payne AM
Chair

John Court
PAC Member

ANNEXURE A

Gas Composition Results from test gas wells at the Stratford Pilot project (provided by AGL on 31 January 2011)

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

Accreditation No 2013

Certificate of Analysis

Lucas Energy Pty Ltd
160 Queen Street
Melbourne VIC 3000
Australia

Attention: Andrew Farley

Project **08PEAD0024243**
Client Ref: 320252

Customer Sample ID		**ST30409080800A**	**ST40309081630A**	**ST50309081617A**
Sample Type		**Gas**	**Gas**	**Gas**
Date Sampled		**04/09/2008**	**03/09/2008**	**03/09/2008**
Time Sampled		**0800h**	**1630h**	**1617h**
Test/Reference	Unit			
Dräger Tube Test ASTM D4810				
Hydrogen Sulphide (ppm v/v)*	mL/m³	<0.20	<0.20	<0.20
Hydrogen Sulphide (ppm w/v)*	mg /m³	<0.29	<0.29	<0.29

Customer Sample ID		**ST60409080800A**	**ST80309081645A**	**ST30409080800B**
Sample Type		**Gas**	**Gas**	**Gas**
Date Sampled		**04/09/2008**	**03/09/2008**	**04/09/2008**
Time Sampled		**0800h**	**1645h**	**0800h**
Test/Reference	Unit			
Dräger Tube Test ASTM D4810				
Hydrogen Sulphide (ppm v/v)*	mL/m³	<0.20	<0.20	-
Hydrogen Sulphide (ppm w/v)*	mg /m³	<0.29	<0.29	-
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	-	-	< 0.01
Carbon Dioxide	Mol %	-	-	0.22
Methane	Mol %	-	-	99.78
Ethane	Mol %	-	-	< 0.01
Propane	Mol %	-	-	< 0.01
I-Butane	Mol %	-	-	< 0.01
N-Butane	Mol %	-	-	< 0.01
I-Pentane	Mol %	-	-	< 0.01
N-Pentane	Mol %	-	-	< 0.01
Hexanes	Mol %	-	-	< 0.01
Heptanes	Mol %	-	-	< 0.01
Octanes and higher hydrocarbons	Mol %	-	-	< 0.01
Total	Mol %	-	-	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		-	-	16.11
Lower Flammability Limit		-	-	5.01
Upper Flammability Limit		-	-	15.03
Ratio Of Upper To Lower		-	-	3.00
Wobbe Index		-	-	50.46
Compressibility Factor (Z)		-	-	0.9980
Ideal Gas Density (Rel to Air = 1)		-	-	0.556
Real Gas Density (Rel to Air = 1)		-	-	0.557

Customer Sample ID		ST60409080800A	ST80309081645A	ST30409080800B
Sample Type		Gas	Gas	Gas
Date Sampled		04/09/2008	03/09/2008	04/09/2008
Time Sampled		0800h	1645h	0800h
GAS ANALYSIS				
Test/Reference	Unit			
Ideal Nett Calorific Value	MJ/m³	-	-	33.88
Ideal Gross Calorific Value	MJ/m³	-	-	37.63
Real Nett Calorific Value	MJ/m³	-	-	33.95
Real Gross Calorific Value	MJ/m³	-	-	37.70
Gross Calorific Val Water-Sat Gas	MJ/m³	-	-	36.97

Customer Sample ID		ST40309081630B	ST50309081617B	ST60409080800B
Sample Type		Gas	Gas	Gas
Date Sampled		03/09/2008	03/09/2008	04/09/2008
Time Sampled		1630h	1617h	0800h
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	< 0.01	< 0.01	< 0.01
Carbon Dioxide	Mol %	4.71	1.27	0.46
Methane	Mol %	95.25	98.72	99.53
Ethane	Mol %	0.04	0.01	0.01
Propane	Mol %	< 0.01	< 0.01	< 0.01
I-Butane	Mol %	< 0.01	< 0.01	< 0.01
N-Butane	Mol %	< 0.01	< 0.01	< 0.01
I-Pentane	Mol %	< 0.01	< 0.01	< 0.01
N-Pentane	Mol %	< 0.01	< 0.01	< 0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		17.37	16.40	16.17
Lower Flammability Limit		5.25	5.06	5.02
Upper Flammability Limit		15.74	15.19	15.07
Ratio Of Upper To Lower		3.00	3.00	3.00
Wobbe Index		46.42	49.48	50.24
Compressibility Factor (Z)		0.9979	0.9980	0.9980
Ideal Gas Density (Rel to Air = 1)		0.600	0.566	0.558
Real Gas Density (Rel to Air = 1)		0.601	0.567	0.559
Ideal Nett Calorific Value	MJ/m³	32.36	33.52	33.80
Ideal Gross Calorific Value	MJ/m³	35.94	37.23	37.54
Real Nett Calorific Value	MJ/m³	32.43	33.59	33.87
Real Gross Calorific Value	MJ/m³	36.02	37.31	37.62
Gross Calorific Val Water-Sat Gas	MJ/m³	35.31	36.58	36.88

Customer Sample ID	ST80309081645B
Sample Type	Gas
Date Sampled	03/09/2008
Time Sampled	1645h

Customer Sample ID		**ST80309081645B**
Sample Type		**Gas**
Date Sampled		**03/09/2008**
Time Sampled		**1645h**

GAS ANALYSIS

Test/Reference	Unit	
Gas Analysis ASTM D 1945-96 (modified)		
Nitrogen	Mol %	< 0.01
Carbon Dioxide	Mol %	1.25
Methane	Mol %	98.73
Ethane	Mol %	0.02
Propane	Mol %	< 0.01
I-Butane	Mol %	< 0.01
N-Butane	Mol %	< 0.01
I-Pentane	Mol %	< 0.01
N-Pentane	Mol %	< 0.01
Hexanes	Mol %	< 0.01
Heptanes	Mol %	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01
Total	Mol %	100.00
Gas Parameters ASTM D 1945-96 (modified)		
Average Molecular Weight		16.40
Lower Flammability Limit		5.06
Upper Flammability Limit		15.19
Ratio Of Upper To Lower		3.00
Wobbe Index		49.50
Compressibility Factor (Z)		0.9980
Ideal Gas Density (Rel to Air = 1)		0.566
Real Gas Density (Rel to Air = 1)		0.567
Ideal Nett Calorific Value	MJ/m^3	33.53
Ideal Gross Calorific Value	MJ/m^3	37.24
Real Nett Calorific Value	MJ/m^3	33.60
Real Gross Calorific Value	MJ/m^3	37.32
Gross Calorific Val Water-Sat Gas	MJ/m^3	36.59

Test Description

Dräger Tube Test	Hydrogen Sulphide results measured at 101.3 kPa abs @ 15°C.
Gas Parameters	The above results are calculated on an air and water free basis assuming only the measured constituents are present. The following parameters are calculated from the above composition at 15°C and 101.325 kPa (abs) using ISO 6976 and the physical constants from the GPSA SI Engineering Data Handbook 11 th Ed.

Authorised By

Michelle Fordham — Chemist — Accreditation No 2013

Laboratory Manager

Diane Cass — Operations Manager

Final Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Samples will be discarded after 30 days unless otherwise notified.

Interim Certificate of Analysis

Lucas Energy Pty Ltd
160 Queen Street
Melbourne VIC 3000
Australia

Attention: Andrew Farley

Project **08PEAD0027299**

Customer Sample ID		**LMGO.3 A**	**STRATFORD 4 A**	**STRATFORD 5 A**
Date Sampled		**24/09/2008**	**24/09/2008**	**24/09/2008**
Time Sampled		**1300 h**	**1215 h**	**1225 h**
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	0.91	0.44	< 0.01
Carbon Dioxide	Mol %	0.25	4.67	1.27
Methane	Mol %	98.84	94.85	98.72
Ethane	Mol %	< 0.01	0.04	0.01
Propane	Mol %	< 0.01	< 0.01	< 0.01
I-Butane	Mol %	< 0.01	< 0.01	< 0.01
N-Butane	Mol %	< 0.01	< 0.01	< 0.01
I-Pentane	Mol %	< 0.01	< 0.01	< 0.01
N-Pentane	Mol %	< 0.01	< 0.01	< 0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.22	17.41	16.40
Lower Flammability Limit		5.06	5.27	5.06
Upper Flammability Limit		15.18	15.81	15.19
Ratio Of Upper To Lower		3.00	3.00	3.00
Wobbe Index		49.80	46.17	49.48
Compressibility Factor (Z)		0.9980	0.9979	0.9980
Ideal Gas Density (Rel to Air = 1)		0.560	0.601	0.566
Real Gas Density (Rel to Air = 1)		0.561	0.602	0.567
Ideal Nett Calorific Value	MJ/m^3	33.55	32.23	33.52
Ideal Gross Calorific Value	MJ/m^3	37.27	35.79	37.23
Real Nett Calorific Value	MJ/m^3	33.62	32.29	33.59
Real Gross Calorific Value	MJ/m^3	37.34	35.87	37.31
Gross Calorific Val Water-Sat Gas	MJ/m^3	36.61	35.16	36.58

Customer Sample ID		**STRATFORD 6 A**	**STRATFORD 8 A**	**STRATFORD 9 A**
Date Sampled		**24/09/2008**	**24/09/2008**	**24/09/2008**
Time Sampled		**1245 h**	**1235 h**	**1205 h**
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	0.06	< 0.01	0.13
Carbon Dioxide	Mol %	0.45	1.27	0.44
Methane	Mol %	99.47	98.70	94.18

Customer Sample ID		STRATFORD 6 A	STRATFORD 8 A	STRATFORD 9 A
Date Sampled		24/09/2008	24/09/2008	24/09/2008
Time Sampled		1245 h	1235 h	1205 h
GAS ANALYSIS				
Test/Reference	Unit			
Ethane	Mol %	0.02	0.03	4.32
Propane	Mol %	< 0.01	< 0.01	0.77
I-Butane	Mol %	< 0.01	< 0.01	0.07
N-Butane	Mol %	< 0.01	< 0.01	0.07
I-Pentane	Mol %	< 0.01	< 0.01	0.01
N-Pentane	Mol %	< 0.01	< 0.01	0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.18	16.40	17.08
Lower Flammability Limit		5.02	5.06	4.80
Upper Flammability Limit		15.08	15.19	14.90
Ratio Of Upper To Lower		3.00	3.00	3.10
Wobbe Index		50.20	49.49	51.18
Compressibility Factor (Z)		0.9980	0.9980	0.9977
Ideal Gas Density (Rel to Air = 1)		0.559	0.566	0.590
Real Gas Density (Rel to Air = 1)		0.560	0.567	0.591
Ideal Nett Calorific Value	MJ/m^3	33.78	33.53	35.44
Ideal Gross Calorific Value	MJ/m^3	37.52	37.24	39.30
Real Nett Calorific Value	MJ/m^3	33.85	33.59	35.52
Real Gross Calorific Value	MJ/m^3	37.60	37.31	39.39
Gross Calorific Val Water-Sat Gas	MJ/m^3	36.86	36.58	38.61

Test Description

Gas Parameters

The above results are calculated on an air and water free basis assuming only the measured constituents are present. The following parameters are calculated from the above composition at 15°C and 101.325 kPa (abs) using ISO 6976 and the physical constants from the GPSA SI Engineering Data Handbook 11 th Ed.

Authorised By

Michelle Fordham — Chemist — Accreditation No 2013

Laboratory Manager

Diane Cass — Operations Manager

Interim Report. A final report will be issued once all testing is complete

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Samples will be discarded after 30 days unless otherwise notified.

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

Accreditation No 2013

Certificate of Analysis

Lucas Energy Pty Ltd
160 Queen Street
Melbourne VIC 3000
Australia

Attention: Andrew Farley

Project **08PEAD0027299**

Customer Sample ID		**LMGO.3 A**	**STRATFORD 4 A**	**STRATFORD 5 A**
Date Sampled		**24/09/2008**	**24/09/2008**	**24/09/2008**
Time Sampled		**1300 h**	**1215 h**	**1225 h**
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	0.91	0.44	< 0.01
Carbon Dioxide	Mol %	0.25	4.67	1.27
Methane	Mol %	98.84	94.85	98.72
Ethane	Mol %	< 0.01	0.04	0.01
Propane	Mol %	< 0.01	< 0.01	< 0.01
I-Butane	Mol %	< 0.01	< 0.01	< 0.01
N-Butane	Mol %	< 0.01	< 0.01	< 0.01
I-Pentane	Mol %	< 0.01	< 0.01	< 0.01
N-Pentane	Mol %	< 0.01	< 0.01	< 0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.22	17.41	16.40
Lower Flammability Limit		5.06	5.27	5.06
Upper Flammability Limit		15.18	15.81	15.19
Ratio Of Upper To Lower		3.00	3.00	3.00
Wobbe Index		49.80	46.17	49.48
Compressibility Factor (Z)		0.9980	0.9979	0.9980
Ideal Gas Density (Rel to Air = 1)		0.560	0.601	0.566
Real Gas Density (Rel to Air = 1)		0.561	0.602	0.567
Ideal Nett Calorific Value	MJ/m^3	33.55	32.23	33.52
Ideal Gross Calorific Value	MJ/m^3	37.27	35.79	37.23
Real Nett Calorific Value	MJ/m^3	33.62	32.29	33.59
Real Gross Calorific Value	MJ/m^3	37.34	35.87	37.31
Gross Calorific Val Water-Sat Gas	MJ/m^3	36.61	35.16	36.58

Customer Sample ID		**STRATFORD 6 A**	**STRATFORD 8 A**	**STRATFORD 9 A**
Date Sampled		**24/09/2008**	**24/09/2008**	**24/09/2008**
Time Sampled		**1245 h**	**1235 h**	**1205 h**
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	0.06	< 0.01	0.13
Carbon Dioxide	Mol %	0.45	1.27	0.44
Methane	Mol %	99.47	98.70	94.18

Customer Sample ID		STRATFORD 6 A	STRATFORD 8 A	STRATFORD 9 A
Date Sampled		24/09/2008	24/09/2008	24/09/2008
Time Sampled		1245 h	1235 h	1205 h
GAS ANALYSIS				
Test/Reference	Unit			
Ethane	Mol %	0.02	0.03	4.32
Propane	Mol %	< 0.01	< 0.01	0.77
I-Butane	Mol %	< 0.01	< 0.01	0.07
N-Butane	Mol %	< 0.01	< 0.01	0.07
I-Pentane	Mol %	< 0.01	< 0.01	0.01
N-Pentane	Mol %	< 0.01	< 0.01	0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.18	16.40	17.08
Lower Flammability Limit		5.02	5.06	4.80
Upper Flammability Limit		15.08	15.19	14.90
Ratio Of Upper To Lower		3.00	3.00	3.10
Wobbe Index		50.20	49.49	51.18
Compressibility Factor (Z)		0.9980	0.9980	0.9977
Ideal Gas Density (Rel to Air = 1)		0.559	0.566	0.590
Real Gas Density (Rel to Air = 1)		0.560	0.567	0.591
Ideal Nett Calorific Value	MJ/m^3	33.78	33.53	35.44
Ideal Gross Calorific Value	MJ/m^3	37.52	37.24	39.30
Real Nett Calorific Value	MJ/m^3	33.85	33.59	35.52
Real Gross Calorific Value	MJ/m^3	37.60	37.31	39.39
Gross Calorific Val Water-Sat Gas	MJ/m^3	36.86	36.58	38.61

Test Description

Gas Parameters

The above results are calculated on an air and water free basis assuming only the measured constituents are present. The following parameters are calculated from the above composition at 15°C and 101.325 kPa (abs) using ISO 6976 and the physical constants from the GPSA SI Engineering Data Handbook 11 th Ed.

Authorised By

Michelle Fordham — Chemist — Accreditation No 2013

Laboratory Manager

Diane Cass — Operations Manager

Final Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Samples will be discarded after 30 days unless otherwise notified.

Certificate of Analysis

Lucas Energy Pty Ltd
160 Queen Street
Melbourne VIC 3000
Australia

Attention: Andrew Farley

Project **08PEAD0029931**

Customer Sample ID		**ST03 A & B**	**ST04 A & B**	**ST05 A & B**
Sample Type		**Gas**	**Gas**	**Gas**
Date Sampled		**23/10/2008**	**23/10/2008**	**23/10/2008**
Time Sampled		**1130 h**	**1210 h**	**1200 h**
Test/Reference	Unit			
Dräger Tube Test ASTM D4810				
Hydrogen Sulphide (ppm v/v)*	mL/m³	< 0.10	< 0.10	< 0.10
Hydrogen Sulphide (ppm w/v)*	mg /m³	< 0.14	< 0.14	< 0.14
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	< 0.01	< 0.01	< 0.01
Carbon Dioxide	Mol %	0.28	4.69	1.30
Methane	Mol %	99.72	95.27	98.69
Ethane	Mol %	< 0.01	0.04	0.01
Propane	Mol %	< 0.01	< 0.01	< 0.01
I-Butane	Mol %	< 0.01	< 0.01	< 0.01
N-Butane	Mol %	< 0.01	< 0.01	< 0.01
I-Pentane	Mol %	< 0.01	< 0.01	< 0.01
N-Pentane	Mol %	< 0.01	< 0.01	< 0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.12	17.36	16.41
Lower Flammability Limit		5.01	5.24	5.07
Upper Flammability Limit		15.04	15.74	15.20
Ratio Of Upper To Lower		3.00	3.00	3.00
Wobbe Index		50.41	46.44	49.45
Compressibility Factor (Z)		0.9980	0.9979	0.9980
Ideal Gas Density (Rel to Air = 1)		0.557	0.599	0.567
Real Gas Density (Rel to Air = 1)		0.557	0.600	0.567
Ideal Nett Calorific Value	MJ/m³	33.86	32.37	33.51
Ideal Gross Calorific Value	MJ/m³	37.61	35.95	37.22
Real Nett Calorific Value	MJ/m³	33.92	32.44	33.58
Real Gross Calorific Value	MJ/m³	37.68	36.03	37.30
Gross Calorific Val Water-Sat Gas	MJ/m³	36.94	35.32	36.57

Customer Sample ID		ST06 A & B	ST08 A & B	ST09 A & B
Sample Type		Gas	Gas	Gas
Date Sampled		23/10/2008	23/10/2008	23/10/2008
Time Sampled		1140 h	1150 h	1220 h
Test/Reference	Unit			
Dräger Tube Test ASTM D4810				
Hydrogen Sulphide (ppm v/v)*	mL/m³	< 0.10	< 0.10	< 0.10
Hydrogen Sulphide (ppm w/v)*	mg /m³	< 0.14	< 0.14	< 0.14
GAS ANALYSIS				
Test/Reference	Unit			
Gas Analysis ASTM D 1945-96 (modified)				
Nitrogen	Mol %	< 0.01	< 0.01	< 0.01
Carbon Dioxide	Mol %	0.44	1.33	0.98
Methane	Mol %	99.55	98.64	93.42
Ethane	Mol %	0.01	0.03	4.93
Propane	Mol %	< 0.01	< 0.01	0.60
I-Butane	Mol %	< 0.01	< 0.01	0.03
N-Butane	Mol %	< 0.01	< 0.01	0.04
I-Pentane	Mol %	< 0.01	< 0.01	< 0.01
N-Pentane	Mol %	< 0.01	< 0.01	< 0.01
Hexanes	Mol %	< 0.01	< 0.01	< 0.01
Heptanes	Mol %	< 0.01	< 0.01	< 0.01
Octanes and higher hydrocarbons	Mol %	< 0.01	< 0.01	< 0.01
Total	Mol %	100.00	100.00	100.00
Gas Parameters ASTM D 1945-96 (modified)				
Average Molecular Weight		16.17	16.42	17.21
Lower Flammability Limit		5.02	5.07	4.82
Upper Flammability Limit		15.07	15.20	14.97
Ratio Of Upper To Lower		3.00	3.00	3.10
Wobbe Index		50.25	49.42	50.78
Compressibility Factor (Z)		0.9980	0.9980	0.9977
Ideal Gas Density (Rel to Air = 1)		0.558	0.567	0.594
Real Gas Density (Rel to Air = 1)		0.559	0.568	0.595
Ideal Nett Calorific Value	MJ/m³	33.80	33.50	35.30
Ideal Gross Calorific Value	MJ/m³	37.54	37.21	39.14
Real Nett Calorific Value	MJ/m³	33.87	33.57	35.38
Real Gross Calorific Value	MJ/m³	37.62	37.29	39.23
Gross Calorific Val Water-Sat Gas	MJ/m³	36.88	36.56	38.46

Test Description

Dräger Tube Test Hydrogen Sulphide results measured at 101.3 kPa abs @ 15°C.

Gas Parameters The above results are calculated on an air and water free basis assuming only the measured constituents are present. The following parameters are calculated from the above composition at 15°C and 101.325 kPa (abs) using ISO 6976 and the physical constants from the GPSA SI Engineering Data Handbook 11 th Ed.

Authorised By

Michelle Fordham — Chemist — Accreditation No 2013

Laboratory Manager

Diane Cass — Operations Manager

Final Report

- Indicates Not Requested * Indicates NATA accreditation does not cover the performance of this service

Samples will be discarded after 30 days unless otherwise notified.

The samples were not collected by Laboratory staff.